International Symposium on PWS: A Key to Service Delivery
(Geneva, 3-5 December 2007)

Symposium Proceedings

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Introduction

The 'International Symposium on PWS: A Key to Service Delivery' was held in Geneva from 3 to 5 December 2007. The event was attended by 120 speakers and participants. The main objective of the Symposium was to carry out a thorough review of the lessons learnt and the achievements of the Public weather Services Programme (PWSP) during the 13 years of its existence, and to make recommendations for the future, with a view to improving delivery of services by National Meteorological and Hydrological Services (NMHS) and other entities engaged in weather, climate and water issues for the next decade and beyond.

The Symposium observed that the PWSP had addressed many of the needs identified in the late 1980's and early 1990's for WMO to assist its Members to more clearly articulate and implement their role in delivering a range of public weather and related services that were important socially and economically, and that were only possible because of the continued investment in meteorological infrastructure. This had been and continues to be important in the context of publicly funded versus commercial services, the free international exchange of data, relationships with private sector meteorology and relationships with the media.

Furthermore, it noted that NMHSs had visibly benefited from the many activities carried out by PWSP with support from experts from many NMHSs who had given freely of their time and expertise for the development and implementation of this programme. Notable among these achievements were production of guidance materials to help NMHSs establish and carry out key PWS functions, organization of training workshops and seminars, and providing expert advice for capacity building activities such the installation of information dissemination facilities in NMHSs.

The PWSP had also been influential in building relations between WMO and the global media, which had led to improved understanding of the respective roles of the media and NMHS's. It was also instrumental in increasing the number of NMHSs delivering weather services to the public through television, radio, print media and the Internet. It also contributed to the quality of these services in terms increasing the timeliness of service delivery, as well as in assisting NMHSs to make it easy for the public to understand weather forecasts and warnings.

The Symposium also noted the role of PWS activities in raising the status of NMHSs in many countries, thus making it easier for them to receive institutional and fiscal support. Major thrusts defining the implementation of PWS including: User focus; Emphasis on the enhancement of the capacity of NMHSs to work effectively with the media; Establishment of the World Weather Information Services (WWIS) and the Severe Weather Information Centre (SWIC) websites, (which provide official weather information and warnings to the media) and; Awareness creation and public education, were noted to have been effective PWS implementation strategies over the years.

These results had been accomplished with quite modest resources through the use of innovative and collaborative approaches involving other WMO programmes, assistance from particular WMO Members, and from links with groups such as the International Association of Broadcast Meteorologists (IABM). The Symposium observed that PWSP had effectively linked with the other elements of Commission for Basic systems (CBS), Technical Commissions such as commission for Atmospheric Science (CAS), Commission for Climatology (CCl) and Commission for Hydrology (CHy), and with other cross cutting programmes. The PWSP had also helped give practical effect to the arrangement between WMO and the International Olympic Committee to improve access to international weather data for those attending the Olympics.

New influences on PWS

The Symposium recognised that in recent years, the world has experienced rapid social changes resulting in new influences impacting PWS. Similarly, rapid technological changes have taken place availing potential for the development of new methodologies for service delivery. The Symposium therefore observed that it is necessary to adopt new approaches to service delivery in order to meet modern PWS user needs. In this regard, the Symposium stressed on the following points:

- The pace of change is making it increasingly important to strengthen communication with key stakeholders;
- The issue of climate change is now firmly on national and international agendas as a major strategic issue that will require increasing attention, careful planning and resources;
- Broad issues of water supplies, the environment, human health, and urbanisation will provide new PWS needs for the future;

- Increased human population and vulnerability in many parts of the world is placing new demands on NMHSs to provide new services to meet the new challenges;
- PWS will be influenced in the future by the increased engagement of the social sciences in environmental issues;
- The issue of evaluation of socio-economic aspects is becoming more relevant in determining the effectiveness of services and in justifying existing or increased investment in NMHSs; and
- All NMHSs face significant challenges and opportunities to maximise exploitation of advances in science and technology in order to enhance the range, relevance and quality of PWS.

These influences are likely to lead to demands for increased resources in WMO to support NMHSs in the development of their PWS. WMO and its Members will also need to meet the changing demands, as well as look at innovative ways of accessing resources, and seek to build partnerships that foster PWS delivery.

Strengthening User Focus

The Symposium stressed that NMHSs must continue to give attention to user needs to ensure that public weather services are valued and used and that available resources are used in the most effective way to achieve the desired outcomes. A key message from the Symposium was that the provision of quality services is much more than the provision of good products. Quality service should be characterised by:

- **Availability** – is the information relevant to the client, and available when the client needs it?
- **Dependability** – can the client expect the information to be delivered on time and without fail?
- **Usability –** is the information presented in a manner which enables the client to fully understand it?
- **Credibility –** does the client have faith in what is (frequently) no more than a professional opinion?

It was emphasised that in addition to the traditionally important linkages with the civil defence authorities, NMHSs need to consider strengthening links with the wider hazard community, such as insurers and academics.

Communicating Effectively with Users and Other Stakeholders

The Symposium agreed that a key feature of building strong relationships with users and decision-makers was to communicate effectively through a variety of mechanisms. NMHSs need not only to understand user needs, but to communicate their capabilities effectively to users, governments, planners and politicians so that the capabilities of NMHSs can be linked to national plans and to internationally agreed priorities such as the UN Millennium Development Goals.

The Value of Partnerships

The Symposium noted that limited resources available to NMHS's in the face of demands for services that are increasing in number and complexity make it essential to look at partnerships and collaborations as ways of leveraging resources to achieve more effective results. The Climate Outlook Forums (COFs) and Climate for Development in Africa (ClimDev Africa) were quoted as good examples of the value of such partnerships. The prominence of climate change issue internationally and for national governments has substantial implications for NMHSs which, in most cases, are not only the principal custodians of the national climate record, but are actively engaged in providing a range of services and information related to weather and climate. There exists, therefore, a real opportunity for leveraging resources through forming partnerships for climate change related service delivery by NMHSs. It recommended that NMHSs should take note of the relevant parts of considerations of the IPCC that apply or could be relevant to the future planning of public weather services, in particular the documents submitted by WMO and included in "Nairobi work programme on impacts, vulnerability, and adaptation to climate change". These documents describe the scope for NMHSs to contribute to this issue in a range of ways, and of the need for the NMHSs to be supported more strongly so that they are able to fulfil their potential.

Increasing Vulnerability of Society

Communities are expected to become more vulnerable due to the combined effects of increasing populations on the one hand, and the impacts of climate change with regard to severe weather, droughts, water supplies, the environment, and energy supplies on the other. If, as suggested by climate change scenarios, there is likely to be an increase in extreme weather events, NMHSs will need to improve further their PWS in relation to civil defence and disaster mitigation, and provide timely warnings to increasingly vulnerable communities. Using its links with the media and other outreach activities such as web sites, NMHSs will need to increase their capability to provide an integrated suite of weather, climate and related information and services on all timescales from historical information to nowcasting, medium range, seasonal and climate forecasting. The continued rapid growth of some very large urban environments is another example of the increasing vulnerability of communities to a range of environmental problems and the need for different kinds of services to help minimise adverse impacts of urbanisation.

Social and Economic Factors in PWS

The need to take account of social and economic factors in the design and effective delivery of public weather services remains a critical issue for the WMO PWS programme. This need has been emphasised by the Millennium Development Goals adopted by the UN and by the outcomes of the WMO Conference on the Social and Economic Benefits of Weather, Climate and Water services held in Madrid, Spain in March 2007 and the adoption of a specific Madrid Action Plan. Further work is needed on how to quantify the economic benefits of PWS and how to communicate this to decision makers in government to enhance the prospects of adequate allocation of resources to NMHSs to enable them to carry out the necessary tasks of meeting social and economic needs. NMHSs can also assist the social science community to bid for the resources needed to undertake important social and economic research.

Recommendations

Below are the recommendations of the Symposium. The recommendations are intended to enable NMHSs adopt a new service delivery paradigm that would enable provision of a suite of integrated services to a wide range of users.

Recommendation 1: The WMO practice of providing a range of PWSP activities in the form of production of guidelines, training activities and workshops to support the strengthening of public weather services in NMHSs should continue.

Recommendation 2: To note the strategic importance of the UN Millennium Development Goals, the IPCC's Nairobi Work Programme and the Madrid Action Plan on social and economic benefits of weather climate and water services, and consider some further evolution of the PWSP so that it can assist Members to address these strategic issues through modernised, integrated service delivery to the public.

Recommendation 3: The structure of the PWSP Open Programme Area Group (OPAG) and Expert Teams should be reconsidered in the light of increased importance of addressing social and economic aspects of public services, the need to harness new science and technology and to enhance service delivery by NMHS's, and the increasing requirement for NMHS to provide an integrated range of services to meet community needs.

Recommendation 4: To focus on assisting NMHSs develop capacities in key areas of service delivery for ensuring availability, dependability, usability, and credibility of the services that NMHSs render to users, and to continuously seek out best practice examples in service delivery and to take necessary steps to ensure that more NMHSs adopt such practices.

Recommendation 5: To support the new 'Learning through Doing', capacity building approach where a mentoring agent works alongside the staff of NMHSs, assisting them to improve their communication with users in selected target sectors, and to develop and deliver an improved range of products and services.

Recommendation 6: To assist NMHSs develop capacities for resource mobilization through the creation of partnerships.

Recommendation 7: To focus on training top managers of NMHSs so that they can acquire skills for communicating effectively with policy-makers and leaders in the different user sectors as a high priority.

The Beginnings of the Public Weather Services Programme in WMO

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Abstract

The origins of the Public Weather Services Programme (PWSP) in WMO were linked to some key considerations in the late 1980's concerning public policy aspects of the role of National Meteorological and Hydrological Services (NMHSs), and to growing debate on models for the provision of weather services to the public. Previously an area seen as the sole domain of nations rather than one for involvement of a UN specialized agency, the WMO decided in 1991 to establish a new programme to assist its Members to improve their weather services to the general public. The programme's initial focus on ways of improving service delivery by improving skills and building relationships with the media and disaster management proved popular and effective. Using its modest resources wisely, the PWSP leveraged effort through linkages with other WMO programmes. As the programme has matured, it has extended its influence and engaged strongly in some key international conferences that emphasise the important role of NMHSs in disasters and in general economic and social development.

After more than a decade of substantial achievements by the Public Weather Services Programme (PWSP) of the World Meteorological Organization (WMO) in helping National Meteorological and Hydrological Services (NMHSs) to improve the delivery of public weather services to their communities, it is interesting to look at why and how this program developed.

This paper addresses some of the background to and motivations for the formation of the PWSP, and the steps taken to bring it about. This perspective is also helpful in assessing how the WMO needs to develop to address changing needs in the future.

The development of the PWSP came at a time of considerable change and turbulence in international meteorology. It was a new activity for WMO and a fairly radical step – not only because of the budgetary pressures, and the inherent difficulty of gaining the agreement of the more than 160 Member States for change, but because it was a move into an area of activity that had been previously regarded solely as a national issue for Members themselves.

Before looking at the evolution of this new PWS Programme, and to help understand why it was such a significant and bold initiative, it is interesting to consider how international cooperation in meteorology developed over the last 150 years or so.

The Scope of International Cooperation in Meteorology

After a number of limited but admirable attempts to set up international meteorological networks as far back as the 17th and 18th century, the movement towards improved global cooperation began to gather momentum following the first International Meteorological Conference in Brussels in August 1853. On the initiative of Lieutenant Matthew Maury of the US Navy, this conference focussed on international cooperation in meteorology to assist ships navigation. It achieved international agreement on a standardised form of ships logs, instructions for taking observations at sea and for the collection of ships' logs.

The First International Meteorological Congress in Vienna in September 1873 created the International Meteorological Organization (IMO) – the precursor to the WMO – and progressed the development of international cooperation by agreeing on definitions of meteorological phenomena, weather symbols for use on charts, the need for global observation networks, standardised instrumentation, and began the first steps towards international exchange of weather data in near real-time via the newly developed telegraph.

It is interesting to note that, while the main areas of economic activity that the weather information was applied to were marine transport and agriculture, it was also around this time that attention was given to making the information more publicly available through the production of weather maps in daily newspapers.

Apart from the application of internationally shared meteorological data in support of activities such as marine transport, the latter part of the 19th century and first half of the 20th century saw significant international efforts in collaborative data collection and research on the meteorology of Polar Regions via the International Polar years of 1882-83 and 1932-33.

The development of aviation as a form of mass transport and demands for improved weather information in world wars became significant influences on international meteorology in the first half of the 20th century. Following the end of the Second World War, meetings of Directors of National Meteorological Services in London (1946) and Washington (1947) led to an intergovernmental agreement on the Convention of the World Meteorological Organization (WMO), which came into force on 23 March 1950, and which in turn led to the designation of the WMO as a specialised agency of the UN in 1951.

The early years of the newly created WMO were focussed on facilitating world wide cooperation in establishing networks of observing stations, standardisation of meteorological observations and instruments, and promoting the provisions of meteorological services of the kind that clearly required some international collaboration and standardisation – for example forecasts for aviation, marine transport and for agriculture.

The area of provision of weather services to the public was seen as the sole province of Members (in most cases the National Meteorological Services (NMSs)), and so did not require international collaboration or direct WMO involvement. However the importance of the underpinning infrastructure and its dependence on international cooperation was recognised through the creation of the World Weather Watch with its three key components of a Global Observing System (GOS), and Global Telecommunications System (GTS) and a Global Data Processing System (GDPS).

This last component had become an important element of the WMO system because of the rapid developments in computer modelling of the atmosphere and the potential impact on extending the useful range of weather forecasting for a variety of purposes. Not only was the rapid exchange of global data sets important, it was also recognised that not all countries were capable of operating the super computers needed to run the increasingly sophisticated models, and it was therefore important that the outputs from these models be exchanged. This was clear recognition of the need for WMO to help its Members improve their weather forecasts by taking advantage of developments in science and technology, especially the advances in computer modelling and, by the 1980's, the outcomes of the Global Weather Experiment of 1979.

Another important dimension to global cooperation in meteorology was the recognition that the health of global data and networks depended on assisting the NMSs of developing countries to bridge the existing technology and economic gaps and so enable them to participate in global cooperation, contribute to the pool of global data, and benefit from the advances in science and technology.

Developments in the 1980's and 1990's

The objective of capitalising on the improvements in science and technology in weather observing, communications, computing and data processing, and the objective of harnessing development assistance funding to accelerate the modernisation of developing country NMSs were both goals and confident expectations of the WMO community in the ten year WMO Long-term Plans drafted in the early and mid-1980's.
However, by the mid to late 80's, the changing approach to the role of government in several advanced countries was beginning to call into question the traditional mode of funding of NMSs, and pressures developed for the generation of alternative funding sources through "commercialisation". This was part of general trend towards varying degrees of commercialisation, privatisation, out-sourcing and similar changes affecting the role of the public sector in many countries.

This produced a number of pressures on some NMSs and some tensions within WMO. Some NMSs decided that, of necessity, they would need to sell data or products that had been previously made available free of charge. While some embraced the idea of a competitive business model for the provision of government services, others could see a dangerous threat to the tradition of free international exchange of meteorological data, or, notably in the case of the US, considered that the provisions of commercial, user-specific services was the proper role of the private meteorological sector rather than the NMS.

The WMO responded to this situation by establishing an Executive Council Working Group on "commercialisation" and so required, for the first time, the Executive Council of WMO to come to grips with the international implications of different approaches to funding of service provisions at the national level. It established an important distinction, in WMO terminology, between "basic" and "specialized" services (Zillman, 1999).

Apart from the addressing the issue of commercialisation and the changes that were taking place in some countries in the basis for service provision, some unprecedented practical issues arose in the context of the aftermath of the Chernobyl nuclear accident in April 1986. This had become a significant issue for the international meteorological community because the wind borne radioactive material from Chernobyl drifted over a number of neighbouring European countries. This, in turn, gave rise to the issue of exchanging forecasts to deal with such cases of trans-boundary pollution. While the initial focus within WMO was to address the question of exchange of forecasts relevant to trans-boundary pollution, it also raised consciousness of the issue of international sharing of a range of weather information produced for domestic populations.

Another development at around this time concerned the UN General Assembly's decision to declare the 1990's as the International Decade for Natural Disaster Reduction – the IDNDR. The objective of this initiative was to decrease the loss of life, property destruction and social and economic disruption and dislocation caused by natural disasters such as floods, tsunamis, tropical cyclones, droughts, earthquakes and other disasters of natural origin. Because most of the main disaster categories were weather related, WMO was closely involved in this initiative, and this was helping to draw out the importance of the linkages between the provisions of accurate and timely weather information to local communities under threat and the availability of information nationally and internationally. Consideration of the availability of information gave rise to examination of the issues such as the infrastructure need to support the information, the skills of the people producing the information, relationships between NMSs and emergency management authorities, the role of the media, and the need for public education so that communities could understand the information received and take appropriate action in response.

The issue of the role of the media was to become later a major focus of the planned new WMO program. In the context of disaster management, a feature of successful national and local performance of weather services in support of natural disaster was the strength of the relationship – or partnership – between the meteorological service and the media. While the role of local and national media had long been recognised, the 1980's saw and expansion of presentation of weather information through international television networks. The BBC had been involved in weather presentation for several decades, but in the 1980's CNN emerged as a new global force in the presentation of weather internationally and the value of credibility of this information was increasing along with the improvements in weather monitoring and forecasting technology. As discussed later, this was to become a major issue for WMO by the late 1990's.

The Origins of PWS as a WMO Programme

The PWSP had its conceptual origins in corridor discussions at the 1987 Tenth World Meteorological Congress on the threat to the long-standing WMO tradition of free and unrestricted data exchange among Members that was emerging from moves towards commercialisation of National Meteorological Services (NMSs) in a number of countries. These discussions took place in a Congress environment of greatly increased emphasis on the potential contribution of meteorological and hydrological services to sustainable development in the wake of the Brundtland Commission Report on 'Our Common Future' (World Commission on Environment and Development, 1986).

It had been long-standing WMO policy to focus WMO programmes and activities (especially the work of its technical commissions) on those matters such as observational networks and standards and aviation and marine meteorological services for which international coordination was essential, with the arrangements for NMS operations and service provision seen as a strictly national issue. However, there was an emerging conviction at the Congress that all countries could gain through greater sharing of experience and expertise in the basic operations of NMSs in serving their national communities. In providing initial guidance for the drafting of the Third Long-term Plan 1992-2001, the 1987 Congress agreed also that more attention should be placed on the need to develop relationships with potential users of meteorological services and to find ways to better meet their requirements.

As part of its preparations for the discussion of detailed guidance for preparation of the Third Long-term Plan at the June 1988 Fortieth Session of the Executive Council, the January 1988 session of the WMO Bureau (the President, Vice Presidents and heads of NMSs running the three World Meteorological Centres) considered the scope for assisting NMSs to enhance their contribution to social and economic well-being of the general community within their countries by development and exchange of expertise and technologies through a 'WMO Public Weather Services Programme'.

While the WMO Bureau strongly supported the desirability of such an initiative to improve services to the public, increase public and political awareness of their value and highlight the importance of international cooperation in supporting the provision of services in every country, it was recognised that it would be difficult to establish a new 'Applications' technical commission (such as existed for aviation, marine and agrometeorological services) and that some other international planning and guidance mechanisms would be needed. It was felt that, in many respects, the World Weather Watch Programme could be seen as already well geared to support the provision of services to the national communities of all countries.

The 40th Session of the Executive Council responded positively to the proposal and provisionally agreed to recommend to the 1991 Eleventh Congress that a Public Weather Services sub-programme be included in the future structure of the scientific and technical programmes of WMO. The aim of the sub-programme would be to provide a focus for the increasingly important aspects of providing meteorological services to the general public. It was recognised that these services had shown a wide scale of variations in the different countries and there were some questions about the relative priority to be given to the new sub-programme. Nevertheless, the Executive Council agreed that the matter should be referred for further consideration to the first session of its new Working Group on Long-term Planning (WGLTP), which was due to meet early in 1989. The WGLTP was requested to study the possible ways of fitting this new sub-programme within the WMO programme structure without creating unnecessary duplication of effort.

It is worth noting here that cost considerations were no doubt also a factor, because establishment of new bodies within the WMO structure imply significant additional costs associated with meetings, documentation, and perhaps translation and simultaneous interpretation services in the official languages of WMO. This is discussed further below. Taking account of the various constraints on the WMO system, a suggestion was made in the WGLTP that the terms of reference of the Commission for Basic Systems (CBS) could be expanded to include questions relating to services to the general public.

The overall scope and thrust of the proposed PWSP were discussed at some length in the 1989 and 1990 sessions of the WGLTP and the Executive Council, and especially within the CBS, which favoured inclusion of the proposed PWSP as a sub-programme of the World Weather Watch Programme. The Executive Council preference and its recommendation to the 1991 Eleventh Congress, however, was that the new programme should be clearly seen as an 'Applications of Meteorology Programme', but that its intergovernmental technical and policy guidance should be provided by CBS and, like aviation and marine services, its Secretariat support should be provided by the World Weather Watch Department. CBS and the World Weather Watch Department were entrusted with identifying a number of initial objectives that could be undertaken if Congress approved the proposal.

In fact, with the Congress focussing particularly strongly on issues associated with enhancing the social and economic benefits of meteorological and hydrological services, and beginning to turn its attention to the major funding and other challenges facing NMSs at the national level, there was particularly strong support for the proposed new programme. It was agreed that the purpose of the PWSP should be to assist Members to provide reliable and effective weather services to the general public and major public user groups; and that its main long-term objectives should be:

- i To strengthen Members' capabilities to provide comprehensive weather services to the general public; and
- ii To foster a better understanding by the general public of the capabilities of Meteorological Services and how best to use these services.

The Congress agreed that the PWSP should be placed under the general responsibility and leadership of CBS and that because of its strong crosscutting nature, close coordination should be established with all WMO constituent bodies. The Congress noted that it would require new and innovative ways of working.

The Congress also set three initial specific objectives for the new PWSP as follows:

- *Formulation and content of forecasts and warnings*: To evaluate the effectiveness of different methods of preparation, formulation and content of weather messages, taking into account regional and climate variations, and develop appropriate guidance information for Members;

- *Presentation and dissemination techniques, public understanding, public information and education*: To survey, evaluate and propose guidance on the wide variety of possible ways to use communication media in the dissemination of public weather services and to develop guidance material for public awareness activities of meteorological services; and
- *Exchange and coordination of hazardous weather information among neighbouring countries*: To arrange for appropriate arrangements and procedures to coordinate and exchange warning information across national boundaries as appropriate, with the objective to provide the public with coherent and responsible public weather information minimising the discrepancies in time, location and severity that arise from uncoordinated statements.

The PSWP thus formally came into existence on 1 January 1992, as part of the WMO Third Long-term Plan 1992-2001, with the challenge of achieving major enhancement in all aspects of the provision, use and societal value of public weather services around the world.

So now the new WMO program had an approved statement of its initial work tasks and a decision on where it should reside in the WMO structure, but it was still not fully determined as to how it would be implemented and resourced. It would take several more years for these practical matters to be resolved, and for substantive progress on the key tasks. This was reflection of the difficulty of establishing a new program at a time of considerable budget constraints in WMO.

In the meantime, discussions continued within in the WMO secretariat and the new programme attracted attention in the annual sessions of the Executive Council (EC) immediately following the 1991 Congress. As well, the EC Working Group on the WMO Long-term Plan, by that time chaired by John Zillman, and the Advisory Working Group of the CBS, which was preparing for the next session of CBS in 1992, addressed the issues of practical implementation of the work.

The session of the Executive Council in 1992 gave particular emphasis to the practical steps and guidance to CBS on getting things moving. It suggested that CBS look at the idea of progressing the work via establishment of a Working Group (though this would have budgetary implications for CBS), and the use of appropriate consultant services.

Some small resources were allocated for the employment of a consultant, and several rapporteurs were appointed by CBS to begin filling in some of the detail. The importance of the linkages and cross-program connections of the new PWS program were becoming evident. Not only where there linkages with WMO's involvement in the IDNDR, there were linkages with the WMO Public Information

Programme. This latter programme had among its objectives the promotion of the work of National Meteorological and Hydrological Services (NMHSs), and improving their visibility and status by increasing awareness among the public and decision makers of the contribution of the NMHSs to safety and security of life and property, protection of the environment, and to economic and social development.

A practical task set for the new programme was the development of a Guide on Public Weather Services Practices. Because the subject material was so extensive, this would be turn out initially to be a “preliminary guide”, but it would be developed further into a more comprehensive set of guidelines as the programme evolved.

PWS Gains Momentum

The PWS programme began to accelerate significantly in 1994. Haleh Kootval, who had been working in the WMO Secretariat in the Regional Programme and on WMO’s involvement in the IDNDR, was assigned to work on the new programme, and funds were provided for an expert meeting that was held in Geneva in March of 1994. For this meeting, the experts were asked to prepare papers that on the three key areas outlined by CBS and approved by Congress as the initial program of work. They would also discuss the proposed Guide.

A further expert meeting was held in Geneva in April 1995, and, later that year, the first PWS training event was held jointly with the WMO Public Information Programme in Singapore to train people in television weather presentation. The TV presentation training was provided by BBC weather presenter Bill Giles of the UK Met Office, and television producer John Teather from BBC Television. This was the beginning of a valuable relationship for the new WMO programme, with the BBC and the wider international broadcast meteorology community.

International awareness of the new WMO programme was helped because WMO had made “public weather services” the theme for World Meteorological Day 1995 held on 23 March. WMO produced promotional and educational material on the theme and this assisted NMHSs to promote awareness within their own countries.

At the Twelfth World Meteorological Congress in Geneva in May 1995, the agenda item dealing with Public Weather Services Programme was debated enthusiastically by many delegations and received strong supporting statements. It was especially strongly supported by the developing country Members of WMO for reasons described below.

By 1995, some of the wider political issues regarding commercialisation and threats to the free exchange of data had been brought into sharp focus. As a result, the WMO Congress was to consider the adoption of a groundbreaking and carefully constructed consensus resolution on international data exchange. This, and the almost world-wide economic pressures for reducing the size of the public sector, had made many of the smaller NMSs realise the importance of improving their visibility and demonstrating their value to their communities and governments by providing, and being seen as the main source of, good quality public weather services.

In November of 1996, the Eleventh Session of CBS established a formal Public Weather Services Working Group to carry on the work of the programme. The detailed work to be undertaken by this Working Group was scoped via an expert planning meeting held in Nassau, Bahamas in May 1997. This meeting, held in conjunction with a session of the Regional Association for North and Central America to reduce costs, considered the preliminary Guide publication, plans for more detailed guides on specific aspects of PWS, and discussed what was to become a very important initiative to undertake a survey of WMO Member needs and existing capabilities in PWS.

Support from the WMO Regions

While this momentum was building through the strong guidance from Congress and the Executive Council, and the practical implementation efforts of CBS, the WMO Secretariat and the small groups experts, rapporteurs and consultants who had become involved, another channel was developing. The six WMO Regional Associations are in some respects similar to a mini Congress. They meet four yearly and consider the full range of WMO programmes but in the context of their geographic Region. Each of the sessions of these bodies were attended by representatives of WMO able to speak on CBS issues, by Haleh Kootval on PWS issues and, from 1995 onwards by John Zillman who had become President of WMO in 1995 and who was vitally interested in the PWS programme, not only for its own worth, but in the context of the broader WMO political considerations of international data exchange, and the role of NMHSs.

Like at Congress and EC, the PWS issue received strong support at the Regional Association meetings. The Regional Rapporteurs for the topic of PWS in all the WMO Regional Associations were also the core members of the CBS Working Group. One Region – RA VI established a formal PWS regional Working Group under the chairmanship of the RA VI Rapporteur Wolfgang Kusch of Germany (who has since become President of Deutsche Wetterdienst and a member of the Executive Council). This was another level of engagement that ensured that the PWS programme now had a strong momentum, and was fully supported by and of benefit to WMO Members.

Engagement with the Regional Associations of WMO helped to spread the word and the benefits of a stronger focus on PWS, but it also helped to leverage the modest resources allocated for the programme. While the volume of support among WMO Members was high, the reality of the WMO budgetary situation meant that the resources allocated to the PWSP were still modest. Haleh Kootval, as the new Chief of the Programme within the WMO Secretariat, developed some innovative strategies to stretch the budget to extract value from every last Swiss franc of the modest budget by linking PWS activities to other WMO activities as far as possible.

For example, the second significant training event was held in Melbourne Australia in 1996 as an event back to back with a regional training event for forecasters conducted by the WMO Tropical Cyclone programme. This reduced meeting costs because the travel expenses for participants in the PWS workshop were mainly the incremental costs of an additional week of accommodation and meals. These workshops in Melbourne have been held bi-annually on the same basis for over a decade, and are a typical example of 28 PWS workshops that have now been held in all WMO Regions since 1995.

PWS and Natural Disaster Reduction

By the time of the 50th session of the WMO Executive Council in 1998, it had become clear that the WMO programme concerned with strengthening the ability of NMHSs to deliver improved public weather services on a routine basis was highly relevant to the issue of effective performance of NMHSs in disaster reduction, and that it was important this message emerged as part of the learnings from the efforts of the IDNDR.

A key feature of high performance of NMHSs in disaster situations was the ability of that service to provide high quality, reliable public weather services on a daily, routine basis. If this was happening, it usually meant that the NMHS was well recognised by both the public and the other elements of government as the regular, reliable source of authoritative advice on a range of weather issues. It also implied that the NMHS had a good relationship with emergency management authorities that was regularly reinforced by meetings and other dialogue aimed at improving planning for disaster management.

Likewise the NMHS staff had regular practice at dealing with the public, and with other government agencies. This encouraged levels of confidence and trust that became very important when services had to be delivered under more stressful, high-pressure situations in a real disaster situation.

Conversely, the high performance of the NMHS during a disaster did much to enhance the overall reputation of the NMHS and this, in turn, improved its ability to provide services to the public that delivered social and economic benefits to the country.

The existence of the PWSP was a help to NMHSs concerned to improve their capabilities to perform on a daily basis as well as in disaster situation, while, within WMO, PWSP was a significant feature of the WMO's engagement with the IDNDR.

A key message being increasingly reinforced in the WMO community was that the high performance of NMHSs was partly a scientific and technical issue – in other words, the capability of the NMHS to produce accurate forecasts. But high performance was also related to the ability of the NMHS to deliver the forecast, warning and information products effectively and this depended to a large extent on the skills of the NMHS staff and senior management, and the quality of the relationships they had with disaster management authorities, other government agencies and the general public.

PWS and the Global Media

Scope for the PWSP to make a difference to some key international issues of the late 1990's was illustrated by the pressure that had mounted within WMO to address some aspects of weather coverage by global media organizations. The pervasive nature of global media and their provision of 'global" weather services had given rise to some awkward issues. A good example was provided by some of the smaller nation NMHSs responsible for tropical cyclone forecasts. In some cases, the forecasts and warnings broadcast by the global TV stations were not totally consistent with the local warnings being issued to the population threatened by the storms. In addition, some government authorities were basing their decisions on the TV broadcast rather than on the advice of the NMHS.

This not only undermined the position and authority of the NMHS, but also could lead to dangerous situations where advice via the media was at odds with the official advice. As well, there was no acknowledgement of the investment by the various national services in the observational, communications and forecasting infrastructure, or of the WMO World Weather Watch, that made the "global" forecasts possible.

When some WMO Members asked that the WMO address this undesirable situation, the PWSP program was the logical vehicle to establish dialogue with the international broadcasters. This was done. Meetings were set up and these led to new understandings and conventions, including, for example, advice on global television broadcasts that affected populations should check with their local warnings for the latest advice. These developments had another beneficial outcome. The need for WMO to have dialogue with the global television broadcasters gave impetus to the strengthening of the newly formed International Association of Broadcast Meteorologists – the IABM, which, as described later, was to become a more influential player in international television weathercasting and the PWSP.

Consolidation and Linkages

By 1998, the WMO Working Group on PWS was well established with the WMO Regional Rapporteurs on PWS as core members. A meeting of the core group was held in Montevideo, Uruguay in August 1998 to review progress on the various tasks assigned to the programme and to plan the details of future work.

One the valuable initiatives addressed around this time was a survey of WMO Members of all aspects of their PWS activities. This was to prove an important resource in assessing the strengths and weaknesses of existing PWS work around the world, and of the different approaches taken by NMHSs depending on their size, geographic location and national needs.

Apart from the agreed work priorities for the programme that focussed on presentation, dissemination, public education and cross-border coordination of warnings, the program had begun to look at different approaches to verification of public weather services. This was in recognition of the fact that having some objective evidence of public weather forecast performance was an important aspect of assuring quality, building credibility and answering sometime ill-informed criticism.

Later in 1998, the CBS decided on a new structure whereby the main subject areas of the Commission's work would be addressed by Open Programme Area Groups (OPAG's) – one of which was the OPAG on PWS. Under this new structure, tasks were assigned to several Expert Teams (ETs) in each OPAG, and the overall work of the OPAG was coordinated by an Implementation and Coordination Team (ICT).

The new organisational arrangements within CBS led to more formal participation of the PWSP in the CBS Management Group. This had advantages of strengthening the linkages within CBS between the groups concerned with weather observing and forecasting infrastructure, and those concerned more with delivery of weather services to the public.

The linkages within CBS also led to improved linkages with WMO's World Weather Research Program (WWRP). The WWRP was increasingly addressing research into high impact weather events and wished to strengthen its links with CBS by having a CBS representative attend meetings of the WWRP's Scientific Steering Committee. It was decided that the best way to achieve this was to have the PWS OPAG Chairman attend the WWRP meetings. This led to an improved focus among researchers, those responsible for the infrastructure and the service providers on the end-to-end process whereby improved science and technology led to improved forecasts and warnings delivered through public weather service channels to the public for the economic and social good of the nation.

Another good example of the value of the PWSP as a crosscutting program was in relation to weather services and the Olympics. Weather services are critical to many aspects of the staging of the Olympic Games. This ranges from the forecast for key public events such as the opening ceremony to information and forecasts for specific sporting events, such as athletics, rowing, cycling and even the equestrian events.

A tradition had developed among the NMSs of countries hosting the Olympics WMO that the hosting nation would invite the NMS of the next scheduled Olympics to send people to work with the current Olympics as a learning experience. However by the late 1990's WMO had signed an agreement with the International Olympic Committee for an ongoing international collaboration. The PWSP was able to give practical effect to this collaboration by setting up linkages to the WMO web site, which in turn had linkages to the majority of WMO Members' web sites. This arrangement was implemented for the Sydney Olympics in 2000 and was designed to allow Olympic athletes and visitors to check on the weather in their home countries.

Another initiative of the PWSP that has now come about and that illustrates the value of the commitment to this type of programme has been the development of the excellent international web sites for both severe weather and for cities forecasts with the strong assistance of management and experts in the Hong Kong Observatory (Hong Kong, China).

PWS Addresses Key Issues for the Future

As covered in papers elsewhere in this PWS Symposium, the PWSP has gradually moved to respond in more recent years to the growing public interest in the climate and water issues. While these are outside the strict definition of public weather services, it is clear that, for many NMHSs, the existence of a strong channel to the public and the media on public weather services on a daily basis represented a powerful opportunity to address some of the weather and climate related issues seamlessly as far as the public is concerned.

A sign of the PWSP's maturity and relevance to major issues was the engagement of the programme in some key international conferences in recent years.

In 2004, the PWSP played a significant role providing speakers for the first World Conference on Broadcast Meteorology organised by the IABM. This conference was part of the proceedings of Forum 2004 in Barcelona – a Universal Forum of Cultures. This was an excellent collaboration between the IABM and WMO and gave strong international exposure to the respective, complementary roles of the media and weather service providers in providing key information to the public.

In 2005, the PWSP ran a very well attended Technical Conference on PWS as part of the intergovernmental session of the WMO CBS held that year in St Petersburg, Russia.

In March 2007, the PWSP was a major contributor to the international conference held in Madrid, Spain on the Social and Economic Benefits of Weather, Climate and Water Services. More details on this can be found in the reports and statement prepared by conference (WMO 2007), and the challenging implications and opportunities for WMO and its Members for the future arising from this conference are addressed in other papers at this Symposium.

Conclusion

The decision by WMO some 16 years ago to begin to venture into new territory in international collaboration in meteorology was influenced by significant policy developments in global meteorology at the time. The commencement of a new program in the UN system is difficult at the best of times and especially so when the WMO was under pressure to do more on many fronts, but was constrained by severe budget guidelines.

Despite these constraints, a new programme was established that has made inroads in clarifying some of the key policy issues for international meteorology as well as for many individual NMHSs. The programme has assisted WMO Members in many practical ways to improve their services to the public and to enhance the visibility of the NMHS in the media, with disaster managers, and within their own governmental structures.

Like all successful international programmes, the PWSP owes much to key supporters in the WMO constituent bodies who gave it birth and nurtured it – the WMO Executive Council and the Congress, the Regional Associations and the Commission for Basic Systems, to the many people who have worked on the programme in expert teams and leadership roles, and to the extraordinarily dedicated staff in the WMO Secretariat who have worked on the programme.

From small beginnings and with very modest resources, the programme has reached a level of healthy maturity in terms of its contribution and relevance to key issues facing WMO and its Members. Its value has been demonstrated as well as its potential to contribute to some of the pressing emerging issues related to climate change, the environment, and the future of water resources. However, there will be significant resource and structural implications if the programme is to evolve further to meet these challenges and the changing expectations of WMO Members.

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PWS in the Front Line of NMHSs: What the PWS Programme Has Achieved So Far

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Abstract

The Public Weather Service (PWS) Programme has enabled National Meteorological and Hydrological Services all over the World, to better serve their customers with regard to weather and climate information for different sectors. It thus contributed to ensuring the safety of life, protection of property and the well-being of the national citizens, and had many socio-economic benefits. The following gives an overview of the PWS Programme, its major achievements as well as an outlook for future activities.

Front-line Services of NMHSs

The Guide to Public Weather Services Practices (WMO, 1999) states "As weather and climate play such a significant role in the cultures and lifestyles of people around the world, National Meteorological or Hydrometeorological Services (NMHSs) have no greater responsibility than ensuring the safety of life, protection of property and the well-being of their nations' citizens. Consequently, the warnings and forecasts that they provide should be timely, reliable and comprehensive. In addition, these forecasts and other information on weather- and climate-related events are vital for disaster management and the decision-making processes of many weather-sensitive sectors. Indeed, the visibility and credibility of an NMS are derived from its ability to provide demonstrably useful and reliable public weather services, tailored to the needs of its national community." It specifies clearly the primary task, of 'front line services' being delivered by National Meteorological and Hydrological Services (NMHSs). NMHSs have to perform this task 24 hours a day, 7 days a week. At the same time requirements and demands from the general public, emergency management and industry for more precise and timely information are increasing year by year.

The PWS Programme

In 1991 the Eleventh World Meteorological Congress established the Public Weather Services (PWS) Programme as a component of the Applications of Meteorology Programme of the World Meteorological Organization (WMO). The implementation of the programme started in 1994 under the umbrella of Commission on Basic Systems (CBS).
The objectives of the programme were to:

(i) Strengthen the capabilities of WMO Members to meet the needs of the community through provision of comprehensive weather services; and to
(ii) Foster a better understanding by the public of the capabilities of National Meteorological and Hydrological Services (NMHSs) and how best to use their services.

Its main purpose is to assist WMO Members to provide the above defined services.

After the CBS adopted in 1998 the Open Programme Area Group (OPAG) structure, the work of the PWS Programme is now co-ordinated, within this framework, through an Implementation Coordination Team (ICT) and three Expert Teams, the

(i) Expert Team on Services and Product Improvement (ET-SPI)
(ii) Expert Team on PWS in Support of Disaster Prevention and Mitigation (ET- DPM), and
(iii) Expert Team on Communications Aspects of PWS (ET-COM)

The establishment of the OPAG structure was a vital step towards the success of the programme.

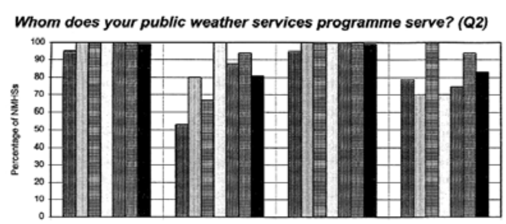

Figure 1a: Sectors served by public weather services (a)

Take a Look at NMHSs

In order to assess the current state of WMO members' national Public Weather Services programmes, a comprehensive survey was carried out among NMHSS in 1997. The results were published in 1999. And they were very impressive: Of the responding Members, 93 (95 per cent) are carrying out a public weather services programme. Only five countries in RAs I, IV and V did not confirm so, but only one explicitly answered in the negative. However, all of them completed the rest of the questionnaire. Consequently, it can be assumed that

nearly all NMHSs carry out a public weather services or similar programme. (WMO, May 1999).This shows the importance of the programme. If this survey was repeated today, the percentage of positive answers would certainly be higher.
Figures 1a and 1b are taken from WMO, May 1999, and illustrate the answers by WMO Regional Associations.

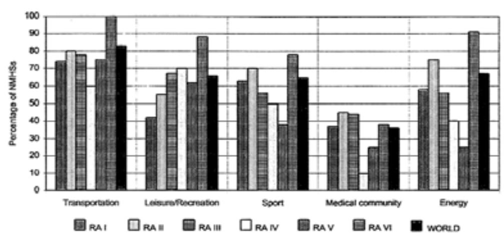

Figure 2b: Sectors served by public weather services (b)

The figures show that the sectors to which the NMHSs give highest priority:

- General public
- Media
- Emergency management followed by
- Agriculture and
- Transport.

A repetition of the survey, on the one hand, would confirm the result, while on the other hand it would also reveal changes, for example in the Energy sector.

In 1998, RA VI established a "Subgroup on Regional Aspects of Public Weather Services". In January 2001, the Subgroup started a survey the aim of which was to

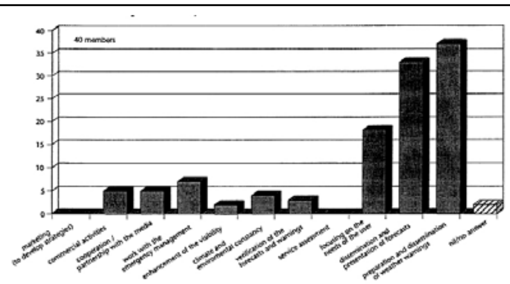

Figure 2: PWS priorities in NMHSs in WMO RA VI (WMO, 2002)

obtain an overview of the regional aspects. 41 RA VI

Members replied to the survey. Their answers were of major importance for the working group. The highest priority was given to the issuing of weather warnings, whereas a relatively low priority was given to the co-operation with the emergency management (Figure 3).
Here, too, the result would be different today.

What has been achieved so far?

It needs to be pointed out that most of work of the programme has been done by the WMO Secretariat. Namely when, at the beginning, Haleh Kootval has been managing the PWS division, she often had to fight all alone. This changed in 1998 when the OPAG Expert Teams became a great support.

The implementation, however, remains in the responsibility of each NMHS.

The very start of the programme was as early as 1994 with a first training workshop in Kenya, followed, in 1995 by a workshop in Singapore. In 1996 the first document was published: Guide to PWS Practices.
Further activities followed, such as

1. Training workshops and seminars
2. Capacity building through publication of guidelines
3. Publication of Technical documents
4. Surveys
5. Projects

Since 1995, the PWS Programme has carried out 28 'Training Workshops' dealing with the following topics:

- Weather presentation on television, radio, print, Internet and other new technologies;
- Disaster preparedness and mitigation;
- Socio-economic applications for weather, climate and water services;
- Quality assurance in PWS;
- Effective Communication of forecasts;
- Improving Media Relations;
- Tropical Cyclone/Hurricane Warning Services;
- Warnings of Real Time Hazards by using Nowcasting Technology;
- Use of Global Data Processing System (GDPS) and World Area Forecast System (WAFS) products and their presentation to the public; and
- Improvement of Public Weather Services for Early Warning and Emergency Response.

These workshops have greatly helped to improve the participants' capabilities.

The training seminars are supplemented by the publication of around 30 'Guidelines' and 'Technical Documents'. These publications form an important base of knowledge for all NMHSs.

Guidelines are important in that they provide reference material for every day in NMHSS by members of staff who are on the frontline in the delivery of public weather, climate and water services. Therefore, capacity building was provided through publication of guidelines:

1. Examples of Best Practice in Communicating Weather Information (PWS-17);
2. Guidelines on Biometeorology and Air Quality Forecasts (PWS-16) (Supplement to PWS-10 below);

3. Guidelines on Capacity Building Strategies in Public Weather Services (PWS-15);

4. Strategy of Developing Public Education and Outreach (PWS-14);
5. Guidelines on Integrating Severe Weather Warnings into Disaster Risk Management (PWS-13);
6. Guidelines on Weather Broadcasting and the Use of Radio for the Delivery of Weather Information (PWS-12);
7. Guidelines on Quality Management Procedures and Practices for Public Weather Services (PWS-11);
8. Guidelines on Biometeorology and Air Quality Forecasts (PWS-10);
9. Guidelines on Cross Border Exchange of Warnings (PWS-9);
10. Guide on Improving Public Understanding of and Response to Warnings (PWS-8);
11. Supplementary Guidelines on Performance Assessment of Public Weather Services (PWS-7);
12. Guide on the Application of New Technology and Research to Public Weather Services (PWS-6);
13. Public Weather Services in Region VI (Europe) – Report of Survey (PWS-5);
14. Guidelines on Graphical Presentation of Public Weather Services Products (PWS-4);
15. Guidelines on the Improvement of NMHSs – Media Relations and Ensuring the Use of Official Consistent Information (PWS-3);
16. Weather on the Internet and Other New Technologies (PWS-2);
17. Technical Framework for Data and Products in Support of Public Weather Service (PWS-1);
18. Guidelines on Performance Assessment of Public Weather Services

There were also a number of technical documents published, such as:

- Weather, Climate and Water Services for Everyone;
- The second edition of the Guide to Public Weather Services Practices;
- Public Weather Service in Focus;
- Public Weather Service – Weather affects everyday life …;
- Guide to Public Weather Services Practices;
- On the Front Line – Public Weather Services;
- The Role of Meteorologists and Hydrologists in Disaster Preparedness;
- Public Educational Packages.

In order to clearly understand the needs of NMHSS with regard to implementation of their PWS programmes and activities, and in order to direct PWSP resources and efforts most optimally, the PWS Programme has conducted several surveys over the years, which include:

- Survey on Improving the Delivery of Public Weather Services;
- The state of WMO Members' national public weather services programmes (May 1997). – Results were published in, 'Public Weather Services in Focus' in 1999;
- Survey on Severe Weather Warning Services – 2006;
- Survey on Effectiveness of PWS – 2005;
- Survey of Indian Ocean Meteorological and Hydrological Services requirements for disaster reduction, including Tsunamis.

Thanks to these seminars, publications and surveys, the PWS Programme is founded on an excellent basis. This must be continued. There is a great demand for the seminars. The documents need to be updated and complemented. Surveys must be repeated from time to time. The PWS Programme has succeeded in initiating projects that prove the abilities of co-operation.

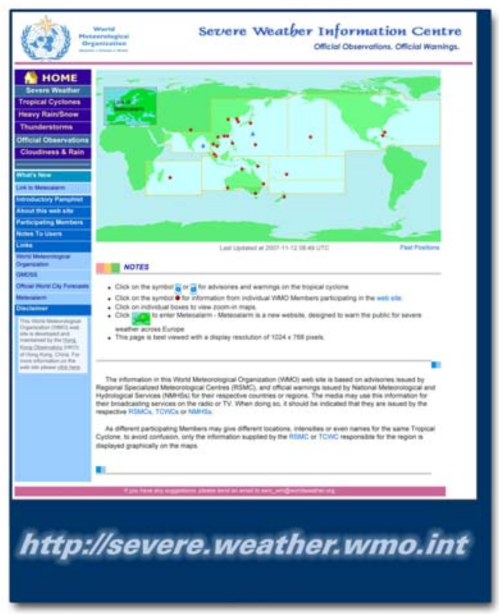

Figure 3: Severe Weather Information Centre homepage at severe.weather.wmo.int.

- Severe Weather Information Centre (SWIC) developed by Hong Kong Observatory (HKO) (Figure 3);
- World Weather Information Service (WWIS) developed by Hong Kong Observatory (WHO);
- Meteoalarm (Eumetnet);
- The Severe Weather Forecasting Demonstration Project (SWFDP) (Regional Subproject – RA I – South Eastern Africa)

Numerical Weather Prediction systems have become increasingly relevant and indeed essential to the NMHSS severe weather forecast process. The goal of SWFDP is to improve severe weather forecast services in countries where sophisticated NWP model outputs are not currently utilized nor readily available. The principle foci of SWFDP are heavy precipitation. The SWFDP was organized as potentially the first of a series of regional subprojects.

In order to improve the reach of forecasts and warnings from NMHSs to the public and especially to international media, the PWSP initiated and guided two initiatives:

- the establishing of the World Weather Information Service (WWIS);
- and the Severe Weather Information Centre (SWIC) Web sites.

The sites provide weather forecasts and climate data for cities of the world. Forecasts in the Web site originate form NMHSs worldwide.

- They provide official forecasts and warnings to the public and to the media. The WWIS is available in English, Chinese, Arabic, Portuguese, Spanish and French. Germany is in preparation.
- Some 116 Members supply official weather forecasts for 1213 cities. 1220 cities from 160 WMO Members also have their climatological data presented in this web site.
- The Severe Weather Information Centre (SWIC) web site provides tropical cyclone, heavy rain, heavy snow and thunderstorm information.

Both, the SWIC and the WWIS, are excellently being carried out by the Hong Kong Observatory (Figure 4).

As a regional initiative, the European “Meteoalarm” is presented. Meteoalarm is developed for EUMETNET, the Network of European Meteorological Services. This initiative is strongly supported by WMO.

- [http://www.meteoalarm.eu/...] will offer you the option of selecting severe weather information for today or tomorrow. If you want further detail on national warning texts you can link to the relevant National Weather Service by clicking on its logo.
- [http://www.meteoalarm.eu/...] is the website that integrates all important severe weather information originating from the official National Public Weather Services across a large number of European countries. This information is presented consistently to ensure coherent interpretation as widely as possible throughout Europe.

Meteoalarm is a perfect example of the importance of the "networking" of the PWS Programme.

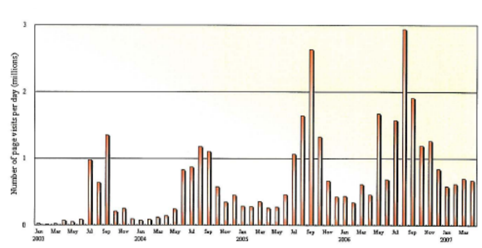

Figure 4: Monthly access statistics of SWIC (Jan. 2003 – April 2007).

But it also shows the difficulties, even limits of international co-operation, beginning with the definition of the colour codes and symbols and ending with the diversity of the various thresholds for one and the same parameter.

In summarizing the following are the impressive achievements of PWS, all participants can be proud of:

Figure 5: Homepage of the European “Meteoalarm” initiative.

- Improved early warning services and products and their presentation;
- User focus in PWS;
- Public awareness and education;
- Capacity building and outreach activities for NMHSs;
- Engagement in demonstration projects;
- Establishing and promoting best practices;
- Building capacity in NMHSs to assess and enhance the socio-economic benefits of weather, climate and water;
- Engaging in surveys and assessments;
- Building the credibility of NMHSs;
- How to initiate a Public Weather Services programme or activities in an NMHS.

Future activities

Although symposium was meant to think about the "roadmap of PWS Programme", the future has already started. We can see this from the following initiatives that have already been started:

- Probability Forecasts and their use in PWS;
- Socio Economics Benefit Pilot Project: Learning through doing;
- Working with the media;
- IABM;
- Climate Broadcasters Network;
- Verification;
- Nowcasting Services.

Summary

The objective of this presentation was to give an overview of the achievements made by PWS until now. I have tried to be as complete as possible. But I could not mention everything. The major achievement is that

- The PWS Programme made it possible that the services provided by NMHSs have gained an image.
- The idea of commitment to service provision has grown to major importance ... and the NMHSs have changed their attitude accordingly.
- The WMO Secretariat has successfully co-ordinated the PWS Programme with the NMHSs implementing it.

I think that the results of the joint work are very impressive. PWS has proved to be successful.We can be pleased to see that the 15th World Meteorological Congress shares this opinion.

Outlook

Taking into consideration the Members' priorities, Congress requested that future directions of the PWSP should aim at:

- Providing guidance on the application of new technology and scientific research to service delivery;
- Capacity building through training in all aspects of PWS, and the publication of guidance materials on topics based on Members' requirements;
- Continuing to provide guidance on the social and economic applications of PWS;
- Continuing to provide guidance on user-based service assessment, and product verification;
- Providing guidance on international and regional weather information exchange.

Literature

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Service Delivery and PWS – an Overview

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Abstract

This paper examines the concept of "Service Delivery" in the context of NMHSs. What does it mean and what does it imply? Service Delivery is not just about dressing up the meteorological "products and services" for the market. Meteorology initially grew from a need to address problems of maritime safety. It developed significantly when faced with the challenge of assisting the safe development of the aviation industry. In the last half-century, however, most of the developments in Meteorology have come from within. Today our users are diverse, and society is complex. We need to re-focus on the users of Meteorology. We should start by defining their needs, be they business customer or general public. These needs should then inform the design of our systems and the progress of our science. Service Delivery can be broken up into four characteristics that should apply to all of our products and services: availability; dependability; usability and credibility. These imply an active engagement with our clients and our public, and a significant brief in public education. It is no longer enough that NMHSs remain passive providers of weather information

Introduction

Over the past couple of years the concept of "Service Delivery" has moved centre-stage within WMO. But what is Service Delivery? What does it encompass and what does it imply? How do NMHSs need to change and develop in order to properly address this challenge and attain good Service Delivery? This talk will attempt to explore these issues.

Lessons from the Pizza Parlour

It is Friday night as we are at home, tired after the weeks work. Hungry too, but we don't feel like donning the apron and setting to at the cooker. So, we phone for a pizza. We place our order, are given the time for delivery, and sit down to wait, uncorking a nice bottle of red wine to begin an evening winding down. So, we have commissioned a service. In terms of this service, there are four attributes that will need to be satisfied if our primary purpose – to be fed while enjoying a relaxing evening – is to be attained. These four attributes are:

1. The Pizza as delivered should be the one we ordered; if we wanted a calzone, we should get a calzone.
2. The food should be good quality; proper crispy dough, nice tomato sauce, generous toppings.
3. It should arrive hot.
4. It should arrive on time.

If we now consider the chef at the pizza parlour; the person who "produces the goods" as it were, he or she only has control over one of these attributes; the second one. We could put the best chef in the world into the kitchen, turning out high-quality pizzas, but unless the other three attributes are satisfied our experience of the service is not good.

In order to provide us with the service we desire, the management of the Pizza Parlour, as well as hiring a good chef, must ensure that the other necessities of good service delivery are in place. They must establish a clear and unambiguous ordering system, whereby the details of the client and the details of their desired pizza remain closely linked. The system should allow the person taking the order to quickly make a realistic estimate of when the pizza will be ready, and how long the delivery will take, so that they can provide a delivery time to the client. The management need to provide transport with warmed boxes so that the product can be delivered hot and in good condition. They need to ensure that their delivery drivers are well-versed in the geography of their area of business, so that they don't get lost and the delivery thus delayed.
The point here is that there are lots of things that need to be organised in the background in order to maintain a good service to the client. At home on a Friday night, however, you are blissfully unaware of all this; you are just happy that you got a tasty hot pizza, as ordered. You don't need, nor want, to know about how it all works behind the scenes. Enough about pizza. What lessons does this have for Meteorology?

Service Delivery – What is it all about?

One view of Service Delivery is that it encompasses all the bits that are "added-on" to the Meteorology in order to provide a product or service; that it is the window dressing. This window dressing would include concepts like: Marketing, Branding Public Relations, and Presentation and indeed good service delivery will include elements of all of these. However, if this were the entire story, then all NMHSs would need to do would be to hire marketing people, give them their product, and get them to "package" it for the client or public. The contention of this paper is that good service delivery is a much broader concept, and one that reaches back into the way we do our Meteorology. It is not just an "add-on"; it should be integral to the way in which we organise ourselves and our science. Like the management of the pizza parlour we must regard the chef (in our case the forecasters, or the system of NWP models and post-processing) of just one part of a complex system that is designed, from the start, to address, and satisfy, the needs of the clients.

Let us try to take a fresh look at what we actually do. We provide information, analysis and forecasts concerning the weather. The information comes from instruments that read, or sense, the weather, ranging from the humble thermometer in the Stevenson Screen to the radiometers on the weather satellites which provide us with images over a multiplicity of spectral channels. Some of this information is straightforward ("The temperature today is 15 degrees"), some of it requires interpretation. Analysis encompasses the synthesising of all the available information into some sensible conceptual view of what the atmosphere is doing; perhaps through the identification of a phenomenon as a tropical cyclone; a thunderstorm; a cold front, or whatever. It allows order to emerge from the chaos of thousands of individual weather observations. Forecasting is then a statement of how we expect the atmosphere to behave over a coming period of time; that period could stretch from minutes and hours to months or even years, depending on the phenomenon under consideration.

There is an analogy with medicine, which we will come back to later. You don't feel well. The doctor makes observations regarding your symptoms; once more these could be simple (the thermometer again!) or complex (maybe a CAT scan). Their analysis (or diagnosis, in medical terms) gathers together this information into a coherent concept of what is happening to your body. Then, drawing on their knowledge and experience, they predict how that somewhat abstract concept (virus, infection etc) will evolve and what the consequences will be for you. Finally, drawing on this forecast, they may make a prescription or provide suitable advice. The advice may not be what you want to hear; the information may not be welcome, but (in general) it is better to get that knowledge earlier rather than later.

Back to the weather. The idea of "Service Delivery" is a concept that can be defined around a number of "abilities":

Availability – is the information relevant to the client, and there when the client needs it?

Dependability – can the client expect the information to be delivered on-time and without fail?

Usability – is the information presented in a manner which enables the client to fully understand it?

Credibility – does the client have faith in what is (frequently) no more than a professional opinion?

To help focus on these "abilities, we might ask the following questions about our products and services:

Will the information help the client to solve their particular problem; answer their particular question; make their particular decision? Do we know what are the clients' problems, questions and potential decisions? And if we don't, should we not ask the client directly?

Looking Back to Look Forward

We might ask at this juncture what the point of Meteorology is anyway. The modern approach to meteorology was first conceived in response to a problem – the loss of many sailing ships in shipwrecks around the coasts of western and northern Europe. We might pause to note that the impetus was probably not humanitarian in origin but concern with the loss or diminution of military power, and with the loss of assets manifested in the merchant ships and their cargoes. So, meteorology was initially developed to address a particular problem. Since then some of the major advances in the science and organisation of Meteorology have come from the need to address other problems, specifically the growth of aviation through the early and middle years of the 20th century and (at various intervals) needs of a military nature. In more recent decades, as expertise in forecasting many days ahead was developed, the needs of agriculture became a major focus of NMHSs. It is interesting to note that these needs always existed; the cycle of tilling, planting, husbanding and harvesting has existed for centuries. However meteorology was simply not relevant to this business until it had developed the capacity to provide reliable information on a time scale which was useful to agriculture; the time scale of days to weeks ahead.

Today we are faced, in the developed world at least, with a much more complex society. The needs of this society – the problems to be addressed to which Meteorology can contribute – are not as obvious as they were heretofore. The developing world has its own set of problems and challenges, and addressing them is rendered more difficult by the widening gap between developed and developing. Technologies appropriate to the former may be completely unsuitable for the latter. So,

- The problems which society has to deal with are many and multi-faceted
- The connections with meteorology are not as obvious as they once were
- Meteorology needs to work harder to embed itself, its services and products, in business and in society.

Let us look back at our "abilities" in more detail and try to define what they mean in the context of service delivery.

Availability

What does the user need? Do they know what they need? Does the NMHS understand the nature of the problem/decision which the user has to make? Does the NMHS appreciate how the information and expertise at its disposal can help the client? Does the user appreciate the extent to which the NMHS can provide useful information and advice? Answering these questions means consultation and discussion; it means the NMHS personnel taking time to get to know the business of the client. It means the preparation of sample products and services which will help the client to understand the extent to which the NMHS (or other meteorological service provider) can offer assistance. Availability can reach right back into the infrastructure of meteorology, resulting in the sitting of an observation system at a location where it will provide readings relevant to a client, or perhaps running an NWP model at a resolution or over a domain which will match a client's specific needs.

Dependability

If a client is going to use weather information in an organised and coherent manner they need to have it delivered in a timely fashion, or perhaps made available quickly and easily on-demand. This implies that attention be given not just to the production of the product or service, but also to the means of delivery (remember the pizza?). Sending information out is one thing, but ensuring that it reaches its intended destination is a step further. If a client is going to depend on a product or service all of the steps in the chain that lead from service provider to user need to be tested and not found wanting.

Usability

Once the client has the information in his or her hands, can they use it? This depends on many factors. Are the appropriate meteorological parameters provided? Are they presented in a manner which allows to client to extract the information they need quickly and easily? Has the user been trained sufficiently to realise the full significance of the information and how it might apply to his or her unique situation? Does the client have a contact point in the NMHS with whom they can follow up on receipt of the forecast, and ask any supplementary questions as they feel necessary? The concept of usability has many consequences for the presentation of the weather information. The style in which a forecast is written, for example, may affect the degree to which it is usable by the client. For visual representation the skills of graphic artists and designers are often required in order to present the information clearly and unambiguously. Our earlier concept of "window-dressing" is relevant here too; although not central to the job of presenting information, it helps if weather information presented graphically also looks well, in terms of composition and use of colour. Indeed, in a competitive environment, such as the World Wide Web, attractive presentation is probably more important, in terms of attracting users, than the quality of the underlying information.

Credibility

Of all the "abilities", this last is probably the most important – certainly in the case of forecast information. In order for information to be of use to a client in making a decision, they need to believe in it. How do we foster this belief? Certainly the underlying quality of the information is an important element here. However all weather information is qualified to some degree, so it is important for the client to understand the limitations of the service provided. The client needs to understand that a forecast will, on occasion, be wrong. While a "meteorological" explanation of why a particular forecast went awry can be useful this is of no real assistance to the client in using and interpreting future forecasts. What is relevant here is the establishment of Verification Scores, allied to a Quality Management Framework.

Verification Scores in this context are not about some abstract scoring of purely meteorological phenomena. Verification Scores only have relevance if they are a tool to identify weaknesses in the system; a process which will allow those weaknesses to be addressed and the ultimate service improved. User-based Verification Scores are part of a feedback process within the forecast system itself. A properly defined Verification Score, however, will also allow the client to acquire a good understanding of how best to use forecast information in his or her specific instance (which will depend on the relative costs of protective or preventative action that might be taken, and the losses that might otherwise ensue).

A properly established Quality Management Framework on the other hand, will provide management of NMHSs with the tools to identify weaknesses in their systems, and to apply resources in such a manner as to strengthen the weak areas effectively.

For all that these are necessary, however, credibility is most often invested by humans in other humans, not in systems. Going back to our medical analogy, if we were to be ill today we could probably type our symptoms into Google and get back a listing of the probable causes; refining our search might indeed lead to a "diagnosis". But would we do this? Most of us would instead go to see our doctor, whom we know and trust. This is despite the fact that the combined wisdom and knowledge available on the web is many times greater than that which our doctor could possible retain. However in order to follow a particular course of treatment we need to believe that this will be effective (even though medical statistics indicate clearly that there is a significant probability that it will not) and this belief derives from trust in the judgement of another. The lesson for meteorology is that credibility in a product or service is very much tied in with the people who deliver that product or service; in the example of our client the individual who personifies the service is the contact point whom they have within the NMHS. The person who is the contact point carries the brand of the NMHS with them when they meet with or speak to clients; if they perform poorly, the brand suffers accordingly. For an NMHS, the implications are careful selection and training of those whom it sends out into the public, or clients, eye.

Meteorology, Public Service, and the Media

The delivery of meteorological services (including Public Weather Services) through the media deserves special consideration in the context of service delivery. Much of what is discussed above is relevant to a single client, or a group of clients, who have a definable need for certain weather services and products. When dealing with Public Services, though, other considerations apply. These are typically “push” services – they are placed out in the public domain, through the media or otherwise, and there is no strong feedback mechanism which would allow an NMHS to gain a sense of how their services are being received. This feedback gap can be addressed through the commissioning of opinion surveys etc but this is not a common practice within the meteorological community, in part because of a lack of resources and in part because it was never seen as part of the work of a “scientific” organisation. The situation is further complicated when the public service is delivered (as it so often is) through the media. The media organisation – be they broadcaster, newspaper publisher or otherwise – now lie between the NMHS and the public, and this organisation is partly a client and partly a medium to reach the ultimate clients. The NMHS thus has to satisfy two completely different sets of requirements if it is to deliver a good and effective service. These can be defined as follows:

Media Needs	Public Needs
Timely delivery	Clear information
Presentation standards	Predictability of coverage
New skill sets	Credibility
Cross-promotion within media	
Media branding	
Exclusivity	

Of course these differing requirements are not mutually exclusive; they often support each other. The media organisation, for example, will be just as concerned with clarity of information and predictability of coverage as the members of the public, while adding other elements (branding, exclusive use) which are primarily aimed at serving the media organisation rather than the public. However credibility – listed above under “public needs” - is just as important to the media organisation, although there will be a strong tendency to personify this credibility in the presenter (in broadcasters) or writer (in publishers) rather than in the NMHS from which the information emanates. The growth of websites as a source of weather information has weakened somewhat this tendency for credibility in weather to be associated with a particular personality; usage of websites appears to be more driven by ease of use/access and quality graphical presentation of information rather than by any other parameter. However, as broadcast and internet technologies converge and the bandwidth available to the public increases (in the developed world at least) it is likely that personality-driven weather information will strengthen once again. The weather man or woman familiar from the television will be coming soon to a (small) screen near you, courtesy of improved video compression techniques and the rapidly increasing computing power available in portable computers and hand-held devices.

Back to Credibility

In discussing credibility earlier in the case of an individual client, we laid emphasis on the need for the client to understand the limitations of the service, and to have ready access to the verification statistics which would allow them to make rational weather-based decisions in respect of their own business needs. Clearly, this implies a sophisticated understanding of the boundaries of weather forecasting, and an acceptance that the losses incurred when the forecast goes wrong are more than balanced by the gains when the forecast is right. This represents a high level of awareness, and it would be unrealistic to expect the public to attain this, just as it would be unrealistic to expect the NMHS to allow, in their public forecast service, for every possible activity in which members of the public might indulge. However, public service forecasts will go wrong from time to time, yet the NMHS must remain credible in the public eye if their services are to be of value. How can this be achieved?
While the level of scientific knowledge and understanding within a community will vary substantially, an NMHS has nevertheless a duty to raise the level of meteorological knowledge and to increase the understanding of the scope and limitations of the services which it provides. Thus the exhortation by CG-XV to NMHSs to “Engage in education, awareness and preparedness activities aimed at helping citizens make the best use of forecasts and warnings information, understand the potential impacts of severe weather, and be aware of the appropriate mitigating actions”.

This exhortation represents a significant challenge for NMHSs that takes them well beyond their traditional roles as passive providers of weather information. Yet it is a challenge that must be met if the public are to invest proper credibility in forecast products and services. If this credibility is not generated and maintained, the weather services on offer are greatly devalued.

Summary

We have travelled some distance with our pizza delivery. Service Delivery is not an add-on; it is not window dressing. It is much more than these. It encompasses an attitude which starts with defining the needs of society, and of individual clients, which then uses those needs to develop the fundamentals of our systems and drive the progress in our science. It remembers that a forecast service is a means to an end; the end being the safety and security of our citizens and the sustainable development of our societies. It recognises that the skills of many other professions must be joined with those of meteorology to achieve the maximum benefit from what we know and understand. It realises that the point of it all is not those within the world of meteorology, but those without.

Experience in Service Delivery from a Developing Country: The Case of Cuba

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Abstract

The Cuban Meteorological Service had very little recognition among the public during the 70's and the beginning of the 80's. Then, the National Forecast Center of the Institute of Meteorology adopted a philosophy more oriented to the users. However, the real shift in this situation started gradually from 1981, when the Weather Report began being presented by meteorologists on television for the first time. The introduction of new technologies improved the quality of the forecasts with time during the 90´s. Warnings and advisories of tropical cyclones and heavy rains, became precise and understandable. New services for the public were added, produced by Centers of Climate, Marine Meteorology, Agrometeorology and Atmospheric Pollution, that also belong to the Cuban Institute of Meteorology.
Ideas that emerged from the WMO Public Weather Services Program gave great impulse to this work. Current results show that Cuba, being a developing country, has a Meteorological Service with a degree of development which fulfills its goals and has the trust of the public due to the efficiency that public weather services have achieved in the country, not only as regards the public but also in the eyes of the top level officials of the Nation, as well as the prestige achieved in the international field.

Introduction

The Cuban Meteorological Service enjoyed very little recognition among the public during the 70's and the beginning of the 80's. The small credibility that the forecast had, could be realized by the fact that it became popular to call the " Institute of Meteorology " as "Institute of Mentirología", playing with words that in Spanish language was representing a jeer, on having changed "Meteorology" into "Mentirología", that is the " science of lies ".

However, during 1980s the National Forecast Center of the Institute of Meteorology adopted a philosophy more oriented to the user. The technical jargon usually used by meteorologists was gradually replaced by simple, plain words that everybody could understand, while the necessary few technical words to be used (such as cold front, hurricane, thunderstorm) were explained over and over, so that with time everybody knew their meaning. The language in the forecasts and weather information became more colloquial, especially that used in warnings and advisories of Dangerous Weather phenomena.

However, the real shift in this situation began in 1981, when the Weather Report began being presented by meteorologists on television for the first time, something that pleased the public from the very beginning. The Weather Report, that was broadcast at first only on week-ends, gradually expanded to a daily prime time evening news broadcast, and a daily morning show by late 1981. New TV programs followed, not only on National TV, but on provincial TV stations by local meteorologists during the 80's and 90's. Direct radio broadcast came together with the television Weather Report, and spread from national radio networks to provincial and municipal radio stations. At the same time, the introduction of new technologies improved the quality of the forecasts with time; from only 69 to 71 % accuracy in 1980 to 89-92 %, in a sustained way, during the period 1999-2007.
Warnings and advisories of dangerous weather phenomena, especially those of tropical cyclones, became more precise and understandable.

New public services provided by Centers of Climate, Marine Meteorology, Agrometeorology and Atmospheric Pollution, also belonging to the Cuban Institute of Meteorology were added from the 80's and 90's.

The ideas that emerged from the WMO Public Weather Services Programme gave great impulse to this work and were implemented at once. The current result is that Cuba, despite of being a developing country, has a Meteorological Service with a certain degree of development, which fulfills its goals and has the trust of the public due to the efficiency that the public weather services have achieved in the country, not only as regards the public but also in the eyes of the high level officials, as well as the prestige achieved in the international arena. The major achievements of this work are briefly described in this paper.

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The Weather Forecast Service

The current weather forecasts system in Cuba comprises the National Forecast Center and the Provincial Forecast Departments that exist in the fourteen provinces and in the Island of the Youth. The National Center carries out weather forecasts for all the country, extending from six hours to a five days, with weather outlooks up to ten days ahead. The Departments of Provincial Forecasts in the fourteen provinces and the Island of the Youth make local forecasts for their respective territories. Also, special forecasts are made for different types of activities such as sports, cultural events, tourism, and outdoor celebrations.

The Weather Reports on Television and Radio.

The Weather Reports are broadcasted by television and radio regularly during the day. Meteorologists from the National Forecast Center offer the information on the National TV and radio networks, while meteorologists from the Forecast Departments in each province are responsible for this task over their territory.

Three daily presentations of meteorologists are carried out on National TV networks, with graphics generated by means of a computer graphic system dedicated entirely to TV meteorology. The actual weather conditions are shown with animated satellite and radar mosaic images, weather maps and forecast models, as well as the forecast of cloudiness, rain, maximum and minimum temperatures, direction and speed of wind, and the state of the sea on the coasts valid the following day. An extended forecast for the following three days and a summary of the 24-hour forecast given by means of a "fly-over" the entire country follows.

Meteorologists from the National Forecast Center also present and comments on the weather forecast and current weather in twelve daily broadcasts on the national radio networks, with forecast updated every six hours. The main national radio network offers a daily program of five minutes with comments carried out by meteorologists,

At the same time, meteorologists from the provincial Forecast Departments transmit the weather information in more than 150 municipal and provincial radio and TV local stations.

Forecasts and Warnings of Dangerous Weather Phenomena

It is something very usual for the Cuban public to watch and listen to the daily Weather Reports through TV and radio, but the audience reaches their highest points when forecasts and warnings of dangerous weather phenomena are issued. They are issued at any time that is considered necessary, and they are usually preceded by early warning, sometimes with several days in advance in cases of long-term events, as is the case of the tropical cyclones or intense rains.

Each warning is previously coordinated with the Civil Defense, the Government and the Media, among which exists a close coordination. When the Country is in danger, TV and national radio transmits directly from the National Forecast Center where meteorologists explain in great details the nature of the danger and what is expected to occur in the threatened provinces. A concise and clear language is employed, with extensive use of graphics. These broadcasts are done very frequently, every two or every hour, increasing the frequency as the hurricane approaches or the threat increases. The perception of risk is increased without panic or sensationalism.

An example of the effectiveness of these warnings, and the protective measures taken by the Civil Defense accordingly, are the few deaths that occur in very dangerous weather events, such as in hurricanes and intense rains. In the very active period of hurricanes in the Caribbean region, which started back in 1995, Cuba has been hit by 8 hurricanes, four of them major hurricanes, and 3 tropical storms, but there has been an average of only 3 deaths per year.

A recent example happened in October 2007. Tropical Storm Noel, a weather system without very strong winds, was very deadly because of the torrential rains that it produced. Early Warnings were broadcast by radio and TV in which meteorologists expressed very clearly that the center of the tropical storm was not important itself, but the areas of very heavy rains that were located to the right and somewhat distant from the center of the Storm. The Eastern provinces of Cuba were already saturated by rains in late September and the beginning of October. Meteorologists called for fast action because the important feature was the rains that would begin in 48 – 72 hours in that region and that it was necessary to take urgent measures of protection. The Civil Defense was informed and weather information was broadcasted very often through national radio and TV. More than 40 000 people were evacuated. Material losses were abundant and amounted to 499 million US dollars. There were a total of 21 987 in buildings and houses affected, as well as 13 169 kilometers of roads and highways. There were also important damages in railroad tracks, drains and bridges, breaks in power lines and communications. Nevertheless, there were no victims during this heavy rain event, but in the days of the recovery, there was a person who died venturing imprudently to cross an overflowing river. In neighboring countries, the same weather system regrettably produced more than 200 deaths due to these heavy rains.

Other Media for Transmitting Weather Information

Each forecast or warning of dangerous weather phenomenon is transmitted to users agreed through e-mail and fax. But the general public has access to other two accessible and fast media: the Website and the Weather Telephone.

The website contains all the information on the Forecasts and warnings in text and graphic form, with links to other sites of interest. There is also information on 5 days forecasts in main Cuban touristic cities, which could be also found in the WMO international website **http://worldweather.wmo.int**. Information on tropical cyclones is accessible through WMO severe Weather site **http://severe.worldweather.wmo.int.**

A new way for transmitting weather information began in 2007: the Weather Phone. The public can easily access a free phone number and find different options: by dialing 1 for weather outlook; 2 for active advisories and warnings on dangerous weather phenomena; 3 for the updated forecast in all Cuban territory; 4 for an updated forecast for the City of Havana and 5 for the updated forecast in the province of Havana. Some provinces have already a similar system for their local interests. It is expected that this new free service be expanded in the near future.

Marine Forecast Services

A Service of Marine Forecasts for the coasts of Cuba is offered for tourism, fishing boats, yachts and other nautical activities as oil rigs operations, etc., while a specialized service for the Gulf of Mexico, Caribbean Sea and Southwest Atlantic Ocean is offered. There is also a specialized meteo routing service for ships crossings the Atlantic Ocean towards Europe.

Climate Services

Climate Services comprise the issuance of information on climate, climatic forecast for the coming month, a climatic summary and the outlook of climate for the following six months. Also, a Monitoring of the state of meteorological drought and ENSO (El Niño-Southern-Oscillation) which has important implications for Cuba. Biometeorological forecasts are offered as part of climate services, as a consequence of studies carried out in the last 15 years by the researchers at the Cuban Climate Center of the Institute of Meteorology (INSMET), the Institute of Tropical Medicine (IPK), as well as the National Unit for Anti vector Watch and Fight (UNVLA). These Biometeorological Forecasts have been carried out for more than 8 years already, and have contributed to decision making and early warnings on diseases, reducing the levels of impact on the population.

Among the climate services applied to human health are: 1) Biometeorological forecasts on scales from one to seven days, to determine the high-risk days for the increase of the cases of non transmissible chronic illnesses like heart attacks (IMA), migraine, (C) bronchial asthma (AB) and vascular brain accidents (BIRD). 2) Climate forecast for conditions of bronchial asthma cases number (AB) and acute respiratory infections (IRA) offered to pediatric hospitals of Havana City for a week ahead. 3) Monthly climate forecasts for expected conditions of acute respiratory infections (IRA), meningococcal illness (EM), pneumococcal meningitis (NEU), viral Meningitis (MV), bacterial meningitis (MB), viral and bacterial hepatitis acute diarrheic Illness and forecast of the Aedes Aegypti mosquito foci number given by national level and by provinces. 4) A quarterly and seasonal bioclimatic outlook for the above mentioned illnesses.

Agrometeorological Services

The Agrometeorological Services constitute an important means to serve the agriculture, especially in the supply of authorized and opportune information for agriculture decision making in planning production from a strategic point of view (the planning of the use of the land, the election of the cultivations and the agricultural machinery) as well as from the tactical point of view (selection of the date of sowing, practical cultivation, the use of the agricultural machinery and the systems for protection of the cultivations).

The information supplied by the agrometeorological service is organized in four main components: the **diagnosis** of weather conditions, the state of the agricultural cultivations, farm animals and the plagues and illnesses that affect them; the **forecast** of agrometeorological conditions of interest for the management of irrigation systems, vegetable or animal activity in cases of bush fires; **Early Warnings**, which are generated when agrometeorological conditions expected to occur pose danger for agriculture; and the **informative system**, that is the backup for the dissemination of information by means of bulletins, summaries, agrometeorological forecasts, special notes of interests and agrometeorological information on the Internet.

Agrometeorological services are offered to different levels; a) local: in this case, the weather information is supplied directly from meteorological stations for the management of irrigation, animal and vegetable health and the prevention of bush fires; b) provincial: resulting information from the cultivations and cattle watch system, the agrometeorological bulletins, forecasts for short and medium ranges and reports on agricultural campaigns; and c) National: in this case, the resulting information of the watch systems, forecast and early warnings on agricultural drought and the level of bush fires danger, the national watch and warning system specialized in agricultural cultivations, animal production and sylviculture (sugar cane, tobacco, pastures, stockbreeding, beekeeping, forests) and the long-term agrometeorological forecasts.

Air Pollution Services

The early warning system for tropospheric ozone turns out to be very important by its incidence in agriculture and human health. Forecasts of Tropospheric Ozone concentrations are made for 1 to 5 days period. With this system, agriculture takes measures to prevent impacts that if not taken would be of a very costly consequence for the economy.

Conclusions

A developing country can achieve success with a proper and creative use of the public weather services ideas, increasing the visibility of the National Weather Service. This is of great importance in cases of dangerous weather phenomena such as hurricanes and torrential rains, because the public need to trust and be confident of warnings and advisories timely issued by the National Weather Service in order to take prompt actions to save their lives and properties. If there is no real confidence, then the situation could developed into a disaster, notwithstanding a good technical forecast. Other public weather services add visibility to the National Weather Service, playing a role in the country's social and economic life.

Experience in Service Delivery through Working with Regional Centres

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Abstract

The collaboration between regional centres and meteorological centres has been enhanced when the Severe Weather Forecasting Demonstration Project (SWFDP) was introduced in November 2006. There are two regional centres for Southern Africa, namely; RSMC Pretoria (South African Weather Service) and RSMC La Réunion (which is mainly focusing on tropical cyclones).
Experience in service delivery through working with regional centres will mostly be based on one of the World Meteorological Organisation's (WMO) Data Processing and Forecasting Systems projects. The Demonstration Project Steering Group was formed and met in Geneva on 14-16 December 2005 to guide and take decisions related to the identification of the most suitable regional project to be conducted as the Demonstration Project in 2006. The decision was made to implement from 2006 the first SWFDP regional subproject in South-Eastern Africa. Participating centres include NMCs of Botswana, Madagascar, Mozambique, Tanzania, Zimbabwe, RSMC Pretoria, RSMC La Réunion, ACMAD, ECMWF, Met Office (UK), and NCEP (USA). It is through this project that service delivery with regional centres has been most beneficiary. It was clear from the beginning that the WMO Public Weather Services Programme (PWSP) was welcomed and was seen as the programme that could give effective guidance in bringing the meteorological services closer to the users.

1. Regional Specialized Meteorological Centres.

1.1 Southern Africa depends on two major Regional Specialised Meteorological centres (RSMCs), i.e. Pretoria and La Reunion for

- observations, they serve as the regional hub for collection and transmission of real-time weather data to NMSs and to Global Centres.
- observations and analyses of tropical storms/cyclones etc.
- downscaling of global products for regional details.
- weather analyses, regional guidance weather forecasts and products and model output.

A typical example is the role played by RSMC Pretoria in improving public weather services in Southeast Africa through a CBS coordinated demonstration project (SWFDP).

1.2 The South African Weather Service (SAWS), in collaboration with the University of Pretoria have been playing a key role in training meteorologists from Tanzania, Lesotho, Oman; and from anywhere in the world as per applications.

1.3 RMTC Nairobi has also produced meteorologists for the Southern African Development Community region (SADC) and other regions within the African continent.

2. Regional Institutions

In southern Africa, there are SADC institutions that also provide products and services for public weather service.

For example, there is the SADC Regional Drought Monitoring Centre (DMC), which supports public weather services by providing meteorological summaries, agro-meteorological bulletins as well as weather forecasts.

The Drought Monitoring Centre also facilitates the seasonal forecast process for SADC.
There is also the SADC Regional Remote Sensing Unit (RRSU) which provides regional products and public weather services.

There is a newly established meteorological structure within SADC called Meteorological Association of Southern Africa (MASA). This structure has been formalized and has the relevant constitution. It is through this structure that the meteorological related activities for SADC countries will be coordinated.

3. Services between Regional Specialised Meteorological Centres (RSMCs) and National Meteorological Centres (NMCs).

3.1 Severe Weather Forecasting Demonstration Project experience (SWFDP).

3.1.1 Brief overview of the WMO sub-regional SWFDP project for Southeast Africa.

This WMO CBS project is a technology transfer project to operational forecast centres aimed at improving severe weather forecasting services in countries where sophisticated model outputs are not currently used.
The key factors of this project is that it was planned to be low cost, high impact, and should demonstrate in a short time the operational use of existing technology by

forecasters in developing countries to the benefit of the end-user.

The proposed methodology included a cascading process of product dissemination including:

I. Global centres to produce and disseminates Numerical Weather Prediction models (NWP) and Ensemble Prediction System (EPS) products relevant to the project to the participating RSMC (Regional Specialised Meteorological Centres) and NMHSs (National Meteorological and Hydrological Centres).

II. The relevant RSMC to analyse all available NWP and EPS information to produce daily guidance forecasts for the next five days on the likelihood of heavy rain and strong winds.

III. NMHSs issue warnings to their emergency services on advice of forecasts after reference to relevant NWP and EPS products available for this project.

3.1.2. The Global centres involved were ECMWF, NOAA and the UK Met Office. Regional centres included RSMC-Pretoria (as the principal RSMC) supported by RSMC Reunion (responsible for tropical cyclone products) and ACMAD.

3.1.3. NMHSs included were Botswana, Madagascar, Mozambique, Tanzania and Zimbabwe.

3.1.4 The planning for this regional project was done at a workshop held in Pretoria, South Africa by the WMO in August 2006. This was followed by a one week training workshop for the five NMHSs during the first week of Nov 2006 in Pretoria with the support of the global centres and RSMCs.

To facilitate dissemination of the NWP and EPS products from the global centres as well as the South African limited area model (UM SA12) and the guidance products from the RSMC-Pretoria to the NMHSs a special webpage was developed by RSMC-Pretoria. This webpage became the principal dissemination medium for the project.

The operational phase of the regional project started on 6 November 2006 and ended in November 2007. A mid-term management meeting held in Feb 2007 in Maputo, Mozambique, assessed the progress thus far. The meeting concluded that this project generally was successful thus far in achieving the aims of the project, and particularly in improving the decision making of forecasters at NMHSs through their improved use of NWP and EPS, supported by the guidance products from RSMC-Pretoria. One of the most significant comments came from emergency managers that stated they could see the improvement in confidence of the forecasters of their country in issuing warnings.

This meeting also discussed the WMO Public Weather Services Programme (PWSP) hence the feedback of emergency managers from the participating NMHSs was crucial.

There were two clear gaps that were identified during this SWFDP that need additional attention, namely;

I. The interaction between the forecasters and the emergency managers and the public was not effective, particularly regarding the severe weather warnings communication and dissemination, and the training of the users and major stake holders like emergency managers;

II. Although forecasters agreed that their forecasting tools have improved significantly, they believed there was a lack in now-casting skills and techniques. It was recognized that more effective use of Meteosat 8 will be needed due to the lack of weather radar coverage over Southern Africa.

4. Operationalising the SWFDP Beyond November 2007.

4.1. The process of implementing the SWFDP operational phase came through the SADC led process. The MASA forwarded a formal request appealing for continued support from WMO, Global Centres and RSMCs involved. Although the operationalisation process is still unfolding, a two week training session led by WMO took place from 29 October 2007 to 09 November 2007 in South Africa, RSMC Pretoria.

The forecasters from all fourteen SADC countries including few representatives from countries outside SADC were trained on the use of NWP and EPS, as well as general public weather services issues related with severe weather forecasting to users. They were also trained on the use of guidance forecasts.
The first week training focused on the use of NWP, EPS, processes and skills related to severe weather forecasting.

The second week led by WMO PWSP focused on the effective service delivery, sharing of experiences by various countries. There was more emphasis on understanding the media including ways of lobbying using media for effective and efficient service delivery more especial during extreme weather periods. Best practices (Hong Kong, China had the most successes in working with media) were also shared.

5. The Feedback from Participating Countries

5.1. The participating countries had to provide quarterly reports throughout the SWFDP project period.

5.1.1 Some Civil Protection authorities have expressed that there is still need for more detail and specifics in the forecasts with regards to actual locations that would be hit by severe weather. They also reflected that it is difficult to mobilise resources for big province when the event may only occur, for example, in a small district.

5.1.2 However, Civil Protection authorities expressed improvements in their countries in terms of:-

- The timelines of severe weather information.
- The relevance of the severe weather information for disaster management.
- The significance of the information.
- The credibility of the information.
- The interaction between the Meteorological Services Department and Civil Protection Departments.
- Relationship and forecast perception by media.

There have been difficulties in receiving feedback from the public for all the participating countries.

5.1.3 Countries expressed some improvement in relationship with media. However there was also feedback that:-

- The media became skeptical when localised strong winds hit towns and villages and blew roofs of buildings leaving households stranded without shelter.

Despite the fact that Meteorological services had some meetings with the media to explain how difficult it is to forecast convective severe weather the media still criticised or questioned the capability of the NMCs service in handling the issues of severe weather events (especially strong localised winds). Botswana was most vocal in this regard.

6. Experiencing Noted When Working Regional

6.1.1 Communication within the region

Some countries experienced problems when retrieving information from the RSMC Pretoria web site. Communication lines were often slow and thus the guidance products could not be used at times.

Interaction between operational forecasters of RSMC Pretoria and each participating countries, and also interaction between participating countries themselves, prior and after the severe weather event has been limited.

The SWFDP project provided a positive platform for RSMC-Pretoria and Global Centres to share information with participating NMCs and to deliver a useful service to them. The weather situation over Southern Africa was continuously monitored for potential severe weather, thereby keeping forecasters alert to potential hazardous weather that affects the southern parts of the sub-continent.

7. Examples of the Guidance Products Issued by RSMC Pretoria During SWFDP.

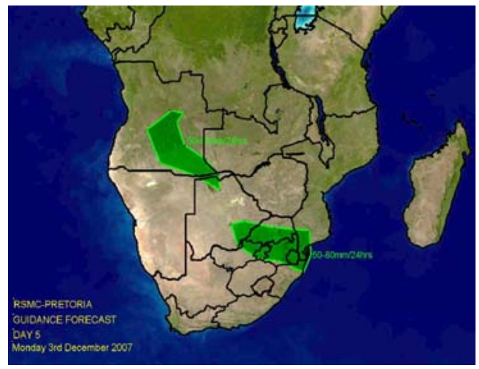


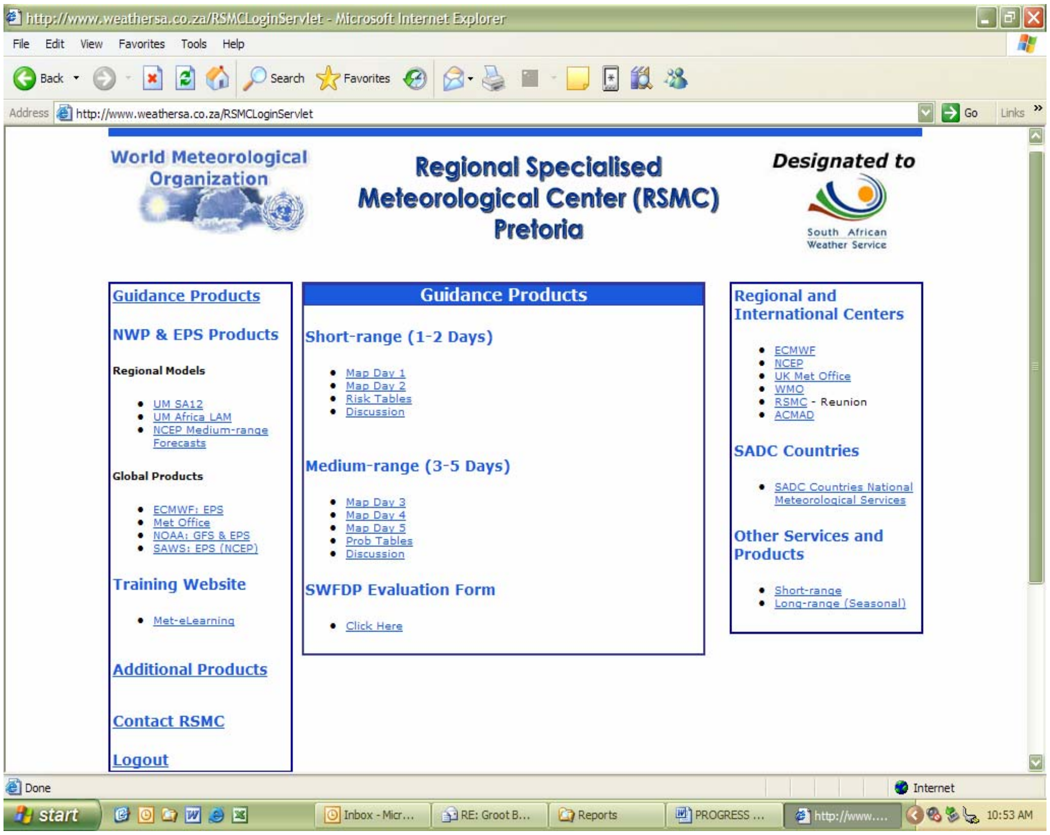
Figure 1 Example of SWFDP forecast map

8. Conclusion

Although the RSMC Pretoria has been in existence for a while, there have not been much related activities until recently. The WMO Severe Weather Forecasting Demonstration Project served as the trigger for the RSMC in playing significant role in the region. This project also served as a platform to share both regional weather systems' experiences, to be exposed to more global products and also interaction with the users among NMCs.

There is now a clear role that can be played by WMO PWSP in supporting closing the gap between the users and the providers of meteorological services within the region.

The PWSP support has already increased the visibility of NMCs including the relationship between these centres and media. The programs including the outreach programs that have been shared by southern African countries are telling examples. However it was clear that countries can still improve in optimizing the usage of WMO guidance material as some seem to be excited to note the PWSP available material that was demonstrated during the project preparatory training.



Example of the SWFDP RSMC Pretoria web page

Public Weather Services – Past and Future and Integration with Emergency Responders

Graeme Leitch
Met Office, United Kingdom

Abstract

The Met Office, UK has delivered public weather services for over 150 years. Throughout that time the Met Office has had to adapt and develop services to meet the needs of the public and their protectors within the emergency response community. In 2004 the United Kingdom Government updated legislation for civil protection and introduced the Civil Contingencies Act (2004). The Met Office was engaged in this process from the outset and has introduced a number of initiatives to ensure emergency responders are aware of Met Office capabilities available to support disaster prevention, mitigation and adaptation.

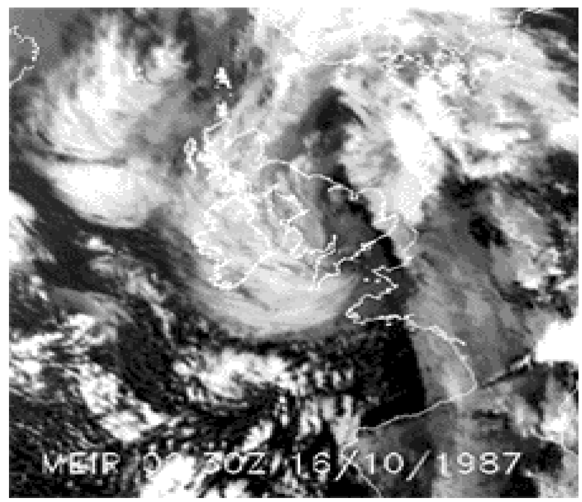
Although the UK is not connected by land to any other national meteorological and hydrological services, with the exception of Eire, we recognise the benefit of ensuring consistent information across national borders. Therefore the Met Office is adapting local warnings services to align with WMO and EU initiatives.

United Kingdom Public Weather Services

The Met Office, UK has provided public weather services, including warnings, for more than 150 years, with the first public weather broadcasts on BBC Radio in 1922. Our relationship with the BBC to provide weather forecasts to the public is still intact today. Over the years the Met Office has continued to build on the basic services available to the public and to those who have responsibility for protecting life and infrastructure on their behalf. The aim of the Met Office today is, "to provide a coherent range of weather information and weather-related warnings that enable the UK public and civil protection community to make informed decisions in their day-to-day activities, to optimise or mitigate against the impact of the weather, and to contribute to the protection of life, property and basic infrastructure."

Although the Met Office has worked closely with government and emergency responders for many years by providing weather forecasts, a change in focus was undertaken following 'The Great Storm' of 15 and 16 October 1987. This event led to the development of the National Severe Weather Warning Service (NSWWS). The aim of the service is to warn the community by providing warnings of severe or hazardous weather which could cause problems, ranging from widespread disruption of communications to conditions resulting in transport difficulties or threatening lives. This support is provided in three ways:

1. to the public at large via the broadcast media;
2. to the emergency responders;
3. to the Ministry of Defence when conditions may become sufficiently severe to warrant military aid.



*Infrared satellite image showing **'The Great Storm'** at 0230 UTC 16 Oct 1987. © Crown copyright.*

A number of other services have also been developed to aid the civil emergency responders; in particular services where weather has an influence, but is not necessarily the cause, e.g. plume dispersion forecasts, storm surge forecast, tracking of airborne animal disease, etc.

From 1959 to 2006 the Met Office provided many of these services and the links to emergency responders through a civil centre network covering the UK. This network of forecast production centres, guided by Met Office Headquarters, had responsibility for forecasting and communicating during severe weather events and other emergencies. Teams of forecasters worked on 24x7 rotas producing a variety of public and commercial services, occasionally providing remote telephone guidance to emergency responders during real time incidents.

Civil Contingencies Act (2004)

Following the fuel crisis, severe flooding in the autumn and winter of 2000, and the outbreak of Foot and Mouth Disease in 2001, the UK Deputy Prime Minister announced a review of emergency planning arrangements. The review included a public consultation which reinforced the Government's conclusion that existing legislation no longer provided an adequate framework for modern civil protection efforts and that new legislation was needed. The Civil Contingencies Act (2004) received Royal Assent on 18 November 2004.

The Act places statutory legislative duties on specific emergency responders, including Police, Ambulance and Fire and Rescue services, local government, executive agencies and utilities. These are known as Category 1 and 2 responders. The Met Office engaged with the Civil Contingencies Secretariat throughout the development and establishment of the Act, but did not have any legislative responsibility placed on it. However, the Act allows for inclusion of a list of preferred suppliers of information and services which can support Cat. 1 and 2 responders. This list states that the Met Office is the preferred supplier for meteorological information and services.

Public Weather Service Advisors

In response to the Act, the Met Office's Public Weather Service (PWS) established the role of Public Weather Service Advisors. The role of the PWS Advisors is to support national, regional and local emergency responders in the planning, exercising, incident and recovery phases of emergencies. It should be noted that this support is provided not just in emergencies caused by weather, but also in emergencies which can be influenced by the weather. The responsibilities of the advisors include:

- Being the point of contact in emergency situations, including attendance at command and control centres.
- Raising awareness of how weather can create or influence emergency situations.
- Facilitating development and regionalisation of risk assessments.
- Being involved in exercises – creating scenarios, providing advice, role playing.
- Providing input to meetings and give presentations.
- Discussing expected impacts of the weather on emergencies.
- Providing interpretation and guidance on specific meteorological products.
- Facilitating links with Met Office specialist scientists.

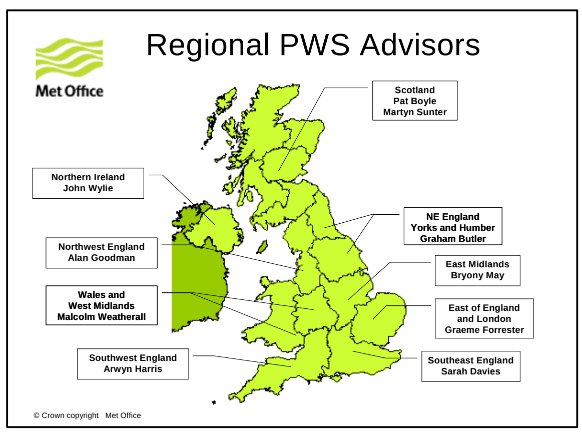
The PWS Advisor role was established in April 2005. The skills for this role include:

- Knowledge of forecasting process and experience in the evaluation of weather conditions by expert interpretation of meteorological observations and data from all available sources.
- A good understanding and empathy with regional and customer sensitivities.
- Ability to operate independently, but to follow a centrally dictated line and ensure consistency of message.
- Excellent communication skills, both written and oral.
- Ability to respond to written and broadcast media requests.

It is notable that the above does not specify that the incumbent has forecaster experience, although the majority of the PWS Advisors are trained forecasters[1]. However, all have science backgrounds.

Met Office Forecast Production Strategy

Following consultation with UK Government and Met Office customers, a change in forecast production strategy was proposed and implemented during 2006. Civil forecast production was rationalised into two offices in Exeter and Aberdeen, which provided more flexible working practices and the option to move people between teams enabling quicker responses to customers. The two centre approach also provides business continuity options; retention of regional and customer knowledge is vital for the long term viability of Met Office services for emergency responders. Initially six PWS Advisor posts were established, but following change in production strategy and due to the success of the concept and customer demand, the PWS Advisor team was increased to eleven (including a team leader based at headquarters).



PWS Input into Disaster Prevention, Mitigation and Adaptation Process

Effective management of an emergency is categorised in four main categories – planning (including risk assessment), exercising, incident response and recovery. The definition of emergency in the Act

[1] Data as of Nov 2007

focuses on the consequences of emergencies. It defines an emergency as:

- an event or situation which threatens serious damage to human welfare;
- an event or situation which threatens serious damage to the environment.

The Met Office, and in particular PWS Advisors, engage with central, regional and local government and other emergency responders in all aspects. The planning phase includes involvement in the National, Regional and Local Risk Assessment process, which can influence policy. Within these Risk Registers there are three weather categories:

- Storm force winds affecting most of the area for at least six hours. Most inland, lowland areas experience mean speeds in excess of 55 mph with gusts in excess of 85 mph.
- Snow lying over most of the country for at least one week. Most lowland areas experience some falls in excess of 10 cm, some drifts in excess of 50 cm, and a period of at least seven consecutive days with daily mean temperatures below 0°C.
- Daily maximum temperatures > 32°C and minimum temperatures > 15°C over most of the area for at least five consecutive days.

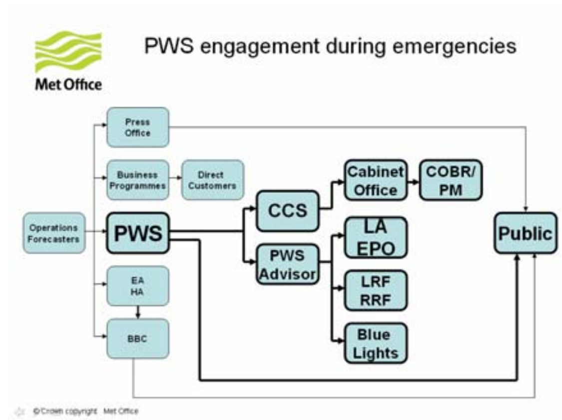
Other categories include fluvial and coastal flooding, which are the responsibility of the Environment Agency, but require significant meteorological input.

UK climatological data is available and can be provided to add value to risk assessments. Without an accurate memory of the nation's weather, there is no baseline to compare current or future events against.

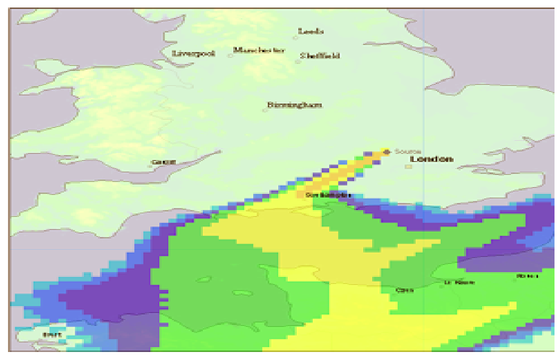
PWS Advisors are actively involved in the exercise process, including developing severe weather scenarios and providing plume dispersion forecast. They are also able to provide media style injects into exercises and role play on behalf of Met Office scientific experts.

PWS Advisors have a network of key national, regional and local contacts and are able to add value to the NSWWS warnings issued by Met Office forecasters. The aim is to provide more detailed local information and the expected impact of the weather. This could include input into decisions, staff stand-by procedures, road and school closures, and positioning of specialised equipment such as high volume pumps.

During real time emergencies, PWS Advisors and other Met Office staff, including Executive Directors, Forecasters, Specialist Scientists and Press Officers are available to support command and control centres. The aim is to provide additional guidance and briefings into emergency management meetings. There have been occasions when this process has included briefings in person and remotely into the UK Cabinet Office Briefing Room (COBR), which can and has been chaired by the Prime Minister.



There is no definitive time period for the length of an active incident and when it should move into the recovery phase. However, during the recovery phase, meteorological forecast services can be provided for clear up activities. Climatological information can also aid in the de-brief process to compare event with normal expectations. It can also support the assessment of any long term impacts that incidents, such as chemical spills, may have on the environment.



*Buncefield refinery chemical fire - hourly averaged NAME predicted plume from 0 – 4000 m at 13Z on Monday 12 December 2005. © **Crown copyright.***

NSWWS Alignment with Meteoalarm

Although the UK and Eire are not connected by land to the area of any other national meteorological and hydrological services, we recognise the benefit of ensuring consistent information across National Borders. This has been brought forward by the introduction of Meteoalarm across some areas in WMO RA-VI (Europe) and is reinforced by the Cross Border Warning Project that has been successful in other parts of RA-VI.

Approximately 65% of funding available to the Met Office Public Weather Service Programme (and thus 32% of the Met Office turnover) is allocated to the impact of severe weather, with the aim of disaster prevention, mitigation and adaptation. It is vitally important that services are developed in consultation with the customers and users.

The civil protection community is fundamental to the development and improvement of public weather services. Therefore, the Met Office seeks feedback from the civil protection community in various formats, including PWS Advisor newsletters, presentations, workshops and external market research. Recent research[2] on proposals to align UK weather warnings with Meteoalarm gained significant approval. The proposals, in line with Meteoalarm, put forward the concept of a 'traffic light' alert system and the need to differentiate between severe (less rare) and extreme (very rare – approx. four times per year) events. The service, called NSWWS Advisory, will be web-based and issued as routine on a daily basis. Live user testing is underway[3] and it is hoped to receive operational approval by March 2008.

In addition to civil protection feedback, the BBC, as the Met Office's partner in warning and informing the public of severe weather, is also engaged in the process. This helps ensure that the public understand and can act on the information provided in the warnings.

A simple key is provided on alert state, with warnings text indicating location, severity and impact of the weather event.

NO SEVERE WEATHER IS EXPECTED	**BE AWARE**	**BE PREPARED**	**TAKE ACTION**

The Met Office website also provides advice of actions to be considered before, during and after an event. This advice has been prepared in conjunction with experts in the field, such as the Environment Agency, Highways Agency and Building Research Establishment.

Following the UK flooding events of June and July 2007, a number of reports and reviews are being undertaken at national, regional and local level. Initial indications would suggest a need for a consistent and joined up message to be delivered both to the civil protection community and the public. The aim is to ensure messaging/warnings include information on the cause, the detail of the impact and the advice to be followed.

Climate Change

There will be a number of natural and man-made risks which will require planning for prevention, mitigation and adaptation from emergency response community. None more so than climate change.

The Met Office provides seasonal forecasts to UK Government for assessment and mitigation action if required. However, there continues to be a thirst for climate change information on severe weather events, particularly on frequency of events, intensity and regional variation. Timescales being discussed include out to 25 years ahead. This will provide further opportunity for the Met Office to engage with Government and the civil protection community, and support the adaptation of policy to ensure impacts are kept to a minimum.

[2] Aug – Oct 2007
[3] Dec 2007

Weather Services in Support of Natural Disaster Mitigation

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Abstract

National Meteorological and Hydrometeorological Services (NMHSs) have a special role to play in the mitigation of natural disasters by issuing early warnings of hazardous weather, to enable government, the private sector and individuals to take actions to minimize risk or to avoid danger. As "natural disasters" arise from the interaction of natural phenomena and human societies, NMHSs must deal with both the scientific and human aspects, in order to ensure that their warning service is effective. Having only accurate forecasts is not enough, NMHSs must pay attention to how the human society responds to weather information including warnings.

The essential elements of effective weather warnings are: be relevant to the target audience, timely for the intended purpose, delivered effectively to reach a wide spectrum of recipients, capable of prompting actions, and suitably 'graded' to trigger matching actions by recipients. Warning systems and services should also be suitably adjusted from time to time to meet the evolving needs of users. One critical element of a successful warning system is the trust that people place on it. A well-run Public Weather Service, which routinely sends out information to the community, helps build up public confidence in the NMHS and serves as the foundation for an effective warning service for disaster mitigation.

Introduction

It is well established that the majority of the natural disasters worldwide are caused by hydrometeorological events. National Meteorological and Hydrometeorological Services (NMHSs) have a special role to play in the mitigation of such disasters through the issuance of early warnings of relevant weather phenomena, so as to enable government, the private sector and individuals to take actions to minimize risk or to avoid danger. It also involves providing real-time weather information while severe weather hits, to support decision making by individuals and by emergency response agencies as the situation evolves. Furthermore, weather information helps government make decisions related to the organization of rescue and relief operations during the post-event phase.

In terms of weather service for natural disaster mitigation, improving the accuracy of weather forecasts alone is not enough. Indeed in spite of rapid global scientific and technological advancements (such as greatly improved numerical weather prediction products and advanced remote sensing capability), the number of people impacted by natural disasters has continued to rise in the last couple of decades (IFRC, 2005). The cause of this deteriorating situation is very complex. But one thing is clear: "natural disasters" arise from the interaction of natural phenomena and human societies (fig. 1) and that addressing only the scientific aspect of the issue would only be half of the business to reduce impact. To help reduce disaster impact, NMHSs must deal with the human aspect of the issue too (fig. 2), that is, one has to take into account how the human society responds to weather information including warnings.

Warnings are not issued everyday and so it is not self-evident that people would listen to them, believe in them and act on them. One critical element of a successful warning system is the trust that people place in it. This has to rely on a long-term effort on the part of the NMHS to reach out to the target audience, to educate them and to convince them (Lam, 2005). In this connection, we should see the operation of the Public Weather Service which routinely sends out information to the community as the foundation of this confidence-building effort. This will be elaborated further later.

Weather Warnings

For weather warnings to be effective, on top of being scientifically accurate, they should be:

(a) relevant to the target audience,
(b) timely for the intended purpose,
(c) delivered effectively to reach the wide spectrum of recipients,
(d) capable of prompting actions,
(e) suitably 'graded' to trigger matching actions by recipients.

Be Relevant

Being relevant is the over-riding consideration. This dictates the types/categories of warnings to be issued. For each country or city, it depends on climate, geography, culture, history and degree of urbanization or development. The warning systems should meet the needs of the community and facilitate their effective responses. As discussed in Lam (2007), such consideration would imply that NMHSs have to cover weather phenomena of a wide temporal spectrum,

ranging from "now" to "decades". Relevance consideration also motivates the introduction of new types of warnings as the social circumstances evolve.
For example, Hong Kong was well served by a simple tropical cyclone warning system based on visual signals a century ago. This worked on a time scale of *a day or so*. But as the increasing population pushed people to live on hill slopes and flood plains, rainstorms had increasing impact. A heavy rain warning was first introduced in the 1960s, followed by a rainfall-based landslip warning in the 1970s. This moved the forecast operation into the time scale of *hours*. As urbanization intensified, heavy rain episodes caused much greater interruptions to the running of a city heavily dependent on commuting and transport. A colour-coded heavy rain warning system was introduced in 1992, to allow more systematic and graded responses to rain situations. Lately, thunderstorm squalls generated an increasing number of incidents (see for example Lam 2005), an alerting service based on automatic anemometer stations and operated via the internet had to be introduced, thus moving the forecast operation into the time scale of *minutes*.

The increasing urbanization of Hong Kong has led to changing social structure and values. There is a growing population of old people living alone or chronically ill. There are also a significant number of underprivileged people left behind by the rapid economic changes. In this background, it was observed that unseasonally hot or cold weather spells impacted on these communities badly. Thus cold and hot weather warnings were introduced in 1999. Now, such warnings trigger the government into opening shelters, social workers and volunteers making calls to the elderly and the chronic ill, etc. With the introduction of these warnings, the Hong Kong Observatory is seen positively by the community as a 'caring' service in a highly populated city. That is the benefit of "being relevant".

Be Timely

"Being timely" for a warning service is a fluid concept with no fixed meaning. It adapts itself to the context (Lam, 2007). The key issue for the NMHS as a warning operator is to appreciate how the intended recipients of the services would evaluate the product delivered.

For the NMHS, the lead time is determined by the time scale of the weather phenomenon concerned, the scientific forecast capability, and the time it takes for warning messages to reach the intended recipients. However for the recipient, it is determined by the time required for him to take the necessary response action. There is no *a priori* reason why the two would match. Indeed the requirement is nearly always beyond what the NMHS could offer. In order to be perceived as delivering timely warnings, the NMHS have to manage user expectations, through education and outreach activities (Lam, 2005) in addition to adjusting the warning systems to reflecting changing circumstances as described above.

Effective Delivery

A major part of the weather warning process is the delivery, which includes the physical dissemination of warning messages and the communication of relevant information to recipients. However, the recipients span a wide spectrum, ranging from the little-educated and the under-privileged to sophisticated users capable of assimilating large amounts of information themselves. "Being effective" covers both the physical means of delivery as well as the contents of the information communicated to the users.

For the former category of recipients, communication means which cost little to the user would have to be employed, such as loud-hailers and the basic radio. In more developed countries, this would include television and telephone. In terms of information contents, the message should be simple and easy to understand. Visual symbols, numbered- or colour-coded warning status would suffice to trigger actions following the pattern established through years of familiarization, that is, local tradition. This is an aspect NMHSs must not forget while adding advanced technology into their operation. Otherwise the most vulnerable sector of the community would be left out in the disaster mitigation effort.

For the latter category of users, diverse communication means could be deployed, ranging from mobile phone, Short Message Service (SMS) and the internet. The broadband capacity of the internet allows detailed information such as real-time observation data, radar and satellite images, predicted tropical cyclone tracks, etc. to be made available to the public. This would enable the sophisticated user to assess for himself the risk associated with his particular circumstances and to devise response actions accordingly.

An effective warning system therefore should embrace a judicious mix of communication means as well as different approaches to the presentation of information to the diverse user communities (fig. 3). Figure 4 shows the trends of the usage of the telephone-based Dial-a-Weather service of the Hong Kong Observatory (HKO) versus that of its website in the past decade. The rapid rise in internet usage has not diminished the use of telephone calls to get weather information. It illustrates very well the persistent needs of a sector of the community which still relies on simple, cheap technology to access weather information.

Prompting Actions

Issuing and disseminating a weather warning is not the end of the story. It is just the beginning. After all, the purpose of a warning service is to mitigate disasters by prompting appropriate actions by the government, the private sector and individuals. It is thus essential that they all understand the warning messages, know how to incorporate the information into their decision making process, and most importantly, be prepared to take appropriate actions.

Prior consultations with government departments and where appropriate private organizations (such as transport operators) are conducted by the Hong Kong Observatory to make sure that their contingency plans make good use of weather warnings as triggers for their response actions. A good example is the Hong Kong Special Administrative Region Government's Contingency Plan for Natural Disasters (Security Bureau, 2007; see also Lam, 2004). For example, following the plan, as a tropical cyclone approaches or as a rainstorm situation develops, the Hong Kong society gradually gears up its state of alertness, takes prescribed collective actions to wind down the busy city and position itself in such a way that the loss of life and property is minimized while the disruption to the city's complex daily activities is also avoided to the extent possible.

In warning messages issued by the HKO, advice on precautionary actions to be taken to avert danger is always appended. Taking the "cold weather warning" as an example, the precautionary announcements would prompt people to dress warm, to visit or phone old people living alone and people with chronic diseases and to be careful with the use of heating devices to prevent fire. The warning also triggers actions by partner government departments, which would open shelters and distribute blankets. The press would pay special attention to cases of coldness-related incidents, etc. A single-threshold system like this effectively switches the entire society into a state of alertness once the specified threshold is reached.

Graded Warnings

A graded warning system, on the other hand, enables the community to build up its response commensurate with the risk involved as the weather situation develops.

In Hong Kong's rainstorm warning system, there are three colour-coded tiers. The 'amber' alerts people to the possibility of a rainstorm with significant impact. A 'red' indicates a situation where students should stay at home or if class is already underway, stay in school, until the rainstorm goes away. The purpose is to avoid having a million students stuck on the roads while heavy rain pours. A 'black' prompts people and workers to stay put or seek shelter if working outdoors. Such a system enables a better balance between the risk and the socio-economic cost involved in preparing for severe weather.

In Hong Kong's number-coded tropical cyclone signal system, number "1" indicates general alert, "3" means primary school and kindergarten students having no school, and "8" means all schools closed and, by established tradition, most organizations releasing their staff to return home to guard the family against wind and rain. Even law courts and the stock market close in a number "8". The city practically comes to a stop at number "8"; it reflects the great value which the community places on the life of individuals.

Evolve to Survive

Figure 5 summarizes the history of how a number of weather warnings in Hong Kong evolved with time in response to changing circumstances. The changes did not take place simply because of the emergence of new technology available to the NMHS. Instead, it arose from regular interactions with the stakeholders, such as the public sector, the private sector, NGOs and individuals. They all have different concerns and, for a warning service to work and meet people's requirements, these concerns have to be addressed during the consultation process.

The evolution of the tropical cyclone warning system in Hong Kong is a good example to illustrate how a weather service could change over time. The system has been in existence since 1884. Over the past 120 years, Hong Kong has evolved from a small fishing village, to a trading port and to an action-packed modern metropolis with 7 million people. The tropical cyclone warning has evolved accordingly, reflecting the advancement of meteorological science and communication technology, the evolution of the built environment and the changing expectations of the society (Lam, 2000). The system started in the form of the firing of a 'typhoon gun' in the early days, then evolved into a set of visual signals and eventually settled down as a numbered system. However, the system is now not just a set of numbers, but a total package including warning messages with detailed information and precautionary advice, predicted track and much related observational data on the HKO website, multiple means of information dissemination, as well as a complex network of interactions between HKO and the various sectors it serves. Because of the immense impact of the number "8" signal on the running of the city, HKO's decision is analyzed microscopically by all sectors concerned every time it is activated. This is the source of immense political pressure. The HKO survives only because it has been sensitive to the needs of all and maintains an open mind regarding adjustments which have to be introduced from time to time to meet changed circumstances.

Public Weather Service as the Builder of Trust

Severe weather does not strike often. The functioning of a warning service might not be put to test as frequently as desirable. A number of questions arise: Why would people believe in the warnings issued only occasionally? How to convince them? How to make them take action? While some may turn to legislation, the best guarantee that a meteorological service could deliver effective warnings when severe weather hits is to exercise it everyday. This is what the Public Weather Service (PWS) does as a matter of routine, through the delivery of useful weather forecasts to a wide spectrum of user communities. Thus, it serves to:

(a) establish and maintain the necessary scientific capabilities,
(b) establish good connections with users,
(c) assure on a daily basis the integrity and readiness of the NMHS,
(d) build up the credibility of the meteorological service among the users

In spite of the emphasis on the human aspect of warning services so far, the scientific aspect is not to be forgotten. No warning could be issued without being preceded by a good weather forecast. Getting the right equipment and systems to monitor weather for the running of a sound PWS is thus a pre-requisite to any warning service. Apart from hardware, the vigilance and the meteorological sense of front-line forecasters must be nurtured and maintained in a permanent state of readiness. Issuing forecasts everyday be it rain or shine, forecasters would be exercising themselves in terms of understanding the mechanism behind the weather forecast, the synoptic interpretation of NWP products, the appreciation of the differences among different sets of NWP products, the reconciliation between actual synoptic situations and NWP outputs, as well as balancing FAR and POD in situations of uncertainty. Only then would forecasters have the strength and resilience to deal with a real-life severe weather situation adequately when it comes.

With good connections with users established during "peace time" in between "disasters", their requirements would be better understood by meteorologists and matched by proper products and delivery modes. The operation of PWS in close contact with the user community provides a bridge to the formulation of warning services fitting more closely the needs of the users. At the HKO, related initiatives include: regular surveys on service performance, liaison or consultative groups for different user sectors, user visits to meteorological facilities to appreciate the strengths and limitations of the forecasting operation, and community networking such as 'joint-up' weather monitoring to enhance coverage and early alert.

By running a PWS rigorously, with forecasts being issued for the public everyday, we have the opportunity to test on a daily basis various components of the whole process of generating meteorological information and delivering it to users. It is comparable to going through a checklist test routinely as part of an ISO process. Then we are assured that when weather warnings are issued, the same machinery would work smoothly to deliver them to users. Indeed, it would be dangerous to see the issuance of a weather warning in support of natural disaster mitigation as a one-off, standalone activity. That mindset will most likely end up having the warning system failing at the moment when it is most needed. Instead, treat the warning function as an occasional fluctuation above the day-to-day continuum of operation, albeit a higher threshold is involved. Then everyday there is an opportunity to identify room for improvement, as is necessary in an ideal quality management process. Experience and expertise built up through regular exercises of forecasting and decision making serves as the solid foundation of a sound warning service.

Credibility takes time to grow. But the credibility of the NMHS among the user communities, in particular the public, is essential so that they would indeed take response actions on receipt of warnings of severe weather. The PWS delivers weather forecasts to the public everyday and serves as the basic building block of this confidence-building effort. Of course the NMHS has to do PWS well over a period of years to achieve positive ratings by the public. But it is also important to use PWS as a banner for various outreach activities. At the HKO, related initiatives include: popular science talks, workshops for various sectors, regular appearances on television and radio to project a positive image, production of education material on videos and webpages to spread the latest knowledge, and community events such as 'Open Day' to increase the transparency of service. An example of how such outreach activities resulted in higher perceived performance ratings by the public is described in Lam (2005).

Conclusions

While natural hazards may not be totally eliminated, the integration of early warnings with appropriate response measures can prevent them from becoming disasters. It takes two to ensure success: the weather service to issue warnings, and the recipient to respond with actions. Effective natural disaster mitigation through weather warnings therefore requires hard work by NMHSs on both scientific and human aspects (fig. 2). The provision of an accurate forecast is only half the business. The other half requires that the warning service be customer-focused and be **relevant**, that is, meeting the needs of the community.

As customers span a wide spectrum, ranging from the little-educated to the sophisticated, a **diversity** of products disseminated over **multiple channels** are required to meet the different needs. All the same, the warning message should always be clear and be easily understood by the intended audience.

To help recipients decide on what actions to take, a warning may be like a simple "on/off" switch based on a single threshold, or a graded system allowing commensurate responses. It is important that **matching actions** are linked to each warning and are carried out by the recipients.

The Public Weather Service is the solid foundation of an effective warning service for disaster mitigation. The daily issuance of forecasts serves to establish scientific capabilities and good connections with users, to assure the readiness of the NMHS, and to build up the credibility of the meteorological service among the users. A well-run PWS wins for an NMHS the trust of its users by establishing itself as a trustworthy **brand,** through the delivery on a daily basis of useful weather forecasts to serve a wide cross-section of user communities. This is the best guarantee that people would act on warnings to minimize the impact of hazardous weather.

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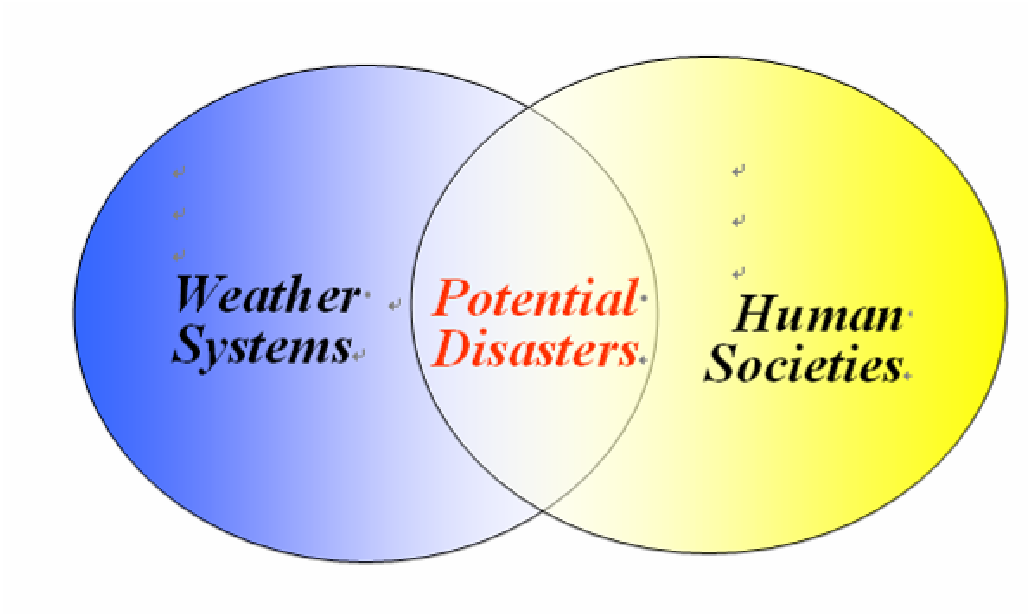

Fig. 1 Weather systems interact with human societies to give rise to disasters (after Lam, 2005)

Fig. 2 Effective natural disaster reduction requires hard work on both the scientific and human aspects (after Lam 2005).

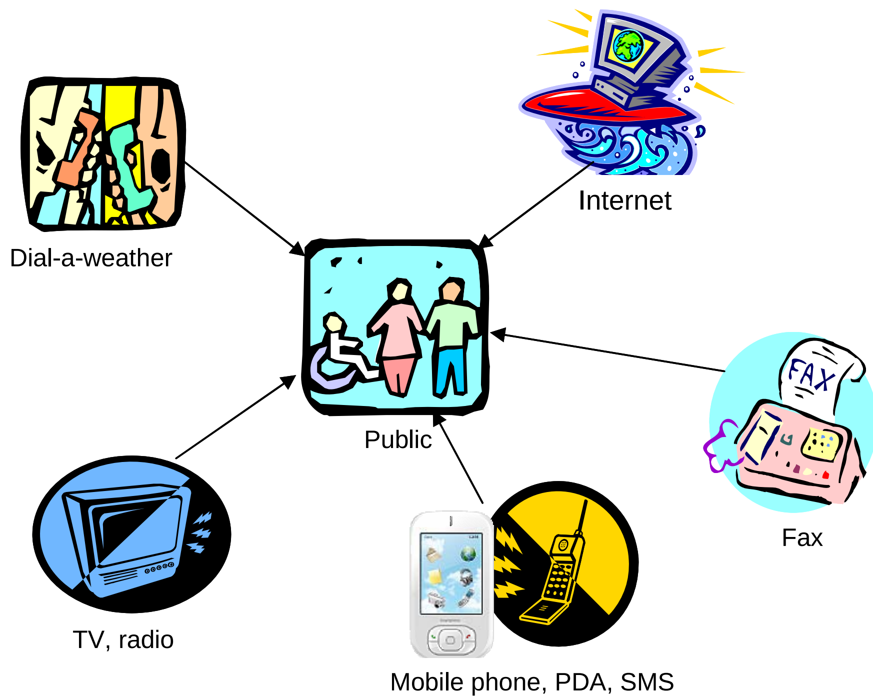

Fig. 3 *Reaching the public through multiple means to communicate weather information of different volumes and degrees of detail.*

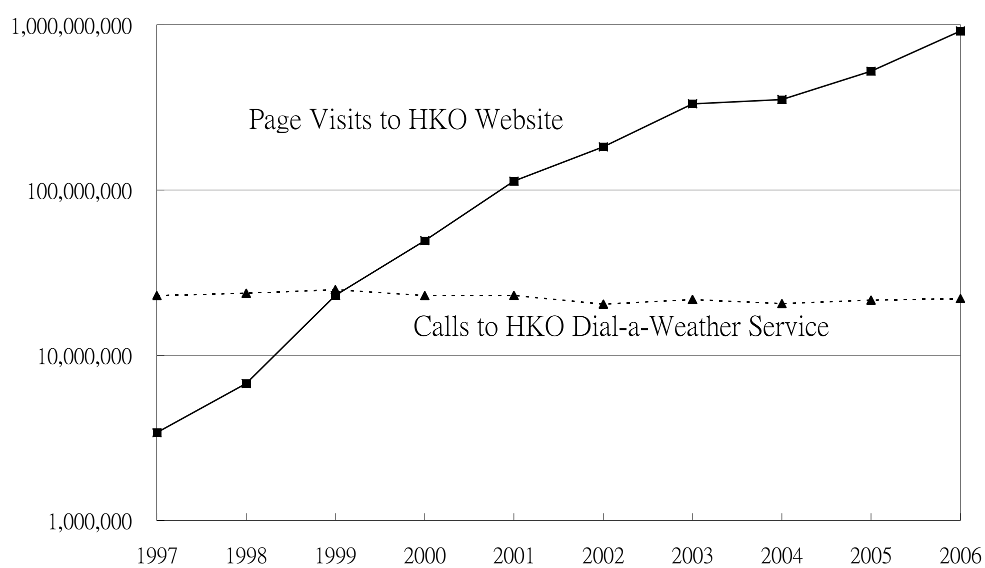

Fig. 4 *The usage of telephone for weather information remained steady in spite of growth in internet usage.*

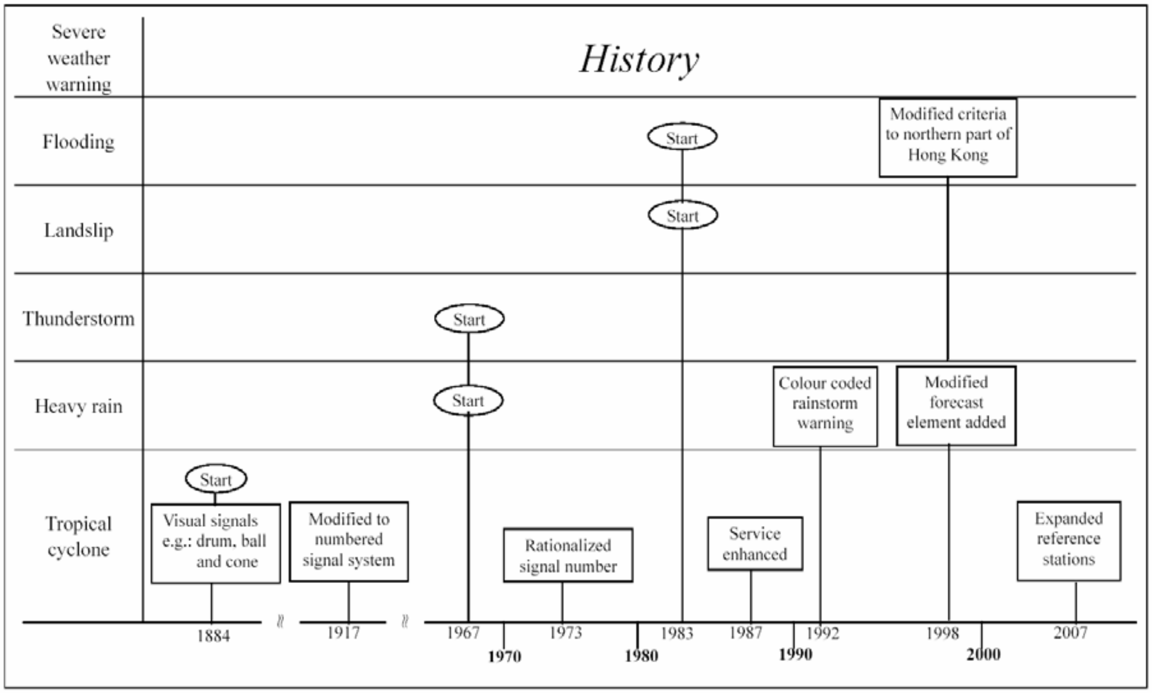

Fig. 5 The evolution of a number of weather warnings in Hong Kong.

New Challenges in Weather Service under Changing Urban Environments

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Abstract

Rapid urbanization will be a major environmental driving force in the world in the 21st century. Urbanization has led to a wide-range of potential consequences for urban weather and climate (e.g., urban heat island, lightning, severe haze, and changes in urban local circulation). In particular more frequent heat wave and high ozone episodes have profound impacts on human health, as well as on cultivated and natural ecosystems. Many researches have been conducted in the fields of impacts of urbanization on environment, and outcomes of these researches can be utilized to establish new operational services. Therefore, urban meteorology and urban environment, and operational weather services are crucial to meet the needs and challenges in the field of urban settlement and its sustainable development. In this paper, we will address the following 3 issues regarding the changes in urban environments and the challenges in city weather services: (1) Changes and related service requirements in urban environments due to urbanization. (2) Approaches for the new service developments, and (3) Illustration of the new services. To meet our goal, it is critical to establish close collaborations between NMHSs (National Meteorological and Hydrological Services) and other agencies in order to provide new services.

1. Changes in Urban Environments Due to Urbanization and Related Service Requirements

Urbanization is rapidly growing in the world. For example, at present there are 3.2 billion people living in cities, accounting for about 50% of the total population. It is estimated that the people living in cities will increase to 5 billions in 2030, which will be about 61% of the total population. Moreover, urbanization is more rapid in developing countries than that in developed countries. In China, the number of people living in cities has increased from 170 million to 540 million between 1978 and 2010, with an increasing rate of 300%. In 2010, the number of large cities (with more than 1 million people) will reach about 125. A big city acts like a big "oven", i.e., emits a large amount of heat, air pollutants, and waste materials. This large "oven' effect has profound impacts on many aspects in cities and their surrounding areas, including dynamical, thermo-dynamical, chemical effects, and cycling interactions among air, water, and soil [Xu and Tang, *Urban Environment and Meteorology*, *2002*].Therefore, city weather services face many new challenges in the changing urban environments.

1.1 Impacts on Urban Weather and Climate

In cities, natural vegetated surface is replaced by buildings and paved streets. These changes alter surface absorption of solar radiation, heat storage capabilities, and evaporation rates [Tim Oke, *Air Pollution Modeling and Its Application*, *2006*], and result in significant changes in meteorological conditions, such as surface temperature, local turbulence, and wind pattern. Measurements show that urban surface temperature is often higher than rural one by 1 to 5 , depending on the size of cities, which is known as "Urban Heat Island" (UHI) effect. UHI effect can modify urban or even local weather and climate. According to study by [Orville et al. 2000], the UHI produced a strong convergence of winds in the urban area and resulted in a local effect of sea breeze in Houston, Texas. This local convergence of wind further leads to an enhancement of thunderstorms, convective activities, and changes of urban circulations [Semonin 1981]. In addition, the measurement of lightning flash in Houston indicates that these enhanced convective activities combining with increase of aerosol loading caused more lightning activities in the urban areas of Houston, [Orville et al. 2000].

Satellite data show that large aerosol loadings are often co-located with large cities [Tie et al., 2006]. The high concentrations of aerosol particles often produce very low visibility (strong haze), depending upon the meteorological conditions. Under a stable PBL (Planet Boundary Layer) condition with weak wind, low visibility (haze day) often occurs in polluted large cities, such as Mexico City and cities in eastern Asia. In southern Asia, heavy aerosol loadings form a mass of brown haze plume which is well known as Asian Brown Cloud (ABC).

1.2 Impacts on urban atmospheric chemistry

Due to increase in population of cities, more energy is consumed for heating, air conditioning and transportations, etc. In Mexico City, there are nearly 20 million inhabitants and nearly 3.5 million vehicles. The energy consumption in the city results in a large emission of various air pollutants, such as gas-phase pollutants (SO_2, CO, NOx=NO+NO_2, and VOCs), particular matters (PMs), and toxic gases. These air pollutants play different roles in atmospheric chemistry. The most harmful air pollutants in urban environments are aerosols, O_3, and toxic gases. Among these gases, SO_2 is a main precursor for the formation of sulfate particles, and emission of PMs has a direct effect on aerosol concentrations. On the other hand, CO, NOx, and VOCs (as ozone precursors) are major factors in the formation of O_3 [ZHAO, TANG etc, *Analysis of Ozone and VOCs Measured in Shanghai:A Case Study, 2007*]. With high NOx and VOCs emissions in Mexico City [Molina.L and M.Molina, 2002], hourly averaged ozone concentrations exceed the Mexican air quality standard of 110 ppb nearly every day, and often as twice as the standard [Garfias and Gonzolas, 1992]. Toxic gases (such as benzene, etc.) can be released either as air pollutants by the exhaust of vehicles or by accidents. The dense buildings due to urbanization reduce wind speeds and dispersions of air flow, which tends to keep polluted air inside the city. As a result, the toxic gases released in large cities have more harmful effects on human health, especially during days when stratification is too stable.

1.3 Impacts on Human Health

Changes of urban weather and climate, together with changes of urban environments have various effects on human health, they are: (a) High ozone concentrations in PBL; Scientists have been studying the effects of ozone on human health for many years, and found that ozone primarily affects the respiratory system. According to a study by Santa Barbara County Air Pollution Control District, California, roughly one out of three people in the U.S. is at risk of experiencing ozone-related health effects. (b) Aerosol particles; Aerosol particles can inflame and damage lining of the lung, and may lead to a permanent damage to human's lungs that could cause a lower quality of human life [Parent, et al., 2007]. An air quality management system has been developed by NILU (Norwegian Institute for Air Research), and it can provide information for exposure time-length of air pollutants. (c) UHI effects; Because of UHI, urban temperature is much higher than rural temperature. As a result, in very hot summer, there is often heat wave occurring in large cities. This heat wave significantly affects on people's life in urban areas. For example, in 2003 summer, heat wave occurred in Europe and Asia, causing 34,071 deaths in Italy and about 10,000 deaths in France. In Shanghai, during the past 10 years, the number of days with the temperature higher than 35 reached 22, that is 13 days more than that 30 years ago.

1.4 Impacts on Urban Eco-system

Potential for ozone to damage vegetation has been known for over 30 years [Fuhrer and Achermann, 1994]. A study by the Fifth Framework Programme of the European Communities within the Programme Energy, Environment and Sustainable Development, (the EU FP5 BIOSTRESS Programme) shows that ozone may affect the surface of plant leaves. Corrosive effects of ozone on the cuticles (a waxy layer that covers the surfaces of plant leaves) have been observed in trees which were fumigated with ozone. As a result, many urban ecosystem and agriculture products in rural area are influenced by high ozone concentrations, especially rice, wheat, and cotton. Study by the CHINA-MAP project suggests that high ozone concentrations have a significant influence on rice production in the Yangtz River Delta (YRD) region where a group of cities with more than 15 big cities are located [Zhou et al, *Interaction Between Physical-Chemical Processes in the Lower-level Atmosphere at YRD, 2004*].

2. Approaches to the New Service Developments

Understanding the wide range of potential consequences requires more research work and demands new city weather services as well. Since 1999, WMO has initiated several urban meteorology and environment research projects, for the purpose of solving the increasing severe urban pollution issues. For example, through the WMO GURME Project, the mechanism of interactions among air, water, and soil pollution in Beijing has been studied, and an operational integrated monitoring network has been set up in Beijing Metropolitan area. Its other activity also includes improving air quality observation with passive sampler and carrying out air quality forecast in the cities such as Moscow, Mexico City and Saint Paul. An air quality decision-making system has been developed by Technical University of Madrid, Spain. The system is a robust tool to take emission reduction actions based on the 72 hours air quality forecasts. In Shanghai, as one of pilot projects of GURME, an ozone warning system has been put into operation and the Shanghai-MARAGE experiment has been carried out. As part of our experiences and lesson learned, several approaches should be taken in the following aspects.

2.1 Establishment of an Integrated 3-D High Density Urban Monitoring Network

The improvements in city weather services require more fundamental measurements (both meteorological and chemical elements). Recently, under the guidance of *Initial Guidance to Obtain Representative Meteorological Observations at Urban Site*, published by WMO, 2006, Shanghai Meteorological Bureau (SMB) established more than 106 automatic weather stations, 89 precipitation stations, 2 weather radars, 5 wind profilers, 2 PBL towers and 2 sounding stations. In addition, some measurements of atmospheric chemical composition have also been conducted, as authorized by the Shanghai local government. The locations of measurement sites are carefully selected to represent different categories of the land surfaces. The chemical composition sites include (1) urban green belt zone, which represents the urban ecosystem condition; (2) rural green belt zone, which represents the rural ecosystem condition; (3) central urban zone, which represents high density of population and transportation; (4) remote rural zone, which represents the urban background (5) industrial zone, which represents particle and chemical emission condition. Our goal is to establish an integrated three dimensional high density urban monitoring network to measure both meteorological parameters and chemical composition. This intensive measurement of meteorological and chemical parameters provides better small-scale dynamical and chemical distributions, and will enhance our understanding of urban environments and help us to improve weather services in Shanghai.

2.2 Establishment of Prediction and Early Warning Systems

In order to meet the above needs, forecast and alert (early warning) systems about urban environment should be established. The systems require various measurements, methods such as statistics and diagnosis and models including a fine scale meteorological model and a chemical (aerosol and ozone) model. Currently, models such as WRF (regional weather prediction model) and WRF-Chem (dynamical and chemical model) have been adapted in SMB for new service. A fully interactive model system including interactive emission model and environment impact model is under development through the cooperation between CMA and NCAR. Combining measurements and prediction methods including model techniques and new products of forecast and early warning for severe urban events can be obtained. These events mainly concern high ozone concentration and its impacts, strong haze with high aerosol loading, UV intensity anomaly and its consequences, heat wave and health, toxic gas dispersions warning for city emergency response, urban ecosystem diagnosis and alert, etc.

2.3 Distribution of Products

Based upon improvements of the three dimensional monitoring networks, and the establishments of prediction and early warning systems, the future urban weather services will provide not only the traditional weather services, such as the weather prediction, but also various alerts and early warnings as mentioned above. These new alert services will be distributed in three different levels to respond to requests from (1) high impact agencies which need joint response from governmental decision level (city and district), and emergency authorities; (2) the public, including housing communities, villages, schools, hospitals, enterprises. The public service will distribute the alerts or warnings through multi-communication tools, such as TV, cell phones, radio, newspapers, internet etc.

3. Illustration of the New Services

Taking ozone prediction and early warning as an example, the ozone prediction and early warning system developed by SMB has three major parts, consisting of the information system, the physical and chemical system, and the prediction products. The information system provides a large-scale prediction of dynamical inputs, chemical emission inventory, and land surface information. The physical and chemical system is based on a recently developed regional dynamical/chemical model (WRF-Chem). The model will first predict small scale meteorological conditions with higher resolution, depending upon the requirements. The output of meteorological conditions will be used as inputs of the chemical model to predict the chemical composition and aerosol concentrations in next day. Then, the impact analysis of chemical and aerosol concentration product is conducted. If the predicted O3 concentrations exceed the national standard, an early warning message will be issued and distributed to different levels of city authorities and the public as well. In accordance with a multi-agency response policy, the SMB will distribute the warning message to the public with two colored warning signs. The traffic control authority will conduct several emission reduction strategies at certain districts in the city. The feedback from them is very important for assessment of the potential O_3 reduction. Similarly, the health authority and hospitals are prepared for an abnormal increase of patients suffering from respiration disorders.

Summary

Rapid urbanization brings many challenges in the urban environment, and new services are demanded in large cities. Many researches have been conducted in the fields of impacts of urbanization on urban environment, such as urban weather and climate, urban atmospheric chemistry, residential health, and urban ecosystem. Outcomes of these researches can be used to establish new operational services in the fields. To meet these needs, WMO has developed several guidelines and established several projects to help NMHSs to improve new services. As a result of our practice, experiences and lessons learned, several approaches have been developed in monitoring and early detection, prediction and early warning, distribution and partnership. New challenge equals new opportunity, which encourages us to improve our service and to explore the new frontier. Weather service for urban environment is a common issue to most of NMHSs. Exchanging ideas, experience, technologies, and lessons-learned is essential to NMHSs. We will improve the urban weather services step by step to meet our goals for better city, better urban environment, and better weather services.

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Innovations and New Technology For Improved Weather Services

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Abstract

The emergence of new, innovative and technologically advanced forecast systems and communication networks offers the opportunity to integrate public weather services dissemination and service delivery. Digital database forecasting and next-generation workstations, along with new and emerging information technology systems and applications, can significantly enhance and improve public weather services provided by NMHSs State-of-the-art Nowcast systems will integrate an array of real-time data and numerical weather prediction output to provide short-term prognostic information while also helping to rapidly generate and disseminate forecast products. Information technology systems and associated applications, including XML, CAP, and RSS, will allow NHMSs to exploit the latest telecommunication networks, including broadband, wireless, and mobile systems. Coupled with GIS and GPS capabilities, NMHSs can satisfy customer and partner demands for increasing precision, accuracy, and detailed, location-specific hydrometeorological forecasts and warnings. Together, these efforts will allow NMHSs to cultivate an innovative and effective PWS program which leverages technological advances to create a holistic forecast and warning dissemination, service delivery, and all-hazard decision support process that best serves the user community.

Introduction

New communication networks and forecast system innovations and technology (e.g. the Internet, wireless communication, digital database forecasting, next-generation workstations, Nowcasting systems) have emerged which provide the opportunity to improve public weather services (PWS). These innovations allow World Meteorological Organization (WMO) National Meteorological and Hydrometeorological Services (NMHSs) to provide hydrometeorological forecasts and warnings in a variety of formats (graphic, digital) beyond the traditional text products. In addition, these innovations can impact NMHS service delivery capabilities. Digital database forecasting and next-generation workstations, along with new and emerging Information Technology (IT) systems and applications, offer the opportunity to further enhance and integrate PWS dissemination and service delivery functions.

This paper provides an overview of several key innovations, technological advancements, and IT systems/applications which are, or can, have a substantial impact on improving NMHSs public weather services and their dissemination and service delivery. The paper will focus on digital database forecasting, next-generation forecast workstations, Nowcasting systems, and IT systems and applications.

2. Digital Database Forecasting

The traditional forecast process employed by most NMHSs involved forecasters producing text-based sensible weather element forecast products (e.g., maximum/minimum temperature, cloud cover) using numerical weather prediction output as guidance. The process is typically schedule driven, product oriented, and labor intensive. Over the last decade, technological advances and scientific breakthroughs have allowed NMHS's hydrometeorological forecasts and warnings to become much more specific and accurate. As computer technology and high speed dissemination systems evolved (e.g. the Internet), NWS customers/partners were demanding detailed forecasts in gridded, digital, and graphic formats. Traditional NWS text forecast products limit the amount of additional information that can be conveyed to the user community. The concept of digital database forecasting provides the capability to meet customer/partner demands for more accurate, detailed hydrometeorological forecasts. Digital database forecasting also offers one of the most exciting opportunities to integrate PWS forecast dissemination and service delivery, which most effectively serves the user community. Both the NOAA/National Weather Service and Environment Canada are currently using digital database forecasting technology to produce routine forecasts. The Australian Bureau of Meteorology is in the process of evaluating and developing an implementation plan for database forecasting using the NOAA/National Weather Service National Digital Forecast Database approach.

2.1 Environment Canada National Weather Element Database

Environment Canada (EC) has developed the National Weather Element Forecast Database (NWEFD) that is populated with the output from the EC numerical weather prediction (NWP) models. EC forecasters manipulate the NWEFD making adjustments to forecast fields based on an analysis of the current state of the atmosphere and model output including known model biases and trends. When complete, the forecaster runs software that creates text-based forecasts. To assist in the development and population of the NWEFD, EC has developed an expert system called SCRIBE.

SCRIBE is an expert system capable of automatically or interactively generating a wide array of weather products for a region or a specific locality[1]. The system uses data from a set of matrices which are generated after the 00Z and 12Z NWP model runs. These matrices contain different types of weather elements including NWP output, statistical guidance model output (Perfect Prog – PP and Updateable Model Output Statistics – UMOS models), and climatological data. SCRIBE's temporal resolution is three hours. SCRIBE produces forecasts twice daily for 1,145 Canadian station locations. When ready, the matrices are sent to each regional SCRIBE system. Upon arrival, the data is processed by the Concept Generator and is synthesized and downsized to a set of well defined weather elements called "concepts". These "concepts" are output in a digitally-coded format called METEOCODE and can be displayed on a graphic interface. Forecasters can modify the "concept" output to incorporate the latest observations as well as the evolving weather scenario/event. The "concepts" are used by the regional offices to generate local forecast products. They are also sent to the NWEFD where a suite of national forecast products are generated. Figure 1 shows the main steps in the SCRIBE data processing.

2.2 NOAA/NWS National Digital Forecast Database

In the 1990s, the NOAA/National Weather Service (NWS) recognized that it had to evolve its hydrometeorological products and services beyond text-based forecasts to meet growing customer/partner demands. In 2003, the NWS launched the National Digital Forecast Database (NDFD). The NDFD is an event driven, information oriented, interactive, and collaborative 7-day hydrometeorological forecast database. The NDFD consists of a 7-day forecast for a set of 14 sensible weather elements on a 5-km domain which covers the contiguous United States, Alaska, Guam, Hawaii, and Puerto Rico – see Table 1. In some locations, the database resolution varies from 1.25 to 2.5-km primarily in areas of significant terrain. Each of the 122 NWS Weather Forecast Offices (WFO) produces and maintains the database for its area of responsibility. Figure 2 shows examples of NDFD output graphics. Using the latest observations, radar and satellite data, guidance products from the National Centers for Environmental Prediction (NCEP), and NWP output, forecasters interactively modify the database using the Gridded Forecast Editor[2]. Several NCEP centers also contribute forecast information into the NDFD including probabilistic hazard and climate outlook information (Table 1). NWS forecast text, tabular, and graphic products are generated directly from the database using product formatters and other output-defined software. Also, the database itself is provided as an NWS product to customers and partners. This allows users to access the database for their own applications, manipulate the database, and extract forecast information tailored to their specific needs. In the years ahead, the NWS will continue to work toward evolving the NDFD into a complete four-dimensional environmental database. Future NDFD expansion will include observations, analyses, aviation-specific elements, additional climate information, uncertainty/probabilistic information, outlooks, watches, and warnings.

3. Next-Generation Forecast Workstations

Continuing advances IT and communication capabilities suggest that the rapid increase in the volume of hydrometeorological data during the last three decades will continue and may even accelerate in the years ahead. The proliferation of automated observing systems and mesonetworks, coupled with improvements and/or replacements of existing remote sensing observing systems portend at least an order of magnitude increase in data. The next generation forecast workstations will need more bandwidth, storage capacity, and processing power to handle the expected rapid increase of data along with increased temporal and spatial resolution NWP model output. This makes it imperative that the next generation forecast workstations are equipped with new, state-of-the-art visualization and information processing techniques, including three-dimensional techniques, to assist forecasters with data analysis and interpretation. Sophisticated diagnostic tools will also be required to examine the data and highlight meteorological processes. In addition, the large volume of data will require an increased reliance on advanced algorithms and processing techniques to monitor both current and forecast conditions, extract and portray the most relevant information, and assist with hydrometeorological decision support. The next generation forecast workstations will assist in the preparation of forecasts, warnings, and their dissemination through a host of communication channels/networks. These workstations will also have the capability to support digital database forecast preparation.

Some next generation workstations may also look to incorporate an Internet-based instant messenger chat (IMChat) capability to allow NMHSs to communicate with key customers and partners during significant hydrometeorological events and all-hazards incidents. The NWS is currently experimenting with the IMChat concept in significant hydrometeorological operations. IMChat is an Internet chatroom-type of connection with key customers and partners to get critical information in real-time for an unfolding time-sensitive event or incident. In turn, NMHSs would receive site-specific reports or other information which can assist with forecast and warning operations.

3.1 Nowcasting Systems

A number of NMHSs have been developing innovative, next generation Nowcast systems. Nowcast systems range in complexity with some that track radar echoes and use extrapolation to produce 0-1 hour nowcasts, while more complex systems utilize a combination of NWP output and probabilistic/uncertainty forecast techniques to extend the Nowcasting time horizon out to 3-6 hours. Some of these systems also incorporate other remote sensing platforms including satellite and lightning data. Many of these systems are still challenged to optimize the role of the forecaster in the Nowcast process. One of the other key focus areas is incorporating real-time verification and feedback to forecasters. An important strength of a Nowcast system is it's ability to rapidly generate hydrometeorological forecast products and disseminate them in a variety of formats. This capability will have significant implications for timely and effective PWS service delivery. Several forecast demonstration projects have been organized through the WMO to test Nowcasting systems and applications. The first demonstration project was successfully carried out in 2000 at the Summer Olympic Games in Sydney. Another demonstration project is scheduled to be conducted during the 2008 Summer Olympics in Beijing.

4 Information Technology Systems and Applications

Since its inception, NMHSs have exploited the Internet to varying degrees. While almost all NMHSs have an Internet web page, the dissemination and services provided vary considerably. The Internet allows NMHSs to present hydrometeorological forecasts and warnings, and climate information to its customers, partners, and the public in graphic and digital formats that would otherwise be unavailable. It also provides opportunities to enhance and expand service delivery. For example, EC has developed an Internet web site exclusively for the media that allows them to tailor EC data to their specific needs. In another example, the NWS implemented an aviation-focused initiative called the Collaborative Convective Forecast Product (CCFP) in partnership with its aviation community. The CCFP initiative was launched based on an assessment which showed that weather-related delays due to convective activity are the single most disruptive force within the U.S. National Airspace System.

The expansion of the Internet in the 1990s, coupled with new computer and telecommunications technologies, has led to a proliferation of IT systems and applications. The evolution of PWS dissemination/service delivery integration is directly linked to the emergence of new computer and telecommunication technologies and information systems (e.g. the Internet, wireless communication technologies, GIS, GPS, mobile communication networks). Namely, these innovations allow NMHSs to provide weather forecasts and warnings in a variety of new formats (digital, XML, CAP) to meet customer demands for more precise and accurate environmental information. In addition, these new and emerging technologies offer the opportunity to further integrate PWS dissemination and service delivery functions. Other evolving capabilities (PodCasts/ VodCasts) can further enhance PWS service delivery.

4.1 Geographic Information Systems and the Global Positioning System

Geographic Information Systems (GIS) are designed for capturing, storing, analyzing and managing data and associated attributes which are spatially referenced to the Earth. The Global Positioning System (GPS), originally developed in the 1970s by the United States for military applications and transitioned for civilian use in the 1980s, is comprised of 24 earth-orbiting satellites which provides location specific information as precise as tens of meters. Together, GIS and GPS provide a powerful technological tool for NMHSs to enhance their PWS service delivery. Utilizing GIS and GPS with mobile communications networks and devices (cell phones, PDAs), NMHSs can effectively deliver user and location specific warnings and forecasts.

The NWS is utilizing GIS technology in its short-fused hydrometeorological warning program through the implementation of storm-based warnings (also referred to as polygon warnings). Currently, four types of short-fused warnings (Tornado, Severe Thunderstorm, Flash Flood, and Special Marine) include polygon information which takes the form of latitude and longitude pairs which highlight the threat area. – See Figure 3. Data from these warnings are collected and databased into a real-time set of GIS shapefiles. These files can be downloaded from the NWS website in real-time and used by customers and partners in other GIS applications. Figure 4 is an example of a graphic display of a NWS severe thunderstorm warning in northern Florida by Media Weather Innovations, a private weather provider. GIS and GPS users include emergency managers/

planners and media partners. Emergency managers and the media can quickly access and download GIS shapefiles via the Internet, add them to their existing GIS fields, and incorporate them into other GIS applications.

4.2 Extensible Markup Language – XML

E**x**tensible **M**arkup **L**anguage (XML) is an Internet-based language format for documents containing structured information or data. An Internet markup language is a mechanism to identify structures in a document. The XML specification defines a standard way to add markup to documents. Structured information contains both content (words, pictures, etc.) and some indication of what role that content plays (e.g., content in a section heading has a different meaning from content in a footnote, which means something different than content in a figure caption or content in a database table). XML is designed to describe data/information and the document tags are user-defined. XML is a cross-platform, software and hardware-independent tool for transmitting data and information. It is important to emphasize that XML complements **H**yper**T**ext **M**arkup **L**anguage (HTML) and is not a replacement for HTML. XML is designed to describe data/information while HTML is designed to format and display data/ information.

Section 1.01 Another benefit of XML is its ability to exchange data between incompatible systems. In many instances, computer systems and databases contain data in incompatible formats. One of the most time-consuming challenges has been the exchange of data between such systems over the Internet. Converting data to XML format can greatly reduce this complexity and create data that can be read by a wide array of applications.

4.3 Common Alerting Protocol – CAP

The Common Alerting Protocol (CAP) is an open, non-proprietary standard data interchange format that can be used to collect all-hazard warnings and reports locally, regionally and nationally, for input into a wide range of information-management and warning dissemination systems. CAP format uses XML and standardizes the content of alerts and notifications across all-hazards including hazardous material incidents, severe weather, fires, earthquakes, and tsunamis. CAP's origins can be traced back to recommendations of the "Effective Disaster Warnings" report issued in November, 2000 by the United States Working Group on Natural Disaster Information Systems, Subcommittee on Natural Disaster Reduction. Systems using CAP have shown that a single authoritative and secure alert message can quickly launch Internet messages, news feeds, television text captions/ scrolls, highway sign messages, and synthesized voice-over automated telephone calls or radio broadcasts to effectively alert the public. CAP is a simple but general format for exchanging all-hazard emergency alerts and public warnings, including hydrometeorological warnings, over a wide variety of communication networks. CAP allows a consistent warning message to be disseminated simultaneously over many different warning systems, thus increasing warning effectiveness while simplifying the warning dissemination task. CAP provides a template for effective warning messages based on best practices identified in academic research and real-world experience. Growing segments of the emergency management community are embracing CAP as a comprehensive, all-in-one approach to provide critical all-hazard information to the public. In turn, the NWS is working towards adopting the CAP standard. Figure 5 shows both the raw CAP code and an example of how CAP is used in real-time from the California office of Emergency Services.

4.4 Real Simple Syndication – RSS

XML is driving a host of new, innovative communication capabilities that can enhance PWS service delivery. This includes Real Simple Syndication (RSS). RSS is a family of web formats used to share and distribute, and publish frequently updated digital content. RSS is commonly used to update news articles and other content that changes quickly. Typically, RSS feeds deliver text and graphic content; however, RSS feeds may also include audio files (PodCasts) or even video files (VodCasts).

RSS is a pull-focused approach to receiving environmental information. Rather than the traditional approach of NMHSs "pushing" hydrometeorological products to its customers and partners, users install RSS readers which allows them to select and tailor the environmental information they need to meet their specific needs. Users subscribe to a feed by entering the link of the RSS feed into their RSS reader; the RSS reader then checks the subscribed feeds for new content on a recurring basis. If new content is detected, the reader retrieves the new information and provides it to the user. Most standard Internet web browsers (e.g. Firefox, Internet Explorer 7, Mozilla, Safari) can read RSS feeds automatically. Alternatively, users can install a stand-alone RSS feed reader or news aggregator. Thus, RSS gives the user the ability to maintain environmental situational awareness and quickly obtain the latest hydrometeorological information from their NMHS as needed. This approach also has the added benefit of reducing the load on NMHS web servers during significant high impact hydrometeorological events and other high-traffic periods. Figure 6 shows the United Kingdom Met Office RSS instruction web page describing how users can access RSS feeds for their products and the NOAA/NWS.Internet site with links to available RSS feeds.

4.5 Keyhole Markup Language – KML

Keyhole Markup Language (KML) is a recent XML-based offshoot designed for geospatial data applications. More specifically, KML is an XML-based language and file format for describing three-dimensional geospatial data and its display in application programs. KML has a tag-based structure similar to HTML with names and attributes used for specific display purposes. KML can be used to store geographic features such as points, lines, images, polygons, and models for display in Google Earth and Google Maps. A KML file is processed by Google Earth and Google Maps in a similar way that HTML and XML files are processed by web browsers. NMHSs may be able to exploit features of KML to add another dimension to delivering user and location specific warnings and forecasts.

5. Future Technology – Dual Polarization Radar and Phased Array Radar

One of the most exciting, innovative future technology enhancements for PWS is in the radar remote sensing arena. Next generation radar systems (Dual-polarization Radar, Phased Array Radar) provide the opportunity to improve severe weather detection, rainfall estimates, winter weather warning, and increase the lead time for severe weather hazards including tornadoes and heavy rain/flash flood events.

Dual-polarization radars transmit radio wave pulses that have both horizontal and vertical orientations. The additional information from vertical pulses will greatly improve forecasts and warning for a variety of hazardous weather including severe weather, heavy rainfall, and winter weather events. Unlike current WSR-88D radars, which transmit one beam of energy at a time, listen for the returned energy, then mechanically tilt in elevation and sample another small section of the atmosphere, a phased array radar system uses multiple beams, sent out at one time, so the antennas never need to tilt. This results in a complete scan of the entire atmosphere in about 30 seconds compared to 6 to 7 minutes for the WSR-88D radar. In addition, the phased array radar system incorporates the dual-polarization radar capabilities.

The benefits of phased array radars on PWS are broad and significant. They will allow NMHSs to issue more timely and improved warnings of severe weather hazards including the potential to issue graphic formatted tornado warnings up to 30 minutes or more in advance, and improve the lead time for flash flood warnings and icing forecasts for aviation interests.

6. Summary

The emergence of new, innovative and technologically advanced forecast systems and communications networks provide a host of exciting possibilities for NMHSs to improve PWS and effectively integrate dissemination and service delivery. NMHS PWS dissemination and service delivery integration will be dictated in large part by the development and application of new, innovative computer and telecommunication technologies and information systems. Digital database forecasting offers one of the most fascinating opportunities to integrate PWS forecast dissemination and service delivery most effectively to NMHS customers, partners and the general public. While it's recognized that digital forecasting is in its formative stages, and new telecommunication technologies are still emerging, NMHSs should keep abreast of this evolving forecasting approach.

Next-generation forecast workstations bring the promise of new methods to assimilate vast amounts of observational data and NWP output, including new visualization and information processing techniques, to assist forecasters with data analysis and interpretation. These workstations will assist with forecast preparation and significant event, high-impact hydrometeorological decision support. In addition, these workstations will likely incorporate sophisticated Nowcast systems which will integrate an array of real-time data and NWP output to provide prognostic information out 6 hours while also helping to rapidly generate and disseminate forecast products.

IT systems and associated applications, including XML, CAP, and RSS, will allow NHMSs to exploit the latest telecommunication networks, including broadband, wireless, and mobile systems, to improve PWS. Coupled with GIS and GPS capabilities, NMHSs can satisfy customer and partner demands forever increasing precision, accuracy, and detailed, location-specific hydrometeorological forecasts and warnings. Together, these efforts will allow NMHSs to cultivate an innovative and effective PWS program which leverages technological advances to create a holistic forecast and warning dissemination, service delivery, and all-hazard decision support process that best serves the user community.

Element	CONUS	Puerto Rico	Hawaii	Guam	Alaska
Maximum Temperature	**Operational** since 12/1/04	**Operational** since 6/21/05	**Operational** since 6/21/05	**Operational** since 9/20/05	**Experimental** since 9/6/06 **Comments closed** 4/6/07
Minimum Temperature	**Operational** since 12/1/04	**Operational** since 6/21/05	**Operational** since 6/21/05	**Operational** since 9/20/05	**Experimental** since 9/6/06 **Comments closed** 4/6/07
12-hour Probability of Precipitation	**Operational** since 12/1/04	**Operational** since 6/21/05	**Operational** since 6/21/05	**Operational** since 9/20/05	**Experimental** since 9/6/06 **Comments closed** 4/6/07
Temperature	**Operational** since 3/15/05	**Operational** since 6/21/05	**Operational** since 6/21/05	**Operational** since 9/20/05	Not available
Dewpoint	**Operational** since 3/15/05	**Operational** since 6/21/05	**Operational** since 6/21/05	**Operational** since 9/20/05	Not available
Weather	**Operational** since 3/15/05	**Operational** since 6/21/05	**Operational** since 6/21/05	**Operational** since 9/20/05	Not available
Quantitative Precipitation Forecast (QPF)	**Experimental** since 6/16/03 **Comments closed** 9/15/05	**Experimental** since 6/16/03 **Comments closed** 9/15/05	**Experimental** since 11/1/06 **Comments closed** 1/1/07	Not available	Not available
Snow Amount	**Experimental** since 6/16/03 **Comments closed** 9/15/05	Not required	**Experimental** since 9/14/04 **Comments closed** 9/15/05	Not required	Not available
Wind Direction and Speed	**Operational** since 12/14/05	**Operational** since 12/14/05	**Operational** since 12/14/05	**Operational** since 12/14/05	**Experimental** since 9/6/06 **Comments closed** 4/6/07
Significant Wave Height	**Operational** since 5/31/07	**Operational** since 5/31/07	**Operational** since 5/31/07	**Operational** since 5/31/07	**Experimental** since 9/6/06 **Comments closed** 4/6/07

Element	CONUS	Puerto Rico	Hawaii	Guam	Alaska
Sky Cover	**Experimental** since 6/16/03 **Comments closed** 9/15/05	**Experimental** since 6/16/03 **Comments closed** 9/15/05	**Experimental** since 9/14/04 **Comments closed** 9/15/05	**Experimental** since 9/14/04 **Comments closed** 9/15/05	Not available
Apparent Temperature	**Operational** since 3/15/06	**Operational** since 3/15/06	**Operational** since 3/15/06	**Operational** since 3/15/06	Not available
Relative Humidity	**Operational** since 3/15/06	**Operational** since 3/15/06	**Operational** since 3/15/06	**Operational** since 3/15/06	Not available
Probabilistic Tropical Cyclone Surface Wind Speeds **6 separate elements:** >34kts (incremental) >34kts (cumulative) >50kts (incremental) >50kts (cumulative) >64kts (incremental) >64kts (cumulative)	**Operational** since 5/31/07	Not available	Not available	Not available	Not available
Wind Gust	**Operational** since 9/20/07	**Operational** since 9/20/07	**Operational** since 9/20/07	**Operational** since 9/20/07	Not available
Convective Outlook Hazard Probabilities **9 separate elements:** Convective Hazard Outlook; Probability of: ▪ Tornadoes ▪ Hail ▪ Damaging Thunderstorm Winds ▪ Extreme Tornadoes ▪ Extreme Hail ▪ Extreme Thunderstorm Winds; Total Probability of: ▪ Severe Thunderstorms ▪ Extreme Severe Thunderstorms	**Experimental** since 2/27/07 **Comments accepted until** 6/29/07	Not available	Not available	Not available	Not available
Climate Outlooks **12 separate elements:** Days 8-14, 30, and 90 Days ▪ Temperature Above/ Below Normal ▪ Precipitation Above/ Below Normal	**Experimental** since 10/18/07 **Comments accepted until** 2/18/08	Not available	Not available	Not available	**Experimental** since 10/18/07 **Comments accepted until** 2/18/08

Table 1. Status of NWS NDFD Elements as of October 2007

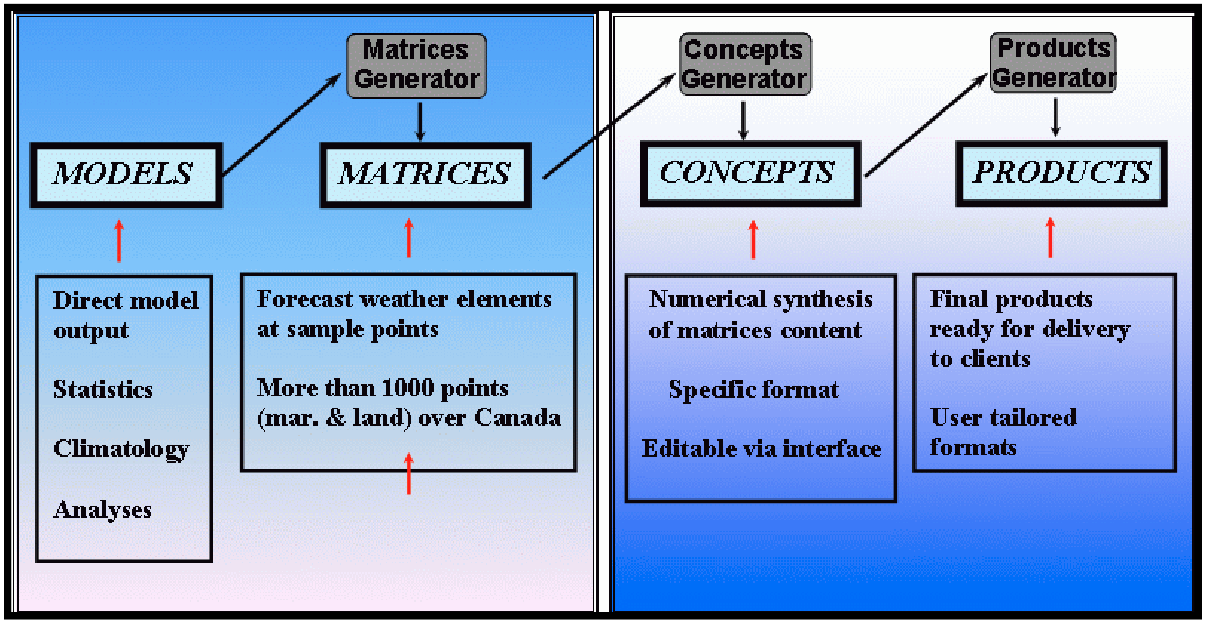
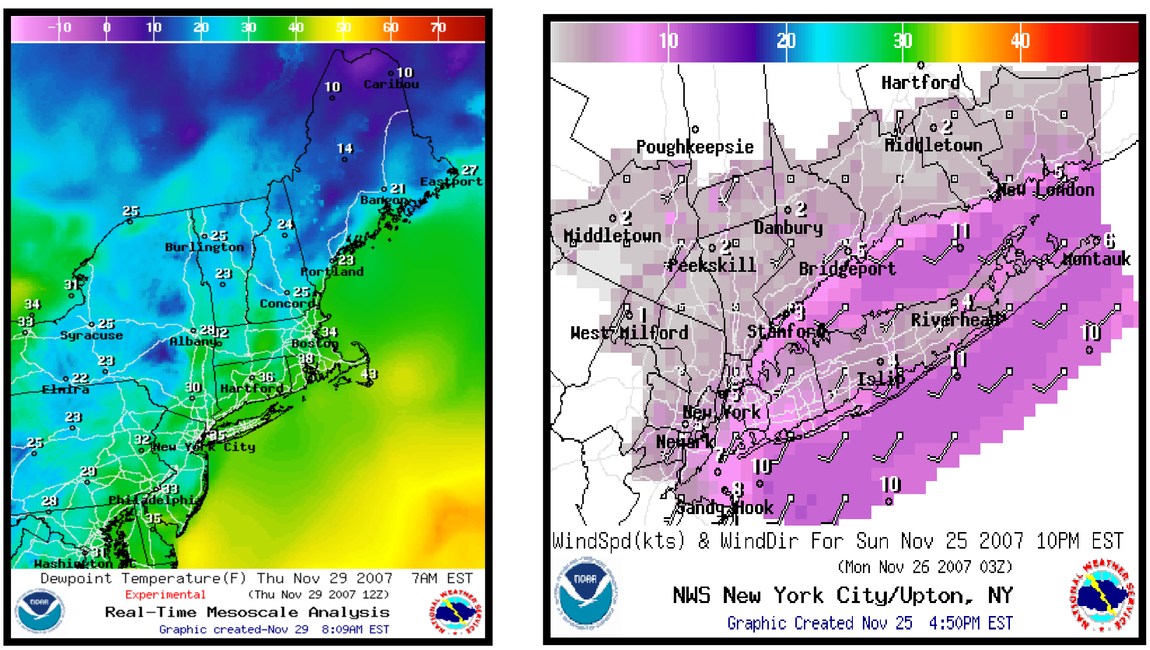


Figure 1. Flow chart depicting the primary steps in the SCRIBE data processing (Landry, C. et. al. 2005)



(a) (b)

Figure 2. Examples of NDFD output graphics: (a) regional dewpoint graphic (b) local wind speed and direction graphic.

WUUS52 KTAE 261332
SVRTAE
FLC063-133-261400-
/O.NEW.KTAE.SV.W.0173.071126T1331Z-071126T1400Z/
BULLETIN - EAS ACTIVATION REQUESTED
SEVERE THUNDERSTORM WARNING
NATIONAL WEATHER SERVICE TALLAHASSEE FL
731 AM CST MON NOV 26 2007

THE NATIONAL WEATHER SERVICE IN TALLAHASSEE HAS ISSUED A
* SEVERE THUNDERSTORM WARNING FOR...
NORTHWESTERN JACKSON COUNTY IN THE PANHANDLE OF FLORIDA...
NORTHEASTERN WASHINGTON COUNTY IN THE PANHANDLE OF FLORIDA...
THIS INCLUDES THE CITY OF CHIPLEY...

- UNTIL 800 AM CST

* AT 726 AM CST...NATIONAL WEATHER SERVICE DOPPLER RADAR INDICATED A
LINE OF SEVERE THUNDERSTORMS CAPABLE OF PRODUCING DAMAGING WINDS IN
EXCESS OF 60 MPH. THESE STORMS WERE LOCATED ALONG A LINE EXTENDING
FROM CHIPLE Y TO 18 MILES SOUTHWEST OF CHIPLEY...OR ALONG A LINE
EXTENDING FROM BONIFAY TO VERNON...AND MOVING NORTHEAST AT 55 MPH.

- SEVERE THUNDERSTORMS WILL BE NEAR...

- CHIPLEY BY 740 AM CST...

DOPPLER RADAR HAS INDICATED SOME WEAK ROTATION WITHIN THESE STORMS.
WHILE NOT IMMEDIATELY LIKELY...A TORNADO MAY STILL DEVELOP. IF A
TORNADO IS SPOTTED...ACT QUICKLY AND MOVE TO A PLACE OF SAFETY IN A
STURDY STRUCTURE...SUCH AS A BASEMENT OR SMALL INTERIOR ROOM.

RELAY REPORTS OF SEVERE WEATHER TO THE NATIONAL WEATHER SERVICE IN
TALLAHASSEE AT (8 5 0) 9 4 2 8 8 3 3. OR...YOU MAY CONTACT THE
NEAREST LAW ENFORCEMENT AGENCY OR YOUR COUNTY EMERGENCY MANAGEMENT.
THEY WILL RELAY YOUR REPORT TO THE NATIONAL WEATHER SERVICE.

**LAT...LON 3064 8546 3073 8566 3075 8565 3075 8561
3078 8562 3080 8559 3082 8560 3098 8550 3098 8518**

Figure 3. Sample severe weather warning with latitude and longitude pairs (highlighted at the end of the warning) which can be utilized by GIS applications.

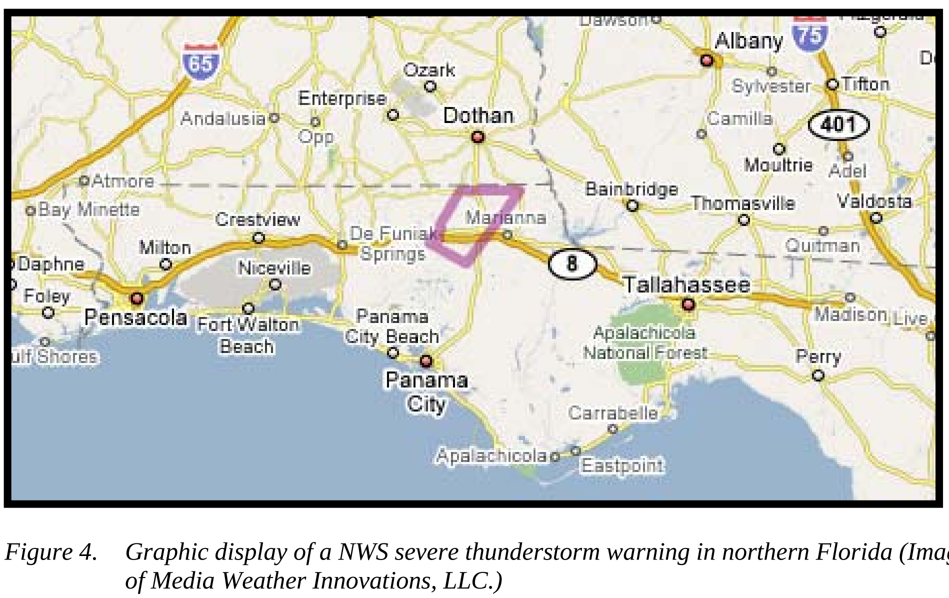
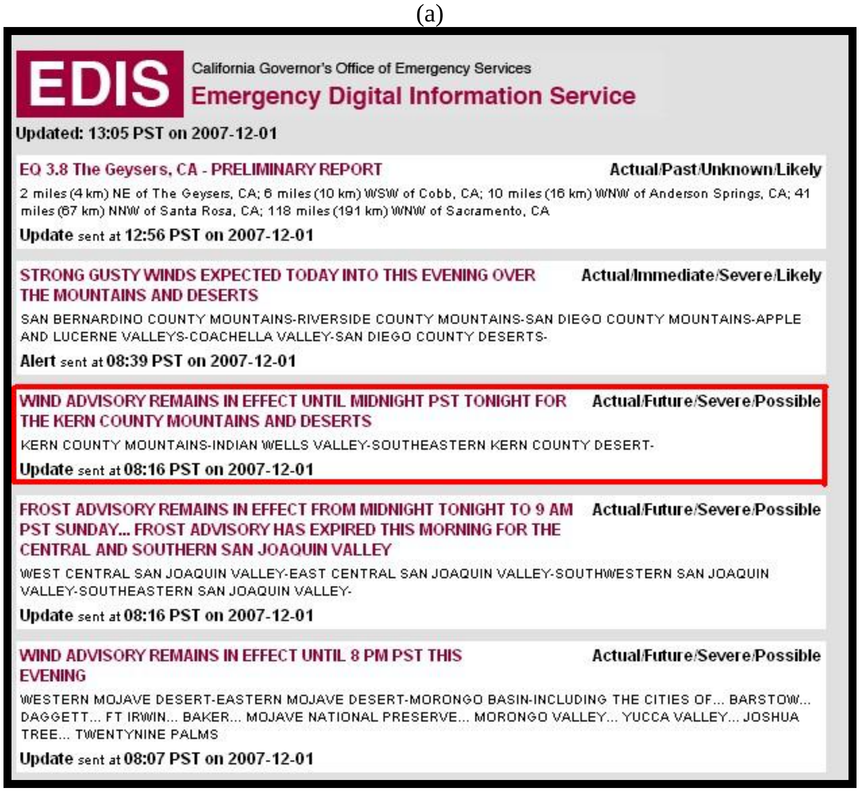


Figure 4. Graphic display of a NWS severe thunderstorm warning in northern Florida (Image courtesy of Media Weather Innovations, LLC.)


```
- <cap:info>
  <cap:category>Met</cap:category>
  <cap:event>Wind Advisory</cap:event>
  <cap:urgency>Unknown</cap:urgency>
  <cap:severity>Unknown</cap:severity>
  <cap:certainty>Unknown</cap:certainty>
  <cap:effective>2007-12-01T16:18:00</cap:effective>
  <cap:expires>2007-12-02T08:00:00</cap:expires>
  <cap:headline>URGENT - WEATHER MESSAGE</cap:headline>
  <cap:description>URGENT - WEATHER MESSAGE NATIONAL WEATHER SERVICE
    SAN JOAQUIN VALLEY - HANFORD CA 818 AM PST SAT DEC 1 2007 CAZ095-
    098-099-020030- /O.CON.KHNX.WI.Y.0020.071201T1800Z-071202T0800Z/
    KERN COUNTY MOUNTAINS-INDIAN WELLS VALLEY- SOUTHEASTERN KERN
    COUNTY DESERT- 818 AM PST SAT DEC 1 2007 ...WIND ADVISORY REMAINS
    IN EFFECT UNTIL MIDNIGHT PST TONIGHT FOR THE KERN COUNTY
    MOUNTAINS AND DESERTS... A WIND ADVISORY FOR THE KERN COUNTY
    MOUNTAINS AND DESERTS REMAINS IN EFFECT UNTIL MIDNIGHT PST
    TONIGHT. STRONG UPPER LEVEL WINDS AND COLD AIR BEHIND A
    DEPARTING STORM SYSTEM WILL BRING GUSTY WINDS TO THE AREA
    BEGINNING LATER THIS MORNING AND CONTINUING INTO THE EVENING.
    WEST TO NORTHWEST WINDS ARE EXPECTED TO INCREASE WITH GUSTS
    AROUND 50 MPH THROUGH AND BELOW MOUNTAIN PASSES AND WIND
    PRONE AREAS. WINDS ARE EXPECTED TO DIMINISH TONIGHT. A WIND
    ADVISORY MEANS THAT SUSTAINED WIND SPEEDS OF AT LEAST 35 MPH OR
    GUSTS OF 45 MPH OR MORE ARE EXPECTED. WINDS THIS STRONG CAN
    MAKE DRIVING DIFFICULT...ESPECIALLY FOR HIGH PROFILE VEHICLES. USE
    EXTRA CAUTION. $$ WEATHER.GOV/HANFORD</cap:description>

    <cap:web>http://www.weather.gov/alerts/CA.html#CAZ095.HNXNPWHNX.
    161800</cap:web>
- <cap:area>
  <cap:areaDesc>Kern County Mountains (California)</cap:areaDesc>
  <cap:geocode>006029</cap:geocode>
    </cap:area>
    </cap:info>
```


(a)



EDIS California Governor's Office of Emergency Services
Emergency Digital Information Service

Updated: 13:05 PST on 2007-12-01

EQ 3.8 The Geysers, CA - PRELIMINARY REPORT — Actual/Past/Unknown/Likely
2 miles (4 km) NE of The Geysers, CA; 6 miles (10 km) WSW of Cobb, CA; 10 miles (16 km) WNW of Anderson Springs, CA; 41 miles (67 km) NNW of Santa Rosa, CA; 118 miles (191 km) WNW of Sacramento, CA
Update sent at 12:56 PST on 2007-12-01

STRONG GUSTY WINDS EXPECTED TODAY INTO THIS EVENING OVER THE MOUNTAINS AND DESERTS — Actual/Immediate/Severe/Likely
SAN BERNARDINO COUNTY MOUNTAINS-RIVERSIDE COUNTY MOUNTAINS-SAN DIEGO COUNTY MOUNTAINS-APPLE AND LUCERNE VALLEYS-COACHELLA VALLEY-SAN DIEGO COUNTY DESERTS-
Alert sent at 08:39 PST on 2007-12-01

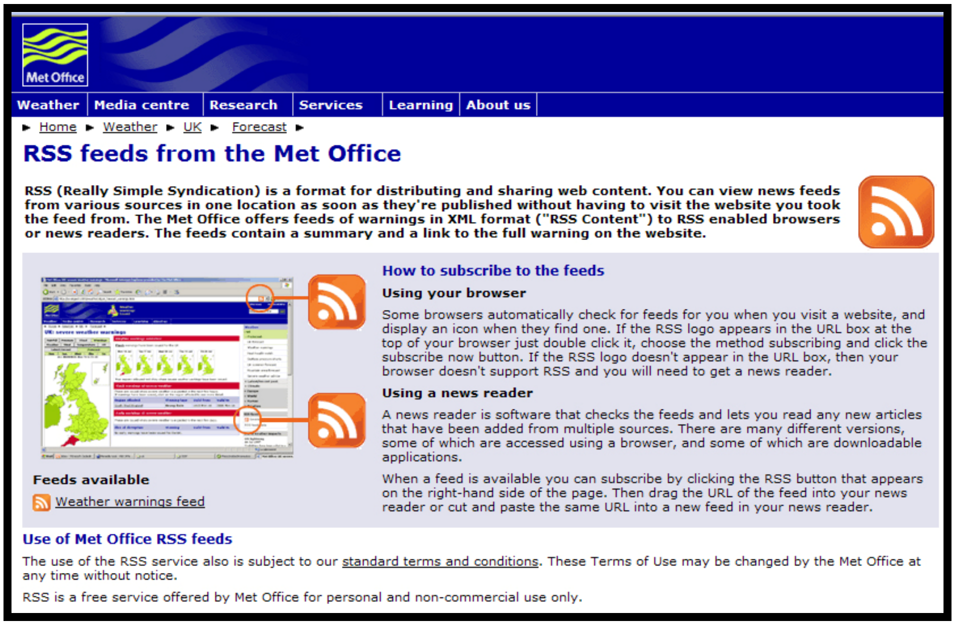
WIND ADVISORY REMAINS IN EFFECT UNTIL MIDNIGHT PST TONIGHT FOR THE KERN COUNTY MOUNTAINS AND DESERTS — Actual/Future/Severe/Possible
KERN COUNTY MOUNTAINS-INDIAN WELLS VALLEY-SOUTHEASTERN KERN COUNTY DESERT-
Update sent at 08:16 PST on 2007-12-01

FROST ADVISORY REMAINS IN EFFECT FROM MIDNIGHT TONIGHT TO 9 AM PST SUNDAY... FROST ADVISORY HAS EXPIRED THIS MORNING FOR THE CENTRAL AND SOUTHERN SAN JOAQUIN VALLEY — Actual/Future/Severe/Possible
WEST CENTRAL SAN JOAQUIN VALLEY-EAST CENTRAL SAN JOAQUIN VALLEY-SOUTHWESTERN SAN JOAQUIN VALLEY-SOUTHEASTERN SAN JOAQUIN VALLEY-
Update sent at 08:16 PST on 2007-12-01

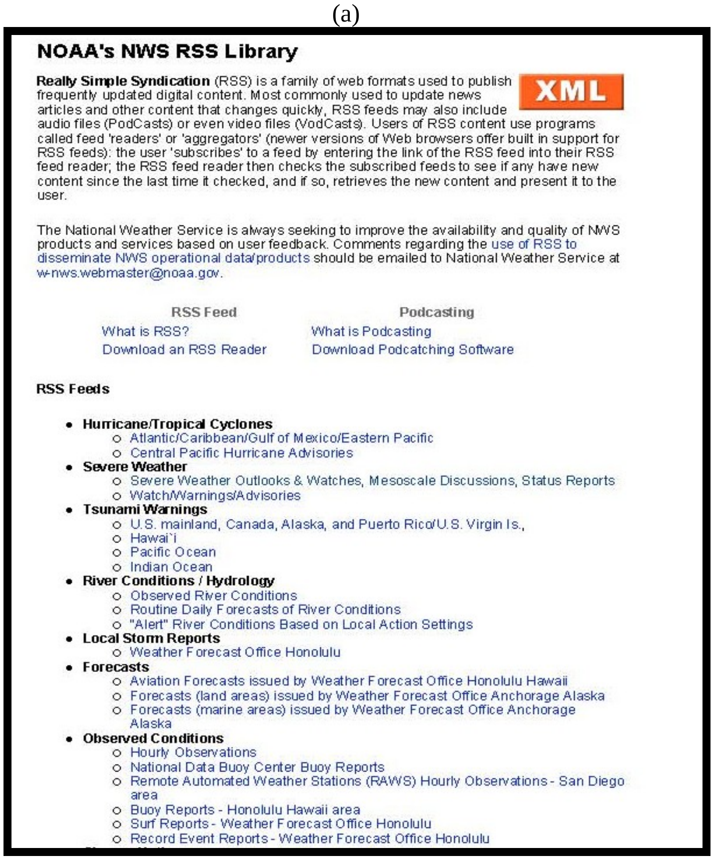
WIND ADVISORY REMAINS IN EFFECT UNTIL 8 PM PST THIS EVENING — Actual/Future/Severe/Possible
WESTERN MOJAVE DESERT-EASTERN MOJAVE DESERT-MORONGO BASIN-INCLUDING THE CITIES OF... BARSTOW... DAGGETT... FT IRWIN... BAKER... MOJAVE NATIONAL PRESERVE... MORONGO VALLEY... YUCCA VALLEY... JOSHUA TREE... TWENTYNINE PALMS
Update sent at 08:07 PST on 2007-12-01

(b)

Figure 5. NWS raw CAP code (a) and real-time application from the California Office of Emergency Services (b).Highlighted text in (a) corresponds to text in red outlined box in (b).



(a)



(b)

Figure 6 Information on hydrometeorological RSS feeds from (a) the United Kingdom Met Office describing how users can access RSS feeds for Met Office products (b) NOAA/NWS.Internet site with links to available RSS feeds.

References

Landry, C. et. al. 2005: Operational Scribe Nowcasting sub-system: Objective Verification Results. *21st International Conference on Interactive Information Processing Systems (IIPS) for Meteorology, Oceanography, and Hydrology*, San Diego, CA 8-14 January, 2005, pp 1-4.

Glahn, H.R. and D.P. Ruth 2003: The New Digital Forecast Database of the National WeatherService.*Bull. Amer. Meteor. Soc.*, 48**,** 195-201

The EMMA / METEOALARM Multiservice Meteorological Awareness System

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Abstract

The EUMETNET project EMMA (European Multiservice Meteorological Awareness System) was started in 2005 and intended to produce graphical maps with awareness levels to be displayed on a common website for the information of the public on cases of imminent meteorological danger. This system offers homogenized meteorological alerts and warnings across European countries. It is understandable at one glimpse also for untrained users, but offers more detailed information for professionals like Civil Protection Agencies. Additional resources of information are given by links to the websites of the National Meteorological Services. The operational implementation of this project took place March 2007 under the product name METEOALARM. All information described is available Online under www.meteoalarm.eu

Concept

The METEOALARM platform shows the integrated information on warnings and alert levels of the actual situation for today and tomorrow in a European map. Warned elements are: Wind, Rain, Snow/Ice, Thunderstorms, Fog, Extreme high or low temperatures, Coastal events, Forest fires, Avalanches, but not all countries warn all elements.

Figure 1. European map of the alert colours

It is a product of the co-operation between the National Meteorological Services, in the framework of EUMETNET; the consortium of the European weather services. The success of a previous project, the "vigilance map" in the French media has shown how large the need for standardised and consistent information becomes during extreme events. Standardisation means that key elements of the message should not change from one event-type to another or from one country to the next. The general public, the concerned authorities and the media have to be informed in a clear and structured way. The complexity of the underlying system and the cooperation between the numerous institutions has to be summarized in a simple surface.

The information in the METEOALARM system is primarily graphically structured and should be readable without further explanations within seconds by the majority of the people. Further information is accessible for most countries via texts in English and local languages providing thereby a more detailed information. The response by the public showed the concept is successful, daily hit rates range between 1 and 12 million.

Figure 2 National map of the alert colours

Harmonising across countries

Public preparedness for catastrophes needs the help of the media who can shape the understanding of the different levels of a danger scale. All different scales need time and media coverage to become accepted, but once they are used in a given socio-cultural context, the lifespan reaches decades like e.g. the Richter scale for earth quakes.

With scales of this type very extreme events can be quantified easily and direct relationship to what is felt as an impact or damage can be established.

Especially in the case of very extreme events occurrence rates are low and past events might be decades away. In these cases much can be learned from other events in the nearby past in other areas of Europe or the world, as these events have a high media presence and are understood through there damages by all parts of the public. Media coverage and experiences learned from e.g. Lothar help disaster prevention in the case of Kyrill not only in the countries where the storm occurred, but in all countries where similar events are possible.

Warning systems have to be adapted to different disaster types, as the necessary reactions by the public can be different, ranging from evacuations in cases of flood to "stay at home" orders in cases of severe wind speeds. But in both cases it is essential to raise and channel the attention towards the media where the warning with more details can be heard or learned. Simply understandable 3, 4 or 5 warning-level colour systems have their main purpose in being transmittable on very different technical communication platforms.

The second criteria which has to be met is the different language and cultural background of the users of these warnings. As Europeans (like other citizens) travel more and more and expose themselves during their travel more to the weather dangers than at home due to higher outdoor activities care has to be taken that also non-residents can be reached easily and find as much as possible of the provided information in their own language.

Public preparedness for the very extreme events can only be achieved if the media are not seen as a partner who follows his own interests of achieving quotes on the cost of scientific truth, but as an strategic partner to combine pictures of extreme events in one area with recommendations and rise of awareness for warning schemes in other areas of Europe.

	Damage / Impact	What to do?	Used how often? Approx. 300 000 km²	Meteo Treshholds - area related, e.g. for rain:
Green	- - -	usual phenomena		
yellow	exposed objects (avoidable)	caution with exposed activities	> 30 per year	> 30 mm/12h
orange	general damages (not avoidable)	keep informed in detail, follow advice of authorities	1 to 30 per year	> 54 mm/12h
red	extreme damage and /or casualties *(mostly) on large areas, threatning life and properties* not avoidable, even in otherwise safe places	follow order of authorities under all circumstances be prepared for extraordinary measures	less then 1 year *for large (5000km²) scale phenomena*	> 80 mm/12h

Figure 3 4-level matrix for impact, advice, return periods and meteorological thresholds

The interest for the media in a homogenised warning scheme lies in the quality of a reference point which a Europe-wide or an international danger scale can provide; the physics and details of the Richter scale are not known to every user, but the value of this scale and its relationship to the damage/impact consequences is clearly visible.

Basic principle of the harmonizing scheme is a matrix which combines for all countries the fundamental information for each of the 4 warning levels.

Within this matrix 3 out of 4 parameters do not differ within Europe and present thereby easily levels of common understanding. For this reason meteorological thresholds have to be adapted to local climatology.

Parameter	Differences within Europe
Impact scale	No
Advice	No
Return period	No
Meteorological thresholds	Yes (Climatology)

Levels of the Website

The information on the website is organised in three different levels, which all have different content and information density:

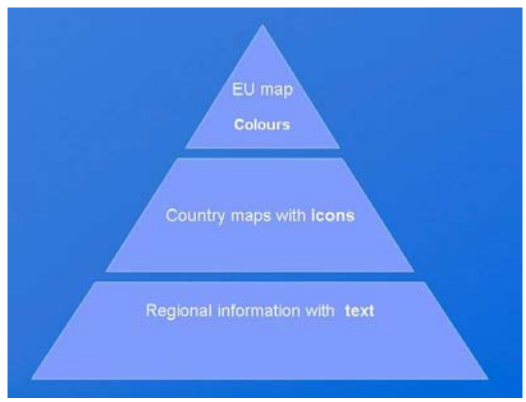

Figure 4 Pyramid of information on the website

Links are made from the 2nd and 3rd level towards the releveant institutions on a national or regional level. On the 1st level the map shows colours only, on the right hand side a table with country banners and icons for these countries is displayed.

The Hazard Chain

Extreme cases tend to be underestimated in the period of their forecast and overestimated in the reporting during and immediately after the event, with less media interest in a later phase when damages have been assessed and mitigation measures are proposed. The big floods in Europe were one of these examples, the aftermath of Lothar another one. Even only a few hours before the event it was not possible to raise the necessary attention by the public to move people towards safer places, mostly because the information in the warning messages did not contain easily understandable advice.

In the last years a general trend in research projects, risk management and new warning systems of the more advanced weather services could be observed which related the pure warnings to a more integrative approach of impact related information systems.

Public authorities interacted more directly which each other on a more competent and higher level, closing thereby gaps between the chain consisting of mitigation, prevention (like land planning measures), warning and alerts with forecasts, damage assessment and relief efforts.

To make this chain work and to minimise damage with the most efficient use of public funds each part of the chain has to interact with the others in an optimised way. Warning systems have to know about the impact of weather to be informative and relevant for practical measures.

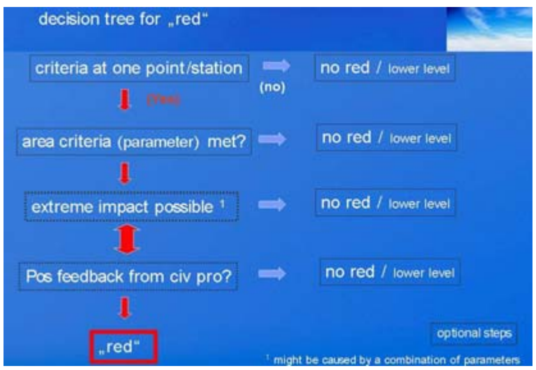

Figure 4 Decision tree for alert level determination

Therefore a well defined decision tree has to care for standardised decisions involving the sufficient number of experts to make the decision well based and well accepted by all institutions involved. On the meteorological level the decision tree looks as described in Fig. 3, but also in this circle experts from Civil Protection should at least be involved to express their opinion.

Usually the expert team for the decisions and the "red" alert level consist of a senior forecaster, expert on climatology, members of the board, media expert and a representative of the civil protection authorities, reflecting the impact a warning given by a National Meteorological Service has.

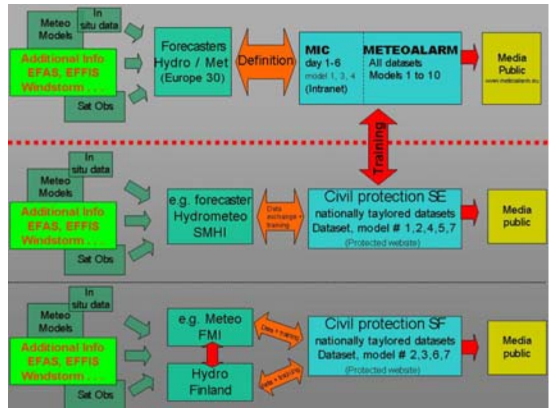

Figure 5 Alert Information flow on European level

For the general flow of information a data and information flow diagram was designed together with the MIC (Monitoring and Information Centre) of the European Commission.

Most important feature is the close cooperation of data providers like Services created though European FP7 projects as Windstorm, EFAS (European Flood Alert System) and EFFIS European Forest Fire Information system), together with Satellite information, in-situ data and numerical weather model results of global and regional relevance being evaluated and filtered by the forecaster with local and regional knowledge before this information is passed on in a very condensed form to Civil Protection. Adequate training for both sides about the necessary abilities and needs is essential before the operational data flow can be established on a day to day basis.

On a European scale the MIC takes the role for coordination and information exchange in a standardised form between the different European countries and also coordinates rescue and support operations of the European Union outside Europe.

Evaluation

A warning system is incomplete without a proper monitoring of the response to the warnings and an evaluation of the results. The evaluation can be done with proper skill scores between the forecast of an event and the resulting damage and/or loss in human life. The second is sometimes rather difficult to gather and it might take months till these investigations are completed.

As a first step the number of occurrences of the different warning levels was counted for the different countries of Europe and the different regions. Already on the country level large differences appear. This might be due to different synoptic regimes in the various parts of Europe for the available evaluation period between February and October, but also attributable to different warning philosophies.

This distribution serves now together with a series of case studies as a tool for a further adaptation of the thresholds.

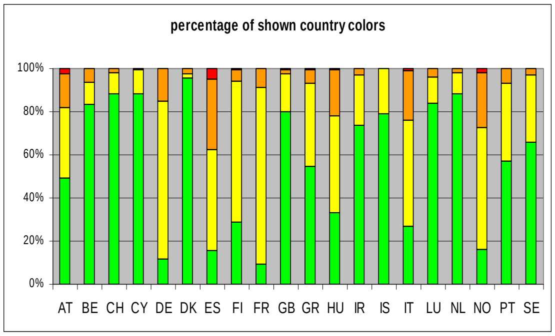

Figure 6 Alert Information flow on a European level

Outlook

In the near future the system will be even further expanded in two dimensions: Firstly more parameters will be added to use the advantage and the user frequency of a multi-hazard platform. Flood warnings, issued together with National Hydrological Services and coastal warnings will be the first elements to be integrated in 2008 and 2009.

Secondly more partners are already in the process of joining. They will extent the outreach of the platform from Central and Western Europe towards the East. A close cooperation will take place with WMO, as METEOALARM serves as content provider for SWIC (Severe Weather Information Center) for Europe and some of the experiences gathered within METEOALARM might be useful for the development of similar systems.

Figure 7 The WMO - SWIC Information system with METEOALARM as its European part

The Development of Hydrological Services

Bruce Stewart
President of the WMO Commission for Hydrology

Abstract

The primary objective of any Hydrological Service (HS) is the management of water resources across their area of responsibility, be it national, regional state or local From a WMO perspective, the main activity of any HS is the collection, storage, analysis and dissemination of water resources information. Basic water resources information is essential for the identification of the locations of the resource, the amount available (including its variability over time) and thus for its allocation or distribution to its many and varied uses. In all ecosystems, water interacts with the solid earth, the atmosphere and living creatures. Therefore, sustainable use of the resource is essential to ecologically sustainable development. Basic water resources data and information, the provision of which is one of the major roles of HSs is the basis on which to make these important decisions on allocation and use of the valuable resource. This paper describes the development of Hydrological Services over recent years and in particular focuses on their role in the provision of water resources information.

Introduction

Freshwater is vital to all forms of life. It is used for drinking, food production, industry, aquatic ecosystems, recreation, transport, sanitation, and many other functions. HSs are particularly important in relation to the extremes of availability (drought and floods) as well as the climate variability and change. Droughts impact on agriculture, ecosystem condition and urban water supplies.

Knowledge of and information about past droughts and the ability to forecast potential future drought conditions are thus valuable hydrological services in terms of the operation of hydrological systems during these times. Floods also inflict damage to urban and rural areas albeit in much shorter time frame than drought. Hydrological services such as design hydrometeorological parameters, flood-plain mapping and forecasting and warning services are thus of great benefit and of significant value to planners and developers.

Accordingly, any additional information, services and products that can be provided by National Meteorological Services (NMSs) are of significant value to HSs.

Mission of a HS

The mission of most HSs is to provide reliable, impartial, timely information that is needed to understand the water resources of their area of responsibility, including:

- minimising the loss of life and property as a result of water-related natural hazards, such as floods, droughts, and land movement;
- effectively managing ground-water and surface-water resources for domestic, agricultural, commercial, industrial, recreational, and ecological uses;
- protecting and enhancing water resources for human health, aquatic health, and environmental quality; and
- contributing to wise physical and economic development of the area's resources for the benefit of present and future generations.

Functions of a HS

A typical HS provides the following types of services:

- national repository of and authority on long-term time series of hydrological information (quantity and quality);
- measurement, collection and storage of hydrological data (including metadata) and relevant catchment characteristics (area, slope, drainage basins, etc.);
- access to/dissemination of hydrological data (event, statistical summaries, time-series, etc.):
  - at varying temporal and spatial scales;
  - in a variety of media (hard copy, electronic, etc.);
  - at different intervals (real time, historical, etc.); and
  - for a range of purposes (operations, research, etc.).
- access to/dissemination of relevant metadata;
- information/products that indicate the present and future state of the freshwater resources (electronic and hard copy formats);
- analysis of the yield potential of river systems, a reservoir site or aquifer (or combinations of the above);

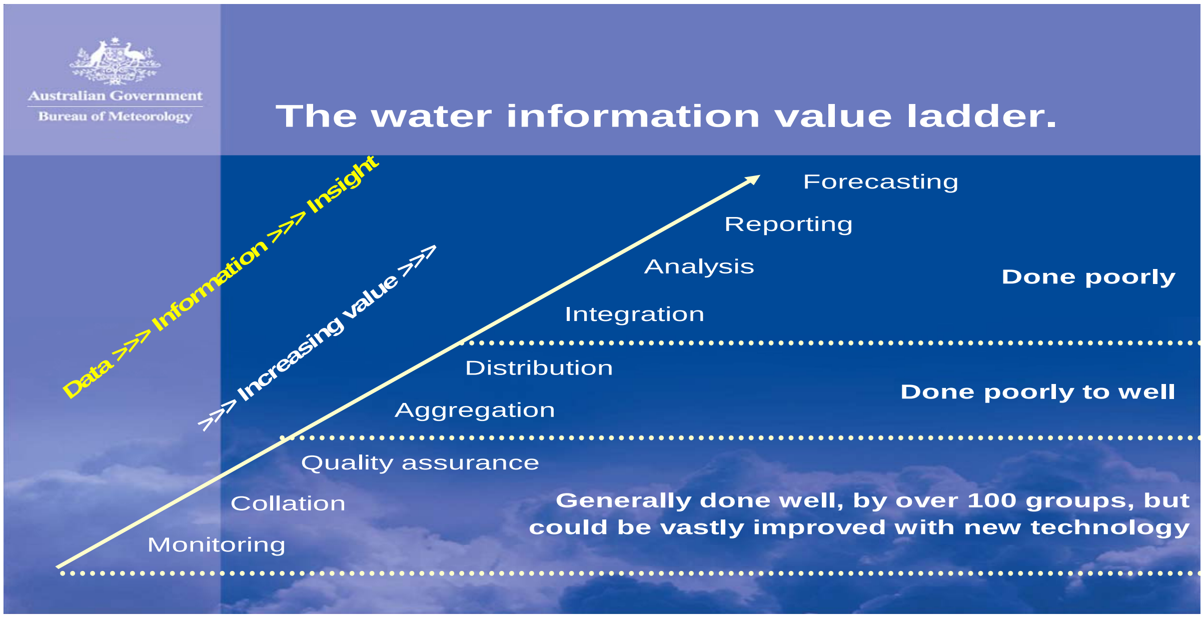

Figure 1 The Water Information Ladder

- analysis of the water quality characteristics of river and aquifer systems;
- analysis of water quality implications of land use changes and pollutions incidents;
- analysis of the environmental flow requirements of river and aquifer systems;
- forecasts and warnings of both high (floods) and low (droughts) flows;
- design hydrological information for the construction and operation of hydrological structures (dams, bridges, culverts, etc.); and
- general advice on hydrological issues.

In essence, it is the aim of NHs to monitor and collect water data and to move this information up the value ladder (Figure 1) to improve the management of the resource.

Development of NHs

The services provided by HSs are usually defined in terms of data and products made available to the user community. As with most disciplines, the types of data and products (services) made available by HSs have evolved with time and the changing needs for and uses of the variety of information that has been collected. HSs therefore need to be forward looking in their activities, and thus while meeting the existing demands of users of hydrological data and products they must continually be on the outlook for future requirements and technical capabilities.

In looking at the development of NHs over recent years I will focus on five areas of key interest. Firstly, the focus and operations of the NHS have moved from resource development to sustainable water resources management. Secondly, the economics of water management have increased in importance. Thirdly, there have been major improvements on modelling capabilities which enable improved water resources management capabilities. The fourth element will discuss changes to the monitoring/information collection framework and finally, the technology available to deliver services has evolved significantly.

Key drivers

As a practising hydrologist in the 1980s, the primary focus of my activities was studies aimed at the development of the resource. I analysed historical information to determine the amount of water available through the construction of storages (dams, weirs, irrigation areas, etc.) and analysed streamflow and rainfall data to determine the design parameters necessary for the constructions of such infrastructure. These developments were driven in the main by growing populations and the associated increasing demand food and increased industrial activity (mining, hydro-power, etc.).

If we look at the drivers today, most if, not all of these remain. We still have the growing population and user demand for resources (food and water). The mining industry continues to expand and hydro-power continues to be a valuable source of energy. However, the scarcity of water and these increasing demands have meant that the key drivers have shifted.

Key concerns these days are:

- Climate Change – while we have always had to deal with a variable climate, the majority of studies, analyses and management techniques have been based on the belief that the hydrological series was stationary, that is, while there may be fluctuations, the mean value would remain roughly the same. There is now mounting evidence of trends in hydrological series. Many areas face a drying and warming climate and thus potentially less water availability.

- Growing Urban Demand – the population of urban centres continue to grow and urban areas continue to spread thus placing greater pressure on urban water supply systems and also reducing the availability of arable land and in some cases water supply catchments.
- Over-allocation of existing supplies – the water in many water supply systems has been allocated on the basis of past availability or existing demand and thus has not been kept in line with current or future availability and thus many systems are over-allocated.
- Un-restricted extractions – in many areas, there are no management plans or restrictions on water extractions (for example pumping from rivers and groundwater extractions). These have resulted in less water being available and have in some case led to mining of the resource. The expansion of farm dams in some areas also reduces the supply of water entering river systems.
- Land-use change – clear felling, expanding plantations and the opening of new areas to agriculture all have impacts on the water resource and un-intended events, such as bushfires, can lead to a reduction in the availability of water and water quality problems. Changes to land-use even within agricultural areas have implications for both water availability and water use.
- Environmental requirements – there has been an increasing emphasis on the requirement for environmental flows to maintain ecosystems - wetland and in-stream environments. Community expectations are that we should see the environment as a rightful and high priority user of water.

All of the above have meant that we have increasing demands for a scarce resource and that HSs are being required to set in place programs that lead to the management of the resource in an environmentally and economically sustainable manner.

The requirement for water information has therefore never been higher then it is today as you cannot manage what you cannot measure!

Economics of water management

There are two aspects to the economics of water management. These are the costing regime for the provision of services and the costing regime for water itself.

The economic framework in which hydrological services are provided comprises of the same three elements that apply to the meteorological sector. These are the “public good”, cost recovery and commercial services. Basic hydrological products and services have strong public good characteristics of non-rivalry and non-excludability, and should therefore be provided to the general community including key economic sectors, in the public interest as public goods and services. These products and services include data collection and processing aimed at national knowledge and information on the resource in support of its sustainable development and in the public interest.

HSs can and do also provide specialist monitoring and provision of services to identified users in response to their needs, at marginal cost and if there is a public interest element to the service provided. Services are also provided on a commercial basis, that is special or value added services. Services provide on this basis are subject to competitive neutrality and associated competition policies and are usually provided where there is no public good element and the user can be identified and has the potential to make an economic gain from the service provided.

The trend over the past years, commencing in the early 1990s, has seen a move away from the provision of water as part of the function of government to one of “user pays”. The International Conference on Water and the Environment, Dublin, 1992 (ACC/ISGWR, 1992) and the UNCED-Agenda 21 (1992) process started this approach by identifying water as an economic good with an associated economic value in all of its competing uses. Since that time there has been a major push, particularly from developed countries, for the users to pay the full cost for water and for water to move to its highest economic value use.

This approach has led in some instances to the development of water training and water markets as a method for water being bought and sold and thus being treated in an economic framework.

Hydrological modelling

The WMO Guide to Hydrological Practices provides guidance on the scientific basis for the hydrological modelling which forms the basis of water resources assessment and hydrological forecasting.

The term “modelling of hydrological systems” usually means the application of mathematical and logical expressions that define quantitative relationships between flow characteristics (output) and flow-forming factors (input). The models vary from purely empirical, black-box techniques, that is, those that make no attempt to model the internal structure and response of the catchment but only match input and output of the catchment system. At the other extreme are techniques involving complex systems of equations based on physical laws and theoretical concepts that govern hydrological processes, so called hydrodynamical models. Between these two extremes are various conceptual models. These models represent a logical consideration of simple conceptual models, for example, linear or non-linear reservoirs and channels that simulate processes occurring in the basin. These models are often referred to as deterministic models. Modelling of hydrological systems also includes stochastic modelling, where the emphasis is on reproducing the statistical characteristics of hydrological time series.

Water resources assessment is the determination of the sources, extent, dependability and quality of water resources for their utilization and control. Water resources are water available, or capable of being made available, for use in sufficient quantity and quality at a location and over a period of time appropriate for an identifiable demand. The scientific basis for water resources assessment is that using the data from networks of site based measurement of flow over both spatial and temporal scales, an understanding of the distribution of the water resource in time and space can be developed. Where data are not available, interpolation, modelling and other techniques are applied.

Data can be estimated by combining the data measured at the gauging stations with physiographic data in the framework of data interpolation or data transfer techniques. Auxiliary data consist normally of physiographic data and, for a given type of data on a given water balance component, data obtained on other components. Such techniques consist primarily of mapping and modelling and less sophisticated methods such as linear interpolation. The adequacy of such interpolation techniques is related to the accuracy of the estimates. This in turn depends upon the density of network stations and their distribution, the accuracy of the measured data, the interpolation technique used, and the availability and accuracy of the physiographic data required. In general, the accuracy of the estimate varies, for a given technique and given related data, with the density of the network stations. By comparing relationships between accuracy of estimate and network density for various techniques, the adequacy of the models and implicitly of the related physiographic data can be evaluated.

Water quality models can be divided into three basic categories, namely physical models, analogue models and mathematical models. Physical models aim to reproduce (usually at a reduced scale) the investigated phenomena (usually a well-defined process). Analogue models use a convenient transformation of one set of water quality properties into another that is easier to study. Mathematical models are where the phenomena are investigated by means of an algorithm that represents, in an analytical form, the relationships between various inputs in the water body, its hydraulic-hydrological characteristics, and the time-space variations of the water quality characteristics.

Hydrological models are usually calibrated using a sub-set of the total data sets available and then testing the calibration using the remaining independent data set to gain an understanding of the accuracy of the model.

Advances in modelling capabilities are heavily tied to advances in the computational capabilities of computers. Models are usually developed on the basis of scientific research and investigation into the physical properties of the movement of water in the landscape.

In recent years, modelling capabilities have improved in terms of greater integration between elements of the hydrological cycle and also closer relationships between meteorological and hydrological modellers. Specific examples include radar and satellite based rainfall estimation, numerical weather prediction inputs to hydrological models and improved seasonal climate outlook information incorporated in hydrological forecasting systems.

Also, there have been significant advances in spatial information modelling capabilities and products using geographical Information System (GIS) technology. Hydrologists use GIS technology to integrate various data and applications into one, manageable system. For example, the suite of tools contained in Arc Hydro facilitate the creation, manipulation, and display of hydro features and objects within the ArcGIS environment.

Ultimately however, the quality of the outputs and products from modelling will still depend heavily on the quality of the water information collected in the field.

Monitoring/information collection framework

By its very nature, (for example, remote locations, event based and direct measurement difficulties), high quality water information is difficult and costly to collect. While there have been significant advances in the recording of information (data loggers) and transmission of information (telephone and satellite telemetry) there has been limited progress in improvements to the measurement of streamflow itself.

Perhaps the greatest advance has been in the development of Acoustic Doppler Current Profilers (ADCP). The ADCP is used measure how fast water is moving across a water column. An ADCP anchored to the seafloor can measure current speed not just at the bottom, but also at equal intervals all the way up to the surface. The instrument can also be mounted horizontally on seawalls or bridge pilings in rivers and canals to measure the current profile from shore to shore, and to the bottom of a boat or float to take constant current measurements as the boat moves. In very deep areas, they can be lowered on a cable from the surface.

However, there has been relatively little activity in the way of intercomparisons between the various instruments and also little in the form of technical guidance and training in instrument use.

Service delivery

As indicated above, in the past, hydrological data and information were largely made available through annual reports and specific studies and analyses. The availability of the Internet and web-based provision of information has resulted in major changes to the manner in which information can be accessed and also the timeliness of information provision.

It is now not uncommon for water information to be available in real-time (in graphical and tabular format) and to be able to obtain historical information through the internet. Also, reports and case studies on water related topics are often available for access or download through the Internet.

NMS and HS Relationships

Most NMSs are involved in activities that support sound water management in their countries, and therefore the activities of the HS. For example:

- NMSs often have a lead role in providing flood forecasts and warnings and opportunities exist to extend this to support water management more widely; and
- NMSs also have a key role in improving earth system simulation and, coupled with other related research and development, will deliver further opportunities for water management.

A key determinant of the long term profitability, competitiveness and sustainability of the water sector will be the extent to which the current challenges in water management are handled. The effective sharing of water among the wide range of competing uses requires good information on the current extent and variability (spatial and temporal) of the resource as well as the ability to understand and predict its variability, both existing and as a result of any long term climate change. NMSs can contribute effectively to the provision of information through their climate observing networks and various weather and climate modelling services and also to the understanding of the resource through its capability to translate this information into hydrological and water resources products.

Extending services for improved water management

Some NMSs operate a national river monitoring and forecasting service which is most commonly directed towards flood forecasting and warning, but has considerable potential to be extended to a more general river forecasting service providing short and medium term water resource outlooks. The river monitoring and forecasting service can involve national scale real-time river data collection and the provision of a range of real-time hydrological data and information through the Internet. This information on river flows has the potential to form the basis of a system that can support more efficient operation of water management systems by enabling them to adapt to the continually varying climate and water allocation demands. Such a national river forecasting system also has the potential for assessing the impact of short-to-medium term climate variability as well as much longer-term climate change.

A challenge for the implementation of such a system is the requirement to address issues of consistency of standards in water resource data collection and data management among the growing number of agencies involved. This will require a strong commitment and coordination at the national level. NMSs can play a key role here through their network of offices and observing sites, their continuing role in water resources data collection and assessment and, in particular, through their operation of national rainfall and evaporation data networks. Moreover, NMSs often have established links with key water groups involved in data collection and resource management.

Science for improved water management

To provide fully effective water management, the capability to understand and predict the movement and availability of water within all components of the hydrological cycle and to be able to simulate the impacts of various landscape changes on the distribution and availability of water is essential. The development of an Earth System Simulator (ESS) provides this capability through full earth-atmosphere simulation. Such simulations can provide predictions of water availability and distribution across space scales ranging from small catchments, through river basins to larger regions and time-scales varying from hours to weeks and longer. Outputs can include water availability in terms of river flows for storage management and water allocation and also variables such as soil moisture that will be valuable to decision-making in many agricultural applications such as water delivery and applications management.

Other areas

Other areas in which improved cooperation and collaboration between NMSs and HSs include the following:

- more accurate and longer duration weather forecasts, especially precipitation forecasts;
- more accurate seasonal outlooks;
- radar and satellite based rainfall estimates; and
- integrated product provision.

Summary/Conclusion

With the pressure of drivers such as population growth and climate change, HSs will continue to focus on the sustainable management of the water resource. Therefore, any tools that can be developed to aid decision making and assist HSs in meeting their mission will we well received. NMSs are in a key position to assist HSs in this regard and continuing cooperation and coordination between these groups will be essential.

Building Public Awareness Towards Hydrological Services

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Abstract

The key issue in hydrological services that is of major concern to mankind is availability of freshwater, whose main source is precipitation that is highly variable both in space and time. Water is essential as the life giving element for all living things. It is also considered as a resource, with a value attached to it, which they need for their survival and physiological well-being. However, water is also one of the most destructive elements on our planet. Excessive water in the form of floods can mean disaster, death, and destruction, while too little water can cause drought, famine and economic depression.

The demand for freshwater continues to increase due to growth in world population that needs water for various uses such as domestic, agriculture, energy, recreation and transportation, while poor watershed management in some countries and deteriorating water quality and drought are all inexorably increasing water scarcity. The net result of all this is competition of water uses, catchment degradation, water pollution, loss of biodiversity among others and these require attention. This paper highlights the current issues and challenges facing hydrological services community as well as identifying the driving forces and goals that can be considered in building public awareness towards hydrological services and briefly discusses how this can be carried out.

1. Introduction

In Chapter 18 of agenda 21 of the United Nations Conference on Environment and Development (UNCED), it is recognized that water is needed in all aspects of life. The general objective of Chapter 18 is to make certain that adequate supplies of water of good quality are maintained for the entire global population, while preserving the hydrological, biological and chemical functions of ecosystems, adapting human activities within the capacity limits of nature and combating vectors of water-related diseases. It was also noted that to fully utilize water resources and to safeguard those resources against pollution, innovative technologies, including the improvement of indigenous technologies, are needed. Further, widespread scarcity, gradual destruction and aggravated pollution of freshwater in many world regions, along with the progressive encroachment of incompatible activities, demand integrated water resources planning and management

National hydrological services are therefore expected to carry out activities that will address the issues raised in Chapter 18 of Agenda 21 of UNCED among others. This paper reviews the organizational structure of national hydrological services or agencies, their roles and services they provide, emerging issues and challenges in water resources and how to build public awareness towards hydrological services.

- **Organizational Structure of Hydrological Services/Agencies**

Hydrological Services are organized differently from country to country. Basically, however, there are four types of organizational patterns (WMO No. 461, 1977; WMO 1994a)

(i) Hydrometeorological service, a single national agency combining the Hydrological and meteorological service
(ii) A single water-resources Agency responsible for most of hydrological activities in a country (National Hydrological Service).
(iii) Hydrological services distributed among several national agencies, sometimes including meteorological service (neither National nor Regional Hydrological or Hydrometeorological Service)
(iv) Hydrological services are mainly under the jurisdiction of state or provincial governments in accordance with water resources development policies (Regional Hydrological or Hydrometeorological Service).

In some countries existing organizational structure do not fall in any one of the above patterns. For example, groundwater, water quality and extreme activities are assigned to an agency different from that responsible for the bulk of hydrological services. In others, glacier and/or snow pack studies are assigned to agencies having little other hydrological responsibility.

3 Roles of and Services provided by a National Hydrological Service

3.1 Roles of a National Hydrological Service

Hydrology is the science that deals with the waters above and below the land surfaces of the Earth, their occurrence, circulation and distribution, both in time and space, their biological, chemical and physical properties, their reaction with the environment, including their relation to living beings (UNESCO / WMO 1992) .Therefore it concerns with the circulation of water and its constituents through the hydrological cycle (or "Natural Water Environment") which comprise precipitation, evaporation, infiltration, baseflow, runoff, channel flow, overlandflow and transport of substances dissolved or suspended in flowing water. Fig. 1 shows the systems representation of the Hydrological Cycle (Freeze, 1979:, modified by H.P. Leniger)

The main goal of a National Hydrological Service is to meet the general requirement of all interests in the country, for hydrological information and services. Such information should include the condition and trend of a country's water resources (surface and subsurface, quantity and quality) that enable governments and the stakeholders to minimize the costs of water related disaster, protect and strengthen the water sensitive sectors of economy to ensure sustainable development and contribute to the health, welfare and quality of the population. The information and services may include forecasts and warnings of hydrological extremes (flood & droughts) and design and operation of water-management structures. However, data and information about past, present and future conditions are necessary to be able to meet the requirements. Therefore, the Hydrological Service will carry all the following activities in order to provide the required water-related information and services covering both surface water and groundwater resources (WMO TD-No. 1056).

i. Establishing the requirements of present and future users of information
ii. Defining the attributes (accuracy etc) of data and information necessary to meet these requirements
iii. Designing and establishing use-specific and basic hydrometric observing networks
iv. Developing methods for transferring information from measurement sites to other locations
v. Collecting data and maintaining quality control over data collection procedure
vi. Processing the archived data and maintaining control of the quality & security of data
vii. Making data accessible to users when, where and in the form that they require. (This means transformation of data into information and may include provision of warnings, either directly or to civil defence agencies)
viii. Inform potential users of the data and information that are available and assisting them to make the best use of them.
ix. Developing new technology and developing and training staff
x. Carrying out research into hydrological and related processes to assist users to interpret and understand the information
xi. Ensuring co-ordination with other agencies that require water related or other relevant information.

3.2 Hydrological services to the public

Generally, the information and services provided by a national hydrological service to the public is required for (WMO, 1994):

(1) Water Resources assessment including potential for water-related development and the ability to supply actual or foreseeable demands
(2) Planning, designing and operating water projects
(3) Assessing the environmental, economic and social impacts of water resources management practices, existing and proposed, and adopting sound policies and strategies.
(4) Assessing the impacts on water resource of other non-water sector activities such as afforestation/deforestation
(5) Providing security for people and property against water-related hazards, particularly floods and droughts
(6) Informing and educating the public and decision makers.

Broadly the information and services can be categorized as Water Use; Water Control; and Water Pollution

3.2.1 Water use: The services here concern the withdrawal of water mainly from rivers, lakes and aquifer; and water supply for use in various socioeconomic sectors such as the following (H. Liniger, 1997) :

3.2.1.1 Domestic use: Fresh water is needed for domestic use (drinking, home, public service- hospitals- and municipal use). Average daily per capita use (individual use) of domestic water is not uniform globally. For example in North and Central America it is 417 litres, Europe 259 litres, South America 235 litres, Africa 47 litres and Asia 86 litres(World Resources)

Institute, 1992). Approximately 2.5 to 3.5 litres per person per day are needed to meet basic drinking water needs (drinking & cooking) while 20 to 50 litres per day is considered enough for drinking, cooking and basic hygiene (DEH,1993).

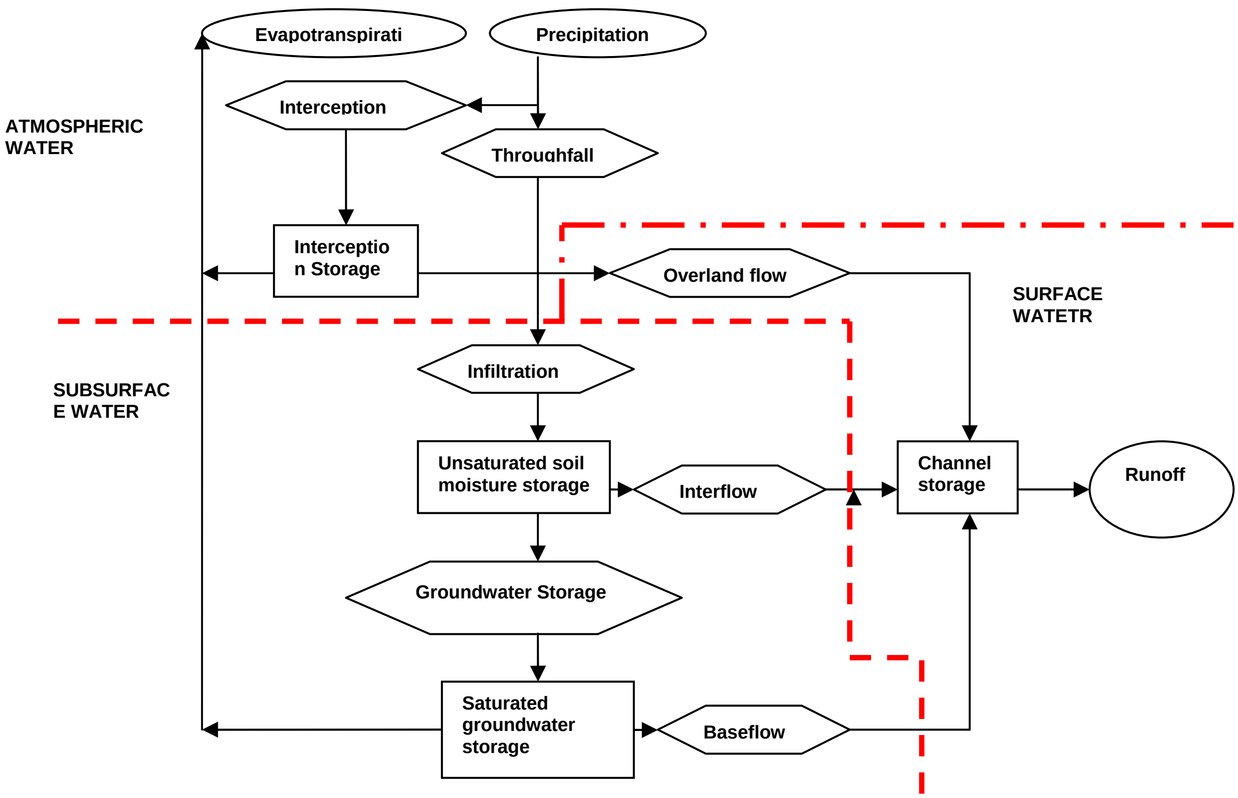

Figure 1   Systems Representation of the Hydrological

3.2.1.2 Agriculture (Food production): Agricultural activities being practiced in countries where Gross National Product (GNP) depend significantly on agriculture are rainfed arable, irrigated arable and pastoral systems all with different water requirements. However, as a rule of thumb, approximately 500 – 700 litres of water are needed to produce one kilogram of dry matter (Frei 1991). Globally, about 70% of total freshwater withdraws is used for irrigation. However, in Asia over 80% of all water withdrawals is used for irrigation, while in U.S.A it is about 40% and in Europe over 30% (Water Resource Institute 1992) Pastoral water requirements on daily basis vary considerably depending on climate and animal's activity. Requirements increase with higher temperatures and lower air humidity and with increased animal products.

3.2.1.3 Hydropower generation: Globally 25 – 30% of electricity supply comes from hydropower. Reservoirs created upstream to ensure constant water flow normally have negative impacts such as submergence of large areas and displacement of people, heavy impacts on water ecosystem.

3.2.1.4 Industrial use: Industries need water for cleaning, manufacturing and cooling during processing. The amount of water used is quite a lot. For example to produce one litre of beer, 25 litres of water are needed; for refining one litre of oil, 10 litres of water is used; 250 – 500 litres of water required to produce 1Kg of paper and 4 – 5 million litres of water to synthesize 1 Kg of streptomycin- antibiotic drugs (DEH 1993). With many countries undergoing industrialization, demand for water is very high.

3.2.1.5 Navigation: Transport and communication take place in major river basin. For some who live in wetlands, flood plain, the means of transport and communication is water. River training and channel deepening to create sufficient depths and acceptable velocity alter the ecosystem along the river.

3.2.1.6 Fishing Industry: Thirteen percent of world's fish comes from inland fisheries and the rest (87%) from marine fisheries. Aquaculture or fish farming provides 12% of the global fish catch with the rest coming naturally. The types of fish that is most important and valuable commercially tend to need high quality water.

3.2.1.7 Recreation: In some countries Tourism and recreation have become revenue earners for governments. Both tourism and recreation require a high level of water quality.

In all the above water uses a hydrologist is called upon to provide information and services, specifying the inflows to the system (river, lake or aquifer) for both normal and drought conditions and to predict how different withdrawals rates and instream flow would affect the flow through the system

3.2.2 Water control: Hydrological information and services provided are to ensure security for people & property against water-related hazards such as floods & droughts by controlling hydrologic extremes, particularly floods, and the erosion and sediment transport which occur during floods. A hydrologist specifies the inputs to the system for given design conditions, and traces the discharge of water and sediment through the system. Such services will be useful in design of flood protection works such as levees and dams and planning and operating water systems/projects; in management schemes such as flood plain delineation and policies to regulate development within flood plains; in erosion and sediment control works and in storm water detention and diversion projects. In addition to water control, provision of forecasts and early warnings of hydrological events on real-time basis to the **community is a requirement in many countries**

3.2.3 Pollution control: Here, the hydrological information and services provided deal with the prevention of the spread of pollutions or contaminants in natural water bodies and the cleaning of existing pollution. Hydrologists must determine the source and extent of pollution, how quickly and how far the pollution will spread and where the pollutants will ultimately end up. Point sources of pollution, such as landfills and channel waste damps must be located; non-point sources of pollution such as drainage or runoff of pesticides and fertilizers from agricultural lands must be identified, the various solutes and liquids which may flow from these sites must be determined; the streams and aquifers through which the contaminants will pass need to be studied; and designs are prepared either to prevent the pollutants from flowing into the natural water system at all or, if pollution occurs to ensure that it is sufficiently limited so that the quality of the recessing water is not significantly damaged.

4 Emerging Issues and Challenges in Hydrology and Water Resources

The emerging issues and challenges encountered in hydrological services and water resources are discussed below.

4.1 According to the report by World Meteorological Organization (WMO / TD-No. 1056), there are key issues facing the global community of hydrological services such as Increasing recognition of the need to sustain freshwater ecosystem while meeting the demands of human users; Increasing adoption of Integrated Water Resource Management (IWRM) as the framework for water management; and Growing demand for a wider range of water-related information services, such as low flow forecasting

4.2 Impacts of climate change on water resources: Hydrological hazards such as floods and droughts are becoming more frequent and are causing increased severe disasters due to current climate extremes and climate change occasioned by global warming. The impacts of climate change are putting increasing demands on humanitarian relief and are already threatening governments' poverty alleviation and sustainable development targets. Similarly, hydrologists and engineers are now being faced with the problem of designing appropriate water management systems that could deliver dependable supplies throughout the year and regulate river flows to moderate the effects of seasonal flows due to climate variability and climate change. The past hydrometeorological parameters may not be valid. There is need to adapt to climate change to forestall the escalating financial and human life loses, the wiping of decades of development in various countries (damage to infrastructure etc, thereby putting Millennium Development Goals to tackle hunger and poverty at Risk), destruction or loss of aquatic ecosystems. Therefore, the need to build public awareness for a paradigm shift for the water managers to consider changing rainfall and runoff pattern in their design calculations since historical data cannot be used solely without incorporating up to date information which includes climate change. In some areas, climate change may also result in decreased precipitation leading to decreased water supplies and increased demands; causing deterioration in quality of freshwater bodies; intrusion of sea water into estuaries, coastal aquifers and flooding of low-lying coastal areas due to sea level rise.

4.3 Competing uses of water: Increasing demand for the various uses of water has intensified competition and conflicts between and among sectoral uses and drought is making this worse in some countries. The world wide water demand for domestic, industrial, livestock and irrigation by 1995 was 44% of the total available runoff (approx 9,000 Km^3 world wide). With increasing demand due to population growth, urbanization, agricultural expansion and industrial development, many countries will experience excessive scarcity of water in future, posing a great challenge to water management as a result of water degradation (UNEP, 1992). Moreover, the inadequate management of water resources (in terms of defining, allocating and enforcing water rights) is exacerbating water use conflicts. Upstream communities are building schemes at higher elevations to meet their own requirements and in most cases ignoring the requirements for downstream communities. Poorly coordinated development and building dams for hydropower generation is also impacting downstream uses such as flood recession agriculture, dry season water supply for live stock and water requirements for conservation purposes.

4.4 Catchment degradation: In some countries, population pressure has precipitated poor land use practices. Cultivation on steep slopes, clear cutting of forests for agriculture, fuelwood, building and construction material and overgrazing are practices that are depleting vegetative cover and exposing the top soil, altering surface runoff and infiltration rates, accelerating soil erosion and significantly affecting water resources.

4.5 Loss of biodiversity: Improperly planned and managed water development projects threaten the terrestrial and aquatic biodiversity. Increased agricultural activities are also becoming a threat to lake ecosystems which are undergoing eutrophication at an accelerated rate and fish kills due to reduced dissolved oxygen levels from organic loads are becoming common occurrence.

4.6 Uncoordinated water resources management: Water resources development and management in some countries or regions are generally fragmented. Inadequate coordination in developing a coherent water policy and institutional framework, resources development and protection, pollution control, and pricing has lead to inefficient utilization of water resources, weakened institutions and occasioned the deterioration of water resources and water environment. Duplication of responsibilities leads to a scenario where gaps and overlaps are not addressed while scarce resources are wasted.

4.7 Water pollution: Water pollution exacerbates water scarcity because it limits use or imposes a higher cost for treatment on downstream users. Pollution may arise from agricultural activities, untreated or partially treated waste water from municipal waste water treatment plants discharged into surface water courses, industrial effluent which injects significant organic loads, heavy metals and other toxic substances into receiving waters

4.8 International waters: The use or development of water resources that are shared by riparian countries have not only cross-sectoral, but also potential international implications and pose complex challenges.

4.9 Environmental issues: Land use changes and water diversions for agriculture, including poor agricultural water management practices have been major drivers of the degradation and loss of ecosystem (river and groundwater are depleted with consequent degradation of downstream aquatic ecosystems, including wetlands, estuaries and coastal ecosystem with devastating effect on fisheries; pollution from overuse of nutrients and agrochemical affecting aquatic ecosystem and human health; and loss of natural resource base affecting peoples livelihoods)

4.10 Water management and allocation: Water management today requires making difficult choices and learning to deal with tradeoffs such as: Water storage for agriculture – water storage for environment; Reallocation overallocation; Upstream – downstream (development upstream will affect downstream in a river basin, often without discussion); Equity – productivity; and this generation – the next ones (some choices made now can be a benefits or a cost, for future generations). In most cases, win-win situation will be hard to find. However, consultative process for reaching decisions can help ensure that the tradeoffs do not have inequitable effects. Informed multistakeholder negotiations are required to deal with the tradeoffs and innovative means to apply decisions.

Allocation of water resources should be a process involving all stakeholders e.g. direct stakeholders, experts from government, NGOs, private organizations and other affected parties often represented by environmental groups. The elements critical for negotiating tradeoffs to ensure a more balanced outcome are:- to foster social action and public debate (public debate based on shared information creates more trust, legitimacy and understanding of the reason for change, increasing the likelihood of implementation and creates opportunities to include poor stakeholders – those with the most to gain (or lose) among them the too-often unrecognized landless, fishers, pastoralists and those dependent on wetlands and forest ecosystem services); to develop better tools for assessing tradeoffs (such tools can help in deciding which ecosystem service are of most benefit to society; and To share knowledge and information equitably (more data needed to be generated, turned into reliable information and shared widely with stakeholders to empower them through better awareness and understanding (knowledge)), (Water for Food, Water for Life,):

These issues and challenges indicate increasing trends of water overconsumption, pollution and increased threats from floods and droughts. The International Conference on Water and Environment (ICWE, 1992) held in Dublin came up with recommendations for actions to be taken to reverse these trends. The recommended actions to be undertaken at local, national and international levels were based on the following four guiding principles (Fresh water is a finite & vulnerable resource, essential to sustain life, development and the environment; Water development & management should be based on a participatory approach, involving users, planners and policy makers at all levels; Women play a central part in the provision, management and safeguarding of water; and Water has an economic value in all its competing uses and should be recognized as an economic good)

5 Building Public Awareness towards Hydrological Services

From the foregoing discussions, it is evident that there is a need to build public awareness towards hydrological services. The aim of building public awareness towards hydrological services is to inform and educate the public (general public, policy and decision makers, users in economic sectors such as those in farming, fishing, transport, energy and tourism) on various issues regarding hydrology and water resources and particularly enhancing: - user awareness of the services available and how they can be accessed; user understanding of the information and services presented; and user faith so that they can act on the information received. This would result in behaviour or attitude change and strengthened links between the hydrologists and water managers and users so that individuals, communities and organizations can make effective use of the available hydrological information and services. This can be achieved through coordinated public education and outreach programmes.

Public education refers to products or services associated with learning about hydrology primarily within the formal education system, including education material, curriculum development and support for educators excluding that aimed at developing professional expertise in hydrology and water resources (hydrological personnel). On the other hand, outreach (provision of community services) refers to products and services about hydrology and water resources that involve short-term contact with members of the public and other users of hydrological services with intention of providing information, raising awareness and exciting interest(U.S. EPA, 2003, WMO/TD-134, 2007).

The necessary steps in developing public awareness towards hydrological services through public education and outreach programme are (WMO/TD-1354,2007):- Initiate the programme by defining the driving forces, goals, and objectives; Identify and analyze the target audience; Create the message; Choose the strategy; Package and distribute the message; Implement the programme; and Evaluate the programme

Driving forces: They are forces that are driving the need for public education and outreach programme and help in determining the scope of the programme and provide a clear focus for it as to n what is required to get it done. The issues and challenges in water resources discussed herein and the recommendations by the ICWE, Dublin are used in identifying the driving forces. Each driving force identified should centre around a specific issue. The driving forces identified are:- Alleviation of poverty and disease; Protection against natural disasters; Water conservation and reuse; Sustainable urban development; Agricultural production and rural water supply; Protection of aquatic ecosystems; Resolving waster conflicts; The enabling environment; The knowledge base; Capacity building; Sustainability of water resources management and development for the benefit of entire human society and future generation.

Goals: Goals are general statements that express the broad focus of your effort (what you hope to accomplish) and they create a setting of what you are proposing. They are also known as aims or mission statements. Goals should link back to the driving forces, be few in number and respond to a genuine need. In most cases, goals aim at bringing changes in behavior, attitude, knowledge or understanding. The ICWE (1992) has several recommended actions which would form part of the goals, such as Capacity building (in human resources development; information base& know-how; institutional & legal arrangements; public awareness); institutional and financial framework in support of water assessment; collection and archival of water-related information; assessment of the resource and dissemination of water information; create public awareness on impact of climate change and variability on freshwater resources and the hydrological cycle; increase awareness on the impact of a sea-level rise from climate change; water resources protection and conservation; water pollution prevention and control; protection of groundwater; protection of aquatic ecosystems and freshwater living resources; efficient and equitable allocation of water resources; protection against depletion and degradation of water resources; enhanced access to water, sanitation and waste disposal; minimized health impacts from urban water resource management; integrated rural water management for sustainable development.

To identify a genuine problem or unmet needs and demands, a need/demand or problem analysis is carried-out in order to understand the current situation (nature, extent and socioeconomic context of the problem), existing responses to the problem (policy, programme/projects), identify existing gaps and potential for improvement and who should be involved in the problem analysis (Partnership- government, NGOs, leaders, donor agencies, community representatives).

Objectives: The objectives indicate how the goals are to be realized. They should be specific, measurable, action-oriented, relevant and time-focused (SMART). Several objectives are developed for each goal to be achieved. However, it is better not to have too many objectives. The desired outcomes are considered when formulating the objectives. For example, is the desired outcome to create awareness, provide information or to encourage action among the target audience? Making SMART objectives will make it easier to identify specific tasks and will enable one to evaluate whether he/she has achieved the objective. For each of the above goals, specific objectives can be developed. After identifying the objectives the next step will to prioritize them by evaluating which of the objectives are most important to help meet your overall goal.

The target audience: The target audience is the group of people you want to reach with your message or whose behaviour or attitudes the public education and outreach programme is attempting to change. The target audience for each programme can be grouped into four common groupings based on:

1. Geographic location (e.g. region, district)
2. Demographic characteristics (e.g. gender, age, recreational activities, organizational affiliation, ownership of property)
3. Occupation (e.g. farmers, fishermen, students, educators)
4. Behaviour patterns (e.g. people who do not heed to warnings)

The various audiences that can be targeted are the primary and secondary schools students and educators, general public, media, hazards venerable communities (general public, media, emergency mangers, NGO, voluntary organizations), those in economic activities (farmers, fishermen, pastoralists, transport, energy supplier, etc) policy and decision makers, users of the hydrological services.

Create Message: The messages are designed to raise general awareness, educate, or motivate action. For it to be effective it must be understood by the target audience and appeal to the people on their own terms. Therefore, the message must be clear, specific, and tied directly to something the target audience values and also should articulate what actions they are supposed to take. The analysis of the overall goals and the supporting objectives will help determine the messages that will be effective. The message intended for behaviour or attitude change of the audience, could be developed such that:

- It affects emotions in order to provide motivation for change of behaviour or attitude
- It highlights individual benefits associated with taking the desired action and consequences of not acting
- It builds upon the existing behaviour

- It proposes actions which are relatively low cost in terms of time, energy, money and materials and avoid actions requiring a lot of steps or training.

Since public education programme is associated with learning within formal education system, the services and products developed would be used to create awareness among the primary and secondary schools students and educators. The driving force, for example, would be to create awareness about the 'Natural Water Environment'- the Global Water Cycle- including its components indicated in Fig. 1 above and the 'Global Water Zones'- Water Environments (Humid tropics & subtropics; Subhumid tropics, subtropics and monsoon areas; Semi-arid and subtropics; Arid tropics and subtropics; Mediterranean zone; Mid-latitude humid zone; Mid-latitude dry zone; Low-latitude zone; Mountains in tropics and subtropics; Mountains in mid-latitude zones) The curriculum developed would assist in learning about the science of hydrology and hydrological processes, thus helping to Create awareness and understanding of the science of hydrology and hydrological processes; and to Create awareness on what to be done to reduce effects of hydrological hazard such as floods and drought

The outreach programme, for example, would create awareness and understanding of a simplified view of an ecosystem, including the functions of some of its most important components (atmosphere, the land surface, the soil and soil parent materials all serving as stores of waster; land surface as regulator determining the direction of overland flow and the amount of surface water, infiltration, evaporation and ground water; plants, animals and people are users). The general public will come to understand and be aware of the various water uses, the aquatics (water) ecosystem perspective, hydrological hazards and the role they can play to ensure sustainability of water resource development. In case of policy and decision makers, they will be aware of usefulness of hydrological services in policy and decision making concerning water resources management, preparedness and mitigation of hydrological hazards such as floods, drought, wide related diseases, water pollution and proper maintenance of natural environment.

Choose the strategy: Strategy deals with the mode of reaching the target audience. The key strategies that can be employed in the outreach programme for building public awareness towards hydrological services are:

- Electronic and print media (radio, television, newspapers) to convey information such as warning, how to use certain services or products
- Conduct seminars, workshop, visits and training courses
- Organizing public events like having open days for public to visit national hydrological service
- Taking advantage of special events such World Water Day
- Holding meetings at community levels

In choosing the strategies to use, make sure that they are appropriate to your target audience and that it is clear what each strategy will achieve.

Package and distribute the message: This deals with the format for the message for eventual delivery to the target audience. The format used for packaging should be appropriate for the target audience. The factor that can influence the format of the message in terms of content, language and presentations are:

- Size, geographical distribution, age and educational background of the target audience
- Existing level of awareness of the audience
- How the target audience normally receives information and their preferred formats and learning
- How the target audience will access the information and frequency of access
- Availability of existing formats or materials that can be used directly or adapted.

It is recommended to use several formats which when combined have the effect of reinforcing the messages. Additionally consideration must be given concerning resources, work and timescales for preparation and distribution of the materials. Consideration of the following questions will help to get materials to the right people:

- How will the material be distributed?
- Should the material be distributed in hardcopy format, electronically or in both forms in order to reach the desired population?
- Are there other modes of distribution that might be more efficient?
- Are there partiners or existing distribution networks that can be used to help distribute materials?
- Can the message be distributed by attaching it to someone else's message?
- When is the best time to distribute the materials?
- Will the material get through to the remote areas and/or those that will benefit most from it?

Programme implementation: Development of action plan is necessary and contains information such as risks and mitigation, what needs to be done (problem/need), when it should be done (plan period/timeframe), who should do it (includes stakeholders/partners), where to do it (locale), why do it (objectives/goals/targets) and how to do it (strategies/procedures/methods). The plan will also contain a set of inputs (activities and the resources required- staff, financial, &others) and outputs (immediate results to be obtained from proper use of the inputs).

Programme evaluation: Evaluation of an outreach programme is necessary and should be incorporated in the plan from the beginning in order to help in assessing the programme success. It provides a feedback mechanism for ongoing improvement of your outreach effort. The types of evaluations that can be carried out are:

- Process evaluation: Focuses on implementation activities and allows for modification or adjustments to the implementation plan depending on findings
- Impact evaluation: Focuses on how far the original objectives have been realized.
- Participatory evaluation process: Focuses on the extend of involvement of the stakeholders

6 Recommendations

The approach in building public awareness towards hydrological services should include both public education and outreach progrmmes. As a start, it is recommended to have the following pilot projects:

1. ilot projects on the Public education be initiated, with “Creating awareness and understanding the ‘Natural Water Environment’- Hydrological Cycle” as the driving force and targeted mainly to formal education system (primary and secondary schools).
2. Pilot projects on the outreach programmes be initiated having “Poverty alleviation” as the driving force (or it could be any of the above listed driving forces), targeted to policy and decision makers and the community living in a region (watershed, district, etc)

The success of such pilot projects would then be duplicated in other areas or regions.

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Lessons from ICPAC's Regional Climate Outlook Forums (RCOFs) in Regional Networking and Consensus Building, and User Liaison for Targeted Climate service Delivery

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Abstract

IGAD Climate Prediction and Applications Centre (ICPAC), formally known as the regional Drought Monitoring Centre (DMC)-Nairobi has been organizing Climate Outlook Forums (COFs) at the beginning of every major rainfall season in the GHA, since 1998 in partnerships with ACMAD, SADC-DMC, WMO, IRI, NOAA, USAID, among many others . The Climate Outlook Forums to provide opportunity for the climate scientists from NMHSs , international and regional centers to develop a single best regional seasonal climate outlook products in order to avoid unnecessary competition and confusing users with products from the individual centers. A part from these climate scientists, the forums also include media experts, and experts from policy-makers, agriculture, food security, water resources, health, and the general user community. Gender and youth are also represented in the forums, together with some general public members who are known to be key focal points for the user of climate information. Local community involved in the use of Indigenous knowledge applications are also invited to such forums. The COFs are preceded with capacity building workshop of national climate scientists on new developments in seasonal climate prediction. Capacity buildings for users are also now integral components of the COFs. The workshop is normally opened by a senior government minister, and several speakers are also invited from various sectors to provide lead presentations on climate risks on the specific sectors.

The COF have made tremendous contribution to public climate services in the region. The interactions between climate scientists and various users have triggered several users specific pilot project to assess and communicate examples of successful use of seasonal climate prediction products, and the values of climate services to specific user sectors. There are however still enormous challenges to climate services in GHA due to lack of integrated policies for mainstreaming climate in all socio-economic development programmes. The capacity of both climate scientists and users is also still very weak. Further, users still find it very difficult to use the probability based products from climate scientists. Data is also very limited in the region for providing some special climate services that are required by some users. The recent recurrent of gigantic floods, droughts, frequent ENSO events, etc seem to be increasing regional interest and demands for climate services. The media in the region has played a commendable dissemination job over the last few years. They have even formed some formal partnerships with local and regional chapters to interact with climate community in enhancing provisions for climate services in the region.

Introduction

The Greater Horn of Africa (GHA) is prone to extreme weather and extreme climate events such as droughts, floods, wind storms, cyclone effects, thunder, lightning, and sandstorms, with devastating environmental and socio-economic impacts. IGAD Climate Prediction and Applications Centre (ICPAC), formally known as the regional Drought Monitoring Centre (DMC) was established in 1989 to address all climate risk challenges of the region for poverty reduction , environment management and sustainable development. One of the major activities of ICPAC since1998 has been organizing Climate Outlook Fora (COFs) at the beginning of every major rainfall season in the GHA. The main objective of such forums is provide the climate scientists from NMHSs , international and regional climate centres with opportunity to develop and release a single best regional seasonal climate outlook products for GHA. This would not only limit unnecessary competition from the climate centres but also provide a forum for standardization and verification of seasonal climate prediction products and services. Such forums also minimize the confusion of the users with products from the individual centers. They also provide direct interface between the users and producers of climate products to openly present their view on what they see as limitations and strengths of the other side.

Capacity Building

Closely associated with these forums are the capacity building training workshops for the climate scientists from ICPAC member countries NMHSs. The experts from University of Nairobi, Department of meteorology and regional IMTR provide key support to such training workshops. Through support from WMO, USAID, NOAA, IRI among others visiting lecturers from various institutions world wide are invited also contribute to the capacity building workshops. Such workshops also give opportunity to the national experts to down scale seasonal prediction products to national levels using similar tools and experts. They also merge national outlooks to come up with ICPAC Climate outlook that is presented to forum as one of the consensus products that are to be integrated with those from the other climate centers when consensus regional climate outlook is being developed. The pre-forum workshop climate scientists also undertake a technical verification of the products that were provided at the previous forum.

Users' capacity building workshops are also now undertaken few days before the forum to introduce the basic concepts and terminologies such as normal, above and below normal that are commonly used by the international/regional/national climate services. The forum also discusses how to effectively address the needs of the specific sectors, especially mitigation processes for the projected climate extremes. The users also take the opportunity to verify from their sector point of view the usefulness of the products that were released at the previous forum, and follow up update services from the NMHSs. The users also document some bad/good practices and lessons on how the last season COF products were used/ or not used. The national climate scientists attend all users capacity building workshops to enable close interactions and partnerships between national climate scientist and users from the specific countries, and to enable concrete follow up strategies to be agreed upon for forecast updates, and implementation of national mitigations strategies. The last session of the users' workshop is often devoted to the discussion of potential pilot project that can be taken jointly at regional or national levels.

Pilot Application Projects

Several pilot projects have been resulted from COFs and the related users specific workshops. The main purpose of these Pilot Applications Projects (PAPs) include among others to:

1) Assess and communicate examples of successful use and impediments of seasonal climate prediction products, clearly describing how the products influence decision-making, and the value of such products to specific sectoral users;
2) Develop new methodologies for better production, dissemination, interpretation, use, and evaluation of climate information and seasonal prediction products in the mitigation of extreme climate events such as floods, droughts, frost, tropical cyclones, etc;
3) Carry out research activities aimed at developing new applications tools that will enable decision-makers to take advantage of seasonal forecast information.

These Pilot Projects have led to some close collaboration with users and climate scientists. They have further enhanced the application climate services in dam and hydropower management for hydroelectric power generation; water management and floods/ drought risk management; Agriculture and food security applications; Health applications, especially efforts to contribute to malaria early warning health systems; conflict early warning by providing rainfall, water resources and forage outlooks that factored in regional conflict early warning indicators; Disaster risk reduction; etc

The Forum

A part from climate scientists from climate centres world wide, NMHSs, and African regional centres, the climate outlook forums (COFs) also include media experts, and experts from policy-makers, agriculture, food security, water resources, health, and the general user community. Gender and youth are also included in the forum, together with some general public members who are known to be key users of climate information. Local community involved in the use of Indigenous knowledge applications are also invited to the COFs. The theme for each COF is normally chosen from the major climate concern fro the region during the season of interest e.g. El Nino / La Nina, drought, floods, etc being key issue during the season. Guest speakers are also invited to introduce various sessions of the forum. The guest speakers are often senior policy makers in the government, lead activists, head on UN agencies, chief executives of private sectors, politicians, among others in order to give the forum visibility, and also to demonstrate the diversity of climate services and inter linkages with other sectors.

COFs are further used as forums for advocacy on the roles of climate in development, and disaster risk reduction. They are also used for education and awareness creation. The COFs are usually opened by a senior government minister in charge of the sector under which the theme of the forum falls. The media experts have also being incorporated as part of the organization and implementation teams of the COFs. The media in the region has played a commendable dissemination job over the last few years. They have even formed some formal partnerships with local and regional chapters to interact with climate community in enhancing provisions for climate services in the region. The climate experts and media experts under the auspices of ICPAC have formed partnership with the media fraternity within the region known as NECJHOGA). National NECJHOGA chapters have also been formed

Conclusion

The COFs have not only triggered close collaborations amongst NMHSs and users, but also donors, UN bodies, some vulnerable communities, integration of Indigenous knowledge among others. They have also enabled some governments to develop national projects on how to live with risks, impacts / vulnerability assessments, and factoring climate information on national disaster management and sustainable development plans. A number of countries have initiated efforts for the development of integrated disaster management policies. The COFs have also facilitated the transfer of emerging technologies in the science of climate prediction and applications that have made enormous contribution to the improvement of the quality of the seasonal rainfall outlook and its use in the region. The process has also enhanced interaction with the users from various sectors thus improving the dissemination of climate information and prediction products for early warning and disaster management. The media in the region has played pivotal roles in dissemination of climate services over the last few years. They have even formed some formal partnerships with local and regional chapters to interact with climate community in enhancing provisions for climate services in the region

There are however still enormous challenges due to lack of integrated policies for mainstreaming climate in all socio-economic development programmes. The COFs are also very expensive, although some innovative ways have now been introduced in recent years to reduce the forum costs. The capacity of the region is also still very weak. Users also still find it very difficult to use the probability based products from climate scientists. Data is also limited in the region for the development of some special products that are required by some users. The recent recurrent of some new the gigantic floods, droughts, more frequent ENSO events, etc seem to be increasing regional interest and demands of climate services. There awareness level regarding the socio-economic benefits of integrating climate information / scenarios in decision making processes on climate sensitive activities is still very low. Lastly, COFs have also influenced the establishment of powerful partnerships and collaboration amongst national, regional and global institutions for providing climate services. Thanks for the foresight of WMO/CLIPS programme, and the associated partners especially IRI.

Meeting the Decision-Support Needs of Customer's for Drought Monitoring and Early Warning: Lessons from the United States

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Abstract

Drought is a normal feature of the climate of virtually all regions of the United States. Since 1996, drought episodes have been particularly severe and have affected large portions of the country for 3-7 consecutive years. Rapid increases in population, particularly in the western and southeastern parts of the county, have exacerbated the economic, social, and environmental impacts associated with these events. As a result, more emphasis is being placed on drought preparedness and mitigation and the development of integrated drought monitoring and early warning systems to aid governments and other users in risk-based decision support. These initiatives take full advantage of customer input at every step of the development and implementation process. Specific reference is given to the U.S. Drought Monitor map product and the newly implemented and evolving National Integrated Drought Information System.

Introduction

Drought is an insidious natural hazard that results from a deficiency of precipitation from expected or "normal" such that when it is extended over a season or longer period of time, the amount of precipitation is insufficient to meet the demands of human activities and the environment (Wilhite and Buchanan-Smith, 2005). Drought is a temporary aberration, unlike aridity, which is a permanent feature of the climate. Seasonal aridity (i.e., a well-defined dry season) also needs to be distinguished from drought. These terms are often confused or used interchangeably. The differences need to be understood and properly incorporated in drought monitoring and early warning systems and preparedness plans.

Drought is a regional phenomenon and its characteristics will vary from one climate regime to another. Impacts are also regional in nature, reflecting exposure to the hazard and the vulnerability of society to extended periods of precipitation deficits. Impacts are a measure of vulnerability. Risk is a product of exposure to the hazard and societal vulnerability.

Drought by itself is not a disaster. Whether it becomes a disaster depends on its impact on local people, economies, and the environment and their ability to cope with and recover from it. Therefore, the key to understanding drought is to understand both its natural and social dimensions. The goal of drought risk management is to increase the coping capacity of society, leading to greater resilience and reduced need for government or donor interventions in the form of disaster assistance. Drought monitoring and early warning systems are the foundation of a national drought policy and preparedness plan. These systems, however, must be associated with an information delivery system that has been derived through extensive interactions with the customers or users of that information so that it is tailored to their specific needs and applications.

For the past decade the United States has been placing an ever-increasing emphasis on drought monitoring and early warning. This process has involved the integration of user's needs and feedback throughout the process of developing new products and decision-support tools. The result of these efforts is the recent emergence of the National Integrated Drought Information System (NIDIS). Although this system is still in its earliest stages of development, it is intended to promote a more proactive approach to drought management with the intent of reducing societal vulnerability through improved decisions based on timely and reliable data and information. The NIDIS concept has grown out of a dedicated effort of the National Drought Mitigation Center (NDMC) at the University of Nebraska-Lincoln and numerous federal agencies to increase awareness of drought conditions, potential impacts, and associated mitigation, preparedness, and policy issues.

Drought Mitigation Planning

As vulnerability to drought has increased globally, greater attention has been directed to reducing risks associated with its occurrence through the introduction of planning to improve operational capabilities (i.e., climate and water supply monitoring, building institutional capacity) and mitigation measures that are aimed at reducing drought impacts. This change in emphasis is long overdue. Mitigating the effects of drought requires the use of all components of the cycle of disaster management, i.e., emphasizing both the risk management and crisis management approach. Typically, when a natural hazard event and resultant disaster has occurred, governments and donors have followed with impact assessment, response, recovery, and reconstruction activities to return the region or locality to a pre-disaster state. Historically, little attention has been given to preparedness, mitigation, and prediction/early warning actions (i.e., risk management) that could reduce future impacts and lessen the need for government or donor intervention future. Because of this emphasis on crisis management, countries have generally moved from one disaster to another with little, if any, reduction in risk. In addition, in most drought-prone regions, another drought event is likely to occur before the region fully recovers from the previous event.

Past experience with drought management in most countries has been reactive or oriented toward managing the crisis (Wilhite et al., 2005). Individuals, government, and others consider drought to be a rare and random event. As a result, little, if any, planning is completed in preparation for the next event. Since drought is a normal part of climate, strategies for reducing its impacts and responding to emergencies should be well defined in advance. Almost without exception, the crisis management approach has been untimely and ineffective and drought relief measures are poorly targeted and do little to reduce vulnerability to the next drought. In fact, it has been demonstrated in many cases that drought relief actually increases vulnerability to future events by reducing the level of self-reliance and increasing dependence on external assistance. If governments and others provide assistance to those most affected by drought, what incentive is there for relief recipients to alter those resource management practices that make them vulnerable? In addition, those agricultural producers and natural resource managers that employ best management practices (BMPs) are usually not eligible for drought assistance programs. In reality, governments are not only promoting poor management through the provision of drought relief, but rewarding it.

Making the transition from crisis to drought risk management is difficult because governments and individuals typically address drought-related issues through a reactive approach and very little institutional capacity exists in most countries for altering this paradigm. Drought mitigation planning is directed at building the institutional capacity necessary to move away from this crisis management paradigm. This change is not expected to occur quickly—it is in fact a gradual process that requires changes in government policies and human behavior.

The Challenge of Drought Monitoring and Early Warning as a Component of Drought Preparedness Planning

A drought early warning system is designed to identify climate and water supply trends and thus to detect the emergence or probability of occurrence and the likely severity of drought. This information, if delivered to decision makers in a timely and appropriate format, can reduce impacts if mitigation actions and preparedness plans are in place. Understanding the underlying causes of vulnerability is also an essential component of drought management because the ultimate goal is to reduce risk for a particular location and for a particular group of people or economic sector.

There are numerous natural indicators of drought that should be monitored routinely to determine drought onset, end, and spatial characteristics. Severity must also be evaluated on frequent time steps. Although all types of droughts (i.e., meteorological, agricultural, and hydrological) originate from a deficiency of precipitation, it is insufficient to rely solely on this climate element to assess severity and resultant impacts because of factors identified previously. Effective drought early warning systems must integrate precipitation and other climatic parameters with water information such as stream flow, snow pack, ground water levels, reservoir and lake levels, and soil moisture into a comprehensive assessment of current and future drought and water supply conditions.

Monitoring drought presents some unique challenges because of the hazard's distinctive characteristics. Some of the most prominent challenges are:

- Meteorological and hydrological data networks are often inadequate in terms of the density of stations for all major climate and water supply parameters. Data quality is also a problem because of missing data or an inadequate length of record.
- Data sharing is inadequate between government agencies and research institutions, and the high cost of data limits its application in drought monitoring, preparedness, mitigation, and response.
- Information delivered through early warning systems is often untimely and too technical and detailed, limiting its use by decision makers.
- Forecasts are often unreliable at the seasonal timescale and lack specificity, reducing their usefulness for agriculture and other sectors.
- Drought indices are sometimes inadequate for detecting the early onset and end of drought. It is essential to use multiple drought indices, since each have their strengths and weaknesses. Numerous drought and water supply indicators, such as streamflow and ground water levels, should also be incorporated.
- Drought monitoring systems should be integrated, coupling multiple climate, water, and soil parameters and socioeconomic indicators to fully characterize drought magnitude, spatial extent, and potential impact.
- Standardized impact assessment methodologies, a critical part of a drought monitoring and early warning system, are largely unavailable, hindering impact estimates and the creation of regionally appropriate mitigation and response programs.
- Delivery systems for disseminating data and information to users in a timely manner are not well developed, limiting their usefulness for decision support.

Trends in drought monitoring and early warning: A U.S. case study

To more effectively monitor drought and provide early warning requires a comprehensive and integrated approach. Too often the collection of climatic and hydrologic data is fragmented between many agencies or ministries. These data are often not reported in a timely manner. Automating the data collection process can substantially improve the timeliness and reliability of drought monitoring and early warning systems. Automatic weather stations exist in many countries but often these stations are not networked. Thus, timely information is not available for assessments.

The analysis of climate and water data is most effective when it is coordinated under a single authority. This authority could be a single agency/ministry or an interagency authority. This authority would be responsible for analyzing data and producing useful end products or decision-support tools for delivery to end users. Stakeholders must be involved from the early stages of product development to ensure the information will serve their diverse needs in terms of timing and content. A delivery system should reflect the needs of this diverse clientele. The Internet is the most cost-effective way to deliver information, but it is inappropriate in many settings. A combination of Internet, extension, and print and electronic media delivery may be required in many instances.

Monitoring and early warning systems to date have typically been based on a single indicator or climatic index. Recent efforts to improve drought monitoring and early warning in the United States and other countries have provided new early warning and decision-support tools and methodologies in support of drought preparedness planning and policy development. The lessons learned can be helpful models for other countries to follow as they try to reduce the impacts of future droughts as part of a comprehensive drought preparedness plan and policy. An effective monitoring, early warning, and delivery system continuously tracks key drought and water supply indicators and climate-based indices and delivers this information to decision makers. This allows for the early detection of drought conditions and timely triggering of mitigation and emergency response measures, key ingredients of a drought preparedness plan.

Until recently, a comprehensive, integrated drought monitoring, early warning, and delivery system did not exist in the United States. Between 1996 and 2007, severe droughts have been widespread in their occurrence and have affected most of the country, reinforcing the need for a more integrated monitoring and early warning system. During this period, many regions have been affected over several consecutive years and on more than one occasion. Some regions of the country have experienced as many as 5 to 7 consecutive drought years. These drought events have highlighted the deficiencies of the nation's drought monitoring efforts and stressed the importance of developing a more coordinated approach that would make optimum use of the Internet for data sharing and analysis, communication, and product delivery. A partnership emerged in 1999 between the National Oceanic and Atmospheric Administration (NOAA), the U.S. Department of Agriculture (USDA), and the National Drought Mitigation Center (NDMC) at the University of Nebraska-Lincoln with the goal of improving the coordination and development of new drought monitoring tools. The U.S. Drought Monitor (USDM) became an operational product on August 18, 1999. The USDM is maintained on the website of the NDMC (http://drought.unl.edu/monitor/monitor.html). This website has evolved into a web-based portal for drought and water supply monitoring. Figure 1 shows the USDM for 20 November 2007. At the time of this writing, drought was affecting large portions of the Southwest and Western United States and most of the Southeast region. Most of the Southeast is in an exceptional drought with a probability of recurrence of 1 in 50 years.

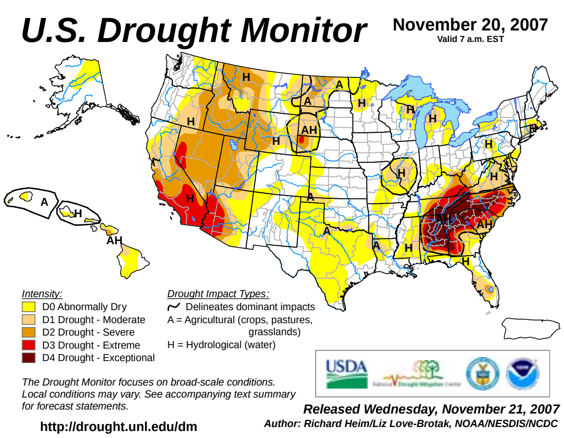

Figure1 U.S. Drought Monitor for November 20, 2007.

The USDM successfully integrates information from multiple parameters (i.e., climate indices and indicators) and sources to assess the severity and spatial extent of drought in the United States on a weekly basis. It is a blend of objective analysis and subjective interpretation. This map product has been widely accepted and is used by a diverse set of users to track drought conditions across the country. It is also used for policy decisions on eligibility for drought assistance. The USDM represents a weekly snapshot of current drought conditions. It is not intended to be a forecast. This assessment includes the 50 U.S. States, Pacific possessions, and Puerto Rico. The product consists of a color map, showing which parts of the United States are suffering from various degrees of drought, and accompanying text. The accompanying text describes the drought=s current impacts, future threats, and prospects for improvement. The USDM is by far the most user-friendly national drought monitoring product currently available in the United

States. Currently, the Internet is the primary distribution vehicle, although the map also appears in local and national newspapers and on television. A single weekly map illustrates the drought pattern in each year. All USDM maps since 1999 are archived on the website and available to users for comparison.

Because no single definition of drought is appropriate in all situations, agricultural and water planners and others must rely on a variety of data or indices that are expressed in map or graphic form. The authors of the USDM rely on several key indicators and indices, such as the Palmer Drought Severity Index, the Standardized Precipitation Index, stream flow, vegetation health, soil moisture, and impacts. Ancillary indicators (e.g., Keetch Byram Drought Index, reservoir levels, Surface Water Supply Index, river basin snow water equivalent, and pasture and range conditions) from different agencies are integrated to create the final map. Electronic distribution of early drafts of the map to field experts throughout the country provides excellent ground truth for the patterns and severity of drought illustrated on the map each week.

The USDM classifies droughts on a scale from one to four (D1-D4), with D4 reflecting an exceptional drought event (i.e., 1 in 50 year event). A fifth category, D0, indicates an abnormally dry area. The USDM map and narrative identify general drought areas, labeling droughts by intensity from least to most intense. D0 areas (abnormally dry) are either heading into drought or recovering from drought but still experiencing lingering impacts.

The USDM also shows which sectors are presently experiencing direct and indirect impacts, using the labels A (agricultureBcrops, livestock, range, or pasture) and W (water supplies). For example, an area shaded and labeled as D2 (A) is in general experiencing severe drought conditions that are affecting the agricultural sector more significantly than the water supply sector. The map authors are careful to not bring an area into or out of drought too quickly, recognizing the slow-onset characteristics of drought, the long recovery process, and the potential for lingering impacts.

The trend of drought monitoring and early warning around the world reinforces the perceived need for a more integrated approach, incorporating those climate and water supply indicators that are available and relevant to the assessment process. A recent publication by the World Meteorological Organization (2006) on drought monitoring and early warning highlights some of this progress in countries such as China, Australia, Portugal, India, South Africa, and Eastern Africa. Drought is a multi-faceted hazard and can only be captured if a variety of tools are used in the assessment of severity. This information must also be delivered to end users in a timely manner and in an understandable format to be effectively used in the decision making process and as part of a drought preparedness plan with the ultimate goal of creating a more drought resilient society.

The United States' National Integrated Drought Information System (NIDIS)

In 2004, the Western Governors' Association, an association of governors from 19 Western states in the United States and 3 U.S. flag Pacific islands, issued a report on the proposed development of a National Integrated Drought Information System (NIDIS). The vision for NIDIS is a dynamic and accessible drought information system that provides users with the ability to determine the potential impacts and the associated risks they bring, and the decision support tools needed to better prepare for and mitigate the effects of drought (Western Governors' Association, 2004). The goals of NIDIS are to:

(a) Develop the leadership and partnerships to ensure successful implementation of an integrated national drought monitoring and forecasting system;

(b) Foster, and support, a research environment that focuses on impact mitigation and improved predictive capabilities;

(c) Create a drought early warning system capable of providing accurate, timely and integrated information on drought conditions at the relevant spatial scale to facilitate proactive decisions aimed at minimizing the economic, social and ecosystem losses associated with drought;

(d) Provide interactive delivery systems, including an Internet portal, of easily comprehensive and standardized products (databases, forecasts, GIS-based products, maps, etc.); and

(e) Provide a framework for interacting with and educating those affected by drought on how and why droughts occur, and how they impact human and natural systems.

A NIDIS bill was passed by the U.S. Congress in late 2006. The implementing agency for NIDIS is the National Oceanic and Atmospheric Administration (NOAA). This process is moving forward and a new drought portal (drought.gov) was released in October 2007. The full implementation of NIDIS will take several years but the goal of this system is to support improved drought preparedness planning through the provision of better decision support tools. As the NIDIS program evolves and matures, the goal is to use this system as a model for other regions and nations in support of drought policy and preparedness models.

Summary

Drought is the most complex of all natural hazards. The lack of progress in drought preparedness planning and the development of national drought policies is a reflection of this complexity. As countries move towards a higher level of preparedness, drought monitoring and early warning systems become paramount because these systems provide the information necessary to make timely decision regarding the management of water and other natural resources. Just as critically important is the development of delivery systems that provide decision makers at all levels and for all primary sectors with data and information that will assist them in making timely decisions. These decision support tools provide end users with information they need to reduce the most serious consequences of drought and reduce the need for government and donor intervention in the form of drought assistance and relief. The goal is to create more drought resilient societies. With the demand for water increasing because of expanding population, urbanization, changes in land use, and many other factors, the time to move to a more risk-based drought management approach is now. Given projected increases in temperature and uncertainties regarding the amount, distribution, and intensity of precipitation, the frequency, severity, and duration of drought may increase in the future. Developing improved drought monitoring and early warning systems in support of drought preparedness planning and policy is an urgent need for all drought-prone counties. This can only be effectively accomplished through routine interactions with users/customers of this information. These customers must be an integral part of the development process for new tools and products. Customers must be engaged from concept development through implementation, with adequate channels for feedback following implementation. Only then will these tools be applied as part of a decision-support system that is directed at drought risk reduction.

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Climate and Environmental Services for Development

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Abstract

This paper discusses Climate and Environmental Services for development for Africa as a component of the ClimDev Programme. Despite the growing understanding of the climate and its potential impacts on society, climate information is still not routinely useful in decision making. A mechanism is needed that connects the relevant climate science to decisions that build resilience to climate change and variability. While we cannot be prescriptive about specific services for individual countries, there are factors that each of these services should have in common. In particular, informed decision making is based on a wide range of physical and social science information. Acquiring it requires cooperation between many institutions across many disciplines and across national boundaries. It depends on forging new partnerships between the traditional providers of environmental information and between the users and beneficiaries of this information. At present few, if any, countries provide comprehensive national climate and environmental services so there is no obvious single institutional model on which to base the development of these new services.
We consider the specific needs of development and propose a framework to enhance cooperation between all stakeholders. New organizational mechanisms are possible because of the African Union, the Economic Commission, and the Development Bank, which provide a strong framework to establish, nurture and grow pan Africa institutions.

Introduction

Climate science has made major advances in the past twenty years from seasonal prediction to understanding anthropogenic climate change. At the same time there is growing awareness of the adverse impact of climate on society, especially within developing economies. Climate change risk reduction is a priority for development. This requires adequate monitoring and dissemination programs at the national level to assess risks (Stern 2006), and the institutional capacity to develop the national capability to transform climate data, which will enable governments to include climate information in economic development programs.
Africa is particularly vulnerable to reduced agricultural production, worsening food security, greater exposure to climate-sensitive diseases, increased incidence of floods and droughts, and conflicts over scarce water resources (APF 2007). In other words, climate change is the major threat to growth and development in Africa. This has led to the ten-year programme "Climate Information for Development Needs: An Action Plan for Africa" (CLIMDEV), which was initiated by the Global Climate Observing System (GCOS) and is now being implemented by the Joint Secretariat of the African Union (AUC), the African Development Bank (AfDB) and the UN Economic Commission for Africa (UNECA) (GCOS 2006).

These first steps lay the foundation for more informed policy and economic decisions aimed at mitigating the adverse consequences of climate change on sustainable development and poverty reduction. There are four main components of the programme: raising policy awareness; undertaking climate risk management; providing climate services; and upgrading and enhancing observations, data management and infrastructure (GCOS 2006). Implementation of this programme will increase the use of climate information and enable societies to be better prepared for the projected impacts of climate change.

The purpose of this paper is to contribute to the debate on how societies can obtain relevant information needed to make informed decisions that reduce their vulnerability to adverse impacts of the climate and environment. We asked ourselves the following questions: What decisions are societies trying to make? What data are needed? How are these data obtained and how are they transformed into useful information? Who are the stakeholders and how do they cooperate, if at all, with each other? Are new institutions needed? For example should each country develop a National Climate and Environmental Service and, if so, would these services be based on existing institutions or would something completely new be needed?

The Decision Making Dilemma

We talk frequently about stakeholders and their needs, but who are they really and what is at stake? Put simply, all of us and nearly every facet of our lives[4]. Climate shapes the natural environment and thereby constrains human development. We are especially vulnerable to the availability of water and have difficulty coping with floods and droughts, which disrupt and displace millions of people each year with long term adverse consequences for economies and security. Reducing the vulnerability of a society to the environment in which they live is a key element of sustained development. Our inability to make climate information relevant often results in underestimates of risk and inadequate preparedness and response to natural environmental hazards, which lead inevitably to human disasters. While no society is immune, developing countries, which lack resilience are particularly vulnerable and can be setback decades if they are not prepared to cope with future environmental hazards (Van Aalst 2006).

Thus the question we must address is how do we make climate information more accessible and useful for all of us from the individual family member to a country's top decision makers? Criticism is often leveled at developers for poor construction planning in the wake of floods or farmers during periods of drought for failing to take into account climate information. In absence of a dedicated Climate Service where do these and other stakeholders go to obtain reliable climate forecasts?

There is a bewildering plethora of sources – multiple government agencies; university departments and institutions; private companies; national, regional and international organizations; some sector specific and others providing general climate and environmental information. The list is very long. The diversity of sources of data and information reflects both the growing need for climate information and the absence of a defined structure to support climate services in most countries.

Why National Climate Services are needed

Discussing the issue in the context of the United States, Miles et al. (2006) suggest that a National Climate Service should exist to promote science to support decision-relevant questions, to translate new climate information into relevant decision environments, and to build national and district level capacity to anticipate, plan for, and adapt to climate variability and change. In other words, we need climate forecasts and we need to be prepared for the projected impacts of climate variability and change.

The National Research Council identified the following five guiding principles for climate services (NRC 2001):

1. The activities and elements of a climate service should be user-centric.
2. If a climate service function is to improve and succeed, it should be supported by active research.
3. Advanced information (including predictions) on a variety of space and time scales, in the context of historical experience, is required to serve national needs.
4. The climate services knowledge base requires active stewardship.
5. Climate services require active and well-defined participation by government, business, and academe.

Specifically, according to Miles et al. (2006), a Climate Service would increase societal resilience to climate impacts by providing the following:

- Understanding of climate trends and variations as well as possible.
- Understanding of the impacts of climate on human and non-human systems
- Decision support tools based on that information, and
- Increasing society's capacity to act on that information.

It is difficult to argue against the need for increased societal resilience to climate, yet no country has developed a Service capable of delivering the tools needed (cf. Miles et al. 2006, NRC 2001, Changnon et al. 1990). Thus we cannot simply apply a successful template from one country to another. Rather, we will consider how to construct a Climate Service from the various institutions that contribute something to one or more of the elements of a Climate Services defined above.

[4] Stakeholders and users are used interchangeably and refer to all sectors of society that use weather, climate and related environmental information (e.g., agriculture, development, energy, health, industry, insurance, media, transport, and the general public)

Developing National Climate Services Within Africa

Climate Services should be national services because every part of a country is affected by climate variability and change. A National Climate Service exists to serve national needs related to enhancing economic development, managing risk, protecting life and livelihoods, and promoting environmental stewardship (NRC 2001).

From the scientific perspective, it is easiest to think of a climate service as an extension of a country's National Meteorological or National Hydrometeorological Service. However, a climate service is a much larger undertaking, which involves a broader partnership of producer and user organizations, scientists and social scientists. It requires: interlinked global, national and regional observing systems; comprehensive modelling and analytical capability to be able to downscale global and national information to address problems at regional and local scales; and a distributed decision-relevant research and application capability. It is the latter, in particular, that sets it apart from an exclusively science based service, such as weather forecasting. An effective National Climate Service is one that is focused on collaborative problem solving. This means a service, which is fully engaged with the user to produce mutually defined climate information that is most useful for individual applications. For development, in particular, there is a need for climate change risk assessments to be part of a government's economic planning. Therefore this component of a climate service would be integral to a ministry of finance and planning or even the office of the prime minister or president so that climate information can be used to manage to the risks to public sector investment (see, for example, Bettencourt et al. 2006). Institutionally, this component would be a National Center for Climate and Development, which would focus on policy decisions (Dinku 2007).

Table 1 NCS functions (after Miles et al. 2006)
1. Integrate global, national, and regional observations infrastructure to produce information and assessments of use to stakeholders
2. Develop models for decision support
3. Perform basic and applied research on climate dynamics and impacts relevant to stakeholders
4. Create and maintain an operational delivery system and facilitate the transition of new climate applications products to NCS member agencies and partners
5. Develop and maintain a dialogue among stakeholders, member agencies, and researchers relevant for planning and decision making
6. Identify climate related vulnerabilities and build the national capacity to increase resilience
7. Represent regional and national climate issues and concerns in regional, national and international policy arenas and facilitate communication on NCS needs and performance
8. Outreach to stakeholder groups

Each African country needs a National Climate Service, which identifies, produces, and delivers authoritative and timely information about climate variations and trends and their impacts on built and natural systems on regional, national and global space scales. This information informs and is informed by decision making, risk management, and resource management concerns for a wide variety of public and private users acting on regional, national and international scales (Miles et al. 2006) African nations need national climate services to build societal resilience. A National Climate Service is not only an information provider; it must stimulate social learning to increase the capacity of society to act on this information. The functions and services of a National Climate Service are summarized in Table 1 and 2.

The climate information component is quite well developed. Africa already has a number of institutions that provide climate information that need strengthening. These include multinational organizations such as the African Centre of Meteorological Application for Development (ACMAD), the AGRHYMET Regional Centre of the Permanent Interstate Committee for Drought Control in the Sahel (CILSS), the Southern African Development Community (SADC) Drought Monitoring Centre (DMC) and the Intergovernmental Authority on Development (IGAD) Climate Prediction and Applications Centre (ICPAC); and country specific National Meteorological or National Hydrological Services. Each of these is linked to an extensive, global network of climate information providers, such as the European Centre for Medium Range Weather Forecasts (ECMWF); the International Research Institute for Climate and Society (IRI); the National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) Climate Prediction Centre (CPC); and the Hadley Centre of the UK Met Office, amongst many others.

Less well developed are the applications. The impact of climate variability and climate change on the livelihood of a farmer, on the health of a village, on the availability of water resources and energy supplies for a country, requires environmental information at the appropriate scale. Often, this creates an observing capacity that is highly fragmented with different organizations and communities establishing independent networks for different applications. This fragmentation can lead to gaps in observations, which limit the ability of countries' to provide information on climate trends and adaptation strategies (IRI 2006). While different organizations should continue to provide data for their specific needs, a National Climate Service needs to provide an overarching structure that will significantly increase the utility of these data to manage climate change impacts.

Stakeholder/user interactions with information providers have developed in a largely unstructured manner, generally user-driven and limited to the specific requirements of a single entity. Some climate sensitive sectors have developed their own climate support services, for example, the International Federation of the Red Cross and Red Crescent Societies (IFRC) have made climate change part of their disaster preparedness and response and have established their own climate centre to help their staff and volunteers understand and address the risks of climate change (see, for example, the Red Cross/Red Crescent Climate Guide). The health community in Africa has built on the Climate Outlook Forum organized by the DMC in Africa to create the Malaria Outlook Forum, which uses both health and climate information to forecast potential malaria epidemics to better prepare the medical community (Patt et al. 2007). Agriculture and drought control communities have engaged directly with National Meteorological and National Hydrometeorological Services and helped establish regional centres (e.g., AGRHYMET and DMC). Universities in most countries have also developed specialized climate services, which provide decision-relevant research tailored to individual needs; see, for example, the Centre for Science and Technology Innovations (CSTI) at the University of Nairobi, Kenya. Where a national capacity is absent, government departments as well as individual economic sectors often address their problems to the international climate science community.

One particularly successful decision support application has been the use of climate information by the public health sector to help identify malaria epidemic risk through the cooperation of the health and climate communities (Da Silva et al. 2004). Journalists have also taken an active role in developing climate awareness; for example, the Network of Climate Journalists in the Greater Horn of Africa (NECJOGHA) plays an active role in educating journalists about climate issues and informing various climate-sensitive sectors of African society.The strength of a National Climate Service will be in its ability to connect climate scientists with stakeholders at the scales which the local, regional, national and international stakeholders operate.

Managing A National Climate Service

How should a National Climate Service be managed? Given the institutional arrangements for the delivery of specific environmental services will differ from country to country, we focus on defining the common requirements. While a single governmental institution should lead a National Climate Service, it is inherently a partnership of environmental and social science organizations. Depending on the capacity of a particular country, the leadership might reside in an Environment Agency, a National Meteorological Service, a National Hydrological Service, or similar body. Within the United States, for example, Miles et al. (2006) propose NOAA's Climate Program Office as the lead organization at the national level. Typical governmental partners would include Ministries of Agriculture, Health, Environment, Fisheries, Planning, and Finance. It will be important to draw on existing interests and capabilities across government and across all stakeholders in both the public and private sectors. Intra-governmental cooperation and coordination will require incentives and strong central government leadership with a dedicated budget for Climate Services. It is also important to recognize that many of the human resources needed to operate a National Climate Service will reside in university research departments and that they will continue to play a prominent role in delivering climate services to decision-makers. Integrating these capabilities into a National Climate Service will be a challenge in many countries.

The lead institution would be responsible for combining operational and research activities of multiple agencies into a coherent whole; securing funding for the work of the National Climate Service, negotiating, designing and implementing national observing systems and climate assessments in collaboration with international partners and institutions; and participating in bilateral and international negotiations, coordination and consultations on climate matters. A National Climate Service can and should draw on the wealth of climate and environmental knowledge and expertise that exists in other countries and international institutions.It is, however, at the regional and local level that services are actually delivered. It is here that interactions with most decision-making stakeholders occur. These stakeholders include the local, state, tribal and resource managers; elected officials; private sector resource managers; non-governmental organizations, research community; and the general public. A National Climate

Table 2 NCS services at the national and regional level (after Miles et al. 2006)

1. Serve as a clearing house and technical access point to stakeholders for regionally and nationally relevant information on climate, climate impacts, and adaptation; developing comprehensive databases of information relevant to specific regional and national stakeholder needs
2. Provide education and training on climate impacts, vulnerabilities, and application of climate information in decision making
3. Create decision support tools that facilitate the use of climate information in stakeholders' near-term operations and long-term planning
4. Provide user access to climate and climate impacts experts for technical assistance in use of climate information and to inform the climate forecast community of their information needs
5. Provide researcher, modeler, and observations experts access to users to help guide research, modeling and observation activities
6. Propose and evaluate adaptation strategies for climate variability and change

Service will be judged on its relevance and therefore must be completely engaged with its stakeholders. These must play an active role in the overall management of the enterprise, participating directly in institutional governance. The National Climate Service should be evaluated on criteria listed in Table 3.

Table 3 Evaluation Criteria for a National Climate Service
1. Ability to establish and sustain partnerships among and between agencies, researchers, operators and users and how well do those partnerships function at the national and district level..   2. Performance on the quality and relevance of regional research activities to stakeholders   3. Performance on the quality and relevance of decision support and decision support tools   4. Detailed and systematic investigations to document the impact of the Service on regional planning and decision making by user communities

Another important facet in the success of a National Climate Service is international cooperation. This is particularly important where cooperation and coordination can reduce the financial burden of service delivery to all participating countries. It is also important in the design, establishment and operation of a pan Africa climate observing network, which is the shared responsibility of many countries. Efficient and cost effective implementation and management of this system might best be served by a multinational organization of national climate institutions.

One example of a successful organizational model is EUMETNET, the network of European National Meteorological Services, which provides a framework to organise co-operative programmes between its Members in the various fields of basic meteorological activities such as observing systems, data processing, basic forecasting products, research and development, and training. Through EUMETNET Programmes, its Members are able to develop their collective capability to serve environment management and climate monitoring and to bring to all European users the best available quality of meteorological information. EUMETNET enables them to make more efficient management of their collective resources. Examples of EUMETNET projects include the Consolidated Observing System (EUCOS), which is designing and coordinating an optimized Europe-wide surface observing network; and the European Climate Support Network (ECSN), which aims, amongst other activities, to provide high quality climate data and products for all of the Members. EUMETNET has the authority and capacity to contract the management of the system to one of its Members via a competitive bidding process. In this way, efficiency is achieved while maintaining collective accountability.

A similar organizational model may also be appropriate for Africa. The backbone of this network could be composed of the National Climate Services and existing regional centers, aligned within the existing economic regions (SADC, ECOWAS, etc.) and under the auspices of the African Union. The network of African National Climate Services, which we might call AUCLIMNET, would be tasked to design the regional observing networks in cooperation with CLIMDEV.

Summary

National Climate Services are an essential instrument in helping to increase the resilience of countries to the adverse effects of climate. These services must encompass a wide range of environmental and social science disciplines to provide the necessary tools to make well-informed decisions. They must draw on the existing expertise from many organizations, while vesting in a single governmental body to coordinate and integrate the climate-related activities. Table 4 summarizes some of the first steps that most countries could undertake to create effective climate services. In the short term, it is particularly important to ensure that climate change risk is factored into public sector investment strategies. Therefore it is important to establish and strengthen the link between climate, development and public policy within the leading government ministries.CLIMDEV already provides the rationale for the development of climate and environmental services and climate networks. Together AUC, AfDB and UNECA can provide the impetus leading to the formation of National Climate Services. In turn, these would become a mechanism for the implementation of CLIMDEV.

Table 4 First Steps Towards the Creation of a National Climate Service (after NRC 2001)
Improve Capability to Serve National Needs   1. Increase the use of climate information by fostering cooperation and dialogue between government agencies, the private sector and academe.   2. Create user-centric functions within existing agencies to encourage dialogue with users and to adapt existing information to meet user needs. In particular, ensure that climate change risk information is properly integrated into finance and planning departments in developing countries.   3. Support new instrumentation and technology to improve the quality of climate information, especially relevant to the expansion of forecasting and prediction to air quality, hydrology and human health.   4. Empower providers and users to carry out experiments designed to promote and assess the use of climate information   5. Build capacity in long term prediction to provide capabilities in analyzing the limitations and uncertainties, and impacts of climate change.

Improve Use of a Nation's Weather, Climate and Environmental Observations

6. Inventory existing observing systems and data holdings in all national organizations.
7. Promote efficiency by seeking opportunities to combine observation networks to serve multiple purposes (e.g., weather, climate, water, agriculture, health networks).
8. Create incentives to develop and promote observing networks at the local level throughout a country.
9. Ensure that research accomplishments transition into climate products and services.

Address Societal Needs

10. Make better use of ensemble climate products from major prediction centres to improve impact studies, vulnerabilities and responses.
11. Where appropriate develop regional and local enterprises to expand the nature and scope of climate services to provide a geographical specific focus on societal needs.
12. Increase support for interdisciplinary climate studies at universities and other institutions to increase understanding of societal impacts.
13. Foster climate policy education in universities.
14. Enhance the understanding of climate through public education.

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Embedding Weather and Climate Services within an Agricultural Risk Management Framework

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Abstract

Increased preparedness to better manage risks arising from weather or climate related events will lead to better social, economic and environmental outcomes. Such increased preparedness can be aided by forecasts. However, weather and climate forecasting is not the panacea to manage all risks. Instead, it is one of many risk management tools that sometimes play an important role in decision-making. Tailoring the required weather/climate information to decision makers requires understanding when, where and how forecasting can be used most effectively. This is a complex and multi-dimensional issue that is best addressed via a participatory, cross-disciplinary approach bringing together institutions, disciplines and people as equal partners. To create climate knowledge, climate science can provide insights into climatic processes, agricultural systems science can translate these insights into management options and rural sociology can help to determine the options that are most feasible or desirable. Any scientific breakthroughs in weather or climate forecasting capabilities are much more likely to have an immediate and positive impact if they are conducted and delivered within such a framework. In addition to problem orientation and stakeholder engagement, a better understanding of temporal and spatial variability is required for sound decision making. This can only be achieved if the uncertainties associated with forecasts are also communicated. Given the large degree of unreducible uncertainty associated with the semi-chaotic bio-physical processes that drive weather and climate systems, only probabilistic approaches to forecast dissemination should be considered.

Motivation

Agriculture is arguably one of the most weather/climate sensitive sectors in our global economy. Many developing countries remain heavily dependent on agriculture for national income, while agriculture occupies a special place in the national psyche of many developed nations. Hence, any effort that helps to reduce the vulnerability to weather or climate related risks is likely to lead to considerable global benefits, both economic and social.

Climate risks are a consequence of unforeseen variability and hidden trends that often impact negatively on agricultural systems. Although floods, droughts, storms, heat waves and frosts have always been an integral part of human existence, our collective coping strategies have so far been limited by our ability to quantify the impacts arising from the complexity of systems responses to weather, climate, environment and management. The exposure to unquantified risks has led to the development of conservative management approaches that often fail to capitalise on the up-sides of variability and sometimes even fail to adequately buffer against severe down-sides.

While weather forecasts have always played an important, but not very well defined role in tactical, short-term decision making, seasonal climate forecasting (SCF[5]) has only recently developed into a serious scientific contribution to better agricultural risk management (Hammer et al., 2000; Sivakumar, 2000). Even more recently, SCF has begun to merge with information related to climate change. Hence agricultural practitioners are now more readily able to adapt to climate change by learning from climate variability (Frankenhauser et al., 1999; Meinke and Stone, 2005). As a consequence, recent research has focused on managing variability at frequencies of several months or lower, while managing the high-frequency component of the weather-climate continuum within agricultural systems has received proportionally less attention. Some notable exceptions are attempts to incorporate knowledge based on phenomena that are at the interface of weather and climate, such as the MJO, into farmers' decision making (Donald et al., 2006).

It is now time to fully integrate weather information into this risk management framework. In fact, Motha (2007a) calls for the formulation of an agricultural weather and climate policy in order to overcome an existing science-policy divide. This is echoed by Meinke et al. (2006) and Nelson et al. (2007), who refer to an existing policy relevance gap in climate science.

The following discussion is motivated by Motha's call for action. The information is provided in the hope that agro-meteorologists together with their key clients (the farming community and policy makers) will benefit from the insights gained by agro-climatologists and their engagement with the same user community.

[5] Note that the acronym 'SCF(s)' is used here for 'seasonal climate forecast(s)' as well as for 'seasonal climate forecasting'

Discussion

Many extreme events are a consequence of known climate phenomena. Some of these phenomena can be predicted, while many appear to be modulated by climate change in terms of frequency and/or intensity of these events. Much of the research effort in climate science is therefore directed towards improving model derived predictions.

There is some scientific evidence that the accuracy of both statistical methods as well as forecasts based on Global Circulation Models (GCMs) might increase with time. To make such scientific advances useful, they need to be merged with similar advances in our understanding of the dynamics of agricultural systems (Hammer, 2000; Motha, 2007b). SCF based on GCM output are seen as one way of reducing the sensitivity of rural industries and communities to climate risk, but adoption of these technologies has so far failed to live up to expectations.

Due to their design, statistical methods connect more readily with agricultural applications - they are still the most widely used approach to produce SCF products. This is in spite of the fact that GCMs, which account dynamically for many climate/environment interactions, have been under development for several decades. Power et al. (2007) identified 3 key impediments hindering their adoption, namely (a) low forecast skill, (b) a mismatch between the forecasts provided and user requirements, and (c) the difficulties arising from the complexity of the forecast. They point to two 'revolutions' currently underway: one is our enhanced ability to monitor the ocean system via the Argo float program, while the second is much improved data gathering of the global climate systems via satellites. The former will drastically improve parameterisations of GCMs, while the latter provides the much needed data for model evaluation. However, in spite of all these developments, statistical methods still have an important role to play in risk management. New, tailor-made forecasts based on the clever use of statistics continue to add value to decision making in highly variable climates (e.g. Donald et al., 2006; Maia et al., 2007).

Motha and Stefanski (as cited by Stone and Meinke, 2006) discuss how weather and climate services can distil valuable information from many diverse data sources. This process can add substantial value to services provided by agencies whose mandate it is to inform agricultural practitioners and policy makers about weather and climate related risks, such as the United States Government Joint Agricultural Weather Facility. These applications are grouped into tactical (short-term) and strategic (long-term) products, such as the 'Weekly Weather and Crop Bulletin' (tactical) or the 'U.S. Drought Monitor' (strategic). A more detailed discussion about matching climatic timescales with decision needs of various agricultural stakeholders is provided by Meinke and Stone (2005).

Stern and Easterling (1999) point out that climate and weather forecasts are often ill-suited for direct use in decision-making. Farmers need to make management decisions on a daily basis in the face of weather and climate variability. Often the greatest benefits are obtained by farmers who have the resources and knowledge to take advantage of a range of productivity-enhancing technologies (Stone and Meinke, 2006). However, farmers' information needs differ strongly depending on their location and their socio-economic circumstances. Risk management of a high input system (usually found in well-developed economies) is very different from the risk management that resource poor farmers in developing countries need to adopt. Often it is not a matter of optimizing production, which could in fact increase profits as well as risks, but more a matter of maximising input efficiencies. These two contrasting cases result in fundamentally different risk management frameworks that need to be recognised and understood by climate-related service providers. This requires good decision analyses. Patt and Gwata (2002) propose six factors that limit farmers' use of SCF: credibility, legitimacy, scale, procedures, choices and cognition. They also suggest several types of corrective actions that service providers might be able to take in order to overcome such obstacles. Clearly farmers are more interested in forecasts that relate directly to their actual decisions. For instance, timing and cessation of the wet season is often much more relevant than predicting the onset of the monsoon based on climatologically criteria (Lo et al., 2007). Recognising and redressing the most limiting factors via quantitative systems analysis is therefore an essential first step before SCF can be successfully applied. This might require a shift in thinking in order to move from a product focus, which is still dominant in many meteorologically based institutions, towards a process focus that is emerging among trans-disciplinary boundary spanning institutions (Hansen et al., 2002; Cash and Buizer, 2005; Stone and Meinke, 2006).

Adoption of the existing knowledge depends strongly on the variables that are forecasted and specifically on their accuracy, likely economic and natural resource benefits and how well they are communicated. Ash et al. (2007) point to the insufficient integration of forecast information with farmers' decision making as a key constraint in the widespread adoption of SCF. In particular, the probabilistic nature of the forecasts needs to be better communicated. To achieve better integration, effort is required to better target (a) regions with useful forecast skill, (b) farming systems or enterprises that are amenable to incorporation of SCF, and (c) specific farming decisions that have a low downside risk. The incorporation of SCF into farming decisions also needs to account for the adaptive capacity of farmers and rural communities by recognising the complexity of the system and the fact that climate is just one variable in a matrix of many, all of which are relevant for decision making under uncertainty and risk management.

Adoption of SCF is also hampered by the fact that SCF is a complex innovation that has a low level of compatibility with how farmers make decisions, mainly because attribution of advantages are difficult to make in any single year (Hayman et al., 2007). However, it is an innovation with the advantage of being low cost and applicable across the whole farm (economies of scale) and across a range of enterprises (economies of scope). Some SCF applications can have high educational value, allowing users to learn about their range of available and possible choices, chances and consequences. Hypothetical management decisions can be evaluated in silico (i.e. via dynamic computer models that can mimic farm management interventions) rather than via long and costly in vivo experimentation. This can help decision makers to improve their clarity of thinking by translating imperfect information based on SCF into practical risk management. Hence, future improvements of SCFs need to consider their dual role as (a) an innovation in farm management, and (b) a means to build capacity for better farm-level risk management (Hayman et al., 2007). It is therefore essential that improvements in SCF capabilities are purposefully designed and guided by a clear problem orientation. This process has to start with the enduser of a SCF product. This will then determine whether or not 'downscaling' of GCM output is appropriate or indeed necessary.

Hertzler (2007) argues that a new approach is needed to make better decisions under uncertainty. He proposes the use of real options analysis as a means to decide when to keep options open and when to foreclose options and create new ones. The real options approach combines common sense with mathematical rigour by quantifying the potential future value of uncertain forecasts and by outlining new ways that risks can be managed and externalised via risk sharing contracts (e.g. developing new insurance products such as index yield insurance). For such an approach to work, farmers and the financial sector need to collaborate in developing such novel financial tools. However, the broader adoptability of this approach in both developed and developing nations is yet to be explored.

Effective management also requires a supportive policy environment for the self-management of climate risks. In many cases, science provides policy with analyses of simple climate variables such as rainfall and temperature, which are largely beyond the influence of policy. This results in a relevance gap between climate science and the goals of, for instance, drought policy. Well-designed bioeconomic modelling system can be used to overcome the moral hazard and timing issues that have been used to justify reliance on simple biophysical measures of climate risk. Nelson et al. (2007) use such models in Australia to relate climate-induced income variability to the diversity of farm income sources, providing a practical measure of adaptive capacity that can be positively influenced by policy.

While science is geared towards providing detailed, quantitative solutions to precise questions, decision makers such as farmers and policy makers require holistic evaluations of multiple sources of risk. This leads to a science-policy divide that must be bridged (Motha, 2007a). Breaking down the science-decision making relevance gap highlights the importance of creating boundary spanning organisations (Cash and Buizer 2005) that nurture societally responsive (and therefore valuable) climate science. Nelson et al. (2007) drive this point home with a quote by the famous statistician John Tukey, who said: Far better an approximate answer to the right question, which is often vague, than the exact answer to the wrong question, which can always be made precise.

The notion of using SCF as a means to achieve better risk management is sound, but depends on redefining the concept of climate knowledge and who is likely to benefit from it. Integrating SCF to improve real life decision making – either on the farm or in policy – is challenging and requires integrative and participatory methods embedded within institutions capable of and interested in supporting this kind of science. Future research needs to focus on improving the skill and relevance of SCF to specific decision makers. Successful application of SCF requires approaches that are relevant and credible to decision makers, and delivery of SCF technologies in a manner that is legitimately focused on their interests (Cash and Buizer, 2005).

Essential to achieving relevance, credibility and legitimacy is matching the development of SCF technology with the needs of decision makers operating in diverse contexts across multiple temporal and spatial scales. Potential users of SCF in both developing and developed countries have diverse climate risk management needs. Part of the reason for slow uptake of SCF has been limited attention to contextually relevant communication of SCF to specific user groups. Participatory engagement to understand user needs and adoption constraints is crucial to realising the societal value of SCF.

The rhetoric and lexicon of climate scientists, agro-climatologists and agro-meteorologists needs to shift beyond forecasts of weather, climate variability and climate change to embrace a broader concept of 'climate knowledge'. This broader concept would empower both decision makers and scientists by defining the achievements of science against the participatory evolution of user relevant outcomes across diverse contexts and multiple scales. This requires approaches that integrate our knowledge of weather and climate risk with the vulnerability of natural and socioeconomic systems to create a new kind of climate knowledge much closer to the holistic management of multiple risks faced by decision makers.

However, no matter how good the science is, some inherent uncertainty will always remain. Scientists have an obligation to adequately communicate such uncertainty, so that people are empowered to making their own decisions: In an uncertain world, people have options. They have the opportunity, but not the obligation, to take action when presented with alternative scenarios based on climate knowledge. The adoption of climate knowledge takes place within a process of deciding which risks should be retained and managed adaptively, not managed at all, or shared through some form of risk sharing mechanism. Scientists who are developing forecasts and forecast products must not only be aware of this socio-economic context, they must also engage closely with the end-users of these products to design adoptable tools and/or methods.

So far, climate prediction science has, by default, driven the development of SCF and related applications and tools. Experience over the last decade indicates the need for a problem and user oriented approach to forecast application development that is characterised by participatory approaches without disciplinary dominance (Garbrecht et al., 2005). The same is true for weather-related information. Motha (2007a) points out that farming communities must cope with issues of climate variability and climate change. He continues by saying that the challenge for agricultural meteorologists is to develop a coordinated, national agricultural weather policy to assist agriculture as it deals with these issues. Agricultural weather policy must be formulated so that proactive long-term preparedness activities are strengthened to ensure agricultural sustainability and to preserve natural resources.

Motha (2007a) calls for a well-integrated, user-oriented weather and climate policy that will help to overcome some of the existing science – user relevance gaps. This will require ongoing adaptation of scientific practice and institutional arrangements. To obtain useful answers that help the farming sector to improve agricultural risk management, we need to ask the right questions, proactively engage with the user community and form the right partnerships.

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Development of User-Driven Climate Products and Services for Key Socio-Economic Sector Applications

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Abstract

Climate raises a number of challenges, e.g. adaptation to its change and variability, decision making integrating climate risks and uncertainty, etc. but also safety and well-being of people, sustainability of infrastructures. Most socio-economic activities are influenced by climate. Also extreme hydro-meteorological events account for 90% of all natural disasters. This paper intends to review ongoing World Meteorological Organization (WMO) and National Meteorological and Hydrological Services (NMHSs) contributions to the provision of appropriate climate services to users, responding to their needs.

Introduction

A distinction is often made between weather and climate considering associated timescales and forecast lead times:

i Weather is the current state of the climate system (atmosphere, ocean, land surface, surface water, cryosphere) in terms of such variables as temperature, pressure, precipitation, humidity, cloudiness, radiation, soil moisture, land cover, vegetation properties, etc.It is generally admitted that weather time-scales cover phenomena from real time to about 15 days, which is considered as the limit of day-to-day weather predictability. In that case, forecast is essentially an atmospheric initial value problem, since the time scale is too short for variations in the ocean significantly to affect the atmospheric circulation.

Weather services encompass a wide range of current weather observations, forecast, warning and emergency response, and information services to the general public, shipping and aviation, the defence, and other socio-economic users, with the first mission to protect life and property, and to enhance national economies.

ii Climate summarises the average, range and variability, statistics of weather elements and the accumulation of daily and seasonal weather events observed over a long period of time at a location or across an area.

Climate services cover:

- Delivery of climate data/products and applications using long time series of historical data (up to two centuries); climate monitoring
- Long Range Forecast: monthly, seasonal, inter-annual climate forecast (which are no longer depending only on prescribed initial ocean conditions)
- Climate predictions for lead times greater than 2 years and climate scenarios, which are projections in the future representing plausible pathways depending on different hypothesis of socio-economic evolution, more directed towards guiding policy.

Climate services deal mainly with:

- provision to users of historical data and metadata, climate summaries and diagnostics, statistics, drought monitoring, large scale atmospheric circulation patterns, graphical information, documentation and characterization of extreme events (e.g. their return periods, which are useful for design purposes), …
- monthly, seasonal, inter-annual long range forecast, which can be expressed as probabilities of averaged parameters (e.g. expected seasonal conditions), taking advantage that the oceanic circulation is the major source of predictability in the seasonal scale
- climate watches and early warning
- assessment of climate variability and change (long term trends)
- climate projections based on the Intergovernmental Panel on Climate Change (IPCC) Special Report on Emission Scenarios (SRES).
- climate impact on a given socio-economic sector
- assessment of vulnerability to climate, its impacts, variability and change, for adaptation to and mitigation of climate change purposes.

There is an old saying that expresses the thought that "climate is what you expect, weather is what you get". Both weather and climate applications and services are important contributors to aid decision and policy making.

Under the "Climate" general heading, the Conference on "Living With Climate Variability and Change (LWCVC)" held in Espoo in July 2006 recognized that there are several different planning horizons relating to climate variability and change, which can be conveniently drawn as follows:

- the *intermediate horizon*, extending out from about one month to a few years (the domain of seasonal to inter-annual climate prediction) for which the focus is on the maintenance of a community's quality of life; climate change is likely to be inconsequential in this period but climate variability is usually very important;
- the *long horizon*, relevant for business and government and extending over periods of 5 to 15-20 years, with concern being on the way a society goes about its business and improving its quality of life; both climate variability and climate change are critical to this planning process;
- the *"sunk-capital" horizon*, including investments in infrastructure planned with life times of 50 years or more, with concern for planning that is critical for long-term social stability; projections of both future climate variability and climate change are pertinent on this time horizon; and
- the *centennial horizon*, with concern for the consequences of significant perturbations to the life support systems of the planet caused, for example, by anthropologically-forced climate change. To date the IPCC has focused mostly on this horizon because, as several scientists have put it, "this is the time scale over which climate change becomes readily distinguishable in the models". There is an increasing recognition of the need to develop a probabilistic framework for presenting multiple scenarios and their components.

Climate Research

Adaptation to climate variability and change requires climate predictions with lead times consistent with these horizons, and an understanding of the role of climate in various human activities. This is actually mainly the role of Climate Research, conducted under the World Climate Research Programme (WCRP) within the World Climate Program (WCP), and other programmes such the International Geosphere-Biosphere Programme (IGBP), the Global Energy and Water Experiment (GEWEX), etc.

Results from WCRP and WCP are providing essential contributions to the IPCC Assessment Reports (especially AR4), e.g. the collection and processing of historical climate data allowing to estimate the variability and long term trends of Essential Climate Variables; the computation of climate indices (joint CCl/CLIVAR/JCOMM activity); the development of climate models (some seasonal to inter-annual prediction models are already run in semi-operational mode) ; coordinated climate projections based on SRES scenarios (see CMIP3 Multi-Model Dataset Archive at http://wwwpcmdi.llnl.gov/ipcc/about_ipcc.php); the estimation of the uncertainties; the detection and attribution of climate change; the downscaling of large scale model outputs; and more generally the understanding of the climate system and of the interactions between its components.

With respect to applications and climate information, WCRP, WCP, IGBP, ESSP share interest in understanding the needs and the decision processes, cf sectors such as Health, Energy, Tourism, and Urban environment, etc. in collaboration with WMO technical commissions CHy, CAgM, CCl.

Overview of the WMO Commission for Climatology (CCl) Structure and Activities Related to Climate Products and Services

The vision of the WMO Commission for Climatology (CCl) is "to stimulate, understand, lead and coordinate international technical activity to obtain and apply climate information and knowledge in support of sustainable socio-economic development and environmental protection".

The Commission for Climatology advises and guides the activities of the World Climate Programme (WCP), through the World Climate Applications and Services Programme (WCASP), and the World Climate Data and Monitoring Programme (WCDMP) while providing support to many activities under the framework of the Climate Agenda. Associated websites are listed in the references.

The World Climate Applications and Services Programme (WCASP) fosters the effective application of climate knowledge and information for the benefit of society and the provision of climate services, i.e. climate information and products, including the prediction of significant climate variations both natural and as a result of human activity.

The Climate Information and Prediction Services (CLIPS) project under WCASP deals with the implementation of climate services around the globe. It exists to take advantage of current data bases, increasing climate knowledge and improving prediction capabilities to limit the negative impacts of climate variability and to enhance planning activities based on the developing capacity of climate science.

The World Climate Data and Monitoring Programme (WCDMP) is a program of the World Climate Programme that facilitates the effective collection and management of climate data, quality control and homogeneity tests, the rescue of non digitised historical records, the monitoring of the global climate system, including the detection and assessment of climate variability and changes. All these topics are covered by CCl OPAG1 and 2.

Focus on applications and services is reflected in the CCl structure. The Commission for Climatology, at its thirteenth session, CCl-XIII (21-30 November 2001, Geneva, Switzerland), established an Open Program

Area Group (OPAG) on Climate Applications, Information and Prediction Services. CCl-XIV (3-10 November 2005, Beijing, China) decided to split the work into two streams, creating OPAG 3 on Climate Information and Prediction Services (CLIPS), and OPAG 4 on Climate Applications and Services.
The CCl OPAG Terms of References (ToRs), membership, 2005-2009 workplans and documents produced are available at the CCl website http://www.wmo.int/pages/prog/wcp/ccl/index_en.html

CCl OPAG3, Climate Services and CLIPS Project

CCl OPAG 3 Terms of Reference read as follows:

a) To maintain an active and responsive overview of all activities related to climate information and prediction services (the CLIPS project), including research needs; operations, verification and application services; El Niño and La Niña, climate and water, climate and agriculture, and cross-cutting activities including capacity-building, training, natural hazards, etc.;
b) To ensure that the subsidiary bodies of the OPAG are well informed of global and regional activities within the OPAG's areas of responsibility;
c) To monitor the roles, activities and priorities of Expert Teams and Rapporteurs established by the Commission under the responsibility of the OPAG, to ensure coordination of work between the Teams and to advise on changes;

OPAG 3 is comprised of three Expert Teams (ETs) and two Rapporteurs:

3.1 Expert Team on Research Needs for Intra-seasonal, Seasonal and Inter-annual Prediction, including the Application of these Predictions
3.2 Expert Team on CLIPS Operations, Verification and Application Services
3.3 Expert Team on El Niño and La Niña
3.4 Rapporteur on Climate and Water (to liase with Commission for Hydrology (CHy)
3.5 Rapporteur on Climate and Agrometeorology (to liase with Commission for Agrometeorology (CAgM)

CLIPS is an end-to-end concept, linking research, data analysis, products including climate predictions, and services, through to end users in key socio-economic sectors such as renewable energy, health, tourism, agriculture, water resources and urban management.

The Twelfth World Meteorological Congress (Cg-XII) in June 1995 recognized that important advances had been occurring in climate science and services and recommended the establishment of the Climate Information and Prediction Services (CLIPS) project and included it in the WMO Fourth Long-term Plan for 1996-2005 (see relevant paragraphs 3.2.2.7 to 3.2.2.10 in Cg-XII Report).

The Fourteenth World Meteorological Congress (Cg-XIV, May 2003) continued its support to CLIPS project, and highlighted the need to pursue and spread its activities.

The Fifteenth Session of World Meteorological Congress (Cg-XV, May 2007) adopted Resolution 3.2.5/1 (Cg-XV) — World Climate Applications and Services Programme, including the CLIPS Project, which further consolidates CLIPS and applications and services within the WCASP (see http://www.wmo.int/pages/prog/wcp/wcasp/wcasp_home_en.html).

Cg-XV acknowledged the accomplishments and contributions of CLIPS to the development of climate services around the world and also recognized the outcomes of the Conference on Living With Climate Variability and Change (LWCVC) held in Espoo, Finland (July 2006), and endorsed the Espoo Statement. Cg-XV urged the Secretary-General:

- to work with CCl to revisit the goals and objectives of CLIPS in regard to providing climate services that contribute to real-world decision-making within multidisciplinary contexts;
- to present a draft Implementation Plan for the future evolution of CLIPS activities to the fifteenth session of the CCl (CCl-XV, 2009), for its review and appropriate recommendations to the Sixteenth Session of Congress (Cg-XVI, 2011).
- within the implementation plan to propose options for a cross-cutting guidance mechanism for CLIPS, to include the WCRP, ETR, DPM, LDCs and other relevant programmes.

Over the past 12 years, the main activities underpinning the CLIPS project implementation include:

1. Promotion of operational climate prediction services, particularly on seasonal to inter-annual scales;
2. Providing an active interface between the research and operational communities;
3. Promotion of consensus-based climate outlook product generation, both at the regional and global level, through its support to the Regional Climate Outlook Forum (RCOF) process, and WMO El Niño/La Niña Updates;
4. Development of a worldwide inventory of ENSO impacts
5. Definition of functionalities of Regional Climate Centres (RCCs), and their designation and implementation
6. Establishment of a global network of CLIPS Focal Points and its coordination through Regional CLIPS Rapporteurs. Responsibilities

of individual Focal Points will vary according to national or regional requirements and may include:

- Acting as CLIPS Project Office contact points
- Acting as national sources of information on CLIPS-related activities
- Providing assistance in national training
- Advising on national requirements for data access and distribution, training and projects
- Advising on national requirements for forecasts
- Acting as national focal points for forecast interpretation
- Providing an interface to users and user groups
- Coordinating research activities
- Arranging training for users
- Distributing training and other materials
- Feeding material to CLIPS and national web pages
- Reporting on national climate, prediction and applications research results
- Reporting on climate applications and benefits achieved through their use
- Advising on the development of the CLIPS Curriculum, a resource for training of meteorologists and end users

- Integration of CLIPS activities into the regional Working Groups on Climate Related Matters (WGCRMs);
- Promotion of climate applications through showcase projects and user liaison activities (e.g., Espoo Conference; update of WMO TN No. 145 on Guide on best practices in user liaison, taking into account the LWCVC outcomes; contributions to national and regional workshops on "Socio-Economic benefits of weather, climate and water services", leading up to the WMO Madrid conference on Secure and Sustainable Living: Social and Economic Benefits of Weather, Climate and Water Services (March 2007) and its Action Plan; etc.);
- Development of CLIPS Curriculum and web-based information;
- Cross-cutting activities with other WMO technical programmes, especially WCRP, WCDMP, PWS, DRR, AgMP, HWR, ETR and WWW, Technical Commissions CBS, CAgM and CHy as well as other global systems such as GCOS and GEO;
- Closer integration of climate applications activities and CLIPS, including partnerships with UN bodies and international organizations such as WHO, UNWTO, IRI, etc.
- Capacity building of NMHSs in providing climate services through a worldwide programme of CLIPS Training Workshops for Focal Points; l OPAG4 and Applications CCl OPAG 4 Terms of Reference aim:

a) To maintain an active and responsive overview of all activities related to climate applications (WCASP), (including applications of climatology to human health, energy, tourism and urban and building climatology);
b) To ensure that the subsidiary bodies of the OPAG are well informed of global and regional activities within the OPAG's areas of responsibility;
c) To monitor the roles, activities and priorities of Expert Teams and Rapporteurs established by the Commission under the responsibility of the OPAG, to ensure coordination of work between the Teams and to advise on changes;

OPAG 4 is comprised of four Expert Teams (ETs) that focus on climate applications to important socio-economic sectors:

4.1 Expert Team on Climate and Health
4.2 Expert Team on Climate and Energy
4.3 Expert Team on Climate and Tourism
4.4 Expert Team on Urban and Building Climatology

Other technical commissions are also contributing to such activities, especially:

1) CHy in the framework of the WCP-Water programme, as far as the impacts of climate variability and change on water resources are considered;
2) CAgM in the framework of the WMO's Agricultural Meteorology Programme, which assist the agricultural community with the provision of tailored products to help to develop a sustainable agriculture, optimise agricultural practices, improve production and reduce losses.

The ETs proactively interact with users sectors, especially with:

- The World Health Organization (WHO) and the International Society of Biometeorology (ISB) for Heat-Health Warning Systems (HHWS), and applications of climate information in several diseases control
- the World Tourism Organization (WTO) for the sensitivity of tourism activities to climate variability and change
- the International Association for Urban Climate (IAUC) for urban and building climatology issues.

Principal SMART (**S**pecific, **M**easurable, **A**chievable, **R**ealistic and **T**ime-bound) goals of each OPAG4 ET are given in the table below, which are reflecting the main general objectives of WMO Technical Commissions, more specifically here:

- to provide reference guidance documents related to climate issues such as the Guide to Climatological Practices
- to implement operationally agreed upon standardized methods, techniques, procedures, algorithms, formats, services.

Deliverable	Due Date
(b) HEALTH	
Develop WMO/WHO Guidance on Heat Waves and Health	Full draft by May 2007
Foster pilot projects based on Guidance document	
Develop Guidelines on Universal Thermal Climate Index (UTCI)	by May 2009
Develop and maintain an online virtual document library and bibliography on health/climate issues , including: - seasonal prediction for infectious diseases and other health outcomes - uncertainties associated with climate change health impact assessmentsattribution of observed health trends to observed climate change	by April 2009
Develop list of producers of seasonal predictions	by May 2007
Review and assess the utility for health applications of seasonal prediction products developed by various NMHSs, centres and agencies	by December 2007
Develop a survey paper on seasonal prediction for infectious diseases and other health outcomes	by June 2008
Provide to ET 3.3 information on ENSO-related health impacts for their atlas project on ENSO impacts	by April 2007
Develop joint WMO/WHO fact sheets on climate change and health (update WHO original), climate variability and extremes and health	by April 2009
Develop a fact sheet on climate and fire health impacts, in relation to natural fires related to seasonal dry spells	by April 2009
(c) URBAN and BUILDING	
Update TN 149 on Urban Climatology and its relevance to Urban Design	Full draft Dec 2006
Update TN 150 on the Application of Building Climatology to the problem of Housing and Building for Human Settlements	Full draft Dec 2006
Online urban climate bibliography	Summer 2006
Urban Model Intercomparison	Summer 2006
International Conference on Urban Climate (ICUC6)	June 2006
International Conference on Urban Climate (ICUC7)	Mid summer 2009
Development of curricular and training materials	Start July 2007
ENERGY	
Update TN 172 and TN 175 on "Meteorological Aspects of the Utilization of Solar Radiation as an Energy Source" and "Meteorological Aspects of the Utilization of Wind as an Energy Source", respectively, into a single document "Meteorological Aspects of Utilization of Renewable Energy Resources"	To be determined (TBD)
Prepare a report on case studies that demonstrate the benefits of, and problems related to, the use of climate information and predictions in support of energy operations, taking special account of end-user liaison	TBD
Prepare a status report on climate data needs for supporting wind and solar energy development, on the adequacy of WMO-specified instruments and observing practices to supply these, and on opportunities to use modelling, data interpolation methods and satellite observations to overcome problems in providing site-specific information	TBD
Develop, in partnership with NMHS climate services programmes, the WMO RAs and CLIPS Focal Points, tailored climate products for application to the energy sector, including special attention to services at high latitudes	TBD
TOURISM	
Assessment of Climate and Tourism Research and Practice	TBD
Capacity Building Workshops (If Necessary Additional Funding Can be Obtained) The ET will explore opportunities to host or participate in capacity building workshops of three types: • consultative meetings to obtain stakeholder (scientists and tourism professionals) input into the assessment outlined in the assessment; • dissemination of information on climate change vulnerabilities; dissemination of the results of the	

assessment	
Tourist Education and Outreach Products (with WTO)	TBD

Note also other Climate-Health related activities outside CCl (mainly under WCRP):

i. Health and meteorological experts agreed to form the Health and Climate Partnership for Africa to enhance the use of meteorological information to mitigate health impacts.
ii. The health community leads the Partnership (World Health Organization Multi-disease Surveillance Centre, based in Ouagadougou, Burkina Faso) with support from the African Centre of Meteorological Applications for Development (ACMAD), AGRHYMET Regional Centre meteorological services, research organizations and non-governmental organizations.
iii. Malaria, Meningitis and other climate sensitive diseases (Cholera) (emphasis on detection and prevention with research focused on a better understanding of the relationship between near real-time observed environmental parameters and health outcomes)
iv. Representative observations of several key basic meteorological parameters
v. Linking research and development activities and specific health applications
vi. Downscaling seasonal forecasts to a geographical region relevant to health outcomes (used in MALOF: MALaria Outlook Forum).

User-driven aspects

Climate products and services derived from climate data and predictions should include the appropriate content, based on an understanding of the targeted users' needs, to ensure that this information will be more readily applicable to their planning, risk management strategies, processes, and decision making.

Recognizing this fact, WMO's World Climate Programme (WCP) has systematically addressed a number of issues related to climate applications and services over the past years, with the ultimate objective of enhancing the capacities of the NMHSs in providing user-driven climate services that may indeed be applicable to the national and regional interests.

For that purpose, CCl is addressing training and capacity-building through WCASP and CLIPS. This is especially useful for those NMHSs who don’t have any climate program, as climatology is a specialized domain on its own, with specific approaches in terms of understanding the climate system, of data processing, and tools.

As underlined during the Espoo conference on “Living With Climate Variability and Change” (2006) and Madrid conference on “Socio-Economic benefits of weather, climate and water services” (2007), systems that successfully link knowledge with action tend more and more to be multi-disciplinary, including all kind of knowledge producers on one side (e.g., meteorologists, climate scientists, civil engineers, economists, medical doctors, …), and knowledge users (decision makers, such as politicians, energy providers, road and airport managers, farmers, consumers, …) on the other side.

Although in most modern NMHSs the automatic climate production (e.g. climate normals, wind roses, other statistical information, climate summaries at different time/space scales, climate outlooks, etc.) covers a wide range of needs, this “user-driven” aspect, i.e. what is it that we are trying to do with respect to the two-way dialogue with users at various levels, is considered in most climate applications and services, in order to better satisfy users’ needs, with tailored products first when appropriate, and then with such products becoming integrated in operational suites. One reason for that is probably that, in contrast to weather services, climate services need probably much more interaction with users because there are so many ways to produce climate services that all cannot be covered in advance.

Basic best practices in Climatology are described in the Guide to Climatological Practices, whose 3rd edition should be available in 2008.

Prof Ogallo will be talking in his presentation about what is done within the RCOF process, but it might bear repeating that that mechanism is an excellent way to build and sustain the relationships between providers and users. In that specific case, the expected benefit of long range forecast for the users depends as much on the quality of the forecast from a climatological point of view, as on the users cost functions, their decision-making procedures (e.g. to shift to another type of seed), and their constraints.

Examples of need for multi-disciplinary approaches can be found for most of the socio-economic sectors, especially those considered by CCl (health, tourism, energy, urban), simply because not any single potential player has the necessary knowledge allowing to cover all relevant aspects.

The two-way dialogue can be engaged through different means:

- quality management approaches for NMHSs activities, where the overall strategy is driven by user/customer needs, including assurance that customer expectations are satisfied, and that remedial action is taken on under-performing processes; continual performance monitoring and improvement; audits by external and independent experts, customer satisfaction surveys;…

- Promotion of climate applications through user liaison activities, e.g. Espoo and Madrid conferences, involving stakeholders, and all kind of users including decision makers (see especially the Sector Keynote Abstracts and
- Working Groups Reports in the final report of Espoo conference where the key needs of the socio-economic sectors from the scientific/technical sector are expressed)
- multi-disciplinary meetings such as UNFCCC (see e.g. WMO and NMHSs contribution to the UNFCCC Nairobi work programme on impacts, vulnerability and adaptation to climate change), RCOFs, CCl technical conferences, etc…
- showcases
- establishment of networks of focal points in charge of collecting feedback information from the user community (e.g. CLIPS)
- surveys
- permanent technical commissions at national level involving NMHSs, users from public/institutional and private sectors; e.g. the French "Conseil Supérieur de la Météorologie" (Higher Council of Meteorology) and its 11 commissions, representing a major tool for listening to customer (http://www.meteofrance.com/FR/qui_sommes_nous/CSM/index.jsp)
- capacity building (e.g. communicate to end users how to best use climate information, or the concepts of uncertainty and confidence intervals)
- provision of additional information that can be easily used as an aid to decision making (e.g. how to behave in case of expected extreme weather and related impacts; what to do in case of an heat wave being forecasted; how to deal with a probabilistic forecast, with uncertainty; …)
- develop guidance on best practices in different sectors, illustrated by case studies and "success stories". This is the subject of the recently updated WMO TN No. 145 on Socio-Economic benefits of Climate Services, covering most of socio-economic activities in terms of users needs (22 papers).

Conclusion

Climate covers a wide range of scales, and has a tremendous number of applications.

NMHSs, WCP and CCl are trying to do their best for covering most economic sectors and listening to them, in order to satisfy their needs for tailored products, allowing them to meet their objectives, in terms of day to day operations, socio-economic benefits, risk management, and decision making.

The two key components of the services side of the WCP and CCl (CLIPS and sectoral Applications) have been reviewed here.

References

Presentations at the Conference on "Secure and Sustainable Living: Social and Economic Benefits of Weather, Climate and Water Services", Madrid, Spain (March 2007): available at ftp://ftp.wmo.int/Documents/Madrid07/Presentations/

Madrid Action Plan: available at http://www.wmo.int/pages/madrid07/

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ECONOMIC VALUATION AND APPLICATION OF SERVICES

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Abstract

The application of economic valuation to hydrometeorological services has gained prominence as national meteorological and hydrological services (NMHS) focus more on providing gains to society. In addition, NMHS programs are increasingly called on to justify their budgets. In this paper we briefly discuss several issues related to the economic valuation and application of hydrometeorological services. We first make a distinction between "the economy" and "economics" to encourage a clear understanding of what valid and reliable economic research and application can do to support NMHS efforts. Next, we cover some issues related to data validity, which leads into a discussion of appropriate methods for economic assessment, particularly benefit-cost analysis. Then we describe a soon-to-be-released resource—a primer on economics for NMHS—and summarize the paper's conclusions. A brief discussion of available resources rounds out the paper.

Introduction

As discussed in *Elements for Life* (2007), published in conjunction with the WMO UN International Conference on Socio-Economic Benefits of NMHS Services (Madrid, Spain, 19–23 March 2007), there are several reasons for assessing the economic value of hydrometeorological services (Lazo 2007). These include

- Justifying programs to decision makers (e.g., funding agencies)
- Evaluating programs for their economic viability
- Guiding research investment to maximize benefits to society
- Informing users about benefits to encourage their involvement in or use of hydrometeorological programs
- Developing end-to-end-to-end systems where user needs are incorporated into the research, design, and implementation of hydrometeorological programs.

Here we discuss several issues related to the economic valuation and application of hydrometeorological services. We first make a distinction between "the economy" as the term is often used in common parlance and "economics" as a social science. Next, motivated by recent work on impact damage estimation, we explore some issues related to the validity and reliability of data on damages from hydrometeorological events—an effort that should undertake valid economic assessment just as the valuation of benefits from hydrometeorological services does. This leads into a discussion of appropriate methods for economic assessment. As part of an effort to build a foundation for the use of economic research and applications, we describe a resource we are developing, the *Primer on Economics for National Meteorological and Hydrological Services*.[6] We will be releasing this primer as an introductory overview of benefit-cost analysis (BCA)

[6] In this paper, we use the term "national meteorological and hydrological services" or simply "NMHS" to refer generically to the body of weather-water-climate–related services and informational products provided by the agencies or entities responsible for such services. Many countries have both public sector and private sector entities that provide hydrometeorological services, and different countries offer different sets of services under different program names, but all countries deliver hydrometeorological services in some form. Here and in the primer, we focus primarily on public provision of weather-water-climate–related services and informational products. As indicated by the World Meteorological Organization, "NMHSs constitute the single authoritative voice on weather warnings in their respective countries, and in many they are also responsible for climate, air quality, seismic and tsunami warnings" (see http://www.wmo.int/pages/governance/policy/ec_statement_nmhs.html).

to encourage the use of appropriate economic methods for assessing hydrometeorological programs.

The Economy and Economics

Measuring the economic impact of hydrometeorological services and information typically involves assessing the impact of hydrometeorological events or forecasts of events on specific economic sectors such as transportation, energy, or agriculture. Changes in measures of output, employment, revenues, or taxes are presented as the economic impacts of these events or forecasts.

Although these measures do result in useful information, we would like to make a distinction between "the economy" and "economics." Merriam-Webster (http://www.m-w.com) defines *economy* as "the structure or conditions of economic life in a country, area, or period; also: an economic system." The term economy, then, is usually construed as the productive system of a country or region, and economic impacts are interpreted as disturbances to productive activity. Output, employment, revenues, or taxes are all related to productive activity – but they do not necessarily indicate changes in societal well being.

In what seems to follow the same conceptual meaning focusing on production, *economics* is defined as "a social science concerned chiefly with description and analysis of the production, distribution, and consumption of goods and services" (http://www.m-w.com). But digging deeper we find that ***social sciences*** are concerned with understanding "the institutions and functioning of human society and with the interpersonal relationships of individuals as members of society (http://www.m-w.com)." As a field of study of human behavior, economics extends well beyond the productive activities of an economy; economics as a social science considers the full range of impacts on individuals, firms, and society. This includes changes in public goods, environmental effects, health impacts, population distributions, vulnerable populations, and all other aspects of individual and societal welfare. Welfare economics is the area of economics specifically concerned with the overall welfare of society, including economic efficiency and income distribution.

Focusing only on the economy as a system of production can bias decisions toward purely monetary/economic outcomes and neglect adequate consideration of overall societal welfare. According to Lazo et al 2007a,

> The distinction between measures of economic activity and measures of economic welfare is important. Measures of activity, even if expressed in monetary units (e.g., output), do not tell us the *value* of the activity. In other words, these measures do not tell us what people would be willing to pay for that activity. Welfare measures, on the other hand, are specifically designed to quantify what people are willing to pay for something. As a result, welfare measures of benefits are appropriately compared to the costs that people pay for those benefits.

We emphasize the distinction between "the economy" and "economics" to clarify that:

- Economics as a social science considers societal welfare and not just productive activity.
- Economics has a strong theoretical–methodological framework for assessing and discussing societal welfare that includes a wide range of considerations beyond production activities.

To achieve one of the WMO's stated goals—"a strategic approach to the implementation of the PWSP [Public Weather Services Programme] that would help NMHSs to realise a quantum change in the delivery of products and services[7]"—we encourage continuing to develop a focus on societal welfare rather than the more limited conception of maximizing "economic" measures.

Damage Data

Hydrometeorological services rely on data, and great care, effort, and expense are put into observing, assimilating, manipulating, creating, and disseminating data. In essence, the fundamental function of hydrometeorological services can be characterized as the collection and transformation of data into information; e.g., transforming observations into forecasts. The hydrometeorological community does an incredible job in this complex effort.

But data on damages from hydrometeorological events, although of considerable importance to the hydrometeorological community, receive little attention. We do not address this topic with particular expertise but instead from a position of concern about the quality of damage data we have identified while updating NCAR's *Extreme Weather Sourcebook* (a collection of data on severe weather events in the United States, available at (http://www.sip.ucar.edu/sourcebook/index.jsp). As we worked to update damage data in this resource from 1999 to 2006, we dug deeper into the sources of these data and looked at how damages from hydrometeorological events are assessed in the United States.

As an example, the National Weather Service (NWS) has built "Storm Data,"[8] which is probably the primary source of damage data used in the United States. Under NWS Storm Data guidelines for calculating hail

[7] See the homepage for the International Symposium on PWS: A Key to Service Delivery: http://www.wmo.ch/pages/prog/amp/pwsp/PWS_Symposium_en.htm.

[8] See http://www.ncdc.noaa.gov/oa/climate/sd/

damage to a structure's roof,[9] only the cost of the new roofing material is considered as damages. The NWS uses this approach, which precludes any consideration of the labor required for repairing damaged structures, to calculate damages from almost all hydrometeorological events in the United States. On the other hand, for hurricane damages, the insurance industry supplies data on insured losses, which are then doubled and reported—by the NWS and others—as the damage from a hurricane. Because insurance data for hurricanes include the costs of labor for replacing damaged property, this information more closely represents the total real cost of repairing or replacing damaged property. Doubling these numbers is an attempt to account for damages to uninsured property and undercounted damages. For a similar incident, then, an approach deriving damage data from insurance industry information would yield a higher damage estimate than the approach used by the NWS.
Neither the NWS approach nor the insurance industry data are likely include, for example, the costs to the members of a household if they must temporarily relocate, their lost wages if they cannot work for some period of time, or the reduction in profits for a company whose employees are absent for some period during recovery from the storm (unless these are specifically covered under some form of loss insurance). We can see, then, that neither approach captures the total societal impact of hydrometeorological events.

Perhaps unaware of the limits of damage data, some researchers have undertaken analysis of available disaster damage data to argue that there have or have not been changes in weather-water-climate–related impacts on society over relatively long periods of time. It is difficult to put much confidence in this type of analysis when the underlying data on damages are of questionable quality. Furthermore, to the extent that decision makers use storm-impact information, there should be concern about their ability to make fully informed decisions. As stated in the supporting material for Bouwer et al. (2007; Table S2): "Because of issues related to data quality, the stochastic nature of extreme event impacts, length of time series, and various societal factors present in the disaster loss record, it is still not possible to determine the portion of the increase in damages that might be attributed to climate change due to GHG [greenhouse gas] emissions." One of the policy recommendations from Bouwer et al. is "We recommend the creation of an open-source disaster database according to agreed-upon standards."

Numerous experts have assessed loss estimation, including

- *The Impacts of Natural Disasters; A Framework for Loss Estimation* (Committee on Assessing the Costs of Natural Disasters; Board on Natural Disasters; Commission on Geosciences, Environment, and Resources; and the National Research Council. Washington, DC: National Academy Press, 1999).
  - *The Hidden Costs of Coastal Hazards: Implications for Risk Assessment and Mitigation* (H. John Heinz III Center for Science, Economics and the Environment. Washington, DC: Island Press, 1999)
  - *Human Links to Coastal Disasters* (H. John Heinz III Center for Science, Economics and the Environment. Washington, DC: The Heinz Center, 2002)
  - *Risk, Vulnerability and Impact Assessment. Report from a Meeting on Improving the Quality, Coverage and Accuracy of Disaster Loss Data* (International Strategy for Disaster Reduction; formerly Inter-Agency Task Force on Disaster Reduction; Working Group #3. Geneva, May 7, 2004. Available at http://www.unisdr.org/eng/task%20force/tf-working-groups3-eng.htm).

These documents discuss appropriate conceptual and theoretical frameworks for assessing loss from natural disasters and hydrometeorological events, which are largely based on accepted economic theory of social welfare measurement. In addition, assessing societal losses requires valid and reliable economic analysis of costs and benefits of these events, using methods not particularly different from those we discuss in the next section. As a result, we feel that within readily available literature the issues surrounding the need for higher quality damage data are well identified and that a conceptual and theoretical framework for assessing damages already exists. We question, though, whether there is an adequate understanding of the importance of collecting reliable damage data within the hydrometeorological community. We also doubt that it is adequately understood that the currently available damage data are of questionable quality. In the United States at least, the public weather service (NWS) is the agency currently collecting and reporting damage data. We perceive that the agency is investing inadequate resources to ensure that this is undertaken in a reliable and consistent manner.

Economics Primer

To encourage and increase capacity in economic methods, we are completing a document titled *Primer on Economics for National Meteorological and Hydrological Services* (Lazo et al. 2007b).[10] This primer, which covers economic theory, methods, and applications, is primarily for members of the weather community. It is intended to increase their understanding of economic methods and encourage their application in evaluating both the impacts of

[9] See the directive defining NWS protocol for collecting and entering data for Storm Data at http://www.nws.noaa.gov/directives/010/pd01016005e.pdf.

[10] This work was funded in part through the U.S. Voluntary Cooperation Program managed by the NWS International Activities Office.

NMHS and the associated benefits and costs of those services. To this end, the primer

- Describes the concept and practice of an economic BCA
- Discusses why conducting such economic analyses is important and useful
- Offers guidance on how to conduct BCAs and document and communicate the inputs and outputs of such analyses
- Presents illustrations of economic analysis for NMHS projects in the form of case studies.

Given that weather forecasts are quasi-public goods,[11] the economic value of most weather forecasting services is not directly observed in the market. For this reason, it is difficult to determine the economic value of improvements in weather forecasting. In the primer, we offer guidance on the theories, methods, and applications that can be applied to valuing projects or programs that improve hydrometeorological forecasts.

The primer focuses on a step-by-step approach to BCA. Figure 1 from the primer (reproduced here) outlines these basic steps, which are discussed in more detail at a level accessible to noneconomists in the primer itself. An important part of any valuation effort, as indicated on the right-hand side of Figure 1, is making connections with stakeholders. In the NMHS context, stakeholders are typically the users of the information that is to be produced by the program under consideration, but decision makers and different parties within the NMHS itself are stakeholders as well.

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[11] Weather-water-climate–related services and informational products are referred to as quasi-public goods because of their nonrival and limited-excludability nature.

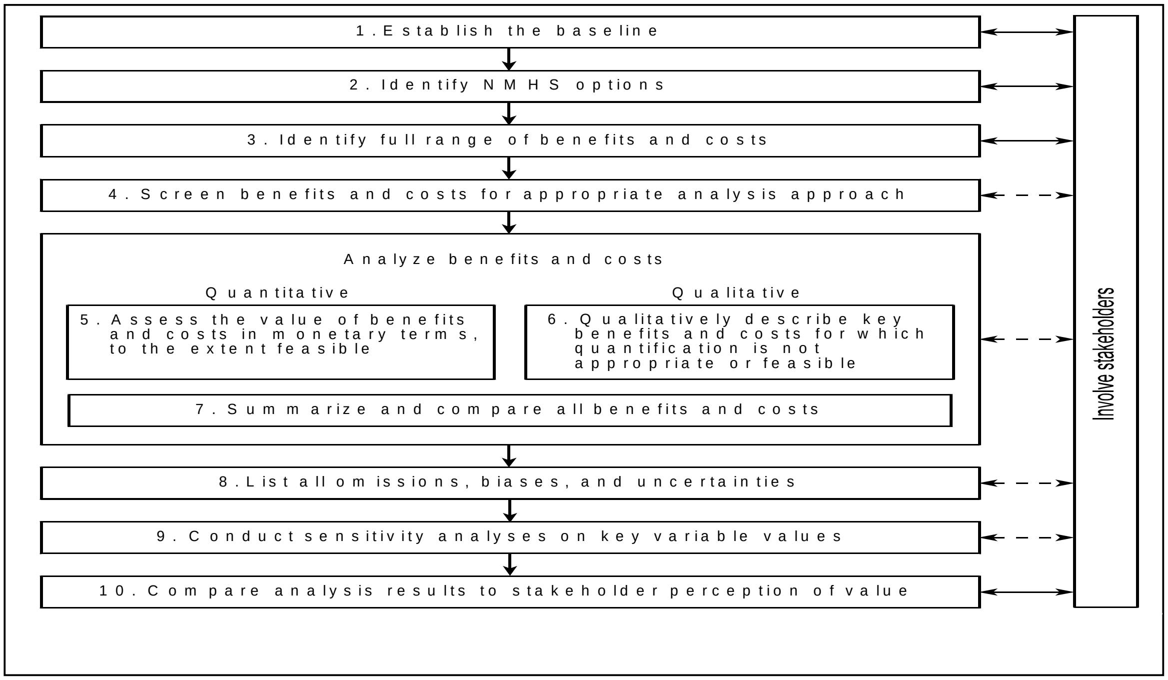

Figure 1 Steps in Conducting an Economic Analysis

Following this core material we discuss specific issues—such as defining a baseline for valuation, choosing which NMHS options to consider, determining benefit and cost categories applicable to NMHS, and screening outcomes—in more detail. We also explain important concepts including methods for determining monetized values, clarifying the difference between market price and nonmarket valuation, discounting and net present value (NPV), setting project decision criteria, and understanding and using sensitivity analysis.

In the final section of the primer, we present five examples of economic analyses that relate to the value of NMHS. These case studies span the entire range of estimation methods—from economic modeling through data analysis to subjective assessment—in addition to a range of objectives. For instance, the objective of Case Study 1 was to estimate the magnitude of impacts from weather variability in the United States, as well as to indicate the sectors of the economy where those impacts are likely to be greatest. The objective of Case Study 3 was to provide a traditional assessment of the costs and benefits of a particular program. Information on each case study includes a summary, methods used, procedures, resources used, data requirements, and economic expertise needed. The five case studies are

- *Sensitivity of the U.S. Economy to Weather* (Larsen et al. 2007) uses statistical analysis to estimate the degree to which economic output in states, economic sectors, and the overall U.S. economy depends on weather variables. Temperature- and precipitation-related weather variables are considered in the analysis. The authors conclude that total annual U.S. economic output can vary by as much as $260 billion depending on weather conditions.

2. *The Economic Value of Temperature Forecasts in Electricity Generation* (Teisberg et al. 2005) estimates the cost savings from using 24-hour temperature forecasts to plan the next day's production of electricity in the United States. Such savings are possible because electric power can be generated from a variety of different generating units. This study's key finding is that the availability of 24-hour temperature forecasts produces annual cost savings in the United States of $166 million, relative to persistence temperature forecasts.

- *Heat Watch/Warning Systems Save Lives: Estimating Costs and Benefits for Philadelphia 1995–98* (Ebi et al. 2004) examines mortality data for the city of Philadelphia during heat waves that occurred from 1995 through 1998. It finds that mortality was lower when authorities declared a heat wave warning and took actions to mitigate the effects of extreme heat. The investigators estimate that during this 4-year period, 117 premature deaths from heat were prevented by heat wave warnings and the associated actions. The dollar benefit of these prevented deaths, estimated to be $468 million over 4 years, vastly exceeds the modest cost of the actions taken.
- *Economic Value of Current and Improved Weather Forecasts in the U.S. Household Sector* (Lazo and Chestnut 2002) employed survey methods in which people were asked questions designed to reveal the values that they place on weather forecasts they use or on possible improvements to those forecasts. The study estimates that the total annual value of current weather forecasts to U.S. households is $109 per household, or $11.4 billion for the United States as a whole. For a package of possible improvements to current weather forecasts, the estimated annual value is $16 per household, or $1.73 billion for the entire nation.

5. *Benefit Analysis for NOAA High Performance Computing System for Research Applications* (Lazo et al. 2003) estimates the benefits to be gained from acquiring new supercomputers to use in research that supports improvements in NWS weather forecasting, as well as a variety of other programs. The investigators reviewed previous work done to estimate the benefits of weather forecasts, especially the benefits of improvements to those forecasts. In large part, the purpose of this review was to identify the types of benefits that are either largest or easiest to use (or both), because these are the key types of benefits on which to focus in assessing the advantages of supercomputer acquisition.

Conclusions

Understanding and characterizing the economic values of hydrometeorological services can help build support for the services and increase the value of these services to society. The value of economic analysis will be enhanced when it is appropriately used and conducted. We call for the international hydrometeorological community to support valid and reliable economic research and assessments of the impact of and values for hydrometeorological services. There are a multitude of examples—based mostly on anecdotal evidence—of the use and value of hydrometeorological forecasts in a number of different sectors. In contrast, relatively few studies have used consistent and valid methods based on economic theory.

Undertaking better economic analysis requires as a minimum a better understanding of the impact of weather, water, and climate on society (not just on the *economy*). This does not require meteorologists to become experts in economics. Instead, it requires them to recognize that there is an art and science to economics (just as there is to meteorology) and that it is necessary to enlist the help of professional economists in undertaking studies of economic impacts.

Collaboration of this nature is facilitated when meteorologists know enough about economics to understand what they want from economic studies—just as economists who work with meteorologists must have a basic understanding of weather and weather impacts and forecasts. We offer the economics primer as a step in developing this shared understanding.

Entraining economics into hydrometeorological activities also requires that the hydrometeorological community advocate funding for this work. Without money to support research and applications relevant to the hydrometeorological community, social scientists will work in other fields of interest where funding is available.

Some useful resources

We expect to make the primer available publicly at no cost in the very near future. We intend the primer to be a living document that will be revised, adjusted, and updated in response to the needs of users of the document. To learn more about resources on economics and hydrometeorological services, visit NOAA's Economics & Social Science (NESS) Web site at http://www.economics.noaa.gov. As an agency, NOAA focuses on the earth's physical sciences, but recognizes that interactions between earth science and social science are vital to its ultimate goal—giving users what they need. The NESS program and Web site is part of NOAA's Office of Program Planning and Integration (PPI). Another valuable resource can be found at http://www.sip.ucar.edu. NCAR, with funding from the U.S. Weather Research Program, established the Collaborative Program on the Societal Impacts and Economic Benefits of Weather Information (SIP) to create a dedicated focal point for assembling, coordinating, developing, and synthesizing research and information on the societal impacts and economic benefits of weather information.

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The Role of Televised Media in Broadcasting Weather Information

Evelyne Dheliat
Weather Presenter and Head of the Weather Service on TF1 in France

As a weather presenter on the French TV channel, TF1, since 1992, I have seen a great deal of changes in my job and my role vis-à-vis the public during this time, as have also my counterparts in other countries. This development is due to two main factors: (1) the constant improvement of weather forecasts and (2) the impact of climate phenomena, which is of increasing concern to the population. Thanks to this constant evolution, the information provided to the viewers has gradually shown the increasing reliability of weather forecasts. Interest in them is therefore on the rise.

Increasingly Reliable Weather Forecasts

Each day, I work with Météo-France on the design of the TF1 weather reports. The information provided is of both short- and longer-term value as we now give seven-day forecasts. Even though the six- and seven-day forecasts rather give trends, I have noticed over the years that their accuracy and reliability have grown. Scientists estimate that they gain one forecast day every seven to ten years. But if only for the short-range forecasts, the gain in quality is constant. In terms of calculation time, the Météo-France computers handle 2 400 billion operations a second! And a calculation time of one hour is sufficient for a 24-hour forecast.

My collaboration with Météo-France also comprises constant development work on the contents and the products placed at our disposal. By products, I mean new techniques for creating visual elements which are particularly informative for the viewers, such as the 24- or 48-hour air mass or humidity and rain forecast, and the evolution of fronts, all now displayed in different shots within a report. Sometimes, these products are the result of a request from me, such as the pressure data for several cities in France. Using the Météo-France records on these data, we then create new products in line with the TF1 graphic charter.

Increasingly Worrying Climate Events

On 26 and 27 December 1999, two exceptional storms occurred in France, which were unprecedented throughout the country's meteorological history. They were a real shock to the population, most of whom suffered a great deal of material damage. There were even several deaths. I noted that, as from this event, a radical change took place in viewers' expectations of weather reports. A new awareness of climate hazards arose. Together with Météo-France, we immediately felt the need for a new kind of information to cover the "risk culture", which gave rise to alert maps.

These maps cover four degrees of risk which are represented by the four colours, green, yellow, orange and red, red being the highest alert. The media only mention alerts as from the orange threshold. This new information given to viewers was quickly and perfectly assimilated by the public. Significantly, the red alert (maximum danger) has been used three times: on 8 September 2002 (storms in Gard) with very heavy losses, including 23 deaths; on 3 December 2003 (intense rain in Hérault) with 10 deaths; and on 6 September 2005, (heavy precipitation in both Hérault and Gard) with no deaths.

The summer 2003 heat wave, with several thousands of deaths in France, was an exceptional climate event that further strengthened viewers' interest in meteorological information. New alert maps were thus created showing the risk and impacts of extreme temperatures in both summer and winter. Since November 2007, the flood risk has also been taken into account among the alerts. Moreover, two public surveys revealed that people were assimilating the notion of "meteorological alert" increasingly well: in 2002, two-thirds of the public knew about it, and in 2005, the number had risen to three-quarters of the public.

There now exist European-scale alert maps but the information is still not widely used by the media, particularly in France. However, they are extremely useful for individual travel and would certainly be appreciated in European weather reports.

As regards the increasingly sensitive public issue of global warming, I have become aware of the important role I could play in sharing information with viewers. I am convinced that the media have a duty to take advantage of the impact they have to motivate people.

Here, I would like to say a few words about a personal experience of mine. When attending the annual "Forum International de la Météo", particularly the one in 2003, I was struck by the difficulty scientists had in communicating concerns about climate change impacts with the public. In France, I was thus the first person to develop, with them, including notably members of the IPCC, short, effective messages about things people can do in their daily lives to help mitigate climate change. Such information filtered into my evening weather reports is heard by more than nine million viewers.

On TF1, the weather report is the most watched and has the broadest appeal of all the channel's programmes, attracting viewers from all walks of life and age groups. The importance of the media to communicate information can also be measured by the public demand and feedback sent to the journalists. Following messages which I had broadcast to help mitigate global warming, many viewers asked me for more information and concrete solutions for everyday life. I did this by writing a book, which was published in October 2007, entitled "*C'est bon pour la planète*" [it's good for the planet], which is one way of spreading information.

I should add that I am fully aware of the economic impact of the weather reports. Many hotel managers have noticed that clients' reservations or cancellations for the weekend, for example, depend on the forecast three days earlier. Weather reports giving snowfall information for ski resorts also play a similarly decisive role for holiday makers.

Televised Weather Reports Worldwide

When I see weather reports broadcast by TV channels worldwide, I have noticed over the years a marked evolution but also a distinct "standardization". Maps and 3D pictures are almost the same from one country to another and even from one continent to another. This is doubtless because the meteorological software on the market is the same everywhere. I noticed this last September in Amsterdam at the IBC2007 exhibition of hardware and software used by TV professionals.

I should also mention the difficulties encountered by certain journalists and weather presenters in making their reports. I am thinking, amongst others, of certain African countries which sometimes have limited financial and technical means. I would like to tell them they have all my respect and admiration. When working with a number of them, I have observed their enthusiasm and their will to deliver good-quality weather information despite the sometimes difficult working conditions.

At WMO's request, I took part in a training seminar for weather presenters from French-speaking African countries in Dakar in September 2004. Each year since then, particularly at the Forums Internationaux de la Météo, I have seen the great, successful efforts they are making to improve their reports. These presenters are aware of the importance of delivering reliable weather forecasts with as much detail as possible in order to prevent natural disasters or improve agricultural yields, among other things.

They have often had to struggle to have this information broadcast as it was sometimes considered secondary by local decision makers. It is extremely important to help the developing countries to benefit in future from good-quality weather information. It is up to us to put our experience at their disposal.

The Future of Weather Information

It is perhaps worth asking how weather reports in the media will evolve over the next few years. Of course, the technical means and the forecasts will continue to improve and ensure an enduring role for presenters.

For my part, I note that we are progressively moving from a basic report with maps of cloud amount and temperatures to increasingly informative reports. However, the space and time slots allocated to the weather are not expandable. We will therefore in future have to constantly make a selection of the information and presentations depending on the dominant meteorological events at the time.

In view of the risks and anticipated impacts of global warming, the public will be increasingly receptive and demanding as regards the quality of this information. It will certainly have to include specific data regarding the risks and secondary impacts of violent and dangerous meteorological phenomena.

As I mentioned above, Météo-France has, for example, recently created new alert maps for floods and flooding after heavy rainstorms, this in response to a pressing demand from the public.

Moreover, the constant improvement of long-range forecasts will ensure that the public will come to expect this information. We can therefore hope that the weather reports will in future be considered by the media as indispensable and of prime importance, which is not always yet the case.

Without entering into the debate that I have occasionally observed among some of my colleagues in other countries, I would like to add a few words about the training of weather presenters.

This training is important for the future as weather information is to occupy an ever more important place in the media.

I think it is not absolutely necessary for a weather presenter to be a trained forecaster. However, it is essential that he receive some basic training in order to interpret and relay the meteorologists' forecasts properly. This may seem obvious, but it is often clear that certain presenters have no knowledge of the subject whatsoever.

Nevertheless, we can assume that meteorology has now obtained its rightful place in the media and that the job of presenter will do so too.

A Story isn't a Story unless it's Told Well. How to Identify, Develop and Build Capacity in Good Storytellers (Service Providers) and their Associated Public Weather Services.

Claire Martin
CBC News, Canada

Abstract

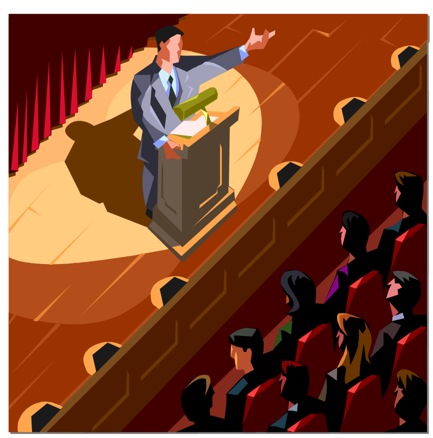
On October 12th 2007 Al Gore and the Intergovernmental Panel on Climate Change won the Nobel Peace Prize. The Prize Committee cited the Intergovernmental Panel on Climate Change for two Decades of scientific reports that have "Created an Ever-Broader Informed Consensus about the Connection between Human Activities and Global Warming." However it is Mr. Gore, the climate-caped-crusader, that is widely believed to have single handedly focused The world's attention on global climate change. This example stands as a testament and a lesson of the power of media, and the importance of having a scientific story driven by a good communicator.

Our world is changing. We are no longer simply scientists – we are sales-people too, and when it comes to selling science, the most important part of our job is to be understood. Good communication is the key.

To discover and develop those within the public service who may have the aptitude to "present" the science, is no small feat. However naturally good communicators can be found in all professions. This talent or trait is often an integral part of a person's nature. Those that are "camera shy" will not come forward for presentation work. Those with an inherent sense of what works will. Remember that being a good communicator is not only having the ability to express oneself, but is also in part the ability to put oneself forward in a group.

There are still certain attributes however that even the most "natural" presenters will need to learn. These attributes can be considered as being part of an inherent skill set required to master the job of presenting/communicating. A good spokesperson

1. Has a smart appearance
2. Is generally at ease in front of a large audience
3. Has a solid understanding of the subject at hand.
4. Is used to communicating ideas in a conversational tone.



A compelling speaker is a storyteller. And the best storytellers use a conversational tone. Of paramount importance is to keep the message simple (Keep It Simple Stupid). On a scientific level, the facts must be kept straight, and the story delivered without embellishment.

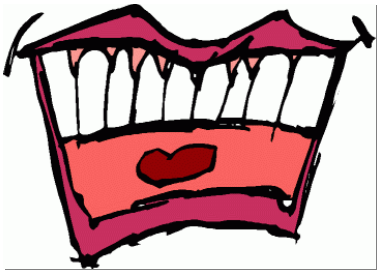
It should be noted here that a spokesperson blessed with the best media skills possible, will still be run aground if visually the image portrayed by that spokesperson is less than appealing. Clothes at all times should be smart – and hair should be neat and tidy. There are some very basic rules to follow when dressing for TV:

1. Jackets hold microphone clips very well.
2. White is considered too "hot" or too highly reflective a colour for a camera to read well.
3. Patterns can be distracting.
4. Jewelry can glint too much.
5. Glasses can reflect the light, making it hard to see the person's eyes.
6. Black is a sharp, easily defined and quintessentially classic.

When it comes to delivering a factual science based subject to the media, it is imperative that the spokesperson understand the subject thoroughly. If there is any doubt about a certain fact, that spokesperson should know where to go for that specific detail. Furthermore the spokesperson should learn to develop a network of contacts of specialists in various fields of study. This network will provide invaluable data for media conferences and often indirectly allows for those specialists to shy away from the glare of the spotlight, all the while knowing that a knowledgeable colleague is delivering the message clearly.

A good spokesperson will never lie under intense questioning, and will learn to deflect certain questions with a promise to find out the data at a later point. This allows for some breathing room for the spokesperson, and ensures that the correct information is delivered at all times.

Passion for the subject is a plus! Never underestimate the potential power of being perceived as "geek" to the subject – it tends to remove political controversy as the spokesperson is considered to be talking from the "heart".



Smiling, especially during a "lighter" TV interview, will generally make an audience feel more comfortable. However the spokesperson must not give the appearance of being glib or insincere with the smile. The art of portraying empathy for an event is often a learned experience. Smile genuinely and in a timely manner. During severe weather events, there is absolutely no need to "brighten" your demeanor for the cameras.

Speaking in front of a camera, calmly, without gasping for air, is in fact a very difficult skill to master. There are some very basic rules to follow that will allow a spokesperson to become quite proficient in calming their speech.

1. Read out loud every now and again. Be aware of when you stop or stutter. Learn to "read ahead" of the sentence you're voicing. This will tend to remove incorrect infections in the sentence.
2. Keep your on-camera answers short and sweet. Much like being a witness in a court case, it is sometimes best to simply answer the interviewer's question, succinctly and without too much added information. Even to a fairly in depth question, most long, run-on sentences will often find themselves on the editing room floor. Proficient spokespeople are very good at answering all questions in one or two sentences. Sometimes it is better to be heard with a somewhat simplified answer to a question, than to not be heard at all.

There are many word games that will aid a spokesperson learn the art of "punching" a word in a sentence for greater comprehension of the nuance of the sentence. For example:

- ***I*** DID NOT BREAK THAT DISH.
- but some one else did!
- I ***DID NOT*** BREAK THAT DISH.
- absolutely, positively did not break it.
- I DID NOT ***BREAK*** THAT DISH.
- but I did crack it.
- I DID NOT BREAK ***THAT*** DISH.
- however I may have broken another similar dish.
- I DID NOT BREAK THAT ***DISH.***
- but I broke the matching cup.

Media training for spokespeople (service providers) is quite frankly (in this authors humble opinion) rampantly lacking in a huge proportion of the world's national meteorological and hydrological services. It is essential that this be addressed as many public weather services will find increasingly themselves under the glare of the media spotlight as our world's climate continues to exhibit vast flux.

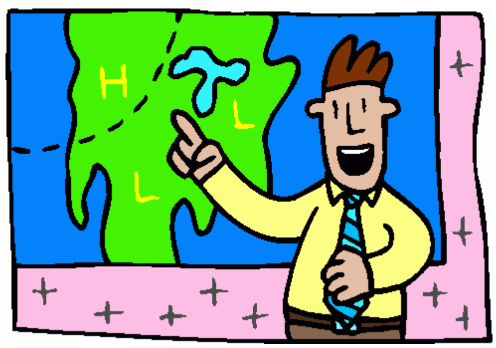
The following tips pertain more to the daily broadcast of weather information as opposed to the one-off interview type media attention that NMS spokespeople usually find themselves addressing.

Basic On-Air Training For Weather Presenting

1. FOR PRIVACY SAKE – YOU MAY PICK YOURSELF A "STAGE" NAME. But be warned, the name will undoubtedly stay with you through your career. If not your real name, pick something you like! If you want to use your real name, be aware personal privacy may well be compromised. For women this will always be a bigger issue than for men. If you decided to pick a new or different "stage name", try to make it simple and something that has the same rhythm and meter as your own – it will roll off the tongue easier that way.
2. GENERAL ON-CAMERA PRESENCE. Your posture/stance for the opening of the weather segment will speak volumes about how the broadcast will go. Be "ready". Stand upright, fully facing the camera, ready to start talking. Never slouch. Have a smile ready to go! Don't forget to smile with your eyes – don't just bare your teeth!!
3. HAIR/CLOTHES/MAKE-UP. Your hair needs to be neat and tidy. Most TV consultants will tell you it should be off or barely brushing the shoulders. Bangs or fringes should not in your eyes – you will find that your eyes convey volumes in TV – try not to cover them up. Clothes need to complement a "chromo-key" wall well. Black is sharp and classic. Jewel tones are vibrant and stand out well. Red is a great colour to wear as well (it is far from the usual blue/green c-key colours), and looks especially good on fair haired people. White will reflect too much light (and will appear "hot" or glow on camera). Patterns can be distracting. Above all else however, try to be neat. Jackets are quite simply the easiest way to hide battery packs required for microphones and ear pieces, and also provide you with a lapel to clip the microphone onto. Jewelry can be a bit of a nightmare! Avoid anything that will swing and hit the microphone. If it is too shiny it will glint constantly on camera.
4. SPEECH. Slow, clipped sentences. No "um's", "ah's" or "like's" permitted! Keep sentences short, and try not to "over-explain" anything. The "Keep It Simple Stupid" rule is paramount here.
5. MOTION AT THE CHROMA-KEY WALL (AKA Green Screen). When weather-presenting, your movements and hand motions should be slow and steady and clearly defined. It is not good enough to vaguely wave your hand at a map. Point properly and fully and exactly at what you're drawing attention to. Note that fair skinned people will "key out" easier than dark skinned people (because of the lack of distinct colour against the green). To compensate for this, it is advised that most presenters use at least 3 fingers to point at something on a weather map. Also for on-air "smoothness" it is highly advisable to follow the motion of whatever atmospheric aspect it is you are pointing at, as a guide to the motion of your hand. Never point against the motion of the graphic. Don't "bop" around your screen either. Move from one side to the other slowly and precisely. Try to build shows with this in mind. If at all possible, practice and choreograph your show ahead of time.
6. LOOK AT THE CAMERA! Remember the eye of the camera is the eye of the person that you're talking to – you want as much as eye contact as possible. With that said however, remember if you're pointing out a specific detail on the maps, break eye contact and look at the map. But don't stay addressing the map too long. People will tune you out if you stop looking at them. And finally don't watch yourself on the monitor in front of you while you're on air – that's what the bathroom mirror is for!
7. TELL THE STORY LIKE YOU'RE TELLING A PERSON. The camera is literally another person – tell the weather story like you would tell a story to your family and friends in a casual setting. Conversationally.

Your First Weather Broadcast

1. ALWAYS START AND END WITH A SMILE. Try to smile through part of the presentation as well. It's a very "welcoming" gesture to have a smiling face delivering the weather. The anti-thesis of this tactic also helps during times of severe weather. Always deliver potentially life-threatening weather seriously. This is the time to command attention on a serious level.
2. EVERY TRANSITION PHRASE NEEDS TO BE DIFFERENT. Don't fall back on set phrases: "let's take a closer look at..", "let's zoom in on.." – a transitional phrase moves you from one area of the country to another, so cover the move with added information about what you're seeing not simply a description of where you're going.
3. TRY TO MOVE WITH ANY TRANSITIONAL GRAPHICS. Practice your show ahead of time – and work out (like a dance move) – which side of the screen you're going to move to, and at which point in the show.
4. DON'T BOP AROUND! This is not a chance to show off your ability to dance! Pick a side of the screen you want to get to – and move decisively there – even if it 's the "wrong" side (i.e. covering part of the weather graphic). Try not to move across the screen more than 2-3 times in a 2-minute hit.
5. SLOW DOWN YOUR SPEECH & BREATHE! Also be aware that not breathing means you'll find yourself gulping for air as the show continues. Try not to smack your lips – again, slower speech will allow you to be more in control. Don't eat just before going on air. Take a swig of water before going on air.
6. VOICE PROJECTION. A general rule of thumb is there is no need to shout (you are wearing a microphone!), but you want to project your voice to the "back of the room".Usual 5-10% louder than a normal talking voice is perfect.
7. IF THINGS GO WRONG TECHNICALLY. Do not point them out on-air. Your viewers don't care if the weather graphics machine/computer has crashed, or stuck, or broken in any way. Ignore anything and absolutely everything that may go wrong. Just keep talking. If things get really bad, stand full frame, in the centre of the camera shot and keep talking. End decisively – it's a good cue for behind the scenes staff that, despite the fact that things are failing, you have finished your on-air segment of the show.
8. CLOSING COMMENTS. Much as it is important to have an opening line ready for the start of the show, it's equally important to have a closing line ready for the end of the show. You can have certain lines ready: "I'm JW, and that's the latest weather forecast."
9. CONTENT. For a national cast, remember every big city in the country pretty much equally important – so pick your stories. The biggest weather story should lead the cast. Warnings – especially life threatening warnings – should always lead the cast. After that, remember to mention most of the big cities if at all possible.
10. PICK UP YOUR FEET. Remember that microphones do pick up some ambient background noise. If you want to "slide" across the front of your maps, that's fine – but you might want to wear slippery shoes or even socks to do so.
11. PHRASEOLOGY. The "Keep It Simple" rule overrides virtually all others at this point. Try to work out ahead of time in your head how you're going to explain certain atmospheric events. Stick to that phraseology.



Possible Problems With Shows

1. WHEN THINGS GO WRONG! As far as "TV world" is concerned, within a newscast, the weather segment is the first element to be 'floated' (timed roughly as opposed to exactly within a newscast). You may/will be cut or given extra time as you go into the studio. Proficient weather broadcasters are quite adept at cutting or expanding shows "on the fly".
2. HOW IS YOUR TIMING? Do you have a sense of whether you are a slow or fast talker? It is by far more usual to be the latter. With that in mind, it is imperative to get a sense of how long you need for "intro" time and "out" times. These are two elements that will always be required in a weather broadcast, so you must allow for the proper amount of time for these two sentences. A basic intro usually lasts about 2-5 seconds ("Good Morning/Afternoon, I'm JW with a look at the weather"). "Out" sentences tend to be longer. Try to remember to ask the control room for

an explicit time count out of a weather hit: 15-10-5-4-3-2-1. At "15" most presenters want to wrap up their last sentence; at "10" they will bring themselves back to centre frame, so that by the "5" second mark they're ending their last sentence. Remember that on '1' you must be done. Try to "hit your mark" consistently – it makes for much smoother TV.

3. COMMON PROBLEMS:
   a. Under-loading A Show: When you go into the studio and have prepared for a (say) one minute cast, and are given twice as long (2 minutes), avoid the impulse to run back to the weather computers and throw extra maps down into your show. Believe it or not, with extra time, you'll find yourself giving a much more in-depth and slower paced presentation. This is not a necessarily a bad thing! Not only that, by training yourself to use maps thoroughly, you'll be better equipped to handle a computer crash on air. If you find yourself suddenly left with a two minute hit and only one map, take a deep breath, and give a good explanation as to what is happening.
   b. Over-loading A Show: This is such a common problem! If you consider that most maps should be given a good 10-15 seconds worth of discussion (anything less is a disservice to the information being shown), and that a "forecast board" of any type should be given at least 30 seconds, a full 2 minute weather cast should never have more than 6-8 separate maps. Try to avoid the temptation to put too much into a presentation. Try to make sure that all areas of the country are shown and given at least a cursory glance during each and every hit. It is often easiest to focus or at least start your presentation on the area having the most dramatic weather of the day. Broaden out your discussion from there, and then usually end your weathercast on the "other" side of the country. Remember nationally speaking, warnings should lead the cast, or at least be the focus on the first 20 seconds. Never bury potentially life-threatening weather.
4. TIMING: Try to get an inherent sense of how long it feels to talk for 2 minutes. National hits are usually give 2-3 minutes. I had a friend who went out and bought a stop watch, she would set it for 2.5 minutes all the time, set it off, and see if, without looking at the watch she could guess/estimate to the nearest couple of seconds, as to when 2.5 minutes was up. Regional and local shows are a completely different beast. We'll deal with them next.
5. ABANDONING A SHOW EARLY: Always be prepared to "bail" early if necessary. Every now and again, you will be pulled off air for breaking news very suddenly. Learn to have a set phrase – a bail phrase – that can get you out of the weathercast very suddenly. An example of a good "bail" phrase is: "That's all for now. Now back to the news."

Local Shows

Local (i.e. highly site specific regional) shows are a completely different beast to national, country wide shows. Local shows are usually highly interactive in nature, and allow for the presenter to openly "place" themselves within a community. With many news stations cutting costs, it has become more common for weather broadcasters to provide weather hits for stations not in their local area, nor sometimes within even a remote proximity to their local area. As far as doing a show goes, from a different location, be very careful not to lie as to where you are! You can allude to the fact that the weather has been rough in a given area, you can show empathy for everyone dealing with the weather, but you need to be careful with your language. Usually you should avoid subjective language during a weather-presentation – a local show however is the one time where you can get away with a certain degree of subjectivity. This works best when the presenter has intimate knowledge of the local, and recent, climate and weather of a given area. You will also often be given time for a "top" and "tail" presentation. The "top" is an overall introduction to a rather short range forecast (usually the next 24 hours), and a "tail" is the final word at the end of the newscast, that allows for repetition of the full (next few days) forecast.

TIPS FOR A LOCAL SHOW

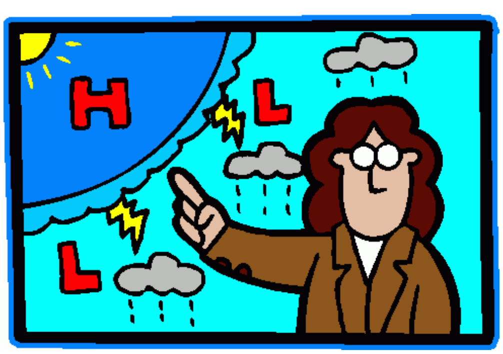
Above All Else, Know Your Area And Know Local Effects.

1. Never start a local show with a national map, unless there is something dramatic going on – furthermore only with an event that you can tie back to your local area. Remember a local show is just that.. local.
2. Know the local climate – thoroughly.
3. Use the news wire service to find out about weather related news events in your local area.
4. Check out local live web-cams of the local area just before going on air. They really will help to make it feel like you're looking out a window.

Local shows are far more "loose" and interactive type shows. The anchor will often thrown with a question to you. And you may even be given extra time to "chat" with them. That's great. Local weather personalities are simply that – personalities within a newscast. You will often be used by the main news anchor as a chance to lighten up the show – be aware of this and be ready to "chat" more freely. Time counts and restrictions may be looser. However on the downside, remember that occasionally you will follow a sad/nasty story. Try to set the tone of the weather presentation accordingly.

Large television networks often use satellite links to bring a weather segment from another part of the country to do a local show – there are inherent dangers here. The time delay issue (because of the sheer amount of time it takes to upload a outgoing signal to a satellite and come back again) is the biggest problem with this type of broadcasting. There is often a good one-second delay between you and the show. A clever way to cover the delay is to use a "slight knowing nod" at the start of the weathercast! This gives the appearance to the audience that you are simply agreeing with what is being said, even though you're actually simply covering the satellite delay. Furthermore, to stop your anchor from interjecting while you've started, you can throw in a "thanks John" to make it feel like you've picked up the show, and that it's now yours.

The long range forecast, the 3-day, 4-day or 5-day forecast boards/graphics, are the most important parts of local shows. Do not short change the audience with a lack of time spent with this graphic. Spend at least 20 seconds on it, during a 2-min hit and 30 seconds during a 3-minute hit. Do not simply "number read" the values of temperature highs and lows expected through the time period in question – add value to the forecasts by explaining temperature trends (for example) and why they are happening.



Section 1.02 SEVERE (LIFE THREATENING) WEATHER

Breaking into Regular Programming

This can be the most demanding part of broadcasting weather information and yet in some ways, it can be the easiest way to be on air. There's very little time for interpretation – and hence misinterpretation.
When severe weather happens, you may have the ability to go on air virtually immediately, but for a very short time (often less than a minute). This type of broadcasting is very compelling for the viewer. As far presenting this type of information goes, there is fairly strictly structured format that is best to follow.

If you have time to make graphics:

1. Make a graphic showing the area or region under the warning
2. Use live weather conditions and radar imagery if at all possible to explicitly show the weather event that is occurring.

Do not even attempt to make any other graphics. There will not be enough time, and quite frankly you're delivering an "as is occurring" message. You need to be up on the weather that is occurring, not bogged down in making pretty graphics.

If you are given a huge amount of time (the American's refer to this as "wall-to-wall" coverage) where the weather segment of the "breaking news" cast, is basically open ended, it is then often easiest to simply chase the severe weather with constant repetition of local weather observations, radar coverage, and nowcasting. Constantly updating weather warnings as they are issued by the NMS is a full time job at this point. Be prepared to really think on your feet.

ALWAYS READ THE NMS ISSUED WARNING AS SCRIPTED. This is of absolute paramount importance. Be careful to state the date and time of the warning, and always site the source of the information being reported (In Canada it is Environment Canada). It is grossly misleading, and potentially libelous to infer some authority over the government issued forecasts at this point. From the NMS issued severe weather bulletin read the areas listed - straight, give no additions. On the radar indicate the cell or cells that the warning refers to, and then return to reading the warning. Restate (or rebroadcast) those areas that are currently under the warning. Do not extrapolate information other than to show where the cell or cells are heading. Remember that there are potential legal liabilities involved in editorializing government issued severe weather watches and warnings.

Ending a "breaking news" type weather broadcast is tough. You don't know when you will be able to be on next, and you don't know where the really bad weather will be – it is best therefore to say something "stay tuned to this station for the latest", or "that's the latest from …".

Here's an example of how a severe weather warning is written in Canada:

WWCN11CWTO051803kad 862 05-06 0273
WWCN11 CWTO 051803
severe weather bulletin issued by environment canada at 2:03 pm edt tuesday 5 june 2007.

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watches/warnings in effect for southern ontario...
tornado warning for:
kingston - odessa - frontenac islands
tamworth - sydenham - south frontenac
brockville - leeds and grenville
prescott and russell
cornwall - morrisburg.

Doppler radar has detected rotation in cells heading west through the Kingston area. Conversation with a trained weather observer in the area has confirmed a large tornado on the ground just east of the city of Kingston…

(a)How to Control Breathing

Learn to punch sentences is certain places, and to follow the punches with a breath. Earlier in the text there is an example of how "punching" a certain word in a sentence can not only change the meaning of the sentence but also control the breathing required to deliver that sentence. Above all else, slow down. What feels like an eternity on TV, is barely a breath for the average viewer at home!

Final Show Tips

Practice a show **out loud** using pauses to punctuate sentences and thereby forcing you to breathe. Remember to take a **long, deep breath** before going starting. Breathe in through your nose and push it all the way out through your mouth. Take a swig of water. Do not eat anything directly before going into the studio. Choreograph your show so that, much like dancing, you know at what point your going to move from one side of the screen to the other. Don't forget to smile when you talk (not just when you make a mistake!!). Learn to control nerves by breathing deeply, and knowing fully the science and story behind what you're about to discuss. Make sure you clear all "land-mines" out of your graphics. A "landmine" is a graphic that is not adequately labeled and hence explaining it will trip you up on air. Therefore label them clearly with place names or data you want to highlight, write on temperatures or amounts or dates that you want to mention. Don't leave anything off!

Good luck!

Communicating Forecast Uncertainty for service providers

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Abstract

Uncertainty is an inherent ingredient of forecasting and communicating it effectively is of great benefit. It helps users make better decisions, and it helps service providers manage the expectations of users for accurate forecasts. This paper addresses the issue of communicating forecast uncertainty. The emphasis is on how service providers can incorporate uncertainty information in their meteorological forecast services, including the best ways to communicate this information to the benefit of users. Examples are given of effective presentation methods and some of the pitfalls are highlighted. Service providers are encouraged to use this information as a guide on how best to communicate forecast uncertainty and make it a routine and effective part of their service.

Introduction

Uncertainty is an inherent ingredient in the hydrometeorological forecasting process. Forecasters are very familiar with the question of uncertainty and predictability and must deal with it every time a forecast is prepared. Sometimes the available computer models or other guidance are consistent in their predictions and the forecaster is confident of the outcome. At other times, the models may differ greatly or the weather parameter may be intrinsically difficult to forecast. Nevertheless, a forecast must be made, even when the confidence is low.

Uncertainty in the forecast can also arise from how the forecaster utilises the available information. Even if the model predictions are highly accurate, they must still be interpreted and translated by the forecaster into actual weather. This interpretation must then be rendered into a forecast, which in turn is received and interpreted by the user. Uncertainty can occur at each of these stages of the 'information chain'.

Communicating the uncertainty of the forecast is vital to users. It allows them to make better decisions that are attuned to the reliability of the forecast. It also helps to manage the expectations of users for accurate forecasts

This paper addresses the issue of communicating forecast uncertainty. Although it includes a discussion on the sources of uncertainty, and touches on the related science (e.g. probabilistic forecasting, the use of NWP ensembles), this is not their focus. Rather, the emphasis is on how service providers, including National Meteorological and Hydrological Services, can utilise forecast uncertainty information, including the best ways to communicate this information to the benefit of users.

Strategies for communicating forecast uncertainty are being developed by many forecast service providers. As these strategies are developed, it is important to be aware of some of the possible pitfalls. For example, meteorologists – as scientists – are quite comfortable with uncertainty and the language of probabilities. This is not usually the case for the general public and so there is a significant risk of misunderstanding.

The conventional text-based forecast offers little opportunity for expressing uncertainty. There is limited space in the forecast, it is not easy for recipients to absorb every word that is there, and it can take the forecaster a long time to get the words 'just right'. Not only that, the verbal language of uncertainty can often be rather subjective, so that what the forecaster intends may not match what the recipient understands. One possible solution is to devise a simple numerical scale for confidence and attach it to all forecasts. This idea is not new! In an article published in Monthly Weather Review in 1906, W. E. Cooke suggested a 5-point scale for describing uncertainty:

- 5 We may rely upon this with almost absolute certainty
- 4 We may rely upon this with tolerable certainty, but may be wrong about once in ten times
- 3 Very doubtful. More likely right than wrong, but probably wrong about four times out of ten
- 2 Just possible, but not likely. If showers are indicated, for example, they will not be heavy even if they occur at all
- 1 The barest possibility. Not at all likely

And a forecast might read: *Southwest district: Fine weather throughout (5) except in the extreme southwest where a few light coastal showers are possible (2). Warm inland (4), with a cool change expected on the west coast (3).*

Another way to express uncertainty is to include in the forecast the next most likely scenario as well as the expected one. This allows users to make back-up plans. Although many users only want a single forecast upon which to base their decisions, some users with more specialised needs can get value from knowing what the alternatives might be. This is especially true of emergency managers who need to know alternative and worst-case scenarios so they can plan their resources with all contingencies covered.

Using probabilities is a common way of expressing uncertainty and is a widespread practice. It is important that the probabilities are based on objective scientific techniques, so that they are reliable, trustworthy and well-calibrated to the true probability distribution of the phenomena in question. The definitions of the probabilities must also be clearly defined and communicated, so that users understand what they mean.

The focus of this paper is on ways to describe and communicate forecast uncertainty, highlighting the key issues that service providers will need to recognise and address.

Why Communicate Forecast Uncertainty

There are several reasons why communicating forecast uncertainty is a useful thing, both for users of the forecast and also for the providers of the forecast. Each of these reasons are described in the following sections.

Knowledge of forecast uncertainty assists decision making

The central reason to communicate forecast uncertainty is to assist people to make more effective decisions. This is especially so when the user of the forecast has options available to them and wants to weigh up contingencies. Such situations are very common, and range in scope from simple day-to-day decisions about such things as what clothes to wear, to major emergency responses such as evacuation planning. The following examples describe how uncertainty information can improve the quality and effectiveness of a decision:

- A farmer wishes to fertilise a crop. For this to be successful, a small amount of rain is desirable to help the fertiliser be absorbed into the soil. The farmer has established a rule that says that if the probability of rainfall is less than 80%, then the risk of wasting the fertiliser is too high, and he waits until the chances improve. The farmer needs a high degree of confidence before deciding to apply fertiliser.
- A Government food agency is assessing food security for the coming year. The seasonal climate forecast suggests that there is a slightly greater than normal chance of below average rains over the growing season. Accordingly, the food agency initiates a food stock-piling program. The consequences of inadequate rain is so great that the food agency responds, even though the uncertainty of the prediction is relatively high.
- An emergency services agency is deciding whether to evacuate a community ahead of an approaching tropical cyclone. The forecast states that there is a 10% chance of destructive winds being experienced. Even though this is numerically low, it is high enough – relative to the potential consequences – for the agency to commence evacuations.

In each of these three cases, users have tuned their responses to differing levels of forecast uncertainty according to their own particular needs. This is why information on forecast uncertainty is such a useful part of the service – it allows people to react to the forecast in the way that is appropriate to their situation. Without this information, for example if the forecast was simply ‘Rain’ or ‘No rain’, then the user is unable to reliably tune their responses.

Communicating uncertainty helps manage user expectations

Meteorologists are routinely faced with uncertainty when making a forecast. They can find this to be stressful if users of the forecast have an expectation that the forecast is always right. Forecasters also know that some situations are more predictable than others – if they are able to communicate this to users then a more effective relationship can be established, one in which users have a realistic understanding of the accuracy and reliability of the service.

Communicating uncertainty retains user confidence

Retaining the confidence of users is critical. Users who understand that forecasts can have a degree of uncertainty, and are able to attune their decision-making to uncertainty information provided by the service provider, are much more likely to retain confidence in the service. Surveys show that uncertainty information does not undermine people’s confidence in the product – on the contrary, it reassures people that they are being dealt with honestly, and gives them confidence that the service is being provided objectively and scientifically.

Forecast uncertainty reflects the state of the science

It is important that meteorological services are based on good science. Uncertainty is inherent in the predictions from NWP models and it is appropriate that this uncertainty is factored into the forecast and warning services that are provided. Little credit is given to the profession, and the credibility of the service provider is undermined, if the accuracy of the service is overstated.

Sources of forecast uncertainty

In order to effectively communicate uncertainty, it is important to understand where it comes from. Some uncertainty accumulates within the forecast process chain, as result of the inherently chaotic behaviour of the atmosphere, limitations in our ability to measure and model the state of the atmosphere, and in our efforts to interpret the observational and model data.

Further uncertainty arises when forecasters endeavour to turn their scientific understanding of the situation into plain language. Terminology and phraseology are often unable to perfectly encapsulate the expected forecast scenario. The format and length of the forecast may also be restrictive. As a result, uncertainty may arise because the forecaster is unable to describe the full story of what will happen.

Finally, uncertainty can occur when the forecast is received and interpreted by the user, who does not always have the same understanding of the terminology or the intent of the forecast.

The strategies to deal with these uncertainties, in terms of communication, will vary. For example, in the case of scientific uncertainty, the use of probabilities can be an effective way to communicate uncertainty levels; in the case of uncertainty due to forecast interpretation, the use of clear language and well-defined terminology would be an important element of effective communication.

How to Communicate Forecast Uncertainty

Human perceptions of uncertainty information

The prime motivation for communicating forecast uncertainty information is to assist better decision making on the part of those receiving the information. For these recipients to respond however, they must first interpret and understand the information.

How people perceive and respond to language and information of this kind has been investigated by behavioural scientists. Much can be learnt from these studies.

For example, it has been shown that the way people interpret and describe uncertainty information can be influenced by the significance or magnitude of the event (Patt and Schrag 2003). Such studies suggest, for example, that if light rain and heavy rain are both objectively forecast to have a 10% chance, people subjectively describe the heavy rain event as being more likely.

People often expect this exaggeration behaviour in others, and so they will ‘decode’ what they are told. Thus, when receiving a forecast that describes a high impact event as a medium likelihood, users will often assign a lower threat level due to a belief that the provider of the forecast was exaggerating.

It is important to bear in mind this tendency by users to ‘exaggerate’ and ‘decode’ the information they receive. An effective strategy is to use objective numerical measures of uncertainty (e.g. probabilities) together with plain language that is clearly defined. An example of this approach is the uncertainty scale used by the Intergovernmental Panel on Climate Change (IPCC), which clearly defines the language and the corresponding probability thresholds (Table 1).

Terminology	**Likelihood of the occurrence/outcome**
Virtually certain	> 99% probability
Very likely	> 90% probability
Likely	> 66% probability
About as likely as not	33% - 66% probability
Unlikely	< 33% probability
Very unlikely	< 10% probability
Exceptionally unlikely	< 1% probability

Table 1: IPCC Likelihood Scale

User Sophistication

It is important to bear in mind that different users will have different requirements for uncertainty information as well as different levels of understanding. For some, particularly those involved in emergency response, detailed quantitative estimates of uncertainty are required. Specific response plans will be in place that describe certain actions to be taken according to defined thresholds. For example, a community evacuation plan may be activated if the probability of cyclone-force winds being experienced increases beyond 20%.

Sophisticated users of uncertainty information are aware of the underpinning reasons for uncertainty, and service providers – when providing this information – can use technical language and speak in some detail. The use of relatively complex graphics is also possible.

For less sophisticated users, service providers need to be quite careful about the use of complex information. Such users are less likely to understand the sources of uncertainty and will prefer simple messages and graphics.

Over time, and with sufficient experience and user education, it is possible to improve the level of user understanding and sophistication. Gigerenzer et al. (2005) showed that in New York, where the public have lengthy experience of probability rainfall forecasts, a majority of users correctly understood a forecast for 30% probability of rain to mean that there is a 3 in 10 chance of rain somewhere in the city. On the other hand, in 4 European cities, where probability forecasting is not used, the majority of users incorrectly interpreted the forecast to mean rain would fall 30% of the time, or over 30% of the area.

Use of colour

Colour is a very powerful tool for conveying information and meaning. Like any tool, it needs to be used carefully. It is a common practice to use colour in the graphical presentation of probability (or other uncertainty) information. Great care should be taken that the colours that are chosen send the right message.

Below (Figure 1) is an example of a probabilistic seasonal rainfall forecast issued by the Australian Bureau of Meteorology. Notice that probability values below 50% are denoted by warm colours.

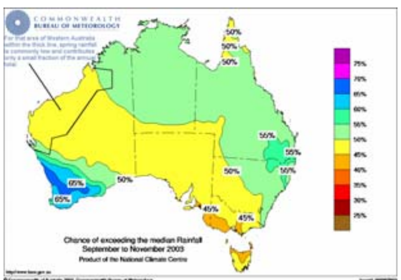

Figure 1: Seasonal rainfall forecast (Australian Bureau of Meteorology)

By using colour this way, users would often interpret the message inappropriately. Numerically, 49% is not very different from 51%, yet users would interpret the forecast by its colours, concluding that the yellow areas will be dry and the light green areas will be wet.

Recognising this problem, a new colour palette was devised that has been more effective in communicating the correct message. In the example below (Figure 2), all values between 40% and 60% are depicted in white or grey. The same level of information is still provided, but the 'emotive' colours have been shifted so that they now apply only to the high/low probability values.

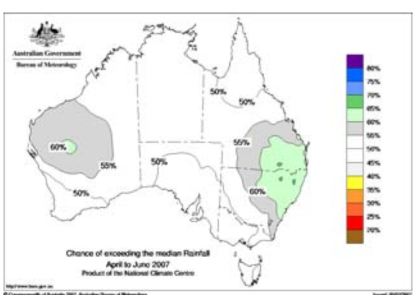

Figure 2 Seasonal rainfall forecast (Australian Bureau of Meteorology)

Examples of uncertainty information

This section provides some examples of effective methods for conveying uncertainty information. The examples make use of the principles and ideas expressed above. Service providers are encouraged to consider these examples when developing or enhancing their delivery of uncertainty information to users.

Words

The language of uncertainty can be either complex or simple. When presenting a weather briefing, or preparing a forecast for the general public, forecasters may make use of phrases such as "chance of", "one or two" or "possible". Sometimes, non-specific descriptors may be applied, such as "later", "developing" or "in the area". These descriptors are deliberately vague because the forecaster is uncertain about the precise time or location of the phenomenon being forecast.

Often the uncertainty associated with a forecast is due to the presence of an unpredictable weather pattern. A narrative description of the situation, including possible alternative scenarios, can be an effective way of conveying uncertainty to more sophisticated users. Radio or television are ideal ways to communicate this information.

Although language is essential for communicating uncertainty, its verbal form can introduce confusion in the mind of the user. What, for example, is the difference between "chance of" and "possible"? Does "chance of" mean the same for one forecaster as another? While it is useful to use such words and phrases so that users do not have an expectation of certainty, it is important to try and apply some consistency. Using clear definitions and procedures will help in this respect – for example, a rule could be instigated that says that a forecast of "possible showers" would only be used when the probability is above a defined threshold of 30%.

Graphs

Simple graphs can be a useful way to present uncertainty information in quantitative terms. The following example shows how a seasonal rainfall probability forecast could be presented as a pie chart:

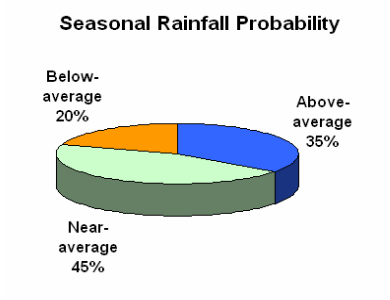

Figure 3 Example of a rainfall probability pie chart

One of the attractive features of this format is that it shows all possibilities at once. Users are therefore made aware not only of the most likely outcome, but also of alternatives.

Another effective way of showing uncertainty, particularly uncertainty that increases with lead time, is the use of time series that include 'error bars'. Below is an example of a time series forecast of temperature that shows the uncertainty at each time step:

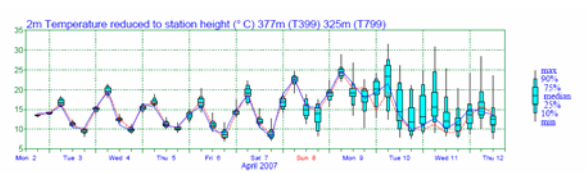

Figure 4 Meteogram of forecast temperature from an ensemble prediction scheme (ECMWF)

Icons

It can be difficult to utilise a pictorial icon for communicating uncertainty. Where icons are used for this purpose, it is common practice simply to superimpose the uncertainty information in numerical terms (e.g. as a probability) on the icon, for example:

Figure 5 Icons showing forecast probability (NOAA National Weather Service)

Charts and maps

Uncertainty information lends itself well to spatial depiction. A chart or map presentation is often an effective way to present both the forecast and the uncertainty associated with it.

The Greater Horn of Africa Consensus Climate Outlook shown below is a good example. Zones of equal probability range are colour-coded (with grey for the neutral forecasts) and show at a glance the spatial distribution of rainfall likelihood.

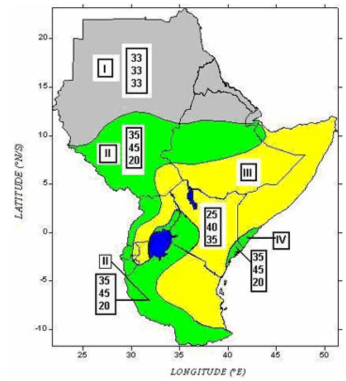

Figure 6 Greater Horn of Africa Consensus Climate Outlook (IGAD Climate Prediction and Applications Centre)

For each region on the map, a seasonal forecast is also provided in the form of a box containing three numbers. These numbers (from top to bottom) are the % probability of above-, near- and below-normal rainfall. The beauty of showing all three numbers together, is that all scenarios are described. In other words, it is made clear to users that although one particular outcome might be the most favoured, the alternatives are also possible.

This format is frequently used for short and medium-term probability forecasts as well. Such forecasts are most commonly produced by ensemble prediction schemes and can be presented in a number of complementary ways. For example, rainfall probability charts can be presented according to defined rainfall thresholds (e.g. the probability of rainfall in excess of 5 mm):

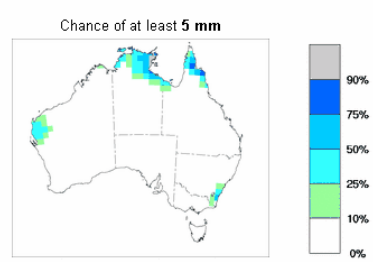

Figure 7 Map showing probability of at least 5mm of rainfall (Australian Bureau of Meteorology)

Another example of effective graphical presentation of uncertainty is the tropical cyclone forecast track (Figure 8), issued by the Cuban National Forecast Center. The depiction of the forecast track as a cone ensures that the general public do not put too much emphasis on a single path and therefore assume they are safe if the path is not shown passing directly over them. Also, this depiction reinforces the fact that, due to its size, a hurricane can affect a very large area and is not confined to a point or narrow swath. The explanatory note at the top of the graphic is very important: "Assuming AVERAGE FORECAST

ERROR – the EYE should track in the white cone in next 72 hours".

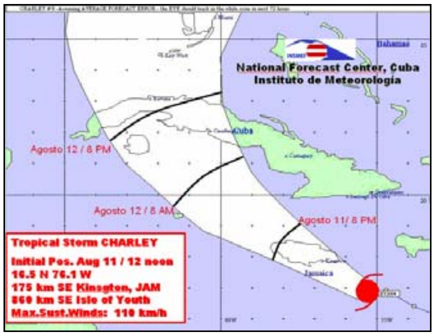

Figure Tropical cyclone track forecast and average error (Cuban National Forecast Center)

Scales of uncertainty

Worded categories

When describing uncertainty, it is often useful to use pre-defined categories that have specific meaning. This assists users to understand the precise level of uncertainty that the forecaster has in mind. Such an approach is demonstrated by the IPCC Likelihood Scale in Table 1.

Numerical categories

Uncertainty ratings can also be assigned using a numerical scale. This does not necessarily add more information than using worded categories, but it is simple and make the forecast easier to read. As long as users know how the numbers are defined, then it can be a quick and efficient way to convey uncertainty information.

This approach has been adopted by the Swiss Federal Office of Meteorology and Climatology who include as part of their forecasts a 'reliability' measure on a scale from 1 to 10 (Figure 9).

Figure 9 4-day forecast, including measure of reliability (out of 10) (Télévision Suisse and Swiss Federal Office of Meteorology and Climatology)

Probabilities

Perhaps the most common way to express uncertainty information is to use probabilities. This is a concept that users are very familiar with. Like any quantitative measure, probabilities should be defined carefully and their meaning should be clearly explained to users.

When defining a forecast probability, the first decision is to choose what quantity the probability will refer to. It may be the occurrence of some phenomenon at a particular location and time, e.g. the probability of a thunderstorm. It may be a category, e.g. the probability of 10-50 millimetres of rain. A common choice is anomaly category, e.g. the probability of above average rainfall. The choice will be dictated by the phenomenon under consideration and the service requirement.

One of the particular challenges for users of probability information is having a reference point for the information. This is particularly important to assist with interpretation and response. It can be a good idea to accompany the probabilistic prediction with a comparison to the normal. For example, a prediction such as "60% chance of a storm this afternoon" is enhanced if a message such as the following is attached "This is about twice the normal chance for this time of year."

Although probabilities are a commonly accepted means to convey uncertainty information, they do come with particular communication difficulties. For a start, many users simply wish to know whether the forecast event will happen or not. These users are not interested in probabilistic predictions and will often view such predictions as an attempt to avoid responsibility and to 'hedge bets'. This is where effective user education is required, so that there is an appropriate understanding of why meteorology is not an exact science.

The consequence of this is that, in the absence of a categorical yes/no forecast, a user may turn to the probabilistic forecast and translate it into a categorical one. For example, a seasonal prediction for an increased chance of above average summertime temperatures may be interpreted as a statement that it will be a hot summer. There are countless examples where the media have oversimplified probabilistic outlooks in this way, in order to generate a catchy headline.

A second challenge is to understand what the probability of occurrence actually refers to. Is it at a point? Over a spatial area? Or over time? Every effort needs to be made to ensure that the terminology is clearly defined and understood, not just by the users, but by the forecasters who issue the forecast as well.

A third challenge is the so-called 50-50 problem. This arises when there is no strong influence on the atmosphere favouring one particular scenario over its alternative. For example, in countries affected by El Nino, during neutral phases there is no strong influence away from the average, and seasonal forecasts may say something like: “50-50 chance of neutral rainfall conditions”. Although this statement has meaning from a strict climatological perspective, it leaves users with a strong sense that the service provider is ‘sitting on the fence’. At times like this, it may be better to present the forecast in another way, perhaps by presenting probabilities of rainfall (in this example) according to defined threshold amounts.

Different media - different methods

The choice of method and format for communicating uncertainty information will greatly depend on the media being utilised. What works well in one channel may not be effective in another.

For face-to-face weather briefings, or radio interviews, or wherever the forecast can be provided verbally, the use of plain language and narrative can be effective. In these settings, the forecaster has time to explain the situation, can discuss alternative scenarios, explain why and how the NWP models are different, and give an overall and comprehensive view of the situation. The use of non-verbal communication skills, such as speech intonation, or body language, can also be very effective ways to give the listener a sense of the forecast confidence.

Where the forecast is presented in a more prescriptive way, such as in writing, then the forecaster should ensure that their description of uncertainty is confined to pre-defined or well-understood terms. If phrases such as “a chance of” are used, there should be some underlying definition that specifies what this chance is numerically equivalent to. Numerical measures of uncertainty may also be used.

Graphical depictions of forecast uncertainty are a very useful presentation style and are especially suitable to web-based display. These can be accompanied by explanatory information to help users interpret what can be rather complex information. For television, the options are more restricted due to the limited broadcast time available. A simple ‘confidence index’ may be the best approach here.

Conclusion

Uncertainty is an inherent ingredient of forecasting and communicating it effectively is of great benefit. It helps users make better decisions, and it helps service providers manage the expectations of users for accurate forecasts.

This paper has addressed the issue of communicating forecast uncertainty. The emphasis has been on how service providers can incorporate uncertainty information in their meteorological forecast services, including the best ways to communicate this information to the benefit of users. Examples have been given of effective presentation methods and some of the pitfalls have been highlighted. Service providers are encouraged to use this information as a guide on how best to communicate forecast uncertainty and make it a routine and effective part of their service.

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Needs of Meteorological Services in Africa's Least Developed Countries (LDCs)

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Abstract: *The economies of the majority of the 35 African Least Developed Countries (LDCs) are based between 10 and 20 per cent on agriculture, which is highly vulnerable to climate variability, and more specifically, precipitation and the harmful impacts of climate changes. There are other socio-economic sectors which influence GDP: health, water resources, food security and the effects of natural disasters of meteorological origin. In this context of devastation and extreme poverty, the National Meteorological and Hydrological Services (NMHSs) must simultaneously develop prevention strategies and new sustainable initiatives aimed at lifting Africa's LDCs out of their under-development status. For the NMHSs of African LDCs to be able to achieve this, a far-reaching programme of both human and material capacity-building will be required, in order to provide the means to accomplish their mission through innovative techniques in sensitive sectors such as agriculture, water resources, food security, health and public security, and to support sustainable development. Early warning systems for natural disasters of meteorological origin and illnesses with climate-related causes (malaria, meningitis) will also be needed as well as the broadcasting of seasonal forecasts to aid sustainable agriculture, for which purpose the NMHSs of African LDCs will require institutional, economic and scientific support from their governments, and national, regional and international agencies (WMO and WIPO).*

1. Introduction

Composite indicators show that the 35 African Least Developed Countries (LDCs) have a GDP of less than US$ 900, with an estimated population of 35 million inhabitants in an area of 12 million km². These LDCs' economies are largely based on the agricultural, stockraising and fishing sectors, which are highly dependent on climate conditions and are thus very vulnerable to current and future climate variability and changes. There are therefore numerous challenges for these different sectors.

Improving means of subsistence at the level of these LDCs will therefore require a strengthening of the NMHSs' human and material resources, and innovative action supporting the sustainable development of agriculture in the broad sense: water resources, health, food security, public security and alternative energy sources.

2. The context

The problems relating to lifting Africa's LDCs out of their under-development status are considerable, above all in the context of changes in climate conditions and their effects on socio-economic sectors.

Climate context

- A rainy season of 2-6 months in most LDCs and of 9-10 months in those of the Gulf of Guinea, and central and southern Africa.
- A notable decline in rainfall over the LDCs of the Sahel, the Horn of Africa and southern Africa.
- A substantial temperature increase, with a dry season of 6-8 months along with high levels of sunshine and evaporation, and a sharp decline in humidity levels and water resources.
- A noteworthy 30 per cent decline in precipitation events in the Sahel region (Le Barbé and Lebel, 1997)
- Climatic variability and changes, leading to an increase in extreme weather phenomena

- ***Socio-economic context***

- Subsistence agriculture is practiced in the LDCs largely because of unfavourable soil and climate factors; it nevertheless remains the region's most important economic sector, supporting 50 to 70 per cent of LDC populations and producing 10 to 25 per cent of their GDP. It is characterized by a notable decline in agricultural production, productive capacity and revenue; over-exploitation and poor quality of land; obsolete agricultural implements; low access to credit and other inputs, the irrational use of natural resources; disappearance of fallow land; and loss of cultivated areas to recurrent droughts or heavy rains.

- Water resources: declining levels of the major rivers such as the Senegal and the Niger, and of lakes Chad and Victoria; the disappearance of pools and water-holes for livestock.

- The increase in diseases of hydrological origin (malaria and diarrhoea) and of lithometeoric origin (meningitis, fevers and allergies).

- Increase in extreme weather phenomena and in their impacts on the economies of these countries; increase in climate-related natural disasters, which slow down LDC development.
- Since 1980: flooding in Mozambique with seven significant droughts and seven extensive floods.
- Flooding in the LDCs of the Gulf of Guinea, Sahel, Horn of Africa and Southern Africa.
- Tropical cyclones and tidal waves on the eastern coast, in Madagascar and Mozambique.
- Droughts in Ethiopia, Eritrea, Chad, Niger, Mali and Sudan.
- Un-seasonal heavy rains in Senegal in January 2002.
- Desertification in the LDCs on the edge of the Sahara and Kalahari deserts.

3. Meteorological Services' requirements

The NMHSs' requirements with respect to LDC development are considerable. For example:

- The need to strengthen the NMHSs' human and material resources; above all recruitment of middle- and senior-meteorological managers in the areas of administration, resource mobilization, strategic planning, marketing and communication.
- The need to train managers for African LDCs, capable of developing strategies for adapting to changes, sustainable development, making governments aware of the importance of the information issued by NMHSs, and contributing to socio-economic development in the above-mentioned sensitive sectors.
- The need to acquire modern technical materials to reduce the uncertainties of short-, medium- and long-range forecasts; to improve systems for preventing natural disasters of meteorological origin.
- The need to increase strategic partnership links with national, regional and international groupings and agencies such as the United Nations, WMO, WIPO, WHO, UNFCCC, World Bank, African Development Banks, ACMAD and AGRHYMET to strengthen productive capacities and finance projects for adaptation to climate change.
- The need to strengthen meteorological observation networks in order to have a databank and facilitate access to it; this will allow better monitoring and evaluation and increase the reliability of forecasts adapted to the sectors of agriculture, health, water resources, and reduction of natural disasters of meteorological origin.
- The need to develop and implement strategic plans for communication, information and transfer of knowledge and products for the users' benefit, by putting in place a notification and early warning system to reduce the harmful effects of extreme weather phenomena on sensitive sectors.

4. Case studies and lessons learned

This project aims to understand the monsoon dynamic, integrating the results of three-month forecasts, as well as forecasts for one to seven days, in agricultural practices, and evaluating the climate's influence on the growth and yield of the two chosen crops (souna millet and groundnut), while placing the farmer himself at the heart of the matter.

Interpretation of the results of the seasonal forecasts for July, August and September 2007 allowed the selection, in collaboration with the target zone's farmers, of seed varieties adapted to an anticipated rainy season, agricultural inputs (manure, urea and fertilizers) and the optimal dates for sowing. A multidisciplinary team composed of staff from the NMS, the ISRA/CERAAS and the DRDR arrived on site in mid-June charged with explaining objectives and procedures, putting in place monitoring mechanisms, training the selected farmers to collect and record the results, and installing thirty raingauges, as a supplement to the existing network alongside the four synoptic stations at Bambey, Diourbel, Fatick and Kaolack. Mobile telephones were supplied to five farmers in each of the five villages, to enable real-time communication of meteorological information and fast information exchange and transfer between the two parties: the Technical Steering Committees (TGC) and the target zone's farmers. This is intended to encourage unhesitating, active communication between the parties, to make consideration of climatic factors part of farming practice, and to change behaviour and mentalities.

Application of the short-range forecast results has allowed a systematic survey of the monsoon dynamic and assessment of its impact on crop growth. Agrometeorological advice is sent by telephone to "pilot" farmers so that they can pass on the information to the neighbouring farmers, who will apply it to their meteorological plots. Seasonal and short-range forecasts have been evaluated to assess how accurate and reliable they are. The crop yields of different meteorological plots and farmers are analysed in an attempt to evaluate the economic impact of the African monsoon and the agrometeorological advice.

In the context of devastation linked to climatic changes and their harmful effects on the economies of these poverty-stricken countries, the NMHSs have a duty to take the lead in promoting innovative action to reduce the effects of natural disasters of meteorological origin: putting in place early warning systems for cyclones for LDCs such as Madagascar and Mozambique, along with information and early warning systems for health problems such as meningitis and malaria; developing seasonal forecasts and broadcasting them at a suitable time to enable planning; and proposing choices and options for the rainy season.

5. Meteorological products for the public

- Daily meteorological, agrometeo-rological and hydrological bulletins are published and broadcast in the media (radio, television and the written press).
- Every Monday and every ten days, meteorological, agrometeorological and hydrological bulletins are published and transmitted to decision-makers and to all the different people involved.
- The results of short-, medium- and long-range forecasts for the different sectors are broadcast according to each different sector's needs.
- Annual reports on the agro-hydrometeorological situation are published and transmitted.
- Opinions, advice and recommendations concerning emergency situations are supplied to all the different people involved to help with the decision-making process.
- Early warnings of extreme weather to support food security are published and transmitted to decision-makers and aid organizations.

6. Conclusion

The NMHSs of African LDCs are therefore obliged to develop priority initiatives in the vital sectors of health, agriculture, food security, water resources and natural disaster risk reduction, on both regional and national scales and in partnership with the scientific and economic agencies.

To be able to achieve these progress objectives, the NMHSs of African LDCs need to strengthen both human and material resources with the support of scientific and socio-economic institutions, whether national or international, with the aim of fully contributing to their countries' development.

Mr Jarraud said that failure to invest sufficiently in the Least Developed Countries' National Meteorological and Hydrological Services would compromise the struggle against poverty and perpetuate vulnerability to climatic hazards, such as tropical cyclones, flooding and droughts.

He also made it clear that disasters linked to weather, climate and water could lead to a 15 per cent reduction in the GDP of some LDCs, paralyzing their economies.

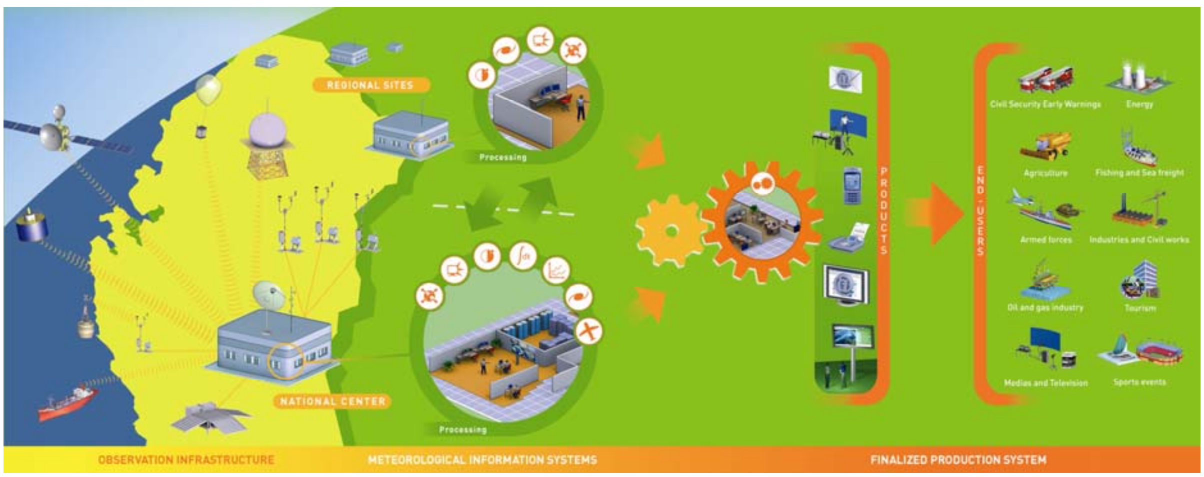
According to him, each dollar invested in the NMHSs has, on average, a tenfold return.

Capacity Development
for Investment and Policy Decision-Makers

Patrick Benichou
Meteo France International

Abstract

Setting up a full capability of service delivery is a real challenge for National Hydrological & Meteorological & Services (NHMSs). Meeting this challenge means technical skills / systems but mainly requires non technical actions such as educating users, NHMS management, policy makers, and donors whenever. Switch to user-oriented strategy is generally needed and will impact on NHMS organization, systems and workflow. It's a long process which must involve all levels in NHMS as well as users themselves or their representatives. Switch to service delivery capability is more and more welcome by donors who may accept to fund modernization projects which are explicitly aiming at maximizing socio economic benefits.



How the development of service delivery capability (right) drives the overall NHMS' modernization process and workflow

Introduction

Setting up a full capability of service delivery is a real challenge for National Hydrological & Meteorological & Services (NHMSs). Meeting this challenge means technical skills / systems but mainly requires non technical actions such as educating users, NHMS management, policy makers, and donors whenever.
Service delivery to all users categories is hereby called PWS and therefore encompasses much more services than services to media and general public only. It is also assumed that delivery of warnings is explicit part of service delivery.

Meteo France International (MFI) is the dedicated entity in charge of transferring know-how, knowledge and technology from Meteo-France. MFI implements comprehensive modernization projects worldwide. PWS has become a key component of such projects.

This paper is split into three parts

- first presentation of overall PWS context, typical NHMS workflow, and assessment of NHMS and decision makers' readiness for PWS.
- description of kind of education needed for users, NMS Management, stakeholders, policy makers, donors
- mention of what a third party can bring to help in the process.

This paper also reflects MFI's experience in leading modernization projects including setting up PWS component in several countries worldwide.

What are we talking about?
Setting up a successful PWS capability assumes a robust and fitted organization within NHMS, and also depends on the local/global context.

A favourable context

General context shows positive and negative features. On the one hand, one can acknowledge a significant and growing understanding of socio-economic impact of weather and benefit of meteorological information; there also is, from MFI experience in more than 60 countries, a general trend and eagerness at NHMS and local policy makers level for developing service capability.

On the other hand, other factors are less favourable, among which the poor readiness / awareness of many NHMSs, which may be due to several reasons: the user-oriented approach, which is very much common in most sectors of economy, is not there yet, NHMSs have a poor knowledge of who their users are / may be, what are / may be their needs / expectations, the status of NHMSs is generally not fitted to cost recovery and strong development of PWS. Last, despite increasing amount of technology available from the market, many NHMSs have not upgraded (or built) their Information System and are simply not aware of any comprehensive system technically able to help them perform services to the users.

In short, PWS is generally not yet enough tackled as a whole in NHMSs' development strategy.

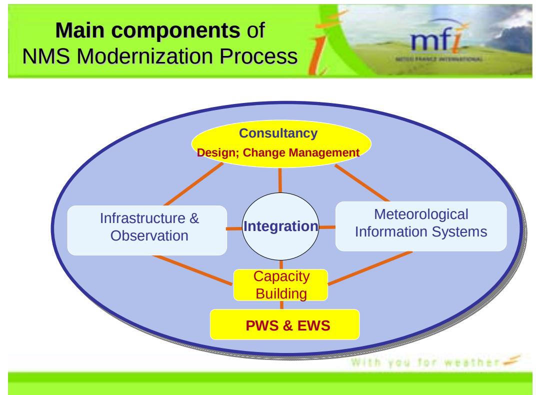


Fig.1. Architecture of NHMS's modernization plan

The above lay-out shows that PWS/EWS can be built after NHMSs has secured a robust Observation system, Information System, performed relevant level of integration to make all investment in equipment cost-effective and provide all sources of data to PWS/EWS component. It also shows that beyond system integration, initial design, consultancy, and capacity building are key factors in the success of PWS/EWS approach.

Last, one have to say that Public Weather Services (PWS), and most probably Early Warning Systems (EWS) are a matter of <u>sovereignty</u> in many countries, which underlines the need for setting up an effective organizational and technical capability in this field.

We can mention two main international references in this respect:

> One is the GCOS – ClimDev Africa initiative (Action Plan for Africa, Apr.2006) which ultimately aims at taking Climate Change into account in countries' governance.
>
> Another significant one is the Madrid07 Action Plan (WMO, Mar.2007). Such document includes a dozen of main actions as agreed upon at the end of this major event. It is striking to observe that those actions (rephrased and summarized hereafter) can be split into:
>
> <u>Technical actions</u> (system enhancement) such as:
>
> - Action 5: strengthen observation systems, models and PWS systems

- Action 9: increase capability of multimedia dissemination

Non Technical actions (methodology and capacity building) such as :
- Action 2: identify user requirements and improve/increase production to end-users
- Action 3: start capacity building endeavours for users and service providers
- Action 4: increase recognition of NMSs contribution by government & stakeholders
- Action 6: improve dialogue between users and providers through tools and methods
- Action 8: increase partnership between users and providers, evaluate performance
- Action 10: develop methods for quantifying benefits per sector, especially for developing countries, present results to government & donors in the goal of modernizing NMSs' infrastructure and service capability

Implementing Madrid07 Action Plan means tackling above listed actions through concrete projects at NHMS level.

Technical vs Non-Technical factors

From previous section, it is clear that setting up a full service delivery capability relies on critical Technical and Non-Technical Factors. From our experience in the recent past, we can make the following statement:

- **Regarding Technical factors:**

- Supply of a compact and integrated production system should be able to help design tailored products (*bottom left part of PWS layout hereafter*), to elaborate (*central part*) from the whole set of raw and expertised data (*top left part*), disseminate (*central right*) a high number of tailor-made products and warning to a wide spectrum of users (*right part*) through different means of telecommunication (fax, voice, internet, …) depending on local telecommunication facilities;

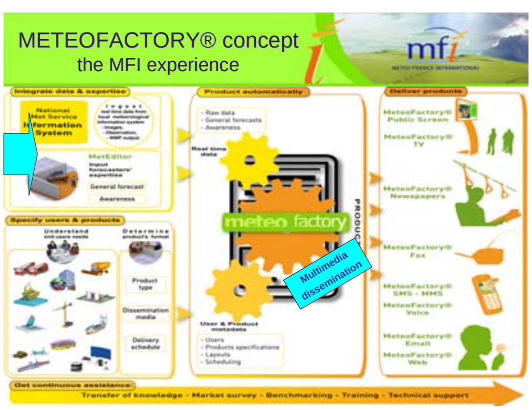


Fig.2. Typical PWS/EWS concept

- Capability of said production system should not be limited to media (TV, newspaper) and general public but should address all sectors of activity / economy;
- Same Production system should technically address Early Warnings the same way as regular production, or at least include EWS as an explicit and integrated part of the overall system.
- For above reason, forecasters' expertise should be explicit part of input data to PWS/EWS production system

- **Regarding Non-Technical Factors:**

- Transfer of knowledge, know-how, experience, should be sought from more advanced NHMSs when/where relevant;
- Identification of relevant user categories, users, and user requirements should be performed;
- Market studies may also be performed;
- Forecasting vs PWS/EWS organization should be updated and thought as a whole, either in a centralized or in a distributed/regionalized mode;
- NHMS's strategy should be updated / changed through a user-oriented approach

The above non-technical aspects are underestimated most of the time.

Somewhere in between Technical and Non-Technical aspects is the design and implementation of a fitted nationwide Info System. Such Information system may be centralized of distributed depending on country size and NHMS's strategy. However, PWS often requires some proximity to the users. Setting up a relevant and comprehensive Information System generally takes time and may be a prerequisite (at least for critical components) to setting up of PWS/EWS capability.)

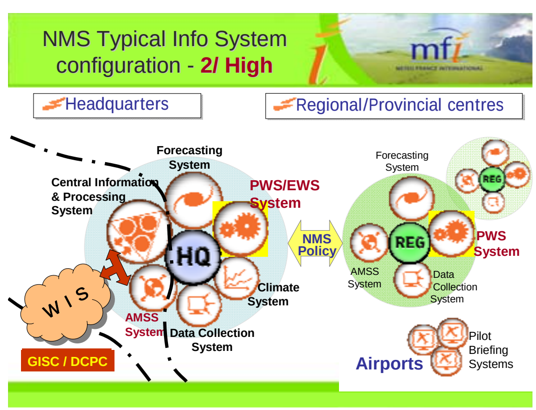


Fig.3. Integration of PWS/EWS in a distributed Information System (High scenario, distributed)

Whom PWS education shall address?

From the above, service delivery capability means a lot of efforts (and therefore time) to educate users, NHMS staff and also management, policy makers , and donors when involved/sought in the process.

Users

Users need to be met, and educated, on different basis: General Public, Macroeconomic scale (economic sector), Microeconomic sector (user level).

- **General Public:**
  This topic is generally addressed through services to medias, and training of media specialists. The main goal is to have a wide majority of people able to get and understand warnings from NHMS, and (re)act according to recommendations. Setting up simple procedures as the proven French "Vigilance" procedure help a quick and effective education of users, and ultimately saving lives and properties and prevent major losses.

- **Microeconomic scale:**
  At this level, it is important to remember about the value of forecasts: as commonly said now, "*forecast has no value unless it influences decision making*".
  Having said that, it is therefore important to
  - Identify users: training is then more with NHMS than with users themselves at this stage;
  - Introduce NHMS's capabilities (forecast skill, EWS, PWS, applied meteorology): in this case training is shared between users of course, and also NHMS when needed;
  - Help users specify their needs and related PWS products (content, delivery time and media, frequency): again, this should be made by NHMS's staff or consultant generally.

The above training/education actions should be performed over a reasonable period of time and involve users, NHMS's personnel, and consultant(s) if/when needed. Such actions may be performed through interviews, survey of user categories, meetings/seminars at HQ ou Regional level.

- **Macroeconomic scale:**

Education at this stage should include several components:

- Perform studies in the field of Economic valuation of meteorological information per region / economic sector. Studies performed in this field show that they are a good opportunity for exchanging between NHMS and user representatives, and therefore train/educate current/potential users in main sectors of economy. Study itself may be led either by NHMS itself or by Consultant; despite abundant literature about case studies, there is a strong need for proven, simple and reliable methodologies for large scale assessment. Such studies generally contribute to better knowledge and awareness ant NHMS, economic sector, policy makers, and donors level (see next sections).
- How to reach most users effectively, how to manage successful warning dissemination?
- How to build successful partnerships?

Above mentioned educational actions/studies mainly address representatives of user categories or economic sectors. They can come in the form of interviews, seminars, expert panel meetings, involving NHMS representatives at suitable level.

NHMS staff

In many countries NHMS staff does need sustained training and support to be able to

- Talk to existing / potential users properly about NHMS capacity
- Design appropriate service / product for particular user(s)
- Operate PWS/EWS system on a daily basis and guarantee production quality and timeliness.

Obviously training is expected in both technical and non technical fields.

WMO training courses on PWS aim at filling the gap, but should be complemented by more intensive training and support on the long run when appropriate.

NHMS Management

In our view, NHMS management should mainly be involved in strategic aspects and also in the choice of the PWS/EWS system

- **Towards user-oriented strategy**

The need for NHMS's management is mainly to get support in :

Assessment of current situation (there are proven methods available such as context evaluation, SWOT/PEST analysis…);

Preparation of a strategic Action Plan including:

- Critical analysis/design of Information and Observation Systems to support service delivery;
- Design of PWS/EWS system, start of systematic Forecast/Production verification,
- Strengthening of Applied Meteorology (taking into account users' value chain),
- Setting up of prioritary partnerships in Civil Security (for warnings) and through relevant organization (e.g. Public-Private-University partnerships) for applied meteorology and related services.
- Update NHMS organizational chart (including PWS entity, Marketing when/where relevant), assess optimum status for NHMS new strategy (separate entity?)

Ultimately, assistance to NHMS's Management should lead to updated Strategic Plan taking into account the user-oriented approach. WMO Strategic Plan is of course a relevant basis in this respect.

Last, assistance to implementation and to Change management may also be sought by NHMS top management.

All above training, assistance, consultancy, support may be brought by Consultant(s) and in some cases by WMO experts.

Such services must preferably be provided through a continuous process, parallel to PWS project implementation.

- **Building the technical solution for PWS**

In many cases, as seen in §2.1, the context is favourable, and the NHMS's willingness to proceed is there. It may not be sufficient. "*What shall we start from? What shall we start with*?" are commonly asked questions, for reasons related mainly to lack of reliable Information System on the one hand, lack of consolidated vision about PWS/EWS and user-oriented organization in the other hand.
Assistance to Management and PWS department may be relevant for:

- Identification of technical solutions to meet users' requirements;
- General training (managers, new PWS and/or Marketing teams)
- Defining and implementing new work positions (assistant forecasters, Marketing, …) in (updated) NMS organization chart

Such assistance may naturally come in parallel of PWS project implementation.

Policy Makers

Policy Makers and Government bodies in general are natural targets for education on PWS/EWS. Main topics may be :

- Education on Workflow (see figure on first page) from observed data to user) to educate Investment makers (umbrella, donors) on cost effectiveness and benefit from investments. Of course 1 $ or 1 € investment on Observation systems will be more easily approved if it leads to integration, contributes to PWS, and finally to country benefit.
- Concept and assessment of socio economic benefit at country level (macro scale as explained in §3.1), and expected impact of modernized NHMS in country economy or welfare. This may help making decisions on major investment in NHMS modernization.
- Administrative status of NMS vs cost recovery: How to change NMS to independent body?
- EWS and Disaster Management

Ministries, Planning Organizations may welcome such education / assistance, which should be provided by NHMS top Management assisted by Consultant whenever necessary.

Files, reports, interviews, even films may be relevant in this respect.

Educate/Convince donors

In the context as described in §2.1, donors are more and more looking at meteorology, and may positively contemplate funding modernization plans for NHMSs. Educating donors is therefore of paramount interest for NHMSs. Main topics are again:

- Meteorology of course! Unlike NHMS umbrella, donors are not (yet) specialized in this field and need to get basic knowledge of meteorology, and mainly typical workflow
- Socio economic benefit of meteorology (as already mentioned in §3.1-4), for better investing in NHMS infrastructure when needed.
- Disaster Management and relation to Meteorology
- Climate Change and relation to States governance (e.g. ClimDev Africa and Millenium Objectives)
- Typical modernization projects

Main donors (World Bank, multilateral funds, AfDB,…) may welcome such information.
Training / consultancy may be provided by Consultant, advanced NHMSs, local NHMS as well. Such education may come in the form of seminar (e.g. Madrid07), country initiatives, preliminary studies, direct contacts, draft projects.

What a third party can bring?

As seen above, setting up a full PWS/EWS capability may often mean modernizing part or whole of NHMS's infrastructure and organization.

In some cases, NHMSs may welcome assistance of a third party in the process, as they may not be familiar to strategic, organizational, technical, impacts of such projects.
A third party may bring services in following fields:

- Act as in-between between NHMS, government, and users, while relying on WMO guidelines
- Help increase confidence between NHMS and users, NHMS and policy makers, or with NHMS management, or with donors.
- Accompany NHMS in the (complex) overall process from design to operational implementation

MFI (Meteo France International) has references in assistance and successful implementation of EWS/PWS in the past years:

- Kenya (EWS/PWS 2007-2008)
- Qatar (EWS/PWS and specific assistance to Asian Games 2006)
- Indonesia (EWS 2005, PWS 2006, regional PWS 2007)
- Libya (TV 2007, EWS/PWS 2007-2008)

Summary

Building capability in service delivery is a wide technical issue which includes upgraded centralized or distributed Information System in all cases, and sometimes strengthening of observation networks
However, setting up a full PWS/EWS capacity may also be the main non-technical issue in NHMS modernization process.

PWS component should address all levels (users, NHMS management, policy makers, donors); it has become a strategic issue which requires Top Management involvement as it can impact on the whole NHMS human and system organization.

Service Capability development is a major challenge in itself and is now driving the whole NHMSs modernization process in many countries.
Education, Assistance, Support, Capacity Building, are strongly relevant in this respect for investment and policy makers, but also for NHMS Management.

Implementing PWS capability is a comprehensive project in itself with technical and mainly non-technical issues; such a project should be quite related to other parts of NMSs activities and systems such as Observation and Information Systems; it is not an immediate process!

Switching to user-oriented strategy requires awareness of NMS Management, Policy makers, donors (whenever); it also require a global vision and strategy update that can be shared with third party assistance/ consultancy.
Setting up a full service delivery capability means parallel projects: technical implementation, strategic update, parallel support to organization and relation to users. Such efforts will ultimately benefit to safety of goods and people, economic sectors and the whole country.

NHMSs have to successfully manage this move in order to fulfil their mission.

http://www.mfi.fr

Political, Economical Technological and Cultural Influences That Will Shape Service Delivery in the Next Decade

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Environment Canada

Abstract

Public Weather Services are often challenged to look beyond 5 days, and the purpose of is to provide insight on the major influences that will impact on the very nature and delivery over the next decade or even two. There are many powerful influences as we look to the decade ahead. However, one particular force which is often overlooked is that of culture. Be it language, customs or ways that we will be doing things in the future, culture will have a significant impact on not only how Public Weather Services are shaped, but also on the range of services delivered. It is also important to realize that these services will not necessarily be homogeneous across all our nations in future, just as is evident today. Moving forward, local capacities, influences and needs will play a significant role in defining the public weather services of the future. However there are many common drivers including socio-political concerns over a changing climate, a new digital age and the ever shifting expectations of stakeholders - an understanding of which will lead to improved future information and services.

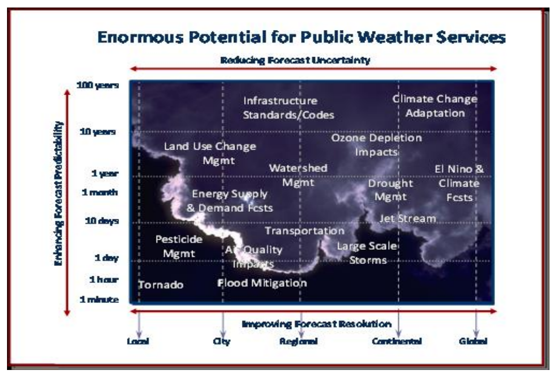
Introduction

There are several key influences, presenting significant challenges and opportunities when considering the evolution of national Public Weather Services (PWS) programs today. A diagnosis of these factors should provide insights into effective planning and development of relevant, user-defined products and services of National Meteorological and Hydrological Services (NMHS) in the future.

Global trends on population demographics, changing climate, public security, economic competitiveness, unsustainable use of the Earth's resources are challenging societies' capacity to cope. Governments are under enormous pressures to mitigate against these escalating risks on their citizens on such concerns as food security, water availability and health. PWS can play a key role to alleviate these challenges.

Glimpse of a Future

NMHS should be an essential part of this public policy response by providing the relevant information and services to permit society to adapt to future changes in weather, climate and other dimensions the environment over very short to long term time scales. Their public weather services programs should become increasingly recognized as providing an expanding core mission-critical capacity for government in more and more nations to cope with these public policy challenges.

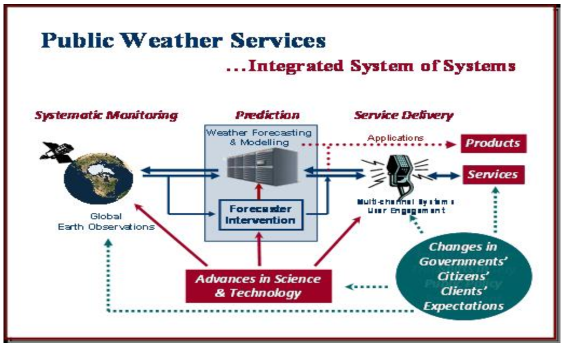


Therefore, the national Public Weather Services program should be different in a decade; however, this will require significant organizational commitment (change & investment) to become a reality. Early recognition and adaptation to changing circumstances (trends) will create opportunities for PWS' to better serve governments, greater numbers of people and interests over the long term. And as a consequence, societies will effectively benefit by the assimilation of new and changing environmental information into policy formulation and decision-making processes that will likely challenge past customs and assumptions.

Noteworthy Barometers

Public Weather Services are the "public" and often the "political" face of NMHS'. The provision of services for most is scientifically complex, and the figure illustrates typical interactions among various systems functioning to support them.

This visualization is also important to better appreciate the importance of monitoring two key barometers: *advances in science and technology* and *public policy*



expectations. Both should have pervasive influence on the products and services of NMHS' in the future. Public expectations, including those of their institutions are shaped by transformative trends in the economy society and the environment at global and local levels. And often, these trends result, eventually in shifts in government policy that would impact on scope of national PWS programs. For that reason, successful evolution of PWS programs will strongly depend upon the degree by which NMHS engage their citizens, clients and partners in establishing priorities, adapt to shifts in their government's public policy and integrate advances in science and technology into their PWS (weather forecast) systems.

Key Global Influences

Natural and human-induced changes in the Earth's land surface, atmosphere, oceans, cryosphere and biosphere will continue to significantly impact our planet, impeding social and economic progress of all nations. Scientific information, assessments and predictions derived from systematic monitoring are essential to support improved decision-making and informed, evidence-based policy development, underpinning legislation, conventions and treaties across a wide range of societal challenges. Specifically, there are several common key global influences[12, 13] that will implicate how governments should see the role of PWS' in future and thereby their products.

First and perhaps foremost, PWS' will be called upon to support their government's goals to reduce their vulnerability to a changing climate. Adaptation responses will be informed by understanding changing patterns and severity of weather, water and climate. Concerns over the natural environment are growing in importance particularly the impacts that pertain to sustainable development. A future could invite PWS' who have significant scientific and technical expertise to serve as watchdogs, reporting on changes to key environmental indicators.

Population growth and changing demographic patterns

will result in continued intensification in urban centres, aging populations in developed countries and significant growth in developing ones.

The use of scarce resources such as water and energy will be a challenge and PWS' will be expected to support local governments in allocating the wise use of these resources.

Human health concerns will continue to mount both in the developed and developing world requiring improved Earth system predictions to track and aid in the forecasting of conditions leading to possible disease outbreaks.

World continues to be unstable and will likely continue into the foreseeable future. Governments concerned about the growing security of citizens particularly from natural and human-induced hazards will turn more and more to PWS' for support in alleviating these risks. This should not be a surprise recognizing our unique science and service delivery capacities today and what they should resemble in future.

Economic globalization respects no borders. Changes in stock market volatility in one part of the globe have almost immediate impacts on others. Globalization is putting increased pressures on nations to become more innovative and competitive in order to remain effective. To this end, PWS' have always been viewed as supporting economic advantage for transportation and primary industries such as agriculture and agri-food. As economies continue to look for more niches in future, environmental factors will continue to impact on their effectiveness.

In future, due to liberal finance and trade policies, competitiveness factors and alternative governance considerations, non-state actors may assume many of the roles once established for NMHS both for profit and not for profit services. Efficiency and effectiveness

[12] Global trends 2015. Central Intelligence Agency, U.S. Gov.

[13] Global trends 2005: An owner's manual for the next decade. Michael J. Mazaar.

considerations are important for reaffirming national or state roles for NMHS'.

Finally, sustainable growth is the culmination of all the factors and a long term goal of governments since the first Summit on the Environment in 1972. Understanding and integrating the impacts of societal growth requires a strong foundation of environmental knowledge. And, in many parts of the world, NMHS' play this role. In the future, reporting on environmental indicators and trends on the impacts of growth will assist governments in making effective choices about the future.

Understanding Emerging Societal Risks

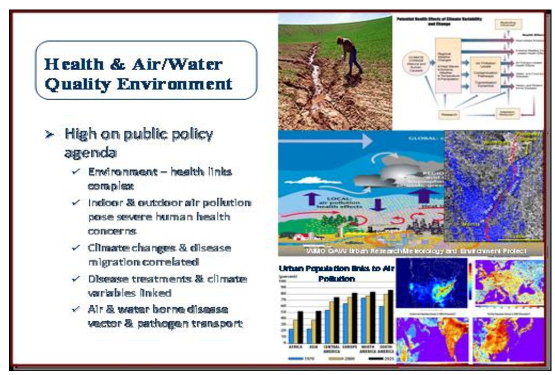
These major global trends continue to challenge national governments, individually and collectively to optimize the benefits and to mitigate the negative consequences. Risks and vulnerability to society continue to mount. Governments are becoming increasing concerned over the health and well-being of their citizens, consequences on

their cities (increasing urbanization and decreasing societal resilience), and access to clean life-essential natural resources (air, water, etc.). In addition to informed policy choices and decisions, governments are also seeking efficient means to effectively serve their people. This should have consequences on ways and means that governments choose to meet this goal, possibly even going beyond national borders. As a consequence, the outputs of NMHS', its PWS' must be responsive to the changing needs and requirements poised by policy problems, informing solutions but in the most effective and yet efficient way.

Over the past 2 decades there has been a dramatic rise in both numbers and impacts of natural hazards.[14] The 4th Assessment Report of the IPCC points to the increasing likelihood of severe weather and environmental events over time. In Canada for instance, floods have increased in number four fold as compared to 50 years ago.[15] As a consequence, Governments, emergency planning and management organizations will expect more from PWS' programming, particularly in the areas of reassessment of hazards, early warning and improved lead time to permit a more effective response. PWS' early warning systems in some parts of the world are a "one-of-a-kind" facility, permitting government agencies to leverage such capacity to serve other warning infrastructures through a multi-hazard approach.

The growing disparity between city and rural lifestyles indicates that specialized services will be required for each. The vulnerabilities of city dwellers will be very different from those in more remote locations. While coastal communities depend on water related hazard warnings, city dwellers may also regularly require information identifying the risks posed by environmental contaminants. Montreal, Canada is installing specialized radar to monitor local weather systems to ensure that the city is prepared to meet flow requirements for wastewater treatment during high impact events while minimizing treatment costs during less eventful times. Other examples worldwide include delivery of options for travel during forecasted poor air quality days, and new air and water borne disease forecasts linking disease with climate variables.

Also likely to rise are the linkages between PWS' and other UN programs such as the World Health Organization and UN-Water. Human health and water availability are very much influenced by environmental factors and PWS' will in future be expected to quantify and qualify these linkages.



Furthermore with the increased environmental pressures on health and water, linkages between PWS' and other UN programs such as the World Health Organization and UN-Water will become more important in future. Human health and water availability are very much influenced by environmental factors and PWS' will in future be expected to inform by quantifying and qualifying these linkages.

Water security continues to remain a significant issue worldwide as demand continues to increase while droughts undermine development. Resolution of these issues is difficult as water 'rights' are almost always multi-jurisdictional requiring complex negotiation mechanisms. PWS' may be able to play a significant policy role in this area through prediction of transboundary movement, systematic monitoring and reporting. It may be surprising to note that in Canada drought is ranked the number one disaster nation-wide

[14] EM-DAT: The OFDA/CRED International Disaster Database http://www.em-datnet.UCL-Brussels, Belgium.

[15] The Canadian Disaster Database. Public Safety Canada, Government of Canada.

and the Great Lakes (the largest freshwater body globally) are at their lowest level ever recorded. [16,17] Energy demand is also greatest in cities and options for energy generation have never been so plentiful. PWS are poised to aid in the decision making process to ensure that the right mix of energy is generated for predicted meteorological and societal conditions. In Canada this type of service is currently delivered through the meteorological private sector. The Canadian PWS is exploring options to ensure that appropriate services are also made available through the public sector. In many cases, PWS' will be able to provide a critical service to Government able to support decisions regarding energy consumption and conservation policies adopted. Surging population and corresponding energy use predicted through the next century will require development of PWS' national scale energy availability alerts or warnings.[18]

Technological Change and Prediction of the "Spheres"

Significant strides made in science, technology and telecommunications over the last decade realized major advancement of observational methods of the atmosphere with new breadth of satellite and earth based instrument sensing of the atmosphere, hydrosphere and cryosphere. These observations contributed to the significant advancements in atmospheric predictability through continued performance of global and regional numerical weather prediction models.

Further S&T advancements in the next decade will offer even more potential benefit for society in future. Continued improvements in computational capacity will improve predictability with even higher spatial resolution scientific environmental prediction models at global, regional and sub-regional levels. More interactive coupled models at earth surface (air-ocean-ice models) and aloft (troposphere-stratosphere) will result in improved predictions of changes in weather, water, climate and atmospheric chemistry. New scientific thrusts to observe, model and predict at the "Earth System" level through initiatives such as the Earth System Simulator and Global Earth Observation System of Systems will lead to better understanding of physical, chemical and biological processes and feedbacks. PWS' can serve as a primary information conduit by providing a variety of new information products and services that will inform decision-making, as well as sound policy and law-making mechanisms at local, national and international levels, beyond its current offerings.

Technological Change and Service Culture

However, not to understate the importance of the benefits of scientific and computer computation enhancements over the past decade, likely the most beneficial advancement for PWS' from the users' perspective has been the world-wide-web and informatics systems facilitating access to knowledge and information *by anyone, at any time, and from anywhere to anywhere* allowing for integration into user designed decision-making processes. The internet, a form of global "real-time newspaper" has also permitted world citizens to become acutely aware of the importance of environmental issues such as climate change, air and water pollution. It has also allowed for improved networking of scientists and other experts world wide to advance the understanding of these issues.

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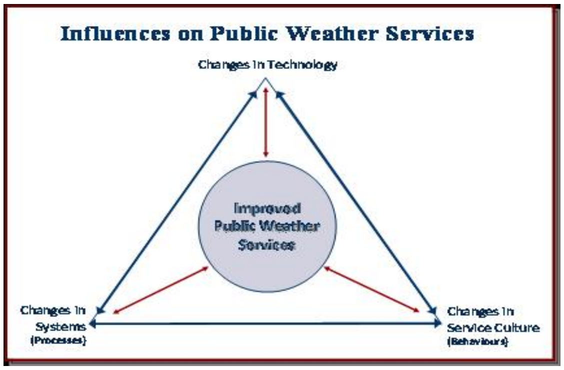
16 The Canadian Disaster Database. Public Safety Canada, Government of Canada.

17 Great Lakes Disappearing Act. The Globe and Mail. Canada. September 24, 2007.

18 Energy Projections: "Global Energy Perspectives" ITASA/WEC Population Projections: United Nations "Long Range World Population Projections: Based on the 1998 Revision".



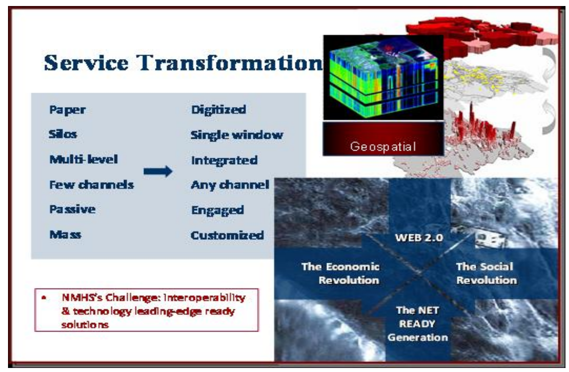
Technology often outstrips the capacity of society to effectively realize the full benefit. For instance, while internet was only thought about two decades ago, the potential is still being exploited through popularization of social learning and networking of Web 2.0 applications today. This is a good illustration of the forces – technology, culture and system processes – that influence service provision that apply to PWS' programs. These influences are mutually interdependent. For example, for NMHS to adopt web-based technologies when citizens do not have access or understand how to use computing or internet technologies would not result in the expected benefit. Likewise, to connect to a "net ready generation" would require NMHS' to integrate information technologies and the necessary changes into their operating systems. For the future, successful PWS' will require simultaneous implementation changes in technologies, systems and internal operating cultures, recognizing the evolution of user means, methods, and needs that support their decision-making processes.

The onset of the digital age is already showing the *golden* promise of on-demand, selective access to user-specified programming and to all sorts of information integral to their decision-making. The rapid expansion of broadband communications, internet and digital broadcast systems (like TV, pod-casts, internet and radio), and the proliferation of intelligent, mobile personal information and wireless communication devices will support an on-demand (from anywhere at any time) fully interactive and integrated communications systems. This offers significant advantage for NMHS' and their PWS' programs where weather, water and climate information can be time-sensitive, such as alerts to potentially dangerous high impact events or instant updates on the status of developing storms. However, this also requires enhanced cooperation with communications systems vendors as well as among NMHS' to harmonize the information content of their products and services, especially among neighbouring states.

This communications evolution will come with at least one significant challenge and one major opportunity for NMHS'. The challenge relates to being aware of not only "what" the citizens or specific clients require but also of their "service culture" or "how" these individuals or groups access information and learn.

The Challenge – Service Transformation

Evolving technologies are amplifying expectations on NMHS to make more information accessible in a timely manner but also in a format and means that is amenable to their changing lifestyles and their preferred means of access. For example, not even two decades ago, newsprint, radio and television were the preferred channels to obtain weather information. When compared to today, the youngest generation of



adults' preference is for internet methods, web searches, mobile text messaging and social networking. NMHS' should be already considering the implications of the "Net Ready Generation" by:

- Moving from paper products to digitized information which will improve the 'reach' of PWS' significantly;
- Transiting from a few individual delivery channels to multi-channel methods offering integrated solutions, which now are including typical Web 2.0 options such as using *Wikis*, *Blogs*, *Shared Forums*, *Feed Reader* and *Widgets*;
- Evolving from static and passive delivery methods to those that involve enhanced user engagement (interactive), push-technologies and user customized services.

There is growing emphasis placed on the value of weather, water and climate information and predictions as it contributes significantly to the efficiencies of National Economies and their global competitiveness. *Timely access to relevant information* is an important element of economic performance. A similar value statement can be said for societal pressures aimed at improving quality of life and the environment. Therefore, meeting the challenge will not only be by adopting advancing technologies but also respecting and integrating the changing practice of how information and learning is being assimilated by societies. Successful implementation will ensure that NMHS' through their public weather services remain a respected, trusted and responsive core responsibility of their governments.

The Opportunity - *Embedded* Services -

The shifting orientation on the application and use of information technologies also present an opportunity for NMHS'. The recruitment and renewal of the workforce is attracting creative and innovative employees who are active users of these evolving technologies. Channelling these technological evolution and creativity capacity will offer significant potential for generating risk-based information and prediction services that would integrate the likelihood of high impact meteorological or hydrological events with their consequences and mitigation strategies. This form of *embedded* products will significantly rely on alliances and partnerships that capitalize on the *significant reach* of PWS' in future.

Successful Public Weather Service programs in future should be service outcome focussed, rather than output focussed. This considers having our outputs embedded within a broader based product or service. Canada's Public Weather Service provider has developed an Air Quality Health Index[19] which also incorporates not only an air quality forecast but information about who would be most impacted by a certain air quality event as well as effective strategies to limit their exposure to the risks to their health. This service is produced and delivered in partnership with health agencies.

Complementary to being outcome focused PWS' need to be stakeholder centric. There are significant differences between a *stakeholder-centric* and a *user-centric* service. The former actually orients PWS' to consider a more comprehensive perspective, moving away from considering solely the "client-server" relationship. It considers all of those impacted by the services beyond the direct recipient. Adoption of a stakeholder centric approach holds great promise and could very much enhance the relevance of PWS' to society.

Conclusions

In conclusion, Public Weather Services will need to adapt to changing public policy, environmental risks and new ways of doing business. Making these changes will certainly not only lead to the sustainability of Public Weather Services over the long term, but rather should be viewed as a key means to support sustainable development goals enabling their governments to make improved choices.

Key will be a successful integration of security, health and environmental issues to further the development of embedded and stakeholder centric solutions. This has already started to take hold beyond energy resource concerns, e.g., growing appreciation of water security.

And finally, utilization of all that technology has to offer will be difficult without integrating the changes in its use by society. Successful Public Weather Services will utilize the most accessible systems and will capitalize upon engagement of stakeholders, partners and especially the decision-makers of the future.

[19] http://www.ec.gc.ca/cas-aqhi/default.asp?lang=En&n=065BE995-1

The Private Sector in Meteorology – The Next Ten Years

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Abstract

A recently published study on the state of private sector meteorology in the United States has found that although there have been significant changes in science, technology, and the business environment, the health of the industry is strong and continues to grow. With the estimated size of the industry approaching $2B in 2007, the Spiegler study shows that the industry doubled over the last decade and that growth over the next five years will continue to be strong. This paper extends that outlook over the next decade by analyzing a diverse set of trends that impact both the industry and the markets served in order to understand the probability of this expected growth over the next five years and beyond.

Background

In 1995, an assessment[20] of the U.S. private sector in meteorology was made in an attempt to describe the viability of the industry at that time. The study was limited to those companies in the private sector meteorology business ("industrial meteorology") and "whose main business areas are other than meteorology, but who have meteorologists on staff involved in applied Research and Development, product development, software development, management, etc." These business areas included aerospace, agricultural, insurance and energy companies who employ meteorologists. The Broadcast Media sector was not included. The value of the industry in 1995 as defined above was estimated at $940M (± $160M).

Although in existence since 1946, private weather companies had not seen the changes in government data (surface observations, as well as ground-based and space-based remotely sensed observations), visualization tools (software), numerical weather prediction (models) output or communications networks (collection and dissemination) as they experienced in the early 90's. This was the beginning of the "National Weather Service Modernization" and it was happening almost in parallel with one of the greatest technological advances of our time, the public release and widespread commercial use of the internet. This is not meant to downplay other technological and scientific advances underway at that time but to highlight one advance that had a major impact on the competitive landscape in the industry. In order to predict what will happen over the next ten years, one must understand the last ten years—what happened, and how we got where we are today.

[20] Spiegler, David B., "A History of Private Sector Meteorology", American Meteorological Society, 1995

Industry Trends- The Last Ten Years

In the U.S., the modernization was a significant upgrade to the National Oceanic and Atmospheric Administration's (NOAA's) observation infrastructure, modelling and operational forecast tools, and the collection and dissemination capabilities of the National Weather Service. Surface observations were automated, weather radars were replaced with Doppler radars and positioned in a geographically balanced network across the U.S., geostationary satellites were equipped with higher resolution (both spatial and temporal) instruments for imaging and atmospheric profiling and the Weather Forecast Offices (WFO's) were equipped with more powerful weather workstations for forecast and warning preparation and dissemination. NOAA also upgraded their data dissemination capability from their Telecommunications Gateway Hub to their WFO's and their private sector partners by adding higher speed server access, introducing internet access and by implementing a high speed satellite communications broadcast. Advanced weather information processing systems (AWIPS) were deployed at the forecast offices to transform the large volumes of data into timely forecasts, watches and warnings. Web sites were generated for local offices, as well as, the NWS' National Centers for Environmental Prediction (NCEP) and NWS headquarters. The impact of this extensive modernization effort on the growth of the private sector was not immediately apparent because the modernization activities occurred over a period of several years.

However, Spiegler's report does show that the composition of the industry changed during this period and further changes are predicted. First and foremost, the barriers to entry into the weather industry were lower than ever before. Access to government data, software processing tools and computer equipment for generating products for key markets were no longer cost prohibitive. There were also new technologies developing to deliver the value-added information effortlessly to end-users. The internet with both its secure and free access websites replaced the need for custom end-user applications on tailored hardware systems supported by a costly data dissemination infrastructure. More recently, mobile telephones, cockpit displays, wireless laptops, personal digital assistants (PDAs) and GPS map displays have all contributed to the growing market need for local weather information. All of these factors combined opened the door for small, innovative companies to provide unique products and services at a fraction of the cost. Competition was fierce and the benefits flowed to the markets.

Market Trends – The Last Ten Years

The markets responded to the same technological advances that impacted the weather industry. Core markets consisting of Agriculture, Aviation, Media, Emergency Management, Energy and Government expanded while new markets emerged. Market segments within the core markets, which had previously been unable to afford value-added weather services, were now targeted by the competitively priced providers. Farmers, who had problems justifying such services in the 80's, could now afford to equip their tractor with satellite delivered products in addition to accessing free websites from their kitchen table.

The vast amount of observation and model data provided through Government resources were also of better quality both temporally and spatially. The competitive players in the industry didn't hesitate to develop more tailored products for specific market uses. Short range hourly forecasts from highly-skilled mesoscale models and improved medium-range forecasts from highly skilled global models became the basis for value-added products in many markets. This spiral cycle of more data, better value-added products, and more competition- driving more value-added products, lower prices, etc. - led to successes in emerging markets. Successes that Spiegler estimates to be approaching $2B in 2007[21].

One such success occurred in the energy market. In the mid 90's when deregulation hit the energy producers, it became very important for them to operate their power generation plants more efficiently. The Government was no longer expected to stabilize energy pricing to the consumer. Instead they opened the door for market competition. The consumer would have a choice as to where they purchased their electricity and their selection was primarily based on price. Therefore, power companies were motivated to operate more efficiently. If they had excess electricity it was more cost effective if they sold it to another region that needed it. This change in the way they operated formed the basis for trading energy as a commodity. The best trades happened when the weather situation was anticipated well in advance, using the best available forecasts, and electricity "futures" were purchased at the lowest possible price. That same electricity could be sold to the weather impacted region at a higher price when competing companies supplying that region realized they didn't have the capacity to meet their customers' demand.

Energy trading expanded beyond just electricity to natural gas and oil. The volatility of this market has attracted many participants in addition to the energy producers themselves. Financial institutions, large and small hedge funds, and moderate sized public utilities have entered the commodity trading sector to profit from the gap between increasing demand and limited supply. The uncertainty of global resources, population growth, efficient and available production facilities, etc. will continue to produce volatility in the energy trading market over the next ten years. While energy trading was initiated by the market's need to regulate itself, its growth and sustainability is partially due to the ability of the weather industry to generate products and services that support their activities.

Other markets in addition to these have experienced similar growth through segmentation. A list of core markets and emerging market segments is found in Table 1. This is merely a representative list not an inclusive one. The most recent segmentation occurred yet again, in the commodity trading market, when weather itself became the commodity. Risk management strategies using weather futures contracts based on temperatures[22] and, even more recently, hurricane futures contracts based on the Carvill Hurricane Index (CHI)[23], have become a successful tool for mitigating weather related impacts on corporate earnings. With the first transaction taking place in late 1997, the weather risk market has grown steadily. According to the Weather Risk Management Association, notional value of traded contracts grew from $4.6B in 2004 to $19.2B in 2007[24].

There are many other critical trends that have

21 Spiegler, David B., "The Private Sector in Meteorology- An Update", American Meteorological Society, 2007

22 Pirone, Maria, "Weather & Commodities: Advances in forecasting & financial risk management", Commodities Now, Dec 2004

23 Carvill Hurricane Index is registered trademark of Carvill Reinsurance.

24 Cooper, Valerie, "Strong Demand Seen for Weather Risk Management Contracts", Weather Risk Management Association, May 2007.

shaped the markets and their use of weather information. Over the last ten years the fastest growing market segment was by far the consumer market. One of the earliest applications on the web was free weather services for consumers. Weather became a draw for bringing the public to a company's web site. This list is just a few of the trends that have helped shape this lucrative market.

- Highly mobile society
- Need for instant access to information
- A generation of weather savvy professionals
- Public awareness of disaster impacts
- Consumer accessibility to technology
- Higher expectations
  - Demand for more local weather
  - Demand for better forecasts
- Active lifestyles
- Population growth along the weather sensitive coastlines

Core Markets : Last Ten Years		
Market:	**Market Segments:**	**Specific Uses/Interests:**
Agriculture	**Farmers Cooperatives Food Processors**	**Crop Management: Growing to Harvesting Crop Management: Growing to Harvesting Market pricing**
Transportation	**Aviation Rail Shipping Trucking Auto (*Emerging*)**	**Commercial, Corporate, General Pilots Operations Operations & Scheduling Operations, Routing & Scheduling Consumers**
Media	**Print Radio Broadcast Internet**	**Local & National Daily papers Local stations Cable, Network & Local TV stations News, search engines, business info, & corporate web sites**
Emergency Management	**Local State Federal**	**Natural Disasters, Threat Phenomenon Natural Disasters, Threat Phenomenon Natural Disasters, Threat Phenomenon**
Energy Operations	**Electricity Nat'l Gas Oil Nuclear**	**Generation, Transmission & Distribution Exploration & Distribution Exploration, Refining & Distribution Regulatory, Disaster Mitigation**
Government	**Defense Environ. Protection US Forest Services FAA**	**Military operations & intelligence Regulatory Fire Fighting Air Traffic**
Emerging Markets : Currently		
Market:	**Market Segments:**	**Specific Uses/Interests:**
Commodities- Trading	**Agriculture (*Core*) Energy Emissions Credits**	**Corn, Soy Beans, Wheat Electricity, Nat'l Gas, Oil CO_2,NOx, SOx, Hg, etc**
Construction	**Architectural Design**	**Winds, Climatology for building design**
Financial services	**Fund Managers Insurer/Reinsurers**	**Risk Management for portfolio of holdings**
Recreation	**Ski Resorts Marinas**	**Operators Boat operators**
Retail	**Seasonal Suppliers**	**Clothing. Snow etc...**
Weather Risk	**Weather Futures Hurricane Futures**	**Temperature/precip based risk management Wind/rain damage index management**

Table 1: Core Markets that have grown over the last ten years and New Markets which have emerged over the last ten years and are in various stages of growth.

The early 90's brought with them the threat of free weather via the internet. However, weather became such a draw that everyone needed it on their site – hotel chains, airlines, news outlets, broadcasters, travel sites – the list goes on. This not only opened up a new market sector but it grew to be a significant business area for private sector providers. And once you had the consumer's interest on their home computer, you could keep them glued to you on their mobile phones, PDAs, wireless laptops and elsewhere. The advertising dollars flowed along with them or the site owners paid for the data. Either way, there was growth in an area where no money had previously passed hands.

The Next Ten Years: Industry and Market Trends

It is safe to say that the next ten years will bring about more change, however, it may not be as abrupt a change as the past ten years. Spiegler believes growth of the weather industry will continue. There is agreement on that point, however, it will not continue in the same fashion. In 2003, Irving Levenson of the Hudson Institute addressed the Commercial Weather Services Association annual meeting with his version of the next ten years. For the most part the first five years have proven to be as expected. Climate change has become a driver of services and interest in the environment. Technology continues to be a driver, but even more so, technologies working together have created even more capabilities. One could almost say endless capabilities. Case in fact is the new iPhone. This product/service is the marriage between wireless technology, the internet and powerful microchip technology. And six months after a pivotal entrance into the marketplace, it is no longer the new technology it's yesterday's very successful headline.

Climate change, technology, business trends, globalization, the government's role in providing services, our science achievements and, of course, government, business and consumer demands for services will dictate the next ten years. In the geosciences there will be movement toward transformative research. According to Dr. Ardent Bement Jr., Director of the National Science Foundation, "We use this term to describe a range of endeavors, which promise extraordinary outcomes; such as, revolutionizing entire disciplines, creating entire new fields or disrupting accepted theories and perspectives. Endeavors that have the potential to change the way we address challenges in science and engineering and also provide grist for the innovation mill. Supporting transformative research is of critical importance in the fast-paced, science and technology-intensive world of the 21st Century,"[25] And, along with transformative research comes transformative products and services changing the world around us.

In the next ten years we are likely to see the marriage of weather forecasts with health, economic and business impacts all rolled into one message. Weather information will be part of a bigger outlook on environmental impacts and a climate change scorecard with detailed instructions on what to do next - head for the beach or start boarding up your windows. You could see images of the 30-day forecast as though you were looking out your window accurate enough to start planning your outdoor event for day 21. More importantly, businesses and consumers alike will integrate this information seamlessly into their day. The businesses that succeed will be the ones that have embraced strategic alliances and expanded their core business simultaneously to become an integral part across many platforms, needs and venues.

The industry will change significantly in ten years. Smaller businesses with niche capabilities will continue to merge with larger ones as these companies expand their talent pool. This has happened quite steadily in the last ten years and will continue in the next. However, mergers between complementary providers to broaden their horizon rather than deepen it will be the focus. Integration of capabilities to offer the full service to the customer will become the norm rather than the exception. One can look at the evolution of the automobile over the last five years to see this in action. What was once a vehicle to transport you from one place to another, has become an integrated information/navigation/entertainment environment for group destination activities. The vehicle is still an important part but its integration with the "biosphere" through the marriage of many technologies makes it more valuable.

There will be more consulting services as the complexity of environmental impacts on business operations, grows. Except these consultants will have expertise on many fronts as they interpret the cause and effect for the customer's business performance. The international borders will blur as companies become more responsive from afar and business models become transparent. We may not reach total transparency and 100% adaptation of these concepts but we will begin to see changes like never before.

Levenson views the significant innovation to happen at the interfaces. For example the interface between the atmosphere and the ocean and land (land-sea interface) will encourage an ecosystem approach to unfold. The U.S. and the international community interface will promote scientific cooperation. The military-civilian

[25] Bement, Jr., Ardent, "Transformative Research: The Artistry and Alchemy of the 21st Century", Texas Academy of Medicine, Engineering and Science Fourth Annual Conference, Austin, Texas, January 2007.

interface will bring about technology transitions. The public sector-private sector interface will bring about partnerships and the research-operations interface will bring about transition issues. Incentives and regulations bring about philosophical debates, while markets and governance bring about blended approaches to issues.

The industry will experience some technology changes in the atmospheric observing infrastructure over the next ten years but not as revolutionary a change as in the 90's. NOAA will have rolled out the NPOESS and GOES-R programs, the Europeans and Asians will continue to launch next generation sensors and GEOSS will continue to gain momentum globally. However, the earth and ocean sciences will establish observing networks as well. Revolutionary findings about the earth's core and the ocean's processes will continue to change the way we think of our planet and our interaction with it.

Some of these new observing platforms will lead to more opportunities for value-added products. When merged with future satellites measuring CO_2 and other greenhouse gases, the integration of products will thrive on an environmentally-focused world stage. The financial markets will continue to mature in their efforts to generate risk management tools, however, these tools will have the added benefit of assisting in society's response to managing climate change.

Developing Countries

Little has been said thus far about the developing countries over the next ten years. Certainly, there will be change but it doesn't necessarily happen in the same way. The technology advances during the 90's do not have to be adopted in order to reach the technologies of today or tomorrow. In fact, the developing countries have the added advantage of "leap frogging' certain technologies so that they land within the horizon of the developed countries. In fact, there is already precedence for this type of change. The most familiar example is in telecommunications. In the 90's, as satellite-based telecommunication technology matured, the need for a land-based telephone infrastructure in some developing countries became obsolete. As voice communication expanded to digital data communication, internet access quickly followed. This capability opens many opportunities for delivering services where obstacles outside of the weather community's control had previously existed. These services could be delivered either by the private sector or the public sector. It is likely that the private sector would expand via globalization alone. However, products and services they offer will be limited.

Limited because service delivery is only part of the picture. The entire infrastructure for providing weather services must be improved. Access to more local observations for current conditions, as well as for assimilating into higher resolution numerical weather prediction models is critical. This would improve local forecasting and tailored product development for weather sensitive markets both in country and globally in addition to improving the warning capabilities of the public weather service. This, however, is a major undertaking in most developed countries and even more so in developing countries.

There are some strategies that can be adopted to move forward. One emphasizes new relationships among Public Weather Services to leverage core strengths in the same way the Private Sector does it through mergers and acquisitions. Some others are to use 'best practices' to maximize infrastructure changes, to embrace the latest technologies and to change the paradigms about what a Public Weather Service 'should do'. Ultimately, the goals are the same, it is how you 'play the end game' (e.g. how you get there) that has changed.

Summary

Developing a ten year vision for the private sector is not a perfect science. Businesses have much shorter time frames that they plan for, or work towards. They then will alter or adjust their course as the business environment around them changes. In today's world, the pace is dictated greatly by technology. The markets are responding to technology impacting their core business and their suppliers' businesses. The complexity surrounding this makes it all the more difficult to predict. If all that we can do is look at our past to predict possible outcomes on our future, while introducing into that analysis the 'delta changes' that we are aware of, then we have done all that we can do.

THE ROLE OF THE PUBLIC SECTOR IN COMMERCIAL WEATHER SERVICES

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Abstract

National Meteorological Services (NMSs) provide core infrastructure and basic public weather services including forecasts and warnings through government funding. Additional, value-added weather services can be either cost recovered or commercial. Recovery of the marginal costs of provision (including overheads) is appropriate where for whatever reason the NMS is effectively the only organisation providing or capable of providing the value-added service. For commercial services, the NMS is not the only possible provider, and so the price for them will be set by the market through competition. An NMS's motivations for providing commercial services may include gaining revenue, seeking benefits from a more customer-oriented and innovative culture, ensuring the professionalism of services, and of course wanting to bring customer benefits through satisfying unmet needs. However, NMSs need to be wary of the complex issues around commercial services, and to consider whether it may be better to work in partnership with private sector companies to facilitate cost-recovered access to data, products, research and development results, and expertise, with a view to maximising the overall community benefit from government funded data and products, rather than competing with the private sector.

Introduction

A number of factors have led to many National Meteorological Services (NMSs) becoming involved in the provision of value-added services, in addition to their core government funded role. These include trends since the 1980s and 1990s for government bodies to take a more "business-like" approach, financial pressures on NMSs causing them to seek additional revenue sources, and an increasing ability for NMSs to add value to the core publicly funded services they already produce.

By value-added services I mean those which are not explicitly funded by the government. There are two types – cost recovered services, and commercial services. This paper covers the nature of the various services, and then goes on to give my views of what role the public sector (i.e., NMSs) should play specifically in commercial service provision. While drawing on experiences with MetService and WMO, the views expressed in this paper are mine and do not necessarily reflect those of my employer or of WMO.

Government Funded Services

All NMSs rely primarily on government funding for their basic infrastructure and for public good services including warnings. Freebairn and Zillman (2002b) cover very well the issue of funding for meteorological services; their paper is recommended for its description of the nature of public goods, private goods, and mixed goods in the context of meteorological weather services, and explanation of various funding and institutional models.

Freebairn and Zillman (2002b) also explain why government funding for such core infrastructure and services is appropriate and necessary. Public good services have characteristics of being non-rival (one or many people can make use of them with little additional cost), and having a high cost of exclusion (i.e., of restricting the use of the information to only certain users). In a companion paper, Freebairn and Zillman (2002a) discuss the economic benefits of meteorological services.

It is important that there is a clear definition and agreement on what services are being funded by the government, with a clear link to the level of funding provided. If there is to be a change in policy, or new expectations on services, or different funding levels, then the services and/or funding should be adjusted so they match.

The level of government funded services varies widely between countries, depending on history, finances, legislation, culture, and indeed the climate and weather of the country.

Historically, the delivery of government funded forecasts and warnings from NMSs to the public has relied on using the media, plus services such as recorded telephone forecasts which have a relatively high marginal cost per caller so are often implemented using cost recovery mechanisms. However, Internet technology is increasingly allowing direct delivery to the public of government funded services at low marginal cost for delivery and customised formatting, so that such delivery may be explicitly government funded rather than cost recovered.

The definition of government funded services is uniquely clear in New Zealand. As described in Steiner *et al* (1997), a commercial contract was put in place in 1992 for delivery of NMS weather services on behalf of the government. The weather services are provided by MetService, a state owned enterprise which is wholly owned by the government but required by legislation to operate in the same manner as private sector companies.

When the contract was first established the revenue was some two-thirds of MetService income, but after 15 years this has now fallen to around a half of its income, through a combination of a reduced real price for the contract (even though the level of services is markedly improved) and MetService business growth in other areas.

Cost Recovered Services

Direct government funding will never cover all the meteorological services required by the community at large. Cost recovery is appropriate where the services provided have the character of a "mixed good" or a "private good" (see the definitions in Freebairn and Zillman, 2002b) *and* where for whatever reason the NMS is effectively the only organisation providing the service.

Such cost recovered services are not truly commercial, since there is no market mechanism for establishing prices, and no explicit competition or contestability. The amount charged should in general reflect the marginal cost of provision, including applicable overheads. The overheads should not be underestimated. For example, the chargeable cost of professional staff time may appropriately be in the range of 1.5 to 2.5 times the actual hourly salary cost, taking into account the cost of recruiting, training and managing staff, as well as their use of facilities.

Some examples where it is appropriate for the NMS to recover costs include the following:

- Costs of access by individuals or private sector companies to information gathered or produced by the NMS (e.g., observational data; weather radar data; publicly funded forecasts and warnings; NWP model output).
- The cost of a member of the public phoning an NMS forecaster for a one-on-one consultation about the weather. This is a good example of something which is "rival" and also has a low costs of exclusion – only one person can benefit from this consultation and it takes the forecaster away from other duties, including perhaps spending time on producing a better forecast or a better warning for all of the public, rather than just one member of the public.
- The cost of a one-on-one consultancy with regard to weather or climate where the NMS has unique expertise which is not available in the private sector, or unique availability of information (e.g., for an investigation into a weather-related disaster).
- Costs of access by telephone to weather forecasts. This is rival in the sense that there is a relatively high per call cost, but there is a low cost of exclusion, and it is appropriate if the government does not fund such a service for costs to be met by those who benefit from the access.
- Costs of access to public funded data and products through Internet web sites, if not already funded by the government. Although the per-access cost is much lower than for services such as recorded telephone forecasts, the overall cost can be significant. If policies allow, the use of targeted advertising is one option for recovering costs.

There needs to be a legislative and institutional framework allowing the NMS to retain the revenues they receive from such cost recovery, or else all that happens is that they incur the costs but the money goes into overall government revenues.

A major area of cost recovery for many NMSs is for their provision of aviation meteorological services. This illustrates an issue which is relevant to Public Weather Services (PWS) – the recovery of costs other than the marginal cost of provision of the service. As a matter of ICAO and WMO policy, NMSs are entitled to include in costs recovered for aviation meteorological services a share of the basic infrastructure contributing to those services, including observing systems, NWP, and core forecasting. This helps to fund the core infrastructure, and implicitly if not explicitly changes the agreement between the government and the NMS, because it effectively reduces the amount the government needs to publicly fund the NMS for core services.

There is a related issue in PWS, where some governments require their NMSs to recover costs not just for access to observational information and products, but to contribute a share of the cost of gathering or producing it. Because such data and products are also freely exchanged internationally, intense debate in the 1990s led to the passing of WMO Resolution 40by 12th Congress in 1995 which resolved the matter.

Commercial Services

By commercial services I mean those value-added services for which the NMS is not the only possible provider and so the price for them will be set by the market through competition. Although the distinction between cost recovered services and commercial services may not always be clear, especially in countries where there is not an active private sector, this does provide a useful framework for considering the issues.

Why do NMSs consider becoming involved in commercial service provision? Five main reasons are:

5- Money – e.g., seeking additional revenues to compensate for reduced government funding, or to fund additional activities and staffing
6- Customer Culture - wanting to establish a customer-focussed culture which can enhance service provision for all areas
7- Innovative Culture – desiring the spin-offs in other areas from applying innovation to commercial services
8- Professional Ethos – wanting to ensure that customers receive commercial services provided to a high professional standard in accordance with WMO and other guidelines
9- Customer Benefit – recognising that there are unmet customer needs and that real benefit could be provided from additional commercial services, thus leveraging the government funding.

Issues With NMSs Providing Commercial Services

Embarking on commercial services may seem initially attractive, for the reasons in the previous section. However, there are a number of issues which need to be taken into account.

By definition, revenues to be obtained from commercial services will be in competition with other providers, and this will require a level of business acumen and experience in working in a highly competitive market which is often lacking in NMSs, at least initially.

Establishing and growing commercial revenues requires an upfront investment of resources before any return is produced, which means that, in the absence of any explicit additional investment into the NMS, commercial services may effectively be cross-subsidised by government funding. There is an overall risk that an NMS may divert resources and focus too much on trying to establish and grow commercial services at the expense of improving its traditional core activities.

If an NMS does manage to gain significant profitable commercial revenues, it then becomes vulnerable should it lose the business to competition from the private sector, and NMS may not have an institutional form that allows them to cope with the impacts (particularly on staffing) of large swings in revenues.

Furthermore, an NMS can find itself in a difficult position with regard to conflict of interest and transparency of costs. The NMS is both the source of basic data and products for private sector companies, and a potential or actual competitor for services with those same companies. An NMS may be tempted to restrict access by a competitor to its information or expertise, which may not be in the best interests of overall community benefit. In many jurisdictions competition law requires full transparency and separation of activities so that the NMS does not have any advantages over other commercial suppliers, which can lead to additional transaction costs to prove this is indeed the case.

While it is true in my experience that embarking on commercial services can have cultural benefits in the way of customer focus and innovation, many of the same benefits can also be realised through taking a more customer orientated approach to the government and to the public and other institutions on whose behalf they fund services, and seeking to apply innovation to those same services.

Any profession is interested in maintaining standards to ensure that customers receive the highest quality service, and meteorology is not alone in this. This is particularly important where the safety of life and property is at stake, which has led to regulatory control and guidelines in, for example, aviation forecasting. And we all cringe at publicity given to clearly unscientific forecasting approaches. One means of dealing with this is education of the public and customers. However, commercial services are by definition responding to customer needs through market mechanisms; regulation and education aside, the customer is the ultimate arbiter of the required service quality, including the level of professionalism applied.

Finally, if there are unmet needs, it is worth exploring whether these are best met through having the NMS work in partnership with private sector companies to facilitate access to government funded data and products, and research and development, on which new services can be based. For the United States perspective on this approach, see National Academy of Sciences (2003).

Conclusions

In my view:

- NMSs should strive to ensure explicit definition of government funded services

- NMSs should ensure they have mechanisms which enable them to implement and benefit from cost recovered services
- NMSs should maximise the opportunities afforded by Internet technologies to deliver government funded public weather services direct to end users, with costs either met explicitly by the government or through cost recovery mechanisms including targeted advertising (perhaps in partnership with private sector companies)
- NMSs should carefully consider whether they may be better to work in partnership with private sector companies to facilitate access to data, products, research and development results, and expertise, with a view to maximising the overall community benefit from government funded data and products, rather than competing with the private sector. Such assistance and facilitation should be cost recovered. Furthermore, in working with the private sector, there should be explicit agreement over how the contribution of the NMS is acknowledged and recognised, to ensure ongoing public and government support for the core government funded infrastructure and services.
- If there are still significant unmet customer needs then approaches for meeting them should be explored using cost recovery mechanisms.

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Emergency and Management of China's Meteorological Disasters

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China's Meteorological Disasters and Their Impacts

China is bounded by the Pacific Ocean to the east, with the Qinghai-Tibet Plateau at its west, covering a vast area, with complicated geographical conditions and significant monsoon climate characteristics. China is one of countries in the world with frequent natural disasters, a full range of disasters causing serious damages and losses. Meteorological disasters account for about 70% of total natural disasters. Each year, the affected crop area by various meteorological disasters is up to 50 million hectares and the affected people by typhoons, torrential rain, drought, high temperature and heat wave, sand/dust storms, thunder/lighting, and other major weather-induced disasters is about 400 million. According to the statistics in 1990-2006, every year the direct economical loss as result of meteorological disasters is about 182.5 billion RMB Yuan (approximately 22.8 billion USD) over the past 17 years, which on the average accounts for 1-3% of GDP. For the past century, the Earth's climate has experienced significant changes mainly characterized with warming. Consequently meteorological disasters have significantly increased in terms of frequency, intensity and severity, leading to many adverse impacts on society, national economy, ecological environment and human health.

Higher Frequency of Tropical Cyclones Causing Huge Damages in China.

The frequency of tropical cyclones approaching to China is rarely high in the world. On the average, seven typhoons choose to land on China's coastal areas each year. During 1990-2006, typhoons caused the economical losses of 32.2 billion RMB Yuan (or about 4 billion USD) as well as 502 deaths in China each year. In 2006, only strong tropical storm "*Bilis*" caused 843 deaths and a direct economical loss of 34.83 billion RMB Yuan (around 4.35 billion USD). Super typhoon "*Saomei*" with an occurrence in 100 years alone claimed 483 lives with the total direct economic loss of 19.66 billion RMB Yuan (about 2.45 billion USD)..

Flooding As Result Of Heavy Rain Is The Most Frequent Natural Disaster With The Heaviest Loss In China.

China is also one of countries in the world that are severely hit by floods induced by heavy rain falling in concentrated periods with a higher rainfall intensity. Floods mainly occur in the middle and lower reaches of the Yangtze River, South China, Central China, North China, Northeast China and other regions. During 1951-2006, the annual mean crop area affected by floods was about 9.75 million hectares. Since the 1990s, the frequency of flood occurrences over the Yangtze River and *Huaihe* River basins has significantly increased. For example, the excessively severe floods occurred in the Yangtze River basin and the *Songhua* River and *Nenjiang* River basins in 1998 caused the direct economic loss of 299.8 billion RMB Yuan. In 2007, flood occurred in the *Huaihe* River basin was only next to that in 1954.

Drought Is The Most Extensive Meteorological Disaster With The Greatest Impact On Agriculture In China.

Drought occurs across the country, with an uneven distribution. Spring drought is severe in the north, and summer drought is more frequent in the Yangtze River basin and its southern parts, and regions between the Yangtze River and *Huaihe* River basins. For example, spring-summer drought occurred in most areas of northern China in 2001. The affected area of farmland by drought amounted to 38.47 million hectares; 15.8 million people and 11.4 million animals suffered the difficulty of getting drinking water. In 2006, the super summer drought once-in-one-hundred-year and the most serious summer drought since 1951 occurred in *Chongqing* City and *Sichuan* Province respectively, with a direct economical loss of 21.64 billion RMB Yuan (～2.7 billion USD). In 2007, serious summer drought occurred in Northeast China and the Southern Regions of the Yangtze River.

Other Severe Meteorological Disasters In China

Sand/dust storm, snowstorm, hailstone, low temperature damage, heavy fog and other meteorological disasters also take place frequently, leading to heavy losses in livestock, industries and mining, telecommunication, and transportation as well as people's lives and properties in local areas. Meteorological disasters often trigger flash floods, flooding, landslides, forest and grassland fires, agricultural pests & diseases and so on, bringing about heavy losses in economic construction and people's lives and properties. Losses caused by flash floods and mud flow account for about 10-20 billion RMB Yuan (1.25-2.5 billion USD) each year. The statistics show that 10,463 forest fires took place in 2003 alone, in which 451,000 hectares of forest were affected.

Meteorological Emergency Management System in China

Emergency management is regarded by the Chinese government as an important task to fulfill its functions. In accordance with relevant national requirements for emergency management, CMA is accelerating all efforts in meteorological emergency management, working out and improving various emergency plans, establishing and improving emergency management mechanisms, and actively promoting emergency management system. As a result, the meteorological emergency management system has taken shape basically, achieving certain results in dealing with emergencies.

Strengthening The Emergency Management System and Enhancing Organization and Leadership

An organizational system for emergency management with established bodies, personnel in place, a clear mandate, smooth information flow and quick responsive capabilities has been established basically within CMA framework. The CMA Emergency Management Office has been created, with a view to leading and coordinating meteorological emergency supportive actions. A Center for Disaster Monitoring, Forecasting, Warning and Assessment under CMA was set up, so as to monitor, predict and warn of meteorological disasters; as well as to investigate meteorological disasters, to collect relevant information, and to make statistical analysis and assessments. 31 provincial (autonomous regional and municipal) meteorological bureaus have established their own bodies for emergency response management. Over 300 prefecture (city) meteorological bureaus and most county-level meteorological establishments have set up relevant bodies in support to emergency responses, so as to fulfill their meteorological emergency response functions.

Institutional Innovations, Emergency Management Plans and Exercises

In accordance with the "*National Overall Emergency Response Program for Emergent Public Events*", CMA has given the top priority to the development of meteorological emergency response plans. Through establishing rules and regulations, CMA is aimed at improving its capabilities in response to breaking events and providing emergent meteorological supports. Arrangements have been made to develop the *Emergency Response Plan for Major Meteorological Disaster Early Warning* and to implement the *Tentative Measures on Issuing Emergent Meteorological Disaster Early Warning Signals.* Meteorological establishments at all levels have formulated emergent meteorological service plans for emergent public events based on their local conditions, covering nuclear substance dispersion, leakage of hazardous chemicals (toxic gases), forest/grassland fires, geological disasters, search and rescue at sea, etc. In 2007, vehicles for emergency response at provincial meteorological bureaus were deployed by CMA to provide on-spot meteorological services.

Strengthening Coordination, Concerted Action In Emergency Response and Joint Disaster Prevention

CMA takes the approach to enhance meteorological emergency response by being open and cooperative, and by taking coordinated joint actions, so as to actively promote the establishment of a joint response mechanism in response to emergent public events nationwide. CMA has established a cooperative mechanism for information sharing and services in meteorological emergency responses with sectors like public security, civil affairs, railway, communication, water resource, agriculture, safety supervision, forestry, etc. Meteorological establishments at various levels also conduct extensive cooperation with such media as radio, television, mobile communication, etc., striving to improve meteorological service availability and capability. In *Shenzhen*, *Zhuhai* and other cities, a joint emergency response mechanism based on meteorological early warning information, has been established among various departments, having achieved good social and economic benefits in disaster prevention and reduction.

Social Mobilization and Outreach

CMA has taken measures to intensify public education in meteorological sciences and related knowledge about disaster preparedness and reduction. On such occasions as the World Meteorological Day, National Science Week and National Science Publicity Day and by opening meteorological science popularization facilities and by organizing students' summer camps and exhibitions. In addition, CMA takes advantage of modern media like mobile phone, newspaper, radio, TV and Internet, it arranges Q&A-for-Prize activities and seminars, and it prepares materials in order to help the public better understand about the weather, climate, warning signals and practical measures in response to meteorological disasters. All of these are designed to increase their

awareness as how to avoid damages and protect themselves during and after disasters. In 2007, CMA provided brochures and CDs on lightning prevention to 420,000 primary and secondary schools across the country in collaboration with other agencies, and CMA together with the China Association of Sciences propagates knowledge about meteorology and related information on disaster preparedness and reduction at villages, schools, neighborhoods and enterprises.

Legislation For Meteorological Disaster Prevention, Preparedness and Mitigation

The Meteorological Law of People's Republic of China was promulgated and implemented on 1 January 2000 and *the Emergency Response Law of the People's Republic of China* came into effect as from 1 November 2007. CMA made and revised 16 regulations and other legal documents. The local legislators and governments issued over 70 bylaws and regulations in total. 4 national standards and 40 industrial standards on meteorological activities have been publicized. In summary, a legal and standard framework based on *the Meteorological Law of People's Republic of China* has taken shape and continues to be improved. These documents have strongly regulated practices in meteorological disaster prevention, preparedness and reduction, and they will contribute to avoiding disadvantages and reducing losses caused by weather and climate events.

Benefit of Meteorological Service Oriented to Disaster Prevention, Preparedness and Mitigation in China

In 2006, CMA made a national survey on the public reactions to meteorological services. The outcome given by interviewees was about 86.5 on average. Based on the survey, it was felt that noticeable improvement and social benefits were achieved with information for high-impact and/or critical weather events and for major social events.

CMA initiated Category I emergency response plan for the first time in response to the super typhoon "*Saomei*" in 2006. CMA monitored, forecasted and warned of the motions of *Saomei* all the way. And the governments at all levels responded according to the warnings and guidance products released by meteorological offices. Before its landfall, the governments in *Fujian* province evacuated 710, 000 people and called 36,000 ships back to harbors; the governments in *Zhejiang* province relocated 1,001,000 people and called 34,400 ships back to ports. In order to avoid the severe damages as result of storm surges, Both *Zhejiang* and *Fujian* provinces took all necessary measures such as suspension of work, teaching at school and business in the dangerous coastal area according to meteorological advisories. The people who lived in the areas between the first risk and the second risk zones along the coast, windward sides in urban and rural areas, infirm houses and sheds, low-lying areas and dangerous areas were all transferred to the safer zones beyond, which minimized casualties.

During the affected period of super strong typhoon "*Rosa*" in 2007, CMA promptly initiated the Category II emergency response order and it issued forecasting and warning information to the State Council, Office of State Flood Control and Drought Relief Headquarters and other agencies at the first time when information became available, disseminating the warnings to the public by all means. According to the forecasts and warnings, the flood control departments of *Fujian, Zhejiang* and *Shanghai* deployed task forces in advance, and they emergently relocated about 1.58 million people and called nearly 70,000 fishing boats back to safety. By the time of the typhoon landing, related areas had already evacuated the people from the risk zones. Compared to other typhoons with the same intensity levels landing in *Fujian* and *Zhejiang*, it was rare that there were no casualties in the areas swept by "*Rosa*" in its passage (*Fujian, Zhejiang*).

In 2007, *Huaihe* river basin experienced basin-wide severe flood just next to what happened in 1954. In view of heavy precipitation process in *Huaihe* river basin, the related meteorological stations had strengthened the monitoring and forecasting. From late June to mid July, among others, the Central Meteorological Office and *Anhui* Provincial Meteorological Office provided weather-tracking services by using various means; they sent latest meteorological information three times a day; and they also provided meteorological information about the development of rainy systems, flood status and river levels to the flood-control headquarters; they provided decisive meteorological information and services for the *Wangjiaba* dam on the *Huaihe* River, which was facing the rising water level pressure. The information provided the scientific basis for making urgent decisions for flood control and flood diversion. It was fully recognized by the State Council leaders and the meteorological information played a very role in the national disaster prevention and mitigation.

Taking Action Through Pilot Projects Within PWS: "Learning Through Doing"

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Abstract

Through the work of the Public Weather Service (PWS) Programme of the WMO over the years, much knowledge has been accumulated in various aspects of PWS and spread to Members through conventional training methods such as workshops, conferences, and publication of guidelines. However, some Members, particularly developing countries including Least Developed Countries, still find themselves ineffective in dealing with challenges in PWS brought by rapid urbanization, economic globalization, environmental degradation, natural hazards, and the threats from climate change.

To assist these Members in enhancing their PWS capabilities, the PWS OPAG will initiate a new thrust by embarking on Pilot Projects based on the concept of "Learning Through Doing". The idea is that the PWS OPAG will select a small group of countries, and arrange for mentoring agents to work alongside the staff of the relevant NMHSs in assisting them to improve their communication with users in selected target sectors, and to develop and deliver an improved range of products and services which would enhance the socio-economic benefits provided through the NMHSs to Members. Details of the realization of such Pilot Projects, including the planning, implementation and review processes, are described in the paper.

Introduction

The Public Weather Service (PWS) Programme of WMO was established in 1994 with a view to "strengthening the capabilities of WMO Members to meet the needs of the community through provision of comprehensive weather services, with particular emphasis on public safety and welfare, and to foster a better understanding by the public of the capabilities of National Meteorological and Hydrological Services (NMHSs) and how best to use their services". The PWS provides a window through which the NMHS communicates weather warnings and forecasts to the public.

In recent years, rapid urbanization, economic globalization, environmental degradation, natural hazards, and the threats from climate change have posed great challenges to Members and their public weather services. Unfortunately, some NMHSs, especially those from developing countries including Least Developed Countries (LDC), are playing catching-up on such fast development trends and simply emerging as ineffective service agents, poorly equipped to deal with the capabilities and skills required for successful modern-day PWS. This highlights the widening polarity of capacities between the developed and less developed NMHSs; hence the need for urgent action on the part of the Public Weather Services Programme (PWSP).

This paper reviews the achievements of the PWSP in the last decade, highlights some of the recent developments impacting PWSP, examines shortfalls in the current PWSP capacity building strategies and explores the way forward to enhance the PWS capabilities of Members.

Achievements of the PWS Programme (PWSP)

PWS is one of the Open Program Area Groups (OPAG) under the overall responsibility of the Technical Commission for Basic Systems. The work of PWSP is coordinated through an Implementation Coordination Team (ICT) and its expert teams. In 1999, two Expert Teams, namely Media Issues; and Product Development, Verification and Service Evaluation were formed to bring out the areas of focus. In 2002, the latter was re-structured as Product Development and Service Assessment and a third Expert Team on Warnings and Forecasts Exchange, Understanding and Use was added. The third team was subsequently restructured as the Expert Team on PWS in Support of Disaster Prevention and Mitigation. The scope of work of the expert teams has now expanded from media to communication including public education and awareness; from product development and assessment to application of new communication technology for product delivery, probabilistic forecasts, and workstation development for product and service improvement; and from exchange and utility of warnings into early warning systems, nowcasting and disaster risk reduction functions.

Over the years, the ICT through its expert teams put together a mass of knowledge in different PWS aspects and produced guidelines on recommended practices, producing success stories and best practices in various areas including: standard framework for data and products, graphical presentation of products; application of research, biometeorology and air quality forecasts; quality management procedures and practices; performance assessment, application of Internet and other new technology; weather broadcast and the use of radio for the delivery of weather information; media relations and ensuring the use of official consistent information; capacity building strategies; public education and outreach strategies; improving public understanding of and response to warnings; cross-border exchange of warnings; and integrating severe weather warnings into disaster risk management. A list of the guidelines published is given in Appendix I.

These guidelines are published and distributed to NMHSs for their reference and use. They are also made readily available on the WMO web site. From time to time workshops and seminars were arranged on topical issues, to spread the latest knowledge, technological know-how and share experience.

A significant milestone in the PWSP is the development and operation of two international web-based projects, namely, the World Weather Information Service (WWIS) and Severe Weather Information Centre (SWIC). The WWIS (http://worldweather.wmo.int/) is operated by China (Chinese version), France (French version), Hong Kong, China (English version), Macao,China and Portugal (Portuguese version), Oman (Arabic version) as well as Spain (Spanish version) for providing official weather forecasts, as well as climatological information from Members to the public and media round the world. By September 2007, there are 116 WMO Members supplying weather forecasts to WWIS covering a total of 1,218 cities. Furthermore, 160 Members are providing climatological information for 1,223 cities to WWIS. The total page visits for all 6 WWIS language versions reached 71 million in the first 9 months of 2007. The SWIC (http://severe.worldweather.wmo.int/) is operated by Hong Kong, China providing official warnings from Members to the public and media worldwide. The page visits to the SWIC website amounted to some 10 million visits in the first 9 months of 2007. Besides providing a source of weather and warning information to meet the needs of the global community, these two websites also serve to promote the image of NMHSs, especially, those of developing Members,

The WMO Madrid Conference and Madrid Action Plan

The WMO International Conference on 'Secure and Sustainable Living: Social and Economic Benefits of Weather, Climate and Water Services' took place in Madrid, Spain from 19-22 March 2007. The purpose of the Conference was to contribute to secure and sustainable living for all the peoples of the world by evaluating and demonstrating, and thence ultimately enhancing, the social and economic benefits of weather, climate and water services. The Conference endorsed a Madrid Action Plan (Appendix II) with the overall objective of achieving, within five years, a major enhancement of the value to society of weather, climate and water information and services in response to the critical challenges represented by rapid urbanization, economic globalization, environmental degradation, natural hazards, and the threats from climate change.

The Actions from the Madrid Action Plan that have direct relevance to the mandate of the PWSP are highlighted in italics in Appendix II. In short, the main recommendation is that NMHSs would need to enhance their efforts to make potential users – including their governments – aware of the range of products and services, including potential new products and services, and their expected benefits for users. This should lead to a dialogue with the users so that the users can specify their requirements and respective service level agreements can be concluded to maximize the benefits provided by the meteorological and hydrological community.

As part of the process leading up to the Madrid Conference, a series of seven regional and sub-regional preparatory workshops was organised by WMO over the period November 2005 to February 2007 in the Philippines, Mali, Brazil, Kenya, Tanzania, Kuwait and Croatia. The principal goal of the preparatory workshops was to provide a forum for promoting interdisciplinary assessment of socio-economic benefits of meteorological and hydrological services involving service providers and different users. The workshops identified regional common issues and national specific differences and noted the following areas of concern:

- Inadequate understanding of user needs and requirements for meteorological and hydrological information and services by NMHSs;
- Lack of awareness of users on the available and potential weather, climate and water services in developing countries, in particular the LDCs;
- The difficulty of integrating weather, climate and water services into national development strategies and priorities including those related to the Millennium Development Goals (MDGs);
- Lack of capacities and specialized competencies in NMHSs of developing countries to deliver timely and relevant services in order to better meet the needs of users; and

- Inadequate communication between NMHSs and users.

The workshops made general and more focused recommendations as follows:

- To integrate the outcomes of the regional workshops into the various strategic plans of Regional Associations;
- To organize national workshops to define appropriate processes for quantitative evaluation of the socio-economic benefits of meteorological and related services including the development and implementation of pilot demonstration projects and sharing good practices and experiences;
- To establish appropriate partnerships between various stakeholders, in particular providers and users;
- To organize capacity building initiatives including training both providers and users to facilitate better delivery of meteorological and related information and products;
- To develop the capacities of NMHSs in marketing and communication; and
- To address emerging needs of users including climate change related issues.

These recommendations are of direct relevance to the PWSP.

Shortfalls in Existing PWSP Capacity Building Strategies

Conventional training methods such as workshops, conferences and symposiums have been the key capacity building activities of the PWSP to address some of the institutional, organizational and individual skill needs of Members in the delivery of their public weather service. Although in recent years there is a shift to strengthen the impact of training by focusing more on specific organizational outputs and outcomes such as "train-the-trainer" approach, most training activities are unfortunately still delivered as isolated, one-off events with a focus on training isolated groups or individuals who may not be in a position or have a holistic view to effect change within an organization. New strategies are required to achieve long-term and sustainable effects in building the capacity of these Members.

Publication of PWS guidelines is an effective means for transfer of knowledge and sharing of experience amongst Members. Although much work has been done by the ICT in publishing PWS guideline documents, there is no real measure of the extent to which they have been used, and the knowledge contained within them applied, by NMHSs. Furthermore, some NMHSs could not benefit as much as they should from the published guidelines in bringing about significant improvement in their PWS. This may be attributed to great inertia of the existing structure and practices which resist changes. There may be a need for some fundamental changes in respect of some Members before they can progress on the PWS front. Nevertheless, there is increasing awareness that some of the processes are social in nature which must be learned by practice, and consciously acquired over time by those who are engaged in it.

These shortfalls of existing capacity building strategies in PWSP clearly highlight the need for a new approach that goes beyond the conventional.

A New Approach: "Learning Through Doing"

An eminent psychologist, Carl Roger (as cited in Kraft, 1978), asserted that "The only learning which significantly influences behaviour is self-discovered, self-appropriated learning." (as cited in Kraft, 1978). Learning cannot be imposed. It can only be acquired through participation. Hence, the name of the non-conventional approach: "Learning Through Doing".

In "Learning Through Doing", the participant will learn through a combination of action and reflection. The approach is participation oriented and outcome focused, with development of partnership and ownership as an important component. This approach consists of a series of learning cycles, each comprising phases of planning, action, feedback and reflection. A cycle starts with an issue, which becomes the learning motivation. The next step is to analyse the situation and make assumptions based on prevailing situation. Based on these assumptions, a plan with input from all stakeholders would be prepared, to be followed by action accordingly. The outcome of the actions will be reviewed and lessons learnt identified. This then forms the basis for verification and/or further refinement of the assumptions, leading to the next learning cycle. The "Learning Through Doing" approach is illustrated schematically in Figure 1.

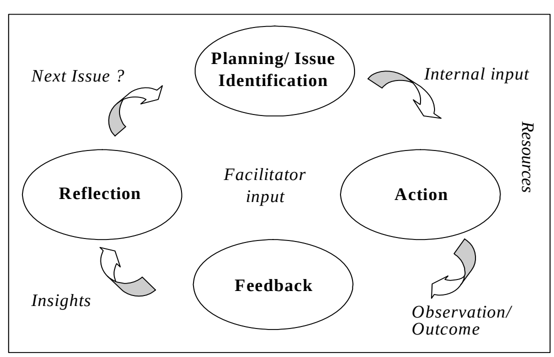

Figure 1: The "Learning Through Doing" Approach

The main characteristics of this approach are:

- learning through participation;
- reflection on action aiming to check the validity of the basic assumptions, thus leading to knowledge which can be applied and tested in future learning cycles;
- collaboration and participation of various stakeholders;
- existence of an external change agent that would enable the creation of a learning environment for the participants and facilitate resourcefulness; and
- capacity building of various stakeholders is an important component of the approach in order to achieve long-term and sustainable effects.

The elements conducive to successful outcomes of this approach are:

- ecognition of the inherent capacity, capabilities and knowledge within the participating organizations and the strengthening or enhancing of this rather than building new capacity;
- the development of trust based on honest, transparent and accountable relationships;
- a long-term commitment to the process of engagement, participation and shared learning where mistakes are considered openly, reflected upon and built upon;
- tangible benefits for the participating organizations;
- the development of commitment and a supportive enabling environment at all levels;
- skills, knowledge and adequate capacity at the organization level supported by sound leadership and mentoring processes to build and enhance capacity where it has been identified as limited or weak; and
- ownership.

In contrast to conventional learning, the "teacher" as a change agent supports the evolution by assessing, intervening, observing and evaluating the process. Its role is not to "educate" participants, rather it is to facilitate their development by bringing people together to learn from each other by sharing experiences to face common problems and develop solutions together. One of the best sources of relevant change agent is from peers who are experienced in actually leading major efforts themselves. On-going actions, feedback, and reflection provide opportunities for continuous problem solving and learning for participants.

It is only when participants buy-in the training and incorporate the insight gained into their knowledge base could the learning effect be long-lasting and sustainable. A major course of action critical to the success of the "Learning Through Doing" approach is thus the creation of ownership. Participants must take on the responsibility for developing their own capacities, and therefore ownership of the change. Nevertheless, it is only when participants believe that an activity is in their best interest, and provides tangible benefits within acceptable costs will they then consider ownership.

Using the approach of "Learning Through Doing", it is possible to design an effective PWS capacity building programme which would focus on continuous, adaptive and interactive learning to enable participants appreciate and manage their changing circumstances and to enhance their abilities to identify and meet development challenges in a sustainable manner.

New Thrust of the PWSP: WMO Pilot Project – "Learning through Doing"

In order to ensure that, in so far as possible, those on the front line of delivering services in NMHSs could benefit from the advice and guidance in PWS which have been collected and published, the ICT considers that the PWS OPAG should embark on a coordinated training and mentoring programme which would focus on "Learning Through Doing". The objective of the programme is to assist developing Members, through learning-by-doing, and through maximizing their existing capabilities, to make potential end-users aware of the range of both available and potential new products and services, and the likely benefits for users. The idea is that the PWS OPAG will select a small group of neighbouring countries, and arrange for mentoring agents to work with the staff of the relevant NMHSs in assisting them to improve their communication with users in a defined range of sectors, and to develop and deliver an improved range of products and services which would enhance the socio-economic benefits provided through the NMHSs to Members. It is proposed that the programme would start off with Pilot Projects, each with duration of 2 to 3 years, involving a small number of Members to test out the concept, before the methodology is widely applied. In the process, the programme will draw on the expertise available through the ICT's expert teams as well as that provided through the Secretariat.

A Pilot Project would comprise three stages, namely the Planning, Implementation and Review stages, as described below:

Stage I: Planning

The ICT assisted by the Secretariat would first identify suitable Members with a common need (e.g. enhancement of early warning system for tropical cyclones) to participate in the Pilot Project. In order to be a candidate, its NMHS should have an operational forecast office and produce a basic suite of products and services. It should have a demonstrable level of commitment in terms of infrastructure and support from the management. The target user sector such as agriculture, health, emergency response etc would also need to be identified early, ensuring that client partners can be found. Findings from relevant studies in the past may be useful at this stage. The ICT would identify suitable experts as mentoring agents at various stages required in the Pilot Project. Working language of the Pilot Project would be agreed by both mentors and recipient Members. Ideally, co-operation of the relevant RSMC or a regional coordination centre would be sought to assist with access to products that may be essential for the Project. To benefit from the economy of scale and for establishing regional networks, two to three Members from the same region would participate in the Pilot Project, so that expertise and experience may be shared. The Secretariat, in consultation with participating Members, would finalize a project proposal, including definition of project scope, duration, milestones and deliverables, for seeking project funds if necessary. Formal agreement would be signed between participating Members and the WMO Secretariat (and funding agencies, if any) before going into implementation. The project proposal and funding agreement, if applicable, would constitute the key deliverables for this stage.

Stage II: Implementation

At this stage, mentoring agents selected by the ICT should act as resource agents and facilitate staff of the participating Members in accomplishing the goal of the Pilot Project. An initial market survey in the selected Members to benchmark the NMHS brand would be conducted to determine if the selected sectors are aware of and use the products and services of the NMHS. Methodology for socio-economic assessment of target sectors would then be established and the baseline impact of the existing set of meteorological products and services clarified. The NMHS would engage the target sector in dialogue in a systematic manner, to reveal the gaps between user requirements and the NMHS's current capability which are addressable, taking into account the macro environment faced by the NMHS's and by making use of the knowledge database accumulated so far in the PWS community. The results would be translated into a business plan for the participating NMHSs in dealing with the target sectors, with improvements in PWS through (i) new or enhanced products; (ii) use of new technology in service delivery; (iii) more effective communicative skills and means; and (iv) more public education and outreach.

The business plan would be put into action and the outcome monitored. A systematic way to monitor the outcome would be set up. A workshop would be organized to share experiences and knowledge with the NMHSs in the same region. The initial market survey report, criteria and methodology for the assessment of economic benefits of the target sectors, the business plan, outcome monitoring plan as well as the organization of the experience-sharing workshop would be the key deliverables of the Implementation Stage.

Stage III: Review

After the execution of the business plan, a post-project survey to assess impact of the improved PWS would be conducted. Enhanced capacity of the NMHS, improved products and more efficient service delivery are useful indicators. The overall evaluation should use as basis the benchmark brand of the NMHS and the baseline social and economic impact, established earlier. Suitable ICT experts may also be called in at this stage to facilitate the overall evaluation and reflection by participating Members. The post-project survey and overall evaluation reports would be the key deliverables of this stage.

A cost-effective way to actualize the idea of "Learning through Doing" would be by injecting some PWS aspects, through cooperation with various OPAGs, into other existing WMO programmes or projects. One potential candidate is the Severe Weather Forecasting Demonstration Project RAI South-Eastern Africa which has room for enrichment by adding a PWS element involving media and disaster management and a nowcasting element. It is proposed that the PWSP should develop opportunities in this direction and identify potential projects which have room for enrichment by adding various PWS elements.

It is hoped that with the help of the Pilot Project, participating Members would start up their learning cycles facilitated by 'mentoring agents' through their own live action in a familiar environment. As a result, the solutions emerged in dealing with target issues would be more relevant and hence more effective. During the process, the impact of expert knowledge in the field through improved PWS could be evaluated in a systematic manner. The process of issue identification, action, feedback and reflection would continue into new learning cycles after the Pilot Project, enhancing the capabilities of participating Members to meet development challenges in future.

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Madrid Conference Statement and Action Plan, WMO, 2007 (http://www.wmo.int/pages/themes/wmoprod/documents/madrid07_ActionPlan_web_E.pdf)

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Appendix I

Published Guidelines on PWS

1385	Guidelines on capacity building strategies in Public Weather Services (PWS-15)
1354	Strategy for Developing Public Education and Outreach (PWS-14)
1292	Guidelines on Integrating Severe Weather Warnings into Disaster Risk Management (PWS-13)
1278	Guidelines on Weather Broadcasting and the Use of Radio for the Delivery of Weather Information (PWS-12)
1256	Guidelines on Quality Management Procedures and Practices for Public Weather Services (PWS-11)
1184	Guidelines on Biometeorology and Air Quality Forecasts (PWS-10)
1179	Guidelines on Cross-Border Exchange of Warnings (PWS-9)
1139	Guide on Improving Public Understanding of and Response to Warnings (PWS-8)
1103	Supplementary Guidelines on Performance Assessment of Public Weather Services (PWS-7)
1102	Guide on the Application of New Technology and Research to Public Weather Services (PWS-6)
1100	Public Weather Services in Region VI (Europe) - Report of Survey (PWS-5) (PDF format)
1080	Guidelines on Graphical Presentation of Public Weather Services Products (PWS-4)
1088	Guidelines on the Improvement of NMSs - Media Relations and Ensuring the use of Official Consistent Information (PWS-3)
1084	Weather on the Internet and Other New Technologies (PWS-2)
1054	Technical Framework for Data and Products in Support of Public Weather Services (PWS-1)
1023	Guidelines on Performance Assessment of Public Weather Services

Appendix II

The Madrid Action Plan

The WMO Madrid Conference Statement and Action Plan (MAP)

The International Conference on 'Secure and Sustainable Living: Social and Economic Benefits of Weather, Climate and Water Services' organized by the World Meteorological Organization (WMO), took place in Madrid, Spain from 19-22 March 2007. The purpose of the Conference was to contribute to secure and sustainable living for all the peoples of the world by evaluating and demonstrating, and thence ultimately enhancing, the social and economic benefits of weather, climate and water services.

As part of the process leading up to the Madrid Conference, a series of seven regional and sub-regional preparatory workshops organised by WMO over the period November 2005 to February 2007 in the Philippines, Mali, Brazil, Kenya, Tanzania, Kuwait and Croatia. The principal goal of the preparatory workshops was to provide a forum for promoting interdisciplinary assessment of socio-economic benefits of meteorological and hydrological services involving service providers and different users. The workshops identified regional common issues and national specific differences and noted the following areas of concern:

(i) Inadequate understanding of user needs and requirements for meteorological and hydrological information and services by NMHSs;
(ii) Lack of awareness of users on the available and potential weather, climate and water services in developing countries, in particular the Least Developed Countries (LDCs);
(iii) The difficulty of integrating weather, climate and water services into national development strategies and priorities including those related to the Millennium Development Goals (MDGs);
(iv) Lack of capacities and specialized competencies in NMHSs of developing countries to deliver timely and relevant services in order to better meet the needs of users; and
(v) Inadequate communication between NMHSs and users.

The workshops made general and more focused recommendations as follows:

- To integrate the outcomes of the regional workshops into the various strategic plans of Regional Associations;
- To organize national workshops to define appropriate processes for quantitative evaluation of the socio-economic benefits of meteorological and related services including the development and implementation of pilot demonstration projects and sharing good practices and experiences;
- To establish appropriate partnerships between various stakeholders, in particular providers and users;
- To organize capacity building initiatives including training both providers and users to facilitate better delivery of meteorological and related information and products;
- To develop the capacities of NMHSs in marketing and communication; and
- To address emerging needs of users including climate change related issues.

The Conference agreed that NMHSs need to enhance their efforts to make potential users – including their governments – aware of the range of products and services, including potential new products and services, and their expected benefits for users. This should lead to a dialogue with the users so that the users can specify their requirements and respective service level agreements can be concluded.

(The Actions from this Plan (MAP) that have direct relevance to the mandate of the PWSP are highlighted in italics.)

Action 1: Review the institutional framework governing meteorological and hydrological service provision in order to strengthen partnerships with different sectors of the economy.

Action 2: Lead a quantum change in the way that weather, climate and water information and services are produced, used and communicated by identifying, confirming and responding to the rapidly increasing and evolving needs of multi-disciplinary stakeholders for appropriately timed and scaled weather, climate and water information and services.

Action 3: *Embark on capacity building endeavours through creation of education and training opportunities for both users and providers of weather, climate and water information to increase awareness of users to the opportunities afforded by weather, climate and water services, and to assist the providers of these services to understand more fully user requirements.*

Action 4: Foster increased recognition by governments and other stakeholders of the contribution that NMHSs and their partners are making to secure and sustainable living.

Action 5: Adopt the following steps to meet the growing demand for weather, climate, water and related information and services:

- strengthening of observational programmes, and the associated research and development;

- development of the next generation of climate and earth system models with resolutions of 10 km or finer, and the corresponding data assimilation systems;
- significantly strengthening multidisciplinary research programmes required to develop the understanding underpinning the development of these models; and
- improving delivery and distribution systems, including early warning systems, to allow NMHSs to meet the needs of institutions, agencies and the general public; consolidating existing and, when appropriate, creating new regional operational centres to mutualise competencies and resources; and

Action 6: Develop analysis of the urban environment as a critical ecosystem requiring targeted observation, research and meteorological and hydrological services.

Action 7: *Facilitate and strengthen dialogue and collaboration between providers and users of weather, climate and water information and services through international, regional and national platforms and programmes, and through the development of appropriate tools and methods.*

Action 8: Strengthen existing, and develop and implement new, multi-disciplinary programmes that will define and improve ways and means to generate and deliver those weather, climate, and water services, which address the developmental, societal, economic, environmental and health concerns of the countries.

Action 9: *Strengthen existing, and establish new, operating partnerships between users and providers of weather, climate and water services to share responsibility for effective delivery of services, and evaluate their performance.*

Action 10*: Facilitate and strengthen the ability of NMHSs to effectively communicate weather services and products, through all forms of media, in such a manner as to maximize the benefits provided to society by the meteorological and hydrological community.*

Action 11: *Encourage the NMHSs and social science research community to develop knowledge and methodologies for quantifying the benefits of the services provided by NMHSs within the various socio-economic sectors; in particular:*

(i) develop new economic assessment techniques including especially techniques of economic assessments for developing and least developed countries;

(ii) develop WMO Guidelines on operational use of economic assessment techniques;

(iii) train national staff on use and practical application of economic assessment of the benefits of services provided by NMHSs;

(iv) PRESENT results of economic assessments to governments and donors/International Financial Institutions with the goal of modernizing the infrastructure of NMHSs and strengthening their service delivery capacity.

Action 12: Encourage the free and unrestricted exchange of meteorological, hydrological and related data to support research and improve operational services.

Action 13: Build on the earlier WMO work on the development of a comprehensive economic framework for meteorological service provision.

Action 14: Develop, as a matter of urgency, the implementation plan to give effect to the actions set out above.

Action 15: Monitor and report every year to key partners on progress with the implementation plan, and organize a further, more broadly based, conference in 5 years to take stock of achievements under this Action Plan.

World Bank Support for NMHS Development In Europe and Central Asia[1]

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Abstract

The World Bank has had a growing involvement with the hydromet sector in recent decades. Within Europe and Central Asia, the Bank recently undertook investments in Turkey, Poland and Russia. The Russian project drew Bank attention to the full circuit of clients of hydromet services, for the first time, and a follow-up study showed that there is a need for investment in this sector around the region. We believe that future World Bank investments in the sector should build on assessment of the demands of national climate, user needs and agency capacity, enabling evaluation of the economic benefits of hydromet services to the national economy. The case for investment could be better made to Governments if data on economic benefits were gathered by the NMHSs. Government awareness of these benefits would help promote sustainability. Donors and financiers, in turn, are reluctant to undertake involvement in the sector in the absence of Governmental support to assure the sustainability of investments. Only the NMHSs themselves will meet the need for better national understanding of the value of their services.

Background

Among the World Bank's earliest operations were investments in hydroelectric power and irrigation that drew on hydrometeorological records. From the 1970s, Bank investments began to focus on significant upgrades of hydrometeorological networks within broader water resources management or irrigation projects, or strengthening agrometeorological networks important for support to agriculture. Since then, strengthening of hydromet capacity has been supported within the scope of projects in water resources management, disaster preparedness, and – more recently – climate adaptation. Such projects as Water Resources Management in Mexico, Emergency Irrigation Rehabilitation in Afghanistan, Natural Disaster Mitigation in Honduras, East Timor Agricultural Rehabilitation in Timor Leste and the Caribbean Mainstreaming Adaptation to Climate Change illustrate this trend. There has been a growing understanding at the Bank that NMHSs comprise an important, self-standing public sector that generates data critically important for public safety and economic development, an appropriate primary target of support from international financial institutions. In many countries, the NMHS is the only institution collecting climate data and is a national focal point dealing with climate change assessment.

The objective of this paper is to describe recent investment activities aimed to develop NMHSs supported by the World Bank in the Europe and Central Asia region (ECA), and to provide an overview of potential developments for the near future.

Status of NMHS in ECA

As a recent World Bank study showed,[2] many NMHSs in ECA faces serious capacity challenges. Twenty to thirty years ago, weather forecasting and overall provision of hydromet services in many ECA countries were at the leading edge of world capacity. Since the late 1980s, many have experienced a significant decline in public financing, leading to an overall degradation of agency infrastructure (see, for example, Table 1).

Table 1. ECA NMHS Capacity in Key Areas

Country	LAM	Radio-sonde	Met radar
Albania	0	0	0
Armenia	0	1	1
Azerbaijan	0	1	1
Belarus	0.5	1	1
Bosnia	0	0	0
Bulgaria	1	1	1
Croatia	1	1	1
FYR Macedonia	1	1	1
Georgia	0.5	0	1
Kazakhstan	0	1	0
Kyrgyz Republic	0	-	-
Moldova	0.5	0	0
Montenegro	1	0	0
Russia	1	1	1
Serbia	1	1	1
Tajikistan	0	0	0
Turkmenistan	0	0	0
Ukraine	0.5	1	1
Uzbekistan	0	0	1

LEGEND

Local Area Model (LAM): 1=operational tailored LAM; 0=no LAM covering national airspace; 0.5=other cases.
Radiosonde: 1 = scheduled launch of 1 radiosonde daily.
Met Radar: 1=operation of a met radar by the NMHS.

Performance has deteriorated in many agencies, performance relative to sector-leading agencies even more so, and some agencies are on the brink of collapse. Many surface data collection stations have closed and the surface stations that remain open record a more limited set of parameters, less frequently, using instruments that are aging and failing. Communications equipment to convey station data to headquarters for analysis is often obsolete, unreliable, labor-intensive and expensive. Ongoing training is inadequate either to keep the skills of senior staff current, or to prepare an adequate number of incoming staff. The scope of the accumulated problem is so great that without massive modernization, networks in some ECA countries are on the way to becoming completely dysfunctional, leaving countries to depend on low-resolution forecasts prepared by others that miss significant local and rapid-onset hazards including floods, frosts and severe storms.

Bank Support For NMHS Modernization In Europe And Central Asia Region.

Two major investment activities supporting NMHSs in the region that are now complete originated as emergency response to massive natural disasters.

Turkey

Following torrential rain on May 21, 1998, the western Black Sea region of Turkey was affected by a devastating flood. During the same week, severe floods also occurred in other parts of Turkey triggering several hundred landslides. On June 27, 1998, the Province of Adama was affected by a strong earthquake that caused massive economic damages and fatalities (about USD 1 billion damage done, about 1000 people hurt and 144 people killed). In October 1998, the World Bank and the Government of Turkey agreed to undertake the Turkey Emergency Flood and Earthquake Recovery Project. One component concerned collection and analysis of real-time hydrological and meteorological data, to produce disaster forecasts, translate forecasts into specific warnings for specific locations, disseminate warnings, and improve response planning. To that end, it financed modernization of the weather forecasting system at the Turkish State Meteorological Service and modernization of the flood forecasting and warning system of the General Directorate of State Hydraulic Works in several regions of Turkey. A modernization program costing about USD 26 million procured and installed about 200 AWS, about 125 hydrological stations, a supercomputer, Doppler radar, an upgraded communications network and development of specialized software for flood warnings. One project challenge was integration of these systems. Another was retaining qualified staff trained during the course of the investment program. An important lesson learned from this project was the need for early initiation of integration between the technical agencies and the national disaster management agency.

Poland

In 1997, Poland endured a massive flood, of a magnitude beyond Poland's records and experience. Fifty-five people died; dozens of towns and hundreds of villages were inundated. Total damage was estimated at USD 3.4 billion (about 2.4 percent of Poland's 1997 GDP). An Emergency Flood Recovery Project was designed with financing from the World Bank and the European Bank for Reconstruction and Development (EBRD) that included development of a monitoring, forecasting and warning system (within a broader program also including flood prevention planning, upgrading of flood prevention infrastructure, and development of non-structural measures to limit damage, including regulations for economic use of risky areas, flood impact minimization plans, warning systems, and flood insurance, among others). The project is now complete.

The monitoring, forecasting and warning system, SMOK, included the following:

- (i) A network of about 1000 automated meteorological and hydrological measuring stations.
- (ii) Upgrade to data processing and transmission systems at airports and forecasting offices.
- (iii) Development of a high-resolution weather forecasting model tuned to Poland, and procurement of a supercomputer to run the model.
- (iv) Development of a hardware/software platform (client service system) to provide access to forecasts by users.
- (v) Introduction of a lightning detection system.
- (vi) Installation of eight Doppler radars.

The system's setup cost was about USD 62 million. Important issues and risks were associated with late introduction of the integrator function, uncertain government commitment to increasing the NMHS budget in line with the operations and maintenance needs of a new system, and the service's difficulty in retaining qualified staff.

Russia

In 2005, the Bank approved the first-ever project with a stand-alone focus on a national NMHS.The Russian Hydromet Modernization Project was the first that undertook NMHS capacity development envisioned to upgrade service delivery to the entire NMHS sectoral clientele – rather than to emergency management or any other single sectoral client.

The main development objective of the project is to increase the accuracy of forecasts provided to the Russian people and economy by modernizing key elements of the technical base and strengthening RosHydromet's institutional arrangements. Corresponding performance indicators and outcomes built into the project design will support evaluation of implementation progress and prompt the introduction of corrections when needed. The total project cost is now estimated at USD 133 million, but may be expanded by increased government co-financing. Completion of the project is expected in 2011.

The project has three main components. The first component aims at upgrade of RosHydromet's overall IT infrastructure (supercomputing, telecoms, archiving), not only to support the agency's forecasting skill but also to ensure delivery of tailored products across Russia's regions and sectors.

The second component aims at upgrading the observation networks that are most important in supporting Russia's key weather-affected sectors, including storm mitigation in the most vulnerable river basins, municipal services in the largest cities, energy enterprises (which benefit from surface stations in the north), aviation (especially upper-air sounding over Siberia), environment and agriculture, which will be a principal beneficiary of upgrades in observing lead times and accuracy. Besides these, other sectors will benefit as well.

A third component, institutional modernization, is designed to help RosHydromet to experiment with approaches to improving overall efficiency of operations, increasing their sustainability and improving the linkages between RosHydromet and users of its services.

There are number of implementation difficulties faced by RosHydromet and the World Bank project team that arise from the overall technical complexity and large scale of the project: difficulty in prioritizing investments, considering that urgent investment needs far exceed available funds; lack of experience in RosHydromet in running such a large-scale program; reticence toward new institutional and financial approaches to optimize operations. Ensuring the sustainability of RosHydromet operations and retaining qualified staff after modernization are major issues which so far do not have clear solutions.

Challenges ahead and new developments

In the near future the Bank will continue to assist in improvement of NMHS performance in ECA, concentrating effort in two sub-regions – South Eastern Europe and Central Asia.

South Eastern Europe is vulnerable to severe storms, floods, droughts and climate change. Weather warnings and flood forecasts could mitigate a significant share of losses by enabling preparatory measures, but are not as effective as they could be because the region's monitoring network is sparse and in many places depends on obsolete instrumentation. To address these issues, the Bank is at present considering investment in NMHS upgrade in South Eastern Europe as a component of a broad regional disaster risk reduction initiative, a framework encompassing disaster preparedness, mitigation, risk insurance and adaptation. The project is still in preparation.

Central Asia is also vulnerable to a range of weather hazards including droughts, floods, strong winds, extreme heat and cold waves, hail and avalanches. The NMHSs in the region are very weak and in urgent need of improvement. The Bank is discussing a potential NMHS modernization program in Kazakhstan, and has initiated analytical work in the Kyrgyz Republic, Tajikistan and Turkmenistan, with the main objective of developing an action plan for NMHS modernization.

There are number of generic challenges attached to NMHS improvements in ECA region which should be taken into account in designing modernization programs.

Most national level modernization proposals developed by NMHSs suffer from similar shortcomings. These proposals often are not based on adequate assessment of the client needs; NMHS interactions with clients are often poor. Some NMHS concentrate on the technological aspects of data collection rather than on delivering information products that meet client needs. Often, NMHS modernization plans envisage direct and massive infusion of various modern technologies and equipment (such as plans to buy and install more radars, automatic weather and hydrological stations, supercomputers, etc.) while limited consideration is given to what would be needed to operationalize the new technologies and equipment and to make them work as integrated system rather than separate units or networks. NMHS rarely develop a phased, prioritized plan or program which defines what sequence of steps should be undertaken to eliminate or minimize a capacity gap accumulated over several decades. Instead, all major problems are targeted and tight schedules are proposed, leading to unrealistic proposals impossible to implement. It should be added, however, that after all limited technical guidance exists on how to undertake major NMHS modernization on the national level, how to use limited resources in an optimal way, how to design observational networks and programs in line with user needs and NMHS mandates, and so on.

In promoting their programs within the government NMHS in most cases do not use economic assessments, which could demonstrate the efficiency of the proposed investments. Further, sustainability of modernized system is often not acknowledged as one of the most important criteria at the design stage. Many donor-supported initiatives in NMHS capacity-building have limited impact due inadequate consideration of the sustainability of these initiatives after external support ends.

We believe that support for NMHS service improvement should be based on:

(vii) Assessment of national climate, including average weather, variability of weather, natural hazards, observed climate change, and other aspects of climate;
(viii) Assessment of user needs, addressing households, key economic sectors and government priorities;
(ix) Assessment of NMHS status, including agency capacity, sustainability, and effectiveness in user orientation;
(x) Assessment of the economic benefits of an upgrade to weather and climate services.

On the basis of these assessments, recommendations for NMHS modernization should be developed, incorporating prioritized planning for improvement of data delivery to national users. Improvement priorities should be developed based on consultation with national policy makers and may include:

(xi) Initiatives in data processing, modelling and information dissemination;
(xii) A menu of high-priority investments in modernization of the basic observation and IT infrastructure (communication and basic observation equipment);
(xiii) Phased overall modernization, to include upgrade of the main elements of NMHS infrastructure, institutional strengthening, and capacity building, such as workforce training and recruitment. The forecast of available financing both from public and commercial services should be a main input factor considered in the development of overall modernization proposals.

NMHSs generate very important national and global public goods used to protect lives and property and to optimize the performance of a number of key economic sectors. Upgrading NMHS services is therefore an important task for the government, international financial institutions and donors.

A Collaborative Epidemic Early Warning And Response Initiative In Ethiopia.

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Abstract

Malaria is the most well known of the climate sensitive diseases. Epidemics of malaria are often triggered by climate anomalies and climate informed early warning systems have been advocated in recognition of this. Africa bears the greatest burden of malaria worldwide and it is estimated that almost 125 million people live in areas prone to malaria epidemics. Ethiopia is the second most populous country in Africa and due to widespread poverty combined with highland and desert-fringe terrain it is the country with the highest proportion of the population (more than two thirds) living at risk of malaria epidemics. Prevention and control of malaria epidemics is a priority for the Ethiopian Ministry of Health and during recent years the Ministry of Health has commissioned the National Meteorological Agency to provide routine meteorological information to inform on changing conditions in epidemic prone districts. This innovative action in epidemic malaria prevention and control is outlined here with consideration of its effective operational uptake and sustainability.

Problem Focus

Many of the world's major public health issues are sensitive to climate. Those that generate most attention are the vector-borne diseases – with malaria, the globally important mosquito borne disease, being the most studied [1]. While economic development has had a major bearing on the distribution of malaria over the past century it is clear that, where malaria is not adequately controlled, true of much of the less developed world, the spatial and temporal distribution of endemic malaria is greatly influenced by seasonality and trends in climate, with periodic epidemics triggered by anomalies in rainfall, temperature, and humidity [2].

It is currently estimated that 3.2 billion people in 140 countries remain at risk of malaria and at least 500 million cases and 2 to 3 million deaths occur each year. Malaria is caused by protozoan parasites of the *Plasmodium* species that are transmitted to people by infected mosquitoes. The malaria parasites enter the human bloodstream through the bite of an infected female *Anopheles* mosquito. Of the four malaria parasites that affect humans, *Plasmodium falciparum* is the most deadly, and unfortunately in Africa the most common. Indeed Sub-Saharan Africa bears the brunt of the global burden of malaria with more than 60% of the world's malaria cases and more than 80% of the world's malaria deaths [3, 4]. The greatest burden of malaria in Africa is in endemic (or stable transmission) areas where the parasite is continuously present in the community. The environment encourages interactions between the *Anopheles* mosquito, malaria parasites and human hosts, providing: surface water in which mosquitoes can lay their eggs; humidity for adult mosquito survival; and temperatures that allow both the mosquito and the malaria parasite to develop and survive. Where malaria control measures are inadequate, the disease distribution is closely linked with seasonal patterns of the climate and local environment. Those most vulnerable to endemic malaria are young children who have yet to acquire immunity to the disease, pregnant women whose immunity is reduced during pregnancy, and non-immune migrants or travelers.

Epidemic (or unstable) malaria tends to occur along the geographical margins of endemic areas, when the conditions supporting the balance between the human, parasite and mosquito vector populations are disturbed. This leads to a sharp, but temporary, increase in disease incidence. More than 124 million Africans live in such areas, and experience epidemics causing around 12 million malaria episodes and up to 310,000 deaths annually [5]. All age groups are vulnerable to epidemic malaria, because their exposure to disease is infrequent and they have little immunity. In the case of 'classic' or 'true' epidemics, the change in equilibrium is brought about by natural causes such as climate anomalies in regions where the environment does not normally allow mosquito and parasite development.

Typically these involve desert-fringes (usually too dry to support transmission) or highland-fringes (usually too cool). The climate anomalies are often periodic and temporary, and there is a return to equilibrium. Examples include the epidemics occurring in the semi-arid areas of Southern Africa in 1996-1997, East Africa in 1997-1998, and the West African Sahel in 1999-2000, all of which were associated with wide-scale and unusually heavy rainfall[6]. Being poorly prepared, health services often become rapidly overwhelmed, leading to perhaps ten times more malaria-related deaths than in non-epidemic years, across all age ranges[7].

Measures to control both endemic and epidemic malaria need to be applied in the right place at the right time, and climate and weather information can help focus appropriate control interventions to protect vulnerable communities [8]. Prevention and control of epidemics has been one of the four key technical elements of the Global Malaria Control Strategy which was adopted by the 1992 World Health Assembly [9, 10]. The prioritization of epidemic prevention and control was voiced at a high level in Africa [11-13] and strongly reflected in the inception, in 1998, of the Roll Back Malaria Partnership[14] which immediately established a Technical Support Network on Epidemic Prevention and Control [15]. It was recognised that in the majority of instances epidemics were first reported from outside the formal health sector. While it was seen as essential that epidemiological surveillance systems be strengthened it was also recognised that information on changes in epidemic potential are most likely to be available from outside the health sector. In view of this considerable interest emerged in developing operational Malaria Epidemic Early Warning and Response Systems (MEWS) which could integrate timely information on changes in community vulnerability, as well as meteorological and environmental conditions, to improve advanced planning and prevention of malaria epidemics[6, 16, 17].

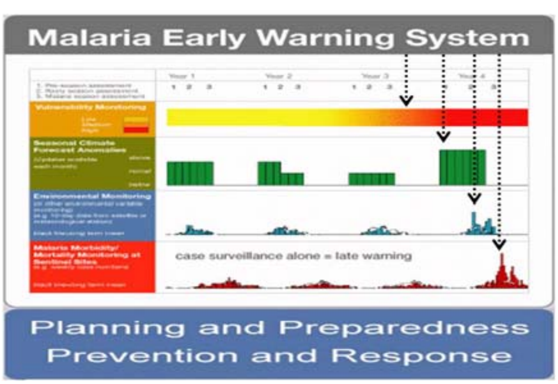

Figure 1 A conceptual model of an Integrated Malaria Epidemic Early Warning and Response System providing incremental evidence of changes in epidemic risk (modified after WHO 2004)

There has been good progress and promising results with MEWS development in Botswana, and Southern Africa[18-21]. However, epidemic risk in Ethiopia and other densely populated countries in the East African highlands remains a major challenge for malaria prevention and control in Sub-Saharan Africa. It is this region which is home to more than three quarters of Africans, of all age groups, living at risk of epidemic malaria. Recently an innovative collaboration between the Ethiopian Ministry of Health and the National Meteorological Agency which was funded by the Global Fund for AIDS, TB and Malaria has begun to address this issue. Success with this venture would provide an excellent example of how meteorological services can aid effective control of a major issue constraining Ethiopia's social and economic development.

<u>An Ethiopian collaborative initiative in climate informed Epidemic Early Warning and Response</u>

Ethiopia has a diverse climate and topography, consequently malaria transmission throughout much of the country shows marked inter-annual, seasonal and geographical variations. However, the majority of Ethiopians live in highland and mid-altitude regions that are prone to highly seasonal and unstable malaria transmission, and it is estimated that more than two-thirds of the country's population (58 million) are at risk of epidemic malaria[26]. Recent malaria epidemics in Ethiopia have been particularly severe. The 1998 epidemic was especially intense and widespread, somewhat reminiscent of the classic epidemic thirty years earlier in which an estimated 3 million cases and 150,000 deaths occurred[22]. During the 1998 outbreak, more than 403 localities in Tigray, 1,544 localities with 3.4 million people in Amhara, 812 localities with more than 1.2 million people in Oromia, 300 localities with more than 216,317 clinical cases in SNNPR were seriously affected, with a high mortality rate among the affected communities. In SNNPR 60% of all hospital admissions in 1998 were due to malaria. Based on the data collected outside of the health system, a local NGO called the Anti-Malarial Association (AMA) reported a total of 7,783 deaths in Western and Eastern Gojam zones of Amhara region between September and December 1998. These figures most likely represent a fraction of the true impact on morbidity and mortality due to the tremendous strains that were placed on health systems during this period and the large proportion of cases that went undocumented. Due to low levels of acquired immunity all age groups were highly vulnerable to the disease. In certain parts of the Amhara region during the 1998 epidemic, the median age at death due to malaria was about 25 years old. Periodic upsurges in malaria cases far exceeding normal seasonal

[26] The desert fringe or semi arid lowlands of Afar and Somali regions are also known to be epidemic prone however these regions are less densely populated.

fluctuations occur periodically in epidemic regions, straining local health institutions beyond their capacity and overwhelming their ability to respond effectively. It is for this reason that interest in the development of epidemic early warning systems, which could provide lead times sufficient for advance preparation and preventative response, is great.

Following a retrospective analysis of the role of meteorological determinants in 'triggering' malaria epidemics in Ethiopia, which suggested the potential to predicts epidemics some months in advance, the Ministry of Health was successful in obtaining a grant from the Global Fund for AIDS, TB and Malaria (GFATM) to build and implement an epidemic early warning system. The early warning system comprises four levels – each producing alerts or 'flags' designed to trigger a surveillance and control response:

Flag	Indicator	Accuracy	Response
1	Long-term forecast	Low	Heighten surveillance
2	Short-term forecast	Low-moderate	Assess and enhance readiness
3	Real time weather data	Moderate	Initiate selective interventions
4	Early detection	High	Mobilise widespread interventions

Table 1. Proposed Early Warning and Detection Graded Response Mechanism for Ethiopia.

The National Malaria Control Programme has, to date, identified 14 sentinel surveillance districts in Ethiopia for monitoring impacts and outcomes of anti-malarial interventions. This heightened surveillance capacity is considered necessary for early detection of anomalous trends in cases and other indicators of epidemics. Their widely dispersed distribution throughout the country ensures that even localized epidemics may be detected. Districts to be considered for the initial installation and assessment of a sentinel early warning system include: Dubti, Jabi Tahnan, Bahir Dar, Guba Lafto, Assosa, Gambella, Hagre Mariam, Fentale, Kersa, Errer, Awassa, Arbaminch, Tahtay Koraro, Alamata. However, the number of stations in the list is considered to be insufficient for the proposed early warning system. Hence, Ministry of Health and the National Meteorological Agency need to work together in revising the list and selecting additional sentinel stations.

In collaboration with the National Meteorological Agency, the general capacity of all epidemic-prone districts to monitor climatological anomalies will be improved through the upgrading of all Class IV weather stations which monitor rainfall only, to Class III status which includes the measurement of minimum and maximum temperature. A total of 319 weather stations will be upgraded in this manner. This enhanced coverage will benefit those districts that are not served by Class III weather stations and thus, cannot receive relevant information about an epidemic indicator as important as minimum temperature. While funds from the GFATM grant will bear the initial cost of upgrading these weather stations with thermometers, NMA will maintain the responsibility of staffing the weather stations, collecting data and reporting. The data will be made available to the general health care system of Ethiopia for utilisation in a malaria early warning system.

Development and deployment of early warning systems based on meteorological and clinical indicators at the district and facility level will be extended to RBM sentinel surveillance sites. Partnerships will also be developed with other government sectors and NGOs to monitor other determinants associated with malaria transmission including ecological changes due to development activities or natural disasters, and social factors such as migratory labour or political unrest. These factors are not currently considered by the health sector in assessing epidemic risk but may play a major role in determining the occurrence and severity of epidemics.

The National Meteorological Agency received approximately US$500,000 through the MoH's GFATM award to be used for activities related to malaria early warning activities. Specifically: upgrading of 319 class IV meteorological stations (currently measuring rainfall only) to class III stations (to be able to additionally monitor minimum and maximum temperatures); work with the MOH on developing sentinel stations in the 14 target districts; provision of meteorological data and information products for malaria early warning and detection.

Progress to Date

Approximately three quarters of the funds available have been used for the purchase of meteorological equipment, purchase of Personal Computers, freight costs and installation of a Local Area Network. The National Meteorological Agency has given due attention to the need for establishing as many as possible 3rd class and 1st class stations in its recent meteorological stations network master plan studies. Additionally, the Agency has already established over a hundred of such stations in the last two years and are planning to establish over 80 more next year. Thus, the newly established stations will bring about wider choices for selection of additional sentential stations.

Following meetings between NMA and MoH staff requests were made for monthly bulletins beginning in January 2007. These bulletins provide updates on the distribution of rainfall, temperatures and relative humidity in a map format. The bulletins are distributed to the Ministry of Health's National Malaria Control Team who then send a hard copy of the bulletin to the regional malaria control departments with a covering letter, the bulletin is also placed on the RANET (community RAdio-interNET) website. To date the maps used in the monthly Health Bulletins have been based on the 'climate suitability for malaria transmission' criteria published by Grover-Kopec, et al. in 2006. These are monthly rainfall greater than 80mm, temperatures between 18-32°C, and Relative Humidity greater than 60% [23]. http://meteo-ethiopia.net/

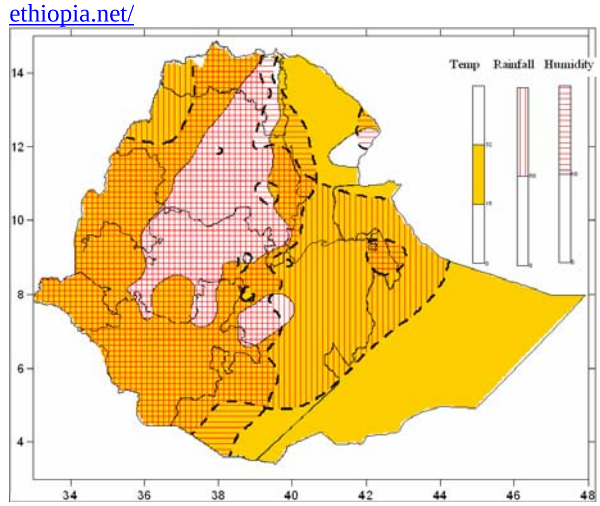

Figure 2. Combined temperature, rainfall and humidity conditions during September 2007. Areas under square patterns with yellowish background are assumed to satisfy favourable climatological conditions for malaria.

The MoH expects that the information to be provided by the NMA will be useful to help: plan on the purchase of drugs; identify where and when to implement more focal epidemiological surveillance; focus vector control more appropriately in space and time; raise community awareness of risk of epidemics; warn relevant players of any potential emergency as necessary.

Initial Constraints and Concerns

Lack of manpower has been flagged as a constraint to meeting the installation requirements in the time allotted in the project. The MoH has called for more detailed information on the effect of topography on climate and hydrology as this is considered crucial to localised changes in malaria risk. Both the MoH and the NMA believes that more concerted interaction is required to make the system most effective. It has been suggested that both the MoH and the NMA each need a dedicated employee with some training in biometeorology to act as the main interfacing focal point within the initiative. The problem of rapid turnover of well trained staff within the government agencies is seen as a major pitfall.

This collaborative initiative between the NMA and the MoH in Ethiopia is a very exciting development which has grown up around a real demand, and investment, for climate and weather service information to improve the control of climate sensitive epidemic diseases – diseases which are recognised as a major constraint to Ethiopia's prospects towards the Millennium Development Goals and other indicators of socio-economic benefit. However, the initiative is in its early stages and will need significant support to enable it to become an effective and sustainable mechanism for epidemic prevention and control. The role of climate and health is currently enjoying a high profile among the international community in terms of demonstrating climate risk management and practical adaptation to a changing climate. Public health is also enjoying significant international investment at present though funding mechanisms such as the Global Fund for AIDS, TB and Malaria. Success here in Ethiopia will very likely encourage similar multi-agency investments elsewhere in other epidemic prone countries.

The successful relationship between the Meteorological community and the aviation industry is held up as exemplary. However, this relationship did not become successful overnight and much concerted interaction had to take place between the two sectors over a significant period of time. We would suggest that the potentially highly beneficial relationship between PWS and the Public Health Services will also require this process – with strong technical support from the two community's natural partners, e.g. the UN WMO and WHO, to explore in detail the institutional and logistical constraints, help identify mechanisms to overcome them and support their implementation in the immediate and medium-term period.

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