SWFDP AND ITS FUTURE DIRECTIONS TOWARDS STRENGTHENING/SUSTAINING WMO'S OPERATIONAL CENTRES

Submitted by WMO, with contributions from the CBS/DPFS and the SWFDP-Southern Africa Regional Management Team chairpersons

1. INTRODUCTION

The Severe Weather Forecasting Demonstration Project (SWFDP) was originally designed in 2004. The SWFDP is a project carried out by the WMO's Commission for Basic Systems (CBS), under the general guidance of its Steering Group (SG-SWFDP). The two main ideas driving the project are still valid today:

- Ensure that valuable forecast information readily available in the Global Data-processing and Forecasting System (GDPFS) regarding severe weather occurrence was effectively used in operations by developing countries, and,

- Further develop the three-layer structure of the GDPFS, applying the *Cascading Forecasting Process*.

The main goals set for the SWFDP were to:

- Improve severe weather forecasting,
- Improve lead-time and reliability of warnings,
- Improve interaction of NMHSs with media and with disaster management and civil protection authorities,

and also:

- Improve the skill of products from GDPFS Centres through the provision of feedback.

2. SWFDP – EXPLOITING THE *GDPFS* FOR ENHANCED BENEFITS

2.1 Why a project on severe weather forecasting?

The World Meteorological Congress, at its fifteenth session (Cg-XV, May 2007), approved a *Vision for Improving Severe Weather Forecasting in Developing Countries* (ftp://ftp.wmo.int/Documents/PublicWeb/mainweb/meetings/cbodies/governance/congress_reports/english/pdf/1026_E.pdf, paragraph 3.1.3.11):

> *"NMHSs in developing countries are able to implement and maintain reliable and effective routine forecasting and severe weather warning programmes through enhanced use of NWP products and delivery of timely and authoritative forecasts and early warnings, thereby contributing to reducing the risk of disasters from natural hazards."*

The World Meteorological Congress, at its sixteenth session (Cg-XVI, May 2011), recognized that this Vision was being implemented through the SWFDP. That through the implementation of the "*Cascading Forecasting Process, an approach that provides improved access to, and effective use by forecasters of existing and newly developed NWP/EPS products made available by advanced GDPFS Centres, national forecasting and warning services have improved significantly, with increased lead-times and greater reliability*" (ftp://ftp.wmo.int/Documents/PublicWeb/mainweb/meetings/cbodies/governance/congress_reports/english/pdf/1077_en.pdf, paragraph 3.1.3.7).

Following the Recommendation by CBS, Cg-XVI endorsed a *Strategy for the SWFDP* (ftp://ftp.wmo.int/Documents/PublicWeb/mainweb/meetings/cbodies/governance/tc_reports/english/pdf/1070_en.pdf, Annex XII, page 193), and approved a vision for the SWFDP as an end-to-end,

cross-programme collaborative activity led by the GDPFS, in which the participants in the Projects (ftp://ftp.wmo.int/Documents/PublicWeb/mainweb/meetings/cbodies/governance/congress_reports/english/pdf/1077_en.pdf, paragraph 3.1.3.8):

(a) Make best possible use of all existing and newly developed products and facilities at the global, regional and national levels, including high-resolution NWP and ensemble prediction products, and very-short-range forecasting, including nowcasting, tools;

(b) Establish sustainable services of reliable and effective early warnings tailored to the needs of the general public and a wide range of socio-economic sectors in LDCs, SIDSs and developing countries;

(c) Ensure a continuous improvement cycle and quality assurance of services, including efficient and responsive feedback loops between the NMHSs and the end users at the national level.

The SWFDP contributes to many of the WMO's high priorities:

(i) Through the use of NWP/EPS from the GDPFS centres for predicting severe and high-impact weather, contributing to disaster risk reduction (DRR) and capacity development (as per objective 5 of the *WMO Capacity Development Strategy*);

(ii) Through evermore skilful and useful prediction services with increasing resolution across all scales of modelling. This includes for climate, increasing forecast lead-times in the medium-range, and beyond, and increasing accuracy to widen the scope of applications, that contributes to climate change adaptation (with a high likelihood of the globe experiencing changing climatology of extreme weather events), and thereby to the Global Framework for Climate Services;

(iii) By benefiting other socio-economic sectors, including aviation, agriculture, and marine safety;

(iv) As a starting point for developing and establishing national severe weather warning programmes for WMO Members, and a vehicle to assess the gaps in the Basic Systems, including WIGOS and WIS, for effective weather warnings' services

2.2 Strategies

Cooperation through the Cascading Forecasting Process

The initial aim of the SWFDP was to demonstrate how cooperative work among operational meteorological centres could be further implemented. This would enhance the forecasting process of several types of severe weather phenomena, which in turn would improve the warning services provided by the NMHSs.

The SWFDP's organization is a three-level system (*Cascading Forecasting Process*) which carries out various functions at the global, regional and national levels. The GDPFS is an underpinning capability for weather forecasts and warning services in all WMO Members. In addition to this organization, several GDPFS Centres are officially entrusted with the responsibility of providing NMHSs with specialized products (e.g. for medium-range forecasting, tracking and forecasting tropical cyclones, long-range forecasting, and transport of radiological pollutants in emergency response). Nevertheless, for severe weather events which can cause many casualties and widespread damage, some NMHSs have had very little access to advanced GDPFS capabilities. Enhancing the exchange and use of existing products or readily adaptable products among GDPFS centres and with these NHMSs was therefore highly desirable.

Continuous learning and modernization

Since their inception the skill of Numerical Weather Prediction (NWP) models (see *Workshop Paper entitled: "Anticipated Advances in NWP, including Strengths and Weaknesses"*) has continuously improved for all forecast ranges, and the models have become increasingly powerful tools for the prediction of hazardous weather worldwide. Notably, the technique used in the Ensemble Prediction System (EPS) stands out as an efficient way to provide the forecaster with alternative scenarios or probabilistic forecasts. Initially designed for medium-range global forecasting, this technique is an efficient way to take into account the various sources of forecast errors (initial state, boundary conditions, model) even for short-range and for limited area forecasting, and to understand the risks associated with severe weather.

Owing to the high computational cost of limited-area NWP and of the the EPS technique using multiple model runs, only a limited number of GDPFS centres have been able to operationally implement such systems. Many of the latest advances in NWP systems, such as so-called "convection-permitting" models with grid-lengths of 4km or less, are particularly suitable for severe weather forecasting in tropical and sub-tropical regions, but are extremely computationally intensive and can be supported only by the most advanced and resourced centres (most likely the global and regional centres). Moreover, to make effective use of NWP and ensemble systems also requires the application of complex model-output post-processing systems to generate forecast products to support severe weather forecasting, and several GDPFS centres provide the forecaster with sophisticated products such as maps of potential vorticity, convection indices, etc. The SWFDP provides the opportunity to encourage operational forecasters to utilize such standard or newly developed products and procedures, which have already been introduced in many GDPFS centres and which could be relevant to a number of NMHSs that have not yet used or applied them.

In addition to NWP systems, GDPFS centres also provide nowcasting systems for very-short-range forecasting of severe weather based on extrapolation of observational data. Appropriate for the SWFDP with near-global coverage are nowcasts based on satellite imagery.

Despite the increasing number of GDPFS centres that run global and limited-area NWP models and nowcast systems, not all forecasters benefit from the recent progress of the NWP techniques or from the training necessary to efficiently use the large numbers of products available from GDPFS centres. This is particularly the case in Least Developed Countries.

The SWFDP framework represents a systematic approach for building capacity and for transferring knowledge and skills to operational weather forecasting teams across the NMHS community. Its approach has been used to implement a series of proven, modernizing enhancements to the forecasting process, as well as providing a channel for the testing of relevant promising S&T research and development outputs. An example is the WWRP/TIGGE project "Global Interactive Forecast System" (GIFS).

The evaluation of the first regional project in Southern Africa showed that the SWFDP was a successful demonstration of how developing countries could be assisted to reduce the technology gap and increase their capacity in operational severe weather forecasting and further enhance national weather warning services for the protection of life and property. The Commission for Basic Systems (CBS) therefore recommended transitioning matured regional projects into a fully operational activity, ensuring the long-term sustainability of the benefits gained with the project. This takes into account sustainability and development of SWFDP activities, including the exploring of synergies with other WMO programmes in order to respond to the needs of other user sectors (e.g. aviation, marine, hydrology, agriculture, etc). To ensure long-term sustainability of the benefits of the SWFDP, ongoing training is a major requirement, which should take place on an annual basis and should become sustainable within the regions.

Regional project management and implementation

SWFDP implementation has four phases (see Annex I). These are a series of specific regional projects dedicated to severe weather forecasting, each exchanging relevant products and experience among selected GDPFS and national centres at the three levels of responsibility – global, regional, and national.

Planning, partnerships and accountability

One of the reasons for the success of the SWFDP is that an efficient management framework has been put in place. Each regional project has been managed within the regional, with appropriate guidance from the Project Steering Group (that provides a linkage to CBS mechanisms), and with considerable support from the WMO Secretariat. Good project management practices have been encouraged, including the setting up of a continuous improvement cycle, with regular reporting and evaluation of progress and objective identification of technical gaps.

The SWFDP management framework consists of individual regional project-specific implementation plans for which management teams are accountable. Following the SWFDP guidance materials (i.e. the Overall SWFDP Project Plan and the Guidebook for Planning New SWFDP Regional Projects), each regional project-specific implementation plan describes key aspects. These include team members' responsibilities, project activities and milestones (typically for 12-18 months) such as training and reporting. These actions build and sustain partnerships of WMO global to regional operational centres with less capable national centres in a geographical region. Country-specific/national implementation plans have also been developed within the SWFDP (resources permitting), addressing gaps and weaknesses, and including a review of current levels of services, training requirements and outputs. Stakeholder engagement is very important and is also included. This should assist in ensuring long term sustainability of projects. For example the SWFDP engages with the meteorological-related groups within the regional economical bodies (i.e. comprising Heads of Meteorological Services and Ministries in charge of meteorology) encouraging regional ownership and sustainability of the benefits gained with the project.

Implementation

The SWFPD implements a *Cascading Forecasting Process* implying the participation of selected countries/centres chosen within a geographical area affected by agreed types of severe weather event. The cascading process aims to ensure the real-time distribution of the relevant available information produced by both Global Centres and a Regional Centre to selected NMHSs. Moreover, it is necessary to continue the cascade by making the final authoritative products of hazardous conditions (advisories or warnings) produced by the NMHSs available to the final users, such as local bodies or teams in charge of hydrology and/or local Disaster Management and Civil Protection Agencies (DMCPA).

Global-scale products, as well as data and information provided by other Regional Centres, are integrated and synthesized by a Regional Centre (typically a designated Regional Specialized Meteorological Centre (RSMC)), which, in turn, provides daily guidance for short-range (days 1 and 2) and medium-range (out to day-5) on specified hazardous phenomena (e.g. heavy rain, strong winds, damaging waves, etc.) to participating NMHSs of the region. This is the "Cascading" concept of the forecasting process (from global centres through regional centres, to a small group of NMHSs), including their PWS structures – Figure 1). Regional Centres interpret information received from Global Centres, prepare daily guidance products for NMHSs, maintain a RSMC Web site and Portal, and liaise with the participating NMHSs, especially in case of predicted severe weather event(s). Regional centres may also run additional limited-area models to provide detailed local forecast information for the region.

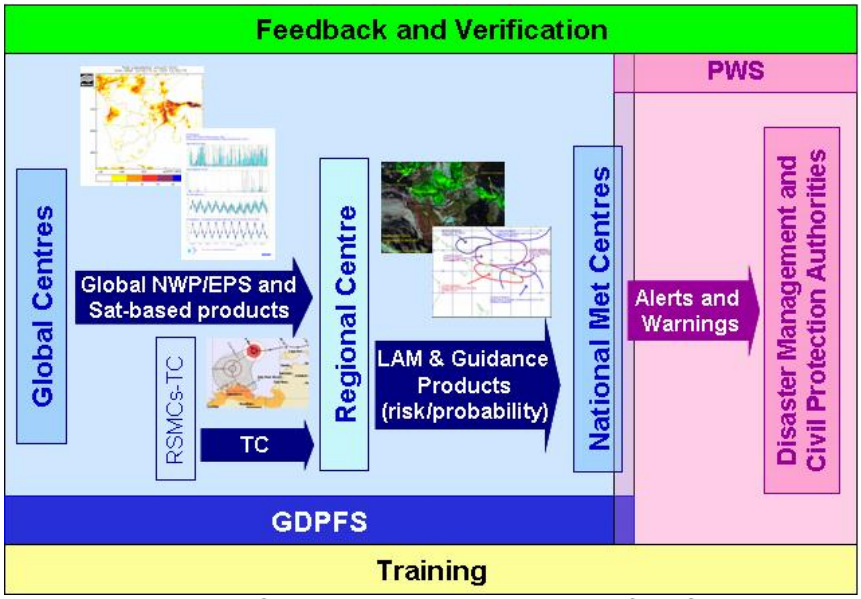

Figure 1 – The *Cascading Forecasting Process* of the SWFDP.

Near real-time verification and evaluation is conducted, based on observations of the meteorological parameters collected at local meteorological stations as well as information gathered on the impacts of the severe weather phenomena, such as those reported by DMCPA services, or news services. This evaluation of the performance of the cascading process, including the quality of the NWP/EPS and guidance products, will then be provided as feedback to the participating centres to further fine tune the process and products.

Training is a critical component of the SWFDP, which is carried out on an annual basis. The forecasters of the NMHSs need to know how to optimally utilize the various products coming from the Global Centre(s) and the Regional Centre(s) in the framework of severe weather forecasting (e.g. interpretation and presentation of NWP and EPS products and probabilistic forecasts, special guidance for selected severe weather events, synthesized satellite images, etc.). Similarly, training is required in service delivery principles and practices including user focus, communication skills and user satisfaction assessment.

Practically speaking there is no need to provide in-depth information on the way the products are produced, but it is essential to emphasize how the products should be used by the forecaster when facing a potentially dangerous weather situation. The presentation of case studies is also indispensable. Annual training is essential both to provide updates on new and evolving products and to provide training opportunities for new staff entering the system.

It would be expected that the staff assigned to the SWFDP project at the centres involved would maintain close working relationships, whereby "training" and consultations are an ongoing aspect of the routines of the project.

Resources for implementation and sustainability

A study was carried out to review the development of the SWFDP since its inception, and to scope out the resource requirements for ensuring effective implementation and long-term sustainability of the benefits gained with the SWFDP (available at ftp://ftp.wmo.int/Documents/PublicWeb/www/swfdp/SWFDP-study-29Aug2012.doc). Figure 2 shows the funding requirements for the implementation and sustainability of a SWFDP regional project (based on 6 NMHSs, 1 regional centres and 3 global centres; and no costs for infrastructure).

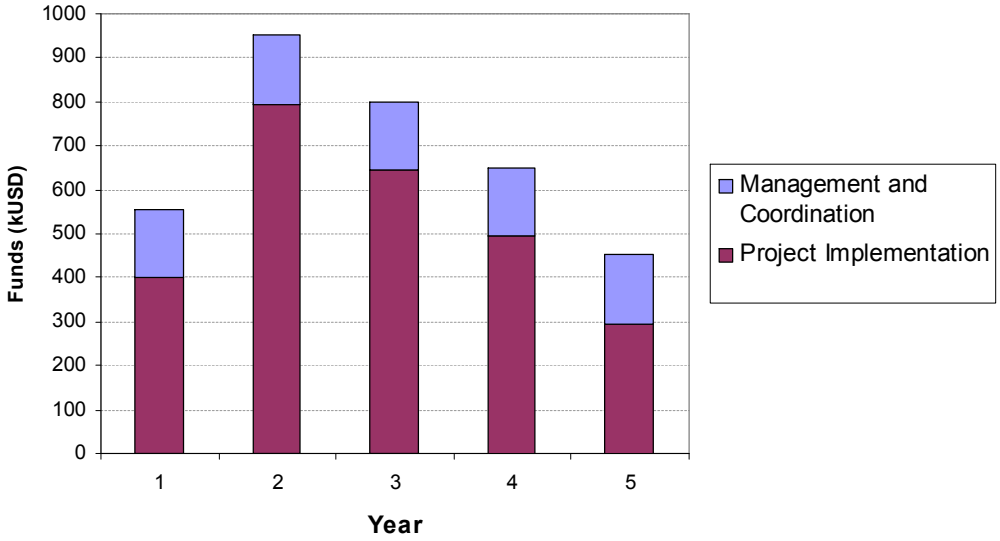

Figure 2 – Funding for implementation and sustainability of a SWFDP regional project (based on 6 NMHSs, 1 regional centres and 3 global centres; and no costs for infrastructure).

The support from advanced global centres that provide NWP/EPS and satellite-based products, and the roles played by the regional centres are critical components for the implementation of the SWFDP regional projects, and has been provided by in-kind contributions by WMO Members. This does not include the special global guidance service (financial resources permitting) provided by advanced global centres (for specific and limited periods, typically 1 or 2 rainy season period(s)) to assist regional centres in fulfilling their regional responsibilities in providing daily regional forecasting guidance to NMHSs in their geographical region. Such additional support can greatly accelerate the uptake of global NWP model outputs and satellite-based products by regional centres, and lead rapidly to more effective exploitation of such resources. This service also includes visits of trained regional forecasters to national centres of countries in a geographical region for hands-on training, to further improve the entire end-to-end chain from production to the delivery of warning services to the users.

The GDPFS programme's regular budget (through savings and re-apportionment from other activities) has financially supported many of the SWFDP-related events, including training and planning activities, while a number of WMO Programmes (e.g. ETR, PWS, TCP, AgM and SAT) have collaboratively provided limited funds to support expert participation at some of the SWFDP-related meetings. Collaboration with these programmes has also included opportunistic use of other organized events to share resources and expertise.

No specific WMO Regular Budget has been allocated to GDPFS for the coordination, management and implementation of the Project; however WMO surplus funds allocated for the 2009-2011 period allowed the expansion of the first SWFDP in Southeast Africa (5 countries) to include all 16 countries in Southern Africa, and to initiate a second project in 2009. The initiation of the 3 other SWFDP regional projects was only realized with extrabudgetary funds that have been provided either by WMO Members through the VCP programme or by external organizations (such as the Word Bank, UNESCAP, Government of Norway, AusAid, and NZAid).

WMO staff responsible for the GDPFS, in collaboration with PWS, have been involved with the coordination, management, tracking and implementation of the SWFDP and its 5 regional projects. In view of the limited resources available, to sustain provision of the support to the existing and new projects requires a dedicated Office, which is estimated to require annually an equivalent of 2 person-years of staff.

2.3 Regional projects

The SWFDP continues to experience important benefits and significant growth, with 5 regional projects (Figure 3), either underway or under development (Southern Africa, South-west Pacific, Eastern Africa, Southeast Asia, and Bay of Bengal/South Asia). These projects presently involve several WMO global and regional operational centres (e.g. RSMCs), 41 NMHSs of developing countries (29 of which are LDCs/SIDSs) (Annex II, Table A-II.1), and engage several WMO programmes (i.e. GDPFS, PWS, TCP, DRR, MMO, AgM, SP, ETR, CD, LDC, RP, and WWRP) and technical commissions (i.e. CBS, CAgM, CHy, JCOMM, and CAS). Status information is provided in Annex II. Others regional projects are in consideration, resources permitting.

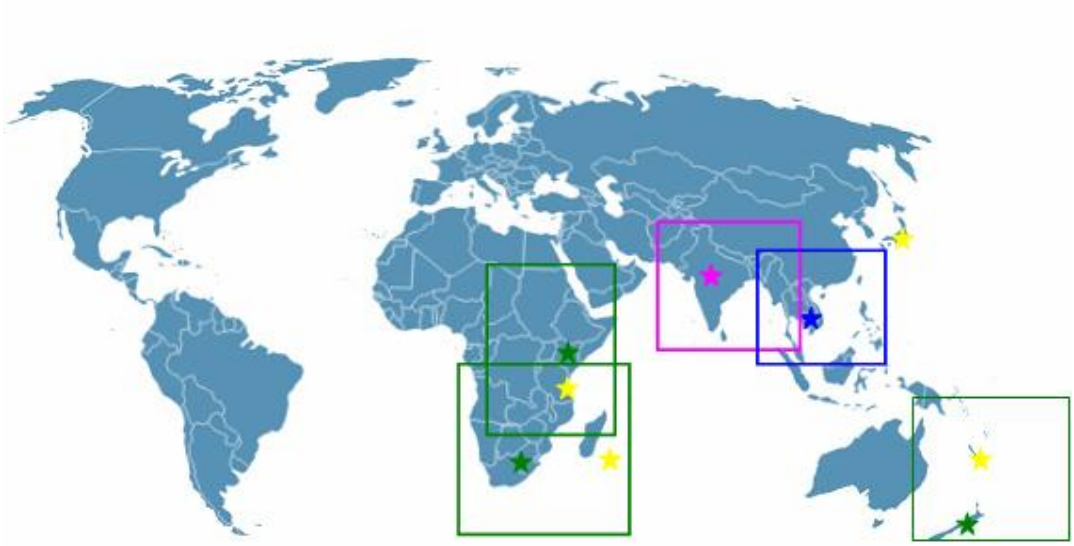

Figure 3 – SWFDP regional projects, either underway (Southern Africa, South Pacific and Eastern Africa – in green) or under development – in different stages: Southeast Asia – in blue (in development since 2010), and Bay of Bengal/South Asia – in pink (early stages of development). Regional Specialized Meteorological Centres (RSMCs), carrying out the central regional role for the project, are RSMC Pretoria, RSMC Wellington and RSMC Nairobi, respectively for the SWFDP regional projects: Southern Africa, South-west Pacific, and Eastern Africa identified (in green). New regional centres – Regional Forecast Support Centre (RFSC) are being established: RFSC Ha Noi for the SWFDP – Southeast Asia (in blue), and RFSC Dar (in yellow) for the Lake Victoria Basin. The RSMC with activity specialization in Tropical Cyclones (RSMC-TC) New Delhi is expanding its role to address other hazards and take the central regional role for the SWFDP – Bay of Bengal/South Asia. Other supporting centres, including RSMCs-TC in yellow.

2.4 Lessons Learnt, so far

The principles applied to the regional project development and implementation, including an efficient management framework at regional level, with appropriate oversight from the SWFDP project steering group and considerable support from the WMO Secretariat has made it a success. The programme has improved NMHS capacity to provide short to medium-range forecasting and warning services of weather-related hazards (thereby increasing their visibility, credibility and value of meteorological services). It has also provided strong evidence of real benefits at the level of the NMHSs' delivery services to their users, and in the value placed on weather forecasting services and improving the 'return on investment' in their overall modernization efforts, particularly where there is strong national interest and leadership.

Another important aspect explaining the positive outcome of the SWFDP is that it is highly cost-effective. The project budget has been building, but is still modest compared with the benefits.

Even taking into account the substantial in-kind contributions of the global and regional centres involved, the overall total cost is much less than what might generally be expected for projects resulting in this level of outcome. It is also certainly very much less than it might cost to implement similar NWP and nowcast capabilities locally in individual NMHSs, and much more likely to be sustainable on a long-term basis. In the early stages and still the case in some senses, funding for project activities has been ad-hoc and not adequately secured for ensuring a long lasting legacy of benefits.

The primary approach to building climate resilience and mitigating extreme weather hazards is through capacity development and investment in NMHSs to provide more timely and useful early warnings. Specifically, this requires institutional strengthening of NMHSs, reinvestment in national observing networks, improved forecasting, and placing a greater focus on delivering information and prediction services that meet the needs of governments, industry and communities, particularly in developing and least developed countries. Sustaining this investment requires technical training, a favourable continuous learning environment, and access to technical expertise and reliable and quality assured products that can help NMHSs attain increasingly higher level of forecasting and service delivery skills. This would largely rely on effective partnerships, as those established through the *Cascading Forecasting Process* that provides improved access to and effective use by forecasters of existing and newly developed products and tools made available by advanced operational global and regional centres, where a tremendous contribution to transfer from proven R&D to Operations can be achieved. The initial choice to develop and build upon a 3-layer cascading process has proven to be a good one, perfectly well in line with today's operational meteorology. In addition, the engagement of the meteorological-related groups within the regional economical bodies (i.e. comprising Heads of Meteorological Services and Ministries in charge of meteorology) is critical to ensure regional motivation and ownership, addressing collective needs, and sustainability of the benefits gained with the project, in a continuous learning environment.

Likely the most important weaknesses identified are that many of the NMHSs of developing and least developed countries do not have an adequate programme for severe weather warnings, and insufficient use of modern NWP forecasts to increase the lead-time for anticipating the development of severe weather situations, several days in advance. Further implementation and development is required in order to establish and formalize national severe weather warnings programmes within national disaster management and civil protection frameworks, with possibly a regional coordination of national programmes across national boundaries. The SWFDP regional projects represent the regional infrastructure to support national warnings programmes.

At this point it should be strongly underlined that the most critical condition for success has been the engagement of high quality and efficient leading centres at the regional level (see *Workshop Paper entitled: "SWFDP Regional Centres and their Impact in Developing and Least Developed Countries"*). The role and functions of these centres as focal point and central hub for all information exchange between the various global, regional and national partners have been essential, including the production of coordinated forecast guidance.

The global NWP products centres have well met the requirements of the SWFDP. It is recognized that these centres carry out their functions reliably, and largely in an automated fashion, with infrequent problems that required technical repair and support from these centres.

Noting that many NMHSs with low capacity would not be able to handle numerical (digital) files, so far, within the SWFDP there have been limited infrastructure requirements as products being available from advanced global centres have been provided in graphical form (Web pages) via Internet for rapid display and dissemination, but may also be made available by other methods (e.g. EumetCast in Africa).

Suitable training is required to trigger a fundamental change in thinking by both weather forecasters and users (e.g. disaster management organizations) whereby alerts of severe weather would become more probabilistic in nature to represent the risks associated with severe and high-impact weather.

Among the main challenges for the SWFDP, has been the need for very short-range forecasting (including the first 12 hours) tools, especially to address the rapid onset of localized severe thunderstorms that produce heavy precipitation and strong winds, in the absence of adequate real-time observational networks, especially in absence of weather radar coverage. In this context, following the outcome of the first phase of the SWFDP in Southeast Africa (in 2008), the RSMC Pretoria Web site has incorporated Eumetsat/MSG derived products for nowcasting purposes. In addition, the project steering group has been coordinating with the WMO Space Programme, to explore collaboration related to training, satellite information (data and products) and dissemination mechanisms to support the SWFDP; which are now a core component of the SWFDP.

Cross-programme synergy has been very positive, and has strengthened the connection between the S&T that underpin the production of forecasts and warnings, with the delivery of timely and authoritative warning services to the public, the news media, and to those responsible for public safety. In addition, in the SWFDP implemented in the Eastern African region, an Agrometeorological component is included in the project, to benefit from the effective relationships that the NMHSs have with their respective socio-economically important Agricultural sector.

3. FUTURE DIRECTIONS TOWARDS STRENGTHENING/SUSTAINING WMO'S OPERATIONAL CENTRES

The SWFDP has reached a stage where a broader view should be taken of its future development. Strengthening the mechanisms established through the SWFDP, and transitioning the SWFDP to become a properly supported activity in the medium to longer-term would be an important strategic investment in WMO's plans to more fully address its priorities, for more of its Members. Therefore, there is a need to consolidate the SWFDP into a sustainable and ongoing programme to strengthen operational centres, to provide guidance of hazardous meteorological conditions and meteorological-related hazards to sustain and increase the capacity of NMHSs in developing and least developed countries to deliver relevant services. This is aligned with the WMO Capacity Development Strategy (Objective 5), and would assist in sustaining the linkages between regional and national centres in their geographical regions; as well as global to regional relationships.

Future plans and anticipated advances include the establishment of the SWFDP service in further geographical areas, providing wider access to existing and expected NWP products and forecast guidance wherever required globally. The ultimate goal is a core set of high-quality NWP including EPS and VSRF systems be used by all NMHSs, thereby building their capability to provide hydro-meteorological forecasting and warning services in support of disaster risk reduction and a range of targeted applications to broaden the benefits of SWFDP to other user sectors in society. It is expected that in the next few years, more countries in new regions (over 100 countries: developing and least developed countries; supported by a network of ~12 regional centres with activity specialization in forecasting hazardous hydro-meteorological phenomena, with contributions by ~6 other regional centres, including those for Tropical Cyclone, and ~13 global centres – Figure 4), be considered, addressing hydro-meteorological and sector-specific hazards (e.g. agriculture, marine, hydrology, aviation, etc.), beyond day-5.

Substantial in-kind contributions from a network of global and regional centres are expected to continue, however this global framework requires the engagement of sustainable high-quality and efficient leading centres at the regional level. For that, there will be a need for:

(1) Sustaining and strengthening existing operational centres, especially RSMCs;

(2) Expanding the role of other existing RSMCs with activity specialization in Tropical Cyclones;

(3) Establishing/building new RSMCs/RFSCs.

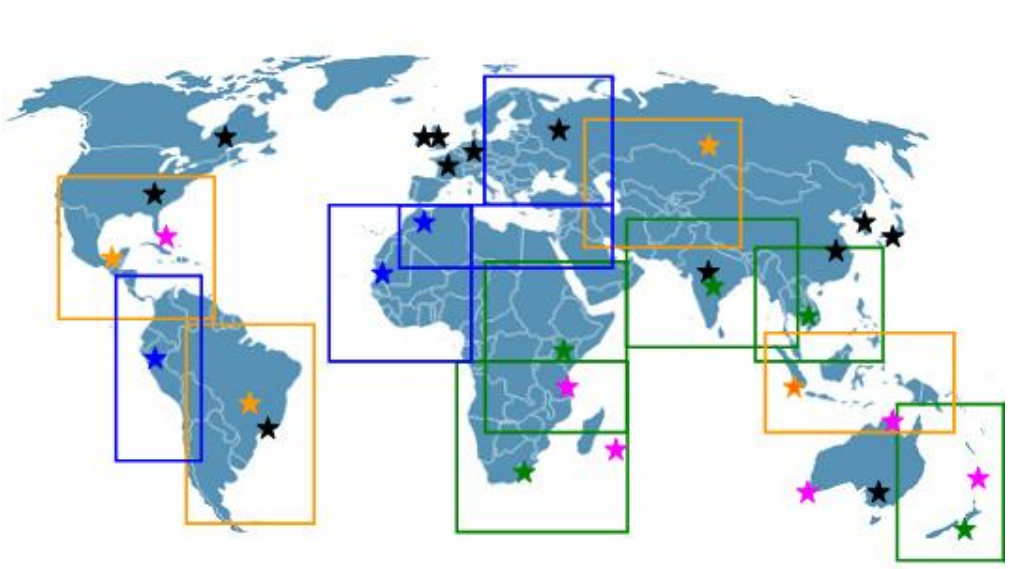

Figure 4 – Existing and anticipated geographical areas for the implementation of SWFDP regional projects, supported by a network of ~12 regional centres with activity specialization in forecasting hazardous hydro-meteorological phenomena – currently the lead regional SWFDP centres (existing SWFDP regional projects in green, early developments being planned for in 2013/2014 in orange, and future geographical regions to consider in blue), with contributions by ~6 other regional centres, including those for Tropical Cyclone (in pink); and ~13 global centres (in black).

With the addition of several more regional frameworks (including RSMCs/RFSCs) and many more NMHSs being engaged in the system, it is no longer sustainable to rely on in-kind contributions of regional and global centres, including to support the annual training activities. Sustainable SWFDP activities will require dedicated funded resources. In addition, country-specific training and development activities to implement effective warning systems and services in NMHSs, especially in LDCs, can greatly accelerate the delivery of benefits and the establishment of sustainable services, but such activities also require short-term funding for the implementation period. Some of the global and advanced regional centres are well-qualified to provide such training and development, particularly where they can provide opportunities for training within their own operational forecasting facilities, and this can provide very cost-effective training while also establishing long-term support networks between operational staff throughout the cascading forecasting process of global centres, regional centres and NMHSs.

Sustainability (including the coordination and implementation of numerous ongoing activities in the SWFDP, and with a continuous cycle of technical and "engineering" enhancements (modernization) to the forecasting process, different for each of the regional projects) has placed a highly excessive demand on the limited resources in the WMO Secretariat that has the overall responsibility for the SWFDP. The necessary conditions to sustain the services under development and allow for the planned expansions to a global service include:

(a) Funding to sustain 5 years implementation of each SWFDP regional project;

(b) An expert from each Region, who would act as regional focal point (project manager) for the implementation of the project and liaise with the WMO Secretariat. This also includes support for the recruitment (including liaison with local universities), training and development of national leaders to be "deployed" at the regional and national centres. They will be working with the regional project manager in developing country-specific implementation plans, in order to address their gaps and weaknesses, which also include audits of current levels of services, training requirements and outputs, and stakeholders' engagement;

(c) The establishment and maintenance of a Project Office (in support of the programme to strengthen operational centres, especially regional centres), which would need to be properly staffed in order to facilitate the further implementation, expansion and mainstreaming of the SWFDP into all WMO Regions and other programmes of WMO;

(d) Throughout the implementation of each SWFDP regional project, the organization of meetings of the regional project management team to (1) prepare regional project-specific implementation plans describing the team members' responsibilities, and project activities and milestones (typically for 12-18 months), such as training and reporting; (2) identify gaps and deficiencies, and areas for improvement; (3) define/refine detailed specifications in terms of data and products to be exchanged, and performance measurements; and (4) explore synergies with other WMO programmes in order to respond to the needs of other user sectors (e.g. aviation, marine, hydrology, agriculture, etc).

(e) From early stages of implementation, engagement with groupings of directors of NMHSs within the regional economical bodies (i.e. comprising Heads of Meteorological Services and Ministries in charge of meteorology) to garner their support and to ensure regional ownership and sustainability (i.e. recognition of SWFDP as a contributing mechanism for the implementation of their regional meteorological development plans and investment strategies).

At the regional forecast support level (i.e. regional frameworks that could address situations (1) – (3) above):

(a) Establishment and maintenance of regional forecasting desks at RSMCs and national warning desks at NMHSs (24/7);

(b) Maintenance and/or establishment (as part of WIS) of the RSMC Web site and Portal (password protected to allow only NMHSs to have access to products), where products from global centres are consolidated. This development should follow the concept of a "dashboard" (design and definition of a forecast process which mirrored forecast office workflow), as an aid to better decision-making. Recognizing the potential for information overload in many forecast offices, including in LDCs, a formalized forecast checklist would help to focus forecasters' attention on the most important weather issues of the day. This "dashboard" would need to be tailored to the needs of each specific NMHS, and therefore includes their participation (this links to activity (c)-(2) below);

(c) Sustaining the necessary enhancement to the mentoring and training effort to empower forecasters (as a major ongoing investment needed, a key to sustainability, and way of introducing new products from advanced centres), by:
   (1) Combining a face-to-face training (including for sharing experiences) with e-learning approaches, by involving WMO's Regional Training Centres (RTCs) for ongoing regional and national training support;
   (2) Establishing and maintaining RSMC Training Desks, as a vehicle for professional development and training of forecasters from NMHSs of countries in their geographical regions and support for attendance of forecasters at such desks. This also includes participation of these NMHSs in the technical and "engineering" enhancements (modernization) to the forecasting process (this links to activity (d) below);
   (3) Training of trainers (i.e. regional forecasters) at or with the support of global centres. This includes training at global centres' desks and global guidance service provided by advanced global centres (for specific and limited periods, typically 1 or 2 rainy season period(s)) to assist regional centres (e.g. accelerate the uptake of global NWP model outputs and satellite-based products by regional centres) in fulfilling their regional responsibilities in providing daily regional forecasting guidance to NMHSs in their geographical region;

(4) Hands-on training of national forecasters by deploying a regional forecaster to national centres (for specific and limited periods, typically 4 weeks total per year);
(5) Utilization and creation of regular/daily weather briefings by the regional centres (focused on potential for severe and high impact weather) in support of NMHSs in their geographical regions, with the participation of global centres (as appropriate);
(6) Establishing a "Training Week(s)" (e.g. webinars) focusing on specific topics to address challenges that forecasters at NMHSs have to face in forecasting (especially severe and high impact weather) that support weather, climate and hydrological services. These "Training Week(s)" will be supported by global and regional centres;

(d) Tailoring the products (including for very short-range forecasting) for severe weather forecasting (focused on high impact weather) in their geographical region that would sustain, and increase, the capacity of NMHSs in developing and least developing countries to deliver relevant services, including for use in a range of application/user sectors in society (e.g. aviation, marine, hydrology, agriculture, etc.). These tailored products (including "blending" and diagnosis products) would use digital NWP data from advanced centres, and observational data both in situ from NMHSs in the region and remote-sensed. This activity is to be supported by advanced global centres in assisting regional centres to implement new proven techniques, and will have the involvement of NMHSs in the geographical region (this links to activity (c)-(2) above);

(e) Carrying out near real-time verification and evaluation, based on observations of the meteorological parameters collected at local meteorological stations as well as information gathered on the impacts of the severe weather phenomena, such as those reported by DMCPA services, or news services. This evaluation of the performance of the cascading process, including the quality of the NWP/EPS and guidance products, will then be provided as feedback to the global and regional centres to further fine tune the process and products. This activity is to be performed by national centres with the support of regional and global centres (this links to activity (c)-(2) above);

(f) Coordinating and harmonizing of warnings across geographical regions by deploying a "Meteoalert" system (a common harmonized platform for coordinating warnings). This will be able to build strong synergies as response and feedback mechanisms, and strengthen interactive methodologies between regional and national centre and so enhance both the evaluation process and the on-line discussions on topical issues, or on severe weather event and its adverse impacts. It will also be able to strengthen the relationship between NMHSs and users, as NMHSs can provide simple and clear forecast information and warning/advisory messages, giving clear statements on what is happening, forecasts of what may happen, and the expected impact. E.g. "skype" accounts will be established for improving communication between regional and national forecasting desks.

Additional activities that well-established Regional Centres may aspire to develop to further enhance the regional support they can provide, and which will require additional funding for infrastructure (improved computational resources and training staff), include:

(1) Implementing high resolution rapid refresh systems (e.g. hourly) and "convection-permitting" models with grid-lengths of ~km, which are particularly suitable for severe weather forecasting in tropical and sub-tropical regions. This activity is to be supported by advanced global centres in assisting regional centres to implement such proven techniques, and will have the involvement of NMHSs in the geographical region (this links to activity (c)-(2) above);

(2) Propagating NWP (important meteorological and other weather-related parameters) into high-impact models (e.g. flash floods and coastal flood forecasting). As an example, the Flash Flood Guidance System (FFGS, currently being implemented at RSMC Pretoria) is primarily a nowcasting tool for estimating the immediate flash flood potential (using satellite-based diagnostic estimates for rainfall amounts as input into a separate model for surface water budget estimates)

that could benefit from incorporating other NWP prediction parameters to refine the water budget model (e.g., evaporation) and NWP based predictions of accumulated rainfall amounts out to 48 hours. This activity is to be supported by advanced global centres in assisting regional centres to implement such proven techniques, and will have the involvement of NMHSs in the geographical region (this links to activity (c)-(2) above).

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SWFDP – Eastern Africa Regional Project Implementation Plan (RSIP) (http://www.wmo.int/pages/prog/www/CBS-Reports/documents/RSIP-SWFDP-EA.pdf)

SWFDP – Southeast Asia Regional Project Implementation Plan (http://www.wmo.int/pages/prog/www/CBS-Reports/documents/RSIP_v4.4.pdf)

ANNEX I

THE FOUR PHASES OF THE *SWFDP* REGIONAL PROJECTS

As described in the *SWFDP – The Overall Project Plan* (http://www.wmo.int/pages/prog/www/DPFS/Meetings/SG-SWFDP_Geneva2012/documents/INF4-SWFDP_OverallPP_Updated_22-04-2010.pdf) and in the *SWFDP – Guidebook on Planning Regional Subprojects* (http://www.wmo.int/pages/prog/www/DPFS/Meetings/SG-SWFDP_Geneva2012/documents/INF5-SWFDP_Guidebook_Updated_22-04-2010.pdf), the each SWFDP regional project consists of four phases, as follows:

Phase I: Overall Project Planning. This phase includes the preparatory work necessary to prepare the project specifications, the list of types of products to be exchanged and the work of the Steering Group (SG-SWFDP) to identify the possible participating centres and to select suitable regional subprojects according to the geographical area, the type of severe weather and the chosen period for the experimentation.

Phase II: Regional Project Implementation Planning and Execution. This phase begins with the preparation of the detailed specifications (data and products to be exchanged, performance measurements, reviewing and reporting) allowing the participants (representatives of the participating GDPFS and national centres) to develop the specific project implementation plan, including a training programme, and to manage its implementation and then to carry out the experimentation itself which is likely to last about one year or 18 months.

Phase III: Regional Project Evaluation. This phase includes the analysis and the evaluation of the entire project as well as contributing to the evaluation of the overall SWFDP with respect to the goals proposed initially. This phase gives the opportunity to identify gaps and deficiencies, and areas for improvement in order to ensure a sustainability of the organization tested during the regional subproject and to provide improved specifications for other similar regional projects.

Phase IV: Regional Project Long-term Sustainability and Future Developments. This phase includes long-term sustainability of the benefits gained and a process of continual improvement. This phase gives the opportunity to continuously take advantage of future capability and technology developments, and to foster broadening of activities in synergy with other WMO programmes. In this phase, the responsibility for management, including seeking funding, lies with the Regional Association, while the SG-SWFDP continues to be informed of developments and to provide advice as appropriate.

It has to be noted that the Phase II, III and IV are specific to each regional project and will be repeated for each of the selected project. From the point of view of the project management, it is clear that the overall SWFDP project begins with the first step of the Phase I and after completion of Phase III of the selected regional projects, the responsibility becomes that of the Regional Associations. It is clear also that each selected regional project of the SWFDP will have its own date of beginning and date of completion of Phase III and transitioning to Phase IV.

ANNEX II

STATUS OF *SWFDP* REGIONAL PROJECTS AS OF APRIL 2013

- The SWFDP in Southern Africa has been implemented successfully and is now in Phase 4, which means it has turned from the roll-out phase to 16 countries, to the phase of continuous development and sustainable activities. The SWFDP – Southern Africa project is to be maintained relative to the implemented routine forecasting framework of the project, i.e. the cascading forecasting process. RSMC Pretoria carries out the lead centre role for the Project. A new project implementation plan (entitled "Regional Phase 4 Implementation Plan ("RP4IP") has been developed and is available at http://www.wmo.int/pages/prog/www/CBS-Reports/documents/Regional-Phase4Impl-Plan_2011draft.doc.

- A second project, in implementation for the South Pacific, commenced its full demonstration phase in November 2010. The SWFDP – South Pacific is focused on heavy rains, strong winds, and damaging waves for nine Island States, with the central RSMC role for the project undertaken by RSMC Wellington, while RSMC Nadi (Fiji) and RSMC Darwin (Australia) enhanced their existing regional forecasting functions. In addition to PWS and DRR, collaboration was established with TCP, MMO and WWRP programmes to properly address the technical aspects of tropical cyclones and marine-related hazards, such as damaging waves and storm surges. The Regional Project Implementation Plan (RPIP) is available at http://www.wmo.int/pages/prog/www/CBS-Reports/documents/ImpPlan_SWFDDP_Nov2010.pdf.

- A third project is in implementation in Eastern Africa, focused on forecasting and warning services for the general public, agriculture and fishery communities. KMD and TMA are hosting, respectively, the RSMC Nairobi for the entire project footprint, and the Regional Forecast Support Centre (RFSC) Dar for the Lake Victoria Basin. The RPIP for the initial demonstration of the project, which commenced in September 2011, is available at http://www.wmo.int/ pages/prog/www/CBS-Reports/documents/RSIP-SWFDP-EA.pdf.

- Developments for the implementation of an SWFDP in Southeast Asia have been made, focusing on heavy rain and strong winds. The Regional Forecast Support Centre (RFSC) Hanoi will take the role as the lead regional centre. A RPIP has been drafted and is available at http://www.wmo.int/pages/prog/www/CBS-Reports/documents/RSIP_v4.4.pdf, and the project would likely commence its implementation in late 2013.

- Plans have initiated in Region Association II to consider a SWFDP regional project for the Bay of Bengal region (South Asia). The RSMC with activity specialization in Tropical Cyclones New Delhi will expand its role to become the lead regional centre for the project. A RSIP is being drafted and the project would likely commence its implementation in late 2013.

Table A-II.1 – SWFDP Participating Countries

Regional project	Participating Developing Countries	Status/Notes
Southern Africa	Botswana, Madagascar, Mozambique, South Africa, Tanzania, Zimbabwe Angola, Comoros, DR-Congo, Lesotho, Malawi, Mauritius, Namibia, Seychelles, Swaziland, Zambia	In implementation since 2006 Expanded in 2008

Eastern Africa	Burundi, Ethiopia, Kenya, Rwanda, Tanzania, Uganda	In implementation since 2011
South Pacific Islands	Samoa, Solomon Is., Vanuatu, Fiji, Cook Is., Kiribati, Niue, Tonga, Tuvalu	In implementation since 2009 Expanded in 2010
Southeast Asia	Cambodia, Lao PDR, Philippines, Thailand, Vietnam	In development since 2008
Bay of Bengal	Bangladesh, India, Maldives, Myanmar, Sri Lanka, Thailand	In development since 2011