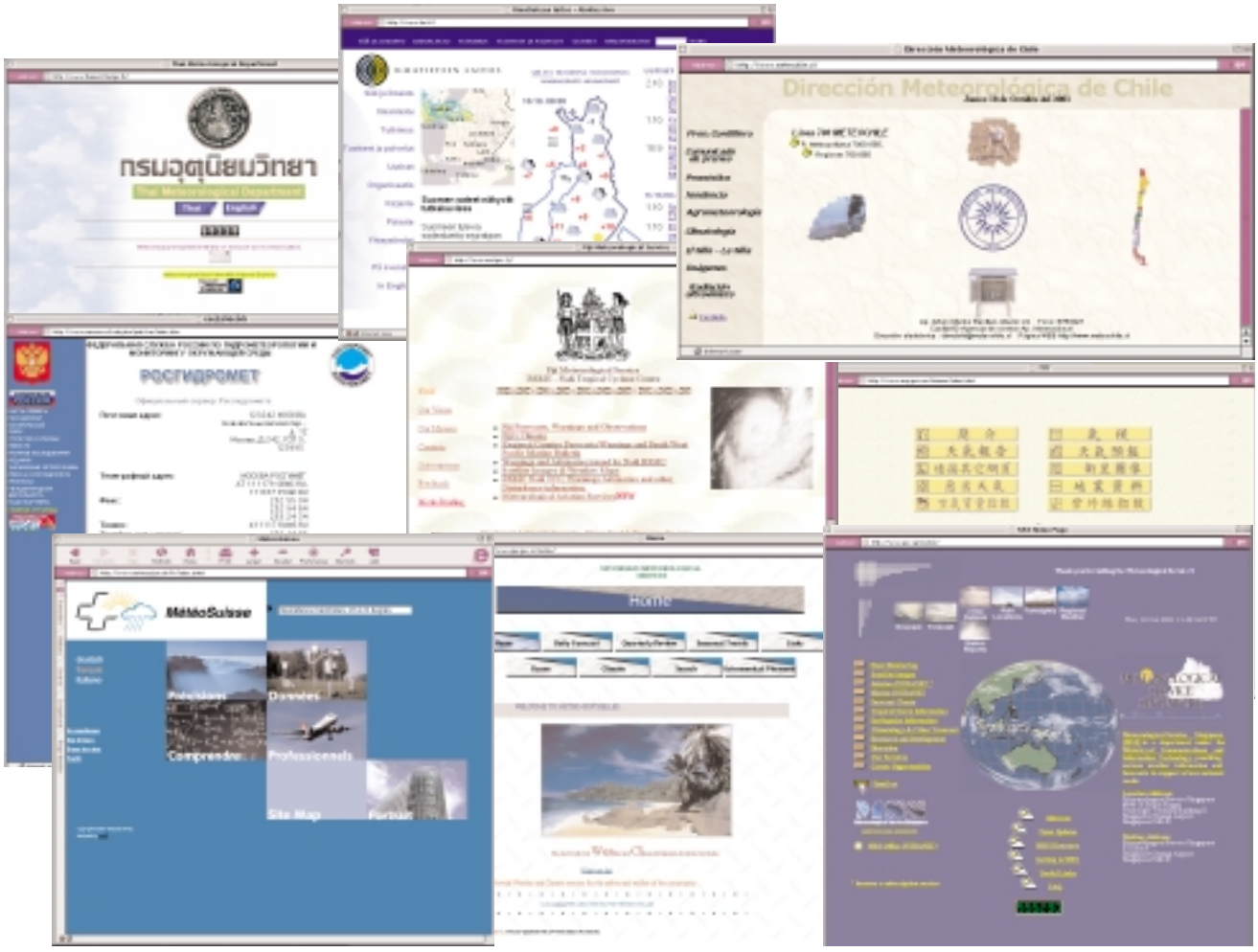
World Meteorological Organization

WEATHER ON THE INTERNET AND OTHER NEW TECHNOLOGIES

PWS-2

WMO/TD No. 1084



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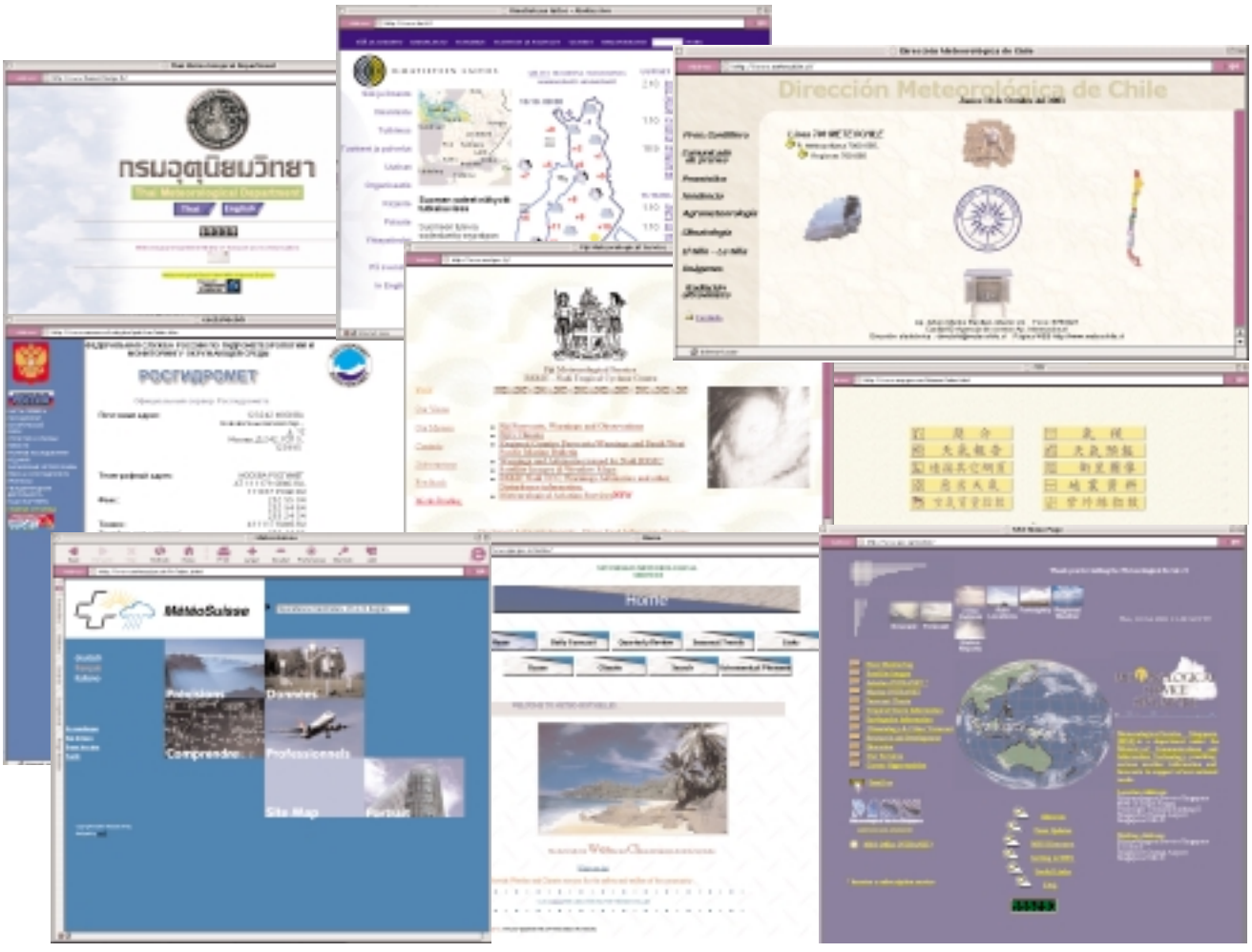

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NOTE

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INTRODUCTION

NMSs AND THE MEDIA

While the tasks of a National Meteorological Service (NMS) are many and varied, the tasks of firstly producing and secondly issuing and disseminating forecasts and warnings for upcoming weather patterns represent the most visible output of the organization. It is with these products that an NMS creates and maintains its visibility in the communities which it seeks to serve. These tasks represent the fundamental public service role of an NMS; if it is not carrying out these tasks in a satisfactory manner, the whole rationale of having an NMS can reasonably be called into question. For the task of producing forecasts, there are well-established standards and a concomitant range of training courses and facilities which an NMS can use to ensure that its forecasters are effectively trained. Most well-established NMSs will also have, within their forecast offices, a body of experience in the local meteorology and in forecasting the local weather; experience which can be passed on to new forecasters over time as they learn their trade. This experience constitutes one of the most valuable knowledge resources of an NMS, and needs to be exploited to the full if an NMS is to realize its rich potential as a service to the public.

It is when we examine the second of the tasks mentioned above – that of issuing and disseminating forecasts and warnings – that difficulties frequently arise. The NMS typically needs to draw on the resources of an outside organization to effectively disseminate its products. This organization can be a newspaper, a broadcaster, or a telephone company, among others. It may be a public service entity, or operate in the private sector. It will have its own goals and ambitions, which may or may not make for an easy relationship with the NMS. For example, it may be purely interested in profit, while the NMS is mainly interested in public service. When we add to this the fact that most of those who join, and train with, an NMS have little or no training and experience in the media, we see more clearly the potential for difficulties. Relations between NMSs and the media can sometimes not be as good as an NMS would wish. A companion set of guidelines (PWS-3, WMO/TD No. 1088) to this publication addresses the matters concerned with relations between NMSs and the media in more detail, and makes practical recommendations for improving relations where this is desirable.

Another complicating factor to consider is that many NMSs now have a commercial arm which seeks to raise revenue for the Service through the sale of forecast and climatological information and, sometimes, through the ancillary marketing of branded goods. The relationship between the public service work and the commercial work of an NMS can either be clear and well-defined, or it can be a grey area. In some instances – such as among those countries of the European Union – there are external factors and controls which can shape and define these public service/private sector relationships, both within NMSs and between NMSs and outside bodies.

This Technical Document was prepared by the Public Weather Services Expert Team on Media Issues in 2001. The document was developed in response to the Expert Team's term of reference to "Advise NMSs on the changing demand for weather information via emerging communication media, such as the Internet".

The purpose of this Technical Document is to provide guidelines which deal primarily with the provision of weather services to the general public through the Web. However, for completeness, weather services that are more appropriate to the specialized user are also mentioned.

WEATHER ON THE WEB – CHALLENGES AND OPPORTUNITIES

Given all these factors, the emergence of new and more efficient technologies for communicating weather information represents both a challenge and an opportunity for NMSs.

The opportunities lie in the fact that an NMS can now, frequently for the first time, issue its forecasts and warnings through a medium over which it has complete control. An NMS can effectively become its own broadcaster. The costs and resources involved in setting up and maintaining a Website, for example, are well within the capabilities of the majority of NMSs. The architecture of Websites, with their hyperlinks, their potential for interactive use and their capacity to display graphical, tabular and textual information, provides a medium through which a vast amount of data and information can be made available.

It should also be noted that the Internet can be used to deliver services to the general public, to specialized users or commercial clients, or even to other meteorological professionals working in cooperation with the NMS. Password-controlled access can be used in these latter cases, to ensure that only appropriate information is delivered to each group, and to ensure that inappropriate information is not accessible by others.

The challenges lie in the sheer number of weather Websites which already inhabit the World Wide Web, and the consequent difficulty in creating and maintaining a strong and loyal following for the NMS site. There is also a challenge in that, where clear and accepted guidelines regarding the distinction between public service and commercial information have not been implemented within an NMS, the availability of new technologies will most likely lead to heightened difficulties in this area.

Chapter 1
POLICIES AND PHILOSOPHIES OF AN NMS ON THE USE OF THE INTERNET

1.1 POLICY CONSIDERATIONS

When approaching the use of the Internet and other emerging communications technologies for the dissemination of weather information by NMSs, it is important in the first instance to have a clearly defined and articulated policy in relation to the communication of weather information. This policy should cover the use of all the traditional media for transmitting weather information – newspapers, radio, television, telephone, etc. – and should integrate the provision of weather information via the emerging media with these more traditional outlets, which will continue to be mainstream for some time yet.

The first policy area that needs to be addressed, therefore, is the question of the level of forecast information to be made freely available on an NMS Website. (It is assumed that warnings of severe weather will be made freely available to the public through any and all of the broadcast media.) The final decision as to what forecast information will be made freely available can normally be taken with reference to other forecasts available in the public domain through newspapers, radio and television.

Indeed, newspaper forecasts can be taken as a simple template for a weather Website, in that they contain information in text and graphical form. The big difference, of course, is the speed with which updated weather information is available to the end-user through the Web.

Having decided on the policy issues regarding the freedom of availability of weather information through the Internet, the next focus should be on how to integrate the "new" weather services on the Internet with existing services in a manner that utilizes the strengths of each medium to the fullest extent and helps to build brand loyalty to the NMS across the full range of services.

The common link between all these services should be the strengths of the NMS. These can be defined as follows:

Quality – The NMS should be seen as the "official" provider of high-quality weather data and services.

Credibility – Every forecast is a "best-guess scenario", but the best-guess scenario of the NMS is backed by good science, vast experience and continuing verification. The NMS should be considered authoritative in its "guess", to reflect these advantages.

Detail – The NMS has access to a vast amount of weather data – both current and historic.

Visibility – The NMS should have a strong profile in its own country.

Public face of weather – Often the forecasters of the NMS will be well-known through television and radio.

Strengths of the Internet:
Availability – The forecast is always there when the user needs it.

Visuals – The forecast or other information can be expressed through words and images, including animated imagery.

Audio – The forecast can be relayed through a sound file.

Hyperlinks – The means to be directed to more detail or background, or to related material, on a particular topic.

Capacity – Vast amounts of detailed information can be made easily available.

Weaknesses of the Internet (with some suggestions as to how to avoid them):
Speed – Pages can be slow to load. Avoid time-consuming animations or graphics – or at least make them optional.

Security – Effective firewalls need to be put into place to protect the NMS site from hackers and to ensure that there is no access, through the Website, to the operational computer systems of the NMS.

Volume – The great number of weather Websites on the WWW means that the NMS will have to fight to be seen. The NMS site should be obviously superior to those available from commercial weather companies which provide forecasts for the NMS territory. It can be better through having better forecasts (not always obvious), more frequent updates, and greater detail. The NMS should also use every possibility to "cross-promote" its Website through the other media on which it presents its products.

The second policy area that needs to be considered, therefore, is how weather information can be relayed on the Internet in a manner that complements the provision of weather information by other media, and which draws on the strengths of the Internet while avoiding its weaknesses.

1.2 MATCHING THE STRENGTHS OF THE INTERNET WITH THE STRENGTHS OF THE NMSs

1.2.1 Availability/Updates

The great convenience of the World Wide Web is that the user can access information at any time. The user will want that

information to be up to date. The timing and frequency of updating forecast information must therefore be optimized. When short-range forecasts (that is, focused on the next 24 hours or less) are made available through a Website, the user should be provided with an updated forecast at least twice per day. An update frequency of four times per day is recommended. Normally, the update frequency will match the update frequency of other routine public forecasts produced by the NMS forecast office. These times should be selected to match likely usage. For example, the first update should be early enough in the morning that users can access "today's forecast" over breakfast; typically we are speaking of an update before 6 a.m. The next update should be before lunch-time; perhaps at 11 a.m. Further updates might be scheduled for 4.30 p.m. and 9 p.m., to facilitate those accessing the Internet in the evening and night. Frequent updates emphasize and enhance the "weather watch" function of the NMS.

Observational weather data, in the form of synoptic reports, radar or satellite imagery for example, will need to be updated far more frequently; the information to be made available should be posted to the Website as soon as it becomes available.

1.2.2 Quality

Most commercial weather forecast sites provide direct model output driven forecasts which are frequently mediocre in terms of forecast quality. An NMS has in its forecast offices a vast store of experience in the evolution of weather over its particular territory of responsibility. It should make full use of this experience. Each and every forecast that an NMS issues for its own territory should be assessed and edited by an experienced forecaster before being issued to the public. This will undoubtedly place an increased workload on the forecast offices, but direct model output forecasts will not normally be good enough to build and sustain a quality service on the Internet or elsewhere. Full use can also be made of techniques such as Model Output Statistics or Kalman Filtering to modify and improve model output automatically.

1.2.3 Visuals

The forecast text should be supported with imagery from satellite and radar as appropriate, together with other maps showing perhaps weather symbols, temperatures and wind speeds, etc. There may be scope for showing maps of temperature and/or rainfall distribution that are model-produced, but there is a difficulty in that these may not be in full accordance with the forecast text. These products should be clearly identified as model-derived, with perhaps a hyperlink directing users to more details on weather models and how their output needs to be verified and frequently modified by a forecaster in arriving at the "official" forecast. A kind of health warning for weather models! While animations of radar and satellite imagery can be provided, these should be optional to the user as they could possibly take a long time to load and many users will not want to spend that length of time waiting for them.

1.2.4 Credibility

A forecast without credibility is without value. Such is the ephemeral nature of the products in which we deal. How can an NMS promote the credibility of its services on a medium such as the World Wide Web? It should be clearly identified as the "official government service" or some such phrase. It should lay stress on its public service mission and ethos. It should make use of its "names"; those forecasters who, through broadcasting on radio and/or television, are well known to the public and constitute a valuable resource for an NMS. Their names (and, if relevant, photographs) should be prominent on the Website, perhaps even appearing as a "by-line" on each forecast. This connection can be strengthened by cross-promotion from the weather forecast services on radio, television, newspaper and telephone, which should regularly give the Website address where the NMS forecast can be obtained.

Another approach, which can be used in parallel, is to keep the media and the public informed as to the skill scores achieved by forecasts issued by the NMS, and through this information to emphasize the credibility of its products. The NMS might even monitor the quality of a variety of forecast products provided to the public through both public and private sector channels, and make the score comparisons available on its own Website. This matter is dealt with more completely in section 3.8.

1.2.5 Detail

Through the Internet the "historical" data for past weather at the observing stations might be made available. This might be in the form of tables of daily values, or it might be in the form of weekly or monthly summaries that emphasize the average and extreme conditions that have been experienced. The Website could also be used to indicate the vast range of climatological information that can be made available and then direct the user to contact a focal point for fuller information. Information of this nature provided to the general public should be compared to long-term averages, and perhaps accompanied by a commentary written by an experienced meteorologist or climatologist.

1.2.6 Other considerations

While the prime focus on any NMS Website must be forecasts for its own national territory, it may also frequently wish to provide forecasts for other countries, perhaps as a service to business and holiday travellers originating in its own country. Obviously, it will not usually be possible to prepare such forecasts with the same degree of care and accuracy as for those of its "home" territory. Such forecasts might normally be prepared directly from model output. However, the Website should contain appropriate hyperlinks to the NMS

sites of these other countries, and to the WMO page which contains links to all available NMS Websites.

It is also important to consider the needs of incoming tourists and business travellers. One of the features of the World Wide Web is that a Webpage can be accessed just as easily from the other side of the globe as from its home country. The NMS might consider some pages where the emphasis was put on forecasts for special tourist locations – such as beaches or cities – and ensure either that these pages are available in a variety of common languages or that the pages in question are structured so as to be independent of language in so far as this is possible.

1.3 RESOURCE ISSUES

One of the consequences of accepting these guidelines is that forecast offices need to allocate considerable resources to providing and maintaining forecasts on the Internet and other new technological media. Quality output will not arise without adequate input! The new technologies offer a substantial challenge to NMSs in that they will be very "hungry" for content. Weather content will always be a major attraction to users on any broadcast medium, but the greater the amount of content which the NMS puts out, the greater the effort required to keep this content correct and up to date.

Chapter 2
COMMUNICATIONS TECHNOLOGIES

2.1 BRIEF DESCRIPTION OF THE ELEMENTS OF THE INTERNET

The Internet is a system of communication based around the transfer of digital information through the global telecommunications networks. These networks were developed primarily to cater for voice communication by telephone, and designed therefore for the transmission of analogue signals. Devices such as the modem act as translators of digital information into an analogue signal suitable for transmission; but networks facilitating direct digital communication are increasingly being put in place.

Global communication networks consist of packet-switching centres (switches), joined by dedicated bulk-communication channels (generally fibre-optic, satellite, radio-relay). The components of global networks are lower-level networks (national, regional, local) again generally connected by dedicated communication channels. End-users are connected to networks with the help of dedicated or switched channels (telephone networks).

The term "Internet" also incorporates exchange protocols; that is, a list of instructions that encode and then decode messages at the sites of sender and receiver respectively, and that perform certain checking routines to ensure that all of a given message is correctly received. The most common protocol is TCP/IP (Transmission Control Protocol/Internet Protocol); another is FTP (File Transmission Protocol).

One of the advantages of the Internet is that it is a distributed system, and is not vulnerable to failure by the destruction of one central element. Although it originated in the academic world, the military soon realized the resilience of the system as a communications tool, and contributed to its early development.

The term "World Wide Web"; also known as "WWW" or just "the Web" refers to an on-line pool of information that can be delivered through the Internet. This delivery is facilitated by the use of a standard computer code, known as HTML, which is used to generate "Webpages" on which this on-line pool of information can be expressed and formatted. Using HTML, the information to be conveyed in a Webpage can be expressed in the form of text, graphic images or photographs.

The software required to read HTML-coded Webpages is commonly referred to as a "browser". Browsers can be either text or graphic; though they are normally encountered on PCs, they can work also on televisions, mobile phones, etc. The most common browsers are Microsoft's Internet Explorer and Netscape's Navigator. A basic browser can incorporate add-on software packages that allow information to be transmitted as animations, as video images, or as sound.

Browsers allow for the two-way flow of information, so that the use of the store of information which the Web represents becomes interactive. This interactivity underlies the use of hyperlinks, which allow the user to jump form one site to another linked site that may contain complementary information. While browsers are primarily used to interrogate the Web, they may also be used to access information stored in HTML format on CD-ROM or other bulk-memory devices.

2.2 OTHER NEW AND EMERGING TECHNOLOGIES

This Technical Document will focus on the provision of weather information through Webpages; however, an NMS should not lose sight of other new technologies that offer the capability to communicate weather information. Among these technologies are:

2.2.1 Electronic (e-) mail

E-mail can be used to widely distribute short text forecasts to many users. Such a service could be free or by subscription.

2.2.2 Video-streaming

This is the use of the Internet to transmit information on video. Typically in the context of weather, a forecast prepared for television might be made available on the Internet after transmission, where it could be accessed by the public at their own convenience.

2.2.3 Short Message Service by mobile phone (SMS)

Such a service could distribute a short forecast each day (or more frequently) to a variety of subscribers. A similar service could be provided through pagers.

2.2.4 Wireless Application Protocol (WAP)

WAP is a standard for transmitting interactive content over mobile phone networks, and is a technology that underlies the convergence of Internet and mobile phone technology. The idea is to receive Webpages (typically a simpler version than normally published) on the display of a mobile phone. A weather service distributed through WAP would encompass all the accessibility benefits of the Internet (anytime), with the added advantage of portability (anywhere).

2.2.5 3G

Shorthand for the so-called "third generation" of mobile phone services. This can also be referred to as "Universal Mobile Telecommunications System" or UMTS. These terms refer to a new global standard for broadband mobile communications. This will allow delivery of Internet and

interactive content to mobile phones/terminals at very high speeds. Such technologies will allow the delivery of "content" more quickly and efficiently than at present.

2.2.6 Digital television

By converting television signals from analogue to digital, a much higher quality of pictures and sound can be achieved. In addition, digital TV allows many more channels to be broadcast simultaneously and thus leads to a proliferation of content. Digital television also enables a convergence of TV and Internet technologies.

2.2.7 Interactive television (iTV)

In this technology, a television set is not merely a receiver of broadcast information, but (usually via a set-top box) enables the user to communicate back to the broadcaster, perhaps to request certain information or to download digital files.

2.2.8 Broadband

This is the name given to a network that can deliver a high bandwidth (currently anything over about 100 Kbits/sec). Such networks include those delivered through cable, satellite, or by Digital Subscriber Line (DSL/ADSL). Such technology will underlie the fusion of digital television and the Internet. Digital television allows a forecast presentation (essentially a television weather forecast) to be stored centrally on a server. ADSL allows data transfer of up to 6 Mbits/sec, and this theoretically enables a subscriber to "play" a TV programme or movie, for example, from the central server much as they would play a tape in their video. This service offers the prospect of subscribers accessing a television weather forecast on their television or on their computer monitor whenever they require it, rather than waiting until such a forecast was scheduled on the normal TV network. To provide a service on such a technology, the forecast would need to be recorded digitally, and then updated frequently, perhaps every three hours.

2.2.9 RANET (RAdio interNET).

This technology, a fusion of radio and internet, offers another means of transmitting Web-type information without "wires", but at radio-frequencies, ensuring much greater coverage and less complex reception equipment. It is rapidly growing in Africa as a means of communicating weather information.

Chapter 3

CONTENTS OF AN NMS WEBSITE

3.1 METEOROLOGICAL OBSERVATIONS

One of the main mandates for an NMS is the requirement to establish and maintain a representative and reliable network of meteorological stations in order to fulfil the international, regional and national obligations stipulated in WMO's recommended practices as regards provision of observations.

With the advent of technology, most NMSs operate Automatic Weather Stations (AWS) which record, archive and transmit meteorological observations every hour generating meteorological parameters such as actual temperature, maximum temperature, minimum temperature, total amount of rainfall, wind speed, wind direction, etc.

Since today's society, industries, business, travel, entertainment, leisure, sport, etc. plan their day-to-day activities based on the prevailing weather, then, it is of paramount importance that NMSs should do their utmost to present the meteorological observations of their network to the public through the media and in particular through their own Internet Websites. It is in this respect that the role of NMSs will be visible to both the private and public sectors of their respective countries.

NMSs may have several ways in which they may wish to present their meteorological observations over the Internet. One method would be to have a map of a country indicating the network of selected meteorological stations that the NMS would want to present to its public. The main advantage of a map is that both the local public and tourists would find it useful and interesting to know the names of the meteorological stations, their locations in the country and their associated prevailing weather.

It will be useful to take into account the importance and interest to the public of meteorological stations selected to be included in the map, such as cities, towns, airports, etc. The actual observations may be updated automatically every three hours if not every hour. The data will mainly be those which have an impact on the public domain. This will include, among others, actual weather, air temperature, sea temperature, precipitation amount, wind speed etc. Other derived parameters might also be presented, for example comfort index, heat stress, or wind-chill temperature. In addition, data pertaining to selected meteorological extreme parameters for each station will be very useful if presented and updated once daily. These will include maximum temperature, minimum temperature, etc.

A Website might also include pictures from Webcams (so-called weather-cams or sky-cams) which, while they do not provide quantitative information, can present a visual indication of weather conditions over a region and thus add to, and enhance, the weather observations themselves. Some of the weather-observing sites might also be equipped with Webcams to supplement the more detailed observations.

3.2 PUBLIC FORECASTS

The NMS is the only official organization that provides public weather forecasts (PWF) for their respective countries. For several decades NMSs have been providing PWF to both the public and private sectors through radio, television, newspapers, etc. All these media have a limited frequency in the dissemination of public weather services products, and in most cases cannot be owned by NMSs. However, with the success of the Internet as a very powerful communication medium which, can be operated within the resources of NMSs, many Services began establishing their own Websites. Unlike radio, television, newspapers, etc., a Website is not restricted to a specific time period when the audience can listen or read but instead it is kept on line round the clock and can be accessed by users at any time they wish. In addition, the frequency with which forecasts can be updated, and their contents is under the full control of the NMS.

Therefore, it is important that all NMSs be encouraged to establish Internet Websites for the provision of public weather services products such as general forecasts, marine forecasts, city forecasts, etc.

3.2.1 General forecasts

This section will deal with the weather parameters which will normally be made freely available to the general public as part of the public service remit of an NMS. The following sections will describe other parameters which, in some cases, will only be made available to selected users for commercial or other reasons.

By "general forecasts" are meant short-term plain-language forecasts, normally not extending beyond 24 hours in coverage. The general forecast is useful to almost everybody e.g. travellers, event organizers, construction workers, etc. The general forecast may simply be posted as a plain-language statement describing different parts of the country. This presentation, however may be enhanced by combining the text with a map of the country divided into different regions as appropriate. High-quality weather graphics and pictograms could be presented to describe the forecast for each region. Extreme meteorological parameters such as maximum and minimum temperatures could also be shown alongside the pictogram for each region. In addition, clicking the mouse on a region of interest could bring the particular forecast for that region on the screen with additional forecast details presented in a story-type format. This format has the benefit of clarity in relating regional forecasts to their intended area, and would be of particular benefit to travellers who might not be familiar with the geography of the territory.

Regardless of whether a forecast is general or more specific in nature (e.g. marine, city, etc.) the approach should be consistent in that a good background map displaying the regions, coastal areas, cities and so on needs to be developed.

The forecast should be presented in a story type format supported by high-quality weather graphics describing the state of the sky or sea in different ways. Repeating the same story should be avoided even during times when the weather may not be changing.

Each NMS will have its own operational manual on the issue of general forecasts; if not as a formal document then as the routine agreed practice of the compilation and issue of forecasts in their establishments. Thus it is hardly necessary to describe the types and forms of general forecast in view of the substantial variety that will exist from one NMS to another. However, it is relevant to consider the commonly used meteorological parameters which most frequently appear in forecasts in the context of expressing them through the medium of a Website. In addition to the material below, the *Guide to Public Weather Services Practices* (WMO-No. 834) may be used as a reference document.

3.2.1.1 Pressure

Pressure charts are the basis for the most commonly used and familiar weather charts, and will, in all likelihood, appear on every NMS Website. Charts of pressure derived from model output can be put on the Website without any alteration; or they can be edited to correct the pressure field where this is appropriate. They will be commonly used with the addition of high/low central pressure indicators, and/or with the addition of weather systems and fronts. Representation can be either as a series of still images or as an animated sequence. An animated sequence of pressure charts is a good way of conveying the broad changes in the synoptic situation to the user; and the Web offers the advantage over a television presentation in that the user can replay the animation as often as desired, examining different aspects of the charts each time.

It may sometimes be useful to accompany the pressure charts with a text description of the synoptic situation; particularly when pressure is represented by a series of still images rather than an animation. It may also be useful to give "spot" values of the pressure at, for example, city locations, as these may not be immediately obvious to the general user from the weather maps. Text accompaniment is especially recommended if forecast changes in atmospheric pressure at such locations are significant (for example, exceeding a tendency of 10 hPa in three hours). It should be remembered that the value of surface pressure on a given day is important for certain industrial and healthcare applications.

3.2.1.2 Temperature

In some countries, temperature forecasts take the form of the expected maximum and minimum temperatures during the coming day or night, or more frequently the range of the expected maximum and minimum values if the forecast is not related to a single location. In other countries, the practice is to provide four distinct forecast values of temperature; these being the expected values in the morning, around midday, in the evening, and at night. Such form of presentation of the thermal regime can have the advantage of being more informative for a user, and can enable difficulties in the interpretation of the more indefinite aspects of the forecast to be avoided. For example, in the case where the movement of a frontal system over a territory is predicted in the forecast text, the information on this changing temperature background can be illustrated in graphical or tabular form; or there can be an indication of the prevailing temperature together with a prognosis for the rise (or fall) of temperature during the forthcoming day or night. This form of presentation can add to the information presented in the forecast text and avoid misunderstanding as to the meaning of the forecast by the general user.

The advantage offered by a graphical or map-based display, such as might be used on a Website, is to give more detail regarding the expected variation of temperature in space and time than is possible in a forecast text; in this way, the user can gain a more complete picture as to the likely evolution of the temperature regime. Needless to say, this extra information places added emphasis on the accuracy of the forecast.

3.2.1.3 Wind

Accurate and detailed forecasts of wind are extremely important for the general public. In this section we will deal with forecasts of wind over land, as marine forecasts are dealt with separately. For most users, the direction of wind will not be of primary importance,; the main interest will be the wind strength, or speed. This information is of particular interest to older people, who often make decisions on whether or not to venture out of doors by reference to the forecast wind strength; similar decisions are made by parents with regard to small children.

For the construction industry, for public and municipal utilities, and for road services an accurate forecast of the wind vector (i.e. direction and speed) is of principal significance when making economic decisions.

The two common ways of representing wind graphically are by wind arrow or by isotach. The understanding of isotachs can be difficult for the general user, but may become easier to appreciate if use is made of filled coloured contours or colour banding. If such charts are used on a Website, there will be a need to provide some background information, such as a colour-key for filled contours or a description and "decode" of the wind arrows.

A Website provides the opportunity to describe specific local winds in detail; for example where the winds are strengthened by funneling through a valley or where some other local conditions give rise to unusual wind conditions. Frequently it is not possible to deal with such winds adequately on radio or television broadcasts, due to time constraints, so the extra detail on a Website can complement the other broadcast media in this respect.

The forecasting of very strong winds will frequently be accompanied by wind warnings. These warnings will need to be given prominence, and should normally be placed on the homepage of the forecast service, with a link leading the user to the more detailed wind forecast.

The forecasts of wind on a Website should also be accompanied by links to pages which describe the international classifications of wind speed; pages which define the potentially harmful consequences of the different strengths of wind. Commonly used versions of this classification include the Beaufort Scale. This background information will assist in avoiding undue panic connected, for example, with the forecasting of "strong" or "stormy" winds. In climates where these are relevant, it would be advisable for this section of an NMS Website to include an appropriate scale of tropical cyclone strength (for example the Saffir-Simpson scale used in North America), and/or the Fujita scale for tornado intensity. These scales give information as to the likely damage caused by the different strengths of tropical cyclone and tornado.

Webpages indicating the forecast of wind may also contain links to pages that give representations of derived parameters, such as the comfort index, heat stress, or wind chill temperature.

3.2.1.4 Precipitation

The form in which precipitation (typically rain or snow) is represented on a Website needs careful consideration. This is partly due to the nature of precipitation itself and also to the differing levels of confidence which the forecaster can have in the precipitation forecast at different times.

By its nature, the variability of precipitation will not be smooth in the manner of, for example, temperature. The degree of detail that can be given in a precipitation forecast will vary from place to place and from time to time. Spatial variability will depend on the topography of a region. Temporal variability will be related to the details of the synoptic situation e.g. whether the expected precipitation is widespread or convective.

These factors will have an effect on the form of presentation of forecast information, i.e. the degree of uncertainty and the variability of the output will have a bearing on the manner in which this information can be expressed on a Website. Because of this, the use of probability forecasting in describing both the occurrence and intensity of expected precipitation is commonly accepted as a useful means of communicating this element of the forecast. There are now common methodologies used within many NMSs for determining and expressing the precipitation forecast in the form of a precipitation probability. Indeed, in the case of convective precipitation there can hardly be any other adequate method for expressing the forecast.

The expression of precipitation forecasts in probability form should be accompanied by text explanations and definitions of probability forecasts that are easily accessible by, and understandable to, the general user. This is a typical scenario where a hyperlink can be used to allow the user access to background information and greater detail relating to the presentation of the forecast.

The expected duration of a precipitation event is also a matter of significant interest to users of weather information. Such extra information should be given if at all possible; these matters can be described and expanded in the text which accompanies the precipitation forecast, where more detail can be given as to the likely times of onset and clearance of frontal precipitation, or the likely frequency of shower activity produced by convective cloud.

3.2.1.5 Cloudiness

Forecasts of cloudiness on Websites are frequently linked with those of precipitation, and can be presented either as a series of still images or in the form of an animation. Normally such cloud forecasts do not contain specialized information (e.g. the details of cloud layers, their type, the cloud base, etc.), but seek to represent the overall level of cloudcover in oktas or otherwise. There are obvious difficulties in representing convective cloud in any realistic graphical manner so it may be necessary to consider using pictograms to give a better representation of cloud conditions.

The use of animation in the representation of the cloud forecast is a particular instance of the advantage that the Web can offer; an animated cloud forecast over a background map can easily convey a complex weather story to the general user. Many people are familiar with animations of satellite imagery through the television forecast presentations, and this provides a basis on which the animated cloud forecast can be easily assimilated and understood.

More detailed data regarding cloud types, the height of the cloud base, etc. can be valuable for energy utilities and others, and may be available on the basis of the output of mesoscale and regional weather models. Such detailed information will normally be too complex for the general user, and should be kept separate from the general cloud forecast representation. Aviation forecasts are dealt with in another section, below.

Forecasts of cloudiness, together with those for precipitation, temperature and wind speed, will be of special interest to the general public during weekends or holiday periods. It will be important during such periods to give more detail on the cloud forecast within the forecast text.

3.2.1.6 Humidity

Humidity may be an important element of the forecast in some climates, and may either be represented directly (as in the percentage of relative humidity, for example), or in an implied form.

This parameter is reasonably well understood by the public because the effects of it can be readily felt by the population, as enhanced wind-chill, for example, or as a high heat index. However, it is not normally shown directly on television presentations, for example, so the Web offers an opportunity to give a representation of humidity which can "add value" to the forecast as a whole.

Rather than show a chart of relative humidity, it may be more relevant to show a chart of some relevant derived parameter, such as heat stress or drying conditions, and to provide a text accompaniment which explains and amplifies the role of humidity and its effect on this parameter.

Given that humidity-dependent parameters will vary diurnally, it may be desirable to provide forecasts in some form at different stages of the day (e.g. morning, mid-afternoon, dusk, night).

The list of the meteorological parameters that may be included in the general forecast is not in any sense limited by the above list. It can be supplemented, for example, by the forecast of the daily duration of bright sunshine, and of the temperature of the soil at various given depths. Forecasts might also refer to the height of snow cover; the condition of snow for skiers; and diverse other parameters, which are part and parcel of the experience of weather by people in the various climatic regions of the globe. Most of these parameters can be represented as contoured maps, and they are not normally shown on television weather presentations where time constraints rule out all but the most basic weather elements. The use of Webpages offers NMSs, for the first time, the opportunity to communicate this extra meteorological information to the interested public. Such more unusual parameters will normally require some associated pages of explanation and description.

Depending on the accuracy of the models available to various NMSs, general forecasts will typically be issued for a period of 24 to 48 hours ahead, with an outlook that looks forward from two to five days.

3.2.2 Forecasts for specific events or periods

NMSs can strongly promote their visibility by the provision of accurate forecasts covering places or events of special interest in their respective countries. NMSs may need to coordinate with their respective tourism organizations in identifying those events or areas of interest that are popular leisure destinations for both tourists and the indigenous public. These sites of potential interest may include recreational areas, beaches, museums and national parks, as well as the highways and roads which will be heavily trafficked by those travelling to such destinations.

The same approach as that indicated above in regard to public forecasting is recommended for the presentation of special forecasts on the NMS Website. The only difference is that for such forecasts the presentation of the graphics and the associated story will be specific to particular areas of interest.

Hence, the approach of presenting the forecast using a high-quality background map, indicating the regions, cities and other potential areas of interest with good weather graphic presentation, supported by concise weather stories, is the recommended methodology for presenting quality forecasts and enhancing the visibility and reputation of the NMS among the general public and the more specialized entities.

For forecasts aimed at regions of mass recreation, additions to the general forecast might include forecasts of potential pollution or contamination, marine and river forecasts, and a note of any relevant weather-sensitive health issues. Forecasts in mountain regions are especially important; activities such as skiing, hillwalking, hiking or climbing, are very weather-dependent.

Forecasts for weekend weather conditions should be available on Websites by the middle of the preceding week. Forecasts should be updated at least daily.

For mass celebratory events, such as open-air concerts and sports competitions, which attract a large attendance, appropriate meteorological support is required and may be delivered though the NMS Website. An accurate weather forecast, in addition to enhancing the attraction of a visit to such sites, may assist in providing for the safety of people during such special events.

3.2.3 Forecasts for weather and road conditions

Consideration should be given to the provision of "en-route" forecasts for major highways. Such forecasts will help the public to plan their journeys more effectively. Of special importance are road forecasts in winter, for example in places where ski tourism is popular. These bulletins may include difficult-to-forecast parameters, such as the occurrence and depth of snow, road surface icing, fog, etc. The presentation of such "road-condition" forecasts in map format, for example where the line indicating the road is coloured appropriately to represent the various hazards, lends itself to dissemination on a visual medium such as the Web.

The following weather parameters are of more interest to the specialized user, and might be provided under password or similar control.

3.2.4 Marine forecasts

Marine forecasts that might be placed on a Website can be divided into two categories: (a): forecasts for inland waters, coastal districts and inshore, and (b): forecasts over the open waters of seas and oceans.

Forecasts for inland waters, coastal districts and inshore

Coastal marine and meteorological forecast information is important both for the economic activity of people living in coastal regions or near inland waters, and for use by people engaging in leisure activities. These leisure activities can be both active (sailing, surfing) and passive (sunbathing) in nature.

The wind regime along the coast will normally be the first and most important element to be represented in an inshore maritime forecast. Representation on a Website can add value and clarity to a coastal forecast by indicating precisely the section of the coast to which the forecast information refers. This also holds for the forecast of wind conditions over inland waters.

More specific marine information that might be carried on a Website could include the expected height and period of waves, represented either numerically (the height of the waves in metres, for example), descriptively (calm, rough, etc.) or by the use of appropriate symbols. The temperature of the water close to the shore (the swimming zone) might also be included in the forecast where this can be reliably predicted. Special mention might be made when sharp changes of

temperature are forecast (caused, for example, by known upwelling). Special attention should certainly be given to the prediction of such potentially dangerous coastal phenomena as surges, fog, and to specific coastal winds such as the bora and the tramontana.

When placing marine weather data on a Website, an NMS should discriminate between information of use to business interests specific to coastal regions (coastal fisheries, port activity, oil exploration and extraction, etc.) and the information requirements of people undertaking leisure activities, such as water sports. The NMS should ensure that policy in regard to the commercial use of weather information is respected. Warnings of coastal and other maritime phenomena that constitute a potential hazard to life or property should, however, always be given prominence on the forecast homepage, with a link to the more detailed coastal forecast.

The graphical information on coastal weather will normally be augmented by a text forecast; this will be of particular importance where a description of a specific meteorological phenomenon is required. Examples might include: "at night a fresh land breeze is expected", or "as a consequence of the increase in wind speed, a rise in the upwelling of deep cold waters is expected and in the coastal zone the water temperature will be lowered by six to eight degrees".

The pages devoted to coastal and inshore marine forecasts offer an opportunity to call the users' attention to the safety precautions recommended for swimmers or those engaged in water sports. Here, the NMS might usefully collaborate with the appropriate national safety authority to provide some links to pages of water-safety instruction. For example, sailors might be reminded of the need to wear lifejackets at all times, while swimmers could be advised to keep close to the shore. Apart from the obvious benefits of reducing the number of injuries and fatalities in marine incidents, such information underlines the public service mission of the NMS and complements the provision of accurate and appropriate marine information.

Forecasts over the open waters of seas and oceans

These forecasts represent those weather elements which are of most interest and importance to mariners and seafarers. This information is frequently provided by the more specialized units within an NMS. On an NMS Website this marine forecast information will normally be shown in a standardized text format. For example: "In a north-east part of the Greenland Sea a wind speed of 15-20 m/s is expected. Wave heights will reach six to eight meters with a wave period of 11 seconds." or "In the centre of the North Sea a deep low pressure is expected to develop, leading to a build-up of wave heights up to six to seven meters over the next two days". Such information might be accompanied by relevant satellite imagery, or the user might be encouraged to use links to satellite imagery that complements the forecast.

Such forecasts should almost always be left in their original text form. The advantage offered by a Website in representing such forecasts is to provide a map whereon the areas to which the forecast refers can be clearly defined.

3.2.5 Forecasts for cities/large centres of population

The content of forecasts for cities is basically as described in the section dealing with general forecasts. However, the urban heat island effect and the very concentration of people which cities represent provide a rationale for the preparation of specific city forecasts. It should also be noted that some NMSs have begun to issue, either in operational or experimental mode, meteorological forecasts for very large cities, the so-called megalopolises, which are very detailed in time and space. These forecasts are based on mesoscale or regional models of the atmospheric circulation that embody a high spatial resolution. The forecast information is represented for discrete periods as short as one to three hours, for periods of 24, 36 or 48 hours ahead. The forecast data (such as temperature, precipitation, cloud cover, wind) for separate regions of the megalopolises can be detailed. There is a special value in such a high level of detail when considering the forecast for coastal cities, or for large cities covering a region with complex orography. An important element of the forecasts for cities is the prediction of meteorological conditions which lead to, or promote, enhanced atmospheric pollution or contamination. Information may also be given as to the potential medical consequences of the expected meteorological conditions (see the section below concerning the meteorological influences on human health).

3.2.6 Hydrological forecasts

The development of centres of human civilization is, historically, closely linked with the hydrology of a region, and a great number of human settlements are located on rivers. The hydrological forecast has a great importance, therefore, both for the population, and for the efficient organization of economic activity.

Different hydrological parameters will assume different levels of importance from region to region and from year to year. Examples might include:

- In winter – the prediction of ice thickness on rivers susceptible to freezing
- In spring – the date of ice drift, especially of spring flooding at various locations
- In summer – periods of low water
- In autumn – dates of complete freezing
- At any time – prediction of flash flooding
- For controlled rivers – prediction of water inflow into reservoirs.

However, individual peculiarities of a given river basin and its hydrology will dictate the most important characteristics to be forecast; these are difficult to generalize. Within the framework of this Technical Document it is not possible to provide an exhaustive list of the hydrological characteristics which might be appropriate to place on a given NMS Website. The individual nature of the forecasts, and the great diversity of information that consequently needs to be communicated, are factors that make a Website such a useful tool in disseminating hydrological information and forecasts.

3.2.7 Agrometeorological forecasts

There is a tremendous and growing public interest in agrometeorological information. Such information is sought not only by farmers but by large numbers of gardeners, both professional and amateur.

Agrometeorological forecasts combine information on the phases of development of various agricultural and horticultural activities with a knowledge of meteorologically derived variables (such as soil moisture at various depths) and with the interpretation of short and medium-term weather forecasts. Frequently an NMS will draw on the resources of agricultural research and advisory authorities in drawing up such forecasts. These forecasts allow the provision of practical recommendations to farmers and gardeners about, for example, the necessity of additional watering of crops, or on the likelihood of the spread of weather-sensitive crop and animal diseases, or on the necessity to take action to prevent frost damage. The economic impact of the efficient dissemination of good agrometeorological information and advice can be substantial.

In considering the provision of agrometeorological information on a Website an NMS will need to consider whether such information is best placed on its own Website, or on the Website of the appropriate national agricultural advisory authority. Such authorities may already operate Websites which reach a substantial number of the farming population. An NMS may not be comfortable with, and may not wish to take responsibility for, the specific nature of some agrometeorological advice, which may go well beyond the more general guidance offered in normal weather forecasts.

On the other hand, an NMS will normally have a higher national profile than an agricultural advisory authority, and such an authority may well feel that agri-information placed on an NMS Website may reach more potential users. In either case, close collaboration is needed between an NMS and the other relevant authorities to ensure the provision of the best and most timely advice to the greatest number of users.

3.2.8 Aviation forecasts

Aviation forecasts can be considered under four separate headings discussed below.

3.2.8.1 Forecasts for general aviation

These forecasts are designated for the provision of safety of flights at low altitude, under Visual Flight Rules (VFR) or similar. Due to the growing popularity of leisure aviation, the operation of private aircraft and glider flying, the forecasts issued for general aviation are very much in demand. Such information is often map-based, as in low-level significant-weather charts. The provision of such charts and ancillary information on a Website will allow users to assess the feasibility of VFR flights from home or office, perhaps saving them a physical visit to the aerodrome or local forecast office.

3.2.8.2 Forecasts for commercial aviation

Internet and Webpage technology can be put to use in a closed communication system (more properly referred to as Intranet) for the purpose of disseminating aviation weather information to commercial pilots, dispatchers, military airports, etc. Such information is not normally put in the public domain, as it has a commercial value. However, when issuing, to the general public forecasts of certain severe weather (fog, high winds, thunderstorms), there may be a value in mentioning the possible disruption of commercial aviation in locations near busy airports.

3.2.8.3 Terminal Area Forecasts (TAFs) and Airfield Weather Reports (METARs)

Both general and commercial aviation will make heavy use of TAFs and METARs. While these are normally communicated over fixed circuits, it may be convenient to also place them on a Webpage.

3.2.8.4 Warnings of severe in-flight weather

The Internet is not an appropriate medium for the dissemination of such warnings, which require a more active (push) form of delivery. In addition, allowing such warnings to be accessed by the general public may cause needless anxiety and alarm.

3.2.9 Forecasts of meteorological impacts on air quality

A number of NMSs routinely issue forecasts of air quality, both for specific regions and individual cities. These forecasts are based on forecasts of the meteorological situation in the lower atmospheric layers (boundary layer), often taken together with measured data on specific atmosphere impurities. Conditions promoting or hindering the accumulation (concentration) of harmful impurities in the atmosphere are normally predicted. Such forecasts can enhance the public service mission of an NMS and where they have been found to be reliable, should be given prominence on the NMS's Website.

3.2.10 Meteorological influences on human health

The interest shown by the general public in the medical consequences of meteorological conditions can be comparable with the interest in the general forecast of meteorological conditions. The following are some suggestions as to what medically-related information might be disseminated on an NMS Website.

(*a*) The comfort sensation by the public under particular meteorological conditions may be expressed by a parameter such as effective temperature, (a function of air temperature, wind velocity, humidity, cloudiness, etc.). In winter, the wind-chill equivalent temperature

may be relevant; in summer, the heat index. A classification of comfort sensations on the basis of such indicators will need to be included if such information is published.

(*b*) A number of meteorological factors have been identified as influencing or aggravating chronic illnesses such as vascular, lung, asthmatic and mental conditions. These meteorological variables include, for example, rapid fluctuations of pressure or of temperature, extreme values of atmospheric pressure, the joint operation of meteorological conditions such as temperature, pressure, humidity and so on, or an extensive duration of individual meteorological factors (continuous heat, continuous cold, prolonged period of humid weather). Specific warnings might be disseminated when such conditions are forecast.

(*c*) The medical condition of a person can be affected not only by meteorological parameters, as above, but also by the presence of impurities of industrial origin in the atmosphere. This is especially true for patients suffering from respiratory illnesses.

(*d*) The forecasting and dissemination of pollen levels is of great benefit to those who suffer from related respiratory conditions, and allows them to plan appropriate levels of activity, or to take preventative medicines.

(*e*) There is now great understanding of the links between skin cancers and exposure to ultra-violet radiation; an exposure which is sensitive to both weather conditions and ozone levels. Some form of "sunburn index" is a worthwhile addition to the information disseminated with the normal forecast.

(*f*) On Websites medical interpretation of the ecological/meteorological forecasts (items 2 and 3) is probably best presented in text form, although there may also be accompanying maps or graphics indicating, for example, the geographical extent of a given set of conditions. There will be a need for an explicit disclaimer regarding the limitations of such information.

(*g*) The forecast of a generalized medical condition of the population requires careful consideration and is not recommended. Such a forecast may have negative consequences as a result of the phenomenon of self-suggestion; this has been noted in some medical and sociological studies.

3.2.11 Forecasts and warnings of forest fires

Forecasts of the likelihood of forest fires are compiled on the basis of information such as the duration of a drought period; soil aridity; forecast values of air and ground temperature; probability of precipitation and its intensity; relative humidity; and the expected wind regime.

Such forecasts can identify regions of enhanced fire hazard. The form of issue of fire hazard forecasts is, more often than not, simple text. However it is possible to graphically illustrate the forecast of degrees of fire hazard on the basis of various indices. As with agrometeorological forecasts, such forecasts can be issued in conjunction with the appropriate national forestry and/or safety authorities.

3.3 NUMERICAL WEATHER PREDICTION PRODUCTS

Global and regional numerical weather prediction (NWP) models, as operated by many NMSs, generate medium-range forecasts, typically out to 72 or 96 hours. Such forecasts will be of interest to many sections of the population which require forecasts with three to five day lead times for planning purposes.

Presenting NWP products on an NMS Website may well provide useful information to the general public, to tourists (both actual and potential), and to those with a more particular interest. However, NWP model outputs are specialized and require interpretation; hence presentation of direct model output may be confusing to the general public. There is also the danger of the model output being inconsistent with the "official" forecast, where a forecaster has seen fit to alter or ignore the model guidance on the basis of his or her experience. It is, therefore, recommended that only carefully chosen products, which can be easily interpreted by the general public, be presented on NMS Websites.

Since regional or limited-area NWP models have a higher resolution than global models, it is recommended that NMSs present only selected products of regional models on their Internet Websites for public use. It is further recommended that such products carry a clear notice that the displayed charts represent "uncorrected" computer model forecasts, and that they may be at variance with the official forecast on occasion.

Selected products of a regional model might be presented in figures, or as contoured or colour-banded maps (with a legend) presented on a detailed background. Selected products might include temperature, forecast cloud amount, pressure fields, rainfall, etc.

The user may be given the choice of displaying any of the available products at a date and time that is of interest and that is within the range of the forecast model.

The user might also be given the facility to view animation loops of the products of interest, although these should be separately selected as they may be slow to load.

It may be helpful to the general public if the NWP forecast information is summarized and displayed in a high-quality pictogram. This method of presentation should aid the understanding of model-driven forecasts by the general public.

3.4 SATELLITE IMAGERY

Satellite imagery are a popular element in weather broadcasting and the public have developed a familiarity with them. It is, therefore, important that an NMS Website include satellite imagery in order to attract a greater number of visitors, if for no other reason. Weather satellite imagery should always include a date/time stamp for clarity, together with good locators (coastlines, rivers, major cities etc). The satellite agency supplying the imagery will need to give their consent for the use of their products on an NMS Website, and the source of such imagery should always be cited.

The satellite images presented should be cropped and re-projected, in a manner such that the country appears in the

centre of the image, to better cater for the local region. It would also be advantageous to have other satellite images covering a larger surrounding geographical area. These are popular and informative to the public in that they allow them to examine the weather conditions of neighbouring countries.

Regardless of whether the images shown are infra-red or visible, or a combination of both, it is important that a special legend is shown alongside each satellite picture to assist in the interpretation of the imagery by the general public. It might also be desirable that weather symbols, familiar to the public, be added to the images to further simplify their interpretation.

As with model output charts, the user should have a choice of displaying satellite images either as still images or in animation mode.

3.5 RADAR IMAGERY

While the use of radar in weather broadcasting on television is not as widespread as that of satellite imagery, it is well-suited as a visual representation of the weather conditions, to display on an NMS Website. The great detail of a radar image provides the opportunity to study in some depth the rainfall distribution over a country or region. Radar can also be a useful educational tool in that it helps to show the public the differences between frontal (dynamical) rainfall and convective rainfall, for example; or how a weather system might gain or lose intensity as it moves in time and space. Placing radar images on a Website also allows the public the opportunity to study them in greater detail than is possible in a television weather bulletin, and to appreciate the meaning of the different colour intensities, for example.

The public does not, in general, find radar imagery as intuitively easy to comprehend as they do satellite imagery. For this reason, it will be necessary to incorporate a clear representation of the area of coverage in radar imagery. This should include coastlines and rivers where appropriate, and the location of cities and major towns. Consideration should also be given to illustrating the "footprint" of the radar, i.e. the circle of coverage centred on the radar site. Where the rainfall patterns shown on the radar imagery are colour-coded for intensity, there should be a clear legend that allows the public to read these colours and appreciate their meaning. Consideration should be given to expressing these rainfall intensities as descriptive terms (e.g. moderate rain, heavy rain, etc.) rather than as numerical rainfall rates, which may not be easily understood by the public.

Each radar image should be accompanied by a clear date/time stamp. As with satellite images, the user should have a choice of displaying radar imagery either as still images or in animation mode.

3.6 WARNINGS AND INFORMATION ON NATURAL DISASTERS

Issuing weather warnings is the sole responsibility of the NMS, and its most important public service function. An NMS should therefore use all possible means of communication to convey weather warnings to the public.

However, the Internet is not an ideal medium for the communication of weather warnings. It is passive; it will not convey warnings to the public without action on their part to look up the Website. Its role in the dissemination of warnings should be seen as complementary to the primary channels of radio, television, etc. in bringing accurate and timely weather warnings to the public.

When a weather warning is issued there should be a very clear indication on the NMS homepage (perhaps a flashing symbol) with a direct hyperlink to the warnings page. Such an indication might be repeated on all the main forecast pages. A Website does offer the opportunity to describe in more detail both the warning and the weather conditions that give rise to it. Maps indicating the area covered by the warning can be displayed, together perhaps with some visual indication of the severity of the expected weather, where this is appropriate. A warnings page on a Website is also a resource for journalists who may be covering the weather story for news bulletins; it allows them to easily access detailed information without taking up valuable forecaster time in telephone calls and briefings.

An NMS, therefore, should present precise and detailed information on weather warnings on its own Website. This information should be published on the Website as soon as possible after the issue of warnings to the media. Times of issue and times of validity should be clearly stated. Warning information on the Website should be updated as frequently as is necessary. It is also very important that operational arrangements are made to remove warnings from the Website when they are cancelled; i.e., when the severe weather has died out or moved on.

3.7 CLIMATE DATA

The collection, organization and maintenance of climatological data is an important function of NMSs, who then provide this data to a wide variety of specialists (researchers, engineers, lawyers etc) as required. The public is not, normally, aware of the vast amount of climate data available within their NMSs.

There are, therefore, two distinct contexts for the placing of climate information on an NMS Website. The first is to provide detailed data on pages subject to controlled access, for the specialized user as the provision of climate data to such users frequently provides a source of income for the NMS. For such users there would need to be free-access pages detailing the range of climatological data that the NMS can provide, and the relevant charges. The NMS might also include in its Website the contact details for the relevant officers who would assist in providing further and information.

The second context is to publish on the Website a summary of the national and regional climate of the country in a manner that would be easily understood by the general public. In addition to selected data on mean values, extreme values, etc., climatological summaries for selected meteorological stations may be presented in a tabular or graphical

format. These pages might also provide a brief overview of the climates of neighbouring countries or popular holiday destinations, together with links to climate data "warehouses" such as that provided by NOAA on the Website ncdc.noaa.gov.

It would also be of value for an NMS to provide, on its Website, a brief report on severe weather events that have affected a country, together with a summary of the resulting damage. Such reports would have considerable value in educating the public as to the potential effects of severe weather, and will also reinforce the public service role of the NMS as the pre-eminent source of information regarding warnings and associated severe weather.

3.8 INFORMATION ON FORECAST QUALITY/VERIFICATION

The accuracy of forecasts, expressed in an understandable form, is of interest to a general user of weather information. This interest will normally be satisfied only by an NMS, which has records of weather both as it was forecast and as it actually evolved, and the resources to evaluations of skill score and other measures of forecast quality.

These evaluations of quality should be divided into the various categories of forecast (short-range, medium-range, long-range, warnings of severe weather, etc.) and should be understandable by an ordinary user of a site. This is a challenge, as there are a variety of ways in which forecast quality can be expressed. The simplest form of expression possible should be used, together with a brief explanation of the technique of evaluation. The representation of this information in the form of maps, graphs and tables is recommended.

The publication of such skill-score evaluations of forecasts on a Website can increase public confidence in the products of an NMS. These evaluations inform users by providing an objective view of the accuracy of the forecast and warnings services, rather than have them base their opinion on a subjective evaluation of the activities of an NMS, as is more usual. The publication of such statistics can also help in impressing upon politicians and government officials the value of an NMS; a matter of great importance when budgetary considerations are under review.

In some cases, where independent evaluations show low forecast quality, it may be necessary to accompany such evaluations with synoptic comments, clearly detailing the reasons for forecast failure, when this occurs.

The comparison on a Website of forecasts from public and private sources may be possible, but these should only be published in a spirit of mutual cooperation with private sector weather suppliers.

3.9 ADVERTISEMENT

Advertising is present on many weather sites; placed there by advertisers because of the great popularity of such sites, expressed in a high "hit-rate". However, an NMS should reflect carefully before accepting commercial advertising on its Website.

Given the increasing demand for commercial advertisements and publicity on weather Websites, each NMS should develop its own policy regarding the placement or otherwise of such advertisements on its Website. These policies will need to be considered in the context of the overall government policy, the laws and regulations governing advertising applicable in each particular country, the likely benefits that will accrue to the NMS and the problems that might be engendered.

Where commercial advertisements are accepted for inclusion on a publicly funded NMS Website, great care should be taken that these advertisements do not weaken the brand or image of the NMS, or impact in any way on its public service function.

It is certainly appropriate, and recommended, that an NMS Website carry information of the following types:

(*a*) Activities taking place within the framework of the NMS, such as the details of seminars, conferences and other such events.

(*b*) Meetings and conferences held under the aegis of WMO, or other international organizations that reflect the cooperation and collaboration of NMSs.

(*c*) Information on scientific and technological achievements, particularly those which underlie the operational work of the NMS. Examples might include improvements made to weather models, to the computing resources available to the NMS, cooperative research ventures with other organizations, etc.

(*d*) Information on seminars or conferences organised by universities or by learned societies working in the field of meteorology.

(*e*) Meteorological products and data that are made available by the NMS (on a commercial or a non-commercial basis) and the procedures for accessing them.

3.10 ABOUT THE ORGANIZATION

Information concerning the structure and role of an NMS is a necessary and important component of an NMS Website.

This section might begin with a brief historical overview of the development of meteorology, both internationally and with reference to the country in question. National citizens who have made a significant contribution to the development of atmospheric and meteorological science should be mentioned, with links to appropriate biographical pages. The structure of the NMS will normally be described, together with the names and photographs of its leading officers.

The NMS should also give some details as to its operations. Topics might include the number of staff devoted to the various functions; a description of its observing, forecasting and communications networks; details of its computing facilities; range of its customer base and of its output products, etc. Development plans might be outlined, together with a mention of the resources needed to implement them.

There should also be, in this section, information on careers in the NMS. This information will normally detail entry requirements; application procedures; salary levels, etc. It should also contain some articles by serving staff members in which they describe their work and how they contribute to

the activities of the NMS as a whole. There might also be mention of social, recreational and sporting facilities available to employees of the organization.

The aim of this section should be not only to give basic information about the structure of the NMS, but to reflect in some way the life of the organization and of those who work within it.

3.11 WEBSITE DISCLAIMER

For additional information refer to the WMO document *Guide on Internet Practices* (http://www.wmo.ch/web/www/reports/Internet-Guide.html), paragraph 7.2

In this part of the Website it will be necessary to:

(*a*) Articulate the conditions under which visitors to the Website are entitled to use the material contained therein.

In publishing forecast products on a Website, an NMS will need to make an explicit statement that, while forecasts are prepared with great care and with the use of the latest science and technology, the NMS cannot guarantee the accuracy of any particular forecast product and cannot be held responsible for any consequential damage or loss should such a forecast prove to be incorrect. Posting complex products intended for interpretation by professionals on Webpages may also lead to problems whenever these products can be readily accessed by inexperienced users. Such users may easily misinterpret these complex products and use them to make wrong decisions. Thus, it becomes particularly important to publish adequate disclaimers on the main pages of the Website. These disclaimers should be drafted with considerable care with regard to local legislation, preferably with the assistance of expert legal advice.

(*b*) Deal with any copyright issues; either with regard to the "external" copyright of material imported into the site or with regard to the use of NMS Website material elsewhere. Webpages often include material, such as graphical illustrations, that are protected by international copyright and care should be exercised when "adapting" such artistic elements for use on the NMS Website. In general, permission should be sought in advance of using external graphics, and full acknowledgment should always be made. Conversely, the conditions under which material on the NMS Website can be copied and used in other Websites or publications need to be fully defined and explained. When using any trademarks or service marks, it is recommended that the trademark (TM) or copyright (©) symbols be used as appropriate. By definition, trademarks are used to identify tangible goods, while service marks are used to identify services.

(*c*) Disassociate the NMS from any concept of endorsement of external sites to which hyperlinks are provided from the NMS site.

When hyperlinks or references to external sites are provided, there should be an explicit statement to the effect that such links or information do not constitute an endorsement or recommendation by the NMS or any of its officers or employees of the content of the external sites. It should be clearly stated that the NMS is not responsible for the contents of any off-site Webpages referenced from the NMS Website.

3.12 AUTHORIZATION/SITE MAP

A Website may be structured so that certain information is made available only under special permission, with access to such information protected by password or other methods. A Website may be used in this way as the vehicle for the bilateral exchange of information between NMSs, for example, or to allow commercial clients access to material that is not put in the public domain. In addition to the protection of material, such arrangements have the advantage that when only a limited number of persons have password access to certain Webpages, optimum access speeds and the most up-to-date information can be made available.

When such arrangements are being put in place, it is desirable that pages which require password access be clearly indicated in advance. It will be frustrating for the general public to spend time waiting for a page to load up, only to find that without a password they cannot view the material contained therein. Where links are provided to password-controlled pages, therefore, the need for such a password should be clearly indicated in advance. Another worthwhile element is a "site map" where the structure of the site is clearly outlined and the links from the homepage delineated. On such a map those pages which require password access can be defined, perhaps by printing their names in red or some such graphical device.

3.13 LINKS

The Website of an NMS should contain a page of links to other weather-related Websites that are known to present information of good quality. These would include perhaps the Websites of NMSs of neighbouring countries, together with a link to the WMO home page. There could be a direct link to the WMO page, which lists the Websites of all WMO Members which provide such a facility. There might also be links to academic institutions that play a role in meteorology, to learned societies devoted to meteorological and hydrological causes, and perhaps to the national broadcaster(s) or other bodies with whom the NMS works closely.

3.14 FEEDBACK FROM USERS

A Website should enable users to easily provide comments and feedback to the NMS through e-mail or other means. Such feedback should always be encouraged, and should always generate an acknowledgement and response. Through such feedback, a Website offers the NMS an unparalleled opportunity to hear from its users; a very inexpensive form of market research. NMSs should make full use of this facility;

comments can be encouraged by the offer of merchandising material, for example, for the 10 best suggestions or comments received each week. Questionnaires can also be used to encourage and guide user response. The interactive facility offered by a Website should be employed to the full.

3.15 EDUCATIONAL INFORMATION

Children learning about weather in school will naturally look to their country's NMS for information and resources to help them in their studies. An NMS's Website should reflect this interest by providing pages specially designed with children in mind. Ideally, educational material should be chosen in consultation with teachers or school inspectors who know the syllabus which will be followed in the schools. There will also be a need to provide information at different levels, reflecting the development of children's knowledge and understanding as they progress through their schooling.

Weather studies may form a part of diverse courses, including mathematics, geography, physics and Earth sciences. Website pages aimed at schoolwork should not just be seen as reference material, but should contain suggestions for assignments and projects, together with data to support such project work. There should be attempts to ensure that real-time weather data are used, where this is possible. Games are always popular, and these can be based on weather elements.

Some suggestions as to the content aimed at schoolchildren follow:

Ages 4-8
Simple weather symbols for sun, cloud, rain etc.
Wind direction and strength. Which winds are warm and which are cold.
Basic temperatures.

Ages 8-12
Basic graphs of, for example, daily rainfall over a period of weeks.
Simple measurements of rainfall, temperature and wind.
Basics of the local and national climate.

Ages 12-15
The basics of the weather chart
Simple cloud types
Scales of temperature and pressure
Basics of the hydrological cycle
Simple weather instruments
Major climate zones of the world
Climate and land use.

Ages 15-18
Synoptic charts
Air pressure and density
Humidity / Water vapour
Weather satellite pictures
More detailed weather records
Weather and landscape
Regional climates and vegetation.

Other material of a more general educational nature, aimed at the general public, may also be included in a Website. Such material might describe the basic physical processes in the atmosphere; or describe the structure of weather fronts, thunderstorms, tropical cyclones etc. The thirst for knowledge and understanding is great, and the combination of text, graphics and animation which a Website provides offers a tremendous resource in this respect. Those who prepare textbooks on weather and meteorology for schools and universities might be partners of an NMS in publishing webpages of educational material.

Chapter 4

TECHNICAL ASPECTS OF A WEBSITE

This chapter is not intended to be an exhaustive or definitive guide to the technical matters connected with establishing and maintaining a Website, but will attempt to outline some of the basic elements that will need to be considered by those embarking on or reviewing such an enterprise. The reader is referred to the WMO *Guide on Internet Practices* which, in addition to much valuable technical information, contains references to more detailed source material.

4.1 SECURITY

NMSs are built around secure and dependable communications; both for the collection of weather observations, satellite and radar data, model output, etc. and the dissemination of various forecast products by a diversity of means. Establishing a Website provides a pathway for the outside world into a computer system, and therefore allows for the possibility of "hacking", or unauthorized access by outsiders to computer systems and files. Therefore, the first technical consideration in establishing a Website will be the provision of adequate security; to ensure that those using the Website cannot gain access through it to the operational computer systems of the NMS.

Unfortunately, with an increase in security comes a trade-off with convenience. As the number of connections into a network increases so does vulnerability to attacks. What resources should one protect? Against whom must the network be defended? When does security become adequate? Such decisions are clearly an iterative process with the answers never being final, on an ever-expanding network. Quickly, one realizes the necessity of implementing a security policy; a set of decisions that collectively determine an organization's stance toward security. The basis for securing operational computer systems from unwanted access are firewall systems; as the name implies, these act as barriers between connected computer systems to regulate the flow of information between them.

4.1.1 Firewall systems

Firewall systems can sometimes be referred to as a gateway. A firewall can be programmed to restrict intercommunication with non-privileged users and/or to restrict specific network information from being accessed by those beyond defined borders.

The most common function of a firewall is filtering, e.g. IP filtering, URL filtering, etc. IP filtering is a basic component of most firewalls. With the implementation of IP filters, a firewall has the ability to restrict types of IP traffic to isolate hosts or networks or to restrict the type of traffic permitted.

A firewall is generally designed to block everything, and then allow services to be enabled on a case-by-case basis after careful assessment of need and risk.

4.1.2 Software versus hardware firewalls

There are essentially two types of firewall. Hardware firewalls are actually black boxes which features packet disassembly – a processor hidden inside analyses incoming packets and rejects those which are not allowed. Hardware firewalls are more stable (no firewall disk) but difficult to program and less flexible.

Software firewalls (where a computer carries out the firewall functions) can perform the same functions as a hardware firewall but are much more flexible, so that more applications can easily be added to their set up, such as FTP, Mail, etc.

4.2 CONNECTING TO THE INTERNET

There are two major options that an NMS can consider in regard to where to host their Webpages; to operate them on their own computers or to contract another agency or commercial service provider.

Operating a Website from within an NMS would require a dedicated computer/server, a permanent connection to the Internet, and an HTML editor. This option is undoubtedly the least expensive, but it does raise many security issues. A permanent connection to the Internet will also be relatively expensive when compared to a dial-up link.

Looking at the outside options; the NMS would need to be aware that some of these options will offer better international availability than others; connectivity to the Internet backbone is important, as is the bandwidth of such connections, which determines the speed with which users can access the NMS Webpages.

An NMS should examine whether it can use the Webserver of the government, or of some sister organization such as a government department or an environmental agency. Universities usually have good connectivity to the Internet, and these represent another possible source of a host server. Finally, of course, there are the commercial Internet Service Providers (ISPs) which will provide server space and which may also offer related services such as Webpage design and construction.

Whatever solution is reached as to where to place the Webpages, the NMS needs to investigate the adequacy of the connection speed supported by the local telecommunication provider and ISPs. The NMS should consider the common access speeds supported by local ISPs; whether the target audience is the general public or a specific user community that is likely to utilize higher connection speeds; and also the level of computer technology widely available within the country. These issues will directly impact download time for Web-based services and could limit the size of files and/or graphics the NMS might like to include on its server. Consideration also needs to be given to the potential international audience, who would have widely varying technical access capabilities and a variety of browser versions.

4.3. RELIABILITY

Whether the NMS is hosting its Website in-house or using an external service provider, the following issues should be addressed to ensure the Website is available at all times, with reasonable response times.

4.3.1 Backup strategies and disaster recovery

Backup strategies should be implemented to ensure the system can be quickly recovered to its current state in the event of hardware failure (e.g., hard disk failure, system destruction by fire, etc.). This would include regular back-ups of the system, with offsite storage and documented back-up and recovery procedures.

4.3.2 Continuous power supply

An uninterrupted power supply should be used to provide protection from damage and avoid downtime due to mains power interruptions, lightning strikes and other irregularities in power supply.

4.3.3 Satisfying peaks in demand

The system should be configured to ensure that the maximum number of concurrent users able to access the system is sufficient to deal with the likely peak demand. As these peaks are likely to occur during extreme weather events, it is essential that all users attempting to access the site (regulars and newcomers) are able to connect to and navigate the site with reasonable response times.

4.3.4 System mirroring

In high-usage situations a system mirror could be considered to spread load and improve response times, and to ensure availability of the system during planned or unexpected downtime of individual servers.

4.3.5 System maintenance

The system administrator or Webmaster should monitor relevant log files and respond to any errors, and ensure that the system performance does not degrade due to uncontrolled disk usage, etc.

4.3.6 Monitoring site usage

Information on the usage of the site, such as numbers and types of visitors, most popular content, etc. can help to determine the best use of resources in developing and maintaining the site. As well as standard log files included with Webservers, a wide range of additional utilities with statistical analysis are available, and should be considered.

CHAPTER 5
DESIGN ASPECTS OF A WEBSITE

The most important features of any Website are speed of loading ease of navigation and clarity of presentation.

5.1 LOADING SPEED

As a guide, a Webpage should not take longer than 20 seconds to load through a normal modem; if it does, many users will simply not wait to view the page but will move on to some other Website. The homepage in particular should be quick to load up; this means keeping it free of animations, advertisements, and other large files. Where animations are being made available through a Website, there should be a note of warning that there will be a delay in loading up these pages; users will be more patient if told in advance to expect some delay.

5.2 NAVIGATION

When designing the navigation through the Webpages of an NMS's Website, the designers should be acutely conscious that most visitors will not be expert in meteorology and will want simplicity. The first layers of the site should therefore be set out with the interested public in mind. Deeper into the site it is allowable to have pages aimed at the professional, containing a great deal of detail and information. A useful feature is a site map, where a user can get an overview of the different pages and levels within the Website, and can go directly to some of the deeper levels if this is their wish. A search tool should also be included, limited to searching files present on the local Webserver.

5.3 PAGE DESIGN

Relevant, high-quality content is paramount on an NMS Website. This quality of content, however, needs to be supported and reflected in the quality of design through which the information is visualized. The design, in terms especially of the layout, colour and use of fonts, etc., should transmit a sense of quality and dignity appropriate to a national organization. In almost all cases, the NMS will not have design expertise "in-house" and will have to employ the services of a professional designer. This is an area which must receive adequate resources at an early stage of the conception and planning of the Website.

The detail of the Website design will vary from country to country in accordance with the visual design culture of each people. This should be seen as a positive point, because a design that derives from the indigenous visual culture of a people can strengthen the identity of the NMS Web pages, and help in distinguishing them from the various commercial weather Websites, which mainly follow an American design style. This Technical Document cannot therefore be prescriptive in defining the best design for a Website, but some basic points can be suggested.

Forecast *texts* should be concise. A series of concise texts for different parts of the country is better than one longer script which seeks to describe different weather regimes within the one text.

When using *graphics*, attention needs to be given to the size of the image, and of the resultant file. The image should fit into the display without scrolling, where possible.

Animations should only be used where necessary, and should not be on the homepage, where they will slow down access and may discourage first-time visitors.

Weather *symbols* should be clear and unambiguous. A short description of each weather symbol used on the Website might be given on a separate page.

Similarly, temperature and wind information should be clear and easy to read. Where *colour bands* are used to denote temperatures, there should be a clear indication as to the temperatures to which the different colours refer.

Maps should clearly indicate major geographical features such as coastline, rivers, mountains, major cities, etc.

A uniform *typeface* should be used throughout the Website, and should be large enough to be clearly read on the smallest computer screen in common use; a 15-inch screen.

Pages should not be too long. Ideally, pages should fit on a display screen with minimal scrolling required. Otherwise, a table of contents with links to subsections should be provided at the beginning.

A uniform style of *layout* should be used throughout the Website. Frames can be used to assist navigation. It is common practice to dedicate a narrow frame at the margin of the browser window to a list of hyperlinks that facilitate navigation within a site.

Each page should prominently show the name or *logo* of the NMS. Each page should also contain a hyperlink to the homepage of the NMS site.

For sites which seek to serve an international audience, pages will need to be provided in a multiplicity of *languages*.

The designers of the Website will need to ensure that all of the facilities of the site are available to users who access the site through the different browsers; principally Netscape, Internet Explorer, Opera and WebTV. There will be a similar need to ensure compatibility with users on both Windows and Unix platforms.

5.4 DEVELOPMENT AND FORWARD PLANNING

A method of developing and implementing new content, or of modifying existing content, should be determined. This may employ the use of an in-house intranet server for development and testing prior to placing the content on the "live" site.

Appendix
GLOSSARY OF TERMS AND ACRONYMS

This Glossary refers primarily to terms and acronyms which appear in the text. A much fuller Glossary is appended to the "*WMO Guide on Internet Practice*", available also on the WMO Website at http://www.wmo.ch/web/www/reports/Internet-glossary.html.

3G	Describes the next generation (the so-called "third generation") of mobile interactive services using the UMTS standard. This technology should have the capability of delivering broadband services to mobile devices. Data transfer speeds could be as high as 2Mbits per second.
ADSL	Stands for "Asynchronous Digital Subscriber Line". This technology allows for much higher rate of data delivery over standard copper "twisted pair" telephone lines. Currently, digital services are delivered via ISDN at a rate of 128 Kbits per second. ADSL would increase this to over 1MBit per second, and perhaps as high as 6MBits per second. The term "Asynchronous" refers to the configuration whereby more of the available bandwidth is given over to the forward path into the home, with less of the bandwidth allocated to the return path.
AWS	"Automatic Weather Station". An set of unmanned instruments for the automatic collection and transmission of weather measurements.
CD-ROM	"Compact Disk - Read-Only Memory". Storage medium for large amounts of information; typically 500MB.
DSL	"Digital Subscriber Line". See ADSL.
EU	The European Union; a group of European nations that form a single market, and which have a common approach to the legal basis for the provision of services through telecommunication and other media.
FTP	"File Transfer Protocol". The basic method for copying a file from one computer to another over the Internet.
HTML	"Hypertext Mark-up Language". The coding method used to format documents and illustrations into web pages.
IP	"Internet Protocol". An IP address is a series of numbers that uniquely identifies a computer which is attached to the Internet. These are in the form of four groups of up to three digits each; the groups being separated by periods.
ISDN	"Integrated Services Digital Network". A system for sending digitised information (voice, video, data) over existing phone lines. Data transfer rates to 128 Kbits per second.
ISP	"Internet Service Provider". A commercial company that provides subscriber access to the Internet through their own servers. They may also provide services such as email, hosting webpages, etc.
iTV	Stands for Interactive Television. A generic name for the merging of television and internet technology; as the name suggests the viewer / user can interact with the broadcaster by sending messages back along the communications network, to alter the nature of the content being delivered, for example.
METAR	METeorological Actual Report. A report of weather conditions from an airfield, coded in a simple, easily understood format.
NMS	National Meteorological or Hydrometeorological Service.
NOAA	National Air and Ocean Administration of the United States of America.
NWP	Numerical Weather Prediction. The term covers both the techniques of computer-generated weather forecasts, and the suite of products emanating from such techniques.
PC	Personal Computer. The ubiquitous machine modelled on the original IBM standard of 1981.
PWF	Public Weather Forecasts. The provision of weather forecasts by NMS's as part of their public service obligations.
RANET	RAdio InterNET; a fusion of radio and internet technology which offers the possibility of wireless transmission of web-type information.
SMS	Short Message Service. The transmission or broadcasting of short text messages direct to mobile phones.
TAF	Terminal Area Forecast; concise forecast for an airfield, expressed in a simple, easily understood format.
TCP/IP	Transmission Control Protocol/Internet Protocol; protocols determining the format, checking procedures etc for the transmission from computer to computer via the Internet.
UMTS	Universal Mobile Telecommunications System; the new global standard for broadband mobile communications. Includes provision for the delivery of internet and interactive content at very high speeds to mobile terminals (the so-called 3G services – see above).
URL	Universal Resource Locator; the "address" of a Website or FTP server, e.g. www.wmo.ch.
VFR	Visual Flight Rules; the rules governing the safe conduct of uninstrumented flight.
WAP	Wireless Application Protocol; a standard for the transmission of interactive content over mobile phoine services; a forerunner of UMTS (or 3G) services.
WMO	World Meteorological Organization.
WWW	World Wide Web; an on-line pool of information that is delivered through the Internet.