

Guidelines on the Role, Operation and Management of National Meteorological and Hydrological Services

2017 edition

WEATHER CLIMATE WATER



WORLD
METEOROLOGICAL
ORGANIZATION

WMO-No. 1195

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EDITORIAL NOTE

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CHAPTER 1. INTRODUCTION

These Guidelines are intended to provide a one-stop, consistent and contemporary reference resource from the World Meteorological Organization (WMO) for managers of National Meteorological and Hydrological Services (NMHSs). They should help with many of the challenges that directors and managers of NMHSs face, including:

- Ensuring that the NMHS is able to meet national needs for meteorological, hydrological and related data and services;
- Responding to newly identified challenges in a rapidly changing world;
- Clarifying and articulating the mandate of the NMHS;
- Formulating and implementing effective strategic plans;
- Developing strong arguments to obtain sufficient financial, technical and human resources to carry out its mandate;
- Recruiting, retaining, motivating and establishing reward systems for staff;
- Maintaining networks, equipment and other supporting infrastructure;
- Providing quality services to meet varied end-user needs;
- Building sustainable capacity;
- Managing development projects;
- Keeping abreast of relevant developments in science and technology;
- Recognizing and having the ability to meet international obligations, agreed development goals and other international initiatives.

The need for guidance in these areas has been the subject of discussions since the mid-1990s. Relevant World Meteorological Congress and WMO Executive Council resolutions have included:

- [Resolution 30 \(Cg-XI\) – Development of national Meteorological and Hydrological Services](#);
- [Resolution 26 \(Cg-XIII\) – Role and operation of national Meteorological Services](#);
- Geneva Declaration of the Thirteenth World Meteorological Congress (*Abridged Final Report with Resolutions of the Thirteenth World Meteorological Congress* (WMO-No. 902), Annex IV);
- [Resolution 28 \(Cg-XIV\) – Role and operation of National Meteorological and Hydrological Services](#);
- Executive Council Statement on the Role and Operation of National Meteorological and Hydrological Services (for decision makers) (*Abridged Final Report with Resolutions of the Fifty-seventh Session of the Executive Council* (WMO-No. 988), Annex VII);
- [Resolution 29 \(Cg-XV\) – Evolution of National Meteorological and Hydrological Services and WMO](#);
- Draft Executive Council Statement on the Role and Operation of National Meteorological and Hydrological Services (*Abridged Final Report with Resolutions of the Sixty-second Session of the Executive Council* (WMO-No. 1059), paragraphs 6.1–6.3 of the general summary);

- World Meteorological Organization Statement on the Role and Operation of National Meteorological and Hydrological Services for Directors (*Abridged Final Report with Resolutions of the Sixteenth World Meteorological Congress* (WMO-No. 1077), Annex XI);
- The role and operation of National Meteorological and Hydrological Services – A Statement by the World Meteorological Organization for Directors of NMHSs (*Abridged Final Report with Resolutions of the Sixty-fifth Session of the Executive Council* (WMO-No. 1118), Annex II);
- The Role and Operation of National Meteorological and Hydrological Services – A Statement by the World Meteorological Organization for Decision-makers (*Abridged Final Report with Resolutions of the Seventeenth World Meteorological Congress* (WMO-No. 1157), Annex XV).

Note that, to provide clarity on terms, definitions of an NMS, NMHS and NHS were agreed by the Executive Council at its fifty-second session in 2000, as follows:

- NMS(s): National Meteorological or Hydrometeorological Service(s)
- NMHS(s): National Meteorological and Hydrological Service(s)
- NHS(s): National Hydrological Service(s)

The present Guidelines update and extend the 1999 publication *National Meteorological and Hydrometeorological Services for Sustainable Development: Guidelines for Management* (WMO/TD-No. 947). An existing 2006 publication covers NHSs, *Guidelines on the Role, Operation and Management of National Hydrological Services* (WMO-No. 1003).

Although these Guidelines focus primarily on NMSs (which may include delivery of hydrological services), the acronym NMHSs will be used throughout to maintain consistency with the previously mentioned resolutions, declarations and statements of the World Meteorological Congress and the Executive Council. Therefore, for this publication, the term NMHSs encompasses any government institution that provides weather, water or climate services.

Also, while these Guidelines are intended to assist WMO Members and the directors and senior managers of NMHSs with information relevant to their national operations, WMO has a separate guide on the internal practices of WMO, the *Reference Guide for Permanent Representatives of Members with the World Meteorological Organization on Relevant Procedures and Practices of the Organization* (WMO-No. 939).

1.1 STRUCTURE OF THE GUIDELINES

The chapters in these Guidelines deal with the role, operations and management of NMHSs.

In terms of the role of an NMHS, various chapters cover:

- The legal and institutional form of NMHSs
- National relationships
- International relationships, with particular emphasis on engagement with WMO

In terms of the operations of an NMHS, [Chapter 5 – Functions](#), has sections on:

- Observing systems
- Information systems
- Forecasting systems
- Research
- Warning systems
- Public weather services
- Aviation meteorological services

- Marine meteorological services
- Agricultural meteorological services
- Climate services
- Disaster risk reduction (DRR)

In terms of the management of an NMHS, various chapters cover:

- Leadership and management
- Capacity development
- Planning
- People management
- Financial management

Chapter 11 provides examples of commercially operated NMHSs.

These Guidelines are intended as a resource that can be referred to as required. The various chapters and sections provide an overview of the key issues, some high-level advice and indications on where to find further relevant information, and can be read as a whole or alone.

1.2 ONLINE MATERIAL AND PUBLICATIONS

Throughout these Guidelines, frequent reference is made to online material on the [WMO website](#). Where possible, WMO publications are referenced via the permanent [WMO library](#) records, which have summary information about the publications and links for downloading the documents. These are generally in pdf format.

The World Meteorological Organization is structured around three sets of core documents: *Basic Documents* (WMO-No. 15), *Technical Regulations* (WMO-No. 49), and *Agreements and Working Arrangements with Other International Organizations* (WMO-No. 60).

The *Basic Documents* (WMO-No. 15) is made up of the WMO Convention, General Regulations, Staff Regulations, Financial Regulations, and Agreements, and is usually updated every four years after a session of Congress.

The *Technical Regulations* (WMO-No. 49) are issued in three (as of 2017) volumes:

- [Volume I – General Meteorological Standards and Recommended Practices](#)
- [Volume II – Meteorological Service for International Air Navigation](#)
- [Volume III – Hydrology](#)

There are eight annexes to the Technical Regulations, which are also called Manuals. For those separated into two volumes, with the first usually covering global aspects and the second regional aspects, only Volume I has formal status, where the words "shall" and "should" have regulatory meaning (see below).

These are the regulatory annexes:

- [International Cloud Atlas](#) (WMO-No. 407)
- [Manual on Codes](#) (WMO-No. 306), Volume I
- [Manual on the Global Telecommunication System](#) (WMO-No. 386)
- [Manual on the Global Data-processing and Forecasting System](#) (WMO-No. 485)
- [Manual on the Global Observing System](#) (WMO-No. 544), Volume I

- [Manual on Marine Meteorological Services](#) (WMO-No. 558), Volume I
- [Manual on the WMO Information System](#) (WMO-No. 1060)
- [Manual on the WMO Integrated Global Observing System](#) (WMO-No. 1160)

The naming of these publications has an important bearing on their status, as does the wording used within them. The Technical Regulations and regulatory annexes, for instance, comprise standard practices and procedures and recommended practices and procedures (in brief, standards and recommended practices). Members are required to follow standards, which are distinguished by the use of the term “shall” and are printed in bold. Members are urged to comply with recommended practices, which are distinguished by the use of the term “should” and are printed in regular font. For more details on standards and recommended practices, see the *Technical Regulations* (WMO-No. 49), General Provisions.

The nature of these core documents brings to light a significant distinction for NMHSs regarding their countries’ membership to WMO. While the membership bestows advantages like capacity development support, training and access to the full scale of WMO global and regional programmes, these core documents also specify the requirements and obligations placed on Members. For example, the part of the Technical Regulations relating to international air navigation contains important regulatory matters affecting the safe operation of aircraft.

It is thus useful for NMHSs to be aware of the distinction between, for example, proposals that will improve the delivery of services, and measures to meet standards of compliance with the Technical Regulations. Increased emphasis on the importance of a culture of compliance may assist NMHSs in their efforts to secure government support for initiatives that will help the Member meet its international obligations.

Guides and other publications

In order to assist NMHSs with implementation of the regulatory material, WMO also issues other publications referred to as Guides, which are prepared by the appropriate WMO technical commissions. These do not have the same formal status as the publications mentioned above. Rather, in accordance with [Resolution 18 \(Cg-II\) – Definition of the guides of the World Meteorological Organization](#), they describe practices, procedures and specifications that Members are invited to follow or implement in establishing and conducting their arrangements in compliance with the Technical Regulations and in developing meteorological and hydrological services in their respective countries.

Other WMO publications in the form of technical documents and reports also contain useful information for Members on specific technical aspects.

A schematic showing the relationship between the different WMO regulatory and guidance material is shown in [Figure 1](#).

It is strongly recommended, therefore, to use the [WMO library](#) on the WMO website to access WMO and other publications, many of which are available online. The [search link](#) can be used to find particular publications, including WMO publications by their WMO number.

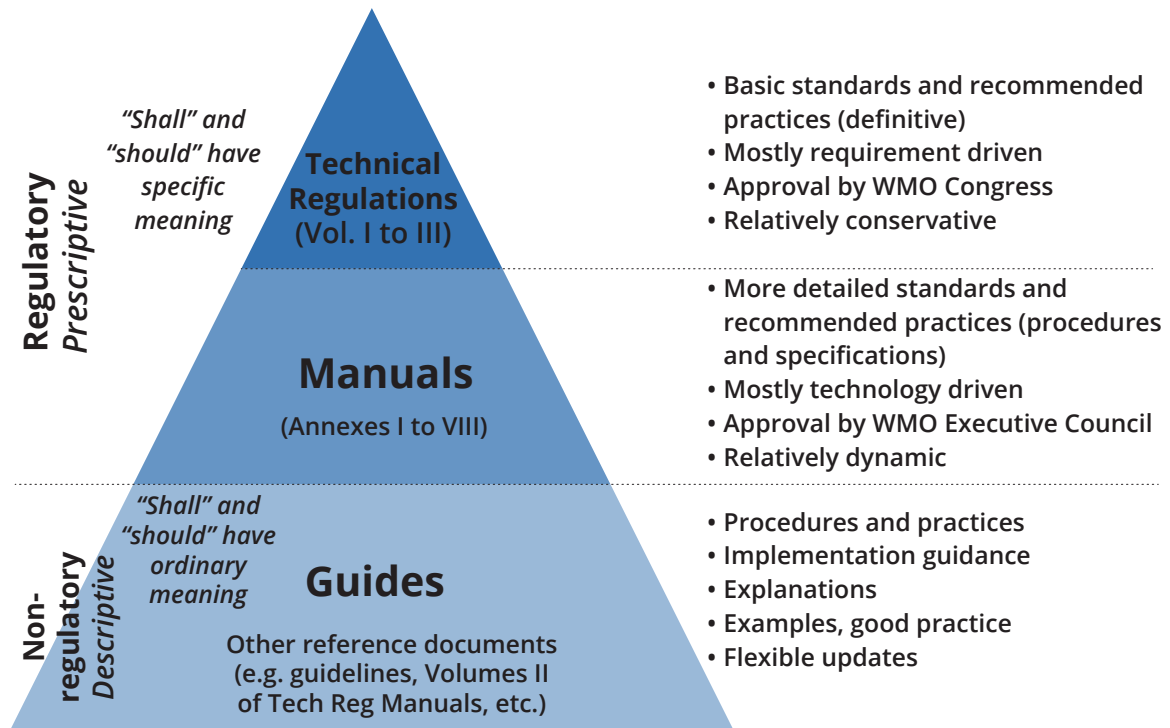


Figure 1. Composition of WMO Technical Regulations and other guidance material

CHAPTER 2. LEGAL AND INSTITUTIONAL FORM OF A NATIONAL METEOROLOGICAL AND HYDROLOGICAL SERVICE

The national legal instrument establishing an NMHS is an important element for its successful operation. It helps to define its mission and mandate; ensure clarity in the definition of its responsibilities; provide legal authority for certain responsibilities; gain recognition of its contribution to society; and facilitate allocation of adequate resources.

The legal instrument is also a means of demonstrating how governments will meet their obligations under various international agreements, including the WMO Convention.

The preamble to the WMO Convention, available as part of the [Basic Documents](#) (WMO-No. 15), includes the following statement, which is relevant to the national legal mandate:

Reaffirming the vital importance of the mission of the National Meteorological, Hydrometeorological and Hydrological Services in observing and understanding weather and climate and in providing meteorological, hydrological and related services in support of relevant national needs which should include the following areas:

- (a) Protection of life and property,
- (b) Safeguarding the environment,
- (c) Contributing to sustainable development,
- (d) Promoting long-term observation and collection of meteorological, hydrological and climatological data, including related environmental data,
- (e) Promotion of endogenous capacity-building,
- (f) Meeting international commitments,
- (g) Contributing to international cooperation[.]

Some interesting and relevant facts about the institutional form and mandate of NMHSs were obtained from a survey conducted in May–August 2011, with the results reported to the Executive Council Working Group on WMO Strategic and Operational Planning in April 2012. Although just 72 NMHSs responded to most questions, the following results were reported:

- Meteorological service providers were predominantly located in ministries of the environment (38%) and transport (29%). Of the nine respondents of least developed countries, more than half were located in the ministry of transport, reflecting the importance of providing weather services to aviation in these countries.
- Nearly two-thirds of the legal and administrative documents for the establishment and operation of NMHSs were under governmental review.

The first section of this chapter covers the aspects that could be included in a national legal instrument. The second section describes other institutional aspects, such as what form an NMHS takes, what its scope can be and what kinds of management structures can be used.

2.1 NATIONAL LEGAL BASIS

The particular form of the national legal instrument establishing an NMHS and the aspects covered by it will vary greatly, depending on national requirements and arrangements.

The Thirteenth World Meteorological Congress affirmed the importance of having national legal instruments that define the mission and mandate of NMHSs to ensure clarity in the definition of their responsibilities and recognition of their contribution to society to facilitate the allocation of adequate resources. The advantages of such a legal instrument are:

- The duties and areas of responsibility of the NMHS are defined for the benefit of both the NMHS and the governments;
- The NMHS is clearly designated as the national authority for the provision of information in support of disaster risk management (DRM) on weather-related hazards (in some cases, also for water- and climate-related hazards), to avoid public confusion;
- Legal protection is provided for the field equipment and officers in the performance of their duties;
- Direct access to essential international communications is assured;
- Coordination of various weather, climate, water and related environmental activities in the country is provided;
- A basis for determining the level of funding needed to fulfil the agreed role is clarified, including provisions for retaining revenues earned by the NMHS to improve its operations.

Over half the NMHSs operated by WMO Members have formal legal instruments (such as a law, act or decree) covering their responsibilities, the establishment and operation of their facilities, government regulation and legal responsibility. Other issues included in the legal instruments are the roles of the NMHSs in the prevention/mitigation of natural disasters, international cooperation, supplementary provisions and funding.

The following can be used as a checklist of aspects that could be included in a national legal instrument:

Legal form of the NMHS (government department, agency):

- Point of accountability in the government
- Which ministry?
- Which minister?

Purpose:

- General benefits
- Contribution to safety and security of society
- Contribution to economic progress

Duties:

- Observations
- Forecasts
- Warnings (the official, authoritative source)
- Collation of information
- Supply of information

- Training provision
- Research and development
- Advice (consultancy)
- International cooperation

Authority:

- National Meteorological and Hydrological Service (includes the Permanent Representative of the country with WMO, who is the official link to WMO)
- Official, authoritative source of warnings
- Involvement in national DRR
- Designated meteorological authority for aviation (varies by country)
- Establishment of stations and communications

Funding:

- Direct government funding
- Cost recovery and charges
- Commercial services
- Retention of revenues earned from cost recovery and commercial services

Governance:

- Advisory and other boards

Management:

- Specific responsibilities and authority of the director
- Status of NMHS staff

Regulations:

- There is often a provision for government regulations to be passed to facilitate the responsibilities and authorities under the legislation.

The following are some examples of national legislation:

- Australia: [Meteorology Act 1955](#)
- New Zealand: [Meteorological Services Act 1990](#)
- United States of America: [National Weather Services Duties Act of 2005](#)

2.2 INSTITUTIONAL FORM, SCOPE AND STRUCTURE

The institutional form of the NMHS will depend on national legislation, national policies on public services and the role of the private sector, so will also vary considerably from country to country.

The majority of NMHSs are governmental institutions. They can be independent departments or agencies (reporting directly to a minister, with their own budget and funding) or part of a larger department (often transport, civil aviation, environment, commerce, fisheries, agriculture, water or defence).

NMHSs that are more commercially oriented may have a special form of government entity, removed to some extent from core government, which enables them to operate with more commercial freedom but may expose aspects of their budgets to the risks of market forces.

The scope of the NMHS will depend on its mandate, national arrangements and policies and geography. The diagram below shows the overall breadth of services that can be provided in an integrated end-to-end NMHS system (see [Figure 2](#)). It shows the flow of meteorological, hydrological and related information to produce services, but there is also a counterpart flow back from the users of information about requirements and the quality of the services.

Almost all NMHSs cover the gathering and exchange of observations and the provision of core forecasts and warnings. Many NMHSs provide aviation meteorological services, but in some countries these are the responsibility of a different agency.

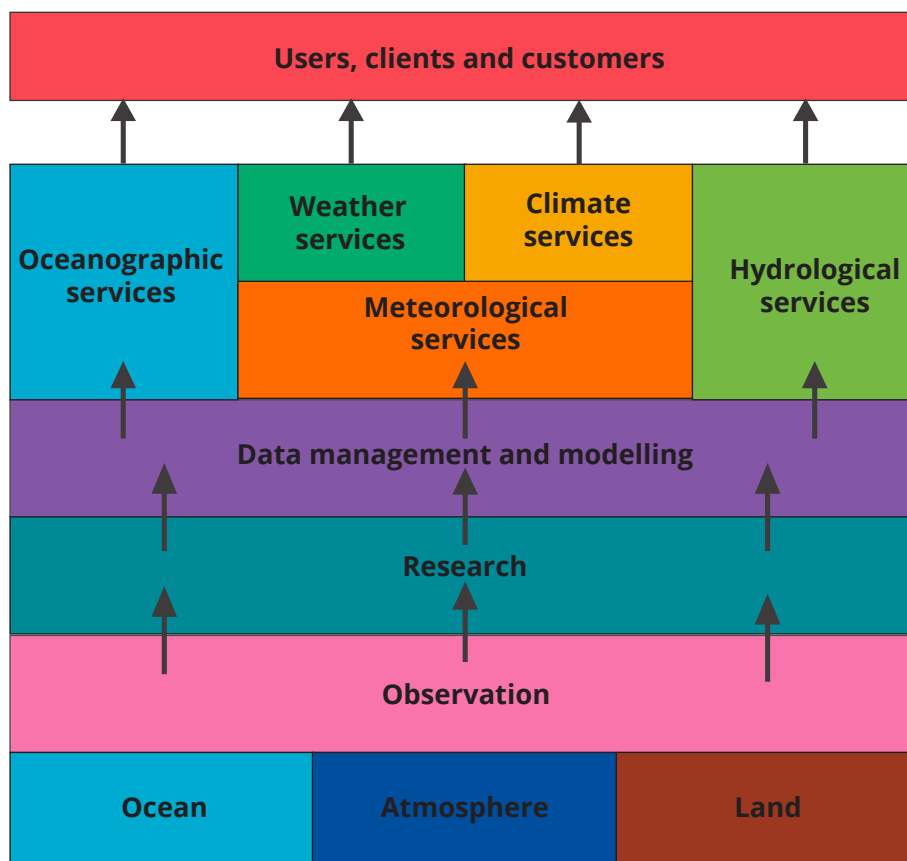


Figure 2. Range of services provided by NMHSs

Source: Zillman, J., 2014: Weather and climate information delivery within national and international frameworks, presented at the First International Conference on Energy and Meteorology: Weather and Climate for the Energy Industry, 8-11 November 2011, Gold Coast, Australia (reproduced with permission)

In some countries, NMHSs may have the responsibility for all or a portion of hydrological and atmospheric environmental matters. In others, these might be in separate government departments or agencies. Some NMHSs also extend beyond meteorology into geophysics; they monitor and research earthquakes, volcanoes and tsunamis.

The organizational structure of an NMHS will depend greatly on its scope (functions and services), as well as the number of offices at other locations around the country. There are many available management texts on how best to structure an organization, as well as online resources, such as via this link to [Wikipedia](#).

Typically, a structure based on function is appropriate. At a high level, this could be:

- Observations
- Forecasting services
- Climate services
- Research and development
- Information systems (information technology (IT) and communications)
- Finance and administration

In more detail, it is a matter of how to cover and group the following functions. Some of them will be combined, and some may be absent if not required:

- Observing equipment installation and maintenance
- IT systems, communications and data management
- Forecast and warning services
- Climatology and climate services
- Commercial services
- Sales and marketing
- Research and development
- Operational numerical weather prediction and post-processing
- International affairs
- Education and training
- Human resources
- Stakeholder relationships
- Public relations
- Outreach
- Quality management
- Finance
- Administration

There are also different ways of handling branch offices. If a branch office primarily carries out a single function, such as observing, it may come directly under an observations division. Where a branch office combines different functions (such as forecasting as well as observing), it may be preferable that it report to a senior manager who is responsible for the branch offices. For a very large country with many offices, there may be several regional managers.

Some examples of organizational structure available online are:

- [Argentina](#)
- [Australia](#)
- [Czechia](#)
- [Finland](#)
- [Hong Kong, China](#)
- [Indonesia](#)
- [Jamaica](#)
- [Republic of Korea](#)
- [Spain](#)
- [Saudi Arabia](#)

The WMO Country Profile Database

In 2015, WMO launched the initial operating capacity of the Country Profile Database. This WMO portal is a valuable resource to WMO Members because it gathers in one place all the information about a Member that has been collected by the various WMO programmes and departments. It also provides the WMO Permanent Representatives with mechanisms to directly update the information for their country or territory.

The Country Profile Database provides geographical/organizational information, institutional information (for instance, based on survey results), programmatic and technical information (such as on national observation networks), information on capacity-building (such as training), and some information on monitoring and evaluation.

The portal consists of a profile page for each WMO Member and also provides some regional information (for example, on regional WMO centres or technical commission memberships). Access to the site, including instructions on how to operate and update the Database, can be found at <http://www.wmo.int/cpdb>. (See Figure 3.)

The WMO website has a [list of all WMO Members](#) from which various types of information, including links to NMHS websites, can be accessed by clicking on the respective Member name. It can be instructive to follow these links and look for the pages entitled “About us” or similar to find out about their legal basis, what functions they perform and how they are organized.

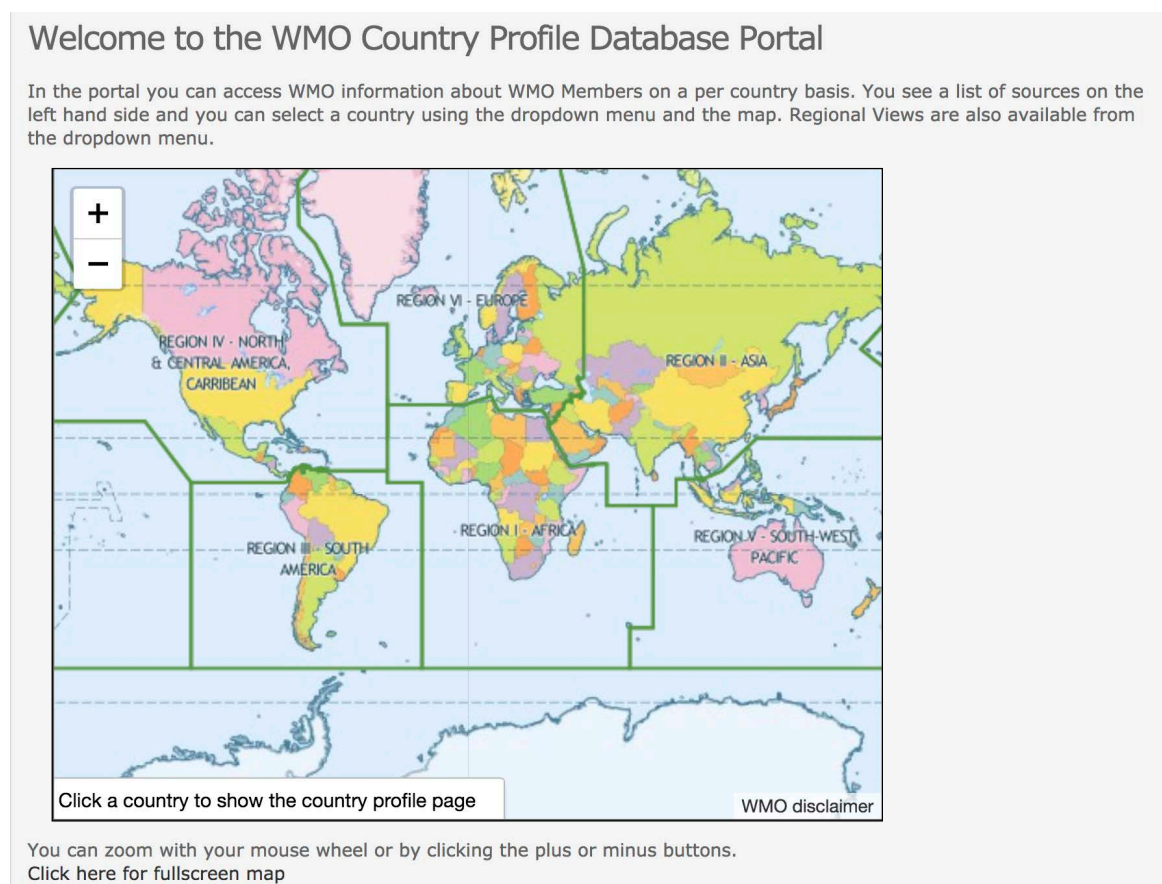


Figure 3. WMO Country Profile Database Portal homepage

CHAPTER 3. NATIONAL RELATIONSHIPS

This chapter covers the important national relationships of the NMHS with:

- The government – as the owner, so to speak, of the NMHS, as part of the government's responsibility for the safety and well-being of its citizens, and as part of the country's role and responsibilities as a WMO Member;
- Partner agencies and special user groups – such as civil defence forces, air traffic control centres, environment agencies, scientific bodies, volcanic observatories, research institutes and universities. Some require services, but they also collaborate in partnership with the NMHS and in some cases provide services back;
- The general public – also covered under public weather services (PWS).

The chapter also covers socioeconomic benefit analysis, since this is an important tool to help justify national resources invested in NMHSs and their operations.

3.1 THE NATIONAL METEOROLOGICAL AND HYDROLOGICAL SERVICE AND THE GOVERNMENT

As discussed in [Chapter 2 – Legal and institutional form of a National Meteorological and Hydrological Service](#), the NMHS in most countries is a governmental institution within core government.

The close connection between the role of the NMHS and the responsibilities of governments was emphasized at the Seventeenth World Meteorological Congress in 2015:

Population safety and security, water and food security, economic growth and sustainable development, increasing prosperity, enhancing resilience to disasters and climate change, and improving public health, are issues of fundamental importance of every government.

To deal with these issues, governments have to develop and implement effective policies that take into consideration the challenges of climate variability and change, and promote fundamental tenets of societal and environmental governance.

However, with regard to societal well-being and economic growth, it is common knowledge that we are challenged by variations in our natural environment, made worse by changes in the climate, which threaten sustainable development of human societies through increased occurrence of severe weather and extreme climate events causing disasters and compromising food security, reduce availability of clean fresh water, cause displacement of populations, and the rise and spread of diseases, among other impacts.

This is further compounded by growing urbanization and the expansion of human habitation into previously unoccupied high risk places, such as arid zones, mountain slopes, flood plains and the coastal zones prone to inundations, exposing populations to food insecurity, air and waterborne diseases, heat stress, drought, landslides, floods, storm surges and tsunamis.

At the national level it is critically important that the head and senior managers of the NMHS have good working relationships with the relevant government ministers, with the head of the agency where the NMHS resides, and with heads of the key priority-setting, planning and resourcing ministries, such as the prime minister's office or finance ministry. In particular, the director of the NMHS is responsible for marketing the capabilities of the NMHS, the services that it is providing and can provide, and the benefits that will come to the country from providing them.

Displays of public interest and support from the general public have the power to influence governments and their administrations. A major step in securing national support is the need to establish close rapport with users and provide clear evidence of the utility of the services to the general public and influential clients. To this end, the prime focus is public weather services, which are covered in more detail in [section 5.6 – Public weather services](#). It is also worth referring to [WMO resources on PWS](#) regarding strategies and guidance for enhancing the credibility of NMHSs. The relationship with the general public is also covered in [section 3.3 – National visibility of a National Meteorological and Hydrological Service](#).

In summary, the realization by finance department decision-makers that there is real public interest – and advocacy on behalf of the NMHS by other agencies – will help support justifiable requests for funds. If the public perception of the usefulness of the NMHS is overwhelmingly supportive, governmental support usually follows.

Obtaining that support must be based on a history of useful services. For example, in generally benign climates, the contribution of the NMHS to tourism and to the industry's ability to plan with certainty, together with a confident assessment of climatic risks, can have major economic benefits (tourism and travel are now estimated to be the world's largest industry). In countries with seasonal or frequent severe weather, floods and droughts, the importance of accurate and timely warnings to preserve lives and mitigate damage must be clearly publicized.

3.2 OTHER GOVERNMENT AGENCIES

In order for the NMHS to fulfil its mission, it is essential that it work in partnership with many other national agencies and authorities, including, where relevant, provincial and local governments. This is mutually beneficial for at least four reasons:

- It assists other government agencies in achieving their own missions through using NMHS products and cooperating with the NMHS;
- It assists the NMHS in ensuring that its services are well used and of broader benefit than would be the case by working alone;
- It assists the NMHS by minimizing duplication of effort where, for example, other agencies may be gathering information and providing services to the NMHS;
- It assists the NMHS in its campaign for funding and resources from the government by having other agencies advocate on its behalf when they are satisfied with the services being provided and when they wish for additional services or infrastructure to be developed to assist them.

The publication from the PWS series, [National Meteorological and Hydrological Services, their Partners and User Communities](#) (WMO/TD-No. 1510) provides excellent advice on the relevant user communities and agencies and how to engage with them. It usefully categorizes the user communities as follows:

Public good activities:

- Human health and welfare
- Emergency management

- Sustainable development
- Natural environment

Special clients:

- Urban settlement
- National defence

Economic activities:

- Transport – air, marine and land-surface
- Agriculture
- Forestry
- Energy
- Tourism and recreation
- Construction
- Communications
- Retail marketing
- Insurance
- Economics and financial services

From such a list, it is relatively easy to identify the key partner government agencies with which the NMHS should be working. A key focus is on public good activities, especially emergency management, concordant with the prime NMHS mission to contribute to the safety of life and property. Where hydrological services are provided by another agency, there is clearly a need for a strong working relationship over flood warnings. The NMHS may also be involved in disseminating tsunami warnings initiated by another agency.

Another example is the need to establish close working relationships with agencies responsible for volcano monitoring (if separate from the NMHS). Information is needed from such an agency in support of aviation services and warnings of volcanic ash, which is a hazard to aircraft operations.

The relationship with another government agency will not usually involve payment in one direction or another, but it may do so. It is appropriate in such cases for payment to be based on cost-recovery principles rather than market pricing ([see the discussion on commercial activities](#)). If payment is involved, then some kind of formal memorandum of understanding or contract is essential.

Even if services are provided for free between government agencies, it is still desirable to have a memorandum of understanding, because this clarifies the relationship, how it works and what is being supplied. This helps avoid misunderstandings and provides the basis for discussions on the level of services and the resources required.

3.3 NATIONAL VISIBILITY OF A NATIONAL METEOROLOGICAL AND HYDROLOGICAL SERVICE

With the increasing availability of weather forecasts and information from sources other than the NMHS and strains on government budgets, enhancing the visibility and positive reputation of an NMHS is becoming increasingly important. An NMHS that is highly visible in its own country reaps the following benefits, among others:

- There is general public support for the NMHS;
- Politicians become aware of that support and are more likely to be supportive in terms of resources and budgets;

- The public is well aware and well educated about the products and services provided by the NMHS. They value them and take action based on them, particularly at times of severe weather events;
- Other organizations are more likely to look to the NMHS when they want to participate in activities or obtain services.

Many of these issues are related to the WMO Public Weather Services Programme, which provides a wealth of resources through the [WMO website section on PWS](#), including a number of useful publications. The reputation and visibility of the NMHS are enhanced by providing attractive, useful and easy-to-understand PWS products and services and exploiting modern technology, including a well-designed website.

One of the purposes of the Public Weather Services Programme is to enable the public to gain a better understanding of the capabilities of their respective NMHSs and how best to use their services.

One publication that is particularly worth consulting is the [Public Weather Services Strategy for Developing Public Education and Outreach](#) (WMO/TD-No. 1354). It is also summarized in a short brochure entitled [Communication, Public Education and Outreach](#) (PWS-SG 2), which makes the important point that such activities may require a change of approach by the NMHS but do not necessarily cost a lot of money.

Much of the communication with the public can be done directly, as well as via the NMHS website and social media. Examples of the use of blogs include [MetService New Zealand](#), [Met Office UK](#), the [Antigua and Barbuda Meteorological Service Climate Section](#) and the [Hong Kong Observatory](#). Twitter feeds include [@MetService](#) and [@metoffice](#). Some NMHSs have a presence on Facebook. MetService New Zealand also uses [regular online TV segments](#).

WMO has issued an excellent publication, [Getting Your Message Across: Media Guide for WMO Information and Public Affairs Focal Points at National Meteorological and Hydrological Services](#) (WMO/TD-No. 1451), which covers the use of social media as well as more traditional media. The traditional media continue to play an important role in raising the visibility of the NMHS.

The Public Weather Services Programme provides useful advice specifically on media relationships and issues on its [website](#), as well as through the PWS publication [Guidelines on the Improvement of NMSs—Media Relations and Ensuring the Use of Official Consistent Information](#) (WMO/TD-No. 1088). Another very useful publication is [Guidelines on Strategies for Use of Social Media by National Meteorological and Hydrological Services](#) (WMO-No. 1086).

The other highly relevant WMO Programme is the [WMO Information and Public Affairs Programme](#).

3.4 SOCIOECONOMIC BENEFIT ANALYSIS

Although it is essential to have good relationships with relevant government ministers and departments and other agencies and good visibility with the general public, this is not sufficient. Increasingly, a more quantitative approach is required to support qualitative statements about the effectiveness and value of the services provided by NMHSs. This emphasizes the increasing importance for NMHSs to engage in the field of socioeconomic benefit analysis. To reinforce this, socioeconomic analysis features as one of the main themes in the [WMO Strategic Plan 2016–2019](#).

Although these Guidelines focus on the end-user benefits of weather services, the approach of using cost–benefit analysis more generally for NMHS projects is also relevant (see [section 8.4 – Project plans](#), in these Guidelines).

The purpose of socioeconomic benefit analysis is to study and demonstrate the value of services for end users. This is particularly important for government-funded services because it provides a justification for the taxpayers' funds used for such programmes.

Access to a comprehensive, contemporary examination of methodologies for assessing socioeconomic benefits was greatly improved through the launch of an authoritative publication at the Seventeenth World Meteorological Congress in June 2015. This was a major collaborative effort between WMO (through the Public Weather Services Programme) and the World Bank Group, with the support of the United States Agency for International Development. The publication, *Valuing Weather and Climate: Economic Assessment of Meteorological and Hydrological Services* (WMO-No. 1153), is available in hard copy and online. To help spread the valuable information in this publication and assist NMHSs to strengthen their capability in socioeconomic benefit analysis, WMO planned a series of training workshops and seminars.

WMO interest in this field dates back to the 1960s. Important milestones were two major international conferences on economic and social benefits of meteorological and hydrological services, held in 1990 and 1994. In 2007, WMO achieved a crucial milestone in evaluating, demonstrating and enhancing the social and economic benefits of weather, climate and water services through the International Conference on Secure and Sustainable Living: Social and Economic Benefits of Weather, Climate and Water Services, held in Madrid. The Conference successfully provided a forum for dialogue among the producers and end users of weather, climate and water information.

The Madrid Conference had three main objectives:

- To assess the value of weather, climate and water information and services and how these benefits can be greatly increased;
- To initiate and promote new approaches to the evaluation of the social and economic benefits of meteorological and related services in the research, education and applications communities;
- To provide the basis for strengthened partnerships in the provision of meteorological and related services.

The major socioeconomic sectoral groups examined were: agriculture, water resources and the natural environment; human health; tourism and human welfare; energy, transport and communications; urban settlement and sustainable development; and economics and financial services. The Conference also formulated the [Madrid Action Plan](#).

Some other relevant publications are:

- Frei, T., 2009: [Economic and social benefits of meteorology and climatology in Switzerland](#), *Meteorological Applications*, 17(1)
- Gunasekera, D. and J. Zillman, 2004: [Economic Issues Relating to Meteorological Services Provision](#), Australian Bureau of Meteorology, BMRC Research Report No. 102
- Hautala et al., 2008: [Benefits of Meteorological Services in South Eastern Europe](#), Technical Research Centre of Finland and Finnish Meteorological Institute
- Lazo et al., 2008: *Primer on Economics for National Meteorological and Hydrological Services*. National Center for Atmospheric Research, United States, and World Meteorological Organization Voluntary Cooperation Programme
- UK Met Office, 2007: *Public Weather Service's Contribution to the UK Economy*, available via this [page](#)

CHAPTER 4. INTERNATIONAL RELATIONSHIPS, INCLUDING WITH THE WORLD METEOROLOGICAL ORGANIZATION

Governments sign various international agreements. Due to the strong national benefits resulting from the international exchange of meteorological information, meteorology has featured strongly in international agreements throughout the history of the United Nations and its predecessor, the League of Nations. The signatory nations to these agreements meet their ensuing obligations through government agencies (including the NMHS) and/or other national arrangements.

For NMHSs, the most important international agreement is the Convention of the World Meteorological Organization, as discussed in more detail in [section 4.1 – Overview of the World Meteorological Organization](#).

Many other international agreements could result in other obligations for the country, with consequent duties carried out by the NMHS. The most important relevant ones are:

- The [International Convention for the Safety of Life at Sea](#), under the [International Maritime Organization](#) (IMO), which provides the basis for meteorological services for ships at sea;
- The [Convention on International Civil Aviation](#), under the [International Civil Aviation Organization](#) (ICAO). Annex 3 to this Convention is entitled *Meteorological Service for International Air Navigation* and is, effectively, identical to the WMO [Technical Regulations](#) (WMO-No. 49), Volume II;
- The [United Nations Framework Convention on Climate Change](#).

There are many additional environmental conventions listed on this [WMO page](#).

Bilateral agreements

It can be useful to work in partnership with other NMHSs on a bilateral basis. Such agreements usually take the form of a memorandum of understanding, specifying areas of collaboration. This may be between NMHSs at similar levels of development that wish to gain synergies from working together. Alternatively, a more developed NMHS may twin with an NMHS from a developing country or a least developed country and assist in developing its capacity.

Regional agreements

There are many examples of WMO Members working together in regional bodies. Examples with a direct relationship to meteorology and NMHSs are the [European Centre for Medium-range Weather Forecasts](#), the [European Organization for the Exploitation of Meteorological Satellites](#) and the [Caribbean Meteorological Organization](#). There are other regional organizations that are less directly related to meteorology but with which it is also mutually beneficial for WMO and NMHSs to work closely together, for example, the [Secretariat of the Pacific Regional Environment Programme](#).

4.1 OVERVIEW OF THE WORLD METEOROLOGICAL ORGANIZATION

The [WMO website](#) constitutes a rich source of information [about](#) the Organization, its purpose and its structure, as does the brochure [The World Meteorological Organization at a Glance](#). While there is no need to mention all of the available material, this section of the Guidelines provides a summary of the most important relevant information, together with links.

The key directions and plans of the Organization are provided in the [WMO Strategic Plan 2016–2019](#) and the [WMO Operating Plan 2016–2019](#). Further information is available via the [strategic planning section](#) of the WMO website. It is also well worthwhile to refer to the [Reference Guide for Permanent Representatives of Members with the World Meteorological Organization on Relevant Procedures and Practices of the Organization](#) (WMO-No. 939).

Purpose

The [WMO website](#) provides convenient access to a number of [WMO policy documents](#). The [Basic Documents](#) (WMO-No. 15) are fundamental. They include:

- The WMO Convention
- General Regulations
- Staff Regulations
- Financial Regulations
- Agreements

Article 2 of the Convention details the purposes of WMO, which are:

- (a) To facilitate worldwide cooperation in the establishment of networks of stations for the making of meteorological observations as well as hydrological and other geophysical observations related to meteorology, and to promote the establishment and maintenance of centres charged with the provision of meteorological and related services;
- (b) To promote the establishment and maintenance of systems for the rapid exchange of meteorological and related information;
- (c) To promote standardization of meteorological and related observations and to ensure the uniform publication of observations and statistics;
- (d) To further the application of meteorology to aviation, shipping, water problems, agriculture and other human activities;
- (e) To promote activities in operational hydrology and to further close cooperation between Meteorological and Hydrological Services; and
- (f) To encourage research and training in meteorology and, as appropriate, in related fields and to assist in coordinating the international aspects of such research and training.

Article 3 of the Convention details which countries can become Members of WMO. It is important to realize that Members are States or territories (countries), not meteorological services, NMHSs, NMSs or NHSs. The word “Member” always starts with a capital “M” when referring to a country or territory, as opposed to a member (small “m”) of, for example, a working group, Executive Council or a technical commission.

Article 9 of the Convention states that all Members shall do their utmost to implement the decisions of Congress, which, in practice, include various resolutions adopted by Congress, as well as the approved [Technical Regulations](#) (WMO-No. 49).

Structure

Officers of WMO include the President and three Vice-Presidents. Eligibility for these posts is restricted, under Article 6 of the Convention, to those who are designated “... Directors of their Meteorological or Hydrometeorological Services by the Members of the Organization for the purpose of this Convention, as provided for in the Regulations”. This, in effect, is the same as the Permanent Representative of a Member (see [section 4.2 – The role of the World Meteorological Organization Permanent Representative](#)).

The WMO Secretariat has its headquarters in Geneva, and provides support to Members and their Permanent Representatives, to various elected officers and to the constituent bodies of WMO. The Secretariat structure is also well described on the WMO website, including an [organigram](#) showing the various departments and reporting relationships of the Secretariat. [Figure 4](#) shows the WMO structure and various bodies.

Aspects of the programmes and structure of WMO are also covered where relevant in [Chapter 5 – Functions](#).

Programmes

WMO operates a number of scientific and technical programmes in order to fulfil its functions. Many of these are of value to NMHSs and are touched on in other parts of these Guidelines.

A full list of the Programmes is given on the [WMO website](#), with links for access to more details.

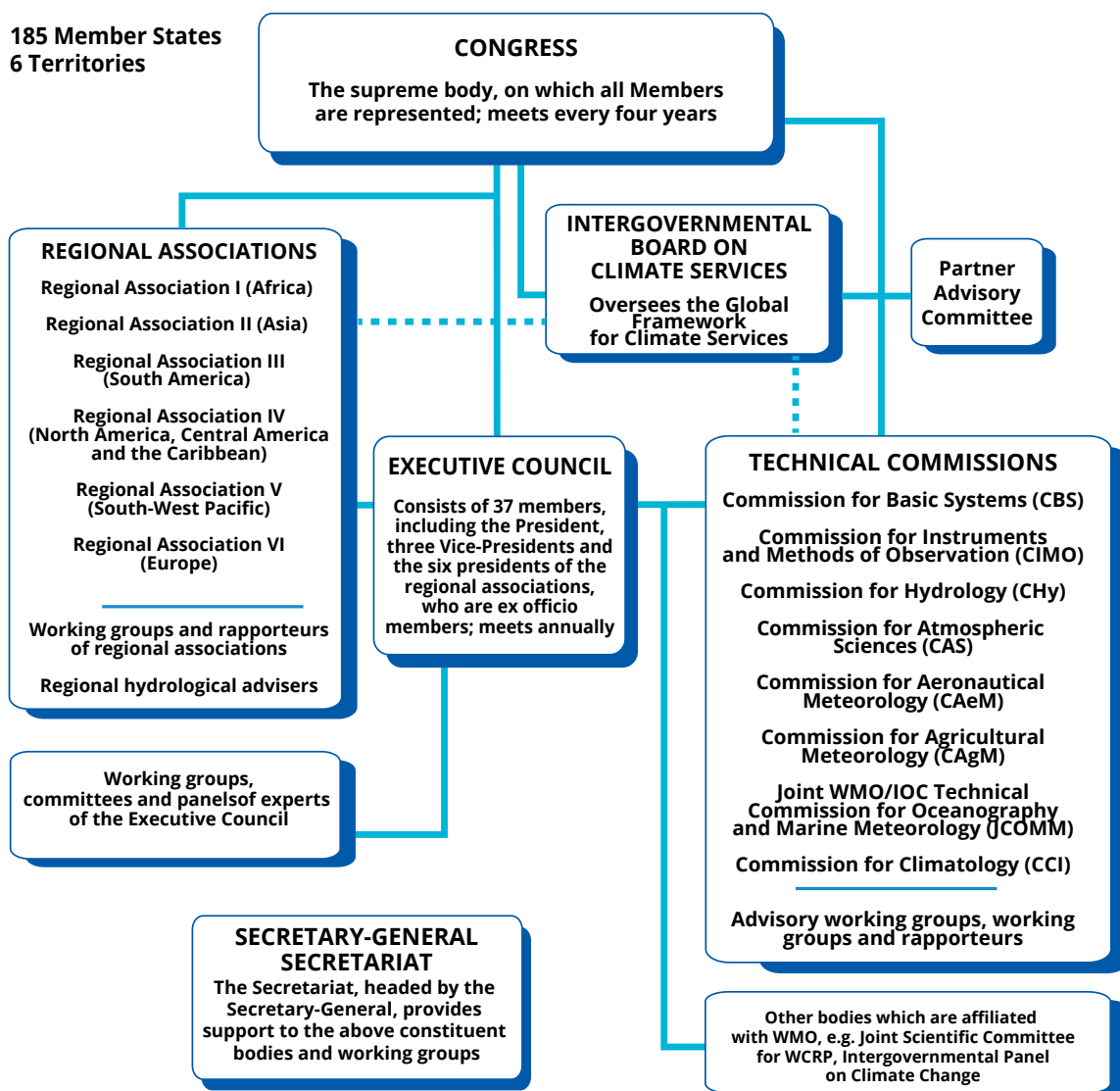


Figure 4. Structure of WMO

4.2 THE ROLE OF THE WORLD METEOROLOGICAL ORGANIZATION PERMANENT REPRESENTATIVE

The role of Permanent Representatives (PRs) of Members is defined in the General Regulations by Regulation 6(a) of the [Basic Documents](#) (WMO-No. 15):

Each Member shall designate by written notification to the Secretary-General a Permanent Representative who should be the Director of the Meteorological or Hydrometeorological Service to act on technical matters for the Member between sessions of Congress. Subject to the approval of their respective governments, Permanent Representatives should be the normal channel of communications between the Organization and their respective countries and shall maintain contact with the competent authorities, governmental or non-governmental, of their own countries on matters concerning the work of the Organization.

The PR must be formally designated to the WMO Secretary-General by the ministry of foreign affairs or other national authority appropriately mandated by the national government, such as the ministry responsible for the NMHS or the permanent mission of the Member with the United Nations Office and specialized agencies in Geneva.

Permanent Representatives appoint hydrological advisers from within their own service, where appropriate, or from the respective National Hydrological Service or equivalent national agency.

The PRs represent their country, not only the NMHS. It is therefore important to establish links and regular meetings with other agencies and organizations involved in meteorology in the country, including universities and the private sector. Such links are especially important in connection with meteorology-related activities that are not the direct responsibility of the NMHS (in some countries, for example, aviation meteorological services may be provided by another agency). This aids coordination of involvement in WMO activities and enables a broader input into policy and technical views that may be conveyed by the PR to WMO.

WMO provides detailed guidance on the role and procedures to be followed by the PRs in the [Reference Guide for Permanent Representatives of Members with the World Meteorological Organization on Relevant Procedures and Practices of the Organization](#) (WMO-No. 939).

Coordination

It is always useful to plan ahead and perhaps have a small committee comprising the PR, adviser(s) on international affairs, other senior manager(s) who have the authority to commit NMHS staff to involvement in WMO working groups, and one or two representatives of other agencies who may be significantly involved in WMO. This committee should meet about twice a year to discuss upcoming WMO events over the next year or two. A [list of upcoming meetings](#) is available on the WMO website, as well as a separate [list of forthcoming constituent body sessions](#).

This committee should provide advice to the PR on priorities for participation in sessions of technical commissions and regional associations and meetings of working groups/teams, as well as membership of technical commissions and working groups/teams, and selection of delegates to meetings.

Country or territory representatives

The PR, with the assistance of advisers, should maintain a register of those from the country or territory (WMO Member) who are involved in various capacities. Every quarter, WMO updates the [Composition of WMO](#) (WMO-No. 5). This publication lists information on the composition of WMO and its constituent bodies and contains the latest official information available in the Secretariat by the middle of the month preceding the month of issue.

The *Composition of WMO* (WMO-No. 5) should be checked regularly to make sure that the contact details and lists of members, particularly of technical commissions, are correct and up to date, and WMO should be formally advised if corrections are needed. These details can only be changed by the Secretariat on official notification from the PR, so it can happen that a member of a technical commission has long since retired or moved, yet is retained on the list until the Secretariat is advised officially otherwise.

Correspondence

The PR will receive, and need to respond to, about 200 regular items of correspondence from WMO per year. This is still often in the form of hard copy mail, although electronic correspondence is increasingly being used and is to be preferred for speed and efficiency.

It is useful to consider the incoming correspondence in a number of categories and how the items should be dealt with. In general, where action is required, this should be clearly indicated at the top of the letter.

- Initial formal notification of an upcoming meeting: This should be circulated to those who need the information, and final decisions should be made about whether there will be participation in the meeting and who should attend.
- Formal notification of an upcoming meeting, with a request for the Secretariat to be advised on who will participate: If the meeting is of an intergovernmental constituent body (Congress, regional association or technical commission), the notification on who will attend must be formally conveyed by the ministry of foreign affairs or similar; if the meeting is of a working group or expert team, the notification may name an individual who is already a member and request the agreement of the PR for that person to participate. This will be the case even where the individual is not an NMHS staff member, as permission should still be formally sought from the PR.
- Seeking nominations for positions: This can concern formal nominations for newly vacant officer positions of technical commissions, regional associations or the Executive Council, to nominations for members of working groups and expert teams. The latter often arise prior to a session of a technical commission or regional association, where the structure and composition of groups and teams is best decided during the session.
- Seeking concurrence for nominations for working group members: It is important to stress that the PR must provide his or her concurrence for individuals who reside in or are affiliated to another country. An expert may normally be resident in a country but move overseas for a period to work at another institution or university; provided they retain good links with the NMHS and other institutions, it may be appropriate to retain their original country affiliation to serve on working groups or teams and to attend meetings.
- Voting papers for postal ballots: Where a vacancy in an elected position has arisen between sessions and following postal nominations, a postal ballot may be held. The PR normally has the authority to vote in such ballots but should seek advice from others within the country as appropriate.
- Requests for checking and updating contact details: WMO maintains registers of those serving on working groups, contacts, focal points, etc. and regularly needs to ensure that these are up to date. Contact details available online should be checked and updated, as requested. It is also useful for the PR and advisers to maintain their own register of those from the country who are involved in various capacities, in order to cross-check such details.
- Requests for contribution to progress reports: Various WMO Programmes regularly assess progress in their areas and seek input or formal reports on what is being done in each country. It is not necessary to answer all requests, especially if a large amount of work is

called for and resources are stretched. Where possible, however, the request should be complied with, making use, of course, of the technical expertise within the NMHS and other institutions as required to draft a response, which is then submitted by the PR.

- Questionnaires: These are regularly used by various entities of WMO to help assess the current status of NMHSs and WMO Programmes in different countries. Where possible, they should be responded to as they don't require much work and the more countries respond, the more valid and representative the results will be. The questionnaires should be completed by those with the appropriate expertise but are often signed off by the PR.
- Requests for input and views on policy and technical issues: On matters of importance regarding certain topics, WMO will sometimes send out information and seek input from PRs directly. Where the subject is of particular interest to a country, the opportunity should be taken to comment, again with appropriate in-country advice.
- Seeking nominations for awards: Nominations are regularly sought for WMO awards, including the [IMO Prize](#), the [Norbert Gerbier-MUMM International Award](#), the [WMO Research Award for Young Scientists](#), and the [Professor Dr Vilho Väisälä Awards](#). Serious consideration should be given to making nominations of worthy candidates or papers so as to give the judges every opportunity to select the best.
- Requests for funding: The WMO regular budget cannot stretch to accommodate all activities that WMO Members would like. Various trust funds have been established and funding for these will be requested from time to time.
- Information items, publications and reports: Perhaps half the correspondence falls into this category, which entails keeping WMO Members up to date and distributing publications and reports of meetings. The main action required is to review the material for its relevance to the NMHS and country and distribute it as appropriate. Such distribution can be swift and efficient where the correspondence is electronic and the publications and reports are available online so all that is needed is a weblink.
- WMO Secretariat vacancy notices: These arrive in hard copy for distributing and affixing to notice boards but are also available on the [WMO website](#).

Besides responding to incoming correspondence, the PR, together with advisers(s), should also be reviewing WMO reference material and providing updates to the WMO Secretariat as required, including updates for the components of the [World Weather Watch \(WWW\) Operational Information Service](#), following related [best practices](#).

4.3 WORLD METEOROLOGICAL ORGANIZATION BODIES AND PARTICIPATION

Forthcoming sessions of WMO constituent bodies are listed on the [WMO website](#), together with links to available documents.

The WMO constituent bodies are:

Congress: [Congress](#) is the supreme body of WMO, so this is a large meeting where a majority of Member countries and territories are represented. It is held in Geneva every four years. Congress reports are available [here](#). Congress determines general policies for the fulfilment of the purposes of the Organization; considers membership of the Organization; determines the General, Technical, Financial and Staff Regulations; establishes and coordinates the activities of constituent bodies of the Organization; approves the plans and budget for the following financial period; elects the President and Vice-Presidents of the Organization and members of the Executive Council; and appoints the Secretary-General through a voting process where it is necessary to choose among candidates. As Congress has parallel sessions, the country or territory delegation should comprise, where possible, at least two members. During Congress, the

official representative of a Member is the Principal Delegate as formally notified to WMO by the Member's ministry of foreign affairs or similar. This may or may not be the PR, who is the official channel of communication between sessions of Congress.

Executive Council: The Executive Council is the executive body of the Organization, which meets annually in Geneva. It implements decisions of Congress; coordinates the Programmes; examines the utilization of budgetary resources; considers and takes action on recommendations of regional associations and technical commissions and guides their work programme; provides technical information, counsel and assistance in the fields of activity of the Organization; and studies and takes action on matters affecting international meteorology and related activities. It has a short meeting after Congress, but the other yearly meetings, which are typically in June, last approximately one week. The 31 elected members of the Executive Council (who include the President and three Vice-Presidents of the Organization) participate fully in the Executive Council. They do not represent the interests of their Member country or territory but serve in an individual capacity. The six elected regional association presidents also participate fully and represent their Regions. Presidents of technical commissions also participate in the Executive Council but without a vote. Other Members can also attend the Executive Council as observers and most documents are available online. The only confidential documents tend to relate to staffing and awards. WMO provides a document with the [rules of procedure for the Executive Council](#). Executive Council reports are available [here](#).

Technical commissions: There are eight [technical commissions](#). They usually meet every four years, except the [Commission for Basic Systems](#), which meets every two years – once in a regular session and the other in an extraordinary session. The election of the officers (president and vice-president) takes place only in the regular session. Some sessions are held in Geneva, but many are hosted by Members in other parts of the world. The session often has an associated technical conference. Technical commissions tend not to meet in parallel sessions, so single-member delegations are common for smaller countries. Attendance by a Member will depend on the topics covered and the relevance of the work to that country. Although the subjects covered are technical, this is an intergovernmental meeting, with the delegation representing the Member, not just the NMHS. Technical commission reports are available [here](#).

Regional associations: Six [regional associations](#) cover the world, with the exception of the area south of 60°S, which is the responsibility of the [Executive Council Panel of Experts on Polar and High Mountain Observations, Research and Services](#). Regional association sessions are usually held every four years, hosted by a Member within the Region, although they can also be held in Geneva. Invitations are sent out to all Members for every session, but most Members normally attend only sessions of the regional association to which they belong. They tend not to meet in parallel sessions. Attendance at the session of the regional association to which the country belongs is recommended, because the issues covered reflect regional and local priorities. This is an intergovernmental meeting, with the delegation representing the Member, not just the NMHS. Regional association reports are available [here](#).

Technical commission members

Designated members of technical commissions should be experts in the field. There is no limit on the number that can be designated by a Member; often there is just one but there has been up to four.

Membership of a technical commission carries no implied obligation to participate in its activities, and it is not necessary to be a member in order to be a delegate to a session. However, membership does have the following implications:

- A member of a technical commission will be kept advised of its general activities;
- Technical commission members are the only people eligible for election to the officer positions of president or vice-president of that commission;

- Only those Members with at least one member designated on a technical commission are eligible to vote in a postal ballot for the vacant position of president or vice-president of that commission;
- The total number of such Members is also relevant when the quorum is assessed for a technical commission session.

Membership and participation in subsidiary bodies

In order to carry out its activities, each constituent body can form various kinds of subsidiary bodies. These are referred to as working groups in the Regulations but also go by various other names in practice, including management groups, open programme area groups, expert teams, implementation-coordination teams, and panels. There can also be single-person "team" in the form of a rapporteur.

The structure of these subsidiary bodies is usually defined and agreed at constituent body sessions, with at least the chairs and co-chairs formally appointed at that stage and perhaps the full membership.

Regional associations and technical commissions mostly have management groups that consist of the president, vice-president and other experts to help manage the work of the body between sessions.

Starting with the Commission for Basic Systems in 1998, technical commissions have been moving to a structure based on open programme area groups with open membership covering a particular Programme area, within which there are small expert teams on specific areas and sometimes an implementation team. This has been found to be a more effective use of limited voluntary expertise.

There are many working groups and teams established by the regional associations and technical commissions. Careful thought and prioritization are needed to decide in which working groups and teams to participate and which staff should be involved. Priorities will naturally be given to those issues of most importance to an NMHS and also those where an NMHS may be in a position to provide technical leadership for the benefit of other WMO Members.

In general, it is a good idea for staff to be involved in issues that are closely related to their daily job. This not only means that they have the appropriate expertise and interest but also helps to reduce the additional effort required, since the activities can fit in with normal duties.

When PRs nominate someone for a WMO working group or team, they should be aware that some work time will need to be devoted to those activities and allow time for it, rather than assuming it can be part of normal duties. Of course, this is not always possible, owing to pressures of other work and duties.

Permanent Representatives and staff managers should also give explicit recognition and due credit to those involved in WMO activities for any extra work carried out and results achieved. Only with the dedicated effort of many volunteers around the world can WMO achieve what it does.

The important subject of volunteerism was addressed by the Executive Council at its sixtieth session in 2008. It is well worth referring to the annex (volunteerism in the work of technical commissions and regional associations) to Resolution 4 (EC-LX) – Role and terms of reference of the Meetings of Presidents of Technical Commissions. It is contained in the [*Abridged Final Report with Resolutions of the Sixtieth Session of the Executive Council*](#) (WMO-No. 1032) and the consolidated [*Resolutions and Decisions of Congress and the Executive Council*](#) (WMO-No. 508).

4.4 WORLD METEOROLOGICAL ORGANIZATION SUPPORT

The previous sections in this chapter concentrated on how to engage with WMO, primarily in terms of participating in its activities and contributing to the general benefit of all Members.

There are also many ways in which an NMHS and its staff can be supported, directly or indirectly, through engaging with WMO. Some of these are:

- Use of data, products and services (including those which are satellite based) exchanged through WMO systems;
- Use of guidance material prepared by WMO bodies;
- Learning through participation in sessions and meetings;
- Networking with staff of other NMHSs through participation in sessions and meetings;
- Learning and networking through participation in WMO workshops and seminars;
- Use of WMO training material;
- Use of WMO Regional Training Centres (see also [section 9.4 – Training and staff development](#));
- Taking up long- and short-term fellowships financed from the WMO Voluntary Cooperation Programme, the WMO regular budget, trust funds and the United Nations Development Programme projects;
- Obtaining other support from the Voluntary Cooperation Programme;
- Regional and subregional cooperation on service delivery and projects, including through activities of the [Regional Programme](#);
- Support from the [WMO Programme for the Least Developed Countries](#);
- Support under the WMO Capacity Development Strategy (see [Chapter 7 – Capacity development](#), and [section 10.6 – Resource mobilization](#)).

CHAPTER 5. FUNCTIONS

The bottom line for most government organizations such as NMHSs is their mission. To achieve their mission, NMHSs carry out many operational functions in a chain of processes that extends from gathering observations to delivering services.

Organizations also need resources, but these are often in short supply and must be shared among competing organizations. This competition for scarce resources requires NMHSs to demonstrate their value by realizing cost efficiencies while delivering high-quality, useful products and services.

Policymakers and the public continually assess the effectiveness of NMHSs according to their ability to meet the service-delivery standards of the nations they serve. When the NMHS incorporates the role of users and customers in day-to-day operations, those customers and users are more likely to receive services that meet their needs.

The importance of service delivery for users and customers was recognized by the Seventeenth World Meteorological Congress in 2015 with the adoption of the [WMO Strategic Plan 2016–2019](#), in which the first Expected Result is "Improved service quality and service delivery".

The current [WMO Strategy for Service Delivery](#), approved by the Sixteenth World Meteorological Congress, seeks to strengthen service delivery across the entire Organization by describing key strategic elements and activities related to a service-oriented culture. It focuses on understanding the value chain to gain knowledge about users, the decisions they must make and how weather-, climate- and water-related information is applied to minimize risk and realize benefits, not only for a specific user group but also for society as a whole.

With this knowledge, service providers are able to develop, produce and deliver services that are useful, relevant and responsive. NMHSs are able to measure the value of their information to society and continually evaluate and improve services. Adopting a more collaborative approach gives everyone in the service delivery process – providers, users and partners – a clear understanding of service needs.

The sections in this chapter follow more or less the traditional order of functions, from observations to service delivery, including support provided by [research](#). For NMHSs to survive and prosper, however, it is important to emphasize that all elements of this chain must be driven by the need to provide services that are relevant and valued by users and customers, who ultimately provide or influence the resources that NMHSs require to operate.

Layout of the following sections

Most of the sections in this chapter have a structure containing at least these headings:

- Overview – a general overview of the function;
- Regulations – what WMO Regulations (standards and recommended practices) apply to this function;
- WMO bodies, Programmes and guidance – discussion of what WMO Programme, bodies and guidance material are relevant to the function and where to find further information about them;
- Checklist for National Meteorological and Hydrological Services – some suggested questions that could be asked by an NMHS, intended to be helpful in a self-assessment of how well that function is being performed and how it could be improved.

5.1 OBSERVING SYSTEMS

Overview

Observations and monitoring of the entire Earth's atmosphere, ocean, land and the related environment form the foundation for the production of weather, climate, water and related environmental services. These observations are also essential for conducting research to improve services, assessing changes in the climate system and developing and operating systems in weather- and climate-dependent sectors, such as agriculture, water, transport and energy, in support of communities' efforts to reduce disaster risks and adapt to climate variability and change.

Observation and monitoring are also one of the pillars of the [Global Framework for Climate Services](#).

NMHSs establish and operate observation networks that form the WMO [Global Observing System](#) (GOS), a component of the [WMO Integrated Global Observing System](#) (WIGOS). The Global Observing System is comprised of operationally reliable surface- and space-based subsystems. These subsystems are owned and operated by WMO Members, which undertake to meet certain standards and responsibilities as part of the agreed global system for the benefit of all nations (see [Figure 5](#)).

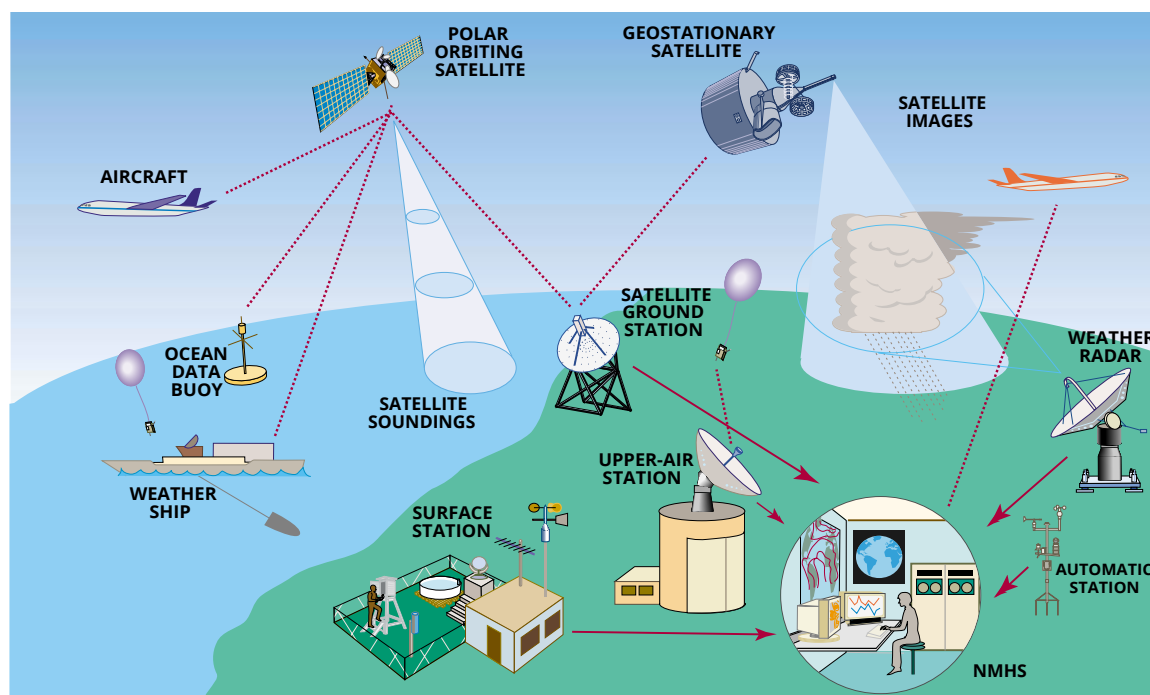


Figure 5. The WMO Global Observing System

[WIGOS](#) is an all-encompassing approach to improve the WMO global observing systems and facilitate their orderly evolution to an integrated, comprehensive and coordinated system. Through its implementation plan, WIGOS will satisfy, in a cost-effective and sustainable manner, the evolving observing requirements of WMO Members, while enhancing coordination of the GOS with systems operated by international partners.

The [Implementation Plan for the Evolution of Global Observing Systems](#) (WIGOS Technical Report No. 2013-4) provides high-level goals to guide the evolution of global observing systems in the coming decades. These goals are intended to be challenging but achievable. The future GOS will build upon existing subsystems, both surface- and space-based, and capitalize on existing, new

and emerging observing technologies not presently incorporated or fully exploited. Incremental additions to the GOS will be reflected in better data, products and services from NMHSs; this will be particularly true for developing countries and least developed countries.

Operating an observational network is one of the most costly functions performed by an NMHS. Observations provide the fundamental underpinnings for all NMHS products, both nationally and globally. There is often a balance to be struck between resources invested in observations and resources invested in other parts of an NMHS to ensure that the public and other users also benefit from services.

Regulations

The [Manual on the Global Observing System](#) (WMO-No. 544), Volume I, which is Annex V to the [Technical Regulations](#) (WMO-No. 49), contains the regulatory material for the global aspects of the Global Observing System. It consists of Part I – General principles regarding the organization and implementation of the Global Observing System; Part II – Requirements for observational data; Part III – Surface-based subsystem; Part IV – Space-based subsystem; and Part V – Quality control. Volume II contains regional aspects, with individual parts for the six WMO Regions and the Antarctic Observing Network. This is not regulatory material but provides practices and procedures for updating the definitions of regional networks.

WMO bodies, Programmes and guidance

The primary Programme within WMO applicable to observations is the [World Weather Watch Programme](#), both through the [Global Observing System](#), which is one of the Programme's core components and is now part of the [WMO Integrated Global Observing System](#), and through the [Instruments and Methods of Observation Programme](#). Reference material on observing stations, etc., is maintained under the [WWW Operational Information Service](#).

Atmospheric chemistry observations (which are also an important component of WIGOS) are implemented through the [Global Atmosphere Watch Programme](#).

Also of importance is the [WMO Space Programme](#), which coordinates environmental satellite matters across all WMO Programmes, including observational aspects and availability and utilization of satellite data and products for weather, climate, water and related applications among WMO Members.

The [Global Observing System](#) and the [WMO Integrated Global Observing System](#) come primarily under the aegis of the [Commission for Basic Systems](#), while the [Instruments and Methods of Observation Programme](#) comes under the [Commission for Instruments and Methods of Observation](#). Other commissions, such as the [Commission for Atmospheric Sciences](#), [Commission for Climatology](#), [Commission for Aeronautical Meteorology](#), [Commission for Hydrology](#), and [Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology](#), also cover observing aspects focused on their particular disciplines and some have their own related regulatory and guidance material.

The [Commission for Basic Systems](#) operates the [Open Programme Area Group on Integrated Observing Systems](#), which is responsible for the development and regular update of the [Implementation Plan for the Evolution of Global Observing Systems](#) (WIGOS Technical Report No. 2013-4). The publication outlines the key activities to be implemented during the period 2012 to 2025, aimed at maintaining and developing all WMO component observing systems. Some of those activities relate to co-sponsored observing systems and will have to be undertaken in close cooperation with partner organizations.

All open programme area groups of the [Commission for Instruments and Methods of Observation](#) are relevant to the [Global Observing System](#).

The [Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology](#) has an [Observations Programme Area](#). It includes the [Data Buoy Cooperation Panel](#) and the [Ship Observations Team](#), which deals with [voluntary observing ships](#).

The [Guide to the Global Observing System](#) (WMO-No. 488) provides a wide-ranging set of guidelines on all aspects of observing systems. It explains and describes GOS practices, procedures and specifications and is aimed at assisting the technical and administrative staff of NMHSs responsible for the networks of observing stations in preparing national instructions for observers. It supplements the regulatory material in the [Manual on the Global Observing System](#) (WMO-No. 544), Volume I.

The [Guide to the Global Observing System](#) (WMO-No. 488) is complemented by the [Guide to Meteorological Instruments and Methods of Observation](#) (WMO-No. 8), which is updated with the technical guidance of experts from the [Commission for Instruments and Methods of Observation](#) and provides more detailed information on the instrumentation aspects of the observing system.

Through the [WWW Operational Information Service](#), the WMO Secretariat maintains the publication [Weather Reporting](#) (WMO-No. 9), Volume A, with all the important information about observing stations globally. It contains a complete list of all the surface and upper-air stations in operation, which are used for synoptic purposes. The contents are arranged in the order of the WMO Regions and in index number order within each Region. The regional sections are followed by sections covering stations in the Antarctic and ocean weather stations.

The Secretariat also maintains the [WMO Catalogue of Radiosondes and Upper-air Wind Systems](#), which, in addition to the information included in [Weather Reporting](#) (WMO-No. 9), Volume A for upper-air stations, provides information on the type of radiosonde, wind-finding equipment, ground systems, radiation corrections applied to temperature observations and other local practices for the radiosondes and upper-air systems in use by Members.

All changes to station details – or corrections thereto – should be communicated to the Secretariat using the feedback form available via the webpage for the [Weather Reporting](#) (WMO-No. 9), Volume A, on the WMO website.

Each [WMO regional association](#) also defines its own [Regional Basic Synoptic Network](#), of which the establishment and maintenance is considered adequate to meet the requirements of Members and of the World Weather Watch, and [Regional Basic Climatological Network](#), considered necessary to provide a good representation of climate on the regional scale, in addition to the global scale. Definitions of these networks are formally agreed at the regional association sessions held every four years.

The WMO [Executive Council Panel of Experts on Polar and High Mountain Observations, Research and Services](#) is in charge of reviewing the [Antarctic Observing Network](#) of surface and upper-air stations to meet the requirements of Members and of the World Weather Watch.

For the [Marine Meteorology and Oceanography Programme](#), the [International List of Selected, Supplementary and Auxiliary Ships](#) (WMO-No. 47) provides information about the ships participating in the WMO Voluntary Observing Ships' Scheme. The WMO website also has [information about data buoys](#) deployed by WMO Members.

The WMO Secretariat coordinates the performance monitoring of observing networks in terms of [quantity](#) and [quality](#). It also maintains a complete table of the [status of current and future satellites](#) operated by members of the [Coordination Group for Meteorological Satellites](#).

Rolling Review of Requirements

Using the [Rolling Review of Requirements](#) process defined in the [Manual on the Global Observing System](#) (WMO-No. 544), Volume I, Part II, user requirements for observations are compared with the capabilities of present and planned observing systems. User requirements are collated

in a comprehensive, systematic and quantitative way in the WMO observing requirements database, which attempts to capture observational requirements to meet the needs of all WMO Programmes. The comparison of user requirements with observing-system capabilities for a given application area is called a critical review. The output from this is reviewed by experts in the relevant application and used to prepare a Statement of Guidance, the main aim of which is to draw attention to the most important gaps between user requirements and observing-system capabilities in the context of the application. A wide range of applications within WMO Programmes has already been addressed.

NMHSs are encouraged to follow the same procedure, with national requirements determined by each individual Member in the light of its own interests and service priorities.

WIGOS self-assessment checklist for WMO Members

To assist NMHSs to gain a better understanding of the WIGOS framework and assess their readiness to implement it, WMO has developed a self-assessment checklist. This helps to identify the key activity areas for effective implementation of WIGOS at the national level. The WIGOS self-assessment checklist templates in the WMO languages (including some examples) can be found [here](#).

Checklist for NMHSs

As a more general list, an NMHS is encouraged to check and follow up on these items, as appropriate:

- Are observational needs regularly assessed through a national counterpart to the Rolling Review of Requirements?
- Are the costs and benefits of changes to the network or observing practices assessed?
- Is there a preventive maintenance programme for elements of the observing infrastructure?
- Is there good quality-control of observations?
- Is there good coordination with other agencies that may also be running national meteorological or other environmental observing programmes?
- Is there a process for reviewing and updating regulations and guidelines?
- Are the regulations and guidelines followed?
- Is the WMO Secretariat informed of changes to observing stations and practices?
- Have all the appropriate focal points been appointed?
- If appropriate, is there a Port Meteorological Officer? (This is also relevant to [section 5.8 – Marine meteorological services](#).)

5.2 INFORMATION SYSTEMS

Overview

Meteorological and related data and products (information) are the lifeblood of any NMHS operation and of the global systems operated by WMO. Effective and reliable information systems are needed both nationally to acquire data and deliver services and internationally for NMHSs to exchange and share data and products for the benefit of all.

WMO policy on the international exchange of meteorological and hydrological data is determined to a large extent by [Resolution 40 \(Cg-XII\) – WMO policy and practice for the exchange of meteorological and related data and products including guidelines on relationships in commercial meteorological activities](#), and [Resolution 25 \(Cg-XIII\) – Exchange of hydrological data and products](#), respectively. These resolutions commit to "broadening and enhancing the free and unrestricted international exchange" of meteorological, hydrological and related data and products as a fundamental WMO principle (*Abridged Final Report with Resolutions of the Twelfth World Meteorological Congress* (WMO-No. 827)).

NMHSs have established and operate telecommunications networks that together form the WMO [Global Telecommunication System](#) (GTS), which facilitates the rapid exchange of observations, data and products to enable NMHSs worldwide to meet their national and international obligations. This system also plays a key role in the dissemination of tsunami early warnings around the world (see [Figure 6](#)).

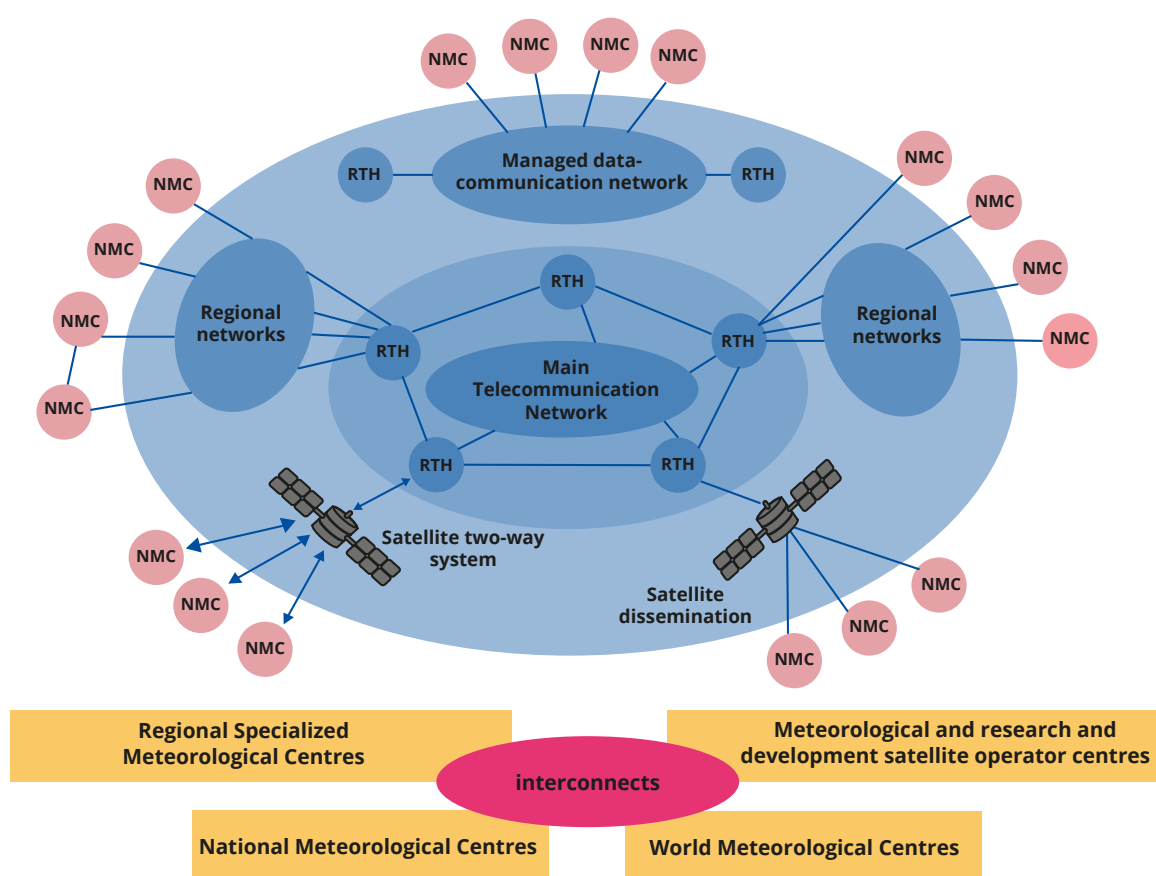


Figure 6. Structure of the Global Telecommunication System

The Global Telecommunication System has a hierarchical structure on three levels:

- The [Main Telecommunication Network](#), linking three World Meteorological Centres (WMCs: Melbourne, Moscow and Washington) and 15 Regional Telecommunication Hubs (RTHs: Algiers, Beijing, Exeter, Brasilia, Buenos Aires, Cairo, Dakar, Jeddah, Nairobi, New Delhi, Offenbach, Toulouse, Prague, Sofia and Tokyo). This core network has the function of providing an efficient, rapid and reliable communication service between the Meteorological Telecommunication Centres.
- The Regional Meteorological Telecommunication Network is an integrated network of circuits covering the six WMO Regions – [Africa](#) (I), [Asia](#) (II), [South America](#) (III), [North America, Central America and the Caribbean](#) (IV), [South-West Pacific](#) (V) and [Europe](#) (VI),

as well as [Antarctica](#) – and interconnecting the Meteorological Telecommunication Centres, thus ensuring the collection of observational data and regional selective distribution of meteorological and other related information to Members. Until the integrated network is completed, [high-frequency radio broadcasts](#) may be used in order to meet the requirements of the World Weather Watch for the dissemination of meteorological information.

- The National Meteorological Telecommunication Networks enable the National Meteorological Centres (NMCs) to collect observational data and receive and distribute meteorological information on a national level.

The Global Telecommunication System forms the foundation for the development and implementation of the [WMO Information System](#) (WIS) (see [Figure 7](#)). WMO Members are cooperating in the design and implementation of the WIS to improve current data communications and the dissemination of weather, climate and water data and information. By using a broader array of communication and data technologies, including the Internet, WIS will reduce operating costs, enhance the reliability of data communications and provide easier, more user-friendly ways to share data and products internationally. In addition to the automated dissemination of observed data and products, WIS will provide data discovery, access and retrieval services for all weather, climate, water and related data and products produced by WMO centres and Members.

The WMO website provides a good [overview](#) of WIS, as well as extensive documentation. The WMO Information System will provide three fundamental types of services:

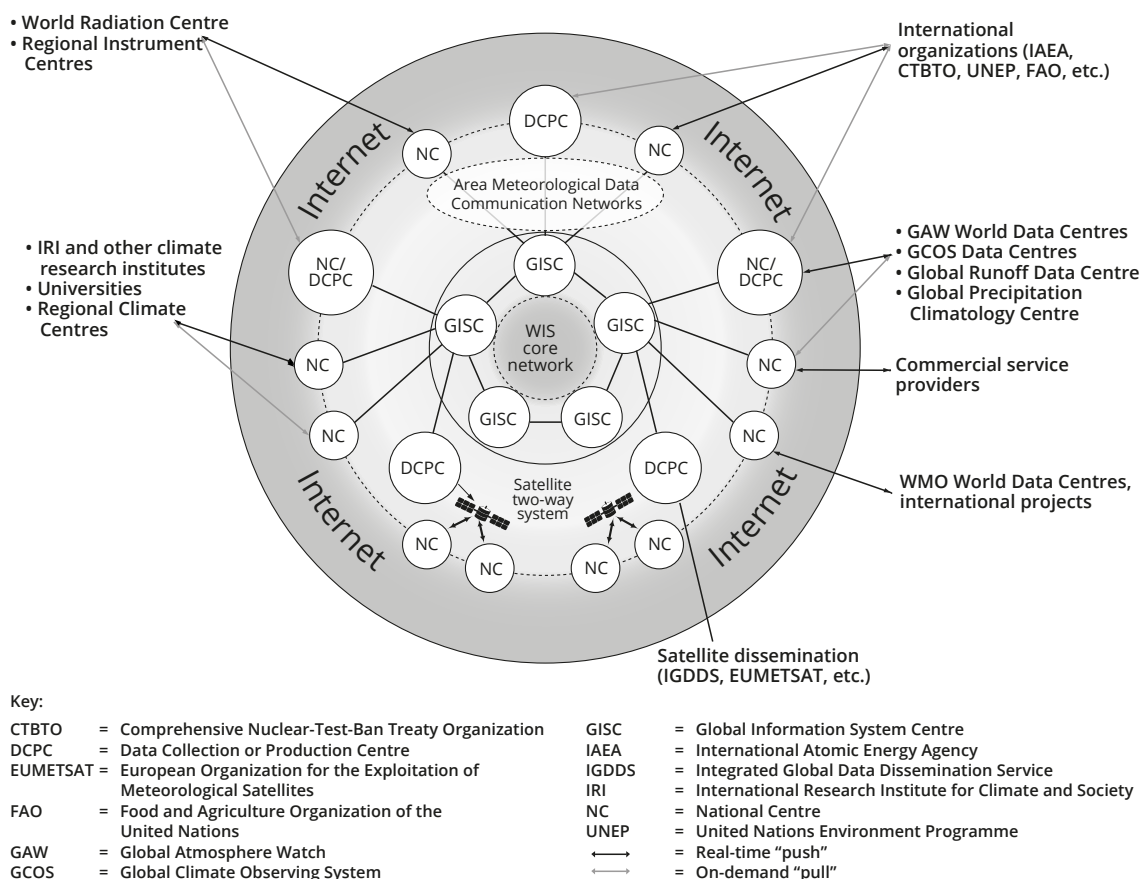


Figure 7. WIS – core components and information exchange

- Routine collection and dissemination of time- and operation-critical data and products: this service is based on a real-time push mechanism, including multicast and broadcast; it will be implemented essentially through dedicated telecommunication means, providing a guaranteed quality of service;
- [Data discovery, access and retrieval](#): this service is based on a request/reply pull mechanism with relevant data management functions; it will be implemented essentially through the Internet;
- Timely delivery of data and products: this service is based on a delayed-mode push mechanism; it will be implemented through a combination of dedicated telecommunication means and public data-communication networks, especially the Internet.

Information is exchanged using [WMO international codes](#), which are independent of language. Historically, alphanumeric codes were used, which were suited to Morse code and then to slow teletype machines. Binary codes were introduced when the use of computers became widespread and data volumes increased. There is a [migration](#) underway from alphanumeric codes to Table Driven Code Forms.

Regulations

The [Manual on the Global Telecommunication System](#) (WMO-No. 386), which is Annex III to the [Technical Regulations](#) (WMO-No. 49), contains the regulatory material for global aspects of the GTS. This consists of Part I – Organization of the Global Telecommunication System; Part II – Operational procedures for the Global Telecommunication System; and Part III – Technical characteristics and specifications of the Global Telecommunication System.

The [Manual on the WMO Information System](#) (WMO-No. 1060), which is Annex VII to the [Technical Regulations](#) (WMO-No. 49), contains the regulatory material for WIS.

The [Manual on Codes](#) (WMO-No. 306), Volume I, which is Annex II to the [Technical Regulations](#) (WMO-No. 49), contains the regulations for codes: [Volume I.1, Part A](#), covers alphanumeric codes; [Volume I.2, Part B](#), covers binary codes; [Volume I.2, Part C](#), covers common features to binary and alphanumeric codes; and [Volume I.3, Part D](#), covers representations derived from data models. [Volume II](#) contains non-regulatory regional codes and national coding practices.

WMO bodies, Programmes and guidance

The primary Programme within WMO regarding information systems is the [World Weather Watch Programme](#), through the [Global Telecommunication System](#), the [WWW Data Management support programme](#), including management of codes, and the [WWW Operational Information Service](#). These operate under the technical guidance of the [Commission for Basic Systems](#) and its [Open Programme Area Group on Information Systems and Services](#).

There are a number of guides available through the [WMO GTS webpage](#) for various technical matters. The [Guide to the WMO Information System](#) (WMO-No. 1061) is also available.

[Exchanging Meteorological Data: Guidelines on Relationships in Commercial Meteorological Activities – WMO Policy and Practice](#) (WMO-No. 837) provides guidance on implementing [Resolution 40 \(Cg-XII\) – WMO policy and practice for the exchange of meteorological and related data and products including guidelines on relationships in commercial meteorological activities](#). Additional reference material, including country notifications on the international exchange of additional data and products, is available [here](#).

Note: Additional data and products refer to data and products additional to those with no conditions on their use.

The WMO Secretariat maintains lists of important details concerning the exchange of information over the GTS. *Weather Reporting* (WMO-No. 9), [Volume C1](#), contains the list of meteorological bulletins for global, interregional and regional exchange on the GTS. [Volume C2](#) contains information on the transmission programmes (that is, contents and, when applicable, schedules) of data-distribution systems of the GTS.

The WMO Secretariat relies on information from Members for updating these publications. It is worth referring to the webpage "[Best practices for the management of the WWW Operational Information Service](#)".

Information systems of NMHSs

Much of the descriptions above relate to the international exchange of information using WMO systems. This requires professional expertise that ranges from IT communication experts to people with in-depth meteorological understanding of the information and how it is represented.

There are many similar issues with in-country communication of information. Communication and information systems are needed for:

- Reception of observations from remote sites, including automatic weather stations;
- Operating the network of forecast and other offices;
- Delivering products and services to users and customers;
- Office functions, including e-mail and document access;
- Managing the NMHS website;
- Satellite reception.

Fortunately, in many parts of the world, the cost of telecommunications is dropping and the bandwidths are increasing, with much now being based on exploiting the public Internet as well as satellite communications for more remote areas. Where appropriate, the important and time-critical public safety role performed by the NMHS should be stressed in discussions with national telecommunication authorities to ensure the best deal for cost-effective and reliable communication services.

Checklist for NMHSs

An NMHS is encouraged to check and follow up on these items, as appropriate:

- Are the communication systems used reliable and cost-effective?
- Is the speed of connections, both internally and internationally, hampering access to needed data and products?
- Is there a process for following up on and implementing changes in the event of any communication outages?
- Is there good coordination with other agencies that rely on, or provide, critical communications?
- Is there a process for reviewing and updating regulations and guidelines?
- Are the regulations and guidelines followed?

- Is the WMO Secretariat informed of changes to meteorological bulletins and other operational information?
- Have all the appropriate focal points been appointed?

5.3 FORECASTING SYSTEMS

Overview

The observations and data gathered by NMHSs are processed to generate products that can support decision-making during events such as tropical cyclones/hurricanes, heatwaves, disease outbreaks, flash floods and drought. The quality of the products is dependent on the adequacy of processing facilities and human resources. All NMHSs contribute to these products through the sharing of observations, which are the basis for generating the forecasts and warnings.

Within the Global Data-processing and Forecasting System (GDPFS) (see [Figure 8](#)), WMO has designated, applying a cascading process, certain NMHSs as Regional Specialized Meteorological Centres (RSMCs), which provide forecast products to all other NMHSs. The range of specializations includes geographical considerations, tropical cyclones, emergency response and atmospheric transport models. In addition, WMO has designated Global Producing Centres and Regional Climate Centres, which focus on longer-range predictions. The climate predictions and information provided by Global Producing Centres and Regional Climate Centres are useful tools for planning and developing activities in climate-sensitive sectors, such as agriculture, water resources, energy and health.

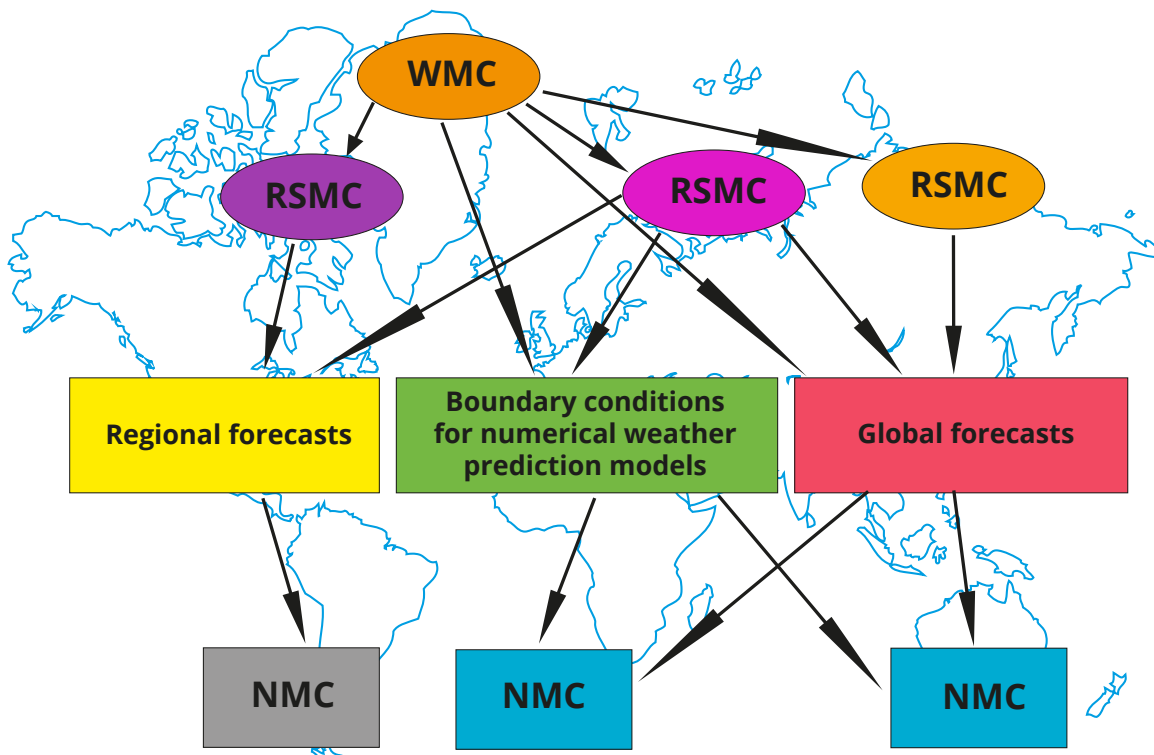


Figure 8. Schematic representation of the WMO Global Data-processing and Forecasting System: a worldwide network of centres

The NMHSs can utilize products from RSMCs to develop forecasts and warnings of severe weather and extreme climate events for their respective countries to support socioeconomic development activities, including in sectors such as aviation, agriculture, marine safety, transport, tourism and energy.

In addition to using global and regional products, many NMHSs run their own national numerical weather prediction models at various levels of sophistication. This may be as simple as limited area models that downscale global model products to higher resolution in space and time without data assimilation, or it may involve variational data assimilation, very high-resolution models and ensemble prediction systems.

Post-processing of received or local numerical weather prediction output through techniques such as model output statistics can also provide improved guidance for forecasters and end-user products.

Through the efforts of WMO Members and with assistance from the various WMO coordination, regulatory, and capacity-building activities, the WMO GDPFS is constantly evolving. At the Seventeenth World Meteorological Congress in 2015, WMO endorsed a strengthened emphasis on severe and high-impact weather events and on providing input into the impacts of those events. For example, the Severe Weather Forecasting Demonstration Project is an end-to-end, cross-programme collaborative activity, led by the GDPFS, in which the goal is to enable participants:

- To make the best possible use of all existing and newly developed products and facilities at the global, regional and national levels, including high-resolution numerical weather prediction and ensemble prediction products and very short-range forecasting, including nowcasting, tools;
- To establish sustainable services of reliable and effective early warnings tailored to the needs of the general public and a wide range of socioeconomic sectors in least developed countries, small island developing States and other developing countries;
- To ensure a continuous improvement cycle and quality assurance of services, including efficient and responsive feedback loops between the NMHS and the end users at the national level.

In addition, the evolution of the GDPFS aims to meet the need to improve numerical modelling input for prediction on all timescales, from very short-term to climate events.

Regulations

The [Manual on the Global Data-processing and Forecasting System](#) (WMO-No. 485), which is Annex IV to the [Technical Regulations](#) (WMO-No. 49) (Volumes I–III), contains the regulatory material for the global aspects of the GDPFS. This consists of Part I – Outline of the WMO Global Data-processing and Forecasting System; Part II – Specifications of Global Data-processing and Forecasting System activities; and Part III – Global Data-processing and Forecasting System implementation.

WMO bodies, Programmes and guidance

The primary WMO Programme applicable to forecasting systems is the [World Weather Watch Programme](#), through its GDPFS component, which operates under the technical guidance of the [Commission for Basic Systems](#) and its [Open Programme Area Group on the Data-processing and Forecasting System](#).

Reports of various meetings with useful updates are available via [this link](#). A [map and list of GDPFS centres](#) are also available.

Checklist for NMHSs

An NMHS is encouraged to check and follow up on these items, as appropriate:

- Is the NMHS aware of available global and regional guidance?
- Is the NMHS accessing relevant global and regional guidance?
- Is the guidance being made available to forecast room staff?
- What training has been given to forecasters for making best use of the guidance?
- Is ensemble prediction system guidance available?
- If the NMHS operates an RSMC with regional specialization, how are regional requirements determined?
- If the NMHS operates an RSMC with activity specialization, how are requirements from other NMHSs determined?
- If the NMHS operates an RSMC, are requirements being met?
- Is the NMHS carrying out limited-area modelling?
- Have the costs and benefits of limited-area modelling been assessed?
- What advice on post-processing of models is being given to provide tailored guidance for forecasters, as well as for end-user products?
- What verification is being done of model products?

5.4 RESEARCH

Overview

All NMHSs have benefited from the scientific progress achieved through sustained investment in global and national research programmes.

Under the [WMO Strategic Plan 2016–2019](#) (WMO-No. 1161), Expected Result 5 is: advance targeted research. This means WMO will focus on “[e]nhanced capabilities of Members to contribute to and draw benefits from the global research capability for weather, climate, water and related environmental science and technology development”. This addresses improvements in the prediction of weather and climate, in observations and in assessments of atmospheric chemistry.

The Seventeenth World Meteorological Congress, in 2015, took into consideration during its deliberations the six emerging challenges for the next decade, clearly identified by the Commission for Atmospheric Sciences, as follows:

- High-impact weather and its socioeconomic effects in the context of global change;
- Modelling and predicting the water cycle for improved DRR and resource management;
- The Integrated Global Greenhouse Gas Information System, with the goal to serve society and support policy;
- The impacts of aerosols on air quality, weather and climate;

- Research on urbanization, and services for megacities and large urban complexes;
- The use of evolving technologies and their impact on science.

Future research will follow a balanced and seamless approach to weather, climate and water services. This will include the development of forecasts of a broader range of environmental parameters, such as air quality, sandstorms and duststorms and changes in vegetation, to meet the needs of users and the urgent demand to reduce the vulnerability of communities. Figure 9 shows the challenges of developing seamless products and services and the available climate information and gaps. The future approach to weather, climate and water research, predictions and services will:

- Entail a unified approach over multiple space and timescales, including a requirement for the downscaling of climate information;
- Invest in increasingly high-performance computing to accommodate the growing complexity and detail of models;
- Develop closer linkages among research, operations and users through, for example, forecast demonstration projects, to enable Members to rapidly operationalize research outputs for service delivery and to allow users to see rapid results from informed decision-making.

WMO bodies, Programmes and guidance

The main Programmes within WMO applicable to research are the [World Weather Research Programme](#) (WWRP), including the [WWRP Observing System Research and Predictability Experiment](#) (WWRP/THORPEX) and the [Global Atmosphere Watch Programme](#). They are under the technical responsibility of the [Commission for Atmospheric Sciences](#).

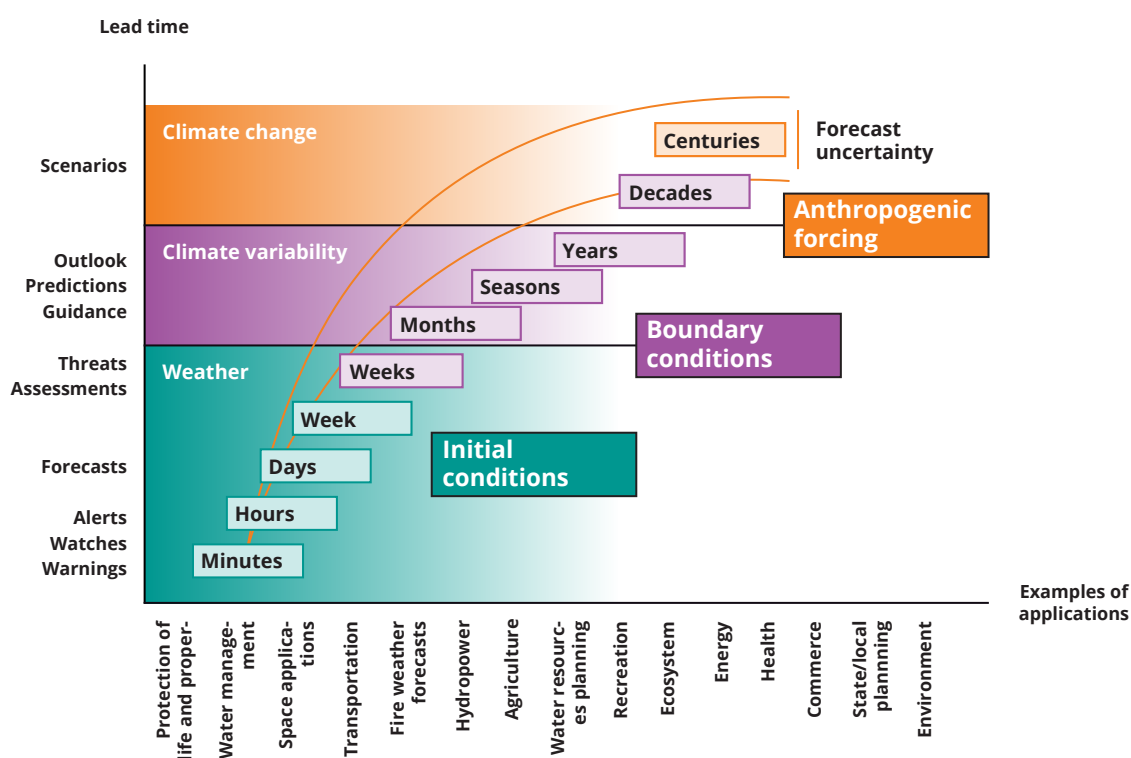


Figure 9. Seamless hydrometeorological and climate services for various applications

Another applicable Programme is the [World Climate Research Programme](#) (WCRP), which is co-sponsored by WMO, the [International Council for Science](#) and the [Intergovernmental Oceanographic Commission](#) of the United Nations Educational, Scientific and Cultural Organization, reflecting the close contacts and coordination of WMO with other international scientific bodies.

A further example of coordination is the [Working Group on Numerical Experimentation](#) (WGNE), established jointly by the WCRP Joint Scientific Committee and the Commission for Atmospheric Sciences.

The structure of the Commission for Atmospheric Sciences includes the [Open Programme Area Group on the World Weather Research Programme](#) and the [Open Programme Area Group on Environmental Pollution and Atmospheric Chemistry](#).

An overall [list of WWRP publications](#) is available, as is the [Strategic Plan for the Implementation of WMO's World Weather Research Programme \(WWRP\): 2009–2017](#) (WMO/TD-No. 1505).

Subject areas within WWRP/THORPEX, many of which have reference material, include:

- [THORPEX](#) – a 10-year (2005–2015) international research and development programme to accelerate improvements in the accuracy of one-day to two-week high-impact weather forecasts for the benefit of society, the economy and the environment;
- [Mesoscale forecasting](#);
- [Nowcasting](#);
- [Sandstorms and duststorms](#);
- [Forecast verification](#) – this website for the WWRP/WGNE Joint Working Group on Forecast Verification Research has many links to resources to assist with national forecast verification efforts;
- [Tropical meteorology research](#);
- [Weather modification](#);
- [Societal and economic research applications](#).

There is considerable international activity in the development of numerical models for the purpose of forecasting on various timescales and for climate simulation. The [Working Group on Numerical Experimentation](#) publishes an annual online report to foster an early interchange of information among workers in these areas. The material in the publication is the response to a call for contributions sent to scientists worldwide.

More detailed information on the Global Atmosphere Watch Programme can be found on the Programme's [webpage](#), including the *WMO Global Atmosphere Watch (GAW) Implementation Plan: 2016—2023* (GAW Report No. 228). Information on the GAW [scientific advisory groups](#) and [expert teams](#) is also available.

An extensive amount of information about the Global Atmosphere Watch stations is available via the [GAW Station Information System](#).

Research function of NMHSs

The amount of effort invested in research at national level will depend on the size of the NMHS, available resources and national needs for research. It is important to involve an operational user for the research who is in a position to help advise and steer research priorities and to benefit from research results, even if that research may take many years.

In terms of applied research aimed at improving forecasting services, the operational user may in effect be the manager of forecast operations. Forecasters and researchers need to work closely together so that the researchers have a good understanding of forecasting problems and the forecasters are kept up to date with the latest relevant science.

Smaller NMHSs can obtain much benefit by exploiting international research and development findings that are widely published and publicized. Case studies into significant national weather events and forecast failures can be carried out with the assistance of operational forecasters, which assists in the important step of research-to-operations implementation.

Other research activities may include post-processing of model data for more accurate and useful spot predictions, including probabilities, and nowcasting techniques exploiting available data from, for example, satellite, radar and lightning-detection systems.

In some cases, NMHS research staff may carry significant responsibility for operational modelling, post-processing and forecasting computer systems. This has positive and negative aspects. It is positive in that there is an in-depth understanding of the nature of the systems and a sense of ownership that does not necessarily apply if the systems are maintained by IT professionals who have little meteorological knowledge. The downside is that meteorologists do not necessarily have the IT skills to ensure that the systems are reliable and robust, and looking after operational systems may not be the optimal use of their time.

Career paths for research scientists need to be established that allow for recognition of science contributions at a senior level without necessarily also leading to heavy management responsibilities.

Research to better understand national and regional climate, climate change and climate-change impacts is of growing importance. Together with the seamless approach referred to earlier, close collaboration between climate and weather research is important.

NMHSs may conduct research on particular topics at the request of other government agencies, such as those for science, the environment and agriculture, and universities may also conduct significant relevant research. It is important to establish and maintain links with other researchers both nationally and internationally, as research works best in a collaborative environment. The Global Framework for Climate Services in particular will require a strengthening of these national and international partnerships on climate timescales to ensure that research addresses the specific requirements of users and that mature research results can support services.

Checklist for NMHSs

An NMHS is encouraged to check and follow up on these items, as appropriate:

- How are research needs established?
- Are there internal operational users within the NMHS for research?
- Is there a research and development plan?
- Are there good links with other researchers and research groups nationally?
- Are there good links internationally?
- Do research staff regularly interact with operational staff?
- Do researchers have regular opportunities to take part in national and overseas conferences and meetings in order to learn and expand their networks?
- Is there a career path for research scientists?

5.5 WARNING SYSTEMS

Overview

Of all the services provided by NMHSs, a warning system to help protect life, property and livelihoods is the most important. Therefore, even though warnings are covered elsewhere – in particular under the sections on [public weather services](#), [DRR](#) and [marine meteorological services](#) – this section focuses on warning systems as a category on its own.

One of the most important issues is ensuring that the NMHS constitutes the single authoritative voice on weather warnings within its country in order to avoid public confusion. This is consistent with statements of the WMO Executive Council and Congress. The best way to ensure this is through the legal mandate of the NMHS (see [section 2.1 – National legal basis](#)). In practice, however, even when the NMHS does have a legal mandate, issues can arise with other providers of forecasts that are styled as warnings. This is a sensitive issue, best dealt with by approaching those providers and discussing the matter of having a single authoritative voice and the need to avoid public confusion. Other agencies should be involved as appropriate to assist in these discussions. The better the relationship with those agencies (see [section 3.2 – Other government agencies](#)) and the more visible the NMHS (see [section 3.3 – National visibility of a National Meteorological and Hydrological Service](#)), the easier it will be to deal with this issue.

Severe weather warnings are increasingly not about the weather elements themselves, but rather the impacts of the weather. See, for example, the [MétéoFrance vigilance](#) display, details of the [UK Met Office national severe weather service](#) and the [European meteoalarm](#), all of which use colour codes relating to likely impact.

Regulations

Relevant regulations include the [Technical Regulations](#) (WMO-No. 49), Volume II, which covers aviation warnings; and the [Manual on Marine Meteorological Services](#) (WMO-No. 558), Volume I, which is Annex VI to the *Technical Regulations* and covers marine warnings.

The Executive Council Statement on the Role and Operation of National Meteorological and Hydrological Services (for decision makers), paragraph 5, is the official text that refers to the single authoritative voice of NMHSs (see the [Abridged Final Report with Resolutions of the Fifty-seventh session of the Executive Council](#) (WMO-No. 988), Annex VII).

WMO bodies, Programmes and guidance

Many WMO Programmes are involved in various aspects of warning systems, including:

- The [Global Data-processing and Forecasting System Programme](#) – in particular the related, emerging Severe Weather Forecasting Demonstration Project
- The [Public Weather Services Programme](#)
- The [Disaster Risk Reduction Programme](#)
- The [Aeronautical Meteorology Programme](#)
- The [Marine Meteorology and Oceanography Programme](#)
- The [Tropical Cyclone Programme](#)
- The [Emergency Response Activities Programme](#)

Guidance on warning systems includes:

- The [tropical cyclone operational plans](#) for various areas
- The [Guide on Improving Public Understanding of and Response to Warnings](#) (WMO/TD-No. 1139)
- The [Guidelines on Cross-border Exchange of Warnings](#) (WMO/TD-No. 1179)
- The [Guidelines on Integrating Severe Weather Warnings into Disaster Risk Management](#) (WMO/TD-No. 1292)
- The [Guidelines on Early Warning Systems and Application of Nowcasting and Warning Operations](#) (WMO/TD-No. 1559)
- The [Guidelines on International and Cross-border Collaboration in the Warning Process](#) (WMO/TD-No. 1560)

Official warnings from WMO centres are provided via the [WMO Severe Weather Information Centre](#) site.

Checklist for NMHSs

An NMHS is encouraged to check and follow up on these items, as appropriate:

- Is the NMHS the official single authoritative voice for warnings?
- Is an end-to-end approach taken that includes warning of the impacts of severe weather?
- In the case of limited resources, is priority given to warning the public to protect life and property?
- Are strategies in place for dealing with other providers who attempt to issue forecasts that are styled as warnings to the public?

5.6 PUBLIC WEATHER SERVICES

Overview

Public weather services, including forecasts and warnings, are an essential component of NMHSs and one of the most visible returns for taxpayers on their investment in NMHSs.

Early warnings and alerts of extreme events contribute to reducing the impact of such events when coupled with effective emergency response systems. NMHSs rely on the communications infrastructure to issue timely warnings. In most countries, the NMHS is part of multisectoral systems for disaster risk reduction and response. Some of them participate in the development, implementation and operation of multi-hazard early warning systems (MHEWSs), including those involving seismology and ocean-related phenomena such as tsunamis. The integration of weather, climate, water and related environmental information into national planning and development policies is an essential element in reducing the risks associated with severe-weather and extreme-climate events.

NMHSs provide forecasts and warnings of floods, water levels and discharge within river basins, watersheds and coastal areas. These products are critical for protecting life and property, for safeguarding the environment and for efficient management of water resources as a contribution to sustainable development. In some countries, NMSs and NHSs are represented by separate institutions, making it essential to engage in close collaboration for the efficient delivery of services.

NMHSs provide data, products and services, such as daily forecasts of temperature, humidity and air quality, long-range predictions and severe weather warnings, that help in monitoring disease outbreaks, which is important for planning and providing public health services.

In this chapter, sections on [warning systems](#), [climate services](#) and [DRR](#) are also relevant to public weather services.

Regulations

Currently, there are no specific regulations on public weather services, but the basic regulations in the [Technical Regulations](#) (WMO-No. 49) and its annexes are followed in a number of guidelines covering public weather services.

WMO bodies, Programmes and guidance

The applicable Programme within WMO is the [Public Weather Services Programme](#). It is carried out under the technical responsibility of the Commission for Basic Systems, whose terms of reference are described [here](#).

The structure of the Commission for Basic Systems includes the [Open Programme Area Group on Public Weather Services](#), which is responsible for implementation/coordination teams and expert teams covering services and products, how to meet user needs in reducing the impact of hydrometeorological hazards, disaster prevention and mitigation, and communication, outreach and public education.

The Public Weather Services Programme was initiated in the mid-1990s and has been prolific in providing publications of various kinds – a full list is available via this [link](#).

The principal guide to operational practices is the [Guide to Public Weather Services Practices](#) (WMO-No. 834). Since its issue in 1999, regular [additional guidelines](#) on various topics have been published – more than 20 as of 2012. These provide valuable advice on topics, including:

- Performance assessment of PWS
- Use of the Internet, new technologies and social media
- Quality management
- Various aspects of warnings
- Public education and outreach
- Biometeorology and air quality
- Capacity-building
- Communicating forecast uncertainty
- Working with the disaster management authorities
- Working with the media
- Social and economic benefits

The following [PWS implementation themes](#) are each worth reviewing for their applicability to an NMHS as they provide practical advice on each topic and on actions to take (a number are also closely related to [section 3.3 – National visibility of an National Meteorological and Hydrological Service](#)):

- WMO strategy for service delivery
- User focus
- Disaster preparedness and mitigation
- Nowcasting
- Socioeconomic applications
- Communication
- Dissemination
- Media issues
- Credibility of NMHSs

- Quality assurance
- Verification
- Public awareness

Other suppliers of public weather services

A particular issue for public weather services is that there are many other sources of public weather forecasts available over the Internet and via the media that may be of variable quality, particularly if they are automated global products, but attractively packaged. Sometimes, they are actually styled as warnings, even where the NMHS is clearly the official authoritative source of such warnings. See [section 5.5 – Warning systems](#), for comments in relation to this issue.

Checklist for NMHSs

An NMHS is encouraged to check and follow up on these items, as appropriate:

- Is the NMHS aware of who the users of its services and information are?
- Is there any dialogue or relationship with the user community?
- Is there a good understanding of user requirements for public weather services?
- Is there an evaluation programme to assess how well public weather services are meeting requirements?
- Is there a public education and outreach programme?
- What are relationships like with the media in terms of service delivery and public communication?
- Are socioeconomic benefits being assessed?
- Is there good coordination with emergency management authorities?
- Have staff acquired the required competencies for delivering public weather services, including training in communication and media presentation?
- Has the Permanent Representative with WMO received training in communication and dealing with media?
- Is there a WMO focal point for public weather services?

5.7 AVIATION METEOROLOGICAL SERVICES

Overview

For the civil aviation sector, NMHSs provide data, products and services that contribute to the safety of aviation and the economic operation of the sector both nationally and internationally. The measurements and forecasts of conditions en route, at, or on the approach to terminal aerodromes are useful for minimizing aviation operating costs. By increasing the efficiency of aviation operations, NMHSs also contribute to a reduction in aircraft emissions and their resulting impacts on global climate change and stratospheric ozone. Aviation meteorological services are one of seven strategic priority areas under the [WMO Strategic Plan 2016–2019](#), especially when considering the sector's major contribution to many NMHS budgets through cost recovery, important developments in quality management, and the competence of NMHS personnel providing services.

The economic and social benefits that can be derived from air transport make it one of the world's most important industries. Air transport is a critical factor in world trade and plays a major role in global development. As an economic catalyst for growth, air transport has a tremendous impact on the performance of regional economies, both through its own operations and as a key link in the value chain that supports other industries. Advances in air transport require that the delivery of services to the sector be improved with a view to promoting the safety, regularity and efficiency of international air navigation. Such improvements require more competent staff and appropriate infrastructure.

The implementation of a quality management system (QMS) comprising procedures, processes and resources necessary to facilitate quality management of the meteorological information supplied to users is of paramount importance, as is the demonstration of competencies for aeronautical meteorological personnel, especially in developing countries and least developed countries ([WMO Strategic Plan 2012–2015](#) (WMO-No. 1069).

Regulations

The WMO [Technical Regulations](#) (WMO-No. 49), Volume II, contains the regulatory material for providing services to international aviation and is identical to ICAO Annex 3 to the Convention on International Civil Aviation. It effectively provides a definition of meteorological services that either must or should be provided to international aviation driven from the customer perspective, with regular updates made in close collaboration between ICAO and WMO. Parts I and II cover international standards and recommended practices, with Part I focusing on core standards and Part II containing appendices and attachments. Part III concerns aeronautical climatology and Part IV format and preparation of flight documentation, which gives example of charts and models used for various aviation meteorological services. While they focus on international aviation, many of the standards and recommended practices are also applicable to domestic and general aviation.

WMO bodies, Programmes and guidance

The applicable Programme within WMO is the [Aeronautical Meteorology Programme](#). It is carried out under the technical responsibility of the Commission for Aeronautical Meteorology, which has these [terms of reference](#).

Within the [structure of the Commission for Aeronautical Meteorology](#) are various expert teams and focal points covering key matters of topical interest. Together with the WMO Secretariat and in close cooperation with ICAO, they develop guidance that accompanies the Technical Regulations.

Various education and training materials and other reference materials are available via a [website](#) operated by the Commission for Aeronautical Meteorology Expert Team on Education, Training and Competencies.

A list of publications including guidance is available [here](#).

The principal guide to operational practices is the [Guide to Practices for Meteorological Offices Serving Aviation](#) (WMO-No. 732). This Guide describes the routine operations of a meteorological office and highlights how customer satisfaction can be ensured. Chapters include the broad functions of a meteorological office serving aviation, the functions of a meteorological watch office, automation and centralization, training of aeronautical meteorological personnel and the location and layout of offices.

Cost recovery is an important issue for aviation meteorological services as it provides a significant proportion of many NMHS budgets. The [Guide to Aeronautical Meteorological Services Cost Recovery: Principles and Guidance](#) (WMO-No. 904) provides useful background on matters such as the ICAO designated meteorological authority. As stated in ICAO Annex 3, "[e]ach Contracting State shall designate the authority, hereinafter referred to as the meteorological authority, to provide or to

arrange for the provision of meteorological service for international air navigation on its behalf". (*Meteorological Service for International Air Navigation*, Annex 3 to the Convention on International Civil Aviation). In some countries, the NMHS is the ICAO meteorological authority, but in others it may be the civil aviation authority or similar body.

Quality management is another important topic in aviation meteorological services, with quality management provisions in the Technical Regulations moving from the status of a recommended practice ("should") to a standard ("shall") in November 2012. The [Guide to the Quality Management System for the Provision of Meteorological Service for International Air Navigation](#) (WMO-No. 1001) provides useful background on the quality management provisions, an outline of the International Organization for Standardization (ISO) 9001 standard on quality management systems and of how to implement them in NMHSs for aviation services, and a case study from Hong Kong, China. Authorized access to the WMO Quality Management website and Quality Management Forum can be obtained via this [link](#).

[Section 8.8 – Quality management frameworks](#), may be consulted for further information about quality management systems overall.

WMO has adopted competency standards for aeronautical meteorological forecasters and aeronautical meteorological observers, as well as qualification standards for aeronautical meteorological forecasters. In an ICAO context, the designated meteorological authority is required to ensure that meteorological personnel providing service for international air navigation comply with the WMO requirements in this regard. Since December 2013, aeronautical meteorological service providers must be able to demonstrate that their aeronautical meteorological forecasters and observers meet the WMO competency standards. Additionally, since December 2016, aeronautical meteorological service providers must be able to demonstrate that their aeronautical meteorological forecasters have successfully completed the Basic Instruction Package for Meteorologists. The competency and qualification standards for personnel providing aeronautical meteorological service can be found in the [Technical Regulations](#) (WMO-No. 49), Volume I, Part V. A competency assessment toolkit is [available](#), which provides a framework for demonstrating competence of aeronautical meteorological forecasters and observers. A WMO Guide on Competency is under preparation (expected publication in 2017).

[Section 9.2 – Workforce capabilities and competencies](#), may be consulted for further information about people management.

Checklist for NMHSs

An NMHS is encouraged to check and follow up on these items, as appropriate:

- Who is the designated meteorological authority?
- What is the legal document that designates the authority?
- Is there a formal agreement between the authority and the NMHS?
- Are there regular meetings with aviation agencies and aviation users?
- Is cost recovery implemented?
- Are quality management systems implemented?
- Do operational practices and procedures follow WMO regulations and guidelines?
- Is there a process for reviewing and planning updated regulations?
- Is competency assessment for aeronautical meteorology staff being implemented?
- Is there regular assessment of the quality of aviation meteorological services?

5.8 MARINE METEOROLOGICAL SERVICES

Overview

Many Members' area of responsibility may be composed in large part of the ocean and marine environment under their country's jurisdiction. Marine conditions significantly influence the weather, affecting safety of life, economic development and management of important coastal resources. NMHSs have a public responsibility to protect their populace from weather and weather-related events that develop or intensify in oceans (non-national territories), and, for many Services, this aspect of a national marine weather programme is often funded from public revenues, as are forecast and warning services for fishermen and small craft sailors.

For maritime and island countries, the equipping of ships for weather observations and the support of drifting- or fixed-buoy observations can improve marine forecasts and warnings. Where tide gauges have been installed, these and related meteorological observations should be provided to the NMHS. On the other hand, support to marine transportation and offshore resource industries (oil, gas, etc.) may be funded through cost recovery or provided as a commercial service by the NMHS or the private sector.

Regulations

The [Manual on Marine Meteorological Services](#) (WMO-No. 558), Volume I, which is Annex VI to the [Technical Regulations](#) (WMO-No. 49), contains the regulatory material for the global aspects of providing marine meteorological services. This covers services for the high seas, coastal and offshore areas, main ports and harbour areas, and training in the field of marine meteorology (not only for NMHS personnel, but also for seafarers and marine observers on board ships). These regulations are informed and directed by the [International Convention for the Safety of Life at Sea](#), under the [International Maritime Organization](#).

WMO bodies, Programmes and guidance

The applicable Programme within WMO is the [Marine Meteorology and Oceanography Programme](#), and more specifically its focus on [marine meteorology services](#). This deals with the provision of marine meteorological and oceanographic services around the globe and, consequently, facilitates and supports the delivery of the most visible outputs of the world's marine meteorological and oceanographic organizations. These include forecasting and warning of gales, storms, severe tropical weather systems, such as tropical cyclones/typhoons/hurricanes, and other marine and coastal hazards.

Marine services and products are disseminated through the [Global Maritime Distress and Safety System](#) (GMDSS) in response to requirements established under the [International Convention for the Safety of Life at Sea](#). The GMDSS is organized around 21 Metareas, as shown below (see [Figure 10](#)).

Guidance for the promulgation of internationally coordinated meteorological information, forecasts and warning services under the GMDSS, which does not apply to purely national services, is contained in a document on the IMO/WMO Worldwide Met-ocean Information and Warning Service. This was approved by the WMO Executive Council at its sixty-second session in June 2010, and adopted by the IMO Assembly in November 2011 in its [Resolution A.1051\(27\)](#).

The [Marine Meteorology and Oceanography Programme](#) is carried out under the technical responsibility of the [Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology](#) (JCOMM). The Commission is an intergovernmental body of technical experts that provides a mechanism for the international coordination of oceanographic and marine meteorological observation, data management and services, combining the expertise, technologies and capacity-building skills of the meteorological and oceanographic communities. It was created in 1999 and absorbed the former WMO Commission for Marine Meteorology. The creation of JCOMM resulted from the general recognition that worldwide improvements

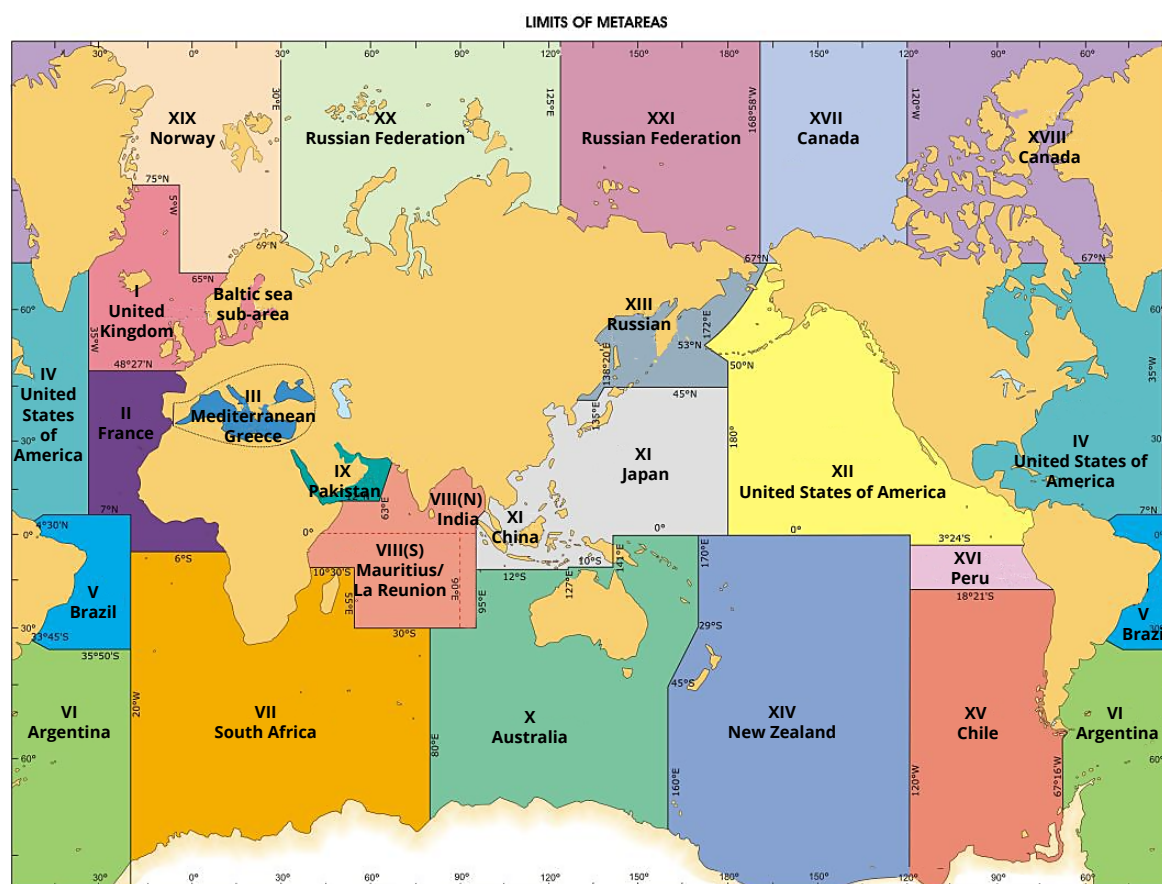


Figure 10. Limits of Metareas

in coordination and efficiency may be achieved by combining the expertise and technological capabilities of WMO and the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization.

The JCOMM structure includes a management committee and three programme areas: [observations](#), [services and forecasting systems](#), and [data management](#). Within the [Services and Forecasting Systems Programme Area](#) are expert teams for marine safety services, waves and coastal hazards, sea ice, and ocean forecasting.

Manuals and Guides are available [here](#) from the JCOMM website, as well as from [WMO](#).

The principal guide to operational practices is the [Guide to Marine Meteorological Services](#) (WMO-No. 471). It is available as a pdf via the [JCOMM site](#) (only in English) and on the [WMO E-library site](#). Other useful guidance is provided in the [Guide to Wave Analysis and Forecasting](#) (WMO-No. 702) and [Guide to Storm Surge Forecasting](#) (WMO-No. 1076). [Weather Reporting](#) (WMO-No. 9), Volume D, is regularly updated by the WMO Secretariat as part of the [WWW Operational Information Service](#) and contains reference information on the GMDSS, Inmarsat-C satellite Land Earth Stations, radio-facsimile and other radio broadcasts, visual storm-warning signals and focal point contact information.

Checklist for NMHSs

An NMHS is encouraged to check and follow up on these items, as appropriate:

- Are there regular meetings with government marine agencies and marine users?

- Is there a Port Meteorological Officer? (This is also relevant to [section 5.1 – Observing systems](#).)
- Are quality management systems implemented?
- Do operational practices and procedures follow WMO regulations and guidelines?
- Is there a process for reviewing and planning updated regulations?
- Is there a process for reviewing and updating the information in [Weather Reporting](#) (WMO-No. 9), Volume D?
- Is there regular assessment of the quality of marine meteorological services?

5.9 AGRICULTURAL METEOROLOGICAL SERVICES

Overview

There is hardly another branch of human activity that is as dependent on the weather and climate as agriculture, despite the impressive advances in agricultural technology over the last half century. More than ever, agrometeorological services are essential, owing to the challenges posed by increasing climate variability, associated extreme events and climate change. These challenges have repercussions in terms of socioeconomic conditions in general, especially in developing countries.

Regulations

Regulations relating to agrometeorological services are contained in the [Technical Regulations](#) (WMO-No. 49), Volumes I–III, and its annexes. In particular, the [Manual on the Global Observing System](#) (WMO-No. 544), Volume I, includes regulations relating to agricultural meteorological stations.

WMO bodies, Programmes and guidance

The applicable Programme within WMO is the [Agricultural Meteorology Programme](#), carried out under the technical responsibility of the Commission for Agricultural Meteorology, whose history and terms of reference are described [here](#). The [structure](#) of the Commission for Agricultural Meteorology includes a management group and a number of expert teams mostly organized within three open programme area groups covering agrometeorological services, support systems, and climate change/variability and natural disasters.

A list of publications of various types is available [here](#).

The principal guide to operational practices is the [Guide to Agricultural Meteorological Practices](#) (WMO-No. 134), which is available as a complete download or in chapters. It provides extensive information about all aspects of the agrometeorological field and services. The publication also has an appendix with a list of numerous periodicals and agricultural bulletins of interest to agricultural meteorologists, which could be reviewed to seek examples of what could be produced on a national level.

Also relevant for disseminating agrometeorological products issued by WMO Members is the [World Agrometeorological Information Service](#). By providing a central location for agrometeorological information, the World Agrometeorological Information Service aids users to evaluate quickly and easily the various bulletins and gain insight into improving their own bulletins. This website also hosts a [tools and resources section](#) to help Members further improve the quality and presentation of their agrometeorological bulletins.

Checklist for NMHSs

An NMHS is encouraged to check and follow up on these items, as appropriate:

- Are user needs for agricultural meteorological services well understood?
- Are the development and delivery of agricultural meteorological services linked to user needs?
- Is performance assessment of the agricultural meteorological services carried out?
- Is there a plan for the evolution and improvement of agricultural meteorological services?
- Do staff have the appropriate skills and competencies for agricultural meteorological services delivery?
- Is there a sharing of best practices and knowledge of agricultural meteorological services delivery?
- Are there links and regular meetings with other national agencies involved in agriculture?

5.10 CLIMATE SERVICES

Overview

NMHSs are ideally placed to play a major role in the delivery of climate services. In most cases, they are the prime national source for high-quality weather and climate observations that are archived into climate databases and available for analysis and to underpin services.

The potential benefits of using climate information are large, since the scope of social and economic activities affected by weather and climatic conditions is enormous. Even small improvements in agricultural productivity, the effectiveness of investments or the management of disease outbreaks, through the use of climate information, can translate into significant benefits if widely applied across multiple sectors. Moreover, given that the livelihoods of billions of people worldwide are influenced by (or are greatly dependent on) activities sensitive to climatic conditions, the significant gaps in the quality and availability of climate information to users limits the realization of potential benefits in many sectors and countries, particularly in developing and least developed countries.

Following the [World Climate Conference-3](#) in 2009, a high-level task force was convened and prepared recommendations on the implementation of a [Global Framework for Climate Services](#) (GFCS). This was considered by the World Meteorological Congress at its sixteenth session in 2011, which charged the Executive Council with providing a detailed plan of action and governance to bring the Framework to reality. This was considered and endorsed by an extraordinary session of Congress in 2012.

[Figure 11](#) shows schematically the components, or pillars, of the Framework, with the indication that the capacity development component encompasses all the others.

Many elements of the GFCS pillars already exist in one form or another. For instance, for the Climate Services Information System, there are already centres that operationally process data, run prediction models and produce climate products for user benefit. However, capability in these respects is not consistent from country to country. It has been assessed that a significant number of countries can, at present, provide only minimal climate services – if any services at all.

While full implementation of the GFCS will involve many other agencies besides WMO, NMHSs will play a pivotal role in the various components and need to be fully involved in its development to maximize the potential benefit to their countries.

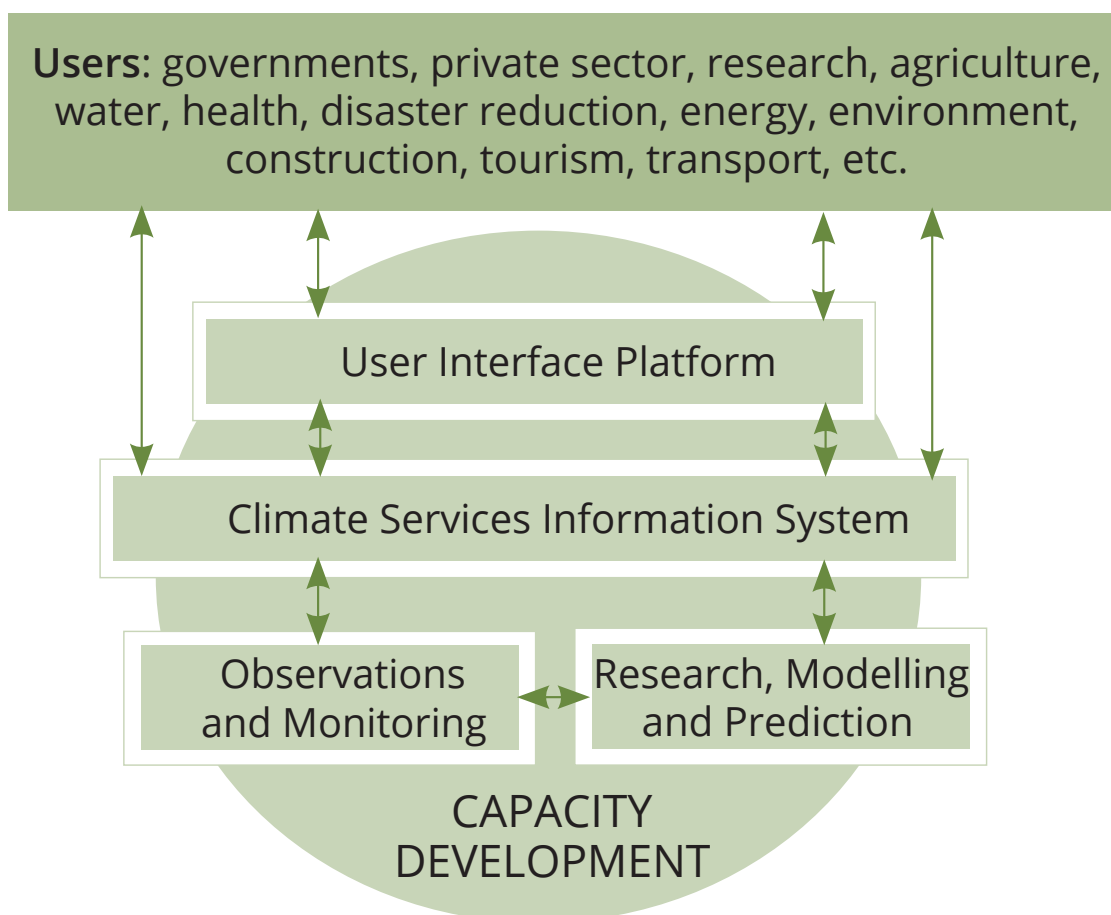


Figure 11. Pillars of the Global Framework for Climate Services

Regulations

Regulations relevant to climate services are to be found in a number of related areas, including:

- The [Manual on the Global Observing System](#) (WMO-No. 544), Volume I, includes regulations relating to the Global Climate Observing System and national networks of climatological stations;
- The [Manual on Codes](#) (WMO-No. 306), Volume I, includes provisions for CLIMAT data;
- The [Manual on the Global Data-processing and Forecasting System](#) (WMO-No. 485), Part I, Appendix 1.1, has useful definitions of meteorological forecasting ranges, including "long-range forecasting" and "climate forecasting"; Part II, Appendix 2.2.16, relates to the mandatory functions of Regional Climate Centres;
- The [Manual on Marine Meteorological Services](#) (WMO-No. 558), Volume I, includes provisions for marine climatology.

WMO bodies, Programmes and guidance

The primary applicable Programme within WMO is the [World Climate Services Programme](#), a component of the [World Climate Programme](#), which also includes the [World Climate Research Programme](#) and the [Global Climate Observing System](#).

The World Climate Services Programme includes two subprogrammes: The [World Climate Data and Monitoring Programme](#) provides international coordination of the WMO Climate System

Monitoring. Its priorities include the provision of guidance to WMO Members in the area of climate data and climate assessment and monitoring, and the publication and dissemination of WMO authoritative reports on the [status of the global climate](#). The [World Climate Applications and Services Programme](#) fosters effective application of climate knowledge and information for the benefit of society and the provision of climate services, including the prediction of significant climate variations, occurring both naturally and as a result of human activity.

The most relevant technical commission is the [Commission for Climatology](#), which has [five open panels of experts](#) on: climate data management; climate monitoring and assessment; climate prediction, projection and delivery mechanisms; user interface for climate adaptation and risk management; and capacity development.

The principal and most useful guide to operational practices is the [Guide to Climatological Practices](#) (WMO-No. 100). It is designed to provide guidance and assistance in developing national activities linked to climate information and services. Chapters cover climate observations, stations and networks; climate data management; characterizing climate from datasets; statistical methods; and services and products.

In addition, a series of publications and reports relate to [climate coordination activities](#), [climate applications and services](#) and the [World Climate Data and Monitoring Programme](#).

Checklist for NMHSs

An NMHS is encouraged to check and follow up on these items, as appropriate:

- Are user needs for climate services well understood?
- Are the development and delivery of climate services linked to user needs?
- Is performance assessment of climate services carried out?
- Is there a plan for the evolution and improvement of climate services?
- Do staff have the appropriate skills and competencies for climate services delivery?
- Is there a sharing of best practices and knowledge of climate services delivery?

5.11 DISASTER RISK REDUCTION

Overview

Disaster risk reduction aims to prevent new and reduce existing risks of disasters and to contribute to an increased resilience to hazards.¹ DRM comprises processes and actions to achieve this objective as well as to manage and transfer residual risks and to minimize losses and damages during hazardous events. The majority of disasters are linked to high-impact weather and hydrological events as well as climate extremes – including rapid-onset hazards such as tropical cyclones and slow-onset hazards such as droughts. DRR, therefore, is one of seven strategic priority areas under the [WMO Strategic Plan 2016–2019](#), since the protection of lives, livelihoods and property is at the core of the priorities of WMO Members and their NMHSs, which play a key role in DRM and contribute significantly to DRR.

¹ Over the years a number authoritative bodies have devised definitions of DRR, for example: United Nations International Strategy for Disaster Reduction (UNISDR), 2009: *UNISDR Terminology on Disaster Risk Reduction*, http://unisdr.org/files/7817_UNISDRTerminologyEnglish.pdf; UNISDR, 2015: *2015 Global Assessment Report on Disaster Risk Reduction. Making Development Sustainable: The Future of Disaster Risk Management*, http://www.preventionweb.net/english/hyogo/gar/2015/en/gar-pdf/GAR2015_EN.pdf; Intergovernmental Panel on Climate Change (IPCC), 2012: *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation*, Annex II – Glossary of terms, https://www.ipcc.ch/pdf/special-reports/srex/SREX_Full_Report.pdf.

A prerequisite of the DRM process are risk assessments that determine the nature and extent of past, existing and potential future risks. Risk assessment involves the identification, analysis and evaluation of (a) hazards in terms of their location, intensity, frequency, duration and probability; (b) vulnerability in terms of its physical, social, economic and environmental dimensions; (c) exposure of people and assets; (d) effectiveness of prevailing or alternative coping and adaptive capacities. Post-disaster hazard data as well as data on loss and damage serve as input for estimating future impacts. Such data need to be temporally and geographically referenced with the hazard event, and quality assured, consistently catalogued and properly archived. Risk assessment is applied differently in the recovery and prevention (or “cold”) phase of DRM, when long-term hazard, vulnerability and exposure analyses need to be conducted, compared to the preparedness and response (or “hot”) phase, when real-time analyses are needed.

Equipped with such risk information, countries can develop risk reduction and adaptation strategies and activities that are frequently presented as a cycle or upward winding spiral, and that include the following four components:

- (a) **Prevention and mitigation:** Disaster prevention expresses the concept and intention to completely avoid the adverse impacts of hazard events through actions taken, normally, in the absence or in advance of a potentially disastrous event. Since the adverse impacts of hazard events often cannot be fully prevented, their scale or severity can be substantially lessened by mitigation measures. Measures can also be taken during or after an event to prevent secondary hazards or their consequences, for example, air, soil or water contamination. Meteorological, hydrological and climate information is essential to determine effective risk prevention and mitigation measures, both structural (for example, the design of the levels of embankments that protect flood-prone areas where settlement and economic activities are vulnerable) and non-structural (for example, spatial planning, improved environmental policies, community-based emergency management planning and training and public awareness raising). It should be noted that in climate change policy, mitigation is defined differently by IPCC, being the term used for the reduction of greenhouse gas emissions.
- (b) **Preparedness:** Preparedness encompasses the application of knowledge and capacities to effectively anticipate, respond to and recover from the impacts of likely, imminent or current disasters. Such coordinated actions aim at the efficient management of emergencies and orderly transitions from response through to sustained recovery, including activities such as contingency planning, stockpiling of equipment and supplies, the development of arrangements for coordination, evacuation and public information, and associated training and field exercises. These must be supported by formal institutional, legal and budgetary capacities. MHEWSs are an essential component of preparedness.
- (c) **Response:** Response actions are taken during or immediately after a disaster in order to save lives, reduce impacts, ensure public safety and meet the basic subsistence needs of the people affected. Some response actions, such as the supply of temporary housing and water supplies, may extend well into the recovery stage. This phase is the focus of humanitarian planning and assistance.
- (d) **Recovery:** Recovery decisions and actions are aimed at restoring or improving livelihoods and health, as well as economic, physical, social, cultural and environmental assets, systems and activities following an emergency or disaster. Ideally, these would be aligned with the principles of sustainable development and resilience, including rebuilding to improved standards (“building back better”) to avoid, reduce or adapt to future disaster risk.

Disasters affect human life and have profound impacts on local and national economies, sometimes setting back development gains by many years in those countries with limited resources. Weather, climate and hydrological services are therefore also essential for financial protection mechanisms in order to cope with residual risks. Residual risks that cannot be effectively reduced can be addressed by disaster risk financing, including risk transfer, such as government-backed insurance schemes and weather-indexed insurance.

Disaster risk reduction is inextricably linked to, and informs, adaptation to climate impacts and change (climate change adaptation – CCA). Natural hazards, including those associated and exacerbated by climate variability and change, threaten society. As reiterated by several United Nations world conferences and summits, DRR and CCA are therefore not only an imperative to protecting investments in development, but also an opportunity for a transformative shift towards a more resilient, sustainable development. Their mainstreaming into development activities is seen as a way to enhance their effectiveness and longer-term impacts. DRR and CCA share the objectives of reducing the negative impacts of hazards through prevention, mitigation, preparedness, response and recovery measures; reducing vulnerabilities and exposure; and increasing resilience in the long-term. However, CCA deals rather with climate change and its impact on hazard patterns, while DRR deals with all hazards, including climate-related hazards but also geophysical and biological hazards. CCA also addresses more specifically the adaptation over the long term (since climate is defined as average weather, although it also looks at the changing risks due to extreme weather events), while DRR deals with all timescales, including sudden-onset hazards such as earthquakes and slow-onset ones such as drought and creeping environmental changes. CCA can therefore be seen as a focused subset within DRR, which in turn must be placed within its wider contexts of development and sustainability. Successful DRR requires consideration not only of the observed but also of the expected or possible changes in hazard characteristics, exposure and vulnerabilities.

What does DRR mean to an NMHS? For an NMHS, DRR is the desirable outcome of effective design, development and delivery of services that identify, provide and communicate hazard and risk information (including authoritative warnings) in such a way that the appropriate stakeholders and decision-makers, and the general public can take actions to protect lives, reduce economic losses and disaster risks, and ultimately increase community resilience through structural and non-structural measures – preventive, responsive and adaptive.

What does DRM mean to an NMHS? For an NMHS, DRM includes the processes by which the NMHS, working in partnership with other stakeholders, understands user requirements and disaster risks – hazards, exposure and vulnerabilities – and delivers effective and meaningful products and services for DRR to relevant decision-makers.

What is the role of NMHSs in DRM? Meteorological, hydrological and climate observations, monitoring, hazard and risk assessments to generate risk knowledge, predictions and related data management and processing by effective and efficient NMHSs are a fundamental input into sound DRM. For example, when “building back better” after a disaster, the location and construction of infrastructure should take into account various climate change scenarios. If construction cannot be undertaken to a certain level, then the appropriate early warning system must be put in place to warn communities of when critical thresholds that result in threats to lives and property are expected to be exceeded (depending on the accepted risk level – that is, also the community’s coping capacity). [Figure 12](#) presents a high-level overview of the pivotal role an NMHS plays – or could play – in its national DRR governance, and demonstrates both routine service delivery and more DRR-specific activities across all timescales, from weather- and flood-specific early warnings through to slower-onset seasonal or climate-service related information, in all phases of DRM:

- (a) Provide a single authoritative voice for meteorological, hydrological and climate hazard information and warnings (and for other hazards under their individual mandates) to be used in prevention, mitigation, preparedness (including early warning), response and recovery, as well as for risk and loss/damage assessments and financial protection;
- (b) Provide advice and approaches for prevention and mitigation actions that could be taken to reduce exposure to hazards and vulnerabilities, and increase societal resilience, through both structural and non-structural measures, such as, for example, the provision of design data climate advice that highlights the potential vulnerability of particular areas to known or expected hazards;
- (c) Inform, mobilize and partner with academic institutions and other experts that can contribute to this information and advice;

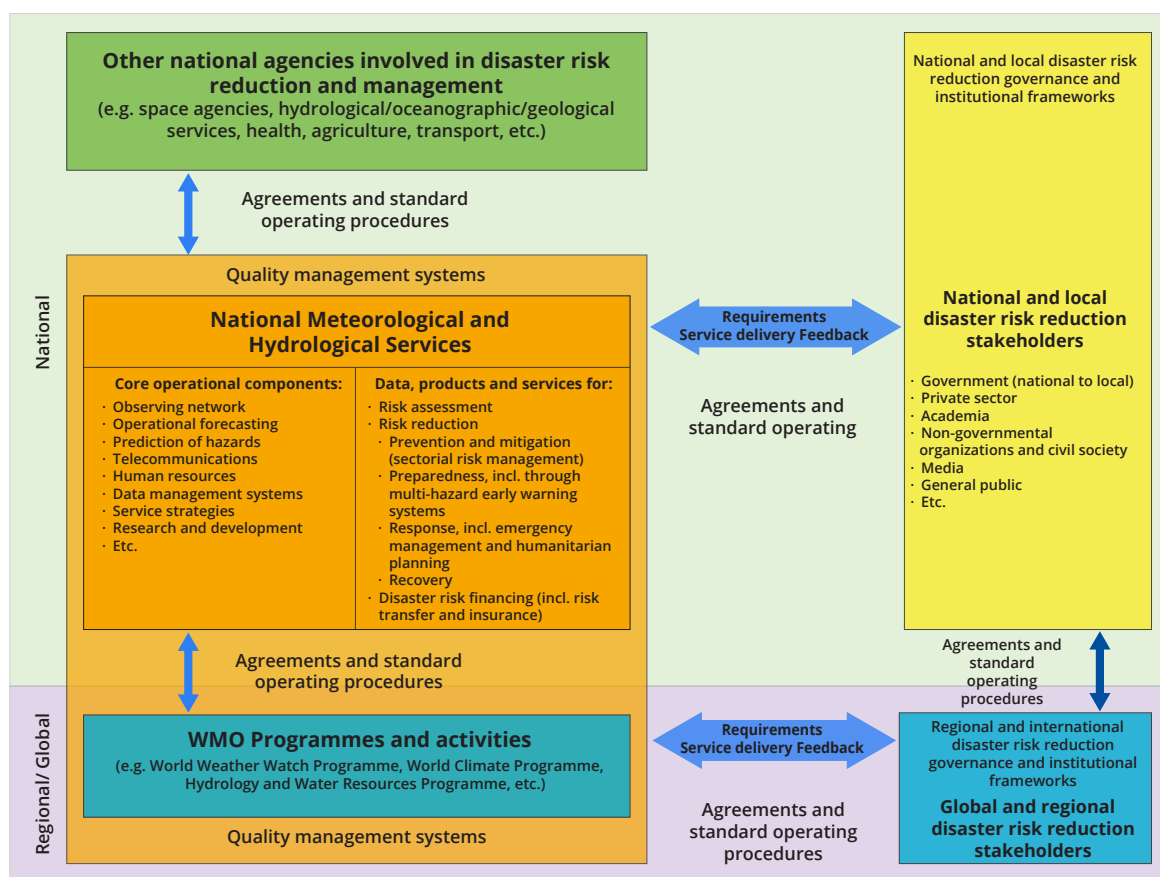


Figure 12. Overarching framework for the development and delivery of products and services by NMHSs and their partners to support DRM

- (d) Educate and raise awareness of the general public and tactical and strategic decision-making authorities (governmental and non-governmental entities) to understand hazards and related risks, warnings and associated uncertainties.

National Meteorological and Hydrological Services, most of which operate 24/7 throughout the year, and WMO as a whole, have an increasingly vast reservoir of scientific and technical expertise, data and tools that can be combined with local, regional and global knowledge to provide targeted services and products for DRM. These include detecting, monitoring, predicting and warning from a single authoritative source of a wide range of hydrometeorological hazards (for example, WIGOS, WIS and GDPFS). In collaboration with other international, regional and national organizations, WMO also contributes to reducing the impacts of other hazards such as those associated with space weather, geophysical phenomena, forest fires, and chemical and nuclear accidents (see, for example, the WMO Emergency Response Activities Programme and the support to the ICAO International Airways Volcano Watch Operations Group). In addition to public safety, such events affect water and food supplies, the environment, transport, health and other socioeconomic sectors.

The importance of service design, development and delivery in supporting the DRM process is most apparent in the activities described above. Therefore, all of these activities align with the six elements of service delivery as defined in the WMO Strategy for Service Delivery.² Moreover, there is a strong argument for considering DRR across all stages of the service delivery cycle. The development of approaches by NMHSs to support DRR should therefore follow the basic principles of establishing user engagement and partnerships to ensure that the development and

² WMO, 2014: *The WMO Strategy for Service Delivery and its Implementation Plan* (WMO-No. 1129), http://www.wmo.int/pages/prog/amp/pwsp/documents/WMO-SSD-1129_en.pdf.

delivery of services will respond to user needs and be continually monitored and improved. The success of service delivery for DRR depends on these factors as well as on respective research, capacity development, and knowledge management.

Regulations

As of 2017, there are no WMO regulations relating to DRR as a whole. However, training modules and guidelines, such as updated guidelines on MHEWS, are under development, as per requirements detailed in national legislation and legal frameworks, which impose requirements for the delivery of quality services to support safety and the protection of livelihoods and assets.

WMO bodies, Programmes and guidance

The World Meteorological Congress at its [fourteenth session](#) in 2003 established the [DRR Programme](#) (through Resolution 29 (Cg-XIV) – Natural Disaster Prevention and Mitigation Programme)³ with the aim of enhancing the contributions of NMHSs to DRR and DRM through improved capabilities and cooperation at all levels and in a more cost-effective, systematic and sustainable manner.

The long-term objective of the DRR Programme is thus to strengthen the technical and functional capacities of Members, their NMHSs and operational and research networks to provide meteorological, hydrological and climate services that will help reduce the risks of disasters. This will support decision-making and planning processes in DRM and emergency management and ultimately contribute to resilient and sustainable development under a changing climate. It requires the cooperation of WMO and NMHSs with multiple stakeholders through partnerships and engagement in various forums.

The thematic scope of the WMO DRR Programme encompasses strengthening of the capacities of NMHSs to:

- Cooperate and engage in disaster risk governance structures (and institutional frameworks) at all (national to local) levels;
- Support preparedness through (MH)EWS;
- Provide hazard information for risk assessments, prevention, response and recovery, and risk transfer in and across sectors such as infrastructure and urban planning, agriculture, health, transport and water-resource management;
- Respond to user requirements and share information and knowledge, for example through education and training, with and among partners and stakeholders.

The scope and goals of the DRR Programme were underpinned by the Hyogo Framework for Action 2005–2015: Building the Resilience of Nations and Communities to Disasters (Hyogo Framework) (adopted by the World Conference on Disaster Reduction, Kobe, Hyogo, Japan, 18–22 January 2005), which shifted the traditional focus of post-disaster response to a more comprehensive approach involving prevention and preparedness measures. The implementation of the Hyogo Framework by national governments has led to changes in national legal and institutional frameworks and policies on DRR, with implications for the role, responsibilities and working arrangements of NMHSs. These changes provided opportunities such as increased recognition of NMHSs by governments and stakeholders, which often resulted in strengthened partnerships and increased resources. However, NMHSs face new challenges and liabilities related to the provision of products and services to a larger and more diverse group of DRR stakeholders (such as government authorities, public and private sectors, non-governmental

³ The name was changed to “DRR Programme” by Congress at its fifteenth session in 2007.

organizations, the general public and the media) who have direct responsibilities for DRR decision-making. To meet these challenges, the WMO DRR Programme has highlighted the contribution of NMHSs to DRR in six thematic areas:

- (a) Hazard and risk assessment;
- (b) Prevention and mitigation;
- (c) Preparedness, especially through MHEWS;
- (d) Humanitarian planning and response;
- (e) Disaster risk financing including transfer mechanisms;
- (f) Engaging in DRR governance.

These thematic areas were derived from the general DRM framework and aligned with the Hyogo Framework, also expressed as activity categories for the implementation of the GFCS DRR priority.

Each of these six DRR Programme themes remains valid and adheres to a “people-centred approach” that was ratified in the Sendai Framework for Disaster Risk Reduction 2015–2030, adopted at the Third United Nations World Conference on Disaster Risk Reduction, Sendai, Japan, 14–18 March 2015. The Sendai Framework is built on elements that ensure continuity with the achievements made by countries and other stakeholders under the Hyogo Framework. However, it introduces a number of innovations, including a strong emphasis on DRM as opposed to disaster management; the substantial reduction of disaster risk (in addition to the reduction in losses of lives, livelihoods and health, and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries) as an expected outcome; and a goal focused on preventing the creation of new risks, reducing existing risks and strengthening resilience. Furthermore, seven global targets were agreed on and will be measured at the global level by appropriate indicators to support the assessment of global progress in achieving the expected outcome. Moreover, national targets and indicators will also contribute to achieving the goal of the Sendai Framework. States also defined the role of stakeholders and of international cooperation and global partnership.

An important role is played by NMHSs in the entire DRM process and thus in achieving all seven Sendai Framework targets. With their (often 24/7) operational capacities, dissemination mechanisms and expertise in the prediction of weather, climate and water hazards, NMHSs are uniquely placed for delivering multi-hazard early warnings, including those that are fast onset for which 24/7 operations are beneficial, by increasing the “availability of and access to multi-hazard early warning systems and disaster risk information and assessments” (Sendai Framework target g). Thereby NMHSs also provide hazard information for risk assessments that is used in the design, planning and implementation of preventative measures and for mitigation, preparedness, response and recovery activities. Combining these attributes will greatly contribute to decreasing societal exposure to hazards and consequently mortality, numbers of affected people, losses and damages (targets a–d). Finally, the role of WMO in international cooperation helps to implement the commitments made by the United Nations system and its Member States (target f).

Now that this new Sendai Framework is in force, with further implications for NMHSs and WMO, WMO has developed a DRR Roadmap for tailoring the DRR Programme to the Sendai Framework, specifically linking to the Framework’s four Priorities for Action through which States call to:

- (a) Strengthen the understanding of disaster risk;
- (b) Strengthen disaster risk governance to manage disaster risk;
- (c) Invest in DRR for resilience;

- (d) Enhance disaster preparedness for effective response, and “build back better” in recovery, rehabilitation and reconstruction.

The DRR Roadmap identifies how NMHSs and WMO are already, or will be in the future, contributing to the implementation of each of these priorities. In alignment with WMO and the DRR Programme vision statements, objectives and strategic goals, the WMO DRR Roadmap presents a vision for WMO support of DRR and aims at guiding WMO activities in all components and phases of DRM required to realise that vision. By doing so, the Roadmap also addresses the DRR-related goals and priorities of other international development frameworks. The Roadmap aims at improving the development, delivery and uptake of meteorological, hydrological and climate services for DRR in the six thematic areas of the DRR Programme. Each thematic area is addressed by the following six activity categories (largely corresponding to the stages and elements of the WMO Strategy for Service Delivery, mentioned above):

- (a) Stakeholder and user engagement;
- (b) Partnerships and collaboration (including resource mobilization);
- (c) Capacity development through knowledge products (for example, guidelines, standards and training modules);
- (d) Capacity development through pilot and demonstration projects;
- (e) Research and development;
- (f) Major DRR-related conferences and meetings.

The implementation of the WMO DRR Roadmap will be divided into specific building blocks grouping complementary activities from almost all WMO Programmes. Such an implementation plan or approach will provide the framework for Members, regional associations, technical commissions and other bodies to implement the Roadmap, leveraging and synergizing their work, and will be valid for each financial (that is, intersessional) period. Each financial period may include different phases such as the development, implementation, operation and evaluation of specific activities (as detailed, for example, in two-year DRR work plans). However, some activities will span across these intersessional periods and therefore need to be planned accordingly to ensure budget continuity. The structure and scope of the DRR Roadmap implementation plan as well as the necessary updates will be decided by the appropriate governing body.

Ultimate oversight of the DRR Programme is provided by the World Meteorological Congress and the WMO Executive Council. Specific guidance is currently given by the Executive Council Working Group on DRR. Relevant decisions are also taken by the sessions of the regional associations and technical commissions. Furthermore, DRR focal points in the regional associations, technical commissions and relevant (co-sponsored) programmes that do not directly serve a technical commission ensure coordination with these bodies and provide advice on the implementation of DRR-related activities within WMO. The annual and joint meetings of the presidents of regional associations and technical commissions provide another forum for guidance and exchange.

To support the implementation of DRR as a WMO priority and to better respond to user needs, as laid out in the WMO DRR Roadmap, guidance on the implementation of the DRR Programme is further provided by user-interface working groups on topics such as hazard and risk assessment, MHEWS and disaster risk financing. These groups have been established by the Executive Council to (a) guide the documentation of good practices and user needs and requirements for products and services thematic areas related to DRR; (b) support the development of, and provide feedback on, WMO DRR knowledge products such as guidelines, standards, training modules, and the like; (c) support the implementation of the national and regional capacity development projects. Their members are representatives of NMHSs as well as experts from other intergovernmental organizations and other international and non-governmental organizations, civil society, academia and the private sector.

Within the WMO Secretariat, the DRR Services Division under the Weather and DRR Services Department, as well as the cross-departmental Steering Committee on DRR, serves the implementation of the DRR Programme.

Publications and reports

A number of WMO DRR Programme publications can be accessed via the [WMO library website](#). More specifically, the following recent thematic publications and reports are available:

General

- Luther, J., 2015: Towards substantially reduced disaster risk in 2030. *WMO Bulletin*, 64(2). <https://public.wmo.int/en/resources/bulletin/towards-substantially-reduced-disaster-risk-2030-0>.
- Tang, X., M.V.K. Sivakumar, J. Luther and M. Williams, 2015: Building climate resilience through disaster risk reduction. *WMO Bulletin*, 64(1). <https://public.wmo.int/en/resources/bulletin/building-climate-resilience-through-disaster-risk-reduction-0>.
- World Meteorological Organization, 2017: A Disaster Risk Reduction Roadmap for the World Meteorological Organization. Geneva. https://library.wmo.int/opac/index.php?lvl=notice_display&id=19866%20-%20Wa5hhEbJcxg#.WhvqOk2ou70.

Multi-hazard early warning systems

- Golnaraghi, M. (ed.), 2012: *Institutional Partnerships in Multi-hazard Early Warning Systems: A Compilation of Seven National Good Practices and Guiding Principles*. Berlin, Springer.
- Luther, J., A. Hainsworth, X. Tang, J. Harding, J. Torres and M. Fanchiotti, 2017: Concerted international efforts for advancing multi-hazard early warning systems. In: *Advancing Culture of Living with Landslides* (K. Sassa, M. Mikoš and Y. Yin, eds). Volume 1 ISDR-ICL Sendai Partnerships 2015–2025. Springer International: 129–141.
- World Meteorological Organization, 2014: Synthesis of the status and trends with the development of EWS. Background Paper prepared for the Global Assessment Report on Disaster Risk Reduction 2015. Geneva, UNISDR. <http://www.preventionweb.net/english/hyogo/gar/2015/en/bgdocs/WMO,%202014a.pdf>.

Hazard risk analysis

- World Meteorological Organization, 2014: Atlas of Mortality and Economic Losses from Weather, Climate and Water Extremes (1970–2012) (WMO-No. 1123). Geneva.

Checklist for NMHSs

An NMHS is encouraged to check and follow up on the following items, as appropriate:

- Is the NMHS engaged, as appropriate, in national DRR and CCA governance (for example, through legislative or policy frameworks or institutional coordination mechanisms)?
- Has the NMHS identified, prioritized and established partnerships and service delivery agreements with the national DRR user community; developed mechanisms for engagement with these users for identification of their specific requirements; tailored delivery of products and services; and obtained ongoing feedback on these products and services?

- Has the NMHS established partnership agreements with other national technical agencies (such as hydrological or ocean services, statistical offices and DRM agencies) as well as global and regional specialized centres (such as Global Producing Centres, RSMCs, or Regional Climate Centres) for improving their services to the DRR user community?
- Is the NMHS developing and delivering core and specialized products and services for DRR decision support (for example, hazard analysis for sectoral risk management and disaster risk financing, and multi-hazard early warnings) in a cost-effective, systematic and sustainable manner?
- Has the NMHS ensured that core operational capacities and procedures (for example, observing networks, operational forecasting systems, telecommunication systems, data management systems and human resources) are built upon QMS principles to support product and service development for, and delivery to, DRR end users?
- Has the NMHS engaged in regional and global efforts for the development of risk information for large-scale and transboundary hazards, through strengthened regional and global cooperation, information sharing, and engagement, for example, in regional and global DRR platforms and Regional Climate Outlook Forums?
- Are national strategic plans for strengthening and modernizing the NMHS derived from and consistent with broad national planning objectives in areas relevant for DRR, including, inter alia, emergency management, sustainable development, CCA, aviation, agriculture, energy and water resources? Are these plans consistent with, and do they specify linkages to, regional and global plans and policies in relevant areas of weather, climate and hydrological services, as appropriate, and are they also compliant with WMO standards?

CHAPTER 6. LEADERSHIP AND MANAGEMENT IN A NATIONAL METEOROLOGICAL AND HYDROLOGICAL SERVICE

In a complex, fast changing and interactive world, it has become clear that, in addition to developing sustainable scientific and technical capability, NMHSs must have effective and adaptive leaders; this needs to be reflected in the capacity-building efforts of individual NMHSs and in the wider WMO context.

The following sections outline some of the challenges of senior leadership and management in an NMHS, make a distinction between the terms "leadership" and "management", and examine in greater depth a set of detailed capabilities needed by a senior executive in an NMHS.

6.1 THE LEADERSHIP CHALLENGE

A senior leadership role in an NMHS is a demanding task. The transition to a management and leadership role in an NMHS can also be challenging for the individual concerned.

For those transitioning from scientific or technical roles within the NMHS, the challenges can be related to new kinds of responsibilities in the management of people, planning and policy development, financial management, identifying opportunities to enhance financial support, dealing with stakeholders and other areas of government, and performing representational roles. Such a transition requires a particular set of skills and behaviours that are not easily acquired.

Those coming to a senior management role at an NMHS from outside may have management and leadership experience in other areas but not be familiar with the specific context of running a meteorological service.

While the terms "management" and "leadership" are sometimes used interchangeably, for the purposes of these Guidelines, "management" is taken to mean the process of managing an organizational activity and the people involved, and "leadership" implies more of a role in setting the direction, developing a vision and inspiring others to develop their full potential.

The importance of leadership- and management-development support for directors and senior staff of an NMHS has been recognized by WMO. A number of mechanisms are available to support capacity development in this area.

It is not possible or appropriate in these Guidelines to provide definitive or extensive material on leadership. The topic is addressed in business courses, books, and training and development programmes around the world. Moreover, a large majority of governments already have significant, high-quality leadership development programmes. For the purposes of these Guidelines, the following sets a context for the leadership role of an NMHS director in the 2010s.

The director of an NMHS has a number of demanding roles, including, typically:

- Chief executive;
- The role of Permanent Representative of the Member with WMO (see [section 4.2 – The role of the World Meteorological Organization Permanent Representative](#));
- Being responsible to a government minister (or a more senior government official);
- Legal responsibilities if the NMHS has a related legal framework;
- Principal advocate for the NMHS in terms of status, visibility and resourcing of the NMHS;

- The key person in setting the vision and culture of the organization for the staff of the NMHS;
- Responsible for development of the staff and infrastructure of the NMHS;
- Spokesperson for the NMHS in the media;
- Principal representative in partnership arrangements;
- A key person in the management of relationships with major user groups;
- Membership of related boards and councils.

In the second decade of this millennium, the pressure on directors and senior staff of NMHSs has increased significantly, owing to issues such as:

- The global focus on the importance of climate change and variability;
- The frequency and severity of major disasters and the increase in populations and infrastructure exposed to risk;
- Increased awareness among users of the issue of climate variability and change and growing demand for user-targeted services;
- Internationally agreed development goals to which WMO Members are expected to contribute;
- International collaborative projects that offer benefits to the Member and the NMHS but require efforts for successful engagement;
- Improvements in observational, forecasting, communication and information technology;
- The overall pace of social and technological change.

A leadership and management issue that has been gaining increasing attention internationally is the need and the potential for greater engagement of women in NMHSs, especially in leadership roles. WMO has shown leadership in this area on behalf of Members, including by holding the Gender Dimensions of Weather and Climate Services conference in Geneva in November 2014. At its seventeenth session, the World Meteorological Congress adopted [Resolution 59 \(Cg-17\) – Gender equality and empowerment of women](#).

Some of the most common challenges for directors and senior staff are:

- Ensuring the NMHS is able to meet national needs for meteorological and related data and services that are relevant and sustainable;
- Clarifying and articulating the mandate of the NMHS;
- Formulating and implementing effective strategic plans;
- Developing strong arguments to obtain sufficient financial, technical and human resources to carry out the NMHS mandate;
- Recruitment, retention, motivation and reward systems for staff;
- Maintenance of networks, equipment and other supporting infrastructure;
- Providing relevant, quality services to meet various end-user needs;
- Developing sustainable capacity and performance;

- Managing development projects;
- Keeping abreast of relevant developments in science and technology;
- Appreciation of, and ability to meet, international obligations, agreed development goals and other international initiatives;
- Stakeholder relations (government, end users, partners, staff).

6.2 A LEADERSHIP CAPABILITY FRAMEWORK

The needs of individual NMHS directors for information, advice and support will vary, as will their own pace of development, depending on factors such as the size of the NMHS, the scope of its responsibilities, the vulnerability of the country and their own background.

In the context of these Guidelines, directors who have a background in meteorology or a related scientific discipline and moved relatively recently into their leadership role may wish to focus on the general leadership and management information, while those from non-scientific disciplines and administrative or business backgrounds may focus more on the material related to the roles, functions and operations of an NMHS.

Specific aspects of the role of the Permanent Representative of a Member with WMO are addressed in [section 4.2](#) of these Guidelines.

Just as competency standards in technical areas such as aviation services have emerged as a significant issue over the past decade to support organizational capability in the delivery of aviation services, so too has the issue of executive capability frameworks for organizations. The leadership capability framework described here sets out the key attributes for senior executives in the Australian Public Service and can be used as a guide to the mix of leadership skills desired in a director of an NMHS (see [Figure 13](#)). Consistent with contemporary trends in management and leadership in the 2010s, this framework is also intended as a guide to help senior executives assess their own development needs or the conditions for recruiting key people to their senior team. In addition, recognizing that different leaders have different natural strengths, this list helps to identify the mix of skills that they might need to develop in their current senior management team.

Shapes strategic thinking

Manifests a sense of purpose and direction

- Personally contributes to, shapes and champions the organization's vision and goals, relating these to government requirements;
- Translates broad strategy into practical terms for others and creates a shared understanding of what has to be achieved;
- Within the overall strategic context, presents others with an integrated picture of the actions and priorities that will be required;
- Provides a clear sense of direction and endeavours to unite understanding among all levels within the organization.

Focuses strategically

- Develops and provides advice to government on potential outcomes and formulates a long-term perspective on organizational success;

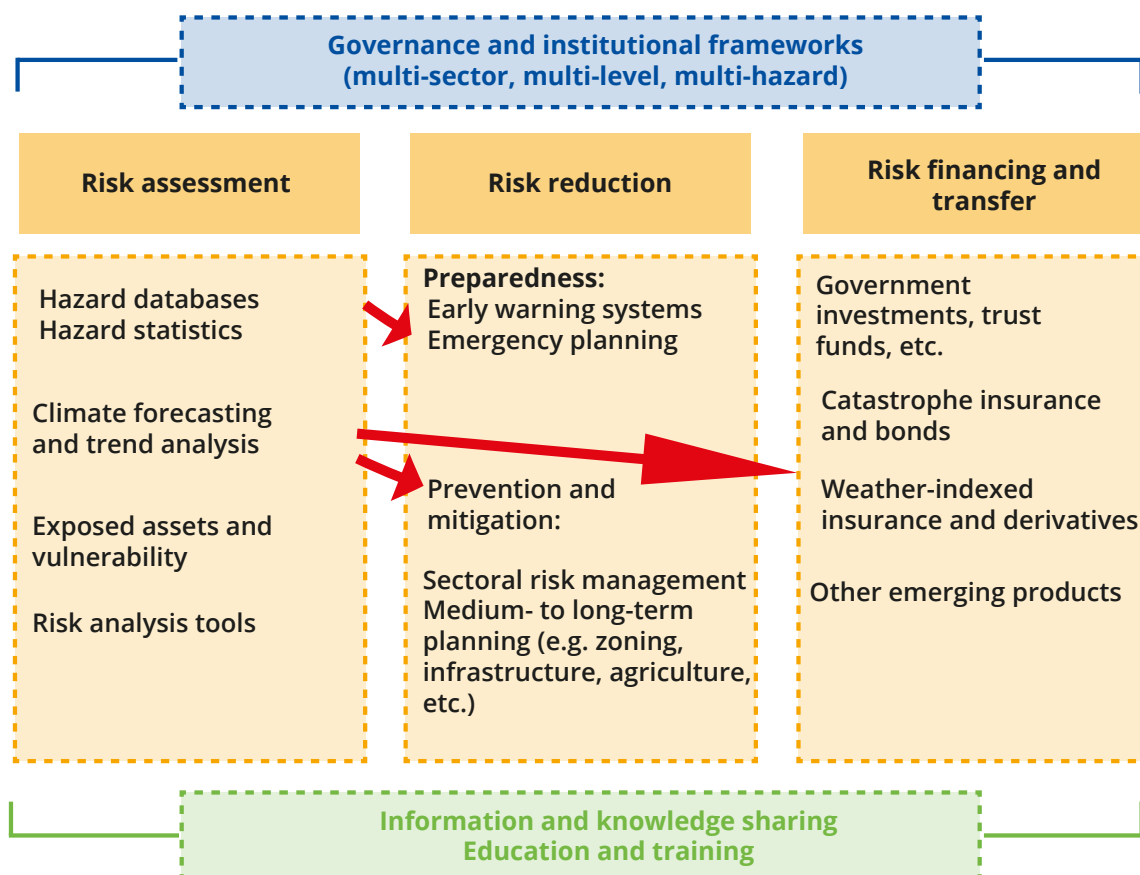


Figure 13. A leadership capability framework

- Integrates a big-picture view of goals into plans on how to achieve them;
- Operates in a framework taking into account the whole of government and the broader context. Ensures portfolio effort contributes to cross-government priorities;
- Envisages what might be and how future possibilities balance with the current situation.

Harnesses information and opportunities

- Seeks to acquire knowledge and is open to new information and different perspectives;
- Values finding out about global best practices (public and private sector) and considers the workings of the organization within this context;
- Demonstrates business acumen by thoroughly researching the market that the organization operates in (as well as opportunities offered and constraints imposed) to yield greater efficiency and improve quality of service;
- Keeps abreast of major technological changes and their impacts.

Shows good judgement, intelligence and common sense

- Grasps complexity and identifies issues that tend to be overlooked by others;
- Thinks problems through from various angles and analyses them dispassionately and objectively;

- Probes and critically evaluates information before applying both intellect and experience to final judgement;
- Is willing and able to question traditional assumptions and practices rather than taking them as given;
- Has the capacity to provide originality of thought and develop innovative solutions.

Achieves results

Builds organizational capability and responsiveness

- Initiates fluid and flexible resourcing activities based on an appreciation of emerging requirements in a constantly changing environment;
- Looks outside of organizational silos to identify what resourcing combination will deliver the best results, rather than being bound by existing organizational structures and processes;
- Responds flexibly to various stakeholder requirements and changing circumstances as they arise, varying deployment of resources within imposed constraints;
- Exploits the advantages offered by information technology;
- Takes action to ensure sustainability.

Mobilizes professional expertise

- Values specialist expertise and places emphasis on creating an environment that facilitates the sharing and effective utilization of professional knowledge and skills;
- Ensures relevant professional input from others is obtained.

Steers and implements change and deals with uncertainty

- Develops and oversees the implementation of change initiatives in a sometimes uncertain environment;
- Defines high-level objectives and ensures translation into practical implementation strategies;
- Undertakes both long- and short-term planning and sets timescales for completion.

Ensures closure and delivers on intended results

- Engenders a culture of achievement by ensuring that ideas and intended actions become reality and planned projects actually result in expected outputs;
- Puts systems in place to establish and measure accountabilities.

Cultivates productive working relationships

Nurtures internal and external relationships

- Builds relationships within government, within the organization and with key people in external organizations;
- Creates proactively a professional network and develops mutually beneficial relationships based on respect;
- Shows commitment to customer service.

Facilitates cooperation and partnerships

- Puts effort into developing a work environment where people pull together and value collaboration and teamwork;
- Creates a sense of interconnectedness with other departments and agencies, ensuring opportunities to share views and ideas;
- Personally manifests interpersonal relations by role modelling and exhibiting team-player behaviour, including a willingness to consult and listen.

Values individual differences and diversity

- Recognizes different skill areas and levels of expertise. Understands others and responds to them in an appropriate way;
- Supports and respects the individuality of others and recognizes the benefits of having a diversity of ideas and approaches.

Guides, mentors and helps people develop their skills

- Inspires ongoing learning in others;
- Gives timely recognition for good performance;
- Motivates others with an enthusiasm to give their all by setting challenging goals, as well as supporting and encouraging them when they need assistance to overcome problems;
- Helps others to address areas of weakness by encouraging them to take an active role in their own development and creating a climate with opportunities to do so;
- Understands when it is appropriate to confront issues and takes action to deal with difficult performance situations.

Exemplifies personal drive and integrity

Demonstrates public service professionalism and probity

- Establishes, adheres to and promotes the values and ethical framework of the organization.

Engages with risk and shows personal courage

- Is prepared to be forthright and to tell it like it is (and not how people might like it to be);

- Is independently minded and willing to challenge ideas and confront issues;
- Is prepared to acknowledge when in the wrong and learns from mistakes;
- Is prepared to ask for help and values advice from others.

Commits to action

- Is determined, highly motivated and action-oriented;
- Takes personal responsibility for getting things done and for the success of the organization;
- Handles issues proactively and tries to shape events;
- Does not procrastinate;
- Readily invests energy and initiative into advancing work.

Displays resilience

- Remains focused on the objectives, even in difficult circumstances;
- Bounces back after setbacks and remains positive;
- Maintains energy and willingly invests extra effort when required.

Demonstrates self-awareness and a commitment to personal development

- Shows commitment to continued learning;
- Actively seeks feedback from a wide range of sources;
- Takes responsibility for self-development and self-management in a way that enables sustained performance;
- Looks for opportunities to enhance own skills;
- Values continuing development.

Communicates with influence

Communicates clearly

- Produces user-friendly verbal and written communication that is clear and concise;
- Ensures unambiguous delivery of the message and checks that it has been understood as intended;
- Keeps people up to date and fully informed of any changes to the original communication.

Listens, understands and adapts to audience

- Listens actively to ensure views and information are properly exchanged;
- Checks with others to ensure their views have been accurately understood;

- Uses and adapts style as necessary to meet the requirements of the audience;
- Creates opportunities to listen to those whose input can add value.

Negotiates persuasively

- Establishes credibility and approaches negotiations persuasively;
- Offers a convincing rationale that has been thought through in advance and carefully positioned with reference to desired organizational outcomes;
- Allows for a genuine contest of ideas, pulls disparate views into a coherent position and finds common ground to facilitate agreement and acceptance of mutually beneficial solutions;
- Reaches negotiated positions, through compromise, which lead to the achievement of the required outcomes.

CHAPTER 7. CAPACITY DEVELOPMENT

The ability of an NMHS to carry out its role of conducting national observations, collecting data and delivering services to meet the needs of the national community and the economy, to contribute to regional and global issues and to conduct research depends on the infrastructure and human resource capacity available to it.

While science and technology developments have had a great impact on meteorology and related sciences, many NMHSs in developing countries cannot take full advantage of these improvements owing to a lack of infrastructure and skilled staff.

7.1 **WORLD METEOROLOGICAL ORGANIZATION CAPACITY DEVELOPMENT STRATEGY**

In the WMO Strategic Plan, capacity-building for developing countries and least developed countries is a strategic priority area because it is critical to enhancing the capacities of NMHSs to improve the quality and delivery of services in cooperation with users in other governmental organizations, civil society, the private sector and intergovernmental groups. WMO action on this is aligned with the Capacity Development Strategy approved by the World Meteorological Congress at its [sixteenth session](#) in 2011, and the Capacity Development Programme approved by Congress at its [seventeenth session](#).

WMO Capacity Development Strategy

The need for WMO capacity development assistance is grounded in the WMO Convention, which recognizes that Members need to work with each other and with other organizations to coordinate, standardize, improve and encourage efficiencies in the exchange of information to further its application to the needs of society. The Convention further notes the vital mission of National Meteorological and Hydrological Services in the provision of weather, climate and water observations and services, and their contributions in addressing societal needs. WMO implements its Programmes through the NMHSs of its Members and utilizes the capabilities of NMHSs to provide effective services for the safety and well-being of society. The scope of the services provided by NMHSs has increased as the need for environmental information has grown. The increasing vulnerability of many societies to natural hazards and extreme weather events, and the sensitivity of national economies to climate variability and change have exposed gaps in the capabilities of NMHSs, particularly those of developing countries, least developed countries and small island developing States. The Sixteenth World Meteorological Congress considered that the collaborative work of WMO depends on observations and technical contributions from the NMHSs of developing and developed countries alike. Therefore, assisting the NMHSs in developing countries to fill these gaps is necessary to the work of WMO and benefits all WMO Members.

The World Meteorological Congress at its sixteenth session adopted the WMO Strategic Plan 2012–2015, which recognizes capacity-building for developing and least developed countries as one of the five strategic priority areas expected to make a significant contribution to the achievement of the expected results. To further elaborate on how capacity-building as a cross-cutting priority will be addressed and in light of the factors discussed above, the Sixteenth Congress adopted [Resolution 49 \(Cg-XVI\) – WMO Strategy for Capacity Development](#).

The purpose of the Capacity Development Strategy is to provide WMO with a coordinated and cohesive approach to capacity development activities to help Members fulfil their mandates and contribute to the goals of the Organization. The overall objective of the Strategy is to foster effective capacity development assistance to WMO Members and facilitate sustainable development of their National Meteorological and Hydrological Services, particularly in developing countries, least developed countries and small island developing States. The Strategy seeks to build upon existing capacities in NMHSs, reduce duplication and utilize opportunities

to leverage investments in strategic partnerships and synergies. It also aims to integrate the roles and requirements of regional associations, technical commissions, WMO co-sponsored programmes and WMO Programmes within the strategic priority areas in the provision of development assistance to Members.

The Strategy requires a collaborative approach to what is a common goal. However, particular emphasis is laid on the role of national governments, especially in planning and sustaining the capabilities of NMHSs, in partnership with the regional and global community. The importance of NMHSs for public safety, security, national development and general socioeconomic benefits flowing from weather, climate and hydrological services is also emphasized. Correspondingly, the Strategy is designed to have its greatest impact at country level. The Organization's facilitative role will focus on strengthening NMHSs, enhancing subregional, regional and global cooperation while providing a framework for NMHSs to advocate services that further national policies, strategies and plans.

A distinction is made between "capacity-building" and "capacity development". The former implies that no capacity exists, while the latter considers existing capacities with an emphasis on a more holistic approach and national ownership of the development process. By using the term "capacity development", WMO acknowledges that its assistance to NMHSs must be informed by existing and planned capacities.

"Capacity development" is thus the process of strengthening the abilities or capacities of individuals, organizations and societies to solve problems and meet their objectives on a sustainable basis. Its essential characteristics can be described as follows:

- It is a continuous improvement process with feedback mechanisms rather than a short-term intervention;
- It aims to augment capacity in a manner conducive to sustained growth;
- It includes the activities, approaches, strategies and methodologies that help organizations, groups and individuals improve their performance and generate development benefits;
- It is an internal process driven by national mechanisms and facilitated by complementing external agencies;
- It should be evaluated based on growth as a whole and over time.

The definition also implies that NMHSs should have linkages to national, subregional and regional planning and political processes to ensure sustainability, as well as coordination and cooperation with related capacity development activities.

"Capacity-building", on the other hand, implies the process that tends to support the initial stages of building or creating capacities, based on an assumption that there are no existing capacities. This can be relevant to crisis or immediate post-conflict situations but it is considered to be less comprehensive than capacity development.

The WMO Capacity Development Strategy recognizes that there are four types of capacity: institutional, infrastructural, procedural and human resources. These four dimensions are distinct yet interrelated and must be considered holistically to achieve sustainable capacity development. The Strategy also recognizes that WMO capacity development activities should be monitored and results evaluated for sustainability over time.

For more information on the Capacity Development Strategy, please refer to the [*WMO Capacity Development Strategy and Implementation Plan*](#) (WMO-No. 1133).

WMO Capacity Development Programme

The overall objectives of the Capacity Development Programme are to implement the Capacity Development Strategy, in close collaboration with the WMO Regional Programme and WMO scientific and technical Programmes, by assisting Members:

- To identify the services required of NMHSs as well as the human, infrastructural, institutional/legal and procedural gaps that limit a Member's ability to deliver these services;
- To identify gaps that may exist in a Members' compliance with WMO Technical Regulations with a view to using this information to further the development and enhancement of their NMHSs towards reaching compliance;
- To formulate strategic plans and appropriate project/programme proposals for NMHSs to meet domestic and international obligations and to seek appropriate national and regional political support for their implementation;
- To gather and exchange information on the needs of potential recipient Members and on the possible assistance that could be offered by other Members and potential development partners and institutions, as well as on the mobilization of the required national and international resources;
- To develop and implement regional and national capacity development projects and programmes, and to enhance services derived from meteorology, hydrology, climatology, and other environmental sciences, as required;
- With the support necessary to ensure that relevant scientific and technical aspects of projects and national development activities are in line with the established WMO standards, guidelines and recommended practices;
- To develop the capacities of their NMHSs and of relevant national and regional institutions by advocating for external and internal support as may be necessary to meet national requirements for services, fulfil national development activities and comply with WMO standards;
- Through the promotion of international cooperation in capacity development of NMHSs and related institutions to ensure that Members have the pertinent capacity and resources needed, particularly to bridge the gap between the levels of relevant services provided;
- To ensure, through the establishment of dynamic and synergistic partnerships with development partners and regional and international organizations, such as those within the United Nations system, that the relevant meteorological, hydrological and environmental aspects of projects derived from these partnerships are developed and implemented according to the recognized standards and guidelines;
- To build the technical, strategic, operational and managerial skills of NMHS staff, including skills for the mobilization of resources, as critical aspects for ensuring sustainable development of the NMHS and related services.

For more information on the WMO Capacity Development Programme, refer to the [Abridged Final Report with Resolutions of the Seventeenth World Meteorological Congress](#) (WMO-No. 1157).

7.2 IMPLEMENTATION OF THE WORLD METEOROLOGICAL ORGANIZATION CAPACITY DEVELOPMENT STRATEGY

The WMO Capacity Development Strategy is being implemented within a strategic framework (see [Figure 14](#)) consisting of an eight-step process (as shown in [Figure 15](#)), combined with other elements related to complementary WMO Programmes and strategies, and the different aspects of NMHS needs.



Figure 14. The strategic framework for the WMO Capacity Development Strategy

The other elements of the strategic framework are:

- The four dimensions of capacity development: human, institutional, infrastructural and procedural;
- The WMO Strategic and Operating Plans 2016–2019 (SOPs);
- The WMO Programmes;
- The complementary roles of the WMO constituent bodies, WMO Secretariat, Members and partners in capacity development;
- The quality management system, which is a set of interrelated or interacting elements that organizations use to direct and control how quality policies are implemented and quality objectives are achieved (see [section 8.8 – Quality management frameworks](#));
- The WMO Strategy for Service Delivery, which seeks to build and institutionalize practices to strengthen service delivery by describing key strategy elements and activities.

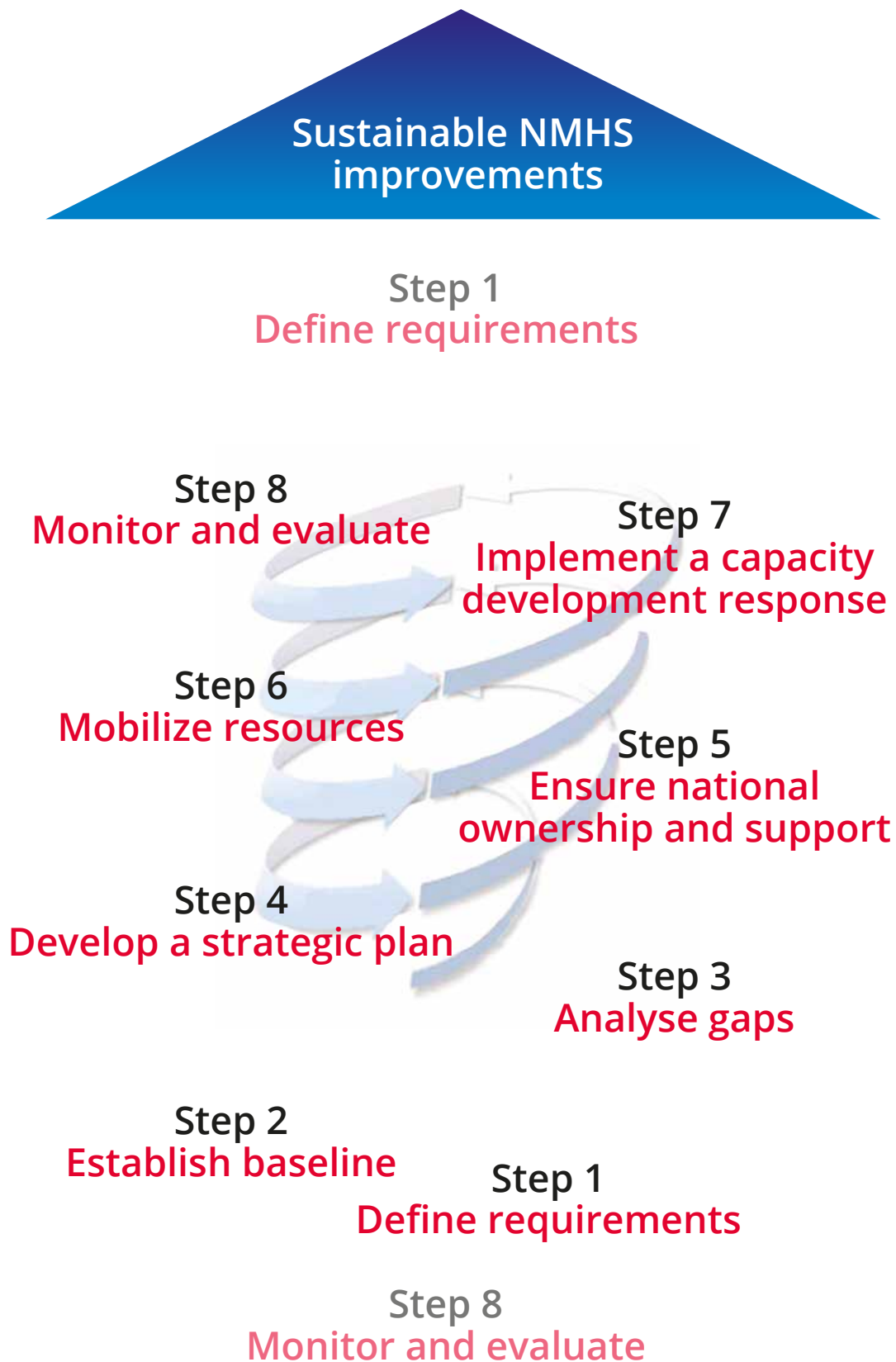


Figure 15. The eight steps of the WMO capacity development process

7.3 **THE CHALLENGES OF IMPLEMENTING THE STRATEGY IN SMALLER NATIONAL METEOROLOGICAL AND HYDROLOGICAL SERVICES**

The Capacity Development Strategy framework provides a pathway for identifying the needs of an NMHS, and, with the help of WMO and donors, developing specific projects to improve the capacity of the NMHS. However, for small NMHSs there are often difficulties in the practical implementation of projects and in realizing the intended benefits for themselves and the Member.

Having a good strategic plan for the NMHS itself is an important prerequisite for a successful project. This enables the government to understand and appreciate how improving the NMHS will assist national plans and objectives, facilitates engagement of the users of NMHS services, and helps the donor to identify how the project will fit with and link to other parts of the NMHS. Strategic planning is addressed in more detail in [Chapter 8 – Planning](#).

With a strategic plan in place, it is easier to identify and develop plans for specific projects. But the project implementation is often a challenge when it comes to the capacity of the NMHS to absorb the project. This can be influenced by factors such as inexperience in specifying and managing projects, lack of skilled staff, changes in government priorities, or weaknesses in other parts of the NMHS affecting the project. In some cases, a project may be successfully implemented but fails after a few years because the NMHS may be vulnerable to resource or priority changes affecting the project's sustainability.

The [WMO Capacity Development Strategy and Implementation Plan](#) (WMO-No. 1133) identifies some successfully implemented projects. But because of the challenges to implementing successful, sustainable projects in smaller NMHSs, WMO, donors and other parties, such as equipment suppliers, are increasingly focusing on ways of improving this process.

Some examples of general guidance on project implementation are included in [Chapter 8 – Planning](#).

CHAPTER 8. PLANNING

Planning in an NMHS is a critically important function that requires substantial effort from the director and senior leadership team. While crises, other urgent matters and everyday routine activities tend to consume most of the available time, good-quality planning and the existence of a plan are important for the long-term success of the organization.

The following sections look at the nature of planning and the different types of plans relevant to an NMHS and show the connection between planning and quality management.

8.1 THE NATURE OF PLANNING

While effective management of the day-to-day running of an NMHS is the most time-consuming aspect of a director's work, planning is key to sustaining and developing the organization.

Plans are needed for different purposes and timescales, but the three most common types applicable to an NMHS are addressed here: Strategic plans usually cover a three-to-five-year timespan. In some NMHSs, a long-term strategic plan may span 10 years or more. This could be internal to the NMHS or may be part of a wider national or donor-driven, long-term development plan. Annual plans are the statement of intent for an operational year, usually linked to the annual budget period for the NMHS. Project plans are relevant to specific development or upgrading initiatives. In the case of major projects supported by donor agencies, a project plan may be substantial and require similar commitment to that needed for strategic and annual plans.

The planning described here is for the whole organization. Other types of plans related to specific functional activities or components of an NMHS, [such as workforce planning](#), are discussed under their specific headings.

The main purpose of planning is to support the operation and development of the NMHS by providing managers and staff with an agreed, clear statement of intended priorities, specific goals and the actions and timeframes to achieve them. Additional important purposes of the plans can be to help secure resources for the NMHS and to communicate to government and external bodies.

8.2 STRATEGIC PLANS

A strategic plan is intended to establish the direction of an NMHS over the period of the plan (for example, three to five years) and the specific goals and the strategies and actions to achieve them. Both the plan and the associated development process are valuable for maintaining and developing the capacity of an NMHS in a sustainable way. Planning on a timescale of three to five years offers the chance to:

- Sharpen and clarify the vision and mission of the NMHS;
- Analyse the external and internal influences for the planning period;
- Identify the desired position for the end of the planning period;
- Assess the gap between the desired position and the present;
- Develop strategies and actions to bridge the gap;
- Secure resources to implement the plan;
- Assign key measures to assess performance;

- Set up a system for monitoring, evaluating and adjusting the plan.

The content of the strategic plan for an NMHS will be influenced by other broader plans, including:

- Relevant national plans
- The [WMO Strategic Plan](#)
- WMO Regional plans
- The contribution of WMO to broad international development

The intended audience is an important consideration for the style and detail of the document. A plan targeted mainly internally as a working document might have more detail than a plan that is also intended for external consumption.

There are a number of ways to structure and develop the plan. The process for preparing a strategic plan for an NMHS is a critical, high-level function that should be established and guided but is necessarily chaired by the director. The planning group should include the senior managers responsible for the key functional areas of the NMHS, including the finance and personnel managers. In a larger NMHS, a small planning group may be convened to support the planning work of the senior executives.

A sample process for developing a strategic plan is shown in [Figure 16](#).

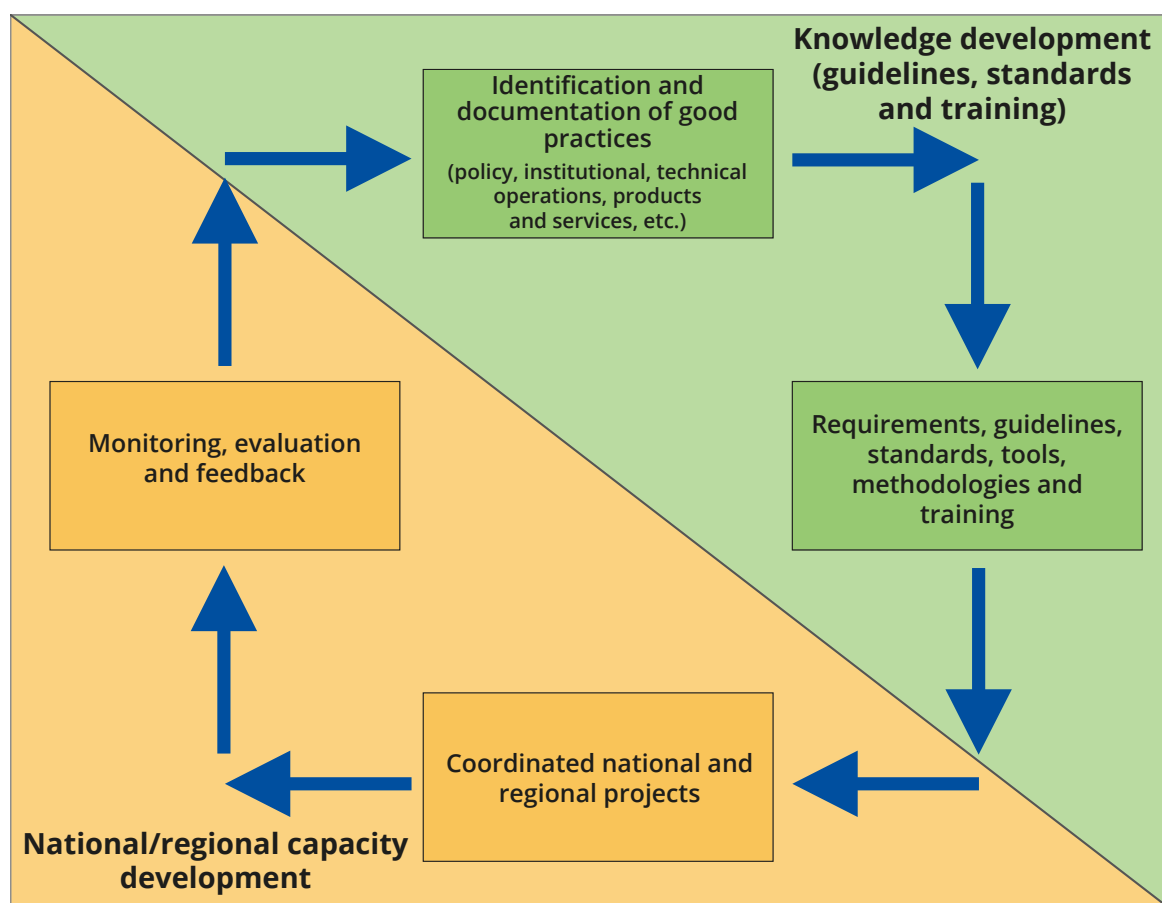


Figure 16. Sample process for developing a strategic plan

Books on management and examples on the Internet provide numerous options for structuring and developing a strategic plan. The terminology varies, but the basic approach described above is fairly consistent in the different models. The WMO Strategic Plan and plans by other NMHSs also give guidance.

Here are some explanations of terms commonly used in developing a strategic plan:

- Vision – a statement about how the NMHS is seen in the world and the benefit or outcome for the nation (the "why?");
- Mission – the description of the role of the NMHS and what it does to carry out that role;
- Values – can be a statement about the organization's values as regards the way it carries out its work and its dealings with staff and clients;
- Environmental analysis – a brief analysis of factors in the external environment that could have an impact on the NMHS. This may include international factors, national factors such as the economy and government policy, and factors affecting weather-sensitive sectors;
- Present situation – a brief summary of the existing situation for the NMHS and how it is performing in carrying out its role. This might include internal factors such as the number and the capabilities of staff, technical equipment and other infrastructure and financial resources;
- Desired position – a statement on the position the NMHS can realistically aspire to by the end of the planning period;
- Gap analysis – identification and brief discussion of the differences between the desired position and the present;
- Analysis of the strengths, weaknesses, opportunities and threats (SWOT) – taking into account the previous four sections, the SWOT analysis is a grouping in bullet-point form, usually displayed in a 2 x 2 matrix, of the strengths and weaknesses, and the opportunities and threats, for the NMHS;
- Goals, strategies and actions – the setting of major goals and outlining of the strategies and specific actions to achieve them;
- Resources – if the document is to be used as part of an argument for funding or if used mainly for internal purposes, this section gives a broad outline of the financial, staff and technical resources needed to implement the plan (see later sections on [workforce](#) and [financial](#) planning);
- Performance measurement, monitoring and review – this section identifies the key measures of performance, how progress will be monitored and when and how the plan will be reviewed (see also [the section below concerning performance setting and reporting](#)).

Some examples of NMHS strategic plans are:

- [United States National Weather Service Strategic Plan](#)
- [Australian Bureau of Meteorology Strategic Plan 2010–2015](#)
- Strategic Plan for the Development of Meteorology in Djibouti 2015–2019
- Strategic Plan for the Development of the National Meteorological Service of Benin

8.3 ANNUAL PLANS

The annual plan for an NMHS is usually the work plan or operational plan devised to align with the strategic plan and support budget proposals. Once finalized, it shows the work expected to result that is consistent with the budget – sometimes referred to as a result-based budget. Alternative names could be “annual plan and budget” or “annual programme and budget” (for a discussion of financial management aspects, see [Chapter 10 – Financial management](#)).

The main features of an annual plan usually are:

- The strategic setting identified in the strategic plan;
- The specific outputs or goals to be achieved in the budget year;
- The activities that will be undertaken to achieve the goals;
- A time frame for goals and activities;
- Identification of those responsible for the activities;
- The resources allocated to implement the plans;
- Mechanisms for monitoring the plan.

The components of the annual plan provide the basis for preparation of the NMHS annual report.

The structure and detail of the plan will depend on the scope of the functions carried out by the NMHS. Typical core programmes might include:

- Observations
- Communications and computing
- Weather services and warnings (and subcomponents such as aviation, marine, or public services)
- Climate services
- Hydrological or water services
- Research
- International programmes

In a programme and budget model, each programme will show the resources allocated to it.

8.4 PROJECT PLANS

Project plans are similar to annual plans but focused on a specific project over a period that can vary from several months to several years. In some cases, the project plans will be included in the NMHS annual plan.

Project plans are usually required for larger upgrade projects that have a specifically identified budget resource. Donors require project plans and will most often have set formats to meet their requirements. This will include how the project can be supported within the overall plans for the NMHS and will aim:

- To define the project – to say what the project is and how it will be controlled;

- To support decision-making – to provide the sponsor or steering committee with the information needed to decide to move on to the delivery stages;
- To provide an ongoing reference – for those coming into the project later on and those who need to know what the procedures and controls are, for example, to submit a change or report a new risk.

The component parts of a successful project charter are:

- Objectives – the agreed objectives for the project;
- Scope – what is included in the project and what is excluded; where confusion may exist;
- Business case – the justification for running the project, together with a list of benefits and how they will be measured;
- Roles and responsibilities – who is doing what in this project; this section can also list the stakeholders, i.e. those with an interest in the project;
- Communications management plan – what information will be given out and how it will be communicated, including internal reports of the project (which may be verbal);
- Quality plan – the level of quality that is needed, how the project will achieve that quality and how the project will be audited to be sure that the quality has indeed been achieved;
- Risk plan – how risk will be controlled in the project and who is responsible for it;
- Project plan – information on what will be produced, the activities needed and the required resources, notably in terms of finance and staff time;
- Control procedures – in anything other than a small project, people need a clear statement of procedures, for instance, for reporting problems. This section can also set down the project manager's authority limits and the procedures for referring anything beyond the project manager;
- Constraints – anything that affects how the project is run and delivered, such as security, a fixed delivery date or limitation on the type of equipment used.

NMHSs seeking technical cooperation assistance should check with donors on guidelines for project formulation. Within WMO, a range of guidance material is available, for example, the [note on the preparation of requests for assistance under the WMO Voluntary Cooperation Programme](#) (see also [section 10.4 – Project budgets](#)).

8.5 PROJECT IMPLEMENTATION

Even with a well-formulated project, projects within an NMHS are often complex due to the nature and variety of technology, the specific skills required for project management, and the difficulty of managing the interface with any contractors and coping with unexpected developments. Moreover, as discussed in [Chapter 7 – Capacity development](#), in the context of the WMO Capacity Development Strategy, the successful implementation of projects in a smaller NMHS can be very challenging due to inexperience, lack of skilled staff and overall resource difficulties.

Pending the development of any more detailed project implementation guidance specifically for NMHS capacity development, there are some existing general guidance materials that can be found on the Internet. In addition to knowledge of project management techniques, the staff assigned to this role need to have demonstrated personal qualities of being systematic, well-organized and paying attention to detail.

8.6 PERFORMANCE MEASUREMENT

Throughout the planning (and subsequent reporting) process, the NMHS needs to choose a set of relevant performance measures. This will, to some extent, depend on the size and complexity of the NMHS, the requirements of the budget process, the requirements for reporting and the systems and resources available to the NMHS to carry out performance assessment.

Some common examples of the types of performance measurement appropriate to an NMHS are:

- The number of observing stations;
- The performance of the observing network in terms of percentage of reports received;
- The number of forecasts and warnings;
- The percentage of correct forecasts;
- The number of climate data products;
- The skill of numerical prediction models;
- Measures of user satisfaction with services provided;
- The progress or achievement of specific NMHS initiatives;
- The number of staff trained.

The setting of performance measures for the NMHS thus provides a basis for reporting back to government, stakeholders, users and the public on how the NMHS is performing and reasons for departures from planned performance. For the NMHS, this can help to highlight the need for additional resources to meet government, user or community expectations.

The performance measures set at an organizational level can also be useful in helping to clarify organizational intent and align the performance of individual managers. The subject of individual performance management is addressed in [Chapter 9 – People management](#).

The WMO technical commissions and certain WMO Programmes and publications provide more detailed guidance on and examples of specific performance measures, for instance, the [Guidelines on Performance Assessment of Public Weather Services](#) (WMO/TD-No. 1023).

8.7 BUSINESS CONTINUITY PLANNING

An emerging trend in larger organizations is the incorporation of the idea of business continuity into the planning and operation of the different programmes of the organization. This is essentially about the formal consideration of plans to continue operation in the face of an unexpected disruption or, more simply, organizational resilience. It is also part of a wider trend towards a more formal consideration of risk management in organizations. For further background on risk management, see the [Wikipedia page on risk management](#).

A well-established example of business continuity planning is the provision of backup power supplies for items of critical infrastructure, such as mainframe computing systems or radars. A more recent example is the provision of backup for computer servers and communication capacity to cope with high demand for Internet servers during major weather events.

Some NMHSs now formally incorporate business continuity planning into all key programmes, especially those that are part of a critical data flow or service delivery chain.

Additional guidance on this topic can be found in publications such as:

- Business Continuity Institute, 2010: *Good Practice Guidelines 2010 – Global Edition*, United Kingdom of Great Britain and Northern Ireland
- International Organization for Standardization, 2012: *Societal Security – Business Continuity Management Systems – Requirements*, ISO 22301:2012. Geneva

8.8 QUALITY MANAGEMENT FRAMEWORKS

The concept of quality management has become increasingly significant for many NMHSs as part of the general evolution of good management practices and specific requirements to meet competency standards in aviation meteorology.

At its fourteenth session in 2003, the World Meteorological Congress, through [Resolution 27 \(Cg-XIV\) – Quality Management](#), decided that WMO should work towards a [Quality Management Framework](#) for NMHSs that would eventually include and develop technical standards and quality management systems, covering quality control, certification procedures and the provision of early and continuing advice to Members on developing their quality management systems. It was also recognized that support from a WMO Quality Management Framework could help Members improve response to customer and/or government requests, as well as improve their competitiveness and effectiveness.

The aim of the Framework is to ensure the development, use and maintenance of WMO technical documentation, supporting quality management systems for meteorological, climatological, hydrological, marine and related environmental data, products and services.

The WMO Quality Management Framework is based on – and fosters – the implementation of the quality improvement loop. This can be seen as containing four steps: preparing and planning; realizing the product; checking results with a view to the client's satisfaction; and, finally, reacting to that information to improve further action. Indeed, one of the main objectives of modern quality management is to control not only the final product but also the entire process.

At its sixteenth session in 2011, Congress recognized that the special emphasis of WMO on service delivery required a renewed effort in documenting that all relevant processes, from physical measurements in observations to forecasts and the issue of warnings and service delivery to users, were undertaken within a sound Quality Management Framework. In this context, Congress urged the technical commissions to explore opportunities to develop new common technical standards under the working arrangements between ISO and WMO.

In order to provide relevant guidance to NMHSs, the [Technical Regulations](#) (WMO-No. 49), Volume I, Part VII – Quality management, has been developed in the edition revised in 2017. In addition, a generic guide on the adoption of a quality management approach to the delivery of services is being produced that is appropriate for all WMO Programmes.

Members operating a well-developed quality management system could support Members currently planning or developing a QMS-based approach to the delivery of services, through a quality management "twinning partnership" framework.

The range of activities and scale of adoption of quality management approaches will vary with national policies and with the size of the NMHS. In terms of good management practice, the adoption of a continuous-improvement approach can be both effective and a relatively simple and inexpensive way of improving the quality, effectiveness and efficiency of NMHS operations and services.

Current approaches to continuous improvement and more formal quality management systems owe much to the pioneering work of W. Edwards Deming. He devised the concept of the Plan-Do-Check (or Study)-Act cycle, now referred to widely as the PDCA or PDSA cycle (see [Figure 17](#)). This embodies continuously cycling through a process of:

- Making a plan for a small improvement;
- Implementing the change on a trial basis;
- Checking (or studying) the results;
- Acting to adopt the change or modifying the plan to make it more effective.



Figure 17. The Plan-Do-Study-Act cycle

CHAPTER 9. PEOPLE MANAGEMENT

People management is one of the most important and difficult aspects of a senior leadership role in an NMHS. The scientific and technical nature of the work, the round-the-clock operations, the authority delegated to staff to issue forecasts and warnings affecting the public and specific user communities and the need to continuously train and develop staff, all present special challenges for senior NMHS managers. This is particularly true for those who have come from a scientific or technical background and have little training or experience in managing people.

The following sections describe some generic approaches to effective people management with some specific information for NMHSs on WMO support in areas such as capabilities and competencies and overall training and staff development. WMO has a long history of supporting the development of the scientific and technical expertise needed in an NMHS and has increased its efforts to support the management and leadership capabilities of senior NMHS managers through specific initiatives, such as human-resource development workshops.

9.1 WORKFORCE ANALYSIS AND PLANNING

Workforce planning is the continuous planning process of shaping and structuring the workforce to ensure there is sufficient and sustainable capability to meet organizational objectives now and in the future.

Workforce planning needs to be closely integrated in, and aligned with, the strategic planning process. In essence, the aim is to have human resource strategies in place to provide the people with the necessary skills and capabilities – the right people for the right jobs in the right place at the right time. For an NMHS, this means having the right people in the different scientific, technical and administrative categories to carry out the functions of the NMHS. Typically, this covers the staff categories associated with forecasting, climate services, observing, communication and information technology, installation and maintenance of equipment and administration. The workforce planning process also informs the human resources strategies so that these strategies can support the plan. It is also closely linked to the financial planning processes, since the cost of the NMHS workforce is a substantial part of overall costs.

Compelling reasons for good workforce planning include:

- Shortage of staff to undertake the NMHS mission;
- Shortage of required skills in existing staff;
- Requirement to reduce staff in some circumstances;
- Improved awareness of the skills and capabilities existing in the NMHS;
- Allowing for staff demographics, such as loss of experienced staff due to retirement;
- Loss of staff to more rewarding job markets;
- Changing requirements and community expectations related to services of the NMHS;
- Tight financial constraints meaning that the NMHS needs to gain optimum performance from available staff.

Some of the benefits of workforce planning for an NMHS are:

- Increased clarity about the human resources needed to carry out the NMHS mission;
- A strengthened case for the resources needed for the mission;

- Increased capability to meet government and community expectations leading to increased trust in, and respect for, the NMHS;
- Increased ability to anticipate and address changing needs;
- Increased understanding of the risks facing the NMHS in the area of human resources;
- Ability to deliver increased value through better use of existing resources. The process and structure of workforce planning is similar to strategic planning. In essence, the plan addresses three key questions:
 - What are the future requirements– or where are we heading?
 - What is the current situation – or where are we now?
 - What is needed to bridge the gap – or how do we get to where we want to be?

The degree of complexity in the workforce plan will be influenced by factors such as the size of the NMHS. It is desirable to make a plan, even if the NMHS does not have fully accurate or complete data.

It is important to note that the workforce plan should be under continuous review and can be adapted for different circumstances. The plan for the next several years (commonly three to five years) will usually be in alignment with, and complement, the NMHS strategic plan.

However, the workforce plan will also serve operational requirements and align with the NMHS planning cycle (typically 12–18 months). The plan will also be useful in addressing changing needs of the NMHS in a shorter time frame. For example, the NMHS may need to deal with an unexpected new project.

Key issues in developing the workforce plan along the lines of the sample outline are summarized below.

Introduction

- Planning approach – describe how the plan will be developed;
- Stakeholder engagement plan – describe steps to engage with stakeholders, staff, the NMHS executive, central government, funding agencies, etc.;
- Workforce segments in the NMHS – describe the basic components of the workforce needed to carry out the NMHS mission.

Demand analysis

- Demand analysis (current and future) – what is expected of the NMHS over the next few years? what is needed from the workforce (numbers, locations, capabilities)? what are the likely funding situations over the next few years?
- Alternative future analyses – are there different possible scenarios that could impact the NMHS?

Internal supply analysis

- Workforce profile – what are the existing numbers, categories, locations and age groups?
- Skills and capabilities profile – what are the present capabilities and skills in the workforce?

- Employee survey – optional, but can provide useful information on current employee attitudes and interests;
- Internal supply analysis (current and future) – summarize the current and expected future situation of the workforce capability with existing staff, identifying current shortages and expected losses due to retirement, etc.

External supply analysis

- Current external supply – what is the current availability of staff with the required skills and capabilities external to the NMHS?
- Future external supply – identify circumstances that may change in the future regarding external supply of staff.

Gap analysis

- Gap analysis – summarize the gaps between what the organization needs, what it has now and what it will need in the future.

Workforce strategies

- Risks and options analysis – identify the existing and future risks to carrying out the mission of the NMHS associated with the workforce situation; analyse the options available to address the situation, including use of existing staff, training plans, partnerships, options for closing the gap with outside recruitment, etc.;
- Action plan – describe the chosen action plan to implement the plan, including the expected future numbers, categories and disposition of staff.

Below is a summary checklist on workforce planning:

- Needs to be incorporated into the organization's planning process;
- Should be informed by strategic planning;
- Focuses on key workforce risks to carrying out the NMHS mission;
- Seeks to understand the NMHS workforce in the context of the wider economic and planning environments;
- Focuses on strengthening workforce capability and capacity, now and in the future;
- Responds to internal and external changes that affect the NMHS;
- Reduces the number of situations where reactive and ad hoc recruitment decisions have to be made in a short time frame;
- Provides a reliable evidence base for managers to make decisions about the workforce and steer development to areas where it has the greatest impact.

9.2 WORKFORCE CAPABILITIES AND COMPETENCIES

The concept of workforce capabilities has already been addressed in [Chapter 6 – Leadership and management in a National Meteorological and Hydrological Service](#). In more general terms, the workforce capability of an NMHS is a description of the ability of the workforce (leaders, managers, staff) to carry out the tasks necessary to achieve the mission of the NMHS.

Workforce “capabilities” refer to the skills and knowledge of the workforce. More broadly, they refer to the ability to achieve an outcome for the NMHS. In contrast, “competencies” refer to the ability to accomplish specific tasks.

Development of a workforce capability framework can be a useful part of the workforce planning process described in [the previous section](#). As indicated in the leadership capability framework (see [section 6.2](#)), the capability framework will include more than technical skills and academic knowledge; it will usually include attributes such as flexibility, service focus, skills in innovation, etc. While development of a customized capability framework for an NMHS might involve outside human resource specialists, a simple model can be adapted from frameworks already in use in other NMHSs.

For NMHSs, internationally agreed workforce competencies have been established for aviation meteorological personnel, and WMO is developing guidance on broader capability frameworks. The WMO technical commissions are addressing the question of the need for formal competency standards in different areas of meteorological and related operations. Competency standards have been approved for aviation meteorological personnel by the WMO [Commission for Aeronautical Meteorology](#), and work is underway on competencies for marine meteorological and climatological personnel. The current state is summarized on the [competencies page](#) of the WMO [Education and Training Programme website](#).

9.3 PERFORMANCE MANAGEMENT

Trends in contemporary people management have seen a decline in complicated performance appraisal systems for individual staff, but some form of performance management of individuals is still regarded as important. For an NMHS, the degree of formality and complexity will depend on the size of the NMHS and any requirements within the government system for such schemes.

Performance management schemes for staff may need to be more formal if they are linked to a quality management system where the NMHS has set targets and it is important to link team and individual performance with the broader NMHS achievements. In some cases, a formal performance management system will be linked to the remuneration or promotion systems in the NMHS. As a minimum, performance management in the NMHS can be used to encourage stronger alignment with the organization's goals and values and assist the personal development of the individual. Instead of the negative connotations of a performance appraisal system, it can be seen as a personal development plan for the individual.

While formal schemes and alignment with annual budgets and performance reports of the organization may require an annual performance management meeting between individuals and supervisors, contemporary management and leadership practice favours much more frequent and informal interaction so that there is greater mutual understanding and two-way feedback between supervisors and staff.

Sources of further guidance on performance management for an NMHS could include systems recommended by the civil service, other NMHSs and various academic and private sector writings accessible via the Internet.

9.4 TRAINING AND STAFF DEVELOPMENT

The key functions of training and staff development for an NMHS are to provide for the current and future needs of the NMHS workforce. These should cover:

- Training of new recruits in the relevant scientific and technical areas of NMHS operations;
- Training of existing staff to improve their scientific and technical knowledge and skills, for example, in new systems;
- Development of existing staff in non-technical skills, such as supervision and leadership.

The size and capability of the NMHS, as well as national approaches and availability of other educational and training facilities, will determine the appropriate approach for an NMHS. For a larger NMHS, this may mean running an in-house training and staff development centre with courses tailored to meet the needs of the NMHS. This would typically provide specialist courses for meteorologists and meteorological technicians in topics such as weather forecasting, climatology, weather observing, instrumentation and maintenance of equipment, as well as more general staff development. For NMHSs both large and small, the arrangements for training courses may involve external institutions, such as universities, colleges or government training institutions. In many developing countries, funding issues and lack of suitable national training resources mean that the NMHS will depend on external funding and support from WMO and donors to obtain training in other countries.

The WMO [Education and Training Programme](#) provides strong support to the WMO community with a special focus on developing countries. Some features of the Programme that assist NMHSs in their national training efforts are:

- Guidance by the [Executive Council Panel of Experts on Education and Training](#), which serves as an advisory body on all aspects of technical and scientific education and training in meteorology and operational hydrology;
- Fostering of collaboration and cooperation with education-related programmes of other organizations; a special partnership is maintained with the Standing Conference of Heads of Training Institutions of National Meteorological Services;
- Regular, worldwide [surveys](#) of Members' training needs, requirements and opportunities;
- Monitoring of, and support to, the functioning of a network of 26 designated WMO [Regional Training Centres](#), which play a key role in education and training for Members;
- Organization/co-sponsorship of training courses, workshops and seminars;
- Preparation and dissemination of training materials and running of a training library, including the Virtual Training Library;
- Provision of long- and short-term fellowships financed from the WMO [Voluntary Cooperation Programme](#), the WMO regular budget, trust funds and United Nations Development Programme projects.

For more complete and up-to-date details, check the WMO [Education and Training Programme website](#).

9.5 OCCUPATIONAL HEALTH AND SAFETY

Occupational health and safety have developed in the past two decades or so as an important management function. This is consistent with the wider adoption of a risk management approach as mentioned in the context of [business continuity planning](#).

In an NMHS, some aspects of the need to consider occupational health and safety are obvious. For example, its operations might include the use of potentially hazardous materials, such as hydrogen gas, involve climbing towers or travel to remote locations by land, sea and air.

Increasingly, however, occupational health and safety are seen as important, not only for the welfare of staff but also for the overall efficiency and effectiveness of the NMHS. Accidents and illness in the workplace have impacts beyond those on the individuals concerned. Staff absences affect productivity, put remaining workers under greater stress and may even affect the ability of the NMHS to carry out critical service delivery, warnings or other operational functions.

A starting point for an NMHS wanting to strengthen its policies and procedures in this area will often be national guidance or legislation. An example of a national law for Kenya is The Occupational Safety and Health Act, No. 15 of 2007.

CHAPTER 10. FINANCIAL MANAGEMENT

Sound financial management is a key performance area for an NMHS, and, in times of almost universal pressure on government budgets, NMHSs face increasing pressure to sustain their operations. In addition, special financial challenges exist for NMHSs owing to:

- The increased focus on issues such as DRR, climate change and variability, food and water security, and environmental sustainability;
- The rapid developments in science and technology related to meteorology, computing and communications;
- The round-the-clock nature of the operations of an NMHS, dispersed staff and facilities, and requirement for rapid and frequent national and international communication;
- The need to manage donor-funded projects that stretch the resource capacity of the receiving NMHS, especially in developing countries.

The following sections are not intended to be a definitive financial management manual or to address the complexities of financial management in a large, well-developed NMHS. Rather, they are intended to assist senior managers who are not experts in financial management so that they can more effectively engage with that function within their NMHS.

The sections deal with financial management frameworks, the different aspects of budgets, and budget monitoring. The section on resource mobilization is more detailed because of its importance to NMHSs in developing countries and to summarize WMO support in this area. It also includes many links to further information.

10.1 FINANCIAL MANAGEMENT FRAMEWORKS

The financial management framework for an NMHS will be influenced by the applicable national government frameworks, legislation and standards. The following descriptions are mostly generic and assume that the NMHS is a government agency or department with funding provided primarily from central government. Complexity and terminology can vary, depending on the size and complexity of the NMHS and its position within government structures. NMHSs that are required to be organized more as a business may use structures and terminology more aligned with the corporate business world.

The financial management framework sets out how the organization's mission is supported by the planning and management of its financial resources, the allocation and spending of funds and the requirements for accountability and reporting. It describes the components of the financial system and the procedures and accountabilities for the management of financial resources. National legislation and regulations usually need to be followed and these are usually set down by the ministry (or department) of finance in the national government.

NMHSs should apply rules and guidelines as to how budget proposals are structured, including timetables, responsibilities, accountabilities and reporting. A typical framework includes:

- Legislation, regulations and policies;
- Principles and ethics to guide managers in sound financial management practices;
- Authority and accountability arrangements detailing the authority delegated to and within the NMHS and the relevant accountabilities;
- Defined roles and responsibilities of managers and financial officers;

- Processes that need to be followed in relation to budget proposals, budget approvals, resource allocation, expenditure, income (if relevant), asset management, monitoring and reporting;
- Systems and tools to assist in providing timely and relevant information for managers and government.

Because the details of the financial framework for an NMHS will depend very much on the national financial framework, an NMHS wanting to strengthen its financial framework should seek, in the first instance, assistance from the relevant government finance department. If the government system is such that there is a particular officer in the department or ministry of finance with responsibility for the NMHS, this is the obvious person to approach. This could be quite useful in strengthening relations within government, especially in a developing country where the NMHS is seeking to increase its visibility in government and to emphasize the alignment of NMHS functions with broader national considerations.

An example of a change in financial management frameworks that has impacted the management of many NMHSs is the adoption of accrual accounting by national governments. Accrual accounting is an accounting methodology under which transactions are recognized as the underlying economic events occur, regardless of the timing of the related cash receipts and payments. Following this methodology, revenues are recognized when income is earned and expenses are recognized when liabilities are incurred or resources consumed. This contrasts with the cash-accounting basis whereby revenues and expenditures are recognized when cash is received and paid, respectively. Some countries use accrual accounting and reporting for all accounting purposes, some still use cash accounting and others use a mixture.

Training in the appropriate financial rules and procedures is important for specialist finance staff, as well as for staff whose work requires some financial management.

10.2 ANNUAL BUDGET PROCESS

The development of an annual budget is usually the most important and time-consuming management activity for the senior management of an NMHS because it has such a powerful impact on staffing, equipment needs, operational performance and scope of development.

The annual budget cycle and the rules for establishing budget proposals, approvals and spending will usually be set down by central government and relevant legislation. The following focuses mainly on the internal processes for an NMHS.

The budget process for an NMHS involves a series of integrated activities that require alignment with a number of other functions. These functions include organizational planning, financial responsibility, accountability and authority, budgeting and reporting, resource allocation and the monitoring and evaluation of budget performance. This can be achieved by engaging in several areas of organizational activity, which can be broadly summarized as (see [Figure 18](#)):

- Embedding internal budget processes into organizational planning;
- Developing and implementing a comprehensive internal budget;
- Engaging with government processes for consideration and approval of budgets;
- Implementing the approved budget internally;
- Monitoring and evaluating budget performance.

Strategic plan process

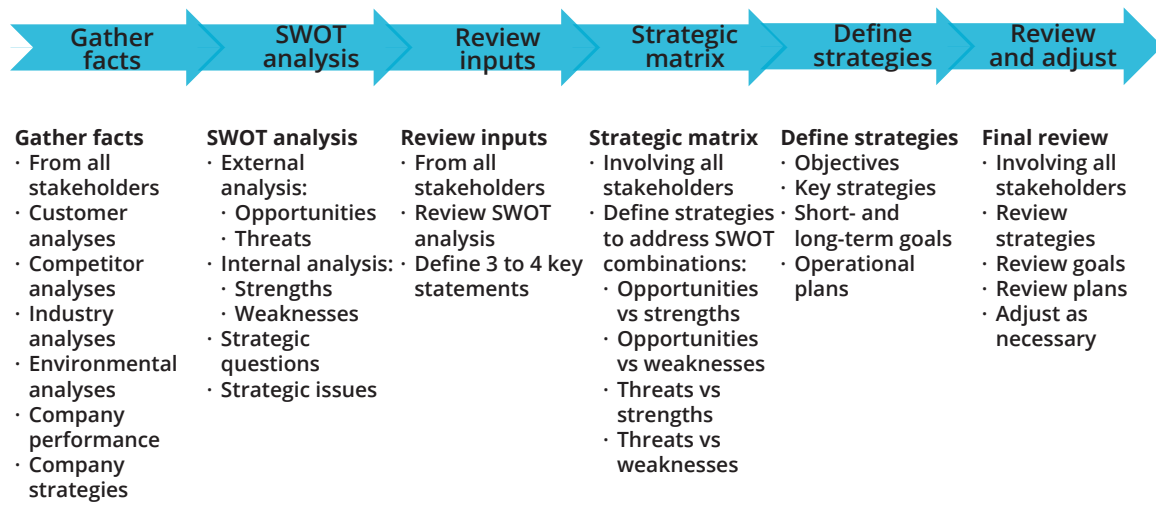


Figure 18. Annual budget cycle

Typical NMHS budget items – some considerations

The presentation of budgets and financial reports for an NMHS will depend on accounting practices that vary by country. Government agencies are generally required to follow practices set down by the ministry of finance (or equivalent). In some cases the whole NMHS budget will be broken down into major categories, while in others using a programme-budget approach, funds will be shown by programme.

The following table provides some notes on typical budget items for the recurrent expenditure and income of an NMHS. Terms are intended to be generic and indicative. The presentation and description of items do not reflect any particular accounting practices except in relation to the practice of allowing for depreciation of assets if using accrual accounting.

Budget item	Description
Salaries and employee expenses	All salary and related costs of staff
Travel	Operational and administrative travel
Spare parts and consumables	Operational and electronic consumables (e.g. radiosondes, gas)
Communications	Running costs for operational and administrative communications
Computing	Running costs for computing
Rent and other building expenses	Rent and utility services for buildings
Furniture and fittings	Office fittings and furniture
Office supplies	Stationery and other office supplies
Other expenses	WMO contributions, exchange rate costs and miscellaneous expenses
Appropriation or revenue	The government appropriation or expected revenue
Other revenue	Income from cost recovery or commercial activities

10.3 CAPITAL BUDGETING AND ASSET MANAGEMENT

The purchase of major new or replacement equipment is generally treated as a separate capital budget item. For an NMHS, this usually means large items such as upper-air stations, radars, and satellite reception, computing and communication systems. The NMHS will usually need to make a special case for the purchase of these items, and the funding, if approved, will appear as a separate part of the budget. The preparation of the case for major capital purchases may take several years and be addressed in multi-year forward estimates.

Important concerns in developing capital budgets are:

- To consider all costs associated with the item;
- To allow for price variations owing to the time needed for the development of proposals and for approval, and to variation in exchange rates;
- To factor in items such as maintenance and spare parts for a period after the supply of the equipment;
- To possibly include some staff costs associated with the purchase and installation/implementation phases;
- To consider the need for adjustments in other parts of the infrastructure (such as in power supplies);
- To consider the impact on items in the recurrent budget (for example, on travel).

10.4 PROJECT BUDGETS

Project budgets are used in an NMHS to identify all the resources needed for a special task or new installation requiring significant organizational resources that cannot be provided as part of normal day-to-day activity.

For an NMHS seeking support from donors for particular new or upgrade projects, the process will usually be complex and demanding. The government will have its procedures; the NMHS will need to consider all factors required for a successful outcome; and the donor will have a set of rules and procedures to be followed as well.

For the NMHS, all the issues identified above under [section 10.3 – Capital budgeting and asset management](#), apply. It is especially important to ensure that issues such as equipment maintenance, spare parts, consumables and training are fully included in project costs so that the project is sustainable.

The history of major projects in both developed and developing countries suggests that the most important factors in their long-term sustainability is having enough of the right people to operate and maintain equipment, enough spare parts, and either stocks or an ongoing budget for relevant consumables. For developing country NMHSs, these factors are especially critical.

Donors have their own requirements for the formulation of projects, and NMHSs need to be aware of donor guidance. WMO can assist with this and has its own guidelines, for example for the Voluntary Cooperation Programme (see the [note on the preparation of requests for assistance under the WMO Voluntary Cooperation Programme](#)).

10.5 BUDGET MONITORING AND REPORTING

Once annual budgets are decided and allocated, the NMHS needs to have systems in place to monitor performance. The complexity of arrangements for monitoring the budget will depend on the size of the NMHS and the availability of administrative staff and appropriate systems. The following guidance on best practice for certain basic processes applies to NMHSs of all sizes. Cash-flow forecasting is another element of business practice that may be applied to NMHSs.

The main purpose of a budget monitoring system is to evaluate actual results against approved budgets to guide current and future decision-making and to provide managers with relevant information so that they are more accountable for performance. Key processes to manage approved budgets effectively include:

- Monitoring and reporting against internal budgets on a consistent and regular basis to assess whether targets are being met;
- Revising the internal budget through a coordinated process;
- Forecasting to manage gaps between budget estimates and actual results in order to identify quickly, and respond to, changes in the external environment or internal activities;
- Reviewing and improving internal budget processes by monitoring the accuracy and timeliness of budget processes to identify areas for improvement.

To measure budget performance, the NMHS needs to monitor the extent to which budget estimates match actual results. This helps ensure financial control and identify where change is required. Monitoring budget accuracy is the responsibility of all managers. Effective monitoring of budget performance requires that managers be provided with relevant, timely and accurate information appropriate to their level of responsibility. It also requires managers to provide feedback in a timely manner about underlying causes and effects of budget variations, as well as planned actions to manage variations.

Ideally, the finance area of the NMHS will provide monthly reports to show actual results against the budget. They will consult with the line managers responsible for spending and identify reasons for variations. The situation for the whole NMHS should then be reviewed by senior management and the results of that review made available to all managers. The effectiveness of internal financial reporting is likely to be enhanced when reports are prepared for each level of budget accountability and summarized appropriately for each level of management. When output and organizational accountabilities differ for the same manager (for example, where a manager has both branch and output responsibilities), budget-to-actual financial reports should be designed to enable the assessment of budget accuracy against both accountabilities.

The budget monitoring process allows the NMHS to keep track of capital expenditure and development projects. This can help identify project variations, such as cost overruns or delays in key milestones, and enable early corrective action. Routine reporting of detailed information on individual projects, such as milestones, percentage of completion and phasing of total projected costs, provides decision-makers with useful information on current and future impacts of project activity.

10.6 RESOURCE MOBILIZATION

A key financial management issue for many NMHSs is the mobilization of financial and in-kind resources to undertake development efforts. Extra-budgetary resources are often the only means to fund expensive new equipment, modernization, training of staff and other initiatives essential for the NMHS to carry out its mission effectively. In recognition of the importance of resource mobilization and the challenge faced by many NMHSs in developing and implementing an effective strategy, WMO has a dedicated [Office for Resource Mobilization and Development Partnerships](#) to assist NMHSs in developing countries. The nature of resource mobilization

efforts will vary from country to country, but the material here provides some general guidance to NMHSs, plus some specific information on the [Office for Resource Mobilization and Development Partnerships](#).

Resource mobilization is the process of locating a source of external funds and negotiating a grant or loan to carry out a development or modernization project. The first part of the process is to develop a resource mobilization strategy. In a developing country NMHS, this will be an important part of an overall strategic plan. The main steps in the strategy are:

- Determining the key developments needed in the NMHS;
- Framing NMHS development needs in the context of broader national, regional and international goals;
- Gaining an understanding of current policies, programmes and priorities regarding development assistance activities from the relevant national authorities (such as ministries of finance, planning and foreign affairs);
- Identifying potential sources of funds;
- Researching the policies, programmes, priorities and procedures of potential donors;
- Making initial contact with potential donors to outline NMHS plans, the need for assistance, and the counterpart support available from the NMHS if donor support is obtained;
- Formally submitting the request for assistance, taking account of the points regarding capital and project budgets and following the procedures required by the donor;
- Following-up to check progress and the need for additional information;
- Once approved, completing formal agreements and moving to the project implementation phase, while also setting in place the required financial management processes and systems.

The [Office for Resource Mobilization and Development Partnerships](#) focuses on securing development assistance for the NMHSs of Members through financing (either directly or through the WMO Secretariat), transfer of technology and expertise, and leveraging strategic partnerships with major development partners, such as development banks, overseas aid agencies, other United Nations agencies and NMHSs in developed countries. This work is undertaken in close cooperation with the WMO Regional Offices and WMO technical Programmes.

The types of activities the [Office for Resource Mobilization and Development Partnerships](#) undertakes to assist NMHSs include:

- Identifying needs at regional and national level;
- Gaining a comprehensive understanding of the needs and operations of funding agencies and development partners;
- Sensitizing development partners and national governments to the value of NMHS products and services and the benefits that building greater capacity can bring to a variety of users;
- Engaging with potential development partners for the establishment of multi-year framework and partnership agreements for joint regional and national interventions;
- Facilitating the development of, and sourcing financial support for, high-impact hydrometeorological infrastructure and service development projects in WMO Member States and Territories;

- Coordinating and expanding the support base and delivery of the WMO Voluntary Cooperation Programme, working closely with Regional Offices;
- Strengthening collaboration with the NMHSs of developed countries and forging links between them and NMHSs of developing countries;
- Assisting NMHSs to demonstrate the socioeconomic value of their products and services and to inform their governments and communities by targeted social-marketing mechanisms;
- Advocating the role of NMHSs in climate observations and climate-change adaptation and DRR;
- Expanding the financial support to regional specialized centres as required;
- Engaging and establishing mutually beneficial relations with the private sector and establishing private–public partnerships as appropriate;
- Facilitating partnerships with other United Nations entities, in particular as part of the United Nations "Delivering as One" process.

Further details can be found at the [Office for Resource Mobilization and Development Partnerships](#) page on the WMO website.

Case studies on successful WMO resource mobilization efforts can be found [here](#).

The range of investment mechanisms and partnership opportunities that can be targeted by WMO and the NMHSs of Members to secure additional investment for enhancing all components of the weather, water and climate services system or to leverage investment in related sectors include: national budgeting processes; United Nations System initiatives; development bank investments; development assistance programmes of the various economic groupings, such as the European Commission, the Asia-Pacific Economic Cooperation, the Association of Southeast Asian Nations, the African Union, the Organization for Economic Cooperation and Development; the overseas official development assistance programmes of national governments; country budgets of overseas missions and embassies; various Climate Investment Funds, the Global Environment Facility, and other mechanisms.

Development banks

Financing provided by the [World Bank Group](#) and regional development banks ([Asian Development Bank](#), [African Development Bank](#), [European Bank for Reconstruction and Development](#), [Inter-American Development Bank](#), etc.) is generally negotiated by the bank directly with the ministries of foreign affairs and/or finance of the respective recipient countries through various modalities (grants, soft loans, loans, etc.). Such modalities are predominantly loans with some grant support and are generally made on a bilateral basis. For this reason, WMO has to focus for the most part on supporting NMHSs to access and engage in these mechanisms through processes at the national level.

Note: WMO and World Bank Programmes have come together in recent years and have seen a significant focusing of their financing towards the modernization of the hydrometeorological sector through direct grant–loan combinations. There are already Programmes in South-East Europe and Central Asia that have both regional and national elements. Similar activities are under consideration in Africa.

Climate funds

The following are key climate funds that countries can approach to support the Global Framework for Climate Services and through which WMO could support engagement of the NMHS:

- **Adaptation Fund** – established by the Parties to the Kyoto Protocol of the United Nations Framework Convention on Climate Change (UNFCCC) to finance concrete adaptation projects/programmes in developing countries (**Non-Annex I countries of the UNFCCC**). WMO became accredited to the Adaptation Fund as a Multilateral Implementing Entity in December 2010, allowing it to work with eligible Members to submit projects aligned with national adaptation plans.
- **Green Climate Fund** – the seventeenth session of the UNFCCC Conference of the Parties (COP 17), held in Durban, South Africa, adopted a governing instrument for the Green Climate Fund and a transitional process for its full operationalization by 2014, to be replenished to the target of US\$ 100 billion annually by 2020. The Fund has become the main multilateral financing mechanism to support climate action in developing countries and is a legally independent institution with its own separate secretariat accountable to the COP. Since the Durban Package did not reach any agreement on long-term sources of climate financing, the biggest challenge for the Fund will be to secure adequate and sustained funding.
- **Global Environment Facility** – the Global Environment Facility Trust Fund (under the Strategic Pilot on Adaptation) and two climate change funds, the **Least Developed Countries Fund** and the **Special Climate Change Fund**, are focused on development. The projects they support therefore emphasize agriculture and food security, health, water resources and disaster prevention.
- **Climate Investment Funds** – two funds that help developing countries pilot low-emissions and climate-resilient development are the **Clean Technology Fund** and the **Strategic Climate Fund**, channelled through the **African Development Bank**, **Asian Development Bank**, **European Bank for Reconstruction and Development**, **Inter-American Development Bank** and the **World Bank Group**. There are three sub-funds under the Strategic Climate Fund framework: the **Pilot Program for Climate Resilience**, the **Forest Investment Program**, and the **Scaling-up Renewable Energy in Low Income Countries Program**.
- Additional Climate Investment Funds, more targeted to clean development mechanisms and carbon funds, may offer alternative opportunities.

United Nations System

Initiatives of United Nations specialized agencies and related partners involved in direct country assistance and financing, including (but not exclusively) those of the **Food and Agriculture Organization of the United Nations**, **International Fund for Agricultural Development**, **United Nations Development Programme**, **United Nations Environment Programme**, **World Food Programme**, **World Health Organization** and WMO, can support modernization of NMHSs. These agencies are part of the governance mechanisms of the **Global Framework for Climate Services** and are encouraged to mainstream GFCS into their country programming. Mainstreaming GFCS into development initiatives of United Nations agencies will be a key component of resourcing for GFCS implementation through direct financing and through the leveraging of related activities.

Note: WMO currently chairs the United Nations System Chief Executives Board for Coordination Working Group on Climate Change, the ideal mechanism to secure full adoption by the entire United Nations System of the GFCS. UN-Water is another useful vehicle to raise awareness of these issues.

Official development assistance

There is an increasing focus on water, environment, health and, more recently, climate change in the official development assistance sector as indicated by a 2011 report of the Development Assistance Committee of the **Organization for Economic Cooperation and Development** (OECD). WMO must ensure that there is an increasing awareness among official development assistance

programmes of the role of weather and climate in these sectors as potentially stalling or slowing down economic development and poverty alleviation and, therefore, of the need for support of climate-resilient development and improved weather and climate services.

Supporting NMHSs in developing countries to engage with their ministries of foreign affairs and their respective official development assistance programmes to direct financing towards capacity development projects for these NMHSs and weather and climate services will be key.

Note: [Official development assistance](#) is a term coined by the OECD Development Assistance Committee used to measure the flow of international aid.

Regional institutions

Regional institutions, such as regional intergovernmental bodies and regional economic groupings, exist in all WMO Regions. The [Regional Economic Communities of the African Union](#), for example, group together individual countries in subregions for the purposes of achieving greater economic integration. They are described as the building blocks of the African Union and are central to the strategy for implementing the [New Partnership for Africa's Development](#). WMO already has a subregional office in place at the headquarters of the [Secretariat of the Pacific Regional Environment Programme](#). Establishing partnerships with relevant regional organizations provides a major opportunity to leverage support for development of weather and climate services.

Private sector

While much of the responsibility to drive climate change solutions that address the needs of the poorest and most vulnerable rests with governments, business will be an essential partner in preparing for, and responding to, the impacts of a changing climate and in building a global green economy.

The challenges that communities in developing countries face as a result of climate change – such as more frequent and intense storms, water scarcity, declining agricultural productivity and poor health – also pose serious challenges for businesses. Community risks are business risks.

Source: United Nations Global Compact, United Nations Environment Programme, Oxfam and World Resources Institute, 2011: [Adapting for a Green Economy: Companies, Communities and Climate Change: A Caring for Climate Report](#).

The GFCS could be used as a platform to consider new forms of public–private partnerships for building climate services that would tackle the most complex challenges to sustainable development and climate resilience. The key is to find the nexus of shared interest at relevant geographic scales, where business incentives align with communities' adaptation needs. The [United Nations Global Compact Caring for Climate](#) initiative, a joint United Nations platform involving more than 400 businesses committed to advancing climate action, provides an avenue to bring the GFCS to the private sector and engage in dialogue on how the private sector can support GFCS.

CHAPTER 11. EXAMPLES OF NATIONAL METEOROLOGICAL AND HYDROLOGICAL SERVICES WITH COMMERCIAL STRUCTURES

In at least two countries, the NMHS has been structured to operate on a more commercial basis that distinguishes between the role of government as the owner, so to speak, of the NMHS and as the client or customer that requires the NMHS to carry out functions and provide services for the good of the nation. Some information on these two examples is given below.

One example is New Zealand, where the [Meteorological Service of New Zealand Limited](#) is a stand-alone State-owned company whose shares are held by two government ministries. As owners, working through a unit of the New Zealand Treasury, they wish to maximize revenues and the profitability of the company.

An entirely separate government agency ([New Zealand Ministry of Transport](#)) acts as the customer for services on behalf of the country and the public. Such services are delivered under a negotiated commercial contract. The Ministry of Transport would prefer to minimize the cost of these services.

Another example is the [UK Met Office](#) in the United Kingdom of Great Britain and Northern Ireland. It operates as a trading fund within the [Department for Business, Energy and Industrial Strategy](#), which effectively has the ownership interest. A large part of the government-as-customer interest is dealt with through a separate unit of the same department – the [Public Weather Service Customer Group](#) (PSWCG). The PSWCG acts as the customer on behalf of the public and public-sector users (including emergency responders) of the public weather service outputs of the Met Office. This public work includes services but also underpins research and infrastructure for many Met Office services and international commitments. The PSWCG sets the requirements for public weather services, aided by the results of independent research into user requirements and performance levels, and authorizes payment from the Department of Business, Energy and Industrial Strategy.

In most countries, the owner and customer roles are combined, but it should be understood that these roles are distinct, especially in discussions with government ministers and officials. Such groups may request or direct the NMHS to carry out additional activities because they own, so to speak, the NMHS, while not necessarily understanding that, as customers of NMHS services, they should also be paying an additional amount through the budget provided for the NMHS. For this reason, where possible, it should be clear what services are being provided by the NMHS on behalf of the government. Of course, the broad nature of these will often be given in the relevant legislation, but this issue is more about the detailed level of services. If these are clearly specified, there can be a discussion about budgetary impacts if changes are sought.

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