WORLD METEOROLOGICAL ORGANISATION

DRAFT POSITION PAPER

On the WMO Contribution to the implementation of the Global Framework for Climate Services

(To be submitted to the Task Force set up by WCC-3)

For the consideration of EC Working Group on Climate and related Weather, Water and Environmental Matters

(Version 15 October 2009)

WMO Contribution to the Global Framework for Climate Services

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WMO Contribution to the Global Framework for Climate Services

Statement of Purpose

The Heads of States and Governments, Ministers and Heads of Delegations present at the World Climate Conference-3 (WCC-3), held from 31 August to 4 September 2009 in Geneva, through the High-level Declaration (Annex1), decided to establish a Global Framework for Climate Services (hereafter referred to as "the Framework"). The Framework is expected to help the global community better equipped to meet the challenges of climate variability and change and bridge the gap between the climate information being developed by climate scientists and service providers on one hand and the practical needs of information users in many climate sensitive sectors of society on the other.

The WCC-3 Declaration decided that a Task Force, consisting of high-level independent advisors (expected to be setup through an inter-governmental process), would recommend the proposed elements of the Framework taking into account the concepts described in "Global Framework for Climate Services: Brief Note" (Annex 2). The Task Force is also asked to propose next steps for developing and implementing the Framework.

This position paper outlines the World Meteorological Organization (WMO) vision of the Framework and its potential role in its implementation. The Paper describes WMO's on-going activities related to the Framework, and its future commitments for its successful implementation. Climate related activities undertaken by WMO in close collaboration with partners over the years, as portrayed in the Climate Timeline (Annex 3), are the foundation and building blocks of the proposed Framework. The paper argues that the Framework is well-placed to build upon the remarkable scientific progress and the solid institutional foundations put in place by WMO over the past 50 years. It further points out that if the Framework is to be science-based, it would have to be built, in particular upon WMO's existing capacities, as the Specialised UN Agency with historic mandate in weather, climate and water.

The position paper fully acknowledges the broader range of actors engaged in climate-related activities. It is also realised that 'climate' has transitioned from a topic of scientific interest into the concerns of public policy and requires active engagement of all sections of the society. Presently, over thirty UN Agencies and Programmes (Table 1) are engaged as partners in dealing with climate change. WMO has a long tradition of "Working Together" with many of these actors (Table 2). While this paper outlines WMO's role, it does so fully cognizant of the important role that is played by the other partners and outlines WMO's further expectations from them and other potential partners for the successful implementation of the Framework. It is hoped that the position paper will help Members of the Task Force in their efforts to define and describe the elements for the Framework.

The position paper takes into account the views of WMO Members as presented at the sessions of its various constitutional bodies, the discussions with various experts and missions that took part in consultative meetings related to the preparations for WCC-3 and the discussions that took place in the various sessions of the Expert Segment of WCC-3 as summarized in the Conference Statement (Annex 4).

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Executive Summary

Impacts of global warming are evident in terms of increasing climate risks and the society has no option but to devise appropriate strategies to cope with them. The adaptation strategies and climate risk management measures need scale-relevant climate information and prediction products developed in a regionally and globally consistent manner but available at the local scale. End-to-end climate services where the climate information and products are effectively used by the sectoral users for the benefit of the society are essential.

The international community has taken concrete initial steps towards strengthening the production, availability, delivery and application of these climate services to help people adapt to climate change and mainstream climate risk management in their decision-making processes by deciding at the WCC-3 to establish a Global Framework for Climate Services. In accordance with the deliberations leading up to and at the WCC-3, the Framework is proposed to have five major components: Observations and monitoring; Research, modelling and prediction; Climate Services Information System; User Interface Programme and Capacity Building which runs across all the components of the Framework.

In the past climate services have often been provided as a continuation of weather services. Application of climate information and products has largely been driven by sectoral professionals and the involvement of the service providers has remained, at best, at marginal levels. An end-to-end climate service, from production to delivery to application requires a multi-disciplinary and multi-sectoral collaboration at global, regional, national and local levels. This imperative has been the motive force behind the proposal of a Global Framework for Climate Services.

WMO's vision for the Framework, therefore, is to "ensure the provision of science based reliable, useful and timely climate information needed by the governments and society in general for adaptation and climate risk management". It is build upon the enhanced capacity of NMHSs[1], including their national partner institutions engaged in climate related activities, to enable them to take active and effective part in the development of climate information and products at global, regional and national level; deliver climate services at the national level within the mandated national arrangements in collaboration with partners; and work with intermediary agencies in different sectors to help support effective application of these services.

Under the Framework, WMO, through the NMHSs of its Members, would continue to operate and strengthen the Observations and Monitoring component; contribute to and effectively engage in Research and Modelling component; establish the operational elements of climate information production and delivery systems as part of Climate Services Information System; work with other UN, inter-governmental and non-governmental organization partners in cross-disciplinary research and outreach to the users in support of User Interface Program; and develop capacities in NMHSs, particularly in developing and least developed countries in the above four components as part of the Capacity Building component.

WMO's role in the Framework begins with observations and monitoring. Here, WMO would commit to improve the spatial and temporal distribution of essential climate observations and add new observing capability necessary for climate risk assessments, such as extreme climate events. With partners, WMO would work to facilitate the integration of climate databases with social and economic data relevant for risk assessments in various sectors at various levels. WMO would strive to improve the climate data records from satellite-

[1] In the document the subsequent use of the acronym NMHSs includes other national partner institutions engaged in climate activities.

based observing platforms, in collaboration with the concerned partners. It would work closely with its partners to further strengthen the Global Climate Observing System and contribute to expanding the rolling reviews of requirements for observations and monitoring to include the participation by partners. WMO would expect that it gets full support from the national governments as well as financial institutions to support this important component of GFCS.

An overarching goal of climate research, modeling and prediction component of the Framework is to improve the capability to make high-quality, reliable and user-relevant climate predictions, particularly from seasonal to decadal scales. In addition, while a relatively greater confidence in the global and continental scale aspects of climate change have been achieved, there is still a long way to go in providing reliable climate change information having adequate regional detail. With partners, WMO would participate in efforts for comprehensive earth system modeling, embarking on an international campaign to secure the vast computing resources necessary for such a massive effort. In addition to improving models for climate prediction, research to downscale global predictions to regional levels would be prioritized. WMO would expect its partners to support the RCCs to optimally translate research advances into enhanced operational skills on regional scales, and build capacities in NMHSs to use global and regional products.

The Climate Services Information System would depend on a network of global, regional and national institutions that would operationally generate, exchange, and disseminate climate information in a regular and timely manner. To that end, WMO would extend the network of global and regional mechanisms for climate prediction/projection (e.g., Global Prediction Centres and Regional Climate Centers) to cover all climatic zones of the world. To facilitate this, WMO would commit to extending the existing weather-focused systems to provide climate information products and services. With partners, new products to be made operational would be identified through multi-disciplinary dialogue. Regional Climate Outlook Forums would be extended to other parts of the world and become operational and regular. WMO, with partners would develop the concept of National Climate Centers and promote NMHSs role in climate services as a mandated activity by governments.

Application is the essential element of ‘services’. Application of climate services in various sectors would require a continuous exchange between providers and users of climate information. The User Interface Programme has necessarily to be developed jointly with other partners in the Framework who are in direct contact with various sectoral user groups. WMO’s role would be to strengthen existing, and establish new, operating partnerships between users and providers of weather, climate and water services to share responsibility for effective delivery of services, and evaluate their performance. WMO through its Technical Commissions and many UN organizations would build the user interface in different sectors. GEOSS user community platforms are recognised to be among the possible execution arms of the User Interface Programme.

In order to strengthening national capacity, WMO would continue, as part of its long-term strategy, to build institutional and human capacities in NMHSs to take up this new challenge. Apart from other mechanisms, the existing Regional Training Centres (RTCs) would play a crucial role in human resource development and would help define the educational and training certification processes for climatologists. Thus, WMO will continue to encourage governments to support the training components of the NMHSs and other multidisciplinary capacity building programmes.

The way that the Framework is financed will be strongly affected by the way that it is governed. Three examples of governance models based on those of existing WMO co-sponsored bodies (viz., WCRP, JCOMM, IPCC) are suggested.

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WMO Contribution to the Global Framework for Climate Services

1. Introduction

1. IPCC Fourth Assessment Report (AR4) highlights two important aspects of relevance in the present context of increased awareness of climate issues. First, some aspects of climate change are inevitable and the society has no option but to devise appropriate adaptation strategies to cope with them. People need to adapt to climate change, as well as better management of risks due to greater climate variability and change. Second, while we have achieved a relatively greater confidence in the global and continental scale aspects of climate change, we have still a long way to go in providing reliable regional detail.

2. To date, 'climate services' that embrace past, present and future climate information, assessment and advice on climate-related issues have developed to meet the needs of those investing in long-term infrastructure. All of the relevant data and much of the professional advice has been provided by the weather community and so climate services have often been provided as an continuation of weather services; extending from monitoring, analysis, and prediction seamlessly through long range weather forecasting to season, inter-annual, and future climate projections. Most of these have largely remained at the global or at best regional level. Only a few countries at present provide effective climate services, however because of the global reach of the World-Wide Web virtually everyone has access to some type of climate information and product.

3. Technological advances in computers, communication and observing systems and instruments, coupled with accumulated scientific knowledge about physical processes, have extended the range of weather and climate science. Figure 1 shows the types of phenomena, along with their typical spatio-temporal extents that are monitored and predicted by WMO entities. Providers of these climate services are largely the Members of the World Meteorological Organization (WMO) and their National Meteorological and Hydrological Services (NMHSs), governments, academia, and other climate relevant entities.

4. It is important to recognize that it is at the regional/national scales that the socio-economic consequences of climate variability and change are most acutely felt. This consideration of scale underscores the critical need for scale-relevant climate information and prediction products to be developed in a regionally and globally consistent manner but available at the local scale. At the same time it is recognised that there is an urgent need for an ongoing exchange between providers and users of climate information. It is therefore, inevitable that the international community must take concrete actions towards strengthen the production, availability, delivery and application of these climate services to help people adapt to climate change and mainstream climate risk management in their decision-making processes. These realisations lead to the development of the concept of Global Framework for Climate Services.

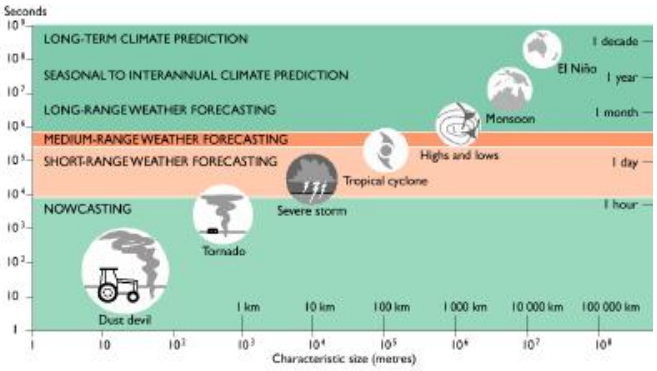


Fig 1. Examples of the range of climate phenomena and climate related hazards on different time and space scales that are monitored and forecast by the NMHSs under the aegis of WMO.

2. The Concept of the Global Framework for Climate Services

5. The Global Framework for Climate Services, proposed at the WCC-3, has the goal to:

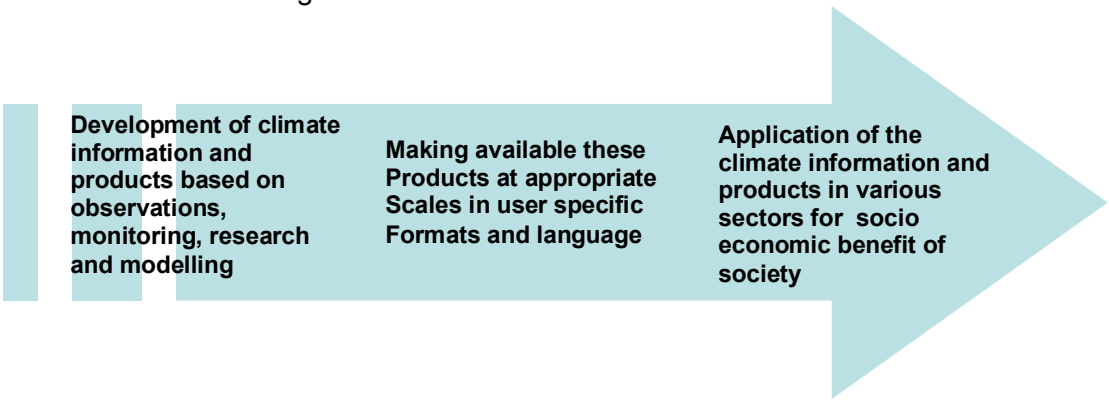
> ***"Enable better management of the risks of climate variability and change at all levels, through development and incorporation of science-based climate information and prediction into planning, policy and practice."***

6. To meet this goal there is need to develop credible, science-based climate information and prediction and projection products, deliver them to all sections of the society at various levels and assist the users in various sectors in their effective and timely application in their respective decision making processes. The most essential feature of a Global Framework for Climate Services is that measures are put in place to determine the effectiveness of the information provided in meeting users' needs to reduce the risks associated with climate change.

7. Due to the global nature of the weather and climate phenomenon, the task of providing the required climate services is beyond any single organization or even small group of organizations. At the same time considering the nature and the immense variety of user needs for the "climate services", it would require not only institutions specialised in climate sciences but also other scientific disciplines supporting various development sectors. It also requires active engagement with end-users. The Framework is therefore suggested as a cooperative arrangement among all nations, International Organisations, scientists from various disciplines and sectors and the non-government organisations to work together towards this goal to support sustainable development and help reduce poverty.

2.1 Pre-requisites of future climate services

8. In economic terms[2], a 'Service' is a continuum of three main processes: service provision, service delivery and service consumption. Consumption is an essential part of the 'service' to be recognized as a service.



9. The climate information and products that are based on global observations and continuous modeling and research include an extensive array of general and user-specific data, prediction, warning and advisories focused on the individual needs of the various climate-sensitive sectors. These products have to be delivered at local scale and in user specific formats and language. However, service providers, not only need to strengthen the production, availability, and delivery of these products, but also need to work closely with various sectors and boundary organisations[3] to ensure their application (or in other words consumption). Such a process only would result in a comprehensive "climate service".

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[2] Valerie Zeithaml, A. Parasumaran, Leonhard Berry (1990): *SERVQUAL* - s. http://www.12manage.com/methods_zeithaml_servqual.html

[3] **Boundary organisations** in this document are defined as the institutions and entities that work with users in given sector(s) (at various levels) and at the same time have certain in-house expertise in understanding and interpreting climate information and products

10. Given the nature of the future climate services, there are a number of important pre-requisites that need to be satisfied for the climate services to be effective, efficient and economical. These include:

- Timely global and local inputs at appropriate resolutions;
- **Interoperability** of systems participating in the process;
- **Assurance of high quality** of inputs as well as processes;
- **Availability** at all levels;
- **Responsiveness and flexibility** to the evolving user needs;
- **Sustainability and consistency** over time;
- **Timeliness** and appropriate resolution; and
- **Efficiency** in the overall use of resources.

2.2 WMO vision for GFCS

11. WMO coordinates the activities of the NMHSs of its 188 Member countries in weather, climate, water and related environmental issues. The importance of coordinating climate activities was recognized quite early and a Technical Commission for Climatology (CCl), an inter-governmental body of experts (Annex 6), was established in 1929, which gradually evolved for dealing with a wide range of climate related matters including climate data, monitoring, applications and services.

12. WMO's vision for the Framework, therefore, is to "*ensure the provision of science based reliable, useful and timely climate information needed by the governments and society in general for adaptation and climate risk management"*. It is build upon the enhanced capacity of NMHSs to enable them to take active and effective part in the development of the climate information and products at the global, regional and national level; deliver climate services at the national level within the mandated national arrangements in collaboration with partners; and work with boundary organisations in different sectors to help support effective application of these services.

13. In doing so WMO will rely on its network of NMHSs; its strong association with its long-term partners in climate activities and on establishing new partnerships at global, regional and national levels required for sustainable operations and uptake of climate services; an effective interface between scientists, service providers and decision-makers; and through coordinated actions with other partners in the UN and boundary organizations.

2.3 Components of GFCS

14. The Concept Note entitled; "Global Framework for Climate Services" (Annex 5) developed for the WCC-3 envisaged the Framework to have four major components: Observation and monitoring; Research, modelling and prediction; a Climate Services Information System; and a User Interface Programme with capacity development as a cross-cutting theme running across all the four components. However, the experts at WCC-3 recommended (Annex 4) that Capacity Building be included as a separate component of the framework. Sections 3 to 7 describe in details each of these components. These components, separated in the write up for convenience of presentation, have to act seamlessly and would require cross-component coordination. In their description that follows certain activities can arguably belong to one or the other component.

15. Under the Framework, WMO, through the NMHSs, would continue to operate and strengthen the Observations and Monitoring component; contribute to and effectively engage in Research and Modelling component; establish the operational elements of climate information production and delivery systems as part of the Climate Services Information System; work with other UN, IGO and NGO partners in cross-disciplinary research and outreach to the users in support of the User Interface Program; and develop

capacities in NMHSs, particularly in developing and least developed countries in the above four components as part of the Capacity Building component. A large part of these requirements could be met through the existing mechanisms associated with WMO Technical Commissions (Annex 5), with appropriate re-orientation and strengthening. New coordination roles for WMO would be necessary in the five components of the Framework.

16. The importance of this undertaking can be illustrated by "services for sea level rise", an example of an emerging service that is presently not integrated at all (Box 1). Another example might be climate services for fisheries. The WMO data, modeling and product line are not designed to serve the needs of the fisheries sector. There are, at best, some loosely-coupled efforts (Box 2) but not anything approaching a user-centric, end-to-end Climate Service.

Box 1 Climate Services for adapting to sea level rise

Projected sea level rises would potentially submerge 2000 small islands by 2030, and 3500 islands by 2050. Prediction of and adapting to sea level rise goes beyond the services of many NMHSs. Climate change impacts from sea level rise in the coastal low-lying regions are complicated by land subsidence, tidal bore, storm surge, swell and coastal inundation, as well as extreme weather. Few NMHSs make observations and monitor sea level. Fewer still have the capacity to model sea level rise, or have information systems and user interfaces that give information on future sea levels for particular coasts.

Various components of the Framework for the purposes of adapting to sea level rise be required.

- Observational evidence and climate model projections from an integrated Observation and Monitoring system (e.g. GRACE, JASON, ARGO);
- Climate Prediction models coupled with coastal information, research results (e.g. IPCC AR5 & surge models, CLIVAR), coordinated by the World Climate Research Programme (WCRP);
- Services that tailor user friendly data delivery, products, and scenario construction involving downscaling of GCMs, visualization products of regional sea level scenarios;
- Products for flood risk managers, building and infrastructure specialists, water supply and ecosystem scientists, coastal and urban planning organizations, social scientists and historians would need to be developed;
- Applications that include assessments of vulnerability for different stakeholders would require expert guidance from Oceanographers, Glaciologists, Geologists, and Climate modelers and require risk assessment tools, visualiyation of potential scenarios).[1]

Box 2. Climate Services for Fisheries

Climate Services for Fisheries are at best, loosely coupled. Some observations important for fisheries including data gathered by ocean-going vessels are available over the WMO Global Telecommunications System. However, there are lots of other information important to the fisheries sector (e.g. observations from deep sea temperature and salinity profiles measured by floating and moored buoys, satellite-sensed distribution of phytoplankton, and monitoring systems for global ocean circulation patterns. Ocean warming and ocean acidification, acting on top of over-fishing, threaten the future productivity of global fisheries.

Through the Interagency Group on Agricultural Biometeorology (WMO, FAO, UNESCO, UNEP) climate influences on fisheries, among other sectors, is examined. The WMO Commission for Agricultural Meteorology (CAgM), has added "food aspects of fisheries" to its notable body of service products developed by Expert Teams, in its role of providing advice and helping to develop agricultural meteorological services of members. The Joint Technical Commission for Oceanography and Marine Meteorology with the IOC of UNESCO (JCOMM) cooperate with partner international organizations (in particular United National Environment Programme (UNEP) and International Council for Science (ICSU) to improve observations of the ocean. They work to incorporate data from both the earth's surface and from satellites. These efforts aim to fulfil requirements for essential climate variables from the oceans.

3. Observations and monitoring

17. The information needed to design effective policies for mitigating the effects of, and adapting to, climate change, for managing risks related to climate variability and climate change and facilitating sustainable development fundamentally depends on understanding the threat posed by weather and climate variability, and climate change, to the activities of the meteorological service user.

The NMHSs that make up the WMO have a long history of working closely with a range of communities and industries to assess their climate and weather sensitivity and then to respond by undertaking relevant research, collecting the data necessary to first understand then second assist in resolving the issue or reducing the risks and finally putting in place operational services to ensure that weather and climate risks are properly managed.

3.1 Basic Building Blocks

18. High-quality data from existing observing systems is crucial for uses in modeling climate processes, detecting human-induced climate change, and monitoring climate variability. Such observations must be of a high quality, be available for long periods and have sufficient spatial density to be useful in decision-making. NMHSs collectively operate a world-wide system that combines a Global Observing System's instrument facilities on land, at sea, in the air and in outer space that measure weather and essential climate variables. The basic building blocks of the Observations and Monitoring component are founded on the system of data observation and exchange built by WMO since 1962, under the banner of the World Weather Watch and soon to be expanded under the WMO Integrated Global Observing System (WIGOS) and the Global Telecommunication System being evolved into a WMO Information System (WIS)[4].

3.1.1 Technical Standards

19. More fundamental still are the technical standards that the galaxies of all these measurements follow. Standards ensure consistency and quality of the data, and that these data can be used together. WMO's foundation of standardized procedures (in timing, quality assurance and control, installation, operations, maintenance, calibration, data management, exchange, and archiving) allow for users to obtain the compatible product of requested and documented quality, i.e. the *data*, from disparate networks anywhere at the earth's surface or from outer space.

3.1.2 Metadata

20. Metadata is information about data, apart from the data itself that characterizes the 'who, what, where, and how' related to data collection such as the whereabouts of the instrument or sensor, its characteristics, the time of observation and any changes in measurement techniques etc. It also includes information needed to understand instrument records that become available as new and sophisticated technologies, such as satellites, are launched (e.g. electronics measuring radiances from the earth). In future, an expanded capability through WMO's Integrated Global Observing System and WMO's Information System (WIGOS and WIS) will improve access to both data and the metadata.

[4] WIS will be the core information system utilized by WMO Members, providing linkages for all WMO and supported programmes associated with weather, climate, water, and related natural disasters. It is being built upon the Global Telecommunication System, using standard elements and at a pace feasible for all Members. WIS encompasses three types of centres. For regional and global connectivity, Global Information System Centres (GISCs) will collect and distribute the information meant for routine global dissemination, while serving as collection and distribution centres in their areas of responsibilities; they provide entry points, through unified portals and comprehensive metadata catalogues, for any request for data held within the WIS. Connected to the GISCs, the Data Collection or Production Centres (DCPCs) will be responsible for the collection or generation of sets of data, forecast products, processed or value-added information, and/or for providing archiving services. National Centres (NCs) will collect and distribute data on a national basis and will coordinate or authorize the use of the WIS by national users.

Box 3 WMO's Role in Observations and monitoring component

WMO current strengths (2009-10)

1. Comprehensive Networks: Operational weather/climate observations (i.e. daily or continuously) by 188 NMHSs, and partners.
2. Network comprises approximately 11000 stations (near-surface observations on land); 1300 land stations, 15 ships and 3000 aircraft for observing the high atmosphere; 4000 ships, 1200 drifting buoys and stationary platforms for ocean observation; five operational near-polar-orbiting meteorological satellites; six operational geostationary environmental observation satellites; Research and Development satellites; , two oceanographic (altimetry) satellites and others.
3. Vast data holdings: WMO Members and partners hold vast quantities of climate-relevant, observed data, quality controlled and documented with metadata.
4. Standards: WMO Members set and uphold standards for the instrumentation, and observing procedures, formats and data and quality, and the exchange of its information.
5. Technical authenticity: WMO, through its eight Technical Commissions and expert working arrangements, provides the technical oversight on all data observation activities.
6. Operational functionality: the gathering, QA/QC, archiving, documenting and exchange of data are systematic and routine, based on WMO regulations and requirements
7. The Global Telecommunications System (GTS): WMO's technology allows reliable and fast movement of large quantities of data.
8. Partnerships: WMO has well established partnerships with satellite operators, airline companies, ship operators and others required to support its comprehensive suite of observations
9. International coordination: institutionalized practices and commitments for monitoring including analysis, assessment, publication and informing on climate, particularly its anomalous behaviours

WMO commitments

1. Strengthen the observing capability of Members by optimizing the density and spatial distribution of observing networks, ensuring modernization of instrumentation, observing systems interoperability, data compatibility and increasing the range, timeliness and quality of observations.
2. Facilitate the establishment of an international space architecture for monitoring climate change
3. Facilitate digitization and archiving of data and metadata.
4. Develop and implement new technologies for observing and monitoring.
5. Reinforce adherence to standards through implementation of a Quality Management Framework.
6. Add new observing capability for parameters defined by users, to meet emerging science requirements and service commitments.
7. Operationalize mature research-based observing systems.
8. Operationalize WMO Information System (WIS), with all relevant improvements to the GTS and data exchange.
9. Integrate weather/climate and hydrological networks and databases through WMO Integrated Global Observing System) WIGOS.
10. Evolve all weather observing standards to meet the requirements for climate observations.
11. Make available the climate-relevant data needed to support the functions of the GFCS.

WMO Expectations from Partners

1. Maintaining and increasing cooperation in shared observing systems
2. Operationalizing mature research-based observing systems
3. Increaseing climate relevance of satellite observations
4. Makeing available archived data from satellites and ocean platforms
5. Developing operational networks for environmental, social and economic data relevant to various sectors of development

3.1.3 Data sharing and exchange

21. WMO's Global Telecommunication System facilities provide for nearly instantaneous collection, exchange and distribution of observations on a real-time basis and its Global Data Processing and Forecasting System's centres conduct numerical computation and analysis, and prepare and distribute weather and climate records, warnings, forecasts, predictions, and outlooks. The data exchange policies for meteorological and hydrological data, set by the World Meteorological Congress[5] and implemented by the NMHSs, make the creation and dissemination of weather forecasts around the world a routine matter.

3.1.4 Integrated Data

22. WMO's comprehensive integrated global observing system across a number of observing domains (e.g. surface, atmosphere, ocean, atmospheric chemistry composition, etc.) will, in future, be coordinated, cost-effective and sustainable, in part through improved observing network design and flexibility to incorporate new observing systems. WMO and partnering agencies that rely on WMO data will benefit from easier integration of climate-relevant observations into prediction and applications models. Through WCRP and the Technical Commissions, WMO stimulates development and launch of new observational platforms (e.g. satellites) to meet gaps and needs identified by the scientific community; and conducts data improvement initiatives with GCOS and GEOSS.

23. However, there is a critical and urgent need for governments to provide the required support to NMHSs and other agencies collecting climate-related data to sustain and improve their national observation networks. Developing countries, particularly, least developed countries would need international support to maintain the required networks.

24. WMO and partnering agencies that rely on our data will benefit from easier integration of climate-relevant observations into prediction and applications models. Observations supporting the Framework will involve multiple observing platforms with enhanced collaboration with partners that take observations (e.g. FAO and UNESCO, and partners involved in WMO's Space Programme, entities such as the Coordination Group

Fig 2: Data rescue efforts are needed to convert hard copy records into electronic form

for Meteorological Satellites and the Committee on Earth Observation Satellites[6]). Even now, a special effort is being launched that would allow building of historical Climate Data

[5] Resolution 25 (Cg-XIII) - Exchange of Hydrological Data and Products; and 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

[6] WMO's Space Programme closely cooperates with the Co-ordination Group for Meteorological Satellites (CGMS) and its three science groups: the International A-TOVS Working Group (ITWG), the International Precipitation Working Group (IPWG) and the International Winds Working Group(IWWG). It also cooperates with the Committee for Earth Observations Satellites (CEOS) and its Integrated Global Observing

Records from all the earth-observing satellites that have operated since the beginning of WMO's Space-based Component of the GOS (satellite) programme in the 1960's. It includes satellite inter-calibration efforts.

3.1.5 Data Rescue and Management

25. Weather and climate data records range from a couple of decades to more than a century in certain places that have been collected by NMHSs but are available only in hard copy formats making them difficult to access and retrieve for day to day operational purposes. The Data rescue and management initiatives, aimed at assisting countries in the preservation of the historical climatological records and their transfer to digital media to create and maintain high quality climatological databases using modern Climate Database Management Systems have been supported by WMO over the years. A very successful technology transfer project called CLICOM (CLImate COMputing) provided computers and data management software to developing countries to develop Climate databases. Yet there are still enormous amounts of historical data that were collected and stored in early years which exist only in manuscript form or on microfilm. Many records are held in public and other archives.

26. An important part of the climate observations and monitoring component of the Framework, therefore, would be extension of the climate record backwards into the past. This is an ongoing process to preserve data of being lost and create easy access data for various analyses. Ready access to data gives the ability to quickly carry out complex analyses of climate adaptation risk. WMO efforts in this area will continue in the Framework.

3.1.6 Modern Technology

27. These efforts and the modern technology to collect, archive, analyze and communicate information are costly, on the order of 12 to 15 Billion $US per annum. Only a few countries are able to implement modern observing systems such as Doppler radar, LIDAR, or drifting buoys, and most countries cannot afford to develop or operate satellites on their own. Nor can they always afford the supercomputers needed to process vast quantities of data currently exchanged, or the storage systems needed to retain the data for future use.

28. With respect to the range of measurements required of NMHSs, in terms of the density of stations needed and the data quality requirements that, in turn, require expensive equipment maintenance and regular upgrades. Generating the quantity and quality of observations needed to support the GFCS would be difficult, particularly for many developing countries without sustained government support.

3.2 Global Climate Observing System

29. Global climate change detection provides a specific challenge for climate monitoring, not only through the need for global coverage, but especially because the rate of change of climate variables (such as temperature and rainfall) tends to be small compared with the background 'noise' of natural climate variability. To address this need, Global Climate Observing System (GCOS) was established as a joint initiative of WMO, the Intergovernmental Oceanographic Commission (IOC) of UNESCO, the International Council for Science (ICSU) and the United Nations Environment Programme (UNEP). Particular attention to the quality and consistency of observations is needed, and, for this

Strategy (IGOS) partnership, the Group on Earth Observations (GEO) and its Global Earth Observation System of Systems (GEOSS). Regular relationship is maintained with UN system organizations such as FAO, UNDP, UNEP, UNESCO, and the Committee on Peaceful Uses of Outer Space (COPUOS).

purpose, GCOS has developed a set of Climate Monitoring Principles to guide the collection, archiving and analysis of in-situ and satellite observations for climate monitoring.

30. Together with NMHSs, and WMO's Commission for Climatology (CCl), GCOS has identified those variables that must be observed Essential Climate Variables (ECVs)[7] in order to better understand the variations and changes in climate. These essential climate variables are needed both to support the work of the UN Framework Convention on Climate Change (UNFCCC) and the Intergovernmental Panel on Climate Change (IPCC). And that work needs these variables, for both current and historical observation, to be exchanged internationally.

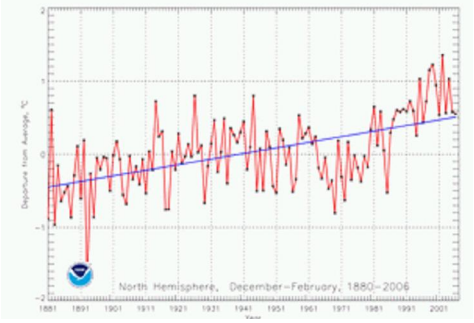

Figure 3 Millions of GCOS-designated observations, processed by experts using standard method of analysis, went into the graphs now commonly used to display the changing climate, as in the temperature trace shown here.

31. GCOS has been branding a system for observing and monitoring climate for these important user groups. It has done so by identifying observing systems that measure any of these variables beginning with a subset of the Global Observing System, other networks (such as GOOS, GTOS , the Global Atmosphere Watch and the Global Cryosphere Watch), and finally by fostering new observing platforms to fill in the gaps. Thus, the current understanding of climate change has been achieved to a large extent through the re-use of weather data initially collected for the purposes of weather analysis and forecasting. Data from GCOS networks has been used in the analysis of the temperature trends for climate change detection (Figure 3).

32. GCOS will continue to play a major role in these efforts. However, developing countries have only made limited progress, with a decline in some regions, in building and maintaining their GCOS observing capability.[8] The 2003 GCOS report on the adequacy of the global observing systems for climate in support of the UNFCCC, and GCOS participation in UNFCCC (SBSTA) activities, are important mechanisms to alert the world on the importance of the observations, and on priorities for remedial action.

3.3 Data Requirements

3.3.1 Rolling Requirements Review

33. Quality records, like those from the GOS and especially the GCOS networks, are important for the development of climate services. WMO's Rolling Requirements Review helps elicit, define, and record user requirements for space-and surface-based observations. The review has been used to define requirements in a variety of applications; for weather forecasting, medium and long range climate outlooks, for IPCC and UNFCCC and observations for agriculture, aviation, and water management, among others. The review process helps identify gaps, or un-met needs in observations. For example, observations, from remote sensors, about snow and glacier extent in Asia, are lacking and that impedes ability to predict river discharge in the early summer.

3.3.2 Data from other user sectors

[7] **Essential Climate Variables (ECVs)** [As of 1-January-2009] Atmosphere (over land, sea and ice) Surface: Air temperature, Precipitation, Air pressure, Surface radiation budget, Wind speed and direction, Water vapour Upper-air: Earth radiation budget (including solar irradiance), Upper-air temperature (including MSU radiances), Wind speed and direction, Water vapor, Cloud properties Composition: Carbon dioxide, Methane, Ozone, Other long-lived greenhouse gases, Aerosol properties Oceanic Surface: Sea-surface temperature, Sea-surface salinity, Sea level, Sea state, Sea ice, Current, Ocean color (for biological activity), Carbon dioxide partial pressure Sub-surface: Temperature, Salinity, Current, Nutrients, Carbon, Ocean tracers, Phytoplankton Terrestrial River discharge, Water use, Ground water, Lake levels, Snow cover, Glaciers and ice caps, Permafrost and seasonally-frozen ground, Albedo, Land cover (including vegetation type), Fraction of absorbed photosynthetically active radiation (FAPAR), Leaf area index (LAI), Biomass, Fire disturbance

[8] GCOS Progress Report 2004-2008 to UNFCCC; Update of the GCOS IO, Paul Mason, GCOS Steering Committee, Stephan Bojinski, GCOS Secretariat, CEOS SIT-24, 11 September 2009, Darmstadt, Germany.

34. Adaptation and climate risk management, including risk assessment, require soci-econmic data from various sectors. Under the Framework, WMO and its partners would identify additional climate observation and monitoring in other major socio-economic sectoral groups (agriculture, forestry, fisheries, urban development, transport, tourism, energy, and health). The review team could take stock of the observation networks and mechanisms for collection of data for other environmental parameters including the other sectors. This will require active involvement of specialists from these climate-sensitive sectors. The rolling review would also allow collection of users needs in order to plan for and adapt to, climate change.

3.4 Monitoring Climate Events

35. Climate data bases underpin establishment of climate normals**,** monitoring worldwide weather and climate extremes, and development of climate change indices. These climate monitoring and analysis activities routinely run by NMHSs in the countries are, in fact, important part of climate services. So are global climate hazards monitoring, a Climate Watch System (with early detection of climate anomalies and climate alerts), which are coordinated internationally with WMO Members are described below. These would have to be sufficiently coordinated with sector users.

3.4.1 Historical time records

36. Many decisions in society depend upon the prevailing climate of the region of interest. For example, airports have to be located in areas where wind-shear is relatively infrequent, different crops are grown in different agro-climatic zones, and dams are built in places that have regular hydrological flows. The key element in having confidence in knowledge about the prevailing climate of a region is through consistent monitoring of the climate and thorough analysis of long-term high-quality observation records. These data and information have been routinely provided by the NMHSs in the countries around the world that have lead to the development of infrastructure and other building codes of practices. The WMO Expert Team on Climate Change Detection and Indices provides guidance on quality controls (QC) and homogeneity of data and analyses of climate extremes in a changing climate in support of informed decisions for adaptation.

3.4.2 Inventory of climate events

37. Tropical cyclones[9] are recorded in historical data bases, with names, descriptive information, and quantitative means for measuring their extent and duration. Similarly, there has been a call for a world-wide inventory of climate event data. On the other hand, droughts, floods, heat waves would be required to be categorized in the same way to build the databases that would help perform climate risk assessments[10]. Other users groups may need products such as indices of climate extremes, or complex indices that combine a number of relevant parameters (e.g. temperature with precipitation and humidity for health sector). A review of user requirements for climate information and products is expected to be undertaken through the Framework (GFCS). All such new products could be used to inform groups that undertake risk assessments.

3.4.3 Monthly climate watches

38. The climate watch system provides advisories and statements to inform users, particularly those involved in natural hazards preparedness, mitigation and response, about evolving or foreseen climate anomalies at the regional and national levels. Climate watches

[9] IBTrACS, International Best Track Archive is a repository for information on all tropical cyclones worldwide, generated to aid global understanding of the distribution, frequency, and intensity of tropical cyclones, and to help assess the risks. Dr. David Levinson. See http://www.ncdc.noaa.gov/oa/ibtracs

[10] The absence of precise and universally accepted definitions of drought, flood, and heat wave would make building quantitative database of these climate events a worthy challenge to WMO Expert Teams.

include observations on current (monthly) climate conditions vis-à-vis means and variance and weekly, 10-day, monthly, seasonal and annual basis. NMHSs should continuously monitor and assess the status of the climate, evaluate available climate forecasts and, if warranted, issue appropriate advisories to users. Global Producing Centres (GPCs) and Regional Climate Centres (RCCs) which could play a major role in the climate watch systems.

3.4.4 Annual State of the Climate

39. Annual State of the Climate report is a current climate monitoring product, which is the outcome of international collaboration, is a retrospective summary of the past year's major climate events. It is coordinated by WMO in collaboration with the Hadley Centre of the UK Meteorological Office, the Climatic Research Unit, University of East Anglia, United Kingdom of Great Britain and Northern Ireland; and the National Climatic Data Center, National Environmental Satellite, Data and Information Service, and National Weather Service of the National Oceanic and Atmospheric Administration (NOAA) of the USA, This summary includes analysis by over 700 authors worldwide. It is used by other UN organizations such as UNEP to relate climate events to services they provide in other sectoral areas such as forestry. Climate monitoring products would continue play a role as important climate products within the Framework. However, the scope and extent of these products would have to be adjusted according to the requirements of the users at global, regional and national levels and would form part of Climate Information Services.

3.5 Partners in Observations and Monitoring

40 Vast international collaboration in observation and monitoring has been an important aspect of WMO's philosophy and service, and will continue to be so under the Framework. WMO has an undeniably strong role in these activities but strongly endorses that this component of the Framework needs strong partnerships, not only in the climate data collection but also for collection and development of standards for the environmental and biodiversity data, and high-quality socio-economic data, in order that the complete information to carry out climate change impact studies, risk assessments and adaptation options is developed and made available. Efforts would be needed to develop collaboration with the groups developing those datasets (for examples, the United Nations Economic and Social Council (ECOSOC); United Nations Economic and Social Commission for Asia and Pacific (UNESCAP) and the United Nations Economic Commission for Africa (UNECA), with mechanisms for merging data for joint studies on impacts and vulnerabilities.

41. No intention is made here towards WMO building a super set of information from all disciplines. Rather, it is recognized that there is a need for a means that allows the integration of observations from multiple disciplines. WMO's role would be to strengthen observation and monitoring network in its domains of air, water, and climate, and to help ensure that they can be integrated with monitoring systems across multiple disciplines. WMO, if required, would be ready to share the experiences and expertise gained by it in monitoring the climate for use in other sectors.

42. The Group on Earth Observations (GEO) is in the process of developing the technical guidelines, sometimes called the Integrated Data Environment, or GEO-IDE, that would set the standards by which data observations from multi-disciplinary sources could be inter-operable. WMO is working with GEO to help towards the realization of workable guidelines and is ready to continue to work with GEO as an important contribution of WMO towards the Framework. WMO is closely working with GEOSS in these developments. It is expected that GEOSS, through its community of practices would support WMO's efforts in further strengthening WIGOS, WIS, and GCOS to provide the strong Observation and Monitoring foundation for the Framework. GEOSS should move to make the emerging data systems in other societal areas compatible with those of WMO's.

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4. Climate research, modelling and prediction

43. Climate research community has a rich history of rising to the challenges of weather and climate prediction, providing the society irrefutable evidence on the reality of climate change and human contributions to it and developing policy-relevant future climate scenarios as key component of the IPCC process. It has advanced significantly during the past three decades, enabling current capabilities to predict seasonal-to-interannual variability in Earth's climate and project climate change on centennial timescales for major regions of the world. However, many scientific challenges remain, particularly to address the societal climate information requirements for adaptation and for climate risk management. An essential need in the context of the Framework is to develop improved methods and tools for quantitative climate predictions and climate projections, on time scales from seasons to decades and spatial scales from local to regional and global, respectively.

Box 4 WMO's Role in research, modeling and prediction

WMO current strengths (2009-10)

10. WMO is co-sponsor of the World Climate Research Programme (WCRP)
11. WCRP's and WMO's Technical Commission on Atmospheric Sciences (CAS) are the world's leading force guiding development of climate models.
12. WCRP and CAS lead research on weather, climate and environmental prediction and create a basis for the development of a seamless prediction system.
13. WCRP's Working Group on Coupled Modelling (WGCM) leads the development of coupled ocean/atmosphere/ land models used for climate studies on longer time-scales.
14. WCRP/CLIVAR works with CCl an JCOMM on Climate Change Detection and Indices (CCDI).
15. WCRP stimulates reanalysis of atmosphere and ocean data and promotes their applications worldwide.
16. WCRP has a strategic Plan that includes scheduled activities to fit the IPCC cycle, the WMO/UNEP Scientific Assessments of Stratospheric Ozone Depletion and a series of other climate-relevant assessments.
17. WCRP addresses the complexity of the climate research and prediction through joint work with numerous partners, including the Earth System Science Partnership (ESSP).
18. WCRP undertakes a multitude of research observations that serve as prototypes for future observing systems.

WMO commitments

12. Continue to sponsor the WCRP and to support its Joint Planning Staff in Geneva.
13. Strengthen mechanisms of collaboration between WCP and WCRP (including CBS and CAS as appropriate) to enable efficient transfer of research advances into operations, and to facilitate flow of user requirements to the research community.
14. In partnership with WCRP expand the RCOF process to other regions, including the Polar Regions.
15. Develop a mechanism for interaction between the research components of RCCs and other regional climate centres, and WCRP, especially its regional panels and monsoon initiatives.
16. Foster links between NMHSs and WCRP, especially for regional and national projects.

WMO Expectations from Partners

8. Maintain and increase cooperation in shared responsibilities (science leadership, and funding) for WCRP
9. Assistance to operationalize mature research-based observing systems
10. Increasing access to, downscaling of and training in the use of climate prediction and IPCC projection data
11. Make available archived data from research initiatives
12. Cooperation in and investment in capacity-building (e.g. through START) in research initiatives within the regions

44. WMO infrastructure, its mandates and human capacity for the generation, distribution and verification of dynamical and empirical seasonal forecasts exist and dynamical seasonal prediction systems are operational or quasi-operational at a number of forecasting centres around the world. But forecast systems are still a long way from realizing the full predictability potential available in the climate system. Climate research is now tasked with even a greater challenge to understand the Earth as a complex, nonlinear interactive system, and assess the impacts of anthropogenic climate change on coupled human and natural systems.

45. The challenge of climate modeling and prediction needs to be addressed by an unprecedented multinational effort, with massive supercomputing, infrastructural and human resource deployment, in order to produce comprehensive high-resolution climate information for the entire planet and reduce uncertainties in present climate information and products.

4.1 World Climate Research Programme

46. The World Climate Research Programme (WCRP) was established by WMO and the International Council for Science (ICSU) as part of the World Climate Programme (WCP) in 1979, and, since 1993, WCRP is also sponsored by the Intergovernmental Oceanographic Commission (IOC) of UNESCO. Its main objectives are to determine the extent to which climate can be predicted, and determine the extent of human influence on the climate system. It is mostly concerned with climate research topics that require interdisciplinary and international cooperation, working on problems that are too large for any one discipline or country. The experts opine that there is an urgent need to further reduce model biases through better representation of physical processes in models and achieving their implementation at higher spatial resolution while improving the understanding of the mechanisms that lead to the variability on the different timescales. WCRP is engaged in addressing these challenges.

47. For much of WMO's history, the climate research and modeling community has organized long and large international observational and modeling projects, in the manner of major field campaigns. The Tropical Ocean and Global Atmosphere (TOGA) project (1985-1994) was one, and the World Ocean Circulation Experiment (WOCE) (1982-2002) was another. These established the physical basis for the understanding and prediction of El Niño/Southern Oscillation (ENSO) and the associated anomalies in global and regional climate and led to a major breakthrough in operational seasonal climate forecasting. The Arctic Climate System Study (ACSYS, 1994-2003) brought to the light the critical role of the cryosphere in the climate system.

48. Completed WCRP efforts have culminated in today's core projects, which are jointly contributing to building the foundation for the coupled-climate and Earth system models of the future. WCRP currently has significant research programs. The Climate Variability (CLIVAR) project, set up more than a decade ago, has provided leadership for coordinated research on climate variability on seasonal, interannual, decadal, and centennial timescales, and has been addressing the associated global as well as regional aspects. Based on new ocean observations and the development of coupled atmosphere-ocean models, CLIVAR and the World Ocean Circulation Experiment (WOCE) have vastly increased understanding of the role of the oceans on the Earth's climate system. The Global Energy and Water Cycle Experiment (GEWEX) has been invaluable in understanding global energy and water cycles processes, and incorporating this knowledge in global climate system models. SPARC (Stratospheric Processes and their Role in Climate) model simulations have been a central element in WMO/UNEP Scientific Assessments of Ozone Depletion, and its research contributes to the scientific basis for the ozone protocols and scenarios used by the UNFCCC. Another project, named Climate and Cryosphere (CliC) examines key processes in the Arctic that affect global climate, and

identifies patterns and rates of change in cryospheric processes.CliC studies on the cryosphere, the hydrometeorology of cold regions, ice masses and sea-level, etc., were a strong input to the scientific programme of the International Polar Year 2007-2008. WCRP's recent efforts to address the immediate needs for regional climate information are through the Task Force on Regional Climate Downscaling (TFRCD), which aims to improve downscaling of global forecast models to a regional scale. These types of research projects have a crucial role to play in the Climate Research, Modelling and Prediction component of the Framework.

49. There is an increasing need in society for information about the future state of the climate system some years, decades and beyond. The Working Group on Numerical Experimentation (WGNE) leads the development of atmospheric models for climate studies and prediction, and the Working Group on Coupled modelling (WGCM) leads the development of climate and Earth System models needed for climate research and prediction. WGCM organises and coordinates climate prediction experiments on decadal and centennial time scales and contribute to a variety of assessments including IPCC Assessments. The new focus is on the development of decadal prediction systems that attempt to account for slow changes in the climate system to support crucial decision making and development of practical applications such as estimates of future energy demand for heating and cooling in cities. But prediction of decadal variations in climate is in its infancy[11] and an area of concerted research. Several coordinated international experiments (ENSEMBLES, CMIP5, CORDEX) are in progress, which will provide some of the information needed to address and prioritise these research challenges. At the same time large uncertainties in present climate projections and climate information make it difficult for planners in various development sectors to use them confidently in their decision making processes and therefore, should be reduced.

4.2 Integrated Research

50. There is a clear recognition that the full understanding of the climate system requires a holistic approach that accounts for all natural processes of the Earth system, and climate-relevant socio-economic processes. To meet the expectations of the proposed Global Framework for Climate Services, there is, therefore, a need for an Earth system approach to observations, monitoring, modeling, analysis and prediction, for which coordinate and accelerate prediction research is essential. In conducting Earth system model studies, WMO (largely through WCRP and otherwise) would have to develop stronger links with other research coordination mechanisms such as the International Geosphere-Biosphere Programme (IGBP) and the International Human Dimensions Programme (IHDP) on Global Environmental Change.

4.3 Research Challenges

51. Climate experts at WCC-3 called upon the scientific community to adopt a more seamless approach to climate prediction. This needs the development of advanced modeling systems that incorporate high-density, high-quality climate observations from multiple platforms and state-of-the-art knowledge on climate processes. Where appropriate, these climate predictions should be suitable for driving application models (e.g., hydrological models). Seamless prediction (on scales from now-casting to seasonal outlooks) is still developing. The WMO Technical Commission on Atmospheric Sciences (CAS) is closely working with WCRP on seamless prediction research.

52. Reanalysis of atmospheric data has greatly improved our ability to analyze past climate variability and has greatly helped in making historical records more homogeneous. This effort is being actively extended to the ocean datasets, and to Arctic and land surface

[11] WCC-3: WS 9 - Towards Prediction of Decadal Climate Variability and Change

data. A further challenge will be to improve estimates of uncertainty in reanalysis products. These efforts are required to support studies of decadal and longer variability.

53. In order to contribute to the provision of the information and products needed by users under the Framework, it will be necessary to downscale information to finer scales. WCRP is launching an evaluation of techniques for use in regional downscaling of global climate projections. One objective is to produce improved multi-model RCD-based high-resolution climate information over regions worldwide for input to impact/adaptation work and to the IPCC Fifth Assessment Report (AR5), which will also promote greater interaction and dialogue between modellers, information producers and the users.

WCRP research addresses the most challenging problems of climate prediction. They include prediction of monsoon variability; interaction between changing atmospheric composition, pollution and climate change. Assessment of the future changes in sea-level requires accelerated development of ice sheet and ice shelf models, reduction of advances uncertainties in estimates of the warming of the ocean. WCRP targets the activities of its affiliated scientists on improving the skill of seasonal climate predictions and discovering the predictability of the climate system on decadal time scales. The huge societal benefit of this research is associated with continuously increasing capacity to predict and assess climate extremes, such as occurrence of heat waves, droughts, floods, storms and tropical cyclones, etc.

4.4 Infrastructure for Computing and Prediction

54. Progress in numerical weather prediction has been closely aligned with the development of computing power over the last fifty years. Over the last decade major advances have occurred in understanding and in predicting climate variability for time periods from a month to a season to a year in advance (and sometimes even longer). The potential for climate prediction on longer scales is tied to the availability of substantial supercomputer resources and a number of facilities with adequate scientific staff and high-speed computational infrastructure.

55. Significant increase in the computing capacity available to the global and regional weather and climate centres is called for in order to accelerate progress in improving predictions. The World Modeling Summit for Climate Prediction in 2008 recommended computing systems dedicated to climate at least a thousand times more powerful than those currently available. As a part of the Framework, WCRP, with strong WMO support, would participate in a concerted international effort for the development of integrated Earth system models.[12]

56. Substantial effort has been made in WMO to set up the infrastructure in the form of global and regional specialized centres for production of predictions. Following advances in computing and communication technology, climate modelling and prediction techniques, WMO GPCs of Long-range Forecasts were established to provide predictions and related outputs and international expertise for seasonal forecasting. At the regional level, the emerging Regional Climate Centres (RCCs) develop regional-scale LRF and related products, and have a strong mandate on supporting NMHSs to improve climate services and facilitate their integration in risk management, planning and adaptation to changing climate, and so would be part of the Framework. RCCs are encouraged to perform downscaling of climate change scenarios, for which substantial collaboration and research inputs, particularly from WCRP/CLIVAR, will be essential.

4.5 Human resources

[12] J.Shukla, Revolution in climate Prediction is Both Necessary and Possibly, a Declaration at the Wold Modelling summit for Climate Prediction, February, 2009

57. Development of highly-skilled human scientific talent via education, training and capacity building, especially through fostering young scientists and strengthening regional and national infrastructure for climate research, particularly in the developing regions of the world is critically needed. Developed countries could significantly help developing countries become self-reliant in research, modeling and prediction, through fellowships, institution building and collaborative research projects.

58. The World Climate Research Program (WCRP) would also focus on supporting capacity building among scientists, because response to climate variations and change requires the capability to appreciate and properly interpret research findings and to apply them to national planning initiatives. WCRP, with IGBP and IHDP collaborate in the SysTem for Analysis, Research and Training (START) programme which engages scientists in developing nations and regions. These efforts would need to be extended through partnerships with Universities.

4.6 Partners in Research

59. To operationalize research advances within the GPCs, RCCs, other regional institutions such as CIIFEN, ACMAD and ICPAC, and NMHSs, their sustained linkages with the research community including universities and research institutions should be ensured.

60. WCRP sponsors four core research projects: Climate and Cryosphere (CliC), with IPO hosted by Norway; Climate Variability and Predictability (CLIVAR) with IPO hosted by the UK; Global Energy and Water Cycle Experiment (GEWEX) with IPO hosted by USA; Stratospheric Processes and their Role in Climate (SPARC) with IPO hosted by Canada; and cosponsors with a number of partners the Surface Ocean-Lower Atmosphere Study (SOLAS) with IPO hosted by the UK.

61. In conducting Earth system model studies, WMO, ICSU and IOC of UNESCO would have to develop stronger links with each other and strengthen research coordination with Earth System Science Partnership (ESSP) and programmes included in it such as IGBP, and IHDP. Existing partnerships between the climate research groups among academic communities, government entities and international research institutions need to be strengthened and new ones forged where required.

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5. Climate Services Information System

60. Climate services have three essential components: (a) historical climate records to meet users' needs for understanding past climate, (b) contemporary climate information or monitoring products to inform users of recent developments, (c) predictions/projections of the future climatic conditions on monthly, seasonal, internannual and longer time scales to assist users to plan for the future. The streams (a) and (b) are closely linked to observations and monitoring of the climate system as described in Section 3. Using these as the basic inputs climate services are developed that can be directly applied to decision making in a wide range of economic sectors.

Box 5 WMO's Role in Climate Services Information System component

WMO strengths (2009-10)

19. WMO's network of institutions that create information and products, include 3 WMCs, 40 RSMCs, 188 NMHSs, 11 GPCs including 2 Lead Centres, 2 RCCs which are formally designated.
20. Close collaboration with regional institutions such as Drought Monitoring Centres (DMCs), ACMAD, ICPAC, CIIFEN, etc.
21. Some established national climate centres.
22. Standards, resolutions, best practices guidance on analysis techniques, criteria for product development and exchange formats
23. Powerful technical support through Intergovernmental Technical Commissions on Basic Systems and Climatology.
24. More than a decade of experience in promoting the development of climate services through Climate Information and Prediction Services (CLIPS) project
25. Years of experience in Regional Climate Outlook Forums
26. Regular issue of WMO El Niño/La Niña Updates
27. Well established sustained linkages between the research and operational communities, particularly through WCRP and WMO Technical Commissions
28. Sustained partnerships with the user sectors, particularly water and agriculture, through Commssions of Hydrology, Climatatology, and Agricultural Meteorology
29. Contributions to early warning systems (e.g., Heat-Health Warning Systems)

WMO Commitments

17. Extend the network of GPCs and RCCs to cover all climatic regions
18. Extend the network of RCOFs including their scope to include user specific climate outlooks
19. Expand RCC and RCOF operations to cover regional climate change scenario development
20. Increase the capacity of NMHSs to provide relevant and reliable climate information and products to national users, for climate risk management and adaptation
21. Develop the concepts of National Climate Centres (NCCs) and National Climate Outlook Forums (NCOFs).
22. Develop additional global climate updates including monitoring and prediction aspects, based on expert assessments.
23. Integrate GPC/RCC product distribution within the WIS

WMO Expectations from Partners

13. Facilitating user feedback and tailoring of climate information products
14. Operationalizing research advances, particularly at the regional and national levels
15. Prioritizing research based on operational needs
16. Regional/National operational infrastructure (computing, high-bandwidth communications, etc.) in developing countries
17. Sustained RCOF operations
18. Promoting climate services information provision as a mandated activity by governments, either within or in close partnership with the NMHSs
19. Engaging with Universities and Research Institutions in a sustained collaborative process on development of information and products.

5.1 Experiences from early initiatives

61. WMO established Climate Information and Prediction Services (CLIPS) project was established in 1995 with the primary objective to develop the capacity of the NMHSs to take advantage of advances in climate science and communication technology, and pass on the benefits to the user community. The Project was designed to build on the latest established atmospheric and oceanographic research results, and operational meteorological and hydrological networks involving international and regional centres as well as the NMHSs. It has been able to exploit the rapidly developing capabilities to predict climate on monthly, seasonal and interannual time scales. The main activities underpinning the project implementation include:

- Promotion of operational climate prediction services, particularly on seasonal to inter-annual scales,
- Providing an active interface between the research and operational communities;
- Promotion of consensus based climate outlook product generation,
- Capacity building of NMHSs in providing climate services ;
- Closer integration of climate products with user applications.

62. Mechanisms, such as RCOFs, GPCs, RCCs, and consensus-based climate outlooks and updates through which the above activities were carried out are briefly described in the following paragraphs. It may be noted that these mechanisms have been successful in generation of the climate information and products and at the same time interact with user groups on pilot basis and do not essentially cover all the regions of the world and are unable to cater to the needs of all the sectoral users. WMO will take steps to further expand these components to be comprehensive and universal in outreach that would form the building blocks of the Climate Services Information System.

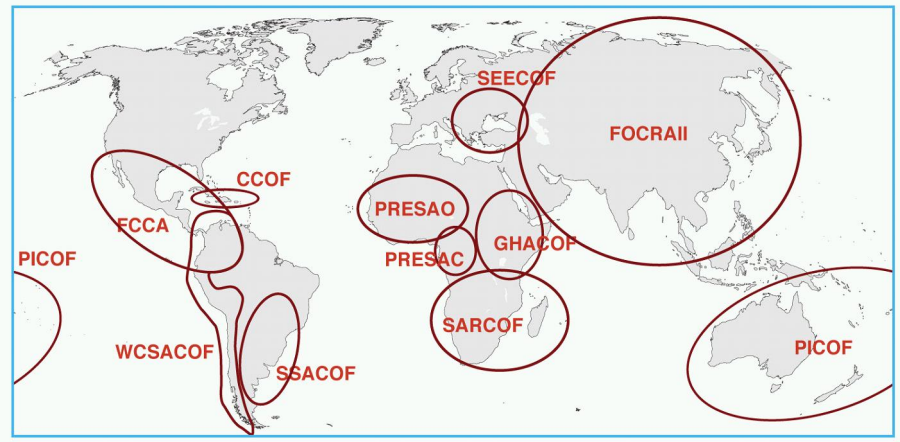
5.2 Regional Climate Outlook Forums

63. Regional Climate Outlook Forums (RCOFs), established more than a decade ago and supported by WMO in partnership with a number of other agencies, bring together national, regional and international climate experts, on an operational basis, to produce regional climate outlooks based on input from NMHSs, regional institutions, Regional Climate Centres (RCCs) and global producers of climate predictions. By bringing together countries having common climatological characteristics, the forums ensure consistency in the access to and interpretation of climate information. Through interaction with sectoral users, extension agencies and policy makers, RCOFs assess the likely implications of the outlooks on the most pertinent socio-economic sectors in the given region and explore the ways in which these outlooks could be made use of.

64. Regional Climate Outlook Forums are one of the vehicles for developing user-driven products and services. Some Forums have been very successful in attracting the interest and support of sectoral user groups and in developing and disseminating seasonal climate predictions and related products. WMO would expand the Forums to include adaptation aspects of climate change along with seasonal and interannual climate forecast discussions. These forums, under the Framework, would continue to be informed by partners within the UN and boundary organizations.

65. Regional Forums are operating in many areas (Fig 4) but need to be extended to other parts of the globe. Further they may serve as effective platform for sharing information for climate change adaptation and would play an important role in the Framework.

Fig 4: Regional Climate Outlook Forums began in with the record-breaking ENSO even of 1997 and are now operational in many regions of the world presently including: SARCOF- Southern Africa COF, PRESAO - Western Africa COF, PRESAC- Central Africa COF, FOCRAII -Forum On regional Climate monitoring, assessment and prediction for Regional Association II (Asia), SSACOF- Southeast of South America COF, WCSACOF- Western Coast of South America COF, CCOF- Caribbean COF, FCCA- Foro Regional del Clima de América Central, PICOF- Pacific Islands COF, SEECOF- SouthEastern Europe COF



66. The activities of RCOFs, which show a rich diversity evolving in response to the specific needs of the regions they serve, have been acknowledged to be quite helpful and have been used to formulate “no regrets” policies that directly safeguard the lives of communities, enhance the resilience of systems and communities to cope and adjust to climate variability and change. Their role in this regard is being recognized and promoted as a contribution to UNFCCC Subsidiary Body on Science and Technology (SBSTA).

5.3 Production of Climate Information

67. This component addresses the need to improve the production and provision of climate information using a three-tier structure, addressing the global, regional, and national scales.

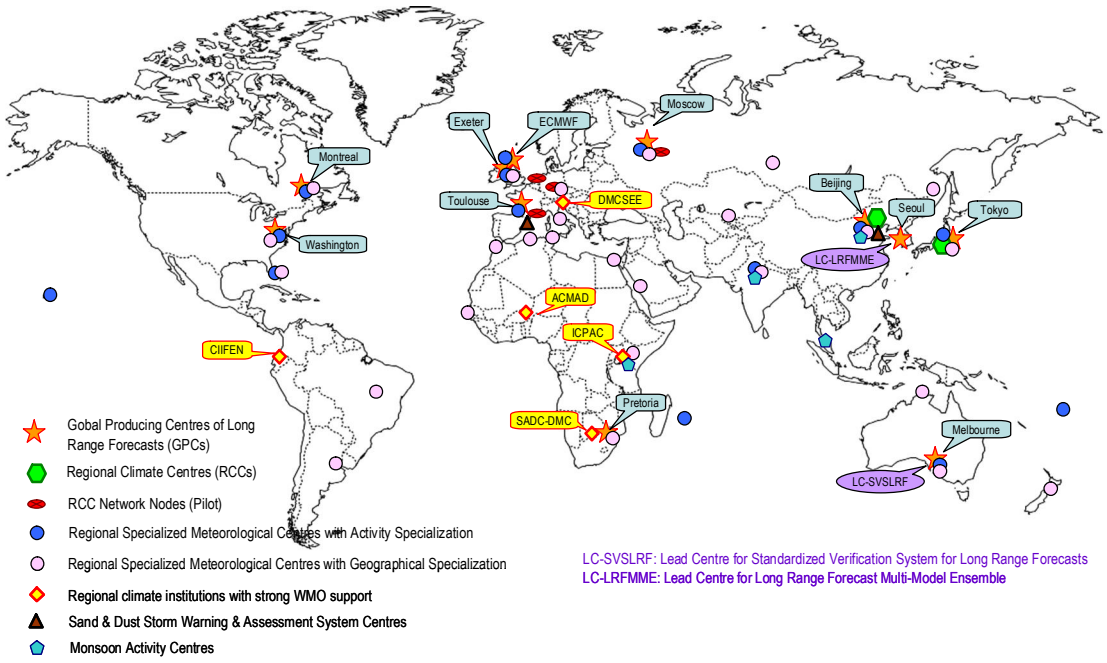


Fig 5. Global network of WMO centres providing climate information.

68. Under the proposed Framework, a coordinated Climate Services Information System would depend on a network of global, regional and national institutions that would generate, exchange, and disseminate climate information routinely and operationally. It would take advantage of and further develop existing networks of global, regional and national entities.

69. Accordingly, Global Prediction Centres, Global Data Centres, and Regional and National Climate Centres, would serve as key elements in this component. What distinguishes this component from Research is that the Services would be routine and operational. As mentioned in the previous section, WMO Members operate a three-tiered climate forecast structure with Global, Regional, and National centres running climate models.

70. They adhere to a fixed production cycle, a standard set of products, and standards. It may also be noted that there is a great deal of multiplicity in the information operationally generated due to a range of modelling and monitoring systems. It is therefore important to assist in expert assessments of the available information and bring out robust signals as well as aspects of uncertainty, for the benefit of the users. For this purpose, WMO's global statements (e.g., Annual Statements of the status of the climate system, El Niño/La Niña Update, etc.), Lead Centres of GPCs, RCCs as well as RCOFs have a key role to play in consensus development.

71. Regional Climate Centres would develop a number of new, more focused products and a broader suite of climate information services and help NMHSs to develop the capacity of scaling down, tailoring, and delivering products to the national scale so as to meet the demands of a wide range of decision makers. Further, there is the important need to devise production systems to meet the user needs more explicitly at the national level and local level. In close collaboration with boundary organisations or specialised sectoral institutions, the products have to be made available in formats that are directly relevant to users in a user friendly language. There is a clear need to devise appropriate linkages with the User Interface Programme of the Framework.

72. WMO's role in this component would be essentially technical, determining the *means* to generate exchange and disseminate information routinely with an operational commitment and in an authentic manner. It would include developing and improving production, delivery and distribution systems, including early warning systems, by consolidating existing and, when appropriate, creating new regional operational centres as necessary, to allow NMHSs to meet the needs of institutions, agencies and the general public within the countries.

5.4 Regular Flow of Data, Information and Products

73. The communications systems used to move input data collected from all over the world and disseminating the products generated in the process would have to ensure that each country has access to what it needs, when it needs it in order to provide effective climate services. The WMO Global Telecommunication System used to transmit weather data and information using leased lines, satellite based systems is evolving into WIS to manage the requirements in addition to those for weather. The Tsunami Warning System for the Pacific uses the WMO System to collect and exchange tide-gauge data. It also forms the backbone for the distribution of Tsunami Warning System bulletins to countries of the Indian Ocean rim and for the Interim Tsunami Advisory Information Service. WIS forms the pillar of the WMO strategy for managing and moving weather, water and climate information in the 21st century. It provides an integrated approach to meet the requirements for routine collection and automated dissemination of observed as well as forecast data and products. It facilitates data discovery, access and retrieval services for all weather, climate, water and related data produced by centres and Member countries. WIS

is designed and being implemented to dramatically extend WMO Members' ability to collect and disseminate data and products.

5.5 Consensus based Climate Outlooks

74. WMO has successfully established a consensus mechanism for the development of updates on El Niño/La Niña conditions which have large influence on the climate around the world. This initiative has been well-received worldwide and is instrumental in improving consistency in terminology and uptake of the seasonal information.

75. The success of El Niño/La Niña can be extended to other aspects of long-range forecasts. Under the Framework, WMO would develop global climate updates and provide the world community with an expert assessment and global consensus on the status of the climate for the current and the upcoming season along with information on robustness and uncertainty of the available signals. Such updates would summarize the monitoring aspects as well as the available predictions of major general circulation features and large-scale oceanic anomalies around the globe (e.g., ENSO, North Atlantic Oscillation, Indian Ocean Dipole, etc.). These updates will feed into the operational activities of RCCs, RCOFs and NMHSs and will contribute to an effective application of science-based climate information in climate risk management.

76. Similarly the climate watch systems at regional and national level can provide advisories and statements to inform users about evolving or foreseen climate anomalies at the regional and national levels through a proactive mechanism, interacting with users and alerting them to major climate anomalies and extremes.

77. Climate Watch Bulletins and Early Warning Systems would continue and expand under the Framework and be a regular component of Climate Service Information System. Under the Framework, integration of data for development of better products would be generated in close collaboration with multiple partners.

5.6 User-provider dialogues

78. Despite rapid progress in the development of climatological data, reanalysis and climate predictions/projections that provide the best possible estimates of past and future climatic conditions currently they are not being managed well enough to exploit the available climate information as users are wary of uncertainties inherent in these products.

79. For many of sectors climate-related information is not the only driver of decision making but may be one of several and even more influential variables to be considered. Clearly non-climate factors will drive investment decision such as these but climate-related factors will need to be considered if the best decisions are to be made.

80. Identifying the *kind* of products and information required by various users and how they should be packaged to be actionable in a real-world decision context, is a shared role between the users and the providers. Therefore it is important that service providers make the users understand the inherent uncertainties in the climate information and products. WMO's role here would be to facilitate and guide interactive, iterative dialogues, between the climate information providers and a wide range of users. This would essentially require clear linkages with the user interface programme including the boundary organizations.

81. An integrated partnership approach will improve professional competency of climate information providers and bring together all of capabilities in a complementary fashion to inform adaptation issues at regional to local scales.[13] WMO's role would be to strengthen

[13] Eileen Shea, Chief Climate Services Division, NOAA's National Climatic Data Center, Asheville, NC, USA

existing, and establish new, operating partnerships between users and providers of weather, climate and water services to share responsibility for effective delivery of services, and evaluate their performance.

5.7 Partnerships required for provision of information for climate services

82. Two types of partnerships are essential for the effective functioning of a climate information system, namely technical partnerships, and those with user communities. Technical partnerships, with space agencies, climate data management and climate monitoring agencies, communications agencies, and the research community (institutes, programmes, and academia) have already been integrated into supporting operational activities, to ensure the timely production and dissemination of high quality information and products. In particular, GCOS (data and monitoring) and WCRP (research, modelling and prediction) are critical partners.

83. With respect to user communities, the system requires ongoing and sustained relationships between provider and user, for development of consensus on products that have implications for the user community, to provide guidance on climate aspects of these products, to update or adjust forecasts, and to facilitate response to evolving user requirements. WMO has long-existing working arrangements with UN Agencies and Programmes including WHO, UNWTO, UNEP, UNESCO and its IOC, ICAO, IAEA, FAO, and with professional societies including IAUC, ISB, ICSU. Interactions within the climate interaction system must extend to regional entities within these agencies, and all relevant national counterparts (e.g. National Health Services).

84. In many cases, boundary organizations and/or extension communities will contribute to both types of partnerships. WMO has experience working with such organizations (e.g. AGRHYMET (Niger), IRI (USA), UNEP Riso Centre, Denmark etc.).

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6. User Interface Programme

85. The most important feature of the Global Framework for Climate Services must be that services are developed through close interaction between users[14] and suppliers, and that value of the service to the global community is judged on its ability to improve decision making in the management of risks associated with climate change. Climate information is widely used in many countries and in many socio-economic sectors, and at many levels of society. In the past climate services were commissioned by NMHSs as service providers who generated and rendered the service but the delivery of climate services was largely automatic without the service provider assigning resources and systems. Nevertheless, the urgency of adaptation to climate change and the complexity of adaptation processes elevate the need for climate information to the level of climate service.

86. The User Interface Programme has necessarily to be developed jointly with other partners in the GFCS who are in direct links and interact with various sectoral user groups and at various levels from Global to regional and national. As such this section is not fully developed and only represents the role that WMO foresees that it can play in UIP.

87. The UIP is aimed at bridging the gap between climate services providers and service consumers, the decision-makers in various sectors and the public at large by:

- Providing the users of climate information an extensive platform to liaise actively with climate service providers and express their needs for climate information, the frequency and modes of delivery of such information and provide feedback on the quality of information provided;
- Prioritizing user needs for climate information for future development work
- Promoting, facilitating and coordinating focused interdisciplinary research and development;
- Facilitating use of climate information, including integration of their uncertainties in decision making, and continually obtaining user feedback in order to drive its growth and improvement;
- Capturing and disseminating knowledge in diverse socio-economic settings;

88. At the **global level, in order to** enhance cooperation within research networks, coordinate applied climate research, and encourage interdisciplinary research to develop applications and products. Appropriate mechanism for undertaking such research would need to be developed with various sectoral institutions.

89. At the **regional level**, UIP would depend on mechanisms carved out on the basis of socio-economic, physical and climatic conditions. These would consist of regional entities, supported by global entities where required, that would represent the regional inter-governmental mechanisms, sectoral development and financial agencies, aid and emergency response agencies, research institutions, regional offices of UN agencies, universities and regional climate centres or other regional entities providing quality regional climate information.

6.1 National level mechanisms

90. The user interface component of the Framework can thus be best understood in a user-centric context, with climate services end-to-end. Climate services are unique to the respective sector and user. The NMHSs as the service providers, or the equivalent

[14] It has to be recognised that 'Users' work at various spatial and time scales - farmers to town planners to river basin managers to national planners and international development organisations – and have different needs from seasonal to decadal and long-term. They work under various economic settings and different financial motives. All these characteristics would require different mechanisms for engagement and feedback.

institution designated within the country to provide climate information, do not have the required in-house expertise to deliver tailored products to suit the needs of users from various sectors. Experience shows that tailored climate information for agriculture may be provided by NMHSs but it may be more effective to involve agricultural research institutes and other intermediate bodies in the delivery and application of such information. Good practices for such an approach are seen in the National Agricultural Monitoring System provided by the Bureau of Rural Sciences of Australia[15] and in a Drought Portal called NIDIS[16].

91. At the national level dialogue between service providers and users in the form of National Climate Outlook Forums is necessary so that users can specify their requirements and respective service level agreements can be arranged.

92. Boundary organizations working in different sectors and with some expertise in climate issues are the best placed to undertake delivery of climate service. NMHSs have to work closely with the boundary organizations to understand the user requirements and deliver the climate services.

6.2 Regional level mechanism

93. Regional Climate Outlook Forums (RCOFS), described under section 5.2, are another example of a User Interface. They bring service providers together with users. RCOFs have strengthened stakeholder engagement with NMHSs, have built capacity for both the climatologist and the users. A number of partners such as the World Bank, NOAA, the International Research Institute for Climate and Society, the European Commission, the FAO, UNEP, World Health Organization, the International Federation of Red Cross and Red Crescent Societies are closely involved in these fora. WMO would expand the RCOFs to include adaptation aspects of climate change along with seasonal and interannual climate forecast discussions. These forums, under the Framework, would continue to be informed by partners such as World Food Programme and IFRCS within the UN and boundary organizations.

94. WMO's CLIPS program demonstrated the new paradigm for climate services that socio-economic decisions can benefit dramatically from better knowledge of both contemporary and near-future climate conditions. Projects begun under the CLIPS program, like the RCOFs, would be made more regular, more timely, and more global in extent within the Framework.

6.3 Global level mechanism

95. In the agriculture and water sectors, WMO through its Technical Commissions on Hydrology and Agricultural Meteorology has developed certain programs that share information, knowledge and best practices. These cases are successful, yet disparate, user interface mechanisms (Box. 6). Through these Technical Commissions, the NMHSs are being encouraged to undertake direct delivery of climate services to the users in these sectors in close collaboration with the concerned ministries and institutions. Within the Framework WMO will further develop such interfaces in these sectors.

96. WMO Expert Team under the Commission for Agricultural Meteorology is investigating standard methods for defining drought. In the future Framework, development of indices and early warning system like these would include partners such as UN Convention to Combat Desertification (UNCCD), and experts from FAO and others like AGRHYMET, Niger etc.

[15] Tokoyo Climate Conference, July 2009
[16] Working Session 9? WCC-3 Conference Geneva, Switzerland (Roger Pulwarthy)

97. At the global level, in other sectors WMO largely interacts with sectoral users in partnership with various UN Agencies and other Inter-government organisations and non-government organisations. WMO will develop these partnerships further. In fact, many projects registered under the GEOSS banner, are also projects with strong leadership by WMO, especially in the User Interface component. There would be a future role in the Framework for WMO in guiding the GEOSS project in this area.

6.4 Partnership with the media

98. The successful communication of climate change and variability information to the users remains one of the least resolved issues within climate change. There is not enough dialogue between scientists and communicators, and that the development of climate services was not being advanced quickly enough. It must be seen as a long-term provider-user relationship of listening and learning. Such a relationship requires access to data, information, ability to generate knowledge, and community collaboration.

99. RCOFs have also developed partnerships with the media. The scope of WMO's Public Weather Services Program, where regular communication with the media is maintained, would be expanded to include Climate Adaptation Outreach Communication through national workshops for the development and implementation of pilot demonstration projects by sharing best practices and experiences by way of incorporating climate information into user focused socio-economic sectors.

100. Awareness workshops that bring scientist and users together would be an important User Interface device in the Framework. WCRP plans on holding subsequent Sea-level Rise workshops every two years especially for Least Developed Countries and Small Island Developing States.

Box 6 Some examples of User Interfaces

WAMIS: World Agro-meteorological Information System is a dedicated web server for agro-meteorological bulletins and products issued by WMO Members. It provides tools and resources like software, training resources, and tutorials. More than a simple webpage, it is a portal to data and information for users in the global agricultural community on near real-time basis. These products are produced on either a weekly, monthly, or yearly time frame. The Weekly Weather and Crop Bulletin, is one example.

HelpDesk for Integrated Flood Management: developed by WMO jointly with Global Water Partnership, and over 20 partner organizations. It is based on the principle of multi-disciplinary collaboration, with hydrology, meteorology and climatology providing flood managers the key inputs, whilst also incorporating a wider range of inputs from various scientific and social disciplines. It promotes effective integration of climate and hydrological information in decision making tools in the flood management. It provides access to a wide range of information for flood prone countries and communities as well as research institutions and development partners

Data and Information Services for Cryosphere: WCRP established a Help Desk to support, and coordinate research into the cyrosphere and how it interacts with the rest of the climate system, part of a project called CliC. It is a single-point access, fully searchable database of information and metadata about the cryoshphere and related research. It helps researchers find data sets, ongoing projects and interactive maps.

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7. Capacity building

101. The Framework is being built using, wherever possible, the existing elements that are either in place or are in the process of being established. However, as the scope of the climate services (from the generation of information and products to its delivery addressing user specific requirements and their application) increases it needs to be recognized that the existing elements in themselves would require strengthening to meet the additional demand and extended scope. Therefore, establishment of the Framework will require capacity-building through:

Box 7 WMO's Role in Capacity Building

WMO current strengths (2009-10)

1. WMO's Education and Training Programme, and related Fellowships programme
2. A global network of 23 Regional Training Centres (RTCs)
3. A well established capacity to build communications skills, through the Public Weather Services Programme
4. Experience over 14 years in national capacity building through CLIPS training workshops worldwide, including the CLIPS training curriculum.
5. Standards, resolutions, best practices guidance on analysis techniques, criteria for product development, exchange and formats
6. Powerful technical support through Intergovernmental Technical Commissions on Basic Systems and Climatology;
7. Extrtabudgetary-funded projects to establish/strengthen climate service infrastructure in developing countries.
8. Experience in multidisciplinary training on climate-related matters.
9. WMO-designated RCCs have training on their products as a mandatory function
10. Expertise in working with NMHSs to improve their capacity to deliver products and services
11. Recognised as a good development partner

WMO Commitment

1. Development of a comprehensive WMO climate training programme based on experiences from CLIPS curricula, to be delivered through RTCs
2. Develop certification mechanism for climate specialists
3. Strengthen training aspects within GPC and RCC infrastructure
4. Promote the upgrading of existing regional or national climate institutions to serve as RCCs
5.
6. Expand the technical capability to work with IPCC scenarios datasets, prediction outputs
7. Increase the capacity of NMHSs to provide climate information and products to national users, for Climate Risk Management and adaptation
8. Develop the concepts of National Climate Centres (NCCs) and National Climate Outlook Forums (NCOFs).
9. Strengthening Internet Technology (IT) and telecommunication facilities of NMHSs to facilitate access to global and regional products
10. Support infrastructure development Integrate GPC/RCC product distribution within the WIS

WMO expectations from Partners

. 1. Financial and technical support to Regional/National operational infrastructure (computing, high-bandwidth communications, etc.) in developing countries
2. Governments and financial institutions to give high priority to financing the NMHSs, communications, power and other infrastructure
3. Universities and research institutes should contribute to human resources development
4. Sustained RCOF operations
5. Support to maintain the national observing networks and to establishing and maintaining national and regional climate institutions
6. Increased investment in capacity-building in climate prediction in NMHSs (particularly from Developing countries)
7. Willingness to take leading role in their specialist areas such as outreach and education for communities
8. Promoting climate services information provision as a mandated activity by governments, either within or in close partnership with the NMHSs

1. Strengthening and aligning institutional arrangements, including clear definition of mandates;
2. Strengthening of existing, and where required, establishment of new infrastructure;
3. Development of human skills and training.

102. Particular emphasis would be placed on the needs of developing and least developed countries including SIDS, and particularly vulnerable regions such as Africa.

103. Human skills in developing, producing and accessing global and regional climate products, including downscaled projected climate change scenarios for assessing climate change impacts, would be developed through access to technology and knowledge (manuals, guidance documents, technical papers, workshop, etc.), and through training. Universities within the countries would be encouraged and facilitated to closely collaborate with the NMHSs with a view to achieving this sustainability. The GFCS Implementation Plan would incorporate the training needs to develop capacity at regional and national levels for identifying user requirements for information and training and for information-sharing techniques.

7.1 WMO Regional and Development Cooperation Programme

104 The WMO regional and development cooperation programme provides assistance, through collaborative efforts of Members, to countries to ensure efficient and reliable operation of National Meteorological and Hydrological Services (NMHSs) for the provision of services to various socio-economic sectors. Through the regional and development cooperation programme and the Voluntary Cooperation Program (VCP) of its developed Members efforts are made to strengthen the infrastructure and institutional requirements of developing and particularly the least developed countries. The VCP provides support to Member countries in the form of equipment, expert services, training and education. It is maintained by voluntary contributions received from partners. These programs, through their intimate knowledge of Member capacity building needs will play a key role in building infrastructure required for strengthening and extending the capacity of the NMHSs to fulfil their role in GFCS.

7.2 Regional Training Centres

105. There are 23 Regional Training Centres and a network of cooperating universities and advanced training institutions which contribute to the education and training effort in meteorology and hydrology, as well as the establishment and development of specialized centres of excellence in various regions. The scope of these training centres would be expanded to include the additional training needs in the countries for developing climate information and products and interacting with boundary organizations as well as the sectoral users within the countries. To develop the human capacity needed in the Framework, WMO's first duty would be to lead the review of the education qualifications and job training required for climate specialists. This would entail establishing minimum standards of education and training for the climate services, as WMO presently does for the meteorological services. WMO would identify the requirements for certification, and develop an organized training focus with curriculum, to be integrated into the Regional Training Centre programmes.

106. Through its Education and Training Programme, WMO assists the NMHSs, especially those of developing countries to become full partners in global collaborative efforts. This includes development of human resources through education and training, provision of educational material and award of fellowships. Training activities are coordinated by themes such as services, use of meteorological data and products or taking and communication observations. Service areas include marine meteorology and tropical meteorology, public weather forecasting, applications in the agriculture and aviation sectors, climate and climate prediction, disaster prevention, environment and hydrology. Use of meteorological data and products includes use of numerical weather prediction model output and use of satellite and radar data and products and products and data from

other remote-sensing systems. Observations training include surface and upper air observing, oceanography, telecommunications, and many others. A number of CLIPS training workshops held across the world have helped to create local capacities in developing and delivering user-targeted climate information. A global network of CLIPS Focal Points assists in national and regional coordination and information sharing in climate activities. These mechanisms can be effectively expanded to include regional climate change adaptation information products.

7.3 Institutional building

108. Capacity-building is much more than training. It requires institutional strengthening in governance, management and funding as well as human resources development. Capacity-building activities for improving adaptation require that the capacity to use climate information becomes part of a larger effort to achieve a specific goal. Through the Regional Programme the mandate, management and human resources issues are addressed. In many countries absence of clear mandates and legislative frameworks on climate related issues present hindrance in the proper functioning of the climate services. Members would be required to be advised and supported in the form of models laws and management practices that they could follow in respective countries to address climate issues. WMO would actively encourage Members to undertake clear definitions of mandates.

7.4 Communication with users

109. In the area of communicating with users WMO will need to build strong partnerships with the other parties supporting the GFCS. Whilst WMO has traditionally worked primarily with the NMHSs there are many other groups who will participate in and benefit from the GFCS and many of the other GFCS partners are already operating in their domains. The links between GFCS partners and then out to the users of GFCS must be seen as a long-term provider-user relationship of listening and learning. Such a relationship requires access to data, information, ability to generate knowledge, and community collaboration. Due to the site-specific nature of resilience and adaptation to climate change, local community and indigenous knowledge of ecosystems, natural hazards and adaptation mechanisms have been developed over long time periods. It will require regular interaction between science and communities for these relationships to be correctly identified and built into downscaling models and mechanisms. Yet climate change and variability may overwhelm these traditional adaptation mechanisms. It is therefore urgent to enhance the human and institutional capacity to increase the interaction between scientific knowledge and local community and indigenous understanding at all levels, once again whilst WMO can play a role here other GFCS partners would be expected to take the lead in these areas.

110. Training in Outreach and Communication would be important for the User Interface component. WMO's Public Weather Services training, especially in Media Training, would be a model to extend towards climate services. Training that helps users and providers better communicate with each other, could be led by other agencies

7.5 Partners in capacity development

111. Closer collaboration would be established with implementing and financing agencies such as the World Bank, regional development banks such as Asian Development Bank, African Development Bank, the European Commission, the United Nations Development Programme (UNDP), the Global Environmental Facility and other bilateral and multilateral development agencies. Collaboration and partnerships would be sought with the UNECA, the UNESCAP, UNECLAC; regional economic groupings such as ASEAN, ECOWAS, IGAD, SADC, CEMAC; the International Group of Research Funding Agencies (IGFA) and other national agencies with funding capacity. Alignment would be sought with other institutional programmes related to climate change, such as the AU-ECA-led ClimDev-Africa.

8. Governance and Resourcing of the GFCS

112. The governance model adopted for the GFCS will strongly influence the way that it is financed and resourced. In this section three possible models are outlined for the governance of the GFCS and within the discussion of each is an outline of the way that it would be resourced. It is clear that there are other governance/resourcing options available but each of these options provides clear differences that should assist in informing future decisions.

113. Before outlining each of the options it is useful to define the way in which the term 'governance' is used in this section. Governance is the process by which accountability for delivering the vision of the GFCS is assigned. Two key components of good governance are that oversight systems are put in place so that resources are used efficiently and that the organisation concerned complies with legal systems in place in the jurisdictions in which it operates.

114. In assessing where accountability lies for achieving the vision of the GFCS it is instructive to analyse key parameters relating to the current provision of climate services. For example:

- Most climate services are provided as 'public goods' by governments, however, in addition to these, there are many organisations and individuals that purchase climate services as 'private goods' from private sector providers;
- Much of the science infrastructure underpinning climate services, such as the collection, exchange and data management associated with meteorological, hydrological, oceanographic and other related data is largely funded by government;
- Nearly all basic climate research (including earth-system model development and validation) and much of the applied research (developing solutions to specific, local problems) is also government funded;
- Because climate variability and change are issues on a global scale, intergovernmental processes have a coordinating role for assisting governments in meeting national requirements; and,
- Every person in the world is a user of climate services and a beneficiary of improved climate services which are primarily delivered through national mechanisms.

8.1 Option 1: GFCS Steering Committee (The WCRP model)

116. A GFCS Steering Committee guiding a small coordinating secretariat, co-sponsored by relevant UN agencies and Programmes (as schematically shown in Figure 6) with a secretariat comprising four to five persons promoting the systematic integration of the GFCS into the programmes of the co-sponsors. An analogue might be the GCOS/WCRP secretariat.

117. Funding would largely be through voluntary contributions to a trust fund as well as through a lesser contribution from co-sponsor, regular budget support for persons within the secretariat.

118. The role of the secretariat would be to coordinate reviews of the end-to-end climate services provision activities through the use of volunteer experts and then to promote systematic 'gap filling' activities that were sustainable and consistent with the programmes of the co-sponsors. The secretariat would not engage in implementation activities, rather, through analysis and advocacy it would assist the co-sponsors to work together to meet the global requirement for climate services. All decisions to expend resources to implement the GFCS would be taken either directly by governments contributing to the GFCS

secretariat trust fund or through their participation in the intergovernmental processes of the co-sponsor UN agencies/programmes. Accountability for implementation of the GFCS would flow though governments to the UN agencies/Programmes that were co-sponsors of the secretariat.

8.2 Option 2: GFCS Joint Technical Commission (The JCOMM Model)

119. A joint technical commission supported by the secretariats of the co-sponsors. An analogue might be the UNESCO/IOC – WMO Joint Commission on Oceanography and Marine Meteorology (JCOMM), though for the GFCS it is conceivable that there would be up to four or more co-sponsors (Figure 7). It is envisaged that the co-sponsors would need to re-structure existing programme activities that contribute to the provision of climate services so as to align then with the identified needs for the GFCS. This would assist in reducing/eliminating duplication between the GFCS and existing programmes and should be encouraged whatever option for governance and resourcing is adopted.

120. Funding would largely be through regular budget support for the programmes of the co-sponsors however, for key, high priority initiatives governments would be called upon for voluntary trust fund contributions.

121. The joint technical commission would meet at regular intervals, possibly yearly initially, to establish expert teams to develop work programmes for the systematic implementation of the GFCS. These work programmes would need to be endorsed by the relevant intergovernmental congress or executive council meeting of the co-sponsoring agency (ies) with responsibility in the subject area. The Joint technical commission would be charged with making recommendations to the co-sponsors decision making bodies and for implementing the decisions of these bodies, it would not, in itself be a body that could commitment governments to the expenditure of resources. Accountability for implementation of the GFCS would flow though governments to the UN agencies/ Programmes that were co-sponsors of the secretariat.

8.3 Option 3: Inter-governmental Panel for GFCS (The IPCC Model)

122. An Intergovernmental Panel for the GFCS jointly co-sponsored by UN agencies/ Programmes that was resourced entirely by voluntary contributions to a trust fund and supported its own intergovernmental decision making process (plenary) and governing council (Figure 8). An analogue might be the Intergovernmental Panel on Climate Change (IPCC). While the IPCC's 'parents' were UNEP and the WMO, if this option were adopted it is likely that the Intergovernmental Panel for the GFCS would have four or more 'parents'.

123. The Intergovernmental Panel would inevitably develop its own governing council which would benefit from having the co-sponsors represented in an effective way so that it did not develop activities that duplicated those of the existing UN agencies/Programmes.

124. Funding would be entirely by voluntary contributions with UN agencies/Programmes, governments and the private sector making contributions, though, as in the case of the IPCC, the Intergovernmental Panel on the GFCS (IPG) would largely be funded through voluntary contributions from governments. Financial management and transparency would be according to established UN principles and procedures. The hosting of the Intergovernmental Panel on the GFCS secretariat within a UN agency would include oversight by that agency of its day-to-day financial operations.

125. The Intergovernmental Panel on the GFCS would establish its programmes so as to align with the work of its co-sponsors, using its resources to bring together experts from the co-sponsors to analyse the need for components of the end-to-end climate services system and to develop strategies to fill gaps as well as to continuously improve the range and quality of services available.

126. Accountability for the implementation of the GFCS would directly fall on governments through the work programme established by the intergovernmental plenary meetings of the Intergovernmental Panel for the GFCS.

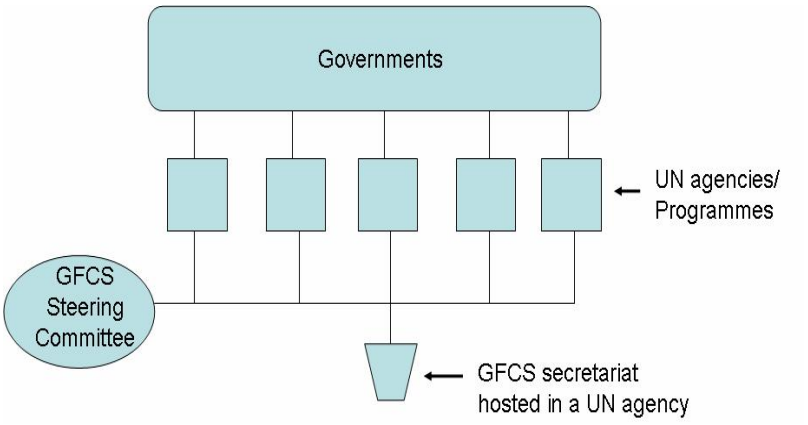

Figure 6: Small secretariat driven by a steering committee established by the co-sponsors.

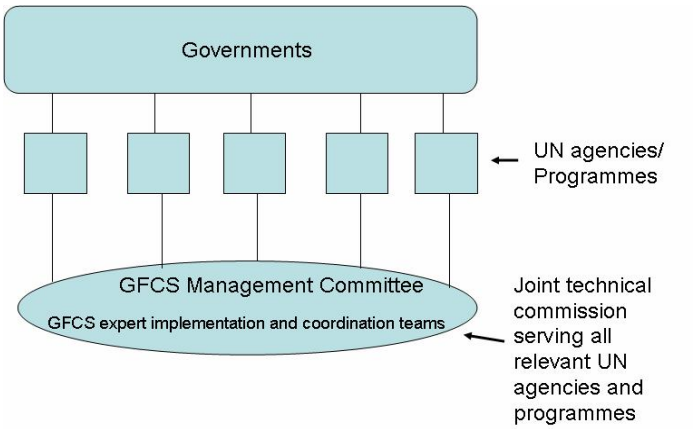

Figure 7: A Joint technical commission established by, and reporting to the intergovernmental oversight bodies of the relevant UN agencies/Programmes

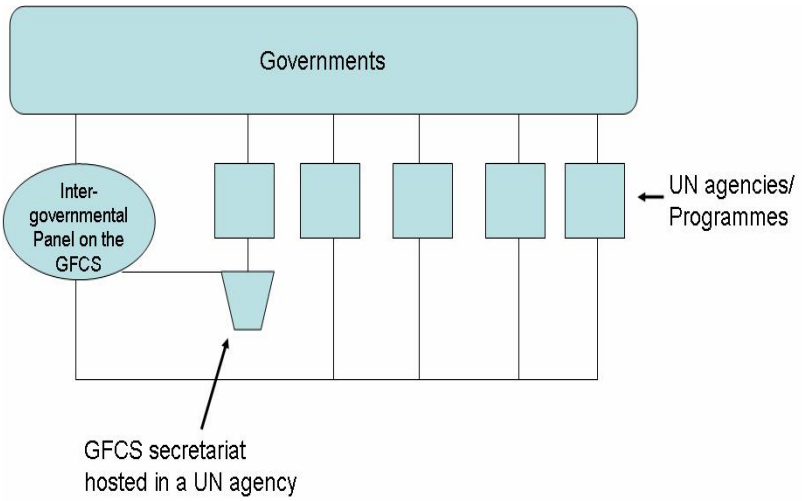

Figure 8: An Intergovernmental Panel with its own intergovernmental decision making mechanisms (plenary) supported by a small secretariat.

ANNEXES

Annex 1: High-level Declaration
Annex 2: Brief Note
Annex 3: The Climate Timeline (To be submitted at the EC WG-CWE Meeting)
Annex 4: Conference Statement: Summary of the Expert Segment
Annex 5: Global Framework for Climate Services: A Concept Note
Annex 6: WMO Technical Commissions

Annex 1, 2 and 4 can be accessed at http://www.wmo.int/wcc3/page_en.php

Table 1 UN Agencies, Programmes and related organizations active in climate issues

United Nations Partners on Climate Change			
United Nations Framework Convention on Climate Change	Intergovernmental Panel on Climate Change	United Nations Environment Programme	World Meteorological Organization
Convention on Biological Diversity	Food and Agriculture Organization	Global Climate Observing System	Global Environment Facility
International Civil Aviation Organization	International Fund for Agricultural Development	International Labour Organization	International Maritime Organization
International Monetary Fund	International Strategy for Disaster Reduction	International Telecommunication Union	Office of the High Commissioner for Human Rights
United Nations Commission on Sustainable Development	United Nations Conference on Trade and Development	United Nations Convention to Combat Desertification	United Nations Department of Economic and Social Affairs
United Nations Development Programme	United Nations Economic Commission for Asia and the Pacific	United Nations Economic Commission for Europe	United Nations Economic Commission for Latin America and the Caribbean
United Nations Educational, Scientific and Cultural Organization	United Nations Human Settlements Programme	United Nations Industrial Development Organization	United Nations Institute for Training and Research
United Nations Population Fund	World Bank	World Food Programme	World Health Organization
World Tourism Organization	United Nations University		

Table 2. WMO Working Together with Partners

A. Working arrangements with specialized agencies of the United Nations,

Working arrangements with the World Health Organization (WHO), 1952
Principles of co-operation with the Food and Agriculture Organization of the United Nations (FAO), 1952
Working arrangements with the International Civil Aviation Organization (ICAO), 1954
Working arrangements with the United Nations Educational, Scientific and Cultural Organization (UNESCO), 1954
Working arrangements with the International Telecommunication Union (ITU), 1960
Working arrangements with the International Maritime Organization (IMO), 1960
Working arrangements with the International Fund for Agricultural Development (IFAD), 1981
Working arrangements with the World Tourism Organization (WTO), 1992
Working arrangements with intergovernmental organizations
Working arrangements with the Agency for Air Safety in Africa and Madagascar (ASECNA), 1962
Working arrangements, with the Arab Center for the Studies of Arid Zones and Dry Lands (ACSAD), 1978
Working arrangements with the Arab League Educational, Cultural and Scientific Organization (ALECSO), 1987
Working arrangements with the Baltic Marine Environment Protection Commission (Helsinki Commission) (HELCOM), 1986
Working arrangements with the Danube Commission (DC), 1962
Working arrangements with the European Centre for Medium-range Weather Forecasts (ECMWF), 1975
Working arrangements with the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT), 1988
Working arrangements with the European Space Agency (ESA), 1973
Working arrangements, with the International Council for the Exploration of the Sea (ICES), 1970
Working arrangements with the League of Arab States (LAS), 1972
Working arrangements with the Permanent Joint Technical Commission for Nile Waters (PJTC), 1977
Working arrangements with the Permanent South Pacific Commission (PSPC), 1987
Working Arrangements with the Economic Community of West African States (ECOWAS), 1966
Working Arrangements with the South Pacific Regional Environment Programme (SPREP), 1994
Working Arrangements with the Arab Organization for Agricultural Development (AOAD), 1994
Working Arrangements with the Interstate Council on Hydrometeorology of the Countries of the Commonwealth of Independent States (ICH/CIS), 1996
Working Arrangements with the Islamic Educational, Scientific and Cultural Organization (ISESCO), 1997
Working Arrangements with the Lake Chad Basin Commission (LCBC), 2000
Working Arrangements with the International Committee for Weights and Measures (CIPM), 2002
Working Arrangements with the Caribbean Meteorological Organization (CMO), 2002
Working Arrangements with the Niger Basin Authority (NBA), 2002

B. Agreements with intergovernmental organizations

Cooperation Agreement between the World Meteorological Organization and the African Union (formerly the Organization for African Unity) (AU), 1975
Working arrangements with non-governmental international organizations
Working arrangements with the International Council for Research Studies and Innovation in Building and Construction (CIB), 1982
Working arrangements with the International Council for Science (ICSU), 1960

Working arrangements with the International Institute for Applied Systems Analysis (IIASA), 1977
Working arrangements with the International Seismological Center (ISC), 1977
Working arrangements with the International Union of Geodesy and Geophysics (IUGG), 1954
Working arrangements withe the International Association for Urban Climate (IAUC), 2008
Working arrangements with the International Organization for Standardization (ISO), 2008

C. Consultative status for non-governmental international organizations

International Association of Broadcast Meteorology (IABM), 1998
International Astronomical Union (IAU), 1955
International Astronautical Federation (IAF), 1964
International Commission on Irrigation and Drainage (ICID), 1960
International Federation of Air Line Pilots Associations (IFALPA), 1954
International Federation for Agricultural Producers (IFAP), 1954
International Federation for Documentation (IFD), 1954
International Organization for Standardization (ISO), 1954, replaced by Working Arrangements (2008)
International Radio Maritime Committee (IRMC), 1954
International Society of Biometeorology (ISB), 1963
International Society of Soil Science (ISSS), 1954
International Union for Conservation of Nature and Natural Resources (IUCN), 1970
International Union of Radio Science (IURS), 1954
Oil Industry International Exploration and Production Forum (E. & P. Forum), 1984
World Federation of United Nations Associations (WFUNA), 1954
World Energy Conference (WEC), 1955
Association of Hydro-Meteorological Equipment Industry (HMEI), 2002
ETC group-Action on Erosion Technology and Concentration (ECT Group), 2008

D. Memorandums of Understanding (MoU) as of 2000

South Pacific Applied Geoscience Commission (SOPAC), 2000
Intergovernmental Coordination Committee of the La Plata Basin Countries (CIC), 2000
Inter-American Institute for Cooperation on Agriculture (IICA), 2000
Caribbean Institute for Meteorology and Hydrology (CIMH), 2001
African Center of Meteorological Applications for Development (ACMAD), 2001
International Organization of the Francophonie (OIF), 2001
Association of Southeast Asian Nations (ASEAN), 2002
International Consortium on Landslides (ICL), 2002
International Centre for Integrated Mountain Development (ICIMOD), 2002
European Meteorological Society (EMS), 2003
Economic and Social Commission for Asia and the Pacific (ESCAP), 2003
Arab Organization for Agricultural Development (AOAD), 2003
East African Community (EAC), 2003
European Commission (EC), 2003
Netherlands Organization for Applied Scientific Research (TNO), 2004
International Research Institute (IRI), 2004
Economic Cooperation Organization (ECO), 2004
Asian Disaster Reduction Centre (ADRC), 2005
United Nations Office for Outer Space Affairs (UNOSAT), 2005
South Asia Co-operative Environment Programme (SACEP), 2005
International Council for Science on the International Polar Year 2007/2008 (ICSU), 2006

WMO Technical Commissions

1. Scope of Technical Commissions

6.1 Technical commissions are the inter-governmental constituent bodies of WMO that largely oversee and technically guide the implementations of various technical Programs through which the organization fulfils its vision and objectives as laid down in its long-term/strategic plans approved by WMO Congress. Experts in respective field from all the Members of WMO are eligible to participate in the work of the Technical Commissions.

2. A Brief History of the Commissions

6.2 In 1951, at its First Congress, the WMO established eight technical commissions:

- CBP The Commission for Bibliography and Publications
- CCl The Commission for Climatology
- CAgM The Commission for Agricultural Meteorology
- CIMO The Commission for Instruments and Methods of Observation
- CSM The Commission for Synoptic Meteorology
- CAeM The Commission for Aeronautical Meteorology
- CMM The Commission for Marine Meteorology
- CAe The Commission for Aerology

6.3 Since some of the sub-commissions of the International Meteorological Organization were actively engaged in work, Congress decided that the sub-commissions shall be listed in an Appendix and shall be related to the appropriate technical commissions. This structure was maintained in 1955, in Resolution 16 of the Second Congress

6.4 These eight technical commissions persisted through until 1971, at the Sixth Congress when there was a major restructure. CSM was replaced by CBS and CAe was replaced by CAS (with similar terms of reference to their predecessor Commission). CBP was not re-created, each Technical Commission becoming responsible for its own documentation. CCl was renamed as the Commission for Special Applications of Meteorology and Climatology (CoSAMC). The Commission for Hydrology was created. The Congress described the Commissions as falling into one of two categories: CBS, CIMO and CAS were described as “Basic Commissions” whereas CAeM, CAgM, CMM, CHy and CoSAMC were described as “Applications Commissions”. The result was:

- CBS The Commission for Basic Systems
- CIMO The Commission for Instruments and Methods of Observation
- CAS The Commission for Atmospheric Sciences
- ---
- CAeM The Commission for Aeronautical Meteorology
- CMM The Commission for Marine Meteorology
- CHy The Commission for Hydrology
- CAgM The Commission for Agricultural Meteorology
- CoSAMC The Commission for Special Applications of Meteorology and Climatology

6.5 In 1979, at the Eighth Congress, CoSAMC became the Commission for Climatology and Special Applications of Meteorology (CCAM) with revised terms of reference. In 1983, at the Ninth Congress CCAM was renamed the Commission for Climatology (CCl) with updated terms of reference that no longer required the broad focus on meteorological applications, but rather a narrower, climate only, focus. In 1987 the Tenth Congress decided that CHy should be considered to be a basic commission of the WMO.

6.6 In 1999, at the WMO’s 13th Congress, the last substantive change to the Commission structure occurred with CMM being abolished and the new, Joint WMO /IOC Commission for Oceanography and Marine Meteorology (JCOMM) being created. The WMO had now arrived at the current structure of technical commissions:

- CBS The Commission for Basic Systems

- CIMO The Commission for Instruments and Methods of Observation
- CAS The Commission for Atmospheric Sciences
- CHy The Commission for Hydrology

- CCl The Commission for Climatology
- CAeM The Commission for Aeronautical Meteorology
- JCOMM The Joint Commission for Oceanography and Marine Meteorology
- CAgM The Commission for Agricultural Meteorology

3. Terms of References of Technical Commissions

6.7 Since 1951, most WMO Congresses have adjusted the individual Commission's terms of reference with the Sixth Congress, in 1971, making the most radical re-structure and essentially laying the foundations for the current arrangement of technical commissions. It is possible to view the WMO's Commission structure in many ways, and the view presented by earlier Congresses, that the fundamental nature of CBS, CIMO, CAS and CHy is different from that of the other four Commissions, is adopted here. This said, while holding the conceptual view of the relative roles and functions of the technical commissions, it is still possible to recognise that many of the "Applications Commissions" also plan, implement and maintain operational infrastructure while the "Basic Commissions" also meet external client requirements (for example, the Public Weather Service component of CBS).

6.8 The general Terms of Reference of the Technical Commissions is as follows while the specific Terms of Reference of each of the Technical Commissions are defined in WMO Publication No 15.

General terms of reference applying to all technical commissions

Within its terms of responsibility as defined hereunder and within the provisions of these Regulations, each technical commission shall:

1 Study and review advances in science and technology, keep Members informed and advise Congress, the Executive Council and other constituent bodies on these advances and their implications;

2 Develop, for consideration by the Executive Council and Congress, proposed international standards for methods, procedures, techniques and practices in meteorology and operational hydrology including, in particular, the relevant parts of the Technical Regulations, guides and manuals;

3 Under the general guidance of Congress and the Executive Council, carry out functions—with other bodies as necessary—relating to the planning, implementation and evaluation of the scientific and technical programme activities of the Organization;

4 Provide a forum for the examination and resolution of relevant scientific and technical issues;

5 Promote training by assisting in the organization of seminars and workshops and in the preparation of related material and the development of other suitable mechanisms for the transfer of knowledge and methodology, including the results of research, between Members;

6 Promote international cooperation and maintain, through appropriate channels, close cooperation on scientific and technical matters with other relevant international organizations;

7 Make such recommendations as it may consider necessary.