WORLD METEOROLOGICAL ORGANISATION

DRAFT Position Paper on Global Framework for Climate Services

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Position Paper on Global Framework for Climate Services

EXECUTIVE SUMMARY

The Heads of State and Government, 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 Conference declaration, decided to establish a Global Framework for Climate Services (hereafter referred to as "the Framework") to strengthen the production, availability, delivery and application of science based climate monitoring and prediction services. The declaration decided that a taskforce, consisting of high-level independent advisors, would prepare a report, including recommend action on the proposed elements of the Framework, taking into account the concepts outlined in the Brief Note annexed to the Declaration. This position paper outlines the overall vision of the Framework for consideration of the taskforce.

Introduction

1. Adaptation to climate variability and change represents an important challenge for the sustainable development of society. Adaptation, to be effective, requires a policy framework, technology and practices to adjust to expected changes, supported by relevant climate information and tools. The Framework is designed to mainstream climate science into decision making at all levels and help ensure that every country and every climate-sensitive sector of society is well equipped to access and apply the relevant climate information. The overarching goal of the Framework is 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 services into planning, policy and practice."*

2. Climate services deal with the generation and provision of a wide range of information on past, present and future climate and its impacts on natural and human systems. Also included is the application of that information for decision-making at various levels in society. As understanding of the climate system grows and the society becomes more aware of the potential benefits from use of this knowledge, communities will increasingly expect that these services are: accessible, dependable, usable, credible, authoritative, responsive, flexible, and sustainable.

The concept and components of the Framework

3. Climate information and products are based on sustained, long-term, high quality observations of climate elements over the land and oceans and in the atmosphere; synthesizing these observations; monitoring various processes and understanding them through diagnostics, research and modeling; and making predictions/projections of what to expect in weeks, months, years or decades. Further, the application of climate services must involve close interaction between the providers and the users. As such, the production and application of climate services requires concerted multi-disciplinary efforts.

4. Given the complexity of and requirements for climate services, addressing the immense variety of user needs for climate services is beyond the capacity of any single organization, a small group of organizations or a country. It calls for an unprecedented collaboration among institutions across political, functional, and disciplinary boundaries. The Framework is, therefore, conceived as an integrating set of international arrangements which will be built upon the established global climate observation and research programmes as well as operational structures into an end-to-end product generation, service provision and application system. Many of these elements (systems, programmes, projects, institutions etc.,) are either in place or are in the process of being established. The Framework must be designed to be an effective, efficient and economically viable mechanism for the generation, delivery and application of climate services.

5. Noting that the "Global Framework for Climate Services" will be user need driven, as a process, and the recommendations incorporated in the Conference Statement, it is proposed to have

five major components: (i) Observations; (ii) Climate research, modelling and prediction; (iii) a Climate Services Information System; (iv) a Climate User Interface Programme; and (v) Capacity Building.

Observations

6. Underpinning an effective climate service is the systematic gathering of high quality basic climate and environmental data. Climate and climate related observations are needed for: climate system monitoring; climate change detection and attribution; operational climate prediction on seasonal-to inter annual time scales; research to improve understanding, modeling and prediction of the climate system; assessment of the impacts of, and vulnerability and adaptation to, natural climate variability and human-induced climate change; and applications and services for sustainable economic development. In addition, related systematic environmental and socio-economic data and information are needed to assess human and environmental vulnerabilities and plan actions that must be taken in various development sectors to adapt to climate variability and change.

7. National Meteorological Services (NMSs), for more than 150 years, have built infrastructure for observation on land, at sea and in the air that measure meteorological and some environmental variables. Various agencies are charged with the national implementation of the individual observing networks and systems. These observing networks across a number of observing domains follow procedures and adhere to standards established through intensive work of the WMO Technical Commissions, which now fall under the WMO Quality Management Framework. The current understanding of climate change has been achieved to a large extent through the re-use of this data initially collected for the purposes of weather analysis and forecasting. Satellite observations have supplemented the observations of earth system in the past 50 years.

8. In response to the decisions at the Second World Climate Conference (1990), the Global Climate Observing System (GCOS) was conceived. GCOS, supported by Global Terrestrial Observing System (GTOS) and Global Ocean Observing System (GOOS), has a goal to provide continuous, reliable, comprehensive data and information on the state and behavior of the global climate system. These observing systems are supported by WMO, FAO, UNEP, UNESCO and International Council for Science (ICSU). To ensure the quality and consistency of observations, GCOS has developed a set of Climate Monitoring Principles to guide the collection, archiving and analysis of in-situ and satellite-based climate observations.The Global Earth Observation System of Systems (GEOSS) provides comprehensive, coordinated Earth observations from all platforms.

9. Considering that weather and climate know no political boundaries, it is vital that the meteorological and hydrological data that are fundamental to operationally conduct analysis and diagnostics, and prepare and distribute weather and climate records, warnings, forecasts and outlooks, are quickly and reliably shared around the world.

10. WMO periodically evaluates the requirements for observations for a variety of applications (e.g. weather forecasting, seasonal climate prediction for application in agriculture, aviation, and water management, among others), and to meet IPCC and UNFCCC requirements, through 'Rolling Requirements Reviews'. The GCOS also reports on the progress and the adequacy of the global observing systems for climate in support of the UNFCCC.

11. These reviews have identified a number of critical issues related to the observations such as: spatial and temporal data gaps; absence of organized and standardized socio-economic data gathering mechanism; limited access to some data; non-availability of historical records in digitized form; appropriate processing and archiving systems to handle vast amount of data; and interoperability of data. It is important to reduce these gaps as they adversely impact on the reliability of climate services including monitoring, predictions and projections.

12. Establishing and maintaining operational observing system requires significant human and financial resources. In competition with major societal and economic issues, observing systems often get relatively low priority and funding in national fiscal planning. As a result, observation networks around the world are deteriorating, in both the developed and developing countries. With respect to data access, restrictive data policies and the non availability of these data sets in electronic form prevent the optimal use of the data and information generated by these systems for the benefit of the society.

13. For strengthening existing climate services and developing new ones, it is imperative that these issues are adequately addressed. Strengthening, upgrading and modernizing the observation networks that NMSs currently use for weather forecasting, to serve the needs of climate services is a high priority. Observational networks established for research, but which have potential ongoing applications in weather and climate services, need to be converted into robust operational observation programmes with sustained funding. It is essential that data are collected to the required standards to meet the purposes for which their use is intended.

14. Collection of environmental, biodiversity as well as socio-economic data, which is largely ad-hoc and not well-organised in most countries, needs to be coordinated. There are a limited number of standards developed so far for observation and archiving of such data. For sector-specific information, products and services, all sectors would also have to systematically collect and manage relevant data for their activities. Barriers to sharing of data among various institutions within the country and with global research community need to be removed.

Climate research, modelling and prediction

15. Climate research, including modeling and prediction aspects, helps the Framework characterize climate variability and change and to generate quantitative climate predictions and climate projections, on a range of time and space scales. The World Climate Research Programme (WCRP), established in 1979 jointly by WMO, the International Council for Science (ICSU), and the Intergovernmental Oceanographic Commission (IOC) of UNESCO as a major component of the World Climate Program (WCP), has helped determine the extent to which climate can be predicted, and the extent of human influence on the climate system. It has successfully laid the science foundation for the climate services of the future. Its current research projects, particularly those pursuing the coupled climate and Earth system models, are poised to push the frontiers of climate predictability further. Climate research has successfully developed policy-relevant future climate scenarios projections for the 21st century that formed a key component of the IPCC process.

16. While climate science has advanced significantly during the past three decades, many scientific challenges still remain. There is an increasing need in society for information about the future state of the climate system in the near term, extending from years to decades, to support development of practical applications and crucial decision making. New focus is required on the development of decadal prediction systems, an area of concerted research still in its infancy. Further, there are many inherent uncertainties in our estimates of the past, present and future behaviour of the climate. Large uncertainties in the climate information, predictions and projections make it difficult for planners in various development sectors to use them confidently in their decision making processes and therefore, have to be reduced to the extent possible.

17. The full understanding of the climate system requires an understanding of all natural processes of the Earth system, along with the climate-relevant socio-economic processes. To meet the expectations of the Framework, there is, therefore, a need for a holistic Earth system approach to observations, monitoring, modeling, analysis and prediction.

18. The potential for climate prediction on longer time scales and with better spatial resolutions is tied to the availability of high-performance computational infrastructure and adequately trained scientific staff. Significant increases in the computing capacity available to the global and regional weather and climate centers is called for in order to accelerate progress in improving predictions. It is widely agreed that more researchers need to be working on the forecast systems to fully exploit the predictability potential available in the climate system, and to address the enormous challenge of understanding the Earth system and its future evolution.

19. Weather research and climate research are closely intertwined; progress in our understanding of the climate processes and their numerical representation is common to both. The models used for weather and climate prediction are essentially based on the same physical principles and formulations, though the way they are deployed is substantially different. Experts advocate adopting a more seamless prediction approach to prediction. Seamless prediction (on timescales from a few hours to centuries) needs to be further developed and extended to aspects across multiple disciplines relevant to climate processes.

20. Availability of highly-skilled human scientific talent, particularly in the developing regions of the world, is critically lacking. There is need to improve skills among scientists to properly interpret research findings and to improve the skills of those who apply this information to national planning initiatives. To address the above-noted needs for climate research, modeling and prediction, to ensure development of the knowledge base, of reliable high-resolution products and to reduce uncertainties in the present climate information and products will take an unprecedented multinational effort, with significant supercomputing, infrastructural and human resource deployment.

Climate services information system

21. The climate services information system (CSIS) is designed to deliver the climate information that users need for the decisions they have to make. Given that climate processes are global in character and operate on a wide range of space/time scales, the flow of information from global to local scales is essential and must be facilitated. For an effective delivery of climate information, an appropriate institutional mechanism is required to generate, exchange and disseminate quality information at global, regional and national levels on an operational basis.

22. CSIS, based on the inputs from the observations and research components, will require physical infrastructure such as computers, institutions, centres; skilled human resources for product development and consultation; and mechanisms for interactions with the users. Many of the elements of what will be the fully operational CSIS already exist in some form, but need to be further developed and standardized.

23. Progress in evolution of climate services was given a systematic direction with the establishment of the World Climate Programme (WCP) in 1979 that laid the foundation for modern climate services. Advances in the provision of climate services have been gradual, useful and timely, but in the last decade the demands for climate information at local level and expectations of better tools for decision making have grown rapidly and continue to outpace capabilities. There are a number of gaps between present capacities and the expectations of the policy makers, planners, operators, nations, communities, and individuals that must be addressed.

24. The CSIS will be based on the three-tiered structure of entities at global, regional and national levels. They include global data centres and global forecast/information producing centres (GPCs), Regional Climate Centres (RCCs) and National Climate Services (NCSs). National Climate Services either within or closely associated with NMSs, mandated by the national governments, would be at the forefront of the CSIS information development, dissemination and application cycle. CSIS will encourage and facilitate the collaboration of NCSs with relevant boundary and specialised sectoral institutions to enable them to work with national agencies, including governmental and non-governmental organizations, universities and national research institutes that are mandated to serve different sectors and at levels of administration. NCSs will get global and regional inputs from the RCCs and GPCs, and will benefit from the consensus development mechanisms of the Climate Outlook Forums (COFs).

25. Climate Outlook Forums (COFs) at regional and national level have shown promising results in user engagement. They have been developed, for the most part, on pilot basis and therefore do not adequately cover all the regions of the world, nor do they adequately cater to the needs of information at local levels and as often as users might need. It is imperative therefore to ensure that the network of these elements is expanded spatially and cover the range of quality products users require, facilitate a common understanding of climate risks and opportunities, provide information on inherent uncertainties, and advice on how the information can be applied for the optimal results.

26. RCCs would need the infrastructure, capacity and mandate to develop high-quality regional-scale climate products using products generated at global scale and incorporating regional information. They will develop, monitor regional climate variability and extremes, conduct climate watches, and downscale prediction and projection products from global centres. RCCs would be expected to develop a broader suite of region-specific products to address regional needs and help NCSs to develop the capacity of downscaling regional products, tailoring them and delivering to the national users. The establishment of RCCs has begun only recently, and will require significant human and financial inputs to accelerate the global implementation.

27. Climate services, therefore, will be strongly rooted in the existing capabilities for the provision of weather services and the years of research, investment, and collaboration among 189 NMHSs. The CSIS will rely on and expand the weather and climate infrastructure developed over time and will strengthen the human expertise needed for its operation. While all WMO NMSs conduct some climate services, especially those related to data, aspects related to prediction, services and user liaison require considerable development. It is essential to devise production systems to meet user needs more explicitly, especially at national and local levels, to provide 'actionable' information. A comprehensive and systematic plan of well defined actions and appropriate resources would be required to turn the existing disparate elements into a coherent, cohesive, and dynamic functioning system.

28. Flow of information and generation of products and services within the system would require regular feedback from users at various levels, for continual improvement of services. The CSIS will therefore have very close links with the Climate User Interface Programme component of the Framework.

Climate user interface programme

29. The climate user interface programme (CUIP) is aimed at bridging the gap between climate services providers and users, the decision-makers in various sectors and the public at large by providing mechanisms through which the users of climate information can liaise actively with climate service providers and vice versa, with the value of the climate service to the community being judged on its ability to improve decision making.

30. CUIP will coordinate, facilitate and oversee the development of mechanisms at various levels (global to regional, national and local (in close relation with the national government)) in various sectors. It will help: users in expressing their needs; prioritizing these user needs; promoting, facilitating and coordinating focused interdisciplinary (applied climate) research; facilitating communication and use of climate information; capturing and disseminating knowledge in diverse socio-economic settings; and obtaining user feedback in implementation of other three Framework components described above.

31. Central to the development of user-specific climate information is the recognition that the needs of the user community are diverse and complex. At the same time it has to be recognised that 'users' work at various spatial and temporal scales and have common as well as different needs.

32. CUIP is seen as a set of activities, projects and initiatives running across all the components of the Framework but particularly concentrating on the application of the climate information and products in decision making in various sectors and at various levels of the user spectrum. CUIP would need to have its roots down to the national levels. The CUIP initiatives/activities may differ from sector to sector. As such it has to be developed jointly with national, regional and global partners who have direct links and interaction with various sectoral user groups.

33. NCSs would need to establish arrangements with boundary organizations/extension agencies in different sectors, and popularize the concept of National Climate Outlook Forums in close collaboration with sectoral ministries or interest groups. At the regional level, CUIP would depend on mechanisms and partnerships developed on the basis of socio-economic, physical and climatic conditions, supported by global entities where required. Regional entities such as River Basin Organisations and economic groupings, possibly in association with RCOFs, can play a crucial role in facilitating such mechanisms. At the global level, CUIP would enhance cooperation within research networks belonging to different disciplines, coordinate applied climate research, and encourage interdisciplinary research to develop applications and tools. It will largely be lead by various UN Agencies and other Inter-governmental organisations and non-governmental organisations.

34. Effective communication of climate information is vital to ensure its appropriate application. The communication strategy under the Framework has to be based on a broad range of contemporary media and user-friendly content. These communication means would have to be in-built into various elements of the Framework to build advocacy, generate awareness, interact and encourage involvement.

Capacity building

35. Implementation of the Framework will require capacity-building through: strengthening and aligning institutional arrangements; strengthening of existing, and where required, establishment of new infrastructure and systems; and development of human skills and training. Particular emphasis should be placed on the needs of developing and least developed countries including Small Island Developing States (SIDS), and particularly vulnerable regions such as Africa.

36. In many countries absence of clear mandates and legislative frameworks on climate related issues are a hindrance to the proper functioning of climate services. There is need for institutional strengthening in governance, management and funding as well as human resources development. At the same time it will require an improvement in the infrastructure within countries to systematically and sustainably undertake high-quality climate observations, undertake research and establish and operate various elements of CSIS. Developing countries would require international support to attain desirable level of capabilities to participate in the implementation of the Framework and optimally make use of its products.

37. To develop the human capacity needed in the Framework, a review of the educational qualifications and on-job training requirements for climate specialists would have to be taken up. New skills would be required to be developed at a much larger scale as the climate service provision is made operational in the countries. Countries would have to develop clear human resources development policies to address this issue. As these skills would be technology intensive, Universities within the countries would be in the best position to participate or take lead in these activities.

Governance and Resourcing of the Framework

38. Implementation of the Framework needs be coordinated and overseen through a governance mechanism to: ensure adequate technical and professional guidance; provide oversight; ensure that resources are used efficiently; assign and ensure accountability for realizing the vision of the Framework; set directions and monitor progress; ensure respective roles and mandates; facilitate resource mobilization; and suggest policy directions, where required. Much has been learnt about climate coordination efforts through experiences from the Coordinating Committee for the WCP. In deliberating on governance structures, the taskforce may wish to take into account the experiences from a number of current models guiding the WMO co-sponsored programmes GCOS and WCRP, and the IPCC.

Global Framework for Climate Services

1. Introduction

1. 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 WCC-3 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 to be better equipped to meet the challenges of climate variability and change and to 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.

2. The WCC-3 Declaration decided that a taskforce, consisting of high-level independent advisors (expected to be set up 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. . Building upon the results of the First and Second World Climate Conferences (1979 and 1990, respectively), and the WMO Conferences in Beijing,[1] Espoo[2], Madrid[3], and the WCC-3 articulated the need for climate services and highlighted two issues that require special attention among others.

3. Firstly, there are several technical challenges. Whilst progress has been made, climate science needs to develop further in order to provide more reliable climate predictions for a few years to several decades ahead, information that would have a profound effect on how we manage our lives. As well, while greater confidence in the global and continental scale aspects of climate change has been achieved, providing reliable detail at regional to local levels is a new area of scientific development, where the impacts and socio-economic consequences of climate variability and change are most acutely felt.

4. Secondly, a major challenge is to communicate climate information, about what is known and what to expect, in a more efficient and effective manner to those who need this information in order to make the right decisions, for their country, their business, their farm, their family, and their lives. The climate information and products must be practical and understandable, and must meet users’ needs. It is therefore essential that while the international community must take concrete actions towards strengthening the production, availability, delivery and application of these climate services, it must provide for an ongoing exchange between providers and users of climate information. These realisations lead to the development of the concept of Global Framework for Climate Services.

5. This position paper outlines the overall vision of the Framework. It describes WMO’s on-going activities related to the Framework, and its future commitments for its successful implementation. The Framework is well-placed to build upon the remarkable scientific progress and the solid institutional foundations put in place by WMO and its partners over many years as shown in climate timeline at Annex 3.

6. ‘Climate’ has transitioned from a topic of scientific interest into the concerns of public policy and requires active engagement of all sections of 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 the paper outlines WMO’s potential role in the Framework, it does so fully cognizant of the important roles that will be played by the other partners. It is hoped that the position paper will help the task force to recommend on the elements for the Framework and their implementation.

[1] Conference Statement, WMO Technical Conference on Climate as a Resource, Beijing, China, 1-2 November, 2005.
[2] Espoo Statement, WMO Conference on Living with Climate Variability and Change: Understanding the Uncertainties and Managing the Risks, Espoo, Finland, 17-21 July 2006.
[3] Madrid Action Plan, WMO Conference on Secure and Sustainable Living: Social and Economic Benefits of Weather, Climate and Water Services, Madrid, Spain, 19-22 March 2007.

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2. The Framework

7. The Global Framework for Climate Services (GFCS) is designed to help ensure that every country and every climate-sensitive sector of society is well equipped to access and apply the growing array of climate prediction and information services made possible by recent and emerging developments in international climate science and technology. GFCS will mainstream climate science into every-day life[4]. The ultimate goal of GFCS is 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."***

2.1 Climate services

8. Climate services consist of the generation and provision of a wide range of information on past, present and future climate and its impacts on natural and human systems and the application of that information for decision-making at all levels in society. They are provided by a variety of national and international, public and private, and research and operational organisations and they are used for a wide variety of purposes to deliver social, economic and environmental benefit in almost every climate-sensitive sector of the community. Some climate services are provided as public goods to the community at large while others are provided and consumed under commercial or other financial arrangements between individuals, firms, organisations or governments.

9. Climate services need to inform decision-makers on what is happening with the current climate and why and how the climate could change in the future. They are closely linked with traditional weather services and are increasingly focussed on the challenges of adaptation to climate variability and change. The past few years have seen a major focus on the development and application of new and better services. As understanding of the climate system grows and the society becomes more aware of the potential opportunities from this knowledge, communities increasingly expect that these services will be:

- Available/Accessible: at time and space scales that meet the user needs,
- Dependable: delivered regularly and on time,
- Usable: presented in user specific formats so that the client can fully understand,
- Credible: for the user to confidently apply to decision-making
- Authoritative: entitled to be accepted by stakeholders in the given decision contexts
- Responsive and flexible: to the evolving user needs, and
- Sustainable: affordable and consistent over time.

10. The climate information is built on observations, assimilation of data from observations into models and using the models for attribution and prediction. The information is assessed and assembled into products that are disseminated to users, and the users in turn provide feedback on their needs for improvement of the products (**Figure 2.1**). The climate information and products include an extensive array of general and user-specific information, prediction, warning and advisories that may range from general public information to customized products.

11. The provision and application of climate services involves a wide range of relationships between the providers and the users of the information. Climate service providers not only need to strengthen the production, availability, and delivery of climate information and products, but also need to work closely with users in various sectors either directly or through boundary organisations to ensure their application. At the same time it has to be recognised that 'users' function at various spatial and temporal scales - from an individual farmer to a town planner, to river basin managers, to national planners, and to international development organisations – and have both common and very different requirements of climate information. Some of this information is self-evident, but some of it will require guided interpretation.

[4] Conference Statement, WCC-3.

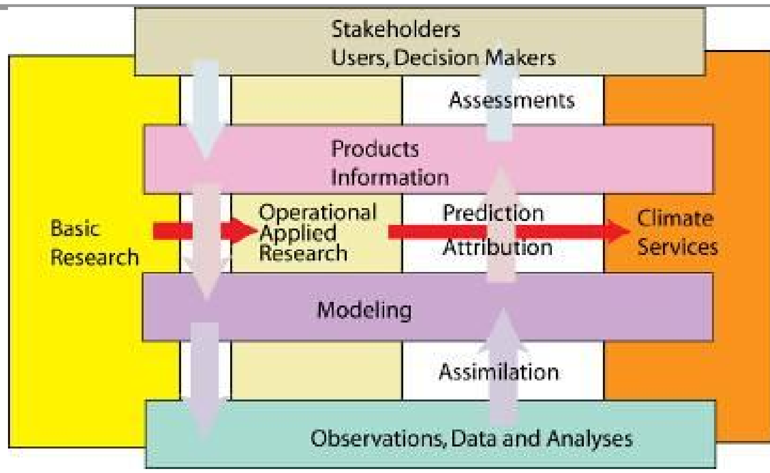

Figure 2.1 Conceptualisation of climate information generation system
(Source: Trenberth, 2008: WMO Bulletin, 57(1), 2008).

2.2 The concept

12. The GFCS will consist of an integrating set of international arrangements which build the established global climate observation and research programmes into an end-to-end product generation and service provision and application system which meets present and future user needs for the full range of climate prediction and information services in support of global, regional, national and local needs in all climate-sensitive sectors of society.

13. Understanding climate processes, analysing climate change trends and making predictions requires information spanning countries, continents and the globe. At the same time considering the nature of interaction between the climate system and human activities, it would require understanding the totality of the Earth system. Production and application of climate services therefore requires concerted multi-disciplinary efforts from not only institutions specialised in climate sciences but also from all scientific disciplines supporting various development sectors.

14. Addressing the immense variety of user needs for climate services is beyond the capacity of any single organization, a small group of organizations or a country. It calls for an unprecedented collaboration among institutions across, political, functional, and disciplinary boundaries. The Framework will:

- Provide a cooperative mechanism in which all nations, International organizations, scientists and sectors can work together to meet the needs of users;
- Enable users to benefit from improved climate information and prediction;
- Mobilize climate science globally to advance the skills of seasonal-to-interannual and multi-decadal climate predictions to generate and provide future climate information on an operational basis;
- Foster principles and mechanisms for sharing new advances in science and information through a cooperative global infrastructure.

2.3 Components of the Framework

15. Development of these products is based on sustained long-term observations of climate elements over the land, ocean and atmosphere; synthesizing these observations; monitoring various processes and understanding them through diagnostics, research and modeling; and making predictions/projections of what to expect in months, years or decades.

16. The Concept Note entitled; “Global Framework for Climate Services” (Annex 4) developed for the WCC-3 envisaged the Framework to have four major components: (i) Observation and monitoring; (ii) Research, modelling and prediction; (iii) a Climate Services Information System; and (iv) a User Interface Programme with capacity building as a cross-cutting theme running across all the four components. The WCC-3 Conference Statement (Annex 5) recommended that Capacity Building be included as an explicit component of the Framework. **Figure 2.2** shows the post-WCC-3 components, and Sections 3 to 7 of this paper describe each in detail.

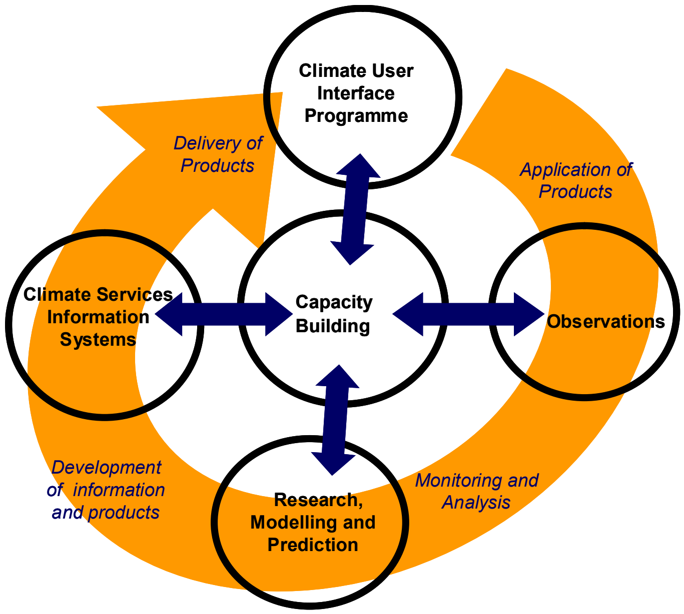

Figure 2.2 Components of the Global Framework for Climate Services

17. While these components are separately considered in the present document for convenience of presentation, they have to essentially function seamlessly and would require substantial cross-component coordination. In their description that follows, certain activities can arguably belong to one or the other component.

2.4 WMO role in the implementation of the Framework

18. Given the complexity of and requirements for climate services, the Framework would have to build an effective, efficient and economical mechanism for the generation, delivery and application of climate services. The Framework is expected to build on many of the existing mechanisms and institutions developed over the years.

19. Providers of climate services are largely the National Meteorological Services (NMSs), governments, academia, and other climate-relevant entities. Climate services have often been, and are perhaps best provided as a seamless continuum from weather services to climate projections.

20. WMO[5] coordinates the activities of the NMHSs of its 189 Members 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), established in 1929

[5] WMO is the United Nations Specialised Agency for weather, climate and water. It has a strong commitment to improvement of the quality and value of meteorological and related services and a long history of support for assessment and demonstration of the social and economic value of meteorological, hydrological and oceanographic data and services.

and deals with a wide range of climate related matters including climate data, monitoring, applications and services.

21. WMO's role in the Framework is built upon the enhanced capacity of NMSs who have for decades provided climate services in the form of historical climate data and related products for taking long-term planning decisions. In so doing, the WMO will rely on the infrastructure and human resources of NMSs; its strong association with its long-term partners in climate activities and on establishing new partnerships required for sustainable operations and uptake of climate services at global, regional and national levels; an effective interface between scientists, service providers and decision-makers; and on coordinated actions with other partners in the UN and boundary organizations. Under the Framework, WMO, through its Members, would:

- continue to operate and strengthen the Observations component;
- contribute to and effectively engage in Research, modelling and prediction component;
- establish the operational elements of 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, as well as their regional networking and user interface mechanisms, particularly in developing and least developed countries as part of the Capacity Building component.

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3. Observations

22. Underpinning an effective climate service is the systematic gathering of basic climate and environmental data, using standardized, well-maintained and modern instruments with globally standardized and sustained observing practices. These data are the foundation on which the provision of climate services is built, and they must be of high quality, consistent and routinely available in agreed-upon formats.

23. The vision for the Observation component of the Framework is to make available the variety of climate data required to monitor the Earth's climate system, understand it better and make better predictions and projections; along with the related environmental and socio-economic data from various application areas to assist society as it determines impacts and vulnerabilities, adapts to climate change, and develops mitigation and adaptation strategies.

3.1 Need for observations

24. Many decisions in society depend upon the prevailing climate of the region of interest. The key element in having confidence in the prevailing climate of a region is through consistent monitoring of the climate and thorough analysis of long-term high-quality observation records. Generally speaking, the more specific in time and space the product is, the more detailed in time and space the observational data requirements would be. Comprehensive, continuous climate and climate related observations are needed for:

- Climate system monitoring;
- Climate change detection and attribution;
- Operational climate prediction on seasonal-to inter annual time scales;
- Research to improve understanding, modeling and prediction of the climate system;
- Applications and services for sustainable economic development;
- Assessment of the impacts of, and vulnerability and adaptation to, natural climate variability and human-induced climate change;
- Meeting the requirements of the UNFCCC and other international conventions and agreements.

3.2 Evolution of observing systems

25. The basis for modern weather and climate networks was laid during the later part of the 19th century and the 20th century was the time when systematically global climate observing, using an array of tools including land surface and radio-sonde networks, ships, aircraft and satellites, came of age. The initial ocean observing system for climate depends on space-based global observations of sea-surface temperature, sea-surface height, surface vector winds, ocean color and sea ice. An urgent and fundamental need identified by GCOS-92 is to achieve global coverage by the in situ networks. These include moored and drafting buoys, tide gauge stations, profiling floats and ship-based systems.

26. The evolution of the space-based component of the WMO Global Observing System (GOS) from a one-satellite system in 1967 to a constellation of a fleet of operational and research & development satellites is one of the most outstanding successes of WMO and its Members. The systems serve not only the observational requirements of weather forecasting as it did in its first years but also a wide range of applications meeting the requirements of climatology, hydrology, oceanography and disaster prevention. **Figure 3.1** illustrates the range of observing systems on land, at sea, in the air and from space. Together with NMHSs, and WMO's Commission for Climatology (CCl), GCOS has identified a set of Essential Climate Variables (ECVs) that meet the national and international requirements for climate analysis, research and prediction (see **Box 3.1**).

27. In addition, related systematic environmental and socio-economic data and information are needed to assess human and environmental vulnerabilities and plan actions that must be taken to adapt to climate variability and change in various development sectors. Adaptive

management requires continuous monitoring and assessments that provide feedback to the decision making processes.

Box 3.1 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

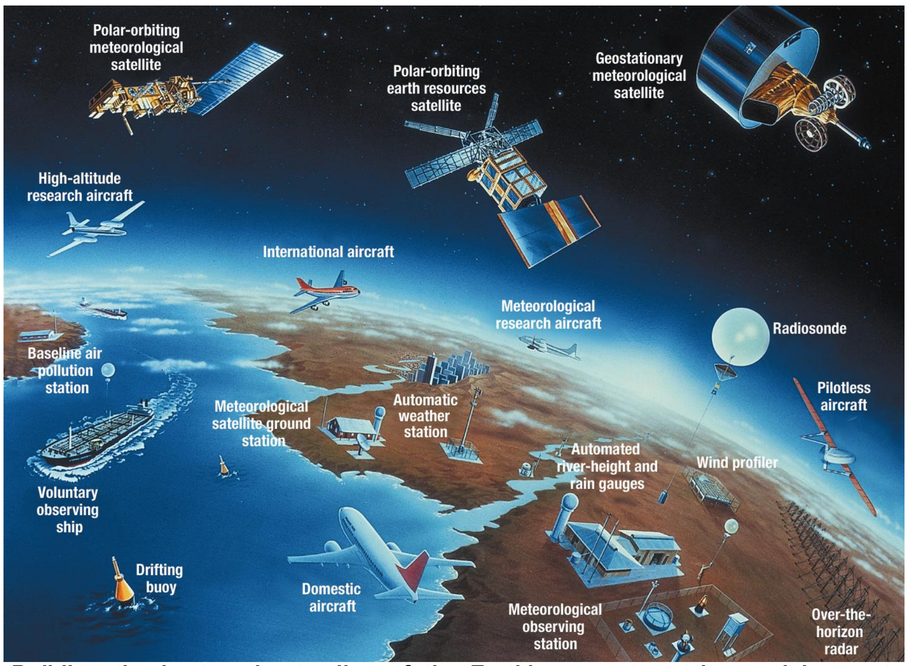

Figure 3.1 Building the best understanding of the Earth's current weather and longer term climate involves observing climate elements from the ground, at sea, in the atmosphere and from space.

3.3 Existing coordination mechanisms

28. In response to the decisions at the Second World Climate Conference, the 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). GCOS addresses the total climate system including physical, chemical and biological properties, and atmospheric, oceanic, hydrological, terrestrial and cryospheric components (Annex 6). GCOS was built initially on the established global observing systems of its sponsors and has made considerable progress over the years, particularly in support of the identified needs of UNFCCC. In several countries, National GCOS Coordinators and National GCOS Committees provide effective coordination of national and local institutions on GCOS matters. In addition National Focal Points for GCOS in more than 130 countries liaise within the National Meteorological Services, on GSN and GUAN issues related to data availability and quality.

29. For terrestrial and ocean components, GCOS is supported by the FAO-led Global Terrestrial Observing System (GTOS) co-sponsored by FAO-UNEP-WMO-UNESCO-ICSU and the IOC-led Global Ocean Observing System (GOOS) and cosponsored by IOC-WMO-UNEP-ICSU. The climate-relevant components of the various global, regional and national observing networks that have been incorporated under the auspices of the GCOS since 1991 have provided most of the data used for climate analysis, prediction and change-detection.

30. Since 2000 the Consultative Meeting on High-Level Policy on Satellite Matters, involving the heads of the satellites agencies, satellite operators and seniors officials of WMO, have provided a forum for high level policy coordination. One of the milestones of this high-level coordination is the initiative of a global network of centers for Sustained Coordinated Processing of Environmental satellite Data for Climate Monitoring (SCOPE-CM) to response to the ECVs requirements.

31. The Global Earth Observation System of Systems (GEOSS) is an intergovernmental initiative which builds upon existing national, regional, and international systems, with the aim to provide comprehensive, coordinated Earth observations from all platforms for the benefit of societies worldwide. GCOS is the climate observation component of the GEOSS, which is organized around nine key societal areas: agriculture, ecosystems, biodiversity, weather, climate, water, disasters, energy, and health. Since almost all of these societal benefit areas are also ultimately the strong beneficiaries of climate observations, GEOSS provides the overall framework for further implementation of GCOS networks and systems, by fostering enhanced integration and interoperability among and between its component observing systems.

3.4 Role of NMHSs in observations

32. Climate data have been collected by NMSs in an organized manner routinely for well over a century. Over time, the systems for observation and for international sharing of the data have improved in many ways. The World Weather Watch (WWW), founded in 1963, established a unique international collaboration on observing systems, telecommunication facilities, and data-processing and forecasting centers. Under the banner of the WWW, NMSs collectively operate a Global Observing System with infrastructure for observation on land, at sea, in the air and from space that measure weather and essential climate variables. Various other national agencies are charged with the national implementation of the individual observing networks and systems. Satellite observations have supplemented the observations of earth system and contributed to weather forecasting and monitoring the planet's well being.

33. The WMO Integrated Global Observing System (WIGOS) (Annex 7), currently being implemented, will coordinate improved observing networks across a number of observing domains (e.g. terrestrial, ocean, atmosphere, including atmospheric chemistry composition, etc.) to include the Global Observing System, the Global Atmosphere Watch and the Global Cryosphere Watch and others[6]. It facilitates integration of climate-relevant observations, thereby contributing to GCOS as well as the vision of the Observation component of the Framework.

34. The data exchange policies for meteorological and hydrological data, set by the World Meteorological Congress[7] and implemented by the NMHSs, are fundamental to the routine creation and dissemination of weather analyses and forecasts around the world. The evolving WMO Information System (WIS)[8] takes advantages of the Internet to support data and information from all WMO programs, and is designed to cater to the climate information needs of WMO, partners and users (Annex 8). WMO's Global Telecommunication System (GTS), at the heart of the WIS, is operated by countries 24 hours a day, seven days a week all year round, that facilitate real-time collection, exchange and distribution of weather observations.

[6] Existing observing networks defined as part of GCOS are the Global Ocean Observing System (GOOS), the Global Terrestrial Observing Systerm (GTOS), the Global Observing System (GOS) and many others,
[7] Resolution 40 (Cg-XII) - WMO policy and practice for the exchange of meteorological and related data and products including guidelines on relationships in commercial meteorological activities and Resolution 25 (Cg-XIII) - Exchange of Hydrological Data and Products.
[8] WIS will be the core information system providing linkages for all WMO and supported programmes associated with weather, climate, water, and related environmental issues. It is being built upon the Global Telecommunication System.

35. High-quality data is crucial for modeling climate processes, detecting human-induced climate change, and monitoring climate variability. Climate observations undertaken at global, regional, and national levels should be of consistent quality, with minimal inhomogeneities, with few gaps in the record over time and with appropriate spatial density and temporal frequency. To ensure the quality and consistency of observations, GCOS has developed a set of Climate Monitoring Principles[9] to guide the collection, archiving and analysis of in-situ and satellite climate observations. The observations coordinated under the WIGOS follow standard procedures established through intensive work of the WMO Technical Commissions (Annex 9) under the WMO Quality Management Framework. The standards so developed are recognised by ISO, and WMO is recognized by ISO as a body that sets standards.

3. 5 Requirements and gaps in observations

36. The current understanding of climate change has been achieved to a large extent through the re-use of data initially collected for the purposes of weather analysis and forecasting. Global climate change detection poses a specific challenge for climate observation gathering, not only through the need for global coverage, but especially because the trends in climate variables (such as temperature and rainfall) tends to be small compared with the background 'noise' of natural short-term climate fluctuations. Greater emphasis therefore is required to ensure that the observation networks that NMHSs currently uses for weather forecasting are strengthened and upgraded to meet the highest possible quality to serve the needs of climate analyses and prediction.

37. WMO's Rolling Requirements Review[10] helps elicit, define, and record user requirements for space-and surface-based observations and help identify gaps, or un-met needs in observations. The review has been used to define requirements in a variety of applications; for weather forecasting, seasonal climate predictions, for IPCC and UNFCCC and observations for agriculture, aviation, and water management, among others. This review has largely focused on the needs of the climate, weather and water communities and is coordinated internationally with WMO Members, but not necessarily sufficiently with sector users. It is important to note that there are a number of critical gaps related to the observations:

- spatial and temporal data gaps;
- absence of organized and standardized socio-economic data gathering mechanism;
- limited access to data;
- non-availability of historical records in digitized form;
- appropriate processing and archiving systems to handle vast amount of data; and
- interoperability of data.

38. Running observing systems require significant human and financial resources due to the range of measurements required, the density of stations needed, and the data quality requirements that require expensive equipment maintenance and regular upgrades. Unfortunately, governments do not always recognize expenditure on the observation networks as investments and therefore do not allocate adequate resources. As a result the condition of observation networks in some areas of the world is on the decline. Further, only a few countries are able to implement modern observing systems, such as radars, radio-sonde and drifting buoys. In developing countries, coping with major societal and economic issues, climate observations often get minimal priority and funding.

39. The GCOS progress reports on the adequacy of the global observing systems for climate in support of the UNFCCC (SBSTA) activities provide an important mechanism to alert the world on the importance of the observations, and on the priorities for remedial action. According to its 2004-2008 assessment report the Global Climate Observing System has progressed significantly over the last five years, but still falls short of meeting all the climate information needs of the UNFCCC and the broader user communities. Particularly, developing countries have only made

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[9] For a list of these climate monitoring principles, see http://www.wmo.int/pages/prog/gcos/documents/GCOS_Climate_Monitoring_Principles.pdf

[10] More on the Rolling Requirements Review can be found at http://www.wmo.int/pages/prog/sat/RRR-and-SOG.html

limited progress, with a decline in some regions, in building and maintaining their GCOS observing capability.[11] Major new effort is needed on the coordinated implementation of national climate and climate related observation networks in support of climate services.

40. Substantial historical climate data exist in old, outdated and often deteriorating media such as paper records or on microfilm, and therefore are not usable or readily accessible for climate studies. This valuable data needs to be rescued, typically through digitization. The WCDMP (See Annex 10 on the World Climate Programme) has undertaken considerable capacity-building in this regard, particularly in developing countries, but progress has not kept pace with requirements. A special effort is being launched that would allow building of historical climate data records from all the earth-observing satellites that have operated since the beginning of WMO's Space (satellite) programme in the 1960's. Efforts to digitize land-and satellite-based climate records, in order to extend the climate record backwards into the past, would be a critically important part of the observation component of the Framework.

41. Generally there is a reluctance to exchange data not only with other countries but also within a country, in part because the data is perceived as a source of income. Sometimes national data policies are very restrictive. Free data exchange would almost certainly provide benefits that would far outweigh perceived risks. For example, the regional climate models, which only can provide local climate information for adaptation planning, require data from the region for their validation. If such data are available, all countries in a region would benefit from more accurate regional climate model outputs. However, there is still some scope for all countries to adhere to the recommended data policies in letter and spirit, by addressing the lack of basic telecommunications facilities that hinders free flow of data, and formulating more open national policies related to data.

42. Collection of environmental and biodiversity data, and high-quality socio-economic data, is largely ad-hoc and not well-organised in most countries. There are a limited number of standards developed so far for observation and archival of such data. For sector-specific information, products and services, all sectors would also have to systematically collect and manage relevant data for their activities. These data, where they exist, may require consolidation, development of metadata, and evaluation of how to merge information with climate-related information, on time and space scales. Some datasets are not easily accessible to the users, and their availability may require high-level government decisions and commitments to changes in policies for data sharing.

43. Under the Framework, however, the Rolling Review referred above would expand to include requirements for climate observation and monitoring products needed by major socio-economic sectoral groups. The Review could help identify data the sectoral users need for adaptation and risk management, including risk assessment that they could then blend with socio-economic data. The review team could include specialists from these climate-sensitive sectors.

44. Some observation networks have been developed through research initiatives. Over time, they have become quasi-operational and have been instrumental in advancing climate prediction and analysis. These networks need to be supported and should, where possible, be converted into robust operational observation programmes with sustained funding.

45. As the gaps in observations have adverse impacts on the understanding of vital climate processes and phenomena, and on the accuracy of climate predictions and projections around the globe, it is important to help reduce the observation gaps by supporting developing countries in strengthening their networks. The GCOS Cooperation Mechanism was established in 2003 as one means by which developed countries can contribute to observing system improvements in developing countries, for example, by supporting the implementation of projects contained in GCOS Regional Action Plans. However, the mechanism is not yet as effective as it could be.

[11] GCOS Progress Report 2004-2008 to UNFCCC.

46. WMO's contribution to the climate observations component of the Framework, along with its strengths and plans for addressing known gaps, is shown in **Box 3.2**.

3.6 Partnerships in observations

47. Extensive international collaboration in observation has been an important aspect of WMO's philosophy and service, and will continue to be so under the Framework. For example, WMO has a regular arrangement of ocean observations through voluntary observing ships. However, such partnerships require to be strengthened and new partnerships with private sector operating in data sparse regions forged. Individual voluntary observers can also fill vital gaps in observations.

48. Observations supporting the Framework will involve increased communication and collaboration with partners involved in WMO's Space Programme, including the Coordination Group for Meteorological Satellites (CGMS) and the Committee on Earth Observations (CEOS). Efforts are underway for coordinated creation of historical climate records from satellites and inter-calibration through the Global Space-based Inter-calibration System (GSICS).

49. It is recognized that there is a need for a mechanism that allows the integration of observations from multiple disciplines. WMO will continue its efforts to strengthen networks in its domains of air, water, and climate, and to help ensure that they can be integrated with monitoring systems across multiple disciplines and would be ready to share the experiences and expertise gained by it in monitoring the climate.

50. Partnerships in the collection and development of standards for the environmental, biodiversity data, and high-quality socio-economic data, are needed in order to make available complete and related information to carry out climate change impact studies, risk assessments and developing adaptation options. Efforts would be needed to establish collaborative arrangements with the groups developing such datasets, such as 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.

51. 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 closely working with GEOSS in these developments with the expectation that, through its community of practices it would support WMO's efforts in further strengthening WIGOS, WIS, and GCOS to provide the strong Observation foundation for the Framework. GEOSS should move to make the emerging data systems in other societal areas compatible with those of the WMO.

3.7 Recommendations for consideration by the taskforce

52. Key recommendations for consideration by the task force, to expand and ensure the completeness, quality, availability and relevance of the observations component of the Framework include:

- Promote strengthening and sustainability of observation networks in order to monitor climate variability and change, and to evaluate the effectiveness of the policies implemented to mitigate change.
- Encourage national governments to invest in their observation networks in order to get better climate information and products for climate change adaptations.
- Facilitate support to developing countries for strengthening and maintaining their observing networks and climate data management including data rescue efforts by engaging a broader range of donor organizations including, for example, foundations interested in climate change and development.
- Explore and develop new and innovative partnerships needed to meet the observation requirements.

- Promote development of operational networks for environmental, social and economic data relevant to various sectors of development, creating relevant data bases and their integration with WIS
- Promote greater coordination on climate observing issues at both national and regional scales, to enable improvements in observing systems without large expenditures.
- Promote and support making mature research-based observing systems operational.
- Promote and support making available archived data from satellites and ocean platforms.

Box 3.2 WMO's Contribution to the Observations component of the Framework

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 behaviors.

WMO Commitments

1. Facilitate the establishment of international space architecture for monitoring climate change.
2. Facilitate digitization and archiving of data and metadata. Develop and implement new technologies for observing and monitoring.
3. Reinforce adherence to standards through implementation of a Quality Management Framework, and through the work of Technical Commissions and Expert Teams.
4. Operationalize WMO Information System (WIS), with all relevant improvements to the GTS and data exchange.
5. Integrate weather/climate and hydrological networks and databases through WMO Integrated Global Observing System) WIGOS.
6. Promote, with all members' and partner's observing programmes, a transition in standards to those required for climate purposes.
7. Promote, within all member countries, a transition to policies on data sharing and use that would support the requirements of an operational Framework.

WMO Potential areas of further contribution

8. 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.
9. Add new observing capability for parameters defined by users, to meet emerging science requirements and service commitments.
10. Operationalize mature research-based observing systems.

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4. Climate research, modelling and prediction

53. Climate research, including modeling and prediction aspects, helps the Framework to meet its needs for improved methods and tools with which to characterize climate variability and change and to generate quantitative climate predictions and climate projections, on a range of time and space scales.

54. Very close collaboration will be essential between the climate research component of the Framework and the operational components of the Climate Services Information System (CSIS), to ensure that research achievements are translated into improved services. At the same time, by connecting with end-users the research component gains a better understanding of priorities for what needs to be predicted and with what level of skill and this will raise fundamental scientific questions to be addressed[12].

4.1 Evolution of cooperation in climate research

55. The climate research community has a rich history[13] of rising to the challenges of understanding and predicting climate, and their efforts have provided society with irrefutable evidence on the reality of climate change and human contributions to it. Both basic research and operational applied research feed into assessments and predictions that are required to be provided by climate services (Figure 2.1).

56. Weather research and climate research are closely intertwined; progress in our understanding of the climate processes and their numerical representation is common to both. The models used for weather and climate prediction are essentially based on the same physical principles and formulations, though the way they are deployed is substantially different. WMO's World Weather Research Programme (WWRP) promotes the development and application of improved weather forecasting techniques, with emphasis on high-impact events. It also promotes research activities in medium range, extended range and seasonal prediction, and closely collaborates with climate research communities on aspects of common interest, particularly on seamless prediction.

57. It has been recognized[14] that most WMO sponsored or co-sponsored programmes contribute in a meaningful way to the development of prediction research, stretching across weather, climate, water and air quality applications of today; prediction research that has the potential to provide a full suite of environmental predictions of tomorrow. Whilst the breadth of environmental prediction extends beyond the remit of WMO, it is the atmosphere that provides the fastest and most fundamental linking mechanisms across the coupled physical-biological-chemical components of the Earth system. As a result, WMO is in a unique position to play a lead role in initiatives that enhance our understanding, and ability to predict or project future states, of the Earth system in service to global society.

58. Recognizing the need to integrate observations, research facilities and scientific breakthroughs WMO, the International Council for Science (ICSU), and the Intergovernmental Oceanographic Commission (IOC) of UNESCO established the World Climate Research Programme (WCRP) as a major component of the World Climate Program (WCP) (Annex 10, 11) in 1979. 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. These efforts are complemented by the World Climate Impacts Assessment and Response Strategies Programme (WCIRP), another major component of WCP targeted at assessing the impacts of climate variability with UNEP as the lead agency.

[12] ICSU-WMO-IOC-IGFA (2009). Review of the World Climate Research Programme (WCRP). 40 pp. Paris, International Council for Science. (Available at www.icsu.org)
[13] S.Arrenhuis (1859-1927) published a paper way back in 1896 which estimated that a doubling of the concentration of carbon dioxide in the atmosphere would lead to a 5 degree warming of the Earth's surface.
[14] "Challenges and Opportunities in Research on Climate, Weather, Water and Environment", Report of WMO Executive Council Research Task Team (EC-RTT), June 2009, WMO/TD No. 1496, 24pp.

59. The climate research and modeling community has organized long and large international observational and modeling projects, in the manner of major field campaigns with active participation of NMHSs. The Tropical Ocean and Global Atmosphere (TOGA, see **Box 4.1**) project (1985-1994) and the World Ocean Circulation Experiment (WOCE) (1982-2002)

Box 4.1 Tropical Ocean-Global Atmosphere (TOGA)

The WCRP's Tropical Ocean-Global Atmosphere (TOGA) Programme was initiated in 1985 as a 10-year effort by the WCRP to improve our understanding of the tropical ocean/atmosphere system and its effect on the climate at higher latitudes. The four main objectives of TOGA were to:

- collect and catalog observations of the tropical atmosphere and ocean;
- assess the evolution of the tropical atmosphere/ocean system in real-time;
- promote the development of computer models to allow short-term climate predictions for the tropics;
- study the influence of the tropical atmosphere/ocean system on the climate at higher latitudes.

The contributions of TOGA programme provide an excellent example, leaving as a legacy knowledge and capability on practical prediction of El Niño. Such predictions have advanced as a result of WCRP research and form the basis for many applications in South America, Africa, and Asia by NMHSs and by ocean services agencies. The measurement techniques developed and demonstrated in TOGA have subsequently been incorporated into operational arrays that now contribute to the Global Ocean Observing System (GOOS).

established the physical basis for the understanding and prediction of El Niño/Southern Oscillation (ENSO) that led to a major breakthrough in operational seasonal climate forecasting.

60. WCRP through its core projects (Annex 11) has successfully laid the foundation for the climate services of the future. Its current research projects, particularly those pursuing the coupled climate and Earth system models, are poised to push the frontiers of climate predictability further. It will facilitate predictions for use in practical applications of direct relevance, value, and benefit to society[15], WCRP is launching an evaluation of techniques for use in regional downscaling of global climate projections with the objective to produce improved high-resolution climate information over regions worldwide for input to impact/adaptation work that will help promote greater interaction and dialogue between modellers, information producers and the users.

4.2 Research challenges

61. While climate science 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, many scientific challenges remain.

62. Climate research has successfully developed policy-relevant future climate scenarios projections for the 21st century that formed key component of the IPCC process. However, as is generally known, political planning horizons seldom exceed 20-30 years. There is an increasing need in society for information about the future state of the climate system in the near term (**Figure 4.1**), extending from years to decades, to support crucial decision making and development of practical applications such as estimates of future water availability and energy requirements. 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.

[15] WCRP Strategic Framework (2005-2015), August 2005, WMO/TD No. 1291, 59pp.

63. The new focus is therefore on the development of decadal prediction systems. Prediction of decadal variations in climate, an area of concerted research, is still, however, in its infancy[16] . 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; and the challenging issues of prediction of monsoon variability; the interaction between changing atmospheric composition, pollution and climate change; and the interaction between climate and the cryosphere. Assessment of the future changes in sea-level requires accelerated development of ice sheet and ice shelf models and reduction of uncertainties in the estimates of the warming of the ocean.

64. There are many inherent uncertainties in our estimates of the past, present and future behaviour of the climate. These range from gaps in the basic observations of climate elements to inadequate understanding of climate processes as to how extreme events are manifest in regional climates. They arise from the lack of observational data required as model inputs as well as the limitations in the capacity of the global models to take into account the local physiographic features. Large uncertainties in the present climate information, predictions and projections make it difficult for planners in various development sectors to use them confidently in their decision making processes and therefore, should be reduced to the extent possible. However, considering that some amount of uncertainty is an inevitable aspect of all climate information, scientific approaches to quantify and communicate uncertainty should be developed so that it can be appropriately integrated into the decision making at the user level.

65. Climate experts at WCC-3 (Annex 5) have called upon the scientific community 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. They have also advocated adopting a more seamless approach to climate prediction. Seamless prediction (on timescales from a few hours to centuries) is still developing and it is important to extend the seamless approach not just to time scales but also to aspects across multiple disciplines relevant to climate processes. 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).

66. Reanalysis of atmospheric data has greatly improved our ability to analyze past climate variability and has greatly helped in making historical records more homogeneous and mutually consistent, while also providing the best possible estimates of past climatic variations in areas having gaps in observations. This effort is being actively extended to the ocean datasets, and to Arctic and land surface data.

67. 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 Framework, there is, therefore, a need for an Earth system approach to observations, monitoring, modeling, analysis and prediction. 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), the International Human Dimensions Programme (IHDP) on Global Environmental Change, etc.

4.3 Infrastructure for Computing and Prediction

68. 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

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

scales is tied to the availability of substantial supercomputer resources and a number of facilities with adequate scientific staff and high-performance computational infrastructure.

69. Significant increases in the computing capacity available to the global and regional weather and climate centers are 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.[17]

70. Collaboration and research inputs into the Framework's operational systems (e.g. GPCs, RCCs and other relevant centres), particularly from WCRP/CLIVAR community, will be crucial to ensure that the latest research advances are optimally exploited for societal benefit. This can be addressed more effectively through appropriate linkages between WCRP and WMO Technical Commissions (e.g., CCl, CBS) that guide the operational systems. Some efforts in this direction have already been made but they should be strengthened and sustained as an ongoing process.

4.4 Human resources requirements

71. 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 participate fully in international research, modeling and prediction, through fellowships, institution building and collaborative research projects.

72. 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, 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 and strengthened through partnerships with Universities.

73. 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 it is widely agreed that more researchers need to be working on the existing forecast systems to exploit the predictability potential available in the climate system, on the enormous challenge of understanding the Earth as a complex, nonlinear interactive system, and on assessing the impacts of anthropogenic climate change on coupled human and natural systems. To address these needs will take 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 the present climate information and products.

4.5 Partners in research

74. To operationalize research advances within the GPCs and other centres providing global climate predictions, RCCs and 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. WCRP's core projects are supported by several country partners, in the form of hosting their International Project Offices (IPOs; see Annex 11). Such partnerships facilitate broad-based support to WCRP activities, and promote networking of research communities. This needs to be further expanded to enhance linkages between

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

research and operational groups at the national level, particularly in developing countries. **Box 4.2** outlines WMO's contribution to climate research and development.

75. 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.

Box 4.2 WMO's Contribution to the Research component of the Framework

WMO's Current Strengths (2009-2010)

1. WMO is co-sponsor of the World Climate Research Programme (WCRP).
2. WCRP and WMO's Technical Commission on Atmospheric Sciences (CAS) constitute the world's leading force guiding development of climate models.
3. WCRP and CAS lead in coordinating research on weather, climate and environmental prediction and create a basis for the development of a seamless prediction system.
4. 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.
5. WCRP/CLIVAR works with CCl an JCOMM on Climate Change Detection and Indices.
6. WCRP stimulates model-based reanalysis of atmosphere and ocean data and promotes their applications worldwide.
7. WCRP has a Strategic Plan that includes scheduled activities to fit the IPCC cycle, the WMO/UNEP Scientific Assessments of Stratospheric Ozone Depletion and several other climate-relevant assessments.
8. WCRP addresses the complexity of the climate research and prediction through joint work with numerous partners, including the Earth System Science Partnership (ESSP).
9. WCRP undertakes a multitude of research observations that serve as prototypes for future observing systems.

WMO commitments

1. Continue to co-sponsor the WCRP.
2. 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.
3. Foster links between NMHSs and WCRP, especially for regional and national projects.

WMO Potential areas of further contribution

4. In partnership with WCRP expand the RCOF process to other regions, including the Polar Regions.
5. 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.

4.6 Recommendations for consideration by the taskforce

76. Climate research, particularly on modelling and prediction aspects, constitutes a critical pillar for the Framework and builds the tools that can be used to generate, interpret and package science-based climate information and prediction products within the Climate Services Information System (CSIS). In order for this pillar to be strengthened and contribute to the Framework more effectively, the following are some key recommendations for consideration by the task force:

- Climate modeling and prediction research needs to be taken up through an unprecedented multinational and unified multidisciplinary effort, with massive supercomputing, infrastructural and human resource deployment;
- Greater emphasis needs to be placed on the development of decadal prediction systems to support decision making in near-term planning;

- Coordinated international efforts are required to produce actionable climate information on finer time and space scales;
- Greater efforts are needed to minimize uncertainties in climate information and at the same time sectoral research communities should develop tools to factor these uncertainties within their decision-making processes;
- An Earth System approach to observations, monitoring, modelling, analysis and prediction is essential in climate research, to accelerate the progress in our understanding and prediction skills;
- International partnerships between institutions around the world including those in developing countries should be developed and strengthened where they already exist;
- Closer linkages should be developed between research, operations and users;
- Development of highly-skilled human scientific talent as well as strengthened infrastructure for climate research, particularly in the developing regions of the world, is critically needed.
- A sustainable mechanism should be established to facilitate the support of the developed countries to developing countries to participate fully in international climate modelling and prediction research.
- A clear and implementable transition path for research and development outputs into operational systems must for part of the end-to-end R&D process.

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5. Climate services information system

77. Given that climate processes are global in character and evolve over a wide range of space/time scales, the flow of information from global to local scales is essential and must be facilitated. For an effective delivery of climate information, it is essential to put in place appropriate institutional mechanisms to generate, exchange and disseminate information at global, regional and national levels on an operational basis.

78. The climate services information system (CSIS) is the component of the Framework that is designed to provide users with the climate information they need for the decisions they have to make. CSIS will involve physical infrastructure such as institutes, centres, computers; professional human resources for product development and consultation; and interactions with the users. A substantial part of what will be the fully operational CSIS already exists. For example, WMO Information System will play an important role in the information process of CSIS. This foundation is strongly supported by WMO and its partners, and by WMOs systems of technical commissions and regional associations.

5.1 Evolution of climate services

79. It has taken many years of research, investment, coordination, collaboration and effort, to develop the present capability to provide weather services through the active involvement of 189 NMHSs. Over time, knowledge about the weather has improved and the use of weather forecasts is a routine matter. People have developed an appreciation for the weather information and look for, and find, products readily available around the world through a wide range of media. Climate services are therefore naturally and strongly rooted in the existing capabilities for the provision of weather services.

80. Progress in evolution of climate services were given a systematic direction in 1979 with the establishment of the World Climate Programme (WCP) (Annex 10) as an integrating framework for the World Climate Data and Monitoring Programme (WCDMP), World Climate Research Programme (WCRP), the World Climate Applications and Services Programme (WCASP) and the World Climate Impact Assessment and Response Strategies Program. The launch of the Climate Information and Prediction Services (CLIPS) project (Annex 10) in 1995 was a turning point in laying the foundation for modern climate services. WMO's present contribution to the CSIS component of the Framework along with its commitments and further potentials is provided in Box 5.3.

81. Through the CLIPS project, the capacity of the NMSs for weather services was enhanced to enable them to take advantage of the advances in climate science and in computing and communication technologies. Through its activities in operational seasonal climate predictions, Regional and National Climate Outlook Forums and consensus-based products, NMSs have developed their capacities to provide:

- operational climate predictions for periods and regions that are feasible, particularly on seasonal to inter-annual scales;
- user-oriented applications products;
- consensus-based climate outlook products; and
- active interface between their operational specialists and research communities.

5.2 The challenge for the CSIS implementation

82. From global to local levels, public and private sector institutions are seeking the tools and knowledge for adaptation and climate risk management. People are demanding climate information over differing time and space scales for planning and operational purposes. It is imperative therefore to ensure that they have the highest quality and widest possible range of products, information on inherent uncertainties, and advice on how the information can be used for the optimal results.

83. The advance made by WMO and partners in the provision of climate services has been useful and timely, but the demands have outpaced and continue to outpace capabilities. The decision to establish the Framework has further raised expectations. There are a number of gaps between present capacities and the expectations of the policy makers, planners, operators, nations, communities, and individuals that must be addressed by the international community.

84. Although the climate-focused centres such as RCCs (Annex 10) and NCSs, and mechanisms such as Climate Outlook Forums (COFs) at regional and national level have been shown to be successful in generation of the climate information and products, they have been developed, for the most part, on a pilot basis. They do not adequately cover all the regions of the world, nor do they deliver information as often as users might need.

85. There is reasonable provision of climate information and predictions at the global scale, but at regional scales there are large gaps. Many climatologic regions in the world lack regional support. While the existing Regional Specialised Meteorological Centres can potentially assume the functions required of RCCs, they would require strengthening of their capacity and mandate. Similarly, although users in areas where COFs have been routine for more than a decade benefit significantly from the interaction with service providers, these forums are not able to cater to the needs of *all* the sectoral users. At the national level, the climate outlook forums have yet to be fully functional.

86. For better seasonal predictions, such as WMO's El Niño/La Niña update, CSIS would expand these products using other major climate oscillations that determine the seasonal variations of climate. Progress in the Research, modelling and prediction component of the Framework will be critically important to the functioning and efficiency of the CSIS. As such, the two will have to work in tandem to transfer research products into operational mode.

5.3 System for operational production of climate information

87. It is time for a major leap forward - a significant escalation of the efforts to make climate information and products readily available and incorporated into all related societal decision-making. The CSIS, to meet this need, will rely on and expand the weather and climate infrastructure developed over time and will strengthen the human expertise needed to make it work. A comprehensive and systematic plan of well defined actions would be able to turn the existing components into a dynamic, global system. The CSIS will be based on the three-tiered structure of entities including data centres and forecast/information producing centres (see **Figure 5.1**), and will also encourage the collaboration of relevant boundary and specialised sectoral institutions. WMO network of existing climate information, products and services centres is shown in Annex 12.

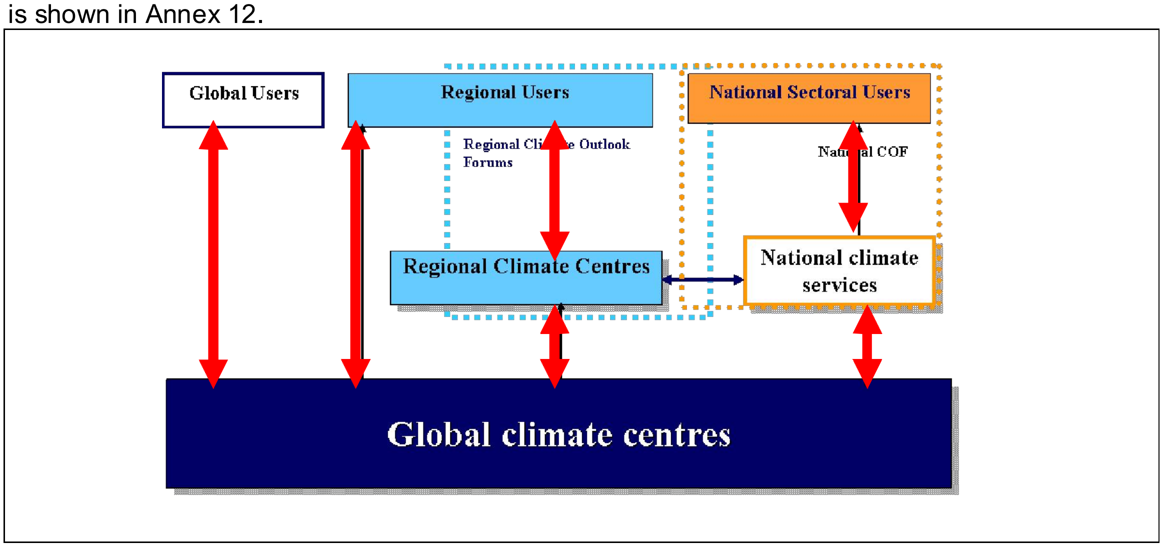


Figure 5.1: CSIS interactions and flow of information with feedback

88. National climate services and/or NMSs, mandated by the national governments, will be at the forefront of the CSIS information development, dissemination and application cycle. These centres will work with national agencies, including governmental and non-governmental organizations, universities and national research institutes that are mandated to serve different sectors and levels of administration. An ideal model would have the NMS/NCS as the nucleus, or core of the collaborative group. The NMS/NCS would support exchange of data and operational products, downscaling, prediction, conduct of climate watches, issuance of warnings and advisories, and provision of climate services to users. They will get global and regional inputs from the RCCs and GPCs.

89. Regional climate centres would require the infrastructure, capacity and mandate to develop high-quality regional-scale climate products using global products and incorporating regional information. RCCs and other mandated regional climate centres would generate and disseminate regional- and sub-regional scale tailored products to NMSs, NCSs, and to certain regional user groups. They will develop regional datasets, monitor regional climate variability and extremes, conduct climate watches, and downscale prediction and projection products from global centres. RCCs would be expected to develop a broader suite of climate information, new region-specific products to address regional needs and help NMSs to acquire the capacity of down-scaling regional products, tailoring them and delivering to the national users.

90. Global climate centres will include those centres developing global climate data sets, information and predictions. WMO designated Global Producing Centres of Long-Range Forecasts (GPCs), the World Data Centres and other centres, will provide specialized data and reanalysis datasets and prediction and projection products, generally at relatively coarse resolution from the perspectives of national-scale users.

Box 5.1 Climate Services for Risk Assessment

Effective disaster risk management must be founded on scientifically sound risk assessment, to quantify and understand the risks associated with natural hazards and their impacts. Risk assessment, in turn, requires quality assured historical and real time data on hazards, and socio-economic data, with reliable regional detail. Changing patterns of climate hazards make those data needs even more imperative. Understanding the challenges posed by climate change to longer-term strategic planning and investments (e.g., infrastructure planning and retrofitting based on building codes as a 100 year flood may become a 30 year flood), would help providers frame future products and services. Climate services would encompass the delivery of climate data and information and the consumption, or application of appropriate data to disaster risk management.

91. To make and disseminate operational products, it would be necessary to move the data collected from every corner of the world and the products generated in the process through an efficient communications system. Each entity within the CSIS must have access to what it needs, when it needs it, in order to provide effective climate services. While the Internet provides a plausible option, time criticality of the data and information would require that WIS, with GTS backup forms the pillar of such a communication system as it facilitates data discovery, access and retrieval services for all weather, climate, water and related data produced by centres and Member countries.

92. In order to establish such a system at the global scale in a consistent and operational mode, CSIS would need a coordination and standardization mechanism that will, among others:

- **support** the individual global, regional and national entities in accessing information they need for their functioning;
- **expand capability** at regional and national scales through establishment of new Regional Climate Centres, facilitating the National Climate Services and other specialized centres, where needed;
- **develop standardized approach** to product development and delivery (operational, timely and on agreed schedules and formats) in order to increase reliability and utility;
- **enhance the professional capabilities** within all operational entities to develop, work with and promote the suite of products;

- **increase prediction skill**s and the range and quality of information by developing appropriate verification methodologies, enhancing interactions between operational and research entities and improving transition of research advances into sustained, operational activities;
- **facilitate access to a wider data base** – from observations of new climate variables, newly digitized historical climate data, and observations from new sensors, such as radar and satellites;
- **foster a service-oriented approach** and maintain interaction with the users to help them get maximum benefit from the products; and
- **ensure** that the process of development and delivery, work within a quality management framework that keeps pace over time with their evolving requirements.

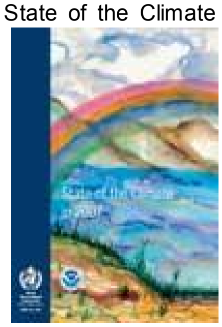
5.4 Climate information, products and their dissemination

93. The process of generation of climate information is cyclical, beginning with identification of user requirements, followed by development and delivery of the information and products based on observations, monitoring, research, modelling and predictions, use/uptake of these, feedback by the user, and product improvement. Flow of information and generation of products within the system essentially includes feedback from users at various levels, for continual improvement of services. Climate services will essentially consist of products that are based on:

- Historical climate records (climate diagnostics, statistical analyses), to meet the needs for understanding past climate, especially the range and extent of climate extremes (see **Box 5.1**).
- Contemporary climate information (based on climate system monitoring), along with information on the factors influencing these patterns (see **Box 5.2**);
- Monthly, seasonal, inter-annual to decadal predictions, for short to medium term planning and risk management; and
- Long-term projections of the future climatic conditions, for decisions related to climate change adaptation and mitigation.

Box 5.2 Climate System Monitoring

Reviews and assessments of past climate patterns, to document the climate as it happens and to explain the factors and processes involved in these situations. Of particular note is WMO's Annual State of the Climate report, which provides a retrospective summary of the past year's major climate events. Coordinated by WMO in collaboration with the Met Office Hadley Centre and the Climatic Research Unit, University of East Anglia, both in the UK; 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, it provides summary analysis by over 700 authors worldwide.



Global climate hazards monitoring and Climate Watch Systems look for current and impending climate anomalies (early detection) and provide 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.

94. With better seasonal forecasts, farmers can plan optimal planting dates, the best mix of crops to grow and which disease- and pest-resilient varieties to choose. Better seasonal predictions of water availability can help water resource managers in planning and operating reservoirs for irrigating the food we eat and for producing power for the places we live. Further information on possible climate information and basic products for CSIS is provided in Annex 13.

95. El Niño/La Niña conditions have large influence on the climate around the world for which WMO has established a consensus mechanism for of its updates. This initiative has been well-received worldwide and is instrumental in improving consistency in terminology and uptake of the seasonal information. The success of El Niño/La Niña Updates can be extended to other aspects and climate monitoring to develop global climate updates and provide the world community with an expert assessment on the status of the climate for the current and the upcoming season

based 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.).

96. It is essential to devise production systems to meet the user needs more explicitly, especially at the national level and local level, to provide 'actionable' information and to make access to information easier for the users. Interaction between the various producing centres (see **Figure 5.1**) would routinely include users, and their work would be enhanced by the Observations, Research and Modelling and the CUIP elements of the Framework.

5.5 User engagement

97. On one hand, the need for climate information and products is increasing rapidly. On the other, despite rapid progress in the development of climate prediction that provide the best possible estimates of future climatic conditions, users at present are often unaware of these products, or are unable to use them effectively. Most of the time they either do not understand these products or lack tools to factor their inherent uncertainties into their decision making processes.

98. NMSs have a long history of working closely with a range of communities and industries within the countries to assess their climate and weather sensitivity. Regional Climate Outlook Forums (RCOFS), described under section 6, is an example of a user interface mechanism that brings service providers together with users. As part of CSIS a number of mechanisms, used and proven useful under the CLIPS project, would facilitate interactive and iterative dialogues between the climate information providers and the representative set of users. As the full scope of dealing with individual users could be highly specified and resource intensive, CSIS interaction with end-users will frequently be through relevant boundary organizations and specialized sectoral institutions, rather than one-on-one basis.

5.6 Partnerships

99. Two types of partnerships are essential for the effective functioning of CSIS, 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/universities) have steadily been integrated into supporting operational activities, to ensure the timely production and dissemination of high quality information and products. In particular, GCOS (climate observations) and WCRP (research and modelling) are critical partners. Technical partners' responsibilities range from global to local in nature.

100. CSIS requires ongoing and sustained relationships between provider and user. WMO has long-existing working arrangements with UN Agencies and Programmes including WHO, UNWTO, UNEP, UNESCO and its IOC, ICAO, IAEA, FAO, UN-Water and with professional societies including IAUC, ISB, ICSU and ICID to extend their working arrangements to incorporate interaction with users in various sectors. 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 Risoe Centre, Denmark etc.).

101. At the national level such partnerships between NMHSs with universities, research institutions and sectoral ministries (e.g. National Health Services, national energy sector, national government ministries) would be useful to carry out the dialogue and bridge the gap between providers and users.

5.7 Recommendations for consideration by the taskforce

102. Key recommendations for consideration by the task force, to expand and ensure the efficient and effective functioning of the elements of the CSIS include:

- Advise regional entities and potential donors to facilitate and promote the work WMO Members will have to undertake in order to implement, operate and sustain the operational elements of the CSIS;
- Prioritize climate research activities to address urgent operational needs and operationalize research advances, particularly at the regional and national levels and facilitate research advances into systematic operational activities;
- Build the required regional/national operational infrastructure (computing, high-bandwidth communications, etc.) in developing countries;
- Promote climate services information provision as a mandated activity by governments, either within, or in close partnership with, the NMHSs; and
- Engage Universities and Research Institutions in a sustained collaborative process with CSIS entities on development of information and products.

Box 5.3 WMO's Contribution to the CSIS component of the Framework

WMO's current strengths (2009-2010)

1. WMO's network of institutions that create information and products, include 3 WMCs, 40 RSMCs, 188 NMHSs, 11 GPCs including 2 Lead Centres, and 2 formally designated RCCs.
2. Close collaboration with regional institutions such as Drought Monitoring Centres (DMCs), ACMAD, ICPAC, CIIFEN, etc.
3. Some established national climate centres/ services.
4. Standards, resolutions, best practices guidance on analysis techniques, criteria for product development and exchange formats
5. Powerful technical support through Intergovernmental Technical Commissions on Basic Systems and Climatology.
6. More than a decade of experience in promoting the development of climate services through Climate Information and Prediction Services (CLIPS) project
7. Regular issue of WMO El Niño/La Niña Up dates based on global consensus
8. Established linkages between the research and operational communities, particularly through WCRP
9. Contributions to early warning systems (e.g., Heat-Health Warning Systems)
10. Institutionalized practices and commitments for monitoring including analysis, assessment, publication and informing on climate, particularly its anomalous behaviors.

WMO Commitments

11. Integrate CSIS product distribution within the WIS.
12. Develop the concepts of National Climate Centres (NCCs) and National Climate Outlook Forums (NCOFs);

WMO Potential areas of further contributions

13. Extend, expand and enhance the network of GPCs, RCCs to cover all climatic regions and increase their effectiveness;
14. Expand RCC operations to cover development of regional climate change scenarios;
15. Develop additional global climate updates including monitoring and prediction aspects, based on expert assessments.
16. Sustained linkages between the research and operational communities.

6. Climate user interface programme

103. The most important feature of the Framework will be the close interaction between users and providers of climate information and products, with the value of the service to the community being judged on its ability to improve decision making. It should be based on a long-term provider-user relationship through formal mechanisms based on user/community participation and a commitment by the service providers to assimilate the outcomes in the design of new and improved services.

104. The vision of CUIP would be to coordinate, facilitate and oversee the development of such mechanisms in various sectors and at various levels: global to regional, national and local (in close relation with the national govt).

105. Central to the development of user-specific climate information is the recognition that the needs of the user community are diverse and complex. Users of climate information and products can be categorised in many ways: users of global, regional and national products; users in different sectors; users in public policy and planning and private sector; intermediate users developing products for end users; well organised to the individual users; and users that are well informed to the layman. At the same time it has to be recognised that 'Users' work at various spatial and temporal scales – from individual farmers to town planners to river basin managers to national planners and international development organisations – and have different needs from weeks and seasonal to decadal predictions and long-term projections. They work under various economic and environmental settings and with different financial motives. While there will be some common needs, in general requirements, perspectives and the way to interact with them will differ in each case.

106. Such interaction is, optimally, the shared responsibility of both users and providers. From a providers perspective their interaction with users has to be effective and efficient but should not significantly divert their human and financial resources away from improving the existing and developing the new products.

6.1 Objectives

107. The climate user interface programme (CUIP) is aimed at bridging the gap between climate services providers and users, 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 vice versa. CUIP will help:

- Users in expressing their needs for climate information, the frequency and modes of delivery of such information;
- Prioritizing user needs for climate information;
- Promoting, facilitating and coordinating focused interdisciplinary (applied climate) research and development to design user-specific products and services;
- Facilitating communication and use of climate information, including integration of the associated uncertainties in decision making;
- Capturing and disseminating knowledge in diverse socio-economic settings; and
- Obtaining user feedback in order to drive the growth and improvement of the observing networks and the climate research and modelling that together underpin the service provision system, and the CSIS itself.

108. CUIP would be seen as a set of activities, projects and initiatives running across all the components of the Framework but particularly concentrating on the application of the climate information and products in decision making in various sectors and at various levels of the user spectrum, and would create a culture within the GFCS that instinctively recognises that the needs of the service user should be the first consideration in the design of all aspects of the end-to-end service provision system.

109. The CUIP initiatives/programmes would differ from sector to sector, as such the CUIP has to be developed jointly with national, regional and global partners who are in direct links and

interact with various sectoral user groups. CUIP needs to be further developed with substantial inputs from partners. The following section largely represents WMO perspectives and the role that it foresees for itself in CUIP.

6.2 National level mechanisms

110. CUIP would need to have its roots down to the national levels. The NMSs, or the NCSs designated within the country as the service providers, may not have the required in-house expertise to support all the users in application of their products for effective decision making. Distinction has to be made between climate services provided for public good purposes and services provided to meet private (commercial) requirements. While the resources (expertise and systems) required for commercial services should be funded by the service user, the human resources and expertise required to provide public services to meet the needs of all sectors may not be available within the NMSs. In many instances efficiency and cost effectiveness may lie in collaborating with organizations that already have a close relationship with the sector. "Boundary organizations", that is, the organizations that already have a level of expertise in both sectoral and climate issues, rather than to have the NMS develop the sectoral relationships and client understandings on their own. Experience shows that tailored climate information for agriculture may be provided by NMSs but it may be more effective to involve boundary organization such as agricultural research institutes or agriculture extension services within the country in the delivery and application of such information (e.g., National Agricultural Monitoring System provided by the Bureau of Rural Sciences of Australia[18]).

111. At the national level dialogue between service providers and users can be established through annual (or seasonal, where required) National Climate Outlook Forums that could be organized in conjunction with the major change of seasons. Such national forums are necessary to maintain a continuous dialogue between the users who can specify their requirements, give assessment of the performance and the respective service providers who can explain the uncertainties and special features of various products that they provide. Larger countries may adopt different forums for different climatic regions. Some countries have recently established Climate Outlook Forums at national/sub-national level, for example, in North-eastern Brazil (NEBCOF, in **Figure 6.1**). Arrangements with boundary organizations in different sectors can popularize the concept of National Climate Outlook Forums Sectoral level agreements can be arranged with various sectoral ministries or interest groups, which can facilitate special products and at the same time may result in partnerships in sharing costs.

6.3 Regional level mechanisms

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

113. Regional level mechanisms can be built around the specific needs of the region for climate services. Regional entities such as River Basin Organisation and economic groupings can play a crucial role in facilitating such mechanisms. Regional Climate Outlook Forums (RCOFs), one of the existing regional level mechanisms, were initiated more than a decade ago and have been supported by WMO in partnership with a number of other agencies. By bringing together countries having common climatologic characteristics, the forums ensure consistency in the access to, and interpretation of, climate information. They not only bring together national but also, regional and international climate experts, on an operational basis, to produce regional climate outlooks, and to increase national professional skills.

[18] Tokoyo Climate Conference, July 2009

114. RCOFs serve as platforms for interaction with sectoral users, extension agencies, policy makers, and the media, and are an important vehicle for getting feedback and developing user-driven products and services. They also need to be extended to other parts of the globe (see **Figure 6.1)**. Under the Framework, these forums would continue to be informed by partners within the UN and boundary organizations.

RCOFs (outlined in red in the map) 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 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, and
SEECOF- SouthEastern Europe COF. Under consideration are COFs for polar regions.
National COFs are also emerging such as the COF for Northeast Brazil (NEBCOF), outlined in blue.

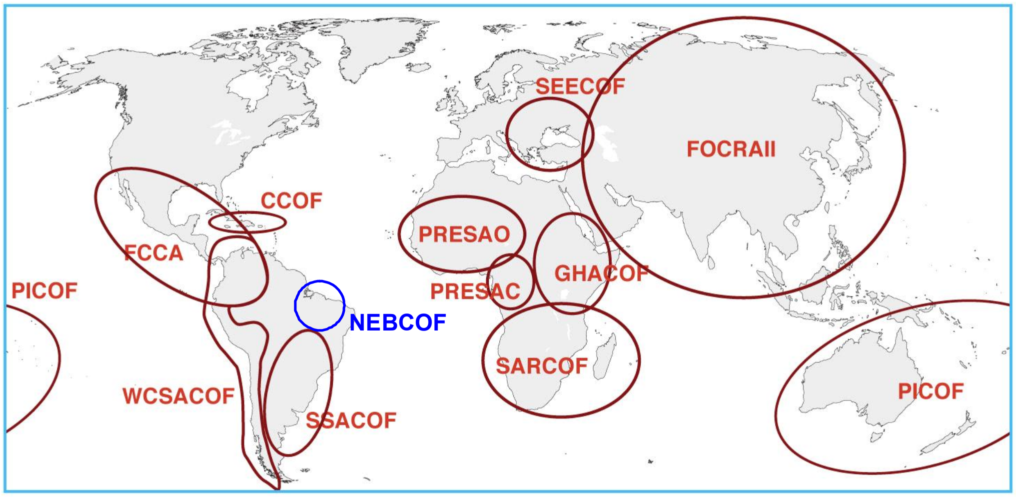


Figure 6.1: Regional and National Climate Outlook Forums (RCOFs and NCOFs) around the world

115. RCOFs have strengthened stakeholder engagement with NMSs, have built capacity for both the climate experts and the users. Regional Forums presently address only specific needs of the regions and need to be extended to cover more sector specific needs e.g., through hydrological outlook forums and malaria outlook forums (see **Box 6.1**), have been launched in some regions, and have demonstrated their value in facilitating an effective integration of climate outlooks into sector specific multi-faceted decision process.

116. 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 that are closely involved in these forums, can play a crucial role by supporting specialized forums addressing the sectoral needs.

6.4 Global level mechanisms

117. At the **global level,** CUIP would enhance cooperation within research networks belonging to different disciplines, 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.

118. WMO through its Technical Commissions for Hydrology, Agricultural Meteorology, Basic Systems, Aeronautical Meteorology, Oceanography and Marine Meteorology, and Climatology has developed many programs that share information, knowledge and best practices among users, and between users and service providers. These cases are successful, yet disparate, user interface mechanisms (**Box. 6.1**). Within the Framework, WMO will further develop such interfaces in these sectors.

119. WMO largely interacts with sectoral users in partnership with various UN Agencies and other Inter-governmental organisations and non-governmental organisations. WMO will further develop these partnerships. Under the UN Secretary General's initiative "Acting on Climate Change: The UN System Delivering as One", a climate knowledge base portal will be developed where climate science, assessment, monitoring and early warnings from all UN agencies will be coordinated by WMO and UNESCO.

120. At the global level, the User Interface Committees of GEO in nine key societal benefit areas can provide an important platform. Similarly, many projects registered under the GEOSS banner can also be developed as mechanisms in the CUIP component of the Framework.

6.5 Communication

121. Effective communication of climate information is vital to ensure its appropriate application. The communication strategy under the Framework has to be based on a broad range of contemporary media. Internet provides one of the most popular and relatively inexpensive means of communication. Many climate service providers have embraced the medium by creating interface portals (e.g., Drought Portal called NIDIS[19]) that provide specialized information targeted to one sector or group of users. In countries with limited Internet access, radio remains a viable option to reach the end-users. The print media in terms of newspapers, the sectoral specialty journals, and the user targeted information brochures are other popular options.

122. The scope of WMO's Public Weather Services Program, which promotes efficient communication through close liaison with media experts specializing in weather and climate information, could be expanded to include Climate Adaptation Outreach Communication and the capacity of NMHSs developed in communicating with media through national workshops, implementation of pilot demonstration projects and by sharing best practices and experiences. RCOFs and NCOFs are also helpful in developing partnerships with the media.

123. Face to face interaction, the time tested mechanism, provides an option to generate awareness, interact and encourage involvement. Roving Seminars for farmers through agricultural extension services in several countries have successfully been used by WMO in raising awareness and promoting the application of climate information. Interactive workshops that bring climate information providers and users together would be an important User Interface device in the Framework.

Box 6.1 WMO's Contribution to the CUIP component of the Framework

WMO's current strengths (2009-2010)

1. Close collaboration with regional institutions such as Drought Monitoring Centres (DMCs), ACMAD, ICPAC, CIIFEN, etc.
2. Powerful technical support through Intergovernmental Technical Commissions on Basic Systems and Climatology.
3. Years of experience in Regional Climate Outlook Forums (RCOFs)
4. Well established sustained linkages between the research and operational communities, particularly through WCRP and WMO Technical Commissions
5. Sustained partnerships with the user sectors, particularly water and agriculture, through Commissions for Hydrology, Climatatology, and Agricultural Meteorology

WMO Committments

6. Develop the concepts of National Climate Outlook Forums (NCOFs);

WMO Potential areas of further contribution

7. Extend the network of RCOFs including their scope to include user specific climate outlooks;
8. Increase the capacity of NMSs to provide relevant and reliable climate information and products to national users for climate risk management and adaptation decisions

[19] Working Session 9? WCC-3 Conference Geneva, Switzerland (Roger Pulwarthy)

6.6 Recommendations for consideration by the taskforce

124. The Climate User Interface Programme (CUIP) is a crucial component of the Framework, aimed at bridging the gap between the Climate Services and Information System and the sectoral users. It needs to systematically address the effective application of climate information and products in decision making at different levels of the user spectrum. It has, therefore, to be necessarily developed jointly with a range of partners having direct links with the sectoral user groups. Within its essentially multidisciplinary context, CUIP has to contend with a complex set of challenges with regard to the needs, capabilities, and communication and user engagement. The following are some recommendations for the consideration by the task force:

- Close interaction should be promoted between users and suppliers of climate information and products, with well-defined principles of engagement and feedback mechanisms.
- CUIP needs to be further developed, jointly with climate service providers and user partners, with well-defined mechanisms at the national, regional and global levels.
- The important role of boundary organizations within the CUIP as effective conduits for the flow of climate information into user-level decision making needs to be facilitated.
- CUIP needs to develop a culture of user focus in every element of the Framework, with information provided by the CUIP being used in all aspects of decision making within the Framework.
- At the national level, National Climate Outlook Forums should be established in all countries to maintain a continuous dialogue between the user representatives and climate providers.
- Regional Climate Outlook Forums should be expanded and strengthened to promote regional climate provider and user networking, and achieve a common understanding of shared challenges.
- Sector-specific outlook forums driven by the sectors themselves should be encouraged for critical socio-economic sectors in the region, such as water, food security and health, in close liaison with RCOFs.
- WMO, with its dedicated programmes dealing with water and agriculture sectors, has a unique opportunity to develop and demonstrate CUIP elements for these sectors.
- The “UN System Delivering as One” initiative can provide an excellent opportunity for WMO to partner with other UN agencies in further developing CUIP.
- A communication strategy should be developed under the Framework using a broad range of contemporary media, to raise user awareness and outreach.

Box 6.2 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

Malaria Outlook Forums (MALOFs): Since 2004, the WHO’s office in the southern African region and the SADC Drought Monitoring Centre have been working with the WMO, the National Meteorological and Hydrological Services (NMHSs), and the Ministries of Health in the southern African countries and IRI to conduct a pre-season Malaria Outlook Forum (MALOF) in close coordination with the Southern African Climate Outlook Forum (SARCOF). The MALOF process continues in the southern African region and, in March 2007, was also initiated in the Greater Horn of Africa region, along with the Greater Horn of Africa Climate Outlook Forum (GHACOF). The MALOF is and has been the cornerstone for implementing an early warning system for malaria in the member states of these African regions. The information developed jointly by climate and health experts in these sessions, together with information on population vulnerability, food security, immuno-suppression and adequacy of control coverage, gives the health community a longer lead-time over which to optimize the allocation of the resources available to combat malaria.

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7. Capacity building

125. The Framework is being built using, wherever possible, existing elements that are either in place or are in the process of being established. However, as the scope of the climate services increases, many of these elements will require strengthening to meet the additional demand and extended scope. Therefore, establishment of the Framework will require capacity-building through:

- Strengthening and aligning institutional arrangements;
- Strengthening of existing, and where required, establishment of new infrastructure; and
- Development of human skills and training.

126. Particular emphasis should be placed on the needs of developing and least developed countries including Small Island developing states (SIDS), and particularly vulnerable regions such as Africa.

7.1 Strengthening and alignment of institutional arrangements

127. In many countries absence of clear mandates and legislative frameworks on climate related issues are a hindrance to the proper functioning of climate services. Capacity-building for the Framework must include institutional strengthening in governance, management and funding as well as human resources development. Members would be required to be advised and supported in the form of model laws and management practices that they could follow in their respective countries to address climate issues. WMO would actively encourage Members to establish clear definitions of mandates (roles and responsibilities) for all stakeholders.

7.2 Strengthening infrastructure

128. The WMO Technical Cooperation Programme has provided assistance to Member countries over time to improve meteorological and hydrological services and capabilities, in the form of equipment, expert services and training and education. These efforts are maintained by voluntary contributions received through collaborative efforts of Members and from partners, but have fallen far short of the demands.

129. Implementation of the Framework will require an improvement in infrastructure within countries to systematically and sustainably undertake high-quality climate observations and the establishment and operation of various elements of CSIS, particularly in the developing countries. The Regional Programme of WMO, with an intimate knowledge of Member strengths and capacity building needs in meteorological and hydrological services, will play a key role in guiding the strengthening of infrastructure and human capacity required for the NMHSs to fulfil their role in the Framework.

7.3 Development of human skills

130. To develop the human capacity needed in the Framework, a review of the educational qualifications and on-job training requirements for climate specialists would have to be taken up. New skills in developing, producing, accessing, interpreting and analyzing global and regional climate products, including downscaled projected climate change scenarios for assessing climate change impacts, would be required to be developed at a much larger scale as the climate service provision is made operational in the countries. A number of CLIPS training workshops held across the world have helped to create local capacities in climate and climate prediction to a certain degree. These experiences would have to be up-scaled and complemented by the incorporation of foundation elements of climate forecasting and services into the basic curriculum of university programmes around the globe, and particularly in WMO Regional Training Centres (RTCs).

131. Countries would have to develop clear human resources development policies to address this issue. This would entail establishing minimum standards of education and training for climate services specialists, as WMO presently does for the meteorological services in a seamless

manner. WMO Regional Training Centers have tremendous potential to expand their scope of human resources development to include the additional needs by Members for training in developing climate predictions and diagnostics, and user-targeted information and products. To ensure common minimum standards across the globe the requirements for certification and recognized training would need to be integrated into the RTC programmes. This will require the development of common curricula and upgrading of the staff and resources at these Training Centres.

132. As these skills would be technology intensive, Universities within the countries would be in the best position to participate or take lead in these activities. Collaboration between Universities, NMHSs, RTCs and regional centres can bring sustainability to these efforts. These efforts should be supplemented by the boundary organizations as well as sectoral users within the countries.

133. Through its Education and Training Programme, WMO assists the NMHSs, especially those of developing countries to become full partners in global collaborative efforts for weather, climate and water. 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 of observations. Service areas, largely focused on weather time frames at present, include marine meteorology and tropical meteorology, public weather forecasting, applications in the agriculture and aviation sectors, disaster prevention, environment and hydrology. WMO's exisiting contributions, its commitments and potential further contributions are listed in Box 7.

Box 7 WMO's Contribution to the Capacity Building component of the Framework

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 from 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. Recognition as a good development partner.

WMO Commitment

1. Development of a comprehensive WMO climate training programme based on CLIPS and RTC curricula and experience, to be delivered through RTCs.
2. Development of a certification mechanism for climate specialists.
3. Strengthen training aspects within GPC and RCC infrastructure.
4. Increase the capacity of NMHSs to provide climate information and products to national users, for Climate Risk Management and adaptation.
5. Promote infrastructure development by Member countries.
6. Enlighten NMHSs on the Framework and the role they are expected to play therein.
7. Collaborate with sectoral partners in their efforts to include climate components in their training materials

WMO Potential Areas of further contributions

8. Promote the upgrading of existing regional or national climate institutions to serve as RCCs.
9. Expand the technical capability throughout the CSIS to work with IPCC scenarios datasets, prediction outputs.
10. Promote strengthening Information Technology (IT), Internet and telecommunication facilities of NMHSs to facilitate access to global and regional products.

134. Climate change threatens to overwhelm traditional adaptation mechanisms to natural climate variability relied on by many communities. It will require regular interaction between science and communities for new relationships to be correctly identified. It is therefore urgent to enhance the interaction between scientists and local communities for sharing of scientific and indigenous knowledge at all levels. The experience of WMO's Public Weather Services Media Training for the NMHSs, would contribute to the communications aspects of climate services in the Framework. With extensive experience in training in delivery of effective weather services, PWS may also support and participate in the education and awareness of user communities through special engagement groups. Training that helps users and providers better communicate with each other, should be a shared responsibility of all partners in the Framework.

7.5 Partners in capacity development

135. NMHSs will need to develop strong partnerships with research and development institutions at the national and local levels. Particularly Universities would serve as excellent partners in preparing the next generation climate service producers with multi-disciplinary perspective and skills to communicate with various users.

136. 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.

7.6 Recommendations for consideration by the taskforce

137. Key recommendations for consideration by the taskforce, for the capacity building needed to quickly implement the Framework include:

- Facilitation of acquiring the financial and technical support required for the full suite of capacity building needs identified for Observations, Research and Modeling, the CSIS and for the CUIP (sections 3, 4, 5 and 6);
- Promotion to governments to support and strengthen the mandates of the NMHSs and other relevant government, academic or boundary institution in their country for national climate services;
- Strengthen and expand the role of WMO RTCs to take up training activities for climate services;
- Promotion to Universities and research institutes to contribute to human resources development.
- Willingness to take leading role in their specialist areas such as outreach and education for communities.

8. Governance and Resources for the Framework

138. The Framework must be coordinated and overseen through a governance mechanism with the following functions:

- Ensure adequate technical and professional guidance are employed;
- Provide oversight: to ensure resources are used efficiently;
- Set and review directions and monitor progress: to assign and ensure accountability for realising the vision of the Framework;
- Ensure respective roles and mandates: so that organisations concerned comply with legal systems in place and within the jurisdictions in which they operate;
- Facilitate resource mobilisation; and
- Suggests policy directions where required.

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

- Many of the climate services are provided as 'public goods' by governments, but in addition to these, there are many organisations and individuals that provide commercial climate services as 'private goods';
- Much of the operational 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 of global scale, intergovernmental processes and coordination are required 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.

140. Much has been learnt about climate coordination efforts through experiences from the Coordinating Committee for the WCP (CCWCP) established by Cg XI *(Res. 12, Cg-XI)* (1991) that had the objective to provide overall coordination between the four components of the WCP and maintain an effective communication with other related international climate activities and the Inter Agency Committee for the Climate Agenda (IACCA) was developed based on the advice of an Inter-governmental Meeting on WCP in 1993.

141. In deliberating on governance structures, the taskforce may wish to take into account the experiences from a number of current models guiding WMO co-sponsored programmes (GCOS and WCRP), and the WMO-UNEP IPCC (Annex 14).

142. National Meteorological Services along with the Space Agencies have invested heavily in the monitoring of the Earth system. They have established infrastructure to deliver the weather services around the world. However, in order to upgrade these systems to meet the additional needs of providing for the climate services would require financial resources. At the same time there are spatial gaps both in climate observation systems as well as in collection of socio-economic data required for adaptation and climate risk management. The climate research and modeling facilities require a new impetus to achieve the new breakthroughs required for improving predictions from seasonal to decadal scales. Further, the infrastructure in terms of regional and national level climate centres would require additional commitments of both human and financial resources. The CUIP and capacity building would require additional resources at various levels. In order to implement the activities under the Framework, appropriate financial mechanism has to be worked out.

ABBREVIATIONS AND ACRONYMS

ACMAD	African Centre of Meteorological Application for Development
ACSYS	WCRP Arctic Climate System Study
AeMP	Aeronautical Meteorology Programme
AGRHYMET	Centre Regional de Formation et d'Application en Agrométéorologie et Hydrologie Opérationnelle
AgMP	Agricultural Meteorology Programme
CAgM	WMO Technical Commission for Agricultural Meteorology
CAS	WMO Technical Commission for Atmospheric Science
CBS	WMO Technical Commission for Basic Systems
CCDI	Climate Change Detection and Indices
CCI	WMO Technical Commission for Climatology
CCWCP	WMO Coordinating Committee on the WCP
CDMS	Climate Database Management System
CEB	United Nations Chief Executives Board for Coordination
CEMAC	Economic and Monetary Community of Central Africa
CIIFEN	Centro Internacional para la Investigación del Fenómeno de El Niño
CliC	WCRP Climate and Cryosphere Project
CLIPS	Climate Information and Prediction Services
CLIVAR	Climate Variability and Predictability (a WCRP programme)
COF	Climate Outlook Forum
COP	Conference of the Parties
CORDEX	WCRP COordinated Regional climate Downscaling EXperiment
CSAP	Climate Services Application Programme
CSIS	Climate Services Information System
CUIP	Climate User Interface Programme
DMC	Drought Monitoring Centre
DPFS	Data Processing and Forecasting System
DRR	Disaster risk reduction
ECOSOC	United Nations Economic and Social Council
ECOWAS	Economic Community of West African States
ECV	Essential Climate Variable
ENSO	El Niño Southern Oscillation
ESSP	Earth System Science Partnership
FAO	Food and Agriculture Organization of the United Nations
GAW	Global Atmosphere Watch
GEO	Global Earth Observations
GEO-IDE	GEO - Integrated Data Environment
GEOSS	Global Earth Observing System of Systems
GCM	Global Climate Model
GCOS	Global Climate Observing System
GEF	Global Environmental Facility
GEWEX	Global Energy and Water Cycle Experiment
GFCS	Global Framework for Climate Services
GOOS	Global Ocean Observing System
GPC	Global Producing Centre of Long-range Forecasts
GPCC	Global Precipitation Climatology Centre
GRDC	Global Runoff Data Centre
GTOS	Global Terrestrial Observing System
GTS	Global Telecommunications System
IACCA	Inter-agency Committee on the Climate Agenda
IAEA	International Atomic Energy Agency
ICAO	International Civil Aviation Organization
ICID	International Commission for Irrigation and Drainage
ICPAC	IGAD Climate Prediction and Applications Centre
ICSU	International Council for Science
IFRC	International Federation of Red Cross and Red Crescent Societies
IGAD	Intergovernmental Authority on Development
IGBP	International Geosphere-Biosphere Programme
IGFA	International Group of Research Funding Agencies
IGM	Intergovernmental Meeting
IGO	Intergovernmental Organization
IHDP	International Human Dimensions Programme on Global Environmental Change
IOC	Intergovernmental Oceanographic Commission (of UNESCO)

IPCC	Intergovernmental Panel on Climate Change
IRI	International Research Center for Climate and Society
ISB	International Society of Biometeorology
ISDR	International Strategy for Disaster Reduction (UN)
ISO	International Organization for Standardization
IT	Information Technology
IUCN	International Union for Conservation of Nature
JCOMM	Joint WMO-IOC Technical Commission on Oceanography and Marine Meteorology
LDC	Least developed country
LRF	Long-range forecasting (or forecasts)
MDG	Millennium Development Goal
NASA	National Aeronautics and Space Administration
NCC	National Climate Centre
NCOF	National Climate Outlook Forum
NGO	Non-governmental organization
NOAA	National Oceanic and Atmospheric Administration
NMHS	National Meteorological and Hydrological Service
NMS	National Meteorological or Hydrometeorological Service
NSIDC	National Snow and Ice Data Center
NWP	Nairobi Work Programme
RCC	Regional Climate Centre
RCM	Regional Climate Model
RCOF	Regional Climate Outlook Forum
RTC	WMO Regional Training Centre
SADC	Southern African Development Community
SBSTA	UNFCCC Subsidiary Body on Science and Technology
SIDS	Small Island Developing States
SPARC	Stratospheric Processes and their Role in Climate
START	WCRP SysTem for Analysis, Research and Training
TOGA	WCRP Tropical Ocean and Global Atmosphere Project
UIP	User Interface Programme
UN	United Nations
UNDP	United Nations Development Programme
UNECLAC	United Nations Economic Commission for Latin America and the Caribbean
UN ECOSOC	United Nations Economic and Social Council
UNECA	United Nations Economic Commission for Africa
UNESCAP	United Nations Economic and Social Commission for Asia and Pacific
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UN-Energy	UN interagency mechanism on energy
UNEP	United Nations Environment Programme
UNWTO	UN World Tourism Organization
VCP	WMO Voluntary Co-operation Programme
WB	World Bank
WCASP	World Climate Applications and Services Programme
WCC	World Climate Conference
WCDMP	World Climate Data and Monitoring Programme
WCP	World Climate Programme
WCRP	World Climate Research Programme
WDC	World Data Centre (ICSU) (WDCs for Meteorology are: Asheville, NC, USA; Beijing, China; and Obninsk, Russian Federation); World Data Centre for Aerosols; World Data Centre for Greenhouse Gases; World Data Centre for Precipitation Chemistry; World Data Centre for Surface Ozone, etc.
WGCM	WCRP/CLIVAR Working Group on Coupled Modelling
WGNE	WCRP/CAS Working Group on Numerical Experimentation
WHO	World Health Organization
WIGOS	WMO Integrated Observing System
WIOC	WCC-3 International Organizing Committee
WIS	WMO Information System
WMO	World Meteorological Organization
WOCE	WCRP World Ocean Circulation Experiment
WOUDC	World Ozone and UV Data Centre
WRDC	World Radiation Data Centre
WWF	Worldwide Fund for Nature
WWRP	World Weather Research Programme
WWW	World Weather Watch

TERMINOLOGY USED IN THIS DOCUMENT

Today, climate is everybody's business. Stakeholders from various sectors and backgrounds have differing conceptions and use the same terms to mean different things. It is therefore important to begin by clearly stating how some of the most important terms used in this document are meant to be interpreted.

'**Adaptation**' refers to adjustment to present climate variability and to anticipated climate change.

'**Boundary organization**' is an institution or entity that works with users in given sector(s) at various levels and that have, at the same time, certain in-house expertise in understanding and interpreting climate information and products.

'**Climate**' is a synthesis of weather in a given area, characterised by long-term statistics (mean values, variance, probabilities of extreme values etc.) of the meteorological elements.

'**Climate change**' as defined by IPCC refers to the change in the state of the climate that can be identified (e.g. by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcing, or to persistent anthropogenic changes in the composition of the atmosphere or in land use.

'**Climate information**' includes historical data, analyses and assessments based on these data, forecasts, predictions, outlooks, advisories, warnings, model outputs, model data, climate projections and scenarios, climate monitoring products, etc., and can be in the form of text, maps, charts, trend analyses, graphs, tables, GIS overlays, photographs, satellite imagery, etc.

'**Climate prediction**' includes forecasts and outlooks and predictions at monthly, seasonal, inter-annual, decadal, and multi-decadal scales. This range includes the following meteorological forecasting ranges as defined in the Manual on the Global Data Processing and Forecasting System (GDPFS) (WMO-No. 485, Volume 1 (global aspects)): long-range forecasts (monthly outlooks, three-month or 90-day outlooks, seasonal outlooks and climate forecasting (including climate variability prediction and climate prediction, beyond two years).

'**Climate Risk Management (CRM)**' is an approach to decision-making in climate-sensitive activities (e.g. agriculture and food security, health, tourism, management of water and energy resources, urban planning and design, transportation, etc.), that seeks to reduce the vulnerability associated with climate risk (both variability and change) and aims to both maximize the positive and minimize the negative outcomes for these sectors.

'**Climate service**' is a continuum of provision, delivery and consumption of climate information and products. Climate services should have the properties of being available, dependable, usable, credible, responsive, flexible and sustainable.

'**Climate Watch**' or '**Climate Watch System**' is a monitoring activity generally at national or subnational scales leading to issuance of advisories and statements to inform users, thereby serving as a mechanism to heighten awareness and initiate preparedness measures, particularly for those involved in natural hazard preparedness, mitigation and response. The elements of the system include thresholds, indices, criteria and databases.

'**Decision-maker**' (see User, below)

'**Framework**' refers to the outline or structure on which improved climate predictions, information and services will be built and is used in this paper to represent the Global Framework for Climate Services. The term carries no political or legal meaning.

'**Global Producing Centre of Long Range Forecasts (GPC)**' is a WMO-designated operational centre producing long-range forecasts of global large-scale fields of a standard set of climate variables including surface temperature, precipitation and others, with a regular predefined frequency. GPCs provide access to their forecasts to all WMO

Members as well as supplying additional information on standard verification statistics to facilitate assessment of their forecast skills for the regions of interest.

'**Homogeneous data**' are those data that have been observed under the same (or very similar) conditions, and with the same (or very similar) equipment, so that they are, in principle, unaffected by non-climatic influences (often referred to as 'inhomogeneities') that could affect interpretation of the climate record. A homogeneous climate time series is therefore one in which variations are caused only by variations in climate.

'Meteorological Elements' are the atmospheric variables or phenomenon which characterises the state of the weather at a specific place at a particular time (e.g., air temperature, pressure, wind speed and direction, humidity, thunderstorm and fog).

'**National Climate Service**' or 'National Climate Centre' can be and often is an entity within a National Meteorological Service (NMS) or a National Meteorological and Hydrological Service (NMHS) to, inter alia, carry out climate studies, conduct climate prediction and projection and develop and provide climate services.

'**National Meteorological Service (NMS)**' has a useful working definition (see 'The National Meteorological Service', by John W. Zillman: WMO Bulletin Vol. 48, No. 2, April 1999). For the purpose of this Paper, an NMS is 'an organization established and operated primarily at public expense for the purpose of carrying out those meteorological and related functions which governments accept as a responsibility of the State in support of the safety, security and general welfare of their citizens and in fulfilment of their international obligations under the Convention of the World Meteorological Organization'. In many countries, the NMSs and a Hydrological Service are co-located, and are referred to as the National Meteorological and Hydrological Service (NMHS).

'**Regional Climate Centre (RCC)**' is a WMO-designated regional institution with capacity to develop high-quality regional-scale climate products based on global products incorporating regional information.

'**Regional Climate Outlook Forums (RCOFs)**' are platforms (generally meetings) in which climate experts (providers of information, predictions, products and services) develop consensus-based regional climate predictions and meet with users of climate information, usually at significant seasonal changes in climate (e.g. beginning of the rainy season). RCOFs produce and disseminate a regional, consensus-based assessment of the state of the regional climate (i.e. a climate prediction) for the upcoming season.

'**Regional Training Centre**' is a WMO centre that, along with a network of cooperating universities and advanced training institutions, provides education and training in meteorology and hydrology. These centres have great potential to include training in climatology, climate prediction, downscaling and in developing climate information and products in their curricula.

'**Service**' is used to describe an action, such as delivery of climate information (see above), guidance, or a product to a client or user, and does not normally imply a physical entity such as an organization or institute unless this is specifically described (as in NMHS above).

'**User**' (or '**decision-maker**' – these terms are frequently used interchangeably) refers to a client with responsibilities for decisions and policies in climate-sensitive settings, who receives and uses (takes into account) climate services including information and products. Users can include individual end-users, a complete sector or a sub-sector of the global socio-economic community, the media, an academic institution, the modelling and prediction communities, the private sector, an NGO, a UN agency, a government agency or Ministry, a state government, etc.

'**Weather'** is the state of the atmosphere at a particular time, defined by various meteorological elements.
