WORLD CLIMATE CONFERENCE-3

Geneva, 31 August – 4 September 2009

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SUMMARY

In the 21st Century, the peoples of the world are facing multi-faceted challenges of climate variability and climate change, which requires wise and well-informed decision-making at every level from households, communities, countries and regions, to international fora, including the UN Framework Convention on Climate Change. Those decisions will require, directly or indirectly, access to the best possible climate science and information, and effective application of this information through climate services.

The first two World Climate Conferences in 1979 and 1990 laid the foundation for building research and observational activities to understand the nature of the climate challenges and to provide the scientific bases for developing the comprehensive and sound climate services that are now being sought by all countries and in virtually every sector of society. The World Meteorological Organization (WMO) and its partners convened World Climate Conference-3 (WCC-3) to provide nations with the opportunity to jointly consider an appropriate global framework for climate services over the coming decades that would 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.

The purpose of the Expert Segment of WCC-3 was to engage a wide cross-section of climate scientists, expert providers of climate information and the users of climate information and services in a wide-ranging discussion on the essential elements of a new Global Framework for Climate Services for consideration by the High-level Segment of the Conference.

The 200 speakers and 1500 participants in the Expert Segment:

- *reviewed* the various elements of the shared challenge facing the climate service provider and user communities;
- *considered* the needs and capabilities for applying climate information in key climate-sensitive sectors, as well as for social and economic benefits;
- *examined* the scientific basis for climate information and prediction services;
- *were advised* on the needs and perspectives of a number of scientific, environmental and socioeconomic groups and organisations;

- *were informed* of the experience of a wide range of countries and climate-sensitive sectors in the implementation of climate services;
- *concluded that:*
  - — Great scientific progress has been made especially through the World Climate Programme and its associated activities over the past 30 years, which provides already a firm basis for the delivery of a wide range of climate services; but that
  - — Present capabilities to provide effective climate services fall far short of meeting present and future needs and of delivering the full potential benefits, particularly in developing countries;
  - — The most urgent need is for much closer partnerships between the providers and users of climate services; and
  - — Major new and strengthened research efforts are required to increase the time-range and skill of climate prediction through new research and modelling initiatives; and to improve the observational basis for climate prediction and services, and the availability and quality control of climate data;

- *called for major strengthening* of the essential elements of a global framework for climate services:
  - — The Global Climate Observing System and all its components and associated activities; and provision of free and unrestricted exchange and access to climate data;
  - — The World Climate Research Programme, underpinned by adequate computing resources and increased interaction with other global climate relevant research initiatives.
  - — Climate services information systems taking advantage of enhanced existing national and international climate service arrangements in the delivery of products, including sector-oriented information to support adaptation activities;
  - — Climate user interface mechanisms focussed on building linkages and integrating information, at all levels, between the providers and users of climate services; and
  - — Efficient and enduring capacity building through education, training, and strengthened outreach and communication.

- *supported the development* of the proposed Global Framework for Climate Services.

The WCC-3 Sponsoring Agencies agreed, therefore, that the essential findings of the Expert Segment, as summarised in this Statement, should be transmitted to the High-level Segment of the Conference for the information of delegates and other Conference participants; and referred to their individual and joint executive and co-ordination bodies for follow-up action, in particular, in the context of the UN Chief Executives' Board (CEB) initiative on the UN System Delivering as One on Climate Knowledge.

PREAMBLE

1. At the invitation of the Government of Switzerland, World Climate Conference-3 (WCC-3) was held in Geneva, Switzerland, from 31 August to 4 September 2009. It was organised by the World Meteorological Organization (WMO), in collaboration with the United Nations Educational, Scientific and Cultural Organization (UNESCO), the United Nations Environment Programme (UNEP), the Food and Agriculture Organization of the United Nations (FAO), the International Council for Science (ICSU) and other intergovernmental and non-governmental partners. The Conference was generously supported by the governments of Australia, Canada, China, Denmark, Finland, France, Germany, Greece, India, Ireland, Italy, Japan, Kenya, Namibia, Norway, Pakistan, Russian Federation, Saudi Arabia, Spain, Switzerland, the United Kingdom and the United States of America, and by the European Union, the European Space Agency, the United Nations Environment Programme and FAO. Additional in-kind support was received from many other countries and organizations. Some 2000 participants from 163 countries and 59 international organizations attended the Conference, with approximately 1500 participating in the first three days of expert presentations and discussions.

2. The theme of the Conference was 'Climate Prediction and Information for Decision Making' and its vision was for "An international framework for climate services that links science-based climate predictions and information with the management of climate-related risks and opportunities in support of adaptation to climate variability and change in both developed and developing countries". In giving effect to the decision of the 2007 Fifteenth World Meteorological Congress to build on the legacy of the First (1979) and Second (1990) World Climate Conferences to establish a new international framework for climate services which will complement and support the work of the WMO-UNEP Intergovernmental Panel on Climate Change (IPCC) and the United Nations Framework Convention on Climate Change (UNFCCC), the WCC-3 sponsors agreed to partition the Conference into two segments:

   - *Expert Segment* (31 August - 2 September) at which climate scientists and other experts from climate service provider and user communities would examine global, sectoral and national needs and capabilities for the provision and application of climate services and identify the essential elements of a new global framework to be elaborated in a Conference Statement; and

   - *High-level Segment* (3-4 September) at which Heads of State and Government and other invited dignitaries would express their views on the proposed framework and ministers and other national representatives would adopt a High-level Conference Declaration calling on WMO and its partner organizations to implement the proposed framework without delay.

3. The Expert Segment of the Conference reviewed a wide range of individual and community-based papers and presentations from climate science, service, application and user communities as well as the results of deliberations by a number of other major climate service stake-holder and community groups. The conclusions and recommendations from the various sessions, forums, workshops and round-tables of the Expert Segment of the Conference are summarised below. More details on the community-based input to the Conference and the discussions during the Expert Segment are included in the full Conference Proceedings.

1 OPENING OF THE CONFERENCE

4. In welcoming the participants to the Opening of the Conference, the Secretary General of WMO, Mr Michel Jarraud, recalled the achievements of the First and Second World Climate Conferences and expressed his hope that WCC-3 would lead to an even more broadly-based contribution to the wise handling of the climate issue by providing far-sighted guidance on the optimum arrangements for the provision of climate services in support of national and international decision-making over the coming decades.

5. The President of Swiss Confederation, HE Mr Hans-Rudolph Merz, President of the Conference, welcomed the participants to WCC-3, stressed the widespread impacts of weather and climate, and expressed his confidence that WCC-3 would lay the foundation for a better future due to better climate information.

6. Dr Alexander Bedritsky, President of WMO and Chair of the Expert Segment of the Conference, noted that improved climate services are now possible to address a broad range of user needs. The global community must now come together to provide the needed information and predictions based on the best available science. The large number of organizations attending the Conference should be seen as a testament to the high level of commitment that now exists to providing improved climate services. Dr Bedritsky emphasised that WMO Members have provided, and will continue to provide, data, information and predictions that are essential for climate services.

7. Dr Gro Harlem Brundtland, the UN Secretary-General's Special Envoy for Climate, represented the Secretary-General at the Opening of the Conference. She noted that the Secretary-General has called climate change the defining challenge of our generation and that, today, it is in our hands to make WCC-3 an important milestone in the quest for peace and security. Climate politics must be based on clear and credible scientific data, so WCC-3 Conference participants should make their voices heard. The world needs the knowledge and initiative of the scientific community now more than ever.

8. Mr Kofi Annan, President of the Global Humanitarian Forum, noted the need for concerted political action on climate change. There is no room for complacency, and deliberations at WCC-3 must provide the impetus to help decision makers reach a new agreement in Copenhagen. Those who are most threatened by climate change have done the least to cause the problem. Therefore, developed countries should take the lead in cutting

greenhouse gas emissions. Weather Information for All, a new initiative by the Global Humanitarian Forum, WMO, and the private sector, to establish surface stations communicating by cell phone technology, will help facilitate the sharing of essential data and the provision of threat alerts.

9. Following the formal opening of the Conference, Dr Bedritsky invited participants to join in the opening of the Expert Segment. He welcomed representatives of WMO's international partners, who addressed the Conference as follows:

   - Mr Walter Erdelen, Assistant Director-General, United Nations Educational, Scientific and Cultural Organization (UNESCO)
   - Mr Manzoor Ahmad, Director, Geneva Office, Food and Agriculture Organization of the United Nations (FAO)
   - Mr Joseph Alcamo, Chief Scientist of the United Nations Environment Programme (UNEP)
   - Dr Deliang Chen, Executive Director of the International Council for Science (ICSU)
   - Ms. Julia Marton-Lefevre, Director General of the International Union for the Conservation of Nature (IUCN)
   - Mr Jean Jacques Dordain, Director General of the European Space Agency,
   - Mr Houlim Zhao, Deputy Secretary General, International Telecommunications Union (ITU)
   - Dr Reid Basher, Special Advisor to the UN Assistant Secretary General for Disaster Risk Reduction;

   with a message of support for the Conference, also from the World Health Organization (WHO).

10. Dr Thomas Stocker, Co-Chair of Working Group I of the Intergovernmental Panel on Climate Change (IPCC), set the science scene for the Conference in terms of new approaches and methods that will be available for use in the IPCC Fifth Assessment Report. These include:
    - Improved short term predictions that will be available to IPCC Working Groups II & III;
    - Improved understanding of the several factors that influence sea level rise;
    - Reduced uncertainties on climate impacts; and
    - Hazards as a result of human-induced climate change.

11. Dr John Zillman, Chair of the WCC-3 International Organizing Committee, concluded the opening session by elaborating the Sponsors' Vision of the Conference.

2 THE SHARED CHALLENGE FOR CLIMATE SCIENCE, SERVICES AND APPLICATIONS

12. The Conference undertook a comprehensive review of the individual and shared challenges faced by those involved in advancing the frontiers of climate science, in turning scientific progress into useful climate services and in applying climate services for social, economic and environmental benefit.

13. It noted that the original 1979 World Climate Programme (WCP) was designed as an integrated framework for climate data, research, applications and impact assessment and that much progress has been achieved over the past 30 years through the four components of the WCP (World Climate Data and Monitoring Programme (WCDMP), World Climate Applications and Services Programme (WCASP), World Climate Impacts and Response Strategies Programme (WCIRP) and World Climate Research Programme (WCRP)), the Intergovernmental Panel on Climate Change (IPCC) and the Global Climate Observing System (GCOS) in providing society with reliable and useful climate information. It was agreed, however, that apart from the role of the IPCC in providing comprehensive user-friendly assessments of the state of knowledge of climate change, less progress has been made in translating scientific progress into user-oriented climate services and their application for the benefit of society.

14. Climate science has a rich history of rising to the challenges of weather and climate prediction, providing the society irrefutable evidence on the reality of climate change and human contributions to it. Climate research is now tasked with even a greater challenge to understand the Earth as a complex, nonlinear interactive system, and assess the impacts of anthropogenic climate change on coupled human and natural systems. Important attributes of climate services include provision of balanced, credible, cutting-edge scientific and user-targeted information that effectively informs policy options.

15. Mitigation of, and adaptation to, climate change is a shared challenge and, in order to address the evolving vulnerabilities of human and natural systems, climate science needs to continue its efforts to resolve the outstanding uncertainties and support climate-resilient development. Assessments must be made of emergency preparedness and response systems; efforts are needed to raise awareness of climate risks and opportunities in climate-sensitive communities; and new tools and products, relevant to decision-making, are urgently needed.

16. Climate change is a risk multiplier, and actionable climate information is a great resource for society. Climate information is about people, and its key role is in saving lives and protecting livelihoods, and, therefore, it is important to integrate it into policy frameworks and development discourse.

17. Climate services are too complex to be undertaken with a fragmented approach, and it is crucial for all stakeholders to closely work together. For example, integrated water

resources management must achieve balance amongst economic efficiency, social equity and environmental sustainability.

18. The insurance industry has, for decades, been concerned with climate change, climate extremes and catastrophic events, and is an important user of climate information. The risks of extreme weather and climate events are rising, especially in developing countries. Various insurance options are helping developing countries manage the impacts of climate change. High quality weather and climate data are the prerequisites for proper insurance risk management. In many developing countries lack of appropriate climate data is the main obstacle for introducing the required insurance systems.

19. The speakers in the session highlighted the following key issues:

- The challenge of climate modelling and prediction needs to be addressed by an unprecedented multinational effort, with massive supercomputing, infrastructural and human resource deployment, in order to produce reliable high-resolution climate information for the entire planet;
- The proposed Global Framework for Climate Services (GFCS) must address the shared challenge of climate change with due consideration to all scientific and societal issues, closely involving all the stakeholders; for example, by
  - developing more climate-information based decision support tools to meet the needs of the food security;
  - working with the climate and water resource management communities to ensure that climate information is integrated into planning activities at local, national and regional levels; and
  - taking the needs of the insurance sector into account as an integral component of climate risk management.

2.1 Advancing climate prediction science

20. Climate services depend critically on predictions of regional climate on timescales from seasonal-to-interannual, to multi-decadal, century and beyond. Climate prediction science must be an important part of any organized climate service. The speakers on ‘advancing climate prediction science’ focused on current capabilities and plans for scientific research and climate predictions on these different timescales, and also emphasized the key role that the World Climate Research Programme (WCRP) plays in organizing and coordinating the science behind these predictions.

21. The experts directed particular attention to the current state of seasonal to interannual forecasting and the opportunities for improvement and to the results from experimental decadal predictions. They uniformly agreed on the need to better understand the modes of natural climate variability.

22. The WCRP is organizing a new set of climate change simulations using mitigation scenarios. These experiments will rely on new climate modeling capabilities: initialized decadal predictions focusing on adaptation out to about 2035, and longer term experiments

out to 2100 and beyond where the magnitude of climate change will be related directly to which mitigation scenario the world follows.

23. The experts identified a number of recommendations for advancing climate prediction:

- *Seamless prediction.* Adopt a more seamless approach to climate prediction by using a modeling framework which includes assimilation of high quality climate observations which are required for the initial conditions. Where appropriate, these climate predictions should include coupling directly to applications (e.g. hydrological models) (2.1.a);
- *Reduction of model biases.* Reduce model biases through better representation of physical processes and higher spatial resolution (2.1.b);
- *Mechanisms leading to variability.* Improve the understanding of the mechanisms that lead to the variability on the different timescales (2.1.c);
- *Computing capacity*. Significantly increase the computing capacity available to the worlds weather and climate centres 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 (2.1.d);
- *Closer collaboration*. Ensure closer collaboration between scientific research, operations and users to ensure that climate services receive the benefits of research as soon as possible, and that research covers the needs of users (2.1.e); and
- *Limitations and uncertainties*. Communicate clearly to users of climate services the limitations and uncertainties involved with climate change model predictions/projections (2.1.f).

2.2 Economic and social benefits of climate information

24. Climate information delivers economic value by providing users whose activities are sensitive to climate conditions with a basis for making decisions. The plenary presentations in the Expert Segment provided examples of the effective use of climate information to deliver economic value in different sectors. For example, seasonal climate information can prove valuable for agricultural planning and drought mitigation strategies, and estimates of the economic value of improved ENSO predictions for the agricultural sector are not insubstantial.

25. With respect to longer time scales, the Conference was advised to consider climate change as a “threat multiplier”, amplifying other potential stresses on economic and social systems. Climate variability and change can exacerbate existing vulnerabilities to the point of tipping systems into critical states. In this context, it is important to recognize costs associated not only with responding to climate change, but also with decisions not to act.

26. There are, however, many impediments to the effective use of climate information for socio-economic benefit. The Conference learned these impediments include a lack of

understanding about climate impacts, what climate information is most relevant, and how best to engage with users to define the right questions and involve them in the solutions. Several speakers stressed the challenges associated with acquiring, and sustaining, resources.

27. The speakers and discussants canvassed the various challenges faced in removing the impediments to delivering greater socio-economic benefits from the use of climate services. Among the approaches advocated are the systematic application of "adaptation science" that is solution-focused and the encouragement of multidisciplinary research. In addition, there was strong support for the following recommendations:

- *Madrid Action Plan*. High priority should be given to completing the actions identified in the March 2007 Madrid Action Plan on the Social and Economic Benefits of Weather, Climate and Water Services, incorporating the principles of climate risk management developed at the July 2006 Espoo Conference on 'Living with Climate Variability and Change' (2.2.a);

- *Economic valuation of climate services*. The international agencies participating at WCC-3 should collaborate on assessing the value of various types of climate services and on ways and means of enhancing that value in the various climate-sensitive sectors of society (2.2.b); and

- *Connecting with users.* Boundary organisations with sufficient capacity to integrate information from producers and mainstream services to users should be provided with sustained, cross-institutional support. Regional support institutions like development banks and insurers should be mobilised (2.2.c).

2.3 Climate extremes, warning systems and disaster reduction

28. Nearly 80% of disasters caused by natural hazards are linked to climate extremes. The IPCC Fourth Assessment Report has provided scientific evidence on increasing risks associated with these hazards as a result of human-induced climate change. Traditionally, many countries have been reactive to disasters. However, the adoption of the *Hyogo Framework for Action 2005-2015: Building the resilience of nations and communities to disasters*, by 168 countries, has led to a new paradigm in disaster risk management focused on prevention and preparedness. The UNFCCC *Bali Action Plan* has stressed the need for disaster risk management as a critical component of climate risk management in all countries. Since the adoption of the *Hyogo Framework for Action*, initiatives are underway to bring together the scientific and technical agencies, disaster risk management and other relevant ministries and sectors (e.g., agriculture, health, environment, development) to coordinate the development of national disaster risk management strategies.

29. The Conference discussed that effective disaster risk management must be founded on quantification and understanding of risks associated with natural hazards. In many countries, institutional capacities and cooperation for risk identification need to be developed. Climate information is critical for the analysis of hazard patterns and trends. However, this must be augmented with socio-economic data and analysis for vulnerability

assessment (e.g., casualties, construction damages, crop yield reduction, water shortages). With this risk knowledge, countries can manage risks using: (1) early warning systems and preparedness; (2) medium and long-term sectoral planning (e.g., land zoning, infrastructure development, agricultural management); and (3) weather-indexed insurance and financing mechanisms. Early warning systems are effective tools for reducing loss of life. However, climate forecasting tools could be used to develop warnings with longer lead times for improved sectoral planning. Analysis of hazard patterns from historical data is necessary; but changing patterns of climate hazards are posing challenges with longer-term investments in areas such as infrastructure planning and retrofitting based on building codes and specifications, derived only from historical records (e.g., a 100-year flood may become a 30-year flood).

30. In light of various experiences, the experts recommended:

- *Identification of requirements*. There is need for a systematic demand-driven approach to identify requirements of various user-communities within different sectors of disaster risk management. This would require partnership and two-way cooperation among the climate information providers and target users. The coordinated framework of disaster risk management under the *Hyogo Framework for Action* is crucial for bridging the user interface (2.3.a);

- *Scaling up of pilot studies*. Development and utilization of relevant climate information for managing risks in some sectors have been piloted. These efforts need to be identified, evaluated and scaled up through a coordinated and operational institutional framework (2.3.b);

- *Increased investments in data*. Historical and real-time climate data are critical, but there is a pressing need for increased investments in National Meteorological and Hydrological Services (NMHSs) for strengthening observing networks, and data maintenance systems (2.3.c);

- *Climate forecasting technologies*. Climate forecasting technologies (e.g., seasonal, interannual, decadal) provide an unprecedented opportunity for improved sectoral planning for disaster risk reduction at different timescales (tactical to strategic planning). However, there is need for coordinated research to improve these tools for providing relevant information for disaster risk management (e.g., predictions of trends and patterns of droughts, tropical cyclones, floods and heat waves at longer time scales). There is a need to operationalise these tools to ensure sustainable delivery and utilization of information in sectoral planning (2.3.d); and

- *Decision maker awareness*. Utilization of climate information must be augmented with systematic public and decision maker awareness programmes (2.3.e).

2.4 Mainstreaming climate information

31. Climate information is already widely used in many countries and in many socio-economic sectors, and at many levels of society. Nevertheless, the urgency of adaptation to climate change, to which there is no alternative, elevates a need for climate information to a new

height. Otherwise, scarce resources planned for national development activities will still be massively redirected to disaster response and recovery actions. Of paramount importance for policy and decision makers are the following questions:

- What is the 'adaptation field', i.e. the likely impacts that can probably not be avoided by mitigation?
- How much of this adaptation field we would afford to adapt to and how much would different levels of adaptation cost?
- How should we handle 'residual impacts' not addressed by adaptation?

32. A broad framing of the adaptation processes from awareness to mainstreaming in current activities and reorganisation due to transformations in risk suggests different entry points for information aimed at decision makers and vulnerable populations, relevant to conditions of vulnerability and available financial mechanisms. This includes practical involvement of communities and governments in the implementation of climate risk reduction strategies and enhancing the resilience to climate risks. Each country will have to develop its own adaptation policies, actions plans, programmes and measures. These must be integrated into the ongoing development processes and might also involve coordination needs between neighbouring countries. The efficient use of climate information becomes an essential requirement in mainstreaming climate change into policy and development.

33. The experts in this session highlighted:

- *Mainstream climate information.* The urgent need to assist developing countries in mainstreaming local and regional climate change and variability information into planning/policy development (2.4.a);
- *Availability of adequate information*. Existing challenges related to availability of adequate information for adaptation to climate change in most vulnerable regions such as Africa, low-lying Asian mega-deltas, and small islands (2.4.b);
- *Learning from experience*. The important role of learning from the successes and positive and negative experiences of addressing challenges in the use of the available climate information (2.4.c);
- *Integrating knowledge*. The value of creating and integrating knowledge bases on local and regional climate hazards, impacts, and, especially, economics of adaptation (2.4.d); and
- *Improved understanding and data*. The central role of accurate and detailed prediction of consequences of climate change at time and geographical scales corresponding to society and people's needs, which, in turn, requires improved understanding of the climate change and sustained efforts in climate research and observation (2.4.e).

3 USER NEEDS AND APPLICATIONS

34. The climate services needed by society embrace past, present and future climate information, research, investigation, assessment and advice on climate-related issues. They include an extensive array of general and user-specific data, prediction, warning and advisory services focussed on the individual needs of the many climate-sensitive sectors of the community. All countries, all governments, all socio-economic sectors and almost all individual members of society are in need of climate services in one form or other.

35. Recognising that individual countries' needs for climate services would be clearly expressed by national delegations in their Statements to the High-level Segment of the Conference, the Expert Segment focussed particular attention on the overall needs and capabilities of the following set of climate-sensitive sectors:

- Human health;
- Sustainable energy;
- Water;
- Transport;
- Tourism;
- Biodiversity and natural resource management;
- Sustainable cities;
- Food security; and
- Oceans and coasts

3.1 Climate and human health

36. Good health status is one of the primary aspirations of human social development. As a result, health outcomes and indicators are key components of the Millennium Development Goals (MDGs). Many infectious and chronic diseases, including malnutrition, are directly or indirectly sensitive to the climate and their control is a primary focus of the MDGs. Climate change is recognized as one of the defining challenges of the 21st century and protecting health from its impacts is a priority for the public health community as recognized during the World Health Assembly in 2008.

37. New opportunities exist for better management of climate related health risks in the context of both development goals and climate change. These are made available through advances in climate science, rapidly advancing communication technology (impacting on data and knowledge sharing) and a new global focus on effective management and even elimination of certain infectious diseases. In support of this, there has been a substantial increase in funding and new partnerships involving the public and private sectors and civil society.

38. Through the development of two white papers (on needs and opportunities), substantive discussions and the working session on climate and human health , the experts proposed the following recommendations:

- *Climate services for the health sector.* There should be full engagement of the public health community, through the WHO, in the establishment of a Global Framework for Climate Services in order to enable the inclusion of climate information in public health decision making (3.1.a);
- *Capacity building in use of climate information.* Research and training opportunities, designed to build capacity and provide evidence for policy and practice, should be developed through effective collaboration across relevant disciplines (3.1.b);
- *Cross-sectoral interaction.* Investment is required in a public service platform within WMO Member and partner institutions to encourage cross-sectoral interaction including cooperation on the establishment of observing and monitoring networks, the development of decision-support tools and systems and the development of 'one stop' advisory services for the health sector that will strengthen health surveillance and response systems (3.1.c);
- *Resource sharing*. The sharing of data, information and capacity (at local, regional and global scales) is necessary for improving health monitoring and surveillance systems to achieve "the most elementary public health adaptation" as stated in the IPCC Fourth Assessment Report. This is especially critical for the least developed countries, which have the weakest surveillance systems. It is imperative that resources are provided for collecting, managing and applying data to the creation of evidence-based policy and practice related to the development of climate-informed health early warning and adaptation strategies (3.1.d); and
- *Partnerships and priorities*. Existing programs, initiatives and organizations working in climate and health should jointly prioritize the development of the Global Framework for Climate Services as it relates to health. Institutional mechanisms that link outputs and responsible actors to the recommendations above are required and a clear framework for activities is essential. Recognizing that partnerships are not always easy to establish, new and innovative mechanisms should be envisioned to make this development possible at all levels (3.1.e).

3.2 Climate and sustainable energy

39. Climate information is essential for ensuring the most efficient production and consumption of essentially all traditional forms of energy including coal and gas-fired generation, distribution and utilisation of electricity; and especially for design and operation of infrastructure and facilities for renewable energy sources: hydro, wind, solar, tidal and bio-energy. Seasonal to multi-decadal climate variations give rise to changes in energy demand but also in energy availability and supply. Primary energy is traded globally and often delivered within complex energy grids. In particular, the generation of renewable energies is often itself climate dependant. Also energy prices may be affected by climate variations. The discussions on sustainable energy highlighted what climate information is available, to what extent it is already being used, and the current and future needs of climate information from the energy sector.

40. The energy and climate experts stressed the following needs:

- *Historical and quality observations*. Historical and high quality weather and climate observations are needed for the energy sector especially in the developing countries (3.2.a);
- *Seamless predictions*. Seamless predictions from global climate models (monthly to seasonal to decadal time-scales) with much improved resolution are needed (3.2.b);
- *Updated re-analysis.* There is need for quality re-analysis of meteorological data that is regularly updated (3.2.c);
- *Reliable access.* Reliable access to climate information using readily available servers and grid technology is important (3.2.d);
- *Joint partnerships.* Establishment of joint partnerships between the energy sector and climate service providers is desirable (3.2.e);
- *Mainstreaming climate information.* It is vital to mainstream climate information into long-term development plans in particular for the energy sector (3.2.f);
- *Vulnerability assessments.* Vulnerability assessments of energy infrastructures including generation, transmission, transformation, processing, distribution, and extraction to severe weather and extreme climate events are needed (3.2.g);
- *Strengthening partnerships.* Partnerships should be strengthened between the energy sector and the climate service community (3.2.h);
- *Active participation.* Active participation by civil society is needed to improve decision making in issues linking climate services and energy (3.2.i); and
- *Capacity building and technical cooperation.* These are necessary between developed and developing countries in the transfer of technology in related energy-climate related issues (3.2.j).

3.3 Climate and water

41. Increasing use of freshwater has greatly stressed the world water availability. Changes in freshwater availability and demand due to demographic, economic, and climatic changes will exacerbate existing problems in the sectors such as health, agriculture, sustainable energy, and biodiversity. Sea level rise, temperature increase, and the changes in hydrological cycle, including the cryosphere, as well as a risk of increased frequency of the extreme events, such as flash floods, storm surges, and land slides, will put additional stress on these sectors.

42. Managing climate risks for humans and ecological systems has attained an unprecedented urgency. Addressing these risks through provision of targeted information on seasonal to decadal and longer term climate variability has to become a key element for a suite of climate services. Technological and societal innovations in how evolving climate information could be used to inform freshwater management are urgently needed and should be stimulated. Participants in the session agreed on the following main recommendations:

- *Hydrological networks*. The continuing degradation of hydro-meteorological networks and databases has resulted in the crisis in our ability to generate information needed for managing climate risk in the water sector. Hydrological networks are the essential foundations for future adaptation to climate uncertainties. A focused priority effort is needed to reverse this decline and to develop re-analysis products so that a diverse suite of climate and hydrological information could be made available across much of the world (3.3.a);

- *Partnership and communication.* Full partnership and sustained communication between the climate community and the end users from the water sector such as flood managers, utilities operators, irrigation managers, and agriculture and health specialists, is a condition-sine-qua-non for the development of the Global Framework for Climate Services. Under this partnership key attention should be placed on:
  - Data quality, availability and data sharing;
  - Climatic information with higher spatial and temporal resolutions, such as the catchment scale and monthly or weekly time scales;
  - Substantial improvements of forecasting skills for seasonal, interannual to decadal variability for better reservoir operation and flood and drought emergency preparedness;
  - Reduction and quantification of uncertainties and biases in future projections; and
  - Quantification of climate impacts on both water quantity and water quality, including low flows, ground water, high surface water temperatures, salinity and pollution, sediment transport, and effects on aquatic ecosystems (3.3b);
- *Integrated models.* There is need for development, benchmarking and application of integrated hydrological and water resource models, including natural and anthropogenic water cycles, and coupled with crop models and reservoir operation models to provide more realistic impact assessment and support decision making in designing adaptation measures (3.3.c); and
- *User interface programme.* Existing programs, initiatives, and organizations working in water resources management should join hands to facilitate the development of the Global Framework for Climate Services, particularly its User Interface Programme component (3.3.d).

3.4 Climate and transportation

43. Transportation is an important component of the tourism industry and represents a major economic sector. It contributes significantly to human-kind's greenhouse gas emissions and is significantly affected by global warming. The implementation of a range of new climate-related services will be essential if implementers and managers of transportation systems are to make the best decisions. Furthermore, decisions made at one particular time, on the basis of the best available existing information, will need to be constantly re-evaluated. In

essence what will be required will be an adaptive management approach, underpinned by a Global Framework for Climate Services, that needs to be:

- accessible to all;
- driven by ongoing research and build on current collaborations between the meteorology and transport communities in dealing with chronic risks;
- constantly improving climate forecasts for specific regions and localities and expressed in a way that makes them easily used by all manner of decision makers;
- improving the range and geographical extent of the collection of Earth-system data, and the exchange of these data between agencies undertaking climate change-related research and infrastructure development; and
- creating information that facilitates accessibility/mobility options that are climate-robust and also consider mitigation, both generally and in specific reference to tourism-related travel.

44. The experts in climate and transportation recommended the following:

- *Climate resilience*. Planning and design infrastructure is needed to account for climate uncertainties to become more resilient to climate changes (3.4.a);
- *Multidisciplinary information*. It is necessary to inform the community broadly as well as professionals from a wide variety of disciplines such as meteorology, hydrology, engineering, statistics, ecology, biology, economics and financial management (3.4.b);
- *Whole-of-life approach*. It is important to take a whole-of-life approach to the management of infrastructure (3.4.c);
- *Risk assessments*. Risk assessments and the cost-benefit analyses of adaptive strategies should be continually updated (3.4.d); and
- *Extreme events*. It is necessary to strengthen emergency response planning and management for extreme events, which current science indicates are likely to increase in frequency under the range of generally accepted climate change scenarios (3.4.e).

3.5 Climate and tourism

45. Climate has a complex influence on the sustainability of the global tourism economy. It is an important driver of major international tourism flows and is the principal resource for some destinations (particularly Small Islands Developing States (SIDS)). Climate variability impacts many facets of tourism operations and environmental conditions that can either attract or deter tourists from destinations. Climate also has broad significance for tourist decision making, expenditures, and travel satisfaction. Consequently, it is expected that the integrated effects of climate change will have profound impacts on tourism businesses and destinations in the decades ahead. The climate and tourism experts concluded that scientific understanding of the climate and tourism interface has improved in the last decade, especially research on climate change impacts as well as adaptation and

mitigation measures within the sector. Key knowledge gaps, however, remain that limit climate information from being used as effectively as it could be by travellers worldwide and by the tourism industry in the pursuit of sustainable tourism and adaptation to climate change.

46. Upon assessing the present use and future needs of climate information by both tourists and the tourism sector in developed and developing countries, the tourism and climate experts agreed on the following main recommendations:

- *Interdisciplinary and sector-wide collaboration on research and practice.* Increased investment and strengthened collaboration between the climate and tourism and transport communities is required to address key knowledge gaps in the climate sensitivity of major tourism segments, transport systems and destinations, the salience of climate in travel decision-making contexts, and the economic and non-market societal value of climate information for the sector. Co-operation is also vital for the development of decision-support tools and standards for specialized climate products, to ensure consistent communication to international travellers and facilitate objective destination comparisons in a global tourism marketplace (3.5.a);

- *Capacity-building in application of climate information.* Major initiatives are needed to significantly advance the application of climate information in the tourism sector, including a series of professional capacity-building workshops in major tourism regions around the world (in order to adequately represent specific end-user information needs and the capabilities of regional providers) and the development of climate information training modules for use by tourism and hospitality schools around the world (3.5.b); and

- *Improved observation networks.* Investment is required to enhance observation networks and climate information provision in areas where tourism is vital to local economies, specifically rural areas and many developing countries (particularly SIDS), in order to improve climate risk management and climate change adaptation in the tourism sector (3.5.c).

3.6 Climate and biodiversity and natural resource management

47. Biodiversity, ecosystems, and the services they provide (e.g. climate regulation, food security, freshwater supply, disaster risk reduction), are the fundamental units of life support on Earth.

48. Biodiversity and ecosystems play a vital role in both ecosystem-based mitigation (carbon sequestration and storage) and ecosystem-based adaptation (i.e. societal adaptation to climate change impacts, e.g. through buffering climate hazards such as flooding).

49. Climate change is significantly impacting biodiversity and ecosystems, and climate information is required to assess vulnerability and identify adaptation options; recognizing that managing for current threats will increase ecosystem resilience and adaptive capacity.

50. To meet the expectations of the Global Framework for Climate Services (GFCS), the experts on biodiversity and natural resource management recommended:

- *Interdisciplinary dialogue between scientists*. It is important to organize a continuous dialogue between climate scientists and biodiversity/ecosystem scientists to translate climate data into impacts on biodiversity and ecosystem services (i.e. climate services) for the benefit of users (3.6.a);
- *Model improvement.* Improving the representation of the functional role of biodiversity and ecosystem processes in Earth system models (research & modeling component of the GFCS) is needed (3.6.b);
- *Biodiversity monitoring.* It is necessary to enhance and integrate biodiversity observing and monitoring activities and systems (such as Long Term Ecological Research (LTER) networks) with the GFCS, through support to GEO BON (Biodiversity Observing Network) and other relevant initiatives (3.6.c);
- *Indigenous knowledge*. It is important to integrate data and knowledge from indigenous and local communities, including citizen based observations, about ecosystem responses and approaches to adaptation, in the design and implementation of climate information systems (3.6.d); and
- *Sharing of information*. It is important to facilitate the sharing of information and good practices on ecosystem-based adaptation to climate change through collaborative international systems such as the UNFCCC *Nairobi Work Programme on Impacts, Vulnerability and Adaptation to Climate Change*, and on the proposed Global Adaptation Network (3.6.e).

3.7 Climate and more sustainable cities

51. Cities impact, and are impacted by, climate change in many ways and at many scales. Climate knowledge should be used more effectively to ensure more sustainable cities.

52. The scientific understanding of urban climates has advanced substantially over the past two decades including conceptualisation, field observations, analysis of processes and model building. However the field is young and much more research is needed to improve understanding to that acquired for other environments. At the same time, there is growing demand for urban climate information in the design and management of more sustainable cities. Implications of global climate change for cities have not been adequately assessed to date. In general, few National Meteorological Services (NMSs) have appropriate expertise in urban meteorology.

53. The experts in the session encourage WMO, through its NMSs, to introduce urban–related climate services through establishing relations to the political and socio-economic stakeholders and urban developers. These service should include:

- *Improving urban climate observation networks*. Urban climate stations and networks should be greatly improved, including vertical information, in all countries. This should be done in line with WMO urban guidelines. International archives of urban climate, morphological and land cover data should be established (3.7.a);

- *Climate research for hot cities*. Highest priority should be given to strengthening observational networks and establishing urban climate research programs for tropical cities where population growth is greatest and vulnerability to excess heat and inundation is highest (3.7.b);
- *Urban climate modelling*. Improved numerical models should be developed to forecast weather, air quality and climate in cities. A focus should be to incorporate urban land surface schemes into global climate models, to down-scale regional climate predictions and projections to the urban scale and to assess their impact on urban health, safety and management (3.7.c); and
- *Education, training and knowledge transfer in urban climatology*. Much greater effort should be directed to increase understanding amongst climatologists, NMSs and indeed urban stakeholders (3.7.d).

3.8 Climate, land degradation, agriculture and food security

54. Food security is dependent upon many socio-economic and environmental factors, including agricultural systems which are resilient to climate variation and extremes in climate. The impact of climate on agricultural production is increased in fragile environments. The indirect impacts of climate on insects, diseases, and weeds increase when there is climate stress imposed on the plant or animal. Water and food are two sides of the same coin; hence, it is important to place emphasis on water management to enhance agricultural productivity. In order to reduce the risk of crop failure and increase the resilience of agronomic and horticultural systems for feed, food, fiber, and fuel production there is an urgent need to develop an improved understanding of the complex interactions between climate and agricultural systems and implement production systems that can adapt to climate variation and climate extremes, especially in developing countries.

55. Agricultural and land management experts reviewed the needs to enhance the contribution of climate information to land management, agriculture and food security, and agreed on the following recommendations:

- *Risk evaluation and information delivery*. An intensive effort is needed on the use of climate forecasts to reduce the risks to crop and animal production, especially in areas where the risks are greatest. Such efforts should include the development of effective dissemination tools for timely provision of this information to decision-makers. Climate information should be adapted and actionable to the meet the needs of users (3.8.a);

- *Cooperation and partnerships.* For a holistic management of climatic risks in agriculture, new and innovative models of cooperation and partnerships are needed between several groups including WMO, FAO, NMHSs, the Consultative Group for International Agricultural Research (CGIAR), National Agricultural Research Systems and Extension Services, National Entities dealing with agriculture, food security and policy issues, the United Nations Convention to Combat Desertification (UNCCD) and Soil Conservation Services. Linkages between producers of climate information and applications and various end users should be enhanced through appropriate mechanisms such as awareness raising, capacity building for intermediaries and end users and strengthening institutional partnerships, especially in developing countries (3.8.b);

- *Adaptation strategies for resilient agricultural systems*. Adaptation strategies to cope with climate variation and extreme events need to be developed and the information transferred to producers in a timely manner so they can adopt these practices to reduce their risk (3.8.c); and
- *Climate change mitigation*. It is important to recognize that agriculture is also part of the solution to mitigate climate change and hence adequate investments should be made in strategies that reduce greenhouse gas emissions while maintaining agricultural productivity (3.8.d).

3.9 Climate in oceans and coasts

56. The ocean covers two thirds of the planet, and hosts the largest biosphere on earth. It plays a dominant role in the global climate system through the transport and storage of heat, water, nutrients and other climate variables such as carbon. The ocean mitigates surface warming through the absorption of heat and greenhouse gases. It provides important living and non-living resources and other ecosystem services for humans. It contributes to the global economy, trade and food and to national security. Its impacts on society are particularly strong within 100 km of the coastline where 40% of the world population lives and ecosystem goods and services are most concentrated.

57. Climate change on time scales from decades to centuries has profound consequences for the marine, coastal and littoral environments with potentially devastating effects through: (1) rising sea level; (2) increasing heat content; (3) increasing sea surface temperature; (4) changes in strength and spatial distribution of the hydrological cycle; and (5) ocean acidification; (6) ocean deoxygenation; and (7) decreasing sea ice volume. Together these effects lead to (8) changes in the distribution and abundance of marine life, altered food webs and changed biodiversity in marine ecosystems. Strategies and governance frameworks for risk management and adaptation responding to these changes need to be developed. This includes coastal defence strategies to cope with sea level rise and storm surge rises; and responsive fisheries management, which rebuilds ecosystem resilience. The implementation of such strategies is critically dependent on climate, ocean and coastal observing, information and prediction systems.

58. The global and coastal ocean experts at the Conference agreed that ocean information is integral and essential to the Global Framework for Climate Services and, in view of that, expressed strong support for the following key recommendations:

    - *Comprehensive ocean observing system.* The Global Ocean Observing System (GOOS) should be a major part of the Global Framework for Climate Services and should be fully implemented in the open ocean and coasts, and further enhanced to include biogeochemical and ecosystem parameters, in line with international agreements and conventions (e.g., UNFCCC, GCOS, CBD); including free and open data access. Such an observing system should be informed by the recommendations from the OCEANOBS'09 Conference (3.9.a);

- *Coastal and global ocean research.* National and international research should be strengthened to improve our understanding of ocean processes on global, regional and local scales and should be an integral part of the Global Framework for Climate Services. There is a need for a better understanding of ocean-atmosphere interactions and the role of the ocean in predicting climate change on time scales from seasons to millennia. Further, quantification of the impact and interaction between climate and ecosystems; and particularly the connection between changes in the open ocean and their impacts on coastal systems need to be understood (3.9.b);
- *Assessments of ocean climate and marine ecosystems in response to user needs*. Sustained and timely operational assessments of the physical, biochemical and ecosystem states of the oceans should be implemented (3.9.c);
- *Comprehensive ocean climate prediction*. Operational systems should be developed and implemented for predicting changes in the ocean climate system on time scales of days to decades, including the development of 'operational marine ecology' (3.9.d); and
- *Capacity building*. Developing nations and economies in transition need to be supported to develop national capabilities that contribute to and benefit from ocean observations, research, information, assessment and prediction. A particular need is to locally develop the capability to take ocean observations, interpret their information and thus provide knowledge for local decision making in support of creating sustainable ecosystem goods and services for their own social and economic benefit (3.9.e).

4 THE SCIENTIFIC BASIS FOR CLIMATE SERVICES

59. For most of the past century, the main focus of climate services, whether provided by National Meteorological Services (NMSs), research institutions or the meteorological private sector has been on the processing and provision of historical climate records for a wide range of planning and design purposes. Though genuine scientifically based attempts at climate prediction date back to the first half of the 20th Century, it is only since the establishment of the Global Atmospheric Research Programme (GARP) in 1967 and the World Climate Research Programme (WCRP) in 1980 that significant progress has been made on the scientific basis for climate prediction and the provision of integrated climate services in some countries.

60. The Conference reviewed the under-pinning role of observations for essentially all types of climate services and the contribution of the WMO-IOC-UNEP-ICSU Global Climate Observing System (GCOS) following its establishment in response to the exhortations of the 1990 Second World Climate Conference. It also reviewed the substantial progress under the auspices of the WMO-IOC-ICSU World Climate Research Programme (WCRP) over the past 30 years in providing a scientific basis for the climate prediction and

information services already in place around the world under the general umbrella of the World Climate Applications and Services Programme (WCASP) and its Climate Information and Prediction Services (CLIPS) Project.

4.1 The essential role of climate observations

61. Long-term observation of the atmosphere, land and ocean is vital for all countries, and must be funded for the public good as economies and societies become increasingly affected by climate variability and change. 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. They have demonstrated that warming of the global climate system is unequivocal and have provided information on climate patterns and trends at regional and national scale.

62. The networks must be strengthened and sustained in order to monitor climate variability and change, and to evaluate the effectiveness of the policies implemented to mitigate change. Observations are needed to support improvement of climate models, to initialise and enable effective use of model predictions to decades ahead and to guide the use of models for longer-term scenario-based projections. Observations are needed to assess social and economic vulnerabilities and develop the many actions that must be taken to adapt to climate variability and unavoidable change. They must be recognised as essential public goods where the value of global availability of data exceeds any economic or strategic value of withholding national data.

63. Full implementation of GCOS is essential for supporting both the adaptation and the mitigation objectives of the UNFCCC, and for ensuring that all countries will be able to manage their response to climate variations and change through the 21st Century.

64. The observational experts at the Conference accordingly agreed on the following recommendations:

- *Long-term sustenance of observing systems*. The established in-situ and space-based components of GCOS should be sustained and operated with continued attention to data quality and application of the GCOS Climate Monitoring Principles (4.1.a);
- *Improvement of operation and planning*. The operation and planning of observing systems should be improved, so as better to identify deficiencies, achieve resilience, and assure reliable and timely delivery of good-quality data, traceable to international standards (4.1.b);
- *Enhancement of observing systems*. Enhancements to observing systems should be implemented wherever feasible, filling gaps in spatial coverage and in the range of variables measured, improving measurement accuracy and frequency where needed, increasing use of operational platforms for satellite sensors, ensuring adequate monitoring of urban and coastal conditions, and establishing key high-quality reference networks (4.1.c);
- *Improvement of data services.* Improvements should be made to the rescue, exchange, archiving and cataloguing of data, and to the recalibration, reprocessing

and reanalysis of long-term records, working towards full and unrestricted access to data and products (4.1.d);

- *Observations for adaptation planning*. All countries should give high priority to the observational needs for adaptation planning, identifying their needs in National Adaptation Programs of Action where applicable (4.1.e); and
- *Regional implementation of GCOS*. Developed countries should commit to assist developing countries to maintain and strengthen their observing networks through support for updating, refining and, most importantly, implementing the GCOS Regional Action Plans and other regional observational and service initiatives such as ClimDev Africa, GOOS Africa, and Pacific Islands GCOS (4.1.f).

4.2 Seasonal to inter-annual climate variability, predictability and prediction

65. Seasonal prediction is based on changes in the probability of weather events due to changes in slowly varying forcings such as sea surface temperature anomalies, e.g., during El Nino. Since seasonal weather is influenced by many factors, including internal variability of the atmosphere and not all sources of potential predictability are properly understood, forecast systems, based on comprehensive models, are still a long way from producing consistently useful results. Opportunities for progress exist through greater convergence of weather and climate forecast models.

66. The experts with a wide range of experiences made the following recommendations:

- *Model quality.* Seasonal prediction information depends critically on the quality of models, and current seasonal prediction models have serious deficiencies. Although these cannot be transformed overnight, long-term commitment of substantial resources for model and assimilation system development, and the supporting research, is required (4.2.a);

- *Climate prediction systems.* Developing and testing models and forecast systems across a range of time scales is essential. Indeed, it is critical that our climate prediction systems simulate the statistics of regional weather with sufficient fidelity. Provision of computer resources to allow development of extremely high-resolution global modeling should be pursued. In particular a priority is to implement the recommendations from the *World Modeling Summit for Climate Prediction* (2008). There is a compelling need for dedicated computational facilities that are 1000 to 10000 times more powerful than available today (4.2.b);

- *Road-map to quality improvement.* Seasonal forecast quality can also be improved by taking into account processes in the cryosphere, land surface, and stratosphere. In essence, the "road-map" for improving seasonal prediction as developed at the *first WCRP Seasonal Prediction Workshop* (2007) in Barcelona should be implemented (4.2.c);

- *Improved observations and assimilation*. The maintenance and improvement of observing systems, data assimilation systems and reanalysis must also all be supported for improved seasonal prediction (4.2.d);

- *Local and regional forecasts.* Much more effort must be invested in demonstrating use and increasing utility of these forecasts at the local and regional level (4.2.e);
- *Interpretation and tailoring of climate products.* Increased use and benefit of seasonal forecasts will occur only with appropriate interpretation and tailoring of climate predictions, and developing more explicit and real-time links with application models (e.g. crop yield prediction). This requires real-time access to model forecast data and relevant observations, both of which should be freely available as a public good (4.2.f); and
- *Culture change.* Building a "chain of communication" that can benefit from advances in climate predictions to society is required. The chain must target decision makers responsible for national infrastructures and welfare, and should include climate intermediaries and NMHSs, sectoral experts, government, business sectors, media, and others. This will enable NMHSs and local climate services to respond to local users by providing locally relevant information (4.2.g).

4.3 Decadal climate variability, predictability and prediction

67. The indisputable evidence of global warming and the knowledge that surface temperatures will continue to rise over the next several decades under any plausible emission scenario is now a factor in the planning of many organizations and governments. It does not imply, however, that future changes will be uniform around the globe. Regional and seasonal variations in climate associated with natural variability will have large impacts, especially over periods of a few decades or less. An important challenge is, thus, to predict regional scale climate variability and change. The decadal time scale is also widely recognised as a key planning horizon for governments, businesses, and many socio-economic sectors for which climate sensitivity and vulnerability is high.

68. Decadal prediction efforts are underway, but they are in their infancy and many challenges exist. The experts stressed these major recommendations to address the challenges:

    - *Enhancement of observing systems.* Dedicated efforts to maintain and enhance the global climate observing system, which is essential for initializing and validating decadal prediction systems. Of particular importance is the Global Ocean Observing System since the feasibility of decadal predictions largely stems from the role the ocean plays in the predictability of slowly evolving modes of variability (4.3.a);
    - *Predictability and prediction on decadal time scales.* Increased investment in the research, computing and modeling systems to be used for decadal predictions in order to: (a) reduce model biases which limit prediction skill and present significant difficulties in the development and testing of the data assimilation schemes; and (b) greatly improve the understanding and representation of the important mechanisms of decadal climate variability and change, and establish the inherent predictability (4.3.b);
    - *User/expert communication.* Mechanisms to increase dialogue between the climate information providers and those in the sector communities in order to make appropriate

and best use of experimental predictions, to better define requirements, and to drive improvements in predictive systems (4.3.c); and

- *Cost-effective investment.* The cost of implementing these recommendations will be substantial. However, it is likely to be very small in the context of the overall costs of adaptation. Furthermore, reduced uncertainty in predictions can be expected to reduce the cost of adaptation (4.3.d).

4.4 Regional climate information for risk management

69. Because of regionally unique climate characteristic and socio-economic structures, focussed and relevant climate information and services are needed for many purposes especially disaster risk reduction, protection against disease, environmental protection, enhanced agricultural production, water resource management and infrastructure planning. In order to meet end-users needs for climate information and services, it is necessary to continually improve technological capabilities through further research and development on key climate processes and climate prediction models and methods. This requires strong regional co-operation in capacity building and provider-user dialogue.

70. The Regional Climate Outlook Forums (RCOFs) conducted in many regions over the past decade have contributed to the improvement of regional climate services through the production of consensus forecasts, exchange of technical information among National Meteorological Services (NMSs) and regionally based interaction between climate service provider and user communities. The emerging WMO framework for climate service provision includes the WMO Global Producing Centres (GPCs) and a network of regional centres including Regional Climate Centres (RCCs) supporting the role of the NMSs.

71. In order to enhance the satisfaction of demands for regional climate information and services for risk management, regional climate services experts at the Conference expressed strong support for:

- *Provider-user partnerships*. Partnerships should be fostered between NMSs and user communities to promote effective user-oriented climate information and services and decision-support system (4.4.a);

- *Integrated weather-climate information*. NMSs should be enabled to promote the production and provision of seamless weather and climate information on daily to centennial time scales (4.4.b);

- *Regional capacity building*. Designation, establishment and development of mechanisms such as RCCs, RCOFs and participation in user planning forums such as Malaria Outlook Forums (MALOFs) should be supported and strengthened as important means of providing user-tailored climate services including climate change projections for the development of adaptation strategies. Regional cooperation with wide range of sectors is essential in improving the capacity to provide and use climate information (4.4.c); and

- *Observation, monitoring and research*. Continued efforts on climate observation, monitoring and research are needed to continuously improve the basis for provision of regional and national climate information and services. Research efforts should be informed through dialogue with climate service providers and users (4.4.d).

5. ADAPTATION TO CLIMATE VARIABILITY AND CHANGE

72. The Conference recognised that the principal international forum for co-ordination of national action on both the adaptation and mitigation responses to climate change is provided by the Conference of the Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC) and that the Intergovernmental Panel on Climate Change (IPCC) provides the critical role of analysing the available climate data and information and producing policy-relevant assessments for the Parties to the UNFCCC. It also noted that under the auspices of its Chief Executives' Board (CEB), the United Nations System is committed to 'Delivering as One on Climate Change'.

73. The Conference further noted the urgency of establishing a Global Framework for Climate Services as an effective means to address user needs for information on shorter term climate variability and change (i.e., on seasonal to decadal scales) that affect societies at the national level and the development of common policies and actions internationally. The results of the three essential issues, discussed below, address factors to consider in providing effective national and international responses to climate variability and change.

5.1 Climate risk management

74. The most dominant message coming from the Conference Round-table on Climate Risk Management was that the proposed Global Framework for Climate Services must engage user communities in developing services tailored to meet their needs for climate risk management. If this is not done, a real danger exists that the services will not be used.

75. The Round-table also noted that there is a lack of critical data available for use in development of climate services. This includes data that are not collected as well as data that are collected but not exchanged because of inadequate data policies. Ownership of data at local scales was seen as being particularly important and this included, as a key priority, making data widely available to engineers and scientists in the developing world.

76. A number of speakers stressed that important science challenges must be overcome, including improved broad scale climate predictions and downscaling to regional and local spatial scales. Scientists and engineers in the developing world need access to, and training in the use of models that assist in local climate prediction and the development of services to meet local needs. It was seen as particularly important that users of services provided through the proposed Global Framework for Climate Services understand the capabilities and limitations of this information and the concepts of probabilities and uncertainties associated with this climate information.

77. Climate was seen as only one component of environmental risk management, that is, as a compounding factor in an already stressed environment. Therefore climate scientists need

to work with a broad community of engineers, social scientists, biologists and the like in developing information that fully meets the needs of decision makers.

78. Finally, the participants in the Round-table noted that many climate services are already being provided to a broad range of users, and that the proposed Global Framework for Climate Services should build on, not duplicate, these activities.

5.2 Climate adaptation and the Copenhagen process

79. The Round-table on adaptation and the Copenhagen process discussed how the proposed Global Framework for Climate Services could support the implementation of relevant elements on adaptation of a Copenhagen agreed outcome, in particular as they relate to the needs for climate information and services to inform decision making on adaptation.

80. In order to enhanced climate service support for the work of the UNFCCC, there was strong support for the following recommendations:

- *Priority on adaptation.* Adaptation has become an important priority, requiring enhanced action towards implementation at all levels and across all sectors, based on a solid knowledge and information base (5.2.a);
- *Action on adaptation*. A robust outcome on enhanced action on adaptation in Copenhagen that will catalyse action on adaptation will be of benefit to all countries, but, in particular, will help the most vulnerable to adapt to the impacts of climate change. Assessment, planning and implementation of adaptation actions needs to be based on, and supported by, strengthened research, systematic observations, monitoring and modelling, improvements to the collection, reliability, provision, dissemination and application of climate data, information and knowledge (5.2.b);
- *Information for adaptation.* Improved climate data and information, including on extreme events, are critical to adaptation. This would enable more robust assessments of vulnerabilities and prediction of impacts, adaptation planning and practices, and reduction and management of risks through consideration of climate information in decision making, and thereby enabling a pro-active approach for adaptation (5.2.c);
- *Need for international cooperation.* The UNFCCC has expressed a need for the type of information and services that a Global Framework for Climate Services is expected to deliver, in particular to support adaptation activities, and has made calls upon the international community to address those needs. In developing a Global Framework for Climate Services, existing global, regional and national initiatives and knowledge, including work and expertise of UN agencies as well as regional centres should be used. At the same time, cooperation needs to be fostered among all countries in sharing knowledge, data, methods and tools for adaptation purposes, as well as between the meteorological and broader climate change community (5.2.d);
- *Benefits of a Global Framework for Climate Services*. A Global Framework for Climate Services can and should support many of the needs already identified under the UNFCCC. It has the potential to assist Parties to the Convention in their adaptation

efforts in the upcoming years, including in the implementation of relevant elements under a Copenhagen agreement. At the same time, a Global Framework for Climate Services can address many of the needs and priorities identified by countries under the on-going work on adaptation under the UNFCCC, such as on research and systematic global climate observations, the Nairobi Work Programme, and National Adaptation Programmes of Actions (NAPAs) of Least Developed Countries (LDCs) (5.2.e); and

- *User interface*. A Global Framework for Climate Services that facilitates strong linkages between developers and users of climate information can provide the information base that decision makers at all levels and across sectors need to act upon, and as such can become a powerful tool to support adaptation efforts (5.2.f).

5.3 Communicating climate information for adaptation and risk management

81. The successful communication of climate change and variability information to the world's public remains one of the least resolved issues within climate change. Disseminators and communicators of climate change information come from a wide background within science and the humanities, but generally with a strong presence from the world of television broadcast meteorology. This group of people is made up primarily (but not exclusively) of broadcast meteorologists, skilled weather presenters, and environmental journalists. It is not however a cohesive group – and there are varying levels of comprehension of the core science within this group of people. However, it is the daily broadcast meteorologist/weather presenter who is recognized as the most trusted, credible and talented person capable of delivering the complex message of climate change.

82. The Conference Round-table on Communicating Climate Information agreed that there was not enough dialogue between scientists and communicators, and that the development of climate services were not being advanced quickly enough – especially in light of the recent accelerated rate of climate change and variability noted by many climate scientists.

83. The round table participants, together with the audience, voiced agreement on the following main recommendations:

- *Climate communicators.* The NMSs should involve those who communicate the daily weather messages from within their own organizations when planning for the mass distribution of timely climatological information. The climate change message must be delivered efficiently and effectively – irrespective of any prevailing political persuasion (5.3.a);

- *Access to climate information*. There is a pressing societal need for climate change information. It is necessary to make sure that weather and climate communicators themselves remain at the very forefront of the science. Researchers, scientists, climatologists and academics within the field are urged to share their knowledge freely, willingly, and in a timely manner to further the process of dissemination. Access to information remains the single biggest hurdle for many weather and climate communicators (5.3.b);

- *Best practices and training*. Best practices in regards to "delivering the message" range widely from country to country, because of differences in the varying regional threats, and difference in the delivery mechanisms around the world. However there are a few rules and techniques that can aid effective delivery of the message. These techniques need to be shared amongst all broadcasters. Weather broadcasters should have access to training in these techniques and be empowered to use them. The World Meteorological Organization has a lead role in this task. It should tap into the professional broadcast organizations to facilitate broadcast and presentation training for those who require it (5.3.c);
- *Unbiased communication of climate information.* Communicators of climate change must remain independent. Every socio-economic sector will potentially be affected by our changing weather, and the communicator should not be aligned with any one single group. It is of the utmost importance that broadcasters who discuss climate change and variability are not perceived by the audience to be unduly influenced by political ideology nor economic considerations (5.3.d);
- *Dialogues with communicators.* There should be a much greater degree of dialogue between climate change scientists, and those who communicate to end-users (5.3.e); and
- *Outreach by climate communicators.* Weather broadcasters should take a lead in reaching out to other communities – in particular the education and health communities – in promoting discourse over climate change and variability (5.3.f).

6. SOCIETIAL PERSPECTIVES ON CLIMATE SERVICES

84. Many different communities, in addition to the established climate service providers, have become increasingly engaged, over the years since the 1990 Second World Climate Conference, with the various scientific, operational, social and policy issues involved in providing and using climate services.

85. It was agreed that these diverse perspectives are extremely important to the design of an effective Global Framework for Climate Services and four different stake-holder groups were invited to conduct forums related to (a) Gender and climate; (b) Climate and communities; (c) Business and industry; and (d) Capacity building, education and training. The most important conclusions from these forums were as follows:

6.1 Climate and Gender

86. The experts and participants of the Gender and Climate Forum of the WCC-3 having considered an extensive body of knowledge and expertise in the area of gender and climate variability and change, recognized that women and men around the globe are distinct carriers, providers and users of climate information, and that mounting evidence shows that

drivers and consequences of climate change are not gender neutral. The experts placed priority on:

- *Mainstreaming gender equality*. Gender equality must be mainstreamed into climate science, mechanisms and activities, and in climate institutions, particularly the World Meteorological Organization (WMO) and National Meteorological and Hydrological Services (NMHS), and into the Global Framework for Climate Services (6.1.a).

87. The Forum participants concluded that the proposed Global Framework for Climate Services should reflect a gender perspective in all its components, namely:

- *Observation and monitoring.* Involvement of local communities, particularly local women in environmental change and climate observations, and provision of adequate preparation and training of women and men is necessary for their full participation as providers and users of climate information (6.1.b);
- *Research and modelling*: Gender parity and equal participation of women researchers in climate research should be ensured at national, regional and international level. Enhance the role of social scientists and the human dimension in climate research (6.1.c);
- *Climate service information system.* Information on gender aspects of climate and health, energy, water and agriculture for mitigation and adaptation, particularly through the collection of gender disaggregated data, at both the country and regional levels needs to be enhanced. National statistics divisions should be trained in gender disaggregated data collection, in collaboration with UN agencies, and legal guarantees for the regular and continuous production of a minimum set of gender specific data in situations of climate change, should be promoted (6.1.d); and
- *Climate services application programme*. Recognizing the level of knowledge and taking into account the realities of access to information for women, it is necessary not only to ensure accessibility and benefits from climate information for scientists and decision makers in all regions, but particularly for local communities, especially local women (6.1.e).

88. The Gender and Climate Forum further recommended:

- *User-oriented information.* Climate information and practical prediction services, including those designed by users is important to assist in empowering local women (6.1.f); and
- *Outreach and capacity-building*: It is important to ensure and support outreach and capacity building for a broad user community, including local women and men of different age groups (6.1.g).

6.2 Climate and Communities

89. Local communities are at the frontline of the impacts of climate change, climate variability and extremes. The community level is a key entry point for better climate risk management. However, the most vulnerable communities rarely benefit from our growing

ability to anticipate future conditions and are often missing in national adaptation plans and programs.

90. The Forum on Climate and Communities was informed by practical experiences on community-based risk management from a range of perspectives, including people working directly with local communities and indigenous peoples, boundary organizations, development and humanitarian organizations, meteorological agencies and academia. They demonstrated that community-based risk management is a very effective, and in fact essential, component of national and international efforts to better manage climate variability and change.

91. Practitioners and experts at the Forum agreed that:

- Empowerment of communities is essential;
- Climate is seldom communities' first concern, so climate risk management needs to be integrated into community development, security and practice;
- Local communities are holders of complex knowledge about local weather, climate, biodiversity, ecosystems and have a history of adaptation to climate variations. Climate risk management should draw on socio-economic data and local vulnerability and capacity assessments to assess and address differential vulnerabilities among and within communities, including gender, age and income differences, and recognize potential trade-offs;
- Communities will accept and use external information when they trust the source and there is a supportive partnership context;
- Much can be achieved by adapting to the current climate, and reducing the current adaptation deficit by including short, medium and long term risk planning; and
- Local communities are holders of complex knowledge about local weather, climate, biodiversity, ecosystems and have a history of adaptation to climate variations.

92. The Forum agreed that science-based climate information can effectively support climate risk management at community level, and made the following recommendations to achieve this at a wider scale:

- *Local knowledge and decision-making.* It is necessary to recognize the central role of local communities in decision-making at local level, and draw on their existing traditional knowledge, values, skills and cultural systems (6.2.a);
- *Build local capacity.* Building capacity at local level empowers communities and strengthens the link between local practice and national policy frameworks (6.2.b);
- *Start now.* Better application of climate information can be generated right now, rather than just on longer-term efforts to enhance observations and predictions (6.2.c);
- *Context-specific climate risk management.* Provision of generic climate information is not enough. Climate risk management is highly context-specific. There is no one-size-

fits-all climate information product and actionable information, as well as guidance and tools, supportive rather than prescriptive is needed (6.2.d);

- *Expectations of users*. It is essential to be transparent on uncertainties and inform local users on what can be expected. Effective communication can ensure that information gets to the right level and is understood, trusted, and actionable (6.2.e);
- *Best practices.* Best practice examples and peer-to-peer learning should be fostered., including through modern media and stakeholder forums (6.2.f); and
- *Partnerships.* Benefit can be gained by investing in partnerships and instituting effective engagement based on dialogues amongst users and suppliers of information and services, often through local champions and boundary organizations (6.2.g).

6.3 Climate and capacity-building, education and training

93. Capacity-building is much more than training. It requires institutional strengthening in governance, management and funding as well as human resources development, in areas such as weather, climate and water. Capacity-building activities for improving adaptation require that the stakeholders demand that they should be service-oriented and driven by the outcomes that stakeholders request. The capacity to use climate information then becomes part of a larger effort to achieve a specific goal. The capacity-building experts developed the following recommendations for action:

- *Capacity development*. Capacity development works best when politicians and scientific leadership have the same vision. Strong leadership is critical for effectiveness (6.3.a);
- *Climate change education.* Mainstreaming of climate change education in curricula at all educational levels is a priority (6.3.b);
- *Interaction between science and communities*. Due to the site-specific nature of resilience and adaptation to climate change, local community and indigenous knowledge of ecosystems, natural hazards and adaptation mechanisms has been developed over long time periods. Yet climate change and variability may overwhelm these traditional adaptation mechanisms. It is therefore urgent to enhance the human and institutional capacity to increase the interaction between scientific knowledge and local community and indigenous understanding at all levels (6.3.c);
- *Adapting to current variability.* Focusing adaptation to climate change scenarios that are far in the future (e.g., over 50 years) with large uncertainties strongly reduces the interest of most stakeholder groups. Climate change must be promoted as an issue of the present. Societies need to improve adaptation to current climate variability and extremes, and, by doing so, will improve their adaptive capacity to future climate scenarios. Efforts should therefore be focused in building the capacity to identify and promote actions that improve adaptation today and reduce vulnerabilities in the future (6.3.d);

- *Accessibility.* Climate information services should be accessible by users, useful in national and regional contexts, and assimilate local inputs and accept feedback. Such information services will be developed through capacity-building at the policy, institutional and individual levels. External players should abide by clear principles of engagement when undertaking capacity development work (6.3.e);
- *Long-term partnerships.* Capacity-building and training must be seen as a long-term provider-user relationship of listening and learning. Such a relationship requires access to data, information, ability to generate knowledge, and community collaboration. It is essential that programmes are monitored and evaluated, and that lessons learned feed back into the programme and to demonstrated useful results (6.3.f);
- *Adapting to high-risks.* Managing climate-related risks to sustainable development is already a requirement in high-risk environments. The tools developed for managing climate-related risks are relevant for climate change adaptation and provide a useful and necessary starting point for capacity development (6.3.g); and
- *Mainstreaming climate information.* Climate information products will be optimized when all links in the existing information chain - leading from information producers to users at various levels - are competent (6.3.h).

6.4 Climate, business and industry

94. Climate change is a cross cutting issue –threatening energy, food and water security, impacting human health and biodiversity and affecting key economic sectors such as transport and tourism. Global coordination and collaboration of the private sector with the public sector is the only way to address these interrelated challenges.

95. Better climate information helps business to focus our research and make the right long-term investments. The viability of businesses depends on their vulnerability to the impacts of climate change and their ability to adapt. Predictive services and climate modelling can help them adjust their business model and open the door to new opportunities. The WCC-3 will help raise awareness and develop climate related services that can assist governments and businesses in making better decisions. The business and industry experts made the following recommendations:

    - *Public-private partnerships*. Innovative partnerships that foster rapid development of advanced technologies to reduce emissions are critical. It is important to bring in all key stakeholders including sub-national actors, to find innovative solutions to climate change (6.4.a); and
    - *Role of the private sector*. The Global Framework for Climate Services will help companies benefit from enhanced climate services and provide better accessibility to climate information - the expertise of the private sector should be utilized to the fullest (6.4.b).

7. IMPLEMENTING CLIMATE SERVICES

96. The Conference reviewed a wide range of experiences from developed and developing countries, from the research and operational communities and from many different parts of the world, in the implementation of climate services. The workshops on "Implementing Climate Services" were focussed particularly on:

- The end-to–end process of making better use of climate observations in support of model development and use for operational prediction;
- The role of national and international research programs in supporting the development and improvement of climate services; and
- The diverse experiences of different regions, countries and institutions in the implementation of climate services.

7.1 From observations to predictions

97. This workshop explored the value chain leading from Earth observation data via processing and modeling to climate information services for decision-makers. It addressed climate adaptation services through two case studies on local and regional sea-level rise, and it highlighted climate mitigation services by presenting an emerging forest-carbon monitoring system. It also explored the range of activities involved in converting raw satellite observations into final climate products and services for end users.

98. The two cases studies reached the following conclusions:

- For sea-level rise, global scenarios need to be translated into local and regional scenarios, requiring incorporating the impacts of topography, land subsidence, river and delta dynamics and other local variables. Developing more effective information services will also require improved observations, which in turn will lead to improved models and scenarios; more coordination of observations and integration of data; and rapid and effective dissemination of user-friendly information, including to the general public via warning systems.
- For a robust forest carbon monitoring with wall-to-wall coverage, governments, space agencies and other organizations are working through the GEO framework to integrate in-situ observations, remotely sensed observations, and methodologies for estimating carbon content. The aim is to allow governments and the emerging carbon markets to measure and certify forest carbon flows more accurately than ever before.

99. End-users are not always fully aware of the vast amount of behind-the-scenes work that goes into preparing remotely sensed and in-situ observations so that these data can be reprocessed, analyzed and transformed into climate information products. Broadening the scope and cross-cutting nature of the data entering the processing stream, and strengthening and sustaining the world's diverse Earth observation systems, is critical for the future of climate services.

100. The experts at the workshop made the following recommendations:

- *Sustained observations*. The climate community should, as a top priority, seek to ensure that climate service providers obtain easy access to sustained and cross-cutting observations and information (7.1.a);
- *Robust scenario development.* Recognizing that predicting climate changes and impacts remains a real challenge, climate service providers should focus on delivering robust scenarios that allow decision-makers to consider a range of options and policy responses (7.1.b); and
- *Sector-specific information.* Because both climate change science and the needs of decision makers are so complex, climate information providers should craft their services to meet a diversity of needs, including for local scenarios with short timescales and global scenarios based on longer time scales (7.1.c).

7.2 Research engagement

101. Climate science has advanced significantly during the past three decades, yet many scientific challenges remain. The essential need is to make quantitative climate predictions on time scales from seasons to decades and spatial scales of local to regional to global. The ultimate goal is to create integrative science. This integration must include the identification of the users' needs from the outset. This will provide climate information and services in a timely manner to decision makers and operational organizations.

102. The societal need for authoritative information on climate variability and change demands increased research and development efforts. These include: improved understanding of climate processes and feedbacks; better emissions scenarios; advanced modeling at high spatial resolutions to capture the regional aspects of climate variations/changes and for realistic representation of crucial climate processes; capacity for gathering, processing, and sharing observational data for model evaluation and initialization; development of hardware and software capabilities for analysing and interpreting the model and observational results; the quantification of uncertainties in a probabilistic manner including recognition of the high-impact-end of the distributions; streamlined transition to an operational mode including the generation of climate products and services; facilitation of feedback from the user community and providing inputs into the research priorities; and resources and skills to synthesize the information and meet user needs for decision-making at the global, regional and local levels.

103. There is a clear recognition that the full understanding of climate requires a holistic approach that accounts for all processes of the Earth system, including socio-economic processes. To meet the expectations of the proposed Global Framework for Climate Services, there is, therefore, a need for:

- *End User focus.* Identification of who the end users' are and a re-evaluation of the products and services to better meet the needs of the user community (7.2.a);

- *Earth system approach.* An Earth system approach to observations, monitoring, modeling, analysis and prediction, i.e. coordinate and accelerate prediction research is essential (7.2.b);
- *Data integration.* Integration of space-based and in situ observational systems that accurately capture key climate variables, and are sustained over decades for a robust determination of trends and variations at the regional and global level (7.2.c);
- *Interactions between models and observations*. Synthesis of observations and model outputs to provide accurate regional / global climate information, and utilization of model-based uncertainties to plan better observing system strategies, constitute important scientific underpinnings of any new climate information system and services (i.e. linking research with operations, services and delivery) (7.2.d);
- *Significantly enhanced high performance computing.* Significant enhancements (of at least a factor of 1000) in high performance computing and tele-communications networks (7.2.e); and
- *Capacity building*. Infusion of highly-skilled human scientific talent via training and capacity building, especially through young scientists and, importantly, in the developing regions of the world (i.e. developed countries must work with developing countries in transferring capacity, technology, education and computing. However, the initiative should come from local experts where the service will be installed) (7.2.f).

7.3 Nations and regions

104. The national and regional workshops on implementing climate services developed a set of recommendations as follows:

- *Communication strategies*. Development of strategies to effectively communicate relevant and tailored climate information (including measures of uncertainties) to stakeholders, decision-makers, general public and media are needed (7.3.a);
- *Ownership*. Development of "ownership" by the population and users, including translation of products into local language is important for the effective use of information (7.3.b);
- *Capacity-building.* To ensure sustainability of services, capacity-building and effective in-country training is necessary, as well as funding for Climate Outlook Forums. Development of appropriate tools (e.g., numerical models) and adequate human resources to develop these tools is an important element in climate application (7.3.c);
- *National activities*. National level information on climate change as well as early warning services are needed for preparation of national adaptation strategies. Matching capability to user requirements needs effective dialogue (7.3.d);
- *Regional climate services*. These services are very important to contribute to enhanced social and economic resilience and decision-making in many climate-sensitive sectors

(e.g., water resources, agriculture, fisheries, health, energy, and disaster risk management) (7.3.e);

- *Climate in development*. Climate information is essential for socio-economic development. Conscious efforts are needed by stakeholders and key players in climate-sensitive sectors to understand the full potential and usefulness of this information (7.3.f); and
- *Integration.* Good linkages between Global Climate Prediction Centres (GCPCs) and Regional Climate Centres (RCCs) are needed for the best use of products at the regional and national levels. Regional coordination is needed to foster improvements at the national level. Lessons learned to better tailor information from GCPCs, RCCs and National Climate Centres (NCCs) should be applied (7.3.g).

8. EXPLOITING NEW DEVELOPMENTS IN CLIMATE SCIENCE AND SERVICES

105. The Expert Segment of the Conference had the opportunity, through plenary poster sessions and other briefings, to preview a wide range of innovative research, service provision and application projects which promise to contribute to the quality, range and utility of climate services in future years. The Conference participants expressed appreciation to all those had contributed scientific and technical presentations during the Expert Segment and were especially appreciative of the information provided on new developments.

106. Areas of particular interest in the poster presentations on "Community and Environment" included:

- Climate issues that are already spurring a call to action with, e.g.,:
  - Analyses of complex systems showing subtle sensitivities to climate; and
  - Application of the most basic weather and climate information as the season unfolds can achieve significant increases in productivity and efficiencies in natural resource utilization and management;
- Assessing how well communities were indeed adapting to climate change. The most vulnerable regions of a country, for example, were often not the most proactive in adaptation planning to a particular hazard, be it flood, storm or drought;
- The need for a systematic framework for climate services. The diversity of the posters suggested that effective adaptation to climate variability and change at country, regional and indeed the global level would benefit from a systematic framework for the delivery and uptake of generalized and targeted climate information services; and
- The critical importance of ongoing climate data for the assessment of fluctuations and trends in risks arising from exposure and vulnerability to natural hazards.

107. Areas of particular interest in the poster presentations on "Climate Science" included:

- Use of climate observations to identify regional trends;
- High resolution modeling at global and regional scales; and
- Studies of regional climate change and climate impacts.

108. Areas of particular interest in the poster presentations on "Regional and National Examples of the Provision of Climate Services" included:

- Variety of fields of services for ecological applications, including agriculture;
- The role of the media to communicate climate information, especially in the hydrological posters;
- Existing activities at national level to enhance a country's capacities to develop tailored user-oriented climate services;
- Good knowledge of the user needs together on the spatial and temporal resolution for successful climate services. It was noted that the civil society could provide helpful guidance for the development of climate information and services at local levels; and
- Demonstration that good exchange of knowledge and experiences at regional and sub-regional levels would be beneficial for all involved in delivering climate services;

109. The Conference participants strongly encouraged all of those who had contributed their work to the Expert Segment to continue to support the progressive implementation of the proposed Global Framework for Climate Services over the coming years.

9. A GLOBAL FRAMEWORK FOR CLIMATE SERVICES

110. The Conference recognised that great progress has been made over the past 30 years towards an integrated global approach to the development, implementation, operation and application of climate services in support of a wide range of societal needs in all countries and in all major socio-economic sectors. It particularly recognised the achievements under the World Climate Programme, especially its World Climate Applications and Services Programme (WCASP) and the Climate Information and Prediction Services Project (CLIPS) in the successful implementation of the Regional Climate Outlook Forums (RCOFs) and their support for enhanced national climate services in many countries.

111. The presentations and discussions made clear, however, that the present arrangements for provision of climate services fall far short of meeting the identified needs and that there is vast, as yet largely untapped, potential to improve these arrangements and enhance the quality and utility of climate services for the benefit of all countries and all sectors of society. There was widespread agreement among both provider and user community representatives that a new global framework is required to enable better management of the risks of climate variability and change and adaptation to climate change at all levels

through development and incorporation of science-based climate information into planning, policy and practice.

112. The participants in the Expert Segment welcomed the extensive preparatory work by WMO and its partner organisations on the design of the proposed Global Framework for Climate Services and the consultations that had already taken place with governments through both technical and diplomatic channels. They were in full agreement that, from the scientific and operational perspective, the proposed Framework should reinforce and complement the established international organisations for the provision and application of weather, climate, water and related environmental information, forecasts and warnings and should build on, and integrate, the existing international systems and programs for climate observations and research which are co-sponsored by WMO, other UN System partner organisations, and ICSU. WMO and user-sector organisations should enhance collaboration in the development of practical guidance on the preparation and use of climate products in different sectors and regions.

113. The participants in the Expert Segment of the Conference called for major strengthening of the essential elements of a global framework for climate services:

- The Global Climate Observing System and all its components and associated activities; and provision of free and unrestricted exchange and access to climate data;
- The World Climate Research Programme, underpinned by adequate computing resources and enhancing interaction with other global climate relevant research initiatives;
- Climate services information systems taking advantage of enhanced existing national and international climate service arrangements in the delivery of products, including sector-oriented information to support adaptation activities;
- Climate user interface mechanisms focussed on building linkages and integrating information, at all levels, between the providers and users of climate services aimed at developing and efficient use of climate information products, including the support of adaptation activities; and
- Efficient and enduring capacity building through education, training, and strengthened outreach and communication.

114. On the basis of the three days of discussion and deliberations during the Expert Segment, the participants supported the development and implementation of the proposed Global Framework for Climate Services.

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