

Incheon  
18–25 November  
2009

# Commission for Atmospheric Sciences

Fifteenth session



**World  
Meteorological  
Organization**

WMO-No. 1050

**Weather • Climate • Water**



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Abridged final report with resolutions and recommendations

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Meteorological  
Organization**  
Weather • Climate • Water

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ISBN 978-92-63-11050-3

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This report contains the text as adopted by Plenary and has been issued without formal editing.

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# GENERAL SUMMARY OF THE WORK OF THE SESSION

## 1. OPENING OF THE SESSION (*agenda item 1*)

**1.1** The fifteenth session of the Commission for Atmospheric Sciences was held in Incheon, Republic of Korea, from 18 to 25 November 2009. The session venue was the Hyatt Regency Hotel, Incheon. The opening ceremony took place at 10.00 a.m. on Wednesday, 18 November 2009.

**1.2** Dr Michel Béland, president of the Commission for Atmospheric Sciences, welcomed the participants to the fifteenth session of the Commission and opened the meeting by introducing the distinguished members of the platform committee, Mr Michel Jarraud, Secretary-General of the WMO, Dr Lee Byung-Wook, Vice-Minister of Environment, Republic of Korea, Mr Lee Chang Koo, Deputy Mayor of Incheon Metropolitan City, Republic of Korea and Dr Chun Byung-Seong, Administrator of the Korea Meteorological Administration.

**1.3** Dr Béland expressed his thanks to the Government of the Republic of Korea and Korea Meteorological Administration for hosting the meeting and for the excellent arrangements that ensured the success of the Commission meeting.

**1.4** Mr Michel Jarraud, Secretary-General of the WMO, in his opening statement, expressed his appreciation to the Government of the Republic of Korea and in particular to Dr Chun Byung-Seong, Administrator of the Korea Meteorological Administration (KMA) and Permanent Representative of the Republic of Korea with WMO, as well as to all his staff, for the warm hospitality and the excellent arrangements made to ensure the success of the session. The Republic of Korea has a tradition of actively supporting WMO's Programmes and activities, as a long-standing Member of the Organization which it joined in February 1956. He also thanked Dr Chun for hosting the technical conference on "Environmental Prediction in the Next Decade: Weather, Climate, Water and the Air We Breathe" which had just concluded successfully.

**1.5** The Secretary-General extended his gratitude to Dr Béland, for his leadership of the Commission and for the work accomplished during the intersessional period since the fourteenth CAS session, held in South Africa in February 2006. He also thanked the vice-president of CAS, Dr A. Frolov, as well as the Management Group, the two CAS Open Programme Area Groups (OPAGs) and all contributing experts. He acknowledged with thanks the participation of the representatives of WMO Members, partner organizations and the delegates to the meeting. A complete list of participants is given in the [appendix to the present report](#).

**1.6** The Secretary-General noted that over the last six decades, WMO has been at the forefront in promoting international research and operational collaboration, in particular to study atmospheric processes, save lives and protect property. It was a key founding organization in the establishment of a number of international Conventions, including three which are especially connected to the work of CAS: the UNECE Convention on Long-range Transboundary Air Pollution (1979), the Vienna Convention for the Protection of the Ozone Layer (1985) and the United Nations Framework Convention on Climate Change (1992). His presentation highlighted three "threads" of WMO's scientific research activities which, collectively, provide a good profile of WMO's major societal contributions, namely, climate, forecasting and disaster risk reduction and the air we breathe.

**1.7** Regarding climate, Mr Jarraud emphasized that the statement resulting from the expert segment of the third World Climate Conference Geneva in September 2009 supported enhanced climate, weather, water and environmental prediction research and services, while the conference's high-level segment unanimously approved a Declaration containing the decision to establish a Global Framework for Climate Services. Now the stage has been set for WMO research programmes – WWRP including THORPEX and GAW – and its co-sponsored programmes – WCRP and GCOS, to provide momentum to the generation of new prediction

services and information, and their delivery to decision-makers in all sectors through an internationally coordinated mechanism.

**1.8** In response to societal needs for forecasting and disaster risk reduction, WMO, the National Meteorological and Hydrological Services of its 188 Members and its partner organizations are especially well positioned today to contribute to the delivery of a new generation of climate services, since 40 years of experience in numerical weather prediction have warranted WMO a key role in the international weather services framework, which already provides the necessary information and warnings to aviation, marine transportation, health and food, energy generation and the general public, among many other sectors. At the same time that climate research was budding, numerical weather forecasting was already a core WMO activity, delivering sophisticated warnings globally and locally through dedicated networks of research and operational centres, in particular under the umbrella of the World Weather Research Programme.

**1.9** The Secretary-General noted that never before have air quality forecasts been so necessary as they are today. WMO pioneered studies and assessments leading to the successful 1985 Vienna Convention for the Protection of the Ozone Layer (1985) and its 1987 Montreal Protocol. More recently, the UNFCCC process has relied on the Global Atmosphere Watch global monitoring system to track and analyze climate change-relevant atmospheric gases. Air quality forecasts are being issued by an increasing number of NMHSs, many of which also provide a wide variety of user-friendly air quality indices and advisories. While the development of regional air-quality forecasts has considerably improved over the last 30 years, delivering them to local communities in a timely fashion is often still a challenge.

**1.10** The Secretary-General warned that since our planet and its population are increasingly vulnerable to global climate change, food and water resources are being stretched further and further, and drastic measures will have to be taken by decision-makers on behalf of all segments of society. It is therefore part of WMO's mission to provide them the information that they will need. Research plays an important role in generation of the appropriate information and services of the future.

**1.11** Dr Lee Byung-Wook, Vice-Minister of Environment, welcomed the participants to the Republic of Korea and noted that the fifteenth session of the Committee is a highly significant event, and that he was confident that it would contribute to considerable progress and growth. He fervently hoped that this session would make it possible for all participants to share their extensive knowledge, expertise, and insights, and provide a forum for far-reaching discussions and outcomes.

**1.12** On behalf of Incheon Metropolitan City's 2.8 million citizens, Mr Lee Chang Koo, Deputy Mayor, warmly welcomed the Commission and its participants. He emphasized that, meteorology is closely connected to our daily lives. Indeed, the increasing recognition of the value of climate information is so important that it could be said to represent a new paradigm shift in the day-to-day culture we create. For the sake of the world and the Republic of Korea, Mr Lee earnestly hoped that the Commission would successfully make advances in meteorology beginning today through this event.

**1.13** Dr Chun Byung-Seong, Administrator of the Korea Meteorological Administration reminded the Commission that the Republic of Korea was first represented at the seventh CAS session in 1978. In the Republic of Korea, public awareness of meteorology has increased so much in the last three decades as to defy comparison. In these three decades, the Republic of Korea has achieved dramatic progress in both its economy and atmospheric sciences. We humans need to expand our vision further into the future, and invest in meteorology as a key to our future, and guarantee of our safety. Every sector of the entire globe is exploring a variety of climate change measures. The Administrator emphasized that our role as meteorologists is at the core of those activities, and the information we produce and provide will lay defining groundwork for such responses or adaptation measures.

## **2. ORGANIZATION OF THE SESSION** (*agenda item 2*)

### **2.1 CONSIDERATION OF THE REPORT ON CREDENTIALS** (*agenda item 2.1*)

In accordance with General Regulations 20 to 23, the Commission noted and approved the report of the representative of the Secretary-General as the first report on credentials

### **2.2 ADOPTION OF THE AGENDA** (*agenda item 2.2*)

The provisional agenda, as contained in Doc 2.2 REV 3, was adopted without amendments on the understanding that, at any time during the session, additions or alterations could be made.

### **2.3 ESTABLISHMENT OF COMMITTEES** (*agenda item 2.3*)

In accordance with Regulations 22 to 31, the session decided to establish a Nomination Committee and a Coordination Committee. The Nomination Committee comprised Dr Neville Smith (Chair, Australia) and the principal delegates from the following Members of the Commission: Switzerland, Poland and Senegal. The Coordination Committee comprised the president of the Commission, the representative of the Secretary-General and a representative of the host country and the chairs of the Open Programme Area Groups for Environmental Pollution and Atmospheric Chemistry and the World Weather Research Programme. The Commission agreed that the work of the session would be carried out in plenary. General Plenary would be chaired by the president of the Commission and consider agenda items 1, 2, 4, and 7 to 13 while the chair of the Open Programme Area Group on the World Weather Research Programme, Dr Brunet would chair Plenary Sessions A, which considers items: 3 and 5.3 and Prof. Hov chair of Open Programme Area Group on Environmental Pollution and Atmospheric Chemistry would chair Plenary Session B and take up items 5.1, 5.2 and 6.

### **2.4 OTHER ORGANIZATIONAL QUESTIONS** (*agenda item 2.4*)

The session agreed on the working hours of the session. It was agreed that minutes of plenary meetings were not required in view of the technical nature of discussions. In accordance with Regulation 3, the Commission agreed to suspend for the duration of the whole session Regulation 109.

## **3. PROGRESS AND FUTURE DIRECTION OF ATMOSPHERIC RESEARCH AND ENVIRONMENT ACTIVITIES** (*agenda item 3*)

### **3.1 REPORT OF THE PRESIDENT OF THE COMMISSION** (*agenda item 3.1*)

**3.1.1** The Commission accepted the report of the president of CAS, Dr Michel Béland noting the considerable progress in the intersessional period made by the CAS Management Group. In particular, it acknowledged the success in linking research closely to coordinated global observations, operational forecasting and prediction, service delivery and capacity-building as WMO implemented a results-based management system and a restructuring.

**3.1.2** The Commission agreed with the president that although creation of a Research Department in the WMO Secretariat on 1 January 2008 was effective in bringing together weather, climate, and environmental research programmes to address the issues facing Members, a review of the CAS mandate and possibly structure at this session (see agenda items 4 and 9) was needed. The Commission further noted that enhancing partnerships between CAS and ICSU and other international organizations would serve Members needs by increasing the visibility of CAS activities and through engaging a broader community (e.g., universities and research laboratories), in CAS research. The Commission requested the CAS president and the CAS Management Group to investigate appropriate new or enhanced collaboration and cooperation between CAS programmes and ICSU.

**3.1.3** The Commission endorsed a “seamless” approach to coordination of weather, climate, water and environmental prediction research and strong linkages to operational observations and predictions as well as users advocated by the president and the report of the EC-LX Task Team on Research Aspects of an Enhanced Climate, Weather, Water and Environmental Prediction Framework (EC-RTT) in June 2008 (see also agenda item 8.1).

**3.1.4** The Commission noted the successful completion of the WMO/IUGG International Aerosol Precipitation Science Assessment publication that was called for by Cg-XIV, approved by Cg-XV and published as a peer reviewed book in 2009 (“Aerosol Pollution Impact on Precipitation: A Scientific Review” Springer Verlag ISBN:978-1-4020-8689-2). The Commission expressed its thanks to the IUGG, co-editors Prof. Zev Levin and Prof. William Cotton, the leader of the peer-review Dr George Isaac, the many contributors and reviewers and the WMO Secretariat. It thanked Canada and France for hosting workshops. It agreed with the president that the CAS Management Group needs to ensure that the recommendations of this review on how to improve understanding of impacts of aerosol pollution on precipitation are addressed whenever possible through the activities of the Commission.

**3.1.5** The Commission agreed with the president that WMO must support sound science practices in research on weather modification, continuously assess the state of knowledge and offer Members advice on the feasibility of weather modification. It agreed that the CAS Management Group had managed successfully an objective review and update of the “WMO Statement on Weather Modification (including an Executive Summary)” and the “WMO Guidelines for the Planning of Weather Modification Activities” thus fulfilling the request of CAS-XIV. It agreed with the assessment of the president that a periodic rolling review of these documents by the Expert Team on Weather Modification Research as stated in the Strategic Plan of WWRP is desirable and requested that Members engaged in operational weather modification activities fund this through contributions to the WMO Trust Fund established at the request of Cg-XV.

## **3.2 REPORT OF THE CHAIR OF THE OPEN PROGRAMME AREA GROUP ON ENVIRONMENTAL POLLUTION AND ATMOSPHERIC CHEMISTRY (*agenda item 3.2*)**

**3.2.1** The Commission accepted the report of the Chair of OPAG-EPAC, Prof. Øystein Hov on the progress made by WMO in addressing issues related to ozone depletion and related impacts of increased ultraviolet radiation, greenhouse gas and aerosol impacts on climate change and the globalization of air pollution. It agreed that the completion of a strategy for Integrated Global Atmospheric Chemistry Observations (IGACO) followed by the embodiment of that strategy in the third GAW Strategic Plan 2008–2015 (WMO/TD-No. 1384) had fulfilled the request of CAS in addressing the observational and science assessment needs of WMO Members. The Commission agreed that the GAW Strategic Plan is an effective mechanism in addressing the Strategic Thrusts and Expected Results of the WMO Strategic Plan.

**3.2.2** The Commission joined the Chair of OPAG EPAC in gratefully acknowledging the support of the Members of GAW scientific advisory groups and expert teams providing services and products needed by WMO Members. It acknowledged the great success of Ozone and Greenhouse Gas Bulletins in addition to the contributions of GAW coordinated research and assessments on atmospheric chemical change to many key issues and societal benefit areas, including climate. The Commission noted that an emerging global carbon analysis tool, which makes use of atmospheric models and observations of greenhouse gases, is already being implemented in a number of regions and acknowledged the valuable contributions of Members in developing this tool.

**3.2.3** The Commission agreed with the Chair that a clear definition of the role of GAW in the WMO Integrated Global Observing System (WIGOS) is needed and that a well coordinated follow-up is needed by CAS and CBS to the decision by EC-LXI (paragraph 3.4.46) that the WIGOS implementation strategy clearly indicates that it complements rather than duplicates implementation plans of WIGOS systems, such as GOS, WHYCOS and GAW.

**3.2.4** The Commission noted the conclusion of the Chair of OPAG EPAC that although the observational component of GAW is maturing rapidly as an IGACO integrated observing system for ozone and UV, greenhouse gases recognized by GCOS and is now organizing global aerosol observations, it still has a long way to go in sustaining and filling gaps in observations, quality assurance, data management and analysis. The Commission encouraged Members and research partners to enhance support of these global observational frameworks by providing observations to fill gaps and activities/facilities to maintain data quality and delivery. The Commission also strongly endorsed the strategy of adding aircraft and satellite experts to GAW scientific advisory groups and expert teams as it continues to implement the concepts and recommendations of IGACO to address Members needs.

**3.2.5** The Commission agreed with the suggestion of the Chair of OPAG-EPAC that near-real time delivery of air chemistry observations for use in weather and environmental forecasting be strongly supported by WMO Members and partners. It recommended that WMO take a lead role in linking the technical work on the regional/continental long range transport of air pollution into a global system that assists the delivery of forecasts and reanalyses with emphasis on heavily impacted urban areas and regions in and downwind of major air pollution sources. This includes the delivery of environmental data to allow for both day-to-day assessment of the long (and very long) range transport of air pollution, and hindcast analysis or scenario calculations.

**3.2.6** The Commission agreed with the Chair that there are great co-benefits to be gained in the pursuit of solutions to disaster risk reduction related to climate change in the areas of human health impacts due to air pollution. It noted the estimate of WHO that 2.3 million people die prematurely due to effects of air pollution; of these 800,000 are dying as a result of pollutants emitted by energy production, transport and industry. Heatwaves cause excess deaths not only because of elevated temperatures but also stresses of air pollution. The Commission agreed that addressing either the issue of climate change or air pollution will yield great benefits in underlining the need for NMHSs and other national organizations to pursue a coordinated approach to environmental prediction. It agreed that WMO leadership in supporting and developing international conventions (e.g. Vienna Ozone, Long-range Transboundary Air Pollution (CLRTAP), UNFCCC and IMO MARPOL) that embody the co-benefits principle is critical in harnessing the full power of weather, climate and environmental research.

### **3.3 REPORT OF THE CHAIR OF THE OPEN PROGRAMME AREA GROUP ON THE WORLD WEATHER RESEARCH PROGRAMME (*agenda item 3.3*)**

**3.3.1** The Commission accepted the report of the Chair of OPAG-WWRP, Dr Gilbert Brunet on the non-THORPEX activities within the WWRP. It agreed that the completion of the first Strategic Plan for the Implementation of WMO's World Weather Research Programme (WWRP): 2009–2017 (WMO/TD-No. 1505) was a milestone and a significant contribution to meeting the Expected Results of the WMO Strategic Plan. The Commission further thanked the Chair of the JSC-WWRP, the Chairs of the Working Groups, Panels and Expert Teams of the WMO and the Secretariat. The Commission especially acknowledged Dr Pierre Dubreuil of Environment Canada who served as editor of this document.

**3.3.2** The Commission concurred with general directions outlined in the WWRP Strategic Plan and noted that the document fulfilled the design of the programme as decided upon at CAS-XIV.

**3.3.3** The Commission acknowledged the general increase in the activity levels of the WWRP to match the vision of CAS-XIV and the improved efforts to meet Members needs and the numerous successes of the programme (see agenda item 5.1). These successes included: (i) two Forecast Demonstration Projects (FDPs) in the MAP D-PHASE Project for flash flooding in Alpine regions and the Beijing 08 effort that focused on convection and severe weather; (ii) Research and Development Projects (RDPs) including MAP, the Beijing 08 RDP, TCS-08, and COPS; (iii) involvement in training and publishing of reports and documents of community interest both as WMO Technical Documents and in the Scientific Literature; (iv) the development of web-based user tools that are widely used by the community including forecasting verification tool set; (v) the

participation of the WWRP in cross-cutting efforts such as forecast verification and the Sand and Dust Storm Warning Advisory and Assessment Project; (vi) further scientific advancements in concerning various aspects of data assimilation, coupled hydrological modeling for flooding, ensemble prediction, convection, tropical cyclones and monsoons, orographic effects, mesoscale meteorology, and verification techniques; and (vii) a variety of workshops, conferences, training sessions, and symposium.

**3.3.4** The Commission noted that the FDPs of the WWRP include a quantification of the operational improvements in prediction from new research advances and the subsequent value to users through well-designed verification and societal and economic impacts efforts. The improvements in service delivery from the Beijing 08 and MAP – PHASE FDPs were impressive and the Commission urged that the visibility of past successes and the potential value of future WWRP FDPs are elevated within WMO Strategic Planning and within the WMO constituent body meetings. The Commission recommended that Members encourage and support future WWRP FDPs as a way to get the latest research improvements into operations, particularly in developing nations where obtaining financial support has been difficult.

**3.3.5** The Commission concurred with the conclusion of the 3rd Joint Scientific Committee of the WWRP that the recommendations of the EC-LX Research Task Team and the Vision papers outlined subsequently in CAS-XV would increase the scope of the WWRP at a time when the WMO Secretariat is already stretched to cover the successful activities of the WWRP and WWRP-THORPEX. The CAS Management Group, the WMO Secretariat within AREP and the Secretary-General of the WMO are requested to take this issue into careful consideration and to prioritize activities accordingly.

**3.3.6** The Commission recognizes and appreciates the growing scientific exchange of information and guidance between THORPEX and the rest of the WWRP, which has been furthered by the attendance of THORPEX Working Group Chairs at the WWRP JSC.

#### **3.4 REPORT OF THE CHAIR OF THE INTERNATIONAL CORE STEERING COMMITTEE FOR THORPEX** *(agenda item 3.4)*

**3.4.1** The Commission accepted the report of the Chair of the International Core Steering Committee for THORPEX, Dr Alan Dickinson, on progress made to advancing the goals of WMO Members with respect to Global Weather Prediction. It agreed that THORPEX has contributed substantively to the advancement of Members needs and fostered a tremendous sense of partnership and collaboration around the world particularly through the following activities:

- (a) Completion of three major field experiments, A-TREC, E-TREC and T-PARC with its two experimental phases, and associated modeling activities that involved collaborative efforts among many countries around the globe to advance understanding and predictive skill for regional aspects of high impact weather including investigations into observing strategies and ensemble prediction;
- (b) Activities to address regional prediction needs, such as the assessment of targeted observations for extratropical and tropical cyclones, THORPEX Africa, and THORPEX involvement in the assessment of the forecast impacts of additional observations over Africa taken as part of the AMMA Project;
- (c) The development and execution of the IPY-THORPEX cluster of projects focused on advancing numerical weather prediction for polar regions;
- (d) The development of the TIGGE database as a major community resource with model data from ten operational global numerical weather prediction centres around the globe and archives for this data established at the CMA, ECMWF, and NCAR. Over 500 users in the operational centres and the academic community have accessed this data set to improve ensemble systems and further the use of ensemble data sets which will result in long-term benefits to forecast services. Research includes projects aimed toward the

continued development of the THORPEX Global Interactive Forecast System (GIFS) including improving forecasts of tropical cyclone track and intensity;

- (e) Initiation of the Year Of Tropical Convection Project to address key uncertainties in global models for climate and weather through advancing the representation of tropical convection and its interaction in processes such as the MJO, Kelvin waves, easterly waves and tropical cyclones;
- (f) THORPEX scientific meetings including the 2<sup>nd</sup> THORPEX International Science Symposium in Landshut, Germany during 4–8 December 2006 and the 3rd THORPEX International Science Symposium and TIGGE User Workshop in Monterey, California during 14–18 September 2009.

**3.4.2** The Commission endorsed the simplified management structure that had been developed for THORPEX and noted that this simplification was motivated mainly by financial constraints.

**3.4.3** The Commission noted the leadership role of Canada, China, France, Germany, Japan, Republic of Korea, Norway, the United Kingdom of Great Britain and Northern Ireland and the United States of America in THORPEX, through their continuing financial contributions to the THORPEX Trust Fund. In this regard, the Commission urged more Members and national and international funding agencies to commit support to the THORPEX Trust Fund and to provide financial support, or support in kind, for national and regional THORPEX research initiatives.

**3.4.4** The Commission recommended that THORPEX should remain focused on making improvements in the prediction of high impact weather worldwide, extending the range of useful forecasts from one day to one season ahead, and encouraging a global integrated approach through careful evaluation and scientific assessment of the potential benefits of a Global Interactive Forecast System and of observing strategies and adaptive observing systems.

#### **4. DECISIONS OF CONGRESS AND THE EXECUTIVE COUNCIL OF RELEVANCE TO THE ATMOSPHERIC RESEARCH AND ENVIRONMENT PROGRAMME** (*agenda item 4*)

##### **Terms of Reference of CAS**

**4.1** The Commission noted that Cg-XV (paragraph 3.3.1.3) had endorsed the terms of reference of CAS proposed by CAS-XIV in February 2006 with slight amendments made by EC-LVIII in June 2006. The Commission agreed that the terms of reference need to be reviewed and updated considering the many changes in the operating environment of CAS within WMO in the past four years. These are well documented in the analysis and recommendations of the Executive Council Research Task Team (EC-RTT) on Research Aspects of an Enhanced Climate, Weather, Water and Environmental Prediction Framework (WMO/TD-No. 1496; <http://www.wmo.int/res>). The Commission adopted [Recommendation 1 \(CAS-XV\) – Terms of reference for the Commission for Atmospheric Sciences](#), on its revised terms of reference. These proposed new terms of reference take into account the desire of Members to better link programmatic activity to the Expected Results of the WMO Strategic Plan. The Commission agreed with the request of EC-LVIII (paragraph 3.3.1.2) that more emphasis should be given to the connection to climate research activities in CAS and made changes accordingly.

##### **Programmatic structure of CAS**

**4.2** The Commission agreed that simplification of the nomenclature and number of WMO programmes is desirable considering the confusing array of activities/initiatives/efforts that are named “programme” and the changes that have taken place in the last four years in WMO. These changes result in part, from the response of WMO to the request of Cg-XV to introduce a results-based management system and in part, from the evolution of CAS activities in the last four years as reflected in strategic plans of implementation for the GAW and WWRP (including THORPEX)



programmes. In offering advice on WMO programme simplification the Commission decided to use the criteria that a programme related to research should be retained, if: (i) it is delivering directly a Key Outcome in the WMO Strategic Plan; (ii) it has been recommended by the Commission as a result of broad international support; and (iii) it is a multifaceted effort bringing together related but complementary activities to more effectively serve Members needs.

**4.3** The Commission noted that CAS-XIV had restructured the Commission into two open programme area groups: the OPAG on Environmental Pollution and Atmospheric Chemistry supporting the Global Atmosphere Watch (GAW) programme and the OPAG on the World Weather Research Programme supporting the WWRP including THORPEX. These programmes fulfil the criteria for programmes and have earned broad acceptance amongst Members. The Atmospheric Research and Environment Programme (AREP) is an umbrella programme for these technical programmes. Considering the need to simplify programmatic structure, the Commission strongly recommended that WMO formally delete AREP as a programme of WMO and recognize GAW and WWRP, including the THORPEX programme as main programmes delivering on key outcomes of the WMO Strategic Plan. The Commission recommended that, in future, the word “programme” is not used to label research activities within a designated main programme or to describe groups of programmes. It encouraged WMO to adopt this practice so as to avoid confusion.

**4.4** The Commission noted the increasing benefits of closely connecting climate, weather and atmospheric chemistry research activities, as recommended in the report from the Executive Council Research Task Team (EC-RTT) on Research Aspects of an Enhanced Climate, Weather, Water and Environmental Prediction Framework (WMO/TD-No. 1496; <http://www.wmo.int/res>). It also noted that the creation of a Research Department in the WMO Secretariat on 1 January 2008 was aimed at strengthening the connection between GAW, WWRP including THORPEX, and WCRP.

## **5. RECOMMENDATIONS ON ATMOSPHERIC RESEARCH AND ENVIRONMENT PROGRAMME ACTIVITIES** (*agenda item 5*)

### **5.1 WORLD WEATHER RESEARCH PROGRAMME** (*agenda item 5.1*)

#### **5.1.1 Nowcasting Research** (*agenda item 5.1.1*)

**5.1.1.1** The Commission thanked Environment Canada for hosting the 9th Symposium on Nowcasting and Very Short Range Forecasting from 30 August to 4 September 2009 and noted that this International Symposium series is the only international major forum focused on exchanging information on research activities and operational techniques for nowcasting systems. The Commission requested that WMO hold this symposium every three years and that the planning and support of this meeting be extended to include the OPAG-PWS of CBS to ensure the treatment of operational issues within the Symposium.

**5.1.1.2** The Commission acknowledged the leadership of the Chinese Meteorological Administration and the significant efforts by the international partners to make the Beijing 08 Forecast Demonstration Project (FDP) a success in terms of both research and well documented and lasting improvements in operational service delivery. The Commission noted that the experiences learned from Beijing 08 have been applied to the Shanghai MHEWS Project and encouraged the continuation of this transfer. The Commission urged that training efforts in nowcasting based on the outcomes of Beijing 08 FDP be conducted for nations in Eastern Asia with similar observational capabilities and forecasting challenges.

**5.1.1.3** The Commission noted the decision of EC-LXI (paragraph 3.1.9) that Members' capabilities in radar-based flash flood forecasting could be greatly developed or enhanced through the collaboration between nowcasting and hydrological experts. In view of the success of the MAP D-PHASE Forecast Demonstration Project (FDP), in research and in documented lasting improvements in operational service delivery, the Commission urged that future FDPs in WWRP and the OPAG-DPFS of CBS consider incorporating the MAP D-PHASE approach to improve



prediction of weather and flooding across the scales from nowcasting to the medium-range using deterministic and ensemble modeling systems for weather and hydrological prediction. The Commission concludes that the successful coupling of atmospheric and hydrological models for flood forecasts in MAP D-PHASE could serve as a model for the implementation of the WMO Flood Forecasting Initiative by the Inter-Commission Task Team and urged a greater partnership between CHy and CAS in these efforts.

**5.1.1.4** Based on Member needs, the Commission urged the expansion of research efforts into satellite-based estimates of heavy rainfall, especially for Members lacking radar capabilities. The Commission noted that the successful past WWRP FDPs in nowcasting have focused on radar-based nowcasting of convective precipitation and severe weather. The Commission noted that nowcasting can integrate a variety of observational platforms (e.g., radars, satellite, and other in-situ observations) and requested that the Chair of the OPAG-WWRP ensure that the Membership of the Working Group on Nowcasting Research reflect the expertise necessary to guide research to advance this integrated approach and to improve nowcasting of a variety of high-impact phenomena.

**5.1.1.5** The Commission noted the EC-LXI (paragraph 3.1.36) decision that called for a CAS-CBS Workshop on Forecast Systems motivated by the changing nature of the operational forecast process and requested that this workshop take place in 2010 or early 2011. It also recommended that the Chairs of the WWRP Working Groups on Nowcasting Research and Mesoscale Forecasting Research, the THORPEX IPO and the Chair of the Joint Scientific Committee (JSC) of WWRP work to ensure that the range of issues (e.g., reliance on visualization, role of local executed modelling and analysis software, future role of forecasters) and opinions expressed in this EC decision and at the WWRP JSC are represented in the design of this workshop.

**5.1.1.6** The Commission noted the importance of the decision of EC-LXI (paragraph 3.1.37) that called for exploration into the possible expansion of the OPERA radar exchange concept to other Regions beyond RA VI as radar data shows promise in both improving NWP and nowcasting high impact weather. It requested that the Secretariat work with the three relevant Commissions (CAS, CIMO and CBS) to name focal points to develop options for possible action (see also paragraph 6.5.5).

**5.1.1.7** The Commission appreciated the progress in planning the SNOW V-10 Project as nowcasting for winter weather is an important and relevant topic for the WWRP. The Commission supported this activity and recommended that the lessons learned in this project and in Beijing 08 be transferred to prediction in support of the Sochi 2014 Winter Games. The Commission also strongly urged the WWRP including THORPEX to work with Roshydromet of the Russian Federation to determine whether a WWRP Forecast Demonstration Project can be developed in association with the Sochi 2014 Games. Should these efforts move forward, the Commission recommended that full advantage be taken from the capabilities existing in European Member States, including the products of European organizations such as ECMWF, EUMETNET and EUMETSAT.

**5.1.1.8** The Commission supported the growing tendency for the Working Groups on Mesoscale Forecasting Research and on Nowcasting Research to collaborate on research problems of mutual interest as the distinction between nowcasting and km-scale numerical modelling activities is lessening with the development of blended nowcasting systems and high resolution models that assimilate radar data. The Commission noted that such efforts are forming the foundation for the establishment of a broader long-term effort within the WWRP that focuses on improving skill in short-term regional forecasts to meet the growing needs of Members in this area (see item 8.2) in a manner analogous to the THORPEX programme's successful contributions to global prediction through concentrating on the main components of the forecast system.

**5.1.1.9** The Commission urged Members to encourage the participation of both academic research and operational centres in the work of the WWRP nowcasting research. In particular, the FDP and Research Demonstration Project (RDP) approach allows comparison between forecasts from a variety of nowcasting approaches in a real-time environment providing a unique opportunity

to improve nowcasting systems, which unlike global models are typically run operationally on a local and regional basis without common areas of overlap. The Commission further noted the benefits of FDP to the Members involved and encouraged Members to support FDPs, particularly in the developing nations as outlined in the EC Research Task Team (EC-RTT). The Commission also recommended the WMO promote close cooperation on nowcasting modeling and exchange of experience between neighboring countries.

**5.1.1.10** The Commission noted the decision of EC-LXI (paragraph 3.1.10) regarding the potential benefits of lightning detection data in nowcasting and recommended that the Working Group on Nowcasting Research represent CAS in collaborations with CIMO and CBS to address the current availability and quality of lightning detection data sets.

**5.1.1.11** The Commission appreciated the incorporation of societal and economic impact activities into the Beijing and MAP D-PHASE FDPs. Recognizing that nowcasting requirements should be driven by client needs and by socio-economic considerations, the Commission urged Members and the WWRP to facilitate and support a strengthening of such activities.

## **5.1.2 Mesoscale Forecasting Research (agenda item 5.1.2)**

**5.1.2.1** The Commission noted the success of the MAP D-PHASE project and thanked MeteoSwiss and their eight international partners for their successful effort. The Commission acknowledged that a long-term legacy of the MAP D-PHASE was the visualization platform, which serves as the prototype for the Swiss Natural Hazards project. The Commission reminded Members that the techniques and lessons learned from MAP D-PHASE (e.g., the visualization platform, development of coupled flood forecasting models and transition of research into operations) could be applied to other research and operational efforts for warning users of weather and flooding hazards.

**5.1.2.2** The Commission was pleased with the incorporation of the Integrated Research Environment (IRE) into the strategies of the WWRP as testing and improving modelling and assimilation techniques using data sets created by test-beds and past major field campaigns is an extremely efficient path toward the difficult task of improving forecast systems. The Commission encouraged IRE development and the continuation of real-time RDP and FDP approaches to improve modelling systems and advance operational transition through international cooperation.

**5.1.2.3** The Commission acknowledged the key role outlined in the WWRP Strategic Plan for the Mesoscale Forecasting Working Group in research to advance data assimilation, improve model physics and develop limited area ensembles and noted that such research is critical during the transition of numerical weather prediction systems to high resolution (km-scale) systems that begin to resolve the convective systems and better represent orography. The Commission strongly urged the involvement of both the academic and operational communities, including modelling consortium supported by NMHSs and research partners, as the transition to such high-resolution modelling systems will benefit from both basic and applied research. In addition, the Commission encouraged the WWRP Working Group on Mesoscale Forecasting Research to enhance collaboration with the THORPEX TIGGE-LAM effort, especially with the aim to promote and coordinate work on optimizing mesoscale ensemble forecasts.

**5.1.2.4** An Asian Tropical Cyclone RDP to evaluate GIFS-TIGGE tropical cyclone tracks and ensemble-based diagnostics (see item 5.2) is planned for the northwest Pacific in 2010 during a time period that will coincide with the Shanghai MHEWS (Multi-Hazard and Early Warning System) Project (see item 6.6). The Commission urged that limited area deterministic and ensemble modelling groups interested in tropical cyclones also participate by producing and sharing their limited area simulations among interested NMHSs and participating researchers, preferably in a near real-time mode. Such products will complement the planned near real-time exchange of GIFS-TIGGE tropical cyclone track prediction. The Commission urged that these efforts should, when possible, contribute to the development of products that will be made available in real-time for Severe Weather Forecasting Demonstration Projects (SWFDP) in southern Africa and in the

South Pacific following EC-LXI decisions (paragraphs 3.1.26 and 3.1.29) and CBS-XIV recommendations (paragraph 11.4.1).

**5.1.2.5** The Commission noted the very early planning stages of a Heavy Rainfall RDP for the Plata River Basin in South America and urged the participation of THORPEX and the Working Group on Mesoscale Forecasting Research in the development of this project and execution of this effort. The Commission further noted that this effort benefits five Members in this region and should be considered as the basis for a subsequent regional SWFDP. The planning of this effort could coincide with a training workshop on ensemble prediction following the example of the successful THORPEX training workshop on data assimilation hosted by Argentina.

**5.1.2.6** Building upon the MAP D-PHASE and the SDS-WAS Projects (agenda item 6.3) and in view of the Report of the EC RTT and the CAS Vision Papers, the Commission encouraged the WWRP to develop plans to include research on coupled modelling (e.g., ice, flooding, air quality and ocean processes).

**5.1.2.7** The Commission appreciated the progress of the COPS (Convective and Orographically-induced Precipitation Study) RDP in southwest Germany and eastern France and considered this RDP as one example of a fruitful co-operation between academic research and NMHSs. The Commission recognized the need to further develop this co-operation to support the efficient transition from academic research to improved services and operations at NMHSs and the provision of available infrastructure at NMHSs for academic research. The Commission also encouraged those involved in COPS to organize an international workshop focused on exchanging and sharing the experience gained from the project as well as the development of enhanced relationship with other interested services.

**5.1.2.8** Both the WWRP FDPs and the SWFDP have demonstrated lasting improvements to service delivery with the WWRP FDPs, including a strong verification component and a clear quantification of the impact of these projects on NMHSs' forecast and users. The Commission recognized that these FDPs require commitment of computational, technical and financial resources, especially for high-resolution modelling and limited area ensemble prediction systems, and urged Member support of planned and future efforts particularly to benefit developing nations.

**5.1.2.9** The Commission noted the role of the JSC-WWRP in initiating and guiding MAP D-PHASE and the Beijing 08 FDPs and RDP projects and urged the JSC to continue to take a proactive role in initiating and directing RDPs and FDPs within the WWRP. The Commission requested that the benefits and lessons learned from the Beijing 2008 RDP, especially regarding verification and ensemble prediction, continue to be incorporated into the Shanghai MHEWS effort. The Commission acknowledged the leadership of the Chinese Meteorological Administration in the Beijing 2008 Olympic Games Mesoscale Ensemble Prediction Research and Development Project (RDP).

**5.1.2.10** The Commission noted the unique difficulties associated with the observational components in nowcasting and mesoscale prediction (e.g., radar quality control, international access to aerosol and radar data in real-time, need for high-resolution observations to verify and initialize models) and that for many nations, the aerosol and hydrological observations lie outside of the National Meteorological Services. The Commission encouraged Members to initiate discussions with the operators of such systems and to establish effective working relationships aimed at increasing access to data and developing activities of mutual benefit.

**5.1.2.11** The Commission noted the increasing prominence of mesoscale modeling in many facets of WWRP work and requested the JSC-WWRP and WGNE to review current coordination arrangements for mesoscale research and come up with a specific proposal for consideration by the CAS Management Group and the next meeting of the Commission.

### **5.1.3 Tropical Meteorology Research** (*agenda item 5.1.3*)

**5.1.3.1** The Commission noted that since the last CAS, the Working Group on Tropical Meteorological Research (WGTMR) and its Panels on Tropical Cyclones (WGTMR/TCP) and Monsoon (WGTMR/MP) have focused on two topics: tropical cyclones and severe weather within monsoon systems. The Commission supports this focus and highlights their contribution to disaster mitigation results in WMO.

**5.1.3.2** The Commission acknowledged the success of the WGTMR and its panels in advancing the understanding of processes related to tropical cyclones and monsoon rainfall, for contributing to improvements in the skill of tropical cyclone track forecasts, for transferring research concepts to operations and for the recent Tropical Cyclone Structure-08 Experiment that focused on the mechanisms and predictability of tropical cyclone formation, intensification, and structure change. The Commission urged the JSC-WWRP to enhance collaborations between the WGTMR and THORPEX efforts in tropical meteorology (e.g., YOTC, T-PARC, GIFS-TIGGE, AMMA) leading to research designed to improve the skill of the prediction of heavy monsoon rainfall and tropical cyclones (e.g., tracks, intensity, structure and genesis) in NWP models and that this research include efforts in observing strategies, data impacts, data assimilation and model physics. Members are also urged to support these efforts.

**5.1.3.3** The Commission thanked Members who have contributed to efforts to evaluate seasonal forecasts of tropical cyclones through contributing their forecasts to the WGTMR/TCP Website. The Commission also urged all Members who have such capability to contribute their forecasts and for the WGTMR/TCP and the Joint WWRP/WGNE Working Group on Forecast Verification Research to organize efforts to verify and assess such forecasts using a common framework. The Commission recommended that research results be subsequently communicated to the Regional Climate Outlook Forums in order to improve the utility of such predictions.

**5.1.3.4** In view of the potential benefit to Members of improved prediction of the interannual variability of tropical cyclones and severe weather within monsoon systems, the Commission requested that the WGTMR/TCP, WGTMR/MP and THORPEX collaborate with the WCRP on research designed to increase knowledge and advance prediction of the interannual variations in the number and intensity of high-impact events (see also item 7.3). Such an effort should build upon past WGTMR/TCP efforts such as the Summary Statements on Tropical Cyclones and Climate Change, the seasonal prediction Website, and on the successful International Conference on Indian Ocean Tropical Cyclones and Climate Change graciously hosted by Oman.

**5.1.3.5** The Commission noted the proposed WWRP RDP called SWICE (Southwest Indian Ocean Cyclone Experiment) is planned for 2011 in the vicinity of the La Réunion Tropical Cyclone RSMC. The Commission urged Members interested in tropical cyclone research and prediction to participate in SWICE, including providing field resources and limited area deterministic and ensemble modelling. The Commission agreed that: (i) the project should include a strong verification component; (ii) links be established between the proposed SWICE effort and the ongoing SWFDP efforts in Southern Africa, including the introduction of GIFS-TIGGE real-time tropical cyclone prediction; and (iii) planning efforts to design targeting strategies for tropical cyclones in SWICE include representatives of THORPEX who have conducted research on this topic.

**5.1.3.6** The Commission noted with appreciation the recent WWRP JSC endorsement of three archive centres proposed by the WGTMR/MP and thanked the hosts of those data centres: (i) Legacy Data Set (Colorado State University, United States); (ii) Radar Information (Nagoya University, Japan); and (iii) Monitoring and Assessment of Extreme Weather and Climate Events (BCC/EAMAC, CMA). The Commission further encouraged Members with relevant institutions to participate by providing data to these archival centres.

**5.1.3.7** The Commission acknowledged the collaborative working relationship within WMO between the Tropical Cyclone Programme (TCP) within the WMO's Weather and Disaster Risk Reduction Services Department, WWRP, and the WMO Office for Education and Training and

noted that this collaboration extends the benefits of research through capacity-building and training and strengthens the link between the WWRP and relevant regional associations. The Commission stressed the need to continue and strengthen this partnership.

**5.1.3.8** The Commission urged Members to participate in the upcoming symposium, workshops and conferences that were supported by the WGTMR/TCP and the TCP, especially the upcoming quadrennial International Workshop on Tropical Cyclones (IWTC-VII) to be held from 15–19 November 2010 hosted by the RSMC in La Réunion and Météo-France. This meeting is a critical venue for bringing tropical cyclone research and those involved in all components of the forecast system for tropical cyclone forecast systems to the same venue. It represents the first time that the workshop will be held in the Indian Ocean Basin and in Africa. Relevant Members are strongly encouraged to provide additional funding support for this meeting to allow attendance by forecasters and researchers from the developing nations.

**5.1.3.9** The Commission thanked the CMA and its institutions for strong contributions to the WGTMR including hosting the International Training Workshop on Tropical Cyclone Disaster Reduction, the 2nd International Workshop on Tropical Cyclone Landfall Processes, the 4th International Workshop on Monsoons and the Training Workshop on Operational Monsoon Research and Forecast Issues in 2007 and 2008. The Commission encouraged WMO support and Member involvement for these meeting series.

**5.1.3.10** The Commission noted the importance of nowcasting and high resolution modelling to provide adequate warnings and prediction of tropical cyclones and severe weather in monsoon systems and recommended strengthening the links between WWRP research in Nowcasting, Mesoscale Forecasting and Tropical Meteorology, to advance monitoring and prediction of heavy rainfall in monsoon systems and rapid intensity changes in tropical cyclones especially at landfall.

**5.1.3.11** The Commission acknowledged the actions of the WGTMR and its panels in publishing documents of community interest. Following the EC-LXI (paragraph 3.1.17) decision, the Commission urged a rapid conclusion of efforts to revise and update the Global Guide to Tropical Cyclone Forecasting with due consideration for the newly emerging requirements and with links to the Tropical Cyclone Forecaster's Website so as to allow operational forecasters easier access to up-to-date tools and reference materials for use in the monitoring and forecasting of tropical cyclone tracks and intensities.

#### **5.1.4 Societal and Economic Research and Applications** (*agenda item 5.1.4*)

**5.1.4.1** The Commission welcomed the recent progress toward establishing an active societal and economic research and applications (SERA) effort with a new Chair of the Working Group on SERA, an enhanced membership and a proposed partnership with the multi-sponsored international Integrated Research on Disaster Risk (IRDR) programme. The Commission strongly recommended that WMO formally establish this joint working group with IRDR with equal resources and membership contributions and requested that the chair of the SERA Working Group be a member of the IRDR Steering Committee. This partnership will benefit Members through creating a group with sufficient visibility and critical mass to provide a strong societal and economic research foundation for disaster mitigation.

**5.1.4.2** The Commission noted and accepted the priority research areas of WWRP SERA research, which are: (i) estimation of the economic and societal value of weather information; (ii) understanding and improving the use of weather information in decision making; (iii) understanding and improving the communication of weather forecast uncertainty; (iv) development of user-relevant verification tools; (v) development of decision support systems and tools; and (vi) development of effective mechanisms for weather information delivery and efficiency assessment of each delivery mechanism.

**5.1.4.3** The Commission noted that the FDP and RDP formats of the WWRP have included a societal impacts assessment. The Commission recommended a greater involvement of the SERA Working Group in the design of future FDPs and RDPs, including collaborations with the Joint

WWRP/WGNE Working Group on Verification Research, to implement, and, where necessary, develop user-relevant verification techniques for these projects.

**5.1.4.4** In view of the decisions of EC-LXI (paragraphs 3.1.28 and 3.1.31), the Commission urged the strong involvement of the SERA Working Group in the evaluation of the impacts and potential benefits of the Sand and Dust Storm Warning and Advisory Assessment System Project (SDS-WAS) in sectors where major impacts occur.

**5.1.4.5** The Commission noted that the numerous research and development issues associated with extending the benefits of weather prediction to society and recommended to the Secretary-General that any follow-up to the Madrid Conference on Secure and Sustainable Living: Social and Economic Benefits of Weather, Climate and Water Services include Technical Sessions designed under the lead of the joint SERA Working Group of WWRP and IRDR.

**5.1.4.6** Improvements in communicating predictions and their uncertainty could greatly benefit society, ecosystems and the economy and open new areas of application for NMHSs. Currently, investments in SERA research are a very small fraction of the funds spent on observational and modelling hardware for weather prediction. Thus, the Commission strongly urged Members to support the priority research activities of a proposed IRDR-WWRP SERA effort through involvement of experts, financial support of projects and open availability of data sets for research. Specifically support is asked for the following priority activities:

- (a) Development of plans for a Warning Information System "Pre-demonstration Project" which will include a GIFS-TIGGE/TIGGE-LAM evaluation component and applications derived from existing efforts (e.g., MeteoAlarm, MAP D-PHASE, the Swiss multi-hazard project called GIN, SWFDPs and other ensemble prediction system applications);
- (b) Exploration of collaborations leading to cooperation between existing disaster impact databases and the THORPEX Africa High Impact Weather Information System;
- (c) Recommending means of pursuing analysis of the benefits of Flash Flood Warning Systems based on knowledge of existing survey instrumentation and other techniques and approaches;
- (d) Development of new methods and criteria to analyse and rank natural disasters based on a new set of metrics, such as direct damage relative to the national GDP, which better quantifies the impacts of disaster on developing nations;
- (e) Identify research opportunities to make comparisons between warning thresholds/criteria defined from a meteorological and from impact/damage/risk methods within the social sciences;
- (f) Development of a new decision-making systems to determine the individual priorities of investments for optimal mitigation of adverse societal and economic effects of high-impact weather.

**5.1.4.7** The Commission noted that the establishment of an newly active SERA Working Group and WWRP research effort on these priority areas will require sufficient financial and technical support from WMO and that the Secretary-General and the Secretariat are asked to consider this point in decisions on budgeting and staffing within the WWRP (e.g., sufficient budgeting for working group activities and SERA projects, expertise in managing social science research in the hiring of relevant posts within the WWRP Secretariat staff).

## **5.1.5 Weather Modification Research** (*agenda item 5.1.5*)

**5.1.5.1** The Commission acknowledged the efforts of the WWRP Expert Team on Weather Modification and the CAS Management Group in advising and guiding Members on the state of the scientific knowledge related to weather modification practices (see paragraph 3.1.5). The Commission encouraged research on weather modification to continue and the Expert Team to include new findings in the WMO Statement and Guidelines on Weather Modification.

**5.1.5.2** The Commission invited interested Member countries to contribute to the Trust Fund for Weather Modification Research that was established at the request of Fifteenth Congress and to support WMO centres of research that will advance the practice of sound science in weather modification.

**5.1.5.3** The Commission noted that a large gap has developed over the past decades between cloud physics and chemistry researchers and the operational weather modification community. Thus, the Commission urged that this Expert Team facilitate improved linkages among weather modification, cloud physics and atmospheric chemistry communities and recommended that a proposed 10th WMO Scientific Conference and Forum on Weather Modification funded under Member contributions, both in-kind and to the Trust Fund, be designed to improve interaction between these communities to strengthen the scientific background for weather modification operations.

## **5.2 WORLD WEATHER RESEARCH PROGRAMME THORPEX ACTIVITIES** (*agenda item 5.2*)

### **5.2.1 THORPEX Predictability and Dynamical Processes** (*agenda item 5.2.1*)

**5.2.1.1** The Commission noted that THORPEX activities in the area of predictability and dynamical processes include basic research to advance knowledge of atmospheric processes associated with high impact weather and that such research is valuable to the long-term development of forecast systems. The Commission encouraged those scientific funding agencies supporting basic atmospheric research to consider funding, as priority research, THORPEX research on predictability and dynamical processes and appreciated that the goals of the Predictability and Dynamical Process Working Group include the transfer of research findings to operations through a partnership between the academic and operational communities and in this regard the Commission encouraged the THORPEX PDP Working Group to work with the GIFS-TIGGE Working Group on ensemble predictions systems to support the development of a GIFS.

**5.2.1.2** The Commission acknowledged and supported the goal of the THORPEX Predictability and Dynamical Processes Working Group to strive to identify the barriers to improving predictive skill. While noting that some barriers to improving predictive skill are inherent to atmospheric flows and cannot be reduced, the Commission encouraged efforts to strengthen the existing collaboration between this working group and the WGNE, in order to advance efforts to develop and test strategies to reduce these barriers, where possible, through lowering model error. The Commission noted that the joint WGNE and THORPEX ICSC session that took place on 3 November 2009 was an important step in strengthening this collaboration.

### **5.2.2 THORPEX Data Assimilation and Observing Systems** (*agenda item 5.2.2*)

**5.2.2.1** Noting the impact of targeted observation, the Commission recommended that the THORPEX Data Assimilation and Observing Systems Working Group sponsor the publication of a review paper on the results of observation targeting; such a paper should take into consideration the outcome of THORPEX projects (e.g., A-TREC, E-TREC, and T-PARC) and past operational activities.

**5.2.2.2** The Commission supported and encouraged Member involvement in the priority activities of the mission of the THORPEX Data Assimilation and Observing Systems Working Group which are to:

- Address data assimilation issues including the development of improved understanding of the sources and growth of errors in analyses and forecasts;
- Promote research activities that lead to a better use of observations and the understanding of their value;
- Provide input and guidance for THORPEX regional campaigns for the deployment of observations to achieve scientific objectives;

with specific contributions regarding T-PARC, AMMA and the Winter Storms Reconnaissance Program, IPY and general studies including contributions to the international efforts to optimize the

use of the current WMO Global Observing System (GOS) and to the development of well-founded strategies for the evolution of the GOS.

### **5.2.3 Field Campaigns** (*agenda item 5.2.3*)

**5.2.3.1** The Commission thanked those services, international organizations, research institutes and universities for their participation in both the Summer and Winter phases of T-PARC. The Commission specifically recognized the importance of advancements in prediction of the rapid intensification of and structural changes within tropical cyclones and the potential contributions to these areas from the Tropical Cyclone Structure and Intensity (TCS-08) campaign taking place in collaboration with T-PARC. The Commission also urged continued support of T-PARC research and the subsequent technology transfer and capacity-building efforts on the lessons learned from these campaigns, such as adaptive measurements for tropical cyclones and utilizing ensemble prediction systems to improve the skill of tropical cyclone and winter storm forecasts and the communication of these forecasts to emergency planners and the public. The Commission welcomed the plan of the Japan Meteorological Agency to organize an International Conference on Advancements in Typhoon Track Forecasts.

**5.2.3.2** The Commission welcomed plans for the 2012 THORPEX-North Atlantic Waveguide and Downstream Impact Experiment (T-NAWDEX), which will investigate the diabatic physical processes that are primarily responsible for degradation in 1–7 day forecast skill in global prediction systems and of their representation in numerical weather prediction (NWP) models. The Commission encouraged the continuation of this planning process and urged Members to support and participate in T-NAWDEX as an integral component of THORPEX.

**5.2.3.3** The Commission noted the growing links between THORPEX and HyMeX (Hydrological cycle in the Mediterranean EXperiment), lead by Météo-France, which includes an emphasis on extreme weather events (heavy precipitation and flash-flooding, strong winds and large swell, droughts, etc.) that regularly affect the Mediterranean region causing heavy damages and human loss. The Commission encouraged THORPEX involvement in HyMeX and Member involvement in this effort, including the Members in Northern Africa.

### **5.2.4 THORPEX sub-projects** (*agenda item 5.2.4*)

**5.2.4.1** The Commission acknowledged the development of the IPY-THORPEX cluster, and recommended the establishment of THORPEX Polar project as a legacy of the International Polar Year (IPY) to continue the project's work on improved understanding and prediction of high impact weather over polar regions, the impact of polar process on weather prediction, and advances in data assimilation over polar regions.

**5.2.4.2** The Commission noted the significant progress in the establishment of the Year of Tropical Convection (YOTC) project that is developing with the full support of WWRP and WCRP as a THORPEX project. Significant parts of the YOTC datasets are in place and ready for use by the YOTC and other communities. The Commission encourages funding agencies to provide the necessary resources for related research initiatives, contributing to bridging the gaps between weather and climate related research and forecasting.

**5.2.4.3** In order to prepare the appropriate databases to underpin research on monthly to seasonal forecasting, the Commission recommended that the activities of the WCRP CLIVAR Climate-System Historical Forecast Project (CHFP) and THORPEX should be coordinated and requested the THORPEX ICSC to take the appropriate action.

### **5.2.5 Ensemble Prediction: TIGGE and its Limited Area Modelling Counterpart TIGGE-LAM** (*agenda item 5.2.5*)

**5.2.5.1** Noting the early research results on the use of multi-model ensemble forecasts and, in particular, the dependency, of the gain of multi-model systems, on the component systems, parameters, forecast ranges and bias corrections applied, the Commission strongly recommended



that the GIFS-TIGGE Working Group encourage, in collaboration with the WWRP SERA Working Group, support and sponsor more research in order to establish the cost/benefits of operational multi-model systems. It noted that such research should include a strong focus on extending the lead-time of warnings of hydrometeorological disasters and other high impact weather events.

**5.2.5.2** The Commission urged participation of operational modelling centres to contribute to the TIGGE-LAM archive to enable researchers to test whether the benefits of the TIGGE approach extends to high resolution modelling.

**5.2.5.3** The Commission welcomed the recent proposal from the HEPEX (Hydrological Ensemble Prediction Experiment) to establish linkages with THORPEX. The Commission noted the natural linkages between the intent of TIGGE and the goals of HEPEX and recommended the development of a specific joint project(s) as a focal point for such collaborations.

## **5.2.6 Global Interactive Forecast System (GIFS) (agenda item 5.2.6)**

**5.2.6.1** The Commission recognized the progress of the WWRP-THORPEX programme to deliver the THORPEX Interactive Grand Global Ensemble (TIGGE) archive, to conduct research that identifies areas where forecast skill and confidence might be improved by the multi-model approach and to demonstrate the concept of a multi-centre Global Interactive Forecast System (GIFS) by delivering tropical cyclone tracks in real-time. The Commission further noted the encouragement of TIGGE activities by EC-LX and CBS-XIV, including demonstrations of the potential value of GIFS in operational forecasting aimed at reducing human suffering, mitigate costs and deliver benefits and thus recommended:

- (a) Regional, CBS, and CAS-related entities in the WMO collaborate with the THORPEX GIFS-TIGGE Working Group to plan and execute a series of GIFS Forecast Demonstration Projects (GIFS-FDPs) with special emphasis on benefiting Members in the developing world. A special meeting of the GIFS-TIGGE WG should be convened which would involve other THORPEX Working Group members, the THORPEX IPO, experts from CBS, and from the planned GIFS FDPs to discuss the way forward on the GIFS vision;
- (b) To take advantage of existing and planned activities, infrastructure and experience, wherever possible, GIFS FDPs will be carried out in conjunction with CBS regional SWFDPs (Severe Weather Forecasting Demonstration Projects), which, as demonstrated by the Southern Africa SWFDP, have an effective mechanism for cascading the benefit of new forecast systems to decision-makers in WMO Members States. In regions where they have not been established yet, the formation of SWFDPs is encouraged to take full advantage of GIFS developments;
- (c) Following the direction of EC-LX regarding the continuation of real time exchange of Tropical Cyclone (TC) track data, GIFS FDPs will first focus on tropical cyclone forecasts. The Commission encouraged the participation of the relevant TIGGE data providers, TIGGE archive centres, Tropical Cyclone Warning Centres (TCWCs) and Regional Specialized Meteorological Centres (RSMCs including RSMCs with activity specialization in Tropical Cyclones) in executing such GIFS RDPs, which will require training and the development of a common set of products;
- (d) Subsequently, GIFS FDPs should focus on improving prediction of heavy rainfall and other problems of high priority interest to the needs of Members, such as improving food security;
- (e) For the longer term, CBS and CAS experts should work with the THORPEX community to develop a way forward with the GIFS vision, including additional applications with prototype GIFS probabilistic products for high impact precipitation, wind speed, and near surface temperature forecasts that, if successful, could be transitioned into operations to benefit the international community, especially for the developing world.

### **5.2.7 GIFS Forecast Demonstration Projects (FDPs) (agenda item 5.2.7)**

**5.2.7.1** The Commission noted the success of the CBS Severe Weather Forecasting Demonstration Project (SWFDP) and the repeated encouragement of EC-LXI through paragraphs 3.1.4, 3.1.26, 3.1.29 and 3.1.31 for demonstration projects of the GIFS concept to take place in association with the SWFDP effort. The Commission noted that the joint meeting of the THORPEX GIFS-TIGGE Working Group and SWFDP Steering Group is an important step in establishing such an effort and encouraged participants in this joint meeting to develop a timetable and plan for such an effort and to present these plans to the THORPEX ICSC and the OPAG DPFS within CBS.

**5.2.7.2** The Commission was pleased to learn of the early stages of planning for a North Western Pacific Tropical Cyclone Ensemble Forecast Research Project that proposes to make use of the TIGGE tropical cyclone track forecasts in near-real time. The Commission encouraged such a project and recommended Member participation both in terms of providing data sets and becoming involved in this study to develop techniques to extract useful information from the TIGGE tropical cyclone track database. The Commission further noted the potential importance of such an effort in the subsequent development of GIFS Forecast Demonstration Projects.

**5.2.7.3** The Commission also noted the plan by KMA to provide typhoon tracks and EPSgrams for major cities of RA II region produced by ensemble forecast, in 2010 and 2011, respectively, through the KMA website, in order to support NMHSs in the field of numerical weather prediction.

### **5.2.8 THORPEX Regional Activities (agenda item 5.2.8)**

**5.2.8.1** The Commission welcomed the establishment of the five THORPEX Regional Committees and was pleased that each Regional Committee had developed broad research and implementation plans. Also, the Commission noted that the Regional Committees facilitate provision of funding, logistical and other support, planning, coordination and implementation for many THORPEX activities. The Commission encouraged Members and the WMO to work toward the implementation of these regional plans.

**5.2.8.2** The Commission noted the request of EC-LX to the Secretary-General and Members to support the efforts of THORPEX Africa to conduct research and improve both operational prediction and society's capacity to utilize weather information. The Commission thanked those Members within Africa for providing comments on the THORPEX Africa Science and Implementation Plans and for naming points of contact for participation by their NMHSs and urged other Members within Africa to act. The Commission urged Members and funding agencies within and outside of Africa to support the components of the THORPEX Africa Plan.

### **5.2.9 Summary (agenda item 5.2.9)**

**5.2.9.1** The Commission concluded by noting with appreciation the report on the THORPEX activities and plans highlighting the future development of the programme since the beginning of its implementation in 2005. The Commission expressed its thanks to the many scientists who have contributed, and continue to contribute, their expertise to the ongoing success of the programme. The Commission further noted the prominent attention, guidance and encouragement given to THORPEX by the Executive Council (EC-LVI, EC-LVII and more recently EC-LX) and urged Members and the WMO to take action on these EC decisions. The Commission was particularly pleased with the results and implications for improving predictive skill from:

- (a) The work on observation targeting;
- (b) The development of the THORPEX Interactive Grand Global Ensemble (TIGGE), which was now providing valuable data for research on ensemble prediction;
- (c) The success with the IPY-THORPEX project cluster;
- (d) The completion of the field phases for T-PARC;
- (e) The establishment of the Year of Tropical Convection (YOTC project);

- (f) The preparations for an international field experiment (the THORPEX North Atlantic Waveguide and Downstream impact Experiment – T NAWDEX) in autumn 2012 (at the same time as HYMEX) to study disturbances on the North Atlantic waveguide and their downstream impacts over Europe.

**5.2.9.2** Finally, the Commission encouraged the THORPEX ICSC to carry out its planned comprehensive independent mid-term review of the THORPEX programme.

### **5.3 ENVIRONMENTAL POLLUTION AND ATMOSPHERIC CHEMISTRY/GLOBAL ATMOSPHERE WATCH ACTIVITIES** (*agenda item 5.3*)

#### **5.3.1 General** (*agenda item 5.3.1*)

**5.3.1.1** The Commission noted that the WMO Global Atmosphere Watch (GAW) atmospheric chemistry research programme is designed to monitor and understand changes in atmospheric composition over long time periods (decades) globally. Coordinated chemical observations and modeling enable assessments of ozone depletion, global warming, changing climate, health impacts of pollutants and damage to ecosystems and as such constitute an important part of the development and implementation of international conventions to limit emissions of atmospheric pollutants and reduce risk to society.

**5.3.1.2** The Commission acknowledged with pleasure that the Integrated Global Atmospheric Chemistry Observations (IGACO) strategy is being implemented through the GAW programme, following the WMO Global Atmosphere Watch (GAW) Strategic Plan 2008–2015 (WMO/TD-No. 1384) (GAW Rep 172) as requested by CAS-XIV.

**5.3.1.3** The Commission noted that the GAW programme contributes to the Expected Results (ERs) in the WMO Strategic Plan 2008–2011 on: observing systems ER 4; disaster prevention and preparedness ER 6; provision of environmental applications and services ER 7; use for decision-making and implementation by Members and partner organizations, including Conventions ER 8; and enhanced capabilities of NMHSs in developing countries to fulfill their mandates ER 9.

**5.3.1.4** The Commission noted that a key role of GAW is the coordination of global observations and data from 26 Global Stations, 410 fully operational Regional Stations, and 81 fully operational Contributing Stations (<http://gaw.empa.ch/gawsis/>). Two new sites were designated as Global Stations since CAS-XIV in 2006 (Cape Verde and Trinidad Head, United States). The Commission recognized that in many instances measurements are made under very difficult conditions by dedicated personnel.

**5.3.1.5** The Commission agreed on the usefulness of the GAW Station Information System (GAWSIS, <http://gaw.empa.ch/gawsis/>), a system for tracking and providing information on monitoring efforts in GAW and recommended the establishment of GAWSIS as a permanent World Data Centre for Metadata within GAW with a view of becoming a DCPC for WIS. Information includes lists of stations and contacts and station reports, these include site characterization, measurement programme (including metadata and hyperlinks to data archives), contacts and bibliographic references. The Commission urged the Members that operate stations in relevant networks to make observational data available through GAW WDCs in a timely fashion and agreed with the OPAG EPAC JSC recommendation that station information for interested networks contributing to GAW should be included in GAWSIS even if the data are not available through GAW WDCs.

**5.3.1.6** The Commission recognized that the 20 year old GAW programme as documented in the GAW Strategic Plan for 2008–2015 is a mature observing system of WMO supported by a large number of Members. The Commission agreed that a sound quality management framework is embodied in GAW (calibration, measurement guidelines, audits and intercomparisons). The Commission acknowledged with thanks that the GAW World Central Facilities including QA/SACs, WCCs, CCLs and WDCs, in cooperation with GAW stations and Scientific Advisory Groups (SAGs), have contributed to the improved quality of GAW data. It urges WMO Members hosting

these centres to continue and, as needed, expand their support. GAW SIS supported by Switzerland and six World Data Centres (WDCs) kindly hosted by Canada, Japan, Germany, Norway, the Russian Federation and the United States are essential components of the GAW data management system. The Commission also acknowledged that technical reports of the GAW working groups, expert teams and many facilities are of high quality and freely accessible on-line. The Commission noted that the networking provided by many GAW activities works towards building the community. The Commission recommended that WMO-GAW continue to provide a global framework for interconnected local, regional and global issues that bridges between operations, policy and research.

**5.3.1.7** The Commission noted that there is a gap in many applications of atmospheric research and services related to total column and vertical profile observations of atmospheric composition. Recognizing that they are very difficult to obtain from satellites alone especially in the lower four kilometers of the atmosphere, the Commission endorsed an integrated approach to routine vertical profiling of atmospheric composition involving multi-platform observations (satellite, aircraft, surface in situ and remote sensing) and data assimilation using advanced atmospheric models.

**5.3.1.8** The Commission noted the increasing interest for natural allergenic species and, specifically, pollens. In direct link with air quality and health, with recognized cross-effects between pollinoses and chemical and biological atmospheric pollutants, pollens are also a concern in the context of climate change and evolution of plant geographical distributions. Pollen are subject to processes directly affected by meteorology: plant physiology leading to pollen production, release of grains, their atmospheric transport, transformations, dry and wet deposition. The Commission supported the development of observational and modelling activities and of international collaboration on this topic in the context of GAW.

### **5.3.2 Ozone depletion, Ultraviolet Radiation and the Vienna Convention (*agenda item 5.3.2*)**

**5.3.2.1** The Commission noted that the implementation plan for Integrated Global Atmospheric Chemistry Observations for ozone and UV (IGACO-Ozone/UV) was published in May 2009. The initiative started in 2006 at the Finnish Meteorological Institute (FMI) in Helsinki, which kindly hosts the IGACO-Ozone/UV Office. Several international workshops have been held under this activity. As a result of these workshops it has become apparent that the use of different ozone absorption cross sections by satellite and surface-based observational communities is an impediment to satellite validation and also might be the cause for discrepancies between different surface-based observational techniques. The Commission noted that WMO-GAW and the International Ozone Commission under IAMAS have established in 2009 an ad-hoc expert team to lead a project to standardize use of absorption cross sections in global ozone observations. The Commission urged the various communities to agree on common cross sections.

**5.3.2.2** The Commission welcomed the acknowledgement in 2007 of the GAW Dobson, Brewer and ozonesonde networks as “baseline networks” of the Global Climate Observing System (GCOS). It urged WMO Members to support these networks as WMO input to the UNFCCC and the Vienna Convention of Protection of the Ozone Layer and requested the WMO Secretariat to maintain a tool to track the fitness for purpose of the network, and report the status of the network at relevant WMO governing body meetings.

**5.3.2.3** The Commission noted that WMO continued to host the triennial joint WMO/UNEP Ozone Research Managers meeting supporting the Vienna Convention. The Commission appreciated the value of the recommendations that came out of these meetings and urged WMO to continue to work together with UNEP’s Ozone Secretariat and Members to maintain and improve the WMO-GAW ozone observing system. The Commission acknowledged the key role of the WMO Secretariat in the WMO/UNEP Scientific Assessment on Ozone Depletion, both as an organizer and in the review of the Assessment report. It urged the WMO Secretariat to continue this work and ensure that observations and research of GAW are used in these assessments.

**5.3.2.4** The Commission expressed its satisfaction with the Antarctic Ozone Bulletins, which are published each year during the Antarctic ozone hole season and asked the WMO Secretariat to produce a compilation of the development of the ozone hole in a timely manner.

**5.3.2.5** As part of the continuous efforts to improve data quality and long-term stability of the total ozone networks, data analysis workshops have been conducted in conjunction with the meetings of the Ozone SAG. Dobson and Brewer data have been compared to satellite data and several stations with data quality issues have been identified with assistance being offered to solve the problems. Also DOAS (in particular SAOZ and the INTA's instrument) and FTIR data have been compared with data from satellites, and Dobson and Brewer instruments as collaboration between GAW and NDACC. The Commission recommended that intercomparisons are continued so as to generate essential information for merging global observations.

**5.3.2.6** The Commission expressed appreciation to the Members for supporting ozone quality assurance activities including intercomparisons. Since the last Commission meeting, Dobson intercomparisons had been held for RA II in Japan, RA V in Australia, for South and Central America in Argentina and RA I in South Africa. Dobson campaigns had been held annually for RA VI in Hohenpeissenberg, also in Arosa, El Arenosillo and a Langley absolute calibration campaign at Izana. The calibration of World Primary Standard Dobson Instrument was verified during the summer of 2007. Regular Brewer intercomparisons, performed by the Regional Brewer Calibration Center for Europe, have been arranged in El Arenosillo, Spain, and in Arosa, Switzerland. ESA and NASA have supported some Brewer and Dobson campaigns (i.e., SAUNA I and II campaigns). Brewer workshops have been arranged by Canada in the United Kingdom, Republic of Korea and Italy. The Commission also noted that the Jülich Ozone Sonde Intercomparison Experiments (JOSIE) have been conducted several times since the mid-1990s and standard operating procedures (SOPs) have been formulated to be established in the GAW-ozone sounding network. The long-term sustainability of these networks is vital, therefore these activities are important not only for the intercomparison exercises but as capacity-building and for the transfer of knowledge from the participating experts to instrument operators in developing countries.

**5.3.2.7** Considering the importance of the ground-based and balloon-sonde networks as sources of long-term data sets and the value of these data for satellite validation and trend analysis to support the WMO/UNEP Scientific Assessments of Ozone Depletion, and taking note of Resolution 15 (Cg-XV), CAS strongly recommended that the Dobson, Brewer and ozonesonde networks be maintained and that the data quality be assured through world standards, regional standards, regular Dobson, Brewer and ozonesonde intercomparisons and workshops, paying attention to the homogeneity amongst moving calibration instruments. Specifically, in view of the considerable number of Brewer instruments deployed in Region II (Asia), CAS supported the GAW Ozone SAG recommendation to create a Regional Brewer calibration centre for Asia. Further, CAS regarded with interest the collaboration between JMA and NOAA on the automatization of Dobson spectrophotometers, and recommended that this work be continued so that more stations could take more frequent measurements, and appreciated the JMA's contribution of GUI-based DOBSON processing software.

**5.3.2.8** The Commission acknowledged the total ozone observations conducted by the Russian Federation using filter ozonometers (M124/M83) that cover a large area of Siberia. These instruments are regularly calibrated against the St. Petersburg Dobson, which is calibrated against the European reference instrument. The Commission urged WMO-GAW to assist the Russian Federation in replacing these filter-based ozonometers by more accurate and precise Brewer and SAOZ instruments. In the meantime, the intercomparisons between the filter ozonometers and the global Dobson network should be maintained and strengthened.

**5.3.2.9** GAW Regional Calibration Centres (RCC) for UV exist in NOAA, Boulder, Colorado (United States) and in PMOD/WRC, Davos (Switzerland). While the United States and European facilities can be linked through intercomparisons there is not yet a world calibration centre for UV measurements. The Commission recognized that expanding UV monitoring, particularly in developing regions, requires greater access to calibration facilities to maintain data quality and the

stability of long-term monitoring. Due to the lack of UV calibration centres, CAS asked Members to identify potential regional calibration centres in under-represented areas. There would then be a need for intercomparisons between existing and new calibration centres. CAS urged the Members to identify a potential world calibration centre (which could be an existing regional centre).

**5.3.2.10** The Commission noted that a special session on WMO UV SAG activities had been held at the IRS2008, International Radiation Symposium of the International Radiation Commission of ICSU. The Commission also welcomed the renewed interest of WHO in UV radiation and the intent to work together with the UV SAG.

**5.3.2.11** Realizing that in general, satellites tend to overestimate the amount of radiation reaching the ground by 10% to 20% compared to the best-calibrated ground instruments, although giving good global coverage, the Commission urged the SAG UV to continue engaging with the satellite community to improve the accuracy of the available data and to improve its accessibility to the user community.

**5.3.2.12** The impact of total ozone on UV irradiance has been studied quite extensively in the past. While there has been progress in recent years, the influence of other factors determining UV irradiance such as clouds, aerosols and albedo, are less well understood. The importance of such studies is highlighted by the fact that these other factors will very likely be affected by climate change. These changes may have a higher impact on UV than changes in ozone. Noting the current interest in vitamin D and UV and also the importance of UV in atmospheric chemistry, the Commission recognized that it is imperative to monitor and study UV in its own right and not only as connected to ozone depletion. Further analysis might include statistical investigations on UV irradiance changes, with time and location dependency. CAS recommended that new process studies on the impact of clouds, aerosols and albedo be undertaken. In addition one should also analyse existing data series to study the UV variability due to changes in clouds, aerosols and albedo.

**5.3.2.13** In view of the fact that there are many other damaging effects of UV than just erythema, and also positive effects, CAS recommended to organize a joint meeting with WHO and the International Commission on Non-Ionizing Radiation Protection (ICNIRP) for information exchange between the UV monitoring and the UV effects community where one can identify action spectra to be reported in addition to CIE erythema.

**5.3.2.14** Due to the advantages of referring to more than a single action spectrum, CAS encouraged the spectral measurement of UV, thus allowing any action spectrum to be applied to the data, now or in future years. It should be noted that with additional calibration and maintenance the Brewer instrument is capable of spectral UV irradiance measurements, albeit over a limited wavelength range. The Commission urged all Brewer users to undertake spectral UV irradiance measurements.

**5.3.2.15** Despite the fact that ozone recovery may lead to decreased UV irradiance and that the impact of climate change on UV is not well known, UV observations are terminated at many places, because the ozone issue is considered to be solved. CAS urged its Members to maintain high quality UV observations in a changing climate due to its impact on humans and living organisms in general, and for driving atmospheric chemistry. CAS also reminded the Members about the need to deposit all quality assured UV data on a regular basis in publicly available databases to enable their scientific use.

**5.3.2.16** The WMO-GAW World Ozone and UV Data Centre (WOUDC) in Canada is the main data repository for routine global stratospheric ozone and ultraviolet radiation observations. The Commission strongly recommended that this work continue and urged Environment Canada to secure the continued operation and the further development of the WOUDC and resources with a view towards integration of WOUDC into the WMO Information System as a Data Collection or Production Centre (DCPC). The Commission noted with concern the decreasing trend in the UV data submissions and urged member states to maintain their levels.

### **5.3.3 Atmospheric Chemistry and Climate Change** (*agenda item 5.3.3*)

**5.3.3.1** The Commission noted that climate change and atmospheric chemistry are closely connected and that in the GAW programme these connections are addressed through systematic and comprehensive observations and research of the chemical composition of greenhouse gases, ozone, reactive gases and aerosols in the atmosphere. While greenhouse gases provide a direct connection with climate change through changing radiative forcing, the connection between aerosols and reactive gases with climate is more complex and has numerous feedbacks. Due to their diversity and importance as air pollutants and for the sake of ease of reference, reactive gases are dealt with as a group in section 5.4, Globalization of Air Pollution.

**5.3.3.2** The Commission noted that the Global Climate Observing System (GCOS) and WMO/GAW agreed in 2005 that the “WMO/GAW Global Atmospheric CO<sub>2</sub> & CH<sub>4</sub> Monitoring Network” is a “comprehensive network” of GCOS. It recommended that GAW strive to achieve similar status for the global N<sub>2</sub>O and aerosol networks.

**5.3.3.3** The Commission recognized that climate variability and change influences atmospheric chemistry through the modification of factors that affect the life cycle (sources, transport, chemical/physical transformation and removal) of a pollutant in the atmosphere. These include temperature, surface properties, cloud cover, precipitation and boundary layer mixing properties. The Commission noted that WMO had a particular responsibility and proven ability to lead the technical analysis of how climate variability and change interact with air pollution both ways on a regional to global scale through these factors. It urged GAW to continue to work on this issue and Members to give their full support. The Commission further recognized that as Members attempt to reduce anthropogenic emissions of pollutants, air pollution may nevertheless become more resilient than expected due to climate change and population growth. The Commission agreed that a better understanding of the links that exist between climate, ecosystems and biogeochemical cycles is required.

**5.3.3.4** The Commission agreed that it is vital for Members to continue atmospheric chemistry observations, analysis and assessment related to climate change as it provides the only way of telling whether mitigation is working. It noted that there are substantial air-quality co-benefits to mitigating climate change as studies have indicated that reduction in combustion emissions of CO<sub>2</sub> in megacities will likely be accompanied by reduced emissions of primary pollutants such as NO<sub>x</sub> and particulate matter with substantial improvements in public health. However, the interactions between air quality and climate change are complex and not fully understood. Changes in pollution levels maybe gains/loses for climate, depending on whether the changes result in direct and/or indirect radiative forcings that are warming or cooling. It is therefore important for Members to integrate air-quality and climate-stabilization goals in the design of environmental policy to realize potential synergistic benefits.

**5.3.3.5** The Commission recommended to develop both greenhouse and aerosol observation networks in GAW to improve the understanding of climate and air pollution connections.

#### **Greenhouse Gases**

**5.3.3.6** Greenhouse gases (GHGs) include the main species CO<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O, as well as fluorocarbons and several minor gases. The Commission recognized that a comprehensive network in GAW for observation of GHGs and their analysis and assessment has been up and running for decades. The Commission welcomed the introduction of the annual WMO/GAW Greenhouse Gas Bulletins which report on the outcome of Members efforts through GAW networks to determine the latest trends and atmospheric burden of the most influential, long-lived greenhouse gases, carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O) and chlorofluorocarbons. The Commission recommended that the Greenhouse Gas Bulletin continue to be made available at the annual sessions of the Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC).

**5.3.3.7** The Commission recognized the importance of the work by the World Data Centre for Greenhouse Gases (WDCGG) operated by Japan and recommended that it continue. The WDCGG produces a global analysis for major greenhouse gases including CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O, which is published annually as the WDCGG Data Summary and distributed widely. This global analysis is a major contribution to the WMO Greenhouse Gas Bulletin. The Commission noted that the website of the WDCGG was largely revised in July 2007 and is constantly accessed with the data volume provided from its FTP server increasing.

**5.3.3.8** The Commission noted the effective work of the GAW GHG Scientific Advisory Group (SAG) in producing a number of documents including guidelines for measurements and technical reports on analysis methods and coordinating integrated global greenhouse gas observations, quality assurance and analyses. Because of the potential role of greenhouse gas observations in the future of emissions control and emissions trading, the quality of these measurements will be seriously scrutinized. The Commission agreed that traceable, accurate measurements will be critical to support any carbon mitigation actions. It recognized the key role played in ensuring mergeability of data by GAW/NOAA in hosting the Central Calibration Laboratories and maintaining the WMO World Reference Scales for greenhouse gases CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, as well as for CO, and in providing the World Calibration Centre for CO<sub>2</sub> focusing on round-robins. It agreed that strengthening the link to National Metrology Institutes of the Bureau of International Weights and Measures (BIPM) is important. The Commission recommended that all Members ensure that their measurements are traceable to the WMO scale, are accompanied by adequate statements of uncertainty and meet the data quality objectives that are reviewed every two years by the GAW community. The Commission noted the importance of quality assurance and control activities regarding greenhouse gases and urged Members to continue, expand and participate in them as required. The Commission welcomed the recommendation by JSC OPAG-EPAC to establish a World Calibration Centre for CO<sub>2</sub> with a mandate to conduct audits of continuous carbon dioxide observations globally in conjunction with the existing WCC for surface Ozone, Methane and Carbon Monoxide hosted by Switzerland.

**5.3.3.9** The Commission remarked that common standards are needed for halocarbons and recommended that this is arranged through WMO-GAW coordination.

**5.3.3.10** Recognizing the importance of independent verification of carbon mitigation efforts, the Commission noted that an emerging carbon tracking tool which uses atmospheric models and observations of greenhouse gases, is already being implemented in a number of regions and acknowledged the valuable contributions of members in developing this tool. The Commission urged that Members consider contributing to the development of carbon tracking tools to estimate the net exchange of carbon dioxide and other greenhouse gases between the atmosphere and Earth surface on a regional basis. Such tools will make use of atmospheric observations coordinated by GAW as input to data assimilation by inverse atmospheric models driven by analyzed winds from NWP centres (see also agenda item 8.3).

**5.3.3.11** The Commission acknowledged the Greenhouse gases (GHG) total column program performed by the Total Column Carbon Composition Observing System (TCCON), of crucial importance for the new GHG satellite-based measurement validation, and as complementary network of the surface GHG network. The Commission encourages the SAG-GHG to obtain an integration of total column ground and satellite based measurement systems with surface in-situ GHG networks.

### **Aerosols**

**5.3.3.12** The Commission recognized that atmospheric aerosols (i.e. suspended particulate matter) need to be a core component of GAW because of their importance in advancing climate change prediction, improvement of weather forecasts and reducing impact on human health and ecosystems of aerosols from air pollution, biomass burning and sand and dust. The Commission noted the efforts of WMO GAW to implement a global aerosol observation system as required by the implementation plan of GCOS. The Commission recommended that Members continue to support aerosol observation implementation to fill gaps in the global networks measuring core



variables recommended by the GAW Scientific Advisory Group for Aerosols. It further recommended to Members, the Secretariat and the SAG Aerosol to enhance the coverage, effectiveness and application of long-term aerosol measurements within GAW and with cooperating networks worldwide and to increase the amount of data, data quality and final products. The Commission urged the GAW Scientific Advisory Group for Aerosols to document protocols and recommendations concerning sampling and analytical techniques for aerosol chemistry in general, and specifically for organic compounds.

**5.3.3.13** The Commission acknowledged the efforts of the GAW SAG for Aerosols in developing coordinated networks for surface in situ aerosol chemistry, surface-based aerosol optical depth (AOD), such as AERONET, GAW-PFR and SKYNET, and the GAW Aerosol Lidar Network (GALION) for surface-based vertical profiling of aerosols. These are useful for many applications including improved weather, climate and air quality prediction. The Commission urged Members to include aerosol measurements in their observational activities and to follow WMO guidelines and data quality objectives set by GAW. It thanked Switzerland and Germany for hosting major workshops to coordinate the GAW AOD and GALION LIDAR implementation plans.

**5.3.3.14** The Commission noted that when studying aerosol impacts on climate, the largest uncertainties by far are associated with the effects of the carbonaceous aerosol. This effect on climate is mainly due to the carbonaceous aerosols that absorb and scatter solar radiation in the atmosphere. The Commission urged the Members to support the expansion of carbonaceous aerosol work in GAW.

**5.3.3.15** The Commission noted the move of the GAW World Data Centre for Aerosols (WDCA) from the Joint Research Centre of the European Commission (JRC) to the Norwegian Institute for Air Research (NILU). It thanked the JRC for excellent service and acknowledged NILU agreeing to maintain this practice.

#### **5.3.4 Globalization of Air Pollution** (*agenda item 5.3.4*)

**5.3.4.1** The Commission noted that the transport of air pollution across national, regional and continental boundaries is an important aspect of the global cycling of air pollution, including impacts on ecosystems and health. It further noted that emissions of air pollutants and related problems are increasing in developing countries. On the other hand, in countries where mitigation procedures have been in place for a long time, very clear reductions in concentrations have been observed in the past decades for several components, and developing countries can benefit from the gained experience. However, the importance of the globalization of the pollutants is increasing as for some components there are no clear signs of leveling off and the Commission agreed that these need further study and actions.

**5.3.4.2** The Commission recognized the importance of GAW participation in the activities of the UNECE Convention on Long-range Transboundary Air Pollution (CLRTAP) and in this regard noted that WMO/GAW continues to co-chair the Task Force on Measurements and Modelling (TFMM). It further noted that in the new Monitoring Strategy for EMEP, collaboration with GAW and recommendations from GAW reports are included. The UNECE CLRTAP Task Force on Hemispheric Transport of Air Pollution (TF HTAP) has initiated a comprehensive modelling study to assess the importance of intercontinental transport of air pollution. A series of Task Force meetings and workshops have taken place focusing on policy relevant science questions, taking stock of previous research and exploring specific topics related to model intercomparisons, emission inventories, and observations. The Commission recommended for GAW to continue collaboration in this activity.

**5.3.4.3** The Commission recognized that the various observational components of GAW are in different states of development. Some, such as those for stratospheric ozone and greenhouse gases, are mature with regular data collections and storage at designated data centres and public access to the data and others are less mature such as aerosols and reactive gases (VOCs, nitrogen oxides, CO, tropospheric ozone) are still in a development phase. The Commission

recommended that Members utilize the guidelines and implementation plans for the latter that are developed by WMO-GAW to move forward collectively delivering a unified global data set. The Commission also recommends that GAW assists CIMO in updating Chapter 17 of the WMO CIMO Guide to reflect the maturity of monitoring greenhouse gases.

**5.3.4.4** The Commission recommended that GAW continue and enhance its links to regional activities, such as the southeast Asian network EANET, the European network EMEP and North American networks in order to address the questions of globalization of air pollution.

### ***Precipitation Chemistry***

**5.3.4.5** The Commission recalled that one major aspect of the GAW mission is to organize, participate in and coordinate assessments of the chemical composition of the atmosphere at a global scale. In this way, GAW provides reliable scientific information for national and international policy makers and supports international conventions.

**5.3.4.6** The Commission noted that there are currently two precipitation related assessments being carried out within the GAW umbrella and recommended for this work to be finalized at a good pace. The purpose of the WMO Precipitation Chemistry Scientific Global Assessment for the period 2000–2008 is to inform the global science community of the status of precipitation chemistry and major ion deposition on both global and regional scales. The Commission noted with satisfaction that scientists from different geographical regions are participating in this work. WMO, in cooperation with the UN Group of Experts on Scientific Aspects of Marine Environmental Protection (GESAMP) is also assessing the atmospheric input of chemicals to the ocean and corresponding impacts on ocean biochemistry and climate through the WMO lead GESAMP Working Group on the Atmospheric Input of Chemicals to the Ocean (WG38). The objective of the assessment is to improve our understanding of the impacts of the atmospheric deposition of nitrogen, phosphorus and dust (iron) to the ocean.

**5.3.4.7** The Commission welcomed the rejuvenation of the World Data Centre for Precipitation Chemistry (WDC PC) which recently moved from Albany, New York and is presently being managed in collaboration with the Illinois State Water Survey, the analytical laboratory for the United States National Atmospheric Deposition Program. The Commission urged to continue with the biannual laboratory intercomparison studies, to post results of present and past intercomparison information on the WDC PC website, to post links to relevant WMO reference materials, and to work toward the establishment of a one-stop location for access to GAW precipitation chemistry data, whether via link to an established regional or national programme, or directly via the WDC PC online archive.

**5.3.4.8** The Commission encouraged the initiative that WDCPC may serve a new role in analyzing filters, as aerosol chemistry is lacking a central calibration facility. An aerosol filter survey may be addressed in the near future, with laboratory analysis in a round robin.

**5.3.4.9** Regarding global coverage, the Commission remarked that the number of official GAW precipitation chemistry measurement sites remains insufficient in South America, Africa, Asia, and Oceania. New, high quality sites have recently been established under the DEBITS (Deposition of Biogeochemically Important Trace Species) programme in each of these areas; however, the DEBITS sites remain in tenuous financial circumstances. Members should consider supporting these sites on the long-term under the GAW programme.

**5.3.4.10** The Commission recognized that in order to meet current objectives to provide adequate global precipitation chemistry data coverage:

- (a) Support for establishing and maintaining monitoring sites and laboratories in underrepresented areas is required;

- (b) Appropriate training, whether on-site or at a central location is needed. This should be coupled with a programme to conduct "expert reviews" or programme "audits" of national GAW programmes. Global alignment of methods and procedures as well as assurance of data quality poses a major challenge in developing countries, requiring special workshops and training to improve programme quality;
- (c) Funds are needed to bring poorly-performing laboratories into control through the purchase and distribution of certified reference materials. These materials should be coupled with expert visits to laboratories.

**5.3.4.11** The Commission requested Members to support the above important quality assurance activities and programme coordination with appropriate levels of funding.

### ***Reactive Gases***

**5.3.4.12** The Commission noted that the lack of coherent information related to VOC and NO<sub>xy</sub> compound concentrations is recognized as a major gap in Earth observations that urgently needs to be filled. There are strong requests from the scientific community to improve the coordination of existing monitoring efforts and to centralize data access.

**5.3.4.13** The Commission recognized the importance of NO<sub>xy</sub> measurements and requested Members to consider hosting a World Calibration Centre (WCC) for these and to organize the question of standards and a Central Calibration Laboratory (CCL) in collaboration with national metrological institutes. The Commission agreed with the recommendation of the NO<sub>xy</sub> meeting (October 2009, Germany) to focus initially on global coordination of nitric oxide (NO) and nitrogen dioxide (NO<sub>2</sub>) observations and analysis. Further, the Commission agreed that the future addition of other, equally scientifically desirable, but currently technically more difficult measurements of the reactive nitrogen (NO<sub>y</sub>) family should be supported. The Commission encouraged GAW NO<sub>xy</sub> stations to add, or continue existing, measurements of PAN, HNO<sub>3</sub>, RONO<sub>2</sub> etc. to better establish and demonstrate the capability of these measurements in the context of a global network. The expertise developed by station operators in this way should pave the way for later inclusion of these measurements, including realistic DQOs and SOPs, more formally in the GAW NO<sub>xy</sub> network in the future. The Commission noted with appreciation that the Max-Planck-Institute for Biogeochemistry Jena (Germany) is able to take over the task of a Central Calibration Laboratory (CCL) for Hydrogen (H<sub>2</sub>).

**5.3.4.14** The Commission noted that the main purpose of making measurements of VOCs in a worldwide network is their use as tracers of atmospheric emission, transport, mixing, chemistry, particle formation, scavenging and deposition. This particularly includes identifying emissions from various source types (industrial, biomass burning, etc), probing long-range transport, and quantifying chemical processing by different types of radicals (hydroxyl, nitrate radical, halogens). Knowledge of their distribution, their variation with respect to time and their correlation with other species can provide unique information on the workings of the atmosphere. Furthermore, some VOCs are known to act as precursors to aerosols, both sulphate and carbonaceous, which can play a role in global change. In fact, lack of information on the distribution of these species introduces considerable uncertainty in climate models. Recently a global flask network for a limited number of VOC species supplemented by sites where more frequent measurements are made of a wider range of species had been started based on the WMO-GAW greenhouse gas network of NOAA. The Commission urged Members to strengthen their activities in implementing VOC measurements globally as recommended by the GAW sub-group on VOCs (GAW Report No. 171) and to emphasize quality assurance/quality control activities.

**5.3.4.15** The Commission was looking forward to the publication of a review on CO in the form of a GAW report giving details of the measurement network and the best operating practice together with an overview showing trends over the last decade and a half. It further requested reports describing the status of four of the major elements of GAW reactive gases (ozone, CO, VOCs and NO<sub>xy</sub>).

## **6. RECOMMENDATIONS ON COLLABORATIVE RESEARCH AND ACTIVITIES AT THE RESEARCH-OPERATIONS INTERFACE** (*agenda item 6*)

### **6.1 WMO INTEGRATED GLOBAL OBSERVING SYSTEM/WMO INFORMATION SYSTEM AND NEAR-REAL-TIME CHEMICAL DATA DELIVERY** (*agenda item 6.1*)

**6.1.1** The Commission foresaw that the expansion of the GTS into WIS would lead to easier data discovery and data access. Through WIS, data will be accessible to a much wider community than the National Meteorological and Hydrological Services (NMHSs). The Commission agreed that chemical data delivered in NRT and assimilated using numerical weather and chemical prediction models are useful for improvement and validation of such models as well as in detecting problems with data quality. Moreover, it will enhance the delivery and quality of products such as the WMO Antarctic Ozone Bulletin.

**6.1.2** The Commission is pleased that a WIS-WIGOS Pilot Project entitled "Improvement of Dissemination of Ozone and Aerosol Observations through the WIS" (GAW-IDOA) has been approved by the EC-WG on WIGOS and WIS. IDOA aims at improving the availability of ozone (total column, profiles and surface) and aerosol (Aerosol Optical Depth (AOD) and suspended Particulate Matter (PM)) observations to the user community through WIS (noting that WIS includes the GTS) and at preparing documentation to help other communities to make their observing practices compatible. The pilot project combines activities already proposed by the CAS SAGs for Ozone and Aerosols, the CAS ET-NRT CDT, and the CBS ET-EGOS. Considering Resolution 15 (Cg-XV), the Commission urged all Members who carry out regular ozone (total and profile) and aerosol observations to support this project and to submit their data for easy access by users in near-real-time via the WMO Global Telecommunication System of the WMO Information System (GTS/WIS).

**6.1.3** The Commission recognized that for the success of WIS, it was important to consider the access to WIS of institutes outside of NMHSs. There are several agencies and institutes working with GAW that are not part of – or affiliated with – NMHSs and who are requested to submit data to the system. Vice versa, being able to acquire data for their use is very relevant for these institutes. Therefore, the Commission strongly recommended that WIS was accessible to a large community of NMHSs, partners and users. For instance, in the IDOA project (paragraph 6.1.2), the World Optical Depth Research Calibration Centre at PMOD Davos Switzerland and the Norwegian Institute for Air Research are data providers external to NMHSs and will be contacted with requests to implement or develop software for transmitting aerosol data over WIS in BUFR/CREX format. The Commission agreed that gateways that permit access for external providers and users to the GTS network need to be identified.

**6.1.4** The Commission noted that a WIS-WIGOS Pilot Project entitled "Improvement of Interoperability of GAW World Data Centres with WIS and Establishment of Prototype Services to Facilitate User Access to GAW Data" (ET-WDC PP) had been approved by the EC WG on WIGOS-WIS. The aims of this project are to:

- (a) Improve the possibilities to discover data archived at individual GAW World Data Centres (WDCs);
- (b) Improve dissemination of data archived at the WDCs beyond their designated communities;
- (c) Establish tailored services for the GAW global stations allowing them comfortable access to data and information products;

while retaining the visibility of the individual data centres. A progress report was submitted for the WIGOS steering group meeting which took place in October 2009. The Commission recommends to the data centres to continue to progress in implementing the project plan including developing the necessary functionality needed for compliance with WIS. Recognizing that several data centres

are struggling to meet existing requirements, WMO Members supporting them are encouraged to continue and, where possible, expand support for these data centres.

**6.1.5** The Commission noted that a meeting to discuss the flow of reactive gas data between GAW and the MACC project funded by the European Union and coordinated by ECMWF was held in October 2009.

**6.1.6** The Commission recognized that effective implementation, sustainment and maintenance of information and observation systems require an effective and regular review of requirements, capabilities and future planning. It noted that the Rolling Review of Requirements (RRR) process was the basis for doing this for both WIS and WIGOS. It also noted the existing documentation within the RRR database and the Statement of Guidance (SoG) for Atmospheric Chemistry was last updated in 2004 even though requirements development has continued outside the RRR process. The Commission decided to work with CBS, in particular its ET on the Evolution of the GOS, to update the RRR documentation and to develop procedures and processes to keep the RRR documentation current.

## **6.2 RESEARCH TO OPERATIONS IN NUMERICAL WEATHER PREDICTION** (*agenda item 6.2*)

**6.2.1** The Commission noted the important role of the GAW programme in coordinating atmospheric chemistry observations and process research activities that enhance Member's ability to incorporate aerosols, ozone and greenhouse gases and related environmental variables into numerical weather prediction models as well as climate models. Tasks specified in the GAW Strategic Plan and implemented through working groups and expert teams of the OPAG-EPAC (see agenda items 5.3 and 6.4) are accelerating such advances. These activities fulfill the need for near-real-time data exchange of observations of chemical variables as well as research on data assimilation and modelling that was called for in the WWRP Strategic Plan (Chapter 5.3). Joint activities between CAS and CBS such as the WIGOS GAW Pilot Project on near-real-time data delivery (see agenda item 6.1), the WMO Sand and Dust Storm Warning Advisory and Assessment System (agenda item 6.3) and IGACO-ozone are recommended by the Commission as key to the transitioning of research to operations and enhancing Members ability to delivery better forecasts, predictions and services.

**6.2.2** The Commission expressed appreciation for the co-sponsorship of the 4th WMO Workshop on The Impact of Various Observing Systems on NWP Forecasts by THORPEX and the role that THORPEX research has played in developing the Global Observing System. It requested that the CBS OPAG-IO and the THORPEX Working Group on Data Assimilation and Observing Systems (DAOS) jointly organize the 5th Workshop on the Impact of Various Observing Systems on the NWP to be held in 2012.

**6.2.3** The Commission acknowledged CBS-XIV (paragraphs 6.1.12, 6.1.13 and 6.1.33) advocating the development of strategies to operationally sustain key meteorological observing components of IPY, THORPEX and AMMA and further noted the specific call for CAS involvement in IPY aspects of this issue along with the CBS OPAG-IO, CIMO and the EC Panel of Experts on Polar Observations, Research and Services. The Commission requested that the THORPEX International Project Office to be the CAS focal point within the Secretariat for this issue and that the THORPEX DAOS Working Group continue to build stronger linkages with CBS OPAG-IO on their activities related to optimizing the future Global Observing System. The Commission further noted the focus of the THORPEX International Polar Year cluster on satellite data assimilation for enhanced polar weather and climate prediction (see agenda 5.2) and requested that the THORPEX IPY group and the Secretariat communicate results these results to operational centres.

**6.2.4** The Commission noted and concurred with the decision of CBS-XIV (paragraph 6.1.34) that encouraged NWP centres to stimulate studies to optimize observation targeting in coordination with THORPEX. It suggested that NWP centres consider participating in data impact studies from past and future THORPEX field campaigns, from operational efforts (e.g., Winter Storms

Reconnaissance Programme and for tropical cyclones) and from the adaptive use of satellite data. The Commission thanked Japan Meteorological Agency for hosting the International Conference on Advancements in Typhoon Track Forecasts in December 2009 that highlights the outcome of studies using T-PARC 2008 observations to improve operational forecasts to mitigate the impacts of tropical cyclones.

**6.2.5** The Commission noted the important linkages forged between WWRP, THORPEX and the CBS OPAG on Data-Processing and Forecasting Systems (DPFS) in the last four years. CAS-XV joined with CBS-XIV (paragraphs 6.3.2 and 6.3.53) in recommending that this linkage is maintained, particularly, to incorporate modifications to the Manual on GDPFS and the transfer of research to operations through close cooperation of: (i) THORPEX Working Group on GIFS-TIGGE; (ii) the Joint WWRP/WGNE Working Group on Forecast Verification Research (see agenda item 7.4); and (iii) the OPAG DPFS. The Commission requested that the president invite CBS to appoint a representative(s) of the OPAG DPFS to the THORPEX ICSC and to the JSC-WWRP as well as to continue sending a representative of the CBS Expert Team on Ensemble Prediction Systems ET-EPS to meetings of GIFS-TIGGE. This ensures that GIFS developments transition smoothly into operational practice.

**6.2.6** The Commission welcomed the decision of CBS-XIV (paragraph 8.14) to continue collaboration on topics of mutual interest between the WWRP WGSERA (agenda item 5.1.4) and the WMO Public Weather Service (PWS) Forum: Social and Economic Applications and Benefits of Weather, Climate, and Water Services. The Commission emphasized that this collaboration is essential to the transition of research and operations to services. It recommended that the president invite CBS to exchange representatives between WWRP WGSERA and the WMO-PWS Forum.

**6.2.7** The Commission agreed with the assessment of the JSC-WWRP (see agenda item 5.1), the EC Research Task Team (see agenda item 8.1) and EC-LXI (paragraph 3.1.31); that Forecast Demonstration Projects (FDPs) are an excellent mechanism to transfer research to operations and the documented enhancement of the ability of Members to provide better services. The Commission cited the recent WWRP FDPs (e.g., MAP D-PHASE and Beijing 08) and the CBS-led SWFDP in southern Africa as successful examples and urged an expanding emphasis on such projects in the activities of CAS. The Commission recommended that the JSCs of the CAS OPAGs and the Secretariat provide information to the CAS Management Group that allows a regular assessment of the priorities for future FDPs and that the Secretariat maintain an up-to-date account of past, on-going and planned FDPs.

**6.2.8** The Commission noted with appreciation the efforts of transition from research to operations by the WWRP including THORPEX and the potential for future transition as summarized in agenda item 11.4 of the final report of CBS-XIV related to THORPEX Africa, forecast systems, tropical cyclones (IWTC), nowcasting, FDPs, GIFS-TIGGE, TIGGE-LAM and the relationship of GIFS-TIGGE prototype projects to the CBS-led SWFDPs. The Commission specifically noted the encouragement of EC-LX, EC-LXI and CBS-XIV (paragraph 11.4.1) related to GIFS prototype projects, noted the recent progress in this area through the proposed "North Western Pacific Tropical Cyclone Ensemble Forecast Research Project" in 2010 and urged Member participation in this project.

### **6.3 SAND AND DUST STORM WARNING ADVISORY AND ASSESSMENT SYSTEM (agenda item 6.3)**

**6.3.1** The Commission welcomed the substantial progress made by WWRP, GAW and operational partners in WMO in implementing the WMO Sand and Dust Storm Warning, Advisory and Assessment System (SDS-WAS) to deliver enhanced protection of society through coordinated observations, forecasts, warning advisories and scientific assessments. It noted the development of a science and implementation plan for the project outlining the impacts of sand and dust storms and reflecting the research and operational aspects of the project. The Commission thanked China and Spain for hosting regional centres for the Nodes serving Asia and Northern Africa, Middle East and Europe, respectively. It urged Members to support regional implementation

plans being developed by regional steering groups that foster further collaboration between and within these two regional Nodes.

**6.3.2** A major strength of the SDS-WAS Project and its regional nodes is the provision of an internationally accepted framework that enhances the integration of research and operational activities. This, in turn, accelerates the improvement of observations, assimilation and modelling of sand and dust within regional and global numerical weather prediction models. The Commission recommended that SDS-WAS continue to plan, initiate and guide a broad research agenda that will improve prediction of sand and dust storms and their influence on weather and climate.

**6.3.3** The Commission accepted with thanks the review of the SDS-WAS Project implementation plan by the CBS OPAG-DPFS requested by CBS-XIV (paragraph 6.3.46) and CAS. The GDPFS Manual (WMO-No. 485) of CBS is intended to facilitate cooperation among Members to ensure adequate standardization in the good practices and procedures in operational forecasting and data processing. The Commission agreed with the OPAG-DPFS and recommended that the Secretariat appoint a small ad-hoc joint task team with representatives from the CBS OPAG-DPFS and CAS to prepare, for the consideration of management groups and EC, an amendment to the GDPFS Manual covering the various operational aspects of the SDS-WAS.

**6.3.4** The Commission welcomed the interest of Members in the Arabian Peninsula and Asia in utilizing the SDS-WAS to address their national and regional needs. It thanked the Korea Meteorological Administration for hosting a workshop in October 2009 to consult with Asian Members on implementation of coordinated observations, predictions and analyses. It recommended that the SDS-WAS project leaders and WMO Secretariat conduct consultations through workshops and other means to decide how Member needs would be best served in the Arabian Peninsula, and western or southwestern Asia. It also welcomed proposals from the Americas.

**6.3.5** The Commission recommended that SDS-WAS regional Nodes adopt common standards for data exchange formats, graphical presentation of forecasts and data exchange. The proposed adoption of the GRIB and netcdf formats of WIS by the North African, Middle East and Europe node was welcomed. The Commission endorsed the principle that both research and operational partners are able to participate in data exchange through WIS. The Commission also recommended that formal invitation letters be sent to observational and modeling partners by the Secretary-General of WMO encouraging participation in exchange of observations and forecasts in support of SDS-WAS.

**6.3.6** The Commission urged SDS-WAS to cooperate with GAW, GOS and other components of WIGOS to generate appropriate observations of sand and dust and to deliver them through WIS in a timely manner to be used for data assimilation and validation of dust forecasts and reanalyses. The Commission encouraged Members to implement core aerosol measurements as recommended by the GAW Aerosol Scientific Advisory Group (WMO/TD-No. 1178) and to assist GAW in implementing an integrated global aerosol observing system serving the needs of SDS-WAS users. CAS-XV agreed with CBS-XIV (paragraph 10.18) and recommended that research demonstration projects are used in SDS-WAS to promote the exchange of surface-based in situ and remote sensing aerosol observations (PM<sub>10</sub>, PM<sub>2.5</sub>, AOD and LIDAR).

**6.3.7** The Commission welcomed the initiative by the European Space Agency to work jointly with WMO to: (i) develop satellite datasets tailored to the specific needs of the SDS-WAS community of practice; (ii) provide these datasets, derived from existing European, United States and other available space-borne measurements, in a homogeneous and community accepted format; (iii) implement a free near real time service; and (iv) initiate in early 2010, a large ESA funded call for research proposals. It thanked ESA, the Secretariat and the SDS-WAS Centre for Northern Africa, Middle East and Europe for a successful consultation workshop 8–9 September 2009 hosted by the Centre in Barcelona. The Commission endorsed the joint activity of WMO and ESA to serve sand and dust storm users (NMHSs and partners) and recommended that Members encourage user participation in this project.

**6.3.8** The Commission requested Members to develop sand and dust forecast verification and assessment tools to evaluate model performance using near-real-time observations. It noted that China Meteorological Administration has already implemented a formal verification scheme. It urged them to interact with the Joint WWRP/WGNE Working Group on Forecast Verification Research (agenda item 7.4) and the CBS Coordination Group on Verification for the preparation of reference material on verification to be inserted in the amendment to the GDPFS Manual on SDS-WAS (paragraph 6.3.3).

**6.3.9** The Commission agreed that the success of SDS-WAS critically depends upon developing efficient mechanisms of transitioning research tools and services to operations through training and joint demonstration projects conducted in collaboration with Members and other Commissions. The Commission requested the WMO Office of Education and Training serving regional needs to work with the SDS-WAS Project on training and capacity-building. It endorsed the close collaboration of SDS-WAS with the OPAGs of CBS and activities of the Commissions for Agricultural Meteorology and Aeronautical Meteorology.

**6.3.10** The Commission gratefully acknowledged Spain/ECI for establishing a Trust Fund for building observational capacity related to SDS-WAS in the Magreb region of northern Africa. It endorsed the request of EC-LXI (paragraph 3.1.28) to the Secretary-General to assist and guide developing countries in their efforts to upgrade aerosol observations. It noted the intention of Spain with the assistance of the Regional Steering Group and WMO Secretariat to organize an SDS-WAS technical workshop for users of SDS-WAS services in Africa in 2010 or 2011 and requested Members to participate. It requested that WMO and the Secretariat consider including SDS-WAS in the technical part of the First Conference of Ministers Responsible for Meteorology in Africa: Weather, Climate and Water from a Development Perspective scheduled for Nairobi Kenya in 15–19 March 2010.

#### **6.4 URBAN-REGIONAL AIR QUALITY GURME** (*agenda item 6.4*)

**6.4.1** The GAW Urban Research Meteorology and Environment (GURME) project is addressing observational and modeling needs, capacity-building related to air quality activities, and producing air quality and related products for users. The Commission noted that GURME has established itself as a global unifying activity on air quality questions. The Commission agreed that it is, on the one hand, participating in and applying the latest research and developments in air quality, forming good collaboration between research and operational communities, and on the other hand, building capacity in developing countries, for instance through pilot projects. It also agreed that GURME provides a very useful link for local and regional activities on the global scale.

**6.4.2** The Commission noted that GURME had, jointly with COST and thus with ESF and EU, published reports on the existing off-line and on-line mesoscale meteorological and chemical transport modeling systems in Europe, an overview of tools and methods for meteorological and air pollution mesoscale model evaluation and user training and a review of the capabilities of meteorological and chemistry-transport models for describing and predicting air pollution episodes. The Commission urged for this very beneficial collaboration to continue. The Commission also noted that GURME is making connections to regional modeling studies (such as those in the Project Atmospheric Brown Clouds, ABC) and recommended to pursue additional avenues related to modeling and measurements on different scales. It also requested for GURME to participate in studies on air pollution effects on climate change and vice versa. The Commission recommended that Members develop further air quality forecasting (AQF) and dissemination skills as part of expanding and improving their service products due to the demands on NMHSs to improve the air quality-related services to decision makers and the general public. One such activity is the recently approved GURME pilot project in India to improve air quality forecasting and real time observations in support of the Commonwealth Games. The Commission also took note of the increasing emphasis on the effects of maritime emissions, and welcomed the willingness of Finnish Meteorological Institute (FMI) to develop a proposal of a GURME pilot project for this theme, building on the existing cluster of projects in the northern Europe.



**6.4.3** The GURME community is working on incorporating the use of satellite observations in Air Quality Forecasting into GURME activities. Some new techniques are being provided through pilot projects. Noting the importance of geostationary satellites for air quality applications, the Commission recommended that GURME collaborate with appropriate satellite partners and users to assess current applications worldwide.

**6.4.4** The Commission recommended that expert and training workshops should be organized in a more comprehensive manner in the WMO Regions or sub-regions in order to further the science, the research-operational interface and to make possible the expansion of air quality forecasting to countries that require this service but that lack expertise. The GURME SAG is collaborating with NOAA and Environment Canada on the establishment of the first (in a planned annual series) International Workshop on Air Quality Forecasting Research; this will be held in December 2009 in Boulder. The Commission noted that an expected outcome of this workshop will be a review of the existing top end operational air quality forecasting activities of NMHSs. If need be, a second workshop may also be organized to further this review.

**6.4.5** Noting the large proportion of excess deaths due to air pollution during heatwaves (for example, estimated at 20–38 per cent during the European heatwave of 2003), the Commission requested coordination between air quality forecasting and heat health warning systems.

**6.4.6** The Commission noted that GURME has funded developing country scientists to participate in international meetings and encouraged this to continue.

## **6.5 NOWCASTING APPLICATIONS AND SERVICES** (*agenda item 6.5*)

**6.5.1** The key link in this activity is the CBS-PWS/CAS-WWRP Joint Steering Committee on Nowcasting Applications (JONAS) which was established in 2006 to enhance the transition from research to services in nowcasting. It is co-chaired by representatives of the Working Group on Nowcasting Research of the OPAG-WWRP and of the OPAG-PWS. The Commission supported the establishment of JONAS and agreed that it fills an important gap in the advancement of operational nowcasting in NMHSs. The Commission requested that JONAS continue to be engaged in the application of nowcasting to public weather services supplementing the operational transition of nowcasting systems and services through the FDPs and training undertaken by the WWRP, but concluded that the mandate of JONAS should include measurements standards, product standards and data requirements.

**6.5.2** The Shanghai World EXPO Nowcasting Service Demonstration Project (WENS) is being executed jointly with PWS to demonstrate how nowcasting applications can enhance multi-hazard early warning services (MHEWS) during the Shanghai 2010 World EXPO (see agenda item 6.6). Noting that the many lessons learned from the Beijing 08 FDP from technical system design to communication of forecast information are being successfully transferred to WENS, the Commission recommended that an appropriate analysis report of outcomes of WENS be published that includes an assessment of the transition of Beijing 08 outcomes to WENS and documents the improvements in service delivery.

**6.5.3** Considering that the WWRP efforts on nowcasting research and its transition to operations have focused mainly on Doppler and conventional radar-based nowcasting techniques and that such radars are not readily available in least developed and developing nations, the Commission recommended that the WWRP-WGNER and JONAS have a greater focus on the inclusion of satellite-based techniques in future FDPs. It further noted that a growing emphasis on satellite-based approaches is consistent with decision of EC-LXI (paragraph 3.1.36).

**6.5.4** The Commission noted that EC-LXI (paragraph 3.1.10) “welcomed the developments in ground-based short-range and long-range lightning detection systems that have occurred in recent years, with long-range systems capable of covering areas without weather radar coverage” and “recommended that CIMO, CBS and CAS address the current availability and quality of these data so that measurements can be optimized for future applications in nowcasting and other forecast applications including the exploitation of these measurements in combination with weather radar

observations and other measurements". The Commission urged the WWRP Nowcasting Working Group to be the research focal point for this assessment within CAS.

**6.5.5** The Commission acknowledged the potential of the European Operational Programme for the Exchange of Weather Radar Data Information (OPERA) to provide a basis for international standards for the exchange of radar data and to enable their use in prediction systems. It requested that JONAS and WWRP-WGNER provide a nowcasting perspective on EC-LXI (paragraph 3.1.37) that asked that the possibilities of applying the OPERA technological concept in other regions are explored. The Commission requested that WMO JONAS and WWRP-WGNER develop jointly a response to this challenge and complete a report reviewed by the commission management groups for presentation to the Executive Council. The Commission welcomed the willingness of the Finnish Meteorological Institute (FMI) and OPERA to share the experiences in the international exchange of weather radar observations with WMO and interested member states.

**6.5.6** Since the reporting of JONAS activities to the WWRP is an important user influence on the direction of WWRP activities, the Commission requested that the activities of JONAS continue to be reported at the JSC-WWRP. Since the OPAGs CBS-PWS and CAS-WWRP also have mutual interests in the area of the WWRP SERA activity (agenda item 5.1.4), the Commission recommends that CAS invite CBS to appoint nominate a representative of the OPAG PWS to attend future JSC-WWRP meetings.

## **6.6 SHANGHAI MULTI-HAZARD EARLY WARNING SYSTEM (agenda item 6.6)**

**6.6.1** The Commission agreed that the Shanghai Multi-Hazard Early Warning System (MHEWS) project provides an excellent coordination framework for technical capacity development in forecasting of various hazards by NMHSs. Through a coordinated approach, working closely at the strategic planning and operational levels, with a number of disaster risk management agencies and sectors, MHEWS partners ensure warning and forecasting information are utilized effectively in sectoral planning, emergency preparation and response activities. The project consists of the following components:

- (a) Demonstration project on the application of nowcasting to Public Weather Service delivery;
- (b) Tropical cyclones:
  - (i) EWS for Tropical Cyclones and Marine-associated Hazards;
  - (ii) Forecast and Verification Demonstration Project;
- (c) WWRP demonstration project on mesoscale ensemble NWP;
- (d) GURME demonstration project on air pollution;
- (e) Heat and Health Warning System (HHWS) demonstration project and intercomparison;
- (f) Project for the development of the MHEWS programme governance, institutional coordination mechanisms and community preparedness.

**6.6.2** The project is to be ready for implementation and demonstration at the World EXPO 2010 to be held in Shanghai. The Commission expressed its appreciation for the development of the WMO CMA Pavilion at the EXPO and requested Members to collaborate as required with CMA in providing suitable materials for and expert assistance at the Pavilion.

**6.6.3** The Commission recognized the excellent progress of the project under the lead of RES/AER with the contribution of all the relevant WMO technical departments. It stressed the importance of the project, particularly noting that through an extensive consultation process, engaging experts from disaster risk management agencies, NMHS and other regional and international agencies, Shanghai MHEWS has been identified as one of the good practices in early warning systems, recommending that it serve as a model to the Members for applying MHEWSs.

Countries in need of technical capacity development requiring a multi-hazard approach should benefit from lessons learned in this overall project and its components.

**6.6.4** The Commission appreciated the development in the Shanghai MHEWS tropical cyclone project that proposes to include the near-real-time exchange and use of GIFS-TIGGE tropical cyclone tracks prediction in this component of the Shanghai MHEWS as a step towards implementing decisions of EC-LXI (paragraphs 3.1.26, 3.1.29, 3.1.31) regarding GIFS. The Commission concurred with efforts to conduct the proposed multi-year "North Western Pacific Tropical Cyclone Ensemble Forecast Research Project" and "Landfall Typhoon Forecast Evaluation and Assessment Demonstration Project" that are scheduled to begin in 2010. The Commission urged the THORPEX IPO and WWW/TCP to enhance the cooperation and collaboration between these projects. These projects would make the GIFS-TIGGE tropical cyclone tracks available to all Members in the NW Pacific concerned with tropical cyclone prediction. The Commission urged the WMO and Members to give high priority to the support of these projects through:

- (a) Continuing and potentially expanding the near real-time exchange of ensemble predictions of tropical cyclone tracks established for T-PARC and the implementation of a password protected access system to this data set for the members of the ESCAP/WMO Typhoon Committee;
- (b) Training for Typhoon Committee Members to be led by the WMO on the use of ensemble predictions of tropical cyclones;
- (c) Creating technological tools to support this effort including a web site so that Members can display and access these GIFS-TIGGE forecasts;
- (d) Making the lessons learned and technological tools developed feed into a future GIFS-TIGGE FDP within SWFDP on tropical cyclone prediction as recommended by the decisions of EC-LXI (e.g., paragraph 3.1.31);
- (e) Inviting international partners with appropriate capabilities to participate in a tropical cyclone prediction effort with the mesoscale deterministic and ensemble prediction systems.

**6.6.5** The Commission noted the technical and/or financial support for the planning and carrying out of the Tropical Cyclone Component of Shanghai MHEWS from the Tropical Cyclone Programme of WDRR, the WWRP and special funds for Shanghai MHEWS. The Commission recommended that this partnership continue for the development of the proposed "North Western Pacific Tropical Cyclone Ensemble Forecast Research Project" in 2010, since the project will directly contribute to the Shanghai EXPO 2010 via CMA/NMC, CMA/SMB and CMA/STI efforts.

**6.6.6** The Commission considered there may be an issue with consistency of colour schemes used in colour-coded warning products and that this may create a problem for users accessing multiple products. It also recognized this was related to existing practice with individual countries. The commission requested the CBS OPAG on Public Weather Services (PWS) to reconsider current guidance and usage and provide or update guidance on the usage of colour schemes for warning products.

**6.7 GROUP ON EARTH OBSERVATIONS LINKS TO ATMOSPHERIC RESEARCH AND ENVIRONMENT PROGRAMME ACTIVITIES** (*agenda item 6.7*)

**6.7.1** The Commission noted the following GEOSS Tasks that rely upon the leadership of WWRP, THORPEX and GAW programme activities:

- (a) Societal Benefit Area: Health – Task HE-09-02: Monitoring and Prediction Systems for Health: Sub-Task (a) Aerosol Impacts on Health and Environment: Research, Monitoring and Prediction;

- (b) Societal Benefit Area: Climate – Task CL-09-01: Environmental Information for Decision-Making, Risk Management and Adaptation: Sub-task (a) Towards Enhanced Climate, Weather, Water and Environmental Prediction;
- (c) Societal Benefit Area: Climate – Task CL-09-03: Global Carbon Observation and Analysis System: Subtask (a) Integrated Global Carbon Observation (IGCO);
- (d) Societal Benefit Area: Weather – Task WE-06-03: TIGGE and the Development of a Global Interaction Forecast System for Weather;
- (e) Societal Benefit Area: Weather – Task WE-09-01: capacity-building for High Impact Weather Prediction: Sub-task (b) Socio-economic benefits in Africa from Improved Predictions of High Impact Weather.

**6.7.2** The Commission noted with appreciation the close cooperation on these selected topics between GEO and WMO. It agreed that there is potentially great benefit in cooperation, particularly in implementation and resource mobilization for these activities that include primarily the improvement of observational networks, but also data assimilation, modeling and capacity-building. The Commission agreed that visibility and acknowledgement of WMO activities in GEO documentation is essential. The Commission urged that this close cooperation continue and urged the WMO Secretary-General to include representation from WMO research in pertinent aspects of GEO planning and WMO delegations to GEO meetings, where required.

## **6.8 CAPACITY-BUILDING** (*agenda item 6.8*)

**6.8.1** The Commission acknowledged that many Members have been and are engaging in a number of partnerships and in providing support for building capacity in the GAW, WWRP and THORPEX programmes through established operational entities and facilities. It noted that the GAW Scientific Advisory Groups (SAGs) play an important role in giving advice on actions to be taken to improve the quality and availability of observations and data. Many activities are, however, operated on an ad-hoc and opportunity basis. Thus, the Commission recognized that more resources are needed to maintain and expand the operation of observation stations, the support for the scientific use of data and modelling activities, especially in developing countries, and urged Members to sustain and enhance these activities.

**6.8.2** The Commission supported the goals of the capacity-building efforts in the GAW programme, mainly to:

- (a) Conduct GAW training and education activities in developing countries for “start-up” training and beyond including workshops, station audits/visits, intensive training at the GAW training and calibration centres, and participation in international scientific meetings appropriate for the individual country’s GAW scientific programme;
- (b) Promote twinning relationships between countries with less experienced station personnel and established atmospheric scientists, who may wish to collaborate in the measurement programme at the station, and the use of GAW station data for research.

**6.8.3** The Commission stressed that training and education are critical to the long-term success of the GAW programme to help developing/developed countries fulfil their commitment to maintain and operate Global or Regional stations and to enhance the overall scientific capacity and further expand the scientific infrastructure in the host developing countries. In this context it congratulated Germany for its support to the GAW Training and Education Centre (GAWTEC), which has become a very essential part of the capacity-building efforts of the GAW programme. With additional in-kind contributions by Swiss Empa, United States NOAA and others, as well as travel support by WMO, training and education of station personnel from GAW stations is carried out by teaching measurement techniques and data analysis twice a year for about 10 trainees per two-week session. Since the first GAWTEC training course in the summer of 2001, more than

180 trainees from 55 countries have benefited from this training. The Commission concluded that the quality and availability of data to WMO Members has been greatly enhanced through GAWTEC and recommends continued support by all sponsors.

**6.8.4** The Commission also recognized the efforts by Australia, the Czech Republic, Germany, Spain, Switzerland, and the United States for their GAW capacity-building activities and congratulated all the Members having engaged in twinning activities which are one of the most effective ways for building capacity.

**6.8.5** Capacity building, especially in developing countries, is one of the goals of GURME. The Commission recognized the considerable effort that GURME is putting in building capacity for urban air quality forecasting and management by organizing expert and training workshops and through pilot projects in selected urban regions. The Commission recommended that opportunities to collaborate with other initiatives to improve national and regional capabilities in air quality activities are pursued by the JSC OPAG-EPAC and GURME.

**6.8.6** The Commission noted that countries can advance their capabilities also through participation in the many GAW expert and specialized workshops, organized to meet Member needs such as the biennial Brewer ozone workshops, biennial WMO/IAEA Meeting of Experts on Greenhouse and Related Trace Gas Measurements that provide an international forum for discussing recent developments and improvements, as well as problems and challenges in the field of precise measurements of atmospheric trace gases. It recommended that these workshops continue to take into account the needs of developing countries.

**6.8.7** The Commission noted the many activities in GAW related to implementation that train and build capacity in developing countries including instrument relocation and twinning between more advanced and less developed partners, the provision of guidelines for the different GAW measurement variables and methodologies by expert groups through the GAW report series and the assistance provided through several trust funds targeted by Members or Parties to conventions at capacity-building in GAW. These include a trust fund established by the Parties under the Vienna Convention, one for Brewer total ozone calibration by Canada and one for aerosol and ozone instrumentation in Northern Africa by Spain. The Commission recommended that these targeted training and capacity-building activities for developing countries are continued by WMO GAW and that developed country Members consider contributing.

**6.8.8** The Commission noted the role of the WWRP in capacity-building through FDPs that transfer research concepts, tools and techniques to operations and through training workshops that build research and operational capacity, particularly in developing nations and supported this role being formalized in the WWRP Strategic Plan: 2009–2017: “To promote and conduct training courses to further the exchange of information between the research, NMHSs and user communities and to transfer research advances into operational practice among NMHSs and weather-related applications (e.g., hydrology, health and agriculture, climate and seasonal prediction services)”.

**6.8.9** The Commission acknowledged that WWRP training workshops are often conducted through partnerships between the WWRP, CBS, the Tropical Cyclone Programme of WDRR and the WMO Education and Training Department. The Commission urged Member participation and support for the ambitious schedule for future WWRP training workshops as outlined in the Strategic Plan for the Implementation of the WMO’s World Weather Research Programme (WWRP): 2009–2017 (WMO/TD No.1505) and the continuation and strengthening of the partnerships within the WMO in these future WWRP training efforts as the WWRP is primarily a research programme.

**6.8.10** The Commission urged Members and scientific funding agencies to support the THORPEX Africa project, the SDS\_WAS project, the production of an AMMA Forecasters Handbook, future FDPs (including THORPEX/CBS GIFS-FDPs within the SWFDP), the proposed North Western Pacific Tropical Cyclone Ensemble Forecast Research Project, YOTC, SWICE and other projects associated with WWRP that will build Member capacity in developing and least developed nations.

**6.8.11** The Commission appreciated the unique approach of the Joint WWRP/WGNE Working Group on Forecast Verification Research that includes publications in the scientific literature and in WMO Technical Documents, training workshops, web-based tutorial materials and a web-based software tool-box. The Commission encouraged an expansion of such approaches within CAS when appropriate as a cost effective means of capacity-building.

**6.8.12** The Commission expressed appreciation for the support from Members (both in-kind and through the Voluntary Cooperation Programme of the WMO), the involvement of WWRP and THORPEX scientists and the Working Groups and Panels of OPAG-WWRP who have recently carried out successful training workshops on the following topics: (i) verification at FMI; (ii) data assimilation in Argentina; (iii) monsoon forecasting at the CMA; (iv) nowcasting in Australia; and (v) tropical cyclones with the 6<sup>th</sup> IWTC in Costa Rica. The Commission noted with enthusiasm that the recently defined agenda of the WG SERA (see agenda item 5.1.4) will now include capacity-building efforts.

**6.8.13** The Commission supported enhanced efforts in capacity-building in respect of the utilization of seasonal and sub-seasonal forecasts, for example, down-scaling techniques to enable NMHSs to develop products and services based on forecasts from major numerical NWP centres to suit the needs of their community.

## **6.9 COLLABORATION BETWEEN THE COMMISSION FOR BASIC SYSTEMS AND THE COMMISSION FOR ATMOSPHERIC SCIENCES** (*agenda item 6.9*)

The Commission took note of and greatly appreciated the many areas of collaboration and coordination between CBS and CAS including with the THORPEX IPO. The Commission recognized the continuance and strengthening of this relationship was very important. The Commission appreciated the concurrence of this view from the president of CBS. Noting the benefits this increased coordination could bring, the Commission requests that its Management Group establish regular contact with the CBS Management Group to facilitate planning and coordination of inter-commission activities and consider the possibility of joint or overlapping meetings if and as needed.

## **7. COLLABORATIVE ACTIVITIES AT THE WEATHER-CLIMATE INTERFACE** (*agenda item 7*)

**7.0.1** The Commission expressed its appreciation at the success of collaborative efforts undertaken by the weather and climate communities, for example through the work of the WGNE, and noted the need to further enhance these efforts. In accordance with Resolution 14 of Cg-XV which, inter alia, requested the president of the Commission for Atmospheric Sciences to coordinate activities with other relevant Programmes, particularly the WCRP, the Commission requested the president of CAS to explore new opportunities for engagement with the WCRP, for example, through participation in the JSC-WCRP. The Commission also requested the Secretary-General to support and facilitate the efforts of the president of CAS to enhance collaboration between the CAS and the WCRP.

### **7.1 MODEL DEVELOPMENT AND NUMERICAL EXPERIMENTATION: WORKING GROUP ON NUMERICAL EXPERIMENTATION ACTIVITIES** (*agenda item 7.1*)

**7.1.1** The Commission congratulated WGNE on its 25th anniversary and noted with approval the role of the extensive activities of the WGNE in fostering the development of atmospheric models for use in weather prediction and climate studies. In particular, over the last four years WGNE has continued to strengthen its role in support of CAS through increasing collaboration with WWRP, notably through its involvement in the implementation of THORPEX and collaboration with WCRP. By maintaining a close relationship with operational centres, WGNE has ensured synergy between NWP research and operations thus supporting the WMO and CAS objective of transitioning research to operations. It recommended that future WGNE activities place an

emphasis on enhancing collaborations between weather, climate, water and environmental prediction research as recommended by the EC-RTT (see agenda item 8.1).

**7.1.2** The Commission noted the importance of WGNE's involvement in reviewing reanalysis and data assimilation projects, which provided the data for numerous retrospective studies and analyses of the Earth system, and in documenting systematic errors in numerical models. With regard to the latter, it is clear that the WGNE has a pre-eminent role. The Commission urged that Members support the production of reanalyses, which form the basis of numerous investigations in weather and climate, and that funding agencies place a high priority on such activities.

**7.1.3** The Commission appreciated the emphasis that WGNE had placed on documenting research activities in atmospheric and oceanic modelling and noted the valuable contribution its annual report made to the modelling community. WGNE is urged to consider in its activities the critical research regarding ocean modelling issues related to weather and climate (see agenda item 8.5).

**7.1.4** The increasing emphasis that WGNE is giving to the representation of parameterization of physical and chemical processes related to weather, climate, water and the environment in numerical models of the Earth-system is timely. The Commission noted the recommendation by the EC-RTT (see agenda item 8.1) for improving traditional parameterizations of atmospheric processes such as convection, boundary layer, clouds, precipitation and atmospheric chemistry in climate and weather models. The Commission agreed with the WGNE view that a reinvigoration and increase in activities related to parameterization research is a crucial area for numerical weather prediction and climate modelling. The Commission welcomed the initiatives that have already been taken by the climate and weather research communities to strengthen the WGNE efforts on physical parameterization by collaborating more closely with the WCRP/GEWEX parameterization study group, the WWRP Working Group on Mesoscale Weather Forecasting Research and the THORPEX Predictability and Dynamical Processes Working Group. The Commission strongly supported the proposal to hold a major international conference on parameterization for large-scale models and the preparation of a White Paper tied to such a conference. It recommended that it include the atmospheric chemistry research community in these activities as appropriate.

**7.1.5** Noting the crucial need for improved parameterization for weather prediction and climate models, the inclusion of atmospheric composition, including aerosol, (in support of air-quality forecasting as well as better weather and climate models), and the need for a "seamless" approach to modelling, the Commission decided that WGNE will need to provide leadership and advice in these areas. The Commission also agreed that WGNE should directly advise and receive advice from the JSC-WWRP, the THORPEX ICSC, and, as required, the JSC-EPAC on progress in atmospheric modelling.

**7.1.6** The Commission agreed that the combined efforts of the WGNE and the WGCM (Working Group on Climate Modelling – WCRP) are adequate to provide the overall coordination and integration of modelling activities for both WWRP and WCRP. It also agreed that the existing modelling groups within WWRP/THORPEX and WCRP can support the modelling activities that are envisioned.

## **7.2 YEAR OF TROPICAL CONVECTION** (*agenda item 7.2*)

**7.2.1** The Year of Tropical Convection (YOTC) initiative, supported by both WWRP/THORPEX and WCRP, is expected to play an important role in a comprehensive analysis and modelling approach to tropical convection that affects weather and climate on a variety of spatial and temporal scales. The Commission stressed the importance of the need to improve forecasts of tropical convection and stressed the need for the active involvement of scientists from developing countries and tropical island nations in YOTC activities. It recommended that WMO place a high priority on this joint collaborative project as key research in delivering better weather forecasts and climate predictions that are the foundation of global weather, climate water and environmental services.

**7.2.2** Since a number of WMO Members are situated in regions characterized by intense tropical convection, such as the tropical maritime areas, the Commission urged Members to participate in YOTC and to nominate scientific focal points.

**7.2.3** The Commission noted the importance of predictions of the tropical Madden-Julian Oscillation (MJO) in weather, seasonal and climate predictions and noted the past contributions of the United States CLIVAR MJO Working Group in this area. The Commission endorsed the creation of an international YOTC Task Force on the MJO with a two-year focused agenda on model simulation and forecast improvements, and assessments of MJO predictability and forecast skill, with international participation and sponsorship from both THORPEX and WCRP. The YOTC Task Force would report to the CLIVAR/AAMP within WCRP and the THORPEX ICSC within WWRP. The Commission noted that a task-focussed approach forms a useful model and urged the various Working Groups to utilise this approach when planning their activities.

**7.2.4** Finally, the Commission noted the excellent progress of the YOTC Project in completing their Science and Implementation Plans, arranging access to high resolution forecast products (at ECMWF and NCEP) and satellite products at NASA, establishing a Project Office and thanked ECMWF, NASA, NCEP, NOAA and the NSF for the strong support given to YOTC. The Commission took note of the YOTC priorities and strongly urged Members to provide the necessary financial and technical resources to implement the YOTC project.

### **7.3 SUB-SEASONAL TO SEASONAL PREDICTION** (*agenda item 7.3*)

**7.3.1** The Commission noted that there are growing requirements for operational sub-seasonal to seasonal predictions of weather, climate, water and air pollution. It agreed that an effective way to undertake the necessary research to improve predictions at these ranges was to strengthen the collaboration between the programmes of CAS particularly, WWRP and WCRP, and also the CBS, with the goal of developing a seamless approach to seasonal weather and climate prediction. The Commission also agreed that such a collaborative effort should be focussed on ensemble prediction systems (EPS), tropical convection, polar processes, surface-atmosphere interactions, coupled data assimilation and potential societal and economic benefits from improved sub-seasonal to seasonal prediction.

**7.3.2** The Commission noted that global re-analyses and historical re-forecasts are an essential resource for this field of activity. Global re-analyses are used to initialize and verify historical re-forecasts and, as such, play an essential role in assessing the skill of sub-seasonal to seasonal forecasts and guiding further research and improvement. The Commission expressed concern that global re-analysis and re-forecast projects do not receive proper attention by funding agencies and urged Members to take appropriate action to rectify this situation.

**7.3.3** Noting that:

- (a) Coordinating the research activities of the WCRP CLIVAR Climate-System Historical Forecast Project (CHFP) and the THORPEX Interactive Grand Global Ensemble (TIGGE) on sub-seasonal and seasonal predictions is timely;
- (b) Research on tropical convection is the main focus of the YOTC project which is already a collaborative WCRP/WWRP effort and more international effort;
- (c) Future re-analysis projects would provide an appropriate framework for undertaking an interdisciplinary research programme that includes, but is not limited to, research on coupled data assimilation methodologies, re-forecast applications to calibrate model output and research on verification;
- (d) It was necessary to promote a seamless approach to the application of sub-seasonal to seasonal predictions through physical and social science researchers, service providers and users and leveraging the work of existing programmes (for example, Regional Climate Outlook Forums - MERIT, HEPEX, ClimDev Africa, the Disaster Risk Reduction Programme and the Global Environmental Change and Human Health Initiative);



- (e) Sub-seasonal to seasonal forecasts should be provided in an easily accessible form for a wide community of users;
- (f) The EC-RTT report as well as the WCC-3 Conference Statement: Summary of the Expert Segment emphasized that seasonal prediction is where weather and climate research and service providers meet;

the Commission requested the JSCs of the WWRP and the WCRP and also the THORPEX ICSC to set up an appropriate collaborative structure to carry out an international research initiative on sub-seasonal to seasonal forecasting. It recommended that this is closely coordinated with the present existing CBS infrastructure for long-range forecasting (with centres producing long-range forecasts and regional climate centres) and with the future developments in WMO climate service delivery and the Global Framework for Climate Services called for in the High-Level Declaration of WCC-3.

**7.3.4** The Korean delegation informed the Commission that the Korea Meteorological Administration and the United States National Centres for Environmental Prediction (NCEP) have jointly established the WMO Lead Centre for Long-Range Forecast Multi-Model Ensemble (LC-LRFMME) to support the improvement of Long-Range Forecasts (LRF), which in turn will help reduce socio-economic losses and enhance benefits associated with seasonal variability. The main function of the LC-LRFMME is to collect and standardize data from an agreed set of GPCs and provide these high-quality forecast products to WMO members via the LC-LRFMME KMA website (<http://wmolc.org>), a single-portal data dissemination system developed to facilitate the consolidation of GPC output and inter-comparison of forecast signals from the various GPCs.

#### **7.4 JOINT WWRP/WGNE WORKING GROUP ON FORECAST VERIFICATION RESEARCH** (*agenda item 7.4*)

**7.4.1** The Commission expressed its admiration and thanks for the work carried out by the JWGFVR. The Commission noted that, in addition to the development and promotion of new verification techniques, the JWGFVR plays a valuable and continuing role in the training of weather and climate services and researchers in the use of verification techniques. In this regard, the Commission welcomed the JWGFVR publication on the verification of precipitation forecasts ("Recommendations for the Verification and Intercomparison of QPFS and PQPFS from Operational NWP Models" (Revision 2 October 2008, WMO/TD-No. 1485)). It recommended that the OPAG-WWRP support the completion of a similar publication on guidelines for the verification of cloud predictions which will enhance significantly the assessment of the accuracy of prediction of clouds in weather and climate models. Clouds and precipitation are currently amongst the least predictable atmospheric properties that are of high societal interest and closely linked to atmospheric aerosol impacts on clouds and precipitation (see WMO/IUGG book on "Aerosol Pollution Impact on Precipitation: A Scientific Review", paragraph 3.1.4).

**7.4.2** The Commission congratulated the JWGFVR on the extensive outreach programme that has been developed. In particular, the website on verification methods, EUMETCAL modules, Workshops and Tutorial sessions are valuable to research and operational users. The Commission agreed that the continuation of these workshops was desirable and supported the development of travelling tutorials which would help reach more of the community. The Commission thanked FMI for hosting the recent 4th International Workshop on Verification Methods and the associated training workshop. The Commission noted that the JWGFVR receives more requests for training workshops than can be supported and noted that increasing the number of workshops would require additional support from the WMO Office of Education and Training and transferring training modules to other groups, such as the Verification Working Group of GDPFS.

**7.4.3** The Commission acknowledged the rapid progress of the JWGFVR and WWRP researchers in the area of spatial verification methods, which are central to verifying, assessing the information content and detecting systematic errors in predictions made by high resolution (km-scale) numerical weather prediction models. The Commission requested the CBS Coordination Group on Verification to consider, with a high priority, the introduction of such

methods in the reference material provided to Members for the verification of their higher resolution forecasts.

**7.4.4** The Commission took note of the valuable support provided by the JWGFVR to Forecast Demonstration Projects (FDPs), notably MAP D-PHASE, the Beijing Olympics FDP and RDP (B08FDP and B08RDP) and the South African SWFDP. The Commission urged that this valuable support extend to future projects of Members such as future SWFDP, SNOW V-10, Shanghai MHEWS, SWICE, GIFS-TIGGE Demonstration Projects, and other activities where collaboration is noted elsewhere in these CAS documents.

**7.4.5** The Commission supported the group's plans to develop improved verification methods for high-impact weather forecasts including tropical cyclone predictions where the focus to date has been mainly on predictions of cyclone track, developing seamless verification methods in support of seamless prediction, as well as developing methods to verify forecasts of parameters of direct relevance to society, such as air quality predictions and agreed that the development of societally relevant forecast verification approaches will require close collaboration with the WWRP Societal and Economic Research and Applications Working Group.

## **8. FUTURE PROGRAMME OF WORK OF THE COMMISSION** (*agenda item 8*)

**8.0.1** The Commission extended its sincere thanks to those experts who wrote the "vision papers" for this session of CAS that were made publicly available on an open website for comment by anyone approximately three months before the meeting. It also thanked those who took the time to read and provide constructive comments that significantly contributed to the decisions of the Commission.

### **8.1 PRIORITIES IN STRENGTHENING AND PROMOTING LINKAGES BETWEEN CLIMATE, WEATHER, WATER AND ENVIRONMENTAL PREDICTION RESEARCH AND SERVICES** (*agenda item 8.1*)

**8.1.1** The Commission welcomed the report of the EC Task Team on Research Aspects of an Enhanced Climate, Weather, Water and Environmental Prediction Framework (EC-RTT) (WMO/TD-No. 1496) and noted the decisions of EC-LXI (paragraphs 8.1 to 8.9) including the suggestion that a prioritization of the twenty-nine Specific Recommendations (see [Annex I to the present report](#)) would help focus activities, collaborations and eventual funding decisions and a request that the president of CAS address these needs through broad consultation, and report to the EC Working Group on Strategic and Operational Planning and the sixty-second session of the Executive Council in June 2010. It agreed that the pre-CAS consultation was an important step in fulfilling the request of EC.

**8.1.2** Considering the need for sustainable development, the reduction of loss of life and property caused by natural disasters and other catastrophic events related to weather, climate and water, as well as safeguarding the environment and the global climate for present and future generations of humankind, and considering further the need for close cooperation with other international organizations also working in the areas of hydrology, climate and environment, the Commission endorsed the recommendations 1.1–1.10 by the EC-RTT on challenges and opportunities in research on climate, weather and environment (see Annex I to the present report), as well as the mechanisms recommended in 1.11–1.20, 2.1–2.4 and 3.1–3.5.

**8.1.3** The Commission recommended that WMO implementation priorities be based on broad criteria that capture, in order of importance, (1) WMO's mission and strategies, (2) emerging societal needs, (3) WMO Member capabilities and concerns, and (4) the feasibility of near-term accomplishments as broader goals are achieved. Further consideration should be given to the urgency, importance, cost, and potential benefit of such activities. In terms of responding to the request from EC-LXI, the Commission considered that a categorization of the specific recommendations, based on where responsibility for implementation would lie, would be a useful exercise. This analysis was based on the following categories: (a) those specific recommendations for which CAS and its partners are solely responsible for implementation; (b) those specific

recommendations that require cross-Commission collaboration for implementation; and (c) those specific recommendations that are largely directed at external agencies for implementation. The results of this categorization are shown in [Annex II to the present report](#).

**8.1.4** The Commission's view is that the priorities for the recommendations categorised under (a) (see Annex II to the present report) would be established through the normal planning processes of the Commission. It requested its president to continue the consultation process on the other categories through effective engagement with the presidents of technical commissions and presidents of the regional associations, and to deliver the results of this consultation to the EC-WG SOP.

**8.1.5** The Commission noted that the successful integration of different research communities does require some standardization of terminology and encouraged additional work in this area.

## **8.2 THE NEXT GENERATION OF REGIONAL PREDICTION SYSTEMS FOR WEATHER, WATER AND ENVIRONMENTAL APPLICATIONS** (*agenda item 8.2*)

**8.2.1** The Commission noted the growing needs in the areas of weather, water and environmental prediction in response to population and demographic trends, resource usage, health requirements and environmental changes. The Commission recognized the crucial role of limited area modelling in responding to these needs. The majority of Members have or are interested in gaining access to these models and their products. The Commission therefore noted that limited area modelling provides a wide opportunity for Member participation in research and development of next generation regional prediction systems.

**8.2.2** The Commission further noted that these models are used to predict a wide variety of high impact weather events and that the ever increasing horizontal resolution of these limited area models requires non-hydrostatic models that are convection permitting. The Commission therefore suggested research activities that include: i) optimizing observations and observing strategies; ii) data assimilation; iii) convection permitting ensembles; iv) model development including parameterization of physical processes; v) verification and predictability research to quantify the likely improvements in the prediction of a variety of high impact weather events. The Commission acknowledged that several of these research challenges are currently unmet by the WWRP Working Group on Mesoscale Forecasting Research and noted the need for increased collaboration between the Working Group on Mesoscale Forecasting Research and other relevant working groups. The Commission therefore requested that the JSC of the WWRP provide the CAS Management Group with suggestions on how to facilitate this collaboration, including potential changes to the organizational structure of the WWRP.

**8.2.3** The Commission acknowledged the great potential benefit to Members that could arise from:

- (i) Coupling and integrating when appropriate, numerical weather prediction systems with modelling systems for air quality, hydrology, oceanography and sea ice;
- (ii) Developing enhanced prediction chains where tailored products from numerical weather prediction models are applied to benefit areas such as disaster risk reduction, food security, health and ecosystems.

The Commission concluded that the development of these more comprehensive systems requires a long-term strategy that includes enhanced research activities in CAS.

**8.2.4** The Commission noted that the developments noted in 8.2.3 had already begun to take place in some operational centres. Within CAS, examples include: i) the SDS-WAS (agenda item 6.3) and GURME (agenda item 6.4) projects related to air quality; ii) the MAP-D-PHASE; iii) a proposed La Plata Basin project and collaborations with HYMEX and HEPEX for flood and water management; iv) the THORPEX-IPY cluster effort within Canada for sea ice. The Commission urged that Members support and participate in these projects and future similar activities initiated by CAS or relevant partners.

**8.2.5** The Commission noted that Members are already active in some of these areas and recommended that the JSC-WWRP and ICSC-THORPEX work with these Members and other relevant partners, such as WCRP GEWEX and CHy and, drawing from their existing experiences, to develop a comprehensive strategic vision for research on coupling meteorological/hydrological prediction models as requested in EC-RTT decision 1.5 (see Annex I to the present report). The Commission also asked the JSCs of OPAG-EPAC and OPAG-WWRP and the ICSC-THORPEX to investigate whether their long-term plans should consider research on the integration of NWP systems with prediction models for food security, energy, disaster impacts, health, ecosystem and other critical application areas. The Commission encouraged WWRP and GAW to jointly establish research activities to help determine the benefits of fully interactive versus off-line chemical transport model for air quality and weather forecasting.

**8.3 THE LEAD ROLE OF WMO IN GLOBAL PARTNERSHIPS FOR AIR QUALITY/ENVIRONMENTAL FORECASTING AND MONITORING CARBON DIOXIDE AND OTHER GREENHOUSE GASES**  
*(agenda item 8.3)*

**8.3.1** The Commission noted that changes in air pollution, climate and the biogeochemical cycles of trace constituents such as carbon and reactive nitrogen compounds, ozone and aerosols in the atmosphere give rise to environmental problems. Meteorological processes often strongly influence their severity and rate of change. The analysis and abatement of these problems requires an interdisciplinary approach both nationally and internationally. The Commission urged WMO and its partners to intensify efforts to develop appropriate partnerships across disciplines nationally and internationally to address these challenges. The Commission agreed that it was important to develop a common understanding of air pollution, its health impacts, its long range transmission and the interaction with weather and climate change.

**8.3.2** The Commission agreed that many international conventions and initiatives would benefit greatly from a common approach developed with the help of WMO and its partners nationally and internationally. These include: the WMO co-sponsored Intergovernmental Panel on Climate Change (IPCC), the United Nations Framework Convention on Climate Change (UNFCCC), the WMO-UNEP supported Vienna Convention on Protection of the Ozone Layer, the Reactive Nitrogen Initiative, the Global Earth Observation System of Systems (GEOSS), Global Monitoring for Environment and Security (GMES), the Convention on Long-range Transboundary Air Pollution (CLRTAP), the Male declaration, and the International Maritime Organization (IMO) MARPOL.

**8.3.3** The Commission endorsed the recommendation of the CAS Management Group (2008) that WMO work towards establishing an Integrated Global Carbon Observation Prediction and Assessment System, acknowledging that monitoring requirements may be forthcoming to support global emission reduction and mitigation policy, and recognizing that CO<sub>2</sub> interacts strongly with the biosphere and hydrosphere, that considerable research is necessary to support such a system, and that such research would need to be compatible with what might ultimately become operational – that is, aiming at operational implementation:

- (a) Strengthening the observing systems needed to support air quality prediction at multiple scales recognizing that near-real-time delivery of environmental data is an important component of forecasting urban and regional pollution that needs to be implemented for urban and regional observations and air quality forecasts at the national or local levels. WMO should continue to provide advice and capacity-building;
- (b) Integrating and expanding existing observing systems and validating and incorporating satellite and aircraft measurements, keeping in mind their quality assurance, to produce a global, near real time database of atmospheric CO<sub>2</sub> and other greenhouse gases in a timely manner for its analysis;
- (c) Developing and implementing an ensemble based reanalysis for research and operational applications that includes surface-atmosphere interactions;

- (d) Applying model-based systems to analysis and prediction of the transport and evolution of CO<sub>2</sub> and other greenhouse gases where appropriate. These systems should be linked to operational frameworks to insure reliable access to data, production of forecasts, and delivery of services.

**8.3.4** The Commission recommended that WMO Members, including NMHSs and their national partners in other agencies and the WMO Secretariat, play a leading role in enhancing environmental observations, predictions and service delivery through the following actions:

- (a) Strengthen the observing systems needed to support air quality prediction at multiple scales recognizing that near-real-time delivery of environmental data is an important component of forecasting urban pollution that needs to be implemented for urban observations and air quality forecasts at the national or local levels. WMO should continue to provide advice and capacity-building;
- (b) Lead a global partnership to link globally the technical work on the regional/continental long range transport of air pollution. This includes the delivery of environmental data to allow both for day-to-day assessment of the long (and very long) range transport of air pollution; hindcast analysis and scenario calculations. Near-real-time delivery of pollution related observations and the forecasting of pollution should be pursued at the international, national and local levels depending on the issue at hand;
- (c) Provide reliable, quantitative information routinely to groups striving to reduce carbon dioxide emissions through the Global Atmosphere Watch programme, which is recognized as coordinating the comprehensive greenhouse gas network of the Global Climate Observing System (GCOS), and support research to ensure the basis for a global carbon monitoring system involving observations and data assimilation in atmospheric models driven by analyzed winds from numerical weather prediction models to deduce net atmosphere/Earth surface carbon exchange and estimates of uncertainties;
- (d) Support the analysis of the reactive nitrogen cycle with a view to advise and build capacity among its Member States in order to minimize reactive nitrogen loss to waterways and to the atmosphere, while the use of reactive nitrogen fertilizer is enhanced in regions where food production is nitrogen deficient;
- (e) Take the lead in the technical analysis of how climate variability and change and air pollution interact both ways on a regional basis, and in combination on a global basis, as these are issues of immediate concern throughout the world affecting societies to an extent that is not well known but could be significant (air pollution events, floods, droughts; water supply, food supply, etc.);
- (f) Contribute to the capacity-building in individual countries of methods to estimate emissions of reactive gases and mechanisms for quality control and aggregation of country- or regional-level emissions to the global scale. Efforts should include contribution in the area of source characterization by countries with longer experience of assembling emissions databases.

**8.4 ADVANCING WEATHER, ICE AND ENVIRONMENTAL PREDICTION IN THE POLAR REGIONS: AN INTERNATIONAL POLAR YEAR LEGACY** (*agenda item 8.4*)

**8.4.1** The Commission noted that research activities of CAS will help improve weather and climate prediction in polar regions, which will benefit all Members.

**8.4.2** The Commission noted that the Executive Council Panel of Experts on Polar Observations, Research and Services decided that the design and development of polar prediction systems is an important task that will require effective collaboration across the relevant Technical Commissions along with other partners as appropriate. The Commission recommended that efforts

be made to further polar prediction for weather and climate and to extend efforts to snow, ice, carbon and ecosystem modelling and analysis.

**8.4.3** It was agreed that the successful development of polar prediction systems requires the involvement within the Commission of WWRP, including THORPEX, GAW and WCRP. The Commission also agreed that collaboration and cooperation with other WMO technical commissions and their programmes as well as WMO Member support is essential.

**8.4.4** As important steps forward in the polar analysis and prediction, the Commission noted in particular:

- (i) The success of the THORPEX IPY cluster including a high-resolution sea-ice modelling system in Canada;
- (ii) The success of the JCOMM IPY Ice Logistics Portal;
- (iii) The European GMES Marine Core service and its polar prediction and sea ice information provision services;
- (iv) The scientific and operational advances in satellite data assimilation.

It agreed, given the scarcity of in-situ observations in the polar regions, that these achievements will result in improvements in numerical weather prediction, the accuracy of the climate record and improvements in other modelling systems that will use atmospheric and surface fields in their initial conditions.

**8.4.5** The Commission concurred with the Executive Council Panel of Experts on Polar Observations, Research and Services on the requirement for effective collaboration and therefore recommended that any efforts to develop a future prediction system include outcomes from the IPY-THORPEX cluster of projects, and from the planned THORPEX Legacy Project.

**8.4.6** The Commission recommended support by Members of the concept of the International Polar Decade with the following main tasks in mind:

- (a) Long-term integrated monitoring of changes in the physical, chemical and biological state of polar regions;
- (b) Study of large-scale and local changes in the environment of polar regions and their role in global climate processes;
- (c) Improvement in the predictions of severe and high-impact events in polar regions, and the development and establishment of systems of hydrometeorological safety for population and territories.

## **8.5 OCEAN PREDICTION ISSUES RELATED TO WEATHER AND CLIMATE** (*agenda item 8.5*)

**8.5.1** The Commission recognized the importance of ocean prediction issues and acknowledged the important contribution that the oceans make to the predictability of both weather and climate. However, it was noted that considerable work remains to be done in order to fully capitalize on this potential through the ongoing improvement of operational ocean data assimilation and prediction systems, and the development of fully coupled (atmosphere-ice-ocean) prediction systems.

**8.5.2** The Commission welcomed developments by the ocean, atmospheric and climate science communities in regional coupled prediction and noted the strong link to the matters discussed under 8.2. The Commission noted that existing activities such as YOTC, T-PARC and TCS-08 are ongoing and relevant.

**8.5.3** The Commission recognized the progress made in ocean data assimilation, ocean observing systems and ocean prediction more generally, including scientific studies on ocean predictability. The Commission further recognized that close collaboration with WCRP is essential on matters related to coupled ocean-atmosphere climate analysis and prediction as much relevant expertise is contained therein. The Commission welcomed the proposed sub-seasonal to seasonal prediction project which will involve both WCRP and WWRP including THORPEX.

**8.5.4** The Commission further recognized the lead role of the GODAE OceanView science team in ocean prediction activities and welcomed the intent to co-ordinate work related to weather and climate prediction, and urged all relevant working groups under the OPAG-WWRP to identify opportunities for productive collaboration.

## **9. WMO LONG-TERM PLANNING RELEVANT TO THE COMMISSION** (*agenda item 9*)

### **9.1 COMMISSION MANDATE AND STRUCTURE** (*agenda item 9.1*)

**9.1.1** The Commission noted that revised Terms of Reference of CAS-XV had been recommended to the Executive Council (*agenda item 4*) to take into account progress in the Commission and changes in WMO requested by Cg-XV. It agreed that the implementation of Open Programme Area Groups by CAS-XIV that created two OPAGs, one for the World Weather Research Programme and one for Environmental Pollution and Atmospheric Chemistry, with a CAS Management Group had been successful and decided that this structure be retained. The Commission adopted [Resolution 1 \(CAS-XV\) – Working structure of the Commission for Atmospheric Sciences](#), and [Resolution 2 \(CAS-XV\) – Commission for Atmospheric Sciences Management Group](#). It noted the governing mechanisms for THORPEX as previously decided by Congress, the Executive Council and CAS-XV.

**9.1.2** Noting the intention of the Executive Council (EC-LXI, paragraphs 8.17 to 8.19) to review the effectiveness of technical commissions and in particular, an option for a change in the format of Commission meetings proposed by the Secretariat to EC “that would see the technical commissions meet together at an eight-day, joint technical conference/intergovernmental meeting held every second (even) year. This joint technical commission meeting would have two components: (1) an intergovernmental component of two days where the work of the technical commissions is organized and elections for officers confirmed; and, (2) up to six days of a scientific/technical component where academia, operations and industry could meet and work together, and the management groups of the various technical commissions could meet to coordinate their work”. The Commission recommended that the president, vice-president and the Management Group review this option as well as other options in the reform of Commissions and in particular, the functioning of CAS and offer WMO guidance as appropriate. The Commission noted that Commission reform is a long process requiring Congress approval and broad consensus amongst Members. It therefore requested the president and the Management Group to report progress at the next session of CAS.

**9.1.3** The Commission requested that in the future the leadership positions of the Commission should be agreed at the Session as appropriate. It reinforced the underlying principle that the membership of CAS bodies should be experts in the relevant field and the overall membership should take due account of geographical representation and gender equity and attempt whenever possible to ensure rotation of participation among the Members of each region. It also requested the Secretariat to monitor and report on this aspect at sessions of the Commission.

**9.1.4** The Commission noted the several instances where changed terms of reference were brought to the session without a clear documentation of the background and purpose for the proposed changes. The Commission agreed that, in future, all proposed changes to the terms of reference of the Commission and its working bodies be accompanied by documentation that clearly articulates the changes that are being proposed, the objective of each change, and the



desired outcome in terms of the operation of the Commission and its programme areas. A template should be prepared by the Secretariat for this purpose.

## **9.2 WMO STRATEGIC PLAN 2012–2015 (agenda item 9.2)**

**9.2.1** The Commission noted that WMO has adopted the Results-based Management approach and that the Strategic Plan, the WMO Operating Plan as well as Monitoring and Evaluation are an integral part thereof. It further noted that EC-LX and EC-LXI had endorsed the guiding principles and the schedule for delivering the draft WMO Strategic Plan for the period 2012–2015 by April 2010.

**9.2.2** The Commission recalled Resolution 11 (EC-LX) which, inter alia, recognized the needs for links between the WMO Strategic Plan, Regional Strategic Plans and National (Members') Strategic Plans, and urged Commissions to ensure their active and timely engagement in the preparatory process of the next WMO Strategic Plan and WMO Operating Plan.

**9.2.3** The Commission agreed with the recommendations by the sixty-first session of the Executive Council with regard to the overall structure of the next Strategic Plan based on a set of Global Societal Needs (GSN). It also supported the use of the "results chain", i.e. Strategic Thrusts (ST) -> Expected Results (ER) -> Key Outcomes (KO) -> Deliverables -> Activities, as the structure of the strategic planning process.

**9.2.4** The Commission endorsed the recommendation of EC-LXI to involve regional associations and technical commissions in the development of Expected Results and Key Performance Indicators, Key Outcomes and a manageable number of related performance measurement parameters and to ensure that these are based on Members' needs and adequately reflect the programme areas of the Organization. Such involvement would also facilitate the establishment of baselines and realistic target setting. Noting the plan of the Secretariat to deliver the first complete draft of the Strategic Plan and Operating Plan by December 2009, the Commission requested the newly elected president and Management Group to review the plan in early 2010 as feedback to the second draft.

## **9.3 MONITORING AND EVALUATION OF COMMISSION FOR ATMOSPHERIC SCIENCES ACTIVITIES (agenda item 9.3)**

**9.3.1** Noting the successful completion of strategic plans of implementation for the Global Atmosphere Watch programme and for the World Weather Research Programme including the THORPEX programme, the Commission agreed that there was now a sound basis for managing, coordinating and evaluating activities within programmes, between these programmes and between the other major WMO co-sponsored research programme, the WCRP. It requested that the CAS Management Group, the JSC of GAW, the JSC of WWRP and the ICSC of THORPEX use these implementation plans to support the WMO Strategic Plan and assist the WMO Secretariat to use the Results-based Management System to effectively report progress to Members through the Executive Council and Congress. The Commission requested the president to bring forward a paper for consideration at the next Commission session that shows the Commission plans in the context of the overall WMO plans, including performance indicators.

**9.3.2** The Commission noted that a periodic review by an expert panel is common for major international research programmes. The Commission requested the president of CAS to present options for any review to EC-LXII. The Commission further noted that these options should include inter alia, draft Terms of Reference for any review, the proposed funding of the review mechanisms and the proposed timeline of the review.

## **9.4 REVIEW OF PREVIOUS RESOLUTIONS AND RECOMMENDATIONS OF THE COMMISSION AND OF RELEVANT EXECUTIVE COUNCIL RESOLUTIONS (agenda item 9.4)**

The Commission reviewed the resolutions and recommendations adopted at its previous session which were still in force, as well as those of the Executive Council related to



CAS activities, Accordingly, the decisions of the present session were recorded in [Resolution 3 \(CAS-XV\) – Review of previous resolutions and recommendations of the Commission](#) and [Recommendation 2 \(CAS-XV\) – Review of resolutions of the Executive Council relevant to the fields of responsibility of the Commission for Atmospheric Sciences](#).

## **10. ELECTION OF OFFICERS** (*agenda item 10*)

The Commission elected Dr Michel Béland (Canada) as president and Dr Tetsuo Nakazawa (Japan) as vice-president of the Commission for Atmospheric Sciences.

## **11. THE COMMISSION AND GENDER** (*agenda item 11*)

### **Participation of women in the work of the Commission**

**11.1** The Commission acknowledged the figures on the participation of women in the working bodies of the Commission provided by the WMO Secretariat and noted that their proportional representation lags behind that of the professional personnel of the WMO Secretariat.

**11.2** The Commission noted Resolution 34 (Cg-XV) on Gender Mainstreaming of the Fifteenth World Meteorological Congress, which calls for Members to adopt and actively implement the WMO Policy on Gender Mainstreaming as a tool to enable them to render sufficient focus on the efforts of ensuring gender equality. It further noted Resolution 6 (EC-LIX), establishing the Executive Council Panel of Experts on Gender Mainstreaming and that this Panel was to meet for the first time in November 2009. The Commission recalled Resolution 1 (CAS-XIV) on Participation of Women in the Work of the Commission and, recognizing that these efforts need to be renewed with new initiatives, adopted [Resolution 4 \(CAS-XV\) – Participation of women in the work of the Commission](#). The Commission designated Dr Marianne Diop-Kane as the CAS focal point for gender issues.

## **12. DATE AND PLACE OF THE SIXTEENTH SESSION** (*agenda item 12*)

The Commission noted with appreciation that the delegates from Egypt, Brazil and Turkey had, on behalf of their Governments, extended invitations to WMO to host the sixteenth session of CAS to be held in 2013. The Commission also noted that the date and place of its sixteenth session would be determined in accordance with Regulation 186.

## **13. CLOSURE OF THE SESSION** (*agenda item 13*)

**13.1** The Assistant Secretary-General thanked the Korea Meteorological Administration for hosting the Commission session and for the kind hospitality extended to participants. He also thanked the Commission president for his leadership of the meeting and congratulated him on his re-election as president of CAS, and committed the Secretariat to working in close collaboration with the president and the CAS Management Group in furthering the aims of the Commission and in the achievement of the tasks the Commission had set itself for the next four years. The Australian delegation congratulated the meeting on its achievements during the session and based on discussions with other delegations called attention to six areas in which the Commission should be setting specific goals within the context of the Results-Based Management: (1) Implementation and successful completion of the Year of the Tropical Convection project; (2) Extension of capacity-building programmes to the developing countries showing real evidence of progress and achievement; (3) Elevation of the JSC-WWRP to a status of international respect and recognition, noting that the changes in the terms of reference and the proposed review will assist in this regard; (4) Evidence of real progress from the implementation of a joint strategy in hydrometeorology that cuts across relevant programmes of this and other Commissions; (5) Implementation of a comprehensive initiative in air quality involving all programme areas of the Commission and

including regional aspects; (6) Evidence of progress in strengthening the governance arrangements of the Commission, particularly in relation to broader participation and gender equity and the preparation of plans that include expected results and performance indicators for consideration at the next session.

**13.2** In his closing address, the president of the Commission thanked all those who had contributed to the successful completion of the work of the session, in particular the delegates, and the Government of the Republic of Korea and the Korea Meteorological Administration and its Head, Dr Chun Byung-Seong, for the excellent arrangements and facilities made available to the session, as well as the staff of both the WMO and the local Secretariats, including the interpreters, translators and those producing the documents behind the scenes. He congratulated Dr Tetsuo Nakazawa (Japan) as vice-president of the Commission for the next intersessional period. He also congratulated the new Chairs of OPAGs and experts and wished them the very best.

**13.3** The fifteenth session of the Commission for Atmospheric Sciences closed at 11.48 a.m. on 25 November 2009.

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# RESOLUTIONS ADOPTED BY THE SESSION

## Resolution 1 (CAS-XV)

### WORKING STRUCTURE OF THE COMMISSION FOR ATMOSPHERIC SCIENCES

THE COMMISSION FOR ATMOSPHERIC SCIENCES,

**Considering** that there is a continuing need to:

- (1) Determine the requirements of WMO Members and transfer knowledge, technologies and advice to them concerning atmospheric science issues,
- (2) Conduct research in atmospheric and related sciences to advance understanding and predictability of the Earth system relevant to WMO Members,
- (3) Meet the requirements of environmental security and environmental conventions,
- (4) Coordinate the international aspects of the activities of the Commission with relevant scientific bodies,
- (5) Standardize functions, constants, terminology and bibliographic practices applicable to the atmospheric sciences,
- (6) Support research on the policy and socio-economic impacts of advances in understanding of atmospheric sciences,

**Decides:**

- (1) To establish:
  - (a) The Open Programme Area Group on the World Weather Research Programme (OPAG-WWRP), which has the responsibility for the implementation of all Commission activities related to weather research and development;
  - (b) The Open Programme Area Group on Environmental Pollution and Atmospheric Chemistry (OPAG-EPAC), which has the responsibility for the implementation of all Commission activities related to atmospheric chemistry, including the Global Atmosphere Watch programme;
- (2) To request:
  - (a) Each OPAG to develop contributions to the WMO Disaster Risk Reduction Programme;
  - (b) Each OPAG to contribute to the development and implementation of the WMO Integrated Global Observing System and to coordinate their activities with the WMO Space Programme, other WMO and jointly sponsored programmes, and with the Group on Earth Observations developing the Global Earth Observation System of Systems, in accordance with the agreed work programme of the Commission;
  - (c) Each OPAG to contribute to the development and implementation of the WMO Information System and to coordinate with the Intercommission Coordination Group on the WMO Information System;
  - (d) Each OPAG to contribute to the development and implementation of societal and economic applications research related to weather, climate, environmental pollution and atmospheric chemistry;
  - (e) Each OPAG to take into consideration Resolution 4 (CAS-XV) – Participation of women in the work of the Commission;

- (3) To select, in accordance with Regulation 32 of the General Regulations:
- (a) Gilbert Brunet (Canada) as chair of the OPAG on the World Weather Research Programme and chair of the Joint Scientific Committee of OPAG-WWRP;
  - (b) Øystein Hov (Norway) as chair of the OPAG on Environmental Pollution and Atmospheric Chemistry (and chair of the Joint Scientific Committee of OPAG-EPAC);
- (4) To retain the working structure as established by the Commission at its fourteenth session, with terms of reference of working groups as given in the *Abridged Final Report with Resolutions and Recommendations of the Fourteenth Session of the Commission for Atmospheric Sciences* (WMO-No.1002), Annex II, with the exception of the terms of reference of the Joint Scientific Committee of OPAG-WWRP, which are given in the annex to this resolution, and the following changes in name:
- (a) The Working Group on Mesoscale Weather Forecasting, to be renamed the Working Group on Mesoscale Forecasting Research;
  - (b) The Joint Working Group on Verification, to be renamed the Joint WWRP/WGNE Working Group on Forecast Verification Research;
  - (c) The Working Group on Nowcasting, to be renamed the Working Group on Nowcasting Research;
  - (d) The Working Group on Societal and Economic Applications, to be renamed the Working Group on Societal and Economic Research and Applications;
  - (e) The OPAG-EPAC Joint Scientific Steering Committee, to be renamed the Joint Scientific Committee (JSC) of OPAG-EPAC;

**Requests** the chairs of the OPAGs:

- (1) To act upon matters referred to the OPAG by the president of the Commission;
- (2) To prepare and submit a report to the CAS Management Group and the Commission no later than three months prior to their sessions;
- (3) To advise the president in bringing forward a paper for consideration by the Commission at its next session that shows the plans of the Commission in the context of the overall WMO Plans, including performance indicators;
- (4) To advise the president in selecting, as appropriate, chairs and members of the working structure, on the advice of the chairs of the Joint Scientific Committees when relevant, taking into account technical expertise, gender and geographical balance;

**Authorizes** the president to select, in accordance with Regulation 32 of the General Regulations, chairs of the working structure of the Commission, as appropriate.

### **Annex to Resolution 1 (CAS-XV)**

#### **TERMS OF REFERENCE OF THE JOINT SCIENTIFIC COMMITTEE OF THE OPEN PROGRAMME AREA GROUP ON THE WORLD WEATHER RESEARCH PROGRAMME**

The Joint Scientific Committee (JSC) has the following terms of reference:

- (a) To provide the overall scientific guidance for the World Weather Research Programme (WWRP), including The Observing System Research and Predictability Experiment (THORPEX);

- (b) To develop a strategic science and implementation plan for WWRP and a work programme aligned with the WMO strategic planning process;
- (c) To review and assess, in close coordination with the Open Programme Area Group on Environmental Pollution and Atmospheric Chemistry (OPAG-EPAC), the societal and economic component of WWRP and contribute to other WMO societal and economic research and application-related activities;
- (d) To review and assess the development of all elements of WWRP, formulate recommendations to guide further actions and report on the progress of the programme to the president of the Commission for Atmospheric Sciences;
- (e) To facilitate, coordinate, prioritize and focus on weather research and development activities, which are planned and implemented through the project committees and working groups, to meet the objectives of the Commission;
- (f) To facilitate the exchange of information among scientists participating in the programme and relevant scientific institutions and agencies, at the national and international levels;
- (g) To collaborate, as appropriate, with OPAG-EPAC, the Commission for Basic Systems and other technical commissions, relevant groups of the JSC/World Climate Research Programme (WCRP) and the WCRP projects committees, academia, users of forecast products and other partners;
- (h) To delegate to each working group and expert team, as required, the responsibility to promote the timely exchange of information, data and new knowledge through publications, workshops and meetings.

The Joint Scientific Committee of OPAG-WWRP shall consist of up to ten scientists selected for their scientific knowledge, capability and breadth of vision. The members of the Committee should be drawn to ensure geographical representation and an appropriate gender balance. The chairs of the working groups and expert teams of WWRP including THORPEX are ex-officio members of the Joint Scientific Committee. The members of the Committee are appointed by the Commission or, in the absence of a decision by the Commission, by the president of the Commission upon recommendation by the JSC chair, after consideration of nominations made by the Members of the Commission.

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## **Resolution 2 (CAS-XV)**

### **COMMISSION FOR ATMOSPHERIC SCIENCES MANAGEMENT GROUP**

THE COMMISSION FOR ATMOSPHERIC SCIENCES,

**Noting:**

- (1) The views of the Sixth World Meteorological Congress on retaining the system of advisory bodies to provide advice to presidents of technical commissions,
- (2) The future policies, strategy, objectives and outline plans of the Commission for Atmospheric Sciences adopted by the Fifteenth World Meteorological Congress,
- (3) Resolution 1 (CAS-XV) — Working structure of the Commission for Atmospheric Sciences,

**Recognizing:**

- (1) That the effectiveness of the Commission depends to a large extent on the effective management of its activities and coordination of cross-cutting aspects of the programme areas between sessions,
- (2) That the Management Group will be required to ensure the integration of the programme areas, evaluate the progress achieved, coordinate strategic planning and decide on any necessary adjustments to the working structure during the intersessional period,

**Decides:**

- (1) To establish the CAS Management Group to provide the president with appropriate and timely advice to ensure that the Commission can respond effectively, following the terms of reference given below:
  - (a) To provide management oversight of the work of the Commission, as undertaken through the Open Programme Area Groups (OPAGs) and associated primary scientific and expert groups and rapporteurs;
  - (b) To review the short- and long-term strategic planning and work programmes of the Commission and manage and coordinate their adoption and implementation;
  - (c) To maintain overall responsibility for ensuring the excellence, relevance and impact of the work of the Commission and the transfer of research results, techniques and information between Members in the fields of atmospheric and related sciences, including environmental aspects;
  - (d) To review the internal structure and working methods of the Commission, including its relationship with other bodies, both inside and outside WMO, and to develop proposals for more effective modes and substructures, where appropriate;
  - (e) To be the focal point for formulating the contributions to the relevant elements of the WMO strategic planning process and for communication on scientific matters of relevance to the Commission;
  - (f) To establish the membership of working bodies of each OPAG, as appropriate, upon the recommendation of the OPAG chair;
- (2) That the composition of the CAS Management Group should be as follows:
  - (a) President of CAS (chair);
  - (b) Vice-president of CAS;
  - (c) Immediate former president of CAS;
  - (d) Chair of the OPAG on Environmental Pollution and Atmospheric Chemistry (OPAG-EPAC);
  - (e) Chair of the OPAG on the World Weather Research Programme (OPAG-WWRP);
  - (f) Chair of the International Core Steering Committee for THORPEX;
  - (g) A co-chair of the Working Group on Numerical Experimentation;
  - (h) Up to six members at large broadly representing the diversity of the membership of the Commission. The members of the CAS Management Group should be drawn to promote gender equity, appropriate programme and geographical representation, and linkages to partners in research, operations and service delivery. The members are

appointed by the Commission or, in the absence of a decision by the Commission, by the president of the Commission, after consideration of nominations made by the Members of the Commission;

The composition of the CAS Management Group is therefore:

- (a) President: M. Béland
  - (b) Vice-president: T. Nakazawa
  - (c) Chair of OPAG-EPAC: Ø. Hov
  - (d) Chair of OPAG-WWRP: G. Brunet
  - (e) A co-chair of WGNE
  - (f) Expert: P. Bougeault (filling former president position)
  - (g) Gender focal point: M. Diop-Kane (Senegal)
  - (h) B. Parker (Regional Association I (Africa))
  - (i) Y.F. Luo (Regional Association II (Asia))
  - (j) A. Grimm (Regional Association III (South America))
  - (k) J. Butler (Regional Association IV (North America, Central America and the Caribbean))
  - (l) N. Gordon (Regional Association V (South-West Pacific))
  - (m) E. Astakhova (Regional Association VI (Europe))
- (3) To authorize the president to call on regional rapporteurs and other experts, keeping in mind Regulation 34 of the General Regulations, to participate in any particular task when the president considers such additional assistance necessary.

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### Resolution 3 (CAS-XV)

#### REVIEW OF PREVIOUS RESOLUTIONS AND RECOMMENDATIONS OF THE COMMISSION

THE COMMISSION FOR ATMOSPHERIC SCIENCES,

**Noting:**

- (1) Regulation 190 of the General Regulations that calls for an agenda item reviewing previous resolutions and recommendations of the Commission,
- (2) The action taken by the competent bodies on the resolutions and recommendations of the previous sessions,

**Decides** not to keep in force any resolutions adopted before its fifteenth session.

**Note:** This resolution replaces Resolution 4 (CAS-XIV), which is no longer in force.

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**Resolution 4 (CAS-XV)****PARTICIPATION OF WOMEN IN THE WORK OF THE COMMISSION**

THE COMMISSION FOR ATMOSPHERIC SCIENCES,

**Noting:**

- (1) The Report of the Second WMO Conference on Women in Meteorology and Hydrology, Geneva, March 2003,
- (2) The WMO Policy on Gender Mainstreaming,
- (3) Resolution 34 (Cg-XV) – Gender Mainstreaming,
- (4) Resolution 6 (EC-LIX) – Executive Council Advisory Panel of Experts on Gender Mainstreaming,

**Considering:**

- (1) That WMO activities have direct bearing on the United Nations Millennium Development Goals relating, inter alia, the promotion of gender equality,
- (2) The need for trained, qualified professionals regardless of gender, in the work of the Commission,
- (3) The need to encourage national education programmes in science and technology that actively target girls and woman, predisposing and training them to enter the research fields of meteorology and related sciences,
- (4) The need to increase opportunities and inducements to recruit women in research within National Meteorological and Hydrological Services and partner institutions, and to provide equal opportunities for career advancement to the highest levels,

**Welcoming** and supporting the active participation of women delegates in the Commission,

**Encourages** the increased participation and involvement of women in the work of the Commission;

**Urges** Members:

- (1) To implement the recommendations made by the Second WMO Conference on the Participation of Women in Meteorology and Hydrology (Geneva, March 2003) in order to speed up the process of equal opportunity for increased participation of women in these professions;
- (2) To submit nominations of women candidates for expert groups;

**Recommends** that Members:

- (1) Continue to encourage, promote and facilitate equal opportunities for women in science and technology in order to prepare them for careers in scientific professions, such as meteorology and related sciences;
- (2) Facilitate the participation of women in the research, education and training activities of the Commission;



- (3) Provide active encouragement and support for equal opportunity for the participation of women in all fields of meteorology and related sciences at decision-making levels, and in national, regional and international research programmes;

**Further recommends** that Members encourage the promotion of science studies in schools, as a means of ensuring the participation of women and men on an equal basis in this field of work;

**Decides** to appoint and support a gender focal point with appropriate expertise, and to designate this person as a member of the CAS Management Group;

**Requests** the Secretary-General:

- (1) To report to the Commission at its next session on progress made on the main aspects of the implementation of this resolution during the intersessional period;
- (2) To provide active encouragement and support for equal opportunity for the participation of women in all fields of meteorology and related sciences at decision-making levels, and in national, regional and international research programmes;

**Requests** the Gender Focal Point:

- (1) To document details of the role of women in the working bodies of the Commission;
- (2) To liaise with the WMO gender focal points on related issues, and to jointly collect and disseminate information, including studies and policies on the role of women in areas relevant to the Commission;
- (3) To collaborate with women's networks established by the regional associations;
- (4) To explore, document and make recommendations for addressing the needs for capacity-building relevant to Commission programmes in each region;
- (5) To submit reports in accordance with timetables established by the CAS Management Group;

**Requests** the president together with the CAS Management Group:

- (1) To regularly review details of the role of women in the working bodies of the Commission;
- (2) To proactively solicit women's names for expert groups and activities of the Commission;
- (3) To develop and implement strategies for enhancing the role of women within the Commission.

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**Note:** This resolution replaces Resolution 1 (CAS-XIV), which is no longer in force.

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# RECOMMENDATIONS ADOPTED BY THE SESSION

## Recommendation 1 (CAS-XV)

### TERMS OF REFERENCE FOR THE COMMISSION FOR ATMOSPHERIC SCIENCES

THE COMMISSION FOR ATMOSPHERIC SCIENCES,

**Noting:**

- (1) The *Abridged Final Report with Resolutions of the Fifteenth World Meteorological Congress* (WMO-No. 1026),
- (2) Abridged final reports with resolutions of the fifty-eighth (WMO-No. 1007), fifty-ninth (WMO-No. 1027), Sixtieth (WMO-No. 1032) and Sixty-first (WMO-No. 1042) sessions of the Executive Council,
- (3) The *WMO Strategic Plan* (WMO-No 1028),

**Recognizing** that the terms of reference need to be reviewed and updated considering the many changes in the operating environment of the Commission for Atmospheric Sciences in the past four years,

**Considering** that there should be a clear linkage between the terms of reference of the technical commissions of WMO with the WMO Results-based Management approach and overall Organization objectives and strategic thrusts,

**Recommends** that the terms of reference for the Commission for Atmospheric Sciences should be as given in Annex 1 to this recommendation, with further background on working mechanisms and linkages as described in Annex 2 to this recommendation;

**Requests** the Secretary-General to bring this recommendation to the attention of the Executive Council at its sixty-second session for consideration.

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## Annex 1 to Recommendation 1 (CAS-XV)

### TERMS OF REFERENCE FOR THE COMMISSION FOR ATMOSPHERIC SCIENCES PROPOSED AT ITS FIFTEENTH SESSION

The Commission for Atmospheric Sciences is responsible for promoting, coordinating and facilitating research and access to its results, technology transfer from research to operations, training and capacity-building activities in atmospheric sciences including weather and its forecasting, climate, water atmospheric chemistry, and related environmental sciences.

The specific objectives of the Commission are:

- (a) To identify the requirements of WMO Members, including those related to support of environmental and climate conventions, and to facilitate the transfer of knowledge, technologies and advice concerning atmospheric science issues;
- (b) To support and facilitate research in atmospheric and related sciences to advance the understanding and prediction of atmospheric processes within the broader Earth system, with emphasis on the following:

- (i) Weather, climate, water and related environmental analysis and prediction for timescales ranging from minutes to seasons to multidecadal, embracing new developments in environmental prediction,
  - (ii) Refining the end-to-end prediction process so as to improve the forecasting of high-impact events associated with serious consequences for populations and economies;
  - (iii) Atmospheric composition and air pollution, their interaction with weather and climate, studies of transport, transformation, deposition and impacts of air pollutants and related monitoring;
  - (iv) The physics and chemistry of clouds, greenhouse gases, ozone and aerosols;
  - (v) Weather modification science assessment with emphasis on the underlying physical and chemical processes and the development of rigorous evaluation procedures;
  - (vi) Processes in tropical and polar regions where the lack of understanding has large impacts on global predictive skill;
- (c) To maintain and develop the Global Atmosphere Watch Programme using an integrated approach to observations and research, focusing on greenhouse gases, atmospheric chemistry and air quality, contributing to scientific assessments in support of international environmental and climate conventions and policies;
- (d) To maintain and develop the World Weather Research Programme, including the Observing System Research and Predictability Experiment (THORPEX), focusing on knowledge of high-impact weather and partnerships in multidisciplinary research advancing the broader science of environmental prediction;
- (e) In accordance with the WMO Strategic Plan, to coordinate the activities of the Commission with relevant WMO bodies and promote cooperation between WMO Members, international scientific organizations, environmental institutions and other scientific groups;
- (f) To standardize functions, constants, terminology and bibliographic practices applicable to atmospheric sciences;
- (g) To support and facilitate the effective transfer of advances made by atmospheric science research to reduce societal impact of weather, climate and pollution on societies, economies and ecosystems;
- (h) To conduct scientific assessments in atmospheric science as required by Members or by the delivery of the science programmes of the Commission.
- 

## **Annex 2 to Recommendation 1 (CAS-XV)**

### **BACKGROUND MATERIAL ON TERMS OF REFERENCE FOR THE COMMISSION FOR ATMOSPHERIC SCIENCES**

To fulfil its mandate, the Commission for Atmospheric Sciences relies upon the advice and guidance of Joint Scientific Committees (or equivalent) of three WMO-sponsored technical programmes and their scientific advisory groups, working groups and expert teams:

1. The World Weather Research Programme (Open Programme Area Group on the World Weather Research Programme, OPAG-WWRP), including

2. The Observing System Research and Predictability Experiment (THORPEX) (International Core Steering Committee, OPAG-WWRP)
3. The Global Atmosphere Watch (GAW) Programme (OPAG on Environmental Pollution and Atmospheric Chemistry).

On matters related to climate research, the Commission cooperates with and seeks advice from the World Climate Research Programme, which is jointly sponsored by WMO, the International Council for Science and the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization.

Strategic plans for implementation developed by the Joint Scientific Committees for each of these programmes have been published. The Commission recognizes that THORPEX is a separate operating programme, which is well integrated into WWRP on the advice of the Commission at its fourteenth session, and administered as a separate extrabudgetary entity.

Considering the strategic thrusts and expected results of the current draft WMO Strategic Plan for 2012–2015 (see the appendix to this annex), the implementation of programme activities will contribute to Expected Results 1 to 7 in varying degrees.

The following list shows which main expected result is contributed to by each of the objectives in the terms of reference:

- Expected result 1: (f)
- Expected result 5: (b), (c), (d), (e), (g)
- Expected result 6: (h)
- Expected result 7: (a)

However, many activities related to the objectives serve more than one Expected Result.

Expected result 1 on enhancing Member information and services related to prediction is well addressed by research to technology transfer catalyzed by cross-cutting forecast demonstration projects developed between the Commission for Atmospheric Sciences, other Commissions and Regions.

Expected result 2 on risk reduction is served by several activities of the Commission for Atmospheric Sciences that are cross-cutting in WMO, including Forecast Demonstration Projects and the Tropical Cyclone Warning System.

Expected result 3 on predictions serving climate mitigation and adaptation are served by many activities including development of better seasonal forecasts and a carbon monitoring system using GAW greenhouse gas observations.

Expected result 4 on enhancing integrated observations and their delivery is served by Research and Development Projects of the weather, climate and environmental activities of the Commission that deliver, in part, sustained atmospheric observations through long-term research-based systems and, in part, improvements to existing observations maintained by established meteorological systems of other Commissions.

Expected result 5 is served mainly by Commission for Atmospheric Sciences programmes that are solidly founded in research wings of established National Meteorological and Hydrological Services as well as in other national research establishments and organizations.

Expected result 6 on capacity-building is addressed by parts of many research activities of the Commission that have strong training, methodology development and instrument procurement. It coordinates closely with more formal WMO training mechanisms with substantive effect.

Expected result 7 is related to the strong support of at least four major International Conventions in which WMO is a founding partner. The Global Atmosphere Watch programme alone serves three on ozone, long-range transboundary transport of pollution and climate.

### Appendix to Annex 2 to Recommendation 1 (CAS-XV)

#### STRATEGIC THRUSTS AND ORGANIZATION-WIDE EXPECTED RESULTS<sup>1</sup>

| STRATEGIC THRUSTS   | ORGANIZATION-WIDE EXPECTED RESULTS   |
|---|--|
| I. Improving service quality and service delivery   | 1. Enhanced capabilities of Members to deliver and improve access to high quality weather, climate and water and related environmental predictions, information and services in response to users' needs and to enable their use in decision-making by all relevant societal sectors |
|   | 2. Enhanced capabilities of Members to reduce risks and potential impacts of hazards caused by weather, climate and water and related environmental elements   |
| II. Advancing scientific research and application as well as development and implementation of technology | 3. Enhanced capabilities of NMHSs to produce better weather, climate, and water and related environmental information, predictions and warnings to support in particular climate impact and adaptation strategies  |
|   | 4. Enhanced capabilities of Members to access, develop, implement and use integrated and inter-operable surface-based and space-based systems for weather, climate and hydrological observations, as well as related environmental observations, based on World standards set by WMO |
|   | 5. Enhanced capabilities of Members to contribute to and draw benefits from the global research capacity for weather, climate, water and environmental services technology development   |
| III. Strengthening capacity-building  | 6. Enhanced capabilities of NMHSs, in particular in developing and least developed countries, to fulfil their mandates   |
| IV. Building and enhancing partnerships and cooperation   | 7. New and strengthened partnerships and cooperation activities to improve NMHSs' performance in delivering services and to increase the value of the contributions of WMO within the United Nations system, relevant international conventions and national strategies              |
| V. Strengthening good governance  | 8. An effective and efficient Organization   |

<sup>1</sup> Reproduced from the *Abridged Final Report with Resolutions of the Sixty-first Session of the Executive Council* (WMO-No. 1042), Annex VI. The 2012–2015 Strategic Plan must be considered draft until adopted by the World Meteorological Congress in 2011.

## **Recommendation 2 (CAS-XV)**

### **REVIEW OF RESOLUTIONS OF THE EXECUTIVE COUNCIL RELEVANT TO THE FIELDS OF RESPONSIBILITY OF THE COMMISSION FOR ATMOSPHERIC SCIENCES**

THE COMMISSION FOR ATMOSPHERIC SCIENCES,

**Noting** the action taken on its previous recommendations by the Executive Council,

**Considering:**

- (1) That some of these recommendations have become redundant in the meantime,
- (2) That the substance of some of its previous recommendations has been included in the recommendations of the fifteenth session,

**Recommends:**

- (1) That the following Executive Council resolution no longer be kept in force:  
Resolution 5 (EC-LVIII) – Report of the fourteenth session of the Commission for Atmospheric Sciences;
- (2) That the following Executive Council resolutions be kept in force:  
Resolution 6 (EC-XXXVI) – International collection and publication of radiation data;  
Resolution 3 (EC-LVII) – Global Climate Observing System;  
Resolution 11 (EC-LVI) – International Polar Year 2007–2008;  
Resolution 6 (EC-LIX) – Executive Council Advisory Panel of Experts on Gender Mainstreaming.

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**Note:** This recommendation replaces Recommendation 2 (CAS-XIV), which is no longer in force.

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# ANNEXES

## ANNEX I

Annex to [paragraph 8.1.1](#) of the general summary

### **SUMMARY OF GENERAL AND SPECIFIC RECOMMENDATIONS: EXECUTIVE COUNCIL RESEARCH TASK TEAM REPORT (WMO/TD-N. 1496) ON THE CHALLENGES AND OPPORTUNITIES IN RESEARCH ON CLIMATE, WEATHER, WATER AND ENVIRONMENT**

**General Recommendation 1 (Section 2.2) Coordinating and Accelerating Prediction Research: Develop a unified approach to multidisciplinary weather, climate, water and environmental prediction research, step up high-performance computing investments to accommodate the increasing complexity and detail of models, and to accelerate the development, validation and use of prediction models through Specific Recommendations:**

#### **Bridging Inter-disciplinary Gaps in Prediction Research (Section 2.2.1)**

##### Gaps between weather, sub-seasonal and seasonal predictions

- 1.1 Support collaborative climate/weather efforts on the use of Numerical Weather Prediction (NWP) experiments with coupled ocean-atmosphere models for exploring error growth in simulations of modes of organized convection and of interactions between tropical and extratropical by establishing collaboration between the TIGGE and CHFP projects (Brunet et al., 2007).
- 1.2 Accelerate efforts to improve traditional parameterizations of atmospheric processes such as convection, boundary layer, clouds, precipitation and atmospheric chemistry in climate and weather models.
- 1.3 Significantly enhance the computing capacity of the world's existing weather and climate research centres in order to accelerate prediction research (Shapiro et al., 2009, Shukla et al., 2009): the World Modelling Summit recommended computing systems at least a thousand times more powerful than those currently available to strive towards more accurate representation of critical small scale processes.

##### Decadal and multi decadal predictions as an initial value problem as well as a boundary forced problem

- 1.4 Subject IPCC-class models to data assimilation and the prediction of short term weather and ENSO-type variations like in the Transpose AMIP Integrations (Williamson et al. 2008, Brunet et al., 2007)

##### Interactively coupled weather and hydrology prediction systems

- 1.5 Follow the recommendations of HYMEX, HEPEX and the second phase of AMMA to develop stronger links with these efforts and develop a general strategic vision to address the broader issue of collaboration between weather and hydrological research, including coupled meteorology/hydrology models for weather and climate prediction.

Application of air pollution predictions and analysis to problems of human health, ecosystems, climate change and the cycling of greenhouse gases

- 1.6 WMO provide advice, coordination of projects and capacity-building in air quality forecasting globally.
- 1.7 WMO coordinate globally the technical work on the very long-range transport of air pollution between regions and continents.
- 1.8 WMO take the lead in coordinating globally the technical analysis of how climate variability and change and air pollution interact both ways on a regional basis.
- 1.9 WMO play a lead role globally in the analysis of carbon sequestration and reactive nitrogen in view of how the quality of the water supply is affected by reactive nitrogen runoff, and how the reactive nitrogen cycle interferes with air pollution, the carbon cycle and climate change.

Incorporating aerosols and ozone interactively in operational analysis and prediction systems

- 1.10 Provide global coordination of projects to incorporate aerosols and ozone as radiatively and cloud/precipitation active constituents in operational analysis and prediction systems, and thereby, enhance predictive capability for societal use.

**Implementing coordination mechanisms to optimize global and integrated observing systems (Section 2.2.2)**

- 1.11 WMO promote development of observation systems and sensitivity experiments based on the most advanced operational NWP data assimilation systems.
- 1.12 Build capacity for integrated observations globally through WIGOS working in collaboration with WMO research programmes.
- 1.13 WMO Members extend distribution and access to observations for research and associated application development through the new WMO Information System (WIS).
- 1.14 There is an urgent need to initiate a few pilot research projects in the area of coupled-model data assimilation.
- 1.15 Accelerate the utilization of data assimilation techniques for climate model development.

**Promoting Earth-System Reanalysis Projects (Section 2.2.3)**

- 1.16 Take an interdisciplinary weather-climate approach on data-assimilation methodologies in future reanalysis projects.

**Improving and Innovating Weather, Climate and Environmental Products (Section 2.2.4)**

- 1.17 Encourage liaison programmes such as the project Weather And Society\*Integrated Studies (WAS\*IS).
- 1.18 Encourage linkages between weather, climate and hydrometeorological service providers.
- 1.19 WMO promote hydrological forecast research demonstration projects.
- 1.20 WMO support research as an essential component of end-to-end systems for weather, climate, water and environmental services such as the Global Framework for Climate Services that is an expected major outcome of WCC-3.



**General Recommendation 2 (Section 3.3) Linking Research, Operation and Service Delivery: Develop closer linkages between research, operations and users through Forecast Demonstration Projects (FDPs) that accelerate technology transfer, through Specific Recommendations:**

- 2.1 Increase the two-way interactions between research, users and operations that begin early in the defining of a research problem and continue through the research process. Such interactions will help focus basic and applied research on user needs and make a more rapid transfer of research to operations and end users. Operations and users could also increase the efficiency of this process by providing data, in real-time when possible, to meet research needs and facilitate the testing of new research approaches.
- 2.2 WMO should play a major role in identifying and facilitating mechanisms to implement the two-way interactions between research, users and operations.
- 2.3 Increase the involvement of scientists and users from developing countries in FDPs, particularly from NMHSs and their national partners in the research activities of the WMO.
- 2.4 Focus on distilling research advances into products specially at the regional level that can be readily made available and, through training activities, enable their use by those needing information (some research advances, such as ensemble prediction, have great utility but with interaction with users are difficult to distil into user-friendly information).

**General Recommendation 3 (Section 4.3) The Role of WMO Commissions and the Visibility of Science: Implement a process to review and rationalize the roles and mandates of the Commissions, and to improve their effectiveness in enhancing WMO Member capabilities in research, observations, prediction and services, through Specific Recommendations:**

- 3.1 EC and the Secretariat including the Research Department work closely with the PTC so that any necessary modification to the Commissions' structures and their linkages with the organizational structure is effected to maximize the impact of the proposed paradigm change in prediction research. Simplification and clarity of the roles of the Commissions and the Departments should be the guiding principles of any final decisions.
  - 3.2 Develop a process to harmonize research input, and cross-coordination between different Commissions.
  - 3.3 Set up a mechanism connected with budgetary decision making, whereby cross cutting project proposals developed jointly by at least two Commissions, and one regional association could be reviewed and prioritized by the presidents of technical commissions, for consideration by EC and the Secretariat for eventual implementation.
  - 3.4 Recognizing that WMO is fundamentally a science and technology based Organization, establish efficient mechanisms to ensure that optimal science input is provided to WMO decision making processes and bodies (Cg, EC and Secretariat).
  - 3.5 Reaffirm and support international WMO science and technology leadership in its areas of competence, by nurturing a culture of excellence, relevance and impact, whilst recognizing that the increasing complexity of atmospheric related environmental issues necessitates an increasing partnership approach.
-

**ANNEX II****Annex to paragraph 8.1.3 of the general summary****CATEGORIZATION OF SPECIFIC RECOMMENDATIONS OF THE EXECUTIVE COUNCIL RESEARCH TASK TEAM REPORT (WMO/TD-NO. 1496) ACCORDING TO AREA OF IMPLEMENTATION AND RESPONSIBLE BODIES**

| <i>Specific recommendation</i> | <i>Category</i> | <i>Responsible bodies</i>                                  |
|--------------------------------|-----------------|--|
| 1.1                            | a               | THORPEX and WCRP/WGNE                                      |
| 1.2                            | a               | WGNE   |
| 1.3                            | c               | EC to endorse this policy statement                        |
| 1.4                            | a               | WGNE and WGCM  |
| 1.5                            | b               | WWRP THORPEX and CHy                                       |
| 1.6                            | a               | GAW/GURME  |
| 1.7                            | b               | GAW and UNECE LRTAP  |
| 1.8                            | a               | GAW/GURME, WCRP and WWRP                                   |
| 1.9                            | b               | GAW and UNECE LRTAP  |
| 1.10                           | a               | GAW, WWRP and WGNE   |
| 1.11                           | b               | THORPEX, GAW, CBS and WGNE                                 |
| 1.12                           | b               | CBS  |
| 1.13                           | b               | CBS, GAW and WWRP  |
| 1.14                           | c               | Wider Academic community                                   |
| 1.15                           | a               | WCRP, WGNE and WGCM  |
| 1.16                           | a               | WGNE, WCRP and GAW   |
| 1.17                           | a               | WWRP (SERA)  |
| 1.18                           | b               | WWRP including THORPEX, GAW, WCRP, CHy, CCI, CBS PWS, CAgM |
| 1.19                           | b               | WWRP including THORPEX and CHy                             |
| 1.20                           | b               | EC to endorse this policy statement                        |
| 2.1                            | b               | WWRP including THORPEX, GAW, WCRP, CBS and CHy             |
| 2.2                            | b               | WWRP including THORPEX and CBS                             |
| 2.3                            | b               | WWRP including THORPEX, GAW and CBS                        |
| 2.4                            | b               | WWRP including THORPEX, GAW and CBS                        |
| 3.1                            | b               | CAS to offer advice to the PTC and EC                      |
| 3.2                            | b               | CAS to offer advice to the PTC and EC                      |
| 3.3                            | b               | CAS to offer advice to the PTC and EC                      |
| 3.4                            | a               | CAS and WCRP   |
| 3.5                            | c               | EC to endorse this policy statement                        |

## Categories:

- a: specific recommendations for which CAS and its partners are solely responsible for implementation  
b: specific recommendations that require cross-Commission collaboration for implementation  
c: specific recommendations that are largely directed at external agencies for implementation

# APPENDIX

## LIST OF PARTICIPANTS

### 1. Officers of the session

President Michel Béland (Canada)

### 2. Representatives of WMO Members

#### Argentina

Eduardo Ángel Piacentini Delegate

#### Australia

Neville Ross Smith Principal Delegate

#### Belgium

Bernard Strauss Delegate (21 November)

#### Brazil

Dirceu Luiz Herdies Principal Delegate  
Alice Marlene Grimm (Ms) Delegate

#### Canada

Charles Lin Principal Delegate  
Gregory Flato Alternate  
Gilbert Brunet Delegate  
Sylvie Gravel (Ms) Delegate

#### China

Yu Jixin Principal Delegate  
Luo Yunfeng Alternate  
Zhang Xiaoye Delegate  
Liang Feng Delegate  
Wang Jinxing Delegate  
Li Yaohui Delegate  
Tan Zhemin Delegate  
Pu Yifen (Ms) Delegate

#### Croatia

Franz Berger Delegate (21 November)

#### Denmark

Leif Laursen Principal Delegate

#### Egypt

Mohamed Mahmoud Eissa Ahmed Principal Delegate  
Darwish Mohamed Ahmed Alternate

#### Finland

Tapani Stipa Principal Delegate

#### France

Philippe Bougeault Principal Delegate  
Jean-Pierre Chalon Alternate  
Bernard Strauss Delegate

#### Gambia

Lamin Mai Touray Principal Delegate

**Germany**

Gerhard Adrian Principal Delegate  
Franz Berger Delegate

**Ghana**

Vincent Antwi Principal Delegate

**Hong Kong, China**

Lam Kwong Si-lin, Hilda (Ms) Principal Delegate

**Ireland**

Simon Gilbert Delegate (21 November)

**Israel**

Anne Thompson (Ms) Delegate (21 November)

**Italy**

Vinicio Pelino Principal Delegate  
Paolo Rosci Delegate

**Japan**

Shingo Yamada Principal Delegate  
Ko Koizumi Alternate  
Tetsuo Nakazawa Alternate

**Jordan**

Firas Omar Al-Hazaimeh Principal Delegate  
Hatem Sabri Al-Halabi Delegate

**Malaysia**

Alui Bahari Principal Delegate  
Harithas Sivaprakash Delegate

**Morocco**

Mohammed Jamal Eddine Principal Delegate

**New Zealand**

Neil Gordon Principal Delegate

**Nigeria**

Anthony C. Anuforom Principal Delegate  
Ifeanyi Daniel Nnodu Alternate  
Augustine Ogochukwu Udogwu Delegate

**Norway**

Øystein Hov Principal Delegate

**Oman**

Said A. Al Harthy Principal Delegate  
Khalid A. Al Wahaibi Delegate

**Pakistan**

Muhammad Touseef Alam Principal Delegate

**Poland**

Mieczyslaw Ostoyski Principal Delegate  
Lukasz Legutko Alternate

**Republic of Korea**

Byung-Seong Chun Principal Delegate  
Joo-Young Cho (Ms) Alternate  
Dong-Eon Chang Delegate  
Young-Sin Chun (Ms) Delegate

|   |                                      |
|---|--------------------------------------|
| Kwang-Young Chung   | Delegate                             |
| Se-Won Kim  | Delegate                             |
| Kwang-Joon Park   | Alternate                            |
| Hee-Dong Yoo  | Delegate                             |
| Won-Tae Yun   | Delegate                             |
| <b>Russian Federation</b>                                   |                                      |
| Valery Stasenko   | Principal Delegate                   |
| Elena Astakhova (Ms)  | Delegate                             |
| Yury Borisov  | Delegate                             |
| Alexey Konoplev   | Delegate                             |
| <b>Senegal</b>  |                                      |
| Mariane diop-kane (Ms)                                      | Principal Delegate                   |
| <b>Serbia</b>   |                                      |
| Borivoj Rajković  | Principal Delegate                   |
| <b>South Africa</b>   |                                      |
| Deon Terblanche   | Principal Delegate                   |
| Bhawoodien Parker   | Delegate                             |
| <b>Spain</b>  |                                      |
| José Antonio García-Moya                                    | Alternate                            |
| Emilio Cuevas   | Delegate                             |
| <b>Sweden</b>   |                                      |
| Greg Carmichael   | Delegate (21 November)               |
| <b>Switzerland</b>  |                                      |
| Saskia Willemse (Ms)  | Principal Delegate                   |
| Jörg Klausen  | Alternate                            |
| <b>The former Yugoslav Republic of Macedonia</b>            |                                      |
| Vlado Spiridonov  | Delegate                             |
| <b>Tunisia</b>  |                                      |
| Mohamed Hajjej  | Principal Delegate                   |
| <b>Turkey</b>   |                                      |
| Yüseyin Yozgat  | Principal Delegate                   |
| Yüksel Yağan  | Delegate                             |
| <b>United Arab Emirates</b>                                 |                                      |
| Ali Alshehki  | Principal Delegate                   |
| <b>United Kingdom of Great Britain and Northern Ireland</b> |                                      |
| Alan Dickinson  | Principal Delegate                   |
| Andrew Brown  | Alternate                            |
| Simon Gilbert   | Alternate                            |
| <b>United Republic of Tanzania</b>                          |                                      |
| Mohamed R. Matitu   | Principal Delegate                   |
| <b>United States of America</b>                             |                                      |
| Louis Uccellini   | Principal Delegate (18–21 November)) |
| James H. Butler   | Alternate                            |
| William C. Bolhofer   | Alternate                            |
| Fredrick R. Branski   | Delegate                             |
| Gregory Carmichael  | Delegate                             |
| Anne M. Thompson (Ms)                                       | Delegate                             |

**Uzbekistan**

Khasan Imamdjanov

Delegate

**Zimbabwe**

Amos Makarau

Principal Delegate

Khangwari Marimira

Delegate

**3. Invited experts**

Christian Jakob

Co-Chair, WGNE

Martin Miller

Co-Chair, WGNE

**4. Representatives of international organizations****United Nations Economic Commission for Europe (UN/ECE)**

Sonja Vidic (Ms)

**5. Other participants**

Violeta Balan (Ms) (Republic of Moldova)

Mitchell William Moncrieff (United States of America)

Selvan Pillay (Seychelles)

**6. WMO Secretariat**

Michel Jarraud

Jerry Lengoasa

Len Barrie

Liisa Jalkanen

David Parsons

Marc Peeters



