

# Commission for Atmospheric Sciences

Abridged Final Report of the Seventeenth Session

Geneva

23–24 October 2017



WORLD  
METEOROLOGICAL  
ORGANIZATION



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WEATHER CLIMATE WATER



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METEOROLOGICAL  
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WMO-No. 1207

WMO-No. 1207

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ISBN 978-92-63-11207-1

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## GENERAL SUMMARY OF THE WORK OF THE SESSION

1. Mr Øystein Hov, the president of the Commission for Atmospheric Sciences (CAS), opened the seventeenth session of CAS on Monday, 23 October 2017 at 9 a.m. at WMO headquarters in Geneva. The president welcomed the CAS members and other participants. Mr Øystein Hov emphasized the importance for the science community to grasp that “end-to-end” science supports the Earth system value chain to services. For science this implied wider opportunities, especially in light of the significant future growth in these services expected in the weather, climate, water and related environmental domains. The Secretary-General of WMO, Mr Petteri Taalas, addressed the opening by thanking Indonesia for its preparation to host the session in Denpasar, which then had to be relocated to Geneva due to risk associated with the Mount Agung volcano. Mr Taalas thanked the experts from the diverse science community who contribute with their research towards advancing the Programmes and activities of WMO. He made special mention of the value derived from Members who contribute additional resources in support of the WMO research Programmes. Mr Taalas reassured the participants that as WMO is going through the process of its structural revision, the strong role of science in moving WMO forward will be reflected in the reform.

2. The agenda is provided in Appendix 1.

3. The session elected the following officers and selected the following leading experts:

Election of officers:

- (a) President of CAS (Chairperson), Øystein Hov, Norway;
- (b) Vice-president of CAS, Jae-Cheol Nam, Republic of Korea.

Selection of leading experts:

- (a) The session selected Gregory Carmichael, United States of America, as Chairperson of the Environmental Pollution and Atmospheric Chemistry Scientific Steering Committee (EPAC SSC);
- (b) The session also selected Sarah Jones, Germany, as Chairperson of the World Weather Research Programme Scientific Steering Committee (WWRP SSC);
- (c) The session further selected the following members for the CAS Management Group:

Øystein Hov, Norway, president;

Jae-Cheol Nam, Republic of Korea, vice-president;

A representative of the European Commission, Directorate General for Research and Innovation, invited expert;

Gregory Carmichael, United States, Chairperson of EPAC SSC;

Sarah Jones, Germany, Chairperson of WWRP SSC;

Amanda Lynch, United States, invited expert representing the academic research community;

Keith Williams, United Kingdom of Great Britain and Northern Ireland, co-Chairperson of the Working Group on Numerical Experimentation;

Pascal Waniha, United Republic of Tanzania (Regional Association (RA) I – Africa);

Yi-Hong Duan, China (RA II – Asia);

Carolina Vera, Argentina (RA III – South America);

John Cortinas, United States (RA IV – North America, Central America and the Caribbean);

Peter May, Australia (RA V – South-West Pacific);

Jörg Klausen, Switzerland (RA VI – Europe).

4. The session adopted two decisions (given in Appendix 2) and five recommendations (given in Appendix 3).

5. Out of a total of 88 participants, 22 were women, that is, 25%. The list of participants is given in Appendix 4.

6. The seventeenth session of CAS closed at 10.20 a.m. on 24 October 2017.

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## **APPENDIX 1. AGENDA**

- 1. Organization of the session**
    - 1.1 Opening of the session
    - 1.2 Approval of the agenda
    - 1.3 Establishment of committees
    - 1.4 Programme of work of the session
  - 2. Reports**
    - 2.1 Report by the president of the Commission
    - 2.2 Report by the Chairperson of SSC WWRP
    - 2.3 Report by the Chairperson of SSC EPAC
    - 2.4 Report by the Director of the Research Department
  - 3. Science to serve society: Recommendations**
    - 3.1 Science for services
    - 3.2 Seamless prediction in 2023
    - 3.3 Future infrastructures
    - 3.4 Nurturing scientific talents
    - 3.5 Innovation and resources
  - 4. Election of officers and selection of leading experts**
    - 4.1 Election of officers
    - 4.2 Selection of leading experts
  - 5. Closure of the session**
-

## APPENDIX 2. DECISIONS ADOPTED BY THE SESSION

### Decision 1 (CAS-17)

#### ORGANIZATION OF THE SESSION

THE COMMISSION FOR ATMOSPHERIC SCIENCES,

**Approves** the provisional agenda as proposed by the president of the Commission for Atmospheric Sciences (CAS);

**Adopts** the establishment of committees in accordance with WMO General Regulations 23 and 32 and such other committees as it deems necessary, as follows:

(1) Credentials Committee:

Chairperson: Kazuto Suda (Japan)

Member: Mohamed Okka (Egypt);

(2) Nomination Committee:

Chairperson: Branka Ivancan-Picek (Croatia)

Member: Urip Haryoko (Indonesia);

(3) Coordination Committee:

Chairperson: President of CAS

Members: Chairperson of WWRP SSC, Chairperson of EPAC SSC, Secretary-General's representative, Secretariat staff at the session who are responsible for managing the documents, conference officer;

**Agrees** to the programme of work of the session:

(1) Working hours of the meetings: 9 a.m.–noon and 2 p.m.–5 p.m.;

(2) Arrangement and allocation of agenda items for the session;

**Notes** General Regulation 112 for the approval of the minutes.

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**Decision 2 (CAS-17)****GENDER EQUALITY**

THE COMMISSION FOR ATMOSPHERIC SCIENCES,

**Recalling:**

- (1) Decision 77 (EC-68) – [WMO Gender Action Plan](#), which defines the priority action for the 2016–2019 period in relation to gender,
- (2) Resolution 59 (Cg-17) – Gender equality and empowerment of women, which addresses the WMO Gender Equality Policy,

**Acknowledging** the role of WMO in implementing the outcomes of the Conference on the Gender Dimensions of Weather and Climate Services (Geneva, 5–7 November 2014) and in supporting the gender aspects of the Sendai Framework for Disaster Risk Reduction, the Paris Agreement adopted under the United Nations Framework Convention on Climate Change, and the 2030 Agenda for Sustainable Development,

**Reaffirming** the goal of achieving gender equality within WMO and in gender-sensitive weather, hydrological, climate and related environmental services, which will contribute to an improved response to the specific needs and social and economic circumstances of women,

**Recognizing** the need to implement the WMO Gender Action Plan in 2016–2019 in WMO research activities,

**Considering** that women continue to be underrepresented in WMO governance structures and research activities,

**Invites** Members:

- (1) To nominate more women as members of the governance and working structures of WMO research programmes;
- (2) To use the WMO Gender Action Plan as guidance and undertake relevant actions at the national level in relation to the role of women in research;

**Urges** Members to increase participation and involvement of women in research activities of WMO.

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## **APPENDIX 3. RECOMMENDATIONS ADOPTED BY THE SESSION**

### **Recommendation 1 (CAS-17)**

#### **THE ROLE OF SCIENCE IN SERVING SOCIETY**

THE COMMISSION FOR ATMOSPHERIC SCIENCES,

##### **Recalling:**

- (1) Decision 61 (EC-68) – World Weather Research Programme Implementation Plan for the period 2016–2023, and Decision 62 (EC-68) – Global Atmosphere Watch Implementation Plan for the period 2016–2023, which endorsed the implementation plans of the respective Programmes, and that these plans build on the “science-for-services” concept,
- (2) Decision 41 (EC-69) – Guidelines for the development of an integrated operational platform to meet urban service delivery needs, which requested to “expedite work on a Guide for Urban Integrated Hydrometeorological/Climate/Environment Services, using the expertise of the WMO [Global Atmosphere Watch] GAW Urban Research Meteorology and Environment (GURME)” project, thereby improving the connection between research and operations,
- (3) Decision 50 (EC-69) – An integrated research and development approach, which includes the main principles to fill the gap between research and operations,

##### **Recalling further:**

- (1) Decision 42 (EC-68) – Implementation of the WMO Strategy for Service Delivery, in which the Executive Council requested technical commissions to mainstream service delivery into their workplans and guidance materials,
- (2) Decision 29 (CBS-16) – Further implementation of the WMO Strategy for Service Delivery, which defines the workplan for a holistic WMO-wide harmonized approach to service delivery, following the request of the Executive Council at its sixty-eighth session,

##### **Recognizing that:**

- (1) Better integration of science and services requires a move from the current linear model of sporadically transferring research results to operations, to an interactive model in which stakeholders, service providers (including National Meteorological and Hydrological Services (NMHSs)), and scientists across all relevant disciplines in physical sciences, social sciences and the humanities engage to assess and articulate needs and operational constraints, work collaboratively to identify appropriate research opportunities, define and implement research programmes, transfer the research results into operations and applications at appropriate intervals, and refine research programmes according to the feedback process, to take into account the knowledge and experience gained,
- (2) The World Climate Research Programme and programmes of the Commission for Atmospheric Sciences (the World Weather Research Programme and GAW) draw on the capabilities of the larger science community from NMHSs and academia, thus enhancing substantially the potential for innovation, and that those capabilities are fundamental for advancing the WMO Strategy for Service Delivery,

- (3) WMO research activities have a central role in promoting innovation across different service applications, and that their coherence and consistency are an added value for WMO in promoting its international profile,
- (4) Long-term, forward-looking research that supports current investment decisions into new technologies or techniques, but may not reap benefits for NMHS operations for 10 years or more, plays a key role in developing innovative solutions to current problems and is of value to the WMO community,
- (5) The gap between research and operations needs to be closed to be able to offer full and rapidly developing service capabilities in environmental analysis and forecasting; that the underlying science is converging to a seamless Earth-system approach that is a unifying force, optimally served by consolidating research; and that the two-way creative tension between research opportunities and service needs is desirable in the development of innovative services,

**Noting** that the development of specific services in diverse application areas, including agriculture, transport, energy production and health requires the involvement of the scientific community at all stages of the production chain,

**Requests** the Executive Council Working Group on Strategic and Operational Planning to take into account the need for a stronger WMO leadership in science and research and to strengthen the integrated role of research in the “science-for-services” context;

**Recommends** that the Eighteenth World Meteorological Congress adopt Draft Resolution X.X(X) (Cg-18) – Integrated and coordinated WMO research for serving society, as contained in the annex to the present recommendation.

## **Annex to Recommendation 1 (CAS-17)**

### **Draft Resolution X.X(X) (Cg-18)**

#### **INTEGRATED AND COORDINATED WMO RESEARCH FOR SERVING SOCIETY**

THE WORLD METEOROLOGICAL CONGRESS,

**Recalling:**

- (1) Decision 50 (EC-69) – An integrated research and development approach, which includes the main principles to fill the gap between research and operations,
- (2) Decision 41 (EC-69) – Guidelines for the development of an integrated operational platform to meet urban service delivery needs, which requested to “expedite work on a Guide for Urban Integrated Hydrometeorological/Climate/Environment Services, using the expertise of the WMO [Global Atmosphere Watch] GAW Urban Research Meteorology and Environment (GURME)” project, which would improve the connection between research and operations,

**Recognizing:**

- (1) The advances in Earth system prediction that integrate different time scales and compartments, and the growing need of the user community for more sophisticated services,

- (2) That better integration of science and services requires a move from the current linear model of sporadically transferring research results to operations, to an interactive model in which stakeholders assess and articulate their future needs, researchers work in dialogue with stakeholders to define and implement appropriate research programmes, the research results are transferred to operations at appropriate intervals, and stakeholder needs and research programmes are refined taking into account the knowledge and experience gained,
- (3) That the World Climate Research Programme and programmes of the Commission for Atmospheric Sciences (the World Weather Research Programme and Global Atmosphere Watch) draw on the capabilities of a much larger science community than those in National Meteorological and Hydrological Services (NMHSs), and that those capabilities are fundamental for advancing the WMO strategy for service delivery,
- (4) That WMO research activities have a central role in promoting innovation across different service applications and that their coherence and consistency are an added value for WMO in promoting its international profile,

**Noting** that the development of specific services in diverse application areas requires involvement of the scientific community at all stages of the production chain,

**Decides** that WMO research needs to be better integrated and more closely coordinated across weather, climate, water and related environmental domains in order to provide the necessary scientific and technical advances needed to address the growing need for targeted and societally relevant services and to create an attractive environment in which NMHSs, academic institutions, the private sector and end users can engage in research to their mutual benefit;

**Requests** WMO technical commissions and regional associations:

- (1) To co-design in advance, when designing operational projects that rely on research, with WMO research Programmes the full range of activities that are required to bring a new or improved service or supporting system from conception through the different phases of production;
- (2) To promote the development of integrated research pilots to foster the value chain approach by jointly identifying research needs based on regional priorities for meteorological and environmental services;

**Urges** Members to improve connections between NMHSs and research institutions and academia on a national level to ensure that research responds to the requirements for the development of new services, and that the advances in research are appropriately included in operations;

**Requests** the Secretary-General:

- (1) To take all necessary actions, within available budgetary resources, to ensure a strongly coordinated and integrated WMO research function to support science-based services that will promote innovation across the Organization;
- (2) To ensure a coordination mechanism within the Secretariat, led by the Research Department, to identify and coordinate, according to the agreed principles of the integrated research and development approach, WMO activities aimed at developing new or improving existing services and supporting systems in the weather, climate, water and related environmental domains;
- (3) To assist Members in promoting research as part of the development of new and enhancement of existing services, particularly in developing countries, by promoting

capacity-building, facilitating training and exchange of scientists, and providing guidance and advice, as required, within available budgetary resources;

- (4) To take all necessary actions to initiate, develop and maintain WMO collaboration in matters related to weather, climate, water and related environmental research with relevant organizations, agencies, groups and institutions, from both the public and private sectors.

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## **Recommendation 2 (CAS-17)**

### **SEAMLESS PREDICTION SYSTEMS**

THE COMMISSION FOR ATMOSPHERIC SCIENCES,

#### **Recalling:**

- (1) Resolution 17 (EC-69) – Seamless Data-processing and Forecasting System, which requested the Steering Group on the Seamless Data-processing and Forecasting System (DPFS) to develop a detailed implementation plan, and the Commission for Atmospheric Sciences (CAS) to utilize its forthcoming Science Summit and its seventeenth session as a platform for interaction between the Commission for Basic Systems (CBS), CAS and representatives of other technical commissions and regional associations, to define the scientific progress needed to realize the future seamless DPFS,
- (2) Decision 50 (EC-69) – An integrated research and development approach, which endorsed the principles towards better integrated research and development support to Members,
- (3) That the implementation plans of the World Weather Research Programme (WWRP) and of the Global Atmosphere Watch (GAW) Programme, endorsed by Decision 61 (EC-68) – World Weather Research Programme Implementation Plan for the period 2016–2023, and Decision 62 (EC-68) – Global Atmosphere Watch Implementation Plan for the period 2016–2023, respectively, call for development of integrated observations, modelling products and services,
- (4) Resolution 47 (Cg-17) – Global Atmosphere Watch Programme, which established the framework for GAW,
- (5) Resolution 45 (Cg-17) – World Weather Research Programme, which established the framework for WWRP, Resolution 16 (EC-64) – Sub-seasonal to Seasonal Prediction Project, Resolution 17 (EC-64) – Polar Prediction Project, and Resolution 12 (EC-66) – High-impact Weather Project, which approved the establishment the three respective projects,

#### **Noting:**

- (1) That there is predictability inherent in the different components of the Earth system and their interaction, and that an integrated approach to Earth system prediction delivered seamlessly across all domains, and temporal and spatial scales could help leverage this predictability to improve skill and enhance services provided by Members,
- (2) Advances in integrated modelling of the Earth system across spatial and temporal scales and different domains, and recent developments in computational technologies and data mining,

- (3) That predictions acquire value through the decisions and actions that they are used for, that effective actions depend both on the seamless translation of the physical prediction into socioeconomic impacts and on their communication in ways that enable effective user responses, and that research activities aimed at improving the effectiveness of weather-related decision-making must therefore be a partnership between physical and social scientists,
- (4) That users of environmental predictions have different requirements for information on different time and space scales and for different responses, but that consistency from one time and space scale to another and across related aspects of the environment (such as rain and flood) is of great importance to them,
- (5) That improvements to services are constrained by both technology and science and that advances towards seamless services in the senses described above need to be carried out in a way that ensures the most effective services based on available technology and resources,
- (6) The need to promote the strategic position of WMO on seamless prediction at the heart of the United Nations system and scientific international organizations, with an effective mechanism to engage academia and the private sector,
- (7) That advancing the scientific understanding of the Earth system has been endorsed by Decision 65 (EC-69) – Preparation of WMO Strategic Plan 2020–2023, as a strategic objective (strategic objective 3.1) of the Plan,

**Noting also** the request for an interactive approach and dialogue between stakeholders, users and researchers to realize an integrated research and development approach,

**Noting further** that DPFS will constitute the framework for future innovations in seamless prediction and in the delivery of forecast services,

**Considering** the success of Phase 1 of the Sub-seasonal to Seasonal Prediction Project (S2S Project) that developed a widely used database hosted by the European Centre for Medium-range Weather Forecasts and the China Meteorological Administration,

**Having examined** the work done through the sessions of the CAS Science Summit in 2017,

**Endorses** the planned Phase 2 (2018–2023) activities of the S2S Project;

**Encourages** the planned joint collaborative activities of WWRP, the High-impact Weather Project and the GAW Urban Research Meteorology and Environment Project (GURME) on the prediction of high-impact weather and air quality, including the assessment of impacts on the environment;

**Urges** the Working Group on Numerical Experimentation to play a central role in coordinating the development of seamless modelling across WWRP, GAW and the World Climate Research Programme, and to collaborate with technical commissions that have requirements for Earth system modelling, such as CBS and the Commission for Hydrology, and to work with other important modelling centres on high-resolution modelling development;

**Recommends** that the GAW Scientific Advisory Group on Applications and GURME develop a “Guide to Real-time Air Quality Forecasting Practices Using 3-D Numerical Models” in close collaboration with the WMO Education and Training Programme and the CBS Open Programme Area Group on DPFS;

**Recommends** that the Secretary-General:

- (1) Strengthen or establish partnerships with the United Nations system and other international organizations to promote the WMO research agenda towards seamless prediction;
- (2) Promote innovation across the WMO technical Programmes and activities to ensure the co-design of new and improved services and products;

**Recommends** that the Eighteenth World Meteorological Congress adopt Draft Resolution X.X(X) (Cg-18) – A seamless-oriented research structure for WMO, and Draft Resolution X.X(X) (Cg-18) – Seamless regional research for water, as contained in Annexes 1 and 2, respectively, to the present recommendation.

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### **Annex 1 to Recommendation 2 (CAS-17)**

#### **Draft Resolution X.X(X) (Cg-18)**

#### **A SEAMLESS-ORIENTED RESEARCH STRUCTURE FOR WMO**

THE WORLD METEOROLOGICAL CONGRESS,

**Noting:**

- (1) That leveraging the predictive skill at a broad range of temporal and spatial scales that are inherent in the various components of the Earth system and their interactions would allow Members to improve their services,
- (2) That the Data-processing and Forecasting System (DPFS), through Resolution 17 (EC-69) – Seamless Data-processing and Forecasting System, will become a pillar in the future WMO Service Delivery Strategy,
- (3) Decision 50 (EC-69) – An integrated research and development approach, which endorsed the principles towards better integrated research and development support to Members,
- (4) Decision 49 (EC-69) – WMO priority actions in hydrology and water resources management, in support of the ambitious work plan of the Commission for Hydrology,

**Recalling** that the implementation plans of the World Weather Research Programme (WWRP) and of the Global Atmosphere Watch (GAW) Programme, endorsed by Decision 61 (EC-68) – World Weather Research Programme Implementation Plan for the period 2016–2023, and Decision 62 (EC-68) – Global Atmosphere Watch Implementation Plan for the period 2016–2023, respectively, call for development of integrated modelling products and services,

**Considering** that:

- (1) Advancing the scientific understanding of the Earth system has been endorsed by Decision 65 (EC-69) – Preparation of WMO Strategic Plan 2020–2023, as a strategic objective (strategic objective 3.1) of the Plan,

- (2) Collaborations among GAW, WWRP and other partners are essential to make research advances in the emerging strategic areas of WMO, in particular on aspects of model development, the water cycle and urban development,
- (3) The ongoing Sub-seasonal to Seasonal Prediction Project (S2S Project) (Resolution 16 (EC-64) – Sub-seasonal to Seasonal Prediction Project), Polar Prediction Project (Resolution 17 (EC-64) – Polar Prediction Project), High-impact Weather Project (Resolution 12 (EC-66) – High-impact Weather Project), GAW Urban Research Meteorology and Environment Project, and Integrated Global Greenhouse Gas Information System (Decision 51 (EC-69) – The Integrated Global Greenhouse Gas Information System Implementation Plan) complement each other towards a seamless-oriented research structure,

**Agrees that:**

- (1) Research plays a critical role in developing future predictive seamless systems and in underpinning decisions on the development of related observing systems for weather, climate, water and environment;
- (2) The Working Group on Numerical Experimentation should play a central role in coordinating the development of seamless research components across GAW, WWRP and the World Climate Research Programme (WCRP), including interacting and building connections with the Commission for Basic Systems (CBS) and Commission for Hydrology (CHy) subsidiary bodies that work on aspects of numerical experimentation;

**Requests** the Joint Steering Committee of WCRP and the Scientific Steering Committees of WWRP and GAW to provide the Commission for Atmospheric Sciences Management Group with suggestions on how to further strengthen collaborative efforts between the Programmes mentioned in the preceding paragraph to support innovation for DPFS;

**Requests** the Scientific Steering Committee of WWRP and the Joint Steering Committee of WCRP to encourage CHy and the Commission for Agricultural Meteorology to further promote the use of S2S Project database products, and strengthen interactive feedbacks between multi-disciplinary research activities within WMO;

**Requests** the Secretary-General to align the appropriate research activities and resources in WMO to optimally support the development and enhancement of DPFS and of the Global Framework for Climate Services;

**Requests** Members to actively participate in research activities for predictive seamless systems, to contribute to the trust funds of the above-mentioned Programmes and to provide strong support for the implementation of project activities in their respective countries;

**Decides:**

- (1) That GAW, WWRP and WCRP, in collaboration with relevant subsidiary bodies of CBS and CHy, shall play a major role in promoting research across temporal and spatial scales and across environmental domains towards a unified, integrated Earth system modelling approach in an interactive set-up that ensures the transfer of research concepts, tools and techniques to operations as informed by users;
  - (2) To facilitate this integrated and interactive approach by organizing an overarching Open Science Conference on the Earth System, possibly in 2022.
-

## Annex 2 to Recommendation 2 (CAS-17)

### Draft Resolution X.X(X) (Cg-18)

#### SEAMLESS REGIONAL RESEARCH FOR WATER

THE WORLD METEOROLOGICAL CONGRESS,

#### Noting:

- (1) Resolution 12 (EC-66) – High-impact Weather Project, which established the Project,
- (2) Decision 5 (EC-69) – Flood forecasting, which requested the relevant technical commissions to ensure that the future Global Data-processing and Forecasting System is an operational system that has a direct interface to applications such as the Flash Flood Guidance System,
- (3) Decision 49 (EC-69) – WMO priority actions in hydrology and water resources management, which expressed support for the ambitious work plan of the Commission for Hydrology (CHy),

#### Noting further:

- (1) That sustainable development requires a systematic assessment of water resources from global to regional and local scales,
- (2) The common interests of the World Weather Research Programme (WWRP), the World Climate Research Programme and the [International Groundwater Resources Assessment Centre](#) in the monitoring of groundwater and dissemination of data,
- (3) The need to develop links between the Global Atmosphere Watch Programme, WWRP and the Global Energy and Water Cycle Experiment on aspects of extreme events and precipitation processes, such as quantitative precipitation forecasts and urban flooding,
- (4) The role of water vapour as a climate driver and an atmospheric chemical constituent,

#### Stressing:

- (1) The need to strengthen WMO regional activities related to the understanding and assessment of the coupled water cycle, avoiding redundancy and duplications across weather, climate, water and environment programmes,
- (2) The need to establish integrated pilot projects, which should be developed in collaboration with key partners, as well as with stakeholders and users, following the example the Hydrological Cycle in the Mediterranean Experiment,

**Requests** the technical commissions, in particular CHy and the Commission for Basic Systems, to co-design research activities focusing on the exchange processes between Earth system components related to water, in cooperation with the WMO research Programmes;

**Requests** the Secretary-General to strengthen or establish cooperation on water-related issues with relevant United Nations and other international organizations.

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### **Recommendation 3 (CAS-17)**

#### **FUTURE INFRASTRUCTURES**

THE COMMISSION FOR ATMOSPHERIC SCIENCES,

**Recalling:**

- (1) Decision 61 (EC-68) – World Weather Research Programme Implementation Plan for the period 2016–2023, and Decision 62 (EC-68) – Global Atmosphere Watch Implementation Plan for the period 2016–2023, which endorsed the draft implementation plans of the respective Programmes, and that these plans build on the “science-for-services” concept,
- (2) Decision 50 (EC-69) – An integrated research and development approach, which includes the main principles to fill the gap between research and operations,

**Recalling further:**

- (1) Resolution 2 (EC-68) – Plan for the WMO Integrated Global Observing System Pre-operational Phase 2016–2019,
- (2) Decision 30 (EC-68) – Regional WMO Integrated Global Observing System Centres,

**Recognizing that:**

- (1) A country’s future capacity to develop new services on weather, climate, water and the environment, and to implement a comprehensive Earth system approach, depends on the accessibility of high-performance computing and on the ability to assimilate different sources of information and observations into structured predictive systems,
- (2) Infrastructures relevant for National Meteorological and Hydrological Services are becoming more diverse in terms of technology, economy and politics,
- (3) The development of a seamless Earth system approach will require the integration of diverse observational and modelling infrastructures managed by different international initiatives and organizations,
- (4) WMO works on the development of international standards for data compatibility, metadata standards, data exchange and methods and standards for integrated observations through the WMO Information System and the WMO Integrated Global Observing System, and in collaboration with international standardization bodies such as the International Organization for Standardization,

**Recognizing further** the need to ensure long-term sustainability and accessibility of the data created by WMO research projects (such as the THORPEX Interactive Grand Global Ensemble and the sub-seasonal to seasonal dataset hosted by the European Centre for Medium-range Weather Forecasts and the China Meteorological Administration) while recognizing the effort of all organizations and countries that are producing and maintaining the data,

**Recommends** that Members:

- (1) Foster the development of the future observing systems to address the needs of diverse applications ranging from high-resolution urban services to climate applications by exploring novel observation concepts and components;

- (2) Improve links with the user community to better define the infrastructure requirements to support specific applications;
- (3) Take into consideration the co-dependencies of the observing, computing and data-sharing components in the design of future infrastructure for producing and delivering new products and services;
- (4) Take steps to support the further development of common flexible modular components of formats, methods and systems. This includes modularization of all components of the processing chains such as observation operators; quality control, monitoring and alert systems; numerical models and data-assimilation components; exchange formats, verification, and diagnostics and intercomparison tools. It also includes modularization linking different time scales and parts of the Earth system, for example between nowcasting and numerical weather prediction, or between atmospheric chemistry, weather forecasting and climate prediction;
- (5) Establish mutually beneficial formal partnerships to sustain and enhance the continuous advancement of computational systems capable of delivering new services, and ensure access to these facilities for all Members;
- (6) Enhance collaboration with the computing community so that advanced knowledge of the Earth system is reflected in improved codes through the exchange of expertise, advances in numerical computational methods and new tools to make the most efficient use of a future multi-processor environment;
- (7) Support the establishment of high-performance computing projects to further develop Earth system modelling and related data management for improving the transition to an exascale world, taking into consideration existing national initiatives;
- (8) Provide continuous support to existing observational capabilities and associated quality assurance and data management infrastructures, and assess requirements for emerging needs;

**Recommends further** that Members with advanced observational and modelling capabilities use these to contribute to the development and regular assessments of new measurement technologies and systems, using the full range of available techniques and approaches, including sensitivity and observation impact evaluation based on variational or ensemble systems and impact studies, such as observing system experiments and observing system simulation experiments, to inform observing system investment decisions and provide recommendations to the broader community;

**Requests** the Environmental Pollution and Atmospheric Chemistry Scientific Steering Committee of the Commission for Atmospheric Sciences to submit a recommendation on the use of low-cost sensors for air-quality observations to the Executive Council at its seventieth session;

**Requests** other technical commissions to follow a similar approach for new observational technologies in their areas of responsibility;

**Requests** the World Weather Research Programme Scientific Steering Committee, the Environmental Pollution and Atmospheric Chemistry Scientific Steering Committee, and the Infrastructure Panel of the Working Group on Climate Modelling of the World Climate Research Programme to develop a concept of federated data hubs to share data and metadata across WMO research projects to agreed standards, to ensure the compatibility of this concept with the future implementation plan for the seamless Data-processing and Forecasting System, and to submit this concept to the Eighteenth World Meteorological Congress;

**Requests** the Secretary General to interact with international organizations, partners from the private sector, donors and key stakeholders in order to promote the development of research infrastructures for improving Earth system modelling capabilities, including data assimilation and the use of model ensembles, and data-mining knowledge to be applied to non-traditional observations.

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#### **Recommendation 4 (CAS-17)**

##### **STRENGTHENING EARTH SCIENCE NATIONAL TRAINING AND CURRICULA**

THE COMMISSION FOR ATMOSPHERIC SCIENCES,

**Recalling** Decision 63 (EC-68) – Capacity development priorities for 2016–2019,

**Considering** that capacity development is one of the strategic priorities of the WMO Strategic Plan 2016–2019,

**Noting** Decision 50 (EC-69) – An integrated research and development approach, which includes main principles to fill the gap between research and operations,

**Noting also** Decision 54 (EC-69) – Identification of priorities for education and training, which outlines the following priorities:

- (1) Broadening of partnerships with other organizations and agencies,
- (2) Promotion of research and operational capacity through stronger connections to WMO research Programmes, graduate level fellowships and personnel exchanges,

**Noting further** that the concepts of continuum and value chain in the Earth system sciences in university education worldwide should be promoted,

**Observing** that there are new developments in the field of online communication tools, such as webinars and conferences, and that there is an increasing proportion of components of people's lives that are moving to web-based structures,

**Invites** Members to organize summer schools and other training events with participation across National Meteorological and Hydrological Services (NMHSs), academia and national and regional boundaries;

**Encourages** Members to identify pioneering and successful examples of such training events and to share the information with other Members;

**Encourages** NMHSs:

- (1) To make strong and generous links to national academic institutions and to invite students in the Earth system sciences to work as trainees in modern NMHSs;
- (2) To enter into dialogue with relevant private-sector institutions to map experiences of value for the development of scientific talents;

**Encourages** NMHSs and other partners to develop and improve outreach to teachers, at all grade levels, to promote science and make "science, technology, engineering and mathematics"

activities more accessible, for example by providing events in conjunction with WMO and Members' conferences;

**Encourages** Members to explore how data and tools can be made more accessible to allow researchers from all over the world to participate in and contribute to science and research efforts and be used for educational purposes;

**Recommends** that Members work closely with the International Council for Science and influence the national curricula on Earth system sciences in school systems to attract talents into the value chain of environmental prediction. Not only traditional science skills are required, but also the capability to understand user needs and translate them into mature science and operational products and services, and the capability to understand the societal value of such activities;

**Recommends** that the WMO Education and Training Office increasingly considers the use of online resources and novel virtual meeting techniques for education and training in weather, climate and water science, in order to increase the accessibility of educational events.

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### Recommendation 5 (CAS-17)

#### CREATING AN ENVIRONMENT FOR INNOVATION AND ITS OPTIMAL RESOURCING

THE COMMISSION FOR ATMOSPHERIC SCIENCES,

**Recalling:**

- (1) Decision 73 (EC-68) – Cooperation between the public and private sectors for the benefit of society, which promotes a framework for fruitful collaboration between National Meteorological and Hydrological Services (NMHSs) and the private sector for the benefit of society,
- (2) Decision 50 (EC-69) – An integrated research and development approach, which endorsed the principles towards better integrated research and development to support Members,
- (3) Decision 41 (EC-69) – Guidelines for the development of an integrated operational platform to meet urban service delivery needs, which requested to “expedite work on a Guide for Urban Integrated Hydrometeorological/Climate/Environment Services, using the expertise of the WMO [Global Atmosphere Watch] GAW Urban Research Meteorology and Environment (GURME)” project, thereby improving the connection between research and operations,
- (4) Resolution 17 (EC-69) – Seamless Data-processing and Forecasting System, which requested the Steering Group on the Seamless Data-processing and Forecasting System (DPFS) to develop a detailed implementation plan, and the Commission for Atmospheric Sciences (CAS) to utilize its forthcoming Science Summit and its seventeenth session as a platform for interaction between the Commission for Basic Systems (CBS), CAS and representatives of other technical commissions and regional associations, to define the scientific progress needed to realize the future seamless DPFS; and requested the presidents of CAS and CBS to report to the next Joint Meeting of Presidents of Regional Associations and Technical Commissions on the progress made in defining the implementation plan,

**Noting** that:

- (1) Research activities are at the base of any innovation, requiring adequate investment, the involvement of a critical mass of experts through shared facilities and partnership, and a culture that recognizes and values excellence,
- (2) Innovation requires ambitious targets to be set by the community,
- (3) These targets or scientific priorities should be limited in number and be agreed between different stakeholders,

**Convinced** that:

- (1) The urban environment provides unique conditions for catalysing innovation through the simultaneous availability of multiple stakeholders, maximum human and financial potential, and the high potential impact of future seamless products,
- (2) Improved water resource management on sub-seasonal to interannual timescales is also a key area where innovation is needed for future societal benefit,
- (3) Scientific and social aspects related to high-impact weather events, including atmospheric composition and its health impacts, will challenge the innovation capacity of NMHSs in the near future,
- (4) A seamless Data-processing and Forecasting System will be the backbone of future environmental prediction services,

**Mindful** that non-optimal use of resources in research and the duplication of effort between different stakeholders lead to the depletion of innovation potential,

**Satisfied** with the fact that the private sector and foundations create opportunities for innovation through open calls and competition,

**Recognizing** that research needs a balanced approach combining long-term activities that will support continuous improvement and short-term innovation for targeted challenges to drive accelerated progress,

**Recommends** that the Eighteenth World Meteorological Congress adopt Draft Decision X.X(X) (Cg-18) – Creating an environment for innovation and its optimal resourcing, as contained in the annex to the present recommendation.

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**Annex to Recommendation 5 (CAS-17)**

**Draft Decision X.X(X) (Cg-18)**

**CREATING AN ENVIRONMENT FOR INNOVATION  
AND ITS OPTIMAL RESOURCING**

THE WORLD METEOROLOGICAL CONGRESS,

**Recalling:**

- (1) Decision 73 (EC-68) – Cooperation between the public and private sectors for the benefit of society, which promotes a framework for fruitful collaboration between National

Meteorological and Hydrological Services (NMHSs) and the private sector for the benefit of society,

- (2) Decision 50 (EC-69) – An integrated research and development approach, which endorsed the principles towards better integrated research and development, and among which it stressed the role of co-design and continuous consultation between users and stakeholders,
- (3) Decision 69 (EC-68) – Resource mobilization, which approved the WMO Resource Mobilization Strategy that highlighted, among potential mechanisms, appropriate partnerships with the private sector and increased focus on research funding mechanisms,
- (4) Resolution 17 (EC-69) – Seamless Data-processing and Forecasting System, which requested the Steering Group on the Seamless Data-processing and Forecasting System (DPFS) to develop a detailed implementation plan, and the Commission for Atmospheric Sciences (CAS) to utilize its forthcoming Science Summit and its seventeenth session as a platform for interaction between the Commission for Basic Systems, CAS and representatives of other technical commissions and regional associations, to define the scientific progress needed to realize the future seamless DPFS,

**Recalling also** Decision 65 (EC-69) – Preparation of WMO Strategic Plan 2020–2030, which endorsed the overarching priorities of the WMO Strategic Plan for that period, which contains as goals advancing targeted research with the purpose of improved understanding of the Earth system and the implications to weather, climate, water and related environmental matters, and enhancing predictive capabilities in a seamless context through the application of scientific and technological advances,

**Noting that:**

- (1) The development of integrated services for urban environments was requested by Members and supported by the technical commissions and the Global Framework for Climate Services, and that development of such services requires advances in science and innovation to resolve processes on different spatial and temporal scales,
- (2) Research and operations need to work hand in hand with user needs as a target in advancing the seamless DPFS,
- (3) Research activities are at the base of any innovation, and that these require adequate investment, the involvement of a critical mass of experts through shared facilities and virtual partnership, and a culture that recognizes and values excellence,

**Mindful** that non-optimal use of resources in research and the duplication of effort between different stakeholders lead to the depletion of innovation potential,

**Satisfied** with the fact that the private sector and foundations create opportunities for innovation through open calls and competition,

**Recognizing** that research needs a balanced approach, combining long-term activities that will support continuous improvement and short-term innovation for targeted challenges,

**Agrees that:**

- (1) There is a need to join efforts between NMHSs, the private sector, civil society and the academic world in promoting partnerships at the national, regional and global levels;
- (2) There is a need to involve key international partners in co-designing WMO research activities with a special focus on the seamless DPFS and on cross-cutting areas of interest;

- (3) There is a need for a formal engagement of key international stakeholders in setting up the WMO research agenda in order to deliver the WMO Strategic Plan and long-term goals and in providing concrete inputs to research implementation and governance;

**Urges** Members:

- (1) To contribute to the WMO research coordination efforts through global partnerships towards a dramatic increase in predictive skills, to be materialized in improved services of the seamless DPFS;
- (2) To sustain funding for long-term research activities and fund research supporting the development of new products and services, including research activities that incorporate social sciences;
- (3) To work closely with funding agencies and other resourcing mechanisms to ensure inclusion of the unified scientific priorities defined by the WMO Strategic Plan and long-term goals in their agendas;

**Encourages** NMHSs to take a more active part in innovation calls supported by the private sector;

**Requests** technical commissions and regional associations to work towards the establishment of centres of excellence and virtual networks to be driven by ambitious scientific targets in order to catalyse innovation, for example using the Severe Weather Forecasting Demonstration Project as an opportunity to foster innovation through co-design between research and operations;

**Requests** Members to ensure support of communication systems to allow distributed access to the centres of excellence and virtual networks and for effective cooperation on research challenges;

**Requests** the Secretary-General:

- (1) To take all necessary action, within the available budgetary resources, to encourage the culture of innovation and research across the Organization;
  - (2) To assist Members in establishing global partnerships towards the development and utilization of distributed centres of excellence;
  - (3) To assist Members in mobilizing resources through research funding mechanisms;
  - (4) To promote the value of research and innovation in partnership with the private sector and other stakeholders in civil society within WMO, and acknowledge the excellence of groups for their contribution;
  - (5) To ensure that excellence in science is recognized through appropriate incentive schemes;
  - (6) To take all necessary actions to initiate, develop and maintain WMO collaboration on matters related to weather, climate, water and related environmental research with relevant organizations, agencies, groups and institutions, from both public and private sectors.
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**3. WMO Members not represented in the Commission for Atmospheric Sciences****Maldives**

Ahmed RASHEED Principal delegate

**Solomon Islands**

Alick HARUHIRU Principal delegate

**South Sudan**

Abdelgadir LADO Principal delegate

**4. Presidents of constituent bodies and chairpersons of other bodies**

Nadia PINARDI (Ms) Co-president of the WMO–IOC Joint Technical Commission for Oceanography and Marine Meteorology



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