First Report of the Research Board

Virtual Session

28–29 January 2021
CONTENTS

1. Opening of the Session ...................................................... 3
2. Invited talk: ISC President Prof. Daya Reddy ....................... 4
3. Introduction to the Research Board work, what have we achieved so far and where do we want to go? .......................................................... 6
5. Engagement, Coordination and Expectations of the research programmes (WCRP, WWRP, GAW) and WGNE related to the RB ................................................. 8
6. Update from the Research Board Task Teams .............................. 13
7. Identifying research priorities in hydrology .................................... 15
8. Wrap up of Day one and outlook to Day 2 ..................................... 16
9. Concept Notes and ways forward .................................................. 17
10. Interactions and collaboration with the Scientific Advisory Panel (SAP)/INFCOM/SERCOM ............................................. 21
11. Planning for the Open Science Conference on the Earth System (Resolution 62, Cg-18) .................................................. 26
12. Planning of 2021 activities and Wrap up of Day 2 .............................. 28

Annex 1 Agenda and Order of Business ............................................. 31
Annex 2 Workflow for the Research Board and its Substructures .................. 34
Annex 3 Terms of Reference of the Substructures (GAW) ..................... 40
Annex 4 Terms of Reference of the Substructures (WWRP) ....................... 62
Annex 5 Terms of Reference for the Representatives of the Constituent Bodies .... 73
Annex 6 Membership of the RB Members ............................................. 76
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**Attendees**: Celeste Saulo (Chair Research Board (RB)), Deon Terblanche (Vice-Chair RB), Ian Lisk (President Commission for Weather, Climate, Water and Related Environmental Services and Applications (SERCOM)), Michel Jean (President Infrastructure Commission (INFCOM)), Daya Reddy (President International Science Council (ISC)), Jian Liu (UNEP), Martin Visbeck (ISC), Craig McLean (IOC-UNESCO), Gilbert Brunet (SAP-Chair), Pauline Dube (SAP Vice-Chair), Detlef Stammer, Chris Davis, Greg Carmichael, Veronique Bouchet, Carolyn Reynolds, Judy Omumbo, Caroline Brassard, Juli Ungaro, Arlene Laing, Litea Biukoto, Adina-Eliza Croitoru, Faten Attig Bahar, Mary Scholes, Patricia Krecl, Alexey Romanov, Chiashi Muroi, Yihong Duan, Andy Brown, Matt Wheeler, Aaron Salzberg, Antonio Busalacchi, Piero Chessa, Yuki Honda, Monique Baskin, Alicia Cheripka

**WMO Secretariat**: Petteri Taalas, Elena Manaenkova, Wenjian Zhang, Oksana Tarasova, Estelle de Coning, Claudia Volosciuk, Nanette Lomarda, Stoyka Netcheva, Lu Ren, Kate Solazzo, Narelle van der Wel, Rosa von Borries, Mike Sparrow, Alexander Baklanov, Wenchao Cao, Lorenzo Labrador, Michel Rixen, Johan Stander, Anthony Rea, Jürg Luterbacher, Yinka R. Adebayo

1. **Opening of the Session (5 min, C. Saulo)**

The Chair of the Research Board (RB) *Celeste Saulo* welcomed participants to the RB meeting. She stressed that it is time for reflection on many issues, including lessons learned during the COVID-19 pandemic. She welcomed the continued engagement of the RB members in the work of the board. She introduced her new Vice-Chair Deon Terblanche.

The participants were welcomed by the WMO Secretary-General Petteri Taalas. He stressed that we are in very unusual times. The pandemic is a major challenge but WMO activities have been proceeding surprisingly well and key WMO reports, United in Science, and other major flagship WMO reports were published on time. The contribution of the expert community to the reports is highly appreciated and cited by the Secretary-General of the United Nations (UN-SG) Antonio Guterres. He described the implementation of the WMO Reform and difficulties with staffing encountered by the Science and Innovation Department. He also highlighted the resources available for the implementation of climate activities, including research, observations and early warning services. He stressed that a new financing mechanism called SOFF (Systematic Observations Financing Facility) will be used to fill major gaps in observing systems. SOFF is one of the major initiatives to improve our hydromet core systems worldwide. WMO is creating a consortium of UN agencies which will work for the water and climate sustainable development core accelerator to improve the hydrological observing systems. He indicated that the Scientific Advisory Panel (SAP) is working on the vision for the next 10 to 20 years. He further stressed that the work of the SAP and the RB are complimentary, both use synergies and provide important contribution to the WMO Strategy.
Invited talk: International Science Council (ISC) President Prof. Daya Reddy (30 min, Chairs: D. Terblanche, C. Saulo)

Deon Terblanche introduced Prof. Daya Reddy, President ISC.

Professor Reddy presented the work of the ISC. The organization has many partners and ISC views the WMO as a key partner. In his talk he mentioned some of the projects, particularly those that would be of relevance to the WMO. The ISC was founded in 2018 as the merger between the International Council for Science and the International Social Science Council. The ISC vision is for science as a global public good. It has 140 national and regional members distributed around the globe. ISC also has just over 40 member unions and associations. There are four key ISC strategic objectives. The first one is mobilizing science for policy and public action on issues of global public concern. Open science is a central pillar of ISC Strategy making it a collaborative and inclusive enterprise. Concerning cooperation inclusivity, there is the undeniable importance of transdisciplinary approaches that go across disciplines from the natural and social sciences technology, to cross-sectors, communities, civil society, scientific bodies.

There are demands for actionable knowledge to inform pathways towards sustainability at the global level. People talk about this being the Anthropocene. We are aware of the pervasiveness, the revolution that we have experienced with regard to digitization, to data mining, digital computing and the like which brings huge benefits. However, there are also threats associated with misinformation or pseudo-scientific rhetoric and that is the context in which we have to work and be very aware of.

Inequality has been identified as the challenge, a persistent or pervasive challenge right across almost all of our goals. In addition, we have the reality of the COVID-19 pandemic, which has hit us very badly in all sorts of ways, including in our efforts to achieve the goals. For example, there are 71 million people thrown into extreme poverty as a result of the pandemic. But of course, we also note the central role of science and the world at large is able to witness almost in real time, the role of science in responding to this particular emergency.

We have seen in the global sustainable development report and elsewhere that science technology is crucial to accelerate progress towards achieving the SDGs, the others being governance, economy and finance, and individual and collective action. The importance of the science society policy nexus should not be undermined in this context.

He further listed the programmes with which ISC collaborates. ISC has a high-level strategy and from that has flowed a strategic and implementation plan that called for advancing science as a global public. The plan is broken down into four key areas or themes. Firstly, the 2030 agenda for sustainable development within which there are several projects. The same applies to the digital revolution and science in policy and public discourse. Science for policy looks at the evolution of science and science systems. He also described the work done on the development of SDG support tools.

ISC has been engaging in work of relevance to the pandemic in particular the UN framework for the immediate social economic response to COVID-19 in partnership with the International Institute for Applied Systems Analysis (IIASA). The outcome of the first phase of this work has taken the form of a number of reports, which were launched just a few days ago, hitting the theme of transformations within reach, pathways to a sustainable and resilient world.

Another is a collaboration with UNESCO which has led to the UNESCO recommendation on open science. A working paper on open science for the twenty-first century refers to the African urban science platform. This is a collaborative effort involving 16 African countries, the intention of which is to set up a network across the continent, the
distributed network of research, institutes, infrastructure, instructional teaching institutes, and the like, dealing with data intensive cutting-edge research, so that Africa really can be a full partner and can take the lead, as it were, certainly within the African continent and elsewhere, in promoting fundamental and applied data intensive science in an open way.

Regarding climate initiatives and the excellent work within the last ten years e.g. by Future Earth and World Climate Research Programme (WCRP), these achievements are important regarding the forthcoming Conference of Parties (COP) summit in Glasgow towards the end of this year in November. Well ahead of that, the ISC will set up a climate science portal.

ISC collaborated with WMO on the United in Science report, the WCRP Strategic Plan as well as the WCRP review. The proposed Open Science Conference which will be discussed on day two in the agenda certainly captures these sentiments reflected in the WCRP review document and new Strategic Plan.

*Deon Terblanche* thanked the speaker for the insightful talk and shared his wide experience and thoughts on the global world and science and society.

*Antonio Busalacchi* appreciated the presentation of Professor Reddy and highlighted the strong collaboration between WMO and ISC on the science to society and the work that is done under the global framework for climate services (GFCS) He asked the question where the science associated with social science in the frame of GFCS is performed.

*Professor Reddy* responded that there is no precise answer. Looking at the forms of collaboration that we need to try to work towards, it is important to work with the social sciences, e.g. with social science organizations. Within the ISC it is in our Action Plan 1. He further responded to the question related to the issue of a regional science. He stressed that science is not developed all around the world in the same manner, along the same lines and there is a need to do a lot in order to close the gap. He agreed that WMO has a strong role in reaching the regions and expressed a wish to improve these connections between the ISC and WMO in terms of a regional approach.

*Celeste Saulo* thanked Prof. Reddy for the interesting talk and highlighted it was much aligned with the purpose of the RB, stressing the importance of collaboration between the ISC and WMO for the Regions. Prof. Reddy replied that ISC has regional offices in Africa, Asia-Pacific and Latin America and the Caribbean. Their key objective is implementation of the overall ISC Strategy at the regional level and that there are excellent opportunities for regional collaboration with WMO and other.

*Martin Visbeck* commented that the RB should take advantage of the partnership with ISC to bring the 'science for service' concept to the table.

*Tony Busalacchi* commented that in terms of future joint activities with ISC, this could be a potential avenue for enhanced collaboration. Prof. Reddy expressed that ISC is well placed and has a responsibility to draw on the social and economic science expertise within its membership to pursue this form of collaboration. He will raise this with relevant ISC colleagues.
3. **Introduction to the Research Board work, what have we achieved so far and where do we want to go?**

*(10 min, Chairs: C. Saulo and D. Terblanche)*

*Celeste Saulo* introduced the agenda of the meeting *(Annex 1)*. It was adopted without changes. The meeting agenda can be found in Annex 1 to this report. She stressed that the April 2020 meeting put a roadmap for the RB between 2020 and 2021, it reflects what was expected from the concept notes and ways of engagement in the diverse activities and reflections on the status of our programmes. She mentioned that the RB has a primary responsibility to deliver the long-term goals of the WMO Strategy to advance targeted research *(LTG 3)*. She also highlighted the importance of advancing scientific knowledge of the Earth system, enhancing science for services and advancing policy-relevant science.

She expressed big thanks to all involved in activities of the RB that were conducted despite working from home. She highlighted some of the RB results regarding membership. The composition is rather balanced as is the balance in gender. She mentioned, that there are currently vacancies for a representative for WMO Regional Association I and also a stronger connection with hydrology is needed including a new representative likely from Regional Association III to keep the overall balance. She also stressed the need for better links with other UN organizations and funding agencies.

A lot of effort during this year went into building the network, which was a part of the WMO Reform. There are connections that are being built between the Technical Commissions and other bodies. She highlighted the great job that has been done in terms of coordinating and working together. The RB has representatives in all these bodies, particularly strong links exist with INFCOM and SERCOM. RB members are also contributing to the climate coordination panel and the capacity development panel, the joint WMO-IOC collaborative board as well as in the hydrology coordination panel. Close collaboration is also established with the Scientific Advisory Panel. The linkages, collaboration and joint work with INFCOM and SERCOM will be discussed on the second day of the RB meeting.

**Decision:** The Report of the first RB session was approved by the meeting.

Celeste Saulo introduced the agenda item and requested the Secretariat to update the meeting on the formal issues.

Oksana Tarasova made a presentation on the membership, the Research Expert Network and substructures (Annex 2). She described the substructures of the RB and in the research programmes. The procedures for research are described in the Terms of References (ToR) and the rules of procedures, which were approved by the last session of Executive Council (EC-72). She stressed the importance of use of the country profile database for documentation of the membership. Through this database the RB can implement simplified nomination and appointment procedures and avoid writing papers for the concurrence and appointment. The automatic workflow in the database applies only after the decisions about the experts’ engagement in the RB bodies are made through communication within the RB or each of substructures. She described processes of solicitation and selection of the experts and the process of experts’ inclusion in the Research Expert Network. She articulated the difference between the Research Expert Network and the Expert Network used for the intergovernmental processes. She further described the proposed automated approval process for affiliation of expert to the specific groups. She highlighted that all the experts who contributed to the work of Commission for Atmospheric Sciences (CAS) will be migrated to the Research Expert Network. The automated procedures will be implemented within next months. She further stressed that all the substructures should have approved the ToRs and those were submitted to the RB prior to the meeting.

In the follow-up discussion, Detlef Stammer stressed that WCRP has a different procedure from the one described in the document (Annex 2). The WCRP Joint Scientific Committee (JSC) approves the steering groups of WCRP’s high-level activities, including Working Group on Numerical Experimentation (WGNE), while the membership for JSC is negotiated between the co-sponsors. The Chair of the JSC is elected by the JSC members.

Oksana Tarasova clarified that the workflow in the database is not a selection and nomination process, it is only applied to the documentation of the elected/selected members (Annex 2). The Chair of the respective bodies are the only entry point and approve on behalf of the JSC or the RB correspondingly. She deferred the question about the placement of WGNE in WMO structure.

Martin Visbeck enquired about the functionalities of the database and the Secretariat confirmed that additional functionalities should be discussed. The training on the use of the database will be offered to the RB members later in the year.

**Decision:** The RB approved the automatic workflow in the database, the offline process for the selection of the members of the substructures (see Annex 2).

**Decision:** The RB approved the ToRs of the substructures (Global Atmosphere Watch (GAW) (Annex 3) and World Weather Research Programme (WWRP) (Annex 4).

**Decision:** The RB approved ToRs of the representatives of the constituent bodies in the RB (see Annex 5)

**Decision:** The Secretariat will provide a training on the use of the database if needed.
5. **Engagement, Coordination and Expectations of the research programmes (WCRP, WWRP, GAW) and WGNE related to the RB (70 min, Chairs: M. Visbeck, C. Saulo)**

*Deon Terblanche* introduced the agenda item and explained that the purpose of this block is to understand the plans of the research programmes and their expectations from the RB. He stressed that the role of the RB is to help make the work of the research programmes more efficient, more integrated and more impactful, but also see opportunities of using our joint research efforts to advance and tackle some issues, which are maybe more generic and across the research programmes. He invited the Chairs of the research programmes to make presentations.

*Chris Davis*, Chair of the WWRP Scientific Steering Committee (SSC), presented key elements of the programme with three key projects: Polar Prediction Project (PPP); Sub-seasonal to Seasonal Prediction Project (S2S) and High Impact Weather Prediction Project (HIW) and a number of working groups (*Figure 1*). An important connection with social science is through the Societal and Economic Research Applications (SERA) working group. WWRP adopted the approach of co-design with users. Hydrology and urban activities are among top priorities. Paris Olympics Research and Forecast Demonstration Projects (RDP) 2024 (together with The WMO GAW Urban Research Meteorology and Environment (GURME)) and aviation RDP are two successful projects examples. He further highlighted the role of evolving technologies in connection with data assimilation and high-resolution modelling. He articulated the need for the development of the next implementation plan after 2023 and stressed the importance of a legacy of the products that were developed within the current implementation plan. He noted that utilizing the full power of the seamless Global Data-processing and Forecasting System (GDPFS) concept is really something the RB can help advance.

![Figure 1: WWRP Structure](image-url)
Detlef Stammer, the Chair of the WCRP JSC, reminded attendees that WCRP has three co-sponsors and that it has just adopted its new Strategic Plan for 2019–2028 (Figure 2). The plan has four Scientific Objectives (Fundamental Science, Improving Predictions, Improving Projections, and Science for Society). He stressed the importance of bridging science to society through regionalization. The implementation details are being developed now as WCRP has moved into a new structure (see https://www.wcrp-climate.org/wcrp-ip-overview and Figure 2) WCRP’s new lighthouse activities touch on big problems that need international coordination and partnership.

![Figure 2: New WCRP Structure](image)

There are also core projects (“homes”) and short-term projects. All the modelling and data parts are collected together in one of the new homes. He mentioned the WCRP academy and Digital Earth as cross-cutting activities. He further explained the details of four objectives and the approaches to address them. By summertime the transition to the new WCRP structure will be completed. Detlef alluded to the staffing problem in the Secretariat and the issue of overregulated WMO processes. He stressed that a lot of the things can be done through bilateral/trilateral discussions between the existing programmes. He also mentioned the Global Climate Observing System (GCOS) as an important partner of WCRP. The concept notes should bring forward the programmes’ activities. Extremes and risks as well as data assimilation were mentioned among potential joint activities.

Greg Carmichael, the Chair of the Environmental Pollution and Atmospheric Chemistry SSC EPAC) presented the progress and challenges in reaching some objectives outlined in the GAW Implementation plan for 2016–2023. The programme is implemented following “Science for Services” focus. The organization of the programme was modified strategically to align it with the WMO Reform (Figure 3). The Scientific Advisory Group focus on scientific issues, new Expert Teams focus on infrastructure aspects and steering committees of the three key initiatives (Integrated Global Greenhouse Gas Information
System, IG3IS; Global Air Quality Forecasting and Information System, Global Air Quality Forecasting and Information System (GAFIS); Measurement-Model Fusion for Global Total Atmospheric Deposition, Measurement-Model Fusion for Global Total Atmospheric Deposition (MMF-GTAD)) focus on translation of science into services. The groups established connections with new Technical Commissions and their working structures e.g. with the study groups on health and urban services. Greg stressed that atmospheric composition does matters for multiple applications from weather and climate to impacts of air pollution on health. It is an important component of the Earth system. He stressed that there are still substantial gaps in the observing system, though there are emerging observational capabilities including satellite and low-cost sensors that have a potential to fill in some of those gaps. He proposed that the RB can help with a better integration of the research infrastructure between the programmes. He indicated that building observing system requires more interactions with regional centres. Modelling and Reanalysis are important activities in GAW and they demonstrate good progress. These activities also represent a substantial potential for cross programme integration. He presented several examples of the of inter-programmes and inter-commissions integrating activities, including the urban related ones. He indicated that in the area of joint research activities the integration of aerosols research and DRR are not well addressed. As an example of the challenges in coordination of cross programmes and cross-organization activities Greg presented an example of the stratospheric ozone research. He mentioned that capacity building, partnership and communications are important components of GAW as well.

Carolyn Reynolds, the Co-Chair of Working Group for Numerical Modelling (WGNE), described a mission of this working group, which started fostering the development of atmospheric models for use in weather prediction and climate studies on all timescales. WGNE looked at both weather and climate timescales for diagnosing and resolving shortcomings, but in the spirit of becoming seamless and coupled, WGNE is now evolving into looking at the full of system rather than just atmosphere component. WGNE carried out model intercomparing projects. WGNE includes a Madden-Julian oscillation task force, a joint with WWRP working group on forecast verification research. WGNE also shares

![Figure 3: GAW structure](image-url)
knowledge and co-development for Exascale architectures. The plans include the use of Artificial Intelligence (AI) to diagnose model errors (workshop is planned in 2022) and data assimilation studies. With the development of the modelling to the Earth system approach more requests are coming to WGNE. The scope recently extended to an aerosol impact project, which is done jointly with GAW and S2S. It is important to foster links with WCRP and WWRP, and link modelling activities to services in support of the UN sustainability goals. WGNE will continue support of both service-oriented and basic research efforts, support development of bridging Earth system, AI machine learning, and coupled data assimilation across weather and climate timescales. The wider cross-programme Digital Earth activity would probably be useful as well.

The presentations were followed by an open discussion on the potential synergies between the programmes. The Chair noted the following points:

1. All the programmes are certainly in the phase of rethinking strategically where they want to go, so discussions of collaboration are timely.

2. The way the three research programmes and WGNE are organized is somewhat different. Some are more focused on organizing observations as well as the research associated with them. WGNE is more focused on advancing Earth system models and elements around that, while WCRP and WWRP may be more focused on a particular part of the system, weather and climate respectively, but all the presentations referred to at least two other programmes.

The conversations between the programmes that happen currently at the technical levels should be brought at another level where the RB can intelligently and smartly think about the future together. One common line between the programmes was related to observations. In this respect, the GCOS should be also engaged in the discussion.

The members of the RB agreed with the notes of the Chair in the level of interactions. The Chair of the RB also stressed increasing involvement of the programmes with the Technical Commissions, which is something that is very important in the context of science for service concept. The RB has an important role to play in the facilitation of these interactions. GAW established multiple links with the Infrastructure Commission in the context of observations. The RB should further promote the importance of atmospheric composition through all our systems.

Craig McLain stressed that it is a challenge to implement research observations for operations. It would be useful to review what methods are working well. It is important that the meteorological community really understands the value of the contribution of ocean observations to make S2S work correctly. Regional and downscaling models can work well only after the global models are correct. We really do need to have one approach with timescales together for weather and climate, that works for different nations.

Petteri Taalas commented that the Global Ocean Observing System (GOOS) is an important component of the Earth system observations and needs considerable additional attention including staffing of the Secretariat.

Craig McLean replied that the size of the GOOS Secretariat (which receives IOC funding) is an example of where our organizational alignment has to understand differing scales of resource and organizational size in order to facilitate sound partnership.

Wenjian Zhang fully supported SG’s comments on GOOS, highlighting that Cg-18 had a Resolution on GOOS and we need to follow up on this Resolution as soon as possible.
Andy Brown reiterated the importance of working across scales. The success is demonstrated through a number of the cross timescales projects. At the same time, it still looks like programmes are designing their activities in their own compartment and discussing it between the programmes post factum. Exascale computing is a new area where joint activities can be shaped from the beginning.

Jian Liu noted that the programmes are upgrading themselves, but the question of synergies remains open.

Carolyn Reynolds clarified that separation of timescales is rather artificial. Machine learning is an important topic that goes across timescales. Data Assimilation is also a cross timescales process and a way to combine models and observations. More interesting is a coupled data assimilation that is also cross-scale.

Chris elaborated the cross-scales approach further. He stressed that Integration of observation and models should be implemented through the Earth system approach and cross-scale considerations should be applied for time and space. He also stressed that data assimilation has a broad spectrum of applications and they all need to be considered. He also supported the idea of AI/Exascale computing as a cross programme issue.

Detlef Stammer stressed that the programmes are addressing very complex things. He agreed that the integration of observations and models gives great benefits and a special “home” was created for such activities in WCRP. Nevertheless, there are different communities who have a slightly different understanding of what is the Earth system modelling (e.g. in respect to timescales). That has impact on data assimilation aspects. There are many modelling activities and it would not make sense to put all that in WGNE.

Greg Carmichael noted that he sees a challenge of the RB to find a way to make programmes work together. Discussions demonstrated that there are some common aspects, but even in the discussion related to data assimilation, atmospheric composition was missing. At the same time atmospheric composition is an important element of the Earth system observations and modelling. He stressed that finding a structure for communication between the programmes and the RB that happens more than every six months is going to be necessary to achieve the sorts of things we can achieve. He also highlighted that the programmes are expecting the RB to help with the resource mobilization, which is a huge task.

Gilbert Brunet congratulated the programmes on the progress made. He reminded that the conversation is not a new one and to make progress the RB and the programmes have to focus on a few things. He mentioned several successful collaboration examples. He noted that the RB cannot cover all the angles and needs to choose a few things, which would be very beneficial and go forward with implementation.

Martin Visbeck proposed to appoint a liaison person for specific programmes among the RB members. The recommendation has been agreed among the RB members.

**Action:** The RB Chair and Vice-Chair will talk to RB members to take on the task of liaising to the programmes and discuss ways forward to optimally interact between the programme Chairs (Deon, Celeste; end of April 2021)
6. **Update from the Research Board Task Teams**  
*(20 min, Chairs: C. Saulo, J. Luterbacher)*

Veronique Bouchet presented an update on the Task Team on AI and Exascale computing. She reminded the objectives of the Task Team. The most work was related to the development of the concept note. She stressed that the mandate of the Task Team includes engagement with both public and private sector looking at public private engagements. Exascale computing is very much anchored into our modelling systems. As systems continue to develop and modelling advances, the need for high performance computing infrastructure grows. Some activities already underway in major modelling centres. These activities are reflected in the concept note, which also includes recommendations, helping developing countries to transfer knowledge, initiatives in different communities. The Exascale concept is also relevant in the context of the handling and sharing of increasing volumes of the Earth system data in the contexts of the future GDPFS. AI further broadens the topic. AI applies to all elements of the value chain form observations to operational products. When it comes to AI especially related to services and products there is a very strong interest from the private sector. The private sector has already initiated a number of activities in that context. There was also a UN Task Team formed on the topic. The Task Team looked at the targeted activities that can bring programmes together. Veronique proposed to develop a "roadmap" document by mid-March with a description of including long-term actionable activities for the Scientific Advisory Panel to consider. Further, the Task Team is considering dividing the current concept note into two – one focusing on modelling aspects and the other on AI in the context of data science/analytics. This will also mean to bring in additional expertise into the Task Team to cover topics currently not well represented on the TT.

Judy Omumbo presented an update on the work of the Task Team on SARS-CoV-2/COVID-19/Meteorological, and Air Quality Factors. She reminded the group on the scope of their work. The first report on Meteorology and Air Quality (MAQ) Factors and COVID-19 was developed by the group and presented via webinar to engage large number of the stakeholders. The report was based on a set of questions (16). The Task Team has published a paper in the journal Nature Communications on "A framework for research linking weather, climate and COVID-19". The Task Team has found that the current studies are giving contradicting results regarding the influence of meteorological factors and there are a lot of uncertainties due to diversity of interventions implemented by national governments. In mid-March, The Task Team will release the First Report of the WMO COVID-19 Review on Meteorological and Air Quality Factors Affecting the COVID-19 Pandemic (WMO Report No 1262) together with a two-page summary translated in all WMO languages. The next steps of the Task Team include the support of sharing information, contacts, and data/information resources, identifying gaps and additional needs for operational services and their data requirements. The Task Team will liaise with and respond to the needs of the Permanent Representatives of Members or their designated experts, as well as organizations, international research bodies and other stakeholders. It will improve the website, consolidate and promote resources of WMO Members and Programmes in support of corona virus – climate – weather-air pollution nexus research and other activities that scientists, the health sector and the public may undertake. Concerning publications, the Task Team will advise and inform on good practices and minimum standards for methods for integrated infectious disease modelling considering environmental determinants, prepare a peer-reviewed review article and coordinate with the SERCOM-Study Group on Integrated Health Services to ensure that best practices, operational procedures and service readiness are established to deal with pandemic events in the future. In the fall of 2021, the Task Team will recommend to the

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https://doi.org/10.1038/s41467–020–19546–7
WMO leaderships, how corona virus – climate – weather-air quality nexus research and information delivery should be implemented in future WMO activities.

The Chair of the RB appreciated the connection of this group with SERCOM.

Ian Lisk, the president of SERCOM, raised the issue of data policy in relation to health studies. He stressed that collaboration with the World Health Organization (WHO) is extremely important. The SERCOM and its Study Group on Integrated Health Services will greatly contribute to this task.

**Decision:** The RB approved to extend the mandate of the two Task Teams; the Task Team on AI/Exascale computing until Cg-19 end of October and the Task Team on COVID-19 until the end of the year in order to proceed with the new tasks and activities.
7. Identifying research priorities in hydrology
(20 min, Chairs: D. Terblanche, M. Sparrow)

Aaron Salzberg presented the Hydrology Research Strategy for the WMO. It mainly addressed the scientific and knowledge gaps necessary to improve the delivery of hydrologic information and services, in close collaboration with the Technical Commissions WMO’s Hydrological Coordination Panel, UNESCO’s International Hydrology Panel (IHP) and other partners.

Discussion under this agenda item was related to the role of hydrological research within the RB in general. Aaron Salzberg stressed that the issue of hydrological research was identified very early in the work of the RB as an issue that needs more attention. Though some elements are covered by the research programmes, an overall strategy that fits into the bigger scheme of things in terms of how the RB should deal with hydrology is not developed yet. The goal of the Strategy is to provide a framework that communicates clearly to WMO members, external partners, and the general public the rationale and overall approach of WMO’s efforts to advance hydrologic research. Once finalized, the Strategy will be used to develop a work plan that will identify specific partnerships and activities to implement the Strategy. The research objectives include the generation of hydrological information, hydrological and climate forecasting and improved data collection.

Detlef Stammer reminded that GEWEX work within WCRP is also relevant to the hydrology discussion. He suggested that the RB will establish a team for which the Chairs of the three research programmes will help identifying experts that can work together with Aaron and the colleagues from UNESCO. Detlef Stammer mentioned to be realistic in terms of what priorities can be implemented and how the RB will go about it and share the load and work among the multiple institutions. The complexity of the topic is that among the different communities the understanding of hydrology is different and also includes different timescales.

Deon Terblanche reminded that social aspects should be also taken into consideration. Through collaboration between communities the overlaps can be minimized and the way of working together on new things be optimized where possible. Especially for water problems, where social policy regulation issues are much involved.

The RB appreciated that the framework will go through a peer review process.

**Decision:** The RB agreed that Aaron Salzberg in collaboration with Alexey Romanov, hydrology expert from the RB and the Secretariat will coordinate the draft Research Strategy on hydrology for the WMO with solicit inputs from the three programme Chairs, other leading and representing key constituencies within the WMO, IAHS, and UNESCO as well as critical stakeholder groups. Comments on the Research Strategy draft are expected by the first part of March 2021. Aaron, Alexey and the Secretariat will work jointly with UNESCO to develop a workplan with specific activities through a series of solicitations/consultations throughout 2021 that support implementation of the WMO Strategy and IHP.
8. **Wrap up of Day one and outlook to Day 2**  
*(5 min, Chairs: C. Saulo, D. Terblanche)*

_The RB Chair and Vice-Chair_ thanked the RB members and guests for their presentations, contributions, discussions and suggestions. Together with the Secretariat they will prepare the decisions and actions from the first and second day and present the tentative outline of RB priorities for 2021 and the RB workplan under the agenda point 12.
29 January 2021, Second Day
Virtual Session

Attendees: Celeste Saulo (Chair RB), Deon Terblanche (Vice-Chair RB), Michel Jean (President INFCOM), Ian Lisk (President SERCOM), Jian Liu (UNEP), Martin Visbeck (ISC), Craig McLean (IOC-UNESCO), Gilbert Brunet (SAP-Chair), Pauline Dube (SAP Vice-Chair), Detlef Stammer, Chris Davis, Greg Carmichael, Veronique Bouchet, Carolyn Reynolds, Judy Omumbo, Caroline Brassard, Juli Ungaro, Arlene Laing, Litea Biukoto, Adina-Eliza Croitoru, Faten Attig Bahar, Alicia Cheripka, Monique Baskin, Mary Scholes, Patricia Krecl, Alexey Romanov, Chiashi Muroi, Yihong Duan, Madhavan Nair Rajeevan, Andy Brown, Matthew Wheeler, Antonio Busalacchi, Piero Chessa (RB representative in INFCOM).

WMO Secretariat: Petteri Taalas, Elena Manaenkova, Wenjian Zhang, Oksana Tarasova, Estelle de Coning, Claudia Volosciuk, Nanette Lomarda, Stoyka Netcheva, Lu Ren, Kate Solazzo, Narelle van der Wel, Mike Sparrow, Alexander Baklanov, Wenchao Cao, Lorenzo Labrador, Michel Rixen, Johan Stander, Anthony Rea, Jürg Luterbacher, Maxx Dilley.

9. Concept Notes and ways forward
(50 min, Chairs: C. Saulo, D. Terblanche)

Purpose, expected audience and status of the Concept Notes (C. Saulo, 5 min);

Celeste Saulo recalled the main purpose of the concept notes to respond to the Long-Term Goal three (LTG 3) of the WMO Strategy and highlighted the genesis and process so far to get the documents to this stage. She stressed that the scope is to reach a broader research community and attract funding agencies. She underlined that three research programmes are our building blocks. Research programmes have their own implementation plans or they are writing their implementation plans which are often long and complex documents and cannot be easily used to attract a wider audience. The concept notes will hopefully bring a simpler message and articulate the RB priorities. She invited the leaders of each note to briefly summarize future directions and priority actions.

Science for Services, future directions and priority actions
(Concept Note finalized)

Deon Terblanche presented the finalized Science for Services concept note. The concept is about the development and delivery of weather, climate, water and environmental services, which ends towards the research supports overall services objectives. We would like to see closer corporation and alignment of the WMO sponsored and co-sponsored research programmes dealing with services, infrastructure issues, and research interactions, and really foster a co-design of products and services between users, research, source, society and operations in the fields for which we are responsible. We also want to encourage partners from civil society, NGOs, community groups, academia, the private sector to interact with WMO and it is co-sponsored research. And then to identify the priority interventions that should attract resources. This concept note serves as an umbrella for the other concept notes. It identifies several issues. Water is one of those issues, another one is agriculture and food security, where we appear to be fairly weak. In addition, the important role of the oceans in the coupled climate system and the services they provide needs to be addressed. The urban domain is important as well as the aviation sector, the health sector and the risk-based decision-making. It also mentions the enabling technologies, for example the issues related to Exascale
computing and the observational network. It provides a framework for the RB and the two commissions and partners to work together.

**Innovation in Regions, future directions and priority actions (Concept Note finalized, pending final small input)**

*Arlene Laing* stressed that the concept note has changed substantially since October with much more focus on activities, critical gaps and making the case for broadening research into the developing world. The paper describes the approaches to develop and sustain effective partnerships to foster innovations in regions and also to transition research into services and operations. It also contains a proposal of some pilot mechanisms for enhancing research and development in the regions. The future direction and priority actions will involve synthesis and fusion of information. It is important to include the priorities of the WMO Regional Associations that they have identified or in the process of identifying them as well as inclusion of the priorities of the WMO research programmes. It also speaks of societal challenges regarding communicating the need for further research. We have looked at the mobilization of resources, examples taken from different regions and connection with development goals, disaster risk reduction, and risk management. Focusing on early career scientists and advancing their capabilities, not only in science, but also in management and soft skills for learning how to deal with policy makers and to articulate the needs of research within their region and developing mechanism for data sharing and expanding publication opportunities. Data sharing is a very critical aspect that was identified across the board.

**Earth System Modelling, future directions and priority actions (Concept Note in progress)**

*Andy Brown* described the evolution of the concept note and stressed the need for a broader Earth system modelling in the climate context. To deliver on science for services there is a need for better modelling tools. The paper calls for the alignment of the modelling activities between research programmes. There should be an enhanced approach to data assimilation, coupled cross-cutting and cross timescale effort. More efforts are needed to bring together the ocean community.

**Earth System Observations, future directions and priority actions (Concept Note in progress)**

*Madhavan Nair Rajeevan* stressed that support of the forecasting systems requires more sources of data and conventional data sources may be not adequate. There is a need to use unconventional data sources, such as crowdsourcing or cube sets that have small satellites. We also need vertical profiles in lower layers. Mostly composition data are very sparse. Better observations are needed to resolve physical processes. As far as hydrology is concerned, there is inadequate coverage with observations as well as an unwillingness to share the related data. Observation should have an emphasis on snowfall, deep sea, soil moisture, groundwater depth and also storage. There is a need for a holistic water observation. The concept note also points to the lack of critical measurements that underpin atmosphere – ocean coupling as well as lack of observations in the polar region, especially in the Arctic. We do not have substantive observations of the deep ocean below 2000 meters. A globally integrated deep ocean observing system will require substantial international cooperation and collaboration, and also involvement of many institutions. Glacier digital data is often short in duration and covers limited areas though some satellite data are now becoming available. We need observational impact assessment studies. Observing systems cannot be static and should evolve scientifically and technically considering new variables names, new sensors, and innovative measurement technologies. The RB has to take a strategic approach to observations with more resilient systems of observing networks, leveraging innovation, automated, low
maintenance, scalable systems, adapting to emerging technologies, including the Internet of Things (IoT).

**Exascale, Data handling and AI, future directions and priority actions (Concept Note in progress)**

*Veronique Bouchet* informed the RB members that the concept note is currently being revised by the different programmes and technical commissions, input is partially integrated. Part of the input that was received was on the areas of interest that were not necessarily represented in the paper. The group is working on the condensed version of the concept note. The document addresses quite significantly the Exascale content in the context of modelling as described yesterday. In terms of the concept, we would need to address two streams. One would be to finalize the Exascale concept and the associated recommendations that are discussed by the respective task team. The second stream is to develop a plan to establish the needs and challenges that refer specifically to the broader context and handling of the AI concept.

**Discussion on Concept Notes and the way forward (30 min)**

*Celeste Saulo* thanked all contributors for the concept notes and invited the RB to provide feedback and comments.

*Ian Lisk*, president of the SERCOM, noted that in relation to Earth system observations, there seems to be a gap in the document about fundamental surface observations, potentially suggesting that the networks are fit for purpose, an assumption which could be easily challenged. He noted the WMO initiatives to address some of those challenges, including the Global Basic Observing Network (GBON), the SOFF.

*Martin Visbeck* questioned the role of the RB in this space. One aspect is to what extent can Earth observation underpin research itself. Sometimes research networks are the service and the only thing we have. This goes back to yesterday’s similar question: what the role of GCOS is. The key question is whether the Earth system observing system is fit for purpose.

*Andy Brown* stressed that discussions could easily become confusing between observing networks being fit for purpose operationally vs observations which will potentially be interesting in the future. These are real science questions and some investment decisions are based on scarce information.

*Deon Terblanche* reminded that the RB has a focus on science to society and can play a role in identifying gaps in observing networks as part of the value chain.

*Detlef Stammer* mentioned that the design of observing systems depends on your target function: e.g. priority for weather vs climate. WCRP works already with GOOS and others. The value of observations is also on the long time series (for climate research for example). Data assimilation has various purposes: parameter estimation, initialization, or broader focus on coupling optimization.

*Anthony Rea* (Director, Infrastructure Department, WMO) brought to the attention of the meeting a unique opportunity created by the WMO Reform to strengthen the triangle RESEARCH/INFCOM/SERCOM. Requirements from services and from research flow to INFCOM. GBON is defined as essential. However, many more networks are captured and addressed within WIGOS.

*Greg Carmichael* reminded the participants that GAW runs a research infrastructure, which is somewhat migrating to operations. The challenge is to find a roadmap for the pieces the RB wants to focus on.
Madhavan Nair Rajeevan reiterated that the focus on the observations concept note was a priority for operational networks.

Martin Visbeck highlighted that with regards to innovation in regions, an important focus should be to engage with the global south.

Deon Terblanche proposed that the journey to the planned Open Science Conference can help to distil those priorities during the preparations and serves as a means to focus our attention.

Faten Bahar commented that the Young Earth System Scientists (YESS) community would be glad to contribute to the different concept notes. She also commented that implementing different communities of practices in the relevant fields could promote innovation and cooperation across regions.

In connection to WGNE the RB concluded that the group has already a lot of activities and it will be difficult for it to achieve seamless modelling alone. At the same time WGNE has broadened its boundaries on Earth system model development across timescales but should not aim to do everything. It is well realized that WGNE is ‘one’ of the Working Groups in WCRP. There are a number of specialized modelling groups for cryosphere, ocean, land, etc.

Decision: The RB agreed that the three concept notes in progress should be finalized by mid-March 2021 if possible. They should be complemented with input related to future directions and priority action-oriented components that are important for the RB that cover the next financial period of the WMO. These concept notes will also be circulated with SERCOM and INFCOM for their input. All the concept notes will then be shared with the SAP members who will discuss them at the end of March with respect to complementarity and synergies related to the 4 SAP Challenges.
10. Interactions and collaboration with the Scientific Advisory Panel (SAP)/INFCOM/SERCOM
(80 min, Chairs: D. Terblanche, E. de Coning)

Deon Terblanche introduced the agenda item, noting the important connections required between the RB and the Technical Commissions and SAP.

SAP activities and challenges (Gilbert Brunet)

Gilbert Brunet presented the activities of the SAP and its interactions with the RB. He first mentioned the SAP members and their expertise. He then presented the ToRs, including the promotion of the science vision and its downstream trends, with WMO and among its Members as the primary driver for innovation as well as the development of new and improved weather, climate, water, ocean, environmental services. Further, SAP also promotes the global standing and visibility of WMO as a leading scientific organization in the fields of weather, climate, water environmental and social sciences within the UN. SAP advises on new technological and scientific advancement that lead to new applications related to WMO core activities. SAP focusses on the time period beyond 2025 and thus complements the activities and priorities of the RB. The SAP members are currently developing a long-term vision and will address some strategic issues and the RB concept papers can contribute to that process.

The four challenges are:
- Earth system’s weather and climate prediction and insight network including AI and Exascale computing;
- Future challenges of the global observing;
- Environmental services based on science for all; and
- Global innovation and knowledge: toward extensive scientific and socio-economic partnership and cooperation.

Gilbert also talked about the innovation cycle of weather and climate forecasting; the Public Private Engagement (PPE) challenge. The innovation cycle for weather and climate forecasts includes various stakeholders from public, private and academic sectors. The important drivers of the innovation cycle are computational and observational infrastructures, also stakeholders and customer demands that push new initiatives at different positions: R&D, operation and services. All these communities will all have to make strategic choices in the coming years, and some will struggle to keep up. The PPE will play an important and different role for each of these components. A WMO Open Consultative Platform White Paper will be available in the next couple of weeks.

Veronique Bouchet indicated she was pleased to see that Exascale computing and environmental research are part of the SAP considerations.

Martin Visbeck commented on a nice alignment between the SAP and RB. Cities and water areas need to develop more. PPE should also include the broader civil society. PPE is maybe too limited to government-industry interactions.

Gilbert Brunet responded that the water and city questions are described in more detail in the SAP document while PPE is a very complex question on its own.

Pauline Dube noted that global innovation to be successful required us to influence education systems to improve on co-development/co-design. The idea could be to identify a few demonstrators where co-design can be demonstrated.
Bridging the RB with INFCOM/SERCOM activities, experiences after one year (Ian Lisk, President SERCOM):

Ian Lisk presented updates on the activities of the commission relevant to the RB. He gave a generic presentation on the work of the commission and potential collaboration with the RB. The commission works on the long-term strategic goal one, which is all about better serving societal needs. The first theme is about producing normative material, standards and technical regulations related to service delivery. The second theme is related to capacity development, promoting principles of globally consistent service delivery, good practices. The third theme is about the services commission's role in identification of gaps, where good practice does not exist. The regional aspects or the work of the RB are very closely linked with what the services commission is doing as well. And then finally SERCOM works on establishing cooperation and partnership mechanisms. He presented the organization of the SERCOM. The priority at this point is the preparation of the commission session that will take place 22–26 February. There are about 30 documents for consideration and SERCOM also plans to hold a side event on gender. The Commission works on rebalancing expert selection and the impacts of COVID on member services.

There are several activities that are of joint interest between SERCOM and the RB. SERCOM contributed to the Science for Services concept and to Exascale computing. Joint work is also on the study groups on integrated urban and health services and on the high impact weather project. There are also various initiatives going on with volcanic Ash and the sand and dust storms and on aspects of forecasting.

Chris Davis presented the proposal for Phase II of the Aviation Research Development Project. He noted that the first phase concluded in 2020. The WWRP SSC approved the second stage. The project is implemented in collaboration with the Services Commission. The information from the project can help in operations of aircraft in the five phases of flight. It creates a nice multiscale research problem because of the need for extremely fine scale information near airports and along cruise routes. The project works in the terms of forecasting things like convection, ceiling visibility, and precipitation. This project will start this year and end in 2025. There is a significant verification and validation piece with various kinds of observations that are needed and a lot of room for novel observations to be applied. The focus is on a blend between nowcasting and relatively short-range forecasting. The time frame for decision-making ranges from minutes out to a few days and looking to blend probabilistic, statistical information to provide uncertainty. The project is well aligned with WWRP priority activities, including data assimilation, rapid updating analysis and novel observation. SERA working group is also important for the project as it addresses four societal challenges. The project will help to address some of the challenges related to high-resolution forecasting. There is a couple of synergies worth noting including support to the urban agenda as Charles de Gaulle airport is included in Phase II and will overlap with the Paris Olympics urban project. This project can be a good candidate as a pilot for GDPFS. It is expected that the RB will provide connections and a broader perspective to this project.

Decision: The RB approved the second phase of the Aviation RDP as proposed in collaboration with SERCOM.

Ian Lisk expressed support to the user focused approach from SERCOM and gave the example of the International Civil Aviation Organization (ICAO) work.

Deon Terblanche mentioned that this project came out of CAS when it was still in existence. The customer here is very sophisticated with stringent requirements.
Michel Jean referred to the role of the RB and governance stressed that there is no need for a RB strategic approval for the inflight initiative, because this is already ongoing. The GDPFS framework could be exploited in this context.

It was further noted that WMO does not provide any funding for this initiative.

**INFCOM updates on the activities relevant to the Research Board (Michel Jean, President INFCOM):**

Michel Jean presented an update on the work of the Infrastructure Commission that is of relevance to the RB. His overview included the current structure of INFCOM. During 2020 the focus was on setting up the commission and its substructure. The permanent structures are called standing committees, on measurement and traceability, on observing networks, on information management and technologies and on earth systems modelling.

There are also five study groups that cover some critical area such as the GBON, the ocean, observation and infrastructure systems, cryosphere. INFCOM takes the same approach on collaboration with the RB as SERCOM. INFCOM contributed to several RB concept notes, there is also the ongoing activities where INFCOM works extremely close with the RB. In some cases, actually the experts sitting on INFCOM are also sitting on the RB. For the future, there are different avenues where INFCOM and the RB can work together: observing system and measurement and traceability, identification and assessment of new technologies and technique for measurements are important. INFCOM is also interested in non-conventional data; GBON is a perfect example where the design of network is done for the future global Numerical Weather Prediction (NWP) application following a rolling review of requirements process and impact studies. The evolution of the global observing systems is happening in response to WIGOS vision 2040. In terms of Earth systems modelling, data assimilation is also very important, especially in the context of non-traditional areas, e.g. ocean, hydrology, cryosphere which are all associated with non-conventional data. RB can work with INFCOM on the short-term link to the existing GDPFS and its future aspect, which is about full Earth systems modelling. The extension of the interface between INFCOM and the RB can be on balancing the user requirements with capability on the various technical aspects as well as cross-cutting consideration, such as gender balance in science, technology, engineering, capacity development, involvement of young scientists would be a big advantage.

Michel Jean concluded that there is a need to develop a clear vision of where the areas of priorities are, and these should be reflected in the concept notes and in the alignment between the commissions and research programmes. It is now time we move on into tangible actions.

Celeste Saulo noted that the challenge is to put those plans into concrete actions.

**Discussion on potential Global Data-processing and Forecasting System (GDPFS) Pilot Project (10 min)**

Michel Jean mentioned that GDPFS has been known for over 50 years. GDPFS is the global data-processing and forecasting system which is a backbone for coordinating member capacities to prepare and make meteorological analysis and forecast and make it available to members. GDPF is organized using a cascading structure where approximately ten World Meteorological Centres (WMC) feed the network of regional centres and their modelling systems. These centres do further processing or just post-process the information that is generated by the WMC to develop product, services and new information at the national level. The research to operation technology transfer varies from one institution to the other and serves to improve existing services and to
develop new services. Collaboration with CAS was important for research to operation technology transfer. A pilot project were undertaken in order to move the seamless GDPFS concept forward. One is on typhoon forecast and warning improvement in the Asian Pacific, and it is linked to the WWRP High Impact Weather project. The other project is about the seamless prediction from minutes to hours by the German Weather Service - Deutscher Wetterdienst (DWD). Aviation research development project phase two that has been mentioned by Chris Davis is an important activity in this respect. The context of the evolution of the GDPFS will take place in a few weeks from now. It will be about the development of a draft criteria for the pilot projects that can lead to the evolution of the global data-processing and forecasting system and the roadmap for the future GDPFS.

Deon Terblanche asked about two specific GDPFS pilot projects. The question is regarding the second project proposed by DWD. It seems that the national activity and its role as an international demonstration project is not yet clear. It is also not clear how the involvement of a larger community can be insured in that.

Michel Jean confirmed that the selection of the projects is not easy. INFCOM looks at it as the way for prototyping activities that help improve the value of cascading to the Regional Specialized Meteorological Centre (RSMC) in the context of severe weather forecasting and demonstration activities. At this point it is unclear if the proposal will be formally recognized as a GDPFS prototype or not. The reason it was put on the table now is to get feedback from the RB. INFCOM hopes that this project will advance infrastructure in providing the severe weather forecasting demonstration capabilities, moving towards the demonstration project phase two or to other core programme activities.

Chris Davis commented that the criteria for the project states that it should be applied in different regions to reflect the strengths and weaknesses of each region, but the two highlighted projects being considered are targeted and aimed at a particular region. DWD is targeting Southern Africa and the typhoon project is really focused on East Asia. Are there any applications that transcend regions and techniques that can be applied in multiple places and advance GDPFS?

Michel Jean responded that there is no clear answer to that point, but it reflects the challenge that INFCOM is facing in trying to leverage as much of activities that are actually taking place or already planned to take place versus setting up new activities that may be. There are a number of activities, for example the coastal inundation project because many people around the world would benefit from it. The prototyping is currently taking place in Southeast Asia. INFCOM is looking at draft criteria for GDPFS projects with the focus on prototyping. But the commission recognized that doing projects is very regionally dependent, hence there are going to be many considerations of the constituencies in different regions. Linking regional aspects and prototyping together is something that INFCOM will come up with, as well as a clear guidance on how to do that.

Greg Carmichael indicated that atmospheric composition-related activities should be also considered in the context of GDPFS. GAW has been working in the African context and GDPFS should be mindful and proactive in that space.

The RB took note of the deliberation and progress on GDPFS, but more in-detail thinking is needed on the demonstration projects concept, in particular on how the RB can make these more globally relevant so that lessons learned and best practices that are developed in a specific part of the world can actually benefit the broader community.
New WMO Data Policy and role of research

Michel Jean presented a study group under INFCOM that works on the update of WMO data policy. It works to update existing resolutions on data availability, data sharing, and the exchange of that information (Resolution 40 (Cg-XII), Resolution 25 (Cg-XIII), Resolution 60 (Cg-17)) in a more comprehensive resolution. He provided the background on the mentioned resolutions. He stressed that modern modelling systems require broader access to data, especially to the one never used before. New data sharing requires an update of the data policy. The group is working on a new resolution, which covers all aspect of previous data policies. It is about free and open exchange of all types of data that are necessary for the work of WMO. It does also include air quality, ocean and hydrology data. Some of those data will be mandatory. The aim is to bring this resolution to Congress in October 2021.
11. **Planning for the Open Science Conference on the Earth System (Resolution 62, Cg-18) with priorities from the programmes**

(25 min, Chairs: D. Terblanche, J. Luterbacher)

Jürg Luterbacher introduced the topic, referring also to Resolution 62 that decides “to convene an overarching Open Science Conference on the Earth System to facilitate this integrated and interactive approach”.

Deon Terblanche recalled the 2011 WCRP Open Science Conference and the 2014 World Weather Open Science Conference that were milestone events in the evolution of the two programmes. It created opportunities for engagement and reaching out to not only the traditional scientific communities involved in these programmes but the much wider partner and stakeholder communities. The WMO Congress at its last session in 2019 expressed the need for another such event and encouraged better integration between the weather, climate, water and related environmental aspects that WMO research activities and programmes including WCRP, WWRP and GAW and our partners are involved in. 2030 will be a watershed year in relation to all the above issues as stated in the various United Nations agreements, including the Sustainable Development Goals under the 2030 Agenda for Sustainable Development, the Paris Agreement under the United Nations Framework Convention on Climate Change (UN Climate Change, UNFCCC), The New Urban Agenda (Habitat III) and the Sendai Framework for Disaster Risk Reduction 2015–2030. It is therefore important to position the research efforts of WMO and its partners central to the science-based solutions required for 2030 and beyond. There are ample opportunities to address some of the potential solutions in a more integrated manner across timescales and Earth system components, not only between the existing programmes but with partners across the physical and social science domains and the enabling technology and resources:

- Physical science: cloud processes, modes of climate variability, the hydrological cycle and water resources, extreme events, resilient and green urban development, air quality and greenhouse gases, agriculture and food security, sea-level rise and storm surges, tropical cyclones, etc.

- Social Science: Co-design, Sustainable Development, Community-based Early Warning Systems, Policy relevance, Regional needs, etc. – Earth Observing, Data and Simulation Systems: Integrated observations, space, in situ, partner observations, Exascale computing, model development and refinement, AI, data systems, FAIR and open data, digital twins of the Earth system, etc.

- Enabling resources and technology: Training and capacity development, public private partnerships, science funding, next generation engagement, etc.

The RB and SAP have developed several concept notes and challenges that could provide a basis for the design of such an Open Science Conference. The planning for the event creates opportunities for WMO, its core partners and the wider community come together to shape it in a way that will build a consensus on the way forward and influence planning with better clarity on what could be best addressed jointly or separately.

Such a conference should use all the latest means to ensure inclusiveness and for this reason the conference should be a joint venture between the communities of WMO, ISC, UNESCO (including IOC), the private sector with a strong emphasis on the ‘science for service’ thinking. It is now the ideal time to start the planning of an event in 2025 and appoint an initial core planning committee consisting of RB and SAP members with a central role for the leadership of WCRP, WWRP, GAW and key partners.
Tony Bussalachi commented that WCRP and WWRP OSC were instrumental in defining the programmes over the next 10 years. The real value is about the outcome of such an event, way beyond just showcasing. Several RB members agreed with the potential opportunities for promotion and for developing joint activities from the beginning.

Detlef Stammer reminded that WCRP is planning an Open Science Conference around 2023. It is important to define goals and audiences of both events.

Greg Carmichael stressed that a conference to identify priorities for programmes given the proposed timeline of the conference in 2025, is maybe a bit out of time and/or a long shot, as each programme has its own timeline, so expectations of the RB and the programme should be aligned. We need other discussions before that time frame. This notion was supported by Chris Davis, who stressed that the timeline does create a need for each programme to bridge plans of 2–3 years down the road. The timeline of 2024 or 2025 is not clear either.

Deon Terblanche reminded that programmes have individual timelines, for example the S2S project could have a gap between its end and operational transition, something we need to address.

Martin Visbeck noted there is 2–3 years of work to prepare such an event and offered to bring this back to ISC and associated bodies.

Deon Terblanche reiterated that organizing such an event is not easy but can make a big difference in our communities and we have to plan on 2 years to get our act together and 2 years to plan for the event.

Faten Bahar commented that the YESS community is very happy to be part of the Open Science Conference and help within the outreach and the organization.

Jürg Luterbacher concluded that the idea of having an Open Science Conference in the middle of the 2020s receives a lot of support and the next steps will include to set up a few planning meetings among the different partners to start the process.
**12. Planning of 2021 activities and Wrap up of Day 2**  
*(25 min, Chairs: C. Saulo, D. Terblanche)*

The RB discussed the key **actions** identified during the meeting:

1. The RB Chair and Vice-Chair will talk to RB members to take on the task of liaisons to the programmes (*Deon, Celeste*; end April 2021);

2. Approval of new WWRP SSC members will be done via correspondence (*Estelle*; by 5 February 2021);

3. The Concept Notes Science to Services, Innovation in Region, Advances in Earth System Modelling and Advancing Earth System Observations for Research to be finalized (*Jürg* and the *Secretariat*; mid-March 2021);

4. The Concept Notes will be shared with the Scientific Advisory Panel (*Secretariat*; mid-March 2021);

5. The Concept Note Artificial Intelligence/Exascale Computing will be split in two notes and the teams will work towards finalized versions (*V. Bouchet, Secretariat*, end of spring 2021);

6. The RB will engage RB members in different tasks and liaise with programme Chairs (*Deon, Celeste, Jürg*; ongoing);

7. The RB will identify and optimize the synergies between the programmes by following up with the programme Chairs to achieve better integration (*RB Chairs*; ongoing);

8. RB will coordinate the Research Strategy on hydrology for the WMO with solicit inputs from the three programme Chairs, other leading and representing key constituency within the WMO, IAHS, and UNESCO as well as critical stakeholder groups (*Aaron, Alexey*; March 2021)  
**Decision** listed below;

9. Develop a workplan with specific hydrological activities through a series of solicitations/consultations throughout 2021 that support implementation of the WMO Strategy and IHP (*Aaron, Alexey, Deon, Celeste*; ongoing)  
**Decision** listed below;

10. The RB will coordinate and collaborate with SAP on complementary topics, including the Concept Notes (*Jürg* and *Secretariat*; ongoing);

11. The RB will strengthen the collaboration with INFCOM and investigate opportunities for possible GDPFS pilot projects (Typhoon Forecast and Warning in the Asian Pacific; Seamless Prediction from minutes to hours, etc.). The Concept Note “Innovation in regions” can serve as an important concept for the identification of such projects (*Secretariat*; ongoing);

12. The RB will strengthen the collaboration with SERCOM on Science to Services, Urban, Aviation, Health, etc. (*Secretariat*; ongoing);

13. The RB will strengthen collaboration with Regions and contribute to the Regional Association reform (*RB Chairs, Secretariat*; starting March 2021);
14. The RB will strengthen capacity building efforts and education – links with programme’s initiatives with a focus on Early Career Scientists (M. Scholes; Secretariat; starting spring 2021);

15. WMO Secretariat to organize a training on the use of the WMO Expert Database for the members of the RB to optimize the use of information available in the database. The RB members have to express interest to the Secretariat (Secretariat; spring 2021);

16. The RB will engage with funding agencies and reach wider community in order to shape research priority funding (RB Chairs, Jürg; ongoing);

17. The RB in close collaboration with WMO, ISC, UNESCO (IOC), SAP, other partners and organizations as well as the private sector for the Open Science Conference on the Earth system in (RB Chairs, Jürg and Secretariat; ongoing).

List of Decisions:

1. The Report of the first RB session was approved by the meeting;

2. The RB approved the automatic workflow in the database, the offline process for the selection of the members of the substructures (Annex 2);

3. The RB approved the Terms of Reference (ToR) of the substructures - GAW (Annex 3) and WWRP, (Annex 4);

4. The RB approved the ToRs of the representatives of the constituent bodies in the RB (Annex 5);

5. The Secretariat will provide a training on the use of the database if needed;

6. The RB approved the second phase of the Aviation RDP as proposed in collaboration with SERCOM;

7. The RB approved extending the mandate of the two Task Team; the Task Team on AI/Exascale computing until Cg-19 end of October and the Task Team on COVID-19 until the end of the year in order to proceed with the new tasks and activities;

8. The RB agreed that Aaron Salzberg in collaboration with Alexey Romanov, hydrology expert from the RB and the Secretariat will coordinate the draft Research Strategy on hydrology for the WMO with solicit inputs from the three programme Chairs, other leading and representing key constituency within the WMO, IAHS, and UNESCO as well as critical stakeholder groups. Comments on the Research Strategy draft are expected by the first part of March 2021; Aaron, Alexey and the Secretariat will work jointly with UNESCO to develop a workplan with specific activities through a series of solicitations/consultations throughout 2021 that support implementation of the WMO Strategy and IHP;
9. The RB agreed that three concept notes in progress should be finalized by mid-March 2021 if possible. They should be complemented with input related to future directions and priority action-oriented components that are important for the RB that cover the next financial period of the WMO. These concept notes will also be circulated with SERCOM and INFCOM for their input. All the concept notes will then be shared with the SAP members who will discuss those end of March with respect to complementarity and synergies related to the 4 SAP Challenges.

Greg Carmichael supported the summary as presented in the slides, but he noted that though the urban agenda appeared in a high strategy of SAP, this topic must be enhanced within the RB.

Arlene supported this statement. She noted that urban issues are not only being associated with large cities. She reminded that in the Caribbean last year and since 2019 some extreme heat events were experienced even in small islands. The issue of urban health issues including air quality is of a concern.

Oksana Tarasova mentioned in the connection with the capacity building panel that she supports the statement of Pauline that it is not good enough that one has training centres supported by capacity development in educational programme. The RB need to talk about how the national education system works and why Science, Technology, Engineering and Mathematics (STEM) is not really a popular subject. This drives a lack of expertise in technical areas in many developing countries. CAS adopted the recommendation on the support of the national educational curriculum through the reinforcement of the STEM are in the educational system. This resolution has to be followed up by the RB. Respective resolution to Congress or to the Executive Council can be developed in collaboration with the United Nations Institute for Training and Research (UNITAR) and UNESCO that can discuss how to work with the educational system to actually motivate for STEM.

Mary Scholes suggested to pay tribute to Paul Crutzen.

Celeste Saulo, Deon Terblanche and Jürg Luterbacher thanked all participants and closed the meeting.
ANNEX 1

AGENDA AND ORDER OF BUSINESS

Day 1, 28 January 2021, 1100 UTC – 1400 UTC (1200–1500 Geneva time)

Note: All timings include discussion time, unless otherwise stated. We ask all presenters to keep strictly to the allotted time and to send their presentations in advance to Kate Solazzo (ksolazzo@wmo.int).

Preparatory material can be accessed from here

1. Welcome (5 min)
   Welcome by the Chair of the RB (C. Saulo)
   Welcome by the WMO Secretary-General (P. Taalas)

2. Invited Talk: ISC President Prof. Daya Reddy (30 min, Chairs: D. Terblanche, C. Saulo)
   • Society and Science: The Next Chapter (20 min)
   • Q&A (10 min)

3. Introduction to RB work, what did we achieve so far and where do we want to go? (10 min, Chairs: C. Saulo and D. Terblanche)
   • Adoption of the agenda for the session;
   • Approval of April 2020 RB Meeting Report;
   • Presentation of major achievements and highlights of the RB until January 2021 (C. Saulo).

4. Membership, Research Expert Network and substructures of the RB (20 min, Chairs: C. Saulo, D. Terblanche)
   • Overview provided by the Secretariat (O. Tarasova);
   • Approval of new members, mechanisms;
   • Approval of the ToRs of the RB substructures and Representatives in Constituent Bodies.

5. Engagement, Coordination and Expectations of the research programmes (WCRP, WWRP, GAW) and WGNE related to the RB (70 min, Chairs: M. Visbeck, C. Saulo)
   • Presentation of the status of implementation and future strategies of the Research Programmes and WGNE:
     • WWRP – C. Davis (10 min)
     • WCRP – D. Stammer (10 min)
• GAW – G. Carmichael (10 min)
• WGNE – C. Reynolds (10 min)

How can the RB help to identify synergies and support the programmes? (30 min)

6. **Update from RB Task Teams** (20 min, Chairs: C. Saulo, J. Luterbacher)
   - Task Team on Exascale computing/AI: Where are we, what did we achieve so far and what are the next steps and decisions required of the RB? (V. Bouchet, Co-Chair TT, 10 min);
   - Task Team on SARS-CoV-2/COVID-19/Meteorological, and Air Quality Factors Where are we, what did we achieve so far and what are the next steps and decisions required of the RB? (J. Omumbo, Co-Chair TT, 10 min).

7. **Identifying Research Priorities in Hydrology**
   (20 min, Chairs: D. Terblanche, M. Sparrow)
   - Presentation on ideas and prioritization of hydrology research coordinated between the RB, across WMO and other Organizations (A. Salzberg)

8. **Wrap up of Day one and outlook to Day 2**
   (5 min, Chairs: C. Saulo, D. Terblanche)
Day 2, 29 January 1100 UTC – 1400 UTC (1200–1500 Geneva time)

9. **Concept Notes and ways forward**
   (50 min, Chairs: C. Saulo, D. Terblanche)
   - Purpose, expected audience and status of the Concept Notes (C. Saulo, 5 min);
   - Science for Services, future directions and priority actions (J. Ungaro, 3 min, 1 slide);
   - Innovation in Regions, future directions and priority actions (A. Laing, 3 min, 1 slide);
   - Earth System Modelling, future directions and priority actions (A. Brown, 3 min, 1 slide);
   - Earth System Observations, future directions and priority actions (M. Rajeevan, 3 min, 1 slide);
   - Exascale, Data handling and AI, future directions and priority actions (V. Bouchet, 3 min, 1 slide);
   - Discussion on Concept Notes and the way forward (30 min).

10. **Interactions and collaboration with the SAP/INFCOM/SERCOM**
    (80 min, Chairs: D. Terblanche, E. de Coning)
    - SAP activities and challenges (SAP Vice-Chair: P. Dube, 15 min);
    - Bridging the RB with INFCOM/SERCOM activities, experiences after one year:
      - SERCOM updates on the activities relevant to the RB (I. Lisk, President SERCOM, 20 min)
        - Proposal for Phase II of the Aviation Research Development Project (C. Davis, 10 min)
      - INFCOM updates on the activities relevant to the RB (M. Jean, President INFCOM, 15 min)
        - Discussion on potential GDPFS Pilot Project (10 min)
        - New WMO Data Policy and role of research (10 min)

11. **Planning for Open Science Conference on the Earth System (Resolution 62, Cg-18) with priorities from the programmes**
    (25 min, Chairs: D. Terblanche, J. Luterbacher)

12. **Planning of 2021 activities and Wrap up of day 2**
    (25 min, Chairs: C. Saulo, D. Terblanche)
    - Tentative outline of priorities for 2021 and RB workplan
ANNEX 2

WORKFLOW FOR THE RESEARCH BOARD AND ITS SUBSTRUCTURES

Content of the document:
1. Overview of the RB subgroups;
2. Research Expert Network;
3. Expert solicitation processes;
4. Expert selection processes;
5. Appointment process.

1. Overview of the RB subgroups

Figure 1 represents the WMO RB with its subgroups. Several groups under the RB are supported jointly with co-sponsor organizations.

Figure 1. Subgroups under the WMO RB. The number in the diagram indicates the respective workflow for the membership appointment process (see Section 5). Please note that WGNE reports to WCRP JSC as well.
The outlined structure requires setting up the rules for nomination, selection and appointment of the following:

1. RB Chair and Co-Chairs;
2. RB members;
3. Research programmes’ steering committee’s Chairs;
4. Research programmes’ steering committee’s members;
5. Subgroups under the research programmes’ steering committees (Chairs and members);
6. Subgroups directly under the RB (currently WGNE and two task teams).

2. Research Expert Network

As a non-constituent body, the RB has the mandate to convene the large international scientific community, who engage with WMO and who value the opportunity to enhance the societal impact of their research through the relationship with WMO (Resolution 8 (Cg-18) - Research Board).

To technically facilitate this engagement opportunity, the RB established the Research Expert Network (see Figure 2) in the WMO Experts Database to have the Research experts clearly identified in the database. In this regard, a WMO circular letter was sent to Members informing them about the transfer of all the experts associated with the groups of the former Commission for Atmospheric Science into this network and asking the Members to propose experts for the groups of the RB via this Research Expert Network (Ref.: 00907/2021/SI). The nomination process will be similar to the process for the Expert Network for the constituent bodies. The Research Expert Network, as the Expert Network, is a part of the WMO Experts Database.

Figure 2: Experts Database
The purpose of the Research Expert Network is to include experts extending beyond the National Meteorological Services to research institutes, academia and broader network of partner organizations. The Research Network will ensure that experts can be nominated to serve on WMO bodies related to Research, but this will not automatically make them available to serve on intergovernmental bodies. To serve on intergovernmental bodies, nominations should be made to the already existing Expert Network. Experts can be part of both the Expert Network and the Research Expert Network at the same time.

3. Expert solicitation processes

Solicitation of an expert for potential membership (see current RB members in Annex 6) in WMO RB bodies is not regulated by constituent body decisions and can be implemented in such a way as to meet the expertise requirements in the RB bodies. The nominations can be done by the Permanent Representatives, solicited through the informal scientific networks through recommendations of the RB bodies, solicited via partner organizations or through open calls.

In order to improve the process and ultimately benefit both WMO and its partners, partner organizations have been asked to indicate who their focal point(s) is/are in writing to the WMO External Relations Office, for attention Ms Natalie Burke (sburke@wmo.int). These partner organization focal points will then be able to interact with the WMO Research and Science and Innovation department staff as required in the nomination process. These focal points will be granted access as agency approvers to the database to enter and approve experts and also be able to use the database as a resource, for instance, to find experts for their own groups and activities.

The solicitation process allows the creation of a pool of potential experts that can be used in the selection process under WMO rules in addition to direct nomination by WMO Members and partners. This process can be informal. The solicitation process does not require all the experts to already reside in the Expert Network database, but they should indicate willingness to contribute.

Communication of the required expertise and the Terms of Reference of the groups to the potential experts where they are considered to contribute should be part of the solicitation process.

Terms of Reference of any group must be established and approved by the RB before any expert solicitation process (for WCRP the RB represents WMO as one of the programme’s co-sponsors). The required qualifications must constitute an integral part of the Terms of Reference.

It should be clearly understood that solicitation of the experts by any of the described means, does not mean that all the experts will be selected for the substructures of the RB. Solicitation process does not require inclusion of all the solicited experts in the Research Expert Network. In the case of the open solicitation process, the experts who are already available in the Research Expert Network should be examined and be equally considered in the selection process.
4. **Expert selection processes**

The following selection of criteria apply:

(1) Selection criteria for the RB are described directly in Section 4 of the Rules of Procedures (RoP) for the Research Board (Annex 1 to Resolution 12 (EC-72));

(2) For the subgroups the members are selected for their scientific expertise in the area addressed by the specific group, capacity, breadth of vision and teamworking skills. The experts should meet the requirements articulated in the group’s Terms of Reference. The members should be drawn to promote geographical and thematic representation and gender balance. The Chairs of the respective groups should, in addition, to the above, have demonstrated leadership skills;

(3) In the case that an expert is already affiliated to an RB body or other WMO body his/her availability to serve in an additional group must be checked;

For WCRP, as a co-sponsored body, the process is a little different as a membership selection of the JSC is governed by the co-sponsorship agreement\(^2\) and selected by mutual agreement between the three co-sponsors. However, since WMO is one of WCRP’s co-sponsors the RB represents WMO in the new selection process and the selection for the JSC as well as groups co-sponsored by WCRP and other programme(s) (currently WGNE, S2S). For groups such as WGNE and S2S the WCRP JSC will still approve the membership before it goes to the RB for final approval. For the WCRP JSC the three co-sponsors will mutually agree on any changes to the membership as before, with the final step being agreement and inclusion of new JSC members into the WMO Research Expert Network, with such information in the database being fully available to WCRP’s other co-sponsors. The WCRP JSC Chair is elected by JSC members.

The selection process takes place offline (by email) on request of the groups that would require the change in the membership.

5. **Appointment processes**

The appointment of the experts in the subgroups under the RB takes place after the selection of the experts as described in the previous sections and applies only to the experts that **are selected** for the specific function. This process serves to document the **results** of the selection which is made following the processes described in the sections above.

Appointment of the experts for specific positions is a two-step process:

(1) Inclusion of the expert in the Research Expert Network;

(2) Affiliation of the expert to the specific group.

Documentation of the groups and affiliated experts is required to evaluate financial implications of a given organizational approach, to track countries and partner institutions in-kind contributions.

\(^2\) “2.1 The JSC shall consist of eighteen scientists selected for their scientific knowledge, capability and breadth of vision. The members of the JSC will be selected by mutual agreement between WMO, IOC and ICSU and appointed jointly by the three organizations...” from WCRP co-sponsors Agreement 1993
**Step 1: Inclusion of the expert in the Research Expert Network**

For the appointment of the experts in any of the substructures of the RB, the experts must be entered in the Research Expert Network (a group of experts available for the research activities in the WMO expert database, see Annex 2).

The Secretariat should check if the experts whose services are required under any of the bodies under the RB are already included in the Research Expert Network. If not, the Secretariat has to insert the experts into the Research Expert Network (RoP 6.6).

The experts must confirm their availability for the required services (to be verified by the Secretariat).

For the inclusion of the expert in the Research Expert Network the following information is required:

1. Name and affiliation;
2. Nominating body (WMO Member or partner agency);
3. Curriculum Vitae (CV).

**How:** The Secretariat enters the name of the expert in the Research Expert Network of the Experts Database, pending approval by the nominating body (see above). Upon approval by the agency approver the expert becomes available in the Research Expert Network and is eligible for the appointment to serve in a subgroup of the RB. Alternatively, the WMO Member or partner can nominate the experts directly to the Research Expert Network.

**Step 2: Affiliation of the expert to the specific group**

*Workflow 1: RB*

Workflow for Chair/Vice-Chair:

1. RB proposes Chair/Vice-Chair;
2. EC approves;
3. Secretariat enters the name in the database or updates the status.

Workflow for the RB members:

1. RB Chair proposes the potential member to EC (RoP 4.4);
2. EC approves (RoP 4.3);
3. Secretariat updates the status in the database.
Workflow 2: Steering committees (SSC) of the WMO research programmes

For SSC/JSC Chairs (RoP 6.4):  
(1) RB Chair proposes the potential SSC/JSC Chair in consultation with the RB (and co-sponsors where required);  
(2) EC approves;  
(3) Secretariat updates the status in the database.  

For the members of SSC (RoP 6.5):  
(1) Secretariat initiates the workflow;  
(2) Approval Agency approves (the same as a nominating body from step 1);  
(3) SSC/JSC Chair approves4;  
(4) RB Chair approves.

Workflow 3: Subgroups under steering committees of the WMO research programmes

SSC subgroups Chair(s) and members:  
(1) Secretariat initiates the workflow;  
(2) Approval Agency approves;  
(3) SSC Chair approves.

Workflow 4: Direct subgroups under the RB

Chair and the members of WGNE and Task Teams under the RB  
(1) Secretariat initiates the workflow;  
(2) Approval Agency approves;  
(3) RB Chair approves5.

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3 as the Chairs of the SSCs and JSC are the members of the Research Board, the same workflow as for the Research Board members apply  
4 In the case of WCRP the JSC Chair approves JSC members on behalf of the co-sponsor agencies and must consult them for the prior approval  
5 In the case of WGNE, the RB Chair should consult with WCRP JSC Chair prior to approval
ANNEX 3

TERMS OF REFERENCE OF THE SUBSTRUCTURES (GAW)

Organization of the work in GAW aligned with the WMO Reform

Purpose

GAW activities are organized to facilitate research and operations related to atmospheric composition needed to support the value chain from science to services. The foundation of the GAW Programme is long-term high-quality observations supplemented by fit for purpose measurements associated with the applications and services developed by the programme and assisted by the modelling tools.

The components of the programme are listed in the GAW implementation plan and include: observational infrastructure, dedicated quality assurance and quality control infrastructure, atmospheric composition data management infrastructure, fundamental and applied research related to GAW focal area to better understanding atmospheric composition processes in an Earth system framework, modelling elements and the translational components to support environmental services and to complement and improve weather and climate related services.

The various elements interact with each other, and interface with the WMO Technical Commissions on service and infrastructure to transition research to operations. Activities of the GAW Programme are coordinated by the Environmental Pollution and Atmospheric Chemistry SSC which reports to the WMO RB.

Considering the close connection between different components of the programme and after intensive discussions at the SSC meeting in November 2019 it was decided that some streamlining of activities is needed to:

1. address the cross-cutting elements in the programme in a more integrated way,
2. re-enforce research components and improve their collaboration with the other research programmes and initiatives within and outside of WMO, and
3. create unified interfaces with the two new technical commissions.

It is recognized that there are different ways to achieve these objectives through the organization of the work. The SSC agreed that at this point the most efficient and easily implementable solution is to organize activities through three types of bodies articulating in the Terms of Reference the connections and interfaces between them, namely Expert Teams, Scientific Advisory Groups and science for services initiatives Steering Committees.

GAW Expert Teams are responsible for advances in the research infrastructure and address the cross-cutting or common elements between different focal areas, they work in close cooperation with the other groups in GAW, including liaising with the GAW Scientific Advisory Groups and Expert Teams (ET) representatives in the relevant groups under the Technical Commission on Infrastructure.

GAW Scientific Advisory Groups facilitate research related to atmospheric composition along the value chain of science for service and connect infrastructure and service-related groups. The Scientific Advisory Groups (SAGs) work in close collaboration with the other research programmes within and external to WMO scientific bodies and projects. SAGs work with the ET directly or through the respective liaison members to
ensure data from the observational networks are fulfilling research needs for respective parameters, communities and international conventions.

GAW Initiatives Steering Committees are coordinating and facilitating the translation of science to services. This work builds on close cooperation with the SAGs. The Steering Committees are expected to link with the relevant groups under the Technical Commission on Services (where appropriate).

Outreach and training activities are also cross-cutting in nature and are coordinated by the SSC (or temporary created groups under the SSC).

The ToRs below reflect on the core responsibilities of each group and on the interfaces/collaborations they have to implement to carry out their work successfully. A schematic of the interactions between different groups is depicted below.

**Modes of operation for membership and carrying out the work plans**

Required expertise for GAW appointments

- Atmospheric composition observations (including aerosol, reactive and greenhouse gases, stratospheric ozone, atmospheric deposition and solar UV radiation) including measurement methods and quality assurance;

- Good understanding of the processes that drive atmospheric composition changes on different spatial and temporal timescale;

- Atmospheric composition modelling;

- Utilization of the atmospheric composition data for diverse applications;

- Earth system approach and role of atmospheric composition in it;

- Atmospheric composition observations data management;

- Atmospheric composition data products and user community.

**Selection criteria**

The experts are selected for serving on the SAGs, ETs and SCs for their scientific expertise in the areas addressed by the specific groups, and for their capacity, breadth of vision and team working skills. The experts should meet the requirements articulated above and needed to support the work of the respective group as articulated in the Terms of Reference below. The members should be drawn to promote geographical and thematic representation and gender balance. The Chairs of the respective groups should in addition to the above have demonstrated leadership skills.

**Modalities**

- Meetings

Note: Normally GAW would be expected to convene a face-to-face meeting once every two years at the WMO Headquarters. Consideration may be given by WMO to selecting an alternative location provided it increases efficiency without increasing costs to the organization.

- Tele/video conference
Note: Normally the SAGs, ETs and SCs would be expected to convene tele/video conferences on at least a quarterly basis.

- Correspondence including email exchanges and other appropriate online interactions.

Specific Activities

1. GAW ET

1.1. Expert Team on Atmospheric Composition Data Management (ET-ACDM)

Core activities

- Document issues with and coordinate the development and implementation of common data and metadata standards within GAW, in alignment with WIS/WIGOS, and assist contributing networks with utilizing the WIGOS metadata standard;

- Advise the SAGs, WMO ET and partners, and the GAW initiatives’ steering committees on harmonizing data management; enabling FAIR data principles (findable, accessible, interoperable, re-usable) in support of plug and play capabilities (data formats and application programme interfaces, APIs) of GAW data;

- Collect and provide information on NRT (within 3 hrs of observation for real time, within 72 hours of observation for near-real time) data transmission to station operators;

- Facilitate timely submission of quality-controlled data for long-term archival in the respective GAW World Data Centres (WDCs);

- Provide comprehensive and up-to-date guidance on the data and metadata submission processes, revision and re-submission, including consideration of data policy, licences, provenance and data quality as well as consistency between the data and metadata;

- Monitor the data submission to the thematic GAW WDCs and provide consolidated annual statistics on data submission, distribution, and use to EPAC SSC;

- Document/identify issues and propose solutions in support of the further development of GAWSIS, as an integral component of OSCAR/Surface, and as the central catalogue of observing facilities and observations supporting GAW, linking the WDCs and Contributing Data Centres.

- Guide GAW WDCs on implementing WMO data policies, in providing user groups with free and open access to all data, complemented with access to innovative and mature data products, together with tools for Quality Assurance (QA), data analysis and research, following WIGOS policies in particular with regards to metadata documentation;

- Guide GAW WDCs and archives of Contributing Data Centres on implementing new technologies that improve information management within GAW, as well as contributing networks, in line with the evolution of WIS/WIGOS.
Interface with SAGs

- Solicit input from SAGs to articulate the need for the inclusion of new parameters in the data archives and to provide related metadata;
- Communicate to SAGs concerns related to data submissions (e.g. non-reporting stations), data quality and availability of the archived data;
- Jointly with SAGs develop and support the tools for the effective evaluation on new stations in GAW.

Interface with ET

- Work with ET-ACMQ on implementation of the quality flagging and automated data quality control tools in the GAW Wold Data Centres and data centres of the contributing networks;
- Communicate concerns related to data quality of archived data to ET-ACMQ.

Interface with GAW Initiatives Steering Committees

- Assist Steering Committees of the GAW science for services initiatives with the data archival for specific applications.

Interface with WMO groups

- Advise to and interact with the RB on all matters related to atmospheric composition data management;
- Interact with the respective groups under the Technical Commission on Infrastructure on aspects of data management in order to harmonize and integrate atmospheric composition data with the other data management processes in WMO.

Interface with external users and partners

- Assist data archives of contributing networks and other interested parties in the application of the WIGOS metadata standard and the use of GAWSIS-OSCAR/Surface;
- Assist users in access and retrieval of data hosted at the data centres contributing to GAW.

1.2 Expert Team on the Atmospheric Composition Network Design and Evolution (ET-ACNDE)

Core activities

- Review user requirements for the observations related to the three atmospheric composition application areas: atmospheric monitoring, forecasting, and urban applications in support of the WMO Rolling Review of Requirements (RRR);
- Review and harmonize user requirements for the atmospheric composition variables in the other WMO application areas;
- Regularly update the user requirements in the OSCAR database;
● Assess current observational capabilities in light of user requirements;
● Summarize recommendations on integrated network design in Statements of Guidance for each application area and advise on the network development to the GAW Programme and relevant partners.

**Interface with SAGs**

● Work closely with thematic SAGs on collection of the user requirement for specific parameters under different applications and on the evaluation of the observational capabilities;
● Work with SAG-Apps to better understand user requirements across the applications from the integrated modelling perspective.

**Interface with ET**

● Advise ET-ACDM on additions and modifications of parameter definitions, and available in situ observational capabilities in the GAW World Data Centres (WDCs);
● Communicate to ET-ACMQ on the emerging observational capabilities and the needs for quality assurance procedures of those new elements.

**Interface with GAW Initiatives Steering Committees**

● Coordinate the collection and reviews of observational requirements from the science for services initiatives to ensure their incorporation in the broader RRR process.

**Interface with WMO groups**

● Collaborate with the relevant WMO group in particular under the Technical Commission on Infrastructure on harmonization of requirements for atmospheric composition variables and essential climate variables across WMO application areas and programmes (e.g. GCOS);
● Collaborate WCRP, WWRP, and other programmes as appropriate on development of the Statements of Guidance.

**Interface with external users and partners**

● Work closely with modelling centres to provide guidance on the optimized network design for specific applications;
● Communicate with partner organizations concerning the observational gaps identified in the Statement of Guidance.

### 1.3 Expert Team on Atmospheric Composition Measurements Quality (ET-ACMQ)

**Core activities:**

● Develop common quality assurance principles and terminology between thematic GAW groups;
• Advise GAW station operators on the implementation of the quality assurance protocols, Standard Operating Procedures and measurement guidelines;

• Coordinate interactions, monitor the activities and reporting of the GAW Central Facilities;

• Promote the development and use of unified tools for the quality control at the stations;

• Improve data quality by producing documents to help meeting quality assurance requirements, encouraging the stations participating in the programme to utilize GAW Central Facilities to ensure a consistent traceability chain;

• Promote and coordinate intercomparing exercises, disseminate comparison reports, develop quality flagging based on the results of the instruments’ performance;

• Promote the establishment of the missing element of the quality assurance and control system in GAW with particular focus on establishing new Regional Calibration Centres;

• In cooperation with thematic SAGs and ET-ACDM develop and maintain the Standard Operating Procedures and measurement guidelines for instruments, data processing and submission for observations made under GAW, and update the respective sections of the Commission for Instruments and Methods of Observation (CIMO) Guide;

• Guide the implementation of measurement approaches that ensure internal consistency (compatibility) of data contributed by partners through the use of common standard scales maintained by the Central Calibration Laboratories, participation in international comparisons and station audits organized by World Calibration Centres, and utilization of practices recommended by the expert measurement community;

• Survey available and emerging measurement techniques and support the development of standard operating procedures for these in cooperation with the respective SAGs.

**Interface with SAGs**

• In cooperation with thematic SAGs develop and keep updated the Standard Operating Procedures and measurement guidelines;

• Assist SAGs in developing measurement guidelines for the emerging measurement techniques or new chemical variables;

• Work closely with thematic SAGs on the development of the harmonized and automated quality assurance and control tools.

**Interface with ET**

• Assist ET – ACDM in developing and maintaining data-processing and submission protocols and guidelines to ensure inclusion of the data quality flagging;

• Assist ET – ACDM in the evaluation of quality of data residing in the WDCs.
Interface GAW Initiatives Steering Committees

- Advise the science for services initiatives on the GAW observational quality management.

Interface with WMO groups

- Interact with the respective groups under the Technical Commission on Infrastructure in relation to the quality of observations in order to harmonize and integrate atmospheric composition data quality assurance approaches with the ones in the other WMO observing components.

Interface with external users and partners

- Work closely with the research infrastructures and other research programmes and initiatives on the development of good practices for common approaches and automatic tools for quality control of atmospheric composition measurements.

2. Scientific Advisory Groups (SAG)

2.1 SAG on Total Atmospheric Deposition (SAG-TAD)

Core activities

- Facilitate research related to the total atmospheric deposition working closely with the relevant international programmes and projects, as well as joint activities with other major environmental science activities including ambient aerosol and gas monitoring, atmospheric modelling, ecosystem effects research, climate research, etc.;

- Coordinate the work related to quantification of the patterns and trends of the composition of precipitation and total deposition on global and regional scales and produce regular assessments;

- Provide guidance on the development of the methods for the estimation of the total atmospheric deposition with a specific focus on dry deposition and feed those scientific developments to the MMF-GTAD initiative;

- Improve understanding of atmospheric deposition of chemical species of existing or emerging interest (e.g. organic acids, black carbon, metals, phosphorus, mercury, nitrogen);

- Promote the establishment of the new sites, field laboratory and data management operations;

- Assist/supervise the development of the relevant training materials and training delivery and support capacity development activities.

Interface with SAGs

- Work closely with the other thematic SAGs on the improved understanding of the element cycles, exchange processes and chemical transformations.
Interface with Expert Teams

- Work closely with ET-ACMQ on the assessment of the new measurement methodologies, quality assurance and control tools and the revision of existing measurement guidance;
- Work closely with ET-ACMQ on the establishment of good practice guidelines and common procedures for quality assurance;
- Work with the ET-ACDM on the data archival and availability in the WMO WDCs and the needs for additional variable and related metadata;
- Work closely with ET-ACNDE on the provision of the user requirements for the deposition related applications.

Interface with GAW Initiatives Steering Committees

- Advise MMF-GTAD Steering committee on the research related to measurement-model fusion methodologies to obtain total deposition estimates.

Interface with WMO groups

- Collaborate with the WMO and co-sponsored programmes on the aspects of deposition within the Earth System approach by addressing weather (precipitation), hydrological, agriculture and ocean research.

Interface with external users and partners

- Outreach to other scientific and non-scientific communities regarding the state of science related to atmospheric deposition of major ions and other chemicals, including the work of the MMF-GTAD initiative, as well as proper understanding and use of measurement data;
- Communicate the availability of GAW observations to user communities, including ecosystem effects and atmospheric modelling communities.

2.2 SAG on Reactive Gases (SAG-RG)

Core activities

- Facilitate research related to reactive gases working closely with the relevant international programmes and projects, as well as joint activities with other major environmental science activities including reactive gas monitoring, atmospheric modelling, effects research, climate research, etc.;
- Assess the current and emerging needs for measurements and analysis of reactive gaseous compounds to guide scientific developments and future delivery of such information;
- Promote initiatives towards an integrated view of the role of reactive gases in climate and air quality, working closely with the relevant international programmes and projects as well as joint activities with other major environmental science activities;
- Promote/facilitate the expansion of reactive gases observations in undersampled regions, i.e. primarily in the tropics and in the southern hemisphere, to fill large gaps in the global observation network of reactive gases;

- Periodically evaluate the extension of the target species of the GAW reactive gases programme to other substances that are important to advance understanding of tropospheric chemistry, considering the availability of suitable measurement technologies and calibration methods;

- Produce regular assessments of the spatial distribution and trends of the main reactive gases on global and regional scales;

- Assist/supervise the development of the relevant training materials and training delivery and support capacity development activities.

**Interface with SAGs**

- Work together with the other thematic SAGs to develop integrated analyses targeting global challenges such as the nitrogen cycle, air pollution impacts on agriculture and natural ecosystems, and the role of short-lived climate forcers on regional weather and climate.

**Interface with Expert Teams**

- Work closely with ET-ACMQ on the assessment of the new or emerging technologies and methods which are becoming available for reactive gases, quality assurance and control tools and on the revision of existing measurement guidelines;

- Work closely with ET-ACMQ on the establishment of good practice guidelines and common procedures for quality assurance;

- Work closely with ET-ACNDE on the development of the user requirements for the application areas relevant to reactive gases to meet requirements from research communities responding to global environmental challenges;

- Work with the ET-ACDM on the data archival and availability in the WMO WDCs and the needs for additional variable and related metadata.

**Interface with GAW Initiatives Steering Committees**

- Advise GAW Initiatives Steering Committees on the recent developments, observational and modelling capabilities related to reactive gases.

**Interface with WMO groups**

- Collaborate with the WMO and co-sponsored programmes on the aspects of reactive gases within the Earth System approach and addressing weather, climate, health and agricultural, hydrological and ocean research.
Interface with external users and partners

- Outreach to other scientific and non-scientific communities regarding the state of science related to reactive gases, including the production of the relevant Bulletins, as well as proper understanding and use of measurement data;
- Actively entrain stakeholders, policymaker groups, scientific implementation partners and other interested parties to encourage their support and engagement;
- Communicate the availability of GAW observations to user communities, including ecosystem effects and atmospheric modelling communities.

2.3 SAG on Ozone and UV solar radiation (SAG Ozone-UV)

Core activities

- Facilitate research related to understanding short- and long-term variations of total ozone and vertical ozone distribution and solar UV radiation, and their impacts on the atmosphere and Earth System, in close alignment with the recommendations of the Ozone Research Managers Meeting, and working closely with relevant international programmes and projects, in particular Stratospheric Processes and Role in Climate (SPARC), as well as through joint activities with other major environmental science activities including climate, health and ecosystem research, etc.;
- Coordinate work related to the quantification of the spatial distribution and trends of total ozone and vertical ozone distribution and solar UV radiation, in particular, in support of the Vienna Convention and Ozone Assessments undertaken under the Montreal Protocol;
- Report to the relevant bodies including GCOS on the status of the Global Ozone Observing System;
- Regularly review the status of the GAW network for measuring total and profile ozone and UV radiation, to ensure it is fit for purpose to meet the needs of the key stakeholders, including geographic coverage, types of measurements being made and timeliness of data submission to World Ozone and Ultraviolet Radiation Data Centre (WOUDC). Promote and facilitate the expansion of the total ozone and vertical ozone distribution and solar UV radiation global observational network in order to best meet the needs of stakeholders;
- Coordinate the efforts to obtain a fully integrated view of the total ozone and vertical ozone distribution and UV radiation through close engagement and the synergistic use of ground based, aircraft, balloon and satellite observations in model systems and data analyses;
- Actively support capacity building in countries listed in Article 5 of the Montreal Protocol, working in close partnership with UN Environment and the Vienna Convention Trust Fund Advisory Committee, through assistance and supervision of the development of relevant training materials, training delivery and specific action such as instrument relocations.
Interface with SAG


Interface with Expert Teams

- Work closely with ET-ACMQ on the assessment of the new or emerging technologies and methods, including processing algorithms, for total ozone, vertical ozone distribution and solar UV radiation and QA/QC tools;
- Work closely with ET-ACMQ on the establishment of good practice guidelines and common procedures for quality assurance;
- Work closely with ET-ACNDE on the development of the user requirements for the application relevant to total ozone and UV radiation to meet requirements from research communities responding to global environmental challenges;
- Provide direction to the WOUDC regarding data archival and availability as well as data processing and creation of products and services to meet science for service’s needs, including metadata requirements.

Interface with WMO groups

- Collaborate with the WMO and co-sponsored programmes on the aspects of stratospheric ozone and UV radiation within the Earth System approach and addressing climate, health and agricultural, and ocean research;
- Collaborate with the relevant groups under the Technical Commission on Services in relation to UV radiation application for health and other services.

Interface with external users and partners

- Communicate the availability of GAW observations to user communities, including ecosystem effects, health community, climate and atmospheric modelling communities;
- Encourage the use of the UV Index for public information;
- Outreach to other scientific and non-scientific communities regarding the advances in science related to the state of ozone layer and UV radiation, including production of the relevant Bulletins, as well as proper understanding and use of GAW measurement data.

2.4 SAG on Aerosol

Core activities

- Facilitate research related to the atmospheric aerosols working closely with the relevant international programmes and projects, as well as through joint activities with other major environmental science activities working on atmospheric chemistry, aerosol processes, numerical weather prediction, effects research, climate research, etc.;
Articulate the needs for the global atmospheric ground based observing system research infrastructure to support aerosol related global environmental research specifically targeting the role of aerosol on air quality, regional weather and climate and help to establish it, including, by promotion, the expansion of observations particularly in regions where data are sparse or inexistent and supervising the categorization of stations according to GAW stations criteria;

- Analyse variability and trends in aerosol abundance, composition and properties at global, regional and urban scales and provide guidance to ET on the need for further development of technologies and methods for monitoring to support this analysis;

- Promote initiatives towards an integrated view of the aerosol role in climate and air quality through integration of aircraft and satellite observations with surface measurements in model systems and data analyses; in particular, provide guidance on incorporating atmospheric aerosols into the Earth system modelling approach for land, ice, oceans and the atmosphere;

- Support efforts across the GAW value chain to ensure that a clear and comprehensive high-quality data provision chain is maintained operational, easily accessible and widely open, fully responding to expectations of research communities worldwide, by monitoring its usage and analysing feedbacks from its users, reported by ET; promote timely data delivery;

- Promote better coordination of the regional networks worldwide and contribute to the establishment of regional networks where they do not exist. In particular, maintain and develop activities of the GAW Aerosol Lidar Observation Network (GALION) and promote the establishment of an International Network for Near-Surface observations as recommended in GAW Report No. 207;

- Provide regular assessments related to the quantification of variability and trends of aerosol properties on global and regional scales to the science communities and relevant stakeholders, ensure participation of GAW-related communities, and the use of GAW services in international environmental assessments (IPCC, GEO, etc.);

- Stimulate the development of user-oriented products and services and enhance the use of observations to support compliance with emission-reduction treaties;

- Assist/supervise the development of the relevant training materials and training delivery and support capacity building activities, in particular in emerging and developing countries.

**Interface with SAG**

- Work together with the other thematic SAGs to develop integrated analyses targeting global challenges such as the nitrogen cycle, air pollution impacts on agriculture and natural ecosystems, and the role of short-lived climate forcers on regional weather and climate.
Interface with Expert Teams

- Work closely with ET-ACMQ on the assessment of the new or emerging technologies and methods for aerosol measurements, development of the QA/QC tools and update of CIMO guidance;
- Work closely with ET-ACMQ on the establishment of good practice guidelines and common procedures for quality assurance with particular focus on the establishment of new Regional Calibration Centres and Regional Data Centres in the different WMO regions;
- Work closely with ET-ACNDE on the development of the user requirements for the application relevant to aerosol, assessing the current observational capabilities versus user requirements, reviewing and updating the OSCAR database and producing regular gap analysis reports that can lead to recommendations on the network development (e.g. the “statement of guidance”);
- Provide direction to the World Data Centre for aerosols (WDCA) with regard to data archival and availability as well as data processing and creation of products and services to meet science for service’s needs, including metadata requirements.

Interface with GAW Initiatives Steering Committees

- Advise GAW Initiatives Steering Committees on the recent developments, observational and modelling capabilities related to aerosol.

Interface with WMO groups

- Collaborate with the WMO and co-sponsored programmes on the aspects of aerosol within the Earth System approach and addressing weather, climate, health and agricultural, hydrological and ocean research.

Interface with external users and partners

- Communicate the availability of GAW observations to user communities, including ecosystem effects, health community, climate and atmospheric modelling communities;
- Outreach to other scientific and non-scientific communities regarding the state of science related to aerosol, including the production of the relevant Bulletins, as well as proper understanding and use of measurement data;
- Actively entrain stakeholders, policymaker groups, scientific implementation partners and other interested parties to encourage their support and engagement.

2.5 SAG on Greenhouse Gases (SAG-GHG)

Core activities

- Facilitate research related to the greenhouse gases by working closely with the relevant international programmes and projects, as well as with other major environmental science activities including carbon cycle and climate research, climate services, emissions modelling, stratospheric ozone depletion, climate and air pollution etc.;
• Coordinate the work related to the quantification of the spatial distribution and trends of greenhouse gases on global and regional scales and produce regular assessments, including regularly published information on the status of greenhouse gases, e.g. through the WMO Greenhouse Gas Bulletin and contribution to the Climate Statement;

• Facilitate research on the use of isotopes and ancillary tracers to understand greenhouse gas sources, sinks and budgets;

• Stimulate the development of user-oriented products and services;

• Advocate for the expansion of in situ greenhouse gas measurement network at the Earth’s surface and vertical profiles, particularly in data-poor regions like the tropics, climate-sensitive regions like the Arctic, and other regions where observations are used to support compliance with emission-reduction treaties;

• Encourage the improvement of retrievals of GHG distributions from satellite radiance measurements through comparison with in situ observations;

• Assist/supervise the development of the relevant training materials and training delivery and support capacity development activities;

• Develop peer-reviewed data quality evaluation procedures for grading contributions to GAW greenhouse gas measurement, in collaboration with ET-ACMQ, that will encourage improvements in the quality and transparency of those contributions.

Interface with SAG

• Work together with the SAGs on reactive gases and on applications on development of integrated analyses related to improved knowledge of greenhouse gas emissions and source attribution;

• Work with the SAG on applications to promote development of improved atmospheric transport models, which are used to calculate greenhouse gas fluxes from atmospheric observations, with systematic and compatible measurements of the spatial distributions of transport tracers such as SF6 and 222Rn.

Interface with Expert Teams

• Work closely with ET-ACMQ on the assessment of the new or emerging technologies and methods for greenhouse gas measurements, development of the QA/QC tools and update of CIMO guidance;

• Work closely with ET-ACMQ on the establishment of good practice guidelines and common procedures for quality assurance;

• Work closely with ET-ACNDE on the development of the user requirements for the application relevant to greenhouse gases, assessing the current observational capabilities versus user requirements, reviewing and updating the OSCAR database and producing regular gap analysis reports that can lead to recommendations on the network development (e.g. the "statement of guidance");
• Provide direction to the World Data Centre for Greenhouse Gases (WDCGG) with regard to data archival and availability as well as data processing and creation of products and services to meet science for service needs, including metadata requirements and enhanced use and exchange of observed data through FAIR principles.

**Interface with GAW Initiatives Steering Committees**

• Provide guidance on the state of science and recent research findings in the area of greenhouse gases to the Integrated Global Greenhouse Gas Information System (IG3IS), assist IG3IS promotion and implementation working with the partner organizations and communities (including ocean, biosphere and urban communities).

**Interface with WMO groups**

• Collaborate with the WMO and co-sponsored programmes on the aspects of greenhouse gases within the Earth system approach and addressing carbon cycle, radiative forcing and broader climate research, agricultural, ecosystems and ocean research.

**Interface with external users and partners**

• Communicate the availability of GAW observations to user communities, including climate, ecosystems, agriculture and atmospheric modelling communities;

• Outreach to other scientific and non-scientific communities regarding the state of science related to greenhouse gases, including the production of the relevant Bulletins, as well as proper understanding and use of measurement data;

• Actively entrain stakeholders, policymaker groups, scientific implementation partners and other interested parties to encourage their support and engagement.

**2.6 SAG on Applications (SAG-Apps)**

**Core activities**

• Facilitate research related to modelling and data assimilation of atmospheric composition in the Earth System models, working closely with the thematic SAGs within GAW, GAW Initiatives, Numerical Weather Prediction and Climate Modelling centres and with relevant national and international programmes and projects;

• Promote best practices and applications that use observational data in NRT on scales larger than urban, including the development of boundary conditions for regional and local modelling;

• Advise respective communities on the techniques to model and assimilate atmospheric composition observations to better monitor and predict large-scale transport of dust, fire and volcanic emissions and their impacts in liaison with groups such as SDS-WAS, IGAC & Global Emissions Inventory Activity (GEIA), Volcanic Ash Advisory Centres (VAACs);
Working closely with the Earth System modelling community, define evaluation protocols and model performance scoring methodologies for atmospheric composition variables;

Further develop the science basis and encourage development of innovative health and other air quality impacts related services at large scales, such as platforms focused on the global burden of disease and air quality impacts on agriculture, through collaborations with WHO, UNEP and other organizations;

Assist/supervise the development of the relevant training materials and training delivery and support capacity development activities.

**Interface with SAG**

- Work together with the thematic SAGs on development of the relevant modelling tools, approaches and products for the specific areas;
- Work with the SAG on greenhouse gases on development of improved atmospheric transport models.

**Interface with Expert Teams**

- Work with ET-ACMQ on the potential utilization of the model outputs for quality control of the observational data;
- Work closely with ET-ACNDE on the gap analysis reports and optimization of the observational system design for specific applications;
- Work with ET-ACDM on availability, format and timeliness of submission of data to the WDCs to improve data usability within the modelling applications.

**Interface with GAW Initiatives Steering Committees**

- Advise on the model development, improved assimilation methods and advances with the model transport representation, inverse modelling techniques and uncertainties characterization to the GAW initiatives (IG3IS, MMF-GTAD and GAFIS).

**Interface with WMO groups**

- Collaborate with the WMO and co-sponsored programmes and related groups of the Technical Commission on Infrastructure on the aspects of the Earth System modelling, data assimilation, model scores, parametrization of the atmospheric chemical processes and uncertainty characterization.

**Interface with external users and partners**

- Reach out to other scientific and non-scientific communities regarding the state of science related to atmospheric composition modelling and data assimilation, as well as proper understanding and use of air pollution and GHG data products (reanalyses, analyses and forecasts);
- Work together with external partners (UNEP, WHO, IGAC etc.) on development and promotion of the common modelling products and their promotion with the user community;
• Actively entrain stakeholders, policymaker groups, scientific implementation partners and other interested parties to encourage their support and engagement.

2.7 GAW Urban Research Meteorology and Environment SAG (GURME SAG)

Core activities

• Facilitate and guide advances of tools and systems to improve air quality, meteorological and climatological modelling for predictions, forecasting and long-term projections relevant for urban areas;

• Facilitate research related to the improved representation of urban features and processes in models for improving the prediction and forecasting of air quality, weather and climate for urban areas;

• Working with the regional and global modelling communities to improve understanding of the role of interactions between emissions, composition, meteorology, geographical and climate processes that affect urban air quality;

• Guide the integration of observations required to improve and evaluate air quality and meteorological modelling for urban areas, including ground based, aircraft, satellite meteorological and atmospheric composition and long-term climatological measurements taking account of new technologies (e.g. sensors) and crowdsourcing;

• Support the development of the tools and evidence base for reliable assessment and analysis of synergistic impacts on exposure, health, environment and security from air pollution, weather, extreme events and emergencies and climate change for developing effective mitigation and adaptation strategies for urban areas;

• Assist and supervise the development of relevant training materials and delivery and support capacity development activities across regions of the world.

Interface with SAGs

• Work closely with the other thematic SAGs (e.g. SAG-App) to improve the process understanding and develop observational and modelling capabilities for predicting and forecasting air quality, weather and climate for urban environments on multiple scales.

Interface with Expert Teams

• Work with ET-ACMQ on the urban measurement approached and methods and requirements for the quality assurance of such measurements;

• Work closely with ET-ACNDE on the gap analysis reports and optimization of the observational system design for urban applications;

• Work with ET-ACDM on the needs for data archival and data management for urban applications.
Interface with GAW Initiatives Steering Committees

- Provide scientific evidence and guidance to support GAFIS and IG3IS initiatives, as well as directly to WMO members and international agencies to identify, translate and make recommendations on urban air quality observations and forecasting, meteorological and climatological science developments to meet their needs.

Interface with WMO groups

- Work closely with other WMO bodies such as WWRP and WCRP to provide specialist expertise on urban issues related to air quality, weather and climate;
- Collaborated with the respective groups under the Technical Commission on Services, such as the Study Group on Integrated Urban Services, in the development and implementation of integrated urban services from the atmospheric composition, air quality, meteorology and climate perspectives.

Interface with external users and partners

- Work closely with other global organizations, such as the WHO on the latest scientific advances in urban MAQ, for example, to improve approaches and strengthen the evidence base for conducting exposure and health impact assessment of air pollution in cities and towns;
- Extend outreach to other scientific and non-scientific communities regarding the state of science related to the urban environment and assist in developing understanding and use of modelled data (e.g. diagnostics, reanalysis and forecast);
- Actively entrain stakeholders, policymaker groups, scientific implementation partners and other interested parties to encourage their support and engagement.

3. GAW Initiatives Steering Committees

3.1. Integrated Global Greenhouse Gas Information System (IG3IS) Steering Committee

Core activities

- Assess emerging stakeholder and policymaker needs with respect to measurement – based greenhouse gas emission estimates to guide scientific developments and future delivery of such information;
- Facilitate establishment of good practice guidelines and research strategies for projects consistent with the IG3IS objectives; support a regular update to these practices in the IG3IS Science Implementation Plan;
- Collect and summarize the implementation and accomplishments of projects successfully demonstrating IG3IS principles and, where appropriate, incorporate into the good practice guidelines and IG3IS Science Implementation Plan;
• Advise on the scientific and technical matters for potential partners and practitioners seeking to apply IG3IS methods according to IG3IS good practice guidelines and assist with building the required partnerships for implementation;

• Facilitate research and development activities of the IG3IS community especially in response to national and international funding opportunity announcements;

• Promote use of the GAW infrastructure and expertise in the implementation of IG3IS, further promote the extension of GAW through the implementation of individual projects;

• Support and guide activities of the IG3IS office.

**Interface with SAGs:**

• Collaborate with thematic SAGs on long-lived greenhouse gases, short-lived pollutants, urban dynamics, inverse modelling techniques and data assimilation.

**Interface with Expert Teams:**

• Work closely with the ET-ACDM on development of the policy and practice for the sharing of the data produced by the IG3IS projects and activities;

• Work closely with ET-ACNDE on the development and documentation of the user and technical observational requirements for IG3IS implementation on different scales.

**Interface with GAW initiative steering committees**

• Collaborate on cross-cutting topics between air quality and climate information systems with GAFIS.

**Interface with WMO groups**

• Collaborate with the WMO and co-sponsored programmes including relevant groups under the Technical Commission on Services on the aspects of greenhouse gases fluxes addressing carbon cycle, agricultural, ecosystems and ocean research and climate services.

**Interface with external users and partners**

• Promote IG3IS activities to international and national bodies and conventions, including UNFCCC, IPCC and stakeholders, WMO members and sponsoring bodies;

• Actively entrain stakeholders, policymaker groups, scientific implementation partners and other interested parties to encourage their support and engagement.
3.2 Measurement-Model-Fusion for Global Total Atmospheric Deposition (MMF-GTAD) Steering Committee

Core activities:

- Develop an Implementation Plan to establish and execute the MMF-GTAD initiative following its stated near-term and mid-term objectives;
- Facilitate the creation and dissemination of high-quality global MMF maps and high-spatial-resolution data products of atmospheric deposition on an operational basis (including the associated quality-assured measurement data sets and model outputs);
- Facilitate the development of the customized procedures, provide technical advice and tailored products for specific user and stakeholder needs (e.g. ecosystem-specific deposition, derived indicators, long-term deposition trends);
- Develop and implement research mobilization strategy to ensure continuity of the activities.

Interface with Scientific Advisory Groups:

- Work in close cooperation with SAG-TAD, SAG-RG, SAG-Apps and SAG-Aerosols on the continuous improvement to the operational products through research innovations in deposition monitoring, modelling, data assimilation/fusion and new observation systems (e.g. satellite measurements).

Interface with Expert Teams:

- Work closely with the ET-ACDM on development of the policy and practice for the sharing of the data produced by the MMF-GTAD projects and activities;
- Work closely with ET-ACNDE on the development and documentation of the user and technical observational requirements for MMF-GTAD implementation on different scales.

Interface with GAW initiative steering committees

- Collaborate on cross-cutting topics between air quality, climate information systems and deposition with GAFIS and IG3IS steering committees.

Interface with WMO groups

- Collaborate with the WMO and co-sponsored programmes including relevant groups under the Technical Commission on Services on the aspects of deposition for the agrometeorological services, ecosystems and ocean research.

Interface with external users and partners:

- Promote MMF-GTAD activities to international bodies and conventions, including Convention on biodiversity and FAO, stakeholders, WMO Members and sponsoring bodies;
- Continuously engage data users, stakeholders and partners to meet their evolving needs and priorities and encourage their support;
• Work with existing WMO, UN partners, and regional and national measurement programmes (e.g. networks, satellites) to encourage the expansion and improvement of deposition observations to support the goals of this initiative.

3.3. Global Air Quality Forecasting and Information System Steering Committee

Core activities:

• Develop an Implementation Plan to establish and execute the GAFIS initiative following its stated near-term and mid-term objectives;

• Facilitate the development of good practices for air quality forecasting and monitoring services including their presentation and evaluation utilizing diverse approaches;

• Carry out and maintain a survey of regional and global air quality forecasting and information systems and identify regions with a lack of adequate air quality services;

• Support capacity building in areas with a lack of air quality services;

• Collect the user requirements for air quality services for different applications (human health, well-being, agriculture);

• Promote further development of the observational infrastructure required for operational air quality services and encourage quality control and provision of metadata;

• Explore the potential of emerging data set such as low-cost air quality sensors or satellite retrievals from geostationary platforms for operational air quality monitoring and forecasting;

• Promote scientific and operational synergies of air quality forecasting integrated into Numerical Weather Prediction systems;

• Develop and implement a resource mobilization strategy to ensure continuity of the activities;

• Contribute to capacity-building activities.

Interface within Scientific Advisory Groups

• Work closely with SAG-App and SAG GURME on the definition of user- and science-driven metrics for air quality evaluation;

• Closely collaborate with thematic SAGs on cross-cutting issues concerning air quality forecasting.

Interface within Expert Teams

• Work closely with ET-ACNDE on the development and documentation of the user and technical observational requirements for air quality services (timeliness, access).
Interface within Steering communities

- Collaborate with MMF-GTAD on cross-cutting topics between Air Quality (AQ) information systems and deposition product services.

Interface within WMO

- Contribute to WMO regulatory processes (Technical Commissions) on AQ forecasting topics such as data format standards, data dissemination and warning procedure protocols;
- Collaborate with WWRP and WGNE on operational applications of atmospheric composition feedbacks in Numerical Weather Prediction;
- Collaborate with the Study Group on Integrated Health Services under the Technical Commission on Services in areas related to air quality.

Interface with external community

- Facilitate close cooperation for the implementation among operational service providers (e.g. CAMS), semi-operational (e.g. MAP-AQ, SDS-WAS) and research efforts (e.g. PREFIA, PAPILA);
- Engage with the user community to understand the requirements for air quality services (e.g. AQ indicators for human health, air quality regulation for the protection of crops) and co-design new integrated applications to meet their needs.
ANNEX 4

TERMS OF REFERENCE OF THE SUBSTRUCTURES (WWRP)

Organization of the work in WWRP aligned with the WMO Reform

1. Terms of Reference of the WWRP SSC

The ToRs cover the mission statements for working groups and guidelines for the endorsement of projects, approval of partner/joint projects, and development of RDPs and FDPs. It also includes all the appropriate Terms of Reference for the SSC, Working Groups (WGs), Core Projects (CPs) and ETs, including processes for the Chair selection, membership renewal, and review.

Functions

(a) To provide scientific guidance for the WWRP including making appropriate comments and recommendations on major project activities;

(b) To develop a strategic science and implementation plan for the WWRP and a work programme aligned with the WMO Strategic Planning Process;

(c) To review and assess the development of all elements of the WWRP, including FDPs, RDPs and evaluation methods, to formulate recommendations to guide further actions and to report on the progress of the programme to the president of the RB;

(d) To facilitate, coordinate and prioritize weather research and development activities, which are planned and implemented through the project committees and WGs, to meet the objectives of RB;

(e) To facilitate the exchange of information among scientists participating in the programme and relevant scientific institutions and agencies, at the national and international levels;

(f) To collaborate, as appropriate, with Infrastructure and Services Technical Commissions, Regional Associations and other relevant groups of the WCRP and the GAW, committees, academia, and other partners; and

(g) 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.

2. Terms of Reference of CPs in the WWRP

Functions

(a) The WWRP SSC makes recommendations on CPs for the WWRP. Such projects should typically have a lifetime of between 5 years and 10 years;

(b) The recommendations for CPs should be approved by the WMO Executive Council or Congress;

(c) The activities of WWRP CPs should have a global focus and mandate and be supported by International Coordination Offices;
(d) The deliverables of the WWRP and its CPs should be based on the activities proposed in the Implementation Plan and in line with the key priorities outlined in the WMO Strategic Plan.

3. Terms of Reference of WWRP WGs

Functions

Each WG will have a defined area of expertise (listed below) that is jointly defined by the WG and the SSC and approved by the SSC Chair. This area of expertise may evolve over time (subject to approval). Listed below are general functions all WGs have in common, although each WG will emphasize these functions to varying degrees as appropriate to achieve the goals of the WWRP Implementation Plan.

(a) Advance the science of the subject the WG represents, including research performed by group members, coordination and communication of research from across the community, and conducting targeted research activities, all in support of the WWRP Implementation Plan and its Action Areas;

(b) Facilitate communication and collaboration between the research community and operational centres, particularly NMHSs and RSMCs, in collaboration with the Services Commission;

(c) Promote (research) data sharing across the broad community where possible, aligning with the WMO data sharing policies through the Infrastructure Commission;

(d) Advise WWRP and WMO on matters related to their subject area;

(e) Provide presentations or position papers on best practices, state of the science, or other collections of community knowledge that may be provided to a variety of stakeholders, especially in policy or decision-making;

(f) Organize and lead international conferences, at regular intervals, on all or part of the subject areas within the purview of the group. These efforts will often involve collaborations with other WGs or CPs as well a training event;

(g) Develop, guide and/or lead RDPs and Forecast Demonstration Projects (FDPs), in collaboration with other WWRP and WMO entities, to engage the community and advance key scientific areas;

(h) Convene Working Group meetings, at a minimum of once per year (but encouraged to be more often, through online platforms) to evaluate progress on key topics, satisfy reporting requirements to WWRP and WMO, and strategize future plans, aligned with the WWRP Implementation Plan and its action areas;

(i) Seek collaborations with other parts of WMO, including the other WMO research programmes and technical commissions, as well as other UN organizations (e.g. WHO) as needed to fulfil WWRP Implementation Plan goals;

(j) To assist, when appropriate, in the resource mobilization necessary to undertake these activities, including seeking co-sponsorship for conferences, symposiums and large workshops of the WWRP or submitting proposals to regional, national and international funding sources for projects and activities initiated by the WWRP WGs;

(k) Actively collaborate and work with early career scientists to help establish the next generation of international scientific leaders.
4. **Terms of Reference of the Expert Team on Weather Modification Research (ET-WxMOD)**

(a) To keep under review relevant research, advise RB on issues requiring attention related to weather modification and suggest mechanisms for addressing such issues;

(b) To review the criteria for conducting weather modification research to ensure the quality of the science, from the initial design to the final evaluation of field experiments, considering advances in supporting fields, including cloud physics, atmospheric chemistry and numerical modelling;

(c) To serve as a focal point and provide advice and assistance to Members on the manner and means of transferring competence for planning scientific experiments;

(d) To assist in the drafting of WMO documents on the status of weather modification and guidelines for providing advice to Members and to propose revisions to these documents where necessary;

(e) To promote scientific practices in weather modification research. This is done through the organization of quadrennial scientific conference on weather modification.

5. **Mission statements of the WGs and ET**

5.1. **Mission of the Expert Team on Weather Modification (ET-WxMOD)**

Promotes scientific practices in weather modification research through the WMO Expert Team on Weather Modification and through the organization of the quadrennial scientific conferences on weather modification.

5.2 **Mission of the Working Group on Nowcasting and Mesoscale Research (WGNMR)**

WGNMR aims to advance the knowledge of nowcasting and mesoscale processes and predictability; to promote and aid the implementation of nowcasting systems within National Meteorological Hydrological Services (NMHSs) and among their end users, including the use of numerical modelling and assimilation of high-resolution data.

5.3. **Mission of the Working Group on Data Assimilation and Observing Strategies (WGDAOS)**

WGDAOS aims to provide guidance to the WWRP to optimize the use of the current WMO Global Observing System (GOS). The Data Assimilation and Observation Systems (DAOS) Working Group will facilitate the development of data assimilation and observing system methodologies from the convective scale to planetary scales and for forecasts with time ranges of hours to weeks.

5.4. **Mission of the Working Group on Predictability, Dynamics and Ensemble Forecasting (WGPDEF)**

WGPDEF aims to advance dynamical meteorology and predictability research, and their application to ensemble forecasting, promoting the quantification of forecast uncertainty, and the development of ensemble applications and their transition into operations.
5.5 **Mission of the Working Group on Tropical Meteorology Research (WGTMR)**

WGTMR aims to coordinate and advance the research of tropical cyclones, monsoon systems and intra-seasonal tropical variability to improve the prediction of high impact weather in the tropics. WGTMR works with other components of WMO regarding tropical cyclones and monsoons, specifically WCRP. WGTMR has a particular remit to work with developing countries and SIDS, places that are often adversely affected by tropical weather hazards.

5.6 **Mission of the Joint Working Group on Forecasting Verification Research (JWGFVR) (shared with WGNE)**

JWGFVR plans and facilitates the development and application of improved diagnostic verification methods to assess and enable improvement of the quality of weather forecasts, including forecasts from numerical weather and climate models. It also collaborates on forecast verification with the WGNE and the WCRP. JWGFVR will engage in the plans and implementation of the verification component of WWRP projects from the outset.

5.7 **Mission of the Working Group on Societal and Economic Research Applications (WGSERA)**

WGSERA aims to advance the science of the social and economic application of weather-related information and services and review and assist in the development and promotion of societal and economic related demonstration projects. SERA has the responsibility for the entire range of timescales and research issues associated with the WWRP. SERA brings the knowledge of how to design and implement research projects co-designed between physical and social science to achieve more useful information for decision makers and the public.

5.8 **Mission of the Sand and Dust Storms Warning Advisory and Assessment System (SDS-WAS) (SHARED WITH GAW)**

SDS-WAS aims to establish a coordinated global network of SDS research and forecasting centres to enhance operational SDS forecasts through technology transfer from research. SDS-WAS partners with the GAW.

6. **Guidelines for the endorsement of projects by WWRP**

Requests for endorsement of projects (other than RDP/FDP) should be submitted for review to the Chair of the SSC and the WMO Secretariat for the WWRP. The role of the SSC is to review these projects align with the WWRP scientific goals. Project proposals should ideally address issues such as:

- Links with existing activities of WMO such as workshops, training events, symposiums and/or meetings;
- Opportunities to build capacity through fellowships and/or support for post-graduate studies;
- Opportunities to co-fund activities of mutual interest.

WWRP SSC will define, prioritize and, where appropriate, endorse candidate projects (other than RDP or FDP projects) within the WWRP. The SSC is under no obligation to endorse or otherwise participate in any project brought to its attention. By its very nature, the WWRP can be most effective by focusing on a relatively few project areas, to create a critical mass of research effort associated with forecasting problems of highest
priority determined, in part, by their broad societal impact and technical achievability. The proposal should meet the goals of the WWRP Implementation Plan. The endorsement is limited to the duration of the project.

7. **Guidelines for the approval of a joint/partner project**

1. Project committed to working internationally, committed to the concept of Science for Services and, through engagement in WWRP, to making their advances available to the international community, and in particular to developing countries;

2. The project should have long-term (at least three years) independent funding;

3. Project aims are aligned with the WWRP Implementation Plan through the Action Areas, as determined by the SSC;

4. The outcomes of the project will benefit the WWRP Community, for example in the form of published scientific advances, common exploitation of data, diagnostic tools, and software, and training. A plan for how this will take place will be agreed on;

5. The project will report to WWRP in the framework of the WWRP IP (Action Areas) but in a manner that is aligned with the project's own reporting structure. The project will respond to recommendations and requests from WWRP;

6. The project will promote the association with WWRP as part of its own communication strategy.

8. **Criteria for RDP and FDP**

Guidelines for developing and submitting a RDP, a FDP.

8.1 **Guidelines for Developing and Submitting a RDP**

RDPs can be field campaigns, model or assimilation based, or geared to social science research. The RDP focus is on advancing knowledge in research topics relevant to improving the prediction of high impact weather and/or the development of improved tools, techniques, and models. RDPs can address any component of weather forecasting (e.g. observations, data assimilation, modelling, forecasting, dissemination and the utilization of weather products). Thus, RDPs should be based on the priorities of the WGs and Programme(s) of the WWRP. In addition, the RDPs are encouraged to contain a societal and economic research type component.

The following text presents guidelines for submission of RDP proposals to the WWRP SSC. Submission of an RDP is done through the relevant WG (and its relevant contact person in the Secretariat) and then to the Chief of the World Weather Research Programme (WWRP) and Chair of SSC. If an extension of the RDP is needed beyond the specified end date to complete the project, approval should be given by the SSC. If a follow-up phase (with new scientific goals) are proposed, it should go through a new application.

Annual reports should be prepared to WWRP SSC for the duration of the project and a final report should be supplied (linked to the relevant publications) at the end of the project.

A list of all WWRP RDPs will be maintained (by the Secretariat) on the WWRP website, specifying the project, the start and end dates, the goals and links to reports and/or publications. Links to the FDPs’ websites will be provided in this list.
Proforma for a RDP Proposal to the WWRP SSC

TITLE

Proposer(s) Name(s) and Institution(s)

CONTENTS

Project Summary
Background
RDP Proposal
RDP Management
Potential Societal Impacts
Possibilities of following up with FDP
Acknowledgements
References
Supporting Documentation

Project Summary

The project summary will provide a concise summary of the proposal. It should start with the specific aim or goal of the programme, including a list of any specific recommendations and expected outcomes.

The entire document should be kept to a reasonable length, generally not more than 15 pages, not including supporting documentation.

Background

A brief discussion of events that have led to the proposal should be included here. Examples include workshop recommendations, background events, etc. Also included here should be a discussion of the WWRP recommendations arising from the preliminary proposal. The proposal must specifically address weather system research that fits with the WWRP Goals to undertake the necessary R&D leading to the development and demonstration of improved and cost-effective forecasting techniques, with emphasis on high impact weather, and to promote their application among Member States.

High impact weather is defined as weather that affects quality of life, is economically disruptive, or is life threatening and is prominent among the concerns of the International Decade for Natural Disaster Reduction (IDNDR). High Impact Weather can occur in forecasting ranges from the very short-range to the long-range, up to a season.
RDP Proposal

This section should address the full programme of research that is being proposed and will form the bulk of the proposal. The contents are up to the individual but should be in the form of an expansion of the preliminary proposal, addressing any recommendations from the SSC. The following WWRP R&D requirements must be addressed:

- Specification of the problem to be addressed and especially its scientific basis;
- A review of current knowledge in the area, together with a highlight of where knowledge is deficient;
- A comprehensive discussion of how the programme will undertake the research and development, including methodology to be adopted, envisaged field programmes (and their justification), and timescale. If desired, several sections and subsections can be devoted to the RDP Proposal, and
- Start and end dates of the project.

RDP Management

This section should address the management structure of the programme. As a minimum requirement the WWRP requires that two groups be formed:

A SSC comprised of 6–8 scientists in the relevant disciplines, possibly from WWRP CPs, WGs and/or ET, as relevant. This committee will be responsible for producing the science proposal and the scientific implementation of the programme, should it be approved by the SSC. Complex programmes may choose to include additional specialist subcommittees working under the SSC.

A Community Advisory Group comprised of representatives from end users, community groups, industry, forecasting offices, etc. This group will be utilized to provide an impacts perspective on the programme and a review of the plans that are produced. The WWRP SSC is happy to help with recommendations on the membership of these two groups.

This section should also indicate the organizations and institutions that are supporting or are expected to support the programme. Please note that the WWRP will only support programmes that are international in nature.

This part should also describe the resource mobilization component, detailing which funding resources are available as well as their effectiveness. WMO is not under obligation to financially support any RDP.

Potential societal impacts

This section must discuss:

- How end users have been involved in the development of the research proposal;
- The manner in which the research is expected to impact on society; and
- The proposed method whereby potential societal impacts are to be incorporated into the RDP.
Prospects for operational transition including forecasting demonstration projects

This section must address potential FDPs or related programmes arising out of the RDP. Future FDPs may be highly developed in some cases or presented as a planned approach in other cases of more strategic RDPs. All FDPs must follow the WWRP requirements.

Acknowledgements

Acknowledge any funding sources, contributors, etc.

References

Please use the format of either the American Meteorological Society (AMS) Journals, or the Quarterly Journal of the Royal Meteorological Society (QJRMS) for referencing. Reports that are not readily available should have copies of the relevant pages included in the supporting documentation.

Supporting Documentation

Supporting documentation in the form of resolutions from workshops, etc, should be attached here. Also include a short CV for each of the main proposers.

8.2 Guidelines for Developing and Submitting a FDP

FDPs are projects that will serve to exhibit and formally quantify the benefits to be derived from improved understanding and enabling technologies. The improved understanding and technological advances, the benefits of which are to be demonstrated, may or may not be a direct consequence of other WWRP activities. FDPs will involve the dissemination of forecasting information to real users in real time. Candidate FDPs will be selected by the WWRP SSC based on the following:

1. readiness of the science;
2. timeliness of the demonstration, and
3. feasibility of technology transfer and training.

forecasting demonstration projects should be submitted for review to the Chair of the SSC and the WMO Secretariat for the WWRP. The proposal will then be sent for comments to members of the relevant WGs and/or members of the SSC. Proposals for FDPs, along with the discussions and comments of reviewers, are typically presented at the annual meeting of the SSC of the WWRP. The role of the SSC is to review these FDPs in order to determine if the proposal sufficiently meets the guidelines below, suggest improvements in the proposed project and determine if the project should be endorsed as a WWRP activity. The endorsement is limited to the duration of the project.

Submission of an FDP should be done through the relevant WG (and its relevant contact person in the Secretariat) and then to the Head of WWRD and Chair of SSC. If an extension of the FDP is needed beyond the specified end date to complete the project, approval should be given by the SSC. If a follow-up phase (with new scientific goals) are proposed, it should go through a new application.

Annual reports should be prepared to WWRP SSC for the duration of the project and a final report should be supplied (linked to the relevant publications) at the end of the project.

A list of all WWRP FDPs will be maintained (by the Secretariat) on the WWRP website, specifying the project, the start and end dates, the goals and links to reports and/or publications. Links to the FDPs’ websites will be provided in this list.
Proforma for a FDP Proposal to the WWRP

TITLE

Proposer(s) Names and Institutions

Contents

Project Summary

Background and Motivation

FDP Proposal

FDP Management

Acknowledgements

References

Supporting Documentation

Attachment 1: Potential societal impacts

Project Summary

The project summary will be a maximum of one page and provide a concise summary of the proposal. It should start with the specific aim or goal of the programme, including a list of any specific recommendations and expected outcomes.

The entire document should be concise and generally not more than 10–15 pages in length, not including supporting documentation.

Background and motivation

A brief discussion of events that have led to the proposal should be included here. Examples include workshop recommendations, background events, etc. FDP proposals must follow the WWRP requirements:

FDPs will serve to exhibit and formally quantify the benefits to be derived from improved understanding and enabling technologies. The improved understanding and technological advances, the benefits of which are to be demonstrated, may or may not be a direct consequence of other WWRP activities.

FDPs will involve the dissemination of forecasting information to real users in real time. Candidate FDPs will be selected by the SSC based on readiness of the science, timeliness of the demonstration, and feasibility of technology transfer and training.

FDP Proposal

This section should contain an outline of the proposed FDP in sufficient detail for the WWRP committee to arrive at a conclusion on its merits. The contents are up to the individual, but address as a minimum the WWRP FDP requirements noted above. The proposal should specifically address the following issues:

- Basis of the proposal (e.g. what new research outcome or forecasting technique is to be demonstrated);
• forecasting procedure, hosting organization and method of disseminating;
• Expected impact of the proposed programme on society;
• Validation, evaluation and verification methodology to be adopted including a
  means for measuring impacts of the forecasting improvement on users; and
• Start and end dates of the project.

FDP Management

This section should address the management structure of the programme. As a minimum
requirement the WWRP requires that two groups be formed:

An FDP Steering Committee comprised of 6–8 people in the relevant disciplines, perhaps
from WWRP WGs, CPs and/or ET. This committee will be responsible for producing the
FDP proposal and the implementation of the programme, should it be approved by the
SSC. Complex programmes may choose to include additional specialist subcommittees
working under the FDP Steering Committee.

A Community Advisory Group comprised of representatives from end users, community
groups, industry, forecasting offices, etc. This group will be utilized to provide an impact
perspective on the programme and a review of the plans that are produced. The WWRP
SSC is happy to help with recommendations on the membership of these two groups.

This part should also describe the resource mobilization component, detailing the
available funding resources and their effectiveness. WMO is not under obligation to
financially support any FDP.

Acknowledgements

Acknowledge any funding sources, contributors, etc.

References

Please use the format of either the AMS Journals, or the QJRMS for referencing. Reports
that are not readily available should have copies of the relevant pages included in the
supporting documentation.

Supporting Documentation

Supporting documentation in the form of resolutions from workshops, etc. should be
attached here. Also include a short CV for each of the main proposers.

Attachment 1: Societal impacts

Research and Development Projects and forecasting demonstration projects will lead to
societal benefits if and only if that research is successfully turned into products that are
used by decision makers. Thus, the societal aspects of weather are an essential area of
complementary research. Four areas of investigation are identified:

• Obtaining an improved understanding of the nature of the problem and the
  opportunity:

These include the costs of weather-related events and who incurs those costs. Results
obtained from this research, in conjunction with knowledge of predictability, etc., can
help scientists to more effectively prioritize research objectives. More broadly, such research can provide information to help policy makers focus national priorities.

- **Use of forecasting by decision makers:**

Even the most accurate forecasting is of little value if it is not well used. To this end, it is important to understand what information decision makers could effectively use and also effective ways to communicate that information. Research in this area can help to identify those conditions necessary and sufficient for forecasters to contribute to the needs of decision makers.

- **The process of transitioning research to the operational community:**

This process focuses on the needs of forecasters, seeking to provide information of use to decision makers. Both the structure of the process and the content of the information being transferred should be evaluated from the standpoint of the penultimate goal of producing useful products. Thus, in addition to research on the use of forecasts, appropriate research might include the institutional structures through which the transfer process takes place.

- **Evaluation of forecasts:**

There are many measures of forecasting "goodness". Such evaluations are an important component of the programme’s ability to assess progress with respect to its goals. Evaluation from a user perspective is an important component of these projects and should be demonstrated as far as possible within the lifetime of the FDP.
ANNEX 5

TERMS OF REFERENCE FOR THE REPRESENTATIVES OF THE CONSTITUENT BODIES

1. Terms of Reference: Representative of RB-INFCOM

Purpose

This document describes the main tasks, modalities of work and reporting duties of the Research Board – Infrastructure Commission (RB-INFCOM) representative.

Resolution 1 of INFCOM and SERCOM’s first session states:

Invites the Research Board, where appropriate and in consultation with the Management Group of the Services/Infrastructure Commission, to nominate one or more experts to liaise between the Research Board and any subsidiary body of the technical commission.

The following tasks and work modalities will be accomplished in close collaboration with the RB-SERCOM representative.

A. Specific tasks

In its respective areas, the RB-INFCOM representative will:

1. Provide high-level feedback on progress and on issues of mutual interest to the Management Groups of INFCOM and the RB;

2. Act as focal point to the experts representing the RB and Research Programmes in INFCOM substructures, make recommendations for better coordination and provide high-level reports to the RB and INFCOM as requested;

3. Facilitate links between the work of INFCOM subsidiary bodies and the RB as well as the three research programmes in order to enhance the two-way-flow of communication on topics of mutual interest;

4. Support the aims of the Technical Commission Management Group with high-level coordination among all Technical Commissions in close interaction with the RB Management Group;

5. Advise on the implementation of scientific and technological advances, and assist in avoiding duplication of efforts;

6. Upon request by the Technical Commission Management Group or the RB, provide support to high-level outreach activities and engagement with partner organizations, academia and stakeholders.

B. Modalities of work

- The RB-INFCOM representative will participate in INFCOM Technical Commission Management Group meetings and in meetings of the Technical Commission subsidiary bodies, as may be required;
The RB-INFCOM representative will act as focal point for the activities of the science programmes (GAW/WCRP/WWRP) as requested and connect with other science experts who serve in substructures of INFCOM and report on these engagements;

The RB-INFCOM representative will closely collaborate and interact with the RB-SERCOM representative on all aspects related to joint Research Board and Technical Commissions work;

The RB-INFCOM representative will be supported by the Research Board and the WMO Secretariat within the available level of resources;

The RB-INFCOM representative is a member of the Research Board Management Group and will participate in RB Management Group meetings as may be required.

C. Reporting

The RB-INFCOM representative will report to Research Board and INFCOM Management Groups on the work within INFCOM and its subsidiary bodies.

D. Duration

4-year term and renewable, as may be required.

2. Terms of Reference: Representative of RB-SERCOM

Purpose

This document describes the main tasks, modalities of work and reporting duties of the Research Board-Services Commission (RB-SERCOM) representative.

Resolution 1 of INFCOM and SERCOM’s first session states:

Invites the Research Board, where appropriate and in consultation with the Management Group of the Services/Infrastructure Commission, to nominate one or more experts to liaise between the Research Board and any subsidiary body of the technical commission.

The following tasks and work modalities will be accomplished in close collaboration with the RB-INFCOM representative.

A. Specific tasks

In its respective areas, the RB-SERCOM representative will:

1. Provide high-level feedback on progress and on issues of mutual interest to the Management Groups of SERCOM and the RB;

2. Act as focal point to the experts representing the RB and Research Programmes in SERCOM substructures, make recommendations for better coordination and provide high-level reports to the RB and SERCOM as requested;
3. Facilitate links between the work of the SERCOM subsidiary bodies and the RB as well as the three research programmes in order to enhance the two-way-flow of communication on topics of mutual interest;

4. Support the aims of the Technical Commission Management Group with high-level coordination among all Technical Commissions in close interaction with the RB Management Group;

5. Advise on the implementation of scientific and technological advances, and assist in avoiding duplication of efforts;

6. Upon request by the Technical Commission Management Group or the RB, provide support to high-level outreach activities and engagement with partner organizations, academia and stakeholders.

B. Modalities of work

- The RB-SERCOM representative will participate in the SERCOM Technical Commission Management Group meetings and in meetings of the Technical Commission subsidiary bodies, as may be required;

- The RB-SERCOM representative will act as focal point for the activities of the science programmes (GAW/WCRP/WWRP) as requested and connect with other science experts who serve in substructures of SERCOM and report on these engagements;

- The RB-SERCOM representative will closely collaborate and interact with the RB-INFCOM representative on all aspects related to joint Research Board and Technical Commissions work;

- The RB-SERCOM representative will be supported by the Research Board and the WMO Secretariat within the available level of resources;

- The RB-SERCOM representative is a member of the Research Board Management Group and will participate in RB Management Group meetings as may be required.

C. Reporting

The RB-SERCOM representative will report to Research Board and SERCOM Management Groups on the work within SERCOM and its subsidiary bodies.

D. Duration

4-year term and renewable, as may be required.
## ANNEX 6
### MEMBERSHIP OF THE RB MEMBERS

*(Green: Members of the RB Management Group, Red: Vacant Positions)*

<table>
<thead>
<tr>
<th>Name</th>
<th>Country</th>
<th>Region</th>
<th>Institution</th>
<th>ToR – Role</th>
<th>Expertise</th>
<th>Gender</th>
<th>Emails</th>
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</thead>
<tbody>
<tr>
<td>Celeste Saulo</td>
<td>Argentina</td>
<td>III</td>
<td><strong>Director – Servicio Meteorológico Nacional, Secretaría de Investigación Científica y Política Industrial para la Defensa</strong></td>
<td>Chair</td>
<td>Chair RB and Vice President WMO</td>
<td>F</td>
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<tr>
<td>Deon Terblanche</td>
<td>South Africa</td>
<td>I</td>
<td><strong>Former Director of Research at the WMO</strong></td>
<td>Vice-Chair</td>
<td>Co-Chair RB; Observational Infrastructure, Radar Meteorology, Cloud Microphysics and Dynamics, Rainfall Enhancement, Science Strategy and Implementation; Honorary Professor, Brown University, USA</td>
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</tr>
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<tr>
<td>Greg Carmichael</td>
<td>USA</td>
<td>IV</td>
<td>University of Iowa, College of Engineering, Professor, Chemical and Biochemical Engineering</td>
<td>GAW</td>
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<td><a href="mailto:gregory-carmichael@uiowa.edu">gregory-carmichael@uiowa.edu</a></td>
</tr>
<tr>
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<td>Chair of the SSC WWRP</td>
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<tr>
<td>Detlef Stammer</td>
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<td>Carolyn Reynolds</td>
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<td>Lead scientist of the Probabilistic Prediction Research Office in the Marine Meteorology Division of the Naval Research Laboratory (NRL) in Monterey, California</td>
<td>WGNE</td>
<td>Chair WGNE; Basic and applied research on predictability and adaptive observations, ensemble design, global coupled system development, Research to Operations and Operations to Research issues and complexities</td>
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<td><a href="mailto:Carolyn.Reynolds@nrlmry.navy.mil">Carolyn.Reynolds@nrlmry.navy.mil</a></td>
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<td>Yihong Duan</td>
<td>China</td>
<td>II</td>
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<tr>
<td>Patricia Krecl</td>
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<td>Arlene Laing</td>
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<tr>
<td>Alexey Romanov</td>
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<tr>
<td>Jian Liu</td>
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<tr>
<td>Mary Scholes</td>
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<td>IAMAS (IUGG) - International Organization</td>
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<td>Biogeochemistry of savanna and plantation ecosystems. Biogenic trace gas emissions, Soil biological processes and sustainable agriculture.</td>
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</tr>
<tr>
<td>Judy Omumbo</td>
<td>INT</td>
<td>I</td>
<td>African Academy of Science</td>
<td>SIDS/LDC /LLDC</td>
<td>Epidemiology focusing on research to support malaria control programmes;</td>
<td>F</td>
<td><a href="mailto:j.omumbo@aasciences.ac.ke">j.omumbo@aasciences.ac.ke</a></td>
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<td>Name</td>
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<tr>
<td>Caroline Brassard</td>
<td>Singapore</td>
<td>V</td>
<td>Professor Danny Quah</td>
<td>SIDS/LDC/LLDC</td>
<td>Economic development; International aid; Poverty and inequality; Climate Change; Development policy</td>
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<td><a href="mailto:sppcaro@nus.edu.sg">sppcaro@nus.edu.sg</a>; <a href="mailto:CBrassard@gmail.com">CBrassard@gmail.com</a>; <a href="mailto:sppcaro@nus.edu.sg">sppcaro@nus.edu.sg</a></td>
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<tr>
<td>Juliana Ungaro</td>
<td>New Zealand</td>
<td>V</td>
<td>NIWA</td>
<td>SERCOM</td>
<td>Climate change science, mitigation, and adaptation policies in New Zealand and the Pacific Islands; scientific communication, training and consultations</td>
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<tr>
<td>Piero Chessa</td>
<td>Australia</td>
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<td>BoM</td>
<td>INFCOM</td>
<td>NWP, Global Modelling,</td>
<td>M</td>
<td><a href="mailto:Piero.Chessa@bom.gov.au">Piero.Chessa@bom.gov.au</a></td>
</tr>
<tr>
<td>Craig McLean</td>
<td>USA</td>
<td>IV</td>
<td>NOAA</td>
<td>IOC</td>
<td>Acting Chief Scientist and will act as senior scientist for the agency providing direction for science and technology priorities. In his role at Oceanic and Atmospheric Research, he is</td>
<td>M</td>
<td><a href="mailto:craig.mclean@noaa.gov">craig.mclean@noaa.gov</a>, <a href="mailto:monique.baskin@noaa.gov">monique.baskin@noaa.gov</a></td>
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<tr>
<td>Martin Visbeck</td>
<td>Germany</td>
<td>VI</td>
<td>GEOMAR Helmholtz Centre for Ocean Research Kiel</td>
<td>ISC</td>
<td>The role of the ocean in interannual to centennial climate variability; deep water formation in subpolar regions; Sustained global ocean observations; Tropical Atlantic Climate Variability</td>
<td>M</td>
<td><a href="mailto:mvisbeck@geomar.de">mvisbeck@geomar.de</a></td>
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<td>Antonio Busalacchi</td>
<td>USA</td>
<td>IV</td>
<td>UCAR-NCAR</td>
<td>Expert</td>
<td>Earth system prediction, climate variability and predictability, ocean and coupled modelling, tropical air-sea interaction, ocean remote sensing</td>
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<td>Madhavan Nair Rajeevan</td>
<td>India</td>
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<td>Secretary, Ministry of Earth Sciences</td>
<td>Expert</td>
<td>Monsoon variability and prediction; Climate variability and climate change; aerosol and interaction with climate system</td>
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<tr>
<td>Matthew Wheeler</td>
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<td>V</td>
<td>BoM</td>
<td>Expert &amp; member of Joint WMO-IOC Collaborative Board (JCB)</td>
<td>Climate dynamics and variability; Tropical meteorology; Sub-seasonal to seasonal prediction; Coupled atmosphere-ocean prediction systems</td>
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<td>Aaron Salzberg</td>
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<td>Director, The Water Institute at UNC, Holzworth Distinguished Professor, Department of Environmental Sciences and Engineering, Gillings School of Global Public Health (Barbara K Rimer Dean)</td>
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<td>M</td>
<td><a href="mailto:salzbergaa@unc.edu">salzbergaa@unc.edu</a></td>
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<tr>
<td>Faten Attig Bahar</td>
<td>Tunisia</td>
<td>I</td>
<td>The University of Carthage, Tunisia Polytechnic School, Applied Mechanics and Systems Research Laboratory</td>
<td>Young Scientist</td>
<td>Climate, finance, Science communication, Renewable energy technologies and implementation, Energy system modelling, Renewable energy project valuation and financing options, Renewable energy in emerging markets, Energy Efficiency in industry and buildings,</td>
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