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| WEATHER CLIMATE WATER | **World Meteorological Organization****EXECUTIVE COUNCIL****Seventy-Sixth Session**27 February to 3 March 2023, Geneva | **EC-76/Doc. 3.3(4)** |
| Submitted by:Chair of the Research Board 21.II.2023**DRAFT 1** |

**AGENDA ITEM 3: IMPLEMENTATION OF CONGRESS DECISIONS: TECHNICAL MATTERS**

**AGENDA ITEM 3.3: Long-term goal 3: Targeted research**

**SCIENTIFIC ADVISORY PANEL RECOMMENDATIONS
WITH RESEARCH BOARD APPRAISAL**

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| **Summary** |
| **Document presented by:** Chair of the Research Board**Strategic objective 2020–2023:** touches on many, including1.2, 1.2, 1.4, 2.2, 2.3, 3.2, 3.3, 4.1, 4.2, 5.4**Financial and administrative implications:** within the parameters of the draft Operational Plan 2020–2023, will be reflected in the Strategic and Operational Plans 2024–2027.**Key implementers:** Research Board, SERCOM, INFCOM, CDP and other relevant WMO bodies as needed**Timeframe:** 2023-2027**Action expected:** adoption of Draft Recommendation 3.3(4)/1 (EC-76). |

# GENERAL CONSIDERATIONS

### Introduction

1. Established by [Resolution 10 (Cg-18)](https://library.wmo.int/doc_num.php?explnum_id=9827#page=61), the Scientific Advisory Panel (SAP) is the scientific advisory body of the Organization, drafting opinions and making recommendations to Congress and to the Executive Council on matters concerning WMO research strategies and the optimal scientific directions to support the evolution of its mandate in weather, climate, water, and related environmental and social sciences.
2. Since its establishment, the SAP has developed the *SAP Science and Technology Vision Paper*, in consultation with other constituent bodies of WMO, including the Executive Council, Research Board, Commission for Observation, Infrastructure and Information Systems (INFCOM) and Commission for Weather, Climate, Water and Related Environmental Services and Applications (SERCOM). Consistent with the WMO Vision and Long-Term Goals set out in the WMO Strategic Plan, this paper aims to inform WMO Members and constituent bodies on game-changing scientific and critical challenges that could guide the development of the WMO mandate in the coming decades.
3. The *SAP Science and Technology Vision Paper* considers possible future demands and disruptors on existing weather, climate, water, and related environmental services and the emerging capabilities that can help address these coming challenges. It also recognizes the importance of international cooperation in addressing these grand scientific and technological challenges and ensuring that benefits are realized in all countries, particularly lower-income countries, where the importance of translating advances in global science to services with local impact cannot be over-emphasized. The paper concludes with eight final recommendations which the SAP believes should be acted upon to prepare the weather, water, and climate communities for the future.
4. The Seventy-fifth Session of the Executive Council (EC-75) endorsed the draft *SAP Vision Paper* (now the *SAP Science and Technology Vision Paper)* and its set of recommendations, excluding the recommendation on geoengineering ([Resolution 2 (EC-75)](https://library.wmo.int/doc_num.php?explnum_id=11331#page=18)).
5. The Research Board, INFCOM and SERCOM provided additional reviews and input to the draft SAP Vision Paper following EC-75. The SAP has since updated the paper to reflect this additional input and the requests of the Executive Council, and submits the *SAP Science and Technology Vision Paper* as [EC-76/INF. 2.5(4)](https://meetings.wmo.int/EC-76/InformationDocuments/Forms/AllItems.aspx) (Annex 1).
6. The Policy Advisory Committee (PAC) considered the *SAP Science and Technology Vision Paper* and adopted [Recommendation 1 PAC-2(2022)](https://meetings.wmo.int/EC-76/_layouts/15/WopiFrame.aspx?sourcedoc=/EC-76/InformationDocuments/EC-76-INF02-5(1-2)-REPORTS-OF-TCC-AND-PAC_en.docx&action=default) to recommend to EC-76 to request that the Research Board evaluate and prioritize SAP recommendations and advise on their feasibility and concept for implementation. The Research Board has already conducted this priority and feasibility appraisal, presented in detail in [Annex 1](#Annex1) to the resolution.

**Expected action**

1. Based on the above, the Executive Council is invited to adopt [Draft Recommendation 3.3(4)/1 (EC-76).](#Draft_Recommendation)

# DRAFT RECOMMENDATION

## Draft Recommendation 3.3(4)/1 (EC-76)

### Scientific Advisory Panel Recommendations with Research Board Appraisal

THE EXECUTIVE COUNCIL,

**Recalling** [Resolution 10 (Cg-18)](https://library.wmo.int/doc_num.php?explnum_id=9827#page=61), which established the Scientific Advisory Panel (SAP) to provide independent scientific advice to the Organization, drafting opinions and making recommendations to Congress and to the Executive Council on matters concerning WMO research strategies and the optimal scientific directions to support the evolution of its mandate in weather, climate, water, and related environmental and social sciences,

**Recalling** [Resolution 8 (Cg-18)](https://library.wmo.int/doc_num.php?explnum_id=9827#page=53), which established the Research Board to translate the strategic aims of WMO and the decisions of Congress and the Executive Council into scientific research strategies and implementation plans,

**Noting** that recent decades have experienced increasing negative impacts of weather, climate, and water-related events on humanity and that, despite remarkable advances in weather-climate prediction systems, technological, scientific, and socioeconomic challenges remain and will continue to evolve in the future,

**Recognizing** WMO’s leading role in advancing scientific and technological breakthroughs in response to the above challenges,

**Having examined** the final recommendations provided by the Scientific Advisory Panel in Annex 1 to the report by the Chair of the SAP ([EC-76/INF. 2.5(4)](https://meetings.wmo.int/EC-76/InformationDocuments/Forms/AllItems.aspx)),

**Having examined** the appraisal of the priority and feasibility of these recommendations provided by the Research Board in [Annex 1](#Annex1) to the draft resolution,

**Acknowledges** the final recommendations provided by the Scientific Advisory Panel in the *SAP Science and Technology Vision Paper* ([EC-76/INF. 2.5(4)](https://meetings.wmo.int/EC-76/InformationDocuments/Forms/AllItems.aspx)),

**Endorses** the appraisal of the priority and feasibility of the SAP recommendations provided by the Research Board in its Appraisal Report included in [Annex 1](#Annex1) to the draft resolution,

**Recommends** to the World Meteorological Congress the endorsement of the draft resolution provided in the [Annex](#Annex_to_draft_Recommendation) to the present Recommendation.

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[Annex: 1](#_Annex_to_draft_1)

## Annex to draft Recommendation 3.3(4)/1 (EC-76)

**Draft Resolution ##/1 (Cg-19)**

### Scientific Advisory Panel Recommendations with Research Board Appraisal

THE WORLD METEOROLOGICAL CONGRESS,

**Recalling** [Resolution 8 (Cg-18)](https://library.wmo.int/doc_num.php?explnum_id=9827#page=53) – Research Board and [Resolution 10 (Cg-18)](https://library.wmo.int/doc_num.php?explnum_id=9827#page=61) – Scientific Advisory Panel,

**Having examined** the Report from the Chair of the Scientific Advisory Panel (SAP) and the *SAP Science and Technology Vision Paper* as included in the annex therein
([EC-76/INF. 2.5(4)](https://meetings.wmo.int/EC-76/InformationDocuments/Forms/AllItems.aspx)),

**Having considered** [Recommendation 3.3(4)/1 (EC-76)](#Draft_Recommendation) – Scientific Advisory Panel Recommendations with Research Board Appraisal as provided in the annex to this resolution,

**Acknowledges** the final recommendations provided by the Scientific Advisory Panel in the *SAP Science and Technology Vision Paper*,

**Recognizing** there is already ongoing work to address some of these recommendations across the Organization, its sponsored and co-sponsored Research Programmes, and partner organizations,

**Further recognizing** the need to balance the SAP Science and Technology Vision Paper as well as the Research Board appraisal, with the existing work program of WMO bodies, and needs identified by Members, subject to the outcome of budgetary decisions [D. Campbell]

**Decides:**

1. SAP Recommendation #1 be further developed with the leadership of the World Climate Research Programme, with the support of the Research Board, the Scientific Advisory Panel, INFCOM and SERCOM, in order to coordinate and promulgate relevant research and development for climate simulation and analysis capabilities that support WMO Member strategic priorities;
2. SAP Recommendation #2 be further developed by the Capacity Development Panel through a nuanced and pragmatic assessment of developing local capacity, along with a concept note regarding implementation strategies;
3. SAP Recommendation #3 be advanced, guided by existing Research Board Concept Notes, as part of a whole of UN perspective on digital strategy;
4. SAP Recommendation #4 be continued through regular Research Board activities on detection and attribution research;
5. SAP Recommendation #5 be advanced by SERCOM as part of a globally consistent quality assurance process for weather, climate, water and related environmental services from private providers, to best align provider standards with NMHSs;
6. SAP Recommendation #6 be advanced through a concept note developed by the Research Board on pathways to enable closer integration of geophysical and social sciences;
7. SAP Recommendation #7 to be developed with the leadership of the Education and Training Office to develop partnerships for integrative educational best practices with support from the Capacity Development Panel;
8. SAP Recommendation #8 highlighting leadership in attaining net-zero to continue as part of the Green WMO.

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[Annex: 1](#_Annex_1_to_1)

## Annex 1 to Draft Resolution ##/1 (Cg-19)

**Research Board Appraisal of Scientific Advisory Panel Recommendations**

(1) In the *Scientific Advisory Panel Science and Technology Vision Paper*, the SAP proposes a set of recommendations to WMO for scientific research and other strategies to prepare the Members of the Organization for the future. The paper highlights the importance of translating global science into services with local impact, particularly for low-income countries. To meet the future demands for precision in weather, climate, water, and environmental research, the SAP recommends the exploitation of exa-scale computing and Earth system observations through international collaboration. The paper also stresses the need to develop a digital strategy that enables the equitable use of cloud computing and AI.

(2) The SAP recommends a major international effort in research and development coordination to meet the future needs for weather, climate, water, and environmental information. The SAP recommends that this R&D coordination effort focus on developing global kilometre-scale Numerical Earth-system Weather-to-Climate Prediction (NEWP) systems, exploiting recent advances in information technology. The SAP also stresses the importance of environmental sustainability in the computing infrastructure and more broadly in WMO and NMHS operations.

(3) Finally, the paper highlights the need to prepare people to meet the challenges of the future while preserving the traditional areas of expertise. The SAP's recommendations aim to ensure that WMO is prepared for the future and can deliver the benefits of global science advances to all countries.

(4) The Research Board was tasked by the Executive Council Policy Advisory Committee to develop an appraisal of the priority and feasibility of each of the eight recommendations presented by the *SAP Science and Technology Vision Paper* in the context of ongoing and near-term research activities, the mission of the Organization, and the needs of the whole Member community. This appraisal was developed between December 2022 and February 2023, and was agreed by consensus at the Research Board meeting of 17 February 2023. A summary diagram is provided in Figure 1 and supporting documentation is below. Importantly, no recommendation was found to be non-core to the WMO Mission (see [Figure 1](#Figure1)). Because Recommendation 1 represents a significant potential investment of time, expertise and resources by the Members, in this report we devote relatively more detail to the appraisal of this recommendation.

**Recommendation 1: Major international climate research and development effort in the exploitation of global kilometre (k-Scale) computing and Earth-system observations.**

(5) This recommendation proposes the development of ultra-high spatial resolution climate simulation capabilities along with the associated environmental observational data sets and analyses. The proposal by the SAP is that this substantial research and development effort is required to meet Members’ needs for weather, climate, and water-related information.

(6) The most important issue in the view of the Research Board is that this recommendation obscures a promising path for model development, which is the bridging of weather and climate timescales. The “grey zone” between these timescales holds tremendous promise for supporting the Global Framework for Climate Services and the Early Warnings for All Initiative, including the development of highly impactful knowledge support for agriculture, infrastructure, and disaster risk reduction, among many other areas.

(7) There is no doubt that pushing the research envelope with regard to spatial scale is important, and indeed these activities are ongoing. At present, there are approximately ten atmosphere-only (not coupled) models running at the kilometre scale. The explicit representation of deep convection shows significant benefits, although there are open questions with regard to low clouds, extra-tropical systems, land hydrology, oceans, and sea ice. The coupling of climate system components at these scales is not well understood. It is not clear that spatial resolution, in and of itself, is a limiting factor in ascertaining climate sensitivity. There is much to learn about the behaviour of these models, and research is active, particularly through the World Climate Research Programme Lighthouse Activity. Thus, the case for a link between the development of kilometre scale capability and meeting Member needs is yet to be fully made.

(8) A second important issue is the required infrastructure. The critical context is that to develop ensembles of coupled climate simulations at the kilometre scale using current numerical methods, a factor of 1 000 000 increase in computational capacity is required, (current rates of improvement are a factor of 10 per decade). That said, there are opportunities available to improve this picture through improved software engineering, machine learning and Artificial Intelligence approaches, and dedicated hardware.

(9) The Research Board is concerned about the potential detrimental impacts of too strong a focus on this goal. At present, the majority of our Members have limited or no access to the data we can currently provide. Inequalities of accessibility are likely to be exacerbated if data volumes increase massively and quickly. Furthermore, this focus may draw resources away from distributed research and operations, and indeed lead to increased loss of capacity and expertise due to “brain drain”. Finally, there is a concern regarding the emissions profile of the needed infrastructure, be it centralized or distributed.

**(10) Priority:** The Research Board finds this recommendation is highly desirable in the long term but is not an important nor critical means to reach the goal of urgent Member information needs.

**(11) Feasibility:** The Research Board estimates that significant new knowledge is required before the appropriate implementation strategy can be identified, as suggested in the analysis above. In addition, the effort is unlikely to be operationally feasible without massive investments which may result in an opportunity cost with regard to other, more critical, recommendations.

**Recommendation 2: Bridge the gap between developing global science and delivering local impact.**

(12) This recommendation rightly observes that any large investment in kilometre scale climate simulation capabilities must incorporate equity, as also observed in paragraph (9) above, to minimize perpetuating the disparity in service provision between high and low-income countries. The implementation pathway suggested in this recommendation is to work with socioeconomic disciplines to understand the impacts of services and develop relevant applications.

(13) The Research Board suggests that this recommendation should be decoupled from Recommendation #1, as the delivery of local impact based on the best available science is critical across all aspects of the WMO mission. Indeed, the Capacity Development Panel, wherein the Research Board is represented by their Vice Chair, has developed considerable insights into the implementation of this as a wider recommendation, as well as the requirements for additional research.

**(14) Priority:** The Research Board views this as the most critical activity, and assigns it the highest priority.

**(15) Feasibility:** The Research Board estimates that moderate investment is needed for required research and development that leads to better insights into the challenges and for designing appropriate implementation.



*Figure 1. Priority-Feasibility Matrix used as a decision tool by the Research Board in this appraisal.*

**Recommendation 3: Develop a digital strategy.**

(16) This recommendation is also coupled to Recommendation #1 in the SAP Vision Paper, but has great potential beyond this narrow application, in the view of the Research Board. Indeed, the Research Board developed two concept notes that proposed strategies to address this key issue and document aspects that were already underway. Developing a visionary view regarding strategies to level the playing field across all aspects of research, infrastructure and services is critical in many ways. Indeed, innovation in information technology is booming in many low-income countries, and there is potential for WMO to act as an enabler in this space. Furthermore, the Research Board sees potential for WMO to work with other UN agencies to enhance this process and increase its impact.

**(17) Priority:** The Research Board views this as an important activity, particularly if taken forward with a whole of UN view.

**(18) Feasibility:** The Research Board estimates that moderate investment is needed from WMO if implementation strategies are pursued in partnership.

**Recommendation 4: Accelerate the development of attribution science and techniques.**

(19) Fostering detection and attribution research is certainly an activity that is active in the World Climate Research Programme, the World Weather Research Programme, and Global Atmosphere Watch. While for standard variables, the transition to operational capacity hinges most on developing standards for loss and damage negotiations, for example, there remain significant challenges in other aspects, including extreme events, greenhouse gases and air quality.

**(20) Priority:** The Research Board views this as a highly desirable activity, and one that is indeed ongoing.

**(21) Feasibility:** The Research Board estimates that moderate investment is needed particularly for the more challenging areas, but in many cases this research is active, ongoing, and well-funded.

**Recommendation 5:** **Further development of a quality assurance strategy for weather, climate, and water-related services.**

(22) The development of approaches to service quality assurance is lacking in two aspects that the Research Board identified. First, the quality assurance of private providers of WCWE services remains a key issue requiring a coordinated effort at WMO’s level. Second, global consistency is lacking and efforts could be made to develop and implement standards as appropriate. This is the purview of SERCOM rather than a research effort.

**(23) Priority:** The Research Board views this as a very important activity.

**(24) Feasibility:** The Research Board estimates that while funding requirements may be limited, an investment of time from SERCOM is likely to be needed, and this should be considered.

**Recommendation 6: Work across agencies to enable closer integration of geophysical and social sciences to support better understanding of the impacts of weather, climate, and water events.**

(25) The Research Board viewed this effort of integration between natural and social sciences to be a critical activity, requiring substantive engagement not only with agencies but with universities, research and training institutions, and civil society. While there are many integrative activities ongoing in WMO-sponsored and co-sponsored research programmes, the effort needs to be substantially scaled up.

**(26) Priority:** The Research Board views this as a critical activity.

**(27) Feasibility:** The Research Board suggests that this is an effort requiring the development of new knowledge, new approaches, and new merit systems for researchers to enable progress. Additional funding will be necessary at the national level as well as through WMO.

**Recommendation 7: Develop education and training strategies to broaden expertise beyond traditional disciplines.**

(28) The Research Board was very supportive of this recommendation, but deemed that it required more analysis, in collaboration with the WMO Education and Training Office and the Capacity Development Panel, to ensure that efforts were aligned with Recommendations #2 and #6 as well as with research priority areas. WMO can demonstrate leadership through highlighting best practice, but most usefully WMO can work to strengthen partnerships across the Organization with universities and educational organizations worldwide.

**(29) Priority:** The Research Board views this as a desirable activity, but not as high priority as other recommendations as the WMO footprint in education is relatively small.

**(30) Feasibility:** The path forward is clear, but requires time, attention and funding at the national level. The WMO Education and Training Office has a role to play as a clearing house for best practices and targeted training. A priority focus is enhanced partnerships with universities across all departments.

**Recommendation 8: WMO, together with NMHSs, to provide leadership in the move towards net-zero.**

(31) WMO should seize the opportunity to accelerate plans for a net-zero strategy in infrastructure management and operations, and thereby exhibit leadership across the UN family. Furthermore, through the Global Greenhouse Gas Monitoring Infrastructure Initiative, WMO can provide emissions information and data for Members and across the UN. The Research Board is highly supportive of this, but does not see it as an area for WMO research.

**(32) Priority:** The Research Board views this as a desirable activity of immediate import, but it does not have a place in a research vision.

**(33) Feasibility:** This recommendation can form part of executive plans for the Organization and indeed, Member NMHSs, going forward, but does not require a research investment.

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