



WORLD
METEOROLOGICAL
ORGANIZATION

Open Consultative Platform



**REPORT OF
THE THIRD HIGH-LEVEL SESSION
(OCP-HL-3)
20 JUNE 2022**

**OPEN CONSULTATIVE
PLATFORM**

**PARTNERSHIP & INNOVATION
FOR THE NEXT GENERATION OF
WEATHER & CLIMATE INTELLIGENCE**

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Chair, Publications Board
World Meteorological Organization (WMO)
7 bis avenue de la Paix
P.O. Box 2300
CH-1211 Geneva 2, Switzerland

Tel.: +41 (0) 22 730 8403
Email: Publications@wmo.int

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I. FOREWORD



At the First High-level Session of the Open Consultative Platform (OCP-HL-1), established at the initiative of WMO on the occasion of the Eighteenth World Meteorological Congress in 2019, multiple participants identified the issue of clarifying the roles of National Meteorological and Hydrological Services (NMHSs) and other stakeholders as one of the key challenges that will shape the common vision for the future of the weather, climate and water enterprise in the coming decade and beyond. Over nearly 150 years of global meteorological cooperation dating back to the 1873 Vienna International Meteorological Congress, the roles of NMHSs have evolved, driven by various factors such as a

growing demand for information and services, the advancement of science and technology, the changing operational environment, and changing financing modes. NMHSs have adapted to their evolving roles by always following one guiding principle: Continue to improve the services they provide in order to increase human safety, societal and economic benefits, and international cooperation.

We have now reached a historic moment in which unprecedented societal needs for safety, sustainability and prosperity require unparalleled collaboration. NMHSs will therefore have to not only redefine their critically important role in safeguarding life and property but also embrace a more significant role in facilitating an ecosystem of weather, climate and water services inclusive of all stakeholders. The Third High-level Session of the Open Consultative Platform (OCP-HL-3), held on 16 June 2022, launched the second OCP White Paper on the Future of National Meteorological or Hydrometeorological Services: Evolving Roles and Responsibilities. The release of the White Paper and the thematic discussions at OCP-HL-3 have the potential to inform NMHS decisions that will impact the future development of individual NMHSs, as well as the entire global weather, climate and water service community. I have the pleasure of presenting the summary report, which has captured the key messages and suggestions from the speakers and panellists on future scenarios, opportunities, risks and possible governance choices. I hope the messages in this summary report will help NMHSs and all other stakeholders to foresee trends, expectations and potential pathways to a future in which their respective but complementary capabilities and roles are best engaged to maximize the societal benefits of weather, climate and water information and services.

A handwritten signature in blue ink, consisting of a series of fluid, connected strokes that form the name 'Petteri Taalas'.

Prof. Petteri Taalas
Secretary-General
World Meteorological Organization

II. EXECUTIVE SUMMARY

The Third High-level Session of the Open Consultative Platform (OCP-HL-3) of WMO was held on 16 June 2022 during the seventy-fifth session of the WMO Executive Council. OCP-HL-3 formally launched [WMO Open Consultative Platform White Paper #2](#), titled “Future of National Meteorological or Hydrometeorological Services: Evolving Roles and Responsibilities”; this White Paper also set the theme for OCP-HL-3. The invited speakers and panellists shared their thoughts and views about the evolving roles and responsibilities of different players in the dynamic weather and climate service community, especially those related to National Meteorological and Hydrological Services (NMHSs).

WMO Secretary-General Prof. Petteri Taalas opened the high-level session, thanking the Members for the decision made at the Eighteenth World Meteorological Congress to open the door for the private sector and enhance WMO’s Public-Private Engagement (PPE) activities. He emphasized that the role of Permanent Representatives (PRs) is to serve not only the interests of NMHSs but also the interests of governments, the private and academic sectors, and hydrology at the national level. PPE is an excellent opportunity to enhance the impact of the work of NMHSs and provide additional services. The private sector can play a growing role in the value chain from observations to service provision. Public safety-related issues have to remain in the hands of governments. The Secretary-General also reiterated the importance of helping countries build the legal basis for preserving NMHS mandates in public safety and enabling better engagement with the private sector.

WMO President Prof. Gerhard Adrian gave a keynote presentation launching [WMO Open Consultative Platform White Paper #2](#), of which he was the lead author. According to Prof. Adrian, the white paper is a collective endeavour of more than 30 leading experts worldwide. It comprehensively analyses evolving societal needs and observed trends in the technological and operational ecosystems in which National Meteorological or Hydrometeorological Services (NMSs) operate. The primary objective of the white paper is to inform key decisions on the future development of NMSs by taking into consideration risks, opportunities and scenarios relating to foreseen institutional, technological and operational changes, thereby enabling better governance choices. Prof. Adrian shared the [key conclusions](#) of the white paper around the changing environment, partnership building, international cooperation, human resources and leadership, and so forth.

Twelve invited panellists shared their views and answered questions on three thematic panels: Operating models and environment; Legislative/institutional framework; and Human resources, Permanent Representative’s role and global and regional cooperation.

The panellists on the first thematic panel shared their perspectives on how they foresee that internal and external factors such as funding levels, the capability to absorb scientific and technological advances, and approaches to handling the increasingly multi-stakeholder landscape will impact on the roles and responsibilities of NMHSs.

The second thematic panel focused on a critical factor for NMHSs, indeed for all stakeholders: the legislative, policy, and institutional framework. The panellists shared their experiences and insights regarding how this framework needs to be adapted to accommodate the evolving roles of all players within the weather enterprise, especially NMHSs.

The third thematic panel looked at human resources, the evolution of the roles of PRs as representatives of all stakeholders in the weather, climate and water community in their respective countries, and how global and regional cooperation might impact the way NMHSs handle their evolving roles.

Mr. Tatsuya Kimura, Director of the Public-Private Engagement Office at the WMO

Secretariat, presented the following key messages, drawn from the above three thematic panels:

- NMHSs, the academic sector, and the private sector continue to mutually benefit from their individual strengths through partnerships, jointly enhancing the overall societal benefits offered by each.
- Opportunities for innovative public-private partnerships around the use of technology are expanding in different parts of the value chain, for example:
 - Around the ownership/operation of core high-performing computing (HPC) infrastructure software;
 - To improve research for weather/climate/environment challenges;
 - To improve the applicability and usefulness of data for users downstream;
 - To improve access to digital skills for NMHSs;
 - In the area of automated observations, to free personnel resources for more value-added tasks in the core mission of the NMHS.
- The rapidly changing environment has underscored the need for policies and legislation, including national regulations, to provide a clear legal basis and consistent rules for meteorological services. Legal and policy frameworks also ensure that NMHSs will be regarded as vital components of national resilience and as the authoritative source of relevant data and information.
- Private sector entities and other partners can help to advocate for the need for sustained funding for NMHS operations.
- The role of an NMHS Director is now even more outward-looking to help facilitate win-win partnerships with other government agencies and the private sector so that the impact and value of the NMHS can be better understood and realized. With the new WMO Unified Data Policy, NMHS Directors have the opportunity to redefine the importance of the NMHS as the hub for reliable, rapid and unrestricted foundational data distribution.

WMO Deputy Secretary-General Dr Elena Manaenkova closed the high-level session. She reiterated what was written in the WMO Convention on the vitally important mission of NMHSs in observing and understanding weather and climate and in providing meteorological, hydrological and related services in support of relevant national needs. The future roles of NMHSs should be considered in a constantly changing environment and playground with an increasing number of players. It is essential to talk with a diversity of stakeholders who are part of the enterprise and parts of the ecosystem. She reemphasized the importance of the official, authoritative voice of the NMHS in early warnings and free access to public data.



Information on OCP-HL-3, including the video recordings of all the

presentations and panel discussions, documents, slides, and so forth are available at <https://public.wmo.int/en/our-mandate/how-we-do-it/ppe/resources>.

III. KEY MESSAGES FROM PANELLISTS

Thematic Panel 1: Operating models and environment

Prof. Penny ENDERSBY, Permanent Representative of the United Kingdom of Great Britain and Northern Ireland with WMO

In the UK Met Office, we do seek partnerships widely at every step along the value chain with partners that can enhance or improve our capabilities and help us deliver better forecasts with greater impacts. But it is important to make a considered choice about what areas you are going to put your resources in and which ones you want to share or outsource. At the Met Office, we want to be world-leading in some of our core capabilities: observations, numerical weather prediction, climate modelling, guidance and advice. But even here, we have many partners from academia, other NMHSs and other government bodies. Up until recently, owning and operating our supercomputing infrastructure would have been another of those areas where we needed to be the experts ourselves, but we now see this as an area where we can partner with industry to bring the best combination of expertise and capabilities together. Moving our supercomputer to be close to a public cloud provides us with opportunities to leverage the elasticity and scalability of cloud and make our really huge data readily available to clients and partners. So, it is really true that we see the private sector not at all as competition, but as a route for us to enhance both our capabilities and the reach of our predictions. That's really what we want to do with the impact we want to have.



Prof. Alberto ARRIBAS HERRANZ, Europe Lead for Environmental Sustainability Science, Microsoft

NMHSs are very different from each other with respect to priorities, needs and challenges. At Microsoft, we are well aware of the need to embrace and understand those differences. But despite the differences across meteorological services, there are common areas where technology can help. I would like to highlight two particular areas. One has to do with research and innovation. Microsoft can help here by bringing computational tools such as machine learning into weather and climate challenges. One example is data assimilation. Machine learning can facilitate the fusion of data from heterogeneous sources, not only traditional data sources, such as satellites and sensors, but also unstructured data sources, such as social media. The second area I would like to highlight where technology can help has to do with improving the usefulness and the positive impact of weather and climate data. Microsoft can help by enabling the scalability and facilitating the integration of weather data into services. Combining environmental and socioeconomic data is difficult and requires sophisticated platforms and tooling. That is the reason Microsoft has created things like the Planetary Computer – to make this easier and really facilitate the development of applications for water management, agriculture, and biodiversity for use by everybody.

Mr Kai ÖISTÄMÖ, President and CEO, Vaisala

Strong meteorological services are extremely important to their respective societies, not least for the protection of life and property. Official weather forecasts and related weather warnings will remain the responsibility of meteorological services. National Meteorological Services continue to be responsible for national observation networks as part of the national infrastructure. Met institutes' observations also create additional benefits for the economic sectors in their respective societies. Global benefits can be estimated to be in the billions of dollars every year. Private sector entities are free to make observations for their own purposes, but it is unlikely that they will share these data openly in an unrestricted manner as we create these data fundamentally for specific business cases. It is important for each service to consider its own core activities in an evolving technology environment. It is not always necessary to build everything in house – if we look back a few decades, met offices built their own observation equipment in house. Automated observation makes it possible for met services to move their personal resources from routine observation activities to more value-added tasks. Today, the met offices of many countries invest a lot in in-house software development. I would say it is likely that this in-house software development will gradually be reduced in the future as the software becomes more commercially available, and its development is not necessarily a part of the core mission of NMHSs. NMHSs and the private sector benefit mutually from their individual strengths in maintaining and developing beneficial services for their societies and globally.



Mr YU Yong, Deputy Administrator, China Meteorological Administration (CMA)

CMA strives to achieve sophisticated monitoring, precise forecasting and tailored services to promote the digital and smart transformation of met services. We are focusing on four areas. The first is safeguarding lives. We are making efforts to improve weather hazard monitoring and early warning systems and to target specific hazards and key sectors. The second is enabling robust production by providing enhanced services to weather-sensitive sectors, including agriculture, ocean, transportation. The third is creating a better life for all by making personalized and tailor-made services available while ensuring the universal accessibility of a public met service. The fourth is promoting ecological security by strengthening climate change monitoring and evaluation. In June this year, we published a new policy document to better nurture the service market and engage various players to provide guided meteorological services, including: 1) by optimizing the policy environment to promote the gradual opening of meteorological data resources of different classes; 2) by improving the regulations so as to have better monitoring and evaluation systems in place to ensure a market that encourages fair competition; 3) by better engaging with the private sector, establishing and improving the government purchasing mechanism of weather and climate information services, and encouraging the private sector to be a better service provider in the sector.

Thematic Panel 2: Legislative/institutional framework

Mr Naoyuki HASEGAWA, Permanent Representative of Japan with WMO

The Meteorological Service Act in Japan was formulated on the premise that public-private-academic sector collaboration is essential from the beginning. Its purpose is the sound development of meteorological services, and here, “services” includes public and private weather services. The Act itself does not detail the roles to be played by the private sector except that the private sector cannot issue warnings; this is to ensure that the Japan Meteorological Agency (JMA) is the single authoritative voice in this area. The capabilities and services of the private sector are constantly evolving, and therefore, the collaboration framework has been reviewed and updated from time to time. As the regulator, JMA does not provide commercial services in order to avoid competition and conflicts of interest. In order for the public, private and academic sectors to collaborate with each other, we need to have common goals and objectives. We aim to have a society where the data are used together with the data of other sectors, such as retail, transport, demography, to make our life better in all aspects. To this end, JMA will continue to improve our warnings and decision-support activities for disaster prevention. At the same time, we are striving, in collaboration with our partners, to promote the use of weather data, for example, by applying new technologies, such as cloud, to the data sharing framework and by making adjustments to the regulations for quality assurance of weather information.



Mr Jim Anderson, Chair, Association of Hydro-Meteorological Industry (HMEI)

From the industry’s perspective, and representing HMEI, which has about 140 private sector members, there are the things that would help the private sector engage more fully and bring more to bear to solve these common problems that we are all trying to address. One is clear legal frameworks and consistent rules of the road. We often find that we may be operating in countries where there are policies that may prohibit private-sector engagement, or where there are no policies, so we operate in a vague environment. All these types of things create friction or uncertainty that limits private-sector engagement and the investment that we can bring to solve these problems. Two – and WMO has worked hard to address this – it would be helpful to have a common data policy that allows for the distribution of government-owned data for the private sector to use in order to serve their customers, but also one that distinguishes government-owned data from private data and incentivizes the private sector to deliver more of that data to solve various problems. Finally, it would be helpful to have a reform of the programme management and procurement rules associated with large-capacity development projects primarily funded by the international donor community and the development community. This would include having longer-term funding streams rather than very episodic funding mechanisms and funding the services that surround the technical infrastructure, such as training, maintenance, operation, and capacity development services, and the continued on-going support of services. HMEI is working with the World Bank and WMO on the standardized tender specifications as part of this overall programme management and procurement reform initiative.

Dr Agnes L. KIJAZI, Third Vice-President of WMO and Permanent Representative of the United Republic of Tanzania with WMO

Through the Tanzania Meteorological Authority (TMA) Act, No. 2 of 2019, TMA remains the sole authoritative voice for issuing warnings related to the weather and climate in Tanzania. The enforcement of the law and the involvement of the private sector have significantly improved the weather and climate services in Tanzania and resulted in socioeconomic benefits to various sectors of the economy. The functions of TMA are well recognized by both the government, as the main financier, and the general public. The follow-up trends for TMA services, especially warnings, by stakeholders, including the general public, show exponential growth. The budget allocated for the meteorological infrastructure by the government has increased. The Act mandated TMA to provide both public goods and commercial services in relation to meteorology. Therefore, stakeholders that use meteorological services commercially are required by the law to contribute some amount as cost recovery. Furthermore, TMA's five-year medium-term strategic plan 2020–2025 took into consideration the need to involve both the government, as the main financier of public goods, and other commercial stakeholders in financing weather and climate activities in Tanzania. It also took note of involving the private sector in the delivery of specific activities of the Authority so as to ensure the sustainability of weather and climate services in the five-year plan.



Mr Joachim SCHUG, Head of House and Senior Meteorologist, DTN Switzerland

While there are clear distinctions in public and private weather organizations, there are a lot of instances where collaboration between private and national weather services improves the addressing of societal issues, such as risk mitigation, safety and sustainability. Let me give two brief examples of such partnerships through risk communications. One example is from Switzerland. DTN Switzerland has a very dense in-house network of automatic surface weather stations, roughly 380 in this tiny country. This network gives our forecast a database for precise local risk communication. But these data are also shared with our national weather service, MeteoSwiss, to cover gaps in their network. It's a cost-effective use of public money and improves the warning system and the safety of the citizens of Switzerland. A second good example of private-public partnership is that we are coordinating with the National Weather Service in the United States and their municipal meteorologists. DTN provides risk communications for the New York City Emergency Management Department in severe weather planning by offering situational awareness and supporting critical operational and safety decisions being made on a hyper-local level, where conditions are changing. In this way, we support the safety and well-being of the citizens of New York City and its infrastructure.

Thematic Panel 3: Human resources, Permanent Representative's roles, and global and regional cooperation

Dr Albert KLEIN TANK, Director, Met Office Hadley Centre for Climate Science and Services

It is really important for NMHSs to work in partnership with the multi-disciplinary science community, and we need this partnership to be able provide adequate decision support to inform climate solutions across society. The changing risks of extreme events we see today illustrate how existing weather warnings need to be complemented with newly developed climate services. Research and innovation are clearly needed to develop these services. From the science perspective, these are exciting times. There is so much going on: climate model simulations at very detailed spatial resolution, which enable significant weather events to be simulated; large model ensembles to enable detailed risk assessment of extreme events; and improved simulations of very complicated processes in the climate systems, such as ice sheets. In addition to that, there is exascale computing, cloud technology, machine learning and digital twins. If you really look at the pull-through of the latest science and operational climate services partially delivered by NMHSs and by the private sector, I think there is still a lack of a lot of information despite many pilot projects. To address the challenges of climate change, we need to build more collaboration with practitioners in policy planning and business in areas such as hydrology, agriculture, economics and human behaviour. Only through this collaboration can we provide adequate decision support to manage the risks of high-impact weather events and also increase our resilience to climate change and to other risks.

Dr Andrew JOHNSON, Permanent Representative of Australia with WMO

NMHSs and private weather companies should be working together, not in competition with one another. There are at least four fundamental things that are vital to acknowledge with respect to talent. First, talent should be offered a compelling purpose, that is, people should be provided with a job offering that gives them the opportunity to have a significant impact, at the local community level, on industries, on whole countries, and in some cases, on the whole world. A compelling purpose and mission are essential because we are never going to be able to compete for money. Even private weather companies will not be able to compete on a monetary basis with other business sectors of society. The second has to do with flexibility – the ability to work from anywhere and at anytime. The nature of work has changed, and the expectations of employees, both current and future, have also changed. We need to adapt to that if we are going to attract and retain the very best people. The third has to do with opportunity. How do we provide the opportunity for people to move in and out of and across organizations at multiple times during their career? The last has to do with diversity and inclusion. People want to come and work in a place that values diversity and is safe, and a workplace where they can bring their true selves to work. So, if we can pay attention to these four principles, it will put us in good shape to attract the best people in the world to the things that we think are important.



Mr Jonathan PORTER, Senior Vice-President and Chief Meteorologist, AccuWeather

NMHSs Directors have and will continue to embrace a larger role in not only running their agencies but also, importantly, in being the inspirer-in-chief and the strongest advocates at the national level for successful, mutually beneficial, public-private engagement. In the context of the new WMO Unified Data Policy, NMHS Directors have the important opportunity to prioritize funding and resources for reliable, rapid, and open foundational data distribution in their own countries, really redefining the importance of the NMHS as the central hub for this mission-critical data, the fuel for the entire weather enterprise. The NMHS Director role is now even more outwardly facing in order to help facilitate positive partnerships with other government agencies



and the private sector so that the true impact and value of the NMHS can be better understood and fully realized. AccuWeather has had a key focus on partnering with NMHSs around the world to prominently present NMHS-sourced weather warnings to all of our global users. These warnings, importantly, always clearly delineate that they are from the NMHS with the agency logo and other clear attribution, strengthening the NMHS branding. Additionally, Directors should also hold frequent collaborations with the weather industry to arrive at the definition of core data in their country and recognize that this definition will need to evolve over time and encourage discussions, formally and informally, with the private sector, civil protection, broadcast meteorologists and other partners. Putting foundational data in the hands of innovators on an equal opportunity basis drives many positive impacts and much wider use of the data and therefore recognition of the government NMHS in ways that we might not even be able to imagine today. Finally, it is really important to think about how the private sector can be more helpful in advocating for increased government investment in core public infrastructure and capacity development. The private sector wants to be more helpful in this area.

Ms Courtney DRAGGON, Director, International Affairs Office, National Weather Service, National Oceanic and Atmospheric Administration (NOAA), United States of America

In the US, we depend on the support of our external partners, including the private sector, the academic sector, and first responders to advocate for resources for our agency. The weather forecasting system must have an assured, uninterrupted flow of quality data from our observing systems, and ensuring this is an inherently governmental function. To fulfil our mission, we need international collaboration. The benefit of full, free, and open data for the United States is that by volume, we receive about three times as much data as we put into the system. NOAA's environmental data and model output has been found to fuel a very vibrant and growing private sector enterprise in the United States. According to the University Corporation for Atmospheric Research, the private sector in the US is estimated to generate billions of dollars of annual revenue, employ thousands of people, and provide a rich array of products and tailored services. A portion of this revenue in the form of taxes in the United States is in turn then used to fund the public-sector budgets, including for NOAA, the same budgets that provide the observing systems that then provide the data that we share. The health of the industry is underwritten by that convention of full, free, and open data. The industry, in turn, finds that it is beneficial to advocate for the National Weather Service and the resources we get in turn.

IV. TRANSCRIPT OF THE THIRD HIGH-LEVEL SESSION OF THE OPEN CONSULTATIVE PLATFORM

Introduction

Mr Gerald FLEMING, Moderator



Welcome to the Third High-level Session of the Open Consultative Platform of the World Meteorological Organization. My name is Gerald Fleming, and I will be your moderator today.

In this session, we are going to explore the evolving roles and responsibilities, especially those related to National Meteorological and Hydrological Services. This OCP is an event that brings together different stakeholders from the public, the private and the academic sectors to discuss and share our vision about the future of the global weather enterprise.

The first launching event of the Open Consultative Platform, which we call OCP-HL-1, was held during the Eighteenth World Meteorological Congress in June 2019; the second high-level session was held online last year, and now we are here, in Geneva, in person, presenting the third session of this mechanism for cooperation.

At this session we will also formally launch the second OCP White Paper, which is entitled "Future of NMHSs – Evolving Roles and Responsibilities", and reach out to all stakeholders with the key messages in this second white paper, which will help us to guide our future key decisions on institutional, technological and organizational changes. We aim to collect the thoughts and views of all the stakeholders on the theme of our future activities.

Just a few housekeeping points – this session is being recorded and the recording will be shared on the WMO website in due course. When we come to the panel discussions, for those joining online, you can post questions in the chat box – I understand the Q and A box will be used just for technical queries of connection problems and the like – so, in the chat box, and we will try to get to them insofar as possible. Again, I mention our time is limited.

But first, to commence this high-level session, I would like to give the floor to Professor Petteri Taalas, WMO Secretary-General, who will, I'm sure, have some inspiring words to set the scene for us. Professor Taalas.

Opening remarks

Professor Petteri TAALAS, WMO Secretary-General

Thank you, Mr Chair, and thanks for coming to the event physically or virtually. We are grateful that we are finally able to gather at this meeting. I would like to thank our Members for the decision that you made at our main Congress three years ago where you decided to open the doors for the private sector and enhance the PPE activities of WMO. Now the doors have been open for the past years, and of course, this pandemic has slowed down our cooperation a bit. We have also understood



how the private sector engagement is carried out at the national level. One size does not fit all. We have different models in different parts of the world. Here in Europe, many met services have commercial arms. In the USA, that is not the case. In some Asian countries, some met services are giving licenses to the private sector to prove a set of services. And you who are the Permanent Representatives of WMO, your role is to serve the interest of the governments, not only the interests of your meteorological services, but the interests of the governments. That also contains the private and academic sectors and also hydrology at your national level. PPE is a great opportunity, and I foresee that there will be a growing amount of private sector engagement in our business. That is a positive and will enhance the impact of our work. There is a large amount of additional services that can be provided as a joint venture between the public and private sectors but also purely by the private sector. The amount of data that we are dealing with nowadays is getting so large that it is also important to collaborate with private sector from that perspective. Also, in the chain that we have from observations to services provision, the private sector could play a growing role. Of course, public safety-related issues have to remain in the hands of governments. We are very much supporting the legal basis for such things at the national level and helping countries build the legal basis for that. And the legal basis for how the private sector is engaged will make life much easier. With these words, thanks for coming to this event. I'm very much looking forward to the presentations and your views on this. At the Secretariat level, we are very positive towards the wider engagement of the private sector in our work. Thank you.

Keynote presentation: Launch of Open Consultative Platform White Paper #2



Prof. Gerhard ADRIAN, WMO President and lead author of OCP White Paper #2, made a keynote presentation launching OCP White Paper #2 on the Future of National Meteorological or Hydrometeorological Services: Evolving Roles and Responsibilities.

I am delighted to launch WMO OCP White Paper #2 on the Future of National Meteorological or Hydrometeorological Services (NMS): Evolving Roles and Responsibilities. There was a long-lasting discussion within the writing team about which term we should use, and at the end, we used the outcome of an old discussion, and the term as it is defined in the WMO Convention, because that is the main input we received, and this is also the main focus of the text. The White Paper is a collective endeavour of more than 30 leading experts in the world. It provides comprehensive analysis of the evolving societal needs and observed trends in the technological and operational ecosystems in which NMSs operate. It presents key messages and recommendations derived from such analysis. The primary objective of this white paper is to inform key decisions on the future development of NMSs, considering risks, opportunities and scenarios for the foreseen institutional, technological and operational changes and enabling better governance choices.

This is the list of the contributing authors and reviewers who dedicated their time and efforts for White Paper #2. The contributions of the contributing authors will be published in the second volume of this publication without any changes, so you could read all the original contributions which were summarized in a synthesis presented in the first volume of this document. So, this was the role of the leading experts' drafting group: 21 leading experts provided fruitful, written contributions and more than 10 independent experts also devoted their time to review the white paper. This means the white paper is a synthesis report, not the opinions of the individual authors. I therefore believe this white paper represents a wide spectrum of views and opinions based on different national and professional experiences and interests. I would like to take this opportunity to express my sincere appreciation for the efforts of these people.

This is the structure of the white paper. It is fairly a long white paper, so you can first capture the essence by reading the executive summary, introduction and conclusions. It is also compiled in such a way that it does not necessarily need to be read in order from the very beginning.

Now, I will share with you the essence of the conclusions which comprise key messages and recommendations:

1. A major consideration by the drafting team and reviewers was the rapidly changing environment influenced by many external and internal factors. The ability of National Meteorological or Hydrological Services to adapt to such changing conditions and benefit from new technology will require agility, foresight and change management. National Meteorological or Hydrometeorological Services therefore must continually evolve to become more efficient, more effective and higher performing to remain relevant and competitive and to fulfil their public safety mandate. In doing so, NMSs should focus on increasing the benefits of partnerships and collaborate widely across the public and private sectors, as well as with central and regional governments.
2. There is no one-size-fits-all model since NMSs vary significantly; however, all NMSs have a common need to enhance the benefits they provide. For example, in the aforementioned changing environment, efforts towards improving national legal frameworks should focus on defining better the mandate and functions of NMSs, along with possible stakeholders' roles. It's easy to write this sentence, but it's

difficult to achieve this – that’s my experience. This is to ensure that NMSs are regarded as vital components of the national resilience. Another example is about data, which is a fuel for all stakeholders. Strong efforts should be made to ensure better recognition by the governments of the benefits of free and unrestricted access to NMS data, which should result in allocation of more resources to allow NMSs to provide data for socioeconomic needs.

3. Changing operational environment: The global digital drive is calling for an accelerated digital transformation. The automation will lead to organizational changes and reorientation of their service delivery. Also, the public cloud and pervasive Internet offer a new route to access improved forecasting skills of smaller NMSs. Therefore, development of appropriate digital strategies and research avenues is desirable. In relevant strategies and actions, realizing the opportunities for utilizing the WMO Unified Data Policy will benefit the performance of NMSs and should be prioritized.
4. Partnerships: Our progress will require inclusive multisectoral partnerships. Partnerships and collaboration with the private sector and academia have the potential to accelerate improvements. The sustainability of basic infrastructure is an area where opportunities are also arising. Therefore, leadership in interdisciplinary partnerships is needed. NMSs also need to embrace the concept of co-design and co-development, which will result in better services for societies.
5. International cooperation: Cooperation through WMO must continue and expand, in particular, ensuring free and unrestricted international data exchange and capacity development. Regional collaborations are an extremely effective way of raising the collective performance, which has been pushed forward by WMO. Bridging the capacity gap will require innovative international cooperation with a focus on delivering core information and services, in particular, warning services and long-term sustainability.
6. Human resources and leadership: Particular essential aspects are leadership, talent management and skills development. As skills to leverage partnerships is becoming increasingly important, NMS Director career development planning should account for coordinating with all national stakeholders. Directors of National Meteorological or Hydrometeorological Services should endeavour to be leaders of national weather, climate and water enterprises.

These are the major key messages and recommendations excerpted from the white paper. For more details, please go to the WMO Library online and find WMO Publication No. 1294. Original contributions from authors are also available. I hope that this White Paper and my presentation will be useful for the future of National Meteorological or Hydrological Services and all stakeholders as well as for the panel discussion.



Finally, I would like to add something very important: these are the photos of contributing authors. Thank you.

Thematic Panel 1: Operating models and environment

The evolution of National Meteorological and Hydrological Services has always been driven by many factors. Our very first panel topic today is around changes to operating models and the environment, how they vary across from one country to another and how they change over time. The experience and perspectives of our first panel will provide insights into how they foresee factors such as the funding levels, the capability to absorb scientific and technological advances, and handling the increasingly multi-stakeholder landscape will impact on the roles and responsibilities of NMHSs.

Prof. Penny ENDERSBY, Permanent Representative of the United Kingdom with WMO



Q: As an advanced national weather service with over a century and a half of history, UK Met Office's activities cover the full value chain through weather and climate services. But, we have seen other players, non-NMHS players, also very active within the UK, active in the value chain. Do you think that tendency will affect how you resource your research and operational activities? And which parts of the value chain do you think that you and the UK Met Office will put more focus on in the future years?

A: Yes, you are right. We are fortunate to be a large and well-funded met service, but even in the Met Office, we know that we are not able to be unique experts in every aspect of our work because it is just too big and complicated. So, we already do seek to partner widely at every step along the value chain with partners who can enhance or improve our capabilities and help us deliver better forecasts with greater impacts. Lots of you will be familiar with Joy's law, which says that "whoever you are, most of the smartest people work for someone else." And if there are other people who have the advantage, we want to work with them, and not against them. But it is important to make a considered choice about what areas you are going to put your resources in and which ones you want to share or outsource. At the Met Office, we want to be world-leading in some of our core capabilities: observations, numerical weather prediction, climate modelling, guidance and advice. But even here, we have many partners from academia, our Met Office Academic Partnership with several universities, other met services – and lots of them are here today in our Unified Model Partnership – and other government bodies, such as our flood forecasting centre, which we run with UK's Environment Agency. And up until recently, we would have said that owning and operating our supercomputing infrastructure would have been another of those areas where we needed to be the experts ourselves. But our recent contract with Microsoft reflects the fact that we now see this as an area where we can partner with industry to bring the best combination of expertise and capabilities together. So, working with Microsoft – and you're going to hear from Alberto shortly, we are building a dedicated supercomputing capability that they will operate and that is integrated directly into their Azure cloud. And moving our supercomputer to be close to a public cloud provides us with opportunities to leverage the elasticity and scalability of cloud and make our now, really huge data readily available to clients and partners. We can see world met services like us are offering cloud-based big data platforms with web-friendly APIs to make data accessible and usable to others, including other NMHS partners. That means the data can be used on the cloud without the need to download it or maintain local infrastructure. And we need now to get the operating models right to let this benefit all sizes of met services in a sustainable way. And finally, there are some other aspects of our work where we just seek to operate as competent partners alongside real experts who are maybe in the private sector or elsewhere, for example, in visualization or when serving data, and it is equally true of our media or of our digital offerings. So, it is really true that we see the private sector not at all as competition but as a route for us to enhance both our capabilities and the reach of our predictions. That's really what we want to do with the impact we want to have.

Prof. Alberto ARRIBAS HERRANZ, Europe Lead for Environmental Sustainability Science, Microsoft



Q: As an IT giant, Microsoft produces and provides supercomputing infrastructure and services to many applications, including helping NMHSs to better predict weather and climate. As you know, one driver for the weather enterprises is the ever-increasing demand for more accurate and more relevant weather and climate information services. As a close partner with many NMHSs, how do you think the IT industry can best empower weather enterprises to harness the digital technology and address the increasing demands placed upon us?

A: There is a huge potential for collaboration. In terms of how Microsoft can help empower national met services, I would like to start by recognizing what has already been said, that national met services are very different among themselves, so different met services will have different priorities, different needs, different challenges. In Microsoft, we are well aware of the need to embrace and understand those differences so can we achieve our very own mission, which is to use technology to help others around the world to achieve more. But despite the differences across met services, there are also common areas where technology can help, and I would like to highlight two particular areas. One is about research and innovation. All of the met services I know, they all want to continue to improve their understanding and improve their predictions. Microsoft can help here by bringing computational tools such as machine learning into weather and climate challenges. This is why we have recently created a new initiative called the Microsoft Climate Research Initiative to address and help address challenges in climate. One example is data assimilation. Machine learning can facilitate fusion of heterogeneous data sources, and that means not only traditional data like satellite and sensors but also unstructured data like social media. Machine learning has the potential to do this in a very high resolution and to do it very fast. That provides us a huge opportunity to improve our understanding together and to help address new important challenges, such as real-time exposure to pollution or the tracking of CO₂ emissions, which are new demands coming into the space of national met services. The second area I wanted to highlight where technology can help is about improving the usefulness and the positive impact of weather and climate data. Microsoft can help by enabling the scalability and facilitating the integration of weather data into services. That's why we are working with the Met Office. We can really integrate high-performance computing and public cloud. Let me give you a specific example. A company may need to do climate risk assessments. That means it needs data not only from climate predictions, but data on vulnerability and exposure. And combining environmental and socioeconomic data is difficult and requires sophisticated platforms and tooling. That is the reason that Microsoft has created things like Planetary Computer to make this easier and really facilitate the development of applications for water management, agriculture, and biodiversity for everybody. But of course, and this is critical, the data needs to be attributed to its resources. The business models that work for partners need to be created. That's what Microsoft does in all of the sectors that we are involved in. We do this when we work with car manufacturers, and we do this when we work with game designers. I see no reason why we cannot do the same when we work with the weather and climate sector. This is a very important point for everybody. And finally, I just wanted to briefly mention skills because every time I talk to any organization including met services, I hear that it is difficult to attract and retain talent in technology. So, one key area that we really need to address together is culture, and specifically how to create an open culture that enables people from different organizations to work together and a culture that also facilitates that people can move across organizations and take knowledge with them to improve things.

Mr Kai ÖISTÄMÖ, President and CEO, Vaisala



Q: In the age of digital transformation and increasing service-oriented business by the private sector, how will the growing capabilities and business models of private companies and other stakeholders influence the operating models of NMHSs and help NMHSs improve meteorological services in their countries?

A: When listening to the white paper presented, I am very happy to see how Vaisala is very much aligned with WMO and the national met institutes' mission. The strong meteorological services are extremely important to respective societies, not least for the protection of life and property. The official weather forecasts and related warnings will remain meteorological services' responsibility. Met services will continue to play the major role in producing high-quality weather observations that serve their core mission. The accurate and reliable observations are key for forecasting continuity and warning activities. Without this foundation, the forecasts and warnings cannot be made. Meteorological Services continue to be responsible for national observation networks as part of the national infrastructure. As discussed, the free and unrestricted sharing of data within the community of national meteorological services in line with WMO Resolution 40 and Unified Data Policy is a key cornerstone for the creation of a global network effect for all met services being better able to serve their respective societies when it comes to protection of life and property. And Vaisala is very proud of being part of the leading observation technology players. Met institutes' observations also create additional benefits for the economic sectors in their respective societies. Global benefits can be estimated to be in billions of dollars in every year. Private sector is free to make observations for their own purposes, but in the end, it is unlikely that they would share these data openly in an unrestricted manner as we create these data fundamentally for specific business cases. Typically, these can be for some targeted application areas with application-specific decision-making support systems. Private sector has and will use the opportunity to provide business sector with targeted weather services and impact-based forecasting. A good example of an emerging such opportunity could be, for example, autonomous traffic. I don't think this is at all in contradiction with the core mission of meteorological services. Met offices choose the means by which they produce their observation and forecast services. It is important for each service to consider their own core activities in an evolving technology environment, as discussed. It is not always necessary to build everything in house. After all, if we look a few decades back, met offices built their own observation equipment in house. Automated observations is a possibility for met services to free their personal resources from routine observation activities to more value-added tasks. These could include the key GBON areas of upper-air soundings and surface weather observations, as well. Today, met offices in many countries invest a lot in in-house software development. This includes systems that might be also available commercially off the shelf. If I take a couple examples of such, network management solutions, airport weather observation systems, or weather radar signal processing. I would say it is likely that this in-house development will gradually reduce in the future as it will become more commercially available, and it is not necessarily a part of NMHSs' core mission. In summary, I would say met services and the private sector benefit mutually from their individual strengths in maintaining and developing beneficial services for their societies and globally. In conclusion, I would say we are in this journey together.

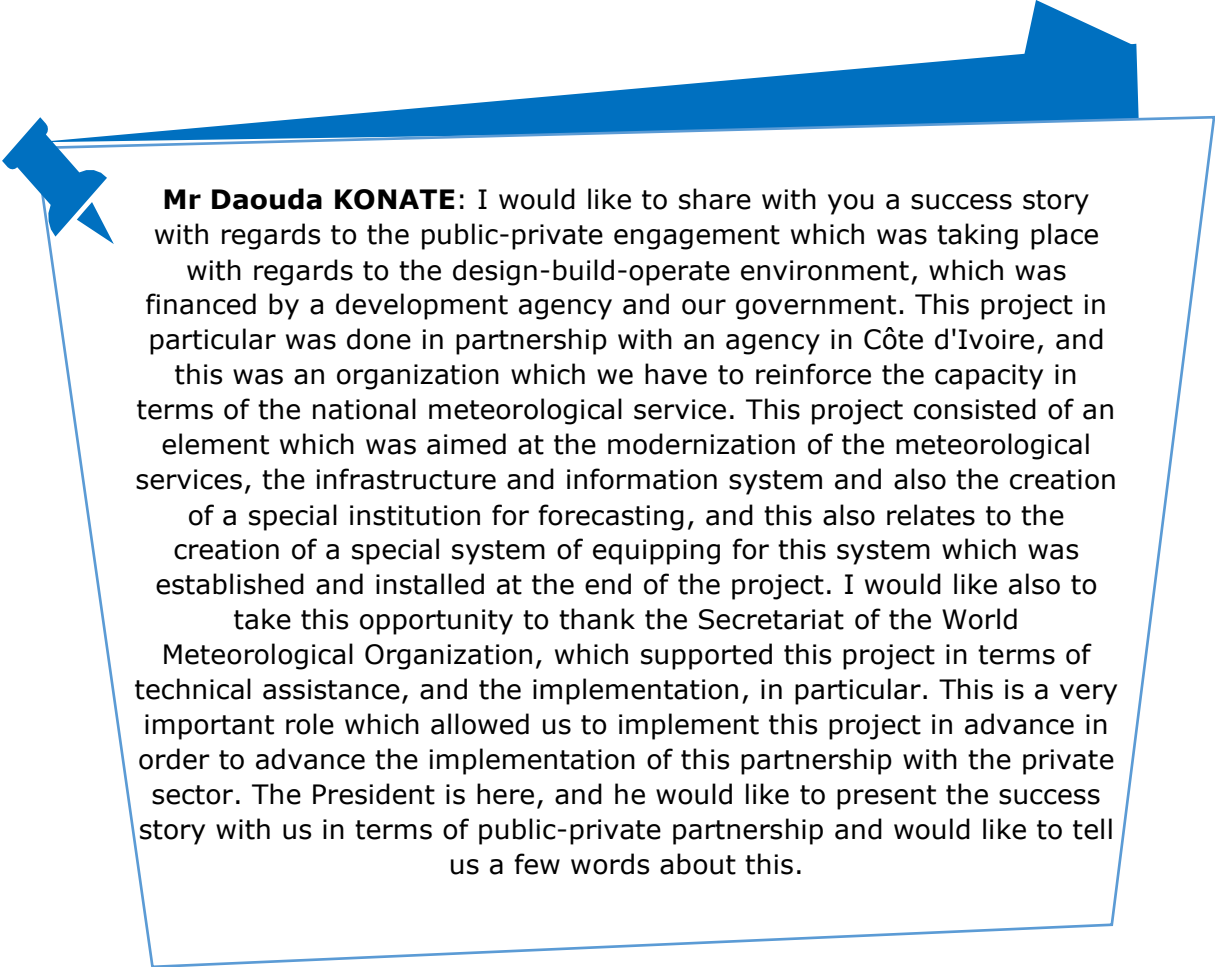
Mr YU Yong, Deputy Administrator, China Meteorological Administration (CMA)



Q: CMA is known for its significant role in delivering both public and specialized services to a huge variety of customers. How will CMA's role in service delivery evolve with the growing domestic market of weather business and an increasing number of private service providers in China? What are the core services that you think CMA is going to focus on?

A: The white paper better explains the future roles played by NMHSs and also our responsibilities. The CMA is the national met service authority and is responsible for assisting DRR-related policy making for the Government, and met forecast and hazard warning services for the general public, as well as tailored and dedicated met services for the various sectors to promote socioeconomic development. Therefore, we formulate China's meteorological development policies and regulate the met service sector. In the past April, the State Council of China published the 2022–2035 Guideline on Fostering High-quality Meteorological Development, which specified the pathway and objectives of this development. CMA strives to achieve sophisticated monitoring, precise forecasting and tailored service to promote the digital and smart transformation of met services, with focus in four areas in particular. First, safeguarding lives. Efforts will be made to improve the met hazard monitoring and early warning systems to target specific hazards and key sectors and to conduct reviews of hazard risks to develop impact-based forecast and risk warnings so as to have in place a warning-led chain mechanism. Second, enabling robust production. The met plus empowering action plan will be implemented to provide enhanced, precise and professional services to met-sensitive sectors including agriculture, ocean, and transportation. Third, creating a better life for all. Service supply will be improved to have a service system that covers both the urban and the rural areas and provides personalized and tailor-made services available while ensuring the universal accessibility of a public met service. Fourth, promoting a sound ecosystem. Climate change monitoring and evaluation will be strengthened to better protect ecosystem and restore met barriers, while promoting the reasonable utilization of climate resources. In June this year, we published a new policy document to better nurture the service market and to engage various players to provide guided met service, which includes, first of all, optimized policy environment to promote the gradual opening of met data resources of different classes; second, to improve the regulations so as to have a better monitoring and evaluation system in place, ensuring a market environment that encourages fair competition; third, to better engage the private sector and to establish and improve the government purchasing mechanism of met services and encourage the private sector to be a better service provider in the sector. We therefore recommend that WMO, in promoting public-private partnership, to uphold utmost principle of safeguarding global public interest while seeking the common development of capacity of its Members, setting the international rules to be observed by both NMHSs and private sector, therefore guiding the engagement of the private sector in an appropriate manner and ultimately elevating the met service capabilities around the world.


Questions and comments from the floor



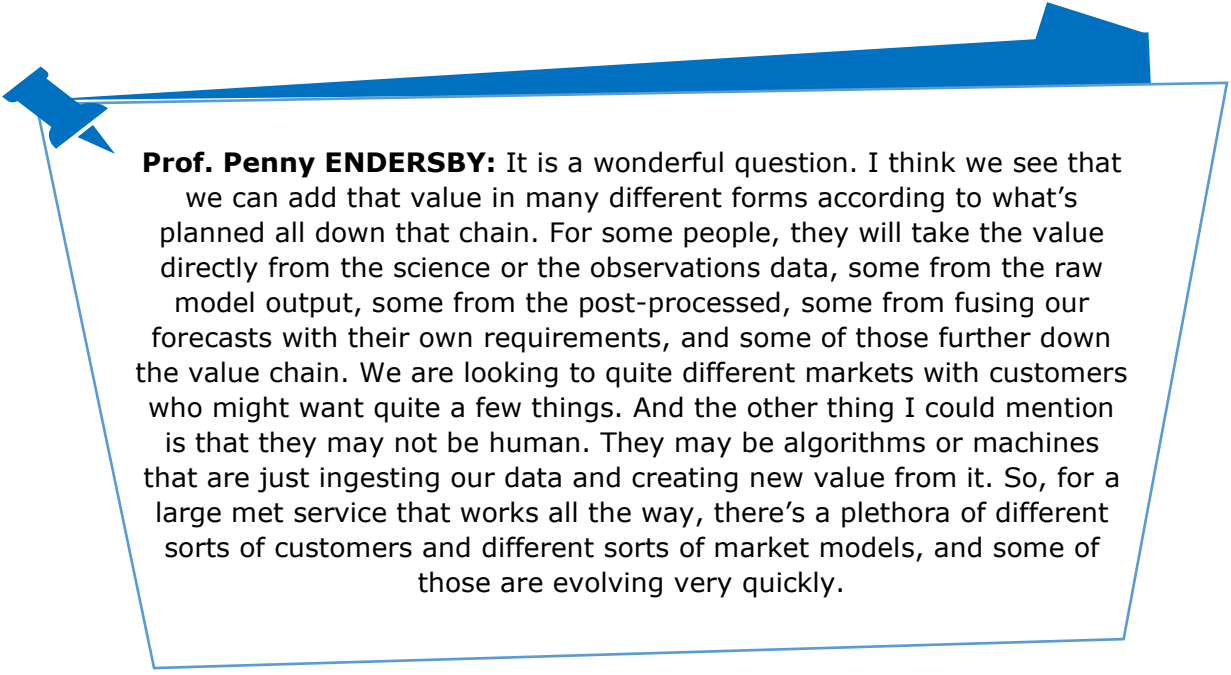
Mr Daouda KONATE: I would like to share with you a success story with regards to the public-private engagement which was taking place with regards to the design-build-operate environment, which was financed by a development agency and our government. This project in particular was done in partnership with an agency in Côte d'Ivoire, and this was an organization which we have to reinforce the capacity in terms of the national meteorological service. This project consisted of an element which was aimed at the modernization of the meteorological services, the infrastructure and information system and also the creation of a special institution for forecasting, and this also relates to the creation of a special system of equipping for this system which was established and installed at the end of the project. I would like also to take this opportunity to thank the Secretariat of the World Meteorological Organization, which supported this project in terms of technical assistance, and the implementation, in particular. This is a very important role which allowed us to implement this project in advance in order to advance the implementation of this partnership with the private sector. The President is here, and he would like to present the success story with us in terms of public-private partnership and would like to tell us a few words about this.



Mr Patrick BÉNICHOU: This 27 million Euro project is the concretization of long-term partnership effort with the SODEXAM in Côte d'Ivoire. It also reflects the oncoming of a new era with design-build-operate projects funded by development partners. At last, we managed to have project running all across the value chain implemented for the benefit of NMHSs, for sovereignty, cost-effectiveness and higher sustainability. I am convinced that the WMO community needs more PPE projects of this kind. We can make it happen together. MFI, as the pioneer of integrated project and PPE DBO approach, is proud to be part of this new agreement and eager to work side by side with SODEXAM in general and President of Region I in particular.



Dr Jan DANHELKA: With a changing environment and possibilities, a lot of information, you may find a lot of things just in a small device. We heard about core business or core activities and functionalities of the National Meteorological and Hydrological Services. I think it is a customer or user who decides what he or she will use. If he finds something more suiting his purpose in this device, he doesn't recognize the core activities. What he recognizes or she recognizes is the added value of the service that you provide. My question is what is the added value in the future of National Meteorological and Hydrological Services? Is it different for the big ones and the middle and small services?



Prof. Penny ENDERSBY: It is a wonderful question. I think we see that we can add that value in many different forms according to what's planned all down that chain. For some people, they will take the value directly from the science or the observations data, some from the raw model output, some from the post-processed, some from fusing our forecasts with their own requirements, and some of those further down the value chain. We are looking to quite different markets with customers who might want quite a few things. And the other thing I could mention is that they may not be human. They may be algorithms or machines that are just ingesting our data and creating new value from it. So, for a large met service that works all the way, there's a plethora of different sorts of customers and different sorts of market models, and some of those are evolving very quickly.

Thematic Panel 2: Legislative/institutional framework

A key factor for any NMHS, indeed for all stakeholders, is the legislative, policy, and institutional framework within which we all must work, and these, of course, vary quite significantly from one country to another. We are going to explore some of these frameworks now, how they need to be adapted to accommodate the evolving roles of all the different players within the weather enterprises, but especially focused on the NMHSs.

Mr Naoyuki HASEGAWA, Permanent Representative of Japan with WMO



Q: What is your legal and institutional system's underlying concept, and how is the JMA (Japan Meteorological Agency) Director-General's role prescribed in the relevant law? How has your agency been promoting public-private engagement by evolving this legal and institutional framework over time? How would you like to see that evolved for other countries?

A: The Meteorological Service Act in Japan was enacted 70 years ago and formulated on the premise that the collaboration of public, private, and academic sectors is essential from the beginning. This basic idea hasn't changed. Its purpose is the sound development of meteorological services, and here, the services include public and private weather services. Therefore, as the Director-General of the Japan Meteorological Agency (JMA), I am not only responsible for the development of JMA's services but also for that of the private services. The Act itself does not detail the roles to be played by the private sector except that private sector cannot issue warnings, to ensure a single voice by JMA. The capabilities and services of private sector are constantly evolving, and therefore the collaboration framework has been reviewed and updated from time to time. The point here is that this review has been always based on the close communication between sectors, typically through an advisory committee consisting of experts from public, private and academic sectors. The current basic concept on the roles to be played by public and private sectors was set up in 1992. There, JMA only provides fundamental public services to protect life and properties, whereas the private sector is to provide customized services to meet diverse needs based on the data and products that JMA provides. As the regulator, JMA does not provide commercial services to avoid competition and conflict of interest. About the future, in 2018, we set the vision for meteorological services in 2030 based on the recommendation by the advisory committee that I mentioned earlier. In order for the public, private and academic sectors to collaborate with each other, we need to have common goals and objectives. And I believe that this vision serves well as the foundation of collaboration. We aim at the society where the data are used together with data in other sectors, like retail, transport, demography, to make our life better in all aspects. To this end, JMA will continue improving our warnings, and decision-support activities for disaster prevention. And at the same time, we are striving, in collaboration with our partners, to promote the use of weather data, for example, by applying new technologies like cloud to the data sharing framework or by making adjustments to the regulation for quality assurance of weather information. We believe that such collaboration efforts will lead to the realization of the society described in our vision.

Mr Jim ANDERSON, Chair, Association of Hydro-Meteorological Industry (HMEI)



Q: What kind of institutional environment would you like to see for all of us that would better leverage the power of the public, private, academic, and indeed, the civil sectors of society in addressing all the various and very many social and economic challenges and that would encourage us to work in a mutually supportive and complementary manner?

A: I think it is always worth stating and acknowledging that no matter what part of the global weather enterprise we come from, whether it is academic, or the private sector, government sector, etc., we all come to it with the same objectives in mind: to help improve human thriving and sustainability. I think sometimes in these discussions around what's the right institutional framework and who should be doing what, we lose sight of that fact, that we're all – and everybody I know in the private sector feels the same way as folks in the government sector – we're really supporting the same higher-level objectives and aspirations. We may come from different parts of it, but have different strengths, but they're very complementary in the end. Obviously, with climate change, the urgency and importance of pursuing these endeavours and bringing as much energy and resources to bear on them as possible, this is an all-hands-on-deck response. It is needed at this time. We all bring different sources of capital, whether that be investment capital, human capital, technical capital, etc., and the private sector can bring some of that, but so can all the other members of the global weather enterprise. From the industry's perspective and representing HMEI, which has about 140 private sector members, things that would help the private sector engage more fully and bring more to bear to solve these common problems that we are all trying to address, one is clear legal frameworks and consistent rules of the road. We often find that we may be operating in countries where there are policies that, perhaps, prohibit private-sector engagement, or there are no policies, so we operate in sort of a vague environment where it is customary for private sector to engage in certain ways but not in others, but there is no legal certainty around it. So, all these types of things create friction or uncertainty that limits private sector engagement and the investment of our capital resources that we can bring to bear to solve these problems. Two, and certainly, the WMO has worked hard to address this, to bring a common data policy that allows for the distribution of government-owned data for the private sector for them to be able to use it to serve their customers, but also distinguishes government-owned data from private data and enables and incentivizes the private sector to deliver more of that data to solve and collect more of that data to solve various problems. I really like some of the comments that were made earlier regarding the collaboration that can happen around all these things and figuring out exactly where the private sector can play and be the most complementary and provide the best support to the national mission that national met and hydromet agencies have. And then finally, for lack of a better word, reform of the programme management and procurement rules associated with large capacity development projects primarily funded by the international donor community and the development community. To do this, to really ensure successful implementation and long-term operation of context-appropriate technologies and services that have a much higher success rate and help really build capacity for climate change mitigation, adaptation, resiliency and sustainability in these countries. This would include having longer-term funding streams, rather than very episodic funding mechanisms that principally fund hardware and infrastructure for short periods of time – people do that for longer periods of time; also, the funding of services that surround the technical infrastructure, so whether that's training services, maintenance, operation, capacity development and continued on-going support of services; also, just the delivery of data services or software services in areas where it doesn't make sense to deploy an infrastructure. Finally, and this is something that HMEI has worked on a great deal with the World Bank and the World Meteorological Organization, is the use of standardized tender specifications as part of this

overall programme management and procurement reform initiatives. Examples of these have now been generated and are beginning to be used, but to accelerate the adoption of more standardized methods and tender specifications and procurement procedures would be great in this area.

Dr Agnes L. KIJAZI, Third Vice-President of WMO and Permanent Representative of the United Republic of Tanzania with WMO



Q: Are the functions of your NMHS, such as issuing warnings and operating infrastructure, well recognized by the public and the financial authorities in your own country? If so, how are your functions supported by legislation and strategic planning? What role do you think the private sector, in particular, probably here the media, might play in disseminating early warnings?

A: Meteorological law in Tanzania was enacted in 2019 and this law governs the provision and operation of weather and climate services in the United Republic of Tanzania. And the Act has mandated the TMA to provide weather and climate services, including early warning to the general public, and also provide tailor-made services to socioeconomic sectors within the country. TMA is also mandated by the law to provide regulatory functions on all meteorological activities undertaken by stakeholders in the United Republic of Tanzania. This law gives room for the private sector to be involved in the provision of meteorological services. The private sector can install instruments for observation of the climatic parameters. They can undertake specific meteorological services within the country but for specific use. However, the private sector cannot issue warnings to the public, but they can disseminate warnings issued by TMA. As through TMA Act, No. 2 of 2019, TMA remains to be the sole authoritative voice for issuing warnings related to weather and the climate in the country. For other types of hazards, the directive of the law is to engage relevant stakeholders, so as to establish a multi-hazard early warning system in the country. The enforcement of the law and the involvement of private sector have significantly improved the weather and climate services in the country with socioeconomic benefits to various sectors of the economy. Now, coming to your question, I can say yes. The functions of the Tanzania Meteorological Authority, TMA, are well recognized by both the government, as the main financier, and the general public. Trends of follow-up of TMA services, especially warnings, by stakeholders, including general public, show exponential growth. Rate of vandalism of meteorological infrastructure has decreased, which is the sign of recognition by the general public of the services issued by TMA. The budget allocated for meteorological infrastructure by the government has increased, which shows how the government recognizes the value of the climate services in the country. And for the case of legislation and the strategic plan, I can say that the functions of TMA, as stipulated in Article 5 of the Tanzania Meteorological Authority Act, No. 2 of 2019, under this article, the law has mandated TMA to provide both public goods and commercial services in relation to meteorology. Therefore, stakeholders who use meteorological services commercially are required by the law to contribute some amount as the cost recovery, since larger amount, including infrastructure, is covered by the government. Furthermore, the Tanzania Meteorological Authority's five-year medium-term strategic plan 2020–2025 is prepared in line with the law. Hence, it took into consideration the need to involve both the government, as the main financier of public good, and other commercial stakeholders in financing weather and climate activities in the country. This includes also the aviation sector, which is commercial and has to contribute some amount to the Agency. It also took note of involving private sector to deliver specific activities of the Authority so as to ensure sustainability of weather and the climate services in the five-year plan. As for the last part, whether the private sector, including media, plays a part in disseminating early warning, I can say that Tanzania Meteorological Authority Act, No. 2 of 2019, recognizes private sector, including media, in the dissemination of weather and

climate forecasts and warnings to the general public. Article 31 (1) directs TMA to issue weather and climate forecasts and warnings for public consumption through media. Also, Article 5 (h) directs TMA to cooperate with other institutions and authorities involved in meteorology and related fields in the aspects of training, studies, research, environment, climate variability and change. Hence, you can see that the role of private sector is clearly defined in the TMA Act, No. 2 of 2019.


Mr Joachim SCHUG, Head of House and Senior Meteorologist, DTN Switzerland



Q: DTN not only provides weather information services to many users, but they also have a data collaboration with public partners, including MeteoSwiss. MeteoSwiss has established a quality control framework that labels data from other observation network operators based on their level of compliance with WMO standards. How do you perceive the opportunities and risks around incorporating more private weather data providers into the WMO framework of technical standards and regulations?

A: DTN, as a leading private global weather company and global data analytics technology company, delivers actionable operational intelligence to organizations with complex supply chains. It's not a pool of weather forecasts. We go more to the customers in the business. We serve customers in over 123 countries of the world, focusing on agriculture, energy and weather-sensitive industries, especially in transport. While there are clear distinctions in public and private weather organizations, there are a lot of instances where collaboration between private and national weather services improves addressing societal issues, such as risk mitigation, safety and sustainability. Let me give two brief examples of these partnerships through risk communications. One example is from Switzerland. DTN Switzerland has a very, very dense in-house network of automatic surface weather stations, roughly 380 automatic weather stations in this tiny country. This network gives our forecast a database for precise local risk communication. But these data are also shared with the national meteorological service, MeteoSwiss, to cover gaps in their network. It's a cost-effective use of public money and improves the warning system and the safety of the citizens of Switzerland. This treasure trove of data are also shared with research institutes. There are a lot of theses done with our data. And what is most important, to answer your question, most of our stations are operated according to WMO standards. This allows a constant monitoring of the quality of our network and also that of the MeteoSwiss and also monitoring of the quality of our forecasts and the warnings. So, it's a really good example that also a private weather company can build up a private network of automatic stations operated according to WMO standards. This is not only for one year. Our network is now in operation since nearly 15 years. A second good example of private-public partnership is that we are doing coordination with the National Weather Service in the United States and their municipal meteorologists. DTN provides risk communications for the New York City Emergency Management in severe weather planning. DTN meteorologists have a deep expertise in municipal operation and community impact. They offer the kind of situational awareness that supports critical operational and safety decisions being made on a hyper-local level while conditions are changing. In this way, we support the safety and well-being of the citizens of New York City and its infrastructure. We expect more cities to adopt this model of cooperation as extreme weather increasingly challenges traditional responses. These are just two short examples of the cooperation between national met services and private weather companies. As climate is changing and extreme weather is challenging our world, collaboration between public and private weather organizations, as well as stakeholders, will increase advanced science research and development and will be of great benefit to our global society.

Questions and comments from the floor



Question: Whether space weather activities are likely to be a major component of NMHSs activities in the future? Where should they lie?

Prof. Penny ENDERSBY: Space weather is a part of our national remit, and we do provide it. It's a different scale, undoubtedly. We've just had the pleasure of having some representatives from the South African met service who are setting up their own space weather capability and helping them train at the moment. It's fairly niche, but it is a threat to our digital systems, our communication systems, our satellites, so it's a good thing that we are able as met services to provide it, and I don't know anyone else who is doing this on behalf of the public or the private on the same level. It is still very much developing capability for the whole globe.

Mr Gerald FLEMING: It is well developed in the United States, not under the National Weather Services, but under – I think, it's NOAA.

Thematic Panel 3: Human resources, Permanent Representative's roles, and global and regional cooperation

Our third theme is very broad ranging. It looks at human resources, looks at the evolution of your roles, the roles of many of you as PRs, the representatives of all of meteorology in your countries, and how global and regional cooperation might impact on how NMHSs handle their evolving roles.

Dr Albert KLEIN TANK, Director, Met Office Hadley Centre for Climate Science and Services



Q: How do you foresee the academic and the research community contributing to and keeping pace with the growing demands on the weather enterprise to provide better decision support systems and services, such as climate change adaptation and mitigation services?

A: First of all, I wish to congratulate Prof. Gerhard Adrian and the entire author team for completing the white paper on the future of NMHSs. I must say, I'm really pleased to see that the voice of science and research is included both in the paper and at this meeting. My main message for today responding to the question is that I think it's really important for NMHSs to work in partnership with multi-disciplinary science community, and we need this partnership to be able to provide adequate decision support to inform climate solution across society. I think that the changing risks of extreme events that we see today illustrate how existing weather warnings need to be complemented with newly developed climate services, and developing these services clearly needs research and innovation. At the UK Met Office Hadley Centre, which I'm heading, we contribute to this in collaboration with academic partners, both in the UK and international. To respond to the threats posed by the changing climate, our science programmes really moved from defining the problem to enabling solutions. So, we develop projections to help local adaptation decisions. We also develop the models to assess greenhouse gas budgets and climate warming targets in light of the Paris Agreement. I think from the science perspective, these are really exciting times. There is so much going on: climate model simulations at very detailed spatial resolution, which enable significant weather events to be simulated, large model ensembles to enable detailed risk assessment of extreme events, and improved simulation of very complicated processes in the climate systems such as ice sheets. In addition to that, there is, of course, as mentioned earlier today, the exascale computing, cloud technology, machine learning and digital twins. I think, altogether, this is really exciting, but if you really look at the pull-through of the latest science and operational climate services partially delivered by NMSs and also by the private sector, I think there is still a lack of a lot of information despite many pilot projects. To address the challenges of climate change, I think we need to build more collaboration with practitioners in policy planning and business in areas such as hydrology, agriculture, economics and human behaviour. So, summing up, in conclusion, I am really keen that we closely collaborate with NMSs and multi-disciplinary science community. Only through this collaboration we can provide adequate decision support to manage the risks of high-impact weather events, and we can also then increase our resilience to climate change and to other risks. I am convinced that, if we do this, that will help us support the solutions agenda both for mitigation and adaptation.

Dr Andrew JOHNSON, Permanent Representative of Australia with WMO



Q: What do you think are the essential skills and competencies that NMHSs need to keep and develop in the coming decade to fulfil their future roles and responsibilities? And how can they best retain those skilled and talented workers when there is a huge commercial booming sector out there – in weather and in IT also – who can often offer better job opportunities and higher levels of payment? How are we going to solve this?

A: Firstly, the thing that troubles me most is that the premise of the question that somehow NMHSs and private weather sector are in competition for talent. I think, no matter where you are in the weather enterprise, we are in a very competitive environment for talent, and indeed NMHSs and private weather companies should be working together, not in competition with one another, and actually seek to be in competition with the rest of the world that is competing for the same talent. I think it's important to recognize that. Whether you agree with that or not, I think there are at least four fundamental things that are vital to acknowledge when we are thinking about talent. The first is – and others have spoken about this earlier – is around offering a compelling purpose, providing people with a job offering that gives them the opportunity to have a significant impact, whether it's at a local community level, with industries, whole countries and indeed, in some cases, the whole world. The compelling purpose and mission is essential because we are never going to be able to compete for money. Even the private weather companies will not be able to compete on a monetary basis with the other sectors in society. So, that mission and purpose is essential. Flexibility, the ability to work anywhere, from anywhere, at any time. I think COVID has shown us many things but one thing it has shown is that the nature of work has changed and that the expectations of employees both current and future have also changed. We need to adapt to that if we are going to attract and retain the very best people. The third is around opportunity. Again, a couple of colleagues have touched on this already. I think, again, this notion that people join an organization and stay there for their whole life no longer holds. So, how do we provide the opportunity for people to move in and out and across organizations at multiple times in their career? And then lastly, around diversity and inclusion, that people want to come and work in a place that values diversity and that is safe, and a workplace where they can bring their true self to work. So, if we can pay attention to those four principles, it will put us in good shape to attract the best people in the world to the things that we think are important.

Mr Jonathan PORTER, Senior Vice-President and Chief Meteorologist of AccuWeather



Q: There is now a very diversified ecosystem of weather and climate services at national and global levels. You are part of a global weather company. How would AccuWeather expect the functions and the roles of NMHS Directors to evolve and adapt so as to maximize social and economic benefits in their countries from a more broad-based and inclusive weather and climate services ecosystem?

A: The important and varied role for NMHSs Directors around the world will continue to evolve given the increased focus by the WMO on building those complimentary partnerships between governments and private sector worldwide to achieve win-win strategic partnerships and outcomes that really keep people safer, reduce injuries and fatalities, as well as helping people, governments and companies avoid financial loss from weather and climate disasters. We know there is an urgency to this critical work given the increasing impacts from weather and climate disasters globally. AccuWeather has had the great pleasure of working with NMHSs' Directors globally for decades, and I find these

leaders to be some of the most passionate, creative, caring and dedicated members of the global weather enterprise. NMHSs Directors have and will continue to embrace a larger role in not only running their agencies but also, importantly, being the inspirer-in-chief and the strongest advocates at the national level for successful, mutually beneficial public-private sector engagement. In the context of the new WMO Unified Data Policy, NMHS Directors have the important opportunity to prioritize funding and resources for reliable, rapid, and open, foundational data distribution in their own countries, really redefining the importance of the NMHS as the central hub for this mission-critical data, the fuel for the entire weather enterprise, as was discussed earlier in our session. And I think, as such, in order to be successful, the NMHS Director role is now even more outwardly facing in order to help facilitate the positive partnerships with other government agencies and the private sector so that the true impact and value of the NMHS can be better understood and fully realized. This can be accomplished in part by, for example, urging public warnings to be classified as the core data in your country and disseminated in CAP format. This enhances the visibility, awareness and brand recognition of the NMHS as the single authoritative voice on official government warnings to as many residents and tourists in your country as possible. This is especially important given that in many countries, the vast majority of people today receive their weather content from the media and private sector as opposed to directly from the NMHS. AccuWeather, who is celebrating our sixtieth anniversary this September, has had a key focus on partnering with NMHSs around the world to prominently present NMHS-sourced weather warnings to all of our global users. A key part of the AccuWeather mission is to save lives, protect property and help people prosper, which is very well aligned with the missions of NMHS organizations. Today, at AccuWeather, we have integrated the official warnings for 70 countries and territories into the widely used and freely available AccuWeather digital properties, available in over 200 languages and dialects globally. These warnings, importantly, always clearly delineate that they are from the NMHS, with the agency logo and other clear attribution, strengthening the NMHS branding. Additionally, Directors should also hold frequent collaborations with weather industry to arrive at the definition of core data in your country and recognizing that will need to evolve over time, encourage discussion formally and informally with the private sector, civil protection, broadcast meteorologists and other partners. Many benefits will accrue from these new understandings and learnings, including improved trust. This will be increasingly important as rapid technology change continues to drive changes in how the sectors collaborate and work together most effectively to generate the best products and services for citizens, business and society. We talked about the importance of open data earlier. Making data available as much as possible is critical. Putting foundational data in the hands of innovators on an equal opportunity basis drives many positive impacts, much wider use of the data and therefore recognition of the government NMHS in ways you might not even be able to imagine today. Talking about and encouraging the success stories as we've done today is really critical, too, because that will inspire additional positive collaboration. Finally, I think it's really important to think about how the private sector can be more helpful in advocating for increased government investment in core public infrastructure and capacity development. The private sector wants to be more helpful in this area. For example, here at AccuWeather, we share metrics about our reach with partners, so they can see how much of a wider audience their weather warnings are being displayed on our platforms and how many more people the NMHS is reaching through AccuWeather's digital platforms. We've had so many of our users comment to us when a country's warnings are integrated into the AccuWeather digital platform, "I didn't even know my country produced these helpful warnings." In conclusion, I'm very excited about the opportunity to strengthen existing partnerships and build new productive partnerships between the NMHS and the private sector globally. I'm very proud of all the important work that we, as a global weather enterprise, have done together in the past and what we can do together tomorrow with an increased focus on collaboration. This is work that is ever more important as the world is relying on our forecasts, warnings and insights as we face increasing impacts from extreme weather globally. Reflecting over recent years, significant progress has been made. We can do so much more together, and people around the world will benefit from our strong collaboration. Our work matters.

Ms Courtney DRAGGON, Director, International Affairs Office, National Weather Service of the United States



Q: The Unified Data Policy is a landmark initiative of global cooperation under the WMO framework. We all know that the National Weather Service has always provided free access to data and products supporting public and commercial interests and also academic research. From the US perspective, what's your advice on how we can increase the governmental recognition of those benefits that come with free and unrestricted access to NMHS data?

A: This is a great question, and the short answer is that we don't do it; our partners do. But I appreciate that you probably would like me to walk through that logic a bit. While we, in the meteorological, hydrological and climatological community, see, and we all understand the necessity and benefits of data sharing, in the US, we depend on the support of our external partners, including the private sector, the academic sector, first responders to advocate for resources for our agency. These are the same resources that fund our observing systems that provide this data. This has been and continues to be an ongoing conversation annually within the United States, so I'll walk through some of the arguments that have been successful for us. To start, the insight and foresight about the state of our planet is factored into everything we do, into our individual decisions and our collective decisions from what we wear each day to things like national security. Societies rely on our predictions and services to get this information. And our observing systems are the vital foundation for what we do. The weather forecasting system must have an assured and uninterrupted flow of quality data from these systems, and ensuring this is an inherently governmental function. To fulfil our mission, we need international collaboration. An accurate forecast three days or more in advance can be made only when the entire globe is observed both from in situ and remote-sensing satellites. No single entity, no government, no university, no one company can do this alone. Therefore, a global system of systems has emerged, which maximizes data sharing. We continually maintain to our lawmakers that weather forecasting is also an inherently global enterprise for two reasons. First, our forecasting models require observations from the entire globe, but it benefits our national citizens and society. Weather patterns over Asia affect the west coast of the United States, Europe watches what happens in the United States because it's coming their way, Asia continues to watch, and then the circle closes with the US watching what comes from Asia. Similarly, weather off the coast of Africa could spawn hurricanes in the Atlantic Basin. So, all of these data are vital to the United States, to our global security, to the protection of life and property, and to our commercial interests, just as those data are vital to national met services around the world. So, this is why we share US data freely and openly – so that we can receive data freely and openly from our international partners. The benefit of full, free and open data for the United States is that by volume, we receive about three times as much data as we put into the system. So, basically, that's why we have an open data policy. So, the second and further down the value chain is that NOAA's environmental data and model output has been found to fuel a very vibrant and growing private sector enterprise in the United States. Just like with observing the globe, with service delivery, we simply can't do it alone. Societies' demands on our services are greater than our one National Weather Service in the United States can provide. According to the University Corporation for Atmospheric Research, the private sector in the US is estimated to generate billions of dollars of annual revenue, employ thousands of people, and provide a rich array of products and tailored services. A portion of this revenue, in the form of taxes in the United States, is in turn then used to fund the public-sector budgets, including for NOAA, the same budgets that provide the observing systems that then provide the data that we share. The health of this industry is underwritten by that

convention of full, free and open data. This industry does not threaten the mandate or the role of the US Weather Service. It relies on us for its foundational data and information to further secure our mission and funding to the US. Thus, they in turn find that it is beneficial to advocate for the National Weather Service and the resources we get in turn. We recognize that this may not be the same for all countries. There is a wide range of national legislative frameworks, approaches to private sector cooperation, and observing capabilities. But I hope some of these rationales were helpful in answering the questions and to giving you insight into why we advocate for open data but also the arguments that have been useful within our government for both that open data and increasing partnership across the enterprise.

Questions and comments from the floor

Question: There should be two separate and clear functions of NMHSs: one, to develop national legislation or to influence the development of national legislation about the hydrometeorological market, and second, to be the leader in the market, providing hydromet services for government and public awareness and responses. Is it a challenge for WMO to support national met services to achieve both of those roles?

Prof. Gerhard ADRIAN: My observation from the discussion this evening is that the discussion is somehow biased in one direction: how the private sector could support National Meteorological and Hydrological Services. We should also think about the other direction – I think that’s what is missing in this discussion. For instance, in the EUMETSAT framework, we were discussing radio-occultation data purchased by a private company. But without the development of this observing system, of this concept, without providing data assimilation systems in the NWP, this would not make any sense for the private sector to offer such things. So, we have also the other way around. This is an example where the public sector or public-funded organizations developed new technology which could be taken later by the private sector to be offered on a broad perspective. We should also keep this also in mind. Of course, one necessary condition – that’s my own personal experience or observation in my home country is, of course, for this, the private sector needs the security for investments. That means we need a clear interface between the public sector and the private sector. That’s not only an issue for the meteorological services. It is a general understanding of the government, of their role in the society, in the economy, or, let’s say, also, the understanding of the government about what is expected from the National Meteorological Services. I could tell you with the free and open data policy, together with the clear act defining our task, we are now certainly an interesting partner for the private sector to develop new services where we as National Meteorological Services will never be active.

Key conclusions



Mr Tatsuya KIMURA, Director, Public-Private Engagement Office, WMO Secretariat

- **NMHSs, the academic sector and the private sector continue to benefit mutually** from their individual strengths **through partnerships**, jointly enhancing the overall societal benefits offered.
- Even the largest NMHSs are seeking to **partner widely at every step of the value chain**.
- **Opportunities for innovative public-private partnerships around the use of technology are expanding** in different parts of the value chain, for example:
 - Around ownership/operation of core high-performing computing infrastructure (HPC), software;
 - To improve research for weather/climate/environment challenges;
 - To improve applicability and usefulness of data for users downstream;
 - To improve access to digital skills for NMHSs;
 - Automated observations, to free personnel resources for more value-added tasks in the core mission of the NMHS.
- **Rapidly changing environment has underlined the need for policies and legislation**, including national regulation.
- Such frameworks provide a **clear legal basis and consistent rules** for meteorological services, and **supports the sound development** of meteorological services across industry, academia, and government.
- Need to **institutionalize sustained funding** for operations. Private sector, other partners can help advocate.
- **Legal and policy frameworks** also ensure that **NMHSs will be regarded as vital components of national resilience** and **as the authoritative source** of relevant data and information.
- NMHSs must continually evolve; emphasize how they serve socioeconomic needs; develop **digital strategies and research avenues**.
- **The NMHS Director role is now even more outward looking**, to help **facilitate win-win partnerships** with other government agencies and the private sector, so that the impact and value of the NMHS can be better understood and realized.
- With the new **WMO Unified Data Policy**, **NMHS directors** have the opportunity to **redefine** the importance of **the NMHS** as the **hub for reliable, rapid and unrestricted foundational data distribution**.
- Successful arguments for partnerships and free and unrestricted data exchange: Our ability to monitor and forecast weather/environment for our nation, and **which generates billions of dollars of annual revenue, is completely based on our ability to access international data** when we need it, in a format that we can use, and with the necessary assurances that we can trust it. Must share to receive.

Closing remarks



Dr Elena MANAENKOVA, WMO Deputy Secretary-General

What I have heard is very powerful conclusion. I keep WMO Convention just in front of my eyes. Convention says on the very first page, "vital importance of the mission of the National Meteorological, Hydrometeorological and Hydrological Services in observing and understanding weather and climate and in providing meteorological, hydrological and related services in support of relevant national needs which should include: protection of life and property, safeguarding the environment and contributing to sustainable development". These are all written in the Convention, which is hard to change. So, we have to stick to this, I believe. The question is then how. I'm a long time at WMO, and in the past, WMO has a practice to issue annual statements or biennial statements on the role of NMHSs. It took some time and effort to develop a statement of the current roles at that time. Now we are talking about the future role in a constantly changing environment and constantly increasing playgrounds with the different players. What I felt most essential in this conversation is that we are talking with diverse stakeholders. We have really proper conversations, talking with anyone and everyone who is part of this enterprise, who is part of this ecosystem. Of course, I cannot but repeat the importance of the official authoritative voice on early warnings and the free access to public data and lots of partnerships with anyone around who is part of the enterprise. I believe that a century and half of the existence of national met services has proven that they have something unique. And this uniqueness needs to be preserved and strengthened.

ANNEX. LIST OF SPEAKERS AND PANELLISTS

Opening remarks	WMO Secretary-General <i>Prof. Petteri TAALAS</i>
Keynote presentation	WMO President and Lead Author of OCP White Paper #2 <i>Prof. Gerhard ADRIAN</i>
Moderator	Broadcast Meteorologist <i>Mr Gerald FLEMING</i>
Thematic Panel 1: Operating models and environment	Permanent Representative of the UK with WMO; Chief Executive, Met Office, UK <i>Prof. Penny ENDERSBY</i> Europe Lead for Environmental Sustainability Science, Microsoft <i>Prof. Alberto ARRIBAS HERRANZ</i> President and CEO, Vaisala <i>Mr Kai ÖISTÄMÖ</i> Deputy Administrator, China Meteorological Administration <i>Mr YU Yong</i>

**Thematic Panel 2:
Legislative/institutional
framework**

**Permanent Representative of Japan with
WMO; Director-General, Japan Meteorological
Agency (JMA)**

Mr Naoyuki HASEGAWA

**Chair, Association of Hydro-Meteorological
Industry (HMEI)**

Mr Jim ANDERSON

**Third Vice-President of WMO and
Permanent Representative of the United
Republic of Tanzania with WMO;
Director-General, Tanzania Meteorological
Authority (TMA)**

Dr Agnes L. KIJAZI

**Head of House and Senior Meteorologist,
DTN Switzerland**

Mr Joachim SCHUG

**Thematic Panel 3:
Human resources,
Permanent
Representative's role, and
global and regional
cooperation**

**Director, Met Office Hadley Centre for Climate
Science and Services**

Dr Albert KLEIN TANK

**Permanent Representative of Australia with
WMO; CEO and Director of Meteorology,
Bureau of Meteorology**

Dr Andrew JOHNSON

**Senior Vice-President and Chief Meteorologist,
AccuWeather**

Mr Jonathan PORTER

**Director, International Affairs Office,
National Weather Service, National Oceanic
and Atmospheric Administration (NOAA), USA**

Ms Courtney DRAGGON

Key conclusions

Director, PPE Office, WMO Secretariat

Mr Tatsuya KIMURA

Closing remarks

WMO Deputy Secretary-General

Dr Elena MANAENKOVA



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For more information, please contact:

World Meteorological Organization

7 bis, avenue de la Paix
P.O. Box 2300
CH 1211 Geneva 2
Switzerland

Public-Private Engagement Office

Phone: +41 22 730 80 57
Email: ppe@wmo.int
public.wmo.int/ppe