WEATHER CLIMATE WATER

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AGENDA ITEM 4: **POLICY AND PRACTICE FOR EARTH SYSTEM DATA EXCHANGE**

AGENDA ITEM 4.1: **WMO Unified Policy for the International Exchange of Earth System Data**

WORLD METEOROLOGICAL ORGANIZATION (WMO) UNIFIED POLICY FOR THE INTERNATIONAL EXCHANGE OF EARTH SYSTEM DATA

DRAFT RESOLUTION

Draft Resolution 4.1/1 (Cg-Ext(2021))

WMO Unified Policy for the International Exchange of Earth System Data

THE WORLD METEOROLOGICAL CONGRESS,

Recalling:

(1) Article 2 of the WMO Convention, which commits Members to facilitate worldwide cooperation in the establishment of observing networks and to promote the exchange of meteorological, hydrological and other geophysical observations,

(2) Resolution 40 (Cg-XII) — WMO Policy and Practice for the Exchange of Meteorological and Related Data and Products, including guidelines on relationships in commercial meteorological activities, which inter alia reminds Members of the need to ensure stable ongoing commitment of resources in order to meet their obligations under Article 2, in the common interest of all nations,

(3) Resolution 25 (Cg-XIII) — Exchange of Hydrological Data and Products,

(4) Resolution 60 (Cg-17) — WMO policy for the International Exchange of Climate Data and Products to Support the Implementation of the Global Framework for Climate Services,

(5) Resolution 80 (Cg-18) — Geneva Declaration-2019: Building Community for Weather, Climate and Water Actions, which presents the WMO high-level policy for partnership and engagement among the stakeholders from public, private, academic and civil sectors,

(6) The long-term goals and strategic objectives of the Organization as laid out in the *WMO Strategic Plan 2020–2023* (WMO-No. 1225) and Vision 2030, which require more data from an ever-broadening range of disciplines and sources to be exchanged,

Recalling further:

(1) Resolution 55 (Cg-18) — Emerging Data Issues, in which the Executive Council was required to consider the recommendations of the Commission for Basic Systems-led

Review of Emerging Data Issues, and continue the evaluation of the emerging data issues and their implications on Members and the weather enterprise as a whole,

(2) Resolution 56 (Cg-18) — Data Policies and Practices, in which the Executive Council was required to establish a process for the review of the WMO data policies and practices expressed in Resolution 40 (Cg-XII) — WMO Policy and Practice for the Exchange of Meteorological and Related Data and Products Including Guidelines on Relationships in Commercial Meteorological Activities, Resolution 25 (Cg-XIII) — Exchange of Hydrological Data and Products, and Resolution 60 (Cg-17) — WMO Policy for the International Exchange of Climate Data and Products to Support the Implementation of the Global Framework for Climate Services,

(3) Decision 39 (EC-70) — Outcomes of the Fourteenth Session of the WMO Consultative Meeting on High-level Policy on Satellite Matters, in which the Executive Council, by recognizing that space-based observations are now playing and will continue to play a critical role in the ability of all Members to deliver vital services to help save lives, protect property and foster economic growth, thereby required that these observations be addressed under policies for international data exchange,

(4) Resolution 34 (Cg-18) — Global Basic Observing Network, which initiated the design of a Global Basic Observing Network to better meet the current and future observational requirements for global Numerical Weather Prediction and climate reanalysis,

Commending those Members and international organizations that have supported the implementation of these data policies by providing access to — and by broadening the volume of — essential data (as defined in Resolution 40 (Cg-XII) — WMO Policy and Practice for the Exchange of Meteorological and Related Data and Products Including Guidelines on Relationships in Commercial Meteorological Activities), available on a free and unrestricted basis, and by providing additional data under fair and transparent conditions,

Recognizing:

(1) The key role of access to timely and reliable weather, climate, water and related environmental data[1] as a basis for informed decision-making at all levels to underpin essential public services that help save lives, protect property and foster economic prosperity,

(2) That the overall economic benefits of the weather, climate, water and related environmental services have grown by orders of magnitude over the last 25 years, enabled by WMO's data policies,

(3) That the growing impact of and reliance on these services continues to increase our dependence on weather, climate, water and related environmental data,

(4) The critical role played by the output of global numerical prediction systems in underpinning all weather, climate, water and related environmental products and services, and thus the importance of broadening and enhancing the free and unrestricted access to such output for all Members,

[1] Environmental data here refers to data (observed and modelled variables) beyond those directly pertaining to weather, climate or hydrology, in particular atmospheric composition, properties of the marine environment, the land surface and the exosphere.

(5) That these global prediction systems in turn depend on a continuous, robust and reliable supply of observational input from all areas of the globe provided by both surface- and space-based[2] observing systems,

(6) The need to take an integrated Earth-systems approach to monitoring and prediction, and the critical dependence it places on data spanning all relevant components of the Earth system and the interactions between them,[3]

(7) The experience and lessons gained by WMO in the development and implementation of Resolutions 40 (Cg-XII) and 25 (Cg-XIII) and 60 (Cg-17),

Noting:

(1) The UN Secretary-General Data Strategy for Action by Everyone, Everywhere, which aims at delivering better data-driven support to people and the planet,

(2) The contribution of weather, climate, water and related environmental data and services to the implementation of the United Nations Sustainable Development Goals (SDGs),

(3) The Paris Agreement under the United Nations Framework Convention on Climate Change, which aims to strengthen the global response to the threat of climate change,

(4) The Sendai Declaration and Framework for Disaster Risk Reduction 2015–2030, with its four priority areas: Understanding disaster risk (DR); Strengthening DR governance to manage disaster risk; Investing in disaster risk reduction for resilience; Increasing disaster preparedness for effective response,

(5) The endorsement by Congress through Resolution 80 (Cg-18) — Geneva Declaration-2019 (Cg-18): Building Community for Weather, Climate and Water Actions, of an inclusive and collaborative approach among the public, private, academic and civil sectors to promote, inter alia, innovative approaches and incentives to enable fair and equitable access to data,

(6) The increased significance of data and digital technologies in informing socioeconomic policy development and decision-making,

(7) Prevailing data policy trends under which many governments and international organizations have already decided to provide access to all publicly funded data on a full, open and free basis, having seen that open provision of data tends to maximize their net contribution to the overall economy,

(8) The need for WMO to help advance the ability of all Members to benefit from this free and unrestricted *[Japan]* data access, emerging technology, and the global trend towards a digital economy with the aim of enhancing shared *[Canada]* benefits between Members and stakeholders,

(9) The activities undertaken by the Coordination Group for Meteorological Satellites (CGMS) and the Committee on Earth Observation Satellites (CEOS) to ensure a robust and continued supply of critical satellite data for the benefit of all WMO Members,

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[2] The term surface-based observing systems is taken to encompass all systems not deployed in space.

[3] Earth system data here encompass data pertaining to weather, climate, hydrology, atmospheric composition, oceans, cryosphere, and space weather. For further details on these domains and disciplines, see Annex 1. For a precise definition of Earth system data, see Annex 4.

Acknowledging:

(1) The WMO long-term goal of closing the capacity gap on weather, climate, hydrological and related environmental services among Members, including their ability to acquire and benefit from the model data and derived products which are essential for the critical mission of saving life and protecting property,

(2) The need for all Members to contribute to maximizing the benefits of global modelling products by participating more fully in the exchange of observational data on which these products are based,

(3) The importance of efficient investment in systems used for acquiring and exchanging weather, climate, water and related environmental data, and of maximizing the contribution of these data to supporting economic development, climate resilience and environmental sustainability,

(4) The significant expansion that has taken place since the adoption of Resolution 40 (Cg-XII) — WMO Policy and Practice for the Exchange of Meteorological and Related Data and Products Including Guidelines on Relationships in Commercial Meteorological Activities, in the number and diversity of providers of observations and other data products including, in particular, a growing role played by private sector entities,

(5) The critical role of research in fostering continuous improvement and innovation of observing systems, products and services, and the importance of ensuring free and unrestricted exchange of data between the research and the operational communities,

(6) The crucial function of the Permanent Representatives to WMO and the role of Hydrological Advisers in helping to maximize the societal impact of Earth system monitoring and prediction efforts, both through coordinating with all stakeholders from the public, private and academic sectors in their States and Territories, and through promoting relevant WMO activities, policies and standards[4],

(7) The continued disparity in available technical and institutional capacities and in financial and human resources that the individual Members have at their disposal for their implementation of WMO Data Policy,

(8) The need for consistency of WMO Data Policy, and of national implementations thereof, with other policies based on international law, including, in particular, the rules governing marine scientific research in the United Nations Convention on the Law of the Sea (UNCLOS),

(9) The right of governments, having done their utmost to implement the decisions of Congress, to, based on their national laws and policies, choose the manner by, and the extent to which, they make data available domestically or for international exchange, while still understanding that without reciprocity, international data exchange cannot be sustained,

Having examined Recommendation 3 (EC-73),

Agrees to have one unified data policy for all WMO domains and disciplines;

Decides that the scope of the data policy shall cover Earth system data exchanged among Members under the auspices of the WMO Convention and decisions of Congress, as described in Annex 1 and Annex 4 of this resolution and specified in detail in the WMO Technical Regulations;

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[4] For guidance to Members regarding coordination of the implementation of this resolution, see Annex 2. Guidelines for public-private sector engagement on Earth system data are provided in Annex 3.

Adopts the following policy on the international exchange of Earth system data:

> *As a fundamental principle of WMO and in consonance with the expanding requirements for its scientific and technical expertise, WMO commits itself to broadening and enhancing the free and unrestricted*[5] *international exchange of Earth system data*;

Agrees further to maintain a two-tiered approach to the international provision and exchange of Earth system data via the following practice[6]:

(1) Members shall provide on a free and unrestricted basis the ***core*** data that are necessary for the provision of services in support of the protection of life and property and for the well-being of all nations, at a minimum those data described in Annex 1 to this resolution which are required to monitor and predict seamlessly and accurately weather, climate, water and related environmental conditions;

(2) Members should also provide the ***recommended*** data that are required to support Earth system monitoring and prediction activities at the global, regional and national levels and to further assist other Members with the provision of weather, climate, water and related environmental services in their States and Territories. Conditions may be placed on the use of recommended data;[7]

Agrees also that Members should provide without charge access to all recommended data exchanged under the auspices of WMO to public research and education communities, for their non-commercial activities;

Encourages all users of Earth system data to honour reasonable requests for attribution of input data wherever possible;

Urges Members to:

(1) Undertake necessary actions to promote alignment of national policies and regulations concerning Earth system data sharing and exchange, nationally and internationally, with the policy promulgated through this resolution;

(2) Provide full transparency on conditions of use and re-use when such conditions apply to exchanges of recommended data;

(3) Accommodate the need for users of recommended data to respect the conditions of use set by the owners of the data, as this will help to facilitate access to the data;

(4) Facilitate the exchange of data from all stakeholders and sectors at the international level when emergencies and natural disasters occur;

(5) Build partnerships to enhance the exchange of Earth system data amongst national and regional stakeholders in order to improve integration of data across disciplines and domains, thereby helping to strengthen them all;

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[5] "Free and unrestricted" defined in Annex 4.

[6] The basis for the practice is that Earth system data required to fulfil Members' commitments under the WMO Convention and WMO strategic objectives are encompassed by the combination of core and recommended data exchanged by Members and relevant international organizations.

[7] "Conditions" may be applied by licensing agreements or other appropriate arrangements.

Requests the Executive Council to:

(1) Oversee implementation of this resolution via appropriate mechanisms for continual monitoring of compliance;

(2) Keep the definitions of core and recommended data provided in Annex 1 under regular review and propose updates as necessary;

Requests the presidents of regional associations to support and monitor the implementation of this resolution within their regions;

Requests the president of the Commission for Observation, Infrastructure and Information Systems, in coordination with the president of the Commission for Weather, Climate, Water and Environmental Services and Applications and the Chair of the Research Board to:

(1) Provide draft technical regulations to support implementation of this resolution, to be submitted to the World Meteorological Congress in 2023;

(2) In light of the commitment to free and unrestricted data exchange and the requirements of Members for access to high quality numerical weather prediction and analysis products, initiate a process of amending the *Manual on the Global Data-Processing and Forecasting System* (WMO-No. 485) to be submitted to the World Meteorological Congress in 2023 *[Indonesia, Senegal, UK, Secretariat]*;

(3) Develop a process for systematic and regular review of the types or domains of data that fall within the established practice and categories of Earth system data, as described in Annex 1, in order to meet both the changing needs of Members, the changing availability of data, and the continued development of modelling capabilities;

(4) Ensure that the regional associations are kept informed of initiatives related to the implementation of this resolution and consulted on developments as necessary;

(5) To take any necessary steps to ensure that WMO technical systems and guidelines will develop and evolve to accommodate the exchange and interoperability of Earth system data envisaged in this policy;

Requests the president of the Commission for Weather, Climate, Water and Environmental Services and Applications, in coordination with the president of the Commission for Observation, Infrastructure and Information Systems, the Chair of the Research Board, and other relevant bodies, to:

(1) Initiate a process to review the emerging data requirements for risk- and impact-based warning and decision support systems;

(2) Seek the engagement of concerned partners, i.e. international organizations/agencies that are reliant on the provision of weather, climate, water and related environmental services by Members on the further application and implementation of WMO's unified data policy;

Requests the Secretary-General to:

(1) Establish, adopt and publicize mechanisms to maximize the impact of this resolution and to ensure that it is effectively *[Peru]* implemented within all Members, including any resource mobilization activities needed, recognizing the need of some WMO Members for support for their implementation efforts, for example through collaboration with relevant United Nations agencies and other international development partner organizations *[P/SERCOM]*;

(2) Enact a system to monitor and report on implementation of this resolution by Members, and set indicators for the specific and substantive evaluation of the performance;

(3) Strengthen effective coordination with relevant WMO partners and stakeholders on matters related to data policy and practice and encourage them to adopt similar policies and practices concerning the free and unrestricted exchange of their relevant data in support of WMO programmes;

(4) Promote further collaboration with Numerical Weather Prediction (NWP) Production Centres and other stakeholders to ensure full, free and unrestricted access to Earth system monitoring and prediction data for all Members to support them in the provision of their public weather, climate, water and related environmental services;

(5) Develop guidance for Members on the implementation of this policy as concerns the relationship between public sector data providers and private sector users of data, keeping in mind the need to preserve the integrity of the publicly-funded international exchange of data as the foundation for all weather, climate, water and related environmental services.

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Annex 1: Discipline and Domain-Specific Practice for Core and Recommended Data

Annex 2: Guidelines to Members on Application of WMO Data Policy

Annex 3: Guidelines on the Application of Data Policy in Public-Private Engagement

Annex 4: Terms and Definitions

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Note: This resolution replaces: Resolution 40 (Cg-XII), Resolution 25 (Cg-XIII), Resolution 60 (Cg-17), and Resolution 56 (Cg-18), which are no longer in force.

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Annex 1 to draft Resolution 4.1/1 (Cg-Ext(2021))

Discipline and domain-specific practice for core and recommended data

Purpose

This annex lists the minimum set of **core data** that Members shall exchange on a free and unrestricted basis to underpin the services they provide for the protection of life and property and for the well-being of all nations.

In addition, it identifies certain **recommended** data that should also be exchanged by Members to support Earth system monitoring and prediction efforts.

Evolving data issues: Earth system data is a rapidly expanding and evolving area, in terms of sources, distribution, variables covered and technology. WMO provides relevant and topical guidance in the *Guidelines on Emerging Data Issues* (WMO-No. 1239). These guidelines will be reviewed and updated periodically, and over time the review may lead to additional datatypes being included in this policy as either core or recommended data.

The scope of this annex is data (as defined in Annex 4) characterizing the past, present and future state of the Earth system, and it encompasses data exchanged in real time or near-real time as well as from historical or archived sources.

The remainder of this annex lists core and recommended data for the following Earth system disciplines/domains:

1. Weather
2. Climate
3. Hydrology
4. Atmospheric Composition
5. Cryosphere
6. Oceans
7. Space Weather

Each discipline/domain has its own categories and set of practices for core data, with subcategories as appropriate, e.g. observations and derived products. These are summarized below and categorized for ease of reference. Importantly, a successful implementation of the Earth system monitoring and prediction approach will depend on all categories as they are intimately linked.

1. Weather-related data

This section lists observational and other data necessary to support weather monitoring and prediction efforts of the WMO Members. Such data are generally exchanged in real or near-real time, depending on the specific application.

1.1 Core observational data:

1.1.1 Surface-based:

Observations provided by the Global Basic Observing Network (GBON) and other observational data, as specified in the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160).

1.1.2 Space-based:

(a) Satellite data required in order to ensure the performance and quality of NWP output, as agreed with Members operating satellites or relevant satellite operators, and listed in the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160);

(b) Satellite data required to support nowcasting applications including the generation of warning and advisory products, as agreed with Members operating satellites or relevant satellite operators, and listed in the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160).

1.2 Other core data:

(a) Global analysis and prediction fields provided by global NWP systems of designated producing centres of the Global Data Processing and Forecasting System (GDPFS), as specified in the *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485)*;*

(b) Limited area analysis and prediction fields provided by NWP systems of designated producing centres of the GDPFS, as specified in the *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485);

(c) All watches, advisories and guidance products for public safety (protection of life and property) issued by WMO mandated centres according to WMO Technical Regulations.

1.3 Recommended data:

(a) All available observations provided by the Regional Basic Observing Network (RBON), which is further specified in the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160);

(b) All other watches, advisories, warnings and alerts for public safety (protection of life and property) issued by Members' designated warning and alerting authorities, unless already shared under specific license or terms and conditions.

2. Climate

Note that some core climate data are covered under the weather, cryosphere, hydrology, atmospheric composition and ocean sections. Core data includes current and historic time series data needed to understand climate change, assess the associated impacts and risks for lives, livelihoods, and property and support climate services. Data shall be made available in a timely manner, with a tentative maximum delay of one year.

2.1 Core observational data:

(a) Measurements provided by the GCOS Upper-Air Network (GUAN) and GCOS Surface Network (GSN) stations (see also 1.1.1 (a));

(b) Climate data as defined in the *Manual on High-quality Global Data Management Framework for Climate* (WMO-No. 1238);

(c) Essential Climate Variables (ECVs) as defined by the Global Climate Observing System (GCOS) in *the Manual on the WMO Integrated Global Observing System* (WMO-No. 1160) to the extent that the Member holds the data in a digital archive.

2.2 Other core data:

Climate reanalysis fields provided by GDPFS centres, as listed in the *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485).

2.3 Recommended data:

Members should exchange all climate data defined in the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160) and encourage all data holders to share their climate data.

3. Hydrology

This section lists data, including (near) real-time data, historical time series and aggregated data, that are fundamental to global knowledge of the hydrological cycle and essential to the application of such knowledge to support and protect life and health; ensure economic prosperity and well-being; and effectively manage resources through the undertaking of operational hydrology.

3.1 Core observational data:

(a) Observations from reference network stations, to be detailed in the *global hydrological observing network* and subsequently specified and adopted into the WMO *Technical Regulations, Volume III, Hydrology* (WMO-No. 49) and its annexes;

(b) All satellite data needed to ensure the performance and quality of hydrological forecast and outlook, as agreed with Members operating satellites or relevant satellite operators and specified in the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160).

3.2 Other core data:

Data from global and regional (large-basin or economic regions) hydrological models and water-related climate reanalysis fields made accessible to users through GDPFS centres, as specified in the *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485).

3.3 Recommended data:

(a) All observations from hydrological observing stations required for users to fulfil the routine functions of National Hydrological Services identified in the WMO *Technical Regulations, Volume III, Hydrology* (WMO-No. 49);

(b) Other data necessary for the understanding of the hydrological cycle and the forecasting of streamflow or future water volumes in catchments at different scales with a focus on the determination of the water balance of catchments, groundwater dynamic, lakes, reservoirs or glaciers;

(c) All advisories and warnings issued according to WMO Technical Regulations.

4. Atmospheric composition

This section refers to the observing component of the Global Atmosphere Watch Programme and other information on the chemical composition and related physical characteristics of the atmosphere that are produced in all parts of the globe. These data support multiple applications and are needed in order to reduce environmental risks to society, meet the requirements of environmental conventions, strengthen capabilities to predict climate, weather and air quality, and contribute to scientific assessments in support of environmental policy. [8]

4.1 Core observational data:

(a) All observational data of atmospheric composition variables as defined in the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160), in particular in section 1.2.2. that refers to six focal areas: ozone, greenhouse gases, reactive gases, aerosols, ultraviolet (UV) radiation and total atmospheric deposition;

(b) All watches, warnings, advisories and alerts for public safety (protection of life and property) issued by Members' designated warning and alerting authorities according to WMO Technical Regulations.

4.2 Recommended data:

(a) All data listed under section 4.1 above for which the data originator is bound to policies that require data licences;

(b) Ancillary observational and modelling data of radionuclides and solar radiation as they serve as tracers for atmospheric transport and/or ocean-land-bio atmosphere exchange or influence chemical reactions in the atmosphere.

5. Cryosphere

This section references those cryosphere monitoring data on snow, freshwater and sea ice, glaciers and ice caps, permafrost and seasonally frozen ground, ice sheets, ice shelves and icebergs that are necessary for specified applications.

5.1 Core observational data:

All relevant observations (in situ, and surface, airborne and satellite-based remote sensing) of the cryosphere or processes affecting the cryosphere which are specified in:

[8] Including obligations specified in the *Paris Agreement to the United Framework Convention on Climate Change* (2015) and *The Vienna Convention for the Protection of the Ozone Layer* (1985).

(a) The *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160);

(b) The *Manual on Marine Meteorological Services* (WMO-No. 558);

(c) The *Technical Regulations, Volume III, Hydrology* (WMO-No. 49);

(d) The *Manual on the High-quality Global Data Management Framework for Climate* (WMO-No. 1238).

5.2 Other core data:

(a) All relevant cryospheric analysis, prediction, and climate reanalysis fields provided by global NWP systems and other Global or Regional Processing Centres operating under the auspices of the GDPFS, as defined in the *Manual on the Global Data-processing and* Forecasting *System* (WMO-No. 485);

(b) All watches, warnings, advisories and alerts for public safety (protection of life and property) issued by Members' designated warning and alerting authorities according to WMO Technical Regulations.

5.3 Recommended data:

Other relevant cryosphere data not listed under 5.1 and 5.2.

6. Ocean

This section lists in situ and remotely sensed observational data both in and above the ocean and at the sea surface, from the open ocean to the coast, along with other data that provide necessary input to ocean monitoring and prediction and for a variety of other Earth system applications.

6.1. Core observational data:

(a) Marine meteorological and oceanographic observations, as defined in the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160);

(b) All other physical Global Ocean Observing System (GOOS)[9] Essential Ocean Variables (EOVs) and physical ocean domain GCOS ECVs, some of which are included in section 2, Climate, above made as part of a GOOS observational network, programme or project, consistent with the Intergovernmental Oceanographic Commission (*IOC) Oceanographic Data Exchange Policy* (IOC Resolution XXII-6)

6.2 Other core data:

(a) Ocean analysis and prediction fields provided by global NWP systems operating under the auspices of the GDPFS, as defined in the *Manual on the Global Data-processing and* Forecasting *System* (WMO-No. 485);

(b) All ocean reanalysis fields provided by the Global Processing Centres of the GDPFS;

[9] GOOS is co-sponsored by the Intergovernmental Oceanographic Commission of UNESCO, the World Meteorological Organization, the United Nations Environment Programme and the International Science Council. It is aligned with a Framework for Ocean Observing oriented to an Essential Ocean Variable approach as per *Strengthening and Streamlining GOOS* (IOC Resolution XXVI-8).

(c) All watches, warnings, advisories and alerts for public safety (protection of life and property) issued by Members' designated warning and alerting authorities according to WMO Technical Regulations.

6.3 Recommended data:

(a) Physical GCOS ECV and GOOS EOV observations that have been collected outside of designated GOOS activities;

(b) All other observed biogeochemical and biological/ecosystems GCOS ECVs and GOOS EOVs;

(c) Observations of pH, chlorophyll-A, suspended particles and downwelling irradiance which are fundamental to address significant scientific and societal ocean/climate-related issues.

7. Space weather

This section references space weather data necessary (core) for provision of the essential operational space weather services. It should be noted that space weather is currently going through the process of being fully integrated into the WMO Integrated Global Observing System (WIGOS) and being specified in the related WMO documents in more detail. Currently global and regional space weather services, requiring near-real time exchange of space weather surface-based and space-based observations, are operated on bilateral and multilateral data exchange agreements between centres. However, as the operational space weather services promptly evolve and are further established, the need for globally coordinated exchange of space weather data will increase significantly in the years to come. Three broad categories of data that need to be considered for such exchange are:

7.1 Surface-based:

All observations required by operational Space Weather Centres providing essential operational services, e.g. International Space Environment Service (ISES) Regional Warning Centres, as detailed in GBON, which will be further specified in the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160), as well as data presented in the *WMO Statement of Guidance for Space Weather;*

7.2 Space-based:

All satellite data required for the performance and quality of essential operational space weather services as agreed with Members operating satellites or relevant satellite operators and reflected in the CGMS Baseline, subsequently adopted into the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160), as well as data presented in the *WMO Statement of Guidance for Space Weather*.

7.3 Other data:

(a) Analysis and prediction fields provided by national operational space weather services;

(b) Advisories and warnings for public safety (protection of life and property) provided by national operational space weather services.

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Annex 2 to draft Resolution 4.1/1 (Cg-Ext(2021))

Guidelines to Members on the application of WMO Data Policy

1. Purpose

1.1 The purpose of these guidelines is to help Members, especially through the engagement of their National Meteorological and Hydrological Services (NMHSs) with other national partners, to maximize the benefit obtained by their combined users from the free and unrestricted exchange of Earth system data, as articulated in the WMO Data Policy. While the primary remit of WMO is international collaboration on meteorological and related Earth system data, the national roles of many NMHSs are currently undergoing substantial changes, and many WMO Members have requested guidance on how their NMHSs and national partners should act with respect to their data within a larger national landscape of Earth system monitoring and prediction.

1.2 This annex draws from the *Guide to the WMO Integrated Global Observing System*, (WMO-No. 1165) Chapter 7, where many aspects of national collaboration on observational data in particular are discussed in more detail. Some of the key points are captured here for ease of reference, and where appropriate expanded to also include other types of Earth system data. (See Annex 4 for the definition of Earth system data.)

2. Current context

2.1 Historically, WMO policy documents and regulatory material have not consistently distinguished between WMO Members, which per the WMO Convention are States and Territories, and their NMHSs. In the early years of WMO's existence, such a distinction would have been unnecessary, since in most countries the NMHS would be not only the sole national provider of both meteorological data and services, but therefore also the primary national user of meteorological data.

2.2 Today, the issue of the national role and responsibilities of the NMHS has become much more complex within many WMO Members. A typical NMHS is now not only responsible for observing and predicting the weather, but also for a growing number of other, closely related services and application areas. At the same time, the NMHS is also often no longer alone within its national territory in undertaking weather observation and prediction activities, and the same may be true for many of its other activity areas.

2.3 It is in the interest of NMHSs to partner with these other operators, which may include different Government agencies operating under various ministries, private companies, non-profit organizations, academia, or even private citizens, in order to be able to base their services on the most comprehensive observational data set possible. This requires technical issues related to data quality, data formats, communication lines and data repositories to be resolved and agreements regarding data policy to be concluded. It is also clearly in the interest of potential collaboration partners to gain free and unrestricted access to Earth system monitoring and prediction data generated by the NMHSs, and in the interest of the Member to minimize duplication and maximize efficiency in the operation of national infrastructure.

2.4 The potential of using national data partnerships as leverage to improve efficiency and effectiveness is well-recognized in the context of WIGOS. For example, the *Vision for the WMO Integrated Global Observing System in 2040* (WMO-No. 1243) strongly promotes the integration of Members' observations, whether they come from the NMHS or partner institutions.

3. Guiding principles and recommendations for national collaboration on Earth system data

3.1 The drive for increased national collaboration on Earth system data is similar in nature to the drive for international exchange of data, and it can be articulated simply as follows: *"Data sharing creates mutual benefits for all stakeholders".*

3.2 Over the last two or three decades, Earth system data have become uniformly recognized as potentially being very valuable economically. More recently, various national and international economic analyses have demonstrated that the highest economic impact of Earth system data is obtained with free and unrestricted *[Japan]* data policies, with the benefits of sharing all available Earth system data found to far outweigh the costs. These costs are represented by the loss of prospective revenue from selling the data to users willing and able to pay for them.

3.3 The sustainability of the basic infrastructure for data collection, processing and dissemination should be considered the responsibility of the Member as a whole, and not just of its NMHS; and compliance of all national entities with the data policy established via this resolution should be seen as essential for maximizing the socioeconomic benefits of Earth system data.

3.4 The recommendation to Members is therefore to adopt the following national practice regarding the exchange of Earth system data *(*see also Annex 3, regarding Public-Private Sector engagement):

(a) NMHSs should strive to act as integrators for Earth system data at the national level, both by strengthening their own observing systems according to the guidance provided by the WIGOS framework, and by building national partnerships and providing national leaderships based on their experience in the acquisition, processing, and dissemination of observational data for environmental monitoring and prediction purposes;

(b) Data practices should be aligned with the WMO Data Policy to ensure that users from all sectors — public, private and academic — are granted free and unrestricted access, without charge and with no conditions on use, at a minimum to the core data as described in Annex 1 acquired by the NMHS;

(c) The technological solutions for access to the internationally exchanged core data should be fully compliant with the free and unrestricted principle to facilitate access and minimize any charges for the data retrieval and delivery;

(d) The provision of observational data by entities outside the NMHS should be welcomed and facilitated, i.e. by opening access to WMO systems such as the WMO Information System (WIS) and WIGOS and their technical tools as broadly as possible;

(e) Members are encouraged to broaden the provision of their data with a minimum of conditions beyond the minimum set of data listed in Annex 1.

3.5 In cases where Members choose to apply conditions on the exchange of recommended data, they may wish to consider using forms of license that may be indicated in WMO guidance materials.

4. Guiding principles and recommendations for national collaboration with the research sector

4.1 Research data is collected by universities, research institutes and many others, in some cases over a limited time period. These data cover multiple domains of the Earth system (atmosphere, ocean, cryosphere, hydrology, environmental science, space science, etc.). The diversity of this data reflects the wide range of Earth science disciplines, research interests and research methods.

4.2 Open data policies are well-recognized to facilitate science and maximize the value of data, efficiency, and expanded capabilities as well as equity[10]. Most data providers from the research community are of a non-commercial nature, and they generally cannot and will not charge a fee for access to the data. However, they may request attribution of the source of the data, not only when used as a basis for scientific publications, but also if they are integrated into operational products and services.

4.3 Given the importance of research as a key enabler of successful weather prediction, and its continued contribution to all WMO application areas, collaboration on data with the research sector is particularly important for WMO, the NMHSs and other related national agencies of the Members of the organization. Regarding the use of Earth system data, there are two main aspects of this collaboration, namely (a) provision of research data for operational use, and (b) access to NMHS-acquired and other Government data for the research sector.

(a) *Provision of research data for operational use.* The WMO community has a long history of using research data as an essential part of the input used to evolve and underpin operational services. For instance, in operational weather prediction, many critical satellite data are provided by research or technology demonstration missions that were not originally designed or deployed for operational purposes. Likewise, within certain domains and for certain application areas, most notably oceanography, cryosphere services and applications related to atmospheric composition, the vast majority of the observational data are provided by research entities;

(b) *Access to NMHS and other Government data for the research sector.* It is necessary to improve data exchange between the operational WMO community and the research community. Research projects are often dependent on external environmental data and services (including weather forecasts), so there is an inherent co-dependency. Harmonizing data formats and data sharing protocols will facilitate much-needed data interoperability, interpretation, and advances in high-quality science. The breadth and scope of the scientific challenge facing the development of an integrated Earth system monitoring and prediction approach is such that even the most well-resourced NMHSs of the most affluent WMO Members cannot take on this effort alone. It is therefore in the interest of all WMO Members to enlist as broadly as possible the scientific community to help in this endeavour. Providing free and unrestricted access wherever possible to all NMHSs' data and, where possible, to the data from national partner organizations dealing with Earth system data should be considered a key incentive for such cooperation.

4.4 This policy therefore calls upon NMHSs and other relevant Government data providers to adopt the following practices in their engagement with the research sector:

[10] The FAIR Data Principles (Findable, Accessible, Interoperable, Reusable) FAIR Principles – GO FAIR (go-fair.org) are recognised as a useful framework for sharing research data in a way that will enable maximum use and re-use.

(a) Provide free and unrestricted access, without charge and with no conditions on use, to all core observational data (as described in Annex 1) acquired by or owned by them for all publicly funded research;

(b) Provide access without charge, to all recommended observational data (as described in Annex 1) acquired by or owned by them for all publicly funded research and education communities for use in their non-commercial activities;

(c) Provide, for all publicly funded research, access without charge *[Japan]* to all relevant analysis and prediction data and other products for use in their non-commercial activities*;*

(d) Honour requests for attribution of data used for operational purposes that are provided by research entities.

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Annex 3 to draft Resolution 4.1/1 (Cg-Ext(2021))

Guidelines on the application of data policy in public-private engagement

1. Purpose

1.1 The purpose of these guidelines is to promote the implementation of the policy of broadening and enhancing the free and unrestricted[11] international exchange of Earth system data through better sharing of data between the public and private sectors. The guidelines are based on the understanding that the application of the free and unrestricted principle depends greatly upon sound, fair, transparent and stable relations between these two sectors.

1.2 Most of the interactions between the public and private sector, including sharing of or access to data and information, happen at the national level. However, private companies operating at an international level interact with the NMHSs and other public entities of different countries. NMHSs and international organizations, such as the European Centre for Medium-Range Weather Forecasts (ECMWF) and EUMETSAT, also act as international data users and providers. Any public-private interaction related to data exchange and sharing must respect *the sovereign right of Members in deciding how weather, climate and water services are organized and provided, specifically the application of national and regional legislation and policies for making data and products available on a free and unrestricted principle, as well as the assignment of key national responsibilities related to public safety (Geneva Declaration-2019 (Resolution 80 (Cg-18)).*

2. General guidelines stemming from the WMO high-level policy on Public-Private Engagement

2.1 *The Geneva Declaration – 2019* (Resolution 80 (Cg-18))*: Building Community for Weather, Climate and Water Actions,* presents the WMO high-level policy on public-private engagement (PPE). It reflects the new paradigm of cooperation and partnership between stakeholders from all sectors of the weather, climate and water enterprise needed for a concerted response to global societal risks related to extreme weather, climate change, water scarcity and other environmental hazards. The Declaration covers inter alia several aspects of the data sharing and exchange between the public and private sectors. The high-level PPE policy supplements the data policy in the current Resolution with the following general guidelines to Members and stakeholders from all sectors:

(a) The expansion and broadening of the free and unrestricted international data sharing should be promoted at all levels with due consideration of national circumstances, and with intellectual property rights duly respected;

(b) All stakeholders should foster and apply fair and transparent data sharing arrangements and adhere to quality and service standards, in order to advance collectively the delivery of the public good;

(c) To establish and maintain a level playing field, all stakeholders should ensure that access to commercial data with use restrictions is treated equally by and between public and private sector entities; [12]

(d) All stakeholders should commit to comply with relevant national and international legislation and policies with respect to both data provision and avoidance of anti-competitive behaviour;

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[11] The term “free and unrestricted” is defined in Annex 4.

[12] For more information, see Zillman, John, *Origin, Impact and Aftermath of WMO Resolution 40* (WMO-No. 1244).

(e) Recognizing their mutual interdependence, all stakeholders should seek opportunities to enhance the sustainability of the global infrastructure through multisector engagements that improve efficiency and better serve society;

(f) Development of innovative data exchange mechanisms and incentives should be encouraged to increase data availability, resolve existing data gaps, promote greater data sharing, and avoid fragmentation.

3. Guiding principles for data exchange between public and private sectors

3.1 Provision and exchange of core data

The draft resolution reinstates the policy of 'free and unrestricted' international exchange of core data (see Annex 1 for the detailed description of core data). Furthermore, the new definition of 'free and unrestricted' makes it clear that these data shall be freely available, with no conditions on use. In applying this policy for the exchange of core data:

(a) Members should ensure that users from all sectors — public, private and academic — are granted free and unrestricted access, without charge and with no conditions on use, to the declared core data;

(b) As articulated in the Geneva Declaration – 2019 (Resolution 80 (Cg-18)), engagement between public and private sectors should be conducted in transparent way and should be aimed at enhancing *[Canada]* mutual benefits to both public and private sectors for the benefit of society *[Canada];*

(c) Members should ensure that, in case of core data purchased from private sector data providers, such data sets are appropriately licensed for free and unrestricted international exchange;

(d) The technological solutions for access to the internationally exchanged core data should be fully compliant with the 'free and unrestricted' principle[13];

(e) Permanent Representatives of Members, who are responsible for authorizing users of WIS (see the *Manual on the WMO Information System* (WMO-No. 1060)), should authorize access to core data with no obstructions;

(f) Recognizing that the development of Numerical Earth system Weather-to-climate Prediction (NEWP)[14] systems and the improvement of the quality of products and services depends on the availability of more Earth system data; Members are encouraged to broaden the provision of their data under the free and unrestricted principle. Moreover, the unrestricted [Secretariat] and free access to all public data adopted by many Members and international organizations, extends significantly the availability of free and unrestricted high-quality data to all other Members.

3.2 Provision and exchange of recommended data

While Members are encouraged to apply the principle of free and unrestricted international exchange to the recommended data they provide, such data sets may have conditions on their use, e.g. for commercial purposes. The originators of such conditions should follow the following general principles:

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[13] At the time of adoption of the draft resolution, the main access to core data provided by Members is through the WMO Information System (WIS); other access options may also be available (ftp servers or similar).

[14] 'NEWP' is an extension to the 'NWP' acronym reflecting the new approach to the numerical modelling and prediction, as recommended by the WMO Scientific Advisory Panel.

(a) Fair and transparent setting of the conditions on use;[15]

(b) Level playing field — same rules to apply to public and private entities using the data sets for commercial purposes;[16]

(c) Avoidance of anti-competitive behaviour (e.g. blocking access to public data with a view of creating competitive advantage for the commercial activities of the public sector entities or their spin-offs) should be regarded as a non-compliance with the high-level policy (Geneva Declaration);

(d) Members should make available a catalogue of recommended data to facilitate their use under the established conditions of use. The experience of Economic Interest Grouping of the National Meteorological Services of the European Economic Area (ECOMET) in Europe presents a good practice for such cataloguing as well as for harmonization of the conditions of use imposed by different countries in the same geographic region;

(e) In exchanging data with conditions on use, the conditions which have been posed by the originator of the data should be made known to initial and subsequent recipients.

3.3 Regional (e.g. the European Union) or national open data policies for access to public data requires public agencies, including NMHSs, to provide free and unrestricted *[Japan]* access to all their data; in addition, there may be a requirement for facilitation of the free access, with the possibility to recover the marginal costs incurred for the reproduction, provision and dissemination. Such data policy acts in favour of the private sector and stimulates business opportunities. Thus, private sector stakeholders should consider reciprocal approaches to data sharing, where economically justified, in particular for data needed for critical services related to saving lives and the protection of property. This comes with the understanding that all sectors of the enterprise commit to their social responsibility and contribute to delivery of the public good.

4. Access to private sector data

4.1 The rapid growth of the data produced by the private sector has been recognized in many WMO documents (see for example, *Geneva Declaration – 2019* (Resolution 80 (Cg-18)), *Guidance for Public-Private Engagement* (WMO-No. 1258), *WMO Strategic Plan 2020–2023* (WMO-No. 1225), *WMO Guidelines on Emerging Data Issues* (WMO- No. 1239), *Vision for the WMO Integrated Global Observing System in 2040* (WMO-No. 1243)). The main difference of these data from a policy and business model perspective is that they are produced through private investments and thus they have a specific private sector owner. The private sector needs to generate a return on investment; thus the business model is clearly ‘for-profit’; nevertheless, the general provisions of the *Geneva Declaration – 2019* (Resolution 80 (Cg-18)), which have been developed in close consultation with the private sector, encourage data sharing with stakeholders from other sectors under mutually-beneficial, fair and transparent arrangements.

4.2 The WIS and WIGOS concepts both acknowledge and enable the uptake of private sector data into the WMO systems at national and international levels, and such approach is expected to bring efficiency, innovation and support sustainability. The demand for accurate and reliable user-specific services and for a new generation of weather and climate intelligence products (e.g. for urban areas and megacities) will inevitably require more integration of private sector data into the data assimilation for the high resolution NEWP.

4.3 Members are strongly encouraged to facilitate a dialogue between the public sector and private companies active in the country, and to consider the use of private sector data to

[15] More detail available in *Guidelines for Public-Private Engagement* (WMO-No. 1258).

[16] More detail available in *Guidelines for Public-Private Engagement* (WMO-No. 1258).

fill the gaps and optimize the national integrated observing networks. In doing this, the following considerations are recommended:

(a) Applying a common approach to quality control and maintenance;

(b) Applying the same standard and recommended practices and procedures, e.g. those established by WMO or other relevant organizations, to ensure interoperability;

(c) Building collective capacity and innovation approaches;[17]

(d) Applying adequate regulatory frameworks, including licensing and certification mechanisms, enabling such collaboration with respective independent oversight.

4.4 *Exchange of data purchased by public sector from the private sector*

With the growing activities of the private sector in providing observational data, or in global NWP, in some countries global or regional data sets will be purchased by public sector entities, such as NMHSs, from private companies. The conditions for the redistribution of such data sets to other Members may vary depending on license agreements. Members are encouraged to consult with other Members on the need and added value of the purchased private data sets for their operations, in particular with those Members operating global or regional NWP. Purchasing of commercial data sets with a license for international redistribution (as core or recommended data) and possible adequate cost sharing models with other Members may be considered by Members, based on economic analysis, and bearing in mind the benefits for all parties, as well as the commitment, via the “shall” language in the draft resolution, to exchange all declared core data on a free and unrestricted basis.

5. General guidelines on the use and exchange of non-NMHS data and non-conventional data

5.1 Non-NMHS data include a growing volume of conventional third-party data, new sensor data or non-conventional data from ‘Internet of Things’ (often produced as by-products of smart systems not intended for meteorological or related purposes). NMHSs are encouraged to study in detail the national data landscape and strive to lead the integration of such data based on the WIGOS principles. Many of the new data come from the private sector and offer opportunities for innovative services. At the same time, NMHSs’ main responsibility remains in maintaining the reference data set of proven quality, compliant with the WMO requirements for quality and traceability. In most countries these are the data forming the long-term data series needed for climate change studies and assessments.

5.2 When organizing such data exchange at the national level, the national regulator (if specifically designated, otherwise by default the NMHS) needs to establish procedures for common quality control across the sectors and disciplines, to ensure compliance with international requirements set by WMO and other relevant organizations. In addition, when operationalizing such data in the provision of requisite services (e.g. those for disaster risk reduction), the continuity of data provision must be considered to avoid disruptions.

[17] For more information, see the *WMO Guidelines on Emerging Data Issues* (WMO-No. 1239).

5.3 The WMO Data Policy does not address specifically the international exchange of non-conventional data. Nevertheless, their importance for the services provided across WMO business areas are recognized to grow in the coming years. Thus, WMO has provided general *WMO Guidelines on Emerging Data Issues* (WMO-No. 1239). As an integral aspect of implementing the draft resolution, the WMO INFCOM will monitor these issues and will consider the need for further guidance or amendments to practice as needed.

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Annex 4 to draft Resolution 4.1/1 (Cg-Ext(2021))

Terms and definitions

Word or Phrase	Definition
Data	Data refers to Observations, Analyses and Predictions, and Derived Products as defined below. In the context of this resolution, the term 'data' is taken to be inclusive of such terms as data sets, information and products.
Observations	Observations refer to direct or indirect measurements made by any surface-based or space-based instrument of any physical or chemical quantity of the Earth system, as defined below. These may be direct or indirect measurements, and the term may include quantities inferred by a human observer. The term may also be taken to include statistical or derived quantities such as temporal or spatial averages, accumulated values, and temporal maximum or minimum values.
Analyses and Predictions	Analyses and Predictions refer to data sets produced by quantitative algorithms, such as numerical or statistical prediction models, applied to observations, describing the past, present and future states of the Earth system as defined below. Such data sets include, but are not limited to, global and limited area Numerical Weather Prediction and climate reanalysis fields encompassed within the scope of the GDPFS.
Derived Products	Derived Products refer to data generated from one or more of the basic data types listed above (Observations, Analyses and Predictions), typically through application of a quantitative algorithm. In the context of this resolution, the term is understood to include certain watches, warnings, advisories and alerts regarding adverse weather, hydrological or other environmental phenomena exchanged among WMO Members.
Earth system, Earth system data	Earth system refers to the various interacting components, or "spheres", of the overall geosphere and (often also to) the physical, chemical, biological and human-related processes through which these spheres interact. In the context of this resolution, the primary emphasis is on the Earth's land surface, cryosphere, hydrosphere, atmosphere and exosphere and the physical and chemical processes taking place within these spheres and those through which they interact. Earth system data is thus to be understood as data (defined above) describing past, current or future states of the Earth's land surface, cryosphere, hydrosphere, atmosphere and exosphere.
Data exchange	Data exchange means making data accessible and available for national and international users at the required timeliness and via agreed channels or on agreed platforms; this includes ensuring interoperability of the data, e.g. via the use of common agreed formats, provision of necessary decoding software, provision of all necessary metadata, etc. as specified in the relevant parts of the WMO Technical Regulations.

Word or Phrase	Definition
Free and unrestricted	Free and unrestricted means available for use, re-use and sharing without charge and with no conditions on use.
Without charge	Without charge, in the context of this resolution, means at no more than the cost of reproduction and delivery, without charge for the data and products themselves.
Conditions on use	In the context of this resolution, conditions on use may be applied only to recommended data; such conditions may be applied using licenses. Note that attribution is not considered a condition on data use and is strongly encouraged in all cases.

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