WMO
Performance Assessment Report

2020 - 2022

Long-term Goal 2

Enhance Earth system observations and predictions: Strengthening the technical foundation for the future

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WMO Unified Data Policy approved

The 2021 Extraordinary World Meteorological Congress (Cg-Ext) approved the WMO Unified Data Policy which is expected to systematically increase observational data and data products across the globe. It paves the way for a sweeping update of policies on the free and unrestricted international exchange of weather, climate and related Earth system data between Members.

This additional exchange of all types of environmental data will enable Members to deliver better, more accurate and timely weather- and climate-related services to their constituencies, with massive socioeconomic benefits as a result. See **Focus Area B**.

Global Basic Observing Network (GBON) established

Cg-Ext 2021 also approved the establishment of GBON and its technical regulations as a fundamental element of WIGOS.

It represents a new approach in which the basic surface-based observing network is designed, defined and monitored at the global level.

GBON sets out an obligation and clear requirements for all WMO Members to acquire and internationally exchange the most essential surface-based observational data at a minimum level of spatial resolution and time interval.

Once fully implemented, GBON will significantly increase the availability of the most essential surface-based data. This is expected to have a direct positive impact on the quality of weather forecasts and information that will help to improve global public safety and well-being.

See more in **Focus Area A**.

Systematic Observations Financing Facility (SOFF) created

Officially established at COP26 in November 2021, this UN fund is a new finance mechanism spearheaded by WMO, UNDP and UNEP will support countries to generate and exchange basic observational data critical for improved weather forecasts and climate services.

Specifically, SOFF will provide technical and financial assistance to less developed countries to meet the GBON requirements. It has been designed as a mechanism for addressing the long-standing problem of missing weather and climate observations from Least Developed Countries (LDCs) and Small Island Developing States (SIDS) in particular.

SOFF is a foundational element and delivery vehicle of the UN Secretary General's Early Warnings For All initiative and contributing to the COP27 Sharm el-Sheikh Implementation Plan, which emphasized the need to address existing gaps in the global climate observing system, the need of enhanced coordination of activities related to systematic observations to provide actionable climate information for early warning systems. See also **SO 4.3**.

Long-term Goal 2

Enhance Earth system observations and predictions: Strengthening the technical foundation for the future

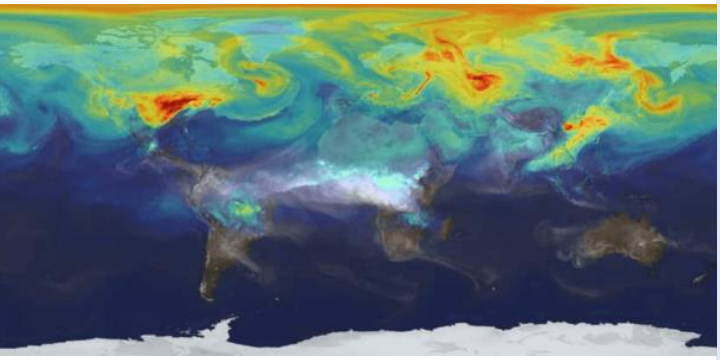
Greenhouse Gas Monitoring Infrastructure endorsed

The 76th session of the Executive Council has endorsed plans for a new Global Greenhouse Gas Monitoring Infrastructure to fill information gaps and support action to reduce heat-trapping gases.

The resolution recognizes the growing importance of greenhouse gas monitoring to support the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement and seeks to leverage WMO's experience in international coordination of weather prediction and climate analysis.

The initiative will leverage all existing greenhouse gas monitoring capabilities – space-based and surface-based observing systems, as well as modelling and data assimilation systems – in an integrated operational framework.

The outputs of the proposed infrastructure will be able to support multiple applications, from assessing individual facilities' or landscapes' greenhouse gas fluxes to contributing to the global stock take.



WIS 2.0 implementation plan and pilot phase initiated

The 76th session of the Executive Council endorsed the WIS 2.0 Implementation Plan, recognizing the urgency to build the WMO data sharing framework for the 21st century in support of the implementation of the WMO Unified Data Policy.

The WIS 2.0 pilot phase has been initiated to build the WIS2 Global Services, setup an initial set of WIS2 nodes and refine the framework to include all the WMO disciplines and domains.

The WIS2 in a box software has been released as Free and Open Source Software (FOSS) to support LDCs, SIDS and developing countries in the transition from GTS to WIS 2.0.

Forward perspective

Implementation of the newly-adopted WMO Data Policy is moving forward as a priority for WMO Members in the coming years and will frame the activities of the Infrastructure Commission.

Whereas GBON can be implemented relatively quickly by WMO Members with a high gross domestic product, many developing countries will need additional investment and capacity development. To this end, SOFF will support 55 countries by June 2023 and a proposed 100 countries by 2027 to close the weather and climate observation gap, including rehabilitation or establishment of up to 400 data-gathering stations. The SOFF Steering Committee selected the first 26 countries to receive SOFF support and approved the funding. SOFF is supported by 10 funders and its initial capitalization stands at USD 65 million as of March 2023.

The implementation of WIS 2.0 to replace the GTS and support the implementation of GBON and the Unified Data Policy will be a critical activity for WMO Members starting from 2024. WIS capacity development activities will be essential in supporting the transition. The WIS2 training plan will aim to deliver training to 40 countries annually over a span of five years starting in 2023.

Only a small number of Members has a Climate Data Management System (CDMS) in place that is compliant with the CDMS Specification (WMO No. 1131) and is able to keep climate records to support climate change mitigation activities. The OpenCDMS software is being developed and will be ready for a pilot phase in 2024 to provide a FOSS implementation of a WMO-compliant CDMS. OpenCDMS will be experimented by at least 10 countries and deployed in many others in parallel with WIS 2.0 implementation.

Long-term Goal 2 | 2022 Key Performance Indicators (Summary)

Strategic Objective 2.1

KPI 2.1.1
Global surface observations exchanged daily

140K
▲20.9%

KPI 2.1.2
Global upper air observations exchanged daily

1'321
▼8.7%

KPI 2.1.3
Global Drifter Array correctly sampled in time and space

29%
▼28.3%

KPI 2.1.4
Global aircraft observations exchanged daily

393K
▼40.6%

Strategic Objective 2.2

KPI 2.2.1
Surface BUFR observations with timeliness <30 min

89%
▲2.3%

KPI 2.2.2
Proportion of accessible data in the GISC catalogue

RETIRED
See note

KPI 2.2.3
Freely accessible to everyone in GISC catalogue

RETIRED
See note

KPI 2.2.4
GISC catalogue data in compliant with Manual on Codes

RETIRED
See note

KPI 2.2.5
Stations exchanging with WIGOS Identifier

1'599
▲1759.3%

KPI 2.2.6
Stations exchanging DAYCLI data

N/A

KPI 2.2.7
Members exchanging hydro data thru WHOS

22
▲37.5%

Strategic Objective 2.3

KPI 2.3.1
Members accessing forecast products developed by GDPFS

N/A

KPI 2.3.2
Monthly verification reports provided by Global Producing Centres (GPCs) to the Lead Centres (LCs)

284
▲9.7%

KPI 2.3.3*
Percentage of mandatory products from designated GDPFS Centres directly accessible through the GDPFS Web Portal

59%
▲26.0%

**As this data starts from 2021, the comparison was made between 2021 and 2022.*

Note: With the transition from GISC to WIS 2.0, these KPIs are retired in 2022. They will be replaced by new WIS 2.0 KPIs, to be piloted in 2023.

Strategic Objective 2.1

Optimize the acquisition of Earth system observation data through the **WMO Integrated Global Observing System (WIGOS)**

Outcome/Focus Area A:

Advance the implementation of WIGOS rapidly through coordinated global and regional plans, in particular further development and operational implementation of Global Basic Observing Network (GBON), electronic metadata inventories for all observing platforms, along with quantitative tools to monitor their data delivery and data quality.

GBON # WIGOS Operational Plan 2020-2023 # Regional WIGOS Centres # WIGOS Data Quality Monitoring System (WDQMS) # WIGOS indicators

Outcome/Focus Area B:

Increase compliance with regulations and standards, and identify critical gaps in observational data coverage and address that through the integrated design of observing networks

Standards and guidance on Earth system observations # Observing Systems Capability Analysis and Review Tool (OSCAR) # WMO-IATA Collaborative AMDAR Programme (WICAP) # Virtual Laboratory for Training and Education in Satellite Meteorology (VLab) # Space-based Weather and Climate Extremes Monitoring (SWCEM) # Global Climate Observing System (GCOS); # Global Cryosphere Watch (GCW); # SOFF

Outcome/Focus Area C:

Develop additional regulatory and guidance material developed to facilitate integration of externally-sourced observations under the WIGOS umbrella

WMO contribution to Global Ocean Observing System (GOOS), # Ocean observing systems monitoring, implementation and maintenance through OceanOPS

Overview

Strategic Objective 2.1

Optimize the acquisition of Earth system observation data through the WMO Integrated Global Observing System (WIGOS)

SDG Contribution

ON TRACK

- **Unified Data Policy** and GBON resolutions adopted at Cg-Ext (2021)
- **Roadmap** for implementation of the Unified Data Policy developed.
- **Guidance for the implementation of GBON** developed and technical regulations further updated to clarify the process for the designation of GBON stations.
- **High Level Guidance for the Evolution of Global Observing Systems** during the period 2023-2027 in Response to the WIGOS Vision 2040 about to be adopted by Congress.
- Guidance for the **design of RBON** by the regions developed.
- **Rolling Review of Requirements (RRR) process** evolved, taking into account WMO's Earth System approach.
- The Plan for the **WIGOS Initial Operational Phase 2020-2023** approved with indicators, and progress made on the 6 priority areas.
- **Regional WIGOS Centres established** in Regions I and III and in Region V with pilot operations, and in Region II operationally.
- Continued improvement of the **WIGOS tools**:
  - ✓ New features introduced in OSCAR/Surface twice per year via new releases addressing user requirements and improving user experience, in cooperation with MeteoSwiss (latest version 1.9 from April 2023).
  - ✓ More observations types incorporated (e.g. in OSCAR/Surface)
  - ✓ WIGOS Data Quality Monitoring System (WDQMS) webtool extended to include additional types of data (GCOS, GBON).
  - ✓ Prototype incident management system webtool further being developed to address user requirements, in particular the needs of RWCs. The IMS webtool is also being migrated to a WMO cloud-based solution.
- **Gap analysis for WIGOS 2040** conducted in relation to operational space missions
- Progress made on the development of **GCOS Surface Reference Network (GSRN)**
- Evolution in the **marine climate data system**
- **SOFF** established and momentum built, agreement with peer advisors signed

CONTINUED EFFORTS REQUIRED

- INFCOM is reviewing the priority actions from the **High-Level Guidance for the Evolution of Global Observing Systems** during the period 2023-2027 in Response to the WIGOS Vision 2040. It will investigate whether some of these actions could be turned into technical regulations and/or new core or recommended data per WMO's Unified Data Policy.

On track

Continued efforts required

Limited progress

COVID-19 Impact

Challenges & Risks

Overview

Strategic Objective 2.1

Optimize the acquisition of Earth system observation data through the WMO Integrated Global Observing System (WIGOS)

SDG Contribution

CONTINUED EFFORTS REQUIRED (cont'd)

- **Establishment of Regional WIGOS Centres (RWCs):**
  - A concept for RWC in RA IV was developed and endorsed by RA IV Management Group. An implementation plan is being finalized aiming at initiating operations in pilot mode in the second half of 2023.
  - A concept and implementation plan for RWCs in RA VI are under development, expected to start operations in pilot mode in late 2023 or early 2024.
  - Antarctica and some parts of RA I (North/Norwest and Central Africa) are not covered by any RWC yet.
- **National WIGOS implementation:** uneven implementation; lack of information and examples provided by Members.
- All regions decided on their transition to RBON. However, considerable effort remains in terms of deciding on the key challenges to be addressed using RBON data (only done by Region II so far).
- **Transition to the new Rolling Review of Requirements process** and development of Statements of Guidance for the Earth System Application Categories. Two pilot projects have been initiated for cryosphere and oceans.
- **Cryosphere:** limited progress on defining requirements for all service areas (hydrology, climate, sea ice).
- **Marine:** only a handful of centres identified for GDPFS.
- **Hydrology:** Integration with WIGOS tools, starting with WIGOS Stations identifiers and registration into OSCAR/Surface, to accelerate (mechanism decided by INFCOM-2).

COVID-19 IMPACT

- **A two-year delay on WICAP** original plan due to the uncertain situation of the aviation industry.
- A very significant drop in aircraft-based observations occurred at the height of the pandemic and observation numbers are still below pre-Covid levels but gradually recovering.
- Space agencies were concentrated on guaranteeing operations under Covid-19, with some delays in research and development activities

CHALLENGES & RISKS

- Substantial **GBON gap in SIDS and LDCs**, which are being addressed with SOFF funding.
- Capacity issues for **surface and upper air observations** in the Southern hemisphere and data availability issues for surface and upper air observations in certain regions of the Northern hemisphere.
- **Underserved marine areas** (Indian Ocean and the Southwestern Pacific Ocean).
- Potential need for overarching oceans observation data management.
- Behind schedule on the Rolling Review of Requirements and Statements of Guidance for agricultural meteorology and aeronautical meteorology and for hydrology.

On track

Continued efforts required

Limited progress

COVID-19 Impact

Challenges & Risks

Focus Area A

Global Surface Observations

Figure 2.1 presents a snapshot of global surface observations as of March 2023.

Region VI produces the highest number of surface observations and has the highest number of well-performing stations.

Regions I, III and V have the largest number of silent stations (black dots on the map), pointing to capacity gaps.

Regions II and IV have the highest number of stations with data availability issues (i.e. stations not properly reporting observations). Some Members have anticipated GBON requirements, leading to substantial increase in data availability in some areas (e.g. Region IV).

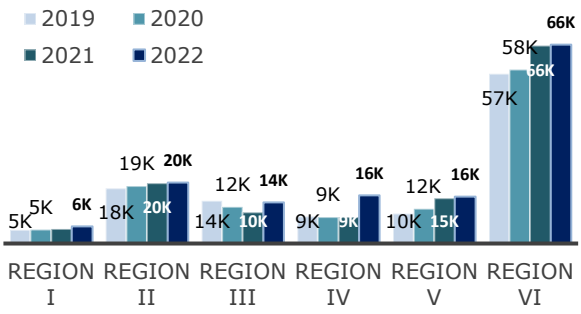


Figure 2.1 Number of surface observations exchanged on a daily basis, March 2023, WDQMS

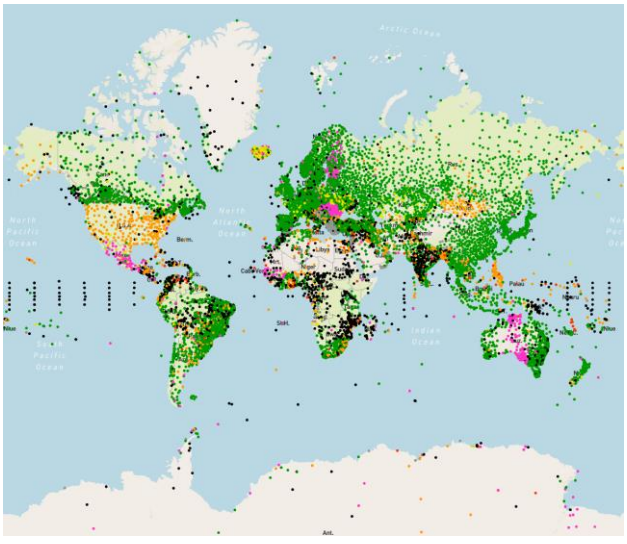


Figure 2.2 Global surface observations, March 2023, WDQMS

Upper Air Observations

Figure 2.3 presents a snapshot of global upper air observations as of March 2023. The capacity and data availability issues related to surface observations are observed in the upper-air observations.

Region II, covering a large area, produces the highest number of upper-air observations. The number of observations exchanged is considerably lower in Regions IV and VI but above the global average.

The largest gaps are observed in the Southern hemisphere, particularly in **Regions I and III**.

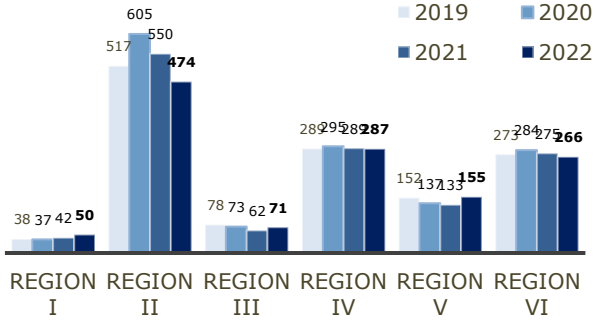


Figure 2.3 Number of upper air observations exchanged on a daily basis, March 2023, WDQMS

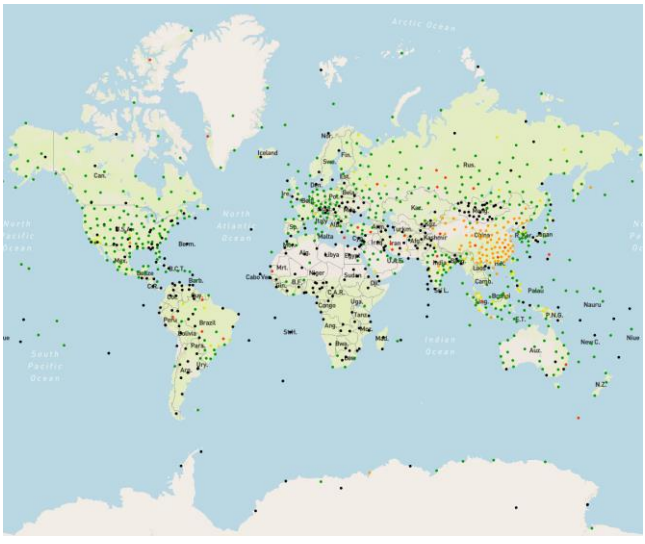


Figure 2.4 Global upper air observations, March 2023, WDQMS

Forward perspective

GBON

As of 1 January 2023, GBON regulations have entered into force and Cg-19 will decide on the initial GBON composition. Compliance monitoring tools for quarterly and yearly reports are under development. It is anticipated that a large number of Members, particularly LDCs and SIDS, but also some middle-income countries, will have difficulty meeting the requirements. KPI 2.1.1 and 2.1.2 are expected to gradually improve over the next few years. **SOFF will help to address part of the capacity gap issue** and budgetary pressure on many NMHSs for observation improvement and capacity development.

In January 2022, **WMO undertook a global GBON gap analysis** which provides a quantitative estimate of the number of surface-based observing stations of the two main types (surface and upper air stations) that will need to be installed, rehabilitated or upgraded. It also demonstrates the level of data exchange required in order to meet the requirements. The results from the global GBON gap analysis were communicated to each Member in August 2022.

The analysis showed that **SIDS and LDCs are currently far from meeting the provisions**. This is largely due to a lack of infrastructure and capacity. In order to achieve the GBON target of about 2300 observing stations (surface and upper air stations) in these countries, **about 2000 stations need to be rehabilitated or newly installed.**[1]

WIGOS Operating Plan

Endorsed by INFCOM-1 and approved by EC-73

Regional WIGOS Centres

Region I: RWCs in pilot mode established in Kenya/Tanzania for East Africa Community countries, in South Africa for Southern Africa Development Community (SADC) countries, and in Morocco for parts of North, West and Central Africa.

Region II: two nodes established in China and Japan and designated as RWCs in operational mode in RA II.

Region III: two nodes in pilot mode established in Argentina and Brazil.

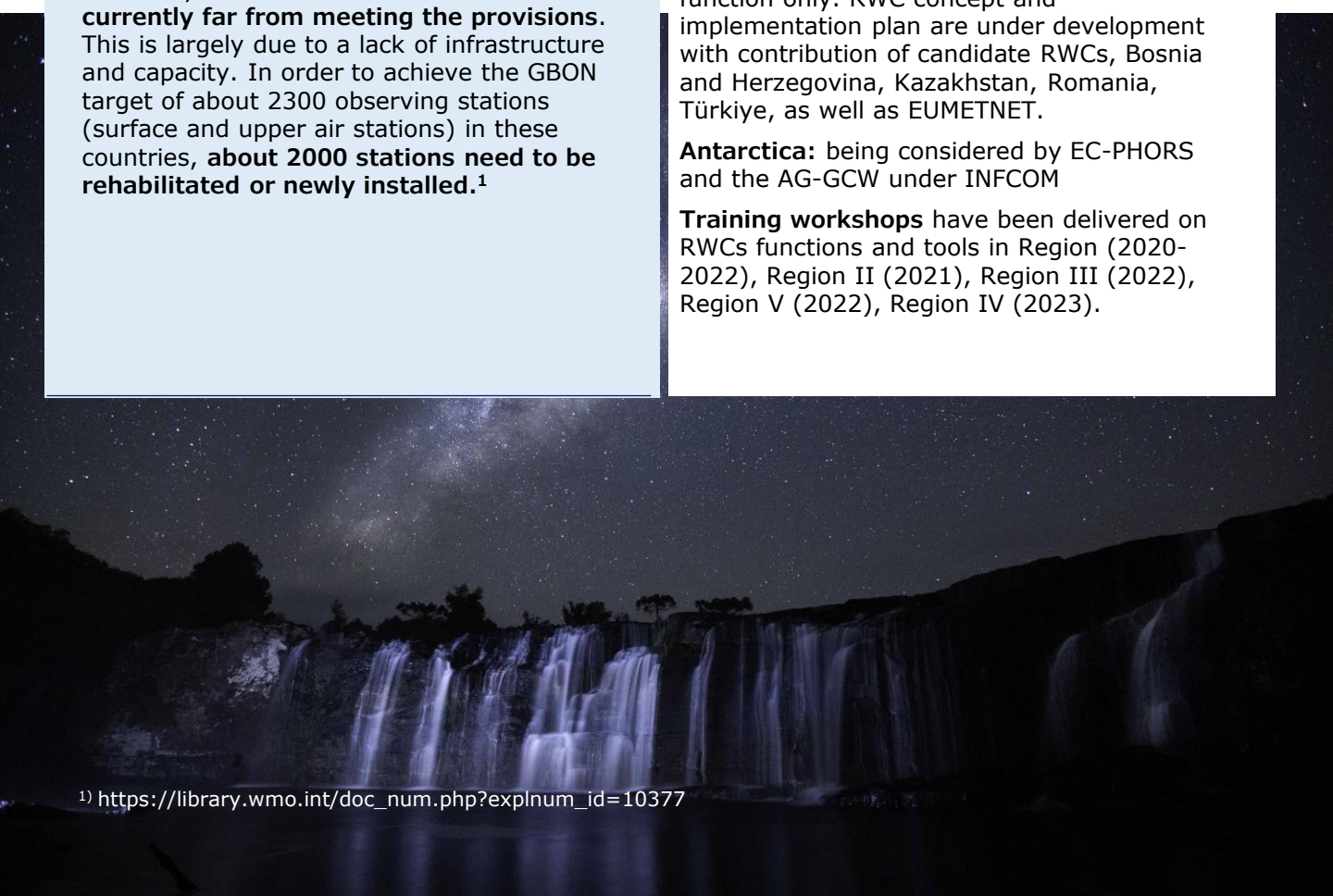
Region IV: a RWC concept developed and approved by RA IV Management Group. British Caribbean Territories, Canada, Costa Rica, Trinidad and Tobago, and United States of America will perform RWC functions.

Region V: RWCs in pilot mode established in Singapore, Indonesia, and Fiji.

Region VI: RWC EUMETNET is performing quality monitoring function for EUMETNET members as well as for the remaining Members of Region VI as an automatic function only. RWC concept and implementation plan are under development with contribution of candidate RWCs, Bosnia and Herzegovina, Kazakhstan, Romania, Türkiye, as well as EUMETNET.

Antarctica: being considered by EC-PHORS and the AG-GCW under INFCOM

Training workshops have been delivered on RWCs functions and tools in Region (2020-2022), Region II (2021), Region III (2022), Region V (2022), Region IV (2023).



[1] https://library.wmo.int/doc_num.php?explnum_id=10377

Focus Area B

Global Drifter Array Network

The level of **global network sampling deteriorated** between 2020 (40%) and 2022 (29%) and is slipping further away from the 68% global target.

Region VI has the greatest coverage (100%), followed by **Region IV** (61%).

All other regions are in deficit between 20% and 30%, with Regions I and V experiencing the largest drops.

OceanOPS note **an excess of activity in the North Atlantic** vs other basins which are **underserved**. These include the **Indian Ocean** (on a continuously decreasing trend), the **Southern Ocean** and the tropical band (+/- 20°). A large gap has developed in the **tropical East Pacific.**

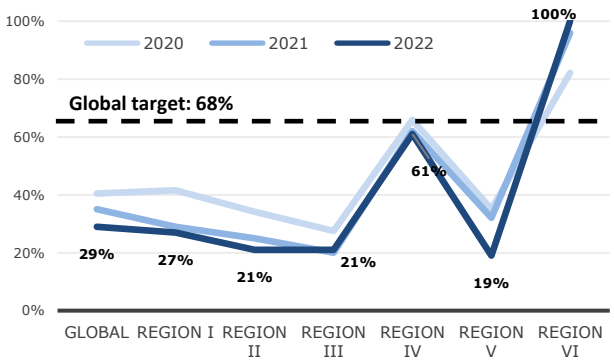


Figure 2.5 Percentage of the Global Drifter Array correctly sampled in time and space, 2023, OceanOps

Forward perspective

The time/space coverage of the drifters array data is on a continuous decreasing trend since the pre-pandemic period. While the balance between basins could gradually be corrected through international coordination, the inflation of instruments and operations will not help the array maintenance. First signs of an increase of activity are noted.

Change is expected to be incremental, with no dramatic year-to-year fluctuations.

Aircraft Observations

Aircraft-based observing systems were severely impacted by the Covid-19 pandemic, which resulted in ABO observation outputs **plummeting by up to 80%** over 2020. They have gradually recovered to about **75% of pre-pandemic levels as of March 2023**.

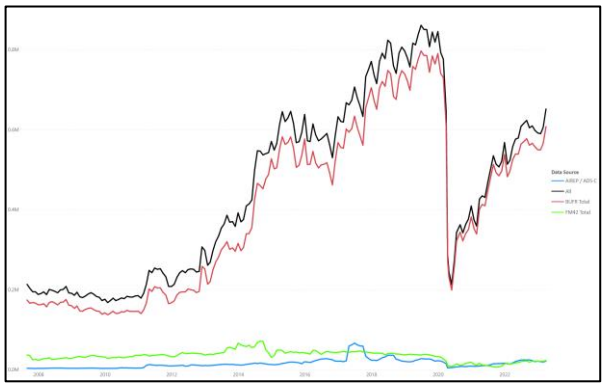


Figure 2.6 Aircraft-based observations monthly mean observations per day on WIS, August 2007- March 2023, Canadian Meteorological Centre, Canada

Whereas data volumes for **Regions II, IV, V and VI** have steadily recovered, the Covid-19 crisis has been particularly devastating to the **ABO** coverage of **Regions I and III.**

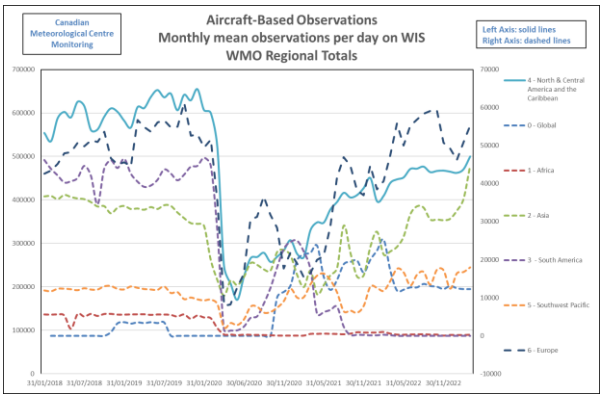


Figure 2.7 Aircraft-based observations monthly mean observations per day on the WIS, by WMO region, January 2018 to March 2023, Canadian Meteorological Centre

In 2021, **the LATAM group** of airlines, the provider of the largest volume of observation data in South America, gradually phased out participation in the AMDAR program, leading to only limited coverage in the region and likely reversing the significant positive impact on forecast skill it had provided. Efforts are underway to develop new programs over the Southern Hemisphere under the **WMO IATA Collaborative AMDAR Programme (WICAP)** but will require external resourcing input.

Forward perspective

Based on industry projections, a return to pre-Covid data volume of ABO is unlikely in the short term. This projection underscores the need to focus efforts on the **development of WICAP**, which supports a regional framework for AMDAR development and expansion.

Aircraft-based Observations

- **WICAP Governing Board** established.
- **WICAP Data Policy** signed.
- Regional plans nearly finalized (**Regions VI** and **III**) or under revision (**Regions I and V)**. **RA IV** resolution adopted on the establishment of regional AMDAR Programme under WICAP.

Highlights of WMO Unified Policy for International Exchange of Earth System Data

Integrated Earth system data policy – encompasses all WMO-relevant Earth system data: weather, climate, hydrology, ocean, atmospheric composition, cryosphere, space weather. It builds on existing WMO data policies used successfully in the past: Resolutions 40 (Cg-XII) (weather), 25 (Cg-XIII) (hydrology) and 60 (Cg-17) (climate).

Clear commitment to free and unrestricted data exchange – clarifies the explicit and literal interpretation of the term "free and unrestricted" exchange, and expressing clear organizational commitment to it is the core principle of the policy.

Expanded scope and purpose – introduces new terminology on data, replacing "Essential" and "Additional" data (Resolution 40), with "Core" data (standard practice, shall be exchanged) and "Recommended" data (best practice, should be exchanged). The scope and purposes of Core and Recommended data, respectively, are described in general terms for each domain or discipline.

Call for subsequent implementation of data policy amending the Technical Regulations (WMO-No. 49) and their annexes (Manuals) with details of what data are to be considered "Core" and "Recommended"**.**

Includes guidelines for national implementation and public-private engagement.

OSCAR/Surface

Ocean observations integrated.

Cryosphere stations (GCW network) being imported and alignment of metadata completed.

GAW requirements on track to being incorporated.

A new project initiated between WMO and MeteoSwiss to develop a **Next Generation of OSCAR** which is planned to be deployed in 2025 and replace the current version in 2026.

Climate Observations

GCOS Status Report published and submitted to UNFCCC: identifies geographical gaps and long-term stability issues in the network, specifically issues linked to lack of proper funding and maintenance.

Development of **GCOS Surface Reference Network** initiated: a small number of stations that provide high-quality traceable observations which can be used to calibrate and validate more general networks and improve their quality. Currently defining the requirements and looking for a lead centre.

GCOS Implementation Plan developed.

Modules for the monitoring of the **GCOS networks** included into **WDQMS Webtool (GUAN and GSN)**.

Hydrological Observations

Tests ongoing for the integration of pilots (**Arctic HYCOS and La Plata Basin**) into OSCAR/Surface. Acceleration of WSI allocation started in 2023.

A new working group with representatives from the observing and modeling community established to address the new Rolling Review of Requirements and Statements of Guidance.

WHYCOS and HydroSOS are supporting partners in **Lake Chad Basin, Lake Victoria Basin, SADC region and Indian Ocean** in implementing hydrological observing and information systems.

Cryosphere Observations

Snow Depth is part of the **GBON variables set**.

Sea Ice Thickness satellite product intercomparison – proposal prepared and submitted to the European Space Agency.

Coordination with Members and partners, launched to address the gaps in the registration of existing snow observations associated with operational stations, already in **OSCAR/Surface**, to support the integration in **WDQMS**.

A joint project on the status of mountain snow cover was launched in January 2022, jointly between **WMO**, the **International Association of Cryosphere Sciences, and Mountain Research Initiative (2022-2024).**

Space-based Observations

An updated strategy designed, and implementation initiated.

Principles for data buy from commercial providers adopted by the Coordination Group for Meteorological Satellites (CGMS), including (i) clear definition of data and (ii) use of free redistribution license.

Working paper on Satellite Data Requirements for Global NWP adopted by INFCOM-2 and presented to J294.

Gap Analysis on the implementation of the space-based observing system into WIGOS 2040 concluded and presented to Expert Team on Space Systems and Utilization and CGMS.

OSCAR/Space database content and gap analysis tools were continuously improved to better support the monitoring of Vision for WIGOS 2040 implementation and WMO gap analysis. In addition, the functionality for machine readable interface (API) to export database content was developed.

OSCAR/Space database content is a key information source for WMO and CGMS in their annual risk assessment of the space-based observation capabilities.

VLab continues maintaining its training framework with increased visibility and a growing participation in the training opportunities worldwide strengthening of collaboration between VLab Members. CGMS and its membership have been a strong sponsor of VLab, which allows to aid the training initiatives for the preparation of users of the new generation of satellites to continue.

Measurement & Quality

Measurement quality classification scheme approved by INFCOM-1.

Intercomparisons of instruments for measurement of solar and terrestrial radiation performed to support global traceability of measurements relevant to **Earth energy budget**.

Interlaboratory comparison for **Regions II and V** completed and a report published. Similar intercomparison started in **Region I** and preparatory work completed in **Region III**.

Online Workshop on Transition to Automated Ground-based Measurements conducted for **Regions I and V**.

Online Training Workshop on **Quality, Traceability and Compliance – General Metrology and Temperature, for RICs and RMICs** conducted.

Audit of space-based measurements endorsed; **WMO-No. 8, Vol. V** updated.

A single concept of a **Measurement Lead Centre approved by INFCOM-1**, as a replacement of the existing WMO/CIMO Testbed and Lead Centre concepts. Regional plans nearly finalized (**Regions VI and III**) or under revision (**Region I**). **RA II and IV** resolution adopted on the establishment of regional AMDAR Programme under **WICAP**.

The Project for the **Assessment of the Performance of Flow Measurement Instruments and Techniques and the Global Hydrometry Facility (WMO HydroHub)** are supporting Members in the adoption of new hydrological measurements techniques.

Forward perspective

Best Practices for the observation of glaciers, ice caps and of permafrost are to be published in 2022 and 2023, respectively.

Project launched to develop **consolidated Cryosphere Observing Requirements** aligned with the framework revised by JET-EOSDE (2021-2024).

BUFR Tables for in-situ sea ice variables for NWP are to be developed in 2022/2023.

Focus Area C

WMO-IOC (Intergovernmental Oceanographic Commission)

Strategy completed and approved by **EC-73**.

Marine Observations

WMO Office on Marine Observations Coordination set up in Brest, France (OceanOPS, Jointly with IOC-UNESCO).

Marine Climate Data System: the metadata hub evolved from 1 observing network to 9 networks established.

First data acquisition centre certified: the NOAA Atlantic Oceanographic and Meteorological Lab in the United States.

Project Highlights

Adaptation Fund - ENANDES – RA III – CHF 6.6 Mio (2021-2025)

In the framework of **ENANDES** Project a **WIGOS Survey on Needs Assessment** was conducted to support the **planning of WIGOS implementation in Region III** as well as to advise on the resources needed. Based on the survey findings, **two workshops** on WIGOS and WIS were carried out to improve the technical capabilities of the countries involved in the development of observation networks that meet the technical standards adopted by the global community. The workshops were intended for participants to revisit the WIGOS concept and the WIGOS Initial Operational Plan (2020-2023) and learn more about the WIGOS tools, with a special focus on WIS 2.0. To discuss and address data access constraints related to WIS and GTS, the workshop included a basic presentation of "WIS 2.0 in a box" designed to **provide low-barrier infrastructure, data and services**, thus resulting in easy and approachable data sharing for **all of the WMO community**.

CREWS Afghanistan – RAII – CHF 950,000 (2019-2023)

Under **CREWS Afghanistan** project, **3D printers**, including **a full set of tools and manuals**, were delivered successfully in the country. The overall goal was **to provide cost-effective observation network**, through establishing local capacities and capabilities. The **Afghanistan Meteorological Department (AMD)** staff attended a training of trainers **organized by UCAR in Turkey** in the full manufacturing and installation process of **3D-Printed Automatic Weather Stations (3D-PAWS).** This knowledge was then **transferred to AMD technicians during a hands-on training in Afghanistan (2022).** The installation progress is **75% completed** and still ongoing. This will provide some **autonomy to the Meteorological Service** in generating automatic stations while increasing the capabilities to generate new observing networks.

CREWS Burkina Faso – RAI – CHF 2.1 Mio (2017 – 2025) and CREWS CHAD – RA I – CHF 1.4 Mio (2019-2024)

In **Burkina Faso**, **diagnostics of observing networks, analysis of the international data exchange status, assessment of availability and quality issues of exchanged observations** were made, and guidance for WIGOS implementation including GBON implementation was provided. **Solutions for improvement of data sharing** were developed, including increased availability and quality of observations and Operation and Maintenance Plan for the observing network.

In **Chad**, an **assessment of the observing networks, technical infrastructure** for international data exchange and availability and quality of the exchanged data was conducted. The status of WIGOS implementation and designation of GBON stations was reviewed and guidance provided. Implementation of the proposed solutions for **improvement of data sharing and development of national plans for sustainable observations** in Chad are in progress.

Strategic Objective 2.2

Improve and increase access to, exchange and management of current and past Earth system observation data and derived products through the **WMO Information System** (WIS)

Outcome/Focus Area A:

Foster the continuous growth and evolution of WIS to accommodate and exploit the different technical capabilities of the Members and provide continued access to all observations acquired under WIGOS and all data generated under the Global Data Processing and Forecasting System for all Members.

#WIS 2.0 technical regulations #Certification and re-certification of WMO Centres #WIS monitoring #WDQMS #WIS2 in a box

Outcome/Focus Area B:

Further develop regulatory and guidance material governing international exchange of data, along with strengthened monitoring of compliance.

#Manual on Codes #Data standards #Data exchange monitoring

Outcome/Focus Area C:

Consolidate and further develop WMO data management systems and practices through WIS to help ensure that all observational data and key products are properly archived.

#Guidance on information management #WIS metadata #Emerging data issues

Overview

Strategic Objective 2.2

Improve and increase access to, exchange and management of current and past Earth system observation data and derived products through the WMO Information System (WIS)

SDG Contribution

ON TRACK

- Amendments of the **Manual on Codes smoothly transitioned to the newly established Expert Team** on Data and continued uninterrupted.
- New volume of **Manual of WIS, updated WIS 2.0 Implementation Plan, WIS 2.0** monitoring concept and **WIS 2.0** protocols adopted by INFCOM-2.
- "**WIS 2.0 in a box**" open-source software developed and provided to Members.
- More than **1800% increase** in the number of stations exchanging data with **WIGOS Station Identifiers** over two years.
- **New guidance** on information management and KPIs on WIS metadata records
- **New CF-NetCDF** data format for radar and marine data in experimental phase
- **Wdqms.wmo.int operational**
- WHOS successfully demonstrated and better linked with WIS and partly WIGOS, and supporting data flow for HydroSOS; **WHOS is newly a pilot of WIS 2.0.**

CONTINUED EFFORTS REQUIRED

- More **automated weather stations needed**, particularly in Regions I and II where issues with the timeliness of data transmission exist.
- A significant percentage of the **BUFR upper air data** remains low-resolution.
- **More capacity building required** on development of metadata to improve data discovery and access.
- Little increase observed in the number of Members exchanging hydrological data through **WHOS**.
- Delay in the development of a **harmonized audit process**, though the work is ongoing and planned for submission to INFCOM-3.

COVID-19 IMPACT

- **WIS 2.0** was partly delayed due to Covid-19 as face-to-face meetings, which are more effective for decisions requiring extensive discussion, were not possible. Thanks to continuous efforts, the delay accrued in 2020-2021 was recouped in 2022 and implementation of WIS 2.0 is back on track.
- **WHOS** development was hampered. Regions were requested to prepare a more systematic implementation plan starting in 2022.

CHALLENGES & RISKS

- **Demand for data and metadata standards** is expected to grow in the coming years, with more data formats and data exchange requirements going beyond the traditional weather data (oceans, hydrology, etc.). This will require increased resources.
- **Skilled IT staff retention** is a challenge for many developing Members' NMHS, leading to issues in developing and sustaining increased data processing and data management capabilities.

On track

Continued efforts required

Limited progress

COVID-19 Impact

Challenges & Risks

Focus Area A

WMO Information System 2.0

Implementation of WIS 2.0 recovered in 2022, after it had suffered delays in 2020-2021 partly due to the governance reform and partly due to COVID-19. **An updated WIS 2.0 implementation plan** and the WIS 2.0 amendments to the Manual on WIS were endorsed by INFCOM-2 in October 2022.

A workshop on **WIS 2.0 demonstration projects** was successfully performed, with **11 projects presenting their implementation of the WIS 2.0 principles**. The outcome was to start a **"WIS 2.0 in a box"** project to provide a plug-and-play solution in facilitating the implementation of WIS 2.0. The version 1.0 of WIS 2.0 in a box was released in January 2023.

Overall, WIS 2.0 received a very strong and positive reaction from the WMO community: **25 Members and partners** are involved in its development, and the WIS 2.0 workshops at INFCOM-2 attracted more than **200 participants** from Members and industry alike.

Data representation and metadata quality

Continuity was ensured on **maintaining the Manual on Codes** in the transition to the new governance structure, with regular amendments implemented every 6 months (see the latest Amendments to Manual on Codes (WMO-No.306) Vol I.2 and Vol. I.3 adopted through Resolution 24 (EC-76) in February 2023).

In intersessional periods of the Executive Council, **a fast-track procedure** authorizing the President of the Infrastructure Commission to amend manuals and the WMO President to adopt such amendments proved to work well for mature standards where very regular technical improvements are needed to keep up with requirements. First applied to the Manual on Codes, it was further replicated to the Manual on WIS and the Manual on GTS, as required.

In November 2020, INFCOM-1 (II) decided to adopt **experimental data exchange in NetCDF for marine and radar weather data**. In 2022, a first version of the integration of **CF-NetCDF** in the Manual on Codes was presented and approved at INFCOM-2.

Forward perspective

The "**WIS 2.0 in a box**" software will facilitate the **implementation of the Unified Data Policy by LDCs, SIDSs and countries with less technical capability.** "WIS 2.0 in a box" was launched through a WIS 2.0 pilot project in Malawi which enabled the software to be designed based on the needs of WMO Members. As of January 2023, **25 Members are exchanging data through WIS 2.0, and 15 more are on the pipeline for implementation**. Moving forward, the focus will **concentrate on Members in Africa, the Caribbean and the Pacific**.

Focus Area B

Surface BUFR Observations

Several KPIs are tracked to measure the **timeliness, accessibility, reusability and interoperability of data**. Timeliness is defined as the delay between the data observation time and its reception in the user's database.

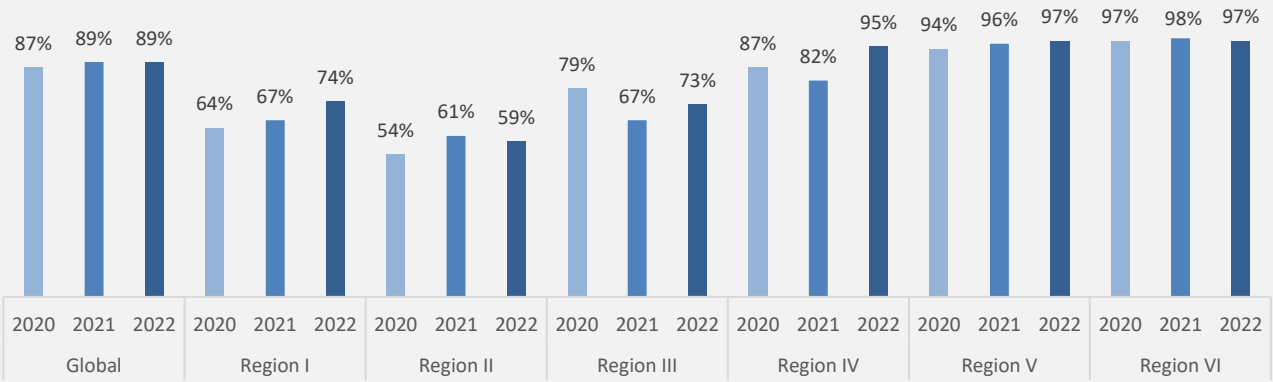


Figure 2.8: Percentage of surface BUFR observations with timeliness lower than 30 minutes, Dec. 2022 ECWF

- ✓ No significant change was observed globally on the average timeliness of the observations, which **remained at around 89%**.
- ✓ **Region VI performs better than average** largely due to the efforts of EUMETNET to increase the timeliness of its members' observations.
- ✓ **The good performance of Region V** is explained by the numerous observations of its high-income Members, which outweigh (and **hide statistically**) the delayed transmissions observed in **other parts of the region.**
- ✓ Nevertheless, continuous **improvement was noted in Region I and IV**, which recovered from 82% to 95%, while **Region I improved from 67% to 74%.**
- ✓ **Delays observed** in data transmission are attributed to the operation of manned stations which are less likely to transmit data on time than automatic weather stations. **The issue is particularly prevalent in Region I.**

Forward perspective

GBON requirements will demand transmissions of observations data on an hourly basis, while current practice in many parts of the world averages around 3 to 6 hours. This suggests that the statistics on data timeliness are likely to be highly impacted once GBON is introduced.

As such, the **replacement of manned observation stations with automatic stations** to improve timeliness of exchanges of BUFR data is critical.

Data in Global Information System Centres (GISC)

10 of the 15 GISC catalogues provide information exchange in JSON files, and as such form the basis for KPI 2.2.2, 2.2.3 and 2.2.4.

Due to a **change of methodology**, the 2021 **actual dropped to 67% from its baseline of 79%,** owing to the introduction of stricter requirements in the evaluation of accessible data in the GISC catalogues, with quality assurance delivered by **Offenbach (Germany).** Therefore, the baseline should be considered "too optimistic".

As of 2021, **30% of the data was freely accessible in the GISC catalogue**. Whereas the newly approved **WMO Unified Data Policy** will guarantee free availability of core data to all market participants – which will boost the free and open data accessibility in the GISC catalogue – **WMO recognizes that some parts of the essential data will always be restricted under license**.

Forward perspective

With the **transition from GISC to WIS 2.0**, these KPIs were **retired in 2022**. They will **be replaced** by the **new WIS 2.0 KPIs** adopted by INFCOM-2, which are to be **piloted in 2023**.

Percentage of data accessible in GISC catalogue

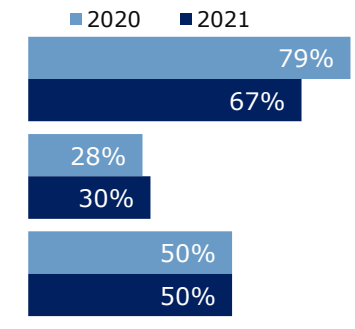


Figure 2.9 Percentage of data accessible in GISC catalogue, 2022, GISC

The extent of data exchange among Members

WIGOS Station Identifiers (WSI) were created to allow an essentially unlimited number of stations to be registered in WIGOS, with mandatory implementation for both new and existing stations.

The identifiers are currently used by the WIGOS (global) tools such as OSCAR/surface and WDQMS Webtool.

The number of stations exchanging data with WSIs is still low, though it increased from 86 in 2020 to 1599 in 2022. These remain low numbers compared with the total number of observations exchanged. According to a survey performed in 2021, Members have significant problems in processing data with WSIs because this requires re-engineering of most of the software stack for observations processing. Though adoption of the software will be slow, it is nevertheless progressing as expected.

Forward perspective

The global transition to the new identifiers is expected to happen slowly over time.

New stations will exchange data with the new identifiers and old stations will keep the old identifiers for long time.

Observational data processing software will need to be updated with significant costs for the Members.

WMO Hydrological Observing System (WHOS)

It facilitates hydrological data access and sharing.

It is a **multi-scale** (local, national, regional and global) registry of hydrological data and information services catalogued using the standards and procedures developed by the Open Geospatial Consortium (OGC) and the WMO.

WHOS ensures interoperability of the data received by converting it all to the **WaterML2.0 format**.

As of January 2023, **22 Members are exchanging hydrological data through WHOS** (incl. global and regional platforms): Argentina, Bolivia, Brazil, Paraguay and Uruguay in Region III; Canada, the Dominican Republic and the United States of America in Region IV; New Zealand in Region V; and Bosnia and Herzegovina, Croatia, Denmark, Finland, Iceland, Italy, Montenegro, Norway, the Russian Federation, Serbia, Slovenia, Sweden, and the UK in Region VI.

Forward perspective

In February 2023, the Executive Council adopted the **WMO Hydrology Observation System (WHOS) Operational Implementation** as **WIS 2.0 pilot** (Resolution 35 (EC-76)). The implementation plan projects **for at least 50 Members** to be sharing data through **WHOS by 2025**. Furthermore, the plan **establishes the exchange of WHOS data through WIS 2.0** by end-2023, and the **development of WHOS technical regulations** for INFCOM-3 in 2024.

Focus Area C

Information Management

A new **Information Management Guide** was completed and approved at INFCOM-2, which provides new guidance on information management for **climate data**.

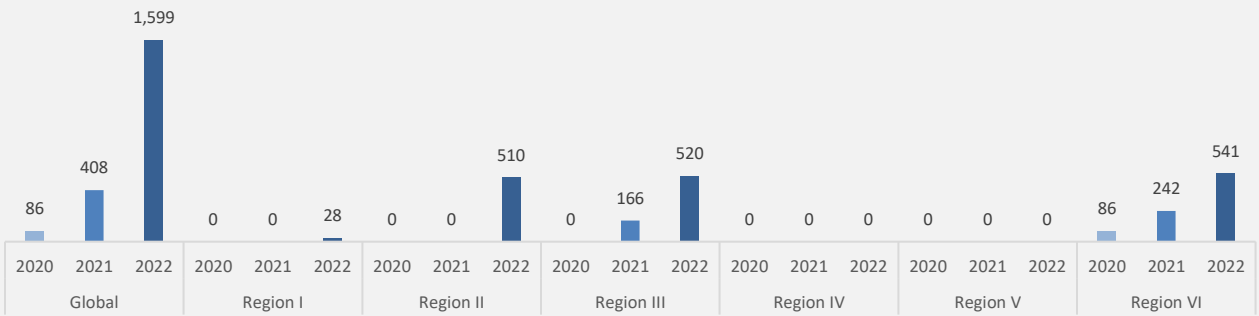


Figure 2.10 Number of stations exchanging data with WIGOS Station Identifier (WSI), 2022, WIS

Project Highlights

CREWS Burkina Faso | RA I | CHF 2.1 Mio |2017-2025 & European Union Intra-ACP Climate Services Programme (ClimSA) | Cross-Regional | CHF 5.9 Mio |2020-2024

The projects updated the **WIGOS metadata in the OSCAR/Surface and enhanced data sharing in WIS**. Further, assessments of national observing networks were conducted, including a **GBON gap analysis and recommendations** on the operation and maintenance of the observing networks with a long-term approach. In December 2022, the **Agence Nationale de la Météorologie received support to exchange data in the WIS on an hourly basis**. This is expected to lead to critical improvements in the skill of numerical weather forecasting models, with direct improvements in food security and flood warning.

Similar activities are implemented under the CREWS Chad and CREWS Togo projects.

CREWS Cambodia & Lao PRD| RA II | CHF 3.3 Mio |2021-2025

In October 2022, a **technical training** was held online for the **Department of Meteorology in Cambodia** in order to realize **dissemination of observation data of the existing automatic weather observation network (AWS)** in the country to the **GTS/WIS network**. This training was organized in cooperation with the **Japan Meteorological Agency and the Thai Meteorological Department**. Among the AWS in Cambodia, **9 are now successfully transmitting data** from Phnom Penh to the GTS/WIS.

CREWS West Africa | RA I | CHF 3.9 Mio | 2018 - 2023) & CREWS Central Africa | RA I | CHF 2.3 Mio|2022 - 2026

Several trainings were conducted on **climate data management, data sharing and exchange**. Furthermore, **24 countries** from the **Central and West Africa region** received diagnostics, training and data exchange solutions provided by the **Global Information System Centre (GISC) Casablanca, Morocco**. These included registering users, creating new stations and updating metadata as well as support on WIGOS Metadata in OSCAR/Surface among others.

Strategic Objective 2.3

Enable access and use of numerical analysis and Earth system prediction products at all temporal and spatial scales from the WMO seamless Global Data Processing and Forecasting System

Outcome/Focus Area A:

Advance the GDPFS to accommodate increased emphasis on probabilistic forecasting and coupled Earth system modelling to improve predictions over time scales ranging from long-term climate variability to seasonal/sub-seasonal to short-term weather events

#Seamless GDPFS #WMO Integrated Processing and Prediction System (WIPPS) #Impact-based operational data-processing and forecasting #Marine data processing and forecasting systems #Operational data-processing and forecasting for emergency response for nuclear, non-nuclear and marine environment #Compliance reviews of GDPFS Centres

Outcome/Focus Area B:

Further develop regulatory and guidance material governing the functioning of the GDPFS

#Pilot projects on seamless GDPFS #Toolbox for accessing seamless GDPFS data and products #Operational aspects of CSIS integrated into GDPFS process #Hydrology data-processing and forecasting integrated into seamless GDPFS

Outcome/Focus Area C:

Enhance the GDPFS to enable all Members to develop and/or improve their own national predictive capabilities benefiting from advances in quantitative model- and impact-based forecasting products

#Technical and regulatory material on GDPFS #Procedure for assessment of Members' NWP capabilities

Overview

Strategic Objective 2.3

Enable access and use of numerical analysis and Earth system prediction products at all temporal and spatial scales from the WMO seamless Global Data Processing and Forecasting System

SDG Contribution

ON TRACK

- **Roadmap** for the **seamless GDPFS** for Earth System modeling, named **WMO Integrated Processing and Prediction System (WIPPS),** developed and approved by INFCOM-2, to be submitted to Cg-19
- Guidelines on Ensemble Prediction System Post-processing published
- **GDPFS Web Portal** developed and launched in 2022
- **Global Seasonal Climate Update** operational as part of GDPFS after two years of a demonstration phase
- Decision on the **establishment of three hydrological activities in GDPFS** and development of designation criteria and functions.
- Renewal of the **Guide to GDPFS** (**WMO-No. 305**) completed and approved by INFCOM-2 and EC-76, including **guidelines on the review process of designated GDPFS centre compliance**
- **Guidelines on High Resolution Numerical Weather Prediction** developed
- Concept of integration of the Severe Weather Forecasting Programme (**SWFP**), the Coastal Inundation Forecasting Initiative (**CIFI**) and the Flash Flood Guidance System (**FFGS**) into GDPFS developed
- All timescales covered: **from nowcasting to climate prediction**
- Continued work on **improving access to products through WIS**

CONTINUED EFFORTS REQUIRED

- **Monitoring of GDPFS** implementation at the national level, including through enhanced Member data on the **GDPFS dashboard**
- Development of **RSMC for marine environmental emergency response**
- Not enough pilot projects on **seamless GDPFS launched**

COVID-19 IMPACT

- **No consultations possible** on the establishment of a procedure to assess Members' NWP capabilities

CHALLENGES & RISKS

- Seamless **GDPFS expanding to new Earth system domains** (hydrology, cryosphere, space weather, health): an emerging need for a coordination mechanism.
- A large number of centres (150+) to manage from the Secretariat.

On track

Continued efforts required

Limited progress

COVID-19 Impact

Challenges & Risks

Focus Area A

Seamless GDPFS: the WMO Integrated Processing and Prediction System

The **WMO Tropical Cyclone-Probabilistic Forecast Products (TC-PFP) Pilot Project** was endorsed by the Standing Committee on Data Processing for Applied Earth System Modelling and Prediction (**SC-ESMP**) as **the first Seamless GDPFS (S/GDPFS) pilot project**.

In 2022, INFCOM-2 approved **a roadmap** for the S/GDPFS until 2026 as well as a new name for it: the **WMO Integrated Processing and Prediction System (WIPPS)**.

Forward perspective

WIPPS will be **seamless** in terms of the **prediction** and **dissemination** of Earth system modelling and prediction (**ESMP**) data products at **all time scales**, and to **long-range** forecasts and **climate change** projections.

The S/GDPFS will be substantially extended to address Members' needs in terms of **a set of products such as nowcasts, high-resolution regional and global ESM predictions, ensembles** in support of impact-based forecasting and warning, hydrological predictions, etc.

In this regard, the **existing GDPFS centres are expected to advance their technologies** by leveraging benefits from new or innovative types of weather and climate observational data, high-performance computing, advanced development of ESMs, post-processing techniques, and use of **artificial intelligence**, including **machine learning** in various aspects of **ESMP processes**. **New types of GDPFS centres** will be added to the S/GDPFS when and as appropriate to fill the **gaps for supporting Members to deliver tailored or value-added products and services to stakeholders**.

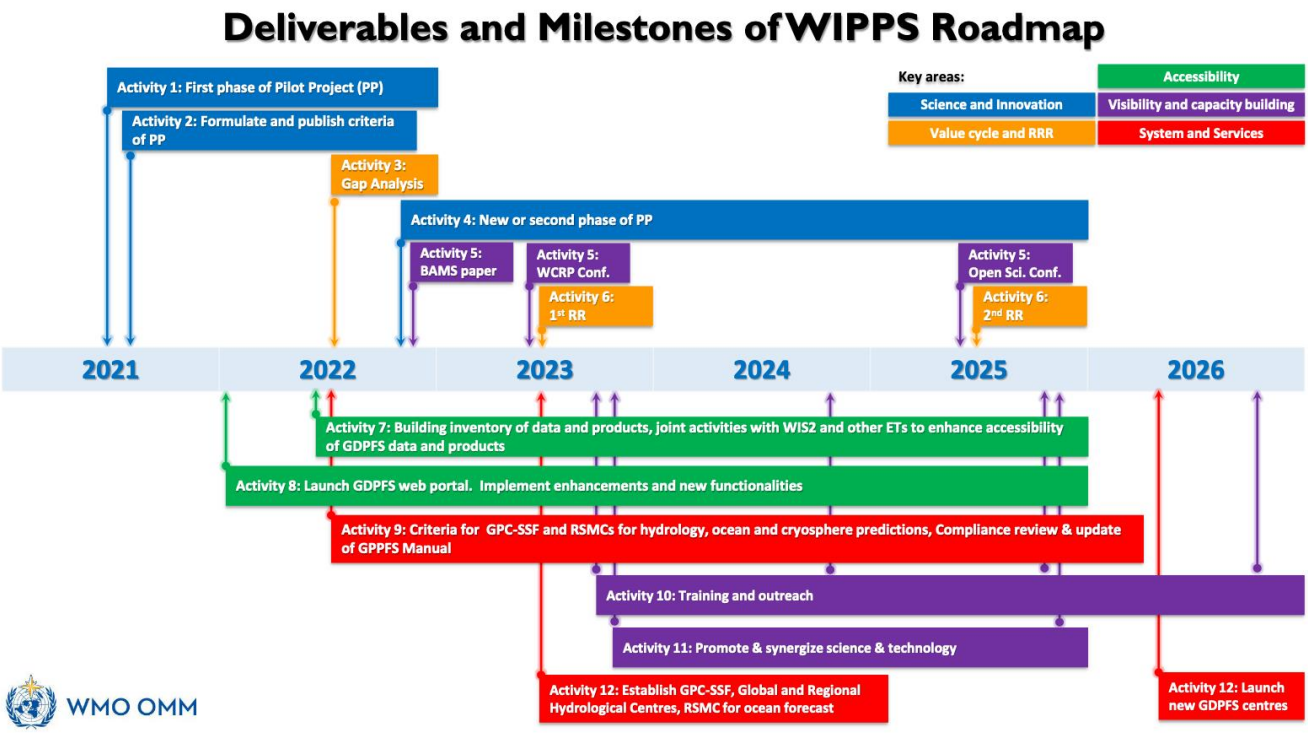


Figure 2.11 Roadmap of the WMO Integrated Processing and Prediction System (WIPPS), the Seamless GDPFS

Number of Members accessing forecast products developed by GDPFS per Region

In some regions the percentage of Members accessing forecast products developed by GDPFS (e.g. weather charts and forecasting model outputs) is high, such as in **Region I (68%) and Region III (75%).** The measuring method to count Members accessing forecast products was changed in 2021 and is now based on self-reporting by Members.

In 2022, WMO launched a **new GDPFS Web Portal** with information on the mandatory products of each RSMC, to significantly improve the discoverability and accessibility of WMC/RSMC products.

Integration of CSIS into GDPFS

A new GDPFS activity regarding sub-seasonal forecasts was established in 2021, covering from **nowcasting to annual to decadal prediction**.

Global Seasonal Climate Update (GCSU) became operational as one of mandatory functions of **LC-LRFMME**.

INFCOM, SERCOM and RB jointly prepared for OCP-3, which took place in September 2022 in **Lisbon, Portugal**, where a workshop was conducted **to identify user requirements and develop a work plan** to improve GDPFS for climate services.

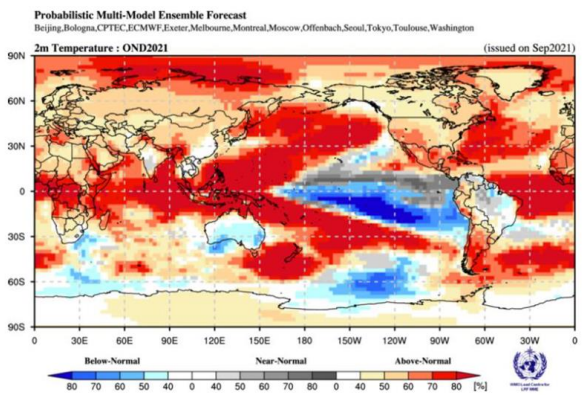


Figure 2.12 Probabilistic Multi-Model Ensemble Forecast, September 2021, WMO

Forward perspective

The demonstration of Global Annual to Decadal Climate Update (GADCU) is led by LC-ADCP and will be operationalized soon.

Guidelines on Ensemble Prediction System Postprocessing (EPSPP)

The purpose of these guidelines is to **assist WMO Members to use information from available EPS forecasts to enhance and improve forecasts for their own specific regions or areas with the limited resources**. It consists of **post processing methods** such as physical postprocessing, e.g. meteorological diagnosis and orographic downscaling as well as statistical postprocessing, which includes bias correction, deterministic model output statistics, and ensemble calibration. Further the post processing methods comprise **verification techniques to test and validate the postprocessing of both deterministic and EPS**.

Furthermore, the guidelines incorporate information on how to get **real-time forecast products, S/W packages for post processing, verification and display**.

GDPFS Symposium

As a follow-up to the adoption of the Unified Data Policy and the need to draft core NWP data, a **GDPFS Symposium** was organized in 2022 to collect user needs, finalize the S/GDPFS Roadmap and establish a coordination mechanism among WMCs and RSMCs.

Forward perspective

More **S/GDPFS pilot projects** expected to be conducted. **Guidelines on the high-resolution NWP** developed, to be published soon.

Focus Area B

Global Data-processing and Forecasting System (GDPFS)

To ensure the quality and sustainability of the designated GDPFS centres' compliance, a review process took place, which allowed for enhancements in their capabilities.

Guidelines on Compliance Review Process for RSMCs were developed. They follow a two-step approach for the auditing of GDPFS centres:

- **RSMCs** are to be screened through an initial compliance review against the criteria laid out by the GDPFS manual;
- An **external audit** will only be conducted for RSMCs which fail to pass the first step described above.

A demonstration of this new process was conducted in the summer of 2022.

To help WMO Members to better understand and enable them to implement GDPFS, the **Guide to GDPFS (WMO-No. 305)** was renewed and approved at INFCOM-2.

Focus Area C

The **GDPFS Web Portal** was launched successfully to help Members discover and access the products and information of WMCs and RSMCs. It is a **one-stop page** of essential information, including focal points, links to websites, and links to mandatory **GDPFS products**. It creates a seamless linkage between **GDPFS and WIS**.

A **GDPFS Dashboard** was also created, presenting data on Members' NWP capabilities.

Forward perspective

During the development of the GDPFS Web Portal, it was found that **not all products were adequately disseminated via WIS**. In response, tasks to **improve the WIS metadata** of GDPFS products were initiated to increase the **discoverability and accessibility** through WIS, with a **specific focus on WIS 2.0**.

Emergency Response Activities

In the context of **ConvEx-3 (2021),** WMO and some RSMCs participated in **a major nuclear emergency exercise to test international arrangements.**

Guidelines on Meteorological and Hydrological aspects of siting and operation of **Nuclear Power Plant** were developed. These guidelines support Members in conducing **environmental assessments.**

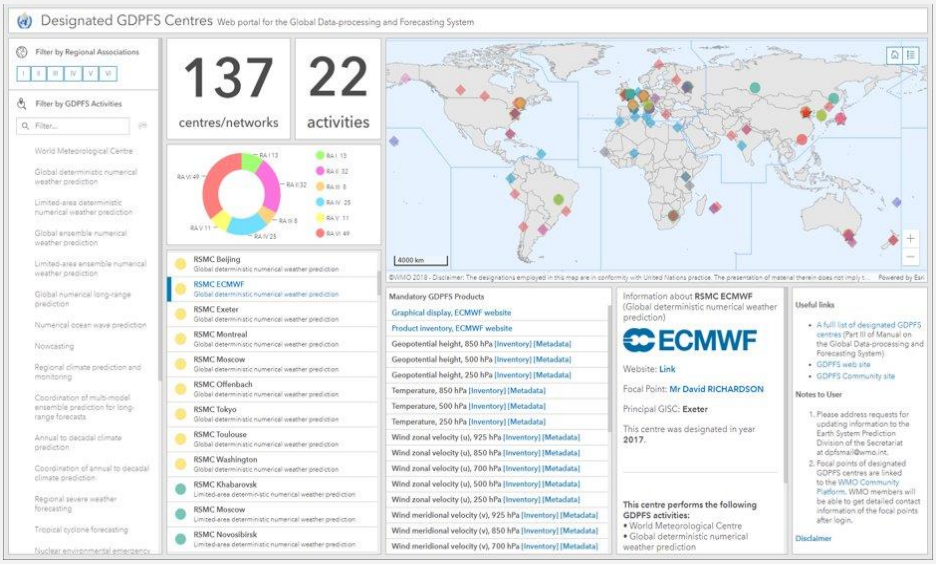


Figure 2.13 Global Data Processing and Forecasting system Source: https://community.wmo.int/gdpfs-web-portal, January 2022