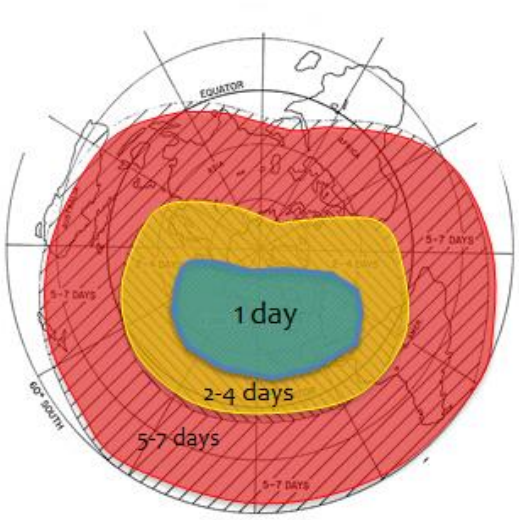
WEATHER CLIMATE WATER

Systematic Observations Financing Facility

Initial concept workshop, 18-19 July 2019
Outcomes and next steps



WORLD METEOROLOGICAL ORGANIZATION

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1. Context

The objective of the workshop was to develop the initial concept of an innovative and sustainable financing vehicle to support developing country weather and climate observations. It brought together 29 participants representing the World Bank, Green Climate Fund, CREWS Secretariat, GCOS Secretariat, ECMWF, UK Met Office, WMO Presidents of Regional Associations, and WMO Secretariat. *See Annex 1 Workshop concept note, agenda, and participants.*

The workshop followed recent developments that put financing systematic weather and climate observations as a foundational piece of the climate action agenda:

In March 2018, the second Hydromet[1] Development Partners Conference concluded that in light of insufficient progress there is a need to improve and sustain hydromet investments, beyond business as usual.

In June 2019, the 18th World Meteorological Congress adopted a sweeping WMO reform and important resolutions, including:

- Resolution 34 by which Congress adopted the overall concept for the Global Basic Observing Network (GBON), which imposes a minimum set of surface and upper air observational data for which international exchange of data will be mandatory in support of global Numerical Weather Prediction (NWP) and climate analysis. *See Annex 2 GBON executive summary.*

- Resolution 74 by which Congress decided to pursue the establishment of the Alliance for Hydromet Development and to establish the WMO Country Support Initiative (CSI). An important element of the CSI is to develop options for innovative financing to address the perennial sustainability issue of investments in and maintenance of operational systems. Innovative financing needs to value the global public good of observations and incentivize performance of National Meteorological and Hydrological Services (NMHS) as well as open data exchange that is vital to the global system. *See Annex 3 Congress resolution on Alliance for Hydromet Development and WMO Country Support Initiative.*

In June 2019, the World Bank Vice President for Sustainable Development joined Congress and discussed with the WMO Secretary-General the need of innovative finance to increase the sustainability and coverage of global observations necessary to meet the goals of the Paris Agreement.

[1] The term "hydromet investments" refers to investments that strengthen meteorological, climatological, hydrological and environmental services and respective country capacity.

2. Systematic Observations Financing Facility - Why is it needed?

- **The Paris Agreement calls for cooperation and enhanced action on systematic observation of the climate system.** Critical weather prediction and climate analysis efforts undertaken for any area on the globe depends on continued access to a robust and reliable supply of observational data from the entire globe. Therefore, observations are providing the foundation and are vital to the success of the Paris Agreement. The costs of observations and analysis are a fraction of the amounts required for effective climate action.

- **Today, important observational data are missing in several parts of the world, particularly from developing countries**. This lack of observational data significantly limits the quality of the information used by governments and all stakeholders as the basis for important decisions related to the reduction of the impact of weather and climate events.

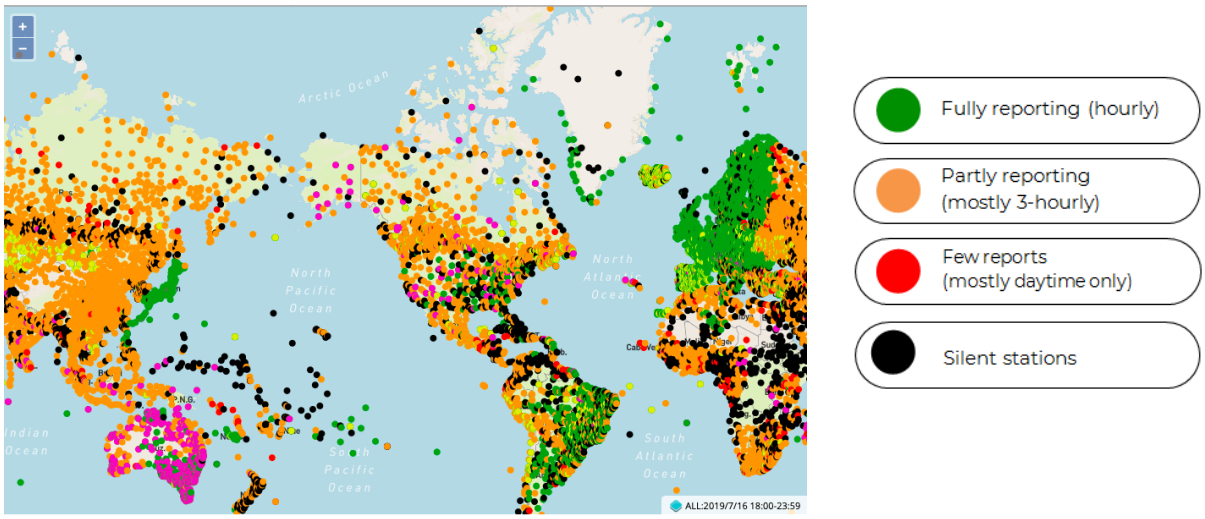


Figure1. Current international exchange of data for global NWP less than optimal (example: Surface pressure observations received by global NWP Centers on July 16 2019, 18Z) - Purple or yellow dots are metadata problems.

- **There is a fundamental mismatch between country-based financing of observations and the value that these observations create for the global community.** Local observations are important for local purposes, but they also contribute to the global public good by enabling weather prediction and climate analysis at national and regional level, and everywhere else on the globe.

- **Today, systematic observation is considered a purely national obligation**. Developing countries are thus expected to fully fund their own observing systems. They may receive projectized "aid" from multilateral and bilateral development and climate finance partners, but this aid-approach does not recognize the "global value creation" of developing country observational data. Global NWP and climate analysis depend on a combination of geographical homogenous and regional specific requirements, but the availability of national resources to meet these requirements varies enormously with location.

- **A comparison of Switzerland to Kiribati illustrates the need to fundamentally change the funding model for developing country observations**. Switzerland (Area: 41,000 km^2, GDP $ 700 billion) spends roughly $ 20 million, i.e. less than 0.003% of its GDP, on its observing network. A similar share of GDP spending for observations for Kiribati (Area: 3,500,000 km^2 of mostly ocean, GDP of $ 200 million) would amount to less than $ 6,000, far less than the cost of even a single Automated Weather Station. It is not reasonable and equitable to expect a country like Kiribati to cover the full costs of observations. It is also unrealistic to expect that a country like Kiribati will ever be able to sustain the provision of observations over their territories or territorial waters on national and "aid" resources alone. *See Annex 4 GBON Workshop presentation.*

- **Therefore, an innovative model to finance observations in developing countries is urgently needed.** Securing even basic global observations that provide vital weather and climate information from all areas of the globe require finance that goes beyond the current business model. Innovative finance needs to go beyond national and "aid" financing and fully value the global public good of these observations. Innovative finance also needs to go beyond providing support via fragmented, time-bound, and largely unsustainable projects through the provision of performance-based long-term finance.

- **Valuing observations from developing countries needs to be linked to provision of verification services, exchanging data and access to NWP products.** Valuing observations from developing countries recognizes the mutually beneficial relationship between the Global Producing Centers (GPC) that generate the NWP, the Regional NWP centers, the Regional Climate Centers and the NMHSs. This will result in substantially enhanced delivery of real time weather observations from NMHSs in developing countries to GPC and improved quality and performance of their models. *See Annex 5 Workshop notes on "Why is it needed"*

3. Systematic Observations Financing Facility - What is it?

- **The envisioned Systematic Observations Financing Facility is a unique facility dedicated to address the economic mismatch between local observations and the value they provide to the global community**. It will provide equitable and predictable finance and technical assistance to developing countries and their NMHSs, monetizing the economic value of their observations. The facility would prioritize support to Africa, SIDS, and LDCs.

- **The scope of the facility covers the different domains of surface-based observations and the foundational elements of the weather and climate value chain.** The facility will be structured in a modular manner, starting with GBON in its first phase.

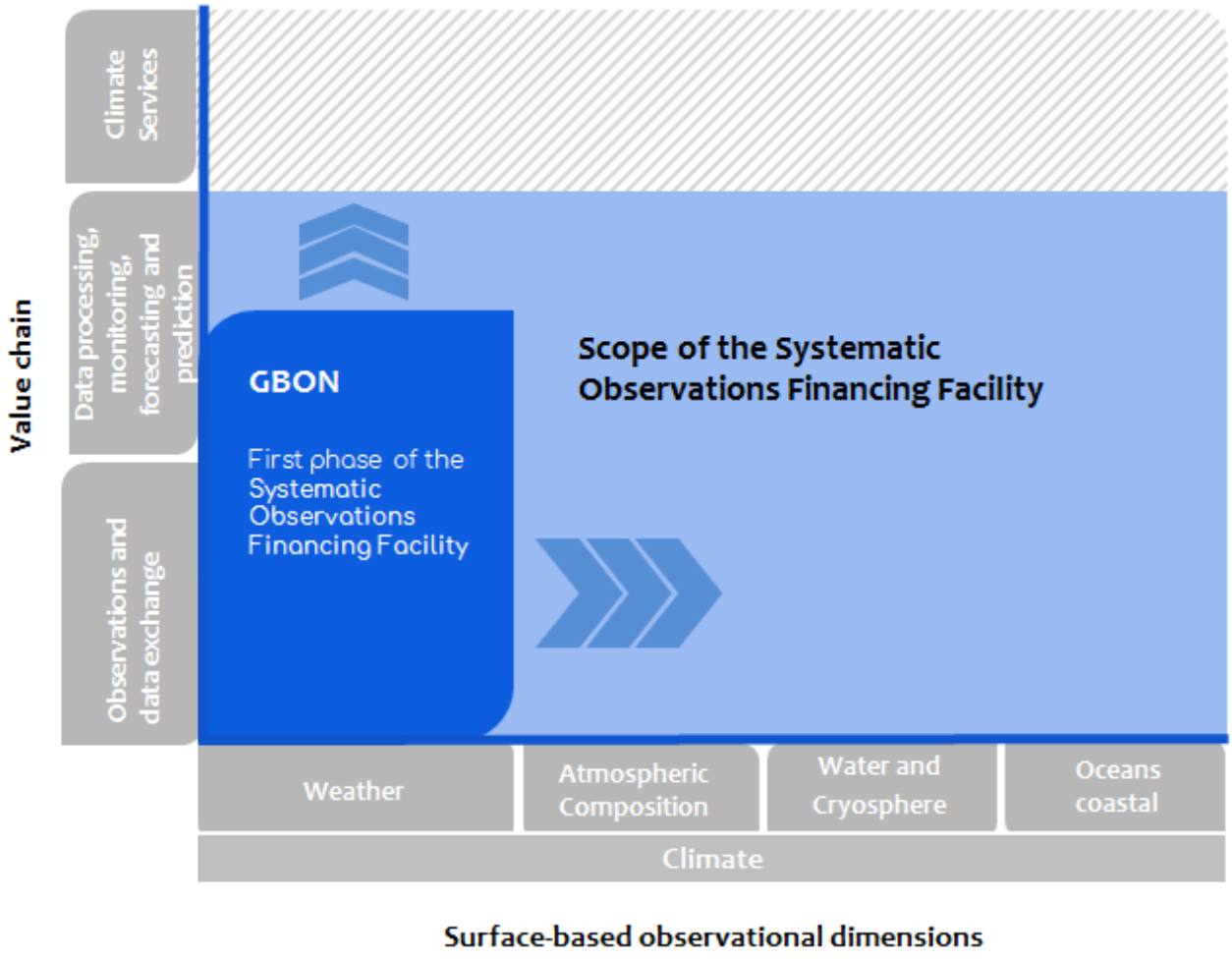


Figure 2. Scope of the Systematic Observations Financing Facility

- **The objective of the first phase of the facility is to achieve sustained GBON compliance in an equitable manner in developing countries.** In other words, the facility aims at turning the map into green by 2025 (see figure 1) by ensuring compliance with basic requirements for surface and upper-air observations required for the global NWP. At the same time, it will satisfy key requirements of the Global Climate Observing System (GCOS) for observations in support of climate analysis as they use the same models and data assimilation. GCOS is a co-sponsored programme that regularly assesses the status of global climate observations and produces guidance for its improvement. *See Annex 6 GCOS workshop presentation.*

- **The envisioned second phase of the facility, would cover the expanded surface-based observational dimensions as well as data processing, monitoring, forecasting and prediction** (see figure 2 above).

    - **Atmospheric composition** - Support the Integrated Global Greenhouse Gas Information System (IG3IS) to improve the quality of national greenhouse gas emission inventories based on atmospheric observations and analysis, as recommended by the 2019 Refinement of the IPCC Guidelines for National Greenhouse Gas Inventories.

    - **Water and cryosphere -** Support closing the gap in hydrological data collection, hydrological observing networks, free exchange of data, and capacity required to fulfill the operational requirements of the WMO Hydrological Observing System.

    - **Oceans -** Support future ocean observations in coastal region, necessary to considerably improve numerical weather models both in the short range (e.g. hurricane forecasts) and in the long range (e.g. droughts and connected food shortages, heat waves in mid latitudes).

- **The financing needs for the first phase, to achieve GBON compliance by 2025, correspond to $750 million.** *See Annex 8 workshop notes "What is it"*

4. Systematic Observations Financing Facility - How will it operate in the first phase?

- **The facility is expected to have three financing windows: technical assistance window, compliance window, and performance window.** *See Annex 9 workshop notes "How is it set up and funded"*

    - **The technical assistance window** covers observation gap assessment and observation infrastructure design and capacity development planning. It will assess "what does it take to turn green" (see figure 1 on current global status).

    - **The compliance window** finances infrastructure and capacity strengthening that is required to achieve sustained compliance with GBON requirements. It will "turn the dots green".

    - **The performance window** provides performance-based payments for operating and maintenance of the observing network. It will "keep the dots green". This would include covering costs of access to and use of NWP products developed by the GPC.

- **The facility will complement existing financing to strengthen developing country capacity on weather forecasts, early warning systems, climate services, and corresponding NMHS capabilities.** While the facility will fully fund GBON compliance and monetize the verification services and global value creation of developing country observations, all other activities on the weather and climate value chain will continue to be funded through "aid" development and climate finance resources. Through its funding, the facility will foster a coordinated and integrated approach to financing developing country's hydromet development, hence also substantially contribute to "aid" effectiveness and better use of scarce national and international public resources. *See Annex 10 workshop notes "How does it operate"*

- **The Facility will work in partnership within the broader institutional ecosystem of hydromet development**, including development and climate finance partners, WMO Country Support Initiative, WMO Infrastructure Commission, WMO Integrated Global Observing System (WIGOS) quality monitoring system, and WMO Secretariat. In collaboration with development partners, the facility will also explore opportunities to crowd in private sector resources. *See Annex 11 workshop note "How to operationalize it"*

- **The WMO Country Support Initiative will provide technical assistance in assessing "what does it take to turn green**". This will include cataloguing the institutional and technical

requirements and gaps, aiming at developing a standardized approach for GBON gap assessments across countries. The assessments will be done in collaboration with development and climate finance partners that prepare and implement projects to strengthen a country's hydromet capacity that have GBON compliance as one of the components.

- **The WMO Infrastructure Commission will approve the design of infrastructure and capacity strengthening required to achieve compliance with GBON requirements**. Based on this approval, the facility disburses resources to developing countries through development partners who act as implementing partners for the facility in order to "turn the dots green".

- **The WIGOS quality monitoring system will assess compliance**. It will provide the independent compliance monitoring function for the facility and certify if a country "keeps the dots green". Consequently, the facility disburses the performance-based payments to cover operating and maintenance costs of GBON.

5. Developing the Systematic Observations Facility - What are the milestones?

- **It is envisioned to launch the facility with initial contributions pledged at COP26 in December 2020**. In order to achieve this ambitious target, the concept for the facility needs to be speedily further developed, politically placed, and champion countries and partners need to be secured. *See Annex 12 workshop notes "How to position and develop it" and Annex 13 workshop notes "Milestones"*

- **Key milestones in 2019 are:**

  - **UN Climate Summit, September –** Seek inclusion of the need for a Systematic Observations Financing Facility in Summit outcomes

  - **World Bank Group Annual Meetings, October -** Launch of the Alliance for Hydromet Development and position the initial facility concept

  - **UNFCCC COP 25 Chile, December**
    - Ministerial event to present the initial concept of the Systematic Observations Financing Facility

  - Presentation of the facility concept at the Earth Observation day
  - Including the facility concept in the GCOS report to SBSTA

- **Key milestones in 2020 are:**

  - **World Economic Forum Annual Meeting, January –** present the facility and showcase the economic value of developing country observations in light with the SDGs, Sendai Framework and the Paris Agreement

  - **WMO Executive Council 72, June** – Approval of the detailed regulatory material establishing GBON mandatory elements

  - **UNFCCC COP 26, December** – Launch of the facility with initial contributions pledged.

6. Transitioning towards the Systematic Observations Financing Facility

- **As the facility is envisioned to be launched at COP 26, a transition period is envisioned.** WMO and its Country Support Initiative will support development and climate finance partners, including Multilateral Development Banks and the Green Climate Fund, in ensuring that their financing for observations responds to GBON requirements.

- **Once the facility is established, development and climate finance partners would refrain from financing the GBON dimension of hydromet development projects.** Their funding would then fully focus on weather, climate, hydrological, and environmental service delivery and corresponding strengthening of national capacities.

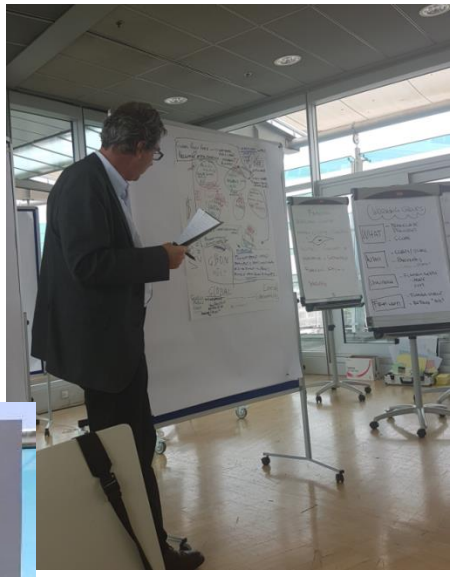
7. Next steps in further developing the concept of the Systematic Observations Financing Facility

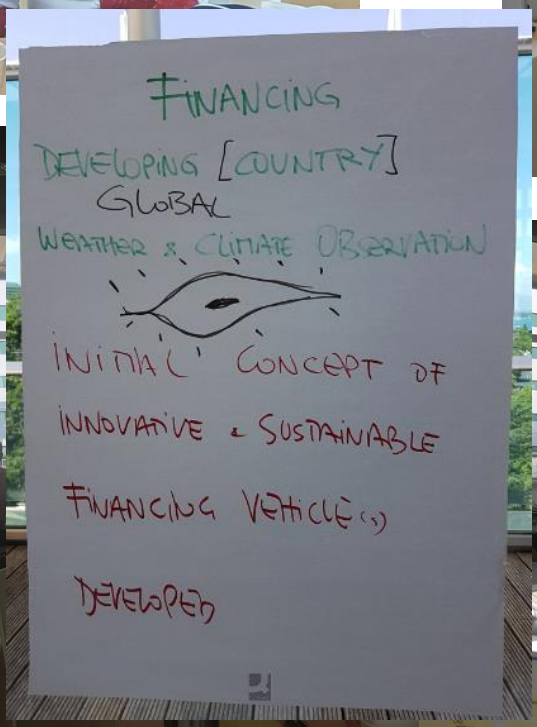
- Workshop participants agreed on the following short-term steps to further develop the concept of the facility. *See Annex 10 workshop notes "How to position and develop it"*

- **End-August 2019 -** WMO Secretariat to prepare a draft initial concept reflecting workshop outcomes, to be shared with workshop participants for feedback and comments

- **End-September** – Additional contributions related to economic analysis, global and local benefits and case studies to be developed by workshop participants and to be shared with WMO Secretariat. *See Annex 10 workshop notes "How to position and develop it" and Annex 11 workshop notes "Milestones"*

- **Mid-October 2019 –** Initial concept developed as input for World Bank Group Annual Meetings and the launch of the Alliance for Hydromet Development. The Alliance declaration is expected to include a commitment to seek innovative ways to finance developing country surface-based observations, through the creation of the Systematic Observations Financing Facility.




FINANCING
DEVELOPING [COUNTRY]
GLOBAL
WEATHER & CLIMATE OBSERVATION
INITIAL CONCEPT OF
INNOVATIVE & SUSTAINABLE
FINANCING VEHICLE(S)
DEVELOPED

Annexes

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Financing developing country weather and climate observation infrastructure in innovative and sustainable ways
18 - 19 July 2019
WMO Headquarters, Salle D (Attic, next to cafeteria)

1. Problem statement

Global threats and challenges related to climate change and the impact of adverse weather and related environmental events are rapidly increasing. **Any weather prediction and climate analysis effort undertaken for any area on the globe depends on continued access to a robust and reliable supply of observational data from the entire globe**.

Today, important observational data are missing in several parts of the world, this is especially true in developing countries, and in many cases this is directly traceable to the inability to invest in and sustain operations of needed observational infrastructure.

This lack of observational data significantly limits the quality of the information used by national and local governments as basis for important decisions related to the reduction of the impact of weather and climate events.

Local observations are of course important for local purposes, but the global impact of local observations means that they also contribute to the global public good by enabling weather prediction and climate analysis everywhere else on the globe. The wealthier developed nations therefore have an inherent interest in helping the less developed and the sparsely populated areas of the globe develop, operate and maintain robust observing systems.

In spite of very substantial investments made by various development partners, past efforts toward developing observational infrastructure in developing countries on a project basis generally have not led to sustained and measurable increases in the availability of observational data from these areas.

Innovative models of financing and operating basic operational systems are therefore needed.

Implementing comprehensive global observing systems that provide vital weather and climate observations from all areas of the globe will require substantial and sustainable investments in observing and data exchange systems and capability in developing countries. This in turn will require innovative financing models that go beyond the current form of providing finance via fragmented projects and instead move towards long term service-oriented funding models.

2. Opportunity

There are major opportunities to tackle the problem in a new and sustainable manner.

Availability of development and climate finance for developing country weather and climate observation infrastructure is rapidly increasing, in particular from the World Bank / IDA and the Green Climate Fund. This financing needs to demonstrate "value for money" and sustainability.

Taking advantage of WMO recent approval of the concept of a **Global Basic Observing Network (GBON), which will impose a set of observational data for which international exchange of data will be mandatory at set**, we aim to move quickly to develop an initial concept of a new vehicle to close the observation gap.

This vehicle would **provide sustainable financing for weather and climate observations in developing countries** unable to shoulder this burden on their own, in many cases due to low GDP relative to geographic area. It would recognize and monetize the immense value of these observations to the entire global community.

This initial concept would be introduced at upcoming opportunities, including UN Climate Summit, coalition of finance ministers for climate action, and UNFCCC COP25, in order to start building support for such a vehicle.

3. Workshop expected outcome

Initial concept of innovative and sustainable financing vehicle developed.

4. Workshop approach

This is going to be highly interactive, "joint thinking" workshop.
While the workshop will be co-facilitated by Lars Peter Riishojgaard and Markus Repnik from the WMO Secretariat, all participants are expected to actively contribute in order to achieve the expected outcome.
The WMO Secretariat will capture the results of the discussion and in consultation with workshop participants produce an initial joint concept of the financing vehicle.

5. Participants

- **Vladimir Tsirkunov**, World Bank / GFDRR Hydromet Lead Specialist
- **Daniel Kull**, World Bank / GFDRR Senior Disaster Risk Management Specialist
- **Joseph Instiful**, Green Climate Fund Lead Specialist EWS and Climate Information Services
- **Urvaksh Patel**, Green Climate Fund Accredited Entity Specialist responsible for WMO
- **Phil Evans**, UK Met Office Chief Operating Officer
- **Nyree Pinder**, UK Met Office Global Partnerships Manager

- **John Harding**, Head CREWS Secretariat
- **David Richardson,** European Center for Medium Range Weather Forecasts Head of Evaluation
- **Erik Andersson**, European Center for Medium Range Weather Forecasts / European Commission
- **Carolin Richter**, Director Global Climate Observing System Secretariat
- **Michael Staudinger**, WMO President Regional Association VI, Europe
- **Daouda Konate**, WMO President Regional Association I, Africa
- **Rob Varley**, Invited senior expert
- **Elena Manaenkova, WMO Deputy Secretary-General**
- **Pavel Kabat**, WMO Secretariat Chief Scientist and Director Research
- **Fernando Belda**, WMO Secretariat Director Observing and Information Systems Department
- **Rob Masters**, WMO Secretariat Director Cabinet and External Affairs
- **Paolo Ruti, WMO Secretariat World Weather Research Programme**
- **Dominique Berod,** WMO Secretariat Chief Basic Systems in Hydrology
- **Jean-Baptiste Migraine,** WMO Secretariat Climate Prediction and Adaptation Branch
- **Joseph Mukabana**, WMO Secretariat Development and Regional Activities
- **Milan Dacic**, WMO Representative for Europe
- **Mario Peiro Espi,** WMO Secretariat, IG3IS Office / Research Department
- **Leontine Kanziemo**, WMO Secretariat Development Partnerships Office
- **Lorena Santamaria**, WMO Secretariat Development Partnerships Office
- **Tamara Comment**, WMO Secretariat Development Partnerships Office
- **Lars Peter Riishojgaard**, WMO Secretariat GBON and WIGOS project manager
- **Markus Repnik**, WMO Secretariat Director Development Partnerships

Annex 2: GBON executive summary

THE WMO GLOBAL BASIC OBSERVING NETWORK- GBON

ABOUT GBON

Reliable weather forecasts and climate analyses are essential for public services that help save lives, protect property and foster economic prosperity. This is all made possible by continued access to a wealth of real-time environmental observations from the entire globe.

Whilst many regions provide a reliable feed of observational data, some areas under-report or have a sub-optimal observing network density. Recognizing the essential role played by these observations, the World Meteorological Organization (WMO) has recently (June 2018) decided to proceed with the design of a Global Basic Observing Network (GBON), to be proposed to its Members for approval at the 18th World Meteorological Congress in 2019. This rapid development cycle is testament both to the importance and to the urgency of resolving these issues.

The provisions within the GBON design are based on up-to-date observational requirements for global Numerical Weather Prediction (NWP) as defined by technical experts working under the WMO Commission for Basic Systems and the Global Climate Observing System. Drawing on 20 years of NWP observational data impact studies coordinated by WMO, the provisions specify - in clear, quantitative terms - the obligations of WMO Members to acquire and exchange these critically needed observations: which parameters to measure, how often, at what horizontal and vertical resolution, and which measurement techniques to use.

BACKGROUND

Global Numerical Weather Prediction - where does the weather and climate data come from?

Since the early 1960's, WMO has coordinated the acquisition and international exchange of meteorological observations in support of weather and climate services worldwide via the Global Observing System of its World Weather Watch Programme.[1]

1 To predict the weather, modern meteorology depends upon the near-instantaneous exchange of weather information across the entire globe. Established in 1963, the World Weather Watch - the core of the WMO Programmes - combines observing systems, telecommunications facilities, and data-processing and forecasting centres operated by Members to make available the meteorological and related environmental information needed to provide efficient services in all countries.

Since that time, the advent of high performance computing and other advanced technologies has transformed weather forecasting from a manual, local task into a globally connected, quantitative process. Complex computer simulations are now routinely fed with millions of measurements provided by a plethora of instruments in space, in the air, based on land, or on in the ocean.

All of today's quantitative weather forecast and climate analysis products - even down to the finest local scales and immediate "nowcasting" time ranges - ultimately rely on global-scale NWP. This therefore acts as a backbone for everything that a modern weather and climate service does.

Global NWP systems are large-scale undertakings: millions of lines of computer code running on some of the fastest supercomputers available, ingesting tens of millions of observations every day. They require gigabit communication lines and petabytes of storage capacity, and typically have hundreds of staff developing, testing, running and diagnosing them. Reliable, real-time access to observational data from the entire globe is critical to the quality of the output from these systems.

Satellites provide global coverage and can measure parameters for both atmosphere and surface, and satellite data make a very substantial contribution to forecast skill. However, global NWP systems still have a critical reliance on surface-based observations for certain key parameters that cannot yet be reliably measured from space: in particular atmospheric surface pressure, the vertical distribution of winds and sub-surface ocean parameters. Surface-based observations are essential over land, over snow and ice surfaces, and they continue to play important roles for calibration and validation of space-based data.

Whilst space agencies provide millions of observations daily to global NWP, substantially improving forecast skill, this is no excuse for WMO Members to neglect their responsibilities for operating and exchanging data from surface-based observing networks. Any lack of observations over one area is known to negatively impact the quality of the forecast and analysis products, not only in the area of missing data but elsewhere on the globe as well. Missing or non-reporting stations, glitches in telecommunication, or excessively restrictive national data policies thus all have an adverse impact both locally and globally. Such gaps in coverage amount to lost opportunities for National Meteorological and Hydrological Services (NMHSs) to deliver the best possible warning and monitoring information to their constituencies.

CURRENT STATUS

The international exchange of observations in meteorology has a long history and has evolved significantly over time. The most frequently cited articulation of WMO policy on this is found in Resolution 40, adopted by the 11th World Meteorological Congress in 1995, and codified in WMO Publication 644, the Manual on the Global Observing System. However, both Res. 40 and WMO 644 arguably fall short of their intended goal by not specifying "hard numbers" for Members to comply with.

This problem has been further exacerbated by the lack of sustained real-time monitoring of data delivery, and by the decision of WMO to leave it to its six Regions - and thus ultimately to individual Members - to specify their requirements and design and implement their own networks accordingly. The lack of a clearly articulated global design and the absence of global compliance monitoring have led to an unrealistic, inflated perception of compliance among the WMO Members, and it has allowed persistent inhomogeneity across in the globe in the volume of observations internationally exchanged.

Figure 1. Surface land pressure observations received by one or more GNWP centres (DWD, ECMWF, JMA or NCEP) on June 17 2018, 18Z; fully reporting stations shown in green, partly reporting stations in orange, minimally functioning stations in red, silent (non-reporting) stations in black.

The WMO Integrated Global Observing System (WIGOS) has recently developed a Data Quality Monitoring System, by which data delivery to four global NWP centres is now monitored around the clock, in near-real time. The figure 1 above shows a typical example of the current data availability as measured by the System. The inhomogeneity across the globe in both network density and reporting practice is striking, and the large data voids (areas without any dots on the map), and the prevalence of dots shown in colours other than green both amount to significant lost opportunities to provide better services.

MEMBERS COMPLIANCE WITH GBON

→THE NUMBERS

WMO Members can be divided into three broad categories, in terms of expected compliance with GBON and its impact on national observing and data sharing practices:

I. Those already compliant with the proposed GBON provisions. This group is estimated to include roughly 20-25% of the Members. There is no significant impact to those Members, other than the positive of receiving more observations and better products.

II. Those currently not in full compliance but who already have data that - if internationally exchanged - would make them compliant with GBON. This group of countries is estimated to include 25-30% of the Members. However, since some of the largest countries in the world fall in this group, it represents a much larger proportion in terms of land area. The main impact on this group is likely to be either on data policy or on telecommunication, depending on the country in question, and is expected to be mostly minor.

III. Those currently not in a position to comply with GBON due to lack of resources. This group includes many developing countries, perhaps half of all WMO Members. In order for GBON to be successful, these Members will need international assistance, in some cases on an interim basis, while in other cases semi-permanent mechanisms will need to be developed.

NATIONAL IMPACT OF GBON: ROLE OF INTERNATIONAL DEVELOPMENT EFFORTS

Overall, the most significant impact of GBON is expected to be a major strengthening of global observational data availability, with all that will follow in terms of availability of better products and services at global, regional, national and local levels. However, it must also be acknowledged that with GBON come new, or at least more clearly articulated obligations that will require additional effort by some Members.

Most, if not all, of the countries belonging to the third group shown above are either current or potential targets for various types of internationally funded development projects, either of a bilateral nature or through multilateral finance mechanisms. If designed and implemented appropriately, these projects could contribute substantially to the GBON implementation. This would be especially valuable in data-sparse areas where the additional observations would make a marked impact on global NWP, and therefore on forecast quality.

Many internationally funded, observations-related development projects are "country-driven". They are based on national weather and climate risks, observing capabilities and national desires to improve them, and the unique capabilities and needs of individual NMHSs. To some extent this approach is politically driven, and therefore it may not be easy to change. However, it risks ignoring the inherently trans-boundary nature of weather and climate, both in their manifestations and in the activities we as humans need to undertake when trying to understand and predict them. Many of the obstacles to effective weather and climate information service provision - especially in relation to observations - are characterized far less by national uniqueness than they are by global commonality.

Access to high-quality NWP products and reliable climate analyses is foundational to any modern weather or climate service, and ensuring that the NWP systems are fed by comprehensive sets of reliable observations is therefore in the self-interest of these same services. However, since the link between local observations and the local quality of NWP outputs is often poorly understood, especially in NMHSs in some developing countries, data delivery from these countries often falls short. When designing projects, it should therefore be the responsibility of the international development community - and certainly of WMO whenever it is involved - to ensure that the requirements for global NWP are addressed, alongside any local requirements of the countries concerned. At the same time, the NMHS should be supported to identify and, if possible, quantify the national benefits of international data exchange, in terms of both improved services and increased economic productivity.

In terms of staff, the WMO Secretariat is a relatively small organization, so it is unrealistic to expect that it can be directly involved in all capacity development projects with observing components. However, where possible, the Organization should seek to implement framework agreements with the major funding agencies and implementing partners, under which the GBON regulatory material would be used in project design, implementation and evaluation.

Many projects struggle to clearly demonstrate their impact, and often this is directly tied to a lack of helpful metrics defined at the outset and incorporated in project results frameworks. However, since WMO will monitor GBON data delivery 24/7, incorporating GBON standards into projects offers the opportunity to define simple, quantitative metrics of success that are directly linked to end user benefits. Monitoring will include overall "colour of the dots on the map", along with performance by station, by station type, by country, including averages, trends, etc. So a very simple measure of the impact of a given project could be, for instance, a "before and after" map display of GBON data delivery.

SUMMARY AND CONCLUSION

With the implementation of GBON, WMO is poised to take an important step in improving observational support for critical global NWP and climate analysis systems. In large parts of the developed world, GBON requirements are already met, and in other parts they will be easy - or at least not overly onerous - to meet. However, in many developing countries they will be impossible to meet using current national resources alone. Fortunately, the international community is ready to help, as evidenced by the sheer number of currently ongoing or imminent development projects involving observing systems.

Many of these projects tend to be designed individually, without mutual coordination or a common strategy, even though meteorology by its very nature lends itself best to a global approach. If accepted in the development community, GBON could fill a void by helping to guide projects toward solutions that address both global and local needs.

As a component of WIGOS, GBON comes with robust technical monitoring and management systems and tools, which could be used to track the impact of individual projects. Shifting project design and evaluation metrics from “number of observing stations purchased and installed” to “number of observations delivered in real-time to global NWP” may have its challenges; but to do so could well turn out to be truly transformational not just for the WIGOS but for all stakeholders in the Global Weather Enterprise.

Annex: Proposed GBON initial requirements specification

This specification has been prepared based on advice from the main Global NWP Centres. If adopted, it will be updated regularly as observations requirements continue to evolve.

For all GBON platforms listed above, Members SHALL disseminate what is observed (and available for dissemination) up to a resolution of 15 km horizontally and hourly temporally (the current goal requirements for Global NWP).

Annex 3: Congress resolution on Alliance for Hydromet Development and WMO Country Support Initiative

World Meteorological Organization
WORLD METEOROLOGICAL CONGRESS
Eighteenth Session
Geneva, 3 to 14 June 2019

Cg-18/Doc. 8.3
Submitted by:
Chair
14.VI.2019
APPROVED

AGENDA ITEM 8: **CAPACITY DEVELOPMENT**

AGENDA ITEM 8.3: **Scaling-up effective partnerships for investment**

DRAFT RESOLUTION

Draft Resolution 8.3/1 (Cg-18)

CLOSING THE CAPACITY GAP
SCALING UP EFFECTIVE PARTNERSHIPS FOR INVESTMENTS IN SUSTAINABLE AND COST-EFFICIENT INFRASTRUCTURE AND SERVICE DELIVERY

THE WORLD METEOROLOGICAL CONGRESS,

Acknowledging:

(1) That according to the World Economic Forum 2019 Global Risks Report, the world's top four risks are weather, climate and water related. These risks and the growing challenges place WMO and its Members centre stage as regards sustainable development and climate action, as reflected in the vision of the WMO Strategic Plan,

(2) That increasing weather, climate and water-related risks require Members and development partners to scale up and increase effectiveness and sustainability of investments for high quality weather, climate, hydrological and environmental services, and enhance cooperation and synergies with all UN Agencies and other bodies for sustainable development,

(3) That the effective implementation of investments to improve weather, climate and water services requires effective coordination and commitment with users to enable the joint design and development of specific products and services, through the Global Framework for Climate Services (GFCS), for example, to ensure the sustainability of investments and adapt interventions to the ends,

Recalling:

(1) Resolution 49 (Cg-16) WMO Capacity Development Strategy, particularly Objective 4, which calls on WMO to actively explore new funding opportunities and develop proposals through dialogue with stakeholders and development partners,

(2) Resolution 3(1)/1 (Cg-18) WMO Strategic Plan and particularly Strategic Objective 4.3, which calls for closing the capacity gap on weather, climate, hydrological and related environmental services through effective partnerships,

(3) Recent Regional Associations' decisions (RA I-17, RA III-17, RA V-17) that request the Secretary-General to scale up support to strengthen NMHSs' infrastructure, capacity, and service delivery through the establishment of effective partnerships, including with the Green Climate Fund and the World Bank; and to increase diversification of WMO country support mechanisms, including the WMO Country Support Initiative (CSI),

(4) The 2019 Cairo Declaration of the African Ministerial Conference on Meteorology, welcoming the creation of the Alliance for Hydromet Development and the WMO Country Support Initiative and committing to mobilize financial and political support to enhance national and regional capacity to perform the public service mandate of meteorological and hydrological services,

Welcoming the announcement of the World Bank together with WMO to jointly create the Alliance for Hydromet Development, made at the World Bank Group Annual Meetings 2018,

Further acknowledging the declaration by the Presidents of the Regional Associations stating the importance of the Country Support Initiative to increase WMO responsiveness in addressing Members' needs and strengthening their capacity and looking forward to the launch of the initiative,

Decides:

(1) To pursue the establishment of the Alliance for Hydromet Development, jointly with the World Bank and in collaboration with a larger group of international development partners, for increased and more effective and sustainable development assistance in support of developing Member countries and territories, based on the concept outlined in Annex 1;

(2) To establish the WMO Country Support Initiative, as a complementary vehicle to support developing Member countries and territories and development partners in translating the commitment of the Alliance for Hydromet Development into practice. The Initiative will provide advisory services aimed at increasing effectiveness of investments in weather, climate and hydrological services, as outlined in the Annex 2 to this resolution;

Invites all Members:

(1) To promote the principles of collaboration that underpin the Alliance for Hydromet Development when providing or receiving development assistance in support of weather, climate and hydrological services;

(2) To scale up the provision of expertise through the WMO Country Support Initiative to support developing Member countries and territories and their development partners, including using existing WMO information infrastructures such as the expert database of the WMO Community Platform;

Invites further Development Partners:

(1) To partner with WMO and the World Bank in pursuing the establishment of the Alliance for Hydromet Development and associated principles;

(2) To utilize and promote the advisory services provided by WMO Members through the WMO Country Support Initiative so that projects in support of weather, climate and hydrological services benefit from WMO standards and good practices and contribute to strengthening integrated global-regional-national WMO systems, in line with the Agenda 2030 and the Sustainable Development Goals, the Sendai Framework for Disaster Risk Reduction and the Paris Agreement;

Requests Technical Commissions:

(1) To provide technical guidance to the Country Support Initiative in translating WMO standards into operational advice tailored to the needs of developing Member countries and territories;
(2) To consider the practical experience gained through the implementation of the WMO Country Support Initiative when further developing technical standards;

Requests Regional Associations:

(1) To provide regional guidance to the Country Support Initiative in translating WMO knowledge and expertise into operational advice tailored to the needs of developing Member countries and territories;

(2) To take advantage of the Country Support Initiative for achieving regional priorities

Requests the Executive Council

(1) To follow the implementation progress of the CSI framework and the Alliance for Hydromet Development;

(2) To ensure that the CSI and other WMO activities which support capacity development are complementary and take into consideration the unique national context of Members;

(3) To take further actions to support the implementation of the CSI and the Alliance for Hydromet Development, as needed, and report to Congress;

Requests further the Secretary-General:

(1) To facilitate the establishment of the Alliance for Hydromet Development in collaboration with the World Bank and other development partners;

(2) To mobilize extra-budgetary resources and Members' expertise to enable the implementation of the Country Support Initiative.

Annexes: 2

Annex 1 to draft Resolution 8.3/1 (Cg-18)

CONCEPT FOR THE ALLIANCE FOR HYDROMET DEVELOPMENT

Global threats and challenges related to climate change and the impact of adverse weather events are rapidly increasing, yet developing countries face major capacity constraints to respond to growing demands for reliable high-quality weather, climate, hydrological, marine and environmental services. While many development partners are contributing to hydromet development[1] and strengthening national capacities, uncoordinated investments have led to a fragmented flow of projects funded by development partners, often resulting in a patchwork of observation infrastructure and technologies that are impossible for NMHSs to sustain.

The Alliance for Hydromet Development is expected to create a shared commitment between WMO and major development partners to scale up and increase effectiveness of development cooperation for high quality weather, climate, hydrological, marine and environmental services.

The Alliance is expected to be guided by principles of collaboration along the lines outlined below: Members of the Alliance commit to:

- **Align efforts to achieve commonly shared hydromet development targets.** Drawing from the WMO Strategic Plan 2020-2023 and major international agreements – Agenda 2030 and its Sustainable Development Goals, Paris Agreement, and Sendai Framework for Disaster Risk Reduction – the Alliance will establish a limited number of high-level hydromet development targets. These targets will guide hydromet development cooperation. Progress on achieving these targets will be measured.

- **Jointly develop a "hydromet gap" flagship report.** This regular and increasingly refined report will provide the analytical underpinning of the Alliance and measure progress in closing the gap.

- **Strengthen inter-connected WMO operational systems through well-coordinated projects.** Today, very important observational data are missing, especially in developing countries. This lack of well performing observation infrastructure limits prediction and understanding of weather and climate patterns across the globe. Members of the alliance will strengthen integrated national, regional, and global WMO operational systems in a coordinated manner.

- **Provide adequate resources for hydromet development** in line with the Addis Ababa Action Agenda on Financing for Development,[2] in particular its action area on international development cooperation. Members of the Alliance will dedicate an adequate share of development and climate finance to strengthen hydromet capacity.

- **Increase effectiveness and sustainability of hydromet investments** in accordance with internationally agreed principles of development effectiveness.[3]

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1 The term "hydromet investments" refers to investments that strengthen meteorological, climatological, and hydrological capacity and services.

2 Addis Ababa Action Agenda of the third International Conference on Financing for Development. Available at: https://www.un.org/esa/ffd/wp-content/uploads/2015/08/AAAA_Outcome.pdf

3 The Busan Partnership for Effective Development Cooperation, June 2012. Available at: http://www.oecd.org/dac/effectiveness/Busan%20partnership.pdf

The WMO Country Support Initiative (CSI) will support the Alliance for Hydromet Development. While the Alliance will create the commitment, the CSI will provide objective technical advice to the members of the Alliance, including on the design of hydromet-related projects based on WMO requirements, regulatory material, standards, and good practices. The initiative will also undertake a continuous and strategic country project mapping, spearhead the creation of the "one-stop-shop" hydromet knowledge platform, and support the development of the "hydromet gap" global flagship report.

The CSI will support development partners in the design of hydromet-related projects based on WMO requirements, regulatory material, standards and good practices. An important aspect of this support is to provide guidance for investments to ensure integration across two areas - integration of country-level investments within WMO regional and global systems, and integration of individual projects into broader country-led programmes

The Alliance for Hydromet Development represents a commitment, it is not an institution. The Alliance will have an open architecture. All development partners committed to strengthen meteorological, climatological, and hydrological capacity and services and willing to adhere to the collaboration principles of the Alliance are invited to join.

The Alliance does not require additional funding for its functioning. As part of its regular work, the WMO Development Partnerships Office will facilitate communication of and within the Alliance and coordinate with the CSI Secretariat on its support to the members of the Alliance. The members of the Alliance will meet on the occasion of the World Meteorological Congress to take stock and discuss how to further increase the ambition level of the Alliance to respond to growing challenges.

The creation of the Alliance has been spearheaded by the WMO Secretariat and the World Bank. It emerged as an outcome of the second hydromet Development Partners Conference that took place in March 2018. The conference agreed that progress made since the first such conference in 2016 was not sufficient and explored ways to move beyond business as usual. At the World Bank Group Annual Meetings in October 2018, the World Bank Vice President and WMO Secretary-General announced their commitment to create the Alliance with an expected launch at the next Annual Meetings in October 2019.

Annex 2 to draft Resolution 8.3/1 (Cg-18)

WMO COUNTRY SUPPORT INITIATIVE

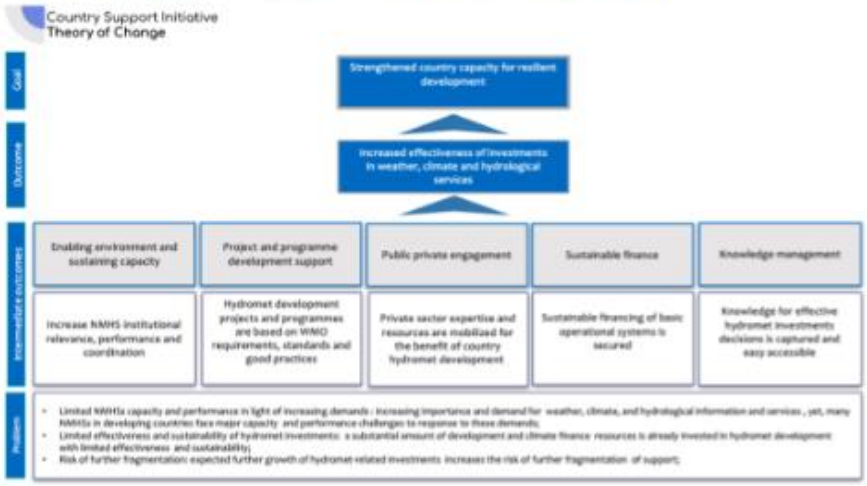
The World Meteorological Organization (WMO) Strategic Plan 2020-2023 puts strengthening Member capacity centre stage. Scaling up effective partnerships for investments in sustainable and cost-efficient infrastructure and service delivery is a strategic objective of this Plan.

While a sizeable amount of development and climate finance resources has been invested in hydromet development,[4] experience has shown that effectiveness and sustainability of these investments has been rather limited. The increasing weather, climate, water and related environmental challenges and consequent expected growth of hydromet-related investments makes increasing effectiveness of these investments a prime development agenda.

The Country Support Initiative (CSI) is forming a "high ambition coalition" with the objective to increase the effectiveness of investments in weather, climate, and hydrological services. The CSI will complement and leverage existing initiatives and funding mechanisms. It will function, on a voluntary basis, as an initiative of like-minded partners. It will provide demand-driven, objective and rapid response advice to developing countries and development partners.

The CSI is a building block of the Alliance for Hydromet Development. While the Alliance will create the commitment, the CSI will provide technical support. The Alliance is being established by WMO and the World Bank in collaboration with international development partners. The Alliance is expected to create a shared commitment and mutual accountability between WMO and development partners to scale up and increase effectiveness of development cooperation for reliable weather forecasts, early warning systems, and climate services.

The CSI will support developing countries and development partners in five inter-linked areas to increase effectiveness of hydromet investments:



[4] The term "hydromet development" refers to investments that strengthen meteorological, climatological, and hydrological capacity and services.

The CSI will create a "one-stop-shop" hydromet knowledge platform and support the development of a regular "hydromet gap" global flagship report. The knowledge platform will include country baseline information, hydromet project mapping, gap analysis and good practices. The information collected and generated will be made available to all countries and development partners, taking advantage of and contributing to the upgraded WMO Country Profile Database. Based on this information, the "hydromet gap" flagship report will provide an increasingly refined analysis of the state of hydromet development, targeting most senior level decision makers. The report will provide analytical underpinning for the members of the Alliance for Hydromet Development to jointly close the financial and effectiveness gaps.

The CSI will create an enabling environment for and sustain the capacity of National Meteorological and Hydrological Services (NMHS). It will support NMHSs on performance and compliance assessments aligned to WMO standards, development of strategic plans, and resource mobilization and coordination of development partners' support.

The CSI will support development partners in the design of hydromet-related projects based on WMO requirements, regulatory material, standards and good practices. An important aspect of this support is to provide guidance for investments to ensure integration across two areas - integration of country-level investments within WMO regional and global systems, and integration of individual projects into broader country-led programmes.

The CSI will support public-private engagement and facilitate mobilization of private sector expertise and resources for the benefit of hydromet development in developing countries. In June 2018, EC-70 adopted the WMO Policy Framework on Public-Private Engagement. The CSI will support interested countries in translating this framework into practice.

The CSI will contribute to more sustainable approaches to financing basic operational systems. This includes developing options for innovative financing models. Innovative finance needs to address the perennial sustainability issue of investments in and maintenance of operational systems, consider the global public good of observations, and incentivize NMHSs' performance, service delivery and open data exchange that is vital to the global system.

At the heart of the CSI is a multi-partner core delivery team. It is comprised of staff from core delivery partners, i.e. staff from NMHSs committed to join the CSI through the provision of adequate human resources, complemented by staff from the WMO Secretariat. The core delivery team is responsible for delivering CSI assignments.

For each assignment, a CSI assignment team is assembled by the CSI Secretariat in coordination with the core delivery team. Creation of the respective CSI assignment teams will consider delivery partners' competencies, geographic and thematic experiences, resources, and linguistic skills. The assignment team is responsible for assignment planning, timely and quality delivery, and reporting on the respective CSI assignment. Each assignment team will be comprised of at least two core delivery partners to combine knowledge and experience, foster joint learning, and ensure objectivity..

A small CSI Secretariat is created to administer the CSI, coordinate implementation of CSI activities, and ensure overall CSI communication and reporting. The CSI Secretariat is accountable to the CSI funding partners and is hosted by the WMO Secretariat in Geneva under WMO management and applicable policies and procedures.

An Independent Technical Advisory Group will provide technical advice to the CSI Secretariat, as requested. The group will advise on the composition of the assignment team, risk management, quality assurance of services and handling potential conflict of interest

situations. The group will comprise top-notch experts from WMO, and international development and research communities.

A donor trust fund will be established to receive financial contributions from CSI funding partners. To become operational, the CSI requires a minimum funding of USD 10 million for its initial phase of up to three years. The CSI provides an opportunity for bilateral development partners to leverage their funding. The WMO Secretariat will serve as the trustee of the CSI trust fund. The CSI trust fund will be administered in accordance with WMO financial rules, policies and procedures and will allow for transparent monitoring and reporting and traceability of financial contributions.

A CSI steering committee will serve as the decision-making body for the CSI activities delivered under the donor trust fund and guide the overall direction of the CSI. The steering committee comprises decision-making members (funding partners) and observers. Observers would include representatives from core delivery partners, WMO technical commissions and regional associations, as well as the trustee, the CSI Secretariat host, and the chair of the WMO Capacity Development Panel.

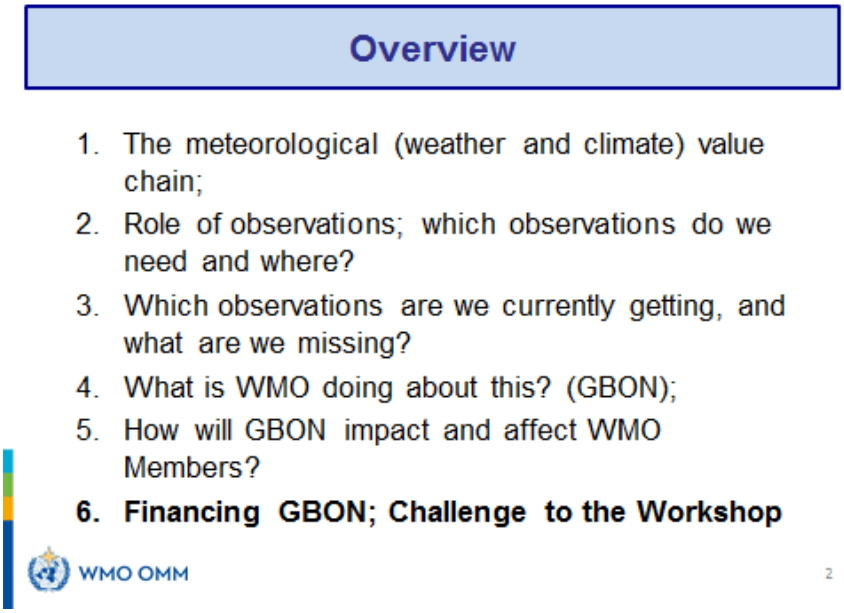
CSI delivery partners will provide advisory services on a cost recovery basis. Basic services up to agreed thresholds are funded through the donor trust fund, i.e. are at no cost for clients, albeit co-funding is encouraged. Additional advisory services requested beyond these thresholds are fully financed by the clients.

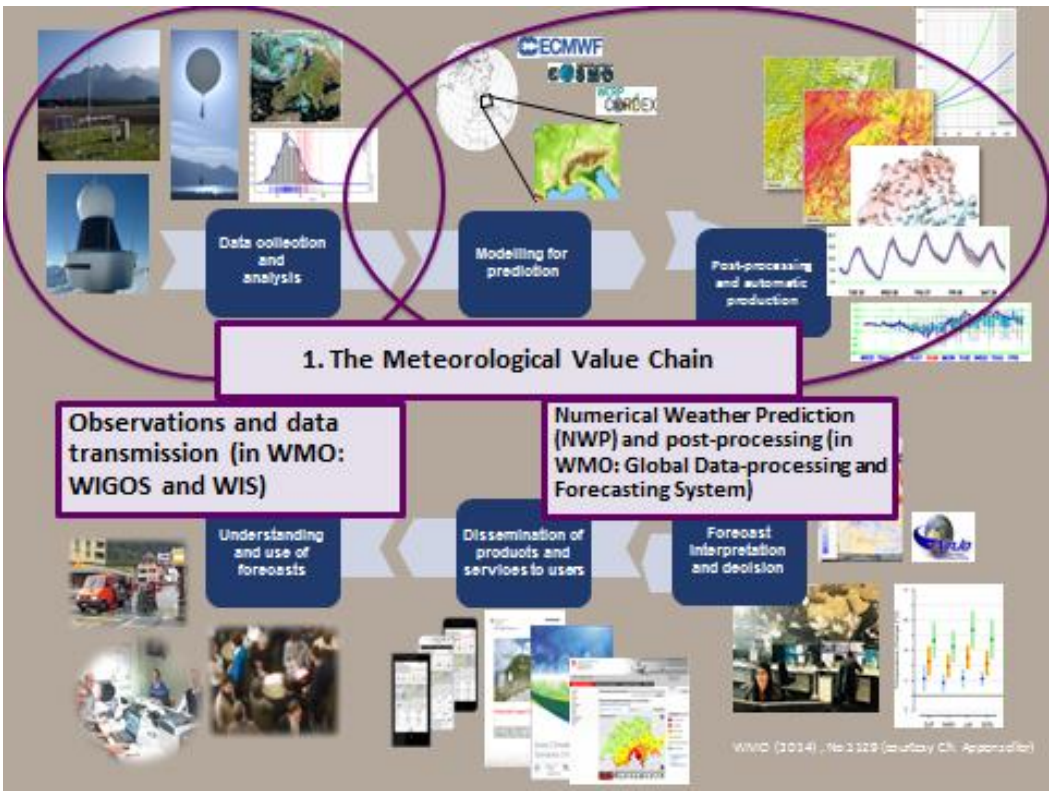
The CSI is expected to be implemented in an action learning manner. The areas of intervention and the Theory of Change provide the scope and the results framework. Implementation experience will be systematically captured and guide the refinement and scaling up of CSI operations. Each CSI assignment will be evaluated by the client, an annual CSI self-evaluation will be undertaken, and an independent external evaluation of the CSI is planned after two years of CSI operation to further shape and scale up the initiative after its initial phase.

The creation of the CSI has been spearheaded by the WMO Secretariat in collaboration with a growing number of committed NMHSs and development partners. The WMO Secretariat is expected to support implementation of the CSI in three ways, serving as trustee of the CSI trust fund, hosting the CSI Secretariat, and contributing to the delivery of CSI assignments.

[Full Concept Note of the WMO Country Support Initiative is provided in Cg-18/INF. 8.3]

Annex 4: GBON workshop presentation





WMO Application Areas listed in the RRR (July 2019)

1. **Global numerical weather prediction**
2. High-resolution numerical weather prediction
3. Nowcasting and very short range forecasting
4. Seasonal and interannual forecasting
5. Aeronautical meteorology
6. Forecasting atmospheric composition
7. Monitoring atmospheric composition
8. Atmospheric composition for urban applications
9. Ocean applications
10. Agricultural meteorology
11. Hydrology
12. **Climate monitoring**
13. **Climate applications**
14. Space weather

Global NWP: direct support to AA's 2-13

Many climate activities depend strongly on NWP through use of reanalysis

WMO OMM

What is NWP?

Zonal wind:

$$\frac{\partial u}{\partial t} = \eta v - \frac{\partial \Phi}{\partial x} - c_p \theta \frac{\partial \pi}{\partial x} - z\frac{\partial u}{\partial \sigma} - \frac{\partial(\frac{u^2+v^2}{2})}{\partial x}$$

Meridional wind:

$$\frac{\partial v}{\partial t} = -\eta \frac{u}{v} - \frac{\partial \Phi}{\partial y} - c_p \theta \frac{\partial \pi}{\partial y} - z\frac{\partial v}{\partial \sigma} - \frac{\partial(\frac{u^2+v^2}{2})}{\partial y}$$

Temperature:

$$\frac{\delta T}{\partial t} = \frac{\partial T}{\partial t} + u\frac{\partial T}{\partial x} + v\frac{\partial T}{\partial y} + w\frac{\partial T}{\partial z}$$

Precipitable water:

$$\frac{\delta W}{\partial t} = u\frac{\partial W}{\partial x} + v\frac{\partial W}{\partial y} + w\frac{\partial W}{\partial z}$$

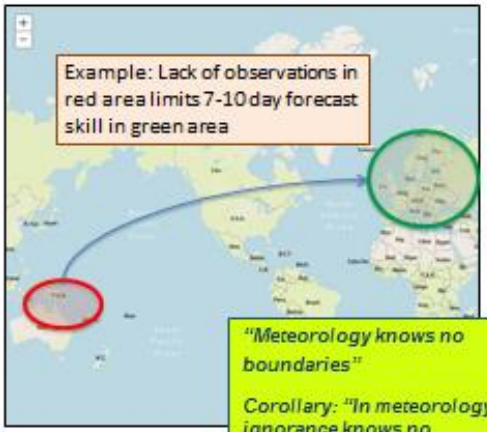
Pressure thickness:

$$\frac{\partial}{\partial t}\frac{\partial p}{\partial \sigma} = u\frac{\partial}{\partial x}x\frac{\partial p}{\partial \sigma} + v\frac{\partial}{\partial y}y\frac{\partial p}{\partial \sigma} + w\frac{\partial}{\partial z}z\frac{\partial p}{\partial \sigma}$$

The act of solving (on a computer) predictive non-linear partial differential equations for ***wind***, ***temperature***, ***humidity*** and ***surface pressure***, based on initial conditions provided by **observations.**

WMO OMM

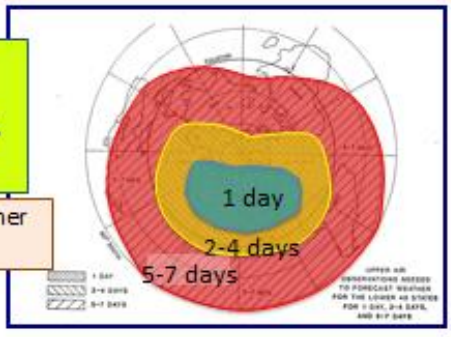
2. Role of observations



- Lack of observations severely limits efforts to understand and predict weather and climate patterns**, both locally and globally**;
- Weather prediction beyond 3-4 days **for any location on the globe** requires observations from the whole world.

"Meteorology knows no boundaries"

Corollary: "In meteorology, ignorance knows no boundaries"

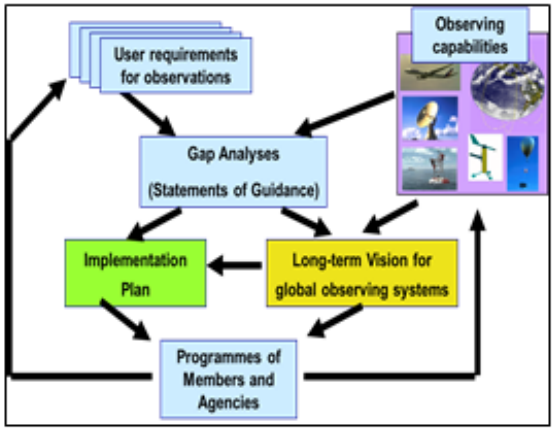


Required coverage of observation for weather prediction over CONUS at various ranges.

WMO OMM

Rolling Review of Requirements (RRR)

- The RRR is the process used by WMO to collect, vet and record **observational user requirements** for all WMO application areas and match them against observational capabilities
- Large body of work done by WMO Expert Teams, e.g IPET-OSDE;
- NWP and climate analysis supported by WMO Impact Workshops (Sedona 2012, Shanghai 2016, etc.)., involving entire global NWP community;
- Result: ***Quantitative requirements*** for observations; Resolution, accuracy, timeliness, etc.



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Rolling Review of Requirements

Which observations are required?

We need this information **everywhere on the globe**, ideally at (something close to) the **three-dimensional** model grid resolution!

Mixed sources; primarily from surface-based observations → **Wind (two components)**

Mixed sources; primarily from satellites → Temperature, Humidity

Exclusively from surface-based observations → **Pressure**

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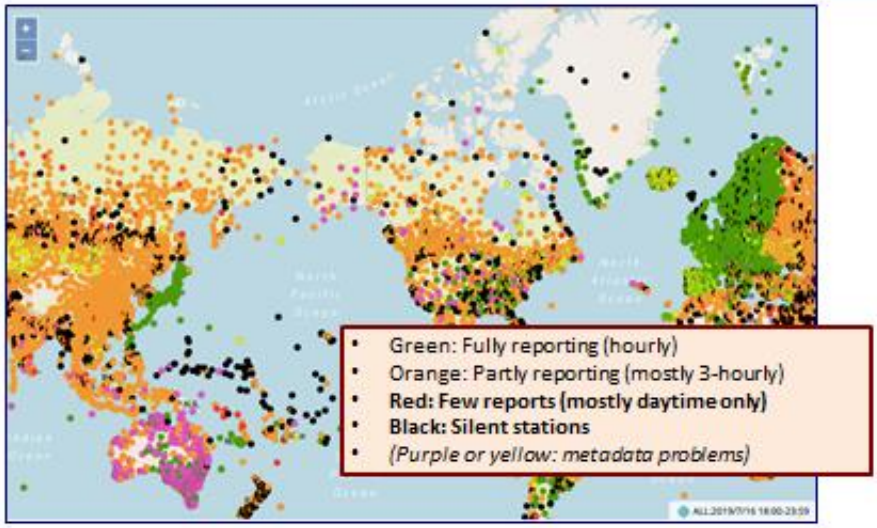
3. What are we currently getting?



Current international exchange of data for global NWP lessthan optimal (Example: Surface pressure observations received by global NWP Centers on July 16 2019, 18Z)

WMO OMM

Why are we doing so (relatively) poorly on observational data delivery?

- Current data exchange practice is largely based on WMO Publication 540 (Manual on the Global Observing System) and on WMO Resolution 40 (Cg-11);
- Resolution 40 was adopted in 1995; NWP has made immense progress since that time, and current requirements are vastly different;
- Congress resolutions define policy and do not contain sufficient technical detail to allow for consistent implementation by all Members;
- Additional material is available in guidance documents such as CBS recommendations, implementation plans, etc.; many Members will, as a matter of principle, base their practice only on regulatory material;
- Current WIGOS monitoring data show unacceptable gaps in data coverage over many areas (previous slide);
  - In many cases additional observations are being made, but not currently exchanged, due to a lack of clarity from WMO regarding the obligation of the Members.

WMO OMM

4. What is WMO doing to improve this?

- In order to increase the observational input to global NWP, the WMO Executive Council (EC-70) requested
  - CBS to *develop an overarching design for the **Global Basic Observing Network (GBON)** to meet threshold requirements for Global Numerical Weather Prediction and Global Climate Monitoring (Analysis) as established by the Rolling Review of Requirements {…}*,
  - The Inter-Commission Coordination Group on WIGOS (ICG-WIGOS) to *develop relevant material for the Manual on WIGOS (WMO-No. 1160) regarding the implementation of the GBON and propose to Cg-18 in 2019*;
- **Overall concept for GBON approved by WMO Congress in June 2019;**
  - Detailed regulatory material establishing mandatory elements (resolution, timeliness,…) to be approved by Executive Council in June 2020.

WMO OMM

5. What is the impact of GBON?

- **Access to better NWP model guidance and climate analysis products for all WMO Members**
- **However, GBON comes at a cost**; There are four broad, but distinct, levels of difficulty of implementation:
  1. Members already complying with the GBON provisions (e.g. Japan, Western Europe); no further action is needed;
  2. Observations complying with the GBON requirements are made, but not currently exchanged (e.g. USA, China); **new data exchange practices need to be adopted**;
  3. Insufficient local (national) resources available to meet GBON requirements (e.g. Africa, South Pacific, Caribbean,…); **use GBON provisions to help steer internationally funded development projects**;
  4. GBON requirements currently not met due to geographic constraints (e.g. Indian Ocean, North Pacific); clear role for new or emerging technologies, space-based remote sensing.

Estimated additional funding needs for item 3 globally, (USD):

- Capital investment: **350 M**
- Annual operating costs: **150 M**

(estimated cost of existing Global Observing System: 2-5 B/yr)

WMO OMM

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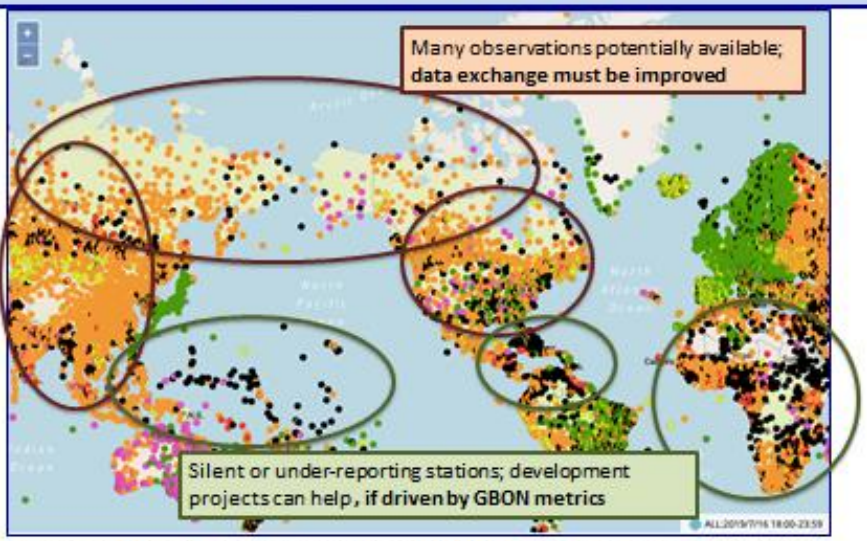
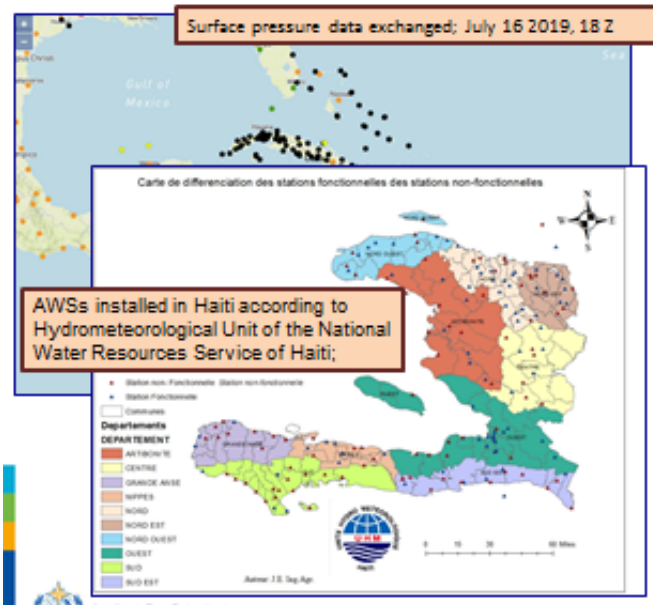
Expected impact of GBON (ii)



Current availability of critical data for global NWP (example: Surface pressure observations received by global NWP Centers on July 16 2019, 18Z)

WMO OMM

6. Observations and project funding (regional example)



- Far too many black dots!
- Let's look at Haiti; LDC; candidate for aid;
- Few observations; let's buy some AWS's (Automated Weather Stations) to fix that;
- Not necessarily the right approach; **do not assume that lack of observations equates to lack of stations**!
- All AWSs - over 100(!) – in Haiti are donated, via many different projects;
- This is an impressive network by any standard, **but**:
- Most stations are non-functioning, none currently report to WMO networks;
- **Number of observations exchanged is a much more useful metric than number of stations purchased!**

WMO OMM

Recommendations to International Development Partners

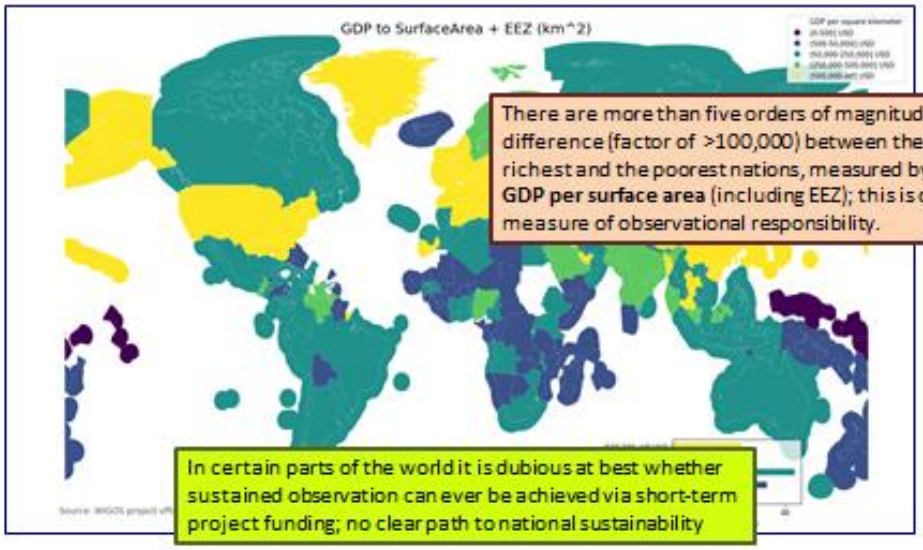
- **Recommendation**: Especially for observing systems, sustained funding programs are found to be much more effective than project funding (example: US support of upper air network in Caribbean and Central America);
- **Recommendation**: Focus on sustaining existing networks with the NMHS first, before installing new networks; this is also in line with the call for "systematic observation" in the Paris Agreement;
- **Recommendation**: Realign your activities with National WIGOS Implementation Plans where they exist;
- **Recommendation**: Human capacity development needs to accompany funding for hardware, even when focusing only on rehabilitating observing systems; focus also on maintenance and repair, availability of spare parts; calibration, encoding, data transmission, e.g. via Regional WIGOS Center;

Slide developed by Joint GCOS-WIGOS Workshop for RA-IV in Belize, July 2019; variations of virtually identical recommendations from every single regional WIGOS workshop held last 4-5 years!

WMO OMM

Joint GCOS-WIGOS Workshop for RA-IV, Belize City, July 10-12 2019

6.1 A (perhaps) provocative look at resources



GDP (World Bank numbers) per surface area (land surface + EEZ)

WMO OMM

Summary

- Observations provide the essential first link in the value chain underpinning all weather and climate services;
- Growing realization in WMO that current extent of data exchange is inadequate to support existing requirements for weather and climate;
- There are many reasons, both technical, financial and political, for the current state of affairs;
- **Sustained operation, integrated observing networks, robust data transmission capabilities are the key ingredients of success in this game!**
- GBON concept approved by 18th WMO Congress in June 2019 to address this issue; final approval of GBON regulatory material expected in June 2020;
- International climate finance and development communities have indicated willingness to help GBON implementation;

WMO OMM

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Challenge to the Workshop;
and looking further ahead

- **How do we honor the Paris Agreement commitment to Systematic Observation, also in countries that demonstrably cannot do this based on national resources?**
- **Can we think of a way to finance GBON in a sustained manner as a global public good?**
- *Still to be done:*
  - *Marine parts of the observing system, especially in remote areas with no islands;*
  - *Other observing systems, beyond NWP and climate analysis requirements, observations for other disciplines: Hydrology, atmospheric composition, cryosphere, oceanography, …);*
  - *Other links in the value chain: NWP, product generation, service delivery;*

Observations as a national obligation; Switzerland and Kiribati;

- *(Remember: Basic requirement for NWP and climate analysis is a near-uniform observational network);*
- **Switzerland**: Area 41K km2; GDP 700 B (USD);
- **Kiribati:** Area, including EEZ, 3.4 M km2, GDP (nominal) 200 M USD;
- Switzerland spends roughly 0.003% (20 M) of its GDP on observations;
- **0.003% of the GDP of Kiribati would be less than 6K USD, not even the cost of a single AWS!**

WMO OMM

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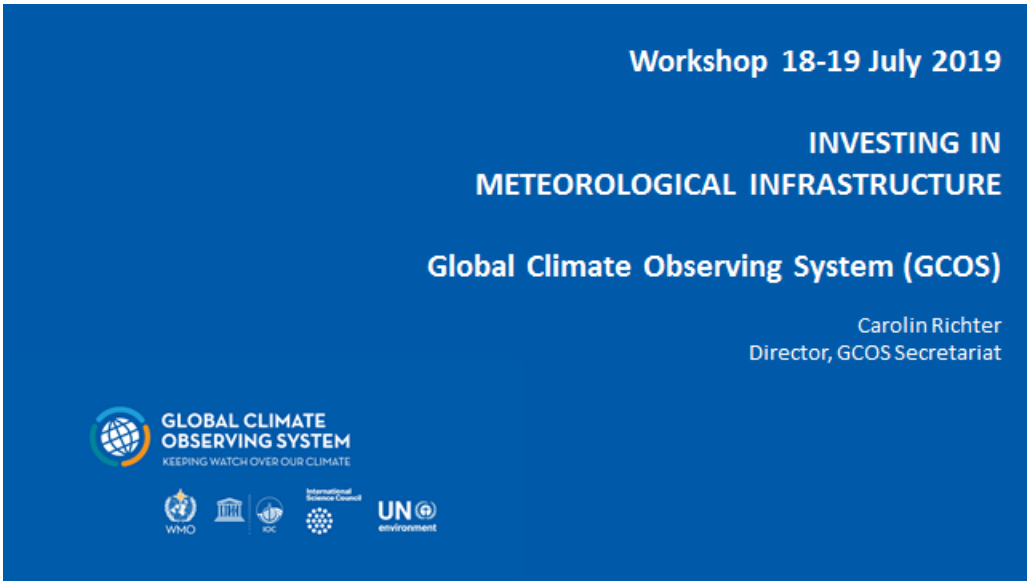
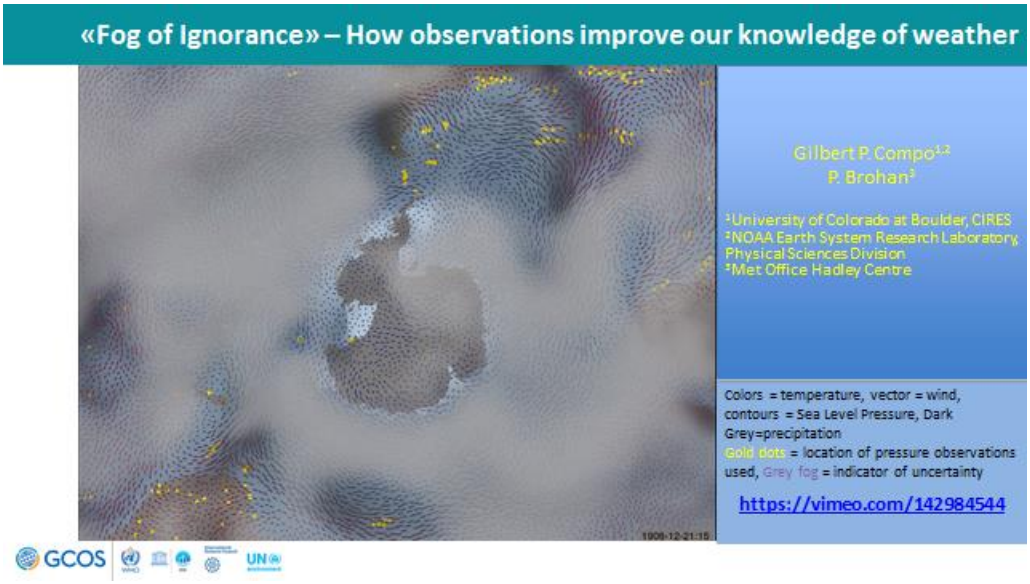
Annex 5: Workshop notes "Why is it needed"

Annex 6: GCOS workshop presentation





Observations are important –

lack of observational data limits significantly the quality of information

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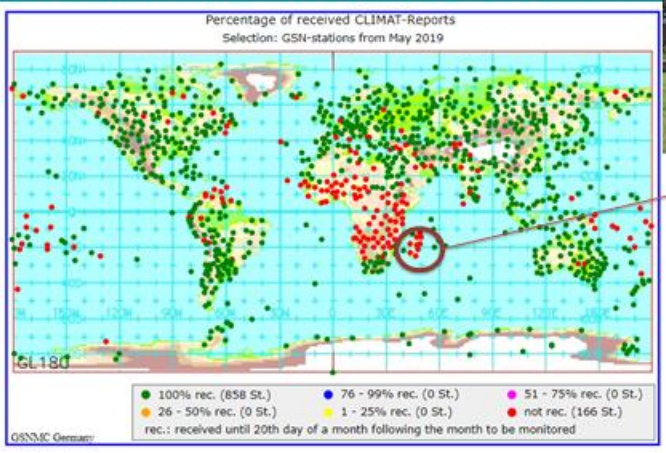
Monthly / Annually
Station Performance of surface stations

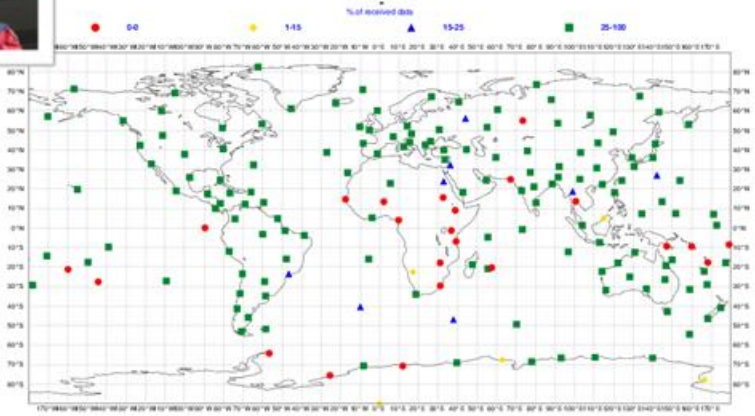


https://www.dwd.de/EN/climate_environment/climatemonitoring/climatedatacenter/_node_mp_id002.html

1 radiosonde costs
~ 150 USD
Monthly salary in Senegal
= 150 USD

Station Performance for Upper-Air Observations

GUAN STATIONS Jun 2019
Frequency of Reception data at ECMWF
Level: 30 hPa Temperature SUMMARY 00/12 UTC

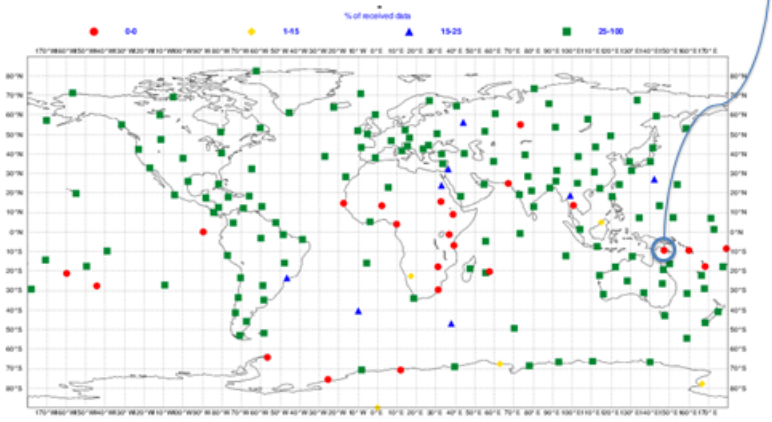


GCOS

ECMWF

Station Performance for Upper-Air Observations

GUAN STATIONS Jun 2019
Frequency of Reception data at ECMWF
Level: 30 hPa Temperature SUMMARY 00/12 UTC



https://www.ecmwf.int/en/forecasts/charts/monitoring/w_guan?facets=undefined&time=2019070800&parameter=Temperature&level=700&area=Summary

ECMWF

€100K: Support for GUAN Station Port Moresby (Papa New Guinea)
[Station in-active since February 2013]
This GUAN (remote & data sparse region) station has in the past received the support of GCOS and the Met Service has informed GCOS that sufficient funding for equipment, maintenance and supplies has not been available for many years. This will provide an expert visit to assess the station, an in-depth service of the hydrogen generator system and radiosondes and balloons to meet the GCOS minimum requirements for a 2 year period.

Global importance of upper air observations

- The ECMWF Deputy Director of Forecasts noted in September 2017 regarding the potential value of rehabilitating the upper air network over Papua New Guinea:

"Radiosondes in PNG can … help predict when Rossby wave trains may be triggered from that area, and then propagate across the Pacific to N. America, and where they influence the mid-latitude storms tracks and ultimately the weather in Europe"

"Isolated radiosondes are individually much more valuable and bring much more benefit to forecast quality than observations in a dense network (benefit per station that is!)"

GCOS

Local weather and climate prediction is embedded in a global system

NMHS Observations
- According to WMO regulations
- Sustainable networks

NMHS exchange observations
- Hourly data
- With global NWP centres through WMO systems

Global NWP Centres
- Global Models and reanalysis for boundary conditions to NMHS local models
- Provide global datasets for climate services

NMHS make
- Nowcasts
- Forecasts
- Projections

NHMS provide
- Warnings
- Planning Advice

- **Therefore one priority is to ensure the availability of basic meteorological observations that are the foundation of all models**
- **ECMWF identified upper air observations whose improvement will have the largest impact**
- **These observations are a global good.**

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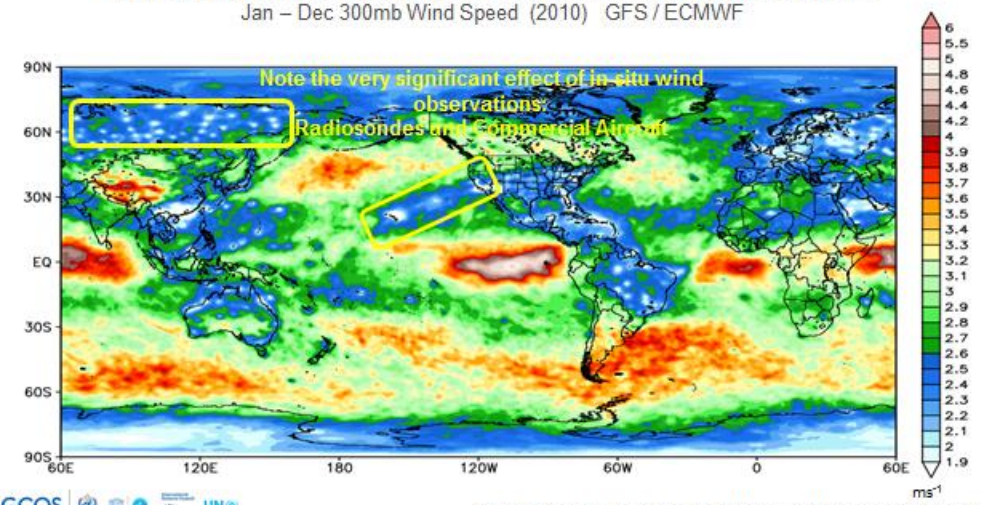
Root-Mean Square of Analysis Differences: 300mb Wind Speed

Jan – Dec 300mb Wind Speed (2010) GFS / ECMWF



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SOURCE: Langland et al.; from 5th WMO Impact Workshop, Sedona 2012

Observations are important –

local observations have a global impact

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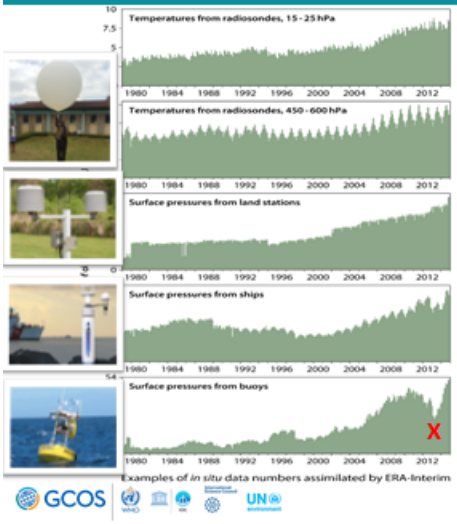
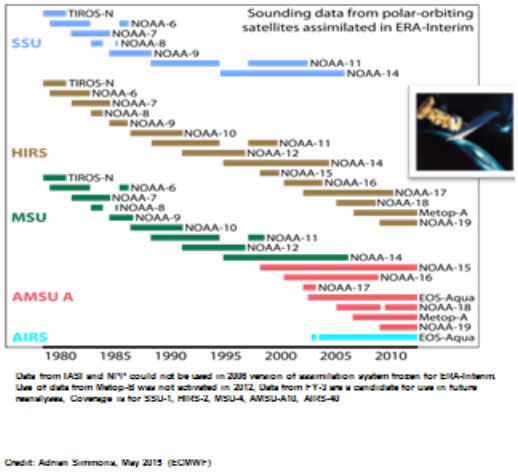
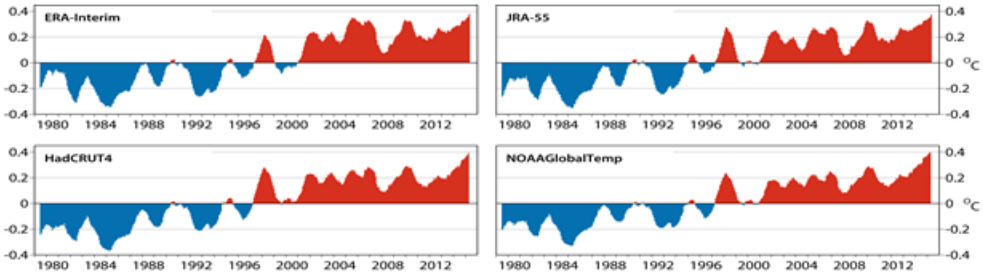
Evolution of the observing system





Credit: Adrian Simmons, May 2015 (ECMWF)

12-month running means of global-mean surface temperature differences from 1981-2010 average



The ERA-Interim and JRA-55 reanalyses estimate global surface air temperature using information from many types of observation and short-range weather-model forecasts.

HadCRUT4 and NOAAGlobalTemp combine monthly climatological air temperature data from land stations with data on sea-surface temperature.

Overall warming estimates are similar; year-to-year variations differ in strength due mainly to differences in high-latitude data coverage and in sea-surface temperature analysis.

Observations are important –

policy support for financing mechanisms

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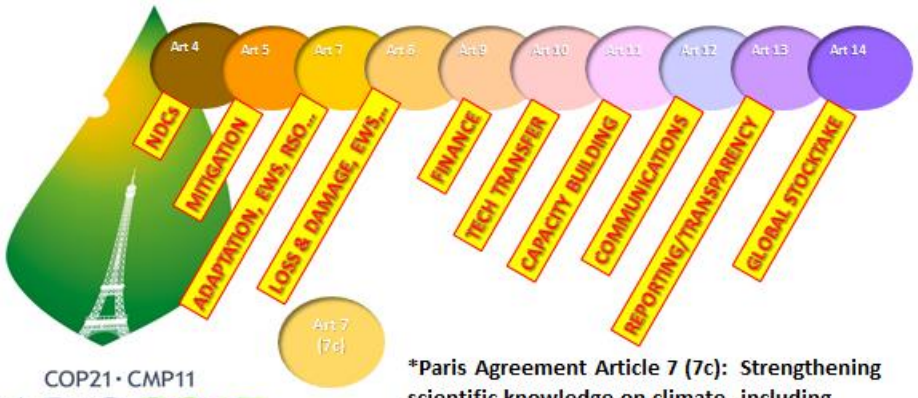
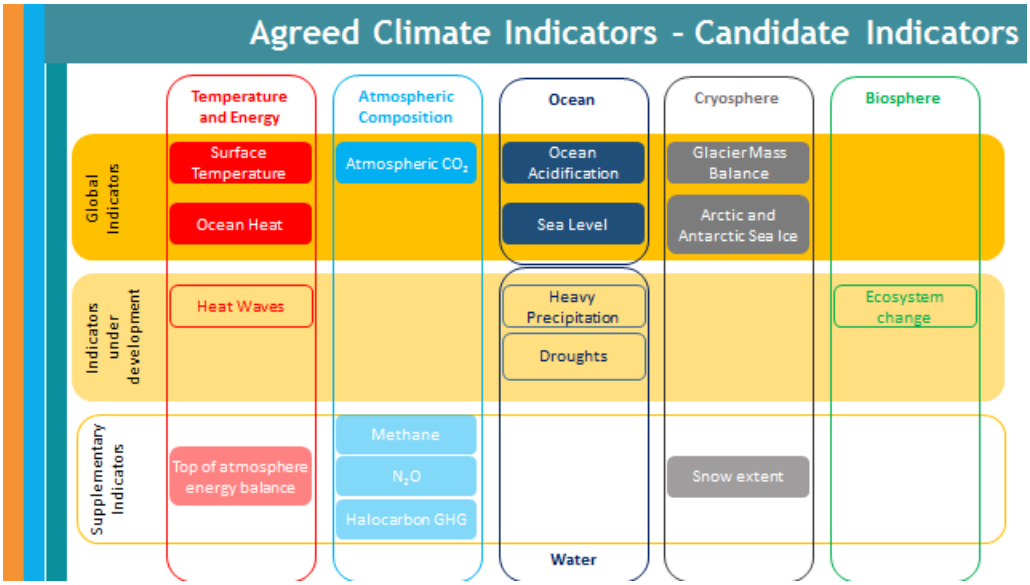


COP21 · CMP11
PARIS 2015
UN CLIMATE CHANGE CONFERENCE

*Paris Agreement Article 7 (7c): Strengthening scientific knowledge on climate, including research, systemic observation of the climate system and early warning systems.

Systematic Observations are fundamental to implementing the Paris Agreement and monitoring its progress.



The Origin of GCOS in 1990 – IPCC FAR & Second World Climate Conference

"We need...to improve the systematic observation of climate-related variables on a global basis..."

"There is an urgent need to create a Global Climate Observing System (GCOS) built upon the World Weather Watch Global Observing System and the Integrated Global Ocean Service System and including both space-based and surface-based components.....".

GCOS

1997	Decision 8/CP.3	Development of observational networks of the climate system
1998	Decision 14/CP.4	Research and systematic observation
2009	Decision 9/CP.15	Systematic climate observations
2016	Decision 19/CP.22	Implementation of the global observing system for climate

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Decision 11/CP.9
Global observing systems for climate
2003
United Nations Climate Change
Welcoming further the establishment of the Global Climate Observing System Cooperation Mechanism by Members of the sponsoring agencies of the Global Climate Observing System, under the guidance of the Global Climate Observing System steering committee, as well as the flexible approach that has been adopt
GLOBAL CLIMATE OBSERVING SYSTEM
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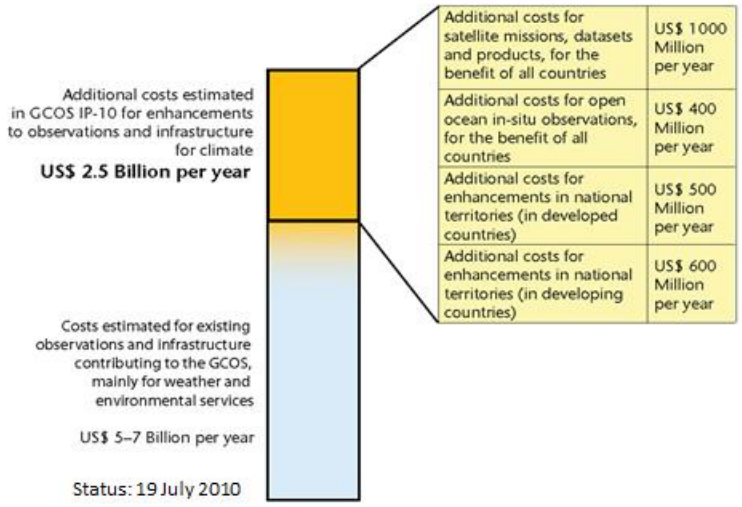
Noting that the Global Climate Observing System Cooperation Mechanism will address priority needs for improvements in global observing systems for climate in developing countries,
WMO
IOC
International Science Council
UN environment
Requests the Global Climate Observing System secretariat to include information on the operation of the Global Climate Observing System Cooperation Mechanism in its regular reports to the Conference of the Parties.


https://gcos.wmo.int/en/cooperation-mechanism
GCOS Cooperation Mechanism
2003
United Nations Climate Change



October 2016

Summary of annual additional cost needed to implement Actions in GCOS IP-10 (draft v2.0)

All numbers in million USD

	Cross-Cutting Actions	Atmospheric Actions	Oceanic Actions	Terrestrial Actions	Total
Estimated total cost / year	200	1100	700	500	2500

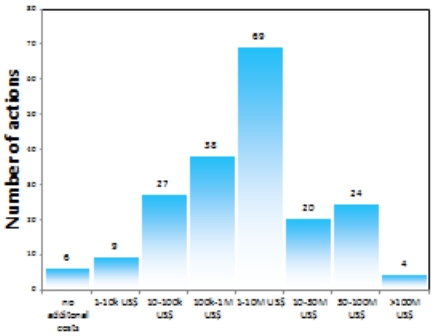
Costs for satellite missions, datasets and products	1000
Costs for open ocean in-situ observations	400
Enhancements in national territories (in developed countries)	500
Enhancements in national territories (in developing countries)	600
Total	2500

Status: 19 July 2010

GCOS

Ranges of estimated costs associated with actions in this plan

- The annual costs are based on estimates, for example for required expert time, standard meeting costs or cash investments for hardware or software and are presented as broad ranges. For many of the cost estimates, reference can be made back to the former GCOS Implementation Plan in 2010.



Estimated cost 2016 GCOS IP

GCOS

Decision 19/CP.22 — Implementation of the global observing system for climate

2016

United Nations Climate Change

6. **Encourages** Parties to work towards the full implementation of the implementation plan and to consider what actions they can take to contribute towards its implementation;

7. **Invites** United Nations agencies and international organizations to support the full implementation of the implementation plan, as appropriate;

8. **Emphasizes**, with regard to the implementation plan, the need to maintain, strengthen and build capacities for climate observations, monitoring and data management, including data rescue, digitization, analysis, archiving and sharing;

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9. Also **emphasizes the need to build capacity** in developing countries through existing relevant mechanisms, including **the Global Climate Observing System Cooperation Mechanism**

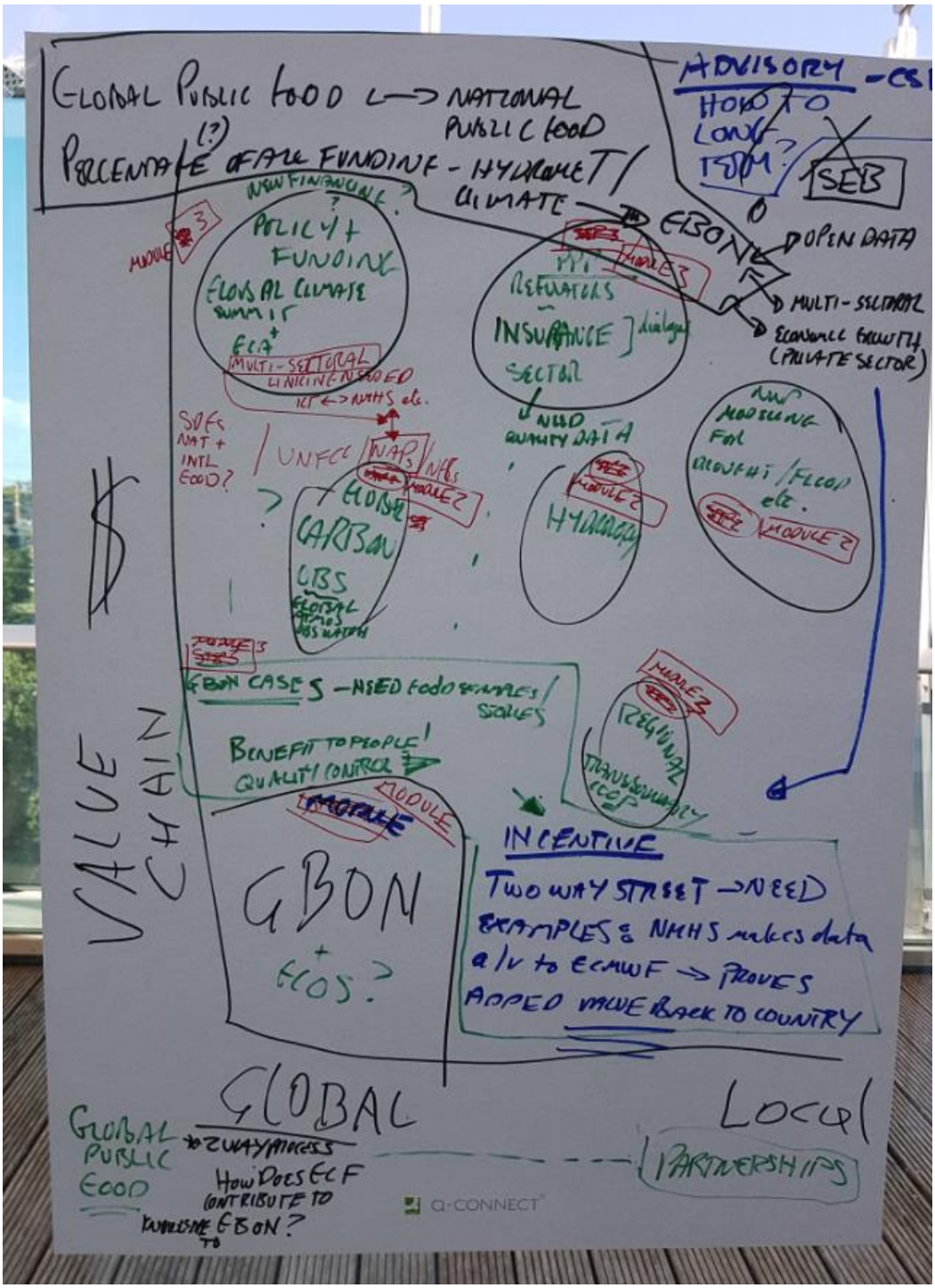
WMO IOC UN environment

GBON & GCOS : GCOS as baseline network for GBON

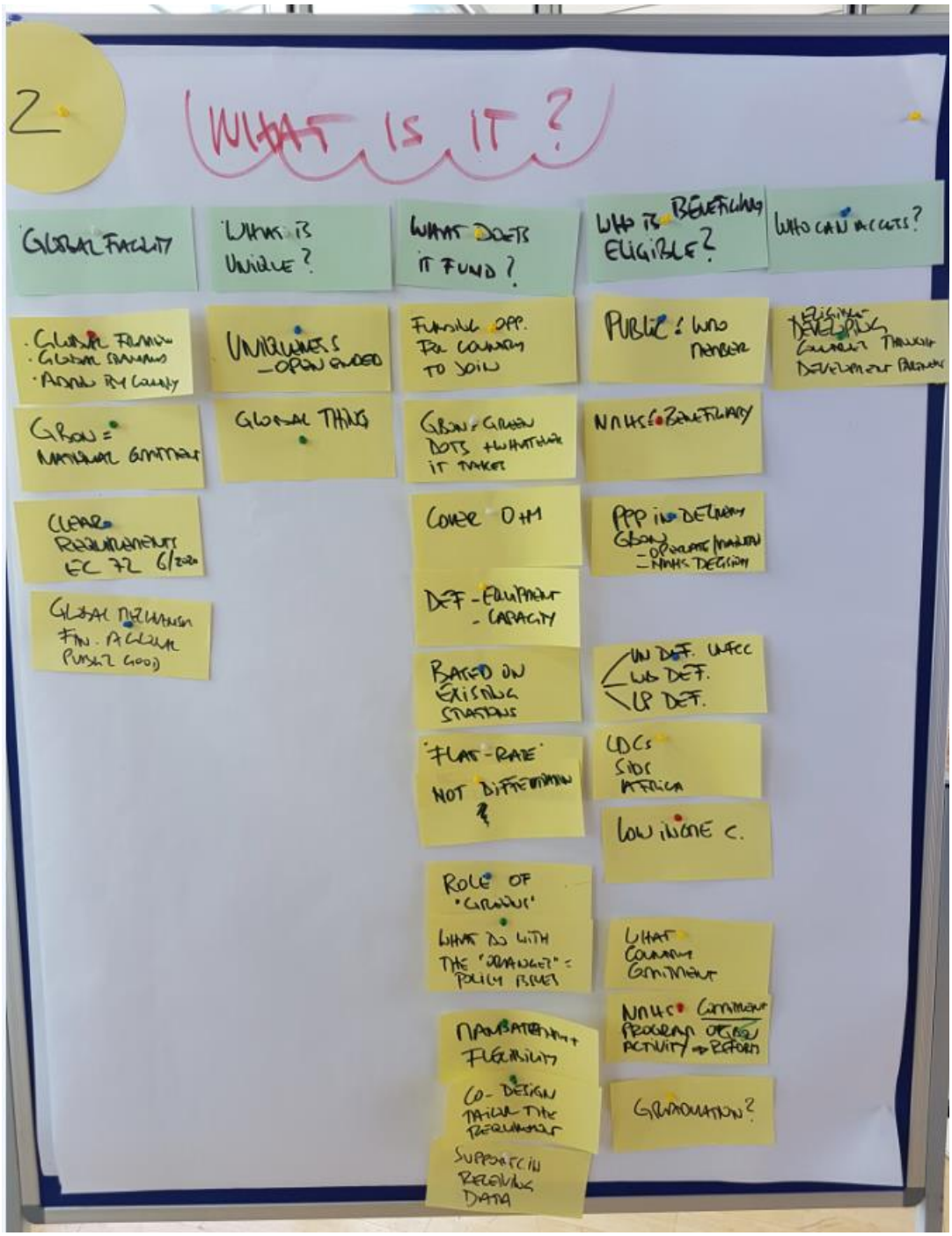
- Radiosonde and surface observations are an elementary part of the GCOS Implementation Plan
- Strong link between GBON and GCOS
- GCOS Surface Network migrates towards daily CLIMAT messages, calculated from hourly surface observations (GBON)
- GCOS Reference Surface Network as baseline for GBON surface
- GCOS Upper-Air (178 stations) represents a good proportion of GBON Upper-Air stations (600 GBON stations for 30 hPa/500 km horiz. resolution, and 150 GBON station for 10 hPa / 1000 km horiz. resolution)
- GCOS Upper-Air as a baseline network for GBON Upper-Air
- GCOS provides a financing mechanism for sustained observations established by UNFCCC

GCOS

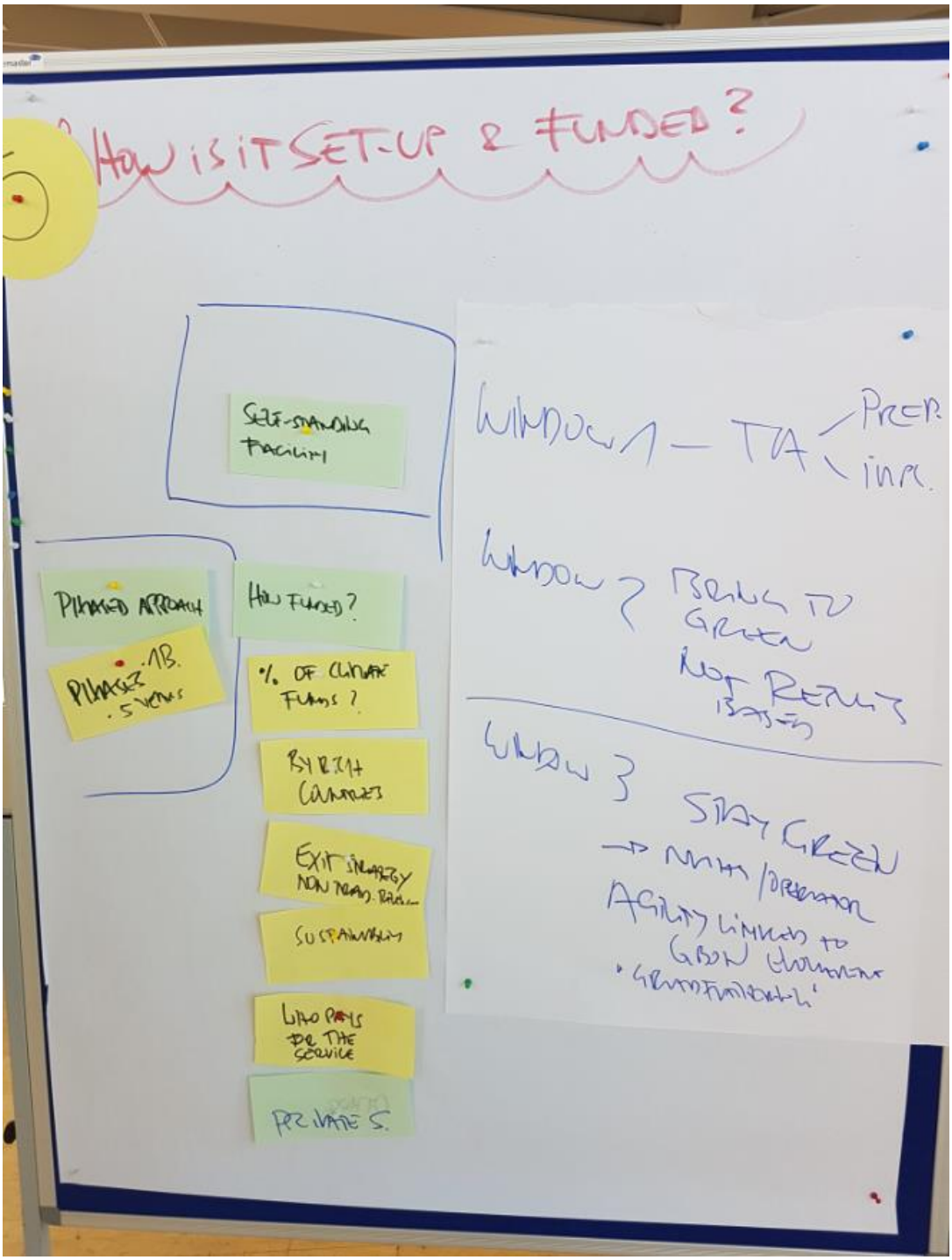
Annex 7: Workshop notes "Value creation beyond GBON"



Annex 8: Workshop notes "What is it"

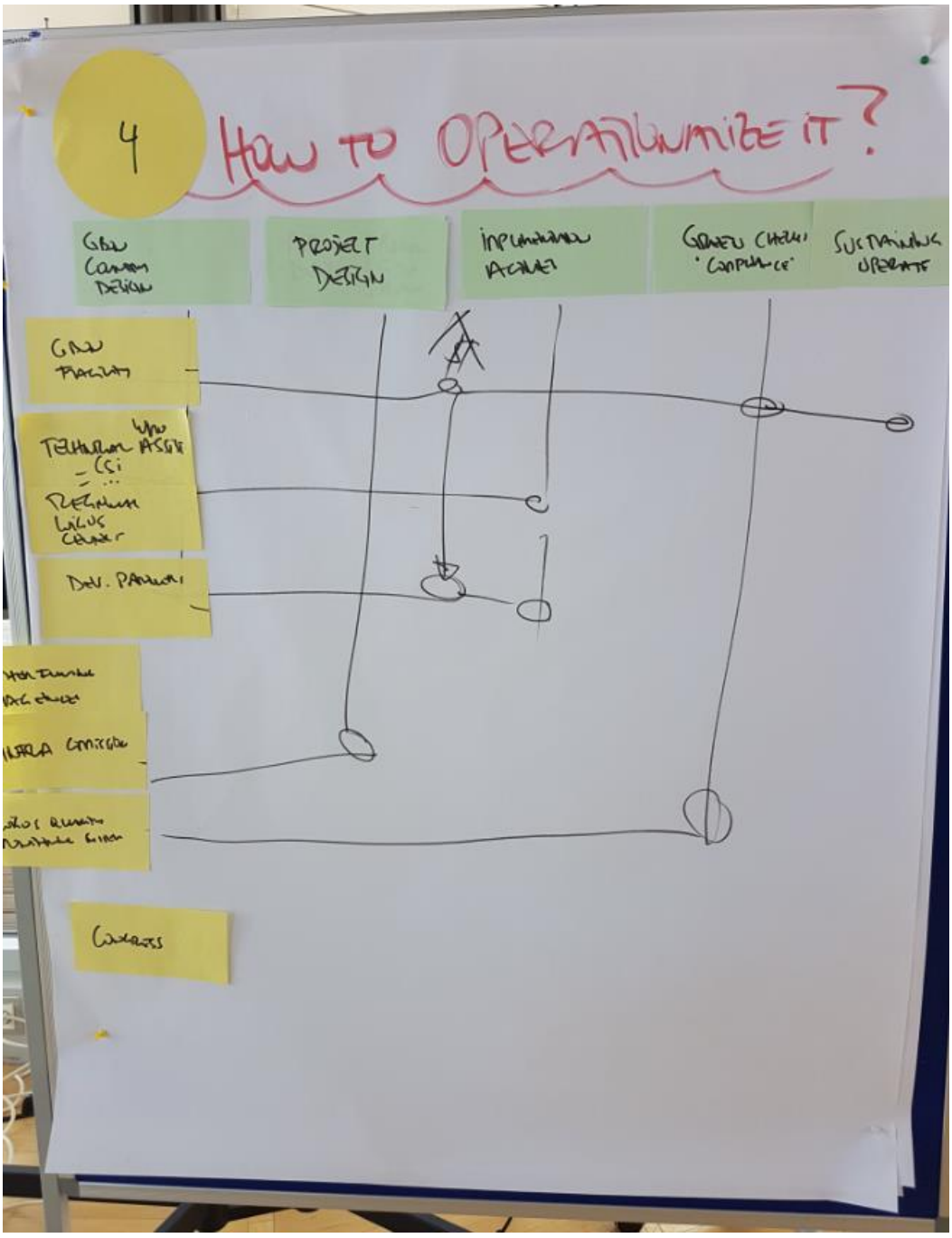


Annex 9: Workshop notes "How is it set up and funded"



Annex 10: Workshop notes "How does it operate"

Annex 11: Workshop notes "How to operationalize it"



Annex 12: Workshop notes "How to position and develop it"

Annex 13: Workshop notes "Milestones"