GLOBAL CLIMATE OBSERVING SYSTEM

WMO unesco Intergovernmental Oceanographic Commission International Science Council UN environment programme

GCOS SC-30

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Item 1.8

GCOS STEERING COMMITTEE

THIRTIETH SESSION

GCOS SC-30, 7–8 December 2022

Virtual Session

2nd GCOS Climate Observation Conference Report - Draft

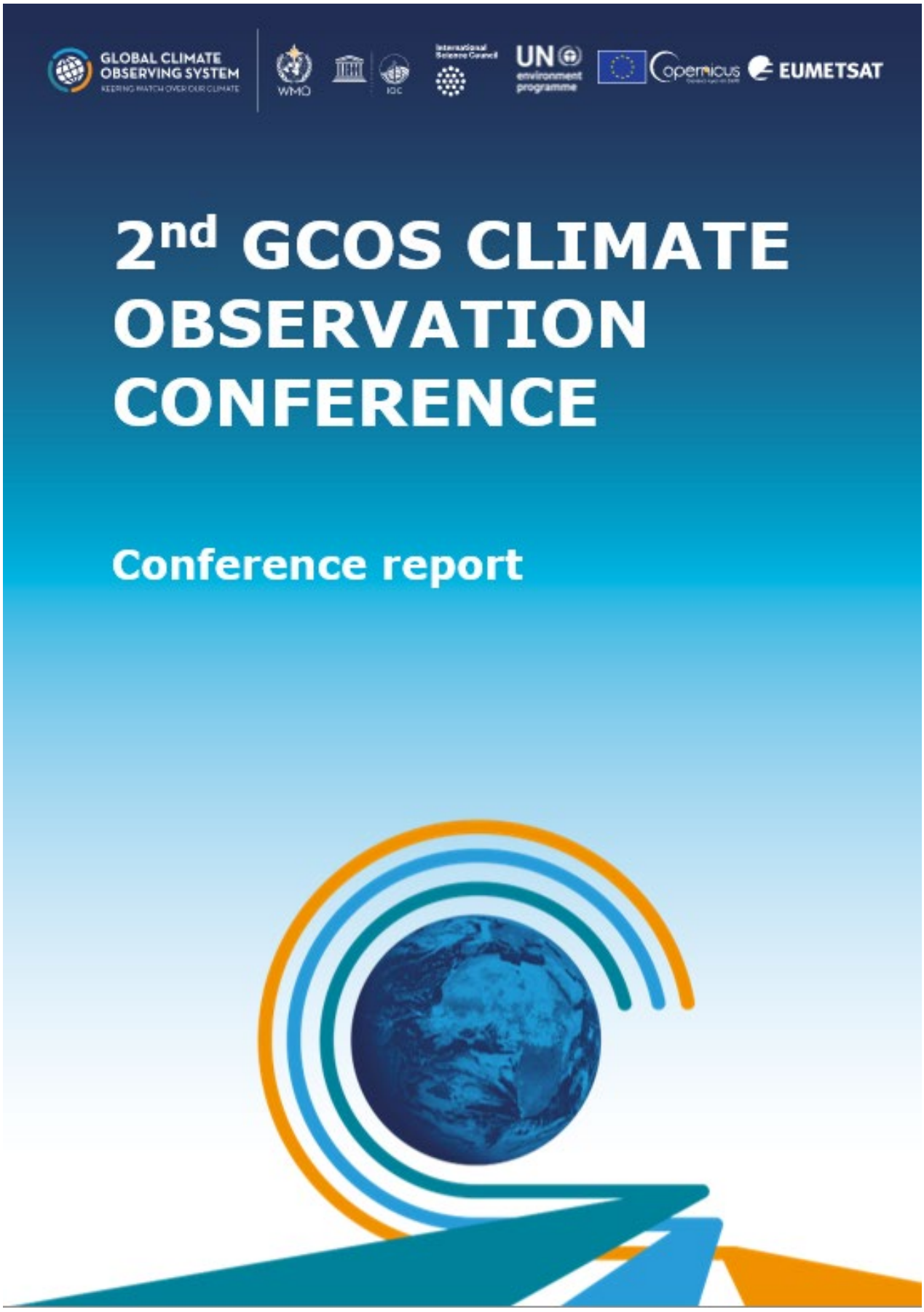
1.1 Description

The Conference report aims to illustrate the development of the sessions and the main discussions that were held at the 2nd GCOS Climate Observation Conference in Darmstadt, 17-19 October 2022, without being exhaustive. The most important outcomes of those discussions are presented in the conference statement (section 1 of the Conference report).

The report is presented here in a preliminary form and will be finalised and published by the end of 2023.

1.2 Report draft

Title page



2nd GCOS CLIMATE OBSERVATION CONFERENCE

Conference report

17-19 October 2022, Darmstadt, Germany

Edited by ... ... & ...

Conference co-organized by the GCOS and EUMETSAT.

The 2nd GCOS Climate Observation Conference 2022 organizing committee (Annex 1) appreciates the additional support from the ...

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1. Conference Statement

GCOS Climate Observation Conference Statement

The Earth's climate is changing as a result of human activities. Observations of our climate show widespread, rapid, and intense changes that are unprecedented over many thousands of years. These changes affect all components of the climate system and every region on Earth. They have led to more frequent and more extreme events, such as heat waves, storms, floods, and droughts, that strongly impact our society, our infrastructures and all living things. Climate observations have been fundamental in the development of scientific assessments and policies, including IPCC reports and the 2015 Paris Agreement. They are the foundation of our understanding of the climate and how to mitigate climate change, adapt to future conditions, and reduce and address future loss and damage.

"Observations underpin all weather, climate, water, and ecosystems services and products. Without the collection and sharing of these observations, the ability to understand, predict, mitigate, and adapt to changes in the climate system is limited," Sabrina Speich, chair of the GCOS Climate Observation Conference, said.

The newly released 2022 Implementation Plan of the Global Climate Observing System (GCOS) specifies the climate observations required to inform science, services and society. The report was requested by the United Nations Framework Convention on Climate Change (UNFCCC). The GCOS Implementation Plan identifies existing gaps in Earth observations and areas in need of improvement. These needs must be urgently addressed to progress towards a comprehensive and sustainable global climate observing system.

Building on the GCOS Implementation Plan, the Climate Observation Conference (17-19 October 2022, in Darmstadt, Germany) fostered international dialogue amongst climate scientists, observations experts, operational services, United Nations agencies, intergovernmental organisations, and policy makers.

In particular, the conference participants unanimously call for UN Member States, and relevant agencies for:

- **Sustained, long-term funding,** which is essential to ensure the continuity and expansion of observations to monitor the Essential Climate Variables. The provision of many observations is still supported through limited-term funding, and the climate observing system remains fragile.

- **Addressing the key gaps in observations,** that have been identified in different components of the observing system in, the atmosphere, the ocean, the cryosphere, the biosphere, the mountains, and lakes and rivers. Priority areas for improvement are parts of, Africa, South America, South-East Asia, the deep ocean, and the polar regions.

- **The improvement of data quality, availability, accessibility and utility**. Many climate observations are underexploited because of the lack of consistency, and clarity, in their processing, interoperability and usability. The conference has provided concrete pathways to improvements, identifying that increased effort is required to ensure that the data can be readily used in reanalysis and are fit for purpose. It also recognized the importance of reference quality observations, with full traceability, and defined and quantified uncertainties.

- **The creation and maintenance of climate data repositories.** To address and understand climate change, the longest possible time series need to be preserved and made available. Climate data must be made available through global data repositories, and their access must be free and unrestricted. The conference also identified the need for increased funding to ensure data can be rescued from hard-copy, or archaic digital formats, to extend existing data time series.

- **Addressing the emerging needs.** Climate information needs are changing. As an example, the increased frequency of observations for adaptation and mitigation measures are needed urgently. The global climate observing system must evolve in response to such needs.

- **The engagement with nations**. Many climate observations are made by national agencies. These agencies need to be supported by their governing bodies and they need to be coordinated transnationally, at regional and global level. The benefits of climate observations need to be widely understood and the contributions of national observations to global datasets require enhancement.

- **The improvement of regional and national climate change information.** Improved understanding of the local decision-making context and associated observational requirements, will help address the gap between the "top-down", global, production of observations and climate information, and the "bottom-up" local-scale decision making.

- **Integrated and collocated observations** of the physical, chemical, and biological components of the climate system, which will enhance our understanding on climate variability, trends and impacts, particularly on fragile ecosystems.

The conference participants call for the establishment of a global goal on observations under the UNFCCC. This should guide the needed "action-oriented framework for observation" to assist recognition, understanding and coordination of activities by international, regional and national stakeholders to deliver climate information on the impacts of climate change and for mitigation and adaptation action and reporting. Observations remain fundamental to the value chain of scientific knowledge and activities that support our understanding of our current and future environment and decisions on sustainable development.

Introduction

The 2nd GCOS Climate Observation Conference supported by EUMETSAT was held in Darmstadt, Germany, from the 17-19 October 2022 (hybrid), with the goal to assess how the current global climate observing system can be improved to better support current and near-term user needs for climate information.

The three-day conference entailed 6 Sessions and 2 Clusters consisting of oral presentations and posters as well as two round table discussions.

- Topic 1: Space and ground-based networks and observing systems – how to address improvements to better meet user needs
- Topic 2: How can climate observations enhance further the understanding of climate change, extreme events, and tipping points?
- Topic 3: How can global climate observations better support national and international climate polices?
- Topic 4: Data processing, archiving, access, and stewardship – how can new technologies help address existing challenges?
- Topic 5: Climate Data Records: what do we need to do to make this information more reliable?
- Topic 6: GCOS 2050: Shaping the future Global Climate Observing System

The Conference was a great success and brought together 140 participants onsite and 400 online participants. The conference fostered international dialogue amongst climate scientists, observations experts, operational services, United Nations agencies, intergovernmental organizations, and policy makers. The participants called for a collective effort to sustain and improve the climate observing system, by defining a "global goal for observations".

This document aims to illustrate the development of the sessions and the main discussions that were held without being exhaustive. The most important outcomes of those discussions are presented in the conference statement.

Foreword

Anthony Rea and Han Dolman

Conference Programme

Monday, 17th October 2022

08:00 – 09:00	Registration
09:00 – 10:30	Opening Session
10:30 – 11:00	Coffee Break & Group Photo
11:00 – 12:30	Topic 1
12:30 – 13:30	Lunch Break
13:30 – 15:30	Topic 1
15:30 – 16:30	Poster Session & Coffee Break
16:30 – 19:00	Topic 1
19:00 – 21:00	Ice Breaker

Tuesday, 18th October 2022

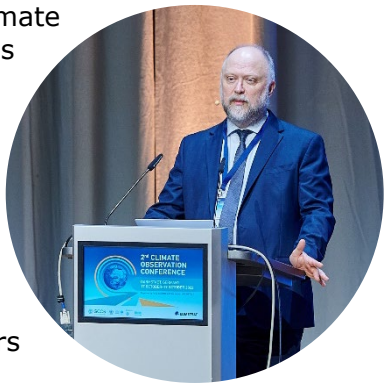
08:30 – 10:00	Cluster 1	
10:00 – 11:00	Poster Session & Coffee Break	
11:00 – 12:30	Topic 2	Topic 4
12:30 – 13:30	Lunch Break	
13:30 – 15:30	Topic 2	Topic 4
15:30 – 16:00	Poster Session & Coffee Break	
16:00 – 17:30	Topic 2	Topic 4
17:30 – 19:00	World Cafe	Cluster 2

Wednesday, 19th October 2022

08:30 – 09:00	Keynote Speech UNFCCC	
09:00 – 10:00	Topic 3	Topic 5
10:00 – 11:00	Poster Session & Coffee Break	
11:00 – 12:30	Topic 3	Topic 5
12:30 – 13:30	Lunch Break	
13:30 – 14:00	Reports from previous Sessions	
14:00 – 15:30	Round Table 1	
15:30 – 16:00	Coffee Break	
16:00 – 17:30	Round Table 2	
17:30 – 18:00	Conference Statement	

Monday, 17 October 2022

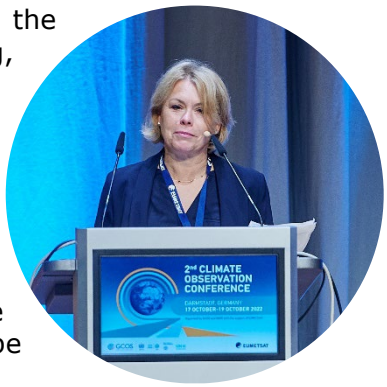
Opening



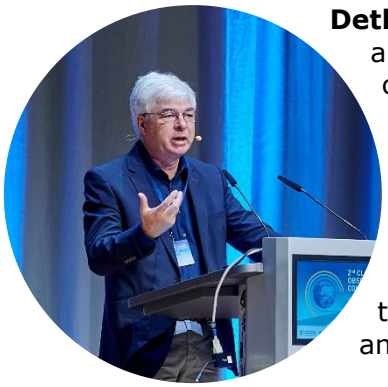
Phil Evans (EUMETSAT Director-General) opened the GCOS Climate Observation Conference 2022 and welcomed the participants. In his speech, he referred to previous efforts of GCOS and their connection to EUMETSAT. He highlighted the central mission of the conference which is to bridge the gap between scientists and decision makers. Connections to the 2022 GCOS Implementation Plan were drawn. Evans invited to three days of fruitful discussions on the key challenges of observing and modelling the entire earth system. This is a call for action and a statement of intent on the global climate observing system. He then invited opening remarks from the co-organisers of the conference and key notes from the speakers at the opening session.

> To know that we know what we know and to know that we do not know what we do not know – that is true knowledge.

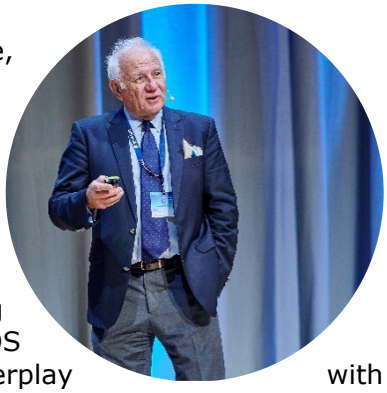
Han Dolman (Chair of GCOS Steering Committee) gave an inspirational speech and invited to celebrate 30 years of GCOS and the recent publishing of the GCOS Implementation Plan In his speech, he referred to previous GCOS conferences, including the last one and expressed his pleasure in seeing so many people in person again. He advocated for the crucial role of observations in this changing world but also pointed out the big gaps in the observation networks still today and in the future.



Sabrina Speich (Chair of the Scientific Committee) highlighted the importance of climate observations for reconstructing, monitoring, understanding, attributing, predicting, projecting, mitigating, and adapting to climate change. She stressed the increasing need for climate adaptation and the requirements for high-resolution measurements. She presented the scientific committee and the organizers and explained the structure of the conference: 6 Sessions and 2 Clusters consisting of oral presentations and posters as well as two round table discussions. Topics focused on space and networks, requirements of science, how can climate observation help climate policy and in decision making, how to shape the climate observing
system in the future.



Detlef Stammer (Chair of Joint Scientific Committee of WCRP) talked about the close partnership between GCOS and WCRP. He congratulated GCOS for their anniversary and praised the successful ongoing cooperation between WCRP and GCOS. The fast pace in optimisation of observation networks can still not meet the new arising challenges and therefore a dynamical evolution in climate science is needed. Since the remodelling of WCRP, GCOS has been an even more critical partner for the entire observation system. He looks forward to a fruitful collaboration in the future and talked about the planned joint activities such as, a workshop on heat, fresh water and carbon monitoring.



Stephen Briggs (Former Chair of GCOS Steering Committee, Reading and Cambridge Universities) presented the history of GCOS and the path to led us to where we are today. Briggs took us with him on the journey from the early stages of coordinated investigation science starting the 1770s with Humboldt to the founding of the International Meteorological Organization in 1873 which we know today as the WMO. A rundown of important world climate conferences from 1979 onwards and milestones in the climate action were shown together with the WWC-2 in 1990 leading to the establishment of GCOS. He presented the concept of GCOS with its goals, objectives and design philosophy as well as GCOS interplay with other climate action bodies. Briggs explained GCOS implementation plan and the status report which are both published in a 6-year cycle focussing on improving the scientific understanding, assessing the state of the environment and adaptation. Steady improvement of GCOS work was illustrated by the addition of new ECVs such as for lightning.

Anna Pirani (IPCC) introduced the participants to the IPCC Assessment Report Introduction production mechanism, especially focussing on the latest report (AR 6). Pirani talked about how the IPCC AR 6 explains the observed changes in the earth system such as anthropogenically driven global warming and investigates trends, while also mentioning the challenges due to limited data availability.

Topic 1: Space and ground-based networks and observing systems – how to address improvements to better meet user needs?

Presentations in the 1st session highlighted that an integrated global observing system covering all domains, and with different rationales in carrying out observations, supported by international cooperation, is needed to monitor climate change and to support both science and decision-making.

The usefulness of such a complex system increases, if observations are framed in terms of a tiered network concept. Several of the networks presented in this session can be assigned to a "reference tier", such as the CMA surface reference network and the GSRN, where traceability is ensured, to a "baseline tier" such as many of the ocean networks including ARGO and to the "additional level" with citizen science observations, which represent an opportunity for low-cost observations on the one hand, and stakeholder engagement and awareness rising on the other hand.

Several presentations stressed the important role that oceans play in regulating the climate system.

Presentations on both in-situ networks and satellite underlined the challenges identified in the GCOS Implementation plan: in terms of ensuring sustainability, the problem arises due to the fact that observation networks are mainly funded through research projects, especially for ocean observations. This leads to a mismatch between short-term research funding and the required long-term series. There is need for long-term planning and funding for observing system, data storage and management. Follow-up missions are highly demanded, especially for extremely useful observations, such as wind (Aeolus) and salinity (SMOS).

The need to fill the gaps in the observation networks was presented by highlighting the scarce and sparse monitoring sites with uneven geographical coverage. Denser observation structures with improved homogeneity and representativeness are requested. A subset of presentations from the ocean community stressed the need for observations in the Greenland shelves, mountains, in-situ observations for Mediterranean Sea; deep ocean observations, including for the Mediterranean, ice-covered oceans, de-oxygenation, acidification, expansion of the ARGO array. More observations are needed to close the carbon budget (particularly in the ocean and land domains).

New needs have been identified, such as to develop satellite observations of greenhouse gases that will contribute to support the UNFCCC Paris Agreement. GOSAT provides 20 years of data of greenhouse gases that will contributeinput for the 1st GST and for the next GSTs. Higher resolution observations for greenhouse gas hotspot detection, for complementing global monitoring with regard to anthropogenic emissions (see GOSAT-GW and CO2Image) and for salinity are currently being developed.

Topic 1 also addressed the data processing while stating that the current capability of ocean observing system depends on data processing techniques. Methodologies are critical and therefore investigating best practices are important. The data access must be free, unrestricted, quality controlled and stored with adequate metadata. The presenters claimed that processing data from multiple satellites through a common retrieval algorithm and using validation resources for assessing bias is fundamental to obtain the uncertainty required for long-term trends (TROPESS).

In terms of validation and calibration, presentations highlighted that the ground-based column GHG validations sets are limited and their geographical distribution is nonhomogeneous. Only a few validation sites exist close to emission sites. Thus, standardized and flexible movable systems are needed. To ensure that long CDR meet the requirements of accuracy and stability, validation and calibration campaign for validation and calibration efforts have been jointly carried

out by NASA and ESA by operating fields campaign using surface-based and/or airborne platforms, that provide anticipatory or coincident measurements with current or future NASA and ESA satellites.

The presenters claimed that national funding can support a regional gap, and it is needed to be sustained on national but also on international levels and shall allow operational implementations of systems such as OneArgo, especially for the ocean domain. Additionally, USA is discussing a continuity framework for satellite observations of climate coordinated by the Keck Institute of Space Studies at CalTech/JPL.

Tuesday , 18 October 2022

Cluster 1: Fluxes and budgets in the Energy Cycle

The presentations in the first cluster addressed the GCOS IP action on improving estimates of latent and sensible heat fluxes and wind stress and the action on the estimation of heat storage. OASIS (the Observing Air-Sea Interactions Strategy) is a programme that is working to develop an integrated approach for observing air-sea interactions globally.

One data gap identified is in in situ observations. There are very few mooring buoys which are well instrumented, with redundant sensors that can provide the highly accurate measurements for flux in the ocean. There is a need to support and expand the Ocean Reference Stations (mooring buoys) which can provide highly accurate measurements to anchor oceanic surface flux fields and motivate and guide model improvement.
Also, data gaps in the satellite observations have been identified. Two new satellite missions' concepts, BUTTERFLY and ODYSEA, could provide synergistic measurements to narrow the capability gaps by revealing how small-scale air-sea interactions influence large-scale weather and climate.
The Earth heat inventory provides a measure of the Earth Energy Imbalance. It is the most fundamental global climate indicator that the scientific community and the public can use as the measure of how well the world is doing in the task of bringing anthropogenic climate change under control.

Many improvements are needed in observations to determine the Earth Heat Inventory such as to extent GOOS to under sampled areas, to increase sampling of subsurface temperature profiles, to improve sampling for soil temperature and monitoring for ground ice and water contents. Additionally, sustained remote-sensing missions with polar-focused orbits and multi-frequency altimetric, gravimetric, geodetic and ice velocity measurements. Satellite missions are needed in high inclination orbits to provide a full- and local-time coverage.

Ocean Heat Content can be calculated from the "space-geodetic approach "using altimetric and gravimetric measurements. Global Ocean Heat Content – Earth Energy Imbalance (OHC-EEI) product and Atlantic Ocean Heat Content product, validated against independent data and with uncertainties calculated are now available to calculate the Earth Energy Imbalance.

Topic 2: How can climate observations enhance further the understanding of climate change, extreme events, and tipping points?

Presentations in Topic 2 covered a wide range of subjects, from space observations to in situ observations and models, and presented the most recent advances in those fields as well as the challenges that the scientific community is facing to improve the understanding of climate change, including extremes.

In terms of sustainability of in situ and satellite observations, presenters showed new examples of the importance of sustaining ocean observing networks (Voluntary Opportunity Ships for surface humidity), Mediterranean Ocean Observing System (MOOSE) and their relevance for characterizing trends and improving forecasting were provided. Libera was presented as the first earth venture continuity mission to measure earth radiation budget (bridging CERES mission).

Presentations advocated for combining, integrating and making multi Essential Climate Variable (ECV) datasets available. This will allow for multiple scientific applications, like the example from ESA/NASA community-based initiative integrating satellite datasets, the C3S global reanalysis, or the C3S Climate Data Store.

The presentations in Topic 2 highlighted that the success of long-term operation and of observing systems depends on the adherence to FAIR principles and adoption of data standards (MOOSE system, GNSS radio occultation).

Several presentations considered changes in the lightning regime, and flash droughts, while indicating the impact of certain data processing (interpolation schemes) in the detection of extremes. They revealed the potential of combining and integrating models and observations to describe and predict different phenomena from flash droughts to sea level rise and cloud and water vapor.

Topic 4: Data processing, archiving, access, and stewardship - how can new technologies help address existing challenges?

The focus of the presentations in Topic 4 was on climate data records, how they are obtained, assured, archived and used. There were many good examples of improvements in the availability, consistency, use, interoperability, and sustainability of the data products but significant challenges and threats still exist. Many of these challenges are already captured within the actions of the 2022 GCOS Implementation Plan.

One key statement addressed the continuity of observations as there is currently a significant decline in observations across Africa and also for ship measurements. Additionally to sustain observations, presenters highlighted that it is necessary to fill the gaps in terms of several aspects. Currently many data-products do not include uncertainty estimates which are needed to assess data quality. More reference quality observations (networks and/or supersites) are needed for all ECVs. Post processing improves climate data records (CDR) and allows the addition of uncertainty estimates. Also reference observations can improve the quality assurance of the wider network through the tiered network concept. Even though long-term time series are a priority, data rescue (Historical and more recent not reported in real-time/delayed mode) remains a significant gap in many countries and across most observing systems.

Other presentations identified new needs as many long term station time-series are experiencing gradual inhomogeneity due to the changing environmental around the station (i.e. urbanization). More studies are required for all relevant ECVs to assess the impact on the observations and update the homogenization to account for these changes. Satellite providers have to consider the benefit and process for Satellite climate norms, similar to that already provided from the in-situ observations.

In terms of data processing, further intercomparison (within the same CDR) and interoperability (between different CDRs) studies are needed to improve the consistency, application and knowledge for all CDRs. Regular reprocessing of data records is essential to capture non-real-time observations, improved quality assurance (i.e. flagging) and new algorithms. New CDRs (i.e. CDR Radio Occultation) will support reanalysis, climate monitoring and modelling and trend analysis. Some of the presentations on reanalysis stated that priority is given to the latest observations rather than to long-term stability.

Ensuring the consistency of precipitation products remains an ongoing challenge. Satellite products can be improved by incorporating in-situ gauge observations. Many of the satellite CDRs rely on collocated in-situ observations for calibration/validation, such as for precipitation, albedo, soil moisture but global coverage/climate zone distribution of these collocated sites remains very limited.

Additional to the mentioned aspects, data sharing remains an ongoing challenge for several ECVs. The new WMO data policy should address these challenges, but this needs to be implemented at the national level.

Cluster 2: GCOS and ECV framework

The Essential Climate Variables (ECVs) defined by GCOS have proven instrumental for establishing an infrastructure for observations that critically contribute to the characterization of Earth's climate. Other communities are building on the ECV model to suggest a minimum set of variables to characterize state and change in a system, like the Essential Agricultural Variables.

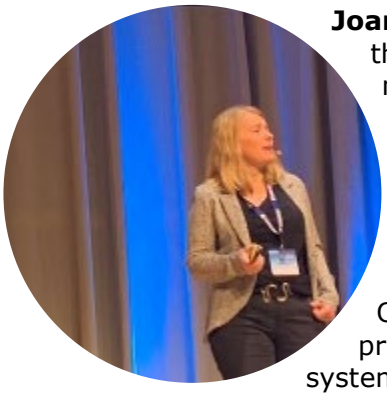
The presentations illustrated the tension between making the ECV framework larger and more complex so that it accommodates more variables and responds to more applications (snow, sea ice), and the need to keep it manageable within the current level of resources.

The requirements estimation was also discussed. Depending on the application, a more sophisticated estimating of uncertainty should be undertaken to quantify requirements.

1.1 World cafe (section to be included depending on answer from ESA) shall we publish it on the GCOS SC-30 with this comment on ESA? Or not?

Wednesday , 19 October 2022

UNFCCC Keynote



Joanna Post (UNFCCC) gave her keynote speech to open the last day of the GCOS Climate Observation Confernece 2022. She stressed that we need increase our ambitions in adaptation and mitigation. The UNFCCC will increasingly rely on strengthened and sustained systematic earth observation (as well as best available science) to assist countries in achieving the PA objectives. There needs to be a paradigm shift in order to bring science and policy together and have good communication between them. Post explained that the Global Goal on Observations (GGO) acts as the umbrella framework for Earth Observation (EO) support of the Paris Agreement implementation. Post presented the link of GCOS and UNFCCC: GCOS had a mandate for systematic observations and to report periodically to the UNFCCC on its activities and the progress of its Implementation Plan. In terms of further collaboration, a new decision on observations, GCOS, GGO and EO will be taken at COP27.

Topic 3: How can global climate observations better support national and international climate polices?

In topic 3 presenters focussed on the current issues both in science and in the policy sector and highlighted several key challenges.
In terms of scientific issues, there are still large uncertainties in the ocean and land carbon sinks and the resulting need to improve understanding of the natural carbon cycle as well as the anthropogenic carbon cycle, especially in regard to managed and unmanaged land. The presentations proposed a combination of bottom-up and top-down approaches to tackle the enhancement of greenhouse gas monitoring.

The answer to "How can global climate observations support adaptation?" is connecting the global, regional and local scales as well as additionally considering the adaptation on ecoregion scale. Even though National observations provide a significant contribution to the global climate observing system, the large gaps are still existing in monitoring networks/platforms. A potential to enhance the understanding of the greenhouse gases lies in the observing and modelling systems that can already provide greenhouse gas budgets in near real time.

In order to support the Parties to the UNFCCC under WMO coordination a global GHG monitoring infrastructure shall be established. Mechanisms to sustain climate and GHG observations need to be put in place. One step is to transform climate observations into information relevant for decision making which is currently still a challenge. Policy makers require actionable information, but it is difficult to extract actionable information from purely scientific data, therefore a mediation strategy needs to be established. Full value of data and information (for both science and policy) can be exploited only with free and open access.

The presentations concluded that space-based climate data has clear policy relevance, yet it is difficult to demonstrate its policy impact. However, many policy documents refer to the ECVs and the GCOS ECVs concept can be applied also in other contexts (e.g. mountains) but with the risk of diluting the value (the "essentiality") of Essential Variables for policy making.
The perception of climate change and indigenous knowledge and practices need to be considered by climate-related policies. Again, the presentations showed the need for international cooperation, capacity building, education and training.

Topic 5: Climate Data Record: what do we need to do to make this information more reliable?

The focus of the presentations in topic 5 was on a range of services, systems, and programs to support the archiving, curation, stewardship, and access to climate data records. The total climate data 'store' is huge and is increasing on a daily basis, and that is only for the data that is digitalized, a significant amount of historical data remains on paper format in National 'archives'. Many services are being developed on a more operational basis, with a focus on the user access to the data, a free and open data policy and fostering collaboration between the data users/providers. However, there are a significant number of data centers which are supported through limited national/project funds and rely on collaborative/community effort. There is a broad range of efforts, and significant resources, which are available, and continue to be developed, for archiving, curation and access to climate data, but there is an urgent need to ensure that the messaging and information from these 'services' is consistent, follows agreed data management principles, and yet while free and open access is fundamental, a suitable level of cyber-security is adopted.

The presentations showed that a number of data centers/archives are a collaborative/community effort, with limited funding and a reliance on National funding. For sustained and continuing climate data records, funding is necessary, which can be secured for some repositories for scientific basis but not for long-term monitoring.

It became evident, that there is an increasing skill gap in the use and understanding of data records and products. Capacity building is required to address this issue.

Data services not only focus on the archiving of and access to the data records but promote an environment of collaboration with the data users, along with tools and guidance on using the data. In terms of consistency, standardized formats, processing and outputs are fundamental. Data and metadata structures need to be more consistent with each other.

Data services not only providing access to the data but include monitoring and modelling information. Presenters highlighted, there is a need to improve the linkages and communication between GCOS (TOPC) and GTN-H, in particular the GRDC (River Discharge), ISMN (Soil Moisture) and groundwater.

Additionally, there is a need to promote the interoperability between data centers/services, to improve consistency/accuracy of products and guidance material, and to avoid unnecessary duplications. A suitable level of cyber-security measures is implemented for all climate data assets.

Topic 6: GCOS 2050 - Shaping the future Global Climate Observing System

Within Topic 6, two roundtable discussions were held with different topics and different speakers. Paolo Ruti (EUMETSAT) chaired both roundtables and facilitated the discussions.

The **first roundtable** was consisting of M. Hakuba (NASA, JPL), S. Speich (Laboratoire de Météorologie Dynamique), C. Stan (George Mason University), R. Engelen (ECMWF) and M. Dowell (EC) and was covering the topic of "**Challenges and solutions for Earth Observations to support the Paris Agreement and reporting for adaptation and mitigation**".

They discussed about the conventional and non-conventional types of data. Earth data are still predominantly used by scientists and engineers, while the potential range of users should be broader. Citizen science is one example of non-conventional type of data that could complement the current networks and systems. Co-designing the observing systems together with the users may bring new ideas of sources of data not used until now.

Their thoughts on the continuity challenges summarised that the continuity of satellite missions can be hindered by a poor advocacy and cost analysis are necessary to support investments. It is important to show the traceability from their investment to their result and impact on science or creating services. They claimed it is important to bring together all actors in the value chain. An outlook into the future resulted in the statement that hybrid constellation are bound to be more common in the future. Private space missions, however, could bring about problems with the traceability and reliability of the data.

The roundtable participants also discussed about the products, the ECVs and their complexity. They said, Users should have the ability to learn by themselves how the products are generated, so that they can choose which one to use. There are good examples of simple access to data and data produces, like the ECV inventory or the Climate Data Store. The user should be guided, and it is important to include assessments, recommendations and intercomparison between different sources of data or data products.

The data management and storage aspect has been a topic in the discussion as well. The amount of data generated is posing serious problems and further efforts must be done to decrease their size. Additionally, working on the cloud is not always the panacea. For many countries, downloading lighter packs of data would be better. Very often, when budgeting, the cost of curating data is not taken into account.

The discussion let to the conclusion, that we need more than new data, we need to make sure that we take full advantage of the data we have, and that means integrating systems and working across communities. Another feature that is very important is the estimation of uncertainty of the data. However, this must be carefully disclosed (the general public prefers hearing about likeliness). Information regarding GHG is not fit for purpose. It would be good to have information about the peaking (GHG emissions), and not only about the temperature. Also, information concerning who is respecting the Paris Agreement and who isn't. There is too much focus on the estimation of the reservoirs and budgets, and not so much on the feedback processes.

There is a clear need to adjust the ECV process to account for new needs. The approach shown by Chiara Cagnazzo (GCOS Adaptation Task Team) could be a way forward. GEO Climate Change working group is also working on adaptation and focusing on certain sectors. Different sectors may prefer different variables: e.g. heatwaves, what the fishermen care about it the subsurface temperature, not the surface one.

Another question was how to better the plan for adaptation. One proposal was to co-design the implementations at least with intermediate users such as operational centres, sciences and process studies. Additionally, loss and damages need to be monitored as well as the impacts extreme events and undertake the attribution of those extreme events.

The **second roundtable** focussed on the question "**How will external drivers and uncharted directions influence what GCOS will be in 10-20 years?**" and was consisting out of Y. Gevorgyan (GEO Secretariat), W. Hazeleger (Utrecht University), A. Arribas (Microsoft), M. Comparini (Thales Alenia Space), R. Floberghagen (ESA), P. Millar (NASA) and P. Evans (EUMETSAT).

Among the participants there was a consensus that increased awareness on how space observations can contribute to make our world more sustainable is necessary. The combined use of space and digital technology should be enforced, as more sophisticate models of what is going on are needed to predict what is going to be the future. Additionally, there is a need to enlarge the community from academic to private/industry in order to be able to have multidisciplinary observations of our planet. GCOS should not only monitor but more interactive-socioeconomic variables need to be introduced. The transition is urgent, stated the roundtable participants. If GCOS is to have a good observing system in the future, given the fact that sensors are developed several years in advance, the kind of the observations needed needs to be decided now. The cycle between the user community and the community that is building new

sensor is very important, in order to improve what they can produce in terms of sensor (with technology).

As Data from the internet and citizen observations will be likely to be used more in the future, infrastructure and guiding needs to be established for this cause. There is disparity between nations in their capability to use the data. Many countries do not have the capability to access this data and the data access is currently limited to the global North. GCOS needs to think how to make this 'good' available also to the global south.

Small satellite missions are less funded missions and part of using the ECV CDR requires investment in data quality, consistency and this are not things that every programme can afford. ESA is helping private companies so that their data can be used. Working together with private sector can be beneficial in terms of having more diversification in the data. There is a responsibility on the government that data needs to be open and free, this needs to be reflected in the procurement when they buy the data because ECV data should not be limited to people who can afford it.

Cloud based solutions are important and bring in partnerships, yet it needs to be made sure that we have the connections with the users. Additionally, one proposal is to bring other vantage point to the other part of the world. Cloud goods, e.g., helps play with cost and effect. They enable to bring different organizations together, while maximizing the element of complementary. Yet some countries cannot access cloud solutions, therefore we need to increase capacity development. Users cannot go through all the licenses, so we need to make it easier for the underdeveloped countries. There is a need to maintain the vast ecosystem of communities and to provide sustained access to all these assets. GCOS needs to be adaptive: climate and biodiversity, public and private. GCOS is a custodian of the ECV but one question remains: how do we need to evolve for the sector that are using it?

ANNEX - Abstracts

Abstracts of the presentation and posters will be attached here.