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GCOS Joint Panels Meeting

**26th Session of the Atmospheric Observation Panel for
Climate (AOPC-26)**

**24th Session of the Ocean Observations Panel for Physics
and Climate (OOPC-24)**

**23rd Session of the Terrestrial Observation Panel for
Climate (TOPC-23)**

**Virtual Sessions
19-23 April 2021**

GCOS-238

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1. INTRODUCTION

The Global Climate Observing System (GCOS) is co-sponsored by the World Meteorological Organization (WMO), the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization (IOC-UNESCO), the United Nations Environment Programme (UN Environment), and the International Science Council (ISC). It regularly assesses the status of global climate observations of the atmosphere, land and ocean and produces guidance for its improvement. GCOS works towards a world where climate observations are accurate and sustained, and access to climate data is free and open

GCOS relies heavily in the work undertaken by its three panels, composed by climate observation experts in the following domains: atmosphere, ocean and land.

While a considerable amount of work is done within each of the panels, on the occasion of the 25th session of the GCOS Steering Committee in Hangzhou (China) back in 2017, it became clear that the programme would benefit by an enhanced cross-panel activity and plans started to facilitate this.

The first GCOS Joint Panel Meeting took place in Marrakesh in 2019¹ together with specific meetings of the each of the panels: AOPC (Atmospheric Observations Panel for Climate), OOPC (Ocean Observations Physics and Climate Panel) and TOPC (Terrestrial Observations Panel for Climate). Cross-panel discussions took place around the following topics: Energy Fluxes, Coastal Land-Ocean Water Fluxes and Extremes.

The situation caused by the COVID19 pandemic hindered the possibility of holding a physical Joint Panel Meeting in 2020. However, during the 26th session (online) of the GCOS Steering Committee, co-chairs of each of GCOS panels were asked to identify areas where panels could work collaboratively. A Joint Panel Virtual Meeting was planned for 2021 to further discuss those ideas and to showcase the progress that had happened since Marrakesh.

The GCOS Joint Panel Meeting finally took place with an online format on the week 19-23 April 2021, with a joint opening and closure session on Monday 19 and Friday 23 respectively, and four cross-panel breakout sessions on Wednesday 21.

This report reflects the main points of discussion during the joint panel session, as well as the results from each of the panel meetings that were held during the same week.

Note the presentations and documents are available on the GCOS web page:

<https://gcos.wmo.int/en/gcos-joint-panels-meeting-2021>

¹ <https://gcos.wmo.int/en/gcos-joint-panels-meeting-2019>

2. GCOS Joint Panel Meeting - Monday 19 April 2021

The meeting was opened by Petteri Taalas, Secretary General of WMO, who welcomed the participants. He mentioned that one of the outcomes of the WMO reform, was a shift towards a more integrated Earth system approach, that aims to break down barriers between different research fields. As a result, weather, climate and water are now seen as a unity and this is reflected in the new WMO governance structure into Commission. He indicated that the reform had also led to the integration of the climate actions into the Infrastructure Commission. A new WMO data policy is being elaborated and will be ready for the extraordinary congress in October 2021. Petteri Taalas complimented GCOS for its major achievements. He mentioned that GCOS is highly recognized by UNFCCC and contributes actively to IPCC, while the ECV (Essential Climate Variable) concept is widely recognized, in particular by the space agencies when defining their programmes. While GCOS networks such as GRUAN, GUAN and GSN play an important role in the in situ observations landscape, they are currently challenged by a lack of funding. Petteri Taalas mentioned that this issue could be addressed by the SOFF (Systematic Observations Funding Facility) which is currently being developed by WMO. Finally, Petteri Taalas called on the importance of other partners to contribute resources to GCOS.

Anthony Rea, Director of GCOS Secretariat, thanked Petteri Taalas and together with Han Dolman, Chair of the GCOS Steering Committee, briefly introduced the GCOS Climate Observation Conference, that will take place online on the 30th August and 3rd September 2021, and the progress of the Joint Study Group JSG-GCOS. GCOS has an old MOU and the Joint Study Group on GCOS is progressing towards an update of the mandate of GCOS and of its MOU.

Han Dolman explained that the joint panel meetings would be combined with individual panels meetings. He stressed the importance of having this opportunity to foster collaboration between GCOS panels, which otherwise tend to work independently. Therefore, a session with four breakout groups on cross-cutting themes was organized. The four themes that were selected for the joint sessions were the following:

- Extremes and Adaptation;
- Paris Agreement and Observations for GHG Science and Reporting;
- Global Climate Data Centres;
- Surface energy and water fluxes.

After the welcome and the introduction, the meeting continued with the following presentation:

- The importance of GCOS for UNFCCC (Joanna Post);
- A vision for GCOS (Han Dolman);
- Key improvements for the next 5-10 years (GCOS Panel chairs);
- GCOS Implementation Plan (GCOS Secretariat).

All the presentations can be found at the website of the meeting:

<https://gcos.wmo.int/en/gcos-joint-panels-meeting-2021>.

3. GCOS Joint Panel Meeting - Wednesday 21 April Breakout Sessions

Session 1: 13:00-15:00 CEST

Extremes and Adaptation

Chairs: Sabrina Speich, Rainer Hollman

Presenters: Regina Rodrigues, Chiara Cagnazzo and Roxy Matthew Koll

The Breakout group on “Extremes and Adaptation” met with a focus on answering the following questions: How can extremes of temperature and precipitation be best described for adaptation? What are the other important extremes for adaptation?

The breakout group started with three seeding presentations by:

Talk 1-Regina Rodrigues (Federal University of Santa Catarina, Brazil): *Marine heatwaves in the context of compound extreme events*

Talk 2- Chiara Cagnazzo (ECMWF, UK): *Adaptation and Extremes from a climate service point of view*

Talk 3- Roxy Matthew Koll (Indian Institute of Tropical Meteorology, India): *Weather and climate extremes in the Indian Ocean region*

A dedicated group under TOPC leadership, led by Nigel Tapper, has been working on adaptation for the last couple of years, and at the last Steering Committee it was agreed that the group should be extended to include the participation of the other two panels. This group will work to identify a plan for the way forward for GCOS that will be presented at next Steering Committee.

The key points arising from the discussion were the following:

- GCOS, through its ECVs, can provide indicators for adaptation, which are indicators to inform adaptation. These indicators provide key information about for example hazards as well as the links to exposure/risk. GCOS can also provide the indicators of adaptation, based on the direct observation of adaptation through some of the ECVs.
- Extremes: Extremes are intensifying, are a compound phenomenon and are often happening across the 3 subsystems (ocean, atmosphere and land). There is a need of better defining and characterizing them, which could be achieved by a task team across WCRP, GCOS and intermediate stakeholders like Climate Services and with links to UNFCCC. Extremes should be defined from compound ECVs, going from single ECVs extremes to multi-ECV assessments and joint analyses. Definitions are needed, i.e. how to measure “very rare”, “very large” events with dependence of time scale.
- Adaptation: There is a clear need on information to be used for prioritization of risks. In selecting the ECV variables *for* and *of* adaptation it is important to consider the stakeholder view rather than the science view. Progress of adaptation needs to be measured through reliable observations. Second order effect of impact needs to be identified, e.g. the primary impact from precipitation is the occurrence of droughts (1st order) which affects the impact on food (2nd order).

The preliminary conclusion from this breakout group was that all ECVs are key variables to define extremes and adaptation and risk assessment. A new task team to work with links to science and stakeholders (across WCRP, GCOS, Climate Services and link to UNFCCC) will be established to better define extremes and related ECVs and to develop indicators for risk assessments, adaptation policies and to track adaptation.

Session 2: 15:00-17:00 CEST

Paris Agreement and Observations for GHG Science and Reporting

Chairs: Karina von Schuckmann, Han Dolman, Martin Herold, Dale Hurst

Presenters: Han Dolman, Joanna Post, Stephen Briggs, Arlyn Andrews

The Breakout group on “Paris Agreement and Observations for GHG Science and Reporting” met to discuss around the following guiding questions: (1) How well do the GCOS ECVs contribute to adequate monitoring of GHG in the context of the Paris agreement? (2) What improvements can we make?

The session started with four presentations followed by a Questions and Answers session, where the audience contributed to the discussion.

Talk 1- Han Dolman (VU Amsterdam, NL): Importance of science-based information for reporting and monitoring at the science-policy interface: A GCOS perspective

Talk 2- Joana Post (UNFCCC, UK): Recommendations for GCOS from a UNFCCC perspective: Global stocktake and the science dialogue process

Talk 3 - Stephen Briggs (ESA, Italy): CEOS support to the UNFCCC Global Stocktake 2023

Talk 4- Arlyn Andrews (NOAA Global Monitoring Laboratory, US): Towards an Integrated Surface-to-Space Global Atmospheric Carbon/GHG Observing System: Tracking Emissions and Climate Feedbacks To Support Mitigation Efforts and Improve Climate Forecasts

The discussion addressed both the challenges around providing observations for GHG Science and their potential solutions.

CHALLENGES

Research

- Improve knowledge of changes in natural cycles to accurately differentiate between natural net fluxes and anthropogenic emissions;
- Improve process understanding for inventories, particularly on the allocation of carbon in the system;
- Better characterize terrestrial emissions.

Monitoring

- Large uncertainties and discrepancies (top-down/bottom-up)
- Move from global to regional and country level: still a way to go
- Challenge for public sector to deal with increasingly privately funded satellite missions
- Improvements needed to deal with time-scales & related uncertainties
- Identify & work to close observing system gaps

Assessment/Policy

- Reinforcement needed for communication to policy (UNFCCC): what is needed? What is possible? What is not possible?
- Incoherent messages from different int. groups
- Improve integration top-down / bottom-up
- Promote broad support to IPCC

SOLUTIONS

Research

- Reinforce the linkage between model/observations interactions;
- Strengthen the collaboration between different international programs;
- Realize regional demonstrators (coherent across programs);
- Improve the model complexity& parametrizations for carbon inventories.

Monitoring

- Work to improve satellite retrievals;

- Develop and establish tools/frameworks for multi-product & -parameter approaches;
- Revise/ reinforce observing system requirements;
- Develop new and more integrated ECVs;
- Strengthen the collaboration between different international programs, and identify/ realize regional demonstrators (coherent across programs).

Assessment/Policy

- Strengthen the collaboration between int. programs, and particularly on message coherency;
- Develop demonstrators (across programs) on information need for mitigation, adaptation & finance;
- Strengthen the collaboration with IPCC, particularly supporting the establishment of guidelines, including through selected demonstrators for specific countries' support.

Potential actions to take forward

- Identify and collaborate among international programs (e.g. GCOS, CEOS, GEO, ...) on specific regional demonstrators to jointly advance on key challenges identified across research, monitoring and assessment/policy, and aiming to develop storylines on achieved advancements to improve communication to policy (UNFCCC), and to reinforce observing system recommendations, and to contribute to specific country support (GEO, UNFCCC);
- Discuss the creation of a taskforce acting across different international programs (e.g. GCOS, CEOS, GEO, ...) to join forces aiming to improve knowledge of changes in natural cycles to accurately differentiate between natural net fluxes and anthropogenic emissions;
- Reinforce the exchange across international on ECV specification, revision and addition; observing system recommendations and support to critical guidelines in support of UNFCCC and GEO;
- Discuss the specific role of GCOS in support of these identified opportunities in the light of the Implementation Plan.

Session 3: 13:00-15:00 CEST

Global Climate Data Centres

Chairs: Peter Thorne (AOPC Co-chair), Thelma Krug (TOPC Co-chair), Weidong Yu (OOPC Co-chair)

Presenters: Peter Thorne (AOPC Co-chair), Thelma Krug (TOPC Co-chair), Weidong Yu (OOPC Co-chair), Eric Freeman (NOAA)

The Breakout group on "Global Climate Data Centres" met to discuss around the following guiding questions: (1) What is needed to improve the network of global data centres? (2) What are the minimum requirements for GCOS endorsed global climate data centres?

The session started with four presentations giving the perspectives of AOPC (Peter Thorne), TOPC (Thelma Krug) and OOPC (represented by Eric Freeman who provided an overview on Marine Climate Data Systems, and by Weidong Yu, who is the co-chair of OOPC). All the presentations can be downloaded at <https://gcos.wmo.int/en/gcos-joint-panels-meeting-2021>.

These presentations fostered the discussion in the second part of the session around the following topics:

Importance of data storing and integration

- While observations are disproportionately funded across the domains and regions and increasing them is a priority, managing, curating and preserving those observations is equally important. Products and services can only be created if data are available.
- Compliance with FAIR principles is one of the basic requirements that needs to be considered when thinking of climate data centres. More than setting up new data centres specific for a variable in particular, a better integration of the already-existing data centres should be sought for. Related to this, efforts must be done to ensure that data are consistent and interoperable across different data centres.
- There are several initiatives already operating that can serve as a best practice example of data archives/centres/processes, and encourage others to get involved, and perhaps attract new resources (e.g. ENVRI FAIR (European Commission)).
- There are already many useful examples in terms of accreditation World Data Systems and <https://www.coretrustseal.org/why-certification/requirements/>.

Funding

- It is worth considering funding mechanisms such as Belmont Forum and Future Earth, which launch calls for projects to be undertaken in several years, to support the creation of data centres. Those projects could seek to be integrated since the onset in Global Data Initiatives.
- Developing and providing services is a way of improving sustainability of data centres.
- Addressing the sustainability of local/national data centres is also fundamental to make sure that Global Data Centres can work. A suggestion is to use international funding to help individual/national data centres to waive periods of funding draught. Another suggestion is to focus: not all the data centres need to do everything, the activity could be spread amongst several global data centres (one could do the archiving, another would do the delivery, another create products and so on).

The role for GCOS

- GCOS could put greater emphasis on highlighting the importance of data management, whose cost is much lower than satellite observations, for instance.
- Deeper reflection on the role that GCOS should be playing: from advocating to a more active endorsement, which would require resources and the backing from the co-sponsors WMO, IOC, UNEP, ISC.
- Should GCOS promote the use of a maturity matrix for the data archives, rather than endorsing the data centre? Metadata (mentioned by many), data quality and stewardship are perhaps more important than the data-centre itself? There are significant regional differences in the data quality/availability in the current archives.
- GCOS should promote a cross-panel approach when considering these issues, in particular for Data management.
- GCOS needs to be concrete and identify one or more actionable IP actions in this area that does not amount solely for a call for funding.

Panel perspectives

- The Ocean community has been working for years in a well-defined, supported by IOC/WMO marine climate data centres MCDS with a tiered approach from DAC (data assembly centres), GDAC (Global Data Assembly Centres), and CMOC (Center for Marine-Meteorological and Ocean Climate Data).
- NCEI – Could the World Data System be a standard for data centres? It is clear that the climate community has already set a good example and this should be recognized and

leveraged. Consider tiering of data-centres, similar to tiered networks (reference, baseline, comprehensive).

- Given the limitation of resources, extra care should be given to consider the gaps that need being addressed as a priority, instead of duplicating efforts.

Session 4: 15:00-17:00 CEST

Surface energy and water fluxes

Chair: Meghan Cronin

Presenters: Chris Wilson, Diego Miralles, Meghan Cronin

The Breakout group on “Surface energy and water fluxes” met with a focus on answering the following questions: How complete is the coverage (spatial and temporal) of Air-sea and Land-Air fluxes (evaporation, sensible heat ...)? What can be implemented now and what developments are needed? How consistent are the existing flux ECVs?

The breakout group started with three presentations on the air-sea flux activities, by Meghan Cronin, Planetary Boundary Layer (PBL) sounding of temperature and water vapor by Chris Wilson and Satellite Land Evaporation by Diego Miralles. Presentations can be found at <https://gcos.wmo.int/en/gcos-joint-panels-meeting-2021>.

The discussion following the presentations focused on the satellite capabilities to observe vertical profile of temperature and water vapor at the needed resolution to derive air-sea fluxes. The main limitation is represented by the physics governing the process of observing close to the sea surface using satellite techniques. The best available technique provides a vertical resolution of 300m which is not sufficient for this purpose. The Butterfly group, a proposed NASA Earth Venture Mission, whose work was presented as a possible solution, uses classic techniques, such as microwave and hyperspectral sounders, that under ideal conditions can provide measurements down to 300-500 m from the surface. Details on satellite capabilities and future developments can be found in the report that was summarized in the presentation (<https://science.nasa.gov/earth-science/decadal-pbl>).

Thus, other techniques need to be considered. AIRS has a near surface temperature that is not a retrieved product but it is obtained by extrapolating the last temperature from the retrieval to the surface and it has been used for surface fluxes studies (<https://journals.ametsoc.org/view/journals/apme/57/5/jamc-d-17-0216.1.xml>).

In-situ observations can be used to observe air-sea fluxes. Microwaves, lidar technique, doppler lidar, are techniques used for atmospheric observations over land that could then be extended to the ocean. However, they are energy consuming so they will need to be implemented on platforms rather than on buoys. The measurements accuracy required for air-se fluxes is very stringent, so the concept of tiered observations could be applied, designing an observing system that includes a small number of high accuracy measurements. The challenge is to make sure that we can test that the required accuracy is truly delivered by these sites. Satellite observations could then be used to improve the models and reanalysis so that these can then be useful to fill in the gaps in the observing system.

Given the inherent, physical limitations in observing the boundary layer from space, it is important to understand how to use global space-based observations from microwave and hyperspectral infrared instruments making profile atmospheric observations to study fluxes and together with in situ observations to generate relevant observations and lead to correct insights. It is necessary to initiate a process study to try bringing together observations from different sources and try determining what is possible and what is missing and how to relate the different observations.

Validation and calibration of satellite is still an important issue that needs to be addressed and where there are still several challenges. This message needs to be delivered to the Satellite Agencies, who should be asked to contribute to funding the establishment and operation of the supersites, as sites with permanent high quality in situ sensing capabilities where validation and calibration can be done.

The next stage could be to have supersites scattered over the oceans in different regimes. Cheaper and lower power technology needs to be developed and this could be done by leveraging of the windfarm energy sector work and getting the attention of the Satellite Agencies. The first step is then to identify how many supersites are needed, where and with which instrumentations.

BSRN (Baseline Surface Radiation Network): at the last GCOS JPM 2019 a collaboration was started to extend the BSRN over the ocean. The current work is focusing on harmonizing the best practices for ocean and land observations and combining the data in an archive.

The whole discussion focused on surface energy fluxes and water fluxes were not addressed during this discussion.

Suggested actions following the discussion are:

Satellite fluxes actions

- Evaluate existing space-based observing capability for use in studying fluxes (Smith)
- Characterize the conditions under which satellite observations meet (or fail to meet) surface flux requirements (Smith);
- Improve methods for combining different satellite and in situ observation sources for use in flux studies (Smith);
- Explore methods to improve subdaily resolution using patchwork of observations from geostationary orbits (e.g., every 15 min) or polar orbiting platforms (e.g., twice a day from each platform).

In-situ actions

- Extend the Baseline Surface Radiation Network (BSRN) to the Ocean;
- Continue Ocean Surface Radiation Best Practice efforts within BSRN & Ocean Best Practice Systems (OBPS). Laura Riihimaki and Meghan Cronin will co-lead an OBPS Community Workshop on Surface Radiation Best Practices in September 2021;
- Estimation of global surface fluxes will require interoperable satellite and in situ measurement of multiple ECVs;
- Coordinate intercomparison experiments to test and validate interoperability between (a) different in situ platforms (e.g. shipbased, buoy, uncrewed surface vehicle, fixed tower) and sensors, (b) in situ and extrapolated satellite retrievals, and (c) observed and modeled variables. A nearshore tower station may provide a useful starting testbed;
- Develop land-based and ocean-based Supersites with direct covariance flux and profiling technology used not only for calibration & validation, but also to understand processes and to test and develop models and parameterizations. Question: Are Supersites = Atmospheric Radiation Measurement (ARM) sites? or Global Atmospheric Watch (GAW) stations? Or some other organized program?
- Leverage technology development to obtain profiler technology suitable for remote applications (i.e. small, low powered, lower cost...). This technology should first be tested in landbased stations before being used in ocean applications. (Tony Lee. Targeting initial land-based test in late 2021 to 2022 with a passive microwave upward-sounding spectrometer).

Modelled Fluxes

- Perform array designs to determine how many supersites are needed within network of reference stations – over land & ocean, where to locate them, initiate through a short-term process study;
- Improve Community practice for FAIR data, latency, continuity;
- Improve communication through SCOR Working Group #162 Observing Air-Sea Interactions Strategy (OASIS), which includes OOPC, AOPC, and BGC & Bio/Ecosystem GOOS Panel representation. Contact Meghan.F.Cronin@noaa.gov to join the slack workspace. See airseaobs.org.

4. GCOS Joint Panel Meeting - Friday 23 April – Wrap up

GCOS chair, Han Dolman, started the meeting by reminding the organization and focus of the wrap up session, where the chairs of each of the breakout sessions briefly had to report on the main conclusions obtained during their discussions.

The four reports can be found on: <https://gcos.wmo.int/en/gcos-joint-panels-meeting-2021>

The chairs of the breakout session agreed to provide short summaries for each of the discussions drawing from the presentations.

Anthony Rea thanked GCOS experts and GCOS panel chairs for their participation and contributions and efforts. He recalled that he and Han Dolman had a meeting with WMO Secretary General Director, and the Assistant Secretary General, who expressed WMO's strong commitment to GCOS.

Han Dolman encouraged attendees to participate and solicit contributions to GCOS/WCRP Climate Conference which will be held in October 2021 (*postponed to 2022*).

Han Dolman expressed his warm appreciation for the hard work done by experts in producing the GCOS Status Report and talked the participants through the outline and timeline for developing the GCOS Implementation Plan, which will be focused on the observation networks who are best positioned to take action to improve the observing system.

Anthony Rea and Han Dolman closed the meeting by reiterating their appreciation to the participants and inviting them to continue the good work.

5. 26th Session of the GCOS/WCRP Atmospheric Observation Panel for Climate (AOPC-26)

Day 1 – Monday 19 April 2021

The meeting started with presentations from the four new members of AOPC, Chiara Cagnazzo, Maria Hakuba, Matilde Rusticucci, and Nadia Smith, focusing on their research and professional interest. The presentations are available at:

<https://gcoss.wmo.int/en/aopc-26-meeting-2021>

Day 2 – Tuesday 20 April 2021

Baseline Networks

Tim Oakley (GCOS Network Manager) provided an update on the GCOS Surface Network (GSN) and GCOS Upper Air Network (GUAN). He reminded the panel the background of these GCOS nominated networks, which are a recognized 'brand' across the WMO and Climate community. The stations nominated to these networks are primarily owned and operated by NMHS who have committed, through WMO regulations, to continue their operation. The key points from the presentation were as follows:

- 2020 monitoring shows no significant change in the performance of the two networks across the regions. RA-I remains the worst performing region, by some margin, and remains the primary focus of any support;
- 2020 showed an increase in BUFR reporting across the GUAN network, with 72% of these stations now reporting either a low- or high-resolution message;
- The GCOS Cooperation Mechanism (GCM) has supported the GUAN operations at Yerevan, Armenia and Gan, Maldives, through funds provided by Japan. The HIGHWAY project which has supported GUAN stations in Kenya and Tanzania, through the GCM, will formerly close at the end of March 2021;
- An update 2021 station list for the GSN (1 deletion, 1 addition and 3 closed/replaced) and GUAN (1 close/replace) was approved by AOPC.

Stefan Klink provided a presentation on the Global Basic Observing Network (GBON).

The GBON concepts was developed in response to the gaps in data coverage. A decision on GBON provisions is expected at WMO Extraordinary Congress in 2021. GBON is initially focusing on global Numerical Weather Prediction (NWP), as global NWP underpins all products and services provided by all WMO members to their citizens and it depends on supply of observations from the entire global domain. As for some countries it is difficult to deliver to GBON requirements, a mechanism for long-term funding of observations is being put in place, the Systematic Observations Financing Facility (SOFF).

As of now, GBON deals mostly with atmospheric observations. However, if approved at the WMO Extraordinary Congress it is the plan to extend GBON to cover other application areas as well, such as the marine domain, CO₂ observations in support of the Paris Agreement and climate observations. Expanding GBON to include climate observations will require careful consideration on how to include the no-real time observations. The decision will need discussions with the various communities and in terms of climate the GBON Study Group requested input from AOPC.

Tanja Kleinert provided a presentation on the WIGOS Data Quality Management System (WDQMS). The international exchange is crucial for the WDQMS. The observations are collected in the NMHS HQ and then transmitted through the GTS. This is where the WDQMS starts. The WDQMS has three functions: a monitoring function, an evaluation function and an incident management function, where problems in terms of gaps in observations are identified, tickets

are raised and the process to ratify a situation is started. WDQMS is one of the WIGOS tools who also comprise of the metadata repository (OSCAR/Surface) and the WDQMS Incident Management System web-tool. Important in this process are the Regional WIGOS Center that evaluates the performances and initiates the incident management system in case of non-compliance. Also important are the WIGOS Station Identifiers (WSI). Of interest for AOPC is resolution 35 that delegates authority to the relevant authority for GRUAN to issue WSIs for non-NMHS observing stations that contribute to the relevant network on behalf of Members under specified circumstances. Finally, there is a new module in the WDQMS web-tool for the monitoring of the GCOS Networks, GUAN and GSN. The variables covered in the monitoring of GUAN are air temperature, humidity and wind and it only covers observations provided in BUFR file format. Variables included in GSN monitoring are daily values of mean surface pressure, mean air temperature, max air temperature, min air temperature, mean water vapor, total precipitation and total sunshine duration. GSN and GUAN are now in the WDQMS. Next step should be to include them to the Regional WIGOS Centres role in monitoring and raising incidents. A more active process within WDQMS would improve data availability and quality.

Next steps in WDQMS evolution are the developing of plans to integrate additional networks, and further work to improve the performance of the tools.

Discussion session on 2 main points:

1. *How GSN and GUAN can be integrated into the GBON and what are the relevant requirements that must be maintained*

The main question is whether once GBON is implemented, GUAN and GSN could be integrated into GBON. The integration of GUAN and GSN into GBON is not seen as mandatory, as the requirements for a GBON station might be different than those for a GUAN station.

Simplification of the network structure would be beneficial for data management and public use and it will improve data quality as the best way to do quality control is to have all data together. An idea could be to have a substructure within GBON that would include requirements for different applications.

At the moment, GBON requirements do not include maintaining/protecting long-term stations, a requirement that needs to be included into GBON if GUAN and GSN are to be fully integrated and achieve relevance to climate applications.

2. *How to ensure that GBON delivers to climate applications. What is the path towards marine and atmospheric composition observations; how to develop a narrative on how GBON links to climate.*

There will not be multiple GBON networks so GBON should be viewed as an opportunity not to be missed to improve access to observations in other areas/applications (i.e., marine / atmospheric composition).

There are concerns that GBON only references a few measurements (e.g., surface pressure and sea surface temperature) over the ocean and this will send the wrong message to the community operating and developing the observing systems because many more observations are needed for climate research and applications. In the initial discussions where GBON was presented to the different regions, many asked about the extension of GBON into supporting and maintaining marine observations, and one region also mentioned the importance of surface atmospheric composition observations. So, there is an interest to extend GBON to cover one or all of the above-mentioned areas. A possible way forward would be to add some text for the GBON decision going to Congress to reference the need of additional observations within GBON and

ask the Infrastructure Commission to perform an analysis to identify the requirements needed to extend GBON provision to supporting climate research and applications.

Many members of the AOPC see the expansion of GBON to cover climate observations as an opportunity. The set of requirements to be included in GBON has to be identified within AOPC:

***ACTION 1.** Identify a set of requirements that GBON should include in order for GBON to deliver to climate applications.*

***ACTION 2.** Identify the relevant requirements for GUAN and GSN that need to be maintained and, depending on this, collaborate with the GBON SG towards the integration of GUAN and GSN into GBON.*

***ACTION 3.** Move forward to include GSN and GUAN in the Regional WIGOS Centres. This will ensure the monitoring and the incident management and thus improve availability and quality.*

Task Teams

1. GSRN

Tilman Holfelder, co-chair of the GSRN-TT together with Sarah Gallagher, presented the status of the task team. The task team is now established and has already met once. It comprises 25 members, covering the different regions of WMO and different expertise. The next two meetings are planned for the 28th and 29th April, where existing reference networks will be presented. The workplan of the team for the next 4 years is going to be presented and discussed. In terms of Lead Center, 6 countries have expressed their interest of taking up this role. The task team will discuss whether there should be one or more Lead Centers and how to move forward with the selection.

***ACTION 4.** The co-chairs of GSRC-TT will report at next AOPC meeting.*

2. Lightning

Steve Goodman, new chair of the task team on lightning, reported on the status of this task team. Steve presented the work plan outputs, status and update, which includes topics where progress is significant and first results are expected by the end of 2021, such as the data records and archive, the reprocessing of existing data, and the establishment of a new data repository for a thunder database. He also pointed out areas that are progressing slower, such as the Schumann Resonances, where sharing of data is still problematic and the Global Electric Circuit, where the balloon campaign needed for measuring the ionospheric potential is on hold pending the development of sensors. Finally, results from studies on the detection of Lightning from space in the last 25 years and the progress made thanks to the GEOS Geostationary Lightning Mapper were also shown. The presentation was followed by several positive comments by the AOPC members.

***ACTION 5.** The chair of the lightning task team will report on progress at next AOPC meeting.*

Day 3 – Friday 23 April 2021

Implementation Plan

Climate observations have been a fundamental part of the UNFCCC since its creation.

The Paris Agreement also notes the importance of systematic climate observations and links this to adaptation planning.

In 2019 the UNFCCC noted the plans of GCOS to provide an overview of the status of the global observing system for climate in 2021, to address gaps and set new requirements for the system and publish an update to the GCOS implementation plan in 2022, and encouraged Parties, the co-sponsors of the GCOS programme and relevant organizations to actively engage in this work.

The 2022 Implementation Plan will be submitted to UNFCCC COP in 2022 and will be, compared to the GCOS IP 2016. It will be a shorter and more concise document than the GCOS IP 2016, with clear priorities and actions more targeted at the observing system and at those who implement them.

In order to provide consistent text, a consultant will be recruited as lead author. The input to the Implementation Plan will come from the GCOS Status Report, Climate Observations Conference and the GCOS panels. Panels will provide the technical content, while the text will be drafted by the lead author. In terms of timeline, the panels are expected to provide input by December 2021. A Public Review will take place in the first quarter of 2022 and the panels, together with the lead author, will finalize the IP by June 2022.

Each member of the panel was asked to propose three actions that they considered to be important for implementation in the next 5 years. The panel will meet in the next months to consolidate the list of actions.

Summary of actions

| Action | | Who | When |
|-----------|--|--|-------------------------|
| AOPC-26/1 | Identify a set of requirements that GBON should include in order for GBON to deliver to climate applications | AOPC | Next AOPC panel meeting |
| AOPC-26/2 | Identify the relevant requirements for GUAN and GSN that need to be maintained and, depending on this, collaborate with the GBON SG towards the integration of GUAN and GSN into GBON. | AOPC | Next AOPC panel meeting |
| AOPC-26/3 | Move forward to include GSN and GUAN in the Regional WIGOS Centres. This will ensure the monitoring and the incident management and thus improve availability and quality. | GCOS Network manager, GCOS Secretariat | TBD |
| AOPC-26/4 | The co-chairs will report at next AOPC meeting | Tilman Holfelder and Sarah Gallagher | Next AOPC panel meeting |
| AOPC-26/5 | The chair will report on progress at next AOPC meeting. | Steve Goodman | Next AOPC panel meeting |

6. 24th Session of the GCOS/GOOS/WCRP Ocean Observations Physics and Climate (OOPC-24)

The 24th session of the Ocean Observations Physics and Climate panel OOPC was held online in the week of 19-23 April 2021, in parallel with the 2nd GCOS Joint Panel Meeting.

In 2020, OOPC activities were heavily impacted by the COVID-19 pandemic, which hindered many of the meetings (including the GCOS meeting scheduled in Cape Town, South Africa from 10-13 March 2020). Furthermore, the departure of the previous OOPC officer Katy Hill in spring 2020, and later on of her replacement Maria Hood in August 2020 left the panel devoid of secretariat support for 6 months. The membership of the panel also underwent major changes in that same period, with four members being replaced and two co-chairs (Sabrina Speich and Weidong Yu) taking over from Bernadette Sloyan.

The new OOPC scientific officer, Belén Martín Míguez, joined WMO in January 2021. A first OOPC meeting was held at the beginning of March 2021 spread in two different virtual sessions with the purpose of introducing the new officer to the panel and sharing updates on the status of the different activities that the panel was carrying out.

On 19-23 April 2021, OOPC met again in three different sessions of 2hours each, with three different foci of attention and discussion: GCOS Status Report, the review of requirements for the Essential Climate Variables and Essential Ocean Variables EO/ECV, and the relationship between OOPC and CLIVAR activities. OOPC panel members also participated in the GCOS Joint Panel Meetings which took place the same week.

All presentations and Agenda from the OOPC meeting are available at:

<https://gcos.wmo.int/en/oopc-24-meeting-2021>.

The joint report, including the Joint Panel Sessions and the AOPC and TOPC sessions, can also be found on the same site.

Next, a report on each of the three sessions will be provided. OOPC Actions are identified throughout the text in italics and summarized in a Table at the end.

Day 1 – Monday 19 April 2021, 15:00-17:00 - Consolidation of GCOS Status Report after the Public Review

Participants

Sabrina Speich (OOPC co-chair), Weidong Yu (OOPC co-chair), Maria Paz Chidichimo, Eitarou Oka, Marjolaine Krug, Karina von Schuckman, Peter Oke, Meghan Cronin, Satya Prakash, Belén Martín Míguez (OOPC officer).

Objective

The session focused on planning how to address and incorporate the comments received during the public review of the GCOS Status Report to produce a new draft.

Background

The GCOS programme has a 5-year assessment and reporting cycle, where the GCOS Status Report (which aims at evaluating the adequacy of the observing system to monitor the ECVs and the degree of success of the Actions identified in the 2016 GCOS Implementation Plan (2016 GCOS-IP)) needs to be finalized and delivered in 2021. Later on, GCOS Implementation Plan 2022 will take into consideration the findings of GCOS Status Report to provide some recommendations on how to improve the climate observing system.

GCOS Status Report has a main text, which reflects the main findings plus three Annexes: Annex A (assessment of the observing system in terms of the ECVs); Annex B (assessment of the

degree of the accomplishment of the Actions identified in 2016 GCOS-IP; Annex C (description of the observational networks contributing to the global climate observing system). In Annex A, the assessment considers two aspects for each ECV: the adequacy of the observational system and the availability and stewardship of the data.

A first draft of the GCOS Status Report was finished in January 2021 and was open for public review from February to April 2021. More than 500 comments were received even though less than 50 were related to OOPC specifically.

Development of the Session

Belén Martín Míguez presented the list of comments to the panel, highlighting that the most important requests for modifications received during the public review concerned Annex A. For several ECVs (namely Sea Surface Temperature, Sea Surface Stress, and Subsurface currents), reviewers considered that a lengthier discussion to justify the assessment was needed.

To properly address the reviewers' comments two possibilities were considered:

- 1) Using a previous document prepared and distributed in spring 2020 by Bernadette Sloyan (former OOPC-chair) and Maria Hood (former OOPC officer) where some instructions and directions were given;
- 2) Using ECVs from other GCOS panels (e.g. AOPC) as a reference to be more consistent.

During the discussion, it was agreed that the most efficient way to proceed was to assign stewards to each of the variables, not only for the sake of GCOS Status Report but for following up on ECV/EOV requirements in general. Those stewards would be the point of reference for Belén Martín Míguez whenever there was a question concerning the ECV/EOV under their responsibility.

OOPC members preferred to have two stewards per variable to ensure that the responsibility was shared, and several points of view were taken into account.

The following table was agreed upon:

Ocean Variables Stewards

| | |
|-------------------------|--|
| Subsurface temperature | Karina Von Schuckmann, Peter Oke, Eitarou Oka |
| Sea-surface temperature | Marjolaine Krug, Weidong Yu (Helen Beggs from Bureau of Meteorology could support) |
| Subsurface salinity | Eitarou Oka, Sabrina Speich, Benjamin Rabe |
| Sea-surface salinity | Tony Lee, Sabrina Speich |
| Subsurface current | Maria Paz Chidichimo, Lisa Beal |
| Surface current | Marjolaine Krug, Lisa Beal |
| Sea level | Peter Oke, Karina Von Schuckmann |
| Sea state | Kathleen McInnes (subject to consultation) |
| Sea ice | Benjamin Rabe, Cryosphere Watch / Rodica Nitu (WMO) coordinating |
| Ocean surface stress | Meghan Cronin, Tony Lee |
| Ocean surface heat flux | Meghan Cronin, Weidong Yu |

The assignment was conditioned by the fact that one OOPC member (Matt Palmer) is stepping down and some others were not present at the meeting, hence, the list could be subject to modification in the future.

The panel also agreed that OceanObs19 papers are a very valuable source of information to review ECV/EOVs requirements in the future (this should be done by the next GCOS-IP).

Sabrina Speich explained that the discussion in the GCOS Status Report-Annex A covered also the evolution of the observing system for each ECV/EOV, in addition to the justification of the scoring.

Eitarou Oka asked about biogeochemistry and biological parameters, which are also part of the ECVs but do not fall under OOPC expertise. Belén Martín Míguez explained that she has been in touch with the officers of BioEco (Lavy Ratnarajah) and BGC panels (Artur Palacz), who had revised the text and provided comments. Likewise, Belén Martín Míguez will consult with them if there are further external reviews which concern biological or biogeochemical variables.

***ACTION 1.** Consolidation of the GCOS Status Report by the ECV/EOVS stewards considering the public reviews received for the ECV/EOV under their responsibility.*

Next, OOPC members discussed the GCOS Breakout Sessions which were going to take place on Wednesday 21 April, their ambition, how they have been organized, and what kind of engagement was needed from OOPC members. The breakout sessions provided an occasion for the three GCOS panels to meet and discuss, as well as to provide input to GCOS Implementation Plan. While it is recognized that the preparation time was not enough, OOPC experts were asked to contribute to them as much as possible, and in fact, three out of the four sessions were led by members of OOPC.

A discussion on Global Climate Data Centres followed. In general, the perception is that there are already a relevant number of data centres existing, and more coordination is needed to assemble those data. Big data and cloud environments should also be considered when dealing with this issue.

OOPC Co-chair Sabrina Speich finished the session thanking OOPC members and encouraging them to participate actively in the GCOS Breakout Sessions on Wednesday 21 April 2021.

Day 2 - Tuesday 20 April 2021, 13:00-15:00 CEST - EOVS Specifications

Participants

Sabrina Speich (OOPC co-chair), Weidong Yu (OOPC co-chair), Eitarou Oka, Marjolaine Krug, Karina von Schuckman, Peter Oke, Benjamin Rabe, Belén Martín Míguez (OOPC officer).

The session counted on the participation of three guests: Lars Peter Riishojgaard (World Meteorological Organization, WMO), Champika Gallage (WMO), and Artur Palacz (project officer for the International Ocean Carbon Coordination project and the GOOS biogeochemistry panel).

Objective

The session focused on planning the review of the EOVS/ECVs requirements and presenting the new ECV/EOVS specification sheets where the requirements are defined.

Developing of the Session

Lars Peter Riishojgaard (Director of the Earth System Branch, Infrastructure Department at WMO, and responsible for GBON (WMO Global Basic Observing Network) and for the new WMO Data Policy) opened the session. He introduced those WMO initiatives, highlighting that both included marine data.

Artur Palacz provided an overview of the cross GCOS/GOOS efforts around EOVS and ECVs and the efforts done to streamline the process and set the requirements in a more transparent, effortless and timely manner.

Artur Palacz's presentation can be found here:

Some questions and comments that arose after the presentation were:

- The modeling community involved in Observing System Simulation Experiments could benefit from having a clearer idea of the requirements established in EOVS and ECVs. The EOVS framework should be brought closer to the modeling community and asking community-specific questions could prompt them to use their tools with a very specific expected output. There is an Ocean Decade programme like CoastPredict that contemplates this kind of interaction;
- The EOVS/ECV framework has certain caveats: it does not include the services; from a perspective it is focusing on the open ocean, not so much on the EEZs;
- The EOVS/ECV framework should also consider other indicator frameworks (like the Sustainable Development Goals, the EC Marine Strategy Framework Directive...);
- Adaptable resolution according to the Rossby radius change with latitude should be considered; in certain regions like the Arctic region, the stakeholder framework for ocean observations is very complex and the focus on climate is not sufficient;
- There is a compromise between constructing an EOVS/ECV framework that is manageable and easy to communicate, and something that can be useful for different applications and regions.

All these points should be considered by the EOVS Task Team; the membership should take into account that OOPC and other GOOS panels experts cannot assume more tasks.

Artur Palacz reminded which were the main actions that OOPC members were requested to undertake:

- Assign persons responsible for each EOVS (already done) and agree on a timeline to complete these revisions. BioEco and International Ocean Carbon Coordination Project (IOCCP) have already initiated the process intending to publish together the revised versions by end of 2021;
- Transfer the information from OOPC EOVS Spec Sheets into the new template and highlight any issues with EOVS subvariable vs. ECV product requirements;
- Make any necessary updates (new products, new data streams, etc.), clear internal inconsistencies, or make adjustments to the new format of some EOVS Specification Sheet tables (mostly a simplification and removal of redundancies).

Artur Palacz also stressed that this should not require a big effort, while the advantages were numerous: the process would save the panel experts time and energy, maintain the legacy of the experts' inputs, improve overall GOOS messaging, and enable full integration with GCOS processes by the next reporting cycle.

ACTION 2. *Transfer information on ECV/EOVS requirements into the new specification sheets, considering the feedback provided during the 2020 public review.*

WMO Rolling Review of Requirements

Lars Peter Riishojgaard explained how WMO compiles all the requirements for variables and WMO application areas and stores them in a database (OSCAR). This has imposed an extra load on OOPC, which has to fit the EOVS/ECV requirements into that database for climate purposes. Both processes (WMO RRR and EOVS/ECV) need to be better aligned to avoid duplication of work.

ACTION 3. *Setting up a meeting WMO/OOPC to explain how WMO uses the requirement process to steer the development of the observing system.*

As far as which EOVs needed to be included in OSCAR requirements database (e.g. including biogeochemistry and BioEco) or not, according to Lars Peter Riishojgaard the decision would require bearing in mind which communities WMO mostly engages with (e.g. Meteorological and Hydrographic Services).

- The panel recognizes that the participation of representatives from WMO and IOCCP has been extremely useful.

OOPC membership

- Belén Martín Míguez inquired about the process of becoming an OOPC member. OOPC experts and Artur Palacz shared their experiences, which differ and have evolved with time. For OOPC the process was open for applications in 2016, while in 2019 experts were invited to join. Artur Palacz explained that since IOCCP is linked to the Scientific Committee on Oceanic Research (SCOR), stricter rules apply: the process is open, there is a turnover (half of the members change every 3y), and they rely on external experts too, as it is not easy to find enough members that also satisfy gender and geographical balance criteria. Benjamin Rabe mentioned that it was his institution (AWI, Germany) who appointed him to sit in OOPC.

Day 3 - Thursday 22 April 2021, 15:00-17:00 CEST - EOVS Specifications

Participants

OOPC: Sabrina Speich (OOPC co-chair), Weidong Yu (OOPC co-chair), Maria Paz Chidichimo, Eitarou Oka, Marjolaine Krug, Karina von Schuckman, Peter Oke, Meghan Cronin, Benjamin Rabe, Belén Martín Míguez (OOPC officer).

CLIVAR: Jose Luis Santos Davila; Jing Li; Liping Ying, Gregory Foltz, Juliet Hermes, Yuko Okumura, Roxy Mathew Koll, Sophie Cravatte, Regina R. Rodrigues, M. Ravichandran.

Objective

The session considered the current and potential interactions between WCRP's project CLIVAR and OOPC, in particular the reviews of the ocean observing systems in the Tropical Atlantic, the Indian Ocean, and the Tropical Pacific.

Background

WCRP is, together with GCOS and GOOS, one of the three co-sponsors of OOPC. The connections between OOPC and WCRP have generally been established mainly through CLIVAR. CLIVAR (Climate and Ocean: Variability, Predictability, and Change) is one of the four core projects of WCRP. CLIVAR's mission is to understand the dynamics, the interaction, and the predictability of the climate system with an emphasis on ocean-atmosphere interactions. Some OOPC experts also serve or have served in CLIVAR.

Development

Sabrina Speich gave a presentation on OOPC, its main activities, and its relation with its co-sponsors, including WCRP. She explained that the OOPC role will have to evolve, to respond to a changing environment where its co-sponsors are also undergoing transformations. OOPC has become increasingly involved in WMO-related activities since JCOMM was dismantled, and the connection with UNFCCC through GCOS is extremely valuable.

The group discussed the somewhat tenuous differences in scope between WCRP/CLIVAR and OOPC (more research-oriented/innovative including modeling vs. more operational/focusing on observations). It also discussed how the connections had been established in the past when CLIVAR experts were invited to OOPC meetings. It was agreed that this linkage has to be discussed and reinforced taking advantage of new opportunities such as the WCRP lighthouse

activities including extremes, marine heatwaves, or ocean acidification as well as modeling activities or (big) data management.

The discussion was followed by talks from two CLIVAR experts and Weidong Yu, formerly also part of CLIVAR, now OOPC co-chair:

1. ***Regina Rodrigues and TAOS Review. See presentation [here](#)***

The presentation described how TAOS review was undertaken, the key elements of the tropical Atlantic in situ observing system, the mooring and Argo network, the operational drivers for the TAOS, as well as the key recommendations with new recommended deployments/sites.

Some of the questions and comments raised after Regina R. Rodrigues' presentation were:

- Regarding the main challenges to implement the recommendations from the review, TAOS was created to ensure more regular funding and raise the profile of the observing system in the Atlantic. It was also meant to integrate several networks including and beyond PIRATA. While the project has succeeded to attract some funds (in France, for instance, the system has been labelled as research infrastructure), the support is not guaranteed. The three main funding countries involved are Brazil, France and the US, but there have been problems with buoys discontinuing operations in 2020 from Brazil. The Belem Statement, instigated by the European Commission, facilitated the MoU between the three countries and has been instrumental in ensuring their engagement and support. This example is worth considering for other observing systems. However, TAOS lacks engagement from African and Caribbean countries. The Ocean Decade may be a possibility to push the system further;
- Unlike other systems (like TPOS, which only considered Biogeochemical variables in addition to the physical ones), TAOS managed to consider biological variables as a result of the work done during the prephase in the Atlantic and the involvement of African countries. Nevertheless, the connection with the coast is not there yet.

2. ***Roxy Mathew Koll: IndOOS. See presentation [here](#)***

The presentation provided an overview of the role of IndOOS in the region and how climate had become one of the most important drivers for the observing system. It also explained how the system evolved in the last decades to become one of the best-observed regions. It described some of the remaining observational gaps as well as some of the main findings. IndOOS relevance is particularly clear in an era of increased vulnerability of the rim countries and small island developing states. The implementation of IndOOS in the future (IndOOS-2) will be facilitated by an IndOOS Resource Forum.

Some of the comments raised after Regina R. Rodrigues' presentation were:

- The review recommended autonomous vehicles and considered drones for the future to sample difficult-to-reach regions. For TPOS there are new programmes with unmanned vehicles in several regions close to the coast;
- Saildrones should also be managed in a more organized way and considering FAIR principles such as other networks but has certain particularities (private-public partnership) that make this transition less straightforward. This should be a question mainly for the Ocean Coordination Group (OCG);
- OOPC activity on Boundary Systems does not consider low-latitude regions, they are focusing on the subtropical regions and on certain well-observed systems in particular (California, Kuroshio, Gulf of Mexico...).

3. ***Weidong Yu: TPOS 2020. See presentation [here](#)***

Weidong Yu described TPOS2020, its goals, its management, evolution, and main outcomes presented in each of the review reports, successes, and difficulties. The second review was the most comprehensive one in terms of recommendations while the third one was more synthetic and provided the way towards implementation. Weidong Yu mentioned that TPOS implementation was underway, going from the east to the west, and the incorporation of biogeochemical measurements was one of the most challenging issues.

After Weidong Yu's presentation the following topics were discussed:

- The integration of the three observing systems in the tropical area (TAOS, IndOOS, TPOS) into a real global system would be useful to get more visibility and better meet the requirements of the stakeholders;
- CLIVAR Research Focus on Tropical Basin Interaction, and OOPC and the three tropical observing systems described in the session should consider how they can collaborate.
- It was also noted that the degree of engagement is very low in certain regions such as the eastern Pacific as well as in the western Pacific (Latin America).

4. **CLIVAR-GOOS workshop. See presentation [here](#)**

Weidong Yu presented the concept for CLIVAR-GOOS workshop, the initial timeline (the workshop was planned in May 2021) and stressed that having a face-to-face workshop was indispensable and that an online format was not an option. This will probably imply that the workshop will not take place until late 2022, to allow for the vaccines against COVID-19 to reach all countries and now it is time to devise a workable plan. The workshop is a clear example of where and how OOPC and CLIVAR join forces.

To bridge the gap until next year, it was suggested that some webinars could be organized. However, the idea was discarded because the Boundary Systems Task Team is already organizing a series of webinars monthly with a similar focus and both initiatives would overlap.

Meghan Cronin briefly introduced the OASIS group, considering how to better monitor air-sea interactions regionally and globally. Getting involved is possible through airseaobs.org and joining the SLACK space.

Peter Oke mentioned that there was an OceanPredict symposium on Synergistic Observation Networks for Ocean and Earth System at the end of 2021, most likely to be held online, where OOPC and CLIVAR could present an abstract.

ACTION 4. *CLIVAR/OOPC will consider attending the OceanPredict Symposium and presenting something jointly.*

ACTION 5. *A follow-up meeting OOPC/CLIVAR should be organized later this year.*

Summary of actions

| | Action | Who | When |
|-----------|---|--|--------------|
| OOPC-24/1 | Assess the pertinence of the public reviews for their incorporation in GCOS Status Report | Belén Martín Míguez and ECV/EOV stewards | Mid May 2021 |
| OOPC-24/2 | Transfer the information already provided in 2019 and the results of the 2020 public review into the new specification sheets | Belén Martín Míguez and ECV/EOV stewards | Sep 2021 |

| | | | |
|-----------|--|---|--|
| OOPC-24/3 | Meeting WMO/OOPC to explain how WMO uses the requirement process to steer the development of the observing system. | Lars Peter Riishojgaard and Belén Martín Míguez | Second half 2021 |
| OOPC-24/4 | CLIVAR/OOPC to consider submitting something jointly in the OceanPredict Symposium | CLIVAR/OOPC | The Symposium is scheduled end of 2021 |
| OOPC-24/5 | Organize a follow-up meeting OOPC/CLIVAR | OOPC co-chairs | After summer 2021 |

7. 23rd Session of the GCOS/WCRP Terrestrial Observation Panel for Climate (TOPC-23)

Due to the COVID-19 pandemic, TOPC did not hold a single in-person meeting but instead held several shorter teleconferences. The main meetings of the whole panel were on the 19 February, 22 February and the 16 April. The following topics were considered:

- New TOPC Co-Chair
- Outcomes of the 28th GCOS Steering Committee
- Global Terrestrial Networks
- Data Centres
- Future Developments

New TOPC Co-Chair

Martin Herold has agreed to be a co-chair of TOPC to support Thelma Krug. The secretariat and panel welcomed him and thanked him for assuming this task.

28th Session of the GCOS Steering Committee

TOPC reviewed the outcomes of the last GCOS Steering Committee and Identified actions for the panel:

- Task Team: Steering committee support for raising additional funds for the GCOS trust fund. Thelma is a member of this group;

***ACTION 1.** Thelma Krug will contribute to the Task Team: Steering committee support for raising additional funds.*

- Task Team: Broadening GCOS Cooperation Mechanism and funding, participation to be decided later by the TOPC Co-Chairs when this group is established;

***ACTION 2.** Participation in the Task Team: Broadening GCOS Cooperation Mechanism and funding to be decided by the co-chairs when group is established.*

- Task Team: Climate Cycles – Wouter Dorigo will participate in this group;

***ACTION 3.** Wouter Dorigo will participate in the climate cycles task team.*

- Task Team: Adaptation – Nigel Tapper will be the chair of this group with TOPC co-chairs Thelma and Martin participating;

***ACTION 4.** Nigel Tapper will be the chair of this Adaptation task team with Thelma Krug and Martin Herold participating.*

- Implementation Plan Writing Team, the co-chairs will represent TOPC;

***ACTION 5.** the co-chairs will represent TOPC on the Implementation Plan Writing Team.*

- ECV requirements the panel members agreed to work on refining the requirements, based on the public consultation, until the end of May 2021;

***ACTION 6.** The ECV Stewards will work on finalizing the ECV requirements, based on the public consultation*

- Total Water Storage should be an ECV, Stephan Dietrich will report back on if there are any implications or overlaps for other hydrological ECV;

***ACTION 7.** Stephan Dietrich will check Total Water Storage ECV to see if there are any implications or overlaps for other hydrological ECV.*

- TOPC shall review its relationship with Global Terrestrial Networks (see below).

***ACTION 8.** The Secretariat will draft a recommendation on the GTN for the GCOS Steering Committee. This will be approved by the panel before going to the Steering Committee.*

Global Terrestrial Networks

The panel discussed the status of the Global Terrestrial Networks. Overall, the main aim of the Global Terrestrial Networks (GTN) is to assure the long-term sustainability of climate observations networks and associated data centres that contribute to the Global Climate Observing System.

In general, observing networks lie between two extremes:

Operational networks with long-term funding committed by governments. However, with differing data policies and national priorities, that may limit or even prevent the free exchange of data to non-commercial applications. Most of those networks collect national quality-assured data sets only, at the expense of timeliness requirements in the value chain.

Research networks. These usually have only short-term, project-based, funding and no long-term commitment to maintain sustainable data centres, which can struggle to survive, even while their data is being used. On the other hand, the data is more usually exchanged freely, maybe with some delay, and data policies are not a restriction.

These issues are not unique to the GTN but to many observations (e.g. ocean observations).

Many of these networks can have multiple uses, not just for GCOS and climate monitoring.

There is considerable interest in the future development of the GBON and SOFF to support terrestrial observations, especially hydrological networks. It was noted the ICOS, as a research framework has been able to secure the long-term support of some sites, however, this not an option for other measurements.

Data centres are described often as being under the auspices of UN bodies, such as WMO, FAO, UNESCO or UNEP. GTN-H is a joint effort of the World Meteorological Organization (WMO) and the Global Climate Observing System. However, it is funded by the German Government and hosted by the International Centre for Water Resources and Global Change (ICWRGC) and the Federal Institute of Hydrology in Koblenz, Germany. This pattern of an international organization taken patronage of a data centre but the financial support coming from the national government is often repeated, e.g. the GPCC hosted by DWD and the GRDC hosted by BfG both funded by Germany, the GGMN hosted by IGRAC both funded by the Netherlands, and HYDOLARE hosted by ROSHYDROMET and funded by Russia but all associated with WMO¹.

It is not clear exactly what "under the auspices of" a UN body may mean.

The amount of support needed for data management is not large, often amounting to one or two persons fulltime. The computing resources needed generally are not large for these in situ networks. These networks have a forum where consistency and comparability can be maintained. However, additional human resources are needed for data acquisition and for public relations and capacity development, as well as for contributions to define standards for data exchange and reuse. Other data centres have no such support and have a high risk of failing. The Permafrost data centre (GTN-P) was moved to the arctic portal because of funding issues, then the arctic portal itself was nearly bankrupt.

Two specific issues were raised. In both these cases the aim was to use the status of WMO and GCOS to encourage the submission of data but WMO has not really helped. (The GCOS secretariat will follow up on both of these.)

HYDROLARE used to send out questionnaires to collect lakes data. While not completely successful they did collect data, however this has now changed with WMO including this in their questionnaire, now HYDROLARE is not getting any data.

GGMN asked WMO to send out requests for data. WMO may have done this but only to the regular points of contact in the countries, not to the relevant people with groundwater data.

Interactions between in-situ networks and EO organizations have been improved (e.g. through the current setup of ECV stewards)

Possible actions:

- GCOS to identify that the Global Terrestrial Networks are of fundamental importance to climate monitoring and, together with their associated Data Centres, should have commitment and sustained resources for their long-term operation.
- GCOS to make clear that data centres and free an open access to data should be seen as a fundamental part of observations and the global climate observing system.
- GCOS to advocate for support to networks, including networks of networks, noting this is a particular challenge in developing countries, particularly with sustainable, long-term resources and planning. GCOS could promote the extension of GBON/SOFF capabilities beyond meteorological observations to other climate observation networks through the INFCOM bodies JSG-GCOS and SC-ON although this will be a long-term activity.
- Highlight the role of GTNs in any GCOS reference network
- Support Data Exchange and Reuse capabilities
- Consider how long-term observations could be supported by infrastructures such as ICOS, eLTER, NEON, AmeriFlux, TERN, CERN etc.
- Give more guidance around user requirements, including:
 - Necessity for open data policies;
 - Lack of timeliness;
 - Alignment with WMO activities where possible;
 - Continually to improve interactions between in-situ networks and EO organizations have been already improved (e.g. current setup of ECV stewards), through cross-panel exchanges and during Joint Panel Meetings: evaluate the value chain from in-situ and EO to modelling.

Next Steps:

***ACTION 9.** The Secretariat will draft a recommendation to and implement the above actions for the GCOS Steering Committee. This will be approved by the panel before going to the Steering Committee*

Data Centres and Networks

Improving Data Centres is very important for TOPC

- How can TOPC/GCOS establish/support existing data centres and support data acquisition?
- Ensure a clear data policy: free, open and easily accessible;
- Ideally data centres should also include all kind of data for the same ECV (in-situ, satellite, UAV, citizen science) and provide them free, open and easily accessible (common licences);

- Increase the speed of delivery of data and information (to make it more climate action oriented), in addition to having long-term consistent ECV time series;
- Work with existing Data Centres – no duplication.

TOPC will report this discussion to the Joint Panel Meeting 2021 and contribute to the development of Global Climate Data Centres.

Status Report and Implementation Plan

The panel agreed to address the comments on the Status Report received in the public review by the end of May 2021. The panel accepted the plans for the report to be finally approved by the writing team and GCOS Steering committee.

The panel briefly discussed the plans for the next GCOS Implementation Plan and welcomed plans to recruit a lead author. They agreed to help draft the report in the second half of 2021.

***ACTION 10.** ECV Stewards and Panel Co-Chairs to address the comments on the Status Report received in the public review by the end of May 2021.*

***ACTION 11.** Panel and ECV Stewards to contribute to the drafting of the next GCOS Implementation Plan.*

***ACTION 12.** Panel and ECV Stewards to contribute to the review, and finalization of the next GCOS Implementation Plan.*

New Developments

The panel considered what new developments are needed to improve terrestrial climate observations. The discussion identified the following:

- Integrating observations from individual ECVs for more data driven synthesis on issues such as:
 - GHG Fluxes e.g. provide information on anthropogenic versus natural GHG fluxes (incl. the consideration of inter-annual variability and extremes); GHG Fluxes e.g. provide information on anthropogenic versus natural GHG fluxes (incl. the consideration of inter-annual variability and extremes)
 - AFOLU
 - Biosphere indicator (the panel noted that phenology of natural forests shows encouraging results)
- Increase the speed of delivery of data and information (to make it more climate action oriented), in addition to having long-term consistent ECV time series
- Improve inputs into specific international policy and assessment processes such as:
 - UNFCCC/Paris Agreement, i.e. Global Stocktake, Adaptation & Mitigation
 - IPCC – how to link ECV observing system/networks to upcoming IPCC assessments
 - Consider overlaps with other Multilateral Environmental Agreements (MEA)
- Develop relationship with GBON and SOFF. If this is successful, this may give a long-term solution to issues such as support for networks, data access and availability, data quality

These ideas were reported to the plenary session of the 2021 Joint Panel Meeting and will be taken up in the development of the new 2022 GCOS Implementation Plan.

Summary of Actions

| Action | | Who | When |
|------------|--|---|---------------------|
| TOPC-23/1 | Task Team: Steering committee support for raising additional funds for the GCOS trust fund. | Thelma Krug will contribute | As needed |
| TOPC-23/2 | Task Team: Broadening GCOS Cooperation Mechanism and funding | Participation to be decided by the co-chairs when group is established | As needed |
| TOPC-23/3 | Task Team: Climate Cycles | Wouter Dorigo will participate | As needed |
| TOPC-23/4 | GCOS Task Team: Adaptation | Nigel Tapper will be the chair of this group with Thelma Krug and Martin Herold participating | As needed |
| TOPC-23/5 | Implementation Plan Writing Team | the co-chairs will represent TOPC | As needed |
| TOPC-23/6 | Finalize the ECV requirements, based on the public consultation | ECV Stewards | End May 2021 |
| TOPC-23/7 | Check Total Water Storage ECV to see if there are any implications or overlaps for other hydrological ECV | Stephan Dietrich | End May 2021 |
| TOPC-23/8 | The Secretariat will draft a recommendation on the GTN for the GCOS Steering Committee. This will be approved by the panel before going to the Steering Committee. | Secretariat | End June 2021 |
| TOPC-23/9 | TOPC will report its view on Global Climate Data Centres to the Joint Panel Meeting 2021 and contribute to the GCOS development of Global Climate Data Centres. | Thelma Krug reported this top the JPM. Further participation to be decided by the co-chairs. | |
| TOPC-23/10 | Address the comments on the Status Report received in the public review by the end of May 2021 | ECV Stewards, Panel CO-Chairs | End May 2021 |
| TOPC-23/11 | Contribute to the drafting of the next GCOS Implementation Plan | Panel and ECV Stewards | Second half of 2021 |
| TOPC-23/12 | Contribute to the review, and finalization of the next GCOS Implementation Plan | Panel and ECV Stewards | First half of 2022 |

Annex A: Agenda

GCOS Joint Panels Meeting ONLINE

19-23 April 2021

(all times in CEST (Zurich) time, UTC+2)

| Day 1: Monday 19 April: Link to the Teams Joint Panels Meeting - Monday session + Individual Panel Meetings | | | | | |
|---|---|---|--------------------------------------|--|--|
| Time | Topic | Details | Presenter | Note/Outcome | Documents/Presentations |
| 14:00-14:05 | Welcome and Introduction from WMO | Live/Recorded message | Petteri Taalas | Opening of the meeting, role of GCOS within WMO | |
| 14:05-14:10 | Welcome and Introduction | GCOS, JSC-GCOS, Science Conference | Anthony Rea, Han Dolman | | |
| 14:10-14:15 | GCOS and UNFCCC | Presentation | Joanna Post | Importance of GCOS for UNFCCC | UNFCCC Presentation |
| 14:15-14:25 | A vision for GCOS | Presentation of Steering Committee ideas for the long-term development of the global observing system | Han Dolman | | GCOS Vision Presentation |
| 14:25-14:40 | Key future improvements in observing system | Key improvements panels would like to see in the next 5-10 years Discussion | Panel chairs (1-2 slides each panel) | Each panel to present 2-3 key improvements they would like to see in the next 5-10 years | Panels chairs Presentation |
| 14:40-14:55 | GCOS Implementation Plan 2022 | Timeline, Outline Instructions to panel (including interaction with editorial board), QA | GCOS Secretariat | Kicking off panel work for Implementation Plan | GCOS Implementation Plan Presentation |
| 14:55-15:00 | Presentation of cross cutting topics for Wednesday meeting | Topics for Wednesday including groups on cross cutting topics. | Han Dolman | Panel members will be invited to select which cross cutting session they will attend | |
| 15:00-16:30 | Time for individual panel meetings Link to the AOPC Teams Meeting Link to the OOPC Teams Meeting | | | | AOPC-26 Documents and Presentations OOPC-24 Documents and Presentations |

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| <p>Day 2: Tuesday 20 April: Time for individual panel meetings</p> <p style="text-align: center;">Link to the AOPC Teams Meeting</p> <p style="text-align: center;">Link to the OOPC Teams Meeting</p> | <p>AOPC-26 Documents and Presentations</p> <p>OOPC-24 Documents and Presentations</p> |
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Day 3: Wednesday 21 April: Joint Panel meeting
Cross cutting issues – Breakout Groups (BOG) - [Link to the Form to Register to the Breakout Groups](#)

| Time | Topic | Details | Presenter | Note/Outcome | Presentations |
|-------------|---|--|---|--|--|
| 13:00-15:00 | Session 1 Teams Breakout Group: Extremes and Adaptation | <p>It is suggested each session comprise short presentations (about 10 min?) followed by a much longer discussion session.</p> <p>In general, the presentations will be made by the group leaders, but they could suggest alternatives if that is more appropriate.</p> <p>The group leaders should moderate the discussions and present conclusions to the final session of the Joint Panel Meeting on Friday 23rd.</p> | Sabrina Speich, Rainer Hollmann | How can extremes of temperature and precipitation be best described for adaptation? What are the other important extremes for adaptation? | |
| 15:00-17:00 | Session 2 Teams Breakout Group: Paris Agreement and Observations for GHG Science and Reporting | | Dale Hurst, Han Dolman, Karina von Schuckmann, Martin Herold | How well do the GCOS ECVs contribute to adequate monitoring of GHG in the context of the Paris agreement? What improvements can we make? | |
| 13:00-15:00 | Session 3 Teams Breakout Group: Global Climate Data Centres | | Peter Thorne, Thelma Krug, Weidong Yu | <p>What is needed to improve the network of global data centres?</p> <p>What are the minimum requirements for GCOS endorsed global climate data centres?</p> | <p>AOPC View by P. Thorne</p> <p>TOPC View by T. Krug</p> <p>CMOC by W. Yu</p> <p>MCDS by E. Freeman</p> |

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| 15:00-17:00 | Session 4 Teams Breakout Group: Surface energy and water fluxes | | Meghan Cronin, Nadia Smith, Diego Miralles | How complete is the coverage (spatial and temporal) of Air-sea and Land-Air fluxes (evaporation, sensible heat ...)? What can be implemented now and what developments are needed? | Air-sea Flux activities by M. Cronin PBL Sounding of Temp and Water vapor by C. Wilson Satellite-base Land Evaporation by D. Miralles |
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| Day 4: Thursday 22 April: Time for individual panel meetings | | OOPC-24 Documents and Presentations |
| Link to the OOPC Teams Meeting | | |

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| Day 5: Friday 23 April: Link to the Teams Joint Panel Meeting - Friday Session | | | | | |
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| Time | Topic | Details | Presenter | Note/Outcome | Documents/Presentations |
|-------------|------------------------------|--|--|--------------|--|
| 14:00-15:00 | Report from Break out Groups | Includes the way forward for GCOS and expected involvement of panels | BOG Rapporteurs Han Dolman / GCOS Secretariat | | Report from Session 1 Report from Session 2 Report from Session 3 Report from Session 4 |

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|-------------|---|--|--|--|--|
| 15:00-17:00 | Time for individual panel meetings Link to the AOPC Teams Meeting | | | | AOPC-26 Documents and Presentations OOPC-24 Documents and Presentations |
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Annex B: List of Participants

2021 GCOS Joint Panels Meeting

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| <p>Arlyn Andrews</p> <p>National Oceanographic and Atmospheric Administration (NOAA) Boulder, United States</p> | <p>Albrecht von Bargaen</p> <p>German Aerospace Center (DLR) Köln, Germany</p> |
| <p>Qingchen Chao</p> <p>China Meteorological Administration Beijing, China</p> | <p>Amos Kabo-Bah</p> <p>Department of Energy and Environmental Engineering Sunyani, Ghana</p> |
| <p>Suda Kazuto</p> <p>Japan Meteorological Agency Tokyo, Japan</p> | <p>Johnny Johannessen</p> <p>Nansen Environmental and Remote Sensing Center Bergen, Norway</p> |
| <p>Paolo Laj</p> <p>Ecole Normale Supérieure Paris, France</p> | <p>Chris Lanconelli</p> <p>European Commission, Joint Research Centre Ispra, Italy</p> |
| <p>Yuko Okumura</p> <p>University of Texas Austin, United States</p> | <p>Joanna Post</p> <p>United Nations Climate Change Secretariat (UNFCCC) Bonn, Germany</p> |
| <p>Laura Riihimaki</p> <p>National Oceanographic and Atmospheric Administration (NOAA) Boulder, United States</p> | <p>Sybil Seitzinger</p> <p>University of Victoria Victoria, Canada</p> |
| <p>Michael Sparrow</p> <p>World Climate Research Division (WMO) Geneva, Switzerland</p> | <p>Petteri Taalas – Secretary General</p> <p>World Meteorological Organization (WMO) Geneva, Switzerland</p> |
| <p>Oksana Tarasova</p> <p>World Meteorological Organization (WMO) Geneva, Switzerland</p> | <p>Sara Venturini</p> <p>GEO Secretariat Geneva, Switzerland</p> |
| <p>Robert Weller</p> <p>Woods Hole Oceanographic Institution (WHOI) Woods Hole, United States</p> | |

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| GCOS | |
| Han Dolman, chair VU University Amsterdam Amsterdam, The Netherlands | Anthony Rea, Director GCOS Secretariat Geneva, Switzerland |
| Simon Eggleston GCOS Secretariat Geneva, Switzerland | Belén Martín Míguez GCOS Secretariat Geneva, Switzerland |
| Tim Oakley GCOS Secretariat Geneva, Switzerland | Caterina Tassone GCOS Secretariat Geneva, Switzerland |
| Magaly Robbez GCOS Secretariat Geneva, Switzerland | |

26th session of the Atmospheric Observation Panel for Climate

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| Peter Thorne, co-chair National University of Ireland Maynooth Maynooth, Ireland AOPC Member | Nadia Smith, co-chair Science and Technology Corporation Columbia, United States AOPC Member |
| Chiara Cagnazzo ECMWF Reading, United Kingdom AOPC Member | Imke Durre NOAA's National Centers for Environmental Information (NCEI) Asheville, United States AOPC Member |
| Maria Hakuba NASA - Jet Propulsion Laboratory (JPL) Pasadena, United States AOPC Member | Rainer Hollmann Deutscher Wetterdienst Offenbach, Germany AOPC Member |
| Dale F. Hurst NOAA Earth System Research Laboratory Boulder, United States AOPC Member | Elizabeth Kent University of Southampton Waterfront Campus Southampton, United Kingdom AOPC Member |
| Shinya Kobayashi Japan Meteorological Agency Tsukuba Ibaraki, Japan | Matilde Rusticucci Universidad de Buenos Aires Buenos Aires, Argentina |

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| AOPC Member | AOPC Member |
| Johanna Tamminen Finnish Meteorological Institute Helsinki, Finland AOPC Member | Steven J. Goodman NOAA Fisheries Silver Spring, MD, United States TT-LOCA |
| Tilman Holfelder Deutscher Wetterdienst Offenbach, Germany TT-GSRN | Philip Jones University of East Anglia Norwich, United Kingdom Stewards for atmospheric ECVs |
| Tanja Kleinert DWD Offenbach, Germany Chair ET WIGOS Tools | Stefan Klink Deutscher Wetterdienst Offenbach, Germany AOPC/SG-GBON |
| Paolo Laj Université Grenoble Alpes Saint Martin d'Hères, France Ex officio GAW | |

24th session of the Ocean Observations Panel for Physics and Climate

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|---|---|
| Sabrina Speich, co-chair Ecole Normale Supérieure (Paris), Laboratoire de Météorologie Paris, France OOPC Member | Weidong Yu, co-chair Center for Ocean and Climate Research SOA First Institute of Oceanography Zhuhai, China OOPC Member |
| Lisa Beal University of Miami Miami, United States OOPC Member | Maria Paz Chidichimo Universidad de Buenos Aires Buenos Aires, Argentina OOPC Member |
| Meghan Cronin NOAA Seattle, United States OOPC Member | Marjolaine Krug Department of Environment, Forestry and Fisheries Stellenbosch Western Cape, South Africa OOPC Member |
| Eitarou Oka The University of Tokyo Kashiwa Chiba, Japan OOPC Member | Peter Oke CSIRO Marine and Atmospheric Research Hobart Tasmania, Australia OOPC Member |
| Matthew Palmer Met Office | Satya Prakash Indian National Centre for Ocean Information Services |

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| Exeter, United Kingdom OOPC Member | Hyderabad Telangana, United Kingdom OOPC Member |
| Benjamin Rabe Alfred-Wegener-Institut Bremerhaven, Germany OOPC Member | Karina von Schuckman Mercator St Agne, France OOPC Member |
| Champika Gallage World Meteorological Organization Geneva, Switzerland | Artur Piotr Palacz International Ocean Carbon Coordination Project (IOCCP) - Institute of Oceanology of the Polish Academy of Sciences (IO PAN) Sopot, Poland GOOS Officer |
| Lars Peter Riishojgaard World Meteorological Organization Geneva, Switzerland | Sophie Cravatte Laboratoire d'Etudes en Géophysique et Océanographie Spatiales (LEGOS) Toulouse, France CLIVAR |
| Gregory Foltz NOAA Atlantic Oceanographic and Meteorological Laboratory Miami, United States CLIVAR | Juliet Hermes South African Environmental Observation Network Pretoria, South Africa CLIVAR |
| Roxy Mathew Koll Indian Institute of Tropical Meteorology Pashan, Pune, India CLIVAR | Jing Li International CLIVAR Project Office Qingdao, China CLIVAR |
| Yuko Okumura University of Texas Austin, United States CLIVAR | M. Ravichandran NATIONAL CENTRE FOR POLAR AND OCEAN RESEARCH Goa, India CLIVAR |
| Regina R. Rodrigues Federal University of Santa Catarina Santa Catarina, Brazil CLIVAR | Jose Santos Davila International CLIVAR Project Office Qingdao, China CLIVAR |
| Liping Yin International CLIVAR Project Office Qingdao, China CLIVAR | |

23rd session of the Terrestrial Observation Panel for Climate

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|---|---|
| <p>Thelma Krug, co-chair</p> <p>National Institute for Space Research (INPE) São José dos Campos, Brazil TOPC Member</p> | <p>Martin Herold, co-chair</p> <p>GOFC-GOLD. Wageningen University Wageningen, The Netherlands TOPC Member</p> |
| <p>Alice Andral</p> <p>Centre National d'Etudes Spatiales (LEGOS/CNES) Toulouse, France TOPC Member</p> | <p>Sarah Carter</p> <p>GOFC-GOLD. Wageningen University Wageningen, The Netherlands TOPC Member</p> |
| <p>Emilio Chuvieco</p> <p>University of Alcalá Alcalá de Henares, Spain TOPC Member</p> | <p>Hiroyuki Enomoto</p> <p>National Institute of Polar Research (NIPR) Tokyo, Japan TOPC Member</p> |
| <p>Darren John Ghent</p> <p>University of Leicester National Centre for Earth Observation (NCEO) Leicester, United Kingdom TOPC Member</p> | <p>Nadine Gobron</p> <p>European Commission Joint Research Centre Ispra Varese, Italy TOPC Member</p> |
| <p>Andreas Güntner</p> <p>GFZ Potsdam, Germany Potsdam, Germany TOPC Member</p> | <p>Werner Kutsch</p> <p>Integrated Carbon Observation System (ICOS ERIC) Helsinki, Finland TOPC Member</p> |
| <p>Diego Miralles</p> <p>Ghent University, Belgium Ghent, Belgium TOPC Member</p> | <p>Claudia Andrea Ruz Vargas</p> <p>International Groundwater Resources Assessment Centre (IGRAC) Delft, The Netherlands TOPC Member</p> |
| <p>Nigel Tapper</p> <p>Monash University Clayton Victoria, Australia TOPC Member</p> | <p>Jean-Francois Cretaux</p> <p>National Centre for Space Studies (CNES), Toulouse, France Stewards for terrestrial ECVs</p> |
| <p>Stephan Dietrich</p> <p>Federal Institute of Hydrology Bundesanstalt für Gewässerkunde Koblenz, Germany Ex officio GTN-H</p> | <p>Wouter Dorigo</p> <p>Vienna University of Technology Vienna, Austria XXXXXXXXXXXX</p> |
| <p>Greet Janssens-Maenhout</p> | <p>Huilin Li</p> |

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|--|--|
| <p>European Commission, DG JRC Brussels, Belgium EU Copernicus</p> | <p>CAREERI/CAS Beijing, China Ex officio GTN-G</p> |
| <p>Ulrich Looser Federal Institute of Hydrology (BfG) Koblenz, Germany Stewards for terrestrial ECVs</p> | <p>Frank Paul University of Zurich, Switzerland XXXXXXXXXXXXXXXXXXXX</p> |
| <p>Philippe Schoeneich Institut de Géographie Alpine Grenoble, France Ex officio GTN-P</p> | <p>Jean-Noël Thépaut ECMWF Reading, United Kingdom EU Copernicus</p> |
| <p>Valery Vuglinsky International Data Centre on the Hydrology of Lakes and Reservoirs (HYDROLARE) St Petersburg, Russian Federation Stewards for terrestrial ECVs</p> | |

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