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Virtual Sessions

Part 1: 19, 20, 23 April 2021

Part 2: 1-3 December 2021

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Chair, Publications Board

World Meteorological Organization (WMO)

7 bis, avenue de la Paix

P.O. Box 2300

CH-1211 Geneva 2, Switzerland

Tel.: +41 (0) 22 730 84 03

Fax: +41 (0) 22 730 80 40

E-mail: Publications@wmo.int

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Due to Covid-19 the AOPC-26 meeting was held online and divided in two sessions, Part I held in April 2021 during the Second GCOS Joint Panels Meeting and Part II held in December 2021.

PART I: AOPC-26/1 – 19, 20 & 23 APRIL 2021

1. Day 1: Monday 19 April

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>

2. Day 2: Tuesday 20 April

2.1 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.*

2.2 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 GSRN-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.*

3. Day 3: Friday 23 April

3.1 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.

3.2 AOPC-26/1 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

ANNEX 1: Agenda AOPC-26/1

Day 1: Monday 19 April 2021 – Chair: Peter Thorne	
Welcome	Peter Thorne
Presentations from the new AOPC Members	Nadia Smith, Chiara Cagnazzo, Matilde Rusticucci, Maria Hakuba
Day 2: Tuesday 29 April 2021 – Chair: Peter Thorne	
Baseline Networks: <ul style="list-style-type: none"> • GSN • GUAN • GBON • WDQMS Discussion on: <ul style="list-style-type: none"> • How GSN and GUAN can be integrated into the GBON and what are the relevant requirements that must be maintained? • How to ensure that GBON delivers to climate applications. what is the path towards marine and atm composition obs? How to develop a narrative on how GBONlinks to climate? 	Tim Oakley, Stefan Klink, Tanja Kleinert
GSRN Task Team: Information/progress since last AOPC-plans and questions to AOPC	Tilman Holfelder, Steve Goodman
Day 3: Friday 23 April 2021 – Chair: Nadia Smith	
AOPC Contribution to GCOS Reports	
Status Report: <ul style="list-style-type: none"> • Updates • Comments to be addressed by panel 	Peter Thorne Caterina Tassone
ECV Requirements: Discussion on unresolved comments or issues	Caterina Tassone
GCOS Implementation Plan 2022: Start planning/work	Peter Thorne, Nadia Smith
Future AOPC commitments and meeting	Peter Thorne, Nadia Smith

PART II: AOPC-26/2 – 1-3 DECEMBER 2021

1. Day 1: Wednesday 1 December – Chair: Nadia Smith

1.1 Report from COP26 – Peter Thorne

The GCOS Status Report was presented at COP26 to UNFCCC and noted.

Peter Thorne participated in a GCOS event in the science pavilion, in a satellite program side event and to a session on earth observations on behalf of IPCC. Anthony Rea also participated in this session representing GCOS.

Text proposed by WMO on the data policy around the historical data sharing was not included in the COP final decision.

IPCC findings were strongly welcomed and for the first-time fossil fuel was mentioned in the final communique.

In the future, there will be an increasing interest on what is needed to monitor and predict a tipping point (e.g., the collapse of the West Antarctica ice sheet). Tipping points occur in the terrestrial and ocean domains, so this is going to be mostly a TOPC and OOPC effort.

1.2 ECVs

Updates on requirements:

Requirements are almost completed. The only requirements not finalized are the ones for the ECV Cloud and the ECV precursors. For the ECV Precursors there have been several discussions with GAW on whether to consider total or tropospheric column for NO₂. It was finally decided that tropospheric column will be used for NO₂, while for the other gases, total column will be maintained. Johanna would like to review this decision and make sure that the change from tropospheric column (in GCOS IP 2016) to total column is well justified. After several months of interaction with GAW for the Atmospheric Composition ECVs requirements, it has finally been agreed that GCOS and GAW will make sure that names, definitions and units are consistent between GCOS and GAW, while requirements will be established respectively by GCOS and GAW according to their needs. Therefore, the decision on whether to use tropospheric or total column for the precursors gas remains a GCOS decision.

Regarding the justification that the Steering Committee had asked for each of the ECV products, only the GHG and Precursors ones are missing.

Everything needs to be completed by the end of the year.

***ACTION 1.** Finalize the requirements for the ECV Clouds and the justification for the products (Nadia and Rainer)*

***ACTION 2.** Finalize the requirements for the ECV precursors and the justification for the products (Johanna)*

***ACTION 3.** Prepare the justification for the ECV GHG products (Johanna)*

***ACTION 4.** Contact Owen Cooper to understand the motivation of the change from tropospheric to total columns for the ECV precursors (Caterina, Johanna)*

***ACTION 5.** Provide the ECV requirements for GHG fluxes to Johanna (Caterina)*

Rationalization of the ECVs:

There are 54 ECVs. Many of these ECVs are for parameters that only differ by where they are measured. The idea is to assign ECVs to logical groups without losing any ECV products that will eventually be allocated differently against ECVs. An obvious example is temperature. There are now 6 different ECVs: Temperature (surface) (atmosphere), temperature (upper air) (atmosphere), Sea surface temperature (ocean), subsurface temperature (ocean), land surface temperature (terrestrial) and Lake surface temperature (terrestrial) which can be grouped in one ECV Temperature. All measure the physical temperature of a given volume and the requirements make sense to be considered holistically to ensure an integrated understanding across the Earth System. Another example could be a single ECV "Surface head and water fluxes) that would include the ECVs Surface Radiation Budget, Ocean surface heat flux and Evaporation from land. Following this very preliminary grouping the current proposal, which requires substantive consideration, would be able to reduce the 54 ECVs to 21.

AOPC agrees with the idea of rationalizing the ECVs, and on combining surface and upper air for the atmospheric ECVs into one ECV spanning from the surface to the upper atmosphere. There are several ways of grouping the ECVs, for example they could be grouped according to the Earth's cycles, or to the users, or to ensure consistency across Earth System domains. It is therefore important to first agree on the benefits of grouping or the challenges of the existing system. This will also facilitate the choice of grouping approach.

This concept is going to be presented to the Steering Committee and if approved a plan on how to proceed will be formulated. As the grouping of the ECVs is cross cutting through the GCOS panels, collaboration among panels will be necessary.

1.3 The GCOS Task Team on adaptation - GATT - Chiara Cagnazzo

Chiara Cagnazzo, co-chair of the GATT, reported on the progress of the task team.

The main objective of the GATT is to map the pathway forward for a GCOS role in the Global Stocktake process. The team will produce guidance and best practices for adaptation observations and identify indicators for adaptation and risk. In order to support adaptation, there is a need for adequate data. Taking actions for adaptation requires different steps: assessing the climate risks, planning of adaptation, implementation of these measures, and monitoring and review of the measures. GCOS can provide the observations to assess the climate risk and for monitoring adaptation.

The team presented and discussed two case studies to demonstrate how ECVs can provide information for adaptation: Observations in support of forest wildfire management and observations in support of pluvial flood risk assessment in urban areas (links).

Two main points were raised during the discussion:

The work on observations for adaptation will most likely result in the Identification of new ECVs and could also impact the reporting and requirements for ECVs.

Adaptation needs are different in different places and therefore potentially distinct observations will be required in terms of quality, quantity, distribution, timeliness etc.. Different areas as well as different sectors need different solutions and clearly GCOS cannot cover every solution. The suggestion from the task team is to start by making a gap analysis in order to understand whether we can support different communities by defining new requirements. Once ECV requirements covering identified adaptation needs are defined, these will be brought back to the three GCOS panels for discussion and feedback.

In terms of case studies, the ones so far proposed are mostly terrestrial related, but others such as heat waves in the ocean, coastal areas, and urban monitoring will be discussed in the future. It is important that the atmospheric ECVs be included in these case studies so that adequacy for adaptation is adequately considered by the panel in future.

2. Day 2: Thursday 2 December – Chair: Nadia Smith

2.1 WMO Congress: GBON, SOFF and Data Policy – Anthony Rea

The Extraordinary Congress approved three, linked, key resolutions:

- The WMO Unified Data Policy (Resolution 1);
- The Global Basic Observing Network (GBON) (Resolution 2);
- The Sustained Observations Financing Facility (SOFF) (Resolution 3).

Development of GBON, SOFF and data policy is the result of two years of work. The ideas for the GBON and SOFF developed from the GCOS/WIGOS Regional Workshop in Fiji in 2017. GBON lays down a minimum resolution of certain variables and the SOFF is a funding mechanism to support developing countries meet the requirements of GBON.

The data policy lays down mandatory free and open exchange of core data and encourages exchange of other important data. Core data for climate includes current and historic time series and they are:

- Measurements provided by GUAN and GSN;
- Climate data as defined in the Manual High-quality Global data Management Framework for Climate;
- ECVs as defined by GCOS in the WIGOS manual;
- Climate reanalysis field provided by GDPFS.

This is an important step for the climate community as it requires that core data in historic archives will be exchanged. Despite the approval of the new WMO Data Policy, the division around data sharing remains and it is unlikely to get all data just because of the new Data Policy. It is going to be a long process and will require going party to party. The role of AOPC is to work together with others to advocate for this policy and to encourage parties to share the data, emphasizing the benefits that will result from the historical data sharing such as the improvement of products estimates, better reanalysis and ultimately better tools for decision making. In order to facilitate the exchange of historical data, clear guidance is required on where and how to share their data to the data providers. AOPC will prepare a document with guidance on where and how members can submit historical in-situ data.

ACTION 6. *AOPC members to collectively write a document on how and where to submit historical data for in-situ observations, including, if possible, a point of contact. Panel members will rely on their expertise for specific data. Paragraphs will be sent to Caterina who will then work together with Dave Berry to produce a final document to be distributed to the WMO members by WMO.*

In terms of the general data policy, members will be held to account through the WDQMS that is able to identify non-compliant countries, although at present this does not apply to historical data. Initially the biggest changes will be seen for the countries that hold a large amount of data that are not shared.

GBON and SOFF - Currently, GBON and SOFF cover basic meteorological observations over the land and oceans. While extension to other variables is anticipated, it will be many years before this is extended to other domains such as hydrology, oceans, cryosphere and the land surface. The long-term provision of stations is also not covered by GBON and GCOS should work on this. Several partners have promised contributions and when the SOFF is launched in mid-2022 it is expected there will be about US\$ 60 million for observations. The SOFF is only targeting the LDC and the small islands, which still leaves many countries that are developing not eligible and therefore they might be unable to reach the GBON target. There are other funding mechanisms that will have to be used for these countries, and efforts will be required to expand SOFF resource provision in a sustainable manner to cover as many of these as possible.

The role of GCOS panels in implementing GBON and the data policy was briefly discussed and shall include the following:

- Stating requirements that will then feed back to the regulatory material;
- Providing the climate voice to INFCOM by having AOPC members sitting on relevant regulatory and oversight boards;
- Advocating;
- Monitoring the data coming into relevant climate data archives to make sure of the increase of data flow which is expected from the implementation of GBON for real-time data and the data policy for historical data.

Peter Thorne congratulated Anthony Rea and his team for the success of the data policy and the GBON and SOFF, which represents an important step forward for the observation community and has required the work of many experts and both the WMO and GCOS Secretariat.

2.2 Networks – Tim Oakley

Report from the GCOS Network Manager

The GCOS Network Manager reported on the two GCOS Baseline Networks, GSN and GUAN. The GCOS Network Manager Annual Report can be found [here](#). Performance of both GSN and GUAN is quite stable, except for RAI (Africa) where performance is degrading.

A plot of the number of GUAN soundings (daily average per month) over the last three years shows that there are on average 1.5 soundings per day (GBON requirement is 2 soundings a day) and a decrease in soundings at the beginning of 2020 can be attributed to the first wave of COVID. However, the number of soundings started increasing again by the end of 2020, probably due the fact that the countries got used to working in the COVID situation. A decrease in 2021 is likely related to lack of funds.

In conclusion:

- Monitoring of GSN and GUAN has continued though 2021;
- There is no significant impact of COVID on monthly statistics, although financial resources in many countries remain an ongoing issue and this has become worse with COVID;
- GCOS Cooperation Mechanism received no funds in 2021 and therefore there is no capability to support GCOS Networks.
- Future work includes:
- Work with WMO (WIGOS) on the implementation of GBON and the alignment with GUAN and GSN (AOPC preparing an IP action);
- Work with WMO (WIGOS) on the future of CBS Lead Centres also in light of WIGOS Regional Centres;
- Work with WMO (SOFF) on support for surface and upper-air operations (GCM).

GCOS Network document:

A document called GCOS networks was approved by the Steering Committee in 2021. Another document in the draft phase is about the process to be accredited as a GCOS network. The document defines 3 levels of GCOS network membership as follows: a GCOS Network, which has oversight by GCOS Network Manager or a GCOS panel and reports annually to GCOS (e.g. GUAN and GSN); a GCOS Affiliated Network, which has oversight but not necessarily by GCOS and annually reports to GCOS; and a GCOS Recognized Network, which has oversight not necessarily by GCOS and has an annual report available but does not report to GCOS. These designations differ only in their oversight and reporting to GCOS, but it does not reflect differing quality or importance.

The proposed process, which is described in detail in the document, consists of the following steps:

- A network wishing to be accredited by GCOS shall approach the relevant GCOS Expert Panel and must complete a proforma;
- The GCOS Expert Panel shall consider the application within 8 weeks. If the application meets the requirements, they shall accept the proposal;
- The Panel recommendation shall then be reviewed and approved by a representative from each of the panels and the GCOS Network Manager within 4 weeks;
- Once approved the network can use the GCOS Network logo on their website and all publications.

Once this process is approved by the Steering Committee, the panels are to identify a few networks as a first test of the process.

ACTION 7. AOPC to apply this process as a test for the accreditation of BSRN

Following the presentation of this document, the panel discussed whether it should have an active or passive approach. In the passive approach, the networks wanting a GCOS affiliation approaches the panel and requests the affiliation. In the active approach the panel actively approaches the networks that are considered able to contribute to GCOS. It is crucial that this process is connected to the need to address gaps in observations. Once priority gaps are identified, the networks that would contribute to address these gaps should be contacted and asked to become an affiliated GCOS network. In any case, the review of the application of a network by the panel should not be solely based on the compliance of the network but should be driven by the needs to address gaps. Further discussion is needed to decide the best approach for AOPC and ideally the approach should be broadly similar across all 3 panels.

Paolo Laj raised the question of the position of atmospheric composition networks that could end up being affiliated with GCOS and not with GAW, or of GAW networks that will then have a GCOS affiliation, possibly leading to discussion within WMO. However, the recognition is mostly for networks that do not have a recognition, and as GAW has recognition, GCOS will not want to have an oversight over a GAW network.

2.3 Update on GRUAN - June Wang

June Wang, co-chair of GRUAN, presented updates on GRUAN. The ICM 13 took place on November 15-19 as an online meeting. The initial goal of GRUAN was to have between 30 and 40 sites. Currently there are 31 sites and 13 are certified. There are still gaps in South America, Africa and some parts of Asia. June asks the AOPC to come forward if they have suggestions on possible new sites in these areas. A challenge for GRUAN is that the path to GRUAN Data Products (GDP) is long and complicated, and it requires up to 4 years. GRUAN is now looking at ways to

reduce this time. The plot of the dataflow which represents radiosonde launches by site since 2005 shows that there are stations that have not been reporting during for several years. The issue of these 'silent' stations is now been addressed by the WG-GRUAN. They are proposing a set of steps to address this problem.

A concern for GRUAN is the imminent ban of the R23, a greenhouse gas used as a cooling agent in the FPH/CFH instruments. These instruments measure the water vapor in the UTLS, which is a requirement for a GRUAN station. Alternative cooling agents are showing promising results, such as the combination of dry ice and ethanol or liquid N₂ and different instruments have also been considered, and most likely Skydew will be used in the near future.

From 2009 to 2021 there have been 117 journal articles where GRUAN data have been used, with the two largest categories in 'field and intercomparison campaigns' and 'satellite validation and algorithm development'. GRUAN also has benefits to other networks and observing systems. It is the pioneer in defining and making reference observations; improving operational radiosondes, assisting operational radiosonde transitions, and has an important role in satellite cal/val.

GRUAN is going to prepare its 4th Implementation plan which will cover 2022-2025. Suggested priorities for next IP are network management (speeding up the certification process, new sites, silent sites), GDP (Other radiosondes, ozone, lidar and MWR), UTLS Water Vapor (R23 replacements and new sensors), priority 2 variables (clouds, radiation, aerosols and trace gases) and benefits to other networks.

2.4 Update on GCOS Surface Reference Network (GSRN) - Sarah Gallagher

The GSRN Task Team is responsible for the initial implementation of the GSRN and will undertake the necessary activities to instigate the network. The task team, established in the 1st INFCOM session, works under the leadership of the GCOS Steering Committee and the INFCOM SC-ON, in close collaboration with SC-MINT. The membership consists of two co-chairs, one nominated and agreed by GCOS, Sarah Gallagher from Met Éireann (Ireland) and the other by SC-MINT, Tilman Holfelder from DWD (Germany); experts selected for their skills and ex-officio members representing the former CCL, AOPC and TOPC, BIPM, GRUAN, GSN, satellite community, HMEI and the director of the lead center.

The first meeting of the GSRN Task Team was held on the 23rd of March 2021 and since then the GSRN TT has been meeting regularly.

Based on the experience of implementing GRUAN, the full implementation of all goals named in GCOS-226, will take decades. Therefore, the GSRN-TT has agreed to define the following goals, to be achieved in a 10-year timeframe, within the initial GSRN:

1. Provide sustained reference quality observations, with full traceability and fully defined uncertainty, on a global scale (on land) of at least the ECVs surface temperature and precipitation in order to quantify their variability, long-term change and inform on extremes;
2. Deliver an implementation plan for the inclusion of additional ECVs;
3. Be a recognized reference network within the WMO tiered system which primarily supports the climate community in quantifying climate change;
4. Publish operational procedures and practices for knowledge transfer and capacity building;
5. Ensure a free and open access archive of accredited GSRN data products;
6. Establish a GSRN affiliated research facility delivering scientific advances in measurement techniques and improving knowledge on climate reference data and instrumentation.

As the success of the implementation of a surface reference network strongly depends on the establishment of a Lead Centre, the GSRN TT has been concentrating on identifying countries

that could host a lead center and provide the necessary resources. Following a call for expression of interest to host the Lead Center, the Task Team has selected the China Meteorological Administration for the role of GSRN Lead Center. The GSRN TT has also started working on a proposal for the governance of the GSRN, on specifying the requirements for the initial GSRN sites and on recommendations for the selection of pilot stations and the initial composition of the GSRN. Work in these areas will continue in the next year and will result in an initial set of documents for the GSRN. The GSRN TT is planning to have an in-person meeting in March 2022, subject to the COVID situation, to progress both on the drafting of these documents and on the establishment of the Lead Center.

3. Day 3: Friday 3 December – Chair: Peter Thorne

3.1 Update on the Task Team on Lightning Observations for Climate Applications (TT-LOCA) -Steve Goodman

Steve Goodman, chair of the TT-LOCA, presented updates from the TT-LOCA. The team was constituted following Action 29 of the GCOS IP 2016 that called for “defining the requirements for lightning measurements, including data exchange, for climate monitoring and encourage space agencies and operators of ground-based system to strive for global coverage and reprocessing of existing datasets”. The team has been working on:

- GCOS IP 2022: The TT-LOCA has been looking at the proposed actions for the IP 2022 and has identified several connections for lightning in theme B (Filling the gaps), theme C (Improving data usefulness) and theme D (Improving data management). The team is proposing, as part of the IP actions, the establishment of a global data center for lightning at the NASA GHRC Hydrometeorology Distributed Active Archive Center (DACC). AOPC will consider this proposal when reworking the actions;
- Defining requirements: The ECV product for lightning is Total Lightning Stroke Density. The requirements for spatial resolution are 10kmx10km, and temporal resolution monthly;
- Exemplary data sets: evaluation of candidate data sets. To be able to produce a harmonized, consistent space and ground-based dataset a sufficient number of ground-based stations is required. Unfortunately, not all current ground-based networks are willing to share this information. A comparison of the ground-based and the space-based lightning measurements in Northern America shows significant differences not only in the magnitude but also in the location of the hot spots. Reconciling the differences between the space-based and the ground-based measurements is a top priority;
- Archive and stewardship: will be supported in the cloud by NASA GHRC Hydrometeorology DAAC will support archive and stewardship;
- Lightning ECV and other variables: identification of ECVs associated with the Lightning ECV. These are clouds, precipitation, composition, NO_x, ENSO, MJO, Upper-level humidity;
- Lightning safety awareness: given the fact that lightning is one of the major natural hazards, the team wants to initiate a collaboration with WHO and WMO Disaster Risk Reduction.

Steve Goodman presented also some examples on the importance of lightning for climate. When looking at the seasonal distribution of lightning during the 1997/98 ENSO winter period and during the 1998-99 La Nina winter period, it is evident that there is a significant difference in the amount of lightning that occurs. There is a huge increase in lightning days and hours during the El Nino. Therefore, lightning hours is a very useful measurement to highlight the interannual variability.

ACTION 8. *AOPC to consider TT-LOCA proposition for IP actions. The GCOS Secretariat will contact Steve Goodman to ensure that the GCOS IP 2022 actions correctly include the need for lightning.*

3.2 GCOS Implementation Plan

The lead author who had been recruited has resigned. The secretariat have tried to fill the gap as best as possible. The outline of the IP, which has been already approved by the Editorial Board, includes different general sections, that are now being drafted either by the Secretariat or by experts, and a chapter 6 which is for the actions. There will be a small group meeting in January to finalize the drafting. The first draft of the IP will be reviewed by an expert to make sure there is a broader perspective, and the Steering Committee members will also review the draft before it is sent to public review. After the meeting of the writing team, the Secretariat will review progress and propose a revised timeline.

The panels have drafted a list of the most important actions, which have been grouped into six themes:

- Ensuring sustainability;
- Filling data gaps;
- Improving data usefulness;
- Improving data management;
- Engaging with countries and stakeholder;
- Addressing emerging needs.

The template for the actions was also presented. Actions from all panels were merged, when possible, under an overarching action. Under each action there are activities, specific actions, benefits, implementers and means of progress.

Discussion of the GCOS IP Actions:

AOPC has expressed a preference of focusing the discussion on Action B4, B3 and A2.

Discussion on GCOS IP Actions B1, B3 and B4:

Action B1: development of reference networks	
Activity:	1) Continue development of GRUAN 2) Implementation of the GSRN

Action B3: create networks of in-situ cal/val observations for satellite products	
Activity:	1) Improved cal/val networks in high and low biomass regions 2) Improve quality of ground-based in-situ measurements of biomass following FRM protocols 3) Improve quality of ground-based in-situ measurements of albedo, FAPAR and LAI

Action B4: Improve Monitoring of trace gas composition and aerosol properties	
Activity:	Sustain observation capabilities both at the surface and of column characteristics of a range of constituents, including GHGs, ozone, aerosol, clouds and water vapor.

- Interlinkages between actions B1, B3 and B4 need to be fully expressed in the activity. We should avoid having or being seen to be advocating for a set of reference networks, a set of satellite cal/val networks and a set of atmospheric composition network, ideally it is better to have networks that measure atmospheric composition at a reference level and that can act as satellite cal/val series.
- B3 could be distributed in B1 and B4. B3 is an action proposed by TOPC, so AOPC needs to communicate to TOPC that B3 cannot be a stand-alone action as it overlaps with two other actions. B1 and B3 and B4 need to be rationalized.
- Title of B3 leads to confusion. It is not only about making observations but rather creating an infrastructure to support cal/val, it is about creating the end-to-end processing chain to enable cal/val and should be redrafted as such.
- B1 is broader than just cal/val. Maybe other reference networks, such NDACC, TCCON etc, could be included, so that B4 can be aligned with B1.

Discussion on GCOS IP action A2:

Action A2: Maintain continuity of satellite missions critical to climate science	
Activity:	1) Sustain satellite altimetry constellation 2) Ensure continuity of satellite gravimetry missions 3) Ensure satellite missions for Earth Radiation Budget (ERB) measurements 4) Ensure continuity of limb-sounding missions capable of measuring ozone and water vapor, nitrogen and carbon precursor species in the Upper Troposphere/Lower Stratosphere (UTLS) 5) Ensure the continuity of space-based Sea Surface Salinity measurements

- This is a cross-cutting action for all three panels.
- Should the missions be prioritized by highlighting that some measurements are at more risk than others and that losing some of these missions would negatively affect climate science?
- Include GHG measurements in the list as these are climate change drivers.
- We are assuming that the need of NWP will ensure other satellite missions and therefore only missions relevant principally / solely for climate are included in this list. However, if these missions were to disappear that would be catastrophic for climate science in particular for the negative impacts upon reanalysis product generation. A general statement on the absolute imperative of sustaining the missions that are already supported by NMHS will need to be included in the text describing the theme.
- We need to define an overarching goal and then include as an example the missions that are at risks. This would avoid missing other satellite missions that are at risk and crucial but that we are not aware of at this time.
- Produce a table that includes the end-of-life date of the instruments or satellite; the ECVs observed in the mission, whether it is a new or continuing mission. This will help with the prioritization of the missions.
- Focus on which satellite should be getting an agreement to continue after 5 years, the IP lifetime However, as the planning time of the satellite communities' spans over 10 years, it would be better to look at which missions do not have an agreement to continue over the next 10 years.
- Action on the life cycle management of existing satellite missions. Include Imke's colleague Ken Knapp to work on this action as he has a lot of expertise in this field.

Discussion on GCOS IP action B7:

Action B7: Proposed new Earth observing satellite missions	
Activity:	1) Establish a Reference Space Calibration System to enhance the quality and traceability of Earth observations. The following measurables are to be considered: high-resolution spectral radiances in the reflected solar (RS) and infrared (IR) wave bands, as well as GNSS radio occultations. 2) Provide measurements of Earth’s energy imbalance (EEI), or global mean net radiative flux, at the top-of-the atmosphere, and with accuracy of at least 0.3 Wm ⁻² 3) Add Instruments in geostationary orbit covering 60S – 60N with the ability to observe greenhouse gases (GHG) to complement the GeoCarb mission. 4) Add Instruments in highly elliptical orbits (HEO) to characterize polar region chemistry with measurements of GHGs, precursors and aerosols.

This is an action on high quality satellite measurements.

- Add an activity on gaining access to commercial satellite data after a finite time period for climate purposes. Action on commercial satellite system in emerging needs: access

Discussion on GCOS IP action B5:

Action B5: Improve estimates of surface heat, momentum and moisture flux over land and ocean	
Activity:	1) Improve measurements of variables needed to calculate surface fluxes (to and from the atmosphere), with the objective to better define the uncertainties of those measurements. The vertical resolution required means that this can only be suitably ascertained from in-situ observations. 2) develop new approaches over the oceans...to measure ocean surface heat flux including: (i) better integration of in situ and satellite measurements; (ii) new satellite missions over the ocean (iii) more simultaneous satellite measurements

The 1st activity in this action is an action proposed by AOPC and refers to in-situ measurements, while the 2nd activity is from OOPC calling again for satellite measurements to measure surface.

- AOPC does not believe that physically it is possible to measure the variables needed to estimate fluxes over the ocean at the required vertical resolution from satellites. AOPC has spoken with experts at NASA and NOAA who have confirmed.
- Higher vertical resolution might be obtained by using satellite data together with data assimilation and reanalysis data, but it is not going to be possible to get this only from satellite observations.
- Activity 2 could be instead focusing on the In-situ measurements over ocean platforms providing high quality data and direct flux measurements. This could be reflected in the means of assessing progress that could be number of sensors over the ocean measuring with sufficient accuracy and number of stations over the ocean measuring direct fluxes, rather than number of satellite constellations.
- Focus on surface observations from the surface where the satellite can be associated; develop a methodology to transfer the information that we are able to get from the satellite, linkage of satellite with observations at surface.
- If OOPC were to insist on the satellite part of this action, AOPC might have to insist to remove this action as it would not be appropriate for the GCOS IP to carry an action which is deemed by panel members and independent experts to. Be physically impossible to attain.

- o AOPC will prepare a response to this action to OOPC. If they insist in keeping the action as it is, a meeting between the OOPC satellite experts and AOPC ones will be organized to try to reach an agreement.

Next step:

The panel is requested to look at the action and identify whether any actions were lost during the merging process and whether there are actions that should be merged or split. For the AOPC actions details need to be added. The actions will be assigned to panel members to be completed. The deadline for AOPC input is the 10th of January. The panel will meet on January 12th to finalize the actions.

***ACTION 9.** Panel members to work on finalizing the assigned actions for the GCOS IP by January 10th.*

3.3 Next AOPC meeting

Panel members were asked to suggest topics for the next AOPC meeting. The following suggestions were made:

- Synergies with the Earth cycles – invite a member of earth’s cycle task team;
- Relationship with GAW: discussion on how to ease collaboration and roles – invite Richard Eckman who has chaired the GCOS-GAW Task Team on requirements for atmospheric composition variables;
- World data system, data services, cloud-based system: invite expert to talk to AOPC about this topic with a explain focus on the theme of global data centers;
- Session that responds to GBON and data policy and how AOPC can help with the GBON implementation;
- Choosing a couple of actions and start to work on how to take them forward.

It was agreed that a final decision on whether to hold next AOPC panel meeting in person in Maynooth, Ireland, or remotely will be taken at the next AOPC meeting in January.

3.4 AOPC-26/2 Actions

	Action	Who	When
1.	Finalize the requirements for the ECV Clouds and the justification for the products	Nadia, Rainer	15 January 2022
2.	Finalize the requirements for the ECV precursors and the justification for the products	Johanna	15 January 2022
3.	Prepare the justification for the ECV GHG products	Johanna	15 January 2022
4.	Contact Owen Cooper to understand the motivation of the change from tropospheric to total columns for the ECV precursors	Johanna Caterina	15 January 2022
5.	Provide the ECV requirements for GHG fluxes to Johanna	Caterina	Done
6.	AOPC members to write a paragraph on how and where to submit historical data for in-situ observations, including if possible, a point of contact. Panel members will rely on their	AOPC members Secretariat	31 March 2022

	expertise for specific data. Paragraphs will be sent to Caterina who will then work together with Dave Berry to produce a final document to be distributed to the WMO members by WMO		
7.	AOPC to apply the process to be accredited as a GCOS network for the accreditation of BSRN	Tim Caterina	End of Q2 2022
8.	AOPC to consider TT-LOCA proposition for IP actions. The GCOS Secretariat will contact Steve Goodman to ensure that the GCOS IP 2022 actions correctly include the need for lightning	AOPC members GCOS Secretariat	24 January 2022
9.	Panel members to work on finalizing the assigned actions for the GCOS IP	AOPC members	10 January 2022

ANNEX 2: Agenda AOPC-26/2

Day 1: Wednesday 1 December 2021 – 15:00-17:00 CET. Chair: Nadia Smith		
Welcome	10 min	Nadia Smith
Updates from COP	10 min	Peter Thorne
ECV: updates on requirements and discussion on rationalizing ECVs	30 min	Caterina Tassone Peter Thorne
Updates from GATT	15 min	Chiara Cagnazzo
GCOS Implementation Plan: Introducing the IP-present outline, themes for actions, examples based on current draft	55 min	Caterina Tassone
Day 2: Thursday 2 December 2021 – 15:00-17:00 CET. Chair: Nadia Smith		
WMO Congress: GBON, SOFF and Data Policy	20 min	Anthony Rea
Discussion on how these decisions will be implemented and possible actions for AOPC	30 min	All
Report from the GCOS Network Manager	10 min	Tim Oakley
GCOS Network document	10 min	Tim Oakley
GRUAN	20 min	June Wang
GSRN	20 min	Sarah Gallagher
Day 3: Friday 3 December 2021 – 15:00-17:00 CET. Chair: Peter Thorne		
Updates from TT-LOCA	30 min	Steve Goodman
GCOS Implementation Plan: addressing missing text/details, assigning responsibilities	60 min	All
Next meeting: discussion on topics to be included in next meeting and experts to be invited	30	All

ANNEX 3: List of Participants AOPC-26 Part 1 and 2

AOPC-26/1 - April 2021

- Peter Thorne (co-chair)
- Nadia Smith (co-chair)
- Chiara Cagnazzo
- Imke Durre
- Maria Hakuba
- Rainer Hollmann
- Dale Hurst
- Elizabeth Kent
- Shinya Kobayashi
- Matilde Rusticucci
- Johanna Tamminen
- Steve Goodman (TT_LOCA chair)
- Tilman Holfelder
- Philip Jones
- Paolo Laj
- Tanja Kleinert
- Stefan Klink
- Tim Oakley (GCOS Secretariat)
- Caterina Tassone (GCOS Secretariat)

AOPC-26/2 - December 2021:

- Peter Thorne (co-chair)
- Nadia Smith (co-chair)
- Chiara Cagnazzo
- Maria Hakuba
- Dale Hurst
- Elizabeth Kent
- Imke Durre
- Johanna Tamminen
- Paolo Laj
- Rainer Hollmann
- Shinya Kobayashi
- Anthony Rea (GCOS Director)
- June Wang (GRUAN co-chair)
- Sarah Gallagher (GSRN co-chair)
- Steve Goodman (TT_LOCA chair)
- Tim Oakley (GCOS Secretariat)
- Caterina Tassone (GCOS Secretariat)

GCOS Secretariat
Global Climate Observing System
c/o World Meteorological Organization
7 bis, Avenue de la Paix
P.O. Box No. 2300
CH-1211 Geneva 2, Switzerland
Tel: +41 22 730 8067
Fax: +41 22 730 8181
Email: gcos@wmo.int