
**GCOS STEERING COMMITTEE
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Programme Director Activity Report

(Submitted by the GCOS Secretariat)

This is a report from the programme director to the GCOS Steering Committee on activities around progress on the Implementation of the Global Climate Observing System (GCOS) with the following contents:

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¹ Available from: <https://gcos.wmo.int/en/gcos-implementation-plan>

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The Steering Committee is asked to note the report.

Director's Remarks on the future of the programme and possible impacts of the WMO reform

The concept of GCOS will need to be maintained to ensure the long-term robustness of GCOS as the global system of climate observing systems. The maintenance of a strong partnership of all formal sponsors in both the WCRP and GCOS will be important to the credibility of international climate science.

This programme is widely owned, by its co-sponsoring organizations and partners within the Earth Observation Community. It is also a key contributor to the global framework for climate policies and an essential component of the total global climate infrastructure.

It had substantial achievements on which many partners, but in particular WMO, IOC and the space agencies have built on and will need to further build on for the next decades to come.

A potential scenario of drastic changes in the programme management and its secretariat might have an effect on the support from supporting organizations, governments and bodies and the many eminent leaders and experts who have contributed their time and support to the GCOS Steering Committee and its panels over the decades.

From the perspective as the programme director, I could envision that the continuation of the well and smoothly working programme secretariat as one entity within the new Infrastructure Department at WMO will allow to pursue the programme objectives and will enable to make its operations and methodologies, without interruption, compliant to the new structure of the Technical Commissions and its Standing Committees and sub-structures.

It would also allow to be the one-single-entry point to WMO's new climate coordination mechanism, as it manages by virtue of its system of systems concept all needed relations in climate observations, science, research and services.

The WMO change management will need to carefully consider and to take into account the programme objectives and its justification, the detailed description of activities, GCOS work methodology, the work plan until 2023, impact on target groups, deliverables, multiplying effects and its financial sustainability. The Annex is elaborating on all these points.

It should be also noted some immediate concrete impact on financial support by radical changes to the programme management:

- The European Commission has just given to the GCOS programme an operational grant of 750,000 Euro over the next three years, to support explicitly the GCOS secretariat. The agreement to be signed is underway. This is a tremendous success having an operational grant established with the European Commission.
- NOAA will contribute potentially over the next 6 years with 165,000 USD annually, dedicated to the staff appointed to coordinate ocean observations for climate.
- There are other sources of which continuation of their funds (in total about CHF 200,000 and often more) will need to be explored then.

The stop or ending of any of this external funding due to changing conditions for the grant allowances would need to be buffered from other budgetary sources.

Introduction to the GCOS work plan

GCOS was established in 1992. Its concept is strongly supported by the global climate agenda, but is now facing new challenges.

With the UNFCCC Paris Agreement of 2015, there is a wide consensus that supporting climate policy to address adaptation and mitigation is vital. The science has improved dramatically: the existence of anthropogenic climate change is clear and warming of the climate system is unequivocal.

This consensus on the need to act to mitigate and adapt to climate change together with improving and expanding observational technologies leads to more demands on the global climate observing system.

In order for climate observations to support an improved understanding of the climate system, a better attribution of events, and more reliable forecasts and projections, GCOS will need to ask for the whole climate system to be monitored. GCOS will incorporate the Earth's water and carbon cycles and energy balance in their entirety and aim to explain the changing conditions of the biosphere.

Observation technology is evolving. An example has been in the oceans with new autonomous equipment collecting data. New and higher resolution satellite data is becoming available. Other developments that use lower levels of technology but are likely to grow must be considered by GCOS.

To ensure high quality data is available, GCOS will need to improve its monitoring of the performance of ECV observations and implementation of the GCOS plans. This should be a central part of the work of its Expert Panels.

Recent activities emerging from the GCOS Implementation Plan:

1. Promoting Global Climate Indicators²

The GCOS implementation plan asks for the development of an agreed set of global climate indicators that can be used to communicate to the widest community the scope and rate of changes to the climate in a widely accessible manner. The current list of climate indicators is being promoted: Global Surface Temperature, Ocean Heat, Atmosphere Carbon Dioxide, Sea Level, Ocean Acidification, Sea Ice Extent in the Arctic and Antarctic and Glacier Change. The experts panels have further also identified indicators under development: heat waves, heavy precipitation, droughts and ecosystem change and so-called supplementary indicators: top of atmosphere energy balance, methane, nitrous oxide, halocarbon green-house-gas and snow extent. No further work on indicators is being planned at the moment.

2. Using Radar to compliment precipitation climatology

The GCOS Radar Task Team³ was established jointly with the Commission of Climatology (CCI) and is responsible for identifying requirements for the use of radar data for climate studies, including specifying adequate metadata and guidance on how to facilitate user access and preservation of data and to handle historical data. The first meeting was held at the Finnish Meteorological Institute in Helsinki in August 2017. The report "Weather Radar Data Requirements for Climate Monitoring (GCOS-223)" of the Task Team is online available. The team has also published an article in BAMS "An Overview of Using Weather Radar for Climatological Studies: Successes, Challenges, and Potential" <https://doi.org/10.1175/BAMS-D-18-0166.1>.

3. Lightning Observations for Climate Applications

Lightning is a new ECV in the atmospheric domain, and an assigned task team, the joint Task Team on Lightning Observations⁴ for Climate Applications is working on developing requirements and guidelines on the use of lightning data for climate, including the review and update of current lightning ECV requirements and the definition of standards and requirements for data management and data exchange of lightning monitoring for climate applications. Further work should be carried on in collaboration with the WMO Integrated Global Observing System (WIGOS) and CBS Inter Programme Expert Team on the Observing System Design and Evolution (IPET-OSDE).

² <https://gcos.wmo.int/en/global-climate-indicators>

³ <https://gcos.wmo.int/en/task-team-radar-observations-climate-applications-ttroca>

⁴ <https://gcos.wmo.int/en/task-team-lightning-observations-climate-applications-ttloca>

4. Regional Workshops in light of the importance of climate observations in supporting adaptation

As called for in the GCOS implementation plan and mandated by the 45th session of the UNFCCC Subsidiary Body on Scientific and Technological Advice, SBSTA45, GCOS is holding regional workshops, particularly in light of the importance of observations supporting adaptation, to identify needs and potential regional cooperation. The workshops are an ideal forum to discuss how observations can support adaptation needs, promote guidance and best practice and design projects to improve observational networks, in particular in the light of the WMO Global Basic Observing Network, GBON.

As a first step, GCOS, jointly with WIGOS, in collaboration with UNFCCC, has organized a workshop in Nadi, in Fiji⁵, from 9 to 12 October 2017, which developed an outline for a *Pacific region observing network plan in support of the GCOS Implementation Plan and the Implementation Plan for the Evolution of Global Observing Systems (EGOS IP)*.

As a result of this workshop, the concept of the GBON was developed. GCOS is contributing to the establishment of GBON.

A joint GCOS/Copernicus/WIGOS/GFCS workshop in collaboration with UNFCCC was held in Entebbe, Uganda, 31 October–2 November 2018 on improving the value chain from observations to climate services to support climate policy, adaptation and mitigation in East Africa. The workshop outcomes included a report and a regional plan to improve the value chain from observations to climate services in East Africa. The key messages and approved report are available⁶.

The third joint WMO GCOS/WIGOS Caribbean Workshop on Observations for Climate and Meteorology took place in Belize, Belize – 10–12 July 2019. The workshop report is still in draft, but key messages are also available⁷.

5. Observations to support Adaptation

The GCOS Terrestrial Observation Panel for Climate, TOPC, has a task team⁸ to look at observations to support adaptation. Adaptation planning requires observations of the current state and assessment of risks of impacts and information on how these are changing. Some of this information comes from global observational systems and so GCOS is including these global monitoring needs in future observational requirements.

6. Progress in providing access to ECVs⁹

The GCOS expert panels have started the process of reviewing progress on the new implementation plan and ensuring mechanisms are in place to monitor the observation, maintenance and free and open accessibility of all the ECVs.

In this context, the work of the Joint CEOS-CGMS Working Group on Climate needs to be highlighted which is tasked with responding on the monitoring of climate from space. This working group has built an inventory for ECVs, which is accessible through a website. The ECV inventory¹⁰ is the backbone of the architecture for climate monitoring from space and provides a comprehensive view as to what Climate Data Records are currently planned or available.

⁵ <https://gcos.wmo.int/en/regional-workshops/pacific-workshop>

⁶ <https://gcos.wmo.int/en/regional-workshops/east-africa-workshop>

⁷ <https://gcos.wmo.int/en/wmo-gcoswigos-caribbean-workshop-observations-climate-and-meteorology>

⁸ <https://gcos.wmo.int/en/terrestrial-observation-panel-climate/ttcao>

⁹ <https://gcos.wmo.int/en/essential-climate-variables>

¹⁰ <http://climatemonitoring.info/ecvinventory>

7. Continued commitment of space agencies

The Working Group on Climate has coordinated and compiled the space agencies' response¹¹ to the GCOS Implementation Plan. This document reiterates the commitment of space agencies worldwide to address actions required for implementation of the Global Climate Observing System.

8. GCOS Network Management¹²

Many actions in the Implementation Plan are related to the operation and monitoring of the GCOS Upper-Air Network (GUAN). A Task Team was created to review the network requirements, assess and document the benefits of meeting stated requirements and to review how it contributes as a baseline network in the tiered network framework with GRUAN and the comprehensive network. A first meeting of the Task Team took place at the DWD Meteorological Observatory in Lindenberg, Germany from 5 to 6 December 2017. The key message from this meeting was a need to refocus the requirements of the GUAN in provided 'guaranteed' high-quality observations and the benefits of its designation as a baseline network. It was also decided that the original data should be retained and archived, and a common format for the raw data should be defined.

The GCOS Secretariat is reporting regularly on the GUAN, the GCOS Surface Network (GSN), and the GCOS Cooperation Mechanism, including the station list update, monitoring statistics for past and current years and current and recent observations projects undertaken by the GCOS network management.

A key component to report, update and encourage the work and responsibilities of the Lead Centres is the biannual meeting between the Lead Centre Representatives, WMO and GCOS. The last meeting was held in Asheville, USA, in September 2018.

Since January 2016 additional monitoring of the GSN stations has been provided through the EUMETNET Quality Monitoring Portal¹³ (QMP).

This enhanced QMP not only provides real-time availability and timeliness statistics for surface and upper-air messages received at the German Meteorological Service, DWD in Offenbach, but also measurement quality as compared with NWP background fields (ECMWF). Members are encouraged to monitor the performance of their GSN stations through this portal and report any issues to the WMO Secretariat.

The GCOS Cooperation Mechanism is the system improvement and resource mobilization activity of the GCOS programme. It has been established following a decision by the UNFCCC SBSTA in 2004 (UNFCCC Decision 5/CP.5) in order "to enable developing countries to collect, exchange, and utilize data on a continuing basis in pursuance of the UNFCCC". Since then, more than 3 million USD have been raised over the years to accomplish projects dedicated to improving climate observation systems.

New funds to the GCOS Cooperation Mechanism have reduced significantly. Currently, the GCOS Cooperation Mechanism is only able to offer low cost emergency support or projects with an explicit request from the donor.

Several actions in the Implementation Plan are related to the operation of the GCOS Reference Upper-Air Network (GRUAN). GRUAN is an international reference observing network of sites measuring ECVs above the Earth's surface. It is the response to the need of WMO for the highest accuracy data possible and is also part of WIGOS. GRUAN measurements provide long-term, high-quality climate data records from the surface, through the troposphere, and into the stratosphere that are being used to determine trends, constrain and calibrate data from

¹¹ [WGClimate IP Response](#)

¹² <https://gcos.wmo.int/en/networks>

¹³ <https://eucos.dwd.de/ravi/>

more spatially-comprehensive observing systems (including satellites and current radiosonde networks), as well as providing appropriate data for studying atmospheric processes. GRUAN has currently 26 sites, with the aim to expand to 30 to 40 sites.

GCOS has established a task team to work on the development of a GCOS Surface Reference Network¹⁴ (GSRN TT). A position paper, developed by members of the community “Towards a global land surface climate fiducial reference measurements network” and published in the International Journal of Climatology in 2018¹⁵, includes the rationale of the existence of a global surface reference network. Basing their work on this paper, the GSRN Task Team is asked to move forward the concept of a global surface reference network towards the practical implementation of such a network and to provide a concrete roadmap for consideration of the key stakeholders. During the meeting, held at Maynooth University in Ireland, from 1 to 3 November 2017, it was decided to produce a document that will include benefits, requirements, network design, governance and management proposals. The report “GCOS Surface Reference Network (GSRN): Justification, requirements, siting and instrumentation (GCOS-226)” of the Task Team is online available. This document will be part of the material used to assess the interest in the GSRN from stakeholders and to investigate about possible resources.

9. Developing the ocean observing system for climate ¹⁶

The GOOS/GCOS Ocean Observations Panel for Physics and Climate (OOPC) coordinates focussed reviews and evaluations to develop and improve the ocean observing system for climate. In recent years, two have spun off into finite lifetime projects (TPOS 2020 and the Deep Ocean Observing System). The current work plan is focussed on *Ocean Heat and Freshwater storage, Air-Sea Fluxes and Wind Stress, Boundary Currents and their interactions with the shelf*.

10. Regional Ocean Observing System reviews and development projects

The GOOS/GCOS Ocean Observations Panel for Physics and Climate, OOPC, monitors progress of regional projects and reviews. In particular, OOPC identifies synergies and issues or advances which need to be raised to the global level or can be used to advance the global observing effort.

The TPOS 2020 project was formed out of a review supported by OOPC and is tasked with redesigning and re-energising the Tropical Pacific Observing System. The project noted in particular the need for further work on refining requirements, observing system design for Ocean Surface Stress and Air Sea Fluxes. As these issues are broader than the Tropical Pacific, TPOS 2020 will collaborate closely with OOPC. The First report was published in 2016, following external review.

Following the approval of the TPOS 2020 Second Report was approved by agency sponsors, and also by the WMO Congress and IOC Assembly. The report has a strong focus on the status of forecast systems; and the work required to improve forecasts particularly on shorter (weather and extreme events) timescale requirements, and on the status of sub-seasonal to inter-annual forecast systems.

Similar regional efforts to evolve, integrate and enhance regional, basin scale observing systems, such as the European funded AtlantOS project and follow up Blueprint for an Atlantic Ocean Observing System, the Southern Ocean Observing System (SOOS) programme, and the Deep Ocean Observing Strategy to extend sustained observations into the full depth of the ocean. Regional reviews have also been completed in the Tropical Atlantic and Indian Ocean.

¹⁴ <https://gcos.wmo.int/en/task-team-proposed-gcos-surface-reference-network-ttgsrn>

¹⁵ DOI: 10.1002/joc.5458

¹⁶ <https://gcos.wmo.int/en/ocean-observations-physics-and-climate-panel>

The need for ongoing regional, basin scale coordination is recognised as part of GOOS discussions on strengthening the governance of the observing system.

11. Ocean ECV Requirements

OOPC is working with the other GOOS Expert Panels for Biogeochemistry and Biology to refine requirements for Ocean ECVs. The three panels work together within GOOS to develop a truly integrated multidisciplinary observing system for Climate, as well as operational services and ocean ecosystem health. Activities focus around integrated observations of key phenomena, with a project underway to design and observing system to monitor variability in the ocean oxycline. In addition, the Biology Panel is developing 'implementation plans' for each Biological EOV.

12. Ocean Observing System implementation and performance tracking

OOPC works closely with the JCOMM Observations Coordination Group, the membership of which comprises globally coordinated sustained oceanographic and marine meteorological observing networks, to set targets for the observing networks which in combination meet requirements for the physical and biogeochemical ECVs. New globally coordinated networks which have joined OCG include HF Radar, OceanGliders, and now Animal Tagging, and Surface ocean CO₂ observations. For Biological Observations, the GOOS Biology Panel is developing implementation plans by EOV, which includes bringing together various regional efforts and moving towards global coordination.

Improved targets and Key Performance Indicators have been identified to improve tracking of the observing system performance for level of effort, coverage, and data delivery for these networks. OOPC ensured that these reflect targets identified as network actions in the GCOS Implementation Plan. The JCOMMOPS technical coordination platform routinely tracks the performance of the observing networks, against targets, we can track the status of the networks against GCOS Actions. The JCOMMOPS team are now working with OCG and OOPC to be able to report on the status of the observing system by variable against requirements.

13. The OceanObs'19 Conference

This major Decadal conference a forum for bringing the community together to chart the course of ocean observing for the next decade. The conference brought together 1500 people, and 140 whitepapers were developed by 2500 unique authors as input to the conference. The GCOS SC was represented, and many members were actively involved in the organisation of the conference and various sessions. The conference statement is available here: <http://www.oceanobs19.net/statement/>

14. Planning cycle for the GCOS towards the Global Stocktake

GCOS recognizes the need for coordination between its planning cycle and the scheduled global stocktake in 2023 and will aim to revise its status report in 2020/2021, plan for a second science conference eventually at the end of 2021 and update its implementation plan in 2022. One of the important tasks of GCOS is to provide requirements for the ECV products. The panels have started working to review the existing ECV requirements, assessing if they are still fit-for-purpose and proposing refinements in consultation with their respective communities. Guidelines for reviewing the GCOS ECV Product Requirements were published in July 2019. A consolidated set of ECV product requirements will be publicly reviewed from January to March 2020.

Annex 1: GCOS Programme – Operational Concept

1. Objectives:

The Global Climate Observing System (GCOS) programme addresses the needs for systematic climate observations. It is essential that it is managed on a sustained basis.

It advocates and coordinates observing systems that support evidence-based policy making and risk management across a range of multilateral environmental agreements, inter alia, Paris Agreement. GCOS is fulfilling normative work in providing monitoring standards, principles and plans, supporting climate research and underpinning climate services.

Its objective is to identify observations that support sustainable development, the requirements of the United Nations Framework Convention on Climate Change (UNFCCC) and other multilateral environmental agreements.

In order to meet these needs, GCOS works towards climate observations being enhanced and continued into the future to provide the empirical evidence needed to understand and predict the evolution of the climate, to guide mitigation and adaptation measures, to assess risks and enable attribution of climatic events to underlying causes, and to underpin climate services. GCOS will need to encourage integrated observations of the physical, chemical and biological properties and processes across the atmospheric, oceanic and terrestrial domains, in order to more fully monitor the Earth's water and carbon cycles and energy.

2. Justification:

GCOS is intended to underpin and support the wide range of international programs and systems for climate research, applications and services and their counterpart activities at the national level in individual countries.

The GCOS programme is the only international coordination mechanism for systematic and sustained global climate observations.

Following its establishment in 1992, by the following four organisations, the World Meteorological Organization (WMO), the Intergovernmental Oceanographic Commission of the United Nations, Educational, Scientific and Cultural Organization (IOC of UNESCO), the United Nations Environment Programme (UN Environment) and the International Science Council (ISC), a GCOS Plan¹⁷ published in 1995 focussed on supporting understanding of climate and climate change.

Since then, much has changed: the science has improved enormously, the UN Framework Convention on Climate Change (UNFCCC) reached its Paris Agreement on limiting climate change, the Sendai Framework for Disaster Risk Reduction was approved.

The UN's 2030 Agenda for Sustainable Development with its 17 goals frame many global policy agenda: SDG 13 unequivocally states the need to take urgent action to combat climate change and its impacts in the sustainable development context. Adaptation and mitigation to climate change and disaster early warning systems are vital.

The four priorities for action identified by the Sendai Framework include *Understanding disaster risk* and *Enhancing disaster preparedness* – both of which depend on observations to support long-term predictions and estimates of risk to support risk management.

New observing technologies have become available from satellites and automated ocean buoys to simple citizen science approaches.

GCOS will need to address the needs for climate observations in light of these recent developments. GCOS advocates and coordinates observing systems that support evidence-based policy making and risk management across a range of multilateral environmental agreements.

To improve and support global climate observations, GCOS cooperates and coordinates with a range of existing observational systems, networks, groups of satellite agencies and capacities. These include the WMO Integrated Global Observing System (WIGOS), the Global Ocean Observing System (GOOS), the Committee on Earth Observation Satellites (CEOS) and the

¹⁷ GCOS (1995) Plan for the Global Climate Observing System (GCOS), Version 1.0, GCOS-14, WMO/TD - No 681

Coordination Group for Meteorological Satellites (CGMS). It also plays a significant role for the broader observation requirements of the Global Framework for Climate Services (GFCS), its key for contributing to Copernicus Climate Change Service (C3S), the World Climate Research Programme (WCRP) and the Group on Earth Observations (GEO).

GCOS collects and synthesizes the observational needs expressed by user communities and produces practical guidance on what should be the focus of observations of the climate system. GCOS supports all components of the World Climate Programme, the assessment role of the Intergovernmental Panel on Climate Change (IPCC), and the systematic observation requirements of the UNFCCC. It specifically encourages the provision of comprehensive and continuous climate and climate-related data and information to climate service providers.

3. Detailed Description of Activities:

The GCOS programme will coordinate with disparate observing systems and encourage the adoption of GCOS Essential Climate Variables (ECVs) in their plans while ensuring the definition and requirements of ECVs do not lead to unnecessary duplication.

Current relationship of GCOS with other observing systems needs to be managed: GCOS integrates the climate related parts of the existing domain-based observing systems: Global Ocean Observing System (GOOS) for the ocean; the WMO Integrated Global Observing System (WIGOS) for the atmosphere that itself integrates the Global Observing System (GOS); Global Atmosphere Watch (GAW), and the Global Cryosphere Watch (GCW), the WMO Hydrological Observing System (WHOS) and other terrestrial observations including Global Terrestrial Networks for x=: glaciers, permafrost, rivers; lakes, and hydrology, (GTN-x). GCOS has a relationship with the Food and Agricultural Organisation (FAO), by virtue of FAO's former lead in terrestrial observations and relates to the WMO-IOC Joint Technical Commission for Oceanography and Marine Meteorology through its Observation Coordination Group (OCG). GCOS reports to the UNFCCC but also may serve other organisations. UNESCO has a special relationship for terrestrial observations through the International Hydrological Programme.

The GCOS panels will use the monitoring performed by other observing systems, such as WIGOS, GAW, GCW, WHYCOS, GOOS etc. in their assessments. They will explore synergies with observing needs for non-climate environmental issues and will consider extending the definitions of ECV to accommodate their requirements.

The GCOS secretariat and panels will collaborate with relevant stakeholders such as UNFCCC, WMO, IOC of UNESCO, ISC, UN Environment, other multilateral environmental agreements (MEA), IPCC and the Group on Earth Observations (GEO).

Collaboration with space agencies through their coordinating bodies, the Committee on Earth Observation Satellites (CEOS) and the Coordination Group for Meteorological Satellites (CGMS) has underpinned the observations of many ECV. Space agencies future plans take into account GCOS recommendations. The GCOS programme will continue and strengthen this collaboration.

The GCOS secretariat will prepare a separate communication plan that will cover:

- Listening to users' needs and define ECV and their requirements in considering current or near future practical capabilities;
- Reviewing the current global climate observation system and make proposals for its evolution to meet new and expanding needs;
- Advocating for improved observations and open access to the data;
- Promoting transparent access to climate indicators to improve public understanding and acceptance of climate change;
- Supporting the capacity building related to observational capabilities in countries with limited resources;
- Explaining the importance and benefits of climate observation, including the use of climate data in provision of climate services for improved social and economic benefit;
- Fundraising.

The GCOS programme has always worked with the relevant observational and user communities. However, in the future, given the broader range of users and needs, there will need to put a larger emphasis on communicating with all these groups, in particular, by involving them in drafting requirements and plans and through open reviews and calls for suggestions.

4. Methodology:

GCOS operates through a continuous performance improvement and assessment cycle of specifying needs, providing support, providing observations performed by independent systems and networks, monitoring performance of observations and back to specifying needs. GCOS will aim to synchronise this cycle on the dates of the Paris Agreement's Global Stocktake, the first of which is in 2023.

Description of work:

- 1) Review and where needed update the definitions of Essential Climate Variables (ECV) considering the needs of users especially the expanded observational needs for adaptation and mitigation to climate change. Monitoring the performance of the observational systems against these needs.
- 2) Prepare plans and guidance for the maintenance and improvement of the global climate observation system. Assist with improving the observational infrastructure in countries with limited resources. Provide capacity development through the GCOS Cooperation Mechanism. Assist the integration of national and regional networks into the global observing systems. Advocate for the implementation of these plans.
- 3) Promote, and facilitate, the establishment and maintenance of data repositories with open access to all climate data, through key stakeholders, inter alia, ECV inventory and Copernicus. The aims and objectives of GCOS will only be met if the data is accessible by users.
- 4) Coordinate with the disparate observing systems. Encourage the adoption of GCOS ECV in their plans and ensure the definition and requirements of ECV do not lead to unnecessary duplication.
- 5) Communicate with users, policy makers, funding agencies and the media to explain the benefits of, and needs for, improved climate observations. Promote examples of the strong impact that GCOS can make in developing countries with direct societal impacts.

Activities of the GCOS Programme are dedicated to:

- Status Report, Planning for Implementation and related workshop, planning for the next assessment cycle;
- Coordination of climate observations, i.e., Reporting to partners; Steering Committee, GCOS Management meetings;
- GCOS science and technical panels: Atmospheric Observation Panel for Climate (AOPC), Ocean Observations Panel for Climate (OOPC), Terrestrial Observation Panel for Climate (TOPC), cross-panel activities;
- Partner activities, i.e., United Nations Framework Convention for Climate Change (UNFCCC), Intergovernmental Panel on Climate Change (IPCC), World Climate Research Programme (WCRP); Global Earth Observing System of Systems (GEOSS), Committee on Earth Observation Satellites (CEOS) and the Coordination Group for Meteorological Satellites (CGMS);
- Regional implementation, with a focus on Southern Pacific, East Africa, Central and South-America; Eastern and Central Europe;
- Network management, i.e., GCOS Surface Network, GCOS Upper-Air Network, Reference Upper-Air Network, Reference Surface Network, Surface Radiation Network, Global Terrestrial Networks;

- New initiatives (Global Framework for Climate Services (GFCS), Future Earth, Programme of Research on Climate Change Vulnerability, Impacts and Adaptation (formerly PROVIA, now WASP);
- Office, Outreach and Visibility (Editing, Translation, Printing), IT-charges, charges with regard to the office space.

The core activities of the programme, panels and steering meetings, are seeking funding for € 160,000 (CHF 180,000) every year.

The major programme activities, i.e., observational requirements for providing supporting to adaptation, regional workshops, cross-panel activities and starting the next assessment cycle, will need funding of € 220,000 (CHF 250,000) in 2019 and € 255,000 (CHF 290,000) in 2020 and 2021.

The GCOS programme needs dedicated programme officers to coordinate the climate observations for each domain, i.e., atmosphere, land and oceans, which will require in total about € 530,000 per year (one scientific officer costs € 178,000).

The GCOS Cooperation Mechanism is managed by an implementation manager which will require an annual support of about € 150,000.

The GCOS programme consists of:

- 1) High-Level Engagement Board¹⁸.** High-level input of GCOS sponsors into Steering Committee. This provides an opportunity for the sponsors to review progress and provide high-level guidance.
- 2) The GCOS Steering Committee.** This is a group of scientific and technical experts appointed jointly by the GCOS sponsoring organisations to
 - a. agree the annual work plan GCOS advise on its further development
 - b. agree on scientific and technical matters and, in particular, on proposed ECVs, their requirements and implementation plans
 - c. review the components of GCOS and report to the sponsors.
- 3) The GCOS Panels¹⁹.** These are groups of experts whose task is to provide scientific and technical input into the GCOS programme on, inter alia, climate monitoring needs, observational capacities and ECV specifications. They maintain an overview of the current status of the observational systems.
- 4) The GCOS Cooperation Mechanism** resulted from deliberations at the 17th session of the UNFCCC Subsidiary Body for Scientific and Technological Advice (New Delhi, 2002), and was formalized in a decision of the 9th session of the Conference of the Parties to UNFCCC, COP9. It uses donor funds to make practical improvements to the observational capacities of countries with insufficient resources. It comprises the GCOS Cooperation Board as the primary means to facilitate cooperation among donor countries, recipient countries and existing funding and implementation mechanisms in addressing high-priority needs for improving climate observing systems in developing countries; and the GCOS Cooperation Fund as a means to aggregate commitments and voluntary contributions from multiple donors (both in kind and financial) into a common trust fund.
- 5) The GCOS Secretariat.** The secretariat supports the Steering Committee, Governance Board, Panels and Cooperation Mechanism in programme development and implementation.

¹⁸ Currently the Sponsors of GCOS are: WMO (who host and support the secretariat), IOC of UNESCO, ICSU (merged with ISSC to become International Science Council (ISC) in 2018) and UN Environment.

¹⁹ Currently (October 2019) there are three panels: the Atmospheric Observation Panel for Climate (AOPC); the Ocean Observations Panel for Climate (OOPC); and the Terrestrial Observation Panel for Climate (TOPC).

The composition of committees and panels is following the WMO policy on gender equality²⁰. The GCOS Secretariat also aim to implement a barrier-free working environment for panel members, in particular, for members with visual impairment.

The GCOS Secretariat is composed in total of 6 internal staff, and one external staff (current gender balance: four women, three man):

- GCOS is employing three scientific officers (one each for Atmosphere, Land and Oceans), internal staff, in charge of managing the corresponding GCOS Panels and related task teams and maintaining the relations to partner programmes and observing systems. Detailed description of their duties and responsibilities are described below in the Staff Table.
- In addition, there is one junior professional officer, supporting the science officers.
- The programme secretariat is led by a director, due to the multi-dimensional and inter- and intra-organisational management of relations, and due to this complexity in need to be supported by an administrative assistant. Both of them are WMO staff, and charged to generally administer the programme and provide support to the GCOS Steering Committee and High-Level Engagement Board.
- The programme secretariat is additionally supported by one external staff, seconded by the UK MetOffice. This staff (Network Manager) is in charge of managing the GCOS Cooperation Mechanism.

Staff Table and Description:

Function:	Duties	Supported by:
Science Officer Atmosphere:	<p>70% recurrent and core activities:</p> <p>a) Take on responsibility of the Atmospheric Observation Panel for Climate (AOPC), co-sponsored by GCOS and the World Climate Research Programme (WCRP);</p> <p>b) Provide scientific and programme management advice to the climate observing communities with respect to the implementation of sustained satellite-based and in situ based observations of Essential Climate Variables through preparation of reports and participation in relevant meetings;</p> <p>c) Identify and coordinate the scientific needs of the climate community related to atmospheric observations in coordination with AOPC, and with guidance from the GCOS and WCRP science panels and expert groups;</p> <p>d) Cooperate closely with the Chairpersons of the GCOS/WCRP AOPC, and liaise with the GCOS Network Manager, in order to identify projects which contribute to the implementation of atmospheric climate observing systems, on global and regional scales, and assess the feasibility and impact of relevant projects;</p> <p>e) Support and establish close liaison between the AOPC and the GCOS//WCRP Terrestrial Observation Panel for Climate (TOPC) which focuses on cryospheric and hydrological issues and climate, and with the GCOS/GOOS/WCRP Ocean Observations Panel for Climate (OOPC) which focuses on marine issues and air-sea-interfaces;</p> <p>f) Organize panel meetings and associated workshops and conferences, prepare supporting documents, taking and writing up the notes, finalizing and publishing the reports, including the implementation of action items, and the response to requests from the Panel;</p> <p>g) Provide relevant input to, and assist in support for the GCOS Steering Committee. Ensure good liaison with WCRP, WMO Technical Commissions, the WMO Integrated Global Observing System Project Office and other relevant partners on all matters relevant to climate observations</p>	<p>Voluntary Contributions (funding is secured to 75% through an Operating Grant from the EC DGROW (Copernicus))</p>

²⁰ <https://public.wmo.int/en/resources/gender-equality>

Function:	Duties	Supported by:
	<p>and related climate services.</p> <p>30% current activities:</p> <ul style="list-style-type: none"> (a) managing Task Teams on radar, lightening, air-sea fluxes and the upper-air and surface reference networks; (b) contribute to the current planning process for the upcoming assessment cycle; (c) support outreach and visibility. 	
<p>Science Officer Land:</p>	<p>70% recurrent and core activities:</p> <ul style="list-style-type: none"> a) Take on responsibility of the Terrestrial Observation Panel for Climate (TOPC), co-sponsored by GCOS and the World Climate Research Programme (WCRP); b) Provide scientific and programme management advice to the climate observing communities with respect to the implementation of sustained satellite-based and in-situ based observations of Essential Climate Variables through preparation of reports and participation in relevant meetings; c) Identify and coordinate the scientific needs of the climate community related to terrestrial observations in coordination with TOPC, and with guidance from the GCOS and WCRP science panels and expert groups; d) Cooperate closely with the Chairpersons of the GCOS/WCRP TOPC, and liaise with the GCOS Network Manager, in order to identify projects which contribute to the implementation of terrestrial climate observing systems, on global and regional scales, and assess the feasibility and impact of relevant projects; e) Support and establish close liaison between the TOPC and the GCOS/WCRP Atmosphere Observation Panel for Climate (AOPC) which focuses on atmospheric issues and climate, and with the GCOS/GOOS/WCRP Ocean Observations Panel for Climate (OOPC) which focuses on marine issues and air-sea-interfaces; f) Organize panel meetings and associated workshops and conferences, prepare supporting documents, taking and writing up the notes, finalizing and publishing the reports, including the implementation of action items, and the response to requests from the Panel; g) Provide relevant input to, and assist in support for the GCOS Steering Committee. Ensure good liaison with WCRP, WMO Technical Commissions, the WMO Integrated Global Observing System Project Office and other relevant partners on all matters relevant to climate observations and related climate services. <p>30% current activities:</p> <ul style="list-style-type: none"> a) coordinate the involvement of GCOS in IPCC task team on GHG and observations for the UN Framework Convention on Climate Change (UNFCCC) and provide input to the preparations of reports to the UNFCCC and its subsidiary bodies; b) managing a Task Team on observations providing support to adaptation; c) drafting a strategic document and contribute to the upcoming planning and assessment cycle; d) support outreach and visibility. 	<p>Voluntary Contributions (funding is secured to 75% through an Operating Grant from the EC DGROW (Copernicus))</p>
<p>Science Officer Oceans:</p>	<p>70% recurrent and core activities:</p> <ul style="list-style-type: none"> a) Support the Ocean Observation Panel for Climate (OOPC) in identifying and coordinating the scientific requirements of the climate community related to ocean observations with the guidance from the GCOS, the Global Ocean Observing System (GOOS) and the World Climate Research Programme (WCRP) science panels and expert groups; 	<p>Research Project from Woods Hole Oceanic Institute, US (75% funding secured for 2020, and potentially to 100% from 2021)</p>

Function:	Duties	Supported by:
	<p>b) Assist in providing scientific and programme management advice to the ocean observing communities with respect to the implementation of sustained satellite-based and in-situ based observations of Essential Climate Variables through the organization of reviews on the adequacy of the observing system, preparation of reports and participation in relevant meetings;</p> <p>c) Monitor and assist in the implementation of ocean activities related to the actions in the GCOS Implementation Plan, assess the implementation status and assist in preparing the progress report;</p> <p>d) Organize panel meetings and associated workshops and conferences, prepare supporting documents, taking and writing up the notes, finalizing and publishing the reports, including the implementation of action items, and the response to requests from the Panel. Take the lead in the generation and maintenance of ocean climate indices for the OOPC and GOOS, as indicators of the growing ability to measure the ocean, as well as monitor the intersessional activities of the Panel, provide relevant input to, and assist in support for the GCOS and GOOS Steering Committees;</p> <p>e) Contribute to the WMO-IOC Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM), in the area of implementation and development of standards and support for the global ocean observing networks;</p> <p>f) Ensure good liaison with WCRP, the WMO Technical Commissions (CBS, CIMO, CCL, etc.), the WMO Integrated Global Observing System Project Office and other relevant partners on all matters relevant to ocean climate research and observations;</p> <p>30% current activities:</p> <p>a) contributing to a task team on air-sea fluxes and to the WMO Ocean Team;</p> <p>b) contribute to the current planning process for the upcoming assessment cycle;</p> <p>c) support outreach and visibility.</p>	<p>– 2025 based on a project with NOAA, US)</p>
Network Manager:	<p>100% technical manager for the programme;</p> <p>a) Plan, prioritise and manage the work of the GCOS Networks;</p> <p>b) Develop and manage projects according to the terms of the GCOS Cooperation Mechanism;</p> <p>c) Manage the technical external relationships with organisations and projects that are developing and supporting climate observing systems globally, in particular those in the priority regions (for example, SPREP, UNEP, UNDP, DFIC_WISER, EUMETNET, COPERNICUS).</p>	<p>Voluntary Contributions (funding is unsecured)</p>
Junior Professional Officer:	<p>100 % support of task teams and expert teams on climate requirements for meteorological networks:</p> <p>a) Monitor the performance of climate observation networks with special regard to the relevant portals for climate data;</p> <p>b) Assist in the preparation and organisation of panel meetings and workshops including documentation and reports;</p> <p>c) Assume responsibility for GCOS internet activities and outreach activities, like exhibitions, brochures and flyers.</p>	<p>National Training Programme supported by Germany</p>

5. Work Plan:

Milestones (October 2019–October 2022):

- January–December 2019: Panels review and update ECV requirements
- October 2019: 27th Steering Committee Meeting, review of process
- January–March 2020: Public review of ECV requirements
- March 2020: Panel Meetings revise requirements based on public review
- March 2020–March 2021 Panels prepare guidance for the maintenance and improvement of the global climate observing system: draft 4th Status Report; Monitor the performance of the observational system against the needs.
- March 2020–March 2022 Plan for regional workshops (potential candidate regions: Eastern-Central Europe, South-East Asia, Southern America): Assist with improving the observational infrastructure in countries with limited resources and assist, provide capacity development through the GCOS Cooperation Mechanism and assist the integration of national and regional networks into the global observing systems.
- October 2020: 28th Steering Committee Meeting will review the process
- March 2021: Panel Meetings agree on revised Status Reports
- March 2021–September 2021: Review and finalise the 4th Status report (SR4): The 4th Status report (SR4) should be published before the GCOS Climate Observation Conference in October 2021 and provided to the 2021 UNFCCC COP.
- March 2021–March 2022: Panels prepare guidance for the maintenance and improvement of the global climate observing system: Panels draft 4th Implementation Plan
- October 2021: Climate Observation Conference (TBC)
- October 2021: 29th Steering Committee Meeting, will consider conference outcomes
- March 2022: Panel Meetings agree on revised Implementation Plan
- March–October 2022: Review and finalise Implementation Plan
- October 2022: 30th Steering Committee Meeting: agree on 4th Implementation Plan which needs to be published in October 2022 to be provided to the 2022 UNFCCC COP.
- December 2022: 4th Implementation Plan is published.

6. Estimated Impact on Target Groups:

The timely delivery of the milestones, full implementation of the plans and open distribution of data products will allow users to have free access to the climate-related information they need.

The availability and quality of observations necessary to monitor, understand, and predict the global climate system would enable communities and nations to live successfully with climate variability and change.

GCOS will plan an observing system that is built, as far as possible, on the climate-related components of partner`s established observing systems. *The "one system – many uses" model is fundamental to the efficient and effective operations of the climate observing system*²¹.

²¹ GCOS Programme Review Synthesis Report March 2014, GCOS-181, World Meteorological Organization, 2014

Observational systems and networks supported by GCOS will meet the following principles:

- **Free and Open:** data is openly available to all users;
- **Transparent:** the methods and assumptions are clear, with standardised metadata, where possible;
- **Highly accurate: climate data** needs high accuracy to distinguish small trends from larger annual variability;
- **Useful:** there should be a clear demand from users;
- **Timely:** there should be a minimum delay before publication to monitor recent trends;
- Based on **best available science**.

An important product produced by GCOS are the ECV requirements. It is not sufficient to simply identify the ECV that should be measured but GCOS also identifies the parameters to be measured for each ECV, called ECV products (e.g. to specify the ECV "Earth Radiation Budget", the upward long-wave irradiance at TOA, the upward short-wave irradiance at TOA, the downward short-wave irradiance at TOA, the solar spectral irradiance and the radiation profile are needed). For each of these ECV products the accuracy, resolution and long-term stability required by users have been specified.

Climate observations will not just be used to improve climate science but also to guide mitigation and adaptation measures, to assess risks and enable attribution of climatic events to underlying causes, and to support the implementation of climate services.

GCOS will include these new user requirements by modifying the current approach: a range of accuracy and resolutions will be provided where the highest accuracy and resolution meets all these needs and the lower accuracy and resolution provides some benefits but not all. It may also be necessary to provide specific requirements for specific applications. Some ECV may need to be measured at different scales in different regions (e.g. the open ocean versus coastal waters, the tropics versus temperate regions). Future ECV product requirements will need to accommodate these differences.

The science panels will work towards revising and updating the ECV product requirements as part of their contribution to updating the GCOS implementation plans.

7. Deliverables:

- **ECV Fact Sheets: Essential Climate Variables (ECV)** updated definitions and observational requirements public available on so-called ECV factsheets. Download will be possible from website.
- **4th Implementation Plan.** The latest is "The Global Observing System for Climate: Implementation Needs", (GCOS-200) (2016)
- **4th Status Report.** The latest is "Status of the Global Observing System for Climate", (GCOS-195) (2015)
- **Communication Plan**
- **Annual Reports of the Panels and Steering Committee meetings**

GCOS products include:

- **Essential Climate Variables (ECV)** definitions and observational requirements (update of revised ECV requirements documented in ECV factsheets, Annex A in Implementation Plan)
- Definitions of Climate Indicators
- **Climate Monitoring Principles** approved by the UNFCCC (decision 11/CP.13) and adopted by Resolution 9, WMO Congress (Cg-XIV)
- GCOS Monitoring Guidelines, (GCOS-143)

Sponsors and partners are referenced in publications and on other print media. Logos of the formal sponsors are part of the programme identity. Logos of sponsors and partners are displayed on outreach material for conference, workshops and similar events.

8. Multiplier Effects

The possibility for replication and extension of the project outcomes is given.

GCOS operates through a continuous performance improvement and assessment cycle of specifying needs → providing support → observations (performed by independent systems and networks) → monitoring performance of observations and back to specifying needs. In the past, this sequence has been unfolding on a roughly 10-year cycle, with an update mid-way.

GCOS will aim to synchronise this cycle on the dates of the Paris Agreement's Global Stocktake, the first of which is in 2023, and the second in 2028.

9. Financial Sustainability

The planning and implementation activities for the Global Climate Observing System (GCOS) are funded through the:

- (a) WMO Regular Budget, which directly supports the position of GCOS Secretariat Director and of the Administrative Assistant, and adds voluntary funds to the GCOS Climate Observing System Fund (COSF);
- (b) GCOS Climate Observing System Fund (COSF), administered under WMO Trust Fund regulations, which is provided by the Sponsors and other voluntary contributors and which supports the recurrent and core planning and programme activities of the GCOS Steering Committee, Panels, and Secretariat;
- (c) GCOS Cooperation Fund (GCF), administered under WMO Trust Fund regulations, which is provided through voluntary contributions from various sources and which supports the Cooperation Mechanism.

The funding of core and recurrent programme activities is based only on annual contributions. The pledging process for voluntary contributions has to be renewed every year; there are no sustained commitments to GCOS with respect to the recurrent and core activities.

After ending of any external funding, the programme management has to continue soliciting for voluntary contributions to continue the activities, or WMO has to fill in the gaps with regular budget.
