



GCOS

KEEPING WATCH OVER OUR CLIMATE



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Final Report of the Joint Study Group GCOS (JSG-GCOS)

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1. EXECUTIVE SUMMARY

The Joint WMO, IOC, ISC and UNEP Study Group on the Global Climate Observing System (JSG-GCOS) was formed in 2020 (the Terms of Reference are included in Appendix D and membership in Appendix E). Under the leadership of the two co-chairs, Qingchen Chao (CMA¹) and Martin Visbeck (GEOMAR²), the Joint Study Group reviewed the GCOS governance and structure.

The role of GCOS is to support [...] relevant aspects of [...] climate-related global programmes. Specifically, the GCOS will ensure the data needs are met for climate system monitoring, for assessing the impacts of climate variability and change and applications to national economic development, as well as research leading to improved understanding, modelling and prediction of the climate system. (1998 Memorandum of Understanding)³.

GCOS performs a vital role in ensuring that Global Climate Observations are globally coordinated to ensure timely delivery of the information; to establish best practice and methods to safeguard high quality and calibration; to advance a fit-for-purpose system across many dimensions; and to ensure that data and information are easily accessible to all users.

GCOS competence and expertise as well its success in providing critical base line information to the international climate processes (UNFCCC) is widely recognized. However, its visibility at the national level and within the scientific community is mixed.

The sponsors last reviewed GCOS in 2014 and made some suggestions for change. However, the governance was not changed. After 30 years its current governance structure needs review, update and strengthening in some areas: clearer relationships with sponsors, observing networks, supporters and key users are essential and greater clarity is needed in how GCOS recommendations can be implemented across the wide range of stakeholders and network partners. Funding for the GCOS coordination as well as for several of its networks needs to be improved with recognition of the diverse national realities and resulting uneven engagement.

The JSG-GCOS has gathered information about the GCOS programme and intensively discussed the current situation. The JSG-GCOS established a number of subgroups and consultations and with the support of the GCOS secretariat provides an extensive set of detailed analysis, shared an interim report that comments on several elements and aspects of the program for reflection by the sponsors.

The JSG-GCOS identified many strengths:

- GCOS is recognized as a **powerful and authoritative mechanism for the international coordination, planning, developing and review of Climate Observing Systems and networks.**
- The **strong scientific and technical expertise** of the panels and the steering committee, together with efficient working arrangements across both, provides effective input into the GCOS implementation plan and the GCOS status reports.
- **GCOS is recognized as one of the key international coordination mechanisms that facilitates climate observations by networks** supported by WMO, GOOS,

¹ China Meteorological Administration

² GEOMAR Helmholtz Centre for Ocean Research Kiel

³ The Memorandum of Understanding between the World Meteorological Organization, the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization, the United Nations Environment Programme and the International Council for Science 1998 see Appendix B.

space-based observations coordinated by CEOS and CGMS as well as many other networks of other important sponsors.

- GCOS **developed and implemented the concept of Essential Climate Variables (ECVs)** which are widely endorsed by the community and scientific programs.
- **GCOS is mandated to report regularly to Parties to the UNFCCC** on its work and progress. It reports to the **Subsidiary Body on Scientific and Technological Advice (SBSTA)** and thereby provides the UNFCCC with status reports and implementation plans, which are recognized by the Conference of the Parties (e.g. Decision 19/CP.22).
- GCOS is acknowledged as the leading independent reference in **defining requirements for climate observations** for climate monitoring, that benefit science, applications, and wider stakeholder needs, including those in support of climate adaptation and mitigation measures and policies and an increasing range of climate services.

Despite successes to date, there are areas in need of improvements. In particular, the JSG-GCOS recommended that the mandate should be revised to better reflect the current situation and to ensure that GCOS remains relevant and functional. The updated mandate needs to address the following areas:

- Provide a more focused and streamlined governance arrangement including provisions for an effective steering committee that guides the strategy and engagement of GCOS and advocates for sustainable, systematic observations for climate.
- Clarify the funding of the GCOS programme and secretariat, so it can perform its coordination functions and support the networks and data systems.
- Articulate the additional needs to address observations for adaptation, mitigation and climate services.
- Provide clear ways for GCOS to make recommendations to its sponsors and the supporting networks (including input into regulatory material, guidelines and best practice).
- Ensure increased and sustained engagement and global participation in GCOS.
- Expand and strengthen the understanding of the needs of, and support for, sustained observations programs in 'the global South'.

The JSC-GCOS provided six high level recommendations summarizing the detailed outcomes and identified another 16 additional recommendations.

1.1 High Level Recommendations (HR)

HR1: GCOS sponsors should consider revising the existing Memorandum of Understanding (MoU) and split the content in two sections. The first section would constitute the main MoU that would lay out the high-level objectives of the program supported by the sponsors. The second section would contain annexes to the main MoU that address operational procedures such as clarifying the role of the signatories with regards to resource arrangements, oversight roles, and a more detailed governance structure including the steering committee and could be updated by the Steering Committee, with the agreement of the sponsors' representatives on the GCOS Steering Committee.

HR2: GCOS Steering Committee should ensure that its organizational structure is fit for purpose and should continue to enhance closer collaboration and integration between its panels to take into account changes in the international landscape, new variables and areas of work, the WMO reform and other needs from sponsors and beneficiaries.

HR3: GCOS should improve its engagement with stakeholders and partners, and the Steering Committee should consider a mechanism for providing a formal recognition of those groups in its revised governance structure.

HR4: The GCOS programme should continue to address new challenges, especially those caused by changing climate on fresh water, food security and biodiversity, by evolving, revising and improving the utility of the ECVs. Their requirements should contribute to a better understanding of the energy, water and carbon climate cycles, support climate adaptation and mitigation measures and policies, and address the biosphere, biodiversity and biogeochemistry, next to the currently recognized GCOS domains of atmosphere, ocean and land.

HR5: The MoU should clarify the role of GCOS as an independent group of experts to the UNFCCC process while meeting the needs and ambitions of its sponsors.

HR6: The Steering Committee should establish a regular structured dialogue with the sponsors (programmatic and resource) on strategic, policy, funding and governance matters of GCOS.

1.2 Recommendations

RECOMMENDATION 1: GCOS should improve its engagement with stakeholders. The GCOS Steering committee should develop a strategy for further improving engagement with all stakeholders and monitor its implementation.

RECOMMENDATION 2: The MoU is revised as shown in Appendix A. This should include clarifying the role of the signatories, funding arrangements, and the role of the steering committee. It should also guide the development of a GCOS strategy and engagement plans. GCOS should continue to respond to the needs of the UNFCCC and respond to the Paris Agreement, i.e. systematic observations, state of the climate, adaptation and mitigation.

RECOMMENDATION 3: GCOS programme should have understanding of the needs of and support for the Global South. Previous efforts need to be strengthened with adequate support. Regional workshops have only been held with support of other programmes and the GCOS Cooperation Mechanism (GCM) has only received minimal support in recent years. GCOS should restart its regional programme working with WMO and other interested bodies and ensure the results are presented to the UNFCCC.

RECOMMENDATION 4: The Steering Committee and sponsors should ensure that GCOS maintains its role in advising the UNFCCC on climate observations. The future work programme of GCOS should continue to address the carbon cycle, adaptation, mitigation and climate indicators to help it meet UNFCCC expectations.

RECOMMENDATION 5: The GCOS Steering Committee should develop a series of multi-year meetings of all stakeholders, across the value chain, to provide advice and input into GCOS. They should be clear on the expectations for these meetings, and commitments to support and funding.

RECOMMENDATION 6: While GCOS should ensure its regular status reports and implementation plans continue, it should also move towards more regular updates on the status of the climate observing system, based on information produced by the corresponding observing networks and programmes. This would check that the global climate observing system (including the ECVs and their requirements) is fit-for-purpose and meets the needs of all users, as far as is practical, and identify remedial actions.

RECOMMENDATION 7: GCOS should ensure appropriate geographical, gender and age representation in its bodies.

RECOMMENDATION 8: The Steering Committee should ensure that the future work programme of GCOS continues to be revised and should improve the utility of the ECV and their requirements. The work programme should clearly address the needs of adaptation and mitigation of climate change; fully integrate observations of the biosphere across all domains;

increase its advocacy of the sustainability and continuity of in situ observations; and work with WCRP to develop a routine, annual, mechanism to discuss WCRP observational requirements.

RECOMMENDATION 9: Consideration should be given to strengthening the capability of the GCOS secretariat team, located within the Infrastructure Department of WMO, and the appointment or designation of a team lead at an appropriate level.

RECOMMENDATION 10: The Chair of the GCOS Steering Committee continue to be recognized and respected as a spokesperson for GCOS in relevant fora, complementary to the representation and advocacy role of WMO and other co-sponsors.

RECOMMENDATION 11: The GCOS Chair should be recognized as a member of the INFCOM Management Group and, by agreement with the President of INFCOM, be invited from time to time to inform EC and Congress on the progress, performance and requirements of the global climate observing system.

RECOMMENDATION 12: The GCOS Chair and Panel Chairs should build close linkages, through expert participation and alignment of efforts, with relevant INFCOM expert teams (and vice versa, where appropriate) and also with SERCOM and Research Board teams, especially where it will help in understanding needs for and application of ECVs to inform climate change and adaptation.

RECOMMENDATION 13: The role of GCOS in reporting progress and needs for ocean climate observations to the IOC should continue to be recognized and strengthened by the IOC.

RECOMMENDATION 14: A revised MoU should be clear that signatories are committing to long-term support for a GCOS Secretariat. The signatories of the revised MoU should ensure that financial and in-kind resources at an appropriate level (currently one million CHF annually) are available for the GCOS secretariat to implement the revised mandate.

RECOMMENDATION 15: GCOS should provide clear value-based information and a clear vision of how it hopes to develop the global climate observing system in the future to potential sponsors.

RECOMMENDATION 16: GCOS should revisit the aims of the GCOS Cooperation Mechanism (GCM) to better align it to the current situation and make it more attractive to potential donors. GCOS should produce a plan to inform potential donors about the GCM and its new focus and mobilise resources.

2. BACKGROUND

Since GCOS was founded by WMO, IOC, UNEP and ICSU in 1992 it has developed an understanding of the needs for climate observations across a range of communities from climate science to policy and public information. GCOS aspires to guide the development of the global climate observing system from observations to data policy, based on a wide range of in situ and satellite observations and programmes and advocates for free and open access to well-curated data and climate information. GCOS works with a wide range of stakeholders across the value chain.

The GCOS programme started in 1992⁴ under the sponsorship of WMO, IOC, UNEP and ICSU (now ISC)⁵.

After celebrating two decades of operation and operating under a MoU signed in 1998 (Appendix B), a review of the programme was undertaken by an ad-hoc group agreed by the co-sponsors, and the main findings and recommendations were published in 2014⁶. In June 2019, the WMO Congress adopted a major constituent body reform with climate observations included in the new technical Commission for Observation, Infrastructure and Information Systems (INFCOM). Later in the year, the co-sponsors submitted a letter to GCOS Steering Committee requesting that the governance and structure of GCOS was reconsidered in the light of the WMO governance reform and strategic directions of all the co-sponsors and using the recommendations in the GCOS Review as a baseline.

Following that request, the Joint WMO, IOC, ISC and UNEP Study Group on the Global Climate Observing System (JSG-GCOS) was formed (the Terms of Reference are included in Appendix D).

WMO, IOC and ISC appointed two co-chairs for the JSG-GCOS, Qingchen Chao (CMA⁷) and Martin Visbeck (GEOMAR⁸) respectively. The co-sponsors nominated members of the JSG-GCOS⁹ which started work in December 2020. This document provides the conclusions of the JSG-GCOS.

2.1 The GCOS programme

The GCOS programme is directed by a Steering Committee which provides guidance, coordination and oversight to the programme. Three scientific panels, the Atmospheric Observation Panel for Climate (AOPC), the Ocean Observations Physics and Climate Panel (OOPC) and the Terrestrial Observation Panel for Climate (TOPC), comprise experts in the respective areas and define the observations needed in each of the main global domains (atmosphere, oceans and land), to prepare specific programme elements and to make recommendations for implementation. They report to the Steering Committee. The GCOS Secretariat, located at the WMO headquarters in Geneva, Switzerland, supports the activities of the Steering Committee, the GCOS panels and the GCOS programme as a whole.

GCOS mandate is to ensure that the international climate observing system meets the needs for assessing the impacts of climate variability and change; applications for national economic development; as well as research leading to improved understanding, modelling and prediction

⁴ <https://gcos.wmo.int/en/about/gcos-story>

⁵ World Meteorological Organization (WMO), Intergovernmental Oceanographic Commission (IOC) of United Nations Educational, Scientific and Cultural Organization (UNESCO), United Nations Environment Programme (UN Environment), International Council of Scientific Unions (ICSU) now the International Council for Science (ISC).

⁶ *GCOS Programme Review: Synthesis report. (GCOS-181)* Published by: WMO: 2014

⁷ China Meteorological Administration

⁸ GEOMAR Helmholtz Centre for Ocean Research Kiel

⁹ See Appendix D

of the climate system¹⁰. In general, the GCOS programme does not directly make observations¹¹ nor does it generate data products. The programme stimulates, encourages, coordinates and facilitates climate observations made by national or international organizations in support their own needs as well as common goals. GCOS provides an operational framework and guidance for integrating and enhancing the observational systems of participating countries and organizations into a comprehensive system focused on the requirement to facilitate a climate response and on the required acquisition of the necessary long-term data records. In its, probably, most influential role, GCOS assesses the adequacy of global observations for climate and reports to the Subsidiary Body on Scientific and Technological Advice (SBSTA) of the United Nations Framework Convention on Climate Change (UNFCCC). In addition, GCOS has organized cooperation projects for developing countries.

GCOS aims to understand the climate data needs of users and express these to the observational community in an intelligible way. To clearly present these observational needs (including their resolution and uncertainty) GCOS has developed the concept of Essential Climate Variables (ECVs) which were developed in the context of the needs of the UNFCCC in the Second GCOS Adequacy Report¹².

An ECV is a physical, chemical or biological variable (or group of linked variables) that critically contributes to the characterization of Earth's climate and human response. ECV datasets 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 the attribution of climatic events to underlying causes, and to underpin climate services. They are required to support the work of the UNFCCC and IPCC. Until now, GCOS has defined a single requirement¹³ for each ECV and for each of its products which has to address all user needs: in the future with the development of regional and more specific demands alongside global needs, a more differentiated approach may be needed.

The climate system is complex and changing rapidly. In identifying and specifying climate observations, GCOS responds to requirements from UNFCCC and other stakeholders such as the scientific community, WCRP, WMO, UNEP, Climate services, and climate information needs from nations. There is an increasing need for more data with a wider range of spatial and temporal resolutions. Increasingly, communities need data-based climate information to address not only climate mitigation, but also adaptation needs which include regional conditions and more localized extreme events, that are changing in frequency and amplitude with time. GCOS needs to articulate the requirements for accurate long time-series capable of capturing the changing climate and climate cycles (energy, water and carbon) at global and increasingly regional scales. The latter are more complex as they need a more regional aware approach. GCOS will need to identify how its global system can contribute to and interact with more detailed information at the local scale. Hence the need for GCOS to have continuous dialogue with governmental and non-governmental stakeholders and observing (in-situ and satellite) networks/systems in order to evolve towards a fit-for-purpose observing system providing free and open ECV data records at the required spatial and temporal scales.

¹⁰ GCOS MoU 1998, see Appendix A

¹¹ There are limited circumstances in which observations are directly made under GCOS auspices – For example: The GCOS Reference Upper Air Network and where the GCOS Cooperation Mechanism funds support of stations in the GSN and GUAN.

¹² Second report on the adequacy of the global observing systems for climate in support of the UNFCCC. [GCOS-82](#), 85 pp.

¹³ ECV requirements specify the observations needed in terms of one or more ECV products (the measurable quantities that describe the ECV) and for each ECV product its spatial and temporal resolution, uncertainty, stability and latency.

The GCOS Cooperation Mechanism (GCM) was established in response to UNFCCC Decision 5/CP.5 to identify and make the most effective use of resources available for improving climate observing systems in developing countries, particularly to enable them to collect, exchange, and utilize data on a continuing basis in pursuance of the UNFCCC goals. In recent years, several countries have provided funds and participated on the Donor Board.

Data exchange, archiving, curation and dissemination are a vital part of the system that is supported by a wide range of stakeholders. GCOS has been successful in advocating for international data repositories that allow users to access comprehensive data holdings, and for improved coordination of holdings of in situ meteorological observations. Data archival has some good examples, such as the exchange of meteorological data, atmospheric composition and ocean data at the International Comprehensive Ocean-Atmosphere Data Set (ICOADS). However, some ECVs still lack recognized data repositories. GCOS has been advocating for data rescue. Data rescue efforts have benefitted from significant efforts internationally including novel citizen science and classroom-based approaches, but a vast volume of data remains in either hardcopy or image form only.

2.2 GCOS Stakeholders: from Observations to Decision Making - the Value Chain

Engagement with stakeholders¹⁴ is best considered within a value chain framework. This starts from a requirement setting process leading to the design and operation of networks providing sustained observations; through free¹⁵ and open global data exchange, processing, curating and storage; to delivery of data and data-based information products to users for user specific processing; and finally enabling improved decision making at appropriate levels. The GCOS role in the value chain is to ensure a dialogue on user needs; the development of ECV requirements in discussion with both users and observing networks; and the on-going evaluation of the fitness-for-purpose of the observing systems and ECV requirements in light of evolving user needs.

A systematic value chain-based consideration and explanation of the system would also be useful to demonstrate the implications of critical gaps in the core climate observing system for the delivery of climate applications and services, thus better motivating the resourcing of those observations and networks.

As the system evolves with the changing climate and new requirements from science and society, it needs to provide feedback via the requirement setting process into the observing requirements in order to ensure that the slate and specifications of ECVs continue to be fit-for-purpose: that will in turn impact the observing systems and the whole value chain. The role for GCOS is to be the authoritative and community supported voice to (1) develop ECV requirements, monitoring principles and guidance, in interaction with stakeholders, (2) be proactive in stimulating the evolution of existing and development of new networks, where appropriate, and (3) regularly monitor the status of the climate observing system and evaluate its fitness for purpose.

A version of the value chain was proposed in by a group composed of representatives of CEOS, CGMS and WMO in 2013 ¹⁶, and another version was included in the GCOS 2016

¹⁴ GCOS Stakeholders include all organizations making, funding, processing, storing or utilising climate observations and data.

¹⁵ 'free' refers to an appropriate and equitable way to access and share the data.

¹⁶ M. Dowell, P. Lecomte, R. Husband, J. Schulz, T. Mohr, Y. Tahara, R. Eckman, E. Lindstrom, C. Wooldridge, S. Hilding, J. Bates, B. Ryan, J. Lafeuille, and S. Bojinski, (2013): *Strategy Towards an Architecture for Climate Monitoring from Space*. Pp. 39. This report is available from: www.ceos.org; www.wmo.int/sat; <http://www.cgms-info.org/>

Implementation Plan¹⁷. The Framework for Ocean Observing (2012)¹⁸ and Tanhua et al., 2019¹⁹ also contributed to the development of this idea. **Figure 1** illustrates a particular graphical representation of the value chain.

This clearly demonstrates that it is vital that GCOS engages with all the stakeholders so that GCOS can support all parts of the value chain. **Figure 2** illustrates the range of stakeholders in GCOS and their functions.

JSG-GCOS decided not to have an Engagement Board as recommended by the 2014 Review but that the GCOS Steering Committee should develop a plan to strengthen the engagement of a large group of stakeholders, including funders, partners, beneficiaries, users, observing systems, data centres and academia. The JSG-GCOS recommends that the GCOS Climate Observations Conferences be held every 4-5 years, in line with the GCOS reporting cycle. This conference, as decided by the Steering Committee and if sufficient funds are available, would improve engagement with a large group of stakeholders, including sponsors and funding, implementing and beneficiary partners (e.g. users, observing systems and data centres, academia) and could provide advice to the Steering Committee. It could advise on fund-raising strategy and activities, including active involvement in raising funds and provide guidance on how to improve engagement with GCOS partners to ensure that GCOS can fulfil the sponsors', partners' and beneficiaries' expectations.

RECOMMENDATION 1

**GCOS should improve its engagement with stakeholders.
The GCOS Steering committee should develop a strategy for further improving engagement with all stakeholders and monitor its implementation.**

¹⁷ GCOS (2016) The Global Observing System for Climate: Implementation Needs [GCOS-200](#). Pub WMO 2016 Geneva

¹⁸ Lindstrom, E., Gunn, J., Fischer, A., McCurdy, A., Glover, L., Alverson, K., et al. (2012). *A Framework for Ocean Observing*. By the Task Team for an Integrated Framework for Sustained Ocean Observing. Paris: UNESCO. doi: [10.5270/OceanObs09-FOO](#)

¹⁹ Tanhua T, McCurdy A, Fischer A, Appeltans W, Bax N, Currie K, DeYoung B, Dunn D, Heslop E, Glover LK, Gunn J, Hill K, Ishii M, Legler D, Lindstrom E, Miloslavich P, Moltmann T, Nolan G, Palacz A, Simmons S, Sloyan B, Smith LM, Smith N, Telszewski M, Visbeck M and Wilkin J (2019) What We Have Learned from the Framework for Ocean Observing: Evolution of the Global Ocean Observing System. *Front. Mar. Sci.* 6:471. doi: [10.3389/fmars.2019.00471](#)

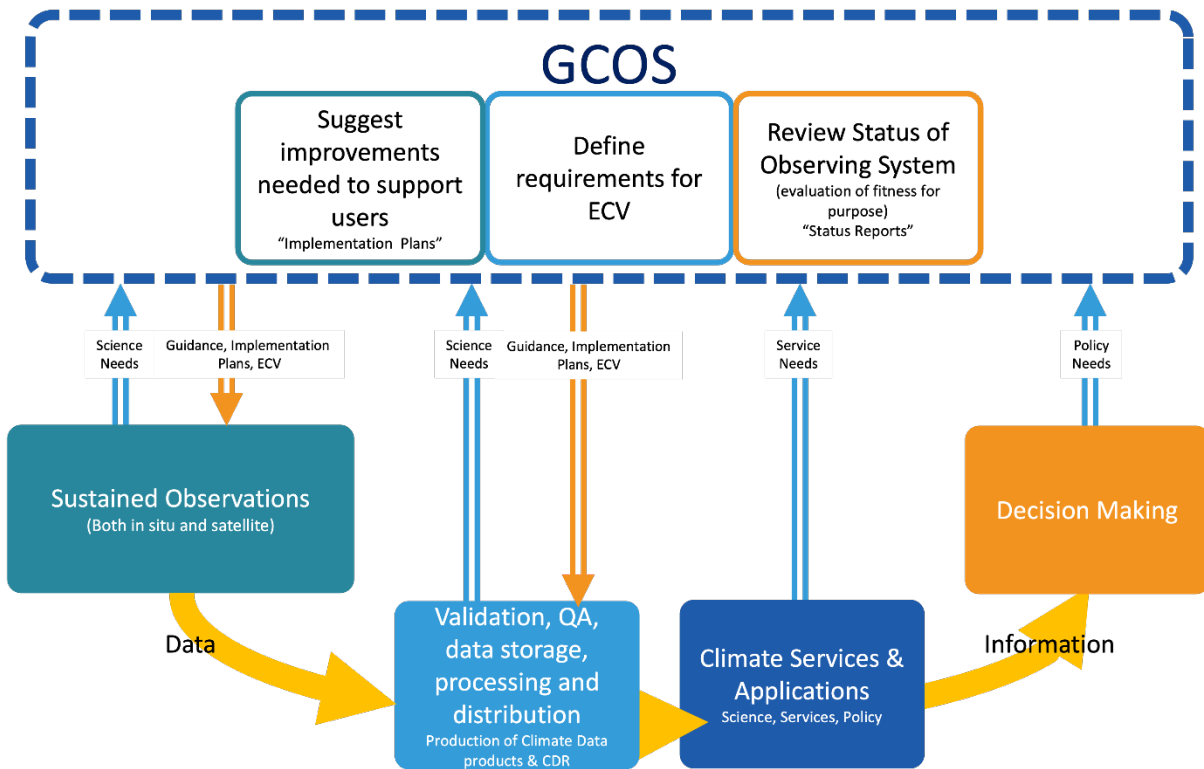


Figure 1. A schematic of the Earth's climate observing value chain. The value chain encompasses the information needs (co-defined by actors in different sectors: science, services and policy); the definition of the Essential Climate Variables that need to be observed with their requirements; the observing networks; and processes for data archiving, access and dissemination along the value chain.

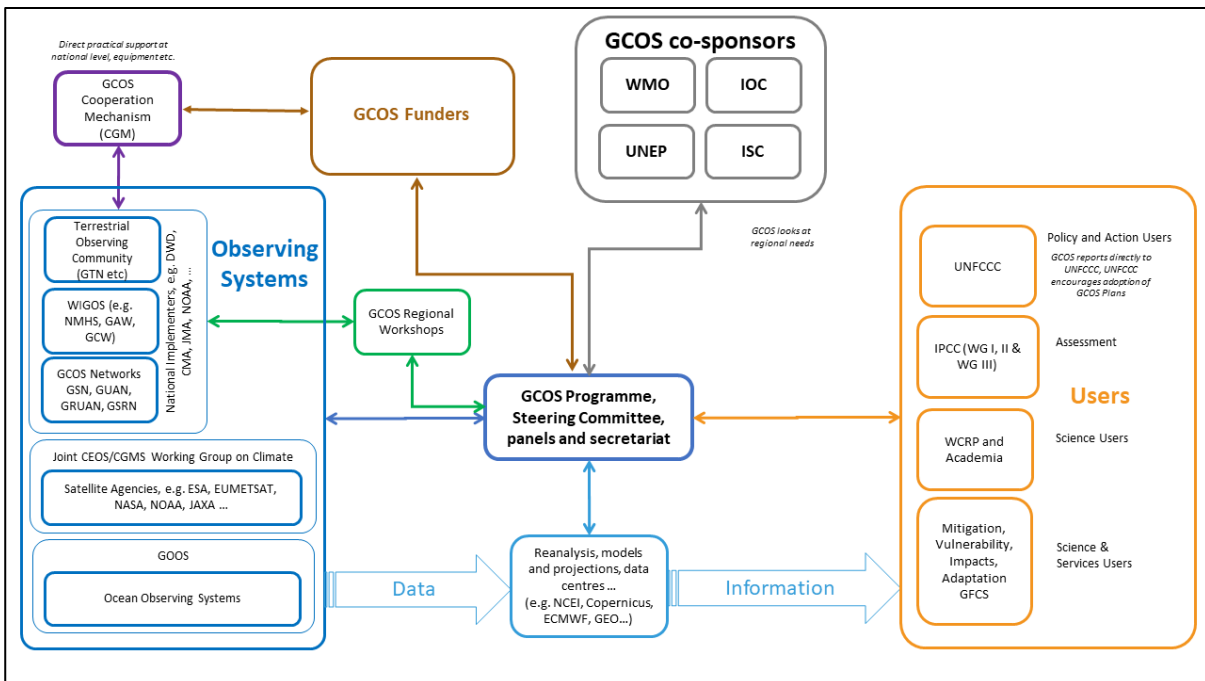


Figure 2. An overview of the GCOS ecosystem of stakeholders including co-sponsors, users, funders and observing systems. GCOS consists of the GCOS Secretariat, the expert panels and the Steering Committee.

Stakeholder views of GCOS include:

- The UNFCCC sees GCOS as the **key observation requirements setting body** for responding to article 5 of the convention, Research and Systematic Observations. The UNFCCC sees observations as fundamental in a science driven process and part of achieving the goals of the Paris Agreement. The on-going process of updating requirements helps with talks internationally. GCOS is a template for intentional collaboration.
- The EU sees GCOS as **providing added value for implementation of Copernicus**.
- The space agencies, coordinated by the CEOS/CGMS Joint Working Group on Climate, **base much of their plans for climate monitoring on GCOS** requirements. Many satellite missions are planned around these requirements and WGClimate maintains the ECV Inventory, a database of all satellite-derived climate data records. The satellite community has actively engaged in the GCOS report cycle providing responses and action plans in response to successive Implementation Plans which have led to demonstrable benefits.
- The UNEP mandate is to foster engagement in the global environmental agenda and to support member states on the basis of multilateral environmental agreements. Therefore, it **relies on GCOS for global climate related requirements**.
- GCOS provides WMO with requirements for its Members to monitor climate.
- GCOS evaluation of the climate related performance of the observing systems should guide their evolution. **GCOS collaboration with WIGOS has assisted in the development of the Global Basic Observing Network (GBON) and its Systematic Observations Financing Facility (SOFF)**. GCOS has been strong in the advocating for structured (tiered) network design within WMO and is leading the development of reference networks, with the implementation of (GCOS Reference Upper Air Network (GRUAN) and the development of Global Surface Reference Network (GSRN) in collaboration with WMO.

3. REVIEW OF GCOS' MANDATE

The current mandate for GCOS, agreed by the four co-sponsors, has led to the development of a well-respected authoritative organization that has contributed to the improvement of the quantity, quality and range of climate observations. GCOS routinely reports to the UNFCCC on article 5 of the convention: Research and Systematic Observations. However, there are some areas where improvements could be made: the role of the sponsors in funding GCOS; the need for the sponsors to consider and respond to recommendations and guidance from GCOS; improvement to the steering committee; increased advocacy for systematic observations; more engagement with all stakeholders; and improved regional and national involvement.

The existing GCOS Mandate, contained in the 1998 Memorandum of Understanding²⁰, states that:

The GCOS shall, as its long-range objectives, support all aspects of the World Climate Programme and relevant aspects of other climate-related global programmes. Specifically, the GCOS will ensure the data needs are met for climate system monitoring, for assessing the impacts of climate variability and change and applications to national economic development, as well as research leading to improved understanding, modelling and prediction of the climate system;

This is expanded upon in Annex A of the 1998 Memorandum of Understanding:

1. *The goal of the Global Climate Observing System (GCOS) is to provide comprehensive information on the total climate system, involving a multi-disciplinary range of physical, chemical and biological properties, and atmospheric, oceanic, hydrologic, cryospheric and terrestrial processes.*
2. *The GCOS is intended to meet the needs for:*
 - a. *Climate system monitoring, climate change detection and monitoring the impacts of and the response to climate change, especially in terrestrial ecosystems and mean sea-level.*
 - b. *Data for application to national economic development.*
 - c. *Research toward improved understanding, modelling and prediction of the climate system.*
3. *The GCOS will build, as far as possible, on existing operational and scientific observing, data management and information distribution systems, and further enhancements of these systems.*

The 1998 Memorandum of Understanding (which defines the governance) only slightly updated the 1992 MoU that was introduced at the very beginning of GCOS. Therefore, it does not reflect in general the demands of the current changing environment of climate policy and climate observations. The decision and operational processes are sometimes slow. The role of each sponsor is not clearly specified, and it is not evident how GCOS is aligned and linked with the sponsors' programs. Meanwhile, the need to engage with an ever-growing number of related agencies is increasing.

²⁰ The Memorandum of Understanding between the World Meteorological Organization, the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization, the United Nations Environment Programme and the International Council for Science 1998 see Appendix B.

Strengths

The current strengths of GCOS can be summarized into five broad areas:

1. GCOS is now recognized as a **powerful and convenient mechanism for the planning, developing and review of Climate Observing Systems and networks and observational requirements**. The GCOS networks, the GCOS Reference Upper Air Network (GRUAN), the GCOS Surface Network (GSN) and the GCOS Upper-Air Network (GUAN), as well as other networks are well-recognized examples for in-situ networks that are managed by partner systems following well-defined principles. GCOS is developing the GCOS Surface Reference Network (GSRN) with WMO. Thus, GCOS is a mature and authoritative brand and organization.
2. The **strong scientific expertise** of the panels and steering committee, together with efficient working arrangements across both, provides effective input into the GCOS implementation plans and the GCOS status reports. It is also the link to the wider community in both directions: bringing in expertise from, and spreading information to, the community.
3. **GCOS is recognized as one of the coordination mechanism that facilitates climate observations by networks** supported by WMO, GOOS, space-based observations coordinated by CEOS and CGMS as well as many other in situ networks.
4. **GCOS developed the concept of Essential Climate Variable (ECV)** which is widely endorsed by the community and scientific programs. GCOS provides recognized and agreed principles and requirements for climate observations. GCOS has been successful in advocating for improved coordination of climate system data holdings. In addition, GCOS is the accepted reference in formulating the guidelines and requirements on ECVs for space observations in strong and fruitful coordination with the Committee on Earth Observation Satellites (CEOS) and the Coordination Group for Meteorological Satellites (CGMS), allowing the definition of suitable observation capabilities. This is a major "heritage" of GCOS.
5. **GCOS reports regularly to Parties to the UNFCCC** on its work and progress and provides the UNFCCC with its status reports and implementation plans, which are recognized by the Conference of the Parties (e.g., Decision 19/CP.22).

GCOS is acknowledged by its stakeholders as the leading independent reference in defining requirements for climate observations for climate monitoring, science, applications, and other stakeholder needs, including contributions to adaptation and mitigation. Therefore, GCOS plays an important role in defining standards, guidance and best practices for observations. It can contribute to adaptation and mitigation actions and provide key links to all stakeholders (science, observation providers, climate services and society). The established review process (including the status report and the implementation plan) is fundamental to this and will need to be adapted and evolved according to the emerging climate related needs.

The elements resulting from the current mandate that should be maintained, (and possibly reinforced) are listed below:

- **GCOS is a mature and authoritative brand and organization.** It is a powerful and comprehensive reference for planning and developing Observing Systems and networks (space and in-situ). The current co-sponsors are important and influential stakeholders in the international climate sphere. GCOS has benefitted from a strong infrastructure supported by WMO, complemented by other co-sponsors and national governments institutes and international programmes.

- **GCOS is flexible, within its mandate, to meet the needs of the UNFCCC.** As GCOS' authority and recognition has evolved so have the activities under its current mandate (although the mandate has not changed). A notable case is the mandates provided by the UNFCCC through the COP and SBSTA, which have consistently recognized GCOS' role in coordinating and advancing Systematic Observations of climate, including observations for research, in their Decisions and Conclusions and made direct requests to GCOS to continue its reporting cycle and report progress on a regular basis to SBSTA. GCOS supports the observational needs of Parties to the UNFCCC needs under article 5 on research and systematic observations.
- **The Essential Climate Variables (ECVs)** and climate indicators concepts are authoritative and widely endorsed by the Community and scientific programs and international bodies, as well as guidance for producing climate observations by different agencies.
- **The on-going cyclical reviews and planning.** The cyclical nature of the GCOS process is also extremely important. Many other assessments in other areas are a one-off assessment of needs/actions and requirements. GCOS' iterative cycle is quite unique and important for its authority. There is great value in the ECV requirements, in the Implementation Plan and Status Reports that GCOS produces. Many international bodies and implementing entities look at elements of the Implementation Plan to decide what projects to fund and how much resource to deploy.

Weaknesses

There are some weaknesses in the implementation of this mandate:

1. The secretariat's opportunities to advance the work of GCOS, is strongly impacted by **the limited availability of resources and the uncertain financial sustainability**, e.g., continuity of funding. The support for secretariat work has shrunk over the past 10-15 years resulting in substantially reduced secretariat support availability to the program and relatively high turnover in staff. The Joint Study Group considered that the current mandate was not being completely executed, largely due to lack of funding, and that it does not necessarily cover all emerging requirements.
2. GCOS activities in observation networks are embedded in the sponsor programs. This significantly decreases the visibility of GCOS and its decisive role in initiating and coordinating observation networks. Therefore, despite the recognition of GCOS by the UNFCCC, it is less well known by some communities making climate observations. Supporting the UNFCCC has always been part of GCOS, in particular reporting on the overall status and adequacy of the global observing system of systems. **Making the role and mandate and work of GCOS clearer and more visible** would assist in explaining the importance of GCOS to the various communities contributing to the global climate observing system.
3. **The global South has insufficient formal engagement in GCOS.** GCOS has already identified this as an issue and started to address it through regional activities. Currently these have had to be postponed due to COVID related travel restrictions.
4. Recommendations and outputs of GCOS are advisory in nature and need not be adhered to by the data producing networks and program sponsors. **There is no formal method to feed GCOS recommendations into the sponsors governance mechanisms.**

The JSG-GCOS also noted that the following improvements in the current MoU would assist GCOS in meeting its goals:

- **The role of the GCOS sponsors needs to be clarified**, particularly in relation to sustained funding for the coordination functions. Sponsor engagement and support to GCOS have varied through time and by sponsor. GCOS could benefit from greater collaboration with its sponsors and their programmes.
- **GCOS needs to clarify its governance and decisions making** so that its recommendations become more effective and guiding for the observing networks and their sponsoring bodies. This can be accomplished through improved formal linkages into the working and decision structures of its constituencies.
- The current mandate should be updated to **recognize the interactions with UNFCCC** and make reference to UNFCCC's Paris agreement and its goals of limiting climate change and supporting adaptation.
- Advocacy and communication about the observational needs and requirements should be a core activity. **GCOS needs to be more actively engaged with implementing agencies and data users** to better identify ECV and their requirements as well as more general climate needs (e.g., need for long time-series).
- The GCOS Steering Committee should support the work of the panels by more actively steering the implementation of GCOS. **The steering committee should be more active in considering matters of strategic direction** for the panels to implement.
- GCOS should, within its resources, **find ways of increasing national involvement in GCOS**. Many observations are made by national bodies and more direct recognition of their contribution and support for developing countries would enhance these observations.

RECOMMENDATION 2

The MoU should be revised as shown in Appendix A. This should include clarifying the role of the signatories, funding arrangements, and the role of the steering committee. It should also guide the development of a GCOS strategy and engagement plans. GCOS should continue to respond to the needs of the UNFCCC and respond to the Paris Agreement, i.e. systematic observations, state of the climate, adaptation and mitigation.

RECOMMENDATION 3

GCOS programme should have understanding of the needs of and support for the Global South. Previous efforts need to be strengthened with adequate support. Regional workshops have only been held with support of other programmes and the GCOS Cooperation Mechanism (GCM) has only received minimal support in recent years. GCOS should restart its regional programme working with WMO and other interested bodies and ensure the results are presented to the UNFCCC.

4. THE GCOS WORKPLAN: IMPLEMENTING THE MANDATE

Lack of adequate and sustained funding has limited the ability of GCOS to fully meet its mandate. This has delayed work on regional engagement, on meeting the needs of adaptation and mitigation. GCOS needs to fully meet the expectations of the UNFCCC and its Paris Agreement.

The ability of GCOS to implement the mandate, described in Chapter 3, is limited by the resources available to it. The secretariat must prioritise elements of the work programme. This chapter highlights important parts of the work programme and notes areas where improvements can be made.

4.1 UNFCCC

GCOS has an active role in the UN system, including strong links to UNFCCC and the Paris Agreement. The GCOS heritage allows it to highlight the expanding role of Systematic Observations for the implementation of the Paris Agreement. This heritage should be used to promote research and operational climate monitoring activities in response to national and international needs. However, the needs of Parties to the UNFCCC are changing, especially with the Paris Agreement and the Global Stocktake and include:

- Comprehensive and systematic observation for the carbon cycle and biosphere is becoming more important and urgent.
- Indicators for Climate Science, Services and Policy making based on observational data are needed.
- Adaptation and mitigation are priorities

RECOMMENDATION 4

The Steering Committee and sponsors should ensure that GCOS maintains its role in advising the UNFCCC on climate observations. The future work programme of GCOS should continue to address the carbon cycle, adaptation, mitigation and climate indicators to help it meet UNFCCC expectations.

4.2 Engagement

GCOS is embedded in a broad and increasingly complex landscape of organizations engaging with climate observations, applications, and services. The growing interaction with those organizations together with demands to enhance climate observations, risks of a dilution of the current approach. Clarity in GCOS' mandate and MoU would ensure the complementarity of GCOS with these organizations and their programmes.

GCOS is built on scientific credibility. In the changing environment and the new challenges (Paris Agreement), it needs to also take into account of a growing range of stakeholders in order to enhance its role as major reference for climate observation requirements. GCOS depends on integrating the views of a wide range of agencies outside the sponsors when reviewing requirements.

GCOS is also working with its sponsors and some of these agencies in evaluating the status of observations e.g. WMO²¹, GOOS and OceanOPS²² and WGClimate²³ and this could enable a more regular assessment for some ECVs in addition to the 5 years evaluation.

GCOS should provide a bridge for the global observation programmes by enhancing communication with the science community, policy makers, and the private sector (for example by showcasing the impact on the Global Stocktake and enhancing transparency in national/regional reporting) and by organizing training courses in developing countries.

RECOMMENDATION 5

The GCOS Steering Committee should develop a series of multi-year meetings of all stakeholders, across the value chain, to provide advice and input into GCOS. They should be clear on the expectations for these meetings, and commitments to support and funding.

RECOMMENDATION 6

While GCOS should ensure its regular status reports and implementation plans continue, it should also move towards more regular updates on the status of the climate observing system, based on information produced by the corresponding observing networks and programmes. This would check that the global climate observing system (including the ECVs and their requirements) is fit-for-purpose and meets the needs of all users, as far as is practical, and identify remedial actions.

4.3 Geographic Representation

There is a risk of geographical imbalance, because of the strong European, North American, Chinese and Japanese representation in the Steering Committee and panels. In part, this reflects the sources of funding for global observations.

This lack of geographical balance can translate into a lack of connection with the countries from the global south and their needs. Many of the SDGs are on geographical balance while adaptation is a local issue. Specifically, targeted indicators for developing countries would improve this balance and SDGs could provide the appropriate framework for this. This would attract more users from the global south.

RECOMMENDATION 7

GCOS should ensure appropriate geographical, gender and age representation in its bodies.

²¹ WMO Data Quality Management System (WDQMS) for the GSN and GUAN. <https://wdqms.wmo.int/>

²² OceanOPS for many ocean networks <https://www.ocean-ops.org/board>

²³ The Joint CEOS/CGMS Working Group on Climate (WGClimate) ECV Inventory of climate monitoring from space <https://climatemonitoring.info/ecvinventory/>

4.4 Requirements and observational needs

GCOS needs to improve its efficiency in better defining requirements across the entire value chain (planning, undertaking, curating and analysing observations of the evolving climate system). This would help streamline the system of multiple agencies to optimize the provision of data and services.

The knowledge and research gaps identified by the IPCC may be helpful for GCOS to stimulate and encourage research or data collection by national or international organizations.

There are some areas where the development of requirements and observational needs should be improved, although addressing these is limited by the current resources:

1. The current requirement concept includes values serving all communities (although this is being modified in the current revision). Requirements defined for science assessment, climate applications or specific stakeholder needs are different. A differentiated approach in defining requirements that can specifically address the different user communities is needed. The development of the current GCOS Implementation Plan (2022) is considering how to approach this.
2. Currently, GCOS does not systematically include adaptation and mitigation, although task teams have started considering how to include the needs of supporting and monitoring adaptation. This work should continue and be included in the panels work.
3. Engagement across the entire data value chain should be improved.
4. A stronger link with Climate Services is an emerging area, and it is of high relevance to GCOS. Considering observations for climate science when looking at possible application areas will provide the link to adaptation and the connection to climate services, bringing the focus on both of those. Relevant indicators linked to mitigation, adaptation, and risk assessments should also be developed and promoted to meet evolving user needs.
5. There has been, so far, less emphasis in GCOS on climate observations to address the biosphere, biodiversity and biogeochemistry. With increasing attention to these themes in earth system modelling, assessments reports and their relevance in many aspects of policy – support for climate observations will become increasingly important. GCOS should ensure that it has the necessary competences and activities to address these needs.
6. There is a need to reinforce the role of in-situ networks within GCOS. Some terrestrial and ocean ECV in-situ networks suffer from poor funding, short term commitment and often lack of organizational and professional data curation. In the atmospheric observations there are gaps in the network that cause issues of continuity. GCOS's success depends on the continuity of these networks and GCOS should work actively with funding organizations and agencies to achieve sustainable resourcing.
7. The World Climate Research Programme (WCRP) is essential to make progress on the understanding of the Earth System. WCRP needs data from the sustained observing system to deliver climate information, such as assessments and projections, therefore WCRP and GCOS should work together closely. This would require having a structured annual dialogue on the needs including a consideration of the integration of observational requirements for research into the GCOS requirements framework. Such a mechanism existed in the past but following the reorganization of WCRP needs to be re-established.

RECOMMENDATION 8

The Steering Committee should ensure that the future work programme of GCOS continues to revise and improve the utility of the ECVs and their requirements. The work programme should clearly address the needs of adaptation and mitigation of climate change; fully integrate observations of the biosphere across all domains; increase its advocacy of the sustainability and continuity of in situ observations; and work with WCRP to develop a routine, annual, mechanism to discuss WCRP observational requirements.

5. GOVERNANCE

While the overall structure of GCOS should remain, a clearer role for the Steering Committee that is more focused on guiding the work of the panels is needed. The Steering Committee should be responsible for developing a detailed strategy, and engagement plan as well as for advocacy for GCOS and sustainable observations.

The JSG-GCOS proposes a new structure for the MoU. The new structure would be comprised of two parts: the main body of the MoU describing GCOS strategic goals and activities and sponsors commitments and technical annexes describing GCOS secretariat and management. With this two-part structure, the technical annexes could be easier to update in an agile manner as the landscape changes, while the strategic goals would be more stable as they are based on high-level concepts.

The JSG-GCOS supports a strong role for the Steering Committee including responsibility for deciding the strategy of the GCOS, guiding the programme and the activities of the Secretariat, and advocacy while maintaining an overarching guidance from the sponsors. The JSG proposes a new MoU, presented in Appendix A to this report.

5.1 Functions and Roles of the Sponsors and Partners

There are five functions listed in **Table 1** that stakeholders may play in GCOS. Individual organizations may take on one or more of these roles. Signatories of the MoU must, as a minimum, have Funding, Programmatic and Strategic Functions. **Figure 3** outlines the proposed governance of GCOS. GCOS should have a steering committee that is the primary decision-making body of GCOS in implementing, developing and overseeing GCOS and its Secretariat as mandated by the sponsors. Reporting to the steering committee are expert panels: standing committees of experts responsible for the ECV and the link to observing systems. Working groups and task teams that are established by the steering committee to address specific tasks can also report to the steering committee. Similarly, working groups and task teams set up by the panels report to the panels.

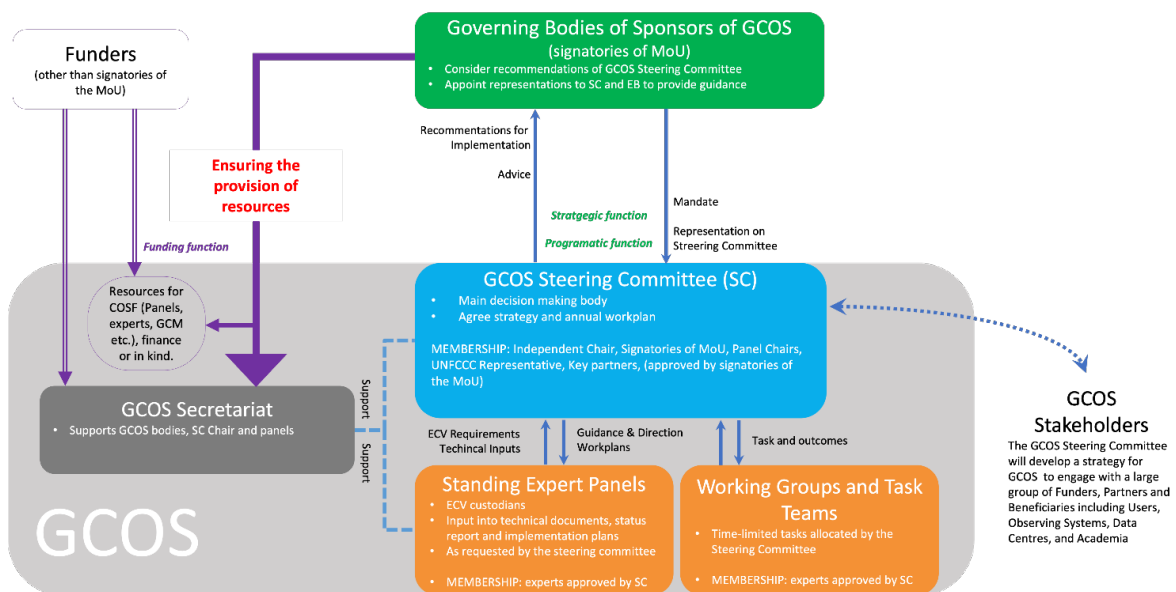


Figure 3. Proposed governance of GCOS

Table 1. Functions and roles of stakeholders in GCOS

Function	Description	Example organizations	Representation on Steering Committee	Inputs into GCOS ²⁴
Programmatic	<ul style="list-style-type: none"> • Endorse the decisions of the Steering Committee in their governance arrangements. • Respond to proposals from the GCOS Steering Committee within its mandate • Provide representation and input to the Steering Committee • Signatories of the MoU 	WMO, IOC	As signatories of the MoU one representative on Steering Committee	Steering Committee
Strategic	<ul style="list-style-type: none"> • Consult with or provide guidance to the GCOS Steering Committee concerning overall strategies of the GCOS. • Provide guidance to the GCOS Steering Committee concerning overall implementation of the GCOS work and delivery. 	UNEP, ISC, UNFCCC, WMO, Copernicus, NOAA	The Steering Committee will select members ²⁵ and may invite others as observers	Science Conference
Funding	<ul style="list-style-type: none"> • Support financially or in-kind activities of the GCOS 	WMO, Copernicus, NOAA		Resources
Implementation	<ul style="list-style-type: none"> • Administrate or implement climate observing networks and data delivery in accordance with the Implementation Plan of the GCOS 	WGClimate, WMO/INFCOM, WMO/GAW, GOOS		Science Conference
Beneficiary	<ul style="list-style-type: none"> • Users of GCOS outputs 	Copernicus, WMO/SERCOM, IPCC, GEO, WCRP, UNFCCC		

²⁴ The GCOS Steering Committee should develop an engagement strategy to ensure that all stakeholders across the value chain can have an input into GCOS in between meetings of the Science Conference and Steering Committee.

²⁵ Given the importance of the UNFCCC to GCOS it is proposed that they can nominate one representative to the Steering Committee.

5.1.1 The GCOS Steering Committee and panel structure

The GCOS Steering Committee and Panel structure (AOPC, OOPC, TOPC) remain broadly fit-for purpose. It is (noting below some possible improvements), a strength of GCOS, linking the 'ownership' of the ECVs to the requirement setting and assessment process. Accordingly, this structure should be retained, while seeking all opportunities to connect at expert level with relevant expertise from the global observing systems such as, WMO WIGOS and GOOS (see Chapter 6).

While retaining the overall structure, some timely refinements in the membership and make-up of the GCOS SC and Panels may enable it to operate more effectively, to improve the representation of all relevant aspects (e.g. domains, variables) of global climate observations, to better represent the needs of its users, to be alert to emerging scientific directions and to reflect the evolving capabilities and priorities of its observing contributors, especially space-based observations.

If one was starting GCOS from the beginning, there are different ways that the panels as a whole might be constructed. There is however no imperative to change the current structure at this point, individual experts (as in many other areas of WMO and partners) are frequently over-committed and the voluntary nature of their contribution needs to be respected, especially if a closer engagement with other WMO (INFCOM, SERCOM and RB teams), IOC/GOOS and satellite agencies is to occur. Consideration should be given to ensuring more balanced, inclusive and comprehensive representation of expertise relevant to all of the ECVs across the panels, which will likely require the maximum number of members of each panel to be increased from the current 12 to more like 16.

Adoption of a smaller but more active Steering Committee, as recommended elsewhere in the JSG-GCOS report, is strongly supported here, with the Chairs of the panels (one per panel) as full members and with other Steering Committee members specifically selected to represent key partners and stakeholders and/or to bring required technical and strategic expertise. This will better support the GCOS Chair and help to engage the Steering Committee more actively in the design, delivery and strategy of GCOS as well as offset the cost of supporting larger panels.

The longstanding relationship between GCOS and the World Climate Research Program (WCRP), which co-sponsors the GCOS panels, is discussed further in section 6.4.

The AOPC has the strongest intrinsic alignment with WMO areas of activity and integration of GCOS through INFCOM will likely offer the most direct benefits of any panel, and these opportunities need to be embraced. A review of the expertise required to ensure AOPC best represents the full suite of ECVs and products covered by AOPC will inform the filling of key gaps in current membership and ensure that GCOS ECV specifications are fully aligned with all other WMO-relevant components and programs, such as the Global Atmosphere Watch (GAW).

In relation to TOPC, the principal direct connections to WMO areas of activity are through cryosphere and hydrological observations. Both are represented in INFCOM and there are likely to be mutual benefits of more direct engagement, especially with the Global Cryosphere Watch in the first instance. A deeper engagement is encouraged with hydrology experts in relation to global water cycle and water-related ECVs and products, and any future exploration of regional or basin scale ECVs and/or implementation of hydrological reference networks, as reflected in the WMO Unified Data Policy (Res 1, Annex 1), would benefit from in-depth discussion and close collaboration. TOPC also has links to GAW, in terms of flux measurements, and connection with INFCOM will also assist in aligning outcomes in this regard.

OOPC is somewhat different in character to the other two panels since it is also (primarily) a panel of GOOS and, while tasked through its terms of reference with addressing GCOS requirements, by definition it embraces directly only the physical oceanography related ECVs,

relying on experts from the other two GOOS panels (Biogeochemical and BioEco) to contribute in relation to the remaining ocean-related ECVs. There were mixed views amongst those consulted as to whether this approach works adequately to ensure ownership and oversight of the full suite of ocean-related ECVs. An option that might be considered in conjunction with the proposal to increase the size of the panels, might be to specifically convene a new 'whole of ocean' OOPC, where all of the ECV-relevant expertise is represented and where the 'P' stands for Panel rather than Physics (as it does currently). Such a panel might be constructed by convening experts from the existing three GOOS panels to form the GCOS ocean observing panel, while keeping the three GOOS panels intact. Clearly it requires some double-duty, but likely not more than is already required and it would provide a clearer focus for collaboration within INFCOM, as well as relevant areas of RB and SERCOM. (Refer to Section 6.2 for further comments on GOOS integration with WMO). The panels will also need to connect with other organizations that do not have the same regulatory approach as WMO, for example the satellite agencies and, for OOPC, IOC/GOOS.

When the panels and/or the panel chairs meet jointly, such as to review the number and structure of ECVs as agreed at the last GCOS SC meeting, consideration should be given to inviting relevant experts from WMO (INFCOM, SERCOM and RB), and WCRP.

WMO secretariat support for GCOS, both for the programmatic work and for the operation of the GCOS Steering Committee and panels, is provided by a small team currently located within the Infrastructure Department. This team has progressively shrunk over recent years and its leadership has transitioned from a dedicated Director role to incorporation within the extensive responsibilities of the Director of the Infrastructure Department. Concerns regarding GCOS funding and fundraising needs are addressed elsewhere in the wider JSG-GCOS report and are acknowledged. However, notwithstanding those concerns, consideration should be given to strengthening the overall capability of the GCOS secretariat team in conjunction with implementing the findings and recommendations of this report. Further, given the flat structure of the existing small team, consideration should be given to appointing or designating a team lead role, even if not at Director level (as per the prior arrangement). Together, these actions would help provide greater continuity as staff change/retire and assist in better managing the existing high workload as well as the proposed increase in the size and expertise coverage of the panels. The team lead role would also facilitate the planning and allocation of work and the improved coordination that is required across the various governance elements of WMO, including INFCOM and WCRP, and the associated secretariat units, including in research and services.

RECOMMENDATION 9

Consideration should be given to strengthening the capability of the GCOS secretariat team, located within the Infrastructure Department of WMO, and the appointment or designation of a team lead at an appropriate level.

5.2 Composition of steering committee, panels and working groups

5.2.1 Steering Committee

This section contains recommended revisions to the Steering Committee ToR.

Role:

- Will provide strategic and scientific guidance and approve the programme budget and serve as a primary decision-making body in GCOS.

- Reports to signatories of the MoU.
- Develops strategy for GCOS to meet the objectives described in the MoU.
- Is responsible for drafting and implementing the overall outreach and communication strategy.
- Advocates for sustainable, systematic climate observations, good data stewardship and free and open access to climate information for all users.
- Oversees the standing expert panels.
- Oversees the working groups and task teams established by the Steering Committee.

Procedures:

- Members shall be appointed for terms of 4 years and may be appointed for a second term.
- The Steering Committee shall be led by a Chair appointed by the Signatories of the MoU.
- The Steering Committee shall meet once a year.
- The Steering Committee Chair may invite observers to meetings.

Membership:

- The membership shall not exceed 12 persons.
- Acceptable balance of geographic and gender representation and discipline.
- Mixture of technical experts and those with a strategic overview.
- Membership shall include:
 - One representative of each of the signatories and one panel chair from each standing expert panel.
 - A representative of the UNFCCC.
 - Representatives of key partners having funding or strategic functions, invited by the steering committee chair.
 - Experts selected by the steering committee chair on the basis of their capacity or technical expertise.
- Membership of the Steering Committee shall be confirmed by the signatories of the MoU.

5.2.2 Standing Panels

Standing Expert Panels:

- The number and role of panels to be decided by the Steering Committee.
- Standing panels serve as custodians of ECVs, provide a connection to observing networks and provide technical and implementation guidance to the Steering Committee.
- Standing panels provide input to technical documentation, such as regular implementation plans and status reports by reviewing status of ECVs and observing networks.
- Panels have an indefinite lifetime.

Membership:

- Agreed by the SC (and any panel sponsors), about 16 members.
- Technical expertise across field.
- Have geographic and gender balance.
- Reports to the SC (and relevant sponsors and partners as necessary).
- If needed, representatives of significant observing systems may be invited to participate .

5.2.3 Working Groups and Task Teams

Working Groups and Task Teams:

- Working groups and Task Teams are established by the SC or the standing panels.

- These perform specific tasks and have a limited lifetime.

Membership:

- Agreed by the SC or the relevant panel.
- Technical expertise across field.
- Have geographic and gender balance.
- Reports to the SC or to the relevant panel.

6. RELATIONSHIPS WITH SPONSORS

GCOS needs strong relationships with all its sponsors. This is especially true for WMO to allow recommendations from GCOS to be incorporated into WMO regulatory material. It is expected that all the sponsors (e.g. IOC) will use their governance mechanisms to help implement GCOS mandate where this is appropriate.

The role of the sponsors in supporting and funding GCOS is considered in Chapter 7, this chapter considers how GCOS should interact with its co-sponsors. This issue is particularly acute with WMO, which, because of its role producing internationally approved regulations and guidelines for its members, requires a formal process for the adoption of any recommendations produced by GCOS about global climate observations.

GCOS is a highly regarded and influential program within the global climate monitoring community and amongst those bodies seeking to effect climate change action. It plays an important role in monitoring the effectiveness of mitigation actions, in informing actors at global to national levels on the critical gaps in ECV data collection and sharing, and in the specification of climate monitoring requirements across physical, biogeochemical, biological and ecological domains to meet emerging research and policy needs, capabilities and priorities. The voices of the GCOS sponsors as 'parents' and advocates for GCOS bring institutional authority to its messages in intergovernmental fora, while the Chair of the GCOS SC brings a highly respected voice regarding the 'whole' of GCOS, its extensive collaborating community and its representation of the full suite of scientifically-based requirements, assessments, gaps and opportunities for improvement across all components of the global climate observing system.

RECOMMENDATION 10

The Chair of the GCOS Steering Committee should continue to be recognized and respected on as a spokesperson for GCOS in relevant fora, complementary to the representation and advocacy role of WMO and other co-sponsors.

6.1 GCOS and WMO

The status of GCOS in WMO, as a program co-sponsored by WMO, IOC, UNEP and ISC, together with the reporting structure for its Steering Committee within WMO, have been somewhat ambiguous under the WMO structure before the constituent body reform approved by the 18th World Meteorological Congress in June 2019. Over time and under different GCOS Directors and Steering Committee (SC) Chairs, the working and reporting relationship between GCOS and WMO has taken different forms. GCOS has built strong collaborative relationships outside WMO that have enhanced the observations available for global climate monitoring, including with programs such as Copernicus and with satellite agencies. At the same time, GCOS's relationship with the UNFCCC has established it as an important and respected contributor to the global climate change discussions from early in the UNFCCC process, even recognizing that it speaks in UNFCCC bodies not as a legal entity, but as a jointly co-sponsored program. From WMO's perspective as one of the four co-sponsors, a potentially much wider discussion regarding actions on systematic observations under the UNFCCC would be achievable if GCOS outputs were better reflected and considered within the WMO governance framework.

The Chair of the GCOS SC should become a member of the INFCOM Management Group, though with the concurrence of the President of INFCOM, he/she may choose to be represented from time to time on Management Group by a GCOS Deputy Chair (if one is appointed) or by the Chair of one of the GCOS Panels, such as the Atmospheric Observing Panel for Climate (AOPC).

RECOMMENDATION 11

The GCOS Chair should be recognized as a member of the INFCOM Management Group and, by agreement with the President of INFCOM, be invited from time to time to inform EC and Congress on the progress, performance and requirements of the global climate observing system.

RECOMMENDATION 12

The GCOS Chair and Panel Chairs should build close linkages, through expert participation and alignment of efforts, with relevant INFCOM expert teams (and vice versa, where appropriate) and also with SERCOM and Research Board teams, especially where it would help in understanding needs for and application of ECVs to inform climate change and adaptation.

6.2 GCOS and IOC

The relationship with the IOC of UNESCO is more straightforward. In the past GCOS has been represented at meetings of the IOC Assembly and Executive Council where it reports on progress. As noted above, the OOPC panel is shared between GCOS and GOOS and is jointly supported by both.

GOOS is the main route for implementation of ocean climate observations and recommendations from GCOS to the relationship is vital.

RECOMMENDATION 13

The role of GCOS in reporting progress and needs for ocean climate observations to the IOC should continue to be recognized and strengthened by the IOC.

6.3 GCOS and other co-sponsors

The other sponsors of GCOS are UNEP and ISC. Neither of these organizations have a regulatory role so, inevitably, relationships are simpler. As part of any revisions to the GCOS MoU, structure and governance, clear roles and responsibilities are needed for all co-sponsors. Potential roles of UNEP and ISC can include the adoption of ECVs in monitoring sponsored by UNEP and the global data centres supported by ISC. Moreover, they can ensure the full participation of the academic community (ISC) and regional actors and key stakeholders from the environmental sector (UNEP).

In the future the number of co-sponsors may change, and any new sponsors will need to clearly state how they will utilise the recommendations of GCOS.

6.4 GCOS-WCRP, panel sponsor

GCOS and WCRP have complementary roles in the overall global climate change monitoring, assessment, research and policy response efforts. and should continue and strengthen their mutual collaboration. Their closer engagement and joint/complementary program planning will be facilitated by participation of the Chairs in their respective SC/JSC meetings. Or more directly and practically, via regular Chair-Chair informal meetings.

7. FINANCE OF THE GCOS ADVISING INFRASTRUCTURE

Sustainable funding is a major issue for GCOS. The GCOS programme (secretariat panels and steering committee) cost a tiny fraction of the amounts spent on climate observations: GCOS needs about one million USD/year. This guides the efficient use of the billions spent annually on climate observations. WMO is the only one of the four sponsors that is currently financially contributing to the GCOS Trust Fund with other external organizations providing the bulk of the funds. The current arrangement is not sustainable. The signatories of the new MoU should ensure funding for the GCOS secretariat.

One significant factor limiting the ability of GCOS to fulfil its mandate is the availability of resources. Despite the current GCOS Memorandum of Understanding (“the MoU”) between the four GCOS co-sponsors where the co-sponsors agreed “to support, through appropriate administrative and financial arrangements, the activities of the Steering Committee and Secretariat for GCOS” not all have done so. WMO is supplying resources and supporting the secretariat. IOC has supplied some funds until recently.

The annual cost of the GCOS Secretariat is, relatively, very small, (about 1 million CHF annually, with a similar level of in-kind contributions) compared with the amounts invested in the climate observing system itself, which, while difficult to estimate, amounts to many hundreds of millions CHF²⁶, without including the satellite component.

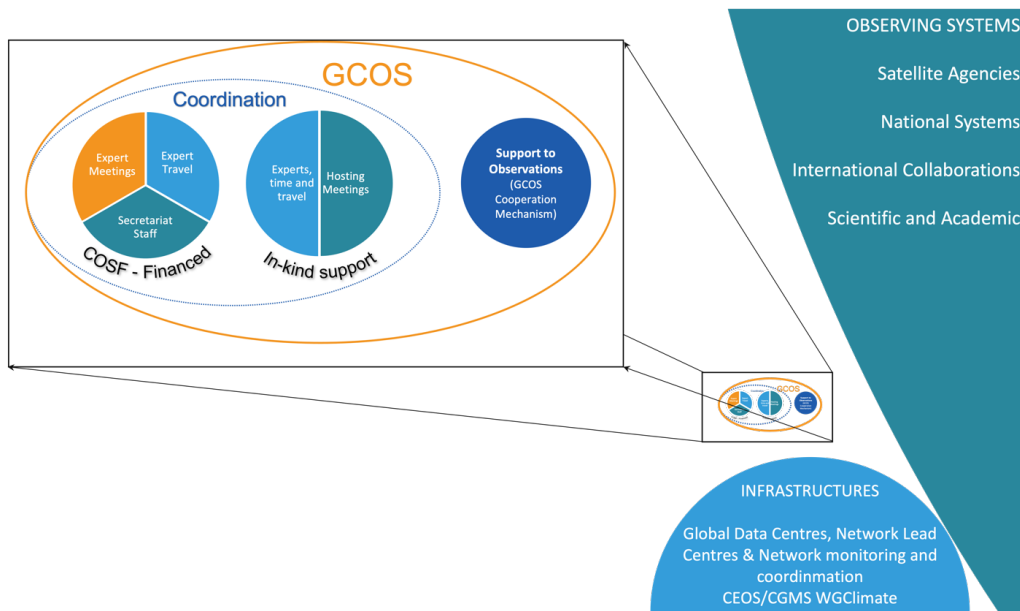


Figure 4. Types of funding and support for global climate observations. Most of the observing systems themselves are supported by countries directly or through scientific bodies. There is an infrastructure of data centres and network support. The whole system is coordinated by a relatively small secretariat supported by the trust fund and some in-kind contributions. There is also a funding mechanism to support network improvements. (Not to scale – the coordination resources are much smaller that for the infrastructures and observing systems. Support for the CGM has been very small recently).

While the resources needed for coordination are by far the smallest contribution overall to global climate observations, they are fundamental to delivering integrated, complete and useful climate observations. Resources for the coordination consist of:

²⁶ While it is difficult to estimate, a previous estimate of NMHS spending on surface-based observations came to roughly 5 billion US\$. While this did include all their monitoring, not just for climate, it did not include funding for research and other agencies for ocean and non-meteorological terrestrial observations.

- 1) The GCOS Trust Fund (the Climate Observing System Fund, COSF) which funds the secretariat staff, meetings of the steering committee and expert panels, travel by experts and meetings of task teams.
- 2) In-kind contributions by experts to participate in GCOS and to host meetings.
- 3) The GCOS Cooperation Mechanism (GCM) which supports system improvements.

7.1 Contributions to Global Observations

The direct support given to global climate observations and associated processing and data centres amounts to billions of dollars. Support for the global climate observations includes:

- Satellite observations that are costly and are supported by a limited number of individual governments and space agencies but provide global coverage for all countries. They are coordinated by the CEOS/CGMS Joint Working Group on Climate. Billions of dollars have been invested in satellite observations that provide near-global observations of many ECV.
- Many global data centres and networks that are supported by single countries, or by groups of countries, as their contribution to the overall system.
- Ocean observations that are generally funded by a small number of countries but have a global reach.
- Some modelling and reanalysis centres which store data and provide access to data sets.
- In addition, each country makes observations on its own territories. Many of these observations are made for multiple purposes in addition to climate, for example, they meet weather forecast, emergency warning and ocean safety needs as well. WMO coordinates meteorological observations.

GCOS uses a tiny fraction of the resources used for observations themselves to coordinate observing systems to maximise value of the observations at minimum cost.

7.2 Current GCOS Secretariat financial arrangements

The GCOS Secretariat is supported by the Climate Observing System Fund (COSF). The COSF is used to:

- 1) Support the secretariat staff
- 2) Support meetings of experts and
- 3) Support travel by experts

As noted above, the COSF should receive contributions from *"the sponsoring organizations, each from funds appropriated in their budgets for this purpose and from extra-budgetary resources"* (1998 MoU). However, currently the only co-sponsor to provide funds to the COSF is WMO. Larger contributions to the COSF are received from the EU and the USA. Specific funding is received to cover the support for OOPC: 50% of this is for GCOS and 50% for GOOS. There are also some smaller contributions. The GCOS secretariat is based at WMO who provides the director, administrative support, office space and IT.

The GCOS Secretariat and its operations require about one million CHF annually. If the work expands this will have to increase. Current available resources are not sufficient to meet the annual running costs. This sum is a tiny fraction of the amounts invested globally in climate observations coordinated by GCOS.

The GCOS Cooperation Mechanism (GCM) has a separate trust fund that has distributed several million CHF, currently, however the income is around 50 kCHF annually. The role and scope of this is being reconsidered, but if it is to play a significant role in the future it will need separate fundraising. Details on the importance of the GCM in the way forward of GCOS are given in section 7.3.

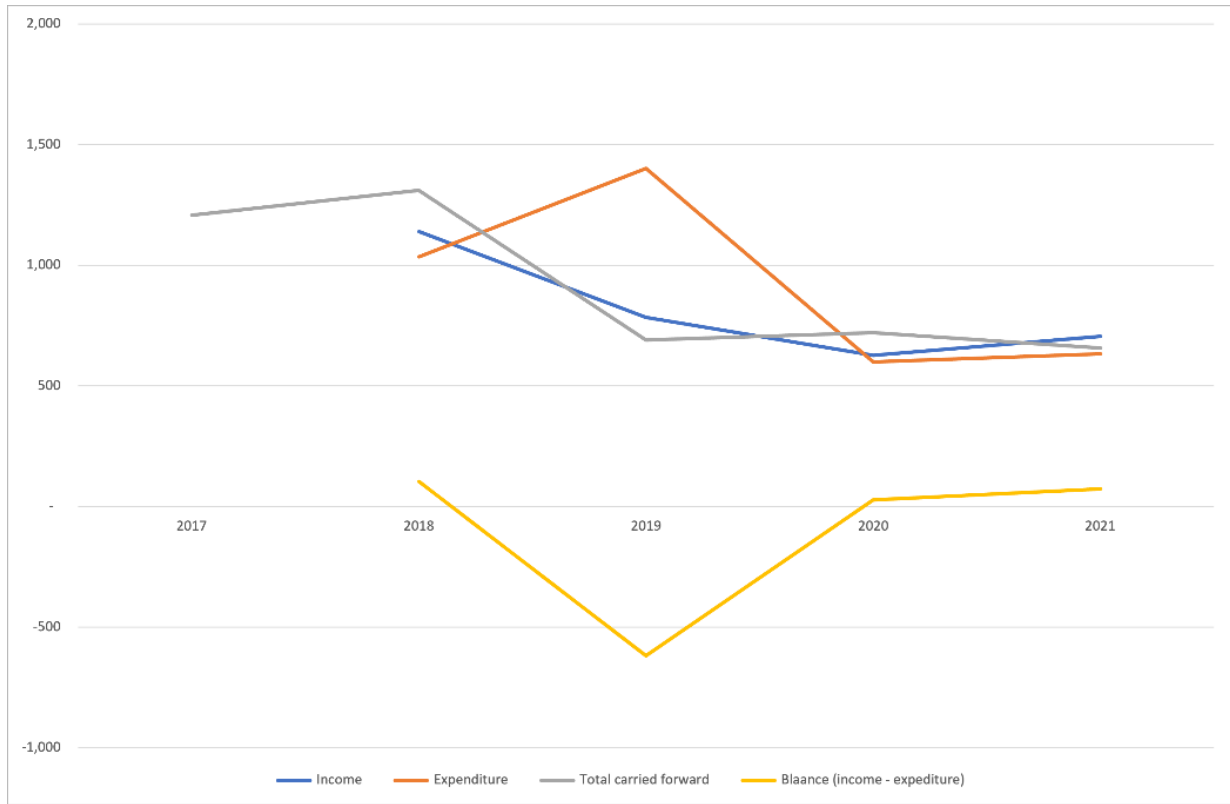


Figure 5. Overview of GCOS Secretariat (the GCOS Trust Fund) financial situation. 2020 and 2021 expenditure reduced due to COVID-19. GCOS needs over 1 million Swiss Francs to cover its costs, income has recently been lower than this.

Table 2. GCOS Secretariat Trust Fund (COSF) Expenditure. (Does not include in-kind support to the GCOS Secretariat and does not include experts time and support for meetings that amounts, roughly a million CHF). Other includes contributions to the GCM.

		2017	2018	2019	2020	2021
Income	WMO		100	173	58	100
	WCRP		21	11	13	-
	European Commission		-	165	253	175
	Woods Hole, USA		310	192	-	159
	UNESCO		-	29	-	-
	JMA		50	50	50	-
	ECMWF		17	-	-	-
	ESA		24	-	-	-
	US State Department		87	74	195	315
	EUMETSAT		23	26	21	21
	DWD		68	66	32	31
	Other		440	-2	5	-95 ²⁷
	Total Income		1,140	784	628	706
Expenditure	Staff		545	637	606	576
	Staff Travel		45	21	0	-
	Meetings and Experts		231	215	-7	-
	Other		216	529	-	57
		Total Expenditure		1,036	1,402	599
	Difference (Income-expenditure)		103	-618	28	73
	Carried forward to next year	1,208	1,311	690	721	658

The Trust Fund has been diminishing over recent years as GCOS income was significantly less than 1 million in the years before 2020. Currently, the main funding is a grant from the European Commission (Copernicus) and a contribution from the United States. The ability of the Secretariat to reduce its costs is limited and meetings are mainly on-line, even before the COVID-19 crisis. While there will be a significant carry-over of funds (due to reduced expenditure in 2020 and 2021) this will not continue if GCOS wishes to remain effective with a wide range of contributions.

7.3 The GCOS Cooperation Mechanism (GCM)

The GCOS Cooperation Mechanism (GCM) is the system improvement and resource mobilization activity of the GCOS programme. It was established following a decision by the UNFCCC SBSTA in 2004²⁸ in order "to enable developing countries to collect, exchange, and utilize data on a continuing basis in pursuance of the UNFCCC". Since then, approximately 4 million US\$ was raised to accomplish projects dedicated to improving climate observation systems.

The purpose of this mechanism²⁹ is to identify and make the most effective use of resources available for improving global observing systems for climate in the global south. The GCOS Cooperation Board was established to facilitate cooperation amongst donor and recipient countries, and existing funding and implementation mechanisms, in addressing high priority needs for the improvement of global observing systems for climate in developing countries. It aims to ensure the most effective use of voluntary contributions for meeting such needs.

This mechanism aimed to address priority improvements in atmospheric, oceanic, and terrestrial observing systems for climate and addresses the full scope of needs for system improvement and sustained operations as well as capacity building for sustained observations.

²⁷ Negative as this is a repayment of unspent funds for the GCM for the HIGHWAY project.

²⁸ UNFCCC Decision 5/CP.5

²⁹ See Terms of Reference of the GCOS Cooperation Mechanism (August 2004)

In recent years only very limited funds are available for the GCM (roughly CHF 50,000 in 2020) and it has focussed on radiosondes. Also, WMO's Global Basic Observing Network (GBON) and its Systematic Observation Financing Facility (SOFF) are supporting basic meteorological observations (including a few ECVs). As SOFF cannot cover all variables, it is appropriate to move the role of the GCM away from supporting atmospheric variables to other domains. The GCM must be kept alongside the SOFF to support observing networks in developing countries, which is crucial for a balanced observing system. Therefore, it is also important to clarify the role of the GCM to potential donors and consider the role of the GCM in coordinating support to countries with limited resources.

7.4 Issues

While current income was insufficient, the inability to travel and hold meetings due to the COVID-19 means that GCOS has sufficient funds for 2022. In order to address the longer-term problem with funding the following issues need to be addressed:

- It is clear that, apart from WMO, the sponsors are not contributing to the Trust Fund or meeting their responsibility for the core funding. Despite commitments in the MoU funds are not available for the COSF from IOC, UNEP and ISC.
- There is a broader structural issue that while there is support for observations, it is more difficult to fund coordination and planning which would make more efficient use of funding for observations.

7.5 Approach

To ensure long-term sustainable resources, GCOS needs to:

- Have a clear message about its role
- Be clear about its value and the resources it leverages
- Increase its visibility
- Foster long-term relationships with potential partners
- Have clear sustainable commitments by the co-sponsors (financial and in-kind)
- Ensure a long-term role with the GBON and SOFF supporting climate observations in addition to their role in NWP.

GCOS needs both in-kind and financial resources to enable travel and meetings. In-kind contributions could range from providing personnel to hosting meetings and supporting travel.

7.5.1 Financial landscape and opportunities

In the past, funding for the secretariat has often come from countries through their NMHS (see above). The US and EU have recently supported GCOS Secretariat because they see the value of its activities to their own work.

In the past, GCOS tends to have engaged with these bodies through personal contacts rather than a more focused approach.

The UNFCCC asks parties and international organizations to support GCOS, but little has been forthcoming. The GCOS Steering Committee and Director should identify the most appropriate contact points in the various bodies and follow up on these opportunities.

7.5.2 GCOS role in fundraising

In the past GCOS's role has been rather passive but this is no longer feasible. With the exception of the GCM GCOS has not raised resources for networks. GCOS reviews and reports performance and advocates for improvements. As noted by the GCOS review (2014) this role is

vital and needs to exist. However, coordination itself has not been enough to attract the sustainable funding streams needed to support long-term climate observations.

Being able to present a clear story about GCOS, especially having a more active role, should make GCOS more interesting to potential funders. For example, being able to offer rapid system performance monitoring should make GCOS more interesting to those funding observing systems across the climate system. Similarly, coordinating a global system of data centres may increase the relevance of GCOS.

It is clear that the funds invested globally in climate observations, that are coordinated by GCOS dwarf the needs of the secretariat (even if its role is expanded). This message needs to be communicated broadly and widely.

7.6 Sources of additional funds:

A number of potential sources of funding include:

- a) Crowdfunding;
- b) Contributions from scientific, research and philanthropic institutions;
- c) Contributions from UN entities, including co-sponsors, and international and regional financial institutions,
- d) Private sector;
- e) Meeting with potential sources of funding;
- f) Support from NMHS.

These all have their advantages and disadvantages.

The JSG-GCOS considered a range of possible options to fund the GCOS secretariat:

- Option 1: Retain the existing system.
- Option 2: Continue the existing co-sponsors arrangement but retain only those co-sponsors committing to providing GCOS sustained support (financial or in-kind).
- Option 3: GCOS changes its sponsors to those who are prepared to contribute to support GCOS. These could include WMO, CEOS and CGMS or individual space agencies, Copernicus, NOAA and other national meteorological services and other bodies.
- Option 4: GCOS becomes a programme executed by the World Meteorological Organization and supported by the other co-sponsors and partners. This would imply a greater support for GCOS from WMO with the GCOS secretariat provided by WMO. The COSF would still need funds for meeting and travel.

The preferred arrangement was based on option 2. A new MoU will be agreed with each signatory committing to support the GCOS Secretariat through contributions to the COSF and in-kind contributions for the lifetime of the MoU. Additional funds, beyond supporting the secretariat, will be solicited from potential donors to ensure all the activities of GCOS can progress. The role of the GCM will be revisited in the light of current developments in observational funding to make it more interesting to donors (see below).

7.7 Financial Conclusions

1. To sustain GCOS the secretariat needs funding of at least one million CHF each year (some of which may be in-kind contributions), and this required resource would need to grow if a broader remit of activities was adopted, such as supporting adaptation and better links to observing networks. This funding supports the secretariat, meetings and expert travel. Recently, income has not reached this level. The existing co-sponsors are not meeting the requirement in the MoU to provide resources to GCOS. In future, there

needs to be more clarity that the sponsors of GCOS who sign the MoU are committing to supporting GCOS.

2. During 2020 and 2021, due to the COVID-19 pandemic, GCOS has held many meetings using teleconferencing and so expenditure (and carbon impact) has been reduced. However, it is also clear that some in-person meetings cannot be avoided and especially given the need for global involvement in GCOS. The GCOS secretariat should, in future, ensure all meetings are justified in terms of their expense and climate impact.
3. Provide the co-sponsors with clear value-based information to assist them in determining what their contribution to GCOS should be. This may be financial or in-kind, but they should bring something to GCOS. In return, the co-sponsors need to be convinced of the value and benefits that derive (or could derive) from GCOS and to support it commensurately in real financial terms. The sponsors have a role in directing GCOS and have a clear interest in its success. Therefore, GCOS should prepare a targeted paper for each co-sponsor that describes the benefits that GCOS brings to each of them, with reference to their own programmes/goals/strategies etc, and to the global communities that they belong to; how it can help deliver greater value if used more proactively to inform their planning, integrating requirements etc. Also, what they would lose if GCOS ceased to be supported. Focus on outcomes, risks, opportunities etc and target at senior management.
4. GCOS should have a clear vision of how it envisages the development of the global climate observing system in the future to help explain to potential funders the benefits of supports for GCOS coordination. This vision should explain how GCOS will implement its mandates. This will be key in "selling" GCOS to potential supporters. It should include:
 - A network of GCOS accredited data repositories with clearly defined requirements providing free and open access to well-stewarded climate data records.
 - A system that can monitor the performance of the observing system in near-real time.
 - A regional support process that identifying needs and potential solutions.
 - Clear requirements that consider different needs and the practicalities of the observing systems.
 - An open and public review process of all the products of GCOS.
 - A system of coordination managed by the GCOS secretariat and expert panels that is responsive to user needs.
 - A significant voice for the observing system reporting into the UNFCCC process.
 - Provision of guidance and feedback on GCOS.
5. Revisit one of the initial aims of the GCOS Cooperation Mechanism (CGM) – the collation and coordination of existing and planned contributions to climate observations in the global south – in order to demonstrate what is being delivered across the board by all players, especially international organizations and the UN. The GCM should identify overlaps, gaps, opportunities for improved efficiency, ways to streamline projects, outreach aspects, building partnerships. This would identify and inform potential donors of the on-ground, in-country, priorities, to link donor funds to opportunities for ongoing support, maintenance and consumables. GCOS should:
 - Prepare a clear and concise paper for UNFCCC to table and to share with all Parties to explain the GCM and benefits of contributing.

- Stage an event at a UNFCCC session with some real-life examples of where GCOS, ECVs, and subsequent observing system improvements etc. have made a real impact.
- Move the CGM focus from meteorological observations (that is being taken up by GBON and the SOFF) to climate observations more generally.

RECOMMENDATION 14

A revised MoU should be clear that signatories are committing to long-term support for a GCOS Secretariat. The signatories of the revised MoU should ensure that financial and in-kind resources at an appropriate level (currently one million CHF annually) are available for the GCOS secretariat to implement the revised mandate.

RECOMMENDATION 15

GCOS should provide clear value-based information and a clear vision of how it hopes to develop the global climate observing system in the future to potential sponsors.

RECOMMENDATION 16

GCOS should revisit the aims of the GCOS Cooperation Mechanism (GCM) to better align it to the current situation and make it more attractive to potential donors. GCOS should produce a plan to inform potential donors about the GCM and its new focus and mobilise resources.

Appendix A: Suggested Revised MoU

The proposed new MoU is divided in two parts:

- (1) The agreement describing GCOS goals and mandate and the sponsor's commitments and
- (2) Three technical Annexes describing GCOS, the governance and financial matters.

To ensure flexibility in updating the technical part, it is divided into three parts as shown below. Authority is delegated to the Steering Committee to formulate and amend the technical parts, with the agreement of the sponsors representatives on the GCOS Steering Committee:

- Annex A: Concept of the Global Climate Observing System
- Annex B: Terms of Reference, structure and functions of the Steering Committee, and the secretariat
- Annex C: Financial arrangements

MEMORANDUM OF UNDERSTANDING BETWEEN THE *[parties to this Memorandum of Understanding]*

The *[parties to this Memorandum of Understanding]*,

NOTING:

- (1) The recommendation of the Second World Climate Conference concerning the creation of a Global Climate Observing System;
- (2) Resolution 18 (Cg-XVI) of the Sixteenth World Meteorological Congress on the World Climate Programme (WCP);
- (3) Resolution 39 (Cg-17) of the Seventeenth World Meteorological Congress on the Global Climate Observing System (GCOS);
- (4) Resolution 48 (Cg-XVI) of the Sixteenth World Meteorological Congress on the implementation of the Global Framework for Climate Services (GFCS);
- (5) The decision of the sixtieth meeting of the ICSU Executive Board that ICSU should join WMO and IOC of UNESCO in the formation of the Global Climate Observing System;
- (6) The decision of the sixteenth session of the UNEP Governing Council that UNEP should support, within available resources, the creation of a Global Climate Observing System and assist in ensuring that its development and implementation are pursued with urgency;
- (7) Resolution 50 (Cg-XVI) of the Sixteenth World Meteorological Congress on the implementation of the WMO Integrated Global Observing System (WIGOS);
- (8) Resolution 39 (Cg-17) of the Seventeenth World Meteorological Congress on the Global Climate Observing System;
- (9) WMO Executive Committee decisions, Decision 7 (Ec-69) WMO Support to Implementation of The Paris Agreement and Decision 14 (Ec-69) Support The Development of Actions Based on The Global Climate Observing System Implementation Plan;
- (10) Resolution XVI-8 of the sixteenth session of the IOC Assembly to undertake the development of a Global Ocean Observing System (GOOS) and participate in the Global Climate Observing System;
- (11) The decisions of the sponsoring organizations on other programmes on similar related Earth Observing Programmes;
- (12) Articles 4 and 5 of the UN Framework Convention on Climate Change (UNFCCC) committing parties to promote and cooperate in systematic observation;
- (13) UNFCCC Decision 1/CP.21, the Paris Agreement;
- (14) UNFCCC Decision 19/CP.22 "Implementation of the global observing system for climate" and earlier decisions of parties to the UNFCCC related to systematic observation and the reporting of the GCOS to the UNFCCC on this matter;
- (15) The outcomes of the Earth Observation Summits in Washington (2003), Tokyo (2004), Brussels (2005), and the Group on Earth Observations (GEO) Ministerial Summits in Cape Town (2007) and Beijing (2010) where GEO was created, endorsed and implemented;
- (16) Agenda 21 which calls for systematic observations in support of sustainable development;
- (17) Recommendations made by the Commission on Sustainable Development toward the development of global environmental observing systems;

RECOGNIZING that the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) states that *it is unequivocal that human influence has warmed the atmosphere, ocean and land and that Widespread and rapid changes in the atmosphere, ocean, cryosphere and biosphere have occurred. The scale of recent changes across the climate system as a whole and the present state of many aspects of the climate system are unprecedented over many centuries to many thousands of years. It also notes that Human-induced climate change is already affecting many weather and climate extremes in every region across the globe. Evidence of observed changes in extremes such as heatwaves, heavy precipitation, droughts, and tropical cyclones, and, in particular, their attribution to human influence, has strengthened since the Fifth Assessment Report (AR5)³⁰;*

RECOGNIZING the importance of the existing observation systems and networks and the evolution of observing systems to the IPCC assessment Reports, improving climate prediction, assessment and attribution and in supporting climate policy and the UNFCCC;

CONSIDERING:

- (1) That the total climate system encompasses a range of physical, chemical and biological properties along with atmospheric, oceanic, hydrologic, cryospheric and terrestrial processes;
- (2) That the required information will encompass climate relevant in situ, airborne and space based data from operational meteorological, hydrological, oceanographic and other relevant programmes, as well as observations from research programmes;
- (3) That the development of an Earth system approach recognizing the Earth system cycles of energy, water and carbon (including fluxes) allows the development of ECV as an integrated whole;
- (4) That climate observations support climate science, public information, climate services, policy development and climate adaptation and mitigation.

AGREE:

- (1) To cooperate in organizing and supporting a Global Climate Observing System (GCOS) based on high-level coordination of existing and planned operational and research programmes for observing the global climate system, promote cooperation among these programmes as required, and ensure continuity and further development of climate observations;
- (2) That GCOS will ensure that the climate observation system evolves and is sustained to enable users:
 - To detect further climate change and determine its causes;
 - To improve modelling and prediction the climate system;
 - To assess impacts of climate variability and change;
 - To monitor the effectiveness of policies for mitigating climate change;
 - To support climate change adaptation and mitigation efforts;
 - To develop climate information services;
 - To promote sustainable national economic development; and
 - To meet requirements of the international environment conventions and agreements on climate observations including those of the UNFCCC, including on adaptation, mitigation and its global stocktake.

³⁰ IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press. In Press.

- (3) To consult and call upon other relevant national and international agencies, institutions and organizations, to collaborate in the organization of, and participate in, the implementation of GCOS;
- (4) To establish a Steering Committee as the primary decision-making body of GCOS in implementing, developing and administering the GCOS and its Secretariat as mandated by the sponsors;
- (5) To delegate to the Steering Committee the authority to formulate and amend, by consensus with the agreement of the sponsor's representatives, the Annexes supplementing this MoU³¹ and establish panels and working groups for technical and implementation activities within its mandate;
- (6) To provide adequate financial resources for the Secretariat and to ensure support for the Steering Committee, panels and working groups;
- (7) To encourage, as appropriate, sponsors and partners to maintain and develop strategic guidance and implementation of systematic observation of climate;
- (8) (8) The GCOS Steering Committee Chair will be a member of or report to the governing bodies of the sponsors as appropriate.

AGREE that this Memorandum of Understanding shall be reviewed every four years by the parties to this Memorandum of Understanding, and may be called for review at any time by one of the parties;

AGREE that other organizations and agencies, which contribute to the implementation of GCOS and wish to join in the sponsorship of GCOS, may become a party to this Memorandum of Understanding, including its appropriate administrative and financial arrangements.

AGREE that this Memorandum of Understanding shall come into force on signature by all parties.

³¹ Annex A: concept of the Global Climate Observing System
Annex B: Terms of Reference, structure and functions of the Steering Committee, and the secretariat
Annex C: Financial arrangements

ANNEX A: CONCEPT OF THE GLOBAL CLIMATE OBSERVING SYSTEM

1. GCOS as a programme

- 1.1 GCOS serves a broad range of user needs for globally coordinated climate observations. Its goal is to provide comprehensive data and climate information on the total climate system, including a range of physical, chemical and biological properties, along with atmospheric, oceanic, hydrologic, cryospheric and terrestrial processes.
- 1.2 GCOS works with existing or planned operational and research programmes for acquiring, storing and distributing systematic global climate system data and identifies gaps in observations, data management and information distribution systems. The ownership and management of the observing systems and networks will remain fully with their operating entities. GCOS advocates for further enhancements of these systems, and encourages new systems to be established, where necessary.
- 1.3 GCOS identifies user data needs to enable the further development of these programmes to ensure continuity and diversification of climate observations. Data needs are organized around the concept of Essential Climate Variables (ECVs).
- 1.4 The GCOS ECVs comprise physical, chemical and biological properties that are essential to describe the climate system. GCOS will:
 - (a) Elaborate the ECV concept to specify its key deliverables and outputs, continuing the process of emphasizing fields and products and de-emphasizing individual observing platforms;
 - (b) Develop systematic observation requirements for climate applications on relevant time and space scales by providing standards, indicators and best practices in the reporting cycle of producing the Status Reports and the Implementation Plans.
- 1.5 GCOS supports climate research, assessments and services.
- 1.6 GCOS underpins interactions among observation, research, assessment and policy communities leading to international decision-making on climate change. In this regard, in particular, it supports the World Climate Research Programme (WCRP), the Intergovernmental Panel on Climate Change (IPCC) and the United Nations Framework Convention on Climate Change (UNFCCC) including its Paris Agreement.
- 1.7 GCOS advocates for the maintenance and improvement of sustained climate observations and the free and unrestricted access to all climate data. It will support the creation and sustainable operation of a network of climate data centres, ensuring the long-term access and archiving of climate observations.
- 1.8 GCOS supports data archiving, dissemination, communication and other infrastructures necessary to support operational climate services. Global Data Centres with free and open access to climate data are required.
- 1.9 To support the Paris Agreement, contributing to its adaptation and mitigation measures, GCOS promotes observing systems that allow the quantification of climate impacts (e.g., health, energy, water and food sectors) and support national economic development.

- 1.10 GCOS will pay particular attention to countries and regions with limited resources.
- 1.11 GCOS will report to the UNFCCC at least annually on progress on systematic observations, and regularly provide reports describing the adequacy and status of the global climate observing system and plans for its improvement and development.

2. Strategy

- 2.1 The strategy of the GCOS programme will have to define clearly how the climate community should implement, maintain and support the climate observing system including:
- (a) Development of a long-term vision for GCOS
 - (b) Enhanced engagement by both stakeholders and implementation networks and agencies including those outside the sponsors of GCOS.
 - (c) Increased visibility of the programme, its achievements and ambitions using available and modern media tools;
 - (d) Development of a communication strategy that will provide additional clarity about the purpose of GCOS;
 - (e) Development of a short statement of strategy, based on the vision, to guide priority setting and to communicate to stakeholders the aims and intended benefits of GCOS;
 - (f) Data on adaptation to and mitigation of climate change and its regional dimensions;
 - (g) The role of the GCOS cooperation mechanism and 'global South' countries can be supported.

3. Engagement with stakeholders

- 3.1 The GCOS cooperation mechanism is the strategic approach to capacity-building to meet some of the needs of developing countries taking into account geographical balance with regard to identifying data and observational requirements and is applied in partnership with existing observing systems and programmes.
- 3.2 GCOS engages with national governments by promoting the role of national and regional coordinators and by providing a series of regional workshops. In addition, the steering committee shall engage with a larger community of stakeholders and implementers to receive advice on the programmes, gaps, needs, ideas, etc. to supplement the governance function of GCOS.
- 3.3 The Steering Committee will develop an engagement strategy. This will aim to seek advice and guidance on the development of the GCOS programme and on fund-raising strategy. It will improve the engagement of partners and stakeholders with the GCOS programme aiming to develop links with groups not traditionally engaged with the GCOS climate-observing community. A regular meeting with all stakeholders, perhaps as part of the 4-5 year GCOS Conference cycle, should be part of the engagement strategy. This engagement should develop advice and guidance on:
- (a) Programme priorities that require new resources;

- (b) Engagement and communication strategy, particularly by providing strategic guidance, and by finding new ways to foster engagement and partnership with users;
- (c) Fund-raising strategy and activities;
- (d) Developments and impacts of new Earth Observing initiatives;
- (e) Improved engagement with the private sector in matters of global climate observations.

4. Links to Sponsors

4.1 All the signatories agree to consider the recommendations of GCOS, related to its mandate, in their decision-making processes. In particular:

- (a) The WMO Commission for Observation, Infrastructure and Information Systems (Infrastructure Commission) will consider recommendations, status reports and implementation plans sent to WMO by GCOS. They shall be incorporated in the WMO regulations, the WIGOS manual and the rolling review of requirements as appropriate. The Infrastructure Commission, the Commission for Weather, Climate, Water and Related Environmental Services & Applications (the Services Commission) and the WMO Research Board shall consider GCOS outputs and provide information to GCOS on climate observational needs.
- (b) IOC will consider recommendations, status reports and implementation plans forwarded to it by the GCOS Steering Committee. They shall be considered by GOOS in the development of ocean observations.
- (c) The Chair of the GCOS Steering Committee shall be a member of the Infrastructure Management Group and shall report to WMO Congress and Executive Council, and the IOC Assembly and Executive Council as needed.
- (d) ISC will promote the work of GCOS to academic institutions globally and ensure full participation of experts in GCOS panels. ISC can support GCOS SC experts in UN negotiations by providing access through the UN major group for Science and Technology accreditation process.
- (e) UNEP will ensure that the work of GCOS informs the regional processes and invite GCOS representatives to attend relevant meetings.

ANNEX B: TERMS OF REFERENCE, STRUCTURE AND FUNCTIONS OF THE STEERING COMMITTEE, AND THE SECRETARIAT

1. Steering Committee

Function:

1.1 The functions of the Steering Committee are to formulate the overall concept and scope of GCOS, and to provide scientific and technical advice to partners and other participating organizations and agencies for the planning, implementation and further development of GCOS.

1.2 Specifically, the Steering Committee will be called upon:

- (a) To identify observational data needs requirements, define design objectives and recommend coordinated actions by sponsoring and participating organizations and agencies, in order to optimize the system's performance and coherence, taking cognizance of the responsibilities, working arrangements and recommendations of established scientific and technical bodies of such organizations and agencies;
- (b) To review and assess the development and implementation of the components of GCOS, and report to the sponsoring organizations and to the participating agencies, as required;
- (c) To facilitate the exchange of information among sponsoring and participating organizations and agencies, and in general make the objectives, resource requirements, capabilities and outputs of GCOS known to relevant national and international bodies;
- (d) To approve the budget of GCOS within the funds available in the COSF;
- (e) To develop, maintain and implement a strategy for GCOS, consistent with this mandate, that will include:
 - (i) A GCOS vision;
 - (ii) An engagement strategy covering stakeholders and implementation agencies, including those outside the sponsors of GCOS, users of climate data and observing systems;
 - (iii) Visibility of the programme, its achievements and ambitions using available and modern media tools;
 - (iv) A communication strategy that will provide additional clarity about the purpose of GCOS; and communication with stakeholders the aims and intended benefits of GCOS;
 - (v) Priority setting;
 - (vi) Guiding the GCOS Cooperation Mechanism (GCM) so that it supports developing countries in observing all ECVs;

- (vii) A plan for capacity development in developing countries that may include the GCM; strong ties to national governments by promoting the role of national and regional coordinators; and holding a series of regional seminars;
 - (viii) To increase engagement with national observing systems;
 - (ix) To support the sponsors and GCOS secretariat in resource mobilisation for both the coordination and execution of the GCOS work.
- (f) To report at least annually to the signatories of this MoU and to the UNFCCC;
- (g) To establish standing panels of experts, working groups and time limited task teams, as needed, to advise the steering committee.

Membership:

1.3 The Steering Committee shall consist of the chair, several ex-officio members and no more than 8 additional individual scientific and technical experts. Membership shall be balanced in terms of geography, gender, age and discipline. Experts in both in situ and remote sensing techniques will be included. Membership includes the following ex-officio members:

- A chair nominated by the signatories of the MoU and appointed by WMO;
- One representative of each signatory of the MoU and one panel chair from each standing expert panel;
- A representative of the UNFCCC.

Additional members should ensure diversity across several criteria and include

- Representatives of key partners having funding or strategic functions;
- Representatives of key GCOS users;
- Representatives of the wider technical or scientific communities.

GCOS steering committee members cannot also be members of a GCOS standing panel or working group.

1.4 New member of the Steering Committee shall be proposed by the Steering Committee Chair following an open call and SC lead preselection process and confirmed by the signatories of this MoU. In this process the membership shall be reviewed bearing in mind the need to ensure reasonable continuity and inflow of new members.

1.5 The members will be appointed for an initial term of four years. Members have the possibility of serving for two terms.

1.6 Representatives from other GCOS stakeholders, as well as individual experts, may also be invited in the capacity of observers on an ad hoc basis to participate in the sessions upon the decision of the GCOS chairperson.

Chairperson:

1.7 The Chairperson shall be selected and appointed by the Executive Heads of the signatories of this MOU for a term of appointment of four-year with a possibility of reappointment for a further term.

1.8 The duties of the Chairperson of the Steering Committee shall be:

- (a) To preside over the sessions of the Committee and respond to its decisions;
- (b) To make procedural decisions on behalf of the Committee between meetings;
- (c) To advise the GCOS Secretariat with respect to the fulfilment of GCOS plans and tasks;
- (d) To conduct, through the appropriate sponsoring organizations, correspondence on matters related to the organization, planning and implementation of GCOS; To carry out specific duties as prescribed by decisions taken in agreement by the sponsoring organizations;
- (e) To arrange for the views of the Steering Committee to be presented to the sponsoring organizations, representing GCOS at WMO Congress and Executive Council and IOC Assembly and Executive Council and similarly for any other signatories of this MoU;
- (f) To be a member of the WMO INFCOM Management Group;
- (g) To prepare annually, with the GCOS Secretariat, a brief report of GCOS planning and implementation activities, including the considerations and recommendations by the Steering Committee, and to present this report to the sponsoring organizations.

1.9 The Chairperson may call for the establishment of a vice chair selected from within the GCOS SC. The vice chair supports the Chairperson.

1.10 The Chairperson may call upon any member of the Steering Committee to assist with specific tasks, or form time limited task teams within the Steering Committee as necessary.

1.11 The Chairperson shall work with the chairs of the GCOS standing panels in the performance of their duties.

Sessions:

1.12 The Steering Committee shall meet at least annually, the venue and dates to be decided by the Chairperson of the Committee in consultation with the Director of the GCOS Secretariat. Sessions shall normally be arranged so as to avoid scheduling conflicts with meetings of executive bodies of the sponsoring organizations.

1.13 The Steering Committee shall meet virtually, in between annual sessions.

1.14 The Director of the GCOS Secretariat, acting on behalf of the Chairperson of the Committee, shall inform the sponsoring and participating organizations and agencies, notify the members and make appropriate practical arrangements for the session.

1.15 The attendance of representatives of each signatory of the MoU shall not be charged to the GCOS Fund.

1.16 The attendance of other Members of the Steering Committee will be charged to the GCOS and the attendance of observers may be charged to the GCOS Fund at the discretion of the Steering Committee chair.

1.17 The working language of the Steering Committee is English.

2. Standing Expert Panels, Working Groups and Task Teams:

2.1 The Steering Committee shall be authorized to establish standing panels of scientific and technical experts "Expert Panels"³² within the budget approved by the sponsoring organizations taking account of relevant scientific or technical groups established by the sponsoring organizations and their constituent bodies.

2.2 Each Expert Panel and Working Group will be guided by Terms of Reference that articulate the scope and mandate approved by the GCOS SC as well as an operations document will detail the procedures including office arrangements, panel member selections and terms of service, reporting duties and financial arrangements.

2.3 Both the Steering Committee and the Expert Panels can establish working groups and time limited task teams, within their area of responsibility and within the budget approved by the sponsoring organizations taking account of relevant scientific or technical groups established by the sponsoring organizations and their constituent bodies

2.4 The membership, terms of reference and special requests addressed to expert panels, working groups and task teams will be documented by the Director of the GCOS Secretariat on behalf of the Chairperson of the Committee.

3. Secretariat

3.1 The general functions of the Secretariat shall be to assist the Steering Committee in formulating the concept and in organizing the implementation of GCOS, and any other organizational or technical task, as the Steering Committee may decide. In particular, the Secretariat, under the responsibility of its Director, shall take charge for:

- (a) Preparing plans and guidance materials for the development and implementation of GCOS;
- (b) Providing support to the Steering Committee;
- (c) Supporting the standing expert panels, working groups and task teams;
- (d) Maintaining scientific and technical liaison with relevant departments and constituent bodies of the sponsoring organizations, and all other relevant institutions or agencies, as required, for the development and implementation of GCOS;
- (e) Serving as the documentation and information centre for GCOS and preparing information or action documents pertaining to GCOS as required by the sponsoring organizations;
- (f) Making arrangements for GCOS planning and coordination activities, in accordance with the provisions of the Financial Arrangements, and following the guidelines provided by the Steering Committee;

³² In 2021, the standing panels are the Atmospheric Observation Panel for Climate (AOPC), the Ocean Observations Panel for Climate (OOPC) and the Terrestrial Observation Panel for Climate (TOPC).

(g) Reports annually to the GCOS SC and provides a plan of work and indicative budget for the next calendar year for approval by the GCOS Steering Committee.

3.2 The Secretariat shall be composed of a Director and an adequate number of scientific technical and administrative assistant staff to perform these functions, supported by the sponsoring organizations and other participating agencies, or supported directly by the Climate Observing System Fund (COSF).

3.3 The Director will be nominated by consensus agreement of the Executive Heads of the sponsoring organizations. The Director and other recruited secretariat staff will normally have the status of a staff member of WMO and will be appointed by the Secretary-General of WMO.

3.4 The Director will be accountable, for administrative and financial matters, to the Secretary-General of WMO, in accordance with the provisions in the Financial Arrangements.

3.5 The duties of the Director shall include:

(a) Directing the work of the Secretariat;

(b) Supporting the activities of the Steering Committee, expert panels, working groups and task teams;

(c) Liaising with the Chairperson and the members of the Steering Committee;

(d) Managing the relations of the Secretariat with the signatories of the MoU and partner organizations, as well as national governments and regional bodies;

(e) Being responsible for raising additional funds for the COSF beyond the contributions of the signatories of the MoU;

(f) Allocating budget against activities according to the priorities agreed by the Steering Committee;

(g) Serving as the channel for communication between the Steering Committee and the signatories of the MoU, funding organizations and other stakeholders;

(h) Collaborating, as required, with the Executive Heads of the signatories of the MoU.

ANNEX C: FINANCIAL ARRANGEMENTS

1. The planning and implementation activities for GCOS will be financed by the sponsoring organizations, with funds appropriated in their budgets, and from extrabudgetary resources, which will have to be adequate enough to maintain the basic resources to operate the GCOS Secretariat. Each sponsoring organization will make appropriate annual financial contributions to the COSF or through other agreed upon arrangements.
2. The Secretary-General of WMO shall administer the COSF made available from the sponsoring organizations and extrabudgetary resources in support of GCOS activities. The Fund will be administered in accordance with WMO Financial Regulations.
3. Contributions in-kind such as secondment of staff, provision of facilities, or support for meetings, publications, or other expenses, may be made by sponsoring organizations, supporting nations and participating organizations and agencies.
4. The Fund will adopt a biennial budget and reporting cycle, consistent with the practice of WMO. Corresponding periodic financial reports will be made available to the sponsoring organizations.
5. The cost of staff seconded to the GCOS Secretariat will normally be supported by the responsible sponsoring organizations. Alternatively, a sponsoring organization or participating agency may choose to make a financial contribution to the COSF, in the appropriate amount, to cover the cost of a position. WMO Regulations shall apply to staff positions.
6. A comprehensive budget estimate for all GCOS planning activities and the activities of the Steering Committee and its supporting staff will be submitted by the Director of the GCOS Secretariat to the Executive Heads of the sponsoring organizations, in due time for consideration in the preparation of programme and budget proposals, as required.
7. Additional contributions and grants to the COSF from sources other than sponsoring organizations may be accepted by the Secretary-General of WMO, provided the purposes of such contributions and grants are consistent with the overall objectives and tasks of GCOS, as described in this Memorandum of Understanding. The specific activities funded from such grants will be treated as an addition to the programme and level of expenditure approved for GCOS.
8. Should the activities of GCOS be brought to an end, then the remaining balance of the COSF, after the settlement of all financial commitments by the Secretary-General of WMO, will either be donated to WMO for the execution of specific scientific and technical activities subject to the agreement of the sponsoring organizations and other donors of GCOS, or it will be shared among the sponsoring organizations and other donors in proportion to their respective contributions to the Fund over the previous two years immediately preceding the end of GCOS.
9. These financial arrangements may be modified at any time by mutual agreement among the sponsoring organizations provided that no modification would result in conflict with applicable WMO Financial Regulations.
10. In case of doubt as to the interpretation or application of any of the present provisions, the Secretary-General of WMO is authorized to rule thereon, subject to prior consultation with the Executive Heads of the sponsoring organizations.

Appendix B: GCOS 1998 Memorandum of Understanding

MEMORANDUM OF UNDERSTANDING BETWEEN
THE WORLD METEOROLOGICAL ORGANIZATION
THE INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION OF THE
UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION
THE UNITED NATIONS ENVIRONMENT PROGRAMME AND
THE INTERNATIONAL COUNCIL FOR SCIENCE

The WMO, the IOC of UNESCO, the UNEP, and the ICSU,

NOTING:

- (1) The recommendation of the Second World Climate Conference concerning the creation of a Global Climate Observing System;
- (2) Resolution XVI-8 of the sixteenth session of the IOC Assembly, to undertake the development of a Global Ocean Observing System and participate in the Global Climate Observing System;
- (3) Resolution 10 (Cg-XII) of the twelfth World Meteorological Congress, to continue the Global Climate Observing System;
- (4) Resolution 21 (Cg-XI) on the relationship between the Global Ocean Observing System and the Global Climate Observing System;
- (5) The decision of the sixtieth meeting of the ICSU Executive Board that ICSU should join WMO and IOC of UNESCO in the formation of the Global Climate Observing System;
- (6) The decision of the sixteenth session of the UNEP Governing Council that UNEP should support, within available resources, the creation of a Global Climate Observing System and assist in ensuring that its development and implementation are pursued with urgency;
- (7) Agenda 21 which calls for systematic observations in support of sustainable development;
- (8) The UN Framework Convention on Climate Change with Articles 4 and 5 committing parties to promote and cooperate in systematic observation;
- (9) Recommendations made by the Commission on Sustainable Development toward the development of global environmental observing systems;
- (10) The Climate Agenda, which supports, in Thrust 4, the Dedicated Observations of the Climate System;

RECOGNIZING the need to acquire comprehensive information on the properties and evolution of the earth's climate system, for detecting climate change, observing climate variability including its impact, supporting climatological applications for economic development, and developing climate system science and predictions,

CONSIDERING that the required information will encompass data from operational meteorological, hydrological, oceanographic and other relevant programmes, as well as observations from research programmes conducted by scientific institutions and space agencies.

AGREE:

- (1) To cooperate in organizing and supporting a Global Climate Observing System (GCOS) based on the coordination of existing or planned operational and research programmes for observing the global climate system, and the further development of these programmes as required to ensure continuity of observations;
- (2) That the GCOS shall, as its long-range objectives, support all aspects of the World Climate Programme and relevant aspects of other climate-related global programmes. Specifically the GCOS will ensure the data needs are met for climate system monitoring, for assessing the impacts of climate variability and change and applications to national economic development, as well as research leading to improved understanding, modelling and prediction of the climate system;
- (3) To consult and call upon other relevant national and international agencies, institutions and organizations, to collaborate in the organization and participate in the implementation of the GCOS;
- (4) To establish a GCOS Steering Committee, to provide scientific and technical guidance for the organization and further development of the GCOS, and a GCOS Secretariat;
- (5) To support, through appropriate administrative and financial arrangements, the activities of the Steering Committee and Secretariat for GCOS.

AGREE FURTHER that the GCOS Steering Committee shall be regarded by the sponsoring organizations as the main scientific and technical body for formulating the overall concept and scope of the GCOS, and advising on the further development of the GCOS.

APPROVE the procedures to be followed in implementing this Memorandum of Understanding which are specified in the following Annexes:

- ANNEX A: Concept of the Global Climate Observing System;
- ANNEX B: Terms of reference, structure and functions of the GCOS Steering Committee and supporting staff;
- ANNEX C: Financial arrangements.

AGREE: that this Memorandum of Understanding shall be reviewed every four years by the sponsoring organizations, and may be called for review at any time by one of the sponsoring organizations.

AGREE: that other organizations and agencies, which contribute to the implementation of the GCOS and wish to join in the sponsorship of the GCOS, may become a party to this Memorandum of Understanding, including its appropriate administrative and financial arrangements.

AGREE that this Memorandum of Understanding shall come into force on signature by all four parties.

Secretary-General
WMO

Executive Secretary
TSC

Secretary-General
ICSU

Executive Director
UNEP

Place GENEVA
Date 7 July 1998

Place PARIS
Date 29.9.98

Place PARIS
Date Sep. 14. 1998

Place Nairobi
Date 18.9.1998

ANNEX A

CONCEPT OF THE GLOBAL CLIMATE OBSERVING SYSTEM

1. The goal of the Global Climate Observing System (GCOS) is to provide comprehensive information on the total climate system, involving a multi-disciplinary range of physical, chemical and biological properties, and atmospheric, oceanic, hydrologic, cryospheric and terrestrial processes.
2. The GCOS is intended to meet the needs for:
 - (a) Climate system monitoring, climate change detection and monitoring the impacts of and the response to climate change, especially in terrestrial ecosystems and mean sea-level;
 - (b) Data for application to national economic development;
 - (c) Research toward improved understanding, modelling and prediction of the climate system.
3. The GCOS will build, as far as possible, on existing operational and scientific observing, data management and information distribution systems, and further enhancements of these systems. The GCOS will be based upon, *inter alia* :
 - (a) Improved World Weather Watch systems and the Integrated Global Ocean Services System;
 - (b) The Global Atmosphere Watch and related atmospheric constituent observing systems;
 - (c) The Global Ocean Observing System for physical, chemical and biological measurements;
 - (d) The Global Terrestrial Observing System for land surface ecosystem, hydrosphere, and cryosphere measurements;
 - (e) The maintenance and enhancement of programmes monitoring other key components of the climate system, such as terrestrial ecosystems (including the International Geosphere-Biosphere Programme), as well as clouds and the hydrological cycle, the earth's radiation budget, ice sheets and precipitation over the oceans (including the World Climate Research Programme);
 - (f) Programmes to monitor the key physical, chemical and biological aspects of the impacts of climate change (including the World Climate Impact Assessment and Response Strategies Programme);
 - (g) Data communication and other infrastructures necessary to support operational climate forecasting (including the World Climate Data and Monitoring Programme and the Climate Information and Prediction Services).

ANNEX B

TERMS OF REFERENCE, STRUCTURE AND FUNCTIONS OF THE GCOS STEERING COMMITTEE AND GCOS SECRETARIAT

1. Terms of reference

1.1 The functions of the GCOS Steering Committee are to formulate the overall concept and scope of the GCOS, and to provide scientific and technical guidance to sponsoring and participating organizations, and agencies for the planning, implementation and further development of the GCOS.

1.2 Specifically, the Steering Committee will be called upon:

- (a) To identify observational requirements, define design objectives and recommend coordinated actions by sponsoring and participating organizations and agencies, in order to optimize the system's performance and coherence, taking cognizance of the responsibilities, working arrangements and recommendations of established scientific and technical bodies of such organizations and agencies;
- (b) To review and assess the development and implementation of the components of the GCOS, and report to the sponsoring organizations, and to the participating agencies as required;
- (c) To facilitate the exchanges of information among sponsoring and participating organizations and agencies, and in general make the objectives, resource requirements capabilities and outputs of GCOS known to relevant national and international bodies.

2. Membership

2.1 The Steering Committee shall be appointed jointly by the Executive Heads of the sponsoring organizations by mutual consent.

2.2 The Steering Committee shall consist of up to sixteen scientific and technical experts selected on the basis of their personal expertise. The Chairs of standing panels will be members *ex officio*.

2.3 The membership of the Steering Committee shall aim to include a balanced geographical representation of major operational and research observing programmes contributing to the GCOS, as well as an appropriate mix of disciplines in atmospheric, oceanic, hydrological, cryospheric and biospheric sciences. Experts in both *in situ* and remote sensing techniques will be included.

2.4 The members will be appointed for an initial term of appointment of two years. The membership shall be reviewed regularly by the Executive Heads of the sponsoring organizations, bearing in mind the need to ensure reasonable continuity and influx of new members. Members shall not normally serve more than six years.

3. Officers

3.1 The officers of the Steering Committee shall consist of a Chair, and First, Second, and Third Vice-Chairs selected by the Executive Heads of the sponsoring organizations and appointed for two-year terms.

3.2 The duties of the Chair of the Steering Committee shall be:

- (a) To preside over the sessions of the Committee and respond to its decisions;

- (b) To act on behalf of the Committee between meetings;
- (c) To guide the activities of the GCOS Secretariat, with respect to the fulfilment of GCOS plans and tasks;
- (d) To conduct, either directly or through appropriate sponsoring organizations, correspondence on matters related to the organization, planning and implementation of GCOS;
- (e) To carry out specific duties as prescribed by decisions taken in agreement by the sponsoring organizations;
- (f) To ensure that the activities and recommendations of the Steering Committee are in accordance with the joint objectives of the sponsoring organizations, as recorded in this Memorandum of Understanding;
- (g) To arrange for the views of the Steering Committee to be presented to the sponsoring organizations;
- (h) To prepare annually, with the GCOS Secretariat, a report of GCOS planning and implementation activities, including the considerations and recommendations by the JSTC, and to present this report to the sponsoring organizations.

3.3 The duties of the Vice-Chairs are to assist the Chair in his tasks and to substitute for him/her when necessary.

4. Sessions

4.1 The Steering Committee shall meet at least annually, the venue and dates to be decided by the Chair of the Committee in consultation with the Secretary-General of WMO. Sessions shall normally be arranged so as to avoid scheduling conflicts with meetings of executive bodies of the sponsoring organizations.

4.2 The Director of the GCOS Secretariat, acting on behalf of the Chair of the Committee, shall inform the sponsoring and participating organizations and agencies, notify the members and make appropriate practical arrangements for the session.

4.3 Each sponsoring organization shall nominate one or two representatives to participate in the sessions of the Committee. The attendance of these representatives shall not be charged to the GCOS Fund.

4.4 Representatives of participating organizations and agencies and of the other observing systems, GOOS and GTOS, may be invited to attend the sessions, in the capacity as observers.

4.5 Individual experts may be invited to participate in the sessions upon decision of the Chair of the Committee. The sponsoring organizations shall be informed of such invitations.

4.6 The Secretary-General of WMO shall provide such interpretation facilities as may be required, within budgetary provisions. Documents will normally be distributed in the original language in which they were submitted.

5. Working Groups and Consultants

5.1 The Steering Committee shall be authorized to establish and convene working groups, panels of scientific and technical experts, special study groups, etc. within its field of responsibility and within the

budget approved by the sponsoring organizations, taking account of relevant scientific or technical groups established by the sponsoring organizations and their constituent bodies.

5.2 The membership, terms of reference and special requests addressed to working groups will be documented by the Director of the GCOS Secretariat on behalf of the Chair of the Committee.

6. GCOS Secretariat

6.1 The general functions of the GCOS Secretariat shall be to assist the Steering Committee in formulating the concept and in organizing the implementation of the GCOS, and any other organizational or technical task, as the Steering Committee may decide. In particular, the Secretariat, under the responsibility of its Director, shall take charge for:

- (a) Assisting the Steering Committee in preparing plans and other guidance material for the development and implementation of the GCOS;
- (b) Providing secretarial support to the Steering Committee;
- (c) Maintaining scientific and technical liaison with relevant departments and constituents bodies of the sponsoring organizations, and all other relevant institutions or agencies, as required for the development and implementation of GCOS;
- (d) Serving as the documentation and information centre for GCOS and preparing information or action documents pertaining to GCOS, as required by the sponsoring organizations;
- (e) Making arrangements for GCOS planning and coordination activities, in accordance with the provisions of Annex C on Financial Arrangements and following the guidelines provided by the Steering Committee.

6.2 The Secretariat shall be composed of a Director and supporting scientific, technical and clerical staff seconded by the sponsoring organizations and other participating agencies, or supported directly by the Climate Observing System Fund (COSF).

6.3 The Director will be selected by consensus agreement of the Executive Heads of the sponsoring organizations and the Officers of the GCOS Steering Committee. The Director will normally have the status of a staff member of WMO and will be appointed by the Secretary-General of WMO.

6.4 The Director will be responsible, for scientific and technical tasks discharged by the Secretariat, to the Chair of the Steering Committee acting on behalf of the sponsoring organizations, and for administrative and financial matters, to the Secretary-General of WMO, in accordance with the provisions in Annex C.

6.5 The duties of the Director shall be:

- (a) To direct the work of the GCOS Secretariat;
- (b) To guide and support the activities of working groups set up by the Steering Committee;
- (c) To maintain liaison with the Chair and the members of the Steering Committee;
- (d) To serve as the channel for communication between the Steering Committee and the sponsoring and participating organizations and agencies;

(e) To collaborate, as required, with the Executive Heads of the sponsoring organizations.

6.6 The climate-related component of the GOOS will form the oceanographic component of the Joint Planning Office for GCOS, under the authority of the Director of the GCOS Secretariat.

6.7 The climate-related component of the GTOS will form the terrestrial component of the GCOS, under the authority of the Director of the GCOS Secretariat.

ANNEX C

FINANCIAL ARRANGEMENTS

1. The planning and implementation activities for the Global Climate Observing System (GCOS) will be financed by the sponsoring organizations, each from funds appropriated in their budgets for this purpose, and from extra-budgetary resources.
2. The Secretary-General of WMO shall administer the Climate Observing System Fund (COSF) made available from the sponsoring organizations and extra-budgetary resources in support of GCOS activities. The Fund will be administered in accordance with WMO Financial Regulations.
3. Each sponsoring organization will make appropriate annual financial contributions to the Climate Observing System Fund or through other agreed upon arrangements.
4. Other contributions in kind such as secondment of staff, provision of facilities, or support for meetings, publications, or other expenses may be made by sponsoring organizations, supporting nations and participating organizations and agencies.
5. The Fund will adopt a biennial budget and reporting cycle, consistent with the practice of WMO. Corresponding periodic financial reports will be made available to the sponsoring organizations.
6. The cost of staff seconded to the GCOS Secretariat will normally be supported by the responsible sponsoring organizations. Alternatively, a sponsoring organization or participating agency may choose to make a financial contribution to the COSF, in the appropriate amount, to cover the cost of a position. WMO Regulations shall apply to staff positions.
7. A comprehensive budget estimate for all GCOS planning activities and the activities of the Steering Committee and its supporting staff will be submitted by the Chair of the Steering Committee to the Executive Heads of the sponsoring organizations, in due time for consideration in the preparation of programme and budget proposals, as required.
8. Additional contributions and grants to the COSF from sources other than sponsoring organizations may be accepted by the Secretary-General of WMO, provided the purposes of such contributions and grants are consistent with the overall objectives and tasks of GCOS, as described in this Memorandum of Understanding. The specific activities funded from such grants will be treated as an addition to the programme and level of expenditure approved for GCOS.
9. Should the activities of the GCOS be brought to an end, then the remaining balance of the COSF, after the settlement of all financial commitments by the Secretary-General of WMO, will either be donated to WMO for the execution of specific scientific and technical activities subject to the agreement of the sponsoring organizations and other donors of GCOS or it will be shared among the sponsoring organizations and other donors in proportion to their respective contributions to the Fund over the previous two years immediately preceding the end of GCOS.
10. These financial Arrangements may be modified at any time by mutual agreement among the sponsoring organizations provided that no modification would result in conflict with applicable WMO Financial Regulations.
11. In case of doubt as to the interpretation or application of any of the present provisions, the Secretary-General of WMO is authorized to rule thereon, subject to prior consultation with the Executive Heads of the sponsoring organizations.

Appendix C: GCOS 1998 Memorandum of Understanding

MEMORANDUM OF UNDERSTANDING BETWEEN
THE WORLD METEOROLOGICAL ORGANIZATION
THE INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION OF THE
UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION
THE INTERNATIONAL COUNCIL OF SCIENTIFIC UNIONS AND
THE UNITED NATIONS ENVIRONMENT PROGRAMME

The WMO, the IOC of UNESCO, the ICSU and the UNEP,

NOTING,

(1) The recommendation, embodied in paragraphs 5 to 8 of Section C in the statement of the Second World Climate Conference, concerning the creation of a Global Climate Observing System;

(2) Resolution XVI-8 of the sixteenth session of the IOC Assembly, to undertake the development of a Global Ocean Observing System and participate in the Global Climate Observing System;

(3) Resolution 9 (Cg-XI) of the eleventh World Meteorological Congress, to establish a Global Climate Observing System;

(4) Resolution 21 (Cg-XI) on the relationship between the Global Ocean Observing System and the Global Climate Observing System.

(5) The decision of the sixtieth meeting of the ICSU Executive Board that ICSU should join WMO and IOC of UNESCO in the formation of the Global Climate Observing System.

(6) The decision of the sixteenth session of the UNEP Governing Council that UNEP should support, within available resources, the creation of a Global Climate Observing System and assist in ensuring that its development and implementation are pursued with urgency.

RECOGNIZING the need to acquire comprehensive information on the properties and evolution of the earth's climate system, for detecting climate change, supporting climatological applications for economic development, and developing climate system science and predictions,

CONSIDERING that the required information will encompass data from operational meteorological, hydrological, oceanographic and other relevant programmes, as well as observations from research programmes conducted by scientific institutions and space agencies.

AGREE,

(1) To co-operate in organizing a Global Climate Observing System (GCOS), based on the co-ordination of existing or planned operational and research programmes for observing the global climate system, and the further development of these programmes as required to ensure continuity of observations;

(2) That the GCOS shall have, as its long-range objectives, to support all aspects of the World Climate Programme and relevant aspects of other climate-related global programmes, specifically to meet the data needs for climate system monitoring, and for use in assessing the impacts of climate variability and change and applications to national economic development, as well as research leading to improved understanding, modelling and prediction of the climate system;

(3) To consult and call upon other relevant national and international agencies, institutions and organizations, to collaborate in the organization and participate in the implementation of the GCOS,

(4) To establish a Joint Scientific and Technical Committee (JSTC), to provide scientific and technical guidance for the organization and further development of the GCOS, and a Joint Planning Office,

(5) To support, through appropriate administrative and financial arrangements, the activities of the JSTC for GCOS and its planning staff.

AGREE FURTHER that the Joint Scientific and Technical Committee shall be regarded by the sponsoring organizations as the main scientific and technical body for formulating the overall concept and scope of the GCOS and advising on the further development of the GCOS.

APPROVE the procedures to be followed in implementing this Memorandum of Understanding which are specified in the following Annexes:

ANNEX A: Concept of the Global Climate Observing System,

ANNEX B: Terms of reference, structure and functions of the Joint Scientific and Technical Committee (JSTC) and supporting staff,

ANNEX C: Financial arrangements.

AGREE that this Memorandum of Understanding shall be reviewed every four years by the sponsoring organizations, and may be called for review at any time by one of the sponsoring organizations.

AGREE that other organizations and agencies, which contribute to the implementation of the GCOS and wish to join in the sponsorship of the GCOS, may become a party to this Memorandum of Understanding, with appropriate administrative and financial arrangements.

AGREE that this Memorandum of Understanding shall come into force on signature by all four parties.

Secretary-General
WMO

Secretary
IOC

Secretary-General
ICSU

Executive Director
UNEP

Place: GENEVA

Place: Paris

Place: Paris

Place: Geneva

Date: 5/2/92

Date: 7/2/92

Date: 20/2/92

Date: 2/4/1992

A N N E X A

CONCEPT OF THE GLOBAL CLIMATE OBSERVING SYSTEM

1. The goal of the Global Climate Observing System (GCOS) is to provide comprehensive information on the total climate system, involving a multi-disciplinary range of physical, chemical and biological properties and atmospheric, oceanic, hydrologic, cryospheric and terrestrial processes.
 2. The GCOS is intended to meet the needs for:
 - (a) Climate system monitoring, climate change detection and monitoring of the impacts of and the response to climate change, especially in terrestrial ecosystems and mean sea-level,
 - (b) Data for application to national economic development,
 - (c) Research towards improved understanding, modelling and prediction of the climate system.
 3. The GCOS will build, as far as possible, on existing operational and scientific observing, data management and information distribution systems, and further enhancement of these systems. The GCOS will be based upon:
 - (a) Improved World Weather Watch systems and the Integrated Global Ocean Services System,
 - (b) Data communication and other infrastructures necessary to support operational climate forecasting,
 - (c) The establishment of a Global Ocean Observing System for physical, chemical and biological measurements,
 - (d) The maintenance and enhancement of programmes monitoring other key components of the climate system, such as the distribution of important atmospheric constituents (including the Global Atmosphere Watch), terrestrial ecosystems (including the International Geosphere-Biosphere Programme), as well as clouds and the hydrological cycle, the earth's radiation budget, ice sheets and precipitation over the oceans (including the World Climate Research Programme).
 - (e) Programmes to monitor the key physical, chemical and biological aspects of the impacts of climate change (including the World Climate Impact Assessment and Response Strategies Programme).
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A N N E X B

TERMS OF REFERENCE, STRUCTURE AND FUNCTIONS OF THE JOINT SCIENTIFIC AND TECHNICAL COMMITTEE AND SUPPORTING STAFF

1. Terms of reference

1.1 The functions of the Joint Scientific and Technical Committee (JSTC) are to formulate the overall concept and scope of the GCOS, and to provide scientific and technical guidance to sponsoring and participating organizations and agencies for the planning and further development of the GCOS.

1.2 Specifically, the JSTC will be called upon:

- (a) To identify observational requirements, define design objectives and recommend co-ordinated actions by sponsoring and participating organizations and agencies, in order to optimize the system's performance and coherence, taking cognizance of the responsibilities, working arrangements and recommendations of established scientific and technical bodies of such organizations and agencies;
- (b) To review and assess the development and implementation of the components of the GCOS, and report to the sponsoring organizations, and to the participating agencies as required;
- (c) To facilitate the exchanges of information among sponsoring and participating organizations and agencies and, in general, make the objectives, resource requirements and capabilities of GCOS known to relevant national and international bodies.

2. Membership

2.1 The JSTC shall be appointed jointly by the Executive Heads of the sponsoring organizations, after consultation with other relevant international organizations and participating agencies.

2.2 The JSTC shall consist of fifteen scientific and technical experts selected on the basis of their personal expertise and appointed by mutual agreement between the sponsoring organizations.

2.3 The membership of JSTC shall aim to include a balanced representation of major operational and research observing programmes contributing to the GCOS, as well as an appropriate mix of disciplines in atmospheric, oceanic, hydrological, cryospheric and biospheric sciences.

2.4 The members will be appointed for an initial term of appointment of two years. The membership of the JSTC shall henceforth be reviewed every second year by the Executive Heads of the sponsoring organizations, after consultation with relevant international organizations and participating national agencies, bearing in mind the need to ensure reasonable continuity in the Committee's membership. To that effect, the term of appointment for any member of the JSTC shall not normally be less than two successive terms.

3. Officers

3.1 The Officers of the JSTC shall consist of a Chairman, a First Vice-Chairman and a Second Vice-Chairman selected by the Executive Heads of the sponsoring organizations and appointed for two-year terms.

3.2 The duties of the Chairman of the JSTC shall be:

- (a) To preside over the sessions of the Committee;
- (b) To act on behalf of the Committee between meetings;
- (c) To guide the activities of the Joint Planning Office for GCOS, with respect to the fulfilment of GCOS scientific and technical planning tasks;
- (d) To conduct, either directly or through appropriate sponsoring organizations, correspondence on matters related to the organization, planning and implementation of GCOS;
- (e) To carry out specific duties as prescribed by decisions taken in agreement by the sponsoring organizations;
- (f) To ensure that the activities and recommendations of the JSTC are in accordance with the joint objectives of the sponsoring organizations, as recorded in this Memorandum of Understanding;
- (g) To arrange for the views of the JSTC to be presented to the sponsoring organizations;
- (h) To prepare annually a report of GCOS planning activities, including the considerations and recommendations by the JSTC, and to present this report to the sponsoring organizations.

3.3 The duties of the Vice-chairmen are to assist the Chairman in his tasks. The First Vice-Chairman or, if not available, the Second Vice-Chairman will replace the Chairman whenever necessary.

4. Sessions

4.1 The JSTC shall meet at least annually, the venue and dates to be decided by the Chairman of the Committee. Sessions shall normally be arranged so as to avoid scheduling conflicts with meetings of executive bodies of the sponsoring organizations.

4.2 The Director of the Joint Planning Office for GCOS, acting on behalf of the Chairman of the Committee, shall inform the sponsoring and participating organizations and agencies, notify the members and make appropriate practical arrangements for the session.

4.3 Each sponsoring organization shall nominate one or two representatives to participate in the sessions of the Committee. The attendance of these representatives shall not be charged to the GCOS Fund.

4.4 Representatives of participating organizations and agencies may be invited to attend the sessions, in the capacity as observers, by the Chairman of the Committee with the consent of the sponsoring organizations. The attendance of such observers shall not be charged to the GCOS Fund.

4.5 Individual experts may be invited to participate in the sessions upon decision of the Chairman of the Committee. The sponsoring organizations shall be informed of such invitations.

4.6 The Secretary-General of WMO shall provide such interpretation facilities as may be required, within budgetary provisions. Documents will normally be distributed in the original language in which they were submitted.

5. Working Groups and Consultants

5.1 The JSTC shall be authorized to establish and convene working groups, panels of scientific and technical experts, special study groups, etc. within its field of responsibility and within the budget approved by the sponsoring organizations, taking account of relevant scientific or technical groups established by the sponsoring organizations and their constituent bodies.

5.2 The membership, terms of reference and special requests addressed to working groups will be notified by the Director of the Joint Planning Office, on behalf of the Chairman of the Committee.

6. Joint Planning Office for GCOS (JPO)

6.1 The general functions of the Joint Planning Office shall be to assist the JSTC in formulating the concept and in organizing the implementation of the GCOS, and any other organizational or technical task, as the JSTC may decide. In particular, the JPO, under the responsibility of its Director, shall take charge for:

- (a) Assisting the JSTC in preparing plans and other guidance material for the development and implementation of the GCOS;
- (b) Providing secretarial support to the JSTC;
- (c) Maintaining scientific and technical liaison with relevant departments and constituent bodies of the sponsoring organizations, and all other relevant institutions or agencies, as required for the development and implementation of GCOS;
- (d) Serving as the documentation and information centre for GCOS and preparing information or action documents pertaining to GCOS, as required by the sponsoring organizations;
- (e) Making arrangements for GCOS planning and co-ordination activities, in accordance with the provisions of Annex C on Financial Arrangements and following the guidelines provided by the JSTC.

6.2 The Joint Planning Office shall be composed of a Director and supporting scientific, technical and clerical staff seconded by the sponsoring organizations and other participating agencies, or supported directly by the Climate Observing System Fund.

6.3 The Director will be selected by consensus agreement of the Executive Heads of the sponsoring organizations and the Officers of the Joint Scientific and Technical Committee for GCOS. The Director will normally have the status of a staff member of WMO and will be appointed by the Secretary-General of WMO.

6.4 The Director will be responsible, for scientific and technical tasks discharged by the Joint Planning Office, to the Chairman of the JSTC acting on behalf of the sponsoring organizations and, for administrative and financial matters, to the Secretary-General of WMO, in accordance with the provisions in Annex C.

6.5 The duties of the Director shall be:

- (a) To direct the work of the Joint Planning Office;
- (b) To guide and support the activities of working groups set up by the JSTC;
- (c) To maintain liaison with the chairman and the members of the JSTC;
- (d) To serve as the channel for communication between the JSTC and the sponsoring and participating organizations and agencies;
- (e) To collaborate, as required, with the Executive Heads of the sponsoring organizations.

6.6 The climate-related component of the GOOS Support Office, established by the IOC in co-operation with WMO, will form the oceanographic component of the Joint Planning Office for GCOS, under the authority of the Director of the Joint Planning Office.

A N N E X C

Financial Arrangements

Funding

1. The planning activities for the Global Climate Observing System (GCOS) will be financed by the sponsoring organizations, each from funds appropriated in their budgets for this purpose, and from extra-budgetary resources.
2. Disbursements from each organization in support of GCOS activities may be made upon the authority of the Executive Head of each organization. Alternatively, sponsoring organizations and participating agencies may choose to make funds available through contributions to a trust fund established for this purpose.
3. The Secretary-General of WMO shall open the trust fund, to be known as the Climate Observing System Fund (COSF), to administer extra-budgetary resources made available for support of GCOS activities. The Fund will be administered by the Secretary-General of WMO, on behalf of the sponsoring organizations, in accordance with WMO Financial Regulations.
4. The Fund will adopt a biennial budget and reporting cycle, consistent with the practice of WMO. Corresponding periodic financial reports will be made available to the sponsoring organizations.
5. The cost of staff seconded to the Joint Planning Office (JPO) for GCOS will normally be supported by the responsible sponsoring organizations. Alternatively, a sponsoring organization or participating agency may choose to make a financial contribution to the COSF, in the appropriate amount, to cover the cost of a JPO position. WMO Regulations shall apply to staff positions financed through the Fund.

Budget estimates

6. A comprehensive budget estimate for all GCOS planning activities and the activities of the Joint Scientific and Technical Committee (JSTC) and its supporting staff will be submitted by the chairman of the JSTC to the Executive Heads of the sponsoring organizations, in due time for consideration in the preparation of programme and budget proposals, as required.
7. Additional contributions and grants to the COSF from sources other than sponsoring organizations may be accepted by the Secretary-General of WMO, provided the purposes of such contributions and grants are consistent with the overall objectives and tasks of GCOS, as described in this Memorandum of Understanding. The specific activities funded from such grants will be treated as an addition to the programme and level of expenditure approved for GCOS.

Liquidation of the assets of the Global Observing System Fund

8. Should either the activities of the Scientific and Technical Committee or the commitment of one of the parties concerned, i.e. WMO, IOC, ICSU or UNEP, be brought to an end, then the remaining balance of the COSF, after the settlement of all financial commitments by the Secretary-General of WMO, will be shared between WMO, IOC, ICSU and UNEP or their liquidating authorities, in proportion to their respective contributions to the Fund.

Logistic support

9. Logistic support and services to the Joint Scientific and Technical Committee and its supporting staff will initially be provided by WMO, from the resources approved for this purpose in the regular WMO budget.

Other provisions

10. These Financial Arrangements may be modified at any time by mutual agreement between WMO, IOC, ICSU and UNEP, provided that no modification would result in conflict with applicable WMO Financial Regulations.

11. In case of doubt as to the interpretation or application of any of the present provisions, the Secretary-General of WMO is authorized to rule thereon, subject to prior consultation with the Secretary of IOC, the Secretary-General of ICSU and the Executive Director of UNEP.

Appendix D: Terms of Reference of the Joint Study Group

Joint WMO - IOC - ISC - UNEP Study Group on the Global Climate Observing System (JSG-GCOS)

These Terms of Reference were adopted by the World Meteorological Organization (WMO), the Intergovernmental Oceanographic Commission of UNESCO (IOC), the International Science Council (ISC), and the United Nations Environment Programme (UNEP). Any adjustments to the Terms of Reference proposed by these governing bodies in their sequential adoption will be harmonized by mutual agreement of the leaders of these bodies.

Purpose

The Joint WMO – IOC – ISC – UNEP Study Group on the Global Climate Observing System (JSG-GCOS, hereinafter “the Study Group”) will consider the governance and structure for the Global Climate Observing System (GCOS) and, if and as necessary, make recommendations for adoption by WMO, IOC, ISC and UNEP.

The governance and structure of GCOS should be reconsidered in the light of the WMO governance reform and the recommendation in the GCOS Review³³. The Review recommended that the co-sponsors of GCOS³⁴ might consider changing the GCOS governance structure in order to strengthen the level of support, recognizing the aim of GCOS to meet the needs of climate system monitoring, for assessing the impacts of climate variability and change, applications to economic development, as well as research leading to improved understanding, modelling and prediction of the climate system.

Making reference to the letter from the Co-sponsors to the Steering Committee in November 2019, the Study Group will use the findings of the 2014 GCOS Review as a baseline, taking into account the changing external environment and, in particular, the strategic directions of the Co-sponsors.

Activities

The proposed Study Group will review GCOS governance and structure, and:

- (a) Develop a proposal for an optimal governance and structure for GCOS, that recognizes GCOS as an activity across the WMO Infrastructure Commission, the Services Commission and Research Board, as well as relevant programmes of IOC, ISC, and UNEP. This proposal will:
 - (i) Ensure that the GCOS programme will continue to provide guidance and support to relevant observing systems to efficiently and consistently meet climate related needs, including driving further developments to address gaps and deficiencies;
 - (ii) Ensure that the GCOS programme will support the WMO earth system approach and climate services, and other relevant WMO activities in the framework of the WMO Strategic and Operating Plans and the WMO Integrated Global Observing

³³ GCOS Programme Review, Synthesis Report, March 2014, GCOS-181. See recommendation 11.

³⁴ As of February 2020, the sponsoring organizations are World Meteorological Organization (WMO), the Intergovernmental Oceanographic Commission of UNESCO (IOC), the International Science Council (ISC), and United Nations Environment Programme (UNEP)

System (WIGOS) (e.g. hydrology, research, disaster and risk reduction, space program);

- (iii) Ensure that the GCOS programme will support the strategic objectives of co-sponsors to ensure consistent and coherent observations of the climate system;
- (iv) Take into account the views of, and strengthen links with, partner agencies, coordinators and operators of major observing systems, as well as co-sponsors and partners of GCOS and other relevant organizations; and
- (v) Ensure that the GCOS governance structure will include an appropriate representation of co-sponsors, partners, stakeholders and donors of GCOS, and seek input, in particular from the United Nations Framework Convention of Climate Change (UNFCCC) and from the Intergovernmental Panel on Climate Change (IPCC), taking into account the historical partnership in terms of systematic observation and assessment of the climate system;

(b) Make recommendations on GCOS outputs that will:

- (i) Ensure that the needs of climate observations are better incorporated into the design, specification and operation of global observing systems, and also improve reporting to partners and stakeholders;
- (ii) Promote ways in which GCOS can partner to influence the requirements and guidance used by implementers of climate observations outside of National Meteorological and Hydrological Services; and
- (iii) Promote ways in which GCOS can participate in, or support, the implementation of initiatives undertaken by international science organizations, such as ISC, IOC, UNEP and others.

Expertise required

Understanding of climate observations and needs, climate policy, and climate services.

Membership

Membership will be drawn from the co-sponsors, and GCOS' partners and stakeholders. Members need to bring knowledge of the relevant activities of their organizations and of how these relate to GCOS.

These include the following recommended members:

- Existing GCOS Steering Committee Chair and one Co-Chair from each of the GCOS panels (currently the Atmospheric Observation Panel for Climate (AOPC), the Ocean Observations Panel for Physics and Climate (OOPC) and the Terrestrial Observation Panel for Climate (TOPC));
- Representatives of WMO, IOC, ISC and UNEP as co-sponsors; and
- Representatives of GCOS partners and contributing organizations including observing systems.

Budget

The 4-year budget allocated to the technical commissions is based on the assumption that the average size of the Study Group is 15 technical experts, including chair and vice-chair.

Members appointed by IOC, ISC, and UNEP would be supported by the respective organizations.

Duration

Recommendations to the co-sponsors of GCOS to be completed by Q1 2021, to be considered by their governing bodies with a view to adopting mutually compatible decisions on GCOS.

Modalities of work

- At least one face-to-face meeting
- By correspondence
- By tele/video conference

Expected outputs to be delivered to the WMO, IOC, ISC and UNEP governing bodies

- Preliminary report on progress to the co-sponsors of GCOS: Q4 2020
- Recommendations to the co-sponsors of GCOS to be completed by Q1 2021

Appendix E: Membership of Joint Study Group

Co-Chairs:

Qingchen Chao (CMA, WMO),
Martin Visbeck (GEOMAR, IOC and ISC)

Members:

Albrecht von Bargaen (WGClimate nominated by DWD)
Han Dolman, (GCOS Chair)
Karim Hilmi (Morocco, IOC).
Thelma Krug (TOPC Chair)
Jian Liu (UNEP)
Joanna Post (UNFCCC)
Sabrina Speich (OOPC Chair)
Kazuto Suda (GCOS SC, JMA)
Toste Tanhua (GOOS Chair)
Jean-Noel Thapaut (ECMWF, Copernicus)
Peter Thorne (AOPC Chair)
Michael Zemp (GCOS SC, Switzerland)

Consultant:

Sue Barrel (Australia)

Secretariat Support:

Anthony Rea
Simon Eggleston
Caterina Tassone
Belén Martín Míguez

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