GCOS

GLOBAL CLIMATE OBSERVING SYSTEM

1992 ★ 2012 20 Years in Service for Climate Observations

WMO

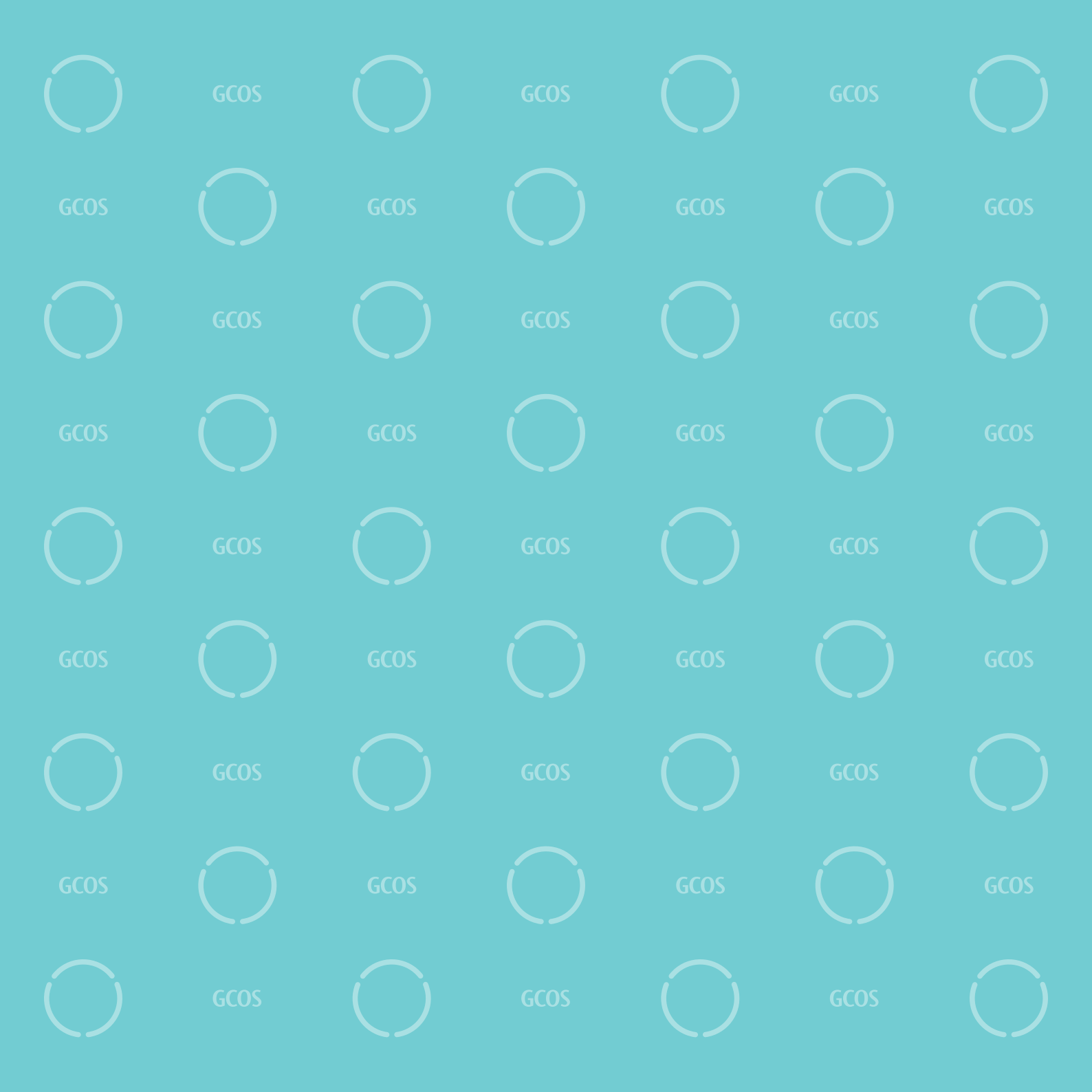
UNESCO

IOC

ICSU

International Council for Science

UNEP


GCOS

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Cover illustration: Summer morning landscape with the sea and mountains, Ukraine. Photo by Kotenko Oleksandr.
Lead author: David Goodrich

The demand for information on global climate has never been greater. Many regions in the world are clearly impacted by changes in climate, and those changes need to be managed now. It took years of work by the Intergovernmental Panel on Climate Change (IPCC), assessing the climate science literature, and by the World Climate Research Programme (WCRP), advancing the state of climate science, to raise the awareness that observations of climate need to be available on a global scale to underpin decisions. The year 2012 marks the 20th anniversary of the system dedicated to providing the observational data and information that is the foundation for our decisions on climate: the Global Climate Observing System (GCOS). This system, sponsored by the World Meteorological Organization, the Intergovernmental Oceanographic Commission of UNESCO, the United Nations Environment Programme, and the International Council for Science, formally came into being at the first meeting of the GCOS Joint Scientific and Technical Committee in Geneva in April 1992. This brochure will examine the forces that brought GCOS into being, some of the major highlights and accomplishments along the way, and a perspective on the future for the system.


Chapter

Background

The Situation in 1992

Consider the state of climate observation and research at the time of the founding of GCOS in 1992. Certainly, some fundamental climate records were already in place. The Global Observing System of the WMO World Weather Watch, established in 1967, provided essential global coordination of the conventional meteorological observing networks operated by individual countries. It served as the main source of climate observations worldwide. Observations of atmospheric carbon dioxide had been underway since 1958 and formed the basis for the WMO Global Atmosphere Watch, tracking changes in the chemical composition of the atmosphere. The satellite era of Earth observation was well underway, with a number of advanced research platforms being readied for launch.

It was an era of large global research programmes, driven by interest in climate. The World Climate Research Programme sponsored the Global Energy and Water Cycle Experiment, the Tropical Ocean-Global Atmosphere Programme, and the World Ocean Circulation Experiment. Interest in ozone depletion drove the formation of the International Global Atmospheric Chemistry Project, created in the late 1980's, to address growing international concerns over rapid changes observed in Earth's atmosphere.

However, it was also growing clear that major problems were embedded in the long-term observational record of climate, a record that would be vital to understanding and addressing the issue of climate change. The highly influential First Assessment Report of the IPCC was published in 1990. In addition to its findings on the state of the climate system, the IPCC made the following statement on the observing system:

> Systematic long term observations of the system are of vital importance for understanding the natural variability of the Earth's climate system, detecting whether man's activities are changing it, parameterising key processes for models, and verifying model simulations. Increased accuracy and coverage in many observations are required. Associated with expanded observations is the need to develop appropriate comprehensive global information bases for the rapid and efficient dissemination and utilization of data. The main observational requirements are:
>
> 1. The maintenance and improvement of observations (such as those from satellites) provided by the World Weather Watch Programme of WMO;
>
> 2. The maintenance and enhancement of a programme of monitoring, both from satellite-based and surface-based instruments of key climate elements for which accurate observations on a continuous basis are required, such as the distribution of important atmospheric constituents, clouds, the Earth's radiation budget, precipitation, winds, sea surface temperatures, and terrestrial ecosystem extent, type, and productivity;
>
> 3. The establishment of a global ocean observing system to measure changes in such variables as ocean surface topography, circulation, transport of heat and chemicals, and sea-ice extent and thickness;
>
> 4. The development of major new systems to obtain data on the oceans, atmosphere, and terrestrial ecosystems using both satellites and instruments based on the surface, on automated instrumented vehicles in the ocean, on floating and deep sea buoys, and on aircraft and balloons; and
>
> 5. The use of paleoclimatological and historical instrumental records to document natural variability and changes in the climate system, and the subsequent environmental response.

"On this auspicious occasion, marking two decades of truly exceptional achievements, it is indeed a pleasure for me to recall that GCOS was a key outcome of the Second World Climate Conference, which WMO organized in 1990 with its partners, and that from the outset GCOS has been a success story in contributing to ensure that the observations and information needed to address climate-related issues are defined, obtained and made available to all potential users. WMO has been pleased to support GCOS unfalteringly over its foundational period, in particular by hosting and decisively sustaining the GCOS Secretariat in WMO Headquarters in Geneva. Allow me to also recall that some of the earliest GCOS achievements, such as its GSN Surface and GUAN Upper-Air Networks, were erected over the WMO Global Observing System (GOS) of the National Meteorological and Hydrological Services (NMHSs) of WMO Members.

Today, in the wake of the 2009 Third World Climate Conference (WCC-3), WMO is spearheading another major global initiative, the Global Framework for Climate Services (GFCS), to assist all socio-economic sectors, in particular those of the developing world which are some of the most vulnerable, in coping with the impacts of climate variability and change, mitigating the risks of natural disasters and safeguarding food security, health and water resources, among some of the main GFCS priorities . Observations and Monitoring is one of the 5 GFCS foundational pillars, so I have no doubt that GCOS will once more rise to the challenges by decisively contributing to a swift and successful GFCS implementation. "

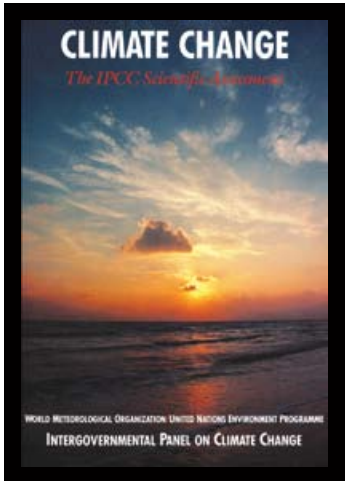
Michel Jarraud, Secretary General, World Meteorological Organization (WMO)

"IOC has had a long and productive relationship with GCOS, as the climate component of IOC's Global Ocean Observing System (GOOS) is the ocean component of GCOS. GCOS has been the role model of a clear framework for thinking about Essential Climate Variables, defining adequacy, requirements, implementation, and reporting on progress. Clearly we at IOC have learned a certain rigor from working in this framework and hope to apply it to further elements of ocean observations. GCOS has allowed us to integrate between atmospheric, oceanic, and terrestrial observations for climate.

GCOS has also been a strong voice for global observations at the UNFCCC, and has allowed the IOC, WMO, FAO, UNEP, and ICSU to speak together on this topic. Having this high-level recognition for observations is important. For our Member States, it provides a very high-level forum to promote their interests, and for our constituency, of the ocean observing community, these high-level plans help to raise funds nationally for ocean observations. "

Wendy Watson-Wright, Executive Secretary, Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization (IOC-UNESCO)

Establishment of the Global Climate Observing System



First Assessment Report of the IPCC, 1990

The need for a systematic approach to climate observation had been noted in other quarters as well. Following the first IPCC assessment (see figure, left), the Second World Climate Conference (WCC-2) was held in Geneva in 1990. A total of 908 participants from 137 countries attended the eight-day conference, and one of its major outcomes was the invitation of the World Meteorological Congress to strengthen monitoring and research within the World Climate Programme (WCP) in consultation with UNESCO, UNEP, and ICSU.

In light of the WCC-2 Conference Statement and Declaration, the Chairman of the Joint Scientific Committee for WCRP moved immediately to convene a meeting of experts to formulate a prospectus for the Global Climate Observing System (see figure below). The meeting was hosted by the UK Meteorological Office at Winchester in January 1991, and the concept and sponsorship arrangements were elaborated and agreed by the proposed sponsors. By early 1992, a Memorandum of Understanding was in place between WMO, IOC, UNEP, and ICSU for the establishment of the GCOS Programme. A Joint Planning Office was established at WMO Headquarters in Geneva, a Joint Scientific and Technical Committee was appointed, and, by mid-1995, a comprehensive GCOS plan had been finalized.

Origin of the Global Climate Observing System

Conference Statement

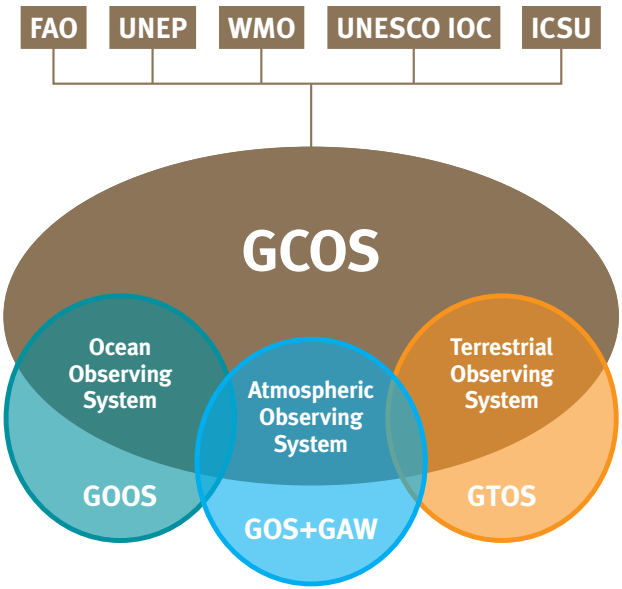
"Present observational systems for monitoring the climate system are inadequate for operational and research purposes. They are deteriorating in both industrialized and developing regions" (Part IC, para 3)

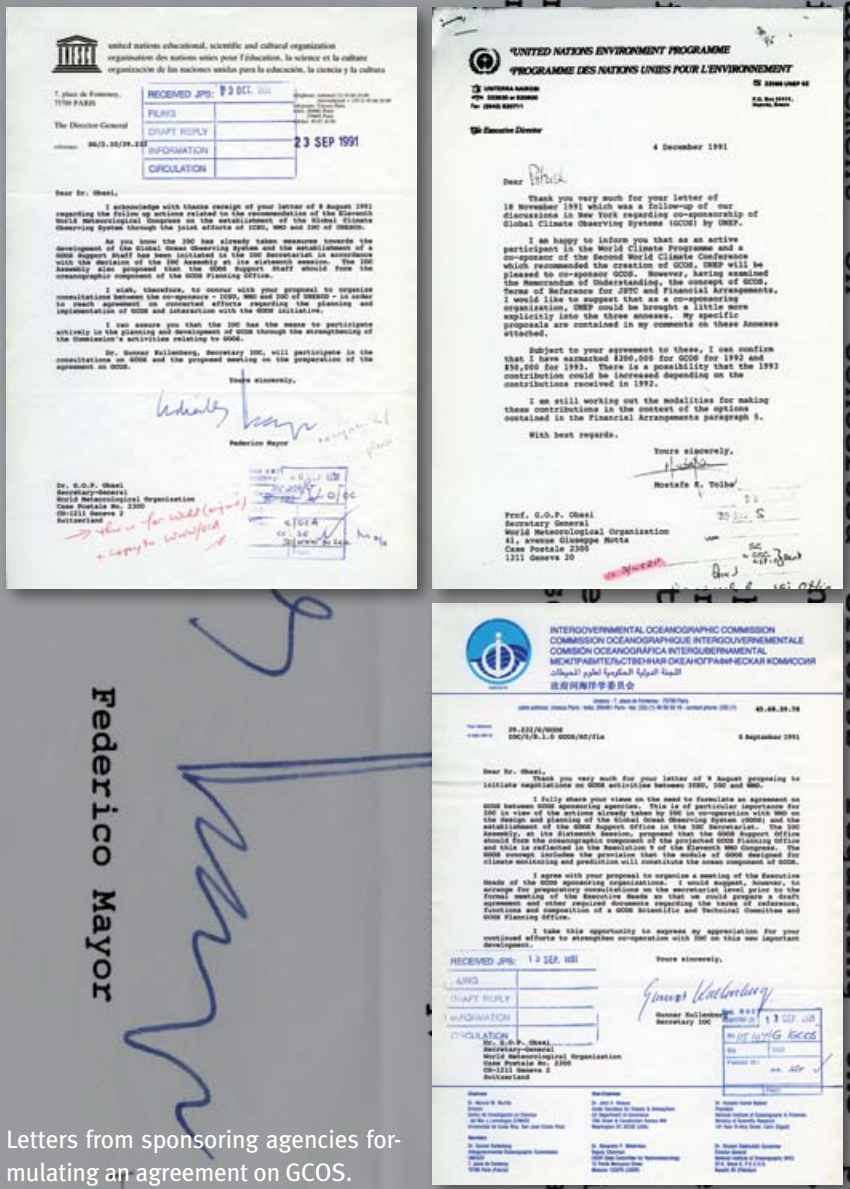
"There is an urgent need to create a *Global Climate Observing System* (GCOS) built upon the World Weather Watch Global Observing System and the Integrated Global Ocean Service System and including both space-based and surface-based observing components" (Part IC, para 5)

The Conference Statement (from *Climate Change: Science, Impacts and Policy – Proceedings of the Second World Climate Conference)* led to a programme proposal prepared by an ad hoc group, convened by the Chairman of the Joint Scientific Committee for the World Climate Research Programme at Winchester, United Kingdom, 14–15 January, 1991.

The fundamental design concept for the GCOS was to build it as a system of climate relevant components of the established observing systems (see figure below).

The GCOS was based on the WMO Global Observing System (GOS) and the Global Atmosphere Watch (GAW) for the atmosphere and the climate-relevant components of the then emerging Global Ocean Observing System (GOOS) and Global Terrestrial Observing System (GTOS), which were also co-sponsored in part by the co-sponsors of GCOS. The basic purpose of the GCOS was to meet the observational need for all components of the WCP, the IPCC, and the United Nations Framework Convention on Climate Change (UNFCCC).





Letters from sponsoring agencies formulating an agreement on GCOS.

The History and Evolution of the Programme Structure

The GCOS Programme was scientifically and technically advised by its Joint Scientific and Technical Committee, which was later renamed the GCOS Steering Committee (*see picture on opposite page)*. Three scientific panels were created to provide advice on the atmospheric, ocean, and terrestrial domains. Respectively, these are the Atmospheric Observation Panel for Climate (AOPC), the Ocean Observations Panel for Climate (OOPC), and the Terrestrial Observation Panel for Climate (TOPC). These panels are all co-sponsored by the World Climate Research Programme. The ocean panel is also sponsored by the IOC-led Global Ocean Observing System (GOOS), and the terrestrial panel is sponsored by the FAO-led Global Terrestrial Observing System (GTOS).

A cross-cutting panel, the Global Observing Systems Space Panel (GOSSP), was formed in 1995. This panel worked to refine the space requirements for space-based observations, but in 2001 the three domain panels absorbed the functions of GOSSP, and it was disbanded. The panel experts were asked to monitor whether requirements were being met by mission planning and implementation.

The second of the cross-cutting GCOS panels was the Data and Information Management Panel (DIMP), created in 1995. In 1997 the DIMP became JDIMP, a joint panel providing support to the three domain panels. The JDIMP had both a scientific and a technical role. In its technical role it addressed data access, archival, and distribution. As a scientific panel, its role was to assess the quality of data for specific science questions. In 2000, however, the GCOS Steering Committee disbanded the panel, determining that most of the functions originally defined for the JDIMP were now being carried out through alternative mechanisms, like the emerging Global Observing Systems Information Center (GOSIC), which was developed as a central entry point for users of GCOS, GOOS, and GTOS data and information systems.

In 2006, GCOS became a sponsor of the WCRP Observation and Assimilation Panel, which was expanded into the WCRP Data Advisory Council in 2012 and at which all three domain panels, AOPC, OOPC and TOPC, are represented.

Inagural Meeting of the GCOS Joint Scientific & Technical Steering Committee, April 13 – 15, 1992, at the World Meteorological Organization, Geneva, Switzerland (* Indicates Members of JSTC)

Front row: Arthur Dahl (UNEP, sponsor), Pierre Morel (ICSU/WCRP, sponsor), Ekundayo Balogun (* Nigeria), Andre Lebeau (* France), Sylvie Kalombratsos (Administrative Assistant Joint Planning Office for GCOS), Fredric Delsol (WMO, Atmospheric Research Programme)

Middle row: Alexandre Vasiliev (* Russian Federation), Shelby Tilford (* First Vice-chairman, USA), Claudio Caponi (* Second Vice-chairman,Venezuela), John Houghton (* Chairman, UK), Thomas Spence (Director, Joint Planning Office for GCOS), Angus McEwan (* Australia), Albert Tolkachev (IOC, sponsor)

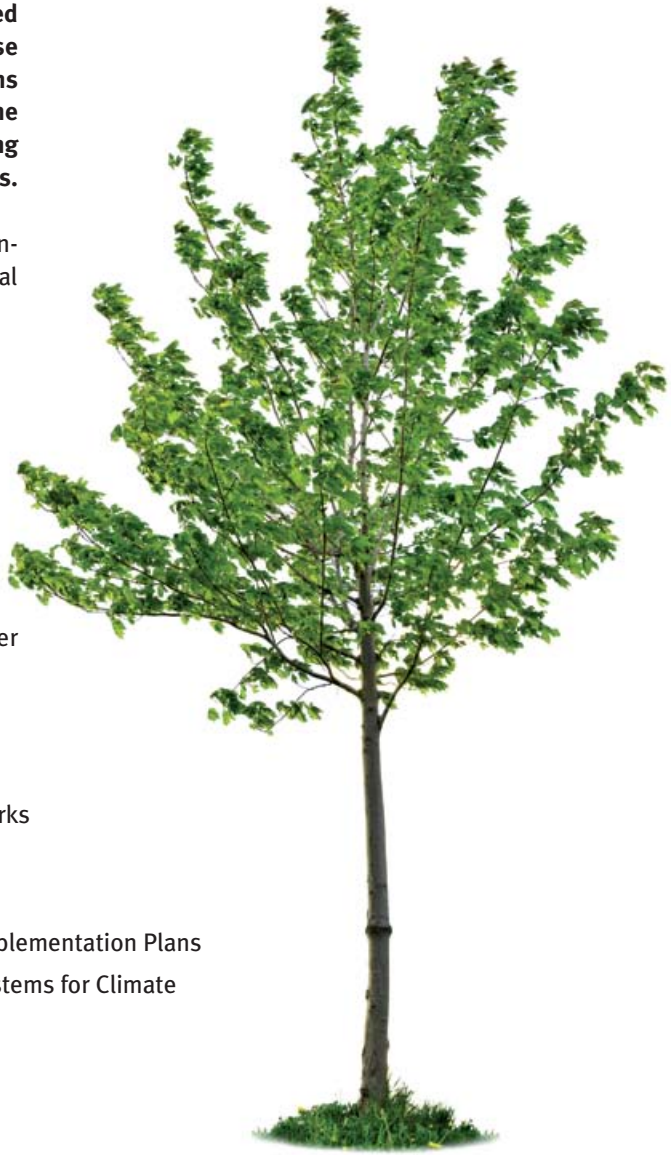
Back row: T. Maruyama (Japan), Worth Nowlin, Jr. (* USA), Yukio Haruyama (* Japan), Douglas Whelpdale (* Canada), Lennart Bengtsson (* Germany), David Axford (Deputy Secretary General of WMO, sponsor), Phillip Goldsmith (* UK), Alex Alusa (UNEP, sponsor), Ichtaque Rasool (WCRP), Su Jilan (* China), Francois Martin (Joint Planning Office for GCOS), Jürgen Meincke (* Germany), Shizuo Tsunogai (* Japan)


Chapter
II

Highlights and Accomplishments

The twenty years of the GCOS programme have been marked by accomplishments through strong partnerships. These achievements range from sharpening routine observations to the exacting demands of climate records, to aiding in the deployment of critical new observing systems, and to assisting developing countries in improving their observing networks.

The GCOS is implemented by a number of "agents of implementation." These include national agencies as well as international organizations, such as the sponsors of GCOS.



The results achieved through working with these partner organizations have been substantial and include:

- Defining the Atmospheric Observing Network
- Developing Ocean Observing Networks for Climate
- Facilitating the Expansion of Terrestrial Climate Networks
- Establishing Important Links to the UNFCCC
- Defining the GCOS Climate Monitoring Principles
- Producing the Adequacy and Progress Reports and Implementation Plans
- Promoting the Development of Satellite Observing Systems for Climate
- Implementing a GCOS Regional Workshop Programme

"The provision of long-term series of observational data is essential if humanity is to address the climate change challenges we face, and to develop our understanding of the climate system. ICSU has been a co-sponsor of the World Climate Research Programme and the Global Climate Observing System since they were established in 1980 and 1992 respectively. ICSU has worked consistently to ensure strong links between the global environmental change research programmes and the global environmental observing systems, of which GCOS was the first to be launched.

Among the five grand challenges identified by the research communities and key stakeholders participating in ICSU's Visioning Process in 2010-2011 is ' to develop the observation systems needed to manage global and regional environmental change' . This is a clear demonstration that the scientific communities now involved in the development of the new decadal research initiative ' Future Earth – research for global sustainability' consider GCOS and its partner global Earth observing systems as vital. I fully share this view. GCOS will be a vital element in the delivery of the new knowledge needed to address the critical environmental and societal challenges of the 21st century at the global, regional and local levels."

Steven Wilson, Executive Director, International Council for Science (ICSU)

"UNEP acknowledges GCOS as an essential mechanism for climate related observations. Sound science is key to assisting countries transition to a low carbon, resource efficient Green Economy. UNEP's requirements for climate observations include observations for ecosystem-based climate adaptation, for early warning, and for producing value added products and services. GCOS is a partner achieving several goals related to Earth and climate observations and is an essential element for the UN system ' Delivering as One' on climate change and across a wide range of related sustainability challenges"

Achim Steiner, Under Secretary General of the United Nations and Executive Director,
United Nations Environment Programme (UNEP)

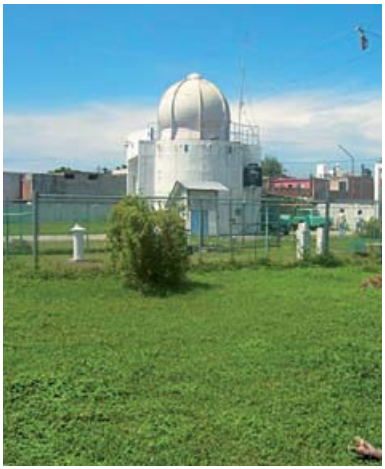
Definition of the Atmospheric Observing Network

At the initiation of the GCOS in 1992, the largest existing observing system, together with operational meteorological satellites, was the World Weather Watch/Global Observing System (WWW/GOS) of WMO. To this day, the National Meteorological and Hydrological Services (NMHSs) provide the fundamental atmospheric networks for climate, as well as for many of the terrestrial networks. But the initial GCOS report from Winchester noted the need for a worldwide system capable of producing observations of greater accuracy and coverage and comprising additional appropriate climate variables. Among those needed were the atmospheric chemistry variables measured as part of the Global Atmosphere Watch.

One of the first tasks of the GCOS Programme was to define a subset of the WWW stations appropriate for basic climate monitoring. The subset of roughly 1000 baseline surface stations became the GCOS Surface Network (GSN), while a select set of 150 upper air stations was designated as the GCOS Upper-Air Network (GUAN). These were built on existing WMO classifications and became the initial baseline components of the atmospheric networks. Considerations for selection of GSN included spatial distribution, length and quality of record, long-term commitment, and degree of urbanization. Similar considerations were used for GUAN, except surface environmental factors were not of major importance. Designation of these networks benefitted both the GCOS and the NMHSs. For the GCOS, designation helped incorporate climate requirements into meteorological service procedures. For NMHSs, designation of a station as part of the global climate network helped sustain support for these long-running sites. These networks provided the foundation for the Regional Basic Climatological Network, which provides far greater spatial detail on the variability of climate.

By 2001, it was recognized that the GSN and GUAN were in need of performance improvements, based on the annual reports prepared by WMO. In fact, the performance of many stations had been deteriorating. At that time more than 25 of the 150 GUAN stations were silent, and nearly 30 percent of the stations in the GSN were not reporting according to WMO standards. This lead to the creation of the GCOS Cooperation Mechanism, which was a means by which developed countries could make contributions toward resolution of problems at priority climate stations, primarily in developing countries. The GCOS Atmospheric Observation Panel for Climate advises on locations with the highest priority needs based on scientific considerations. A dedicated GCOS System Improvement Programme has resulted in the renovation of over 30 GSN and 20 GUAN stations, in addition to providing over 25 station-years of radiosondes. The longer-term intent is to apply GCM funds to needs in the oceanic and terrestrial domains in addition to those in the atmospheric domain.

An example of a particularly successful step forward in implementing a global observing system for climate is the initiation of a reference network for upper-air observations – the GCOS Reference Upper-air Network (GRUAN). This network is the prototype of a hybrid observing system, combining operational upper-air measurement sites with research sites and providing high-quality reference data for atmospheric profiles.



A surface station in Mazatlan, Mexico (left) and the launch of an upper-air station during a GUAN upper-air training workshop in Windhoek, Namibia (right).

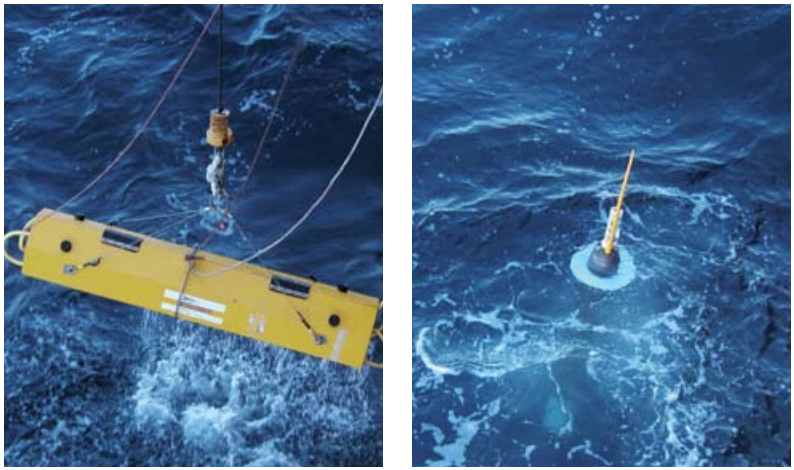
Roger Pielke | Richard Thigpen

Development of Ocean Observing Networks for Climate

One of the great achievements in climate-monitoring over the last 20 years has been the development of ocean observing systems. Knowledge of the global oceans today is partly the result of deployment of both in-situ and satellite systems, materially aided by the IOC-led GOOS/GCOS/WCRP Ocean Observing Panel for Climate.

The Pacific Tropical Atmosphere Ocean (TAO) array, a legacy of the Tropical Ocean Global Atmosphere Programme (TOGA), has been expanded to both the Atlantic and Indian tropics, providing material benefits in seasonal-interannual climate prediction. A major legacy of the World Ocean Circulation Experiment was the development of profiling float technology as implemented in the global Argo float network. The Argo Programme reached its goal of 3000 floats in 2007 and currently has over 3500 floats in the water, providing one of the key data sets for monitoring ocean temperature and salinity. With Argo in mind, the global expendable bathythermograph (XBT) network was redesigned to consist of frequently repeated and high density lines. In addition to the broad coverage provided by these networks, a worldwide system of reference stations, known as OceanSITES, has been deployed, providing full-depth coverage at 60 sites for dozens of variables. Overall, the number of in-situ oceanographic reports has gone from roughly 4.5 million in 1999 to more than 16 million in 2009. Taken as a whole, these platforms provide a rich and complementary perspective on the global ocean.

A particular example for ocean observing systems is that of sea level, one of the most important concerns related to climate change. The satellite record of global sea level now stretches almost 20 years, from TOPEX/Poseidon through Jason-1 and Jason-2. Analyses from multiple international groups have converged on global mean sea-level rise rates of 3.1-3.2 mm/yr. The far longer Global Sea Level Observing System (GLOSS) network time series provide local variations in sea level and the long-term context of satellite measurements.



Sabrina Speich

An Argo float is deployed in the Southern Ocean (left). It then pops out of the water to signal it is working (right).

Facilitating the Expansion of Terrestrial Climate Networks

There has been notable progress in terrestrial networks for climate over the twenty years since the GCOS was founded, particularly in cryospheric measurements. A time series of ice sheet mass balance from space now extends from 1992 to the present. The overall performance of in-situ glacier monitoring networks has been improving, as noted by the World Glacier Monitoring Service, while satellite-based glacier inventories have expanded considerably.

Sustained observations of snow and ice from space appear to be on track. The collection of permafrost data has shown some improvement as a result of a focus on this data during the International Polar Year 2008-2009. Through the Global Terrestrial Network for Permafrost, efforts have been made over the past decade to re-establish a borehole temperature monitoring programme to monitor, detect, and assess long-term changes in the active layer and the thermal state of permafrost.

For other terrestrial measurements, the increased commitment of space agencies to produce fundamental climate data records from existing systems has led to improved availability of global datasets, such as of burned area, fraction of absorbed photosynthetically active radiation, and land cover. The community now increasingly uses these datasets. Nevertheless substantial gaps remain in quality control, which need to be addressed through intercomparison and validation. Some declines have been noted in other terrestrial networks, notably in river discharge measurements received by the Global Runoff Data Centre.

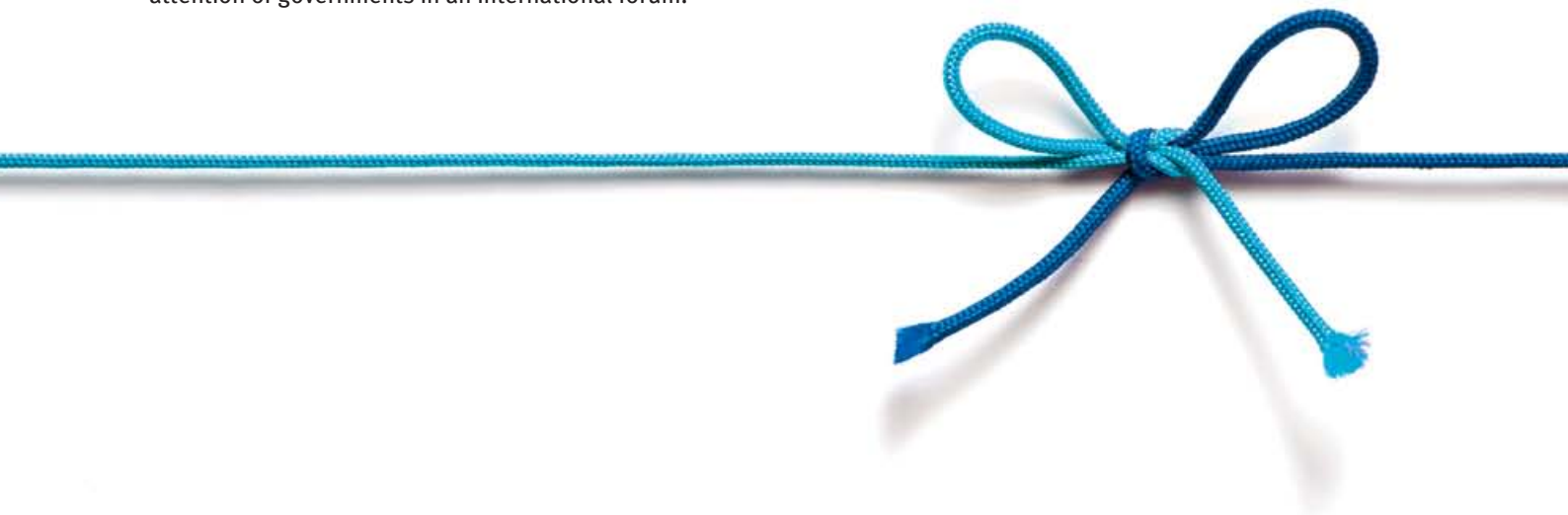
M. Hoelzle/University of Zurich

Density measurements in a snow pit in a glacier accumulation zone.

Establishment of Important Links to the UNFCCC

In 1992, the same year as the founding of the GCOS, countries joined an international treaty, the United Nations Framework Convention on Climate Change, to consider cooperatively what they could do to limit climate change and to cope with its impacts. One of enduring strengths of the GCOS has been its partnership with the UNFCCC, which has been in place since the founding of both organizations. Language on research and systematic observations is in the original 1991 report of the Intergovernmental Negotiating Committee for UNFCCC and was included in the text of the Convention in 1992.

The original GCOS report on the adequacy of the global climate observing systems was requested by the UNFCCC in 1997 and presented to the Fourth Session of the Conference of the Parties to the UNFCCC in Buenos Aires in 1998. Additional interactions have taken place in the two decades since the founding of both organizations, including, for example, the delivery in 2004 of the *Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC* and its 2010 update. The UNFCCC has been and remains a vital mechanism to bring issues of maintenance of the long-term climate record to the attention of governments in an international forum.



"The UN Framework Convention on Climate Changecalls on governments to promote and cooperate in systematic observation of the climate system, including through support to existing international programmes and networks. Since 1999, systematic observation has regularly been considered by the UNFCCC under its Subsidiary Body for Scientific and Technological Advice (SBSTA).

Cooperation with the Global Climate Observing System has been a key dimension for the work under the SBSTA. GCOS has identified the most essential variables for detecting changes in the climate across atmospheric, oceanic, and terrestrial domains, and has provided a strong voice for ensuring the availability and continuity of the long-term record of the climate as a basis for policy development. Its Implementation Plan in support of the UNFCCC recommends actions to help nations obtain the observational information they need to understand, predict, and manage their responses to climate change, especially in the developing world. The support from the GCOS has been fundamental for the UNFCCC and has been acknowledged by its highest decision-making body, the Conference of the Parties.

Climate observations should be further enhanced in the future in order to enable governments to take decisions based on the best-available data and science. We trust that GCOS will continue to be our partner for climate observations in the future—not least as the international community works toward a new global agreement to address climate change. "

Christiana Figueres, Executive Secretary, United Nations Framework Convention on Climate Change (UNFCCC)

Working with Regions

The GCOS Programme began working with regions to identify priority observing system needs following an invitation by the UNFCCC at the 5th Session of the Conference of the Parties in 1999 to organize a Regional Workshop Programme. Conducted between 2000 and 2006, this Programme led to the preparation of Regional Action Plans in ten regions of the world. The plans were prepared by experts from each region, and each contained from ten to fifteen project proposals addressing regional observing system priorities. Implementation of the project proposals has proved more difficult than preparation of the Plans, however. While some projects have been implemented, many remain to be carried out. In 2006, in an attempt to help African regions identify funding for implementing project proposals, the GCOS Secretariat helped organize a major meeting with potential donors in Ethiopia. This meeting led to the establishment of the Climate for Development in Africa Programme, a programme that is now poised to assist funding of African observing system needs. GCOS will continue to work with other regions to help them mobilize resources for addressing priority needs.

More or less in parallel with the Regional Workshop Programme, the Secretariat also established the GCOS Cooperation Mechanism. This mechanism allows developed countries to contribute funds to address specific needs in developing countries. The Secretariat employs an Implementation Officer to manage projects. To date, these have focused on renovation of stations in the GCOS surface and upper air networks. However, the longer-term intent is to apply Cooperation Mechanism funds to needs in the oceanic and terrestrial domains in addition to those in the atmospheric domain.

Definition of the GCOS Climate Monitoring Principles

A fundamental question in the development of a true climate observing system is that of how observations should be made. What properties must a climate measurement have so that it can be used 10, 100, or 1000 years in the future to demonstrate changes in the Earth's climate system? This was an issue much on the mind of scientists around the world in the 1990s. Experience in analyzing the climate record showed that changing instrumentation, gaps in time series, lack of information on observing methods, and undocumented changes in the surrounding environment could introduce spurious signals into the long-term climate record.

These concerns led to the formulation of the GCOS Climate Monitoring Principles. In 1995, an ad hoc international group led by Thomas Karl first proposed a series of ten principles dealing with procedures for instrument requirements, data homogeneity and continuity, and the transition from research to operation. A second set of ten principles specific to satellite monitoring of climate was later appended. The GCOS Programme provided the international mechanism for discussion, modification, and acceptance by the broad international community. It also facilitated the adoption of these climate principles by the Subsidiary Body for Scientific and Technological Advice of the UNFCCC in 1999. These principles today provide the framework for both design and operation of climate networks globally, both satellite and in-situ.

Producing the Adequacy and Progress Reports and Implementation Plans

In addition to determining the principles by which the system should operate, the essential tasks of the GCOS Programme from the start were to:

- Define the system;
- Determine to what degree existing measurements were fit to purpose; and
- Establish what needed to be done to bring the system to its desired state.

With the endorsement of the four sponsors and in support of the UNFCCC, the GCOS reports on the *Adequacy of the Global Observing Systems for Climate* in support of the UNFCCC of 1998 and 2003 took on the first two tasks, while the Implementation Plan of 2004, with its 2010 update, addressed the third. The 1998 Adequacy Report broke the first ground on these issues with a description of the basic outlines of the observing system. National reports of Parties to the UNFCCC followed, describing national commitments and actions to address the reported inadequacies.

However, more detail was needed. A highlight of the Second Adequacy Report of 2003 was the development of the concept of Essential Climate Variables (ECVs). The ECVs are variables for which a set of measurements is considered to be both feasible for global implementation and important for meeting UNFCCC requirements. Agreement on this common set of measurements was vital for national contributions, and this led directly to the development of the GCOS Implementation Plan of 2004. The Implementation Plan provided a detailed list of actions, responsible parties, time frames, and cost estimates – in short, a blueprint for completing the Global Climate Observing System, with the broad agreement of the scientific community and with a mechanism of national commitments to move the plan forward. The satellite components noted in the Implementation Plan

were given greater detail with the production of *Systematic Observation Requirements for Satellite-based Products for Climate*, known as the Satellite Supplement, in 2006. This supplement provided high-level requirements for accuracy, stability, and resolution of satellite-based datasets and derived products in support of the ECVs.

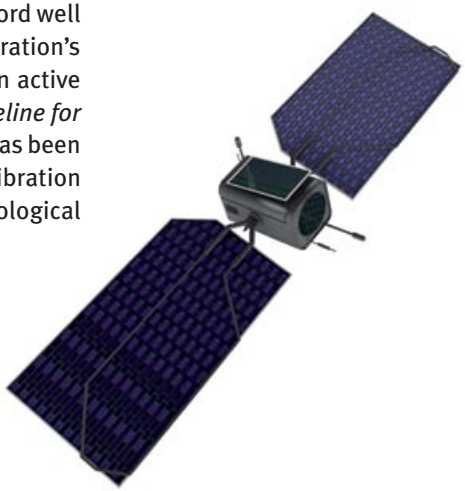
It was not enough to have a plan on the table. Progress on the plan needed to be monitored, and the plan needed to be updated periodically to account for advancing technology and scientific needs. To these ends a Progress Report was prepared in 2009, a revised Implementation Plan was completed in 2010, and an updated Satellite Supplement was completed in 2011. The updated Implementation Plan provided a revised list of ECVs. In each case, these reports were presented to the UNFCCC's Subsidiary Body for Scientific and Technological Advice and disseminated to the broad international community.

Promoting the Development of Satellite Observing Systems for Climate

Satellites provide a vital means of obtaining observations of the climate system from a global perspective, and a detailed global climate record for the future will not be possible without a major, sustained satellite component. Significantly, there has been direct and intense interaction between the GCOS Programme and the satellite community over the twenty-year history of GCOS.

One of the highlights of this interaction has been the development of a strong working relationship between GCOS and the Committee on Earth Observation Satellites (CEOS), the primary international forum for coordination of space-based Earth observations. In 2006, space agencies, through CEOS, responded to the GCOS climate requirements across the atmospheric, oceanic, and terrestrial domains by identifying 58 separate actions to be undertaken. In addition, CEOS requested, and was provided with a more detailed analysis of satellite climate observing needs, the 2006 Satellite Supplement, noted above, and its 2011 update.

The CEOS response represents one point in a continuum of increasing interest in long-term satellite observations of climate. Many of the major Earth observing platforms of the 1990s had climate observation as their major driver. What has changed over the two decades since the founding of GCOS is an improving level of concern for continuity of the climate record, as manifested in the Climate Monitoring Principles. Most major satellite Earth observing systems now have climate considerations included from the start. Periodic studies now highlight potential gaps in the satellite climate record well in advance, with the most recent being the International Aeronautical Federation's *Space Sensors for Climate Monitoring* report from 2010. GCOS has also been active recently in defining requirements for climate datasets, particularly in its *Guideline for the Generation of Datasets and Products Meeting GCOS Requirements*, which has been influential in the development of the Global Space-based Satellite Intercalibration System (GSICS) implemented by WMO and the Coordination Group of Meteorological Satellites (CGMS).



"The Committee on Earth Observation Satellites was established in 1984 to coordinate civil space-based observations of the Earth. On behalf of nations supporting space agencies, CEOS has undertaken the specific task of developing and updating the coordinated response to the space-based observational requirements identified by GCOS. Many of the space agencies that are members of CEOS have nominated dedicated climate focal points to promote implementation.

The CEOS Working Group on Climate, in liaison with other CEOS Working Groups, coordinates and encourages collaborative activities between space agencies in the area of climate monitoring. The Working Group facilitates the generation and exploitation of data records for the Essential Climate Variables required by the UNFCCC, IPCC and others.

Regular consultations between CEOS and the GCOS Secretariat have been mutually beneficial in developing these and related activities. I look forward to continuing interaction."

A.S. Kiran Kumar, Indian Space Research Organization (ISRO) and Chair of the Committee on Earth Observation Satellites (CEOS)


Chapter


The Future

The GCOS is the global system of the climate-relevant components of observing systems, and it has adapted over the years to emerging needs and new concepts.

The last two decades have shown clearly that there is a regular need to assess the observation capabilities and to report on progress made related to the actions recommended to fully implement the global observing system for climate. The latest Progress Report in 2009 concluded that implementation of the various observing systems in support of the UNFCCC had progressed significantly over the previous five years, but that it would be difficult to sustain funding for many important systems. The report noted that there had been only limited progress toward filling the gaps in observing systems in developing countries and that there was still a long way to go before a fully implemented global observing system for climate could be achieved.

Hence, the GCOS Programme will continue to report on the status of climate observing systems and to assess progress. It will regularly assess which climate observations should be made by reviewing societal needs and research requirements, evaluating the technical capacity to observe new variables, and updating the list of Essential Climate Variables that can and must be measured. The GCOS Programme will also need to further assist developing countries through renewed regional activities, both following up on the projects contained in the Regional Action Plans developed through its Regional Workshop Programme and by continuing to provide support through the GCOS Cooperation Mechanism. Gaps in climate observing networks in Africa and South America remain especially large.

The cycle of addressing the progress and adequacy of global observing systems for climate will be repeated approximately every 5 or 6 years. A new progress report is planned for the 2014/2015 timeframe and will likely be combined with an update on the adequacy of climate observing systems. This report will be built on the identification of observing needs for adaptation to climate change.

The emerging Global Framework for Climate Services, endorsed by the Congress of the World Meteorological Organization in 2011, will create new challenges for the global climate observing system. New climate services are being demanded by important user sectors, including water resources, agriculture, health, and disaster risk management. The GCOS must be ready to support the observational needs for these new services at global, regional, and local scales.

"WCRP is proud of its partnership with GCOS in the last 20 years. Since its establishment in 1980, WCRP has always promoted the need for observations and importance of a systematic approach to developing climate quality long-term observations. GCOS has been the lead international programme for advisory and oversight of systematic climate observations with its regular assessments of the adequacy of climate observations, including suggestions for needed improvements.

A very strong interaction of observations and models is central to WCRP, with observations giving the basis for evaluating and improving climate predictions. There is a growing need in many socio-economic sectors for relevant climate information for developing appropriate adaptation and mitigation strategies. GCOS is strongly addressing the need for global coverage and timeliness of data through the promotion of the Essential Climate Variables concept.

GCOS provides the mechanism for WCRP to input into the international process of defining the in-situ and space observing systems for the next decade required for climate studies and in particular for identifying gaps and deficiencies in existing observing systems and addressing other shortcomings, which may have reduced the skill of climate predictions. The WCRP Data Advisory Council works with the GCOS science panels (AOPC, OOPC and TOPC) to achieve these objectives. "

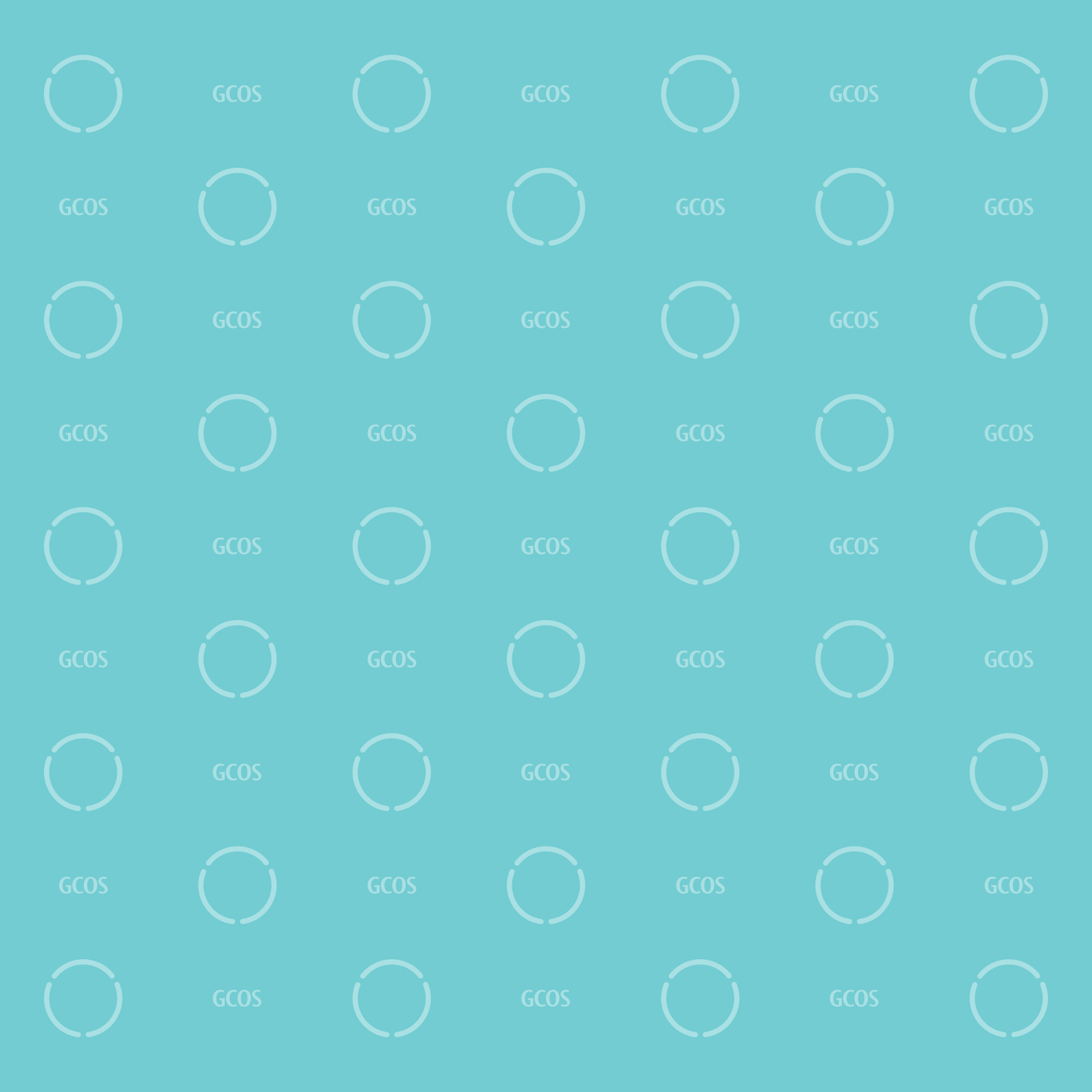
Ghassem R. Asrar, Director, World Climate Research Programme (WCRP)

"The current global observational network is declining. If this decline is not stopped we may, say, twenty years from now, be in a worse situation than today when trying to determine to what extent and how climate is changing. We will have less capability of clarifying to what extent an ongoing climate change might be the result of human activities or be an expression of natural variability in the climate system. A continuous close observation of the climate system is an absolute requirement for dealing adequately with the climate issue."

Bert Bolin (1925-2007), First Chair, Intergovernmental Panel on Climate Change (IPCC), speaking in 1997

Bert Bolin's concerns have largely not materialized. The global efforts of people working for meteorological services, academic institutions, and space agencies have largely kept the continuity of the climate record intact. A small group of people working for the GCOS Programme has coordinated and given an international voice to these efforts. It remains for the next twenty years to maintain this "continuous close observation of the climate system" and to ensure that the remaining gaps in the system are filled.

1992 ★ 2012


GCOS

GLOBAL CLIMATE OBSERVING SYSTEM

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