

# GLOBAL CLIMATE OBSERVING SYSTEM

## SUMMARY OF THE GCOS PLAN

VERSION 1.0

GCOS - 10  
WMO/TD - No. 666



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## PREFACE

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In recent decades, attention has focused on the Earth's climate. Human societies have become more vulnerable to climate change and for the first time in human history, man is able to influence the climate on a global scale, and to produce irrevocable change in the environment. The prospect that the global climate may be modified provides a strong motivation to understand the complex climate system. The scientific community has set up programmes to enhance understanding and to detect and predict climate change.

Comprehensive observations of the climate system are a fundamental and essential element of these programmes. The requirement for observations has been recognized at the national and international levels, and has resulted in a call for a systematic approach to the observational needs. The Global Climate Observing System (GCOS) was established to ensure that the observational needs for climate are met.

This document is a summary of the GCOS Plan, Version 1.0. The Plan was prepared on the basis of input from the Joint Scientific and Technical Committee for

GCOS and with the assistance of many working groups, panels, and individual experts. The Plan will be the basis for the evolving activity of GCOS.

It is acknowledged that GCOS will build on existing systems to the extent possible. New resources will be required to carry out the necessary GCOS planning and for the implementation of the enhancements to the existing systems and of the new operational systems when adequately specified. Future activities will focus on refining the requirements presented here, and coordinating with ongoing programmes and projects to begin implementation.



Sir John Houghton  
Chairman,  
Joint Scientific and Technical Committee  
Global Climate Observing System  
April 1995

In the recent national and international debate about climate change and variability it has become evident that adequate information is not available to governments to enable them to answer critical scientific, economic and policy questions. As a consequence, the Global Climate Observing System (GCOS), an international long-term global observing programme, designed specifically to provide governments with such climate information, was created by the World Meteorological Organization, the Intergovernmental Oceanographic Commission, the United Nations Environment Programme, and the International Council of Scientific Unions.

When fully operational, GCOS will meet the comprehensive scientific requirements for monitoring the climate, and provide the observational basis for detecting climate change, for predicting climate variations and change on a variety of time and space scales, and for observing the impacts of climate change. The GCOS will not typically make observations or generate data products, but will rather encourage, coordinate and otherwise facilitate observations which should be made by national or international organizations in support of their own requirements and common goals. However, the GCOS will provide an operational framework for integrating national and international operational and research observational components of the participating countries into a comprehensive end-to-end system.

The benefits of an efficient and cost-effective global observing system for climate should be evident. It would provide the essential observational information to enable governments to better understand, interpret, and respond to the challenges posed by global climate change. It

would provide critical input to enable climate models and outlooks for seasonal-to-interannual periods to be improved. As a result, key economic sectors impacted by climate variability would benefit.

To proceed, a Joint Scientific and Technical Committee (JSTC) was established to formulate the overall concept and scope of the GCOS (See Annex I). It will establish and update requirements, review existing programmes to assess their ability to meet requirements, and make recommendations for enhancements or new elements, as appropriate. The JSTC also has the responsibility for continuing oversight of the various components of the system. To assist in these tasks, it has established panels and working groups to address science and cross-cutting issues. A Joint Planning Office (JPO), located at the World Meteorological Organization in Geneva, supports the JSTC in its efforts (See Annex II).

In 1993, the JSTC published a draft plan which was widely distributed and reviewed. At its most recent meeting, the Committee approved publication of Version 1.0 of the GCOS Plan, as well as Versions 1.0 of the Data and Information Management Plan and of the Space-based Observation Plan. This summary of the first version of the GCOS plan briefly reviews international activities relating to GCOS, describes the strategy for developing the plan, notes the deliverables resulting from GCOS, outlines the elements of the Initial Operational System, identifies selected components for enhancement, and suggests the role for national governments. Finally, it indicates the resource requirements needed to continue the implementation of the proposed system.

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## INTERNATIONAL ACTIVITY ON THE CLIMATE AGENDA

The Second World Climate Conference in 1990, in both in the scientific and ministerial sessions, recognized the need for a systematic approach to be taken to obtain observations critically needed to answer significant questions about climate change and climate variability. The recommendation from the Conference called for the urgent establishment of GCOS to meet the needs for climate system monitoring, for climate change detection, for climate modelling and prediction, and to provide information for national economic development.

In 1992, the United Nations Conference on Environment and Development, held in Rio de Janeiro,

developed Agenda 21 as a blueprint for global sustainable development. Linking economic and environmental concerns, Agenda 21, explicitly recommended nations contribute to the enhancement of scientific knowledge of climate by developing and expanding GCOS.

An Intergovernmental Meeting on the World Climate Programme, "The Climate Agenda", was convened in 1993 to provide a forum to assist governments to respond to the climate science and applications aspects of the Rio Conference decisions. The Meeting agreed that international climate-related programmes had provided governments with important information.

At the same time, the Meeting urged that an integrated proposal be prepared to address the coordination of existing international climate activities and to project future resource requirements to meet climate objectives. This proposal has now been completed and will be submitted to executive bodies of the sponsoring organizations. "The Climate Agenda — International Climate Related Programmes: A Proposal for an Integrating Framework", advances four thrusts:

1. New frontiers in climate science and prediction.

2. Climate services for sustainable development.

3. Studies of climate impact assessments and response strategies to reduce vulnerability.

4. Dedicated observations of the climate system.

The fourth element, includes GCOS, and is intended to provide, on an operational and continuing basis, those observations of the climate system essential if the preceding thrusts are to meet the requirements of nations.

## THE STRATEGY FOR GCOS

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The scientific strategy of GCOS is based on the concept that analyses and models of the climate require an adequate observational base to be effective in addressing seasonal-to-interannual and decadal-to-centennial climate time scales. The quantity, quality, and continuity of observations required demand that a systematic global programme be implemented. To expedite the establishment of such an observing system, use must be made of existing observing systems, to the degree possible.

The detailed scientific plans for GCOS have taken a comprehensive approach to the climate problem. They have considered the full scope of issues, including the requirements of users/participants, the contributions of existing research and operational programmes and data systems, and the participation of both international and national organizations. The scientific scope included atmosphere, ocean, land surface, cryosphere, hydrosphere, and ecosystem processes. The plans also consider the resources needed to establish, coordinate, and manage an effective system.

The approach is based on meeting the following priority needs:

- Comprehensive observations of climate parameters for early detection and documentation of climate change, its regional distribution and timing; its impact on ecosystems;

- Data for initialization and validation of models for seasonal- to-interannual prediction;
- Enhancements of existing observing networks including the continuation of stations with long observational records;
- Close coordination, during both design and implementation phases, among other observing systems to ensure proper integration of the various elements;
- A comprehensive plan for data and information management which addresses data quality; collection techniques and methods; merger, assimilation and analysis; dissemination; archiving;
- An integrated approach to space requirements which addresses the essential instrumentation and the long-term continuity of missions;
- Mechanisms to encourage nations to implement and maintain their observing systems and networks; and
- Active involvement with developing countries to enable their full participation through capacity building.

The overall goal of GCOS is supported by three specific objectives as shown in the table. These objectives are being met with the cooperation and participation of many regional and national elements, and the following international activities:

- World Climate Programme (including data and monitoring, applications and services, impacts and responses, and WCP-Water)

<b>Objectives</b>	
<b>1.</b>	<b>Design an effective operational climate observing system</b>
<b>2.</b>	<b>Establish, coordinate and manage the Initial Operational System by integrating and enhancing existing components</b>
<b>3.</b>	<b>Develop new components to provide a comprehensive and responsive system to meet future needs</b>

- World Climate Research Programme (WCRP)
- International Geosphere-Biosphere Programme (IGBP)
- World Weather Watch (WWW)
- Global Atmosphere Watch (GAW)
- Hydrology and Water Resources Programme (HWRP)
- Integrated Global Ocean Services System (IGOSS)
- Global Sea Level Observing System (GLOSS)
- Global Ocean Observing System (GOOS)
- Global Terrestrial Observing System (GTOS)
- Global Environmental Monitoring System (GEMS)
- Global Resource Information Database (GRID)
- Committee on Earth Observation Satellites (CEOS).

### **Objective 1: Design an effective operational climate observing system**

The conceptual framework for the design of GCOS considered the key fundamental scientific and implementation issues. In addressing the former, the JSTC developed the scientific priorities based on user/ participant requirements, evaluated the contributions of existing systems in meeting these requirements, and made recommendations for enhancements to existing systems to meet current and future requirements. For the latter, the JSTC considered and proposed mechanisms for engaging national and international organizations and securing long-term commitments, and for the continuing evaluation of progress in achieving the goals of the programme.

Considerable progress has been made toward *Objective 1*:

- A framework for effective planning and design of the global system, involving national and international research and operational programmes, is now in place;
- Plans for the overall programme, the science elements, data and information management, and integrated space-based observation have been completed and published.

### **Objective 2: Establish, coordinate and manage the Initial Operational System**

To initiate the global observing system promptly, the JSTC defined an Initial Operational System (IOS) to include significant ongoing observation programmes which contribute information currently used in climate studies and application. These programmes, with modest enhancements (e.g., filling data gaps, upgrading networks, additional sites, improved practices) could make major contributions toward meeting global climate data needs.

An atmospheric illustration may be cited. Existing operational networks (e.g., WWW, GAW) provide frequent global coverage of atmospheric variables. However, there are large deficiencies — the network provides limited information from some continental areas and most ocean regions; some required parameters are not adequately observed; often the data lack sufficient accuracy, spatial and

temporal coverage, or are not shared effectively. The GCOS Plan proposes improvements which address network integrity, data collection and analysis procedures, and enhanced satellite and surface observational capability, especially regarding data continuity and consistency. These enhancements render the system more responsive to climate needs.

A central element of the IOS is a comprehensive data and information management system. A plan for this activity has been published, outlining the key issues associated with the collection of high-quality data, the subsequent dissemination and assimilation into products, the future access through distributed database concepts, and final archival.

Considerable progress toward *Objective 2* has been made:

- Requirements for the IOS for the atmosphere and ocean are completed, and terrestrial requirements will be completed soon;
- Inventories and assessments of current observational programmes are underway;
- Significant components have been incorporated into the IOS and network enhancements begun;
- Data management projects to improve quality and access have been initiated;
- An evaluation of satellite missions relevant to GCOS has been completed;
- Efforts are underway to assist developing countries with capacity building and training; and
- Programme management has been established.

### **Objective 3: Develop new components to meet future needs**

Although current programmes and enhancements will make substantial contributions, it is essential to continue the aggressive pursuit of new operational capability. Emerging technologies, increased modelling capability, and research and development advances will need continual review to permit rapid transition into future operational systems.

Current programmes are wholly supported by participating countries, so nations must be encouraged to develop and establish new systems for future observations. To marshal resources for their implementation, international mechanisms must be put in place to strengthen the participation of countries in observational activities, especially in regard to emerging technology.

Regarding *Objective 3*, several specific activities have been initiated, including:

- Cooperation with research programmes to foster research and development for new techniques and technologies;
- New collection/assimilation/distribution methodologies have been considered as part of the GCOS Plan.

<b>Deliverables</b>	
<b>1.</b>	<b>A cost-effective IOS for observation to generate needed data products and analyses</b>
<b>2.</b>	<b>High quality, well-calibrated long-term observations critically needed for:</b> <ul style="list-style-type: none"> <li>- seasonal-to-interannual climate prediction,</li> <li>- earliest possible detection of climate trends and climate change due to human activities,</li> <li>- reduction of the major uncertainties in longer-term climate simulations,</li> <li>- observational requirements of the United Nations Framework Convention on Climate Change</li> </ul>
<b>3.</b>	<b>Information to assist national economic and sustainable development</b>
<b>4.</b>	<b>Increased capacity in developing countries to enable them to participate in both observational and analysis activities, and to better address national issues</b>
<b>5.</b>	<b>Improved data and information in support of climate research, climate services, and climate impact assessments as in the "Climate Agenda"</b>

## THE INITIAL OPERATIONAL SYSTEM

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The majority of present observing systems were put in place to meet objectives other than those for climate purposes. However, they do meet many requirements for climate data. A careful assessment of existing systems and their capability is needed and has been started. GCOS atmospheric, oceanic, and land surface science panels have designated key elements, and in many cases, have proposed essential enhancements and augmentations to make them more effective in meeting climate requirements. Only a brief description may be provided here. For further details, the GCOS Plan and the supporting documents of the appropriate panels should be consulted (See Annex III).

### Atmosphere

Typically, the climate is defined in terms of the average atmospheric or weather condition, usually calculated over a 30-year period. Atmospheric data are required to understand better the dynamics of the climate system and its natural variability. Data are needed to monitor the climate, to detect and attribute change, to provide input for both seasonal-to-interannual and decadal models. Fundamentally, the variables needed are those measured routinely by the WWW from the surface and the free atmosphere (e.g., temperature, wind velocity, humidity, precipitation). Important atmospheric constituents (greenhouse gases and aerosols) which play a central role in atmospheric chemistry and in the radiative balance require monitoring. Global coverage with optimal vertical resolution and representative horizontal spacing is vital. Both *in situ* and satellite observations are required.

Atmospheric observations are currently coordinated through existing WMO programmes such as the

WWW and the GAW. Their climate components have been identified as elements of GCOS and both have addressed GCOS requirements, incorporating them into programme plans.

#### *Enhancements to Existing Atmospheric Systems*

The following selected enhancements to current atmospheric systems are of high priority: (1) upgrade WWW and implement high quality networks, (2) upgrade drifting buoys and ships making meteorological observations, (3) improve vertical distribution of tropospheric and stratospheric water vapour from satellite sounding instruments, (4) enhance monitoring of tropospheric and stratospheric ozone, and (5) increase the number of GAW sites and broaden observational elements.

### Ocean

The ocean has many roles to play in climate: the world oceans have enormous potential for heat storage and transport; fluxes of heat and momentum between the air and ocean are of fundamental importance; the ocean currents transport heat at rates that rival atmosphere transport; the deep ocean provides a reservoir, not only for heat, but for carbon dioxide and other greenhouse gases which are absorbed at the surface and removed from circulation, possibly for decades and longer. In addition, its role in biogeochemical cycling is equally significant.

In contrast with the atmosphere, the sparsity of ocean observations has made it impossible to ensure that all critical climate processes have been identified, and consequently that observational requirements may be

adequately summarized. Aware of this limitation, the Ocean Observation System Development Panel (OOSDP) provided a contemporary design for climate which addressed nine key elements and provided rationale, requirements, measurement options, and recommendations to observe appropriate variables in accord with the concept of the GCOS IOS.

Observations will be implemented through existing operational programmes where feasible. These include, *inter alia*, IGOSS and GLOSS. In addition, ocean observing components of research programmes will continue to be essential elements of GCOS/GOOS until they undergo a transition into a more operational status. The implementation also requires a continuing series of satellite missions for ocean variables.

#### *Enhancements to Existing Oceanographic Systems*

The following selected enhancements to current systems are of high priority: (1) continuation and expansion of the Tropical Ocean & Global Atmosphere observing system, (2) increased drifting buoys and ship observations for upper ocean measurement, particularly in data sparse and high latitude areas, (3) continuation of precision satellite altimetry and wind scatterometry missions, (4) expanded use of active and passive microwave sensor instruments, (5) autonomous drifters with profiling capability for temperature and conductivity, (6) expansion of long-term monitoring sites for observations of deep- and bottom-water renewal.

#### **Land Surface and Ecosystems**

Climate is a function of biological and chemical, as well as physical processes. Terrestrial ecosystems have an important role in determining the trace gas composition of the atmosphere affecting the Earth's heat budget. They also have a strong influence on surface albedo (solar energy, absorption and reflectance) and on the hydrological cycle.

Characteristics of the land surface and cryospheric elements (ice sheets, glaciers) are also important for the climate system. Many of these variables are also important for monitoring the impact of change, and for input into models for applications and national policy-making.

Under climate change scenarios, there will be major impacts on the distribution of flora and fauna, biogeochemical cycles, energy, and water fluxes. To understand these effects, it is essential that the measurements and analyses provide integrated atmospheric, hydrologic and ecological information, as well as input data from the socio-economic sectors.

It is anticipated that terrestrial/ecosystem observations for climate will be developed and implemented jointly with the GTOS, GEMS, HWRP, and other activities as appropriate. Activities are closely coordinated with the appropriate research programmes of IGBP and WCRP.

#### *Enhancements to Existing Terrestrial and Ecological Systems*

The following enhancements to current systems are of high priority: (1) improve and standardize ecosystem observations from existing sites, (2) upgrade initialization and validation input for land surface models, (3) continue to produce and expand products using high-resolution radiometry data, (4) increase monitoring and assessment of land cover and land use change in selected biomes using satellite and *in situ* observations, (5) maintain and enhance rainfall, runoff, and other hydrological measurements and expand the World Hydrological Cycle Observing System (WHYCOS), (6) improve soil moisture fields, (7) improve data from visible and IR multi-spectral imagers for ice sheets, ice shelves and glacier boundaries, (8) obtain passive microwave data for surface characteristics, (9) produce fields of photosynthetically active radiation routinely.

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## ROLE OF NATIONAL GOVERNMENTS

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A fundamental tenet of GCOS is that it will be based upon national programmes. The role of the JSTC, the JPO, and other GCOS bodies is to coordinate and facilitate national observing components so as to produce optimal data sets and information for use by the participating countries.

To this point, nations have participated in the planning and development of GCOS through membership in the sponsoring organizations, through established GCOS committees, and through national points

of contact or specific GCOS-related committees. In this way, the national governments have been supportive of the concept of GCOS, and have contributed directly to the work completed to date. Nations should recognize that the present concept and plan for GCOS is based upon their contributions. The continuation and expansion of such interaction is critical, since it allows governments to participate in the development and evolution of GCOS and to provide information about national activity and national programme plans which may contribute.

At present, the continuation of existing observational systems is critical. In many locations, observational programmes are in jeopardy or are being reduced. For the future, it is important that the participating nations undertake new activities to support climate observational requirements — collecting additional and improved data, distributing larger quantities of information, developing more useful products, and providing forecasts or other helpful guidance material to better address their own national concerns. It is anticipated that many improvements may be achieved by focusing existing observations and techniques on climate issues, but clearly new investment will be required.

While emphasis in this section has been on the requirement for national involvement and active participation in the observational aspects of GCOS, it should also be apparent that the thrust of the programme — to coordinate national activities in order to provide integrated information — should be very beneficial to the participating nations. By establishing consistent global methods of data collection and communication, the programme provides “value added” information and thereby increases national benefits.

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## RESOURCE ISSUES

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Active participation of national and international organizations in the work of GCOS is essential. The four sponsoring organizations have broad membership, but there is a need in each nation for an identified focal point for climate activities, particularly to consider observational requirements in support of international programmes.

A critical role for GCOS is to stimulate proactive climate centres in participating countries, to enlist national and international support to meet observation and data needs, and to ensure the benefits of the system are shared by all participating countries.

The mechanisms to secure long-term commitments for observations and for capacity building in developing countries must be continually reviewed. To do this, the JSTC is taking steps to garner resources to assist developing countries increase their capacity for effective participation in, and benefit from GCOS.

In summary, the resources required for the GCOS are principally of three kinds: (1) for planning and international coordination activities, (2) for establishment of national/international centres for support of key GCOS functions in association with related national activities, and (3) for implementation of key parts of the GCOS Plan through support for continuing existing observations, enhancing existing systems, and implementing new observations in the future.

### *International Coordination*

To date, the support for GCOS planning has come principally from the sponsoring organizations with important supplements from nations. These funds support the operational expenses of the small JPO staff. To accomplish the projected activities associated with implementation of the strategy, it is essential to increase the funding available for GCOS. At present, approximately US \$0.3M per year is

available to support GCOS planning and coordination activities. Additional resources needed by 1997 are estimated to be about US \$1.5M per year. Moreover, based on projected activities a total of four additional staff, possibly via long-term secondment, will be needed to conduct programme activities by 1997.

### *Centres for GCOS Activity*

Although the central planning for GCOS will be coordinated by the JPO, it is important that a number of technical centres, co-located with appropriate national agencies/centres, be established to provide essential support for GCOS activity. These centres will address several GCOS functions: (1) data and information management, (2) satellite and *in situ* observation coordination, (3) harmonization of multi disciplinary observations. Such centres would provide technical support, serve as sources of information to users/ participants, provide ombudsman functions, and provide key expertise on evolving technologies.

### *National Implementation*

As noted, the essential observational activities must be carried out by participating countries, but the establishment of independently functioning national programmes is not sufficient — the realized global climate system must be more than the sum of the national contributions. To assist the coordination of resources and effective integration of the effort, a forum should be established to permit national representatives to interact with and comment on the GCOS plans. The JSTC has proposed that an intergovernmental panel be formulated to continue the dialogue initiated by the Climate Agenda Meeting. This forum would permit countries to share experiences related to climate issues, and to enable, through appropriate national contributions, integrated and concerted plans for implementation to be developed.

In the past decade, science and technology have reached levels of capability to make seasonal-to-interannual climate predictions, and to assess the potential for climate change due to anthropogenic forcing. To take the next steps, it is clear that an international effort is required — no one laboratory, agency, or nation acting alone has sufficient resources to generate the essential information or to develop the necessary understanding. There is a collective responsibility to integrate existing intellectual, scientific, and technological capability to advance the research frontier, to provide essential services, and to permit accurate assessments to be made to guide policy and decision-makers.

The paramount issue for GCOS is to provide a framework for the system and to identify the resources needed to provide the observations in support of climate activities and applications. These resources must ultimately derive from national efforts.

Since climate change will directly affect all nations, it is essential to have the participation of all nations. Thus, GCOS has made a commitment to fully involve all countries in the programme. In the case of developing countries, the programme will, in partnership with other programmes, actively support capacity building and training both in making observations, and in developing techniques to fully utilize the data and products for national needs.

While the GCOS and other elements of the Climate Agenda will require substantial investment, the cost to society for failing to address climate and global change issues is potentially much larger. Understanding of both the decadal-to-centennial and seasonal-to-interannual time scales is clearly important. Obviously, the collection of appropriate observations is essential to such understanding. Thus, the GCOS should be viewed as a sound investment in our future.

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## MEMBERS OF THE JOINT SCIENTIFIC AND TECHNICAL COMMITTEE

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## ANNEX I

*Chairman:*

Sir John Houghton (UK)

*Vice-chairmen:*

Dr Lennart Bengtsson<sup>1</sup> (Germany)  
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Mr Robert Winokur (USA)

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Dr Angus McEwan (Australia)  
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Dr Melbourne Briscoe<sup>3</sup> (USA)  
Dr Peter Ryder<sup>4</sup> (UK)  
Dr John Townshend<sup>5</sup> (USA)  
Mr Gregory Withee<sup>6</sup> (USA)

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## JOINT PLANNING OFFICE

*Director:*

Dr Thomas Spence

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- 1 Chairman, Atmospheric Observation Panel
  - 2 Chairman, Ocean Observation System Development Panel
  - 3 Chairman, Working Group on Socio-economic Benefits
  - 4 Chairman, Space-based Observation Panel
  - 5 Chairman, GCOS/GTOS Terrestrial Observation Panel
  - 6 Chairman, Data and Information Management Panel

