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**GCOS IMPLEMENTATION STRATEGY:
IMPLEMENTING GCOS IN THE NEW MILLENNIUM**

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TABLE OF CONTENTS

BACKGROUND TO THE STRATEGY	i
1. INTRODUCTION	1
2. THE SCOPE	1
3. THE STRATEGIC FRAMEWORK	3
4. THE STRATEGY FOR THE NEW MILLENNIUM	4
5. THE PRIORITY COMPONENTS OF GCOS	5
Atmosphere	6
Oceans	6
Terrestrial	8
Data and Information Systems	8
GCOS Products	9
6. IMPLEMENTING ACTIONS	9
7. SPECIFIC ACTIONS FOR THE GCOS SECRETARIAT	13
8. RESOURCE ISSUES	14
International Coordination and Oversight	14
GCOS Monitoring and Archiving Centres	14
National Implementation	15
9. CONCLUSIONS	15

ANNEX I: GCOS PRINCIPLES OF INVOLVEMENT

ANNEX II: LIST OF ACRONYMS AND ABBREVIATIONS

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GCOS IMPLEMENTATION STRATEGY: IMPLEMENTING GCOS IN THE NEW MILLENNIUM

BACKGROUND TO THE STRATEGY

Since the establishment of the Global Climate Observing System (GCOS) in 1992 by its Sponsors¹, several important changes have occurred which have significantly influenced the scope and focus of its activities. It is timely then to revisit its implementation strategy and seek the most effective means for GCOS to achieve its goals. Some of the critical factors are:

- When originally established in 1992, there was an implicit expectation that GCOS would be directly responsible for the implementation and operation of the global observing systems for climate. Since then, the oceanic and terrestrial domain-based observing systems, the Global Ocean Observing System (GOOS) and the Global Terrestrial Observing System (GTOS) have been established and are increasingly involved with implementing many of the observing systems required by GCOS. In addition, the World Meteorological Organization (WMO) clearly expects that the atmospheric component of GCOS will be implemented in cooperation with their technical commissions, including the Commission for Basic Systems (CBS), and with the World Weather Watch (WWW). At the same time, the GCOS Sponsors have emphasized that GCOS needs to “ensure” that the systems required by the climate community are indeed implemented and operated in an appropriate manner;
- GCOS is a cross-cutting observing system involving multiple domains, multiple observing systems components, and multiple users with links to multiple intergovernmental mechanisms. These multiple dimensions have **not** been adequately articulated or exploited. Despite the clear intention of its Sponsors, it is often, incorrectly, assumed that GCOS speaks for the atmospheric domain;
- Extensive planning in the first few years led to the publication of the design for an Initial Operational System (IOS) in 1995, and much work has been carried out since then in its implementation. However, scientific understanding has developed and new issues have emerged such as the need for integration of observations from different domains and better understanding and monitoring of the carbon and water cycles;
- While progress has been made in implementing GCOS, many essential components of the current observing systems used for climate purposes are deteriorating. Sustained effort will be required to prevent further deterioration and to reverse this trend;
- As a result of the continuing evolution of satellite sensors, both in terms of new sampling techniques and improved quality and accuracy, new climate-relevant satellite data allow for the development of composite observing systems that both complement and extend the *in situ* observing networks of the past. These space-based observations also have a need for *in situ* observations for calibration, quality control, as well as providing a link to the historical data;

¹ GCOS is sponsored by the World Meteorological Organization (WMO), the Intergovernmental Oceanographic Commission (IOC) of UNESCO, the International Council for Science (ICSU) and the United Nations Environment Programme (UNEP).

- The resource base available for GCOS is **not** adequate to its mission of ensuring the implementation of an integrated global observing system for climate;
- The global impacts of the 1997-1998 El Niño have increased public awareness of the need to improve the observational basis for seasonal-to-interannual prediction and to reduce the impacts of future El Niños by monitoring regional impacts of climate variability; and
- The Kyoto Protocol and recent decisions from the Conference of the Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC) have highlighted the political interest in improving systematic observation to meet the needs of the Convention, including climate change detection and attribution, and assessing climate impacts for the purposes of mitigation and adaptation. The global carbon budget is receiving increased attention with consequent implications for GCOS in terms of reliable measurements.

These factors demand that GCOS articulate an updated implementation strategy, which clearly states its roles and responsibilities in implementing a global observing system for climate, its relationships with the other components of the global environmental observing system and its linkages to its international sponsors and national observing programmes.

IMPLEMENTING GCOS IN THE NEW MILLENNIUM

1. INTRODUCTION

Since inhabiting the Earth, humans have adapted and modified their lifestyles in response to climatic conditions and their regional and temporal variations. The variation in seasonal conditions from year to year has usually been accommodated by careful planning. Humans have also adapted, but more slowly, to longer-term variations, now usually referred to as climate change. Such adaptations have often been dramatic in nature, including the widespread migration of peoples to other regions.

Our present knowledge of climate and its variability is based primarily on three sources of data. The first is the routine collection of atmospheric, ocean and land surface data by meteorological and oceanographic agencies, and a variety of agencies concerned with terrestrial issues. Such data, collected primarily for purposes such as weather forecasting, aviation and marine operations, agricultural production, and hydroelectric generation, have gaps and inadequacies when they are utilized for climate purposes. The second is the data base resulting from environmental research projects such as those of the World Climate Research Programme (WCRP) and the International Geosphere-Biosphere Programme (IGBP). Such data have, more often than not, taken explicit account of climate needs but the projects have limited lifetimes and cannot be expected to satisfy the operational and long-term needs of the climate community. The third consists of historical or proxy data contained in the ice cores, sediments, tree rings and the like.

In the national and international debates about climate change and variability, adequate information has not been available for governments to answer critical policy questions. Recent scientific developments have demonstrated that seasonal climate predictions can frequently be made with useful skill at lead times of 6-12 months. Effective implementation of such operational products requires the continuation of a range of research observations in the atmosphere and the oceans as well as their extension into other regions of the globe. The development of effective national and regional responses to seasonal predictions, climate variability and change, as well as extreme events, requires a detailed assessment of local and regional climate information. Such local and regional information must be a natural extension of a global system. Finally, it is clear that the research community requires access to long-term records of the climate system to effectively understand both climate change and short-term variability.

The World Meteorological Organization (WMO), the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific and Cultural Organization (UNESCO), the International Council for Science (ICSU) and the United Nations Environment Programme (UNEP) established the Global Climate Observing System (GCOS) to ensure the sustained operation of global observing systems for climate to meet the requirements not only of this generation, but also to be the basis of a system for future generations. GCOS is directed by a Steering Committee (SC) based on advice from scientific and technical panels with the support of a small Secretariat.

2. THE SCOPE

The scientific strategy of GCOS is based on the concept that analyses and models of the climate system require an adequate observational base to be effective in addressing climate variability and change on both seasonal-to-interannual and decadal-to-centennial time scales.

The quantity, quality, and continuity of the observations required demand that a systematic global programme be implemented.

The detailed plans for GCOS have taken a comprehensive approach to climate issues. They have considered the full range of issues, including the requirements of users/participants at local, regional and global scales, the contributions of existing research and operational programmes and data systems, and the participation of both international and national organizations. The scientific scope includes 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 adopted in the design of an Initial Operational System (IOS) for GCOS was based on meeting the following priority observational needs for:

- International policy-making on climate change, including comprehensive, long-term observations of climate parameters for early detection and documentation of climate change, and for determining regional distributions of changes in climate, their timing, and their impact on ecosystems;
- Operational product preparation, including data for initialization and validation of models for seasonal-to-interannual prediction;
- National and regional assessment of the impacts of climate variability, extreme events and climate change; and
- Research into the processes and variability of the climate system, in particular the long-term systematic observations needed to support such research.

In addition, the GCOS-IOS gave specific attention to the need for:

- Ensuring proper integration among all observing systems through close coordination during both design and implementation phases;
- A comprehensive approach for data and information management which addresses data quality; collection techniques and methods; merger, assimilation and analysis; dissemination; and archiving;
- Building upon the global observing capabilities of space-based sensors and combining these with *in situ* observations to link past and future data sets as an integral part of an integrated global observing strategy; and
- Active involvement of developing countries through capacity building.

GCOS is being implemented by nations, with the cooperation and participation of, *inter alia*, the following GCOS partners:

- World Weather Watch (WWW)
- Global Atmosphere Watch (GAW)
- Hydrology and Water Resources Programme (HWRP)
- Global Ocean Observing System (GOOS)
- Global Terrestrial Observing System (GTOS)
- Global Environmental Monitoring System (GEMS)
- Global Resource Information Database (GRID)
- World Climate Programme (WCP, including data and monitoring, applications and services, impacts and responses, and WCP-Water)

- World Climate Research Programme (WCRP)
- International Geosphere-Biosphere Programme (IGBP)
- Diversitas
- International Human Dimensions Programme on Global Environmental Change (IHDP)
- Intergovernmental Panel on Climate Change (IPCC)
- Committee on Earth Observation Satellites (CEOS)
- Integrated Global Observing Strategy Partnership (IGOS-P)

3. THE STRATEGIC FRAMEWORK

When establishing an implementation strategy for the next decade there are several factors that should be considered.

Firstly, since governments around the world already spend billions of dollars taking observations that are relevant to climate, GCOS cannot expect to build a new standalone system solely for climate purposes. Fiscal prudence means that GCOS must be built wherever possible upon existing systems. While this may be efficient from a fiscal perspective, it will mean that the GCOS requirements must be explicitly addressed by contributing networks for them to be effective in meeting climate user needs. When the needs of users cannot be met by improving or adapting current systems, GCOS will seek to mobilize support of nations for new research programmes, technological developments or operational observing systems.

Secondly, the three domains (atmosphere, oceans, terrestrial) are in different stages of maturity. GCOS must therefore adopt different approaches for each of the domains:

- Because of the prior existence of the meteorological network, and the early recognition of the importance of quality and continuity, GCOS can develop its strategy primarily in terms of supplementation and selective enhancement for its atmospheric networks;
- For the oceans, GCOS and GOOS can work with the Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM) to make operational a number of research networks as well as to extend existing networks into new areas of the globe; and
- For terrestrial networks, a major issue is to focus local and regional networks into a global system and to utilize the new satellite observations to provide global estimates of important terrestrial parameters. At present, the climate change issue provides a primary motivation for investment in new activities to understand and observe the global carbon cycle.

Thirdly, national agencies and regional entities are the primary funders and operators of observational systems and networks. For an effective global climate observing system, all nations must be convinced of the need to take and exchange the observations identified by GCOS with special attention to involving developing countries. National and regional needs for climate observations go beyond those currently included in GCOS. Consequently, the current stated needs of GCOS represent a minimum climate observing system and not necessarily a sufficient one from a national perspective. Since data from remote regions such as the southern oceans are required for a truly global system, nations will have to agree to deploy and operate networks in partnership in these remote regions. Many of these partnerships are already in place but others will be needed.

Fourthly, due to the breadth and complexity of a global climate observing system, the GCOS Secretariat will have to work through existing international and regional coordination mechanisms and promote new mechanisms where necessary. In addition, it must articulate

performance standards, which can be monitored to demonstrate to governments and others, where progress is being made and where more effort is needed.

Lastly, many climate users need information on trends, including variability and extreme events as well as in climate means. This will require combining past, present and future observations from different instrumentation and from different time periods, which is a major scientific challenge but a fundamental requirement for GCOS. Obtaining global trends will depend increasingly on space-based technologies. Linking observations from space-based technologies with past and present *in situ* observations poses special challenges in maintaining continuity and quality control of observations and will require an integrated systems approach.

4. THE STRATEGY FOR THE NEW MILLENNIUM

The long-term goal of GCOS is to facilitate and oversee the development of an integrated, responsive global observing system for climate that will “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” (as stated in the GCOS Memorandum of Understanding). Building upon the strategic framework in the preceding paragraphs, the GCOS strategy will be based on four principles and supporting enabling activities:

1. Obtain the support of national governments for implementing a global observing system for climate. GCOS will:

- Communicate with national governments, utilizing the GCOS partners, Sponsors and other appropriate mechanisms, on the importance of implementing an effective global climate observing system;
- Encourage the development of national programmes and implementation plans to build, maintain and operate the networks and observational platforms that comprise the GCOS-IOS. Such programmes and plans should recognize the multi-disciplinary nature of GCOS and the requirement not only to respond to global needs but also to contribute significantly to users at the national, regional and local level;
- Encourage governments to cooperate in observing the global commons, e.g., the oceans and Antarctica;
- Work with the intergovernmental processes of the GCOS Sponsors to encourage national participation in GCOS implementation. GCOS will participate in and inform these intergovernmental processes on the current status of the observing systems for climate, including reporting on the deficiencies and options for improvements in these systems;
- Inform the bodies of the United National Framework Convention on Climate Change (UNFCCC) regularly on the adequacy of the global observing systems for climate for the purposes of the Convention and seek their support for actions to address inadequacies; and
- Encourage the identification of National Coordinators for GCOS to involve their national atmospheric, oceanographic and terrestrial agencies in systematic observations and act as an expert interface for GCOS information.

2. Strengthen partnerships with operational and research observing, data management, and distribution systems. GCOS will:

- Work with the GCOS partners, including the space agencies, and other appropriate programmes and organizations to ensure that GCOS requirements are incorporated in the planning and implementation of the domain-based observing systems and the Integrated Global Observing Strategy (IGOS);
- Identify components of existing networks and platforms that meet the GCOS requirements and, with the appropriate partner, incorporate the identified component into GCOS, subject to the operating standards approved by the GCOS Steering Committee (and other appropriate bodies) and the GCOS Principles of Involvement (Annex I);
- Work with the relevant GCOS partners to improve current networks or to establish new networks when GCOS requirements are not being met;
- Work with the research partners to transition research observing programmes into long-term, routine operating systems based on a clear requirement for those observations;
- Maintain on-line computerized information indicating the source and location of all networks, data sets and products contributing to GCOS.

3. Build capacity and correct deficiencies in the GCOS networks. GCOS will:

- Identify regions and areas that have significant deficiencies in the GCOS-IOSS implementation and encourage the countries involved to develop action plans to address those deficiencies. These action plans will usually incorporate capacity building in developing countries for participation in GCOS;
- Work with interested countries, international agencies, and financial mechanisms to identify and assemble the resources to implement regional action plans; and
- Work with GCOS partners to implement resourced action plans.

4. Keep GCOS relevant to the users and promote cost-effective improvements. GCOS will:

- Continue to liaise with users to be aware of their requirements and incorporate changes in those requirements into GCOS;
- Work with the international research programmes in developing more effective and efficient approaches and incorporating improvements in research and technology into the operational observing systems; and
- Work with the IGOS Partners to address the requirements for observations of the carbon and water cycles, particularly to exploit the opportunities provided by new satellite technologies.

5. THE PRIORITY COMPONENTS OF GCOS

Most current observing systems associated with climate parameters were put in place to meet objectives other than those identified by the climate community. However, many systems can meet requirements for climate data. A careful assessment of existing systems and their capability has been started and will continue. Building upon the reports of the IPCC and a series of meetings with a variety of users, the GCOS science panels for the atmospheric, oceanic, and

terrestrial domains have designated key elements and identified networks that should contribute to GCOS. They have also proposed essential enhancements and augmentations to make them more effective in meeting climate requirements. Since only a brief description is provided here, further details on GCOS plans and the supporting documents of the appropriate panels are available at <http://www.wmo.ch/web/gcos/gcoshome.html>.

Atmosphere

Climate has in the past been defined in terms of the average atmospheric or weather condition, usually calculated over a 30-year period. However, climate dynamics require a range of atmospheric data to understand the system and its natural variability on all time scales, especially decadal-to-centennial, to monitor the climate, to detect and attribute change, and for both seasonal-to-interannual and decadal prediction. Fundamentally, the necessary variables are those measured routinely as part of the World Weather Watch (WWW) of the WMO (e.g., surface, near-surface, and upper-air values of temperature, wind velocity, humidity, precipitation). Important atmospheric constituents (greenhouse gases and aerosols) that play a central role in atmospheric chemistry and in the radiative balance that require monitoring are currently part of the long-term research networks. Both *in situ* and satellite observations are required for global coverage with adequate vertical and horizontal resolution.

The GCOS Steering Committee has established an Atmospheric Observation Panel for Climate (AOPC) to do careful assessments of existing networks and new observing techniques and to recommend, and facilitate the development of, the basic GCOS observing networks or systems. GCOS and WCRP jointly support the AOPC.

As a first step in implementation, the GCOS Surface Network (GSN) and GCOS Upper-Air Network (GUAN) are being established as the international global baseline networks that provide the essential observations that will carry forward into the future the most valuable historic records of the climate system. They will also play the important role of ground-truthing remotely sensed observations and as key reference sites for local, regional and national networks. In addition, the current GAW network has been adopted as the basis for the GCOS component that will provide both the concentrations and flux measurements of atmospheric constituents.

The following selected enhancements to current atmospheric systems are of high priority:

- Improved reporting and enhanced quality control in the GSN and GUAN networks of the WWW and definition of comparable satellite baseline networks;
- Increases in the number of drifting buoys and improved quality in ships making meteorological observations;
- Improved vertical distribution of tropospheric and stratospheric water vapour from satellite and *in situ* sounding instruments;
- Enhanced monitoring of tropospheric and stratospheric ozone; and
- Establishment of GCOS quality standards required of GAW observations.

Oceans

The ocean plays many roles in climate: the world oceans have enormous potential for heat storage and transport; the ocean currents transport heat at rates far in excess of atmospheric transport; air-sea fluxes provide a means for transferring heat, momentum and trace species

between the atmosphere and ocean; and the deep ocean provides a reservoir, not only for heat, but also for carbon dioxide and other greenhouse gases. In addition, its role in biogeochemical cycling is equally significant.

The GCOS Steering Committee has established an Ocean Observations Panel for Climate (OOPC) to do careful assessments of existing networks and new observing techniques and to recommend, and facilitate the development of, the basic GCOS observing networks or systems. GOOS, GCOS and WCRP jointly support the OOPC.

In contrast with the atmosphere, the sparseness of ocean observations has been a major issue for the ocean community for many years. In response to this challenge, the OOPC has pursued an effective strategy building upon a range of research and pilot projects to build an operational system. A major conference on the ocean observations for climate purposes held in St. Raphaël, France, in October 1999 concluded, *inter alia*, that:

- (i) Remote sensing has become a mature technology for collecting regular, global ocean observations. Measurements of sea surface temperature, surface wind vectors, surface wave height, sea-ice and surface topography are considered fundamental; and
- (ii) A multi-faceted, robust *in situ* network must also be implemented in part as a complement to, and calibration for, remotely-sensed data, as well as for its own intrinsic value in various applications. The primary contributions include the:
 - Tropical Pacific El Niño/Southern Oscillation (ENSO) Observing System and the Tropical Atmosphere-Ocean Array (TAO)/Triton moored array;
 - Global array of Argo profiling floats, which will provide of order 100,000 profiles of temperature and salinity annually;
 - Global surface drifter array and surface and subsurface networks operated from voluntary observing ships;
 - Surface and subsurface reference sites, such as sea level stations and fixed point deep measurements;
 - Hydrographic measurements targeting the carbon cycle and the deep ocean circulation; and
 - Acoustic tomography in selected high latitude regions.

The following selected enhancements to current systems are of high priority:

- Expansion of the TAO/Triton observing system into other oceans;
- Increasing the number of Argo floats in data sparse and high latitude areas;
- Continuation of precision satellite altimetry and wind scatterometry missions;
- Expanded use of active and passive microwave sensor instruments;
- Expansion of long-term monitoring sites for observations of deep- and bottom-water renewal; and
- Development of effective strategies for the transition of proven experimental techniques into a sustainable operational mode.

Terrestrial

Terrestrial ecosystems have an important role in determining the trace gas composition of the atmosphere affecting the Earth's energy 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 (vegetation cover as well as cryospheric elements such as ice sheets and glaciers) are also important for predictions of the evolution of the climate system. Many of these variables are also critically important for assessing the impact of climate change, and as inputs into national policy-making. Under climate change scenarios, there will be major impacts on the distribution of flora and fauna, biogeochemical cycles, and energy and water fluxes. To understand these effects, it is essential that the measurements and analyses provide integrated atmospheric, hydrologic and ecological information over land, as well as input data from the socio-economic sectors.

The GCOS Steering Committee has established a Terrestrial Observation Panel for Climate (TOPC) to do careful assessments of existing networks and new observing techniques and to recommend, and facilitate the development of, the basic GCOS observing networks or systems. The TOPC is jointly supported by GTOS and GCOS.

Terrestrial/ecosystem observations for climate are being developed and implemented jointly with GTOS, GEMS, HWRP, and other programmes and activities as appropriate, with an initial emphasis on networks for glaciers, permafrost, and carbon dioxide fluxes between vegetation and the atmosphere. Activities are also closely coordinated with the appropriate research programmes of IGBP and WCRP.

The following enhancements to current systems are of high priority:

- Improved and standardized ecosystem observations from existing and new sites;
- Increased monitoring and assessment of land cover and land use change using satellite and *in situ* observations;
- Systematic observations of the carbon cycle;
- Establishment of a global hydrological network for climate;
- Global observations of soil moisture; and
- Improved satellite data to obtain information on area and volume changes in ice sheets, ice shelves and glaciers.

Data and Information Systems

GCOS networks are designed to be end-to-end observing and data management systems for a variable or suite of variables that meet the standards defined by GCOS. The global observing systems share observing systems and data flows with other programmes. Thus a data flow established for the purpose of the World Weather Watch may also serve the needs of GCOS if it meets the appropriate standards. An end-to-end system includes: (1) acquisition, processing, and quality control of the data, (2) analysis, production, and delivery of data products at all stages of the data flow, (3) evaluation and feedback on performance of the data flow, and (4) archiving of all data, metadata, and products for future users.

Within GCOS, the responsibility for defining the needed data and information system for individual networks rests with the science panels. For example, AOPC has developed a model

for defining atmospheric networks that integrates the data management activities in the process from the taking of observations to the producing of products and archiving of the data.

The Global Observing Systems Information Centre (GOSIC) provides information on the observing requirements, the operational data systems, and the access procedures for finding and obtaining data and products of GCOS, GOOS and GTOS. An Advisory Committee with representatives from all GCOS science panels (AOPC, OOPC, and TOPC) has been established by the observing systems to provide guidance and oversight for GOSIC.

GCOS Products

The GCOS SC and the science panels recognize the importance of developing products from GCOS data, in cooperation with appropriate centres and other scientific organizations. This is an activity currently under discussion within the science panels. As products are defined that in whole or in part depend on GCOS data, a product list will be maintained and used to communicate with clients about the needs and importance of GCOS.

6. IMPLEMENTING ACTIONS

The general approach adopted for implementing GCOS has been to:

- Define a series of end-to-end Baseline Networks (including *in situ*, satellite or composite), which address specific users' needs and can be reasonably implemented by a GCOS;
- Build partnerships with satellite operators, international research programmes, global observing programmes, and others to develop new integrated approaches on cross-cutting issues, such as carbon and water cycles, which are important to climate users. The Integrated Global Observing Strategy (IGOS) is a prime example. Others might be partnerships to develop data bases for adaptation to climate change. Specific components of these integrated approaches would be included in the Baseline Networks; and
- Encourage more broadly the development and improvement of more comprehensive climate observing systems which address the stated goal of GCOS but go beyond the capacity of GCOS, e.g., regional climate networks.

GCOS implementing actions can be organized into 4 sections. (1) Strategic Design; (2) Implementation Mechanisms; (3) Regional Development and Capacity Building; and (4) Outreach. Based on the Implementation Strategy articulated in Section 4, the Priority Components of GCOS discussed in Section 5 and the resource issues of section 6, GCOS, through its Steering Committee and Secretariat, will pursue the following actions.

1. Strategic Design

In line with the principles of working closely with partners, building on existing observational activities and obtaining national support for implementing specific systems or activities, a key objective of the GCOS strategic design is to develop end-to-end Baseline Networks. In this regard, GCOS will:

- Define clearly the GCOS Baseline Networks, including the measurements taken, the standards and "best" practices, monitoring, analysis and archiving of the data and any products produced;
- Develop an Acceptance Process for approving GCOS Baseline Networks;

- Oversee the activities of the Scientific Panels and work with partners to ensure that GCOS standards are upheld;
- Pay special attention to cross-cutting issues among domains, to the development of new observing (e.g., satellite) and data assimilation techniques and to the evolution of composite observing systems; and
- Work with partners to further the development and improvement of comprehensive climate observations and data bases that go beyond the GCOS Baseline Networks but can have important regional and national applications.

2. Implementation Mechanisms

The core of the discussion in sections 3-5 has been on principles and strategy for implementing GCOS. Specific actions or mechanisms will be discussed here.

In response to decisions 14/CP.4 and 5/CP.5 on an intergovernmental process for GCOS, Canada hosted an informal meeting of experts to identify issues and elements related to an intergovernmental process for GCOS. From that meeting, the following elements were identified as the core mechanisms for implementation:

- Make more effective use of the congresses, assemblies, executive councils and other relevant bodies or commissions of the GCOS Sponsors to develop the links with and the involvement of governments in all aspects of GCOS. GCOS will engage the governing bodies using a consistent and complementary message, perhaps through the mechanism of common resolutions and will seek involvement between its Panels and the technical entities of the GCOS Sponsors, e.g., JCOMM, Commission for Basic Systems (CBS);
- Engage the UNFCCC bodies in order to give Parties the opportunity to address deficiencies in observing systems required to meet their commitment to the Convention. GCOS will focus in particular on the actions adopted in decision 5/CP.5 with regard to National Reports, synthesis and analysis of these reports, the organization of Regional Workshops to improve observing systems in developing countries and the reporting to the Conference of the Parties (COP)/Subsidiary Body for Scientific and Technological Advice (SBSTA) on developments in the global observing systems for climate;
- Improve intra and intergovernmental coordination by encouraging nations to identify a national GCOS coordinator. A network of national coordinators could enhance the intergovernmental mechanism process for GCOS. GCOS will work with interested nations to enlarge the core set of national GCOS coordinators and prepare Terms of Reference;
- Use the Regional Workshops to develop linkages at the national level and to assess the adequacy of GCOS. GCOS will organize workshops, in conjunction with existing mechanisms such as WMO Regional Association meetings or regional components of GOOS and pursue the development of regional and national linkages to GCOS Networks; and
- Increase the number of "operational" and/or senior governmental representatives on the GCOS SC so that it can more properly perform its managerial or oversight role. GCOS will seek candidates for the GCOS SC that reflect a balance between science and operations in their experience.

In addition, GCOS will focus on developing ways to build support for implementing the GCOS Baseline Networks and for cooperating on climate observations generally. This will include active participation in the IGOS Partnership, with other Conventions, where appropriate, and in bilateral activities where possible.

3. Regional Development and Capacity Building

GCOS has a major regional initiative (GCOS Regional Workshop Programme) to develop regional action plans for improving climate-observing activities and to build capacity for developing countries to participate in collection and use of climate data. This initiative responds to the invitation by the Conference of the Parties to organize regional workshops, in consultation with Parties and the Global Environment Facility (GEF), to 1) build capacity to participate in systematic observation, 2) identify deficiencies in observing systems in developing countries and 3) develop specific proposals to overcome such deficiencies. In addition, GCOS will use this initiative to identify national contacts.

The GCOS Regional Workshop Programme has the overarching goal of developing a process within a region that will lead to real improvements in observing systems in developing countries. This programme, through a series of 10 Regional Workshops with related consultations and the development of regional action plans, will seek to:

- Assess the contribution of the region to GCOS baseline networks;
- Help participants understand guidelines for reporting on systematic observations to the UNFCCC;
- Identify national and regional needs and deficiencies for climate data (including needs for assessing climate impacts, conducting vulnerability analyses, and undertaking adaptation studies); and
- Initiate the development of a regional Action Plan for improving climate-observing systems.

This programme will have two phases: (1) a Pilot Project consisting of two Regional Workshops lasting one year and (2) a series of eight additional Regional Workshops, each with associated follow-up activities, which would be implemented between 2002 and 2005. The Programme will be managed by the GCOS Secretariat with guidance from a Regional Workshop Advisory Committee of the GCOS Steering Committee and from the GCOS Science Panels. GCOS has received funding from the GEF, through UNDP, to fund approximately one half of the Pilot Project with the rest coming from donor countries and international agencies. During the Pilot Project GCOS will:

- Hold a Regional Workshop for the Pacific Island region in Apia, Samoa, August 14-15 2000 (completed);
- Facilitate the development of an Action Plan for the Pacific Island Countries. Initial planning meeting to be held in mid-2001;
- Complete planning for a second regional workshop for eastern and southern Africa. Main activities included a colloquium at the Sixth WMO Technical Conference on Management for Development of Meteorological Services in Africa (November, 2000), participation in the EUMETSAT African User Forum (September, 2000), and identification of the Drought Monitoring Centres in Nairobi and Harare as regional partners;
- Hold the second Regional Workshop (scheduled for October 2001 in Kenya);

- Facilitate the development of an Action Plan for eastern and southern Africa;
- Review the above activities and adjust model for remaining Regional Workshops;
- Prepare a report on accomplishments and lessons learned for the COP to the UNFCCC and its Subsidiary Bodies for Scientific and Technological Advice (SBSTA) and for Implementation (SBI);
- Prepare a Project Brief and submit a full proposal to GEF in late 2001 for the full Regional Workshop Programme, which would begin in 2002 and continue to mid-2005; and
- Begin planning for 3rd and 4th Regional Workshops.

TIMELINE FOR PILOT PROJECT

Activities 2000-2001	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
	Activities Prior to GEF Funding										GEF Funding						
Pacific Island Workshop																	
Pacific Island WS Follow-Up																	
Meetings in Africa																	
Preparation of Second WS																	
African WS																	
Second Workshop Follow-Up																	
Review Pilot Project																	
Report to COP																	
Preparation of full Project Brief																	
Begin second part of Regional WS Programme																	

SCHEDULE FOR THE 10 REGIONAL WORKSHOPS

	2000	2001	2002	2003	2004	2005
Pacific	•					
Africa 1		•				
R3		•				
R4			•			
R5			•			
R6				•		
R7				•		
R8					•	
R9					•	
R10						•

4. Outreach

Another major conclusion of the Canada meeting on an intergovernmental process for GCOS was the need to build ownership in GCOS. Some recommendations toward this end include the need to incorporate further analysis of the costs and benefits of maintaining and enhancing observing systems, improve communication with other decision-makers in the

sphere of climate, and develop “A GCOS Timeline”, i.e., significant events/opportunities over the next two years.

To address the needs to build ownership in GCOS, GCOS will develop an outreach strategy to support the principles articulated in section 4, including:

- Developing a calendar of significant events / opportunities over the next one to two years;
- Participating where possible in the highest priority events that raise the profile of GCOS. These will include official events like the COP/SBSTA meetings, congresses, assemblies and executive councils of GCOS Sponsors, major scientific, technical and (inter)governmental fora;
- Preparing “communications” materials to describe GCOS in “laypersons” terms, to illustrate the components of GCOS for specific audiences;
- Design tutorials for training clients in areas such as UNFCCC guidelines or preparing national communications on systematic observations; and
- Using the GCOS Regional Workshop Programme and other similar activities to discuss the needs for climate observations and the GCOS strategy.

This section has tried to illuminate the medium-term actions that need to be taken to implement GCOS. Even these actions go beyond the current resources of the GCOS Secretariat but are a reasonable set of actions needed to achieve measurable progress over the next 2 to 5 years. Shorter-term actions (1-2 years) are discussed in the next section

7. SPECIFIC ACTIONS FOR THE GCOS SECRETARIAT

The GCOS Steering Committee has identified a broad range of actions that should be undertaken to implement GCOS based upon the current strategy. However, given the severe resource limitations facing GCOS, it is proposed to focus the activities of the GCOS Secretariat over the next inter-sessional period on the following:

- Complete the GCOS Implementation Strategy and develop an implementation timeline. Seek interagency and national commitments to the strategy. Develop a calendar of significant events;
- Provide oversight, advice on integration and cross-linkages, and generally facilitate the work of the three domain-based science panels so that they can continue to move forward with the development and implementation of specific components of GCOS;
- Continue to monitor developments in the international research programmes and satellite observing systems to identify opportunities for enhanced effectiveness;
- Articulate the requirements of GCOS and, as appropriate, those of its partners (WWW, GOOS, GTOS, etc.) at intergovernmental meetings, including the various WMO Technical Commissions, and at regional and international fora;
- Report to the governing bodies of the GCOS Sponsors on the implementation of GCOS and seek the support of their Members for implementation;
- Engage the Subsidiary Bodies of the UNFCCC/COP in building support for the implementation of global observing systems for climate on behalf of GCOS partners;

- Present the climate-related themes of the IGOS Partners in reports and statements to SBSTA and the UNFCCC;
- Build a network of national GCOS focal/contact points to facilitate communication, develop national reports, and encourage the correction of deficiencies in current systems;
- Develop, in collaboration with the UNFCCC Secretariat, a synthesis/analysis process for the national reports on systematic observations due in November 2000, and use the analysis as the basis for updating the GCOS "Adequacy Report" (GCOS-48) to be completed by 2003-2004;
- Complete the Pilot Project of the GCOS Regional Workshop Programme over the next year and develop a plan and proposal to GEF for the remaining Regional (or Sub-Regional) Workshops over the next 4 to 5 years. (This activity will build on current activities of the GCOS partners and current national and regional initiatives but will be conditional on obtaining additional resources.); and
- Assist in the development of proposals to address regional deficiencies and submit for funding to bilateral activities and international financial mechanisms, as a follow-on to the Regional Workshop Pilot Projects.

8. RESOURCE ISSUES

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 and coordination mechanism for climate activities, particularly to consider observational requirements in support of international programmes.

International Coordination and Oversight

To-date, support for GCOS has come principally from the sponsoring organizations, with important supplements from nations. These funds support the operational expenses of the small staff and meetings of the panels and the Steering Committee. 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. Based on projected activities, four additional staff will be needed to conduct programme activities by 2002, possibly via long-term secondment. In addition, it is clear that many of the GCOS partners require additional resources for the activities they undertake on behalf of GCOS.

GCOS Monitoring, Analysis and Archiving Centres

An important function for GCOS is the continuous monitoring of the performance of the baseline networks to ensure that they are meeting user requirements, and the analysis and archiving of data. These functions are best carried out by existing national and regional operational centres, which would provide regular reports, technical support, serve as sources of information to users/participants, and provide key expertise on evolving technologies. Currently, such centres exist for GSN and GUAN. In addition, there is a need for a mechanism to provide users with information on the requirements for, the sources and location of, and the access procedures for data from the GCOS networks as well as on other related data. GOSIC is a prototype of such a function. A future commitment will be needed to undertake these responsibilities routinely.

National Implementation

As noted, participating countries must carry out observational activities, but many developing countries lack the capacity to carry out those functions. Sustained operational as well as project support from multilateral and bilateral funding agencies will be essential to address these weaknesses. This support will need to cover human resource development, equipment modernization, and operational infrastructure and supplies.

The establishment of independently functioning national programmes is not sufficient, as the global climate observing system is more than the sum of the national contributions. There are many parts of the globe that are remote from all nations where observations are required. To assist in the deployment of resources and effective integration of the effort, a number of bodies will need to be established, if they do not exist already, to put in place the networks required in these remote regions.

9. CONCLUSIONS

Implementing GCOS in the new millennium will require a substantially different strategy than the one previously followed by GCOS and than those of the GCOS partners. In the latter case, they can proceed directly on a project basis. GCOS can proceed only by building a level of interest and ownership in the GCOS programme across a very broad spectrum of organizations, activities and viewpoints. The implementation strategy presented in this document seeks to recognize these complexities while still proposing specific steps to implement a global observing system for climate in a timely manner. The way forward will be difficult due to the multiplicity of issues, organizations, and systems, and due to the continuing need to explain and rationalize the needs and many facets of climate observing systems at the scientific, programmatic, managerial, political and public levels. Nevertheless, the importance of the climate problems demands that we move forward to implement a global climate observing system in spite of these complexities and the limited resources available.

ANNEX I

GCOS PRINCIPLES OF INVOLVEMENT

- P1. GCOS will deliver, on an operational basis, high-quality, well-calibrated, long-term observations of the climate system needed for: seasonal-to-interannual climate predictions; climate system monitoring; early detection of climate trends due to human action; improved understanding of the climate system; impact assessment and adaptation to current and future climates; and national economic and sustainable development applications. Climate observations are required in all three domains of the earth (atmospheric, oceanic and terrestrial).
- P2. Contributions to GCOS will implement one or more components or parts of the overall systems plans developed and agreed on the basis of the above design principles.
- P3. Contributions will recognize the GCOS requirement for long-term records that requires special attention to those aspects involving routine assessments of data quality, continuity and homogeneity as well as the need for permanent repositories for all contributed data.
- P4. Contributing nations and organizations have the right to determine and limit their contributions to GCOS and have full autonomy in the management of those contributions while recognizing these principles.
- P5. Use of the GCOS 'labels' implies acceptance to operate in accordance with the relevant principles of GCOS.
- P6. All contributions of data and products pertinent to GCOS will be described in internationally accessible; on-line computerized directories that conform to agreed-upon standards, including a reference to the originator of the data and their location.
- P7. Contributions will be compliant with the GCOS data policies outlined below:

GCOS Data Policies

- D1. Internationally-agreed standards will be used to the greatest extent possible for the acquisition, processing, archiving, and distribution of data.
- D2. All data should be processed to a level that is generally useful to user communities without a detailed knowledge of the observing instrument (i.e., geo-bio-physical rather than engineering measurements). However, for data from those instruments that utilize sophisticated algorithms for this processing, adequate archives must be maintained to permit recalculation of the geo-bio-physical data as improved processing techniques become available.
- D3. The impact of new systems and technology or changes to existing systems or technology will be assessed prior to implementation and a suitable period of overlap for new and old observing systems will be followed upon implementation.
- D4. Full and open sharing and exchange of data and products will be practised for all GCOS users.

- D5. The exchange of data will occur as rapidly as possible (near real time) following the observation. Corrections arising as a result of further quality control will follow at a later time.
- D6. Results of calibration, validation, algorithm changes, and data homogeneity assessments will be treated with the same care as the data themselves and will be made available to the user community and the designated international data centre.
- D7. Data sets established as part of international research programmes and designated as required for the indefinite future will be archived with the appropriate international data centre.
- D8. Information about the data holdings, including long-term quality assessments, supporting ancillary information (meta-data), and guidance and aids for locating and obtaining the data, should be readily available at both national and designated international data centres.

GCOS/GOOS/GTOS Climate Monitoring Principles²

- 1. The impact of new systems or changes to existing systems should be assessed prior to implementation.
- 2. A suitable period of overlap of new and old observing systems should be required.
- 3. The results of calibration, validation and data homogeneity assessments and assessments of algorithm changes should be treated with the same care as data.
- 4. A capability to routinely assess the quality and homogeneity of data on extreme events, including high-resolution data and related descriptive information, should be ensured.
- 5. Consideration of environmental climate-monitoring products and assessments, such as IPCC assessments, should be integrated into national, regional and global observing priorities.
- 6. Uninterrupted station operations and observing systems should be maintained.
- 7. A high priority should be given to additional observations in data-poor regions and regions sensitive to change.
- 8. Long-term requirements should be specified to network designers, operators and instrument engineers at the outset of new system design and implementation.
- 9. The carefully-planned conversion of research observing systems to long-term operations should be promoted.
- 10. Data management systems that facilitate access use and interpretation should be included as essential elements of climate monitoring systems.

² Extracted from UNFCCC Document FCCC/CP/1999/7: "REVIEW OF THE IMPLEMENTATION OF COMMITMENTS AND OF OTHER PROVISIONS OF THE CONVENTION, UNFCCC guidelines on reporting and review", 16 February 2000 (p. 108).

ANNEX II

LIST OF ACRONYMS AND ABBREVIATIONS

AOPC	Atmospheric Observation Panel for Climate
CBS	Commission for Basic Systems (WMO)
COP	Conference of the Parties (to UNFCCC)
ENSO	El Niño/Southern Oscillation
GAW	Global Atmosphere Watch
GCOS	Global Climate Observing System
GEF	Global Environment Facility
GEMS	Global Environmental Monitoring System
CEOS	Committee on Earth Observation Satellites
GOOS	Global Ocean Observing System
GOSIC	Global Observing Systems Information Centre
GRID	Global Resource Information Database
GSN	GCOS Surface Network
GTOS	Global Terrestrial Observing System
GUAN	GCOS Upper-Air Network
HWRP	Hydrology and Water Resources Programme
ICSU	International Council for Science
IGBP	International Geosphere-Biosphere Programme
IGOS	Integrated Global Observing Strategy
IGOS-P	Integrated Global Observing Strategy Partnership
IHDP	International Human Dimensions Programme on Global Environmental Change
IOC	Intergovernmental Oceanographic Commission
IOS	Initial Operational System (GCOS); Integrated Observing System (GOOS)
IPCC	Intergovernmental Panel on Climate Change
JCOMM	Joint Technical Commission for Oceanography and Marine Meteorology
OOPC	Ocean Observations Panel for Climate
SBI	Subsidiary Body for Implementation (UNFCCC/COP)
SBSTA	Subsidiary Body for Scientific and Technological Advice (UNFCCC/COP)
SC	Steering Committee
TAO	Tropical Atmosphere-Ocean Array
TOPC	Terrestrial Observation Panel for Climate
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
WCP	World Climate Programme
WCRP	World Climate Research Programme
WMO	World Meteorological Organization
WWW	World Weather Watch (WMO)