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The Environmental Foundation – Weather and Climate Observations: A Case Study on the Evolution of Integrated Global Climate Observing

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Author's Note

The desire to limit the length of this study has presented a challenge in providing the proper balance of information. The desire is not to be overwhelming, but sufficiently detailed to give some exposure, perspective and understanding into the institutional processes involved in developing a global observation mechanism. In some cases conclusive findings to support the author's opinion are not fully developed and further in sight should be derived from the panel discussions. Most of the references are available only at selected libraries dealing with intergovernmental documents; however this does include the NOAA Library. In preparing the case study, the actual subject matter and focus continued to be narrowed due both to the length of the paper and the complexity of the subject. In this respect the author recognizes that in some cases there is limited information presented that can be applied to the broader questions posed. To a large degree the whole area of global systematic multi-disciplinary observations is largely unprecedented and many answers are not obvious; thus making for a provocative subject, but hopefully interesting.

Abstract

(The case study examines some of the decisions related to the institutional processes that influenced the planning and development of the Global Climate Observing System (GCOS). GCOS is one of the first attempts since the establishment of the World Weather Watch to significantly increase a comprehensive set of new and modified environmental observations from both the earth's surface and space. GCOS is intended to be a logical next step in the evolution of a total environmental observing program for the planet earth. This program has come at a time when the global public interest and knowledge began to relate closely several major issues – ecological quality; local, regional and global climate change, and natural disaster management. The study assumes that we must ultimately attain a systematic method of observing our earth's environment as an integrated mechanism. The Case will contrast decisions made as a part of the development and implementation of the World Weather Watch (WWW) and those of a generic model, with actions taken to develop GCOS over the last decade. Questions are raised throughout the study regarding specific decisions, particularly with respect to the role of the US, that have been made with respect to GCOS. Because of the scope and complexity of the issue of global observations, only a select number of issues will be addressed. It is not the intent of the study to be critical, but it is an objective to understand the decision process within GCOS, including the US decision processes, and to perhaps offer alternatives for future actions. The readers of the study should assess the quality of the decisions in terms of a degree of satisfaction, and to suggest alternatives or follow-on actions. It is perceived that these decisions have influenced and continue to influence the careers of most participants in the AMS Colloquium. In making an assessment, it should be recognized that much of the language used in governmental and intergovernmental fora tend to avoid or de-emphasize negative decisions, often allow for plausible deniability, can be contradictory in many respects to allow for a spectrum of views, and are adopted not so much for support, but for lack of an objection.)

INTRODUCTION & BACKGROUND

Since the beginning of civilization, the understanding of the earth's environment, and particularly its climate, has been a question that has fascinated and perplexed man. Early records show the desire to observe and document the variations in day-to-day weather. As civilization progressed, interest moved to understanding average variations on a year-to-year basis and other aspects of climatology. This new focus served to form the basis of early climatological observation networks. In the late 20th century concern about the variability and possible change in climate, particularly as a result of human activities, became significant issue. The ability to numerically "model" and simulate climate and its change from processes such as radiative forcing further emphasized this issue. This issue precipitated an increased desire to observe the climate more quantitatively with the desire to relate such an activity within the context of total integrated environmental monitoring. This suggested the need for a global observing system beyond that needed to predict global weather in time frames of days to weeks. The science also made it clear that understanding of climate processes and measurements must embrace more than the atmosphere. As a concept, several scientists, since the birth of the World Weather Watch in 1960, have recognized the increasing need, deriving from science and technology, as well as considerations of effectiveness and efficiency, to establish a much more integrated approach to the design, implementation, and operation of global environmental observing systems. In fact, one of the justifications and

positive cost/benefit factors in the original argument for the World Weather Watch was the contribution it would make to the understanding of climate. Perhaps the most visible process to actually establish such an activity was the establishment of the Global Climate Observing System (GCOS) in 1992. This was recognized by the Eleventh Meteorological Congress (1991), and specified by the UN Conference on Environment and Development (Rio de Janeiro, 1992) in its Agenda 21. Agenda 21 was to be a blueprint for global sustainable development that linked economic and environmental concerns. This linkage recognized the need for nations to enhance scientific knowledge of our earth's environment and to develop and expand a global climate observing system.

GCOS emerged as a joint effort by a number of intergovernmental (e.g. WMO, IOC, and UNEP) and nongovernmental organizations (e.g. ICSU). The Joint Scientific and Technical Committee (JSTC) for GCOS captured this thought in an early statement regarding plans to develop GCOS (WMO, 1992a). "There is a collective global responsibility to fuse existing, diverse intellectual and technological capabilities, and to bring them to bear on the issues of global climate. The foundation of climate assessment and prediction lies in the coupling of observations over a range of spatial and temporal scales with process studies and models in order to understand, assess, and predict global climate change." In 1999 at the Thirteenth Meteorological Congress, The President of the WMO (WMO, 1999a) reemphasized this goal and implied that this formidable challenge is still in a very early stage, " Today, in an effort to develop a more integrated approach to ongoing observation and monitoring of the global environment in the twenty-first century, there was again a need to forge new partnerships between the atmospheric science and satellite communities under the auspices of WMO." Perhaps, this call was in recognition of the WMO Commission on Climatology's concern on the shrinking of the meteorological networks and in particular the decreasing number of Climate Reference Stations. Congress Thirteen (1999) also called for <u>urgent</u> actions to address the issues of declining networks and the inadequate observing infrastructure in many areas of the world, especially in developing countries. This view was also expressed by the Chairman-Emeritus of the Intergovernmental Panel on Climate Change (IPCC), Prof. Bert Bolin, (WMO, 1998a), "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." To give some quantitative perspective, it is useful to look at the reporting from the GCOS Surface Network (GSN) and GCOS Upper Air Network (GUAN). In 2000, less than 55 percent of the designated GSN stations provided half or more of the required observations and this was down from 58 percent in 1999. Similarly, in 2000, less than 67 percent of the designated GUAN stations reported required observations down from 69 percent in 1999.

This case study is not intended to judge the success or progress of the GCOS over the past 10 years, but will examine several of the complex issues and decisions that have been a part of the establishing, planning, and implementing of this activity, and attempt to contrast this activity in a hypothetical "non-political" environment with no institutional boundaries. It will also contrast the development of GCOS with some of the actions thought to be an important part of the decisions affecting the WWW. This paper seeks to understand the decisions that have influenced the structure and growth of GCOS and the role taken by the government and others in the USA. A more interactive dialogue on this study will be discussed in panel discussion format, that will include several of the decision makers involved, and serve as a phase II of the case study on Future Scenarios.

In order to discuss the establishment of a global capability for observing the environment needed to understand, predict and document the climate, it is useful to review some of the previous macro scale decisions that could and would shape how GCOS evolves. Within this context, the macro decisions related to the development of the WWW are considered instructive.

In the early 1960's, Governments via the WMO and individual scientists via ICSU decided to establish a major global meteorological observation and service program called the World Weather Watch (WWW) (WMO, 1972a). The World Weather Watch was developed in parallel with the supporting Global Atmospheric Research Program (GARP) that had as a second objective, the physical understanding of climate. The initial objective of GARP focused on the understanding necessary for making weather forecasts from 1 day to a week or two. As a result, the WWW placed most of its priority on the weather forecast issue and on observing the physical atmosphere in support of numerical weather prediction, and the ability to provide consistent, accurate and timely weather forecasts from all nations of the world (WMO, 1975).

The World Weather Watch (WWW) is the product of one and half centuries of international collaboration and the application of the major advances in science and technology that have taken place during that time. Most Members of WMO have speculated that the WWW would be a major global observing component in any larger observing scheme (e.g. GEMS, EARTHWATCH) being discussed within the UN system. The WWW concept was requested formally by the General Assembly of the United Nations in late 1961 and the Fourth Meteorological Congress adopted the specific program in April of 1963. Also at the urging of the UN, this Congress invited ICSU to jointly develop the Global Atmospheric Research Program (GARP) to understand the transient behavior of large-scale atmospheric fluctuations in order to increase the accuracy of forecasts for a period of one day to several weeks. Additionally, GARP was to determine the statistical properties of the general circulation of the atmosphere that could lead to a better understanding of the physical basis of climate. As such, GARP was considered as a synergistic research element for the development and planning of the WWW.

WWW was designed, planned and implemented as an <u>observation and service</u> program with major components that included telecommunications, data processing and guidance product preparation, system monitoring, and capacity building. Another important aspect was the altruistic attitude that nations with capabilities would volunteer to do major pieces of the program (e.g. satellite operation, numerical prediction, etc.) and share with the rest of the world nations.

WWW, working in close cooperation with GARP, for its first two decades focused on the issue of weather forecasts out to several days. In the early 1980s, following the completion of major GARP experiments aimed at specific scientific questions (e.g. GATE- energy processes in the tropics; MONEX- monsoon processes; etc.) and the First GARP Global Experiment (FGGE), an increase in priority for climate related issues began to emerge. To a large degree the issues focused on understanding that could lead to seasonal and interannual forecasting. By this time the WWW had matured to the point that its infrastructure largely embodied the needs of national meteorological services for providing weather prediction out to multiple days and even a couple of weeks. This overwhelming requirement caused the WWW to focus primarily on those parts of the atmosphere and surface ocean layers needed to provide forecasts on time scales of one to 10 days. This had the real effect to preclude the WWW from embracing requirements for many climate activities associated with parts of the deeper ocean, cryosphere, water cycle, and carbon cycle. The national and international structure and function of the bodies and agencies responsible for the WWW were not primarily designed to focus on these larger climate issues. In fact, there was a real fear by many that to take ones eye off the narrower objective of weather prediction would hinder progress. In addition, non-real time observations, such as cooperative observers were considered part of climatology activities of WMO and were not included in the technical and scientific oversight of the WWW. This also illustrates the potential issue of compartmentalization in institutions such as the WMO.

The reluctance by some WMO Members to aggressively expand the WWW to include climate can be seen from the statement of the Eleventh Congress (WMO, 1991a), "Congress noted that the WWW system, despite its deficiencies and lack of homogeneity in certain areas, represented a truly global network of well co-coordinated facilities, which might be used to support other programmes <u>so long as its original purpose to serve operational meteorology and hydrology was not compromised."</u> In contrast the same Eleventh Congress stated, "Congress acknowledged that there would be an increasing reliance on the systems and <u>services</u> of the WWW in Climate change monitoring and research." Also, in the 1980s, WMO fostered the development of Ozone and Background Air Pollution observing facilities as a part of a research program unrelated to WWW. These stations were to become the backbone of the Global Atmosphere Watch and not linked in any programmatic way to the WWW.

Since the inception of the WWW, Members of WMO recognized the eventual need for a parallel observation and service program that would deal with the surface and near subsurface ocean. Such a program would be developed in close coordination with the Oceanic Sub system of the WWW (WMO, 1970). In this respect, the Intergovernmental Oceanographic Commission (IOC) was looked at as a lead partner with the WMO to establish an Integrated Global Ocean Station System (IGOSS). The importance of IGOSS to the WWW and other programs at WMO was emphasized by the creation of an Executive Council Panel on Meteorological Aspects of Ocean Affairs in 1971. This panel met jointly with the IOC Working Committee on IGOSS to provide a joint expert body over seeing the IGOSS program. In the late 1970s the WMO panel and the IOC Working Committee were merged into the Joint IOC/WMO Working Group for IGOSS and the name of the program was changed to the Integrated Global Ocean Services System. Quite interestingly, the mechanism for integration and collaboration between WMO/WWW and IOC was much more refined than between WWW and the Global Atmosphere Watch, both within WMO!

The IOC was established within the UNESCO framework largely as a result of the International Geophysical Year activities. IOC was established with its own membership, separate from UNESCO, and as a focus within the UN system for ocean science and other marine activities. As a result of this focus, IOC took on a major coordination role within the UN and encouraged joint program activities with other specialized agencies of the UN that were involved in marine and ocean science. WMO was a strong partner to the degree of seconding a full-time science officer from the WWW Department to the IOC secretariat and jointly undertaking the development of an IGOSS. The IGOSS program was being developed to ensure the effective implementation of a systematic ocean observing and services system. The development of IGOSS was pursued in close cooperation with the WWW such that much of the infrastructure (e.g. telecommunications, observing codes, observing platforms, and processing centers) was shared between the two programs. In this respect, the Secretary of the IOC made the following statement regarding the merging of IGOSS and other ocean service activities (WMO, 1991a), "The second major thrust of the co-operation between IOC and WMO concerned ocean observation both above and below the sea: the phase of trying to establish a GOOS as a major component of the GCOS was just beginning. IOC had committed itself to the development of those systems and was looking to WMO for a strong co-operative effort. An initial priority of the GOOS was the climate related subsystem, which would have to be built largely on existing systems such as IGOSS, a joint WMO/IOC undertaking." IGOSS subsequently formed a large part of the backbone of the Global Ocean Observing System (GOOS) and it shares many facilities with the WWW.

CASE STUDY ISSUES

This case study, because of limitations of time, will not address many aspects regarding the overall global environmental observing issues facing nations. For example, the major issue of free and unrestricted exchange of data and products as well as the issue of commercialization will not be addressed in the study. In addition, it should be recognized that a majority of the environmental observing and monitoring serves to support national needs and requirements not part of an international program structure. To discuss and understand the role of intergovernmental bodies and nations involved in the decision making process, this study will contrast actual events with a conceptually non-political generic model for establishing a system for global climate observing and some of the apparent successes of the WWW.

The generic model under consideration has the following elements:

- **(1) Definition of user requirements and/or "Charge"**
- **(2) Definition of observational or data requirements**
- **(3) Development of conceptual roadmap or design for the observing system and its estimated budget**
- **(4) Identification of overall lead responsibility for implementation and oversight**
- **(5) Preparation of implementation strategy and plan**
- **(6) Identification of resources and priority mechanisms**
- **(7) Establishment of system oversight mechanism**
- **(8) Establishment of implementation monitoring**
- **(9) Identification of mechanism for continuing review and change management**

The World Climate Research Program in many respects provided the impetus for GCOS. In fact, the initial design of GCOS resulted from a proposal prepared through a group convened by the Chairman of the Joint Scientific Committee for the WCRP (WMO, 1991b). The report of this group, often referred to as the "Winchester Meeting", to a large degree, did specify a GCOS that followed the generic model above, but some of its specific recommendations appear not to have been implemented or have been significantly altered.

This case study, in many ways, will provide some reflection on the importance of decisions; many in large environmental programs, and how they will most likely affect the careers of many of the AMS Colloquium participants. The impacts of the decisions weigh on many of the pathways to be taken by research scientists, operational and applied scientists, and equipment manufacturers, program/policy leaders in the public and private sector and many others. To emphasize this

relevance, recognize for example that <u>GCOS is a cross-cutting program involving multiple domains, multiple observing components, and multiple users with links to multiple intergovernmental mechanisms.</u>

<u>Definition of User Requirements and/or "Charge"</u>

One of the most important steps in the development and implementation of an activity such as an observing system is to clearly define the end services and product(s) that are responsive to the user. It is this step that can easily serve to provide a measure of success. The definition of user requirements is often used throughout the development and implementation process in order to assess alternatives, priorities and options.

The formal establishment of GCOS began with the Joint Scientific Committee for the World Climate Research Program and was endorsed as a recommendation of the Second World Climate Conference (SWCC) in anticipation of the "Rio Summit".

The Second World Climate Conference (SWCC) was held from 29 October to 7 November 1990 in Geneva. While the Ministerial Declaration of the SWCC did not directly address global climate observing, it did point out the degree of scientific uncertainty in the work of the Intergovernmental Panel on Climate Change. The Ministers; however, did agree to a final scientific and technical conference statement dealing with priorities for enhanced research and observational systems. This statement called for (WMO, 1991b), "…an urgent need to create a Global Climate Observing System built upon the WWW Global Observing System and the IGOSS including both space-based and surface-based observing components. GCOS should also include the data communications and other infrastructure necessary to support operational climate forecasting." Further, the statement specified that, "GCOS should be designed to meet the needs for (a) climate system monitoring, climate change detection and response monitoring, especially in terrestrial ecosystems; (b) data for application to national economic development; and (c) research towards improved understanding, modeling and prediction of the climate system." In combining these three needs, several in the scientific community have suggested a paradigm of trying to observe what's happening, understand how its happening , and do some predictions about what will happen.

The SWCC statement also suggested that the GCOS be based upon an improved WWW, the establishment of GOOS, and other key monitoring components of the climate system ("including the GAW") that reflect changes in terrestrial ecosystems, clouds, the hydrological cycle, the earths radiation budget, ice sheets, and precipitation.

It is unclear that a specific set of user requirements for GCOS were ever developed; however, there appeared to be general set of generic needs that were stated in the form of the objectives of the GCOS. These formal objectives, similar to the needs in the SWCC recommendation, were stated as a part of the Memorandum of Understanding establishing GCOS, and it was agreed to by the WMO, UNEP, IOC, and ICSU. The objectives are as follows:

To provide the data required meeting the needs for:

- **Climate system monitoring, climate change detection and response monitoring especially in terrestrial ecosystems and mean sea-level**
- **Application to national economic development**
- **Research toward improved understanding, modeling and prediction of the climate system.**

A Joint Scientific and Technical Committee (JSTC) for GCOS was formed soon after its establishment. Normally such committees within the intergovernmental framework are expected to be advisory in their capacity. As one of its first actions, The JSTC formed several panels (see Annex 1) to develop observing or data requirements, a data and information plan, and an assessment of cost/benefits for GCOS. Domain-specified data requirements were generated by three of the panels, but a question to be asked, later in this study, relates to the heritage of the requirements back to user needs and/or "products". The linkage from the above objectives to data does not appear to be formally specified in any of the GCOS documents. (Karl, T. et al, 1995) did suggest that the GCOS objectives be tied to specific questions posed by the IPCC. This suggestion recognized that the questions posed by the IPCC, "are thwarted due to an inadequate or nonexistent climate observing system. Among these questions: Is the climate warming? Is the hydrologic cycle changing? Is the atmospheric/oceanic circulation changing? Is the climate becoming more variable or extreme?" It is unclear at this time as to whether this suggestion was ever developed into specific products and specific users beyond IPCC. Corell (Corell, 1995) addressed this point in has talk before the Conference on Earth Observations and Global Change Decision Making, "…observations have two parts: One is collecting the actual data, and the other is putting these data into a system that people can use."

The implicit decision in developing GCOS was to enhance the character of integration across the entire rubric of "climate". The reason for this decision may have several factors. One factor is that the relevant UN institutions are largely, domain oriented rather than function oriented. The second factor was the desire to force a broader vision of global observing such that the integration could provide a pathway to a global environmental observing system. One of the unique aspects and challenges of GCOS, in contrast to the WWW and other international observing systems, is the overriding importance and need to obtain observations from "extra-

territorial", "non-national" and uninhabited areas (e.g. oceans, deserts, over ice, etc.).

Several published papers over the past decade have suggested the benefit of strong integration of observing systems. Zillman in his keynote lecture to the First AMS Symposium on Integrated Observing Systems (Zillman, 97) pointed out that the GCOS sponsors, "have committed (underline for emphasis) themselves to the development of an integrated global observing strategy whose goal is nothing less than comprehensive monitoring, understanding, prediction and protection of the natural systems of the planet and a framework within which governments can ensure the availability of the full range of environmental science services needed by their national communities." (Zillman, 1999) and Landis (Landis, 1999) in a talk before the Integrated Global Observing Strategy Partnership Forum at UNISPACE III specifically identified areas of integration that would be most likely needed. These areas included: research and services; technical assistance and implementation; observing media; observing and services to users; surface- and space-based observing systems; end to end data flow; governmental and non-governmental activities; national, regional and global systems; science and politics; provider plans and user needs; and time spectra. In reflecting these areas of integration in the GCOS charge, some have suggested that GCOS should break down its objective into components that are easier to visualize, achieve and manage. In fact Zillman (Zillman, 1997), while recognizing the importance of integration, did suggest a scheme that did subdivide the planetary domains of global, oceans, atmosphere, and land. The sub divisions were characterized as GCOS missions and included: global radiative properties, ocean characteristics, ocean atmosphere boundary, atmospheric dynamics, atmospheric composition, land-atmosphere boundary, and land/biosphere climate response. These sub divisions appeared to provided some elementary structure to services and products.

Another attempt to provide guidance on actual user products was provided by Carson (Carson, 1991), but the approach was not developed in any detail in the planning of GCOS. Carson specified the user needs as follows: (1) Monitoring the climate and its variability at global and regional scales enabling quantification of fluctuations and detection of climate change; (2) Attribution of climate change to particular causes; (3) detection (and attribution) of the environmental impacts of climate change; (4) diagnostic studies to elucidate the behavior of the climate system and its component parts; (5) development and testing of hypotheses relating to climate variations and to the degree of predictability; (6) Process studies; (7) providing boundary conditions for climate models; (8) initialization of climate model integrations; (9) validation of climate models; and (10) data assimilation techniques for climate model development. Further, it should be noted that Carson did provide additional detail on each of the needs given above.

In the USA, (Unninayar and Schiffer, 1996), the Task Force on Observation and Data Management of the Committee on Environment and Natural Resources did

draft a scheme relating users to data requirements, but was never formally reviewed or put forward as a US position.

Even with some suggested substructure based on domain and process interaction, there is no specification of GCOS user requirements or links to identified specific users identified. This lack of specific user identification appears to be in some conflict with the GCOS concept put forward by the Winchester Meeting" (WMO, 1991b). The Winchester Meeting specified that, " The GCOS will have operational characteristics in that observations will be made against defined requirements…" Most recently (WMO, 2000a) the WMO Executive Council recognized the importance of the UNFCCC as a general user with the following statements: "The Council urged the GCOS Secretariat and the GCOS-SC to give urgent attention to the development of a clear implementation strategy showing how GCOS and its partners proposed to respond to the policy needs of the UNFCCC… Such an implementation strategy for GCOS should make full use of the national reports to be submitted to the UNFCCC … including further analysis of the costs and benefits of maintaining and enhancing observing systems."

(Rasmussen, 2002) raised an interesting point regarding the initiation of GCOS; "In science driven endeavors, the user and observational needs initially are part of experiment designs to advance research. From that research comes an understanding of what is needed operationally to produce an advance in products and services. Rasmussen goes on to suggest that the WCRP could have provided this linkage and now asks, "how can we jump into requirements not knowing what is possible?" In this respect, it could suggest that personalities, institutional compartmentalization and jealousies, and the emerging issues of commercialization and data exchange degraded the institutional processes needed to develop and implement a GCOS.

In contrast, the development of specific user requirements was discussed by the Ocean Observation Panel for Climate in the planning of GOOS. In the associated climate module of the GOOS, the OOPC (IOC, 1998) sensed the need for some form of linkage of the observing system to uses. One way the OOPC suggested to deal with this issue was through the development of "end-to-end" brochures. The OOPC agreed there was a need, "to explain the case and approach for the observing elements of the ocean climate observing system." The development of these brochures still is not completed, so any assessment of their value is not possible, as well as their applicability to GCOS.

CASE STUDY QUESTIONS:

One of the most significant issues in establishing GCOS was the second world climate conference (SWCC) recommendation and the "Rio Summit" approval. There was very little specific background material on the user needs for GCOS; however environmental scientists have

always "pushed" for more observations. The decision to move forward with GCOS without specific user requirements did not prevent governments at the "Rio Summit" from supporting the program, and it may then be useful to ask, to what degree of satisfaction were governments willing to support the decision? The recommendation did specify that GOOS and GTOS should be associated activities to a GCOS; how can these associations best be integrated and instituted?

The de facto first line decision makers of GCOS have been the members of the JSTC (later called the steering committee). The membership had representative scientists involved in climate change detection, climate modeling, and climate prediction. As a result, there appeared to be a decision to skip the step of identifying specific products and services requiring observations and to go to a specific set of data requirements and identify and initial operating system from existing "networks". Establishing specific user products is certainly a task that would be arduous because of the wide and diverse spectrum of needs in terms of observational domain, resolution, and use, and most likely would slow down a perceived momentum in establishing an initial operating system. The tradeoff decision was to show early results of implementation versus establishing a "heritage" (i.e. the derivation of user needs and specifications of product required observations) of user products to generate data requirements. If this was not the most optimal decision, what corrective action is needed? This is a classic issue when dealing with large integrated program development. What institution has sufficient climate credibility that could carry this large objective forward and how should it link to JSTC? The USA has not visibly put forward an informal or formal position on this aspect. Should the USA take the lead in trying to deal with the issue of specific user products?

Definition of observational or data requirements

In a perfect world, observational or data requirements should easily be derived from the "end products" to be provided. In this respect it is useful to consider the perspective from a senior US environmental scientist, Dr. J. Mahlman, involved in

modeling (Mahlman, 1997): "To answer scientific question X and to improve model simulations of the phenomena describing X, we need better measurements. If we obtain these measurements, question X will be answered and the models will be improved. Such promised results are almost never directly realized." Mahlman also points out that, "if a measurement system development and its implementation proceed independently of the underlying scientific questions and careful pursuit of their answers, it is usually a safe bet that much less will be achieved than originally promised."

In the case of GCOS, the JSTC recognized that the majority of existing observing systems were put in place to meet objectives (scientific questions) other than those for climate purposes. Because of this discontinuity between perceived requirements and existing systems the JSTC decided to recommend an initial operating system, and suggested that as a high priority, selected enhancements to atmospheric systems should be made on a high priority basis and include upgrades to the WWW, upgrade to drifting buoys and ships, improved vertical distribution of water vapor from satellite sounding, enhanced monitoring of ozone, and an increase in GAW sites along with additional observational elements. For the ocean systems, improvements would be needed in the following high priority areas: continued and expanded use of TOGA systems; increased numbers of drifting buoys and ships for upper ocean measurements; increased numbers of satellite altimetry and wind scatterometry missions; increased numbers of drifters with profiling capability; and expansion of long-term monitoring sites for deep and bottom water observations. For terrestrial and ecological systems the JSTC called for high priority in the following areas: standardization of ecosystem observations; upgraded input for land surface models; expanded use of high-resolution radiometry data; increased assessment of land cover and land use change; enhanced rainfall and runoff measurements; improved data from visible and IR multi-spectral imagers for ice sheets, ice shelves, and glacier boundaries; and production of photosynthetically active radiation.

The desire to establish a systematic ocean observation and service system has been a long desire of IOC and WMO. Beginning with the WWW and IGOSS, many Members of IOC and WMO speculated on the need for combined global atmosphere-ocean observation and services program. The design of WWW and IGOSS were expected to form the foundation for this activity. A significant step was taken in 1989 when both IOC and WMO formally agreed to begin the development and implementation of an operational ocean observing system. Two years later at the 16th session of the IOC assembly, GOOS was formally adopted based on a recommendation prepared by the IOC Technical Committee on Ocean Processes and Climate. GOOS was established based on the fact, among others, that to understand and forecast climate change, there would be a requirement for an ocean observing system "akin to the World Weather Watch." In recognizing this requirement, IOC and WMO suggested that GOOS focus on some of the major questions of the IPCC, namely the nature of the Ocean's role in controlling climate change. Following the recognition for observing systems by the UNCED conference

(RIO 1992), the sponsors agreed that the GOOS climate module would to a large degree satisfy the ocean requirements of GCOS. Also following UNCED, there was recognition that a terrestrial observation component that focused on climate would also be necessary. This recognition strongly suggested that the GCOS JSTC should ultimately consider the establishment of an Atmospheric Observation Panel for Climate (AOPC), Ocean Observation Panel for Climate (OOPC) and Terrestrial Observation for Climate (TOPC). This direction of GCOS panels resulted in the suggestion to support the establishment of GTOS. In addition to GCOS, the International Geosphere-Biosphere Program (IGBP) clearly indicated need for observations required to understand the carbon cycle and particularly its relationship to climate and helped to justify the need GTOS.

It is interesting to note that no formal integration mechanisms were setup to integrate among the GCOS observations panels; however, is some cases there were individual scientists that participated in more than one panel. The outcome of the panels was quite varied in terms of detail and in some cases reflected the specific interests of those participating. Heritage and links to specific "products" and user requirements has been generalized within the work of the panels. In addition, the JSTC recognized that GCOS should show some early implementation, and called for an Initial Operating System (IOS) (See Annex 2 for an assessment of the IOS) that was based largely on enhancing operational capabilities already in place. These factors appeared important in steering the data requirements along a pathway that was largely domain oriented. In the US, several attempts were made at generating observation requirements, but in most every case, these studies were not fully completed or formally adopted. For example, (Unninayar and Schiffer, 1996) on behalf of the US Task force on Observations and Data Management under the Committee on Environment and Natural Resources prepared a draft report on, "In-situ Observations for the Global Observing Systems." The approach in generating the requirements was largely domain oriented, and based on needed inputs for numerical and statistical models. The report did not include satellite observations, user products, data systems, and aspects of geological processes. The report did not under go any formal review and consequently did not represent any US Government consensus on the issue. The status of this report appears to represent some of the difficulty within the US government decision-making process and/or the possibility that reflects government priority of the issue.

A parallel initiative, based on thematic areas, to deal with user needs has been put forward, initially by the CEOS, within the framework of the Partnership on an Integrated Global Observation Strategy (discussed later in this study). The idea was to focus on an integration of observations within a study area that could be defined by a domain or process. The thematic approach is still under development and little or no evaluation is available. The initial set of Themes with initial planning and implementation include the following: Ocean theme; Integrated Global Carbon Observing Theme (IGCO); Integrated Global Atmospheric

Chemistry Observing Theme (IGACO); and an Integrated Global Water Cycle Observing Theme (IGWCO).

CASE STUDY QUESTION:

The establishment of observational/data requirements was the major concern of the JSTC during the first 5 to 6 years of GCOS. Several panel reports based on media domains were prepared. The implication, based on no formal objection from the GCOS sponsors, is that the JSTC approved observational requirements, based on domains, were acceptable to those responsible for implementation (governments). Second, the "requirement" documents did not address the level of integration, both institutionally and programmatically. A parallel effort was also undertaken in the late 1990s by the partnership on an integrated global observation strategy that focused on a thematic approach that considers selected domains and processes. This approach was largely a result of a proposal from the USA space and satellite agencies (NASA & NOAA/NESDIS). Do these decisions form a sound basis for moving forward? What activities of integration should be adequately specified at the program and institution levels? Can these issues be solved by an adequate data management plan? If so, who should be involved in preparing the plan?

Development of Conceptual roadmap for observing system and estimated budget

In order to secure the necessary resource support for implementing and maintaining a global observing system, National Governments need to understand the scope and infrastructure to be implemented as well as some estimated overall cost. In this respect, it is instructive to look at the preparation of the WWW and the development of its planning. A major component of the WWW roadmap was a series planning documents discussing the issues, both scientific and administrative. These documents were often discussed in the context of informal planning meetings convened by the Secretary General of WMO to integrate the scientific and governmental issues associated with implementation (Riehl, 1966; Johnson, 1977; WMO, 1966, 1967, 1970). WWW also provided clear visibility to end state products, a mechanism for developing country participation, a formal data/product distribution and management system, and a mechanism for participation of satellite systems including a procedure for the placement of satellite receivers, both for data retrieval and telecommunications, in most National Meteorological Services of the world.

Because of the timing of the Eleventh Meteorological Congress (1991), it was difficult to provide any substantial budget for GCOS, which still did not exist, for the financial period of 1992-1996. However, the Congress did agree (WMO, 1991a), "to reinstate a WMO Special Trust Fund for Climate and Atmospheric Environment Activities for the eleventh financial period. It considered that if implemented, such a Fund would provide major support towards improving observing systems, in particular in view of the establishment of the GCOS…" Contributions to the Fund were limited and the few millions of dollars made available were to some degree constrained for specified projects already in progress. An additional Trust Fund, Climate Observing Trust Fund, was created with the signing of the Memorandum of Understanding among GCOS sponsors; however, contributions to the fund have been extremely limited. In this respect, the Twelfth Meteorological Congress (1995) continued the decision of limited funding for GCOS (WMO, 1995a), "Congress nevertheless noted with concern that the reported progress had only been achieved through the expenditure of extrabudgetary resources and that much of that additional support had ended in the past year, to the extent that insufficient resources were now available for adequate planning, coordination and implementation of the programme. Congress noted with great concern that GCOS was now at a critical point in its existence due to the serious lack of resources for its implementation. That critical situation had been exacerbated by the need for GCOS to respond to the many urgent requests emanating from the Fourth Session of the Conference of Parties (COP) to the UN/FCCC and the large additional load that had been placed on the GCOS Secretariat." As late as the year 2000 this problem was continuing (WMO, 2000a) wherein, "The Council recognized that the GCOS Secretariat did not currently have the resources to develop and pursue such (a request by UNFCCC) an implementation strategy in an effective manner and urged that the Executive Heads of the Sponsoring Agencies consider how they might collectively assist the work of the GCOS Secretariat." These decisions point out the recognition of the severe resource shortage for coordinating the development of GCOS.

The first glimpse of how GCOS would deal with the data and information management was published in 1995 as the first report of the GCOS Data and Information Management Panel (WMO, 1995b). The plan did recognize the immense diversity and variability that would be involved and perceived that GCOS must rely upon a distributed system spanning national and discipline borders. The plan suggested what future technology could be used and also a set of principles for the system. Also, the plan did speculate that the data and information would reside at a select number of centers, but be available from a single point. Most importantly the plan recognized that before a specific data system could be designed, the data requirements must be specifically defined. Again the work of the panel of experts was to report to the JSTC (a committee of experts) but there was no mechanism for commitment of national resources necessary to implement a comprehensive integrated data system. The plan appears to have considered many

of the necessary elements of a data system for GCOS with exception of two important aspects. There was no indication of the level of costs or resources that would be needed, and there was no "pathway" to elicit the participation of national governments.

A first version of the GCOS Plan was published in 1995 providing a very broad framework concept of major elements. These elements were characterized in the form of three objectives. The objectives are to: (1) design an effective operational climate observing system; (2) establish, coordinate and manage the Initial Operational System (IOS) by integrating and enhancing existing components; and (3) develop new components to provide a comprehensive and responsive system to meet future needs. The plan indicated that the management of GCOS would involve the sponsoring organizations, the JSTC, and national governments. A linkage among these three components was recognized, but not defined. With respect to an estimated budget the plan suggested that support for GCOS would be required for planning and coordinating international activities, establishing centers for GCOS support, and implementing and maintaining observing systems. The plan did not suggest any resource levels except for the next year funding of the GCOS planning office. There appeared to be little disagreement with the concepts that were discussed in the plan. The plan was approved by the JSTC and published in 1995 (WMO, 1995c).

With the exception of the World Weather Watch, there has been little or no formal integration of systematic satellite (space based) and *in situ* (surface based) observation systems in global operational environmental programs. (Kennel et al, 1997) recognized the inherent need for global observations in monitoring the environment and climate and suggested that the role of the satellites within the traditional institutional structures has presented a challenge. Kennel suggested the need for an Integrated Global Observing Strategy as a way of meeting this challenge.

In recognizing the need and value of integration of "climate" observing, it is important to note that these approaches often require integration across agencies, cultures, and scientific disciplines. Such integration is formidable and it certainly challenges the best of institutional processes, no matter how well intentioned.

CASE STUDY QUESTION:

Since the start of the program, coordination support provided by WMO for GCOS has remained at a level that provides for a director level secretary and one administrative assistant along with funding an annual session of the SC. Funding support from other sponsoring agencies have been extremely limited and often confined to supporting one or two expert's travel to a panel session. While recognizing that this level

<u>of support is not adequate, the members of WMO have kept the resources level funded at best. Is this an adequate decision by nations committed to a global climate observing system? Is the GCOS decision process culminating with the JSC (the GCOS plan was only approved by a group of scientists speaking on their on behalf) inhibiting government participation in major implementation decisions so that funding priorities are unattainable?</u>

<u>Identification of overall lead responsibility for implementation and oversight</u>

The development of a global climate observing system is a major undertaking regardless of what metric is used. Informal consultation indicates the resources needed to adequately carry out a GCOS may well cost in the tens of billions of dollars a year to sustain, and capital costs that could reach 100 billion dollars. With such a large program, the SWCC and the Rio Summit did not express any preference or indication for a lead agency. Similarly, when the UN dealt with the impacts of the 1997/98 El Nino, WMO was not mentioned in many of the adopted resolutions of the General Assembly. In fact, in establishing a process to provide funding to assist developing countries to deal with climate issues using the Government Environmental Facility (GEF) and the "Turner Fund", the leadership designation was given to the United Nations Environment Program. The intergovernmental community, usually the hallmark of collaboration and cooperation, often refrains from suggesting or appointing a lead agency, so it is not surprising that a climate "czar" has not emerged. It is interesting to note that WMO did suggest that it was taking up the leadership role of GCOS, but the words from the Twelfth Congress do not appear to inspire conviction (WMO, 1995a), "Congress was particularly pleased to <u>note</u> the leadership role of WMO in the <u>initial</u> and <u>formative</u> stages of the GCOS programme." In discussions with various UN and Intergovernmental secretariat staff, WMO is not perceived as the international "Climate Agency." Most UN agency personnel appear to shy away from designating any leadership for the overall international aspects of climate issues.

With respect to oversight, the GCOS plan (WMO, 1995c) did specify, "The JSTC also has the responsibility for continuing oversight of the various components of the system." It should be noted that in 1998 the sponsors agreed to a new GCOS MOU, whereby the GCOS JPO became the GCOS Secretariat and the GCOS JSTC became the GCOS Steering Committee (SC) to better reflect its broad mandate. Initially, the membership structure remained the same, with the majority of participants acting in their capacity as independent scientists; however in 2001 (WMO, 2001a) the Steering Committee agreed to add "more operational and senior governmental representatives on the Steering Committee." The results of this

change have yet to be analyzed. It should be noted that the term "governmental representatives" in this context does not imply acting on behalf of governments, but an expert category that can speak to the issues related to the ability of governments to implement.

Quite interestingly, the Winchester Meeting (WMO, 1991b) in recognition of the need for multi-UN agency participation, stated, "It is believed that such a federation of effort should be given a sense of identity and purpose, as well as international visibility, by constituting a Global Climate Observing System Board, which would bring together representatives of these international organizations and national or multinational agencies. The constitution of the Board could include initially three representatives of each of the contributing international organizations (ICSU, WMO and UNESCO-IOC), nominated by their respective governing bodies, and representatives of space development agencies and satellite-operating agencies." "Observer status might be considered suitable for UNEP and FAO who have specific interests in the development of GCOS."

To further support the need for some form of intergovernmental organization, the UNFCCC Conference of Parties at its fourth session in 1998 (Decision 14), "Invites the agencies participating in the Climate Agenda, in consultation with the GCOS secretariat, to initiate an intergovernmental process for addressing the priorities for action to improve global observing systems for climate in relation to the needs of the Convention and, in consultation with the Convention secretariat and other relevant organizations for identifying immediate, medium-term and long-term options for financial support…" Also at the fourth session of the COP, Government's did express some formal interest in global observing, by requesting signatories to Annex I of the UNFCCC to submit information on national plans and programmes in relation to their participation in global observing systems for climate. These reports were to be in the context of reporting on research and systematic observations. The initial reports from this request are just becoming available, and the UNFCCC and GCOS Secretariats are just beginning analysis of the results. The plan is to synthesize and analyze the national reports and prepare an assessment on the adequacy of the global observing system for the Conference of Parties in November 2003. A published report is planned for June 2004

Congress Twelve (1995) did provide some indication it was aware of the need for some mechanism to deal with national governments, but their proposed remedy is unclear. The statement from the Twelfth Session of Congress was as follows (WMO, 1995a): "Congress noted with concern that no clear mechanism yet existed to translate GCOS programme recommendations into national activities. In that respect, Congress welcomed the establishment of a coordinating body to pursue *The Climate Agenda* and stressed that one of the most important roles of the proposed new coordinating body should be to link GCOS with related programmes that delivered climate-related benefits and to make specific proposals to Governments for funding, which would include clear statements of resources required and

ultimate benefits to Governments of the investments requested." There does not appear to be any evidence that Congress's proposal was ever implemented.

It is interesting to note that in many respects, this lack of, or at least diluted, leadership with respect to GCOS is also reflected at most national levels. One of the factors often mentioned with respect to the World Weather Watch was that it had significant support by active politicians, by senior level policy managers, and by senior scientists in the National Governments and Academia from the USA, UK, Australia, the USSR, and Germany just to name a few (Cleveland, 2001). In the USA, there is no recognized lead agency or position for climate. There is a national focal point for GCOS in the USA, but it is a collateral duty of a professional officer on the Environmental Information Service staff within NOAA/NESDIS. By contrast, Australia and, to a lesser degree, Canada has established leadership for GCOS with substructures that permit a unified focused national position.

One of the major dilemmas with the implementation of GCOS continues to be the immense amount of enthusiasm and recognition of need from so many organizations and activities, but the difficulty in motivating these activities into a cohesive and coordinated force. (Zillman, 1995) in discussing leadership and institutional structures, both intergovernmental and non-governmental pointed out that perspectives could be made from either an agency or program structure. This is important because of the large range of cross cutting mechanisms needed to ensure essential linkages and coordination. This appears to present a challenging situation that is inherently multidimensional and enormously complex. This large varied group of organizations, activities, programs, and subsidiary organizations has been specified in several publications (e.g. Zillman, 1997; WMO, 1995d). An attempt to comprehensively list this grouping is contained in ANNEX 1 in order to give a perspective of the large number of stakeholders in GCOS. Each entity of the group does have some part in the planning and execution of GCOS, but the complexity of the interactions among these activities is understood by only an extremely small number of people, adding another component of complexity. This then presents a major difficulty in explaining GCOS in an easily understandable format to policy level decision makers both at the intergovernmental and national level.

CASE STUDY QUESTIONS:

<u>There appears to be overall agreement that implementation of a global climate observing system will be through national contributions in kind. A total assessment, or even a "guesstimate", of the resources needed to carry out the required tasks of implementation appear no where in official reports or the published literature. However, informal discussions on this topic generally acknowledge the costs could approach at least 50 billion us dollars a year. Can such an enterprise move forward without a single international or national leader or</u>

should GCOS continue to evolve building on the shared responsibility of various intergovernmental and international bodies? The assignment of accountability for GCOS appears to be the GCOS SC; can this remain a stable situation and still attain the objectives of GCOS? What future decisions should be made? How should the USA deal with the leadership role internationally and internally? If leadership is not constraining the growth of GCOS, is the level of programmatic and organizational complexity sufficiently understood to permit desirable growth? In the USA, has this complexity provided any problems in eliciting desired support?

Preparation of Implementation Strategy and Plan

With most global programs, particularly those that require implementation by more than one or two governments, it is necessary to have an implementation strategy so each stakeholder and participant can adequately plan. For national governments, lead times are at least 2 years, but more commonly 3 to 7 years when significant resources much be provided by legislative bodies. For sizeable elements such as satellite missions the time frame can be as much as 10 years. Another major aspect of implementation strategy is the need to have national government experts participate in the process, in order to minimize lead times, as this often allows for parallel national institutional processes to move forward. This approach assumes the content of the strategy will be approved while at the same time the public funding process is proceeding. Perhaps the most important aspect of any governmental approval of a strategy is the expected benefit or deliverables. With respect to observing systems, therefore it is important to highlight the products or uses of the data being generated.

GCOS strategy, largely based on observations rather than products and services, specified that the climate modules of GOOS and GTOS should be integrated together with the ongoing operational activity of the World Weather Watch and Global Atmosphere Watch along with other research and operational observing systems. The mechanism of how this complex integration should take place has not been specified. The actions taken in the establishment of GCOS as well as the definition of requirements have forced an implementation strategy that is domain and agency based. Such a strategy is intended to prevent duplication from systems already implemented, focus existing and available expertise so that resources are not diluted, and to use the already established institutional infrastructure to the maximum extend possible. This strategy also prevents a perception of new and increased bureaucracy during an era of desired "less national and international government" by many developed countries. In accepting these advantages, it must

be recognized that "integration" then must occur at a level above the observing platform (s).

CASE STUDY QUESTION:

<u>A fundamental question throughout the study is at what institutional and program levels do the decision makers intend to integrate activities. Should WMO, as a minimum support to climate, have integrated the WWW, GAW, and the climate coop observers into a more visible global atmospheric observation system (GAOS) that would be on a parallel to GTOS and GOOS? If such a decision would be beneficial, should the USA lead in promoting the proposed change? In suggesting that WMO create a GAOS, an implied decision is made that the USA is comfortable with an implementation that is domain based. Recognizing that the domain based strategy has problems with "turf" issues within the USA government and within the UN structure, what other alternatives might be suggested?</u>

<u>Identification of Resources and Priority mechanisms</u>

Although no formal costing of the WWW has been carried out, many governmental experts (Hallgren, 1999) estimate the continuing operational costs at somewhere between around 5 billion dollars a year. In addition, the secretarial administrative costs are estimated to be around 10 million dollars a year. Based on these WWW estimates, it is possible to expect that GCOS could well cost at least 5 times this amount.

In the GCOS plan of 1995 scientific priorities were discussed. The priorities were discussed in terms of time scales noting two complementary activities. One activity was the focus on the seasonal-to-interannual time scales in which the predictability of certain phenomena has socio-economic benefit. The second activity was the focus on the decadal-to-centennial time scales in which the stability of the climate with respect to anthropogenic influence and the early detection of any such climate change could be assessed and the future climate state predicted. The first activity was defined almost exclusively in terms of coupled atmosphere-ocean model initialization and the verification needed to make predictions of ENSO operational. In dealing with the decadal-to-centennial time-frame the focus was on trying to meet the needs and objectives of the UN/FCCC. It was recognized that the observations necessary to meet the UN/FCCC objectives are rather less well defined, but still

important. Further it was specified that comprehensive observations would be needed to identify and quantify climate change and its potential impact on ecosystems and socio-economic activities. Moreover, it was recognized that such comprehensive observations are needed in all components of the climate system (i.e. atmosphere, ocean, ice, and land, including the biosphere). Since the establishment of the GCOS program, it appears that these priorities have had an effect on creation of the GCOS Surface Network (GSN), GCOS Upper Air Network (GUAN), an operational TOGA/TAO array, a coordinated deployment of ARGO floats, and creation of a Global Terrestrial Observation Network (GT-NET) (see ANNEX 2).

In an effort to try an establish a system of priorities that might be used in integrating the observing system components, the sponsors of the three Global Observing Systems (GCOS, GTOS, and GOOS) in 1996 convened a conference on the development of an integrated strategy and identification of priorities for implementation. The conference appeared to identify more problems than it solved, recognizing the disparities in the development of the global observing system components calling it an "overarching concern" with regard to the maturity of each system and identifying the slow organizational development of GTOS in particular. The conference also agreed that a completely uniform approach to prioritization was not possible and recommended the need to identify products and benefits to the specific components of the observing systems.

GCOS, besides identifying those existing observing resources that can be supportive to its objectives, has not estimated the level of resources to carry out its program. Nearly all scientists and international decision-makers have recognized that most of the resources for global observing systems are provided by national governments for implementation and maintenance. In addition, a relatively smaller level of resource (currency and staff) is needed to carry out program coordination. These estimated resources have only been identified in limited fashion to the degree permitted by the sponsoring bodies. For example, the resources for the GCOS program office were identified in the 4 year budget of WMO, but significantly influenced by the overall priority of the Secretary General's budget request, and the budget ceiling imposed by the Congress. Some small change to this can be made on a two-year basis, but budget ceilings are maintained. Similar constraints and limitations have faced the GOOS planning office in IOC and the GTOS planning office in FAO.

CASE STUDY QUESTION:

<u>At this stage of GCOS development (June, 2002) there is no identification, even in estimated terms, of the resources required to implement GCOS either in terms of national commitments or program coordination. The two significant priority decisions made within GCOS</u>

<u>are: (1) begin implementation of those systems already in place that require only some modification and create an initial operating capability and (2) recognize and accept the priorities in observing and data management from existing systems and develop a plan to integrate. The USA appears to be satisfied with these decisions, perhaps in order to try and simplify complexity in an era of less than enthusiastic support for government and UN programs. Are the present GCOS resource levels in line with expectations of the US government and the scientific community? If not what changes or tradeoffs are needed?</u>

<u>Establishment of system oversight mechanism</u>

The WWW that was envisioned in the late 1960s still is the same concept-wise as today, but many of the details have changed to reflect changes in science, technology, and user needs. These changes were in most cases timely, and largely a result of system oversight. System oversight ultimately rests with the WMO governing bodies; however, the actual technical oversight is carried out through a technical commission – the Commission on Basic Systems. In order for global observing systems to take advantage of emerging science and technology, there must be a mechanism for system oversight. For GCOS, there is some limited system oversight by one sponsor (WMO) at least. It is unclear how much influence this arrangement has in policy and program implementation.

The JSTC for GCOS was given the responsibility to formulate the concept and design of the overall system, as well as an effective strategy for its development and implementation. According to the original terms of reference, the JSTC was, "to review and assess the development of implementation of the components of the GCOS." In addition, the WMO agreed to establish a Joint Planning Office to assist the JSTC to formulate the concept <u>and to organize the implementation of GCOS.</u> A Director and Administrative Assistant have staffed the JPO over the last decade. However, during a critical eighteen month period in 1997/98 (at the peak of the recent strong El Nino); the director of the GCOS secretariat was a collateral duty of another WMO director. In addition, professional scientists have been contracted to or seconded to the JPO from time to time. For the most part, the level of professional scientist resource, including the Director, has not been more than two persons. Following the Rio Summit, the UN and those agencies involved in climate activities established a Coordinating Committee on the World Climate Program (CCWCP) (The Climate Agenda Doc 2, 1993). Global observing was a decision activity of the Climate Agenda; however, the GCOS was not considered to be part of the World Climate Program but was referred to as being an associated activity (The Climate Agenda Doc 3, 1993). This is important because in 1993, the Climate Agenda sponsors convened an Intergovernmental Meeting (IGM) on the Climate Program. While recognizing the importance of a climate observing system,

the participants at the IGM did not discuss or consider an intergovernmental forum, and perhaps an opportunity was lost.

One of the unique features associated with the development of GCOS has been the creation of a Partnership of Organizations in support of an Integrated Global Observing Strategy (IGOS). The IGOS Partnership was created in large part because of the interest of policy level management from the major environmental satellite agencies as expressed through the Committee on Earth Orbiting Satellites (CEOS) (NASDA, 1999) (ESA, 1997). It is important to point out that the CEOS and the participation of satellite agencies in the IGOS appeared to be much more influential than those representing the interests of conventional *in situ* observing systems. In this respect it is important to point out the US National Academy of Sciences (NAS) view on the role of satellites in climate monitoring. The NAS Panel on Climate Observing Systems Status (NRC, 1999) suggested a word of caution with respect to satellite observations for climate monitoring. The panel pointed out, "there is only sketchy information on the suitability of remotely sensed data as a source for climate change detection and attribution. Some studies have shown a positive impact of these data. Others have clearly indicated substantial problems, two or which are calibration and poorly documented changes in instrument performance from one satellite to the next."

The IGOS partnership provided for direct participation of the major climate research programs that were expected to support or receive support from GCOS. These programs included the World Climate Research Program (WCRP) and the International Geosphere-Biosphere Program (IGBP). In addition, the partnership included the International Group of Funding Agencies (IGFA) for Climate Research. The IGOS partnership was created in 1997 and has largely focused on specific projects, called themes, in support of both GCOS and broader environmental problems. By most accounts the overall effectiveness of the IGOS partnership and use of its themes has yet to be analyzed or evaluated.

The entire issue of how environmental satellites would participate in GCOS has been a continuing organizational dilemma. A certain level of mistrust exists between the "*In situ*" observing community and the advocates for a strong satellite-observing base. In addition, some have questioned how much influence should come from the satellite technology sector in developing observation requirements that must satisfy users and those dealing with scientific questions. The IGOS was one step in trying to deal with this issue. A second step was taken in 2001 by inviting a representative of GCOS to participate in the WMO Consultative Meetings on High Level Policy on Satellite Matters. This participation has resulted in the inclusion of GCOS requirements in the development of WMO Statements of Guidance for the satellite operators.

CASE STUDY QUESTION

The climate agenda has been an attempt to institutionalize the coordination process among UN agency secretariats involved in climate programs. This activity functions through a coordinating advisory committee that meets less frequently than once a year. The committee does not report to any governing body but facilitates the work of the secretariats. The climate agenda process did sponsor an intergovernmental meeting in 1993 that did not discuss an intergovernmental process for GCOS as suggested in the "Winchester" report. Is the USA satisfied with the decision that it is premature to consider an intergovernmental process for GCOS? When should this process begin? A parallel coordination activity to the climate agenda has been the partnership for an Integrated Global Observation Strategy. This partnership is largely supported by the space and satellite agencies, particularly EUMETSAT, NASDA, as well as NASA and NESDIS in the USA. Is the USA position to support both of these coordination mechanisms? Is there concern it might give a perception of inflated bureaucracy and complexity that could inhibit support from policy decision makers?

Monitor Implementation

In order to assess the progress of observing systems it is necessary to have some form of implementation monitoring that can determine the quantity and quality of data being generated by the observations. For GCOS, most of this activity has been addressed at the specific observation platform level. For example, a specific data-monitoring center has been established to monitor the data provided by the GCOS Upper Air Network (GUAN). Similar centers have been established for the GSN, GAW, TOGA/TAO, ARGO, and for many other *in situ* and space based systems. The present decision of the JSC Panel is to continue using the data monitoring process set up for each platform and to begin the planning for any needed integrated data observation monitoring.

Provide a Mechanism for Continuing Review and Change Management

Most large systems or programs benefit from some form of review mechanism that can provide timely program (or system change management) updates. In the case of the WWW this is provided by the Commission on Basic Systems and its expert team infrastructure and by the implementation working groups that report directly to the intergovernmental WMO Regional Associations. Such system review and update helps assure that governments are kept a breast of needed changes and

improvements in a timely manner. A status report reviewing and updating the WWW has been issued every year since 1968 (WMO, 1968, 1969a, 1977, 1982).

The overall responsibility for the review and update of the GCOS does ultimately rest with the sponsors and their respective governing bodies. The established bodies that actually review and update GCOS are the Steering Committee (Formally called the Joint Scientific and Technical Committee) and in a much less formal way the IGOS Partnership. In both of these cases, there is no required approval or reporting required by the sponsor's governing bodies. Since its inception, guidance from the sponsoring organization governing bodies appear to be no more than a "rubber stamp". With the exception, of WMO and IOC, it appears that neither the Director of the GCOS Planning Office nor the Chair of the GCOS SC participated in most regular sessions of the other sponsoring organization governing bodies.

CASE STUDY QUESTION:

Status of GCOS implementation is available for the initial operating system via an internet web page and often status of implementation is included in summary reports to sponsor governing bodies. The USA position has been to accept this as sufficient at the present stage of GCOS development. When should, if needed, a more formal and visible process be put in place so that governments can review and update as necessary?

Summary of Questions and Proposals Raised by the Case Study

Several questions and proposals have been identified throughout the study that are intended to help guide the reader in recognizing some of the important issues and decisions that have been made with respect to global climate observing both internationally and nationally. In order to discuss the case, a series of propositions based on an integration of the questions in the study are suggested. The integration of the propositions focus on the interrelationships of the following six issues: (1) requirements process, (2) program and system integration, (3) orientation by domains, (4) leadership and accountability including inter- and intra-governmental processes, (5) resource availability, and (6) environmental satellite participation.

Proposition 1

The need for additional observations in support of environmental issues appears as a continuous plea. Do more observations answer the needed scientific questions and provide for climate user needs? Is the USA satisfied with a global observing strategy that is domain based and does not include a service component? How should integration be carried out among GTOS, GOOS, and the atmospheric observing systems?

Proposition 2

There is large complexity and size to a global climate observing system that is intended to support all phases of climate research, climate change monitoring and detection, climate prediction and climate impacts. Costs for operating such a system could well run to the many tens of billions of US dollars per year. How should leadership and accountability be structured, both internationally and nationally?

Proposition 3

Assuming that the UN system is an acceptable forum for intergovernmental mechanisms dealing with climate, Is there a way to insure a direct focus by governments on the issue of implementing an integrated comprehensive global climate observing system? Is there a need to consider a fresh International Structure? On a national basis, there is a similar issue of providing a direct focus by federal agencies and departments on climate in general and global climate observations more specifically. Is the US government as a unit providing a satisfactory focus?

Proposition 4

The resources needed to implement and operate global observing systems (largely only for atmospheric measurements) in support of Weather forecasting out to time frames of a month are estimated to be about 5 billion US dollars a year. To expand global environmental observing to ocean and terrestrial domains as well as to embrace observations needed to understand and simulate mass change and energy processes in atmosphere, lithosphere, hydrosphere, biosphere, chemosphere, and cryosphere is most likely going to cost at least 50 billion dollars. Given this formidable resource size needed to answer important scientific questions, is the present resource level representative of true commitment by UN agencies to support program coordination and National Governments to support implementation?

Proposition 5

It has been suggested that the environmental observing satellite is the only true global observing system; however, the participation of satellite agencies in the planning and implementation of GCOS still appears to be less than satisfying for some stake holders. Environmental satellites are not identified in the GCOS IOS and it is unclear if GCOS planning over the last decade has influenced any change in planned satellite missions. In discussing this proposition it is important to realize an underlying perceived mistrust between some of the *In situ* observing and satellite communities. This perceived mistrust is based on the continued high level of funding for space observing in contrast to systems such as rawinsondes and buoys, and the loss of government funding for *In situ* observing systems because of undelivered promises by satellite advocates. This perception, if true, seems to support the notion that there appears to be an imbalance where more emphasis is being given to the designers of observing systems, than those that will use the data from observations. Is there a need for a special process or mechanism, as promoted by the US and others, to insure satellite observations are included in a global climate observing system and how should this be balanced with a process of setting requirements?

Proposition 6

Is GCOS the appropriate structure to implement a "seamless fabric" of observations that address needs of weather, climate, environmental quality, and other related issues? (At the suggestion of Rasmussen, the term fabric is used in place of the over used term of "system" in order to recognize that some individual observation and data management systems will undergo little or no significant change, and the real need is how to "weave" these observing components into a fabric).

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ANNEX 1

Organizations, Activities, Programs, Experiments and Other Infrastructure with Some Ownership in GCOS

GCOS Sponsors:

World Meteorological Organization (WMO)
United Nations Educational, Scientific and Cultural Organization (UNESCO)
United Nations Environmental Program (UNEP)
Food and Agriculture Organization (FAO)
Intergovernmental Oceanographic Commission (IOC)
International Council of Science (ICSU)

GCOS Panels:

GCOS-WCRP Atmospheric Observation Panel for Climate (AOPC)
Joint GCOS-GOOS-WCRP Ocean Observations Panel for Climate (OOPC)
Global Observing System, Space Panel (GOSSP)
Joint Data and Information Management Panel (JDIMP)
GCOS Panel on Cost/Benefits

From the GCOS Plan: The GCOS objectives are being met with the cooperation and participation of the following activities:

World Climate Program (WCP)
World Climate Program-Water (WCP-Water)
World Climate Research Program (WCRP)
Human Dimensions of Global Change Programme (HDGCP)
International Geosphere-Biosphere Program (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)

In addition to the above (Zillman, 1995) and others have included the following key organizations:

WMO Commission on Basic Systems (CBS)
WMO Commission on Instruments and Methods of Observation (CIMO)

WMO Commission on Hydrology (CHy)
WMO Commission on Atmospheric Sciences (CAS)
WMO Commission on Aeronautical Meteorology (CAeM)
WMO Commission on Climatology (CCl)
WMO/IOC Joint Commission on Oceanography and Marine Meteorology (JCOMM)
WMO Executive Council Advisory Group on Climate and Environment (EC-AGCE)
WMO World Data Centre for Greenhouse Gases
WMO Advisory Committee on Climate Applications and Data (ACCAD)
World Climate Applications and Services Programme (WCASP)
World Climate Data and Monitoring Programme (WCDMP)
World Climate Impact Assessment and Response Strategies Programme (WCIRP)

UNESCO International Hydrological Programme (IHP)
UNESCO Man and Biosphere Programme (MAB)

UN Commission for Sustainable Development (CSD)

UN Framework Convention on Climate Change (Conference of the Parties) (UNFCCC/COP)

Global Environmental Facility (GEF)

Global Ozone Observing System (GO3OS)

UNFCCC Subsidiary Body for Scientific and Technological Advice (SBSTA)

Inter-Agency Committee on the Climate Agenda (FAO-ICSU-UNEP-UNESCO/IOC-WHO-WMO)

Intergovernmental Panel on Climate Change (IPCC)

International Union of Geodesy and Geophysics (IUGG)
International Association of Meteorology and Atmospheric Science (IAMAS)
International Association of Physical Sciences of the Ocean (IAPSO
International Association of Hydrological Sciences (IAHS)
International Geographical Union (IGU)
International Society of Soil Science (ISS)

ICSU Scientific Committee for the International Geosphere-Biosphere Programme (SC-IGBP)

ICSU Special Committee for the International Strategy for Disaster Reduction (SC-ISDR)

ICSU Scientific Committee for Antarctic Research (SCAR)
ICSU Scientific Committee on Oceanic Research (SCOR)
ICSU Scientific Committee on Problems of the Environment (SCOPE)
ICSU Scientific Committee on Water Research (SCOWAR)
ICSU Scientific Committee on Solar Terrestrial Physics (SCOSTEP)
ICSU Committee on Space Research (COSPAR)
ICSU Committee on Data for Science and Technology (CODATA)
ICSU World Data Centers

International Studies, Programs, Groups and Experiments in support of GCOS:

Arctic Climate System Study (ACSYS)
Surface Heat Budget of the Arctic Ocean (SHEBA)
Global Ocean Data Assimilation Experiment (GODAE)
Joint Global Ocean Flux Study (JGOFS)
International Arctic Buoy Programme (IABP)
WMO-IOC Data Buoy Cooperation Panel (DBCP)
World Ocean Circulation Experiment (WOCE)
Climate Variability and Predictability (CLIVAR)
International Global Atmospheric Chemistry Programme (IGAC)
Comprehensive Ocean-Atmosphere Response Experiment (COARE)
Pacific Basin-Wide Extended Climate Study (PBECS)
World Hydrological Cycle Observing System (WHYCOS)
Global Energy and Water Cycle Experiment (GEWEX)
International Satellite Cloud climatology Project (ISCCP)
Global Precipitation Climatology Project (GPCP)
Stratospheric Processes and their Role in Climate (SPARC)
Array for Real-time Geostrophic Oceanography (ARGO)
Carbon Cycle Joint Project
IGOS Ocean Theme
IGOS Integrated Global Carbon Observing Theme (IGCO)
IGOS Integrated Global Atmospheric chemistry Observing Theme (IGACO)
IGOS Integrated Global Water Cycle Observing Theme (IGWCO)

Partnership for an Integrated Global Observing Strategy: In addition to the GCOS sponsors:

Committee on Earth Observation Satellites (CEOS)
International Group of Funding Agencies for Climate Change Research (IGFA)
Partnership for Observations of the Global Oceans (POGO)
International Ocean-Colour Coordinating Group (IOCCG)

ANNEX 2
GCOS IOS NETWORKS

ATMOSPHERIC OBSERVATIONS	REMARKS
GCOS SURFACE NETWORK (GSN)	**- 989 Designated stations (precipitation & temperature 6 hourly observations) reporting data on a monthly basis via CLIMAT message. Stations are part of the WWW Regional Basic Synoptic Networks. No new stations since GCOS start. Since January 1999, 50 –60 percent of stations report. All Data monitored by Germany and Japan. Archived by NCDC.**
GCOS UPPER-AIR NETWORK (GUAN)	**- 150 Designated stations (Wind, temperature, humidity, and pressure at least once per day) reporting data on a monthly basis via CLIMAT TEMP message. Stations are part of the WWW Regional Basic Synoptic Network. No new stations since GCOS start. Since January 2000, 67 percent of stations report. ECMWF is monitoring data . Part of CARDS data set at NCDC.**
WMO GLOBAL ATMOSPHERE WATCH (GAW)	**-22 observatories measuring a suite of gases, aerosols, radiation, and chemistry. Data stored at the following locations: Ozone & UV (Canada), Aerosols (EU/Italy), Greenhouse & Trace Gases (Japan), Solar Radiation (Russian Fed), Precipitation Chemistry (USA), Surface Ozone (Norway). No specific changes to GAW for GCOS . (see note 1)**

ANNEX 2 (cont)
GCOS IOS NETWORKS

OCEAN OBSERVATIONS (GOOS)	REMARKS
DATA BUOYS	- A variety of Buoy programs coordinated by the JCOMM In situ Observing Platform System (JCOMMOPS). No central data system or archive. Includes NDCP, PIRATA, and TAO. (Nothing new since GCOS)
SHIPS OF OPPORTUNITY AND VOLUNTARY SHIPS	- 100 Ships of Opportunity reporting in real time sub-surface mixed layer data (temperature, salinity, pressure). Part of JCOMMOPS. Also 1700 Voluntary ships reporting surface meteorological observations in real-time with 9 ships reporting upper air in realtime. Increased participation due to GCOS/GOOS
TIDE STATIONS	- 247 stations in the Global Sea Level Observing System (GLOSS). Data available centrally at PSMSL. Increased participation due to GCOS/GOOS
SUBSURFACE DRIFTING FLOATS	- New program, ARGO, provides temperature, salinity profiles in the upper ocean. Data available in realtime via Web, Plan for 3000 floats. 416 floats already deployed. Increased participation due to GCOS/GOOS

ANNEX 2 (cont)

GCOS IOS NETWORKS

TERRESTRIAL OBSERVATIONS	REMARKS
GLOBAL TERRESTRIAL NETWORK FOR GLACIERS (GTN-G)	**- Program to provide standard measurements at 60 glaciers as part of the World Glacier Monitoring Service (WGMS). Nothing new for GCOS/GTOS**
GLOBAL TERRESTRIAL NETWORK FOR PERMAFROST (GTN-P)	**- Program to provide standard measurements form stations in the International Permafrost Association (IPA) and the volunteer Circumpolar Active Layer Monitoring (CALM). Nothing new for GCOS/GTOS**
	- **See note 1**

Note 1: FLUXNET is a long term observing program of over 150 micrometeorological towers that measure the exchange of Carbon Dioxide, Water Vapor and Energy between terrestrial ecosystems and the atmosphere. FLUXNET is not included in the IOS of GCOS or GTOS; however the USA report to the UNFCCC on observing systems indicates that AMERIFLUX, a component of FLUXNET is part of GTOS.