GLOBAL CLIMATE OBSERVING SYSTEM

WMO of UNESCO UNEP ICSU

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REPORT OF THE PACIFIC ISLANDS REGIONAL IMPLEMENTATION WORKSHOP ON IMPROVING GLOBAL CLIMATE OBSERVING SYSTEMS

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EXECUTIVE SUMMARY

The Global Climate Observing System (GCOS) Secretariat held the first of 10 planned regional workshops on improving observing systems for climate on 14-15 August, 2000 in Apia, Samoa. The impetus behind this workshop, as well as for the workshops to follow, is Decision 5/CP.5 of the 5th Conference of the Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC). This decision recognizes the need to identify the priority capacity-building needs of developing countries related to participation in systematic observation and invites the GCOS Secretariat, in consultation with relevant regional and international bodies, to organize regional workshops on this issue.

The South Pacific Regional Environment Programme (SPREP) collaborated with GCOS in the organization of the Workshop, and SPREP, as the principal regional entity concerned with climate variability and change, will take the lead in co-ordinating and implementing the actions specified in the Workshop Resolution (see Annex I). Significant support for the Workshop was provided by the World Meteorological Organization (WMO), the United Nations Environment Programme (UNEP), the United States of America, and Australia. The participants of the Workshop included the meteorological service directors from some 20 Pacific Island countries and a number of climate change coordinators from the same countries. The principal goals of the Workshop were:

- To assist participants in identifying regional deficiencies in global observing systems for climate;

- To assess priority observing system needs and funding required to enable countries to overcome deficiencies in observing systems and to allow them to collect, exchange, and utilize data on a continuing basis; and

- To initiate the development of regional action plans and proposals to fund improvements in observing systems.

Day 1 of the 2-day Workshop consisted principally of two sets of presentations (see the Workshop agenda in Annex II). The first set was designed to familiarize participants with GCOS, help them understand the linkages between GCOS and the UNFCCC, and inform them about the possibilities, especially through the Global Environment Facility (GEF), for funding to improve climate observing systems in the Pacific region. The second set reviewed the status and needs of observing systems in the Pacific region, addressing in turn the question of why improved observations are important for the region and the globe, and the deficiencies and needs of key meteorological, oceanographic, and terrestrial observing systems. A key presentation was given on the present status of climate observing systems in the Pacific region and of proposed development projects to address the deficiencies identified. The presentation was based on the findings from a recently completed study, *The Pacific Meteorological Services: Meeting the Challenges*. This report, commonly known as the "Needs Analysis," provides SPREP members with an important head start in identifying climate observing system needs and in developing a regional action plan to address these needs.

Day 2 of the Workshop began with a presentation by Dr John Zillman, who introduced a discussion paper specially prepared for the Workshop on "Developing an Action Plan for Improved Climate Monitoring in the Pacific." The remainder of the day was devoted to group discussion of regional priorities and consideration of next steps to take in realizing the ultimate GCOS objective of making real and significant improvements in climate observing systems in the region.

Discussions during the Workshop identified a number of important issues associated with improving observing systems for climate in the Pacific region, including:

- The significance of the Pacific region to global climate monitoring and prediction and the importance of effective observing systems in the region;

- The importance of setting discussions of climate observing systems within a regional context that reflects Pacific values, aspirations, needs, and circumstances;

- The value of approaching climate observing systems in the context of an emerging Pacific islands framework on climate variability, climate change, and sea level rise that meets national, regional, and international needs for climate information, including, but not limited to, requirements associated with successful implementation of the UNFCCC;

- The recognition that most climate impacts are felt at local and regional levels and that a regional approach to observations for climate will provide the cost-effective provision of climate information, products, and assessments to support the development of regional response strategies;

- The value of addressing climate observing system needs and opportunities as part of an end-to-end system that moves from observations through the management, production, delivery, and application of useful and usable information products;

- The importance of a more complete understanding of regional climate information needs and the need to effectively engage regional decision-makers (communities, governments, and businesses) as partners in the design, development, implementation, and application of observing systems for climate;

- The benefits of undertaking a mix of region-wide and national activities to meet international (UNFCCC) requirements as well as targeted “pilot projects” to meet specific regional needs;

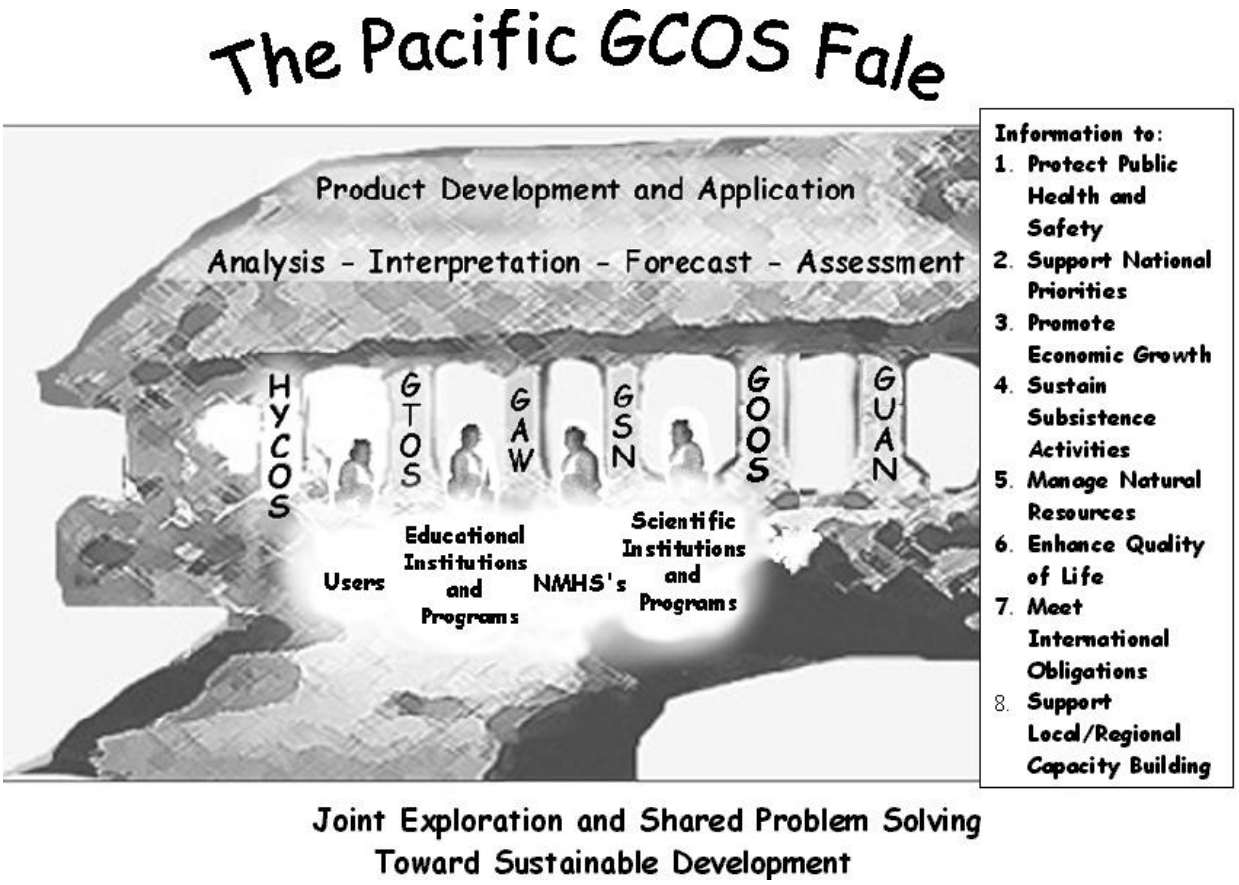
- The importance of identifying needs and opportunities for integration across the individual components of a global climate observing system;

- The value of identifying and engaging appropriate partners in the development and implementation of an Action Plan to improve observing systems for climate in the Pacific and of approaching potential donors with requests to support proposed activities that are appropriate to their interests, missions, and responsibilities; and

- The opportunity to use the development and implementation of a Pacific GCOS Action Plan to enhance cooperation and communication among partners at all levels.

The concept of a Pacific GCOS that emerged from discussions at the Workshop is shown schematically in the Figure. Using the imagery of a Samoan fale (open-sided house), the figure suggests the evolution of a Pacific GCOS that is supported by individual GCOS components (including the GCOS Surface Network (GSN), the GCOS Upper-Air Network (GUAN), and the Global Atmosphere Watch (GAW), and the climate-related networks of the Global Ocean Observing System (GOOS) and the Global Terrestrial Observing System (GTOS)) and provides a regional capability to develop climate information products that address a variety of national, regional, and international needs and responsibilities.

The partners in the Pacific GCOS fale would include national meteorological and hydrological services; relevant national, regional, and international organizations and programmes; scientific and educational institutions and programmes in the region; and the



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users of GCOS information products in Pacific Island communities, governments, and businesses.

Workshop participants identified a number of objectives that a Pacific GCOS could fulfil, including:

- Contributing to global programmes of climate monitoring, detection and attribution;
- Meeting national monitoring and reporting requirements under the UNFCCC;
- Supporting regional climate change mitigation and adaptation programmes;
- Developing a better understanding of the regional and local implications of climate variability and climate change;
- Improving capabilities to monitor and predict climate variability in the region (particularly on seasonal-to-interannual timescales);
- Enhancing national capabilities to respond to the consequences of climate variability;

- Stabilizing and strengthening the meteorological and atmospheric observing networks that form an important part of the fundamental support structure for a global climate observing system;

- Capitalizing on exciting opportunities associated with the emergence of the climate components of a GOOS; and

- Enhancing and integrating elements of the GTOS, including, as a high priority, development of a Pacific Hydrological Cycle Observing System (Pacific-HYCOS) to provide additional information on water resources and extreme precipitation events (e.g., droughts and floods).

A principal outcome of the Workshop discussions was the decision to prepare a Workshop Resolution reflecting the consensus of participants. A draft "Resolution Concerning the Improvement of Global Climate Observing Systems in the Pacific Region" was prepared after the closure of the workshop and subsequently considered, revised, and approved two days later by the same participants during the 7th Regional Meteorological Service Directors Meeting.

The Resolution approved by the Workshop participants was a significant achievement of the Workshop. Two of the key recommendations from the resolution include a recommendation encouraging the countries of the region to support their National Meteorological and Hydrological Services (NMHSs) in the preparation of national reports on activities related to systematic observation (as invited by the Parties to the UNFCCC) and one urging the preparation of a regional Action Plan that would form the basis for the development of proposals for funding improvements for observing systems for climate in the region. Significantly, a series of actions was specified in the Resolution, that if taken by SPREP and the Pacific Island countries, would result in completion of the Action Plan by June 2001. The adopted Resolution is reproduced as Annex I to this report. The principal actions specified in the Resolution include:

- Preparation by SPREP member countries of individual reports on national requirements and priorities for improving observing systems for climate (within 3-4 months after the Workshop);

- Development by SPREP of a consolidated report on regional requirements and priorities for improving observing systems for climate (the report will be submitted to SPREP members for their approval); and

- Development of a Pacific GCOS Action Plan facilitated by SPREP in cooperation with the Council of Regional Organizations in the Pacific (CROP) and the co-sponsors of GCOS. The targeted completion date is June 2001 to enable the Plan to be presented to the COP-7 deliberations in July 2001. The Plan is intended to form the basis for the development of proposals to fund action items.

INTRODUCTION AND BACKGROUND

The Parties to the United Nations Framework Convention on Climate Change (UNFCCC) have recognized the importance of high-quality data for climate-related purposes and have noted that, in many instances, either the geographic coverage, quantity or quality of the data produced by current global and regional observing systems are inadequate. Most of the problems occur in developing countries, where lack of funds for modern equipment and infrastructure, inadequate training of staff, and continuing operational expenses are often major constraints

In response to several pertinent decisions of the Conference of the Parties (COP) to the UNFCCC, the Global Climate Observing System (GCOS) Secretariat initiated a Regional Workshop Programme to address the capacity-building needs and funding required to overcome regional deficiencies in meteorological, atmospheric, oceanographic, and terrestrial observing systems for climate (see Annex III). The central goals of the GCOS Workshop Programme are:

- To assist developing countries in identifying regional deficiencies in global observing systems for climate;

- To assess priority observing system needs and funding required to enable countries to overcome deficiencies in observing systems and to allow them to collect, exchange, and utilize data on a continuing basis in pursuance of the UNFCCC; and

- To initiate development of Action Plans and Proposals to fund improvements in observing systems.

Following each workshop in the programme, GCOS will continue to be involved in facilitating the development of regional Action Plans and related proposals that can be submitted to donor countries and international organizations to fund improvements in observing systems for climate. However, regional partners are expected to take the lead in developing plans and proposals.

The Pilot Project for the GCOS Workshop Programme began in 2000 with planning for the first of ten planned regional workshops between 2000 and 2005. The GCOS Secretariat chose the Pacific Islands for its first Regional Workshop for the following substantive and opportunistic reasons:

- Preliminary analysis indicates important gaps in major observing system networks in the Pacific;

- Pacific Island countries are generally considered among the most vulnerable to the consequences of climate variability and climate change;

- Oceanic and atmospheric circulation patterns and ocean-atmosphere interactions in the Pacific region play important roles in determining global patterns of climate variability and climate change; and

- GCOS has an opportunity to work with an experienced and well-organized regional partner, the South Pacific Regional Environment Programme (SPREP) and to capitalize on the interest and financial support of a number of developed countries flanking the Pacific.

The Pacific Islands Regional Implementation Workshop on Improving Global Climate Observing Systems (the Workshop) was convened 14-15 August, 2000 in Apia, Samoa by

SPREP and the GCOS Secretariat, with support from the World Meteorological Organization (WMO), the United Nations Environment Programme (UNEP), the Australian Bureau of Meteorology, and the U.S. National Weather Service. The Workshop brought together representatives of SPREP member countries, scientific and educational institutions and programmes active in the Pacific region, and relevant regional and international programmes and organizations (a List of Participants is included as Annex IV).

SUMMARY OF WORKSHOP DELIBERATIONS

Opening Remarks

During opening ceremonies for the Workshop, the Prime Minister of Samoa, the Honorable Tuilaepa Sailele Malielegaoi set the tone for the meeting by highlighting the importance of monitoring weather and climate conditions and lessening the impacts of those events through advance warning and guidance. In this context, the Prime Minister made special note of the importance of presenting scientific information about weather and climate in an understandable format that the public, governments, and businesses will find useful and usable. Using a specific example of experience during Tropical Cyclone Ofa, the Prime Minister's remarks highlighted the value of putting weather and climate observations into an integrated context that includes analysis, forecasting, education and public outreach, and practical applications.

Dr Alan Thomas, Director, GCOS Secretariat, provided Workshop participants with an overview of GCOS including its history, objectives, and component networks (see Annex V for an abbreviated opening statement). During his remarks, Dr Thomas highlighted the following objectives of the GCOS Strategic Framework:

- Implementing an integrated observing system that builds on existing operational and research observing and data systems, including the GCOS Surface Network (GSN), the GCOS Upper Air Network (GUAN), the Global Atmosphere Watch (GAW), and the ocean observing systems that comprise the climate components of the Global Ocean Observing System (GOOS) and the Global Terrestrial Observing System (GTOS);

- Obtaining and sustaining national commitments to support elements of the Global Climate Observing System;

- Addressing deficiencies at a regional level; and

- Keeping an integrated observing system for climate focused, relevant to users, and responsive to new scientific insights.

Taking particular note of the last two elements of this Strategic Framework, Dr Thomas briefly described the relationship between GCOS and the UNFCCC and the emergence of a GCOS programme of regional workshops in response to UNFCCC mandates.

Dr Susan Barrell, from the Australian Bureau of Meteorology, then provided the Workshop participants with further details on the relationship between the UNFCCC and GCOS (see Annex VI). Dr Barrell's presentation highlighted a number of key points, including:

- The growing importance of observing systems for climate in the context of the evolution of the UNFCCC;

- The growing recognition of the importance of cooperation between government policy-makers and scientists, particularly those in the climate monitoring and research community working with policy-makers;

- The importance of GCOS' multi-level role which includes direct interaction with the UNFCCC; working with nations to secure national commitments and to meet national responsibilities; and working with appropriate international and regional organizations and programmes; and

- The global benefits of cooperation in climate monitoring, including contributions to climate change detection and attribution; understanding climate processes; anticipating (forecasting) changes in climate at a variety of timescales; assessing impacts; and using climate information to support practical decision-making related to national economic development.

Dr Barrell closed her remarks by highlighting the importance of capitalizing on the emerging partnership between GCOS and the UNFCCC for both the Pacific region and the world as a whole.

Mr Gerald Miles, from the SPREP Secretariat, and Dr Thomas then provided Workshop participants with a brief discussion of the potential role of the Global Environment Facility (GEF) in climate observations in the context of Decision 14/CP.4 at the 4th Conference of the Parties to the UNFCCC in 1998 and Decision 5/CP.5 at the 5th Conference of the Parties session in 1999. Decision 14 urged Parties to actively support meteorological, atmospheric, oceanographic, and terrestrial observing systems and to actively support the building of capacity in developing countries in order to enable them to collect, exchange, and utilize data to meet local, regional, and international needs. This decision was reinforced by Decision 5/CP.5, which further urged the Parties to address deficiencies in climate observing networks and invited the GCOS Secretariat, in consultation with GEF and other international organizations, to identify capacity-building needs and funding required in developing countries. Specifically, Decision 5/CP.5:

- Recognizes the need to identify the priority capacity-building needs related to participation in systematic observation;

- Invites the secretariat of the Global Climate Observing System, in consultation with relevant regional and international bodies**,** including the Global Environment Facility, to organize Regional Workshops on this issue; and

- Urges Parties to actively support and participate in these Workshops.

In addition to supporting the Pacific Regional Workshop (and subsequent workshops in other regions), Dr Thomas and Mr Miles discussed the potential role of GEF in supporting elements of Regional Action Plans to address deficiencies and support capacity building related to observing systems for climate. In this context, both Mr Miles and Dr Thomas noted that GEF would be only one source of funding for implementation of regional Action Plans and that requests for support to GEF, or any sponsor, should be appropriate to that donor's mission and responsibilities. In this context, Dr Thomas emphasized the value of seeking support/contributions from GEF in the context of a region-wide plan which could/would have multiple sponsors. Mr Miles' presentation reviewed the history of the GEF's involvement in supporting Small Island Developing States (SIDS) in the Pacific region, provided a general overview of the funding cycle for GEF projects, and discussed lessons learned by SPREP in dealing with the GEF in securing funds for Pacific Island countries (e.g., the Biodiversity Program and the Pacific Islands Climate Change Assistance Programme (PICCAP)) in the past.

The Regional Perspective: Why Improved Observations are Important for the Region and the Globe

Dr Jim Salinger, of the New Zealand National Institute of Water and Atmospheric Research Ltd. (NIWA), presented a regional perspective on why improved observations in the Pacific are important for the region and the globe (a copy of Dr Salinger's background paper is included as Annex VII). Dr Salinger's presentation highlighted the following points:

- The Pacific region's importance to understanding and assessing climate variability and climate change both locally and globally, noting in particular, critical climate variability processes like the El Niño/Southern Oscillation (ENSO) cycle and the Inter-decadal Pacific Oscillation (IPO); contributions of regional sites to monitoring greenhouse gas concentrations both regionally and globally; and contributing to long-term monitoring of climate trends and detection and attribution of climate change;

- The significant socio-economic consequences of climate variability in the Pacific region and the need to better document and understand climate variability and climate change;

- The essential role of observations as the basis for monitoring and prediction of regional climate on an interannual basis and for managing the consequences of regional variability from ENSO and IPO; and

- The essential role that atmospheric observations in the Pacific play in providing information on trace gas concentrations, sources and sinks, and ozone depletion.

Summary of the Pacific Regional Meteorological Services Needs Analysis Project

Mr Ram Krishna, Australian Bureau of Meteorology, provided the Workshop with an overview of the observational elements of the recently completed report, *Pacific Meteorological Services: Meeting the Challenges,* for which he served as team leader (see Annex VIII). In introducing his remarks, Mr Krishna noted that the focus of the "Needs Analysis" was on the requirements associated with operational weather and climate services and therefore provided insights into primarily meteorological and atmospheric observations (with much less attention on oceanographic or terrestrial observing systems) and on primarily operational (vs. research) requirements. Mr Krishna noted that, from the standpoint of users, three areas emerged as important:

- Improved Cyclone Warnings;

- Information on Climate Variability and associated seasonal/interannual prediction, particularly of droughts and tropical cyclone frequency and intensity; and

- Information on Climate Change (mainly in relation to climate variability).

In this context, Mr Krishna noted the importance of climate to critical issues such as water resource management, disaster management, renewable energy development, forestry, fisheries, agriculture, transportation, tourism, and mining.

Reinforcing the importance of climate observations in the Pacific to both the region and the globe, Mr Krishna then reviewed some of the relevant priorities and projects identified in the Needs Analysis in the context of observing systems for climate, including requirements in the areas of:

- Upgrading and strengthening observational networks;
- Upgrading telecommunications systems;

- Climate information and prediction services; and
- Infrastructure and institutional strengthening.

Review of Current Status and Needs of the GCOS Surface Network and the GCOS Upper-Air Network

Mr Neil Plummer, Australian Bureau of Meteorology, provided the Workshop with an overview of the current status and regional needs of the GCOS Surface Network (GSN) and the GCOS Upper Air Network (GUAN) in the Pacific (see Annex IX). Mr Plummer highlighted the GSN and GUAN networks as fundamental to future climate monitoring but noted that, while essential, they were not sufficient. Mr Plummer then provided an overview of the strengths and weaknesses of these important foundation networks from a GCOS perspective, including:

- The inability of monthly data to capture important information about extreme events and associated deficiencies in the development/provision of a long-term data record on extreme events;

- The absence of adequate rainfall (precipitation) data from the GSN;

- Apparent problems in the transmission of reports to WMO World Data Center A (based on a recent performance monitoring report that suggests a reception rate of only 50%); and

- The challenges and opportunities associated with implementing "Best Practices" for observations and data management from GCOS stations and the overall need to strengthen data management and climate information products.

In this context, Mr Plummer reinforced the importance of starting with a good understanding of climate information needs (in the region and globally) and then using that understanding to help guide observing system design, implementation and evaluation – an idea that surfaced repeatedly during the Workshop.

Review of Rainfall and Hydrology Networks

Mr Charles Pearson, NIWA, presented an overview of the status and needs of hydrological and rainfall monitoring networks of the South West Pacific Region (see Annex X). Mr Pearson described the type of data and observing systems used to convert water level measurements into stream flow data that can be integrated with data on atmospheric processes, soil conditions and ground and surface water reservoirs to provide information on water resource management that is vital to a number of decision-makers in the region. Mr Pearson emphasized the importance of integrating hydrological observations with weather and climate observing systems and the value of greater collaboration among the weather/climate and hydrological communities. Mr Pearson further emphasized the need for, and value of, a more effective dialogue between those scientific communities and the users of the information they produce in government and economic sectors. After providing the Workshop with an overview of the current status of hydrological observing systems in the South West Pacific, Mr Pearson highlighted the emergence of plans for a Pacific Hydrological Cycle Observing System (Pacific-HYCOS) in the context of the WMO World Hydrological Cycle Observing System (WHYCOS) and the value of integrating those plans with improvements in the observing systems for climate.

Realizing the Potential of Ocean Observing Networks: A Pacific Island Regional Perspective

Dr Neville Smith, Australian Bureau of Meteorology, provided the Workshop with a Pacific Islands regional perspective on opportunities to realize the potential of ocean observing networks (see Annex XI). Emphasizing the importance of integrating oceanographic, atmospheric and terrestrial observations into a GCOS context, Dr Smith highlighted the need for a long-term view built on an enhanced dialogue with users to identify needs, develop useful and usable information products and help design (and evaluate) observing systems for climate. In this context, Dr Smith recommended a regional GCOS programme that would combine:

- A number of focused regional "pilot projects" characterized by well-articulated objectives developed in response to regional priorities that would build on the strengths of existing ocean observing systems; and

- An integrated perspective that provides coordination among related climate observing system programmes/projects (meteorological, atmospheric and terrestrial) and provides a regional voice in discussions with donors and partners at national, regional, and international levels.

Dr Smith then provided the Workshop with an overview of some of the existing and emerging ocean observing systems related to international scientific programmes and highlighted some exciting opportunities to take advantage of products that could be developed from those observing systems. In this context, Dr Smith highlighted:

- The importance of planning for future generations as well as meeting immediate needs;

- Opportunities to develop value-added products to enhance economic development and quality of life as well as reduce vulnerability to climate-related disasters;

- The importance of setting observations in the context of an integrated, end-to-end system that moves from observations through analysis and forecasting to practical applications;

- The need to recognize and build on different regional needs and capabilities (every region is different);

- The need for a properly planned and implemented ocean observing system for both the region and the world; and

- The importance of an effective and continuing dialogue with users to expose to them the applications and products derived from observing systems and to seek input on prospective applications (with implications for observing system design).

Draft Pacific Climate Strategy

Mr Pene Lefale, of the SPREP Secretariat, provided the Workshop with an overview of the draft Pacific Islands Framework on climate change, climate variability, and sea level rise that came out of the Cook Islands Climate Change Conference held in Rarotonga from 3 to 7 April 2000. Mr Lefale summarized the key chapters of the draft Framework that dealt with strengthening climate observing systems in the Pacific region. He then urged Workshop participants to pay closer attention to the draft Framework as it provided a political mechanism on actions to address and respond to climate variability, climate change and sea level rise over the next four years.

DISCUSSION OF REGIONAL PERSPECTIVES AND PRIORITIES

At the end of the first day and the beginning of the second day of the Workshop, participants engaged in a general discussion of regional perspectives and priorities related to GCOS. The following items highlight the key points raised during the discussion:

- A need to better understand national circumstances and needs and to more effectively convey the value of GCOS at the national, regional and international levels;

- The potential value of targeted "pilot projects" to address specific deficiencies in GCOS networks and of developing some targeted "pilot projects" to demonstrate the benefits of integrating individual observing networks and systems (GSN, GUAN, GOOS, GTOS, Pacific-HYCOS) into a regional observing system for climate;

- The need for a more detailed understanding of and solution to the data reporting problems identified in association with GSN;

- The need to effectively engage all relevant partners in the region, capitalizing on the relative strengths, unique capabilities, special expertise, and established missions of regional (and international) organizations; scientific and observing system programmes; scientific and educational institutions and programmes; national institutions; and a variety of funding agencies and other donors;

- The need to develop a shared understanding of what a Pacific GCOS would include and why those activities are important to Pacific Island countries, the region, and the world;

- The importance of upgrading and strengthening existing observing systems that provide the foundation for GCOS (with a number of individual Pacific Island countries identifying specific problems associated with upper air or surface network stations, telecommunications, and data management systems);

- The importance of reinforcing national commitments and responsibilities for GCOS[1];

- The importance of developing a Pacific GCOS Action Plan in the context of national, regional, and international needs and priorities;

- The need for an integrated approach that combines individual networks (GSN, GUAN, GAW, GOOS, GTOS, HYCOS) and different observing system technologies (e.g., satellite and *in situ*) and builds on existing networks while investing in new or enhanced systems;

- The need to ensure easy and reliable access to the data and information products of GCOS observing system networks;

- The need for individual countries (and observing systems) to follow the "best practices" guidelines established by WMO and the UNFCCC;

[1] In this context, Howard Diamond (U.S. National Oceanic and Atmospheric Administration (NOAA)) informed the Workshop of the commitment of the U.S. NOAA National Climatic Data Center (NCDC) to produce a global, historical GSN database and urged participants to encourage their national meteorological services to submit their historical data to NCDC.

- The opportunity for Pacific Island countries to use their National Communications (under the UNFCCC) to highlight climate monitoring and observing system needs;

- Recognition that data from GCOS networks have value for weather forecasting as well as climate purposes and the need to ensure that such data are made available to national prediction centers;

- The value of the recently-completed Pacific Meteorological Services Needs Analysis as an important initial step and the need for similar analyses for other GCOS component systems (oceanographic and terrestrial) in the region; and, in this context

- The need to consider coastal concerns (e.g., erosion, sea level rise) as components of a Pacific GCOS as well as more traditional atmospheric and oceanographic concerns.

Emerging from the Workshop discussions was a concept of a Pacific GCOS Programme shown schematically in the figure on page 3. Using the imagery of a Samoan fale, the figure suggests the evolution of a Pacific GCOS that is supported by the individual GCOS component networks (GSN, GUAN, GAW, and components of GOOS and GTOS) and provides a regional capability to develop climate information products that address a variety of national, regional, and international needs and responsibilities. The partners in the Pacific GCOS fale would include national meteorological and hydrological services; relevant national, regional, and international organizations and programmes; scientific and educational institutions and programmes in the region; and the users of GCOS information products in Pacific Island communities, governments, and businesses.

Developing an Action Plan for Improved Climate Monitoring in the Pacific: A Discussion Paper

To facilitate Workshop discussions related to some meaningful steps forward in the development of a Pacific GCOS, Dr John Zillman, Australian Bureau of Meteorology, summarized the key points in a Discussion Paper entitled *"Developing an Action Plan for Improved Climate Monitoring in the Pacific*." The entire Discussion Paper is reproduced as Annex XII to this Report. Dr Zillman's presentation highlighted the following points:

- Implementing an effective observing system for climate in the Pacific represents both an opportunity of immense importance to Pacific Island countries and the world and a significant challenge in terms of integrating national, regional, and international needs and capabilities;

- The national meteorological and hydrological services of Pacific Island countries are essential to the success of GCOS and, conversely, effectively addressing the climate challenge is essential to the future of those services;

- An observing system for climate is more than just meteorological and atmospheric observations;

- An observing system for climate in the Pacific should be designed to meet national and local needs as well as international responsibilities;

- Wherever possible, capitalize on multiple-purpose systems;

- Design and implement a system that integrates "from science to policy," meeting needs for research, forecasts and applications, and detection and attribution of climate change;

- Emphasize the value of regional cooperation and collaboration over the long term and think strategically about the nature of a cooperative regional activity and of the best mechanisms for funding and supporting it.

Dr Zillman then summarized the key issues identified in the Discussion Paper related to support for national climate monitoring plans (as called for by the UNFCCC), upgrading and operation of component observing system networks, and climate data management.

Workshop deliberations on the Discussion Paper were facilitated by comments from a Panel comprised of: Messrs. Pene Lefale (SPREP Secretariat); Arona Ngari (Cook Islands Meteorological Service); Alf Simpson (South Pacific Applied Geoscience Commission (SOPAC)); Rajendra Prasad (Fiji Meteorological Service); and Rishi Raj (Regional Hydrological Advisor for WMO). The following items highlight the key issues raised by the Panel and subsequent group discussion:

- The next steps in the development of a Pacific regional GCOS approach should reflect the needs and priorities of Pacific Island countries and take an integrated approach that addresses the needs of all stakeholders;

- Issues related to long-term maintenance and operation of observing systems, telecommunications, data management, staff development and institutional capacity-building should be addressed;

- The plan/programme that emerges should be "user-driven" and help people deal with today's needs as well as longer-term national and international needs. In this context, issues related to water resources and extreme events should be high priorities;

- Bear in mind that raw observations are of little value in themselves. In the words of one panelist, "data is only of value if it is likely to be used in decision-making."

- Recognize the challenges associated with securing and sustaining funding for such an activity, including the fact that multiple potential sponsors/donors would likely fund different pieces of the programme appropriate to their missions and capabilities;

- In setting up a Pacific GCOS, consider a distributed approach that capitalizes on the special skills and unique capabilities of existing institutions and programmes and combines activities at the national, regional, and international levels;

- Build on existing activities where possible or appropriate rather than creating new institutions. In this context, fix current deficiencies in GCOS networks as a high priority;

- Use the emergence of a Pacific GCOS approach to strengthen linkages between national meteorological and hydrological services and national programmes/institutions responsible for climate change policy; and

- Recognize the importance of GCOS data for climate response (mitigation and adaptation) planning at both national and regional levels.

DEVELOPMENT OF A PACIFIC GCOS ACTION PLAN

Workshop deliberations then turned to the development of a GCOS Action Plan. To facilitate these discussions, Dr Thomas offered some introductory thoughts that reinforced issues that had been raised during the first day-and-a-half of the Workshop: (1) think about steps that will improve national capabilities for climate monitoring, analysis and services; (2) build on current infrastructure to the extent possible; (3) strengthen and enhance core (national) capabilities in observations, analysis, data management, product development and applications; and (4) develop a comprehensive approach to climate that includes, but is not limited to, observations.

In a group discussion led by Mr Richard Hagemeyer (U.S. National Weather Service, Pacific Region), the Workshop participants committed to developing a Pacific GCOS Action Plan and outlined the following elements to be considered in an Action Plan:

Component Observing Networks

- Optimizing data from the GSN and GUAN;
- Connection and coordination with GOOS, GTOS and emerging plans for a Hydrological Observing System (HYCOS); and
- Defining national and regional climatological networks.

Data Management Issues

- Current systems – in-country and regional;
- Availability and distribution of data sets;
- Meta data considerations;
- Data rescue and recovery; and
- Provision of historical data sets.

Communications Challenges and Opportunities

- What and where are the problems?
- What are the emerging opportunities?

Development and Application of Climate Information Products

- Seasonal, interannual, and possibly interdecadal outlooks;
- Derived products for key sectors (e.g., sea surface temperature for fisheries; drought and flood indices;
- Climate change monitoring and trend detection, including establishment of national baselines;
- Climate change assessment scenarios; and
- Advice to governments.

Training and Education

- Climate data analysis and interpretation;
- Identification of available products and awareness of the systems/facilities that provide them;
- Stakeholder engagement and public education; and
- Documentation of how GCOS objectives address national and international needs and priorities.

Critical Partnerships and Resource Requirements

- National centers, institutions and programmes;
- Regional organizations;
- International organizations and programmes;
- Funding requirements and priorities; and
- Potential donors.

The Workshop recommended the following three-step process for creation of the Pacific GCOS Action Plan:

- Preparation of individual reports of national requirements and priorities for improving observing systems by SPREP member countries (by 3-4 months after the Workshop);

- Development of a consolidated report by SPREP on regional requirements and priorities for improving observing systems for climate that will be submitted to SPREP members for their approval; and

- Development of a Pacific GCOS Action Plan to serve as the basis for proposals to fund improvements in observing systems for climate. This Plan would be facilitated by SPREP in cooperation with the Council of Regional Organizations in the Pacific (CROP) and the co-sponsors of GCOS. The targeted completion date is June 2001 in order to be able to present the Plan to the COP-7 deliberations in July.

A small drafting team of representatives from SPREP member countries and other appropriate experts will be established to facilitate the development of the Pacific GCOS Action Plan.

WORKSHOP RESOLUTION

The Workshop concluded with an agreement to draft a Workshop Resolution that reflected the findings and recommendations that emerged from the Workshop and laid out a process for the development and implementation of an Action Plan for Improving Global Climate Observing Systems in the Pacific region. Later in the week, the Workshop Resolution was strongly endorsed by the Seventh SPREP Meeting of Regional Meteorological Service Directors from the Pacific Island countries. It is included in its entirety as Annex I to this Report.

CONCLUDING REMARKS

The workshop was adjourned after some concluding remarks from the organizers. Dr Thomas acknowledged the success of the meeting and thanked the session chairs, speakers, participants, and SPREP for their contributions. Dr Thomas pledged to continue to work with SPREP and the Pacific Island countries to support the development and implementation of a Pacific GCOS Action Plan and to increase international awareness of the Pacific GCOS issues raised during the workshop and the subsequent Action Plan. Mr Miles thanked the GCOS Secretariat and reinforced Dr Thomas' acknowledgement of the contributions of speakers, chairs, and participants. The SPREP Secretariat confirmed their commitment to respond to the findings and recommendations contained in the Workshop Resolution and to work with other appropriate partners in the region to develop a Pacific GCOS Action Plan and to work with Pacific Island countries to secure the funding necessary to implement that Plan.

ACKNOWLEDGEMENTS

GCOS and SPREP wish to thank the principal sponsors of the Pacific Island Regional Workshop, without whose financial support this workshop would not have been possible. These include the World Meteorological Organization, the United Nations Environment Programme, the Australian Bureau of Meteorology, and the U.S. National Weather Service. The organizers would also like to thank Ms Eileen Shea for her work in drafting this report. Finally, they would like to acknowledge the professional support both before and at the meeting provided by Ms Fono Valasi, Ms Alisa Nickel and Ms Saunoa Mata'u.

GCOS - GOOS SPECIAL SESSION ON ARGO

Following the conclusion of the formal Workshop deliberations, participants were invited to attend a briefing on the Argo programme. Argo has been designed as a global array of profiling floats that would provide ocean temperature and salinity data. The Argo briefing was organized jointly with the Pacific GOOS Coastal Workshop, which was being held concurrently with the GCOS Workshop to address the coastal components of GOOS.

Argo programme officials, Dr Stan Wilson (NOAA) and Dr Dean Roemmich (Scripps Institution of Oceanography, USA), provided participants with an overview of the Argo programme.

The Argo programme involves the deployment of a planned 3,000 profiling floats that will return to the surface every ten days and provide a vertical profile of temperature and salinity data at their location (transmitted via satellite). Dr Roemmich noted that these ocean profiles are somewhat analogous to the atmospheric profiles provided by GUAN and would significantly enhance the global data set of ocean temperature and salinity. Regional applications of the Argo programme were described to include:

- Improved seasonal-to-interannual climate forecasts by allowing for the incorporation of sub-surface temperature data;

- Support for improved forecasts of tropical storm intensity by improving understanding of the amount of energy absorbed by a passing storm;

- Supplemental, *in situ* data to support analysis of sea surface temperature and sea level (height) measurements from the Ocean Topography Experiment (TOPEX) satellite altimetry observing system;

- Improvements in fisheries catch-per-unit-effort estimates for important migratory species such as tuna; and

- Improved understanding of the effect of ocean temperature changes on coral reef ecosystems.

The Argo programme will be a multi-national, multi-year programme with deployment of the full suite of 3,000 floats anticipated by 2005. The Intergovernmental Oceanographic Commission (IOC) has endorsed the Argo programme as an important component of GOOS. It is also important to GCOS and a major contribution to climate research programmes such as the Climate Variability and Predictability (CLIVAR) Programme (a component of the World Climate Research Programme). In their endorsement, the IOC noted that the data and derived products from Argo should be made freely available and encouraged plans for an Argo Information Center.

The IOC Resolution addressing Argo requires notification to countries within whose jurisdictions floats will travel, although it did not specifically address issues related to deployment within the Exclusive Economic Zone (EEZ) of a country. Since improving seasonal-to-interannual climate forecasts is seen as a high priority for the Argo programme, initial deployment is targeted for the Western Pacific warm pool area. Since much of this area of the Pacific Ocean falls within the EEZ's of Pacific Island countries, Argo is seeking the support and cooperation of Pacific Island countries. Specifically, Messrs. Roemmich and Wilson noted the need for:

(1) Development of a consensus among Pacific Island countries that Argo is an important part of the ocean and climate observing system in/for the Pacific;

(2) Cooperation of national governments in the deployment of Argo floats within a nation's EEZ; and

(3) Collaboration of local scientific institutions in the analysis of Argo data and the development of derived products.

To facilitate the development of this regional collaboration in the Pacific, Argo has designated Dr Roemmich as a Pacific regional focal point for the programme and Messrs. Roemmich and Wilson encouraged each Pacific Island country to consider designation of a national focal point for Argo.

Following the formal presentations, the Argo Programme representatives responded to questions from the participants, including:

- Requests for a more detailed description of the float technology (which Dr Roemmich provided);

- Concerns about the ultimate fate of floats once they have reached their useful lifetime (they will remain in the ocean at depth);

- Associated questions about the legal implications of Argo float deployment in the context of the London Dumping Convention (and subsequent regional protocols);

- Requests regarding clarification on the nature and availability of Argo data streams; and

- Suggestions that Argo consider investments in regional capacity building (education, training, joint research projects, and assistance in data analysis and interpretation) as part of the Programme in the future.

ANNEX I

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RESOLUTION CONCERNING THE IMPROVEMENT OF GLOBAL CLIMATE OBSERVING SYSTEMS IN THE PACIFIC REGION

The participants[1] in the GCOS Pacific Islands Regional Implementation Workshop on Improving Global Climate Observing Systems,

Welcome:

The opportunity provided by the GCOS Secretariat in partnership with SPREP, and with the support of WMO, UNEP, IOC, ICSU, to identify ways to improve observing systems for climate and in other activities related to climate observing systems in the Pacific region.

Recalling:

(1) That the Conference of the Parties (COP) to the UN Framework Convention on Climate Change (UNFCCC) has encouraged Parties to actively support capacity-building in developing countries to enable them to collect, exchange, and utilize data to meet local, national, regional, and international needs (Decision 14/CP.4), and has recognized the need to identify priority capacity-building needs related to participation in systematic observation (Decision 5/CP.5);

(2) That the COP to the UNFCCC has determined that the Global Environment Facility (GEF) should provide funding to developing countries to build capacity for participation in systematic observational networks to reduce scientific uncertainties (Decision 2/CP.4);

[1] American Samoa, Australia, Cook Islands, Federated States of Micronesia, Fiji, French Polynesia, Guam, Kiribati, Marshall Islands, Nauru, New Caledonia, New Zealand, Niue, Palau, Papua New Guinea, Samoa, Tonga, Tuvalu, USA, Vanuatu, Solomon Islands, World Meteorological Organization (WMO), Intergovernmental Oceanographic Commission (IOC) Perth Office, Food and Agriculture Organization of the United Nations (FAO), Forum Secretariat (FORSEC), South Pacific Geoscience Commission (SOPAC), South Pacific Regional Environment Programme (SPREP), Global Climate Observing System (GCOS) Secretariat; East West Center, Hawaii; National Tidal Facility (NTF), Flinders University, Australia.

(3) That Decision 5/CP.5 urges Parties to address deficiencies in the climate observing networks and to bring forward specific proposals for that purpose and to identify the capacity-building needs and funding required in developing countries to enable them to collect, exchange, and utilize data on a continuing basis in pursuance of the UNFCCC; and

(4) The role and importance of GCOS to facilitate systematic observation regionally.

Recognizing:

(1) That Pacific Island countries are considered among the most vulnerable to the consequences of human-induced climate change, in particular, global warming and the potential threats associated with extreme weather events and sea level rise;

(2) That improved observations of climate will enable provision of information and forecasts which will greatly assist the governments and national communities of member countries to prepare for the season-to-season and year-to-year variations of climate associated with El Niño and other natural phenomenon, as well as to detect and better prepare for long-term, human-induced climate change;

(3) That Pacific Island countries currently face significant challenges associated with natural climate variability, including droughts, tropical cyclones, floods, sea level variations, and changes in ocean temperature;

(4) That oceanic and atmospheric circulation patterns and ocean-atmosphere interactions in the Pacific play dominant roles in determining global patterns of climate change and climate variability;

(5) That measurements of meteorological/atmospheric, oceanographic, and terrestrial variables in Pacific Island settings provide essential data for detecting and attributing climate change; for monitoring, understanding and predicting climate change and climate variability; for developing strategies to ameliorate the potential harmful effects of climate change and climate variability; and for advancing sustainable development globally; and

(6) That the basic observation networks of National Meteorological and Hydrological Services (NMHSs) provide the foundation on which the strengthening of GCOS must be built.

Encourage:

(1) The countries of the region to support their NMHSs to prepare national reports on activities related to systematic observation, as invited by the Parties to the UNFCCC in Decision 5/CP.5.

Urge:

(1) That a regional Action Plan be prepared to form the basis for the preparation of a proposal(s) for funding improvements in observing systems for climate and in other activities related to climate observing systems in the Pacific region;

(2) That the Action Plan be prepared in accordance with the following programme:

a) Within the next 3 to 4 months, SPREP members will develop initial reports on national requirements and priorities for improving observing systems for climate. These reports should be developed through coordination between NMHSs and

PICCAP country teams, where appropriate, and could take advantage of the current opportunity associated with the incremental funding recently provided by GEF to continue PICCAP programmes in participating countries. *All* SPREP members should strive to develop these reports in the context of national implementation programmes pursuant to the UNFCCC guidelines, making use of the "elements" paper prepared by the Workshop, as well as of guidelines contained in FCCC/CP/1999/L4/Add.1, and submit them to SPREP;

b) Upon receipt of these reports, SPREP will develop a consolidated report on regional requirements and priorities for improving observing systems for climate. This report will be submitted to SPREP members for approval; and

c) In cooperation with the Council of Regional Organizations in the Pacific (CROP) and the co-sponsors of GCOS, SPREP will facilitate the development of a Pacific GCOS Action Plan that will incorporate the priorities raised in the country reports, such as those in the initial National Communications, the SPREP-led Pacific Meteorological Services Needs Analysis Project (PMSNAP), and the outcomes of the Pacific Islands Conference on Climate Change, Climate Variability and Sea Level Rise held in Rarotonga, Cook Islands, 3-7 April, 2000 and the findings of the Pacific Islands Regional Implementation Workshop on Improving Global Climate Observing Systems held in Apia, Samoa, 14-15 August, 2000. In order to take advantage of opportunities to report to the UNFCCC, this regional Action Plan should be completed no later than June 2001 and, if possible, presented to the Seventh Conference of the Parties (COP-7) to the UNFCCC deliberations in July 2001. To facilitate this process, the Workshop participants recommend the creation of a core drafting team comprised of 4-6 people from SPREP members.

Requests that:

(1) SPREP and GCOS Secretariat ensure that this resolution is widely distributed within the Pacific region and with appropriate collaborating partners;

(2) SPREP, on behalf of SPREP Pacific Island country members, source PDF A, and other resources to assist with the development of the Action Plan and related GEF proposal;

(3) SPREP, representing its member countries, in consultation with other CROP organizations, use the information developed in the Action Plan to prepare a Full Project proposal to potential donors, including GEF, to fund improvements in observing systems for climate and in other activities related to climate observing systems in the Pacific region;

(4) Development partners consider financing appropriate elements of the Action Plan;

(5) Parties to the UNFCCC in the region and the GCOS Secretariat bring this resolution to the attention of COP and its Subsidiary Bodies; and

(6) NMHSs become actively involved in the preparation of their national reports on activities related to systematic observation, as invited by the parties to the UNFCCC in Decision 5/CP.5.

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ANNEX II

PACIFIC ISLANDS REGIONAL IMPLEMENTATION WORKSHOP ON IMPROVING GLOBAL CLIMATE OBSERVING SYSTEMS

14-15 August, 2000
Apia, Samoa

AGENDA

Day 1

8:30 - 9:15	**Opening Ceremony**	[Akapo Akapo]
9:15 - 9:20	**Meeting Arrangements**	
9:20 - 9:35	**Overview of the Global Climate Observing System and its mission** -- **Alan Thomas**	
9:35 - 10:00	**The UNFCCC and GCOS -- Sue Barrell**	
10:00 - 10:30	**Discussion of GEF** Experiences with GEF -- **Gerald Miles** The GEF position on funding observing systems -- **Alan Thomas**	
10:30 - 11:00	**Break**	
11:00 - 11:45	**The Regional Perspective** -- Why improved observations are important for the *region* and the *globe* -- **Jim Salinger**	
11:45 - 12:15	**Summary of the Needs Analysis** -- Elements of the Needs Analysis relevant to observations -- **Ram Krishna**	
12:15 - 1:45	**Lunch**	[Rajendra Prasad]
1:45 - 2:30	**Review of Current Status and Needs of the GCOS Surface and Upper Air Networks -- Neil Plummer**	
2:30 - 3:10	**Review of Rainfall and Hydrology Networks** -- **Charles Pearson**	
3 :10 - 3:40	**Review of Oceanographic Observation Networks** -- **Neville Smith**	
3:40 - 4:00	**Break**	
4:00 - 5:00	**Summary and Discussion of Day 1** How important is GCOS in terms of the regional perspective? -- **Alan Thomas and Sue Barrell**	
5:00 - 5:15	**The goals of Day 2 -- Alan Thomas**	
5:15	End of Day 1	

Day 2 [Arona Ngari]

8:15 - 9:00 **Discussion Paper on Needs Related to Climate Observing Systems in the South Pacific** -- **John Zillman**

9:00 - 10:00 **Panel Discussion -- Issues Raised by Discussion Paper**
Pene Lefale, Janita Pahalad, Rishi Raj, Alf Simpson, Arona Ngari

10:00 - 10:30 **Break**

10:30 - 12:00 **Requirements for Observing Systems for Climate: Regional Priorities**

Observations:

- Temperature
- Precipitation, atmospheric moisture, and the hydrological cycle
- Atmospheric circulation
- Radiation balance
- Ocean observations
- Other climate observations

Requirements:

- Observations
- Hardware
- Operations
- Data management
- Training and Staffing

12:00 - 1:30 **Lunch** [Akapa Akapo]

1:30 - 3:00 **Development of an Action Plan, Part 1--*What* would be reasonable to try to accomplish individually and collectively? -- Dick Hagemeyer**

3:00 - 3:30 **Break**

3:30 - 5:00 **Development of a Plan of Action, Part 2--*How* to go about it.**
Discussion of next steps, including identification of specific actions to take in the development of a proposal -- **Dick Hagemeyer**

5:00 - 5:30 **Formulation and Discussion of Workshop Resolution**

5:30 - 6:00 **Break**

6:00 - 6:45 **Argo Presentation --** Joint presentation on Argo to both the GCOS and Global Ocean Observing System (GOOS) meetings -- **Stan Wilson**

6:45 - 8:00 **Social Function** -- To be held jointly with the GOOS workshop participants

ANNEX III

AN OVERVIEW OF GCOS REGIONAL WORKSHOPS ON IMPROVING GLOBAL CLIMATE OBSERVING SYSTEMS

BACKGROUND

The Parties to the United Nations Framework Convention on Climate Change (UNFCCC) have recognized the importance of high quality data for climate-related purposes and have noted that in many instances either the geographic coverage, quantity, or quality of the data produced by current global and regional observing systems are inadequate. Most of the problems occur in developing countries, where lack of funds for modern equipment and infrastructure, adequate training of staff, and continuing operational expenses is often a major constraint.

Decision 14 at the 4th Conference of the Parties to the UNFCCC in 1998 urged Parties to actively support meteorological, atmospheric, terrestrial, and oceanographic observing systems. It also urged Parties to actively support the building of capacity in developing countries in order to enable them to collect, exchange, and utilize data to meet local, regional, and international needs. Decision 5 at the 5th Conference of the Parties in 1999 reinforced the earlier decision by urging the Parties to address deficiencies in climate observing networks and by inviting them, in consultation with the Global Climate Observing System Secretariat, to identify the capacity-building needs and funding required in developing countries to enable them to collect, exchange, and utilize data on a continuing basis in pursuance of the Convention. Specifically, Decision 5:

- *Recognizes* the need to identify the priority capacity-building needs related to participation in systematic observation;

- *Invites* the Secretariat of the Global Climate Observing System, in consultation with relevant regional and international bodies, including the Global Environment Facility, to organize regional workshops on this issue; and

- *Urges* Parties to actively support and participate in these regional workshops.

THE GCOS STRATEGY FOR INITIATING IMPROVEMENTS IN OBSERVING SYSTEMS

Regional workshops are a fundamental element of GCOS's four-part strategy for improving observing systems for climate. For each region, the ***first*** part of our strategy is to acquire a basic understanding of the particular observing system deficiencies of the region and to identify a regional partner with whom to work. As a small secretariat, GCOS must rely on collaboration with regional organizations. Such organizations will enable us both to utilize existing regional expertise and to develop relationships with those most capable of carrying out the priority actions identified at workshops. The ***second*** part of our strategy is the regional workshop itself. Workshops will serve both to build consensus on what needs to be done and to lay the groundwork for the development of an action plan in the ***third*** phase of the strategy. Action plans will provide a detailed strategy for addressing the priority observing system needs identified in regional workshops. The development of detailed action plans and proposals will normally be undertaken by regional entities; however, GCOS can continue to play an active, though reduced, role in this phase. Action plans might address needs for training, analysis, continuing operations, infrastructure, and/or hardware procurement. The ***fourth*** phase of the strategy is implementation and involves, first, obtaining the necessary resources and, second, using them to make the needed

improvements. We recognize that there is no source of funds for continuing operations and thus that the countries involved will need to be responsible for maintaining their observing systems. We also recognize that no single source of funding exists for all of the needs countries are likely to have. Hence, a proposal may need to be directed toward a consortium of funding organizations and donor countries, such that each member of the consortium would be requested to fund that portion that best relates to its mandate or interest.

REGIONAL WORKSHOP GOALS

GCOS launched its regional workshop program in response to the UNFCCC invitation in January 2000. The first GCOS Regional Implementation Workshop is scheduled to take place in the South Pacific region in August 2000. Our long-term objective is to organize 1 to 2 workshops per year in different developing regions of the world during the next five years. The fundamental aim of the program is to initiate processes that will lead to real and substantial improvements in global climate observing systems.

The central goals of GCOS's regional workshops are:

- To assist developing countries in identifying regional deficiencies in global observing systems for climate;

- To assess priority observing system needs and funding required to enable countries to overcome deficiencies in observing systems and to allow them to collect, exchange, and utilize data on a continuing basis in pursuance of the UNFCCC;

- To initiate development of action plans and proposals to fund improvements in observing systems.

WHY ARE IMPROVED OBSERVATIONS IMPORTANT?

At the global level, improved observing systems for climate will enhance the ability of scientists to understand, detect, and predict climate change. Better knowledge of climate change will in turn enable improvements in strategies to mitigate and, as necessary, adapt to its potential harmful effects. Accurate observational data are also important for a broad range of sustainable development needs. At the regional level, both developing and developed countries need observational data to improve impact analyses, seasonal-to-interannual climate predictions, and monitoring of sea level rise and of such extreme events as hurricanes and drought. There is a confluence of interests between the need to improve the climate observing system globally and the need for improved observations at national and regional levels. In supporting improved observations, the Parties to the UNFCCC have understood the importance of accurate, long-term data for developing sound climate change policies.

ANNEX IV

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ANNEX V

OPENING STATEMENT BY THE GCOS DIRECTOR

Dr Alan Thomas

Honorable Prime Minister Tuilaepa Sailele Malielegaoi, Mr Tutangata, Directors of Meteorological Services, and Colleagues: It is a pleasure for me to address the opening of this Workshop on behalf of the Global Climate Observing System and its Sponsors and partners.

Established in 1992 by the World Meteorological Organization, the Intergovernmental Oceanographic Commission of UNESCO, the UN Environment Programme, and the International Council for Science, GCOS's mission is to ensure the availability and quality of atmospheric, oceanic, and terrestrial data for climate. These data are used to predict and respond to climate phenomena, such as El Niño, for research and climate system monitoring, and for assessing impacts and adaptation measures to changes in climate. Climate data also are important for advancing sustainable development nationally.

This workshop is the first in a series to be organized by GCOS in collaboration with regional partners and in response to the decision adopted by the Conference of Parties of the UN Framework Convention on Climate Change at its 5th session in Bonn, Germany last November. The success of these workshops depends greatly on having strong regional partners such as SPREP. The goals of GCOS for these workshops are to assist in the identification of deficiencies in global observing systems for climate regionally, to assess priority observing system needs and funding options, and to initiate the development of action plans and proposals to fund improvements in observing and related systems.

There are several reasons for starting in the Pacific region:

(1) SPREP, with the national meteorological services and other regional organizations, has been exemplary in developing climate issues from a regional perspective;

(2) The Pacific Island countries are highly sensitive to both short- and long-term changes in climate; and

(3) The Pacific Island countries are in a critical location for obtaining the observations necessary for an improved global picture of climate variability and change.

We appreciate the efforts of SPREP in organizing this workshop here in Apia. We also wish to thank those who have provided significant support for this workshop, in particular Australia, the United States, WMO, and UNEP. We also appreciate the opportunity to have this workshop coincident with the Regional Meteorological Service Directors meeting and thank the Directors for their participation.

In conclusion, GCOS looks forward to working with SPREP and the countries of the region to develop an agenda that will lead to real improvements in climate services, particularly in observing systems.

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ANNEX VI

THE UNFCCC AND GCOS

Sue Barrell, Bureau of Meteorology, Australia

Summary

The partnership that has developed between the UN Framework Convention on Climate Change (UNFCCC) and the Global Climate Observing System (GCOS) is a key development in the history of climate monitoring. It offers the potential of not only assisting countries in meeting their commitments as Parties to the Convention but also provides a basis for sustained and systematic improvements in global climate monitoring that will serve both present and future generations.

This presentation to the first Regional implementation Workshop will briefly describe the evolution of the UNFCCC and highlight the important role that has been played in the development of the climate change issue by the World Meteorological Organization (WMO), United Nations Environment Programme (UNEP) and other UN and international scientific and specialised organisations. Key landmarks in raising global concern over climate change issues, especially in relation to increasing understanding of the scientific underpinning of the issues and in developing strategies to address those concerns, include:

- The Villach Conference (1985);
- Establishment of the Intergovernmental Panel on Climate Change (1988) under the co-sponsorship of WMO and UNEP;
- The Second World Climate Conference (1990), which recommended establishment of the GCOS;
- IPCC (First) Assessment Report (1990);
- Establishment of GCOS in 1992 under the joint sponsorship of WMO, UNEP, Intergovernmental Oceanographic Commission (IOC) of UNESCO and International Council for Science (ICSU);
- Signing of the UNFCCC by 154 countries in 1992;
- IPCC Second Assessment Report (1995);
- Third Session of the Conference of the Parties (COP3) to the UNFCCC in Kyoto (1997);
- UNFCCC/COP4 (1998);
- UNFCCC/COP5 (1999);
- First GCOS Regional Implementation Workshop, Samoa (2000).

The climate change issue has highlighted the importance of cooperation at a governmental level between policymakers and scientists, in particular the climate monitoring and research community together with policymakers. A key focus of the presentation will be on the strengthening relationship between the FCCC and GCOS.

Recent decisions of the UNFCCC/COP have important implications for all countries, although there are clearly implementation issues that are specific to either developing or developed countries. The decisions and actions that have already been commenced to implement them will be discussed in some detail, including the rationale for the workshops.

Related issues that will also be addressed include:

- National monitoring plans and reporting requirements;
- Identification of deficiencies and gaps in global and regional networks;

- Role of an intergovernmental mechanism for GCOS;
- Global benefits of cooperation in climate monitoring; and
- Linkages between research and monitoring.

The IPCC Third Assessment Report, which is currently going through its formal government review stage, will serve to highlight many of the deficiencies in our understanding of climate and climate change and to reinforce the need for monitoring climate on all scales, for detection of trends and changes as well as for model validation.

The series of GCOS regional implementation workshops are a key part of building global cooperation in climate monitoring and, in particular, in assisting developing countries to meet their commitments under the convention. The aim of the workshops is to help the countries to understand their own needs in relation to climate monitoring and to identify strategies for improving their monitoring systems for climate. While the principal focus of the workshops is on capacity building and in preparing proposals for funding through the Global Environment Facility (GEF), it is important that long term operational issues are also identified and addressed to the extent possible.

Action to improve the global monitoring of climate is urgent. The lessons learned from efforts now being directed at recovering information from low quality or broken records of observations and at reconstructing the past climate of our planet are salutary. The earlier that we can build an effective global alliance in climate monitoring, the better informed we can be about the behaviour of the climate system, and the sooner we can provide policymakers with coherent and structured information to guide their decisions.

ANNEX VII

THE REGIONAL PERSPECTIVE: WHY IMPROVED OBSERVATIONS ARE IMPORTANT FOR THE *REGION* AND *GLOBE*

Dr Jim Salinger, National Institute of Water and Atmospheric Research New Zealand

Summary

The Pacific Islands, occupying a vast area of mainly ocean (more than 25 million km^2) experiences patterns of climate variability and change that are significant on both global and regional scales. Improved observations from this region are crucial in assessing increasing climate variability and climate change, both globally and locally.

The region has oceanic and atmospheric circulation patterns and ocean-atmosphere interactions that have dominant roles in determining global patterns of climate variability and climate change. Interannual variability in the Pacific is dominated by the El Niño/Southern Oscillation (ENSO) phenomenon. ENSO is driven out of the Pacific Basin. It has the strongest sea surface temperature (SST) signals of one sign along the equator over the central and eastern Pacific and a boomerang-shaped pattern of weaker SST signals of opposite sign extending over the middle latitudes of both hemispheres in the North and South Pacific. At the same time there is an exchange of atmospheric mass between the western and eastern equatorial Pacific, with mean sea level pressure anomalies of one sign over the Indo-Australian region, and of the opposite sign over the central and eastern tropical Pacific. Major climatic anomalies occur both globally and regionally during El Niño and La Niña events. During an El Niño, the trade winds weaken, and heavy rainfall and flooding occur over Peru and drought over Indonesia, Australia and southern Africa. Above average global temperatures also occur. In the tropical South Pacific the pattern of occurrence of tropical cyclones shifts eastward, so there are more cyclones than normal in areas such as the Cook Islands and French Polynesia. The southwest Pacific becomes drier, while the central and eastern Pacific become wetter. La Niña events tend to bring opposite climate anomalies to the Pacific and some regions of the globe.

Recently shifts in climate have been detected in the Pacific basin, driven by a newly described feature of the atmospheric, the Interdecadal Pacific Oscillation (IPO), which modulates climate on time scales of one to three decades. The IPO causes significant shifts in climate in the Pacific Basin and probably beyond. It is a significant source of climate variation on decadal time scales throughout the Pacific region, on a background, which includes global mean surface temperature increases. There is a tight coupling between the ocean and atmosphere. The main centre of action in SST departures is in the north Pacific near the dateline at 40 ^oN, with an opposing weaker centre just south of the equator in the eastern Pacific north the Easter Island at 10 ^oS. There is also another weaker centre of action, in the south west Pacific near the Cook Islands at 20 ^oS, which is in the same phase as the north Pacific centre. The matching atmospheric sea level pressure pattern (SLP) is one of an east/west seesaw at all latitudes, but again centred over the north Pacific, with the centre of action over the Aleutian Islands. These cause decadal changes in climate averages. The IPO also modulates interannual ENSO climate variability over the region and in other parts of the globe.

Finally, climate warming has seen global mean surface temperatures rise by 0.4-0.8 ^oC since the second half of the 19^{th} century, with the ten globally averaged warmest years all occurring since 1983. Observed trends and variability in climate derived from high quality, long-term climate data from the region show that mean island near-surface air temperatures

increased by between 0.3 to 0.8 ^{o}C during the 20th century, with the largest increase in the zones south west of the South Pacific Convergence Zone (SPCZ). Marine surface temperatures show parallel trends. In regions northeast of the SPCZ most the warming occurs since the mid-1970s, while regions to the southwest show steady warming throughout the second half of the 20th century. The SPCZ represents a pivotal line for long-term changes in annual rainfall, with increases in annual totals in those areas to the north east, and decreases to the south west after the mid 1970s. This monitoring of climate is from stations largely from island sites, many being coral atolls free from urban and other environmental influences that could bias the record. The climate observations provide confirmation of global warming trends in an oceanic locale.

Long term climate observations exist for a number of climate monitoring locations throughout the Pacific Islands (e.g. Apia, Banaba, Noumea, Papeete, Rarotonga, Suva) back to the late 19th or early 20th century, and there are some more records that are on paper archives in dispersed locations. These earlier records, together with the marine temperature series that are being digitised are essential to better knowledge of the oceanic and atmospheric circulation patterns and ocean-atmosphere interactions that cause regional and global climate variability. It is also important to continue to restore climate monitoring at the over 40 climate sites that were making observations for at least the second half of the 20th century. These records have allowed climate science to uncover ENSO and IPO and to monitor the pattern of regional global warming. These will also provide important data to verify and validate general circulation models of global climate, which are likely to uncover other phenomena of natural climate variability and human induced change.

Measurements of atmospheric greenhouse gases and ozone concentrations in remote Pacific Island settings, such as at the monitoring stations on Mauna Loa, American Samoa, and Tarawa provide essential data on global concentration and trends in a clean atmosphere. It was from these remote sites that the increase in global greenhouse gases (carbon dioxide) was detected on Hawaii. Combined measurements of several gases in an ocean setting provide bountiful information on sources and sinks of greenhouse gases. Ground-based monitoring of stratospheric ozone is essential for detection of latitudinal and longitudinal gradients.

For the detection and attribution of climate change, particularly in Pacific, local climate observations and assembly of high-quality time series of climate data are required. This is obtained through the correction of time-varying biases and the continuation of high-quality observations to monitor future variability and changes. Knowledge on observed climate change and variability is essential for regional and local policy makers to assess and detect whether climate change is occurring in the region and determine the rate at which climate change is happening. Policy makers are then able to make decisions on the adaptive strategies required and further their vulnerability assessment studies.

Climate variability is well known to have a significant impact on human societies and on economic activities. The small island states of the Pacific are particularly vulnerable to extremes of climate (cyclone-induces storm surges, sea-level rise, etc.). Although these countries are in an oceanic environment, rainfall variability can be quite extreme because of ENSO, with seasons of both floods and droughts. Real-time climate monitoring, in concert with the new technologies of global monitoring of sea surface temperatures and other climate variables by satellites, together with tethered ocean observations by the tropical Pacific array (TAO), provide critical input to seasonal climate prediction models. These provide the basis for developing seasonal climate forecasting for the region. The analysis of the observed data is required for the scientific underpinning to enable the development of timely seasonal climate outlooks for the island nations of the tropical South Pacific. The records are used to develop predictive statistical relationships between ENSO and other major influences on seasonal climate and seasonal climate variations across the tropical South Pacific. Such seasonal climate forecasts will allow policy makers to take effective

action to mitigate seasonal climate hazards and to take advantage of climatic opportunities as they arise.

A reliable Pacific climate observing system, including atmospheric trace gases, is thus essential for both the region and the globe to better understand and document climate change, evaluate its impacts, and assess mitigation strategies. It also provides the basis to monitor and predict climate in the region on an interannual basis so as to manage regional variability and extremes caused by ENSO, and on decades as a result of the IPO. Trace gas information from a Pacific setting gives essential information on greenhouse and related gas concentrations, sources and sinks, and stratospheric ozone depletion.

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ANNEX VIII

FINDINGS OF THE PACIFIC METEOROLOGICAL SERVICES NEEDS ANALYSIS PROJECT RELATED TO OBSERVING SYSTEMS

Ram Krishna, Bureau of Meteorology, Australia

Summary

Background to the project

Sponsors: AusAID, SPREP, WMO, Australian Bureau of Meteorology, Fiji Meteorological Service, French Polynesia Meteorological Service (Météo-France), Meteorological Service of New Zealand, US National Weather Service (Pacific Region).

Scope

No distinction was made between the Regional Basic Synoptic Network (RBSN) and proposed GCOS network. Further, the analysis was confined to meteorological observing systems. The Pacific Meteorological Services are not involved in other components of GCOS (i.e., the oceanographic and terrestrial components), and these are not very well developed in the sub-region.

Socio-economic status

Most Pacific Island Countries (PICs) may be categorized as micro-states and micro-economies with agriculture, forestry, fisheries, tourism, small-scale manufacturing, and mining as the main components of the cash economy. Their economies are characterized by a fairly large subsistence component, mainly agriculture and fishing. Foreign aid forms a large part of the annual national public expenditure in most countries.

Major weather and climate concerns and user needs

The economies and social activities of Pacific Island countries are highly sensitive to weather and climate. Severe weather phenomena that adversely affect the economy and the society are: tropical cyclones, droughts, floods, and prolonged heavy rain (not necessarily associated with cyclones). National activities that are particularly sensitive and need to respond to fluctuations in weather and climate are air, sea, and road transportation, disaster management, energy planning, and water resources planning. Climate variability (seasonal to interannual scale) features strongly as a significant new area of concern among users of weather and climate information, especially in respect of severe weather. Users generally appear not to be concerned greatly with climate change except in the context of climate variability. Many users do not see a distinction between the two.

The main concerns of users that surfaced in most countries are:

- Improved cyclone warnings (for public, aviation and marine interests);
- Climate variability and associated seasonal/interannual prediction, particularly of droughts and cyclone frequency and intensity; and
- Climate change (mainly in relation to climate variability).

Areas of improvement identified

Related areas identified for improvement (focussed on common regional needs) to address these concerns for NMSs were :

- Observations;
- Communications;
- Infrastructure; and
- Human resource development.

Projects recommended

Projects have been recommended under the following broad themes:-

- Severe weather warnings;
- Climate information and prediction services;
- Upgrade and strengthen observational networks;
- Upgrading telecommunication systems; and
- Infrastructure and institutional strengthening.

Each theme contains appropriate human resource development aspects.

Observations

NMSs range from those that are funded from external sources and reasonably well equipped with high levels of expertise to those that have very limited resources, limited operations (a single observation station basically), and limited expertise levels. Over the last 2 or 3 decades, relatively slow economic development or economic decline in many PICs has led to significantly reduced resources and expertise levels available to Pacific Meteorological Services. In the post-independence era, because of social development priorities in areas such as education and health, funding support to meet operational meteorological needs and staffing levels has declined in many NMSs. This has adversely affected observational networks and contributed to inadequate equipment (especially the more expensive equipment such as barometers and anemometers), irregular maintenance, lack of continuity and quality of reports, reduction of observational programmes, and inability to meet cost of consumables (especially radiosondes for upper air observations). National economic development appears unlikely to improve significantly in the near future to change the situation in many countries.

An analysis of the WMO WWW monitoring results carried out in October 1999 shows that the RBSN reporting programme in the sub-region performed below expectation and also that there has been a decline in the number of stations and volume of reports during the last 4 years (based on full WMO Region V results), especially surface stations. The most likely reasons for this are: a) reports are not made; and b) reports are not inserted into the respective communication networks, or the networks are not working. The findings of the team suggest that both the reasons apply.

Lack of availability of operational resources (either national or external – including personnel) and appropriate management practices are seen as the paramount factors responsible for the decline in observations, and need the highest priority in any meaningful plan to improve the situation.

Projects proposed under the two themes, "*Upgrading observation networks*" and "*Upgrading communication systems,*" address these issues. The project "*Upgrading infrastructure*" is also relevant to the improvement of observations with respect to appropriate facilities for

accommodation for, and maintenance of, equipment and communication, archival, and security of data.

The study also revealed that there has been a considerable decline in the coverage of ship reports over the last 2 decades, and a regional project to address this is included. Upgrading of satellite data acquisition facilities to receive high-resolution imagery, a weather surveillance radar network (for those NMSs that have the capacity to sustain their operations and operational costs), and a lightning detection network have also been proposed. A number of projects that address the deficiency in communications are also included.

Climate data management

The Climate Computing (CLICOM) system has been used by most PICs for the last 10 to 15 years. While some countries, notably Fiji and the Solomon Islands, have developed high levels of expertise, the success achieved by many other countries is not satisfactory. This is an area that needs a great deal of attention, in parallel with any efforts to improve observational standards and coverage.

Conclusion

The immediate priority challenge is the improvement of the quality and time coverage of data output from currently active networks. Extension of the current networks to the level that existed some two or three decades ago or to those needed to meet GCOS requirements is the next major challenge.

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ANNEX IX

REVIEW OF CURRENT STATUS AND NEEDS OF THE GCOS SURFACE NETWORK AND THE GCOS UPPER-AIR NETWORK

Neil Plummer, Dean Collins, Kelvin Wong and Paul Della-Marta
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Summary

Introduction

The development of the GCOS Surface Network (GSN) and the GCOS Upper air network (GUAN) reflect significant progress in the fundamental requirement to collect global data suitable for long-term climate monitoring under an operational framework.

The GSN, with its 989 surface observation stations, is particularly suited to the detection of the spatial patterns and scales of global temperature change and of global atmospheric circulation changes. The GUAN has been established to monitor global, hemispheric and regional temperature, moisture and wind trends and variability in the troposphere and stratosphere. Data from this network will also be important for monitoring changes in atmospheric circulation. A total of 150 sites have been selected with a further 15 sites for use as a standby network, network upgrades, or furthering monitoring in specific regions.

Despite progress in the selection of these networks, concerns remain over the adequacy of the existing meteorological observation networks to satisfy the needs of GCOS. This was reflected in a report (GCOS-48, October 1998) submitted to the Subsidiary Body for Scientific and Technological Advice of the Conference of the Parties for the COP-4 (and as requested by COP-3). In short, an urgent commitment is required to both halt and reverse the decline of existing observation systems and to exchange information more effectively.

Development of networks

In order to select the GSN stations from among the existing 10,000 or so stations making surface observations (approximately one station per 5°x5° square of the world), criteria were formulated to assess spatial coverage, availability, homogeneity, urban influence and quality of data. It was also felt that priority should be given to those stations that were listed on the WMO Reference Climatological Station (RCS) lists and locations where monthly data were already distributed as CLIMAT reports. It was considered desirable to include stations that were part of the GUAN, Regional Basic Synoptic Network (RBSN) and Global Atmosphere Watch (GAW) networks. Through compiling essential metadata for as many stations as possible, a computer algorithm was developed to select an appropriate network. The initial selection of the GSN is described in Peterson et al. (1997) and those operated by SPREP Member countries in WMO Regional Association V, following revision by WMO and its members, are included in Table 1.

The selection process for the GUAN considered performance records of existing upper air stations and station quality information from the Lead Centre quality monitoring programme of the WMO Commission for Basic Systems (CBS). The process considered the following guidelines, in order of importance: (1) The position of the station in its contribution to a spatially homogenous network; (2) The performance of the site in producing consistently high quality data; (3) The existence of a historical record of reasonable length. The network has been reviewed by the CBS Working Group on Observations and is shown in Figure 1.

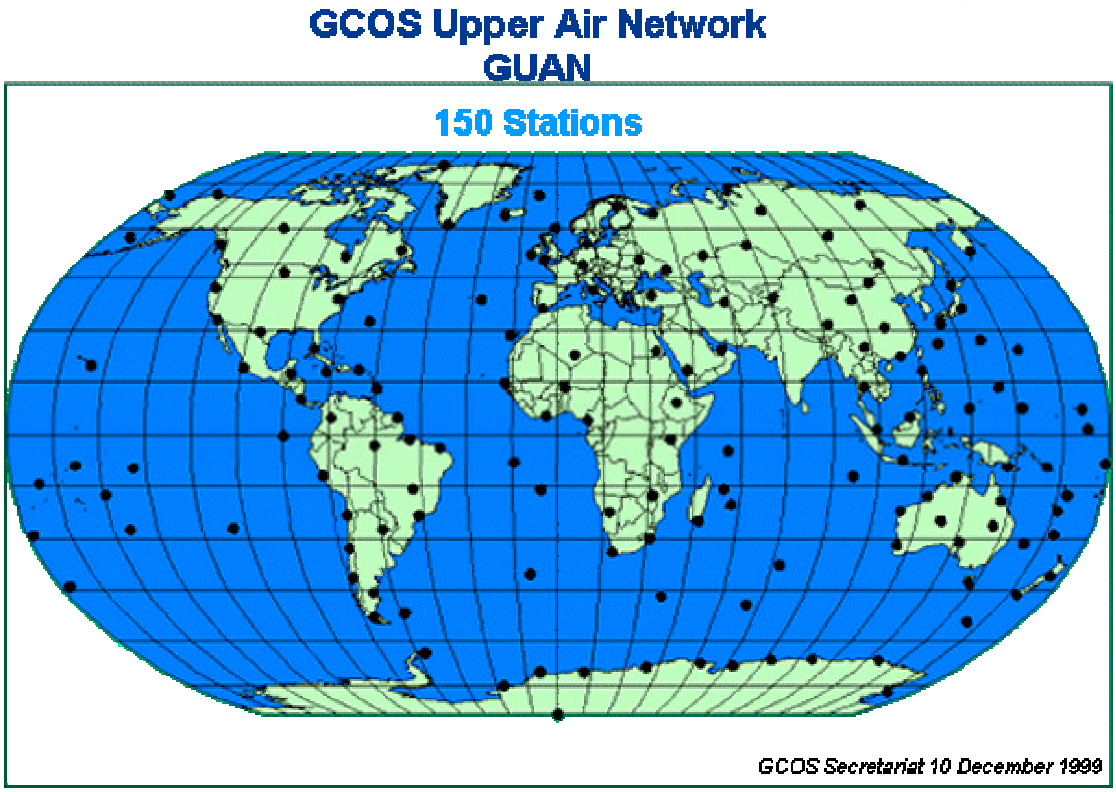

Figure 1. The GCOS Upper Air Network (Source: http://www.wmo.ch/web/gcos/gcoshome.html)

Best practice for networks

The Atmospheric Observation Panel for Climate (AOPC) was established to define the requirements for meteorological observations for GCOS. Stations in the GCOS networks, and their parent organisations, must collect and manage data according to "best practices". Following approval from WMO CBS, "best practice" for the GSN includes:

- transmitting monthly CLIMAT messages on the Global Telecommunications System (GTS) in an accurate and timely manner;
- carefully archiving observational and related metadata (e.g. station history information) in the country of origin in both the original and digital forms;
- providing up-to-date digital copy of the historical climate data and metadata to the designated GSN data depository;
- establishing a period of overlap when there are significant changes in sensor devices or station location; and
- accompanying installation of automatic instrumentation with accurate calibration and intercomparison tests

The CLIMAT messages are required (in the new code) for the routine monitoring of ongoing data quality by the GSN monitoring centers in the Deutscher Wetterdienst (DWD) and Japan Meteorological Agency (JMA). The recent emphasis on examining changes in climate extremes for the Intergovernmental Panel on Climate Change Third Assessment Report has increased the need to collect historical daily observations, especially maximum and minimum temperature, precipitation and mean sea level pressure. In September 1999 the Secretary-General of WMO requested that each of its members forward historical data series and metadata for their respective GSN stations to the World Data Centre A in a specified format. WMO also requested that countries develop national plans for managing

their GSN data and urged countries to develop and improve the denser networks required for climate monitoring at the regional and national scale.

The concept of "best practice" has also been extended to the GUAN and requirements include:

- long-term continuity;
- provision of detailed metadata to allow bias adjustment;
- use of high altitude soundings (to reach 5 hPa, if possible);
- rigorous quality control;
- back-up release in case of failure or major data loss; and
- co-location with atmospheric constituent measurements where possible

Ideally, upper air observations should be provided twice daily and should be reported on the GTS in the normal upper-air code form. The European Centre for Medium-Range Weather Forecasts (ECMWF) has a responsibility for operational quality control on these data. The Hadley Centre of the United Kingdom Meteorological Office and NOAA's National Climatic Data Center (NCDC) in the US cooperate to act as a joint analysis centre for the GCOS upper air data. These centres also cooperate with the ECMWF so that the quality control work done on the real time data flow by that center is taken into account in further processing, analysis, and improvement of the global GUAN data set. The NCDC also acts as a long term archive for the data and supporting metadata.

Current status of networks

The GSN monitoring centres at DWD and JMA are routinely monitoring the performance of the GSN through assessing the availability, timeliness, completeness and correctness of CLIMAT reports collected from the GTS. The quality monitoring of temperature and precipitation data within the reports has also started. The first results, covering the period January to June 1999, can be found in GSNMC (1999). The following summarise the major findings of the report for the globe:

- low CLIMAT reception rate (but wide regional variations)
  - only 49% of messages expected from GSN were received by the 8th day
  - only 54% by the 20th day
- many countries need to update their CLIMAT reporting stations in WMO Volume A
- some countries were not reporting in the "new" CLIMAT format

A significant improvement in the receipt of GSN CLIMAT messages is anticipated and updated data for WMO RA V suggests that such a trend is already underway (Figure 2). The Hadley Centre also routinely monitors the reception of GSN CLIMAT reports.

Daan (2000) reports that only about 70% of the GUAN were reporting monthly CLIMAT TEMP messages although a larger proportion were reporting TEMP once or twice daily. Monitoring of CLIMAT TEMP from the Hadley Centre shows inadequate reception over large areas of the globe. For example, analysis in May 2000 exhibits gaps over Central America, Africa and southeast Asia. A number of stations in the South Pacific are not reporting.

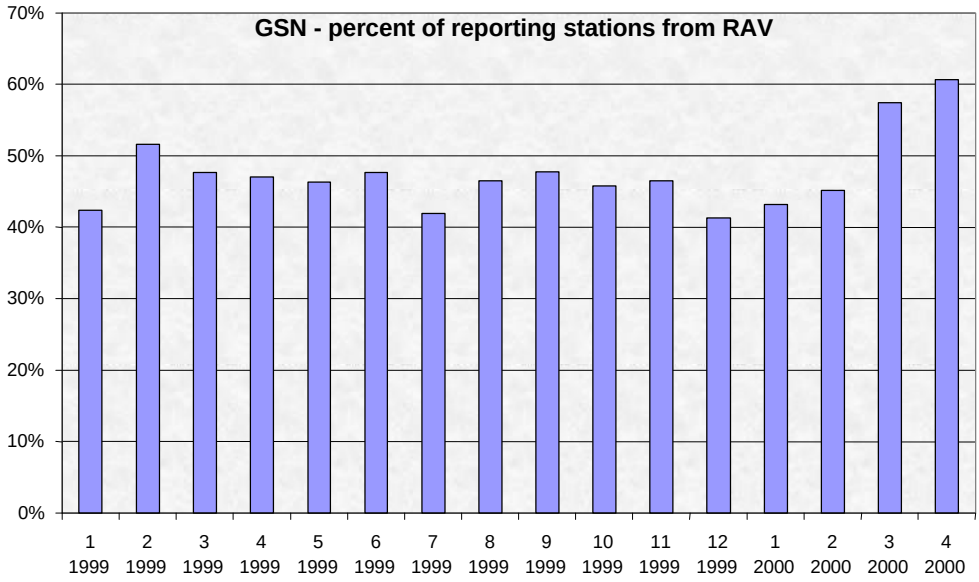

Figure 2. Percentage of GSN stations reporting CLIMAT messages (Jan 1999 to Apr 2000) in WMO RA V (Source: GSN Monitoring Centre, DWD/JMA).

Immediate challenges

The Asia-Pacific Network (APN) for Global Change Research recently funded two workshops on climate extremes, both hosted by the Bureau of Meteorology. If the outcomes from these workshops are an indicator of the willingness to commit to the future needs of climate change science then the future holds promise. Figure 3 is taken from Manton et al. (2000) and shows trends in hot days and warm nights for selected countries over southeast Asia and the South Pacific. However, these workshops also confirmed a number of deficiencies in the foundations on which this work is built on. These included: the difficulties in maintaining existing stations; inadequate numbers of stations with long, homogeneous data series; and poor metadata.

The islands of the South Pacific will provide essential data for the GSN and, particularly in light of the global decline in upper air soundings, the GUAN. There are several immediate challenges for countries within the region in order to progress towards achieving the goals of GCOS, and most fall outside the scope of this paper. However, in terms of the GSN and GUAN, wherever possible nations will need to:

- commit to the request of the WMO Secretary-General in the exchange of real-time and historical climate data and metadata;
- develop organisational infrastructure to promote and sustain a commitment to stations within these priority networks;
- develop data monitoring and reporting systems that can integrate with information flowing from the GCOS Monitoring Centres to improve the effectiveness of the networks;
- embrace the “best practice” requirements together with the principles for long-term climate monitoring (Karl et al. 1995); and
- strengthen capabilities to manage climate information through programs to recover and computerise climate records, develop secure and robust databases and improve quality monitoring systems.

While most strategies to address the above will require support from outside the region (and perhaps a focus at the regional level), there is sufficient evidence to suggest that many countries in the South Pacific are already making progress towards satisfying the objectives of GCOS.

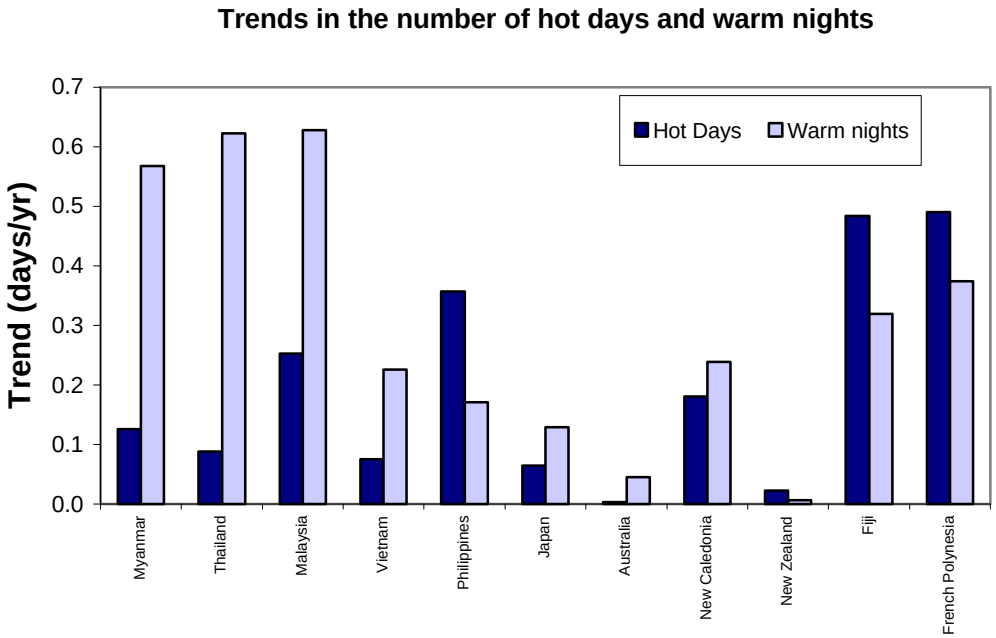

Figure 3. Trends in the number of hot days and warm nights (in days per year) over parts of southeast Asia and the South Pacific from 1961 to 1998. (Source: Manton *et al.* (2000))

Acknowledgments

The authors would like to thank Stefan Rösner (GSNMC-DWD), Dr Sue Barrell (Australian Bureau of Meteorology), Dr Tom Peterson (U.S. National Climatic Data Centre) and Dr William Westermeyer (GCOS Secretariat) for providing information and guidance.

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Attachment 1

Table 1. List of Stations for the GCOS Surface Network (GSN) operated by SPREP Member countries in WMO Region V (Source: GSNMC (1999)).

*** identifies those stations that are subject to approval by Permanent Representative**

Australia
94101 KALUMBURU
94120 DARWIN AIRPORT
94131* TINDAL AWS
94150 GOVE AIRPORT
94170 WEIPA AMO
94203 BROOME AIRPORT
94212 HALLS CREEK
94238 TENNANT CREEK
94259 BURKETOWN
94275* GEORGETOWN
94287 CAIRNS AIRPORT
94299 WILLIS ISLAND
94300 CARNARVON AIRPORT
94302 LEARMONTH AIR
94312 PORT HEDLAND AMO
94322 RABBIT FLAT
94326 ALICE SPRINGS
94332 MT ISA AIRPOR
94340 RICHMOND
94346 LONGREACH AIRPORT
94367 MACKAY
94380 GLADSTONE
94403 GERALDTON AP
94430 MEEKATHARRA AP
94461 GILES
94476 OODNADATTA AP
94480 MARREE
94482 BIRDSVILLE
94485 TIBOOBURRA
94492* THARGOMINDAH
94510 CHARLEVILLE AP
94516 ST GEORGE
94541* INVERELL
94589 YAMBA
94601 CAPE LEEUWIN
94626 CUNDERDIN
94637 KALGOORLIE BOULDER AMO
94638 ESPERANCE
94653 CEDUNA AP
94670 SNOWTOWN
94689* BROKEN HILL
94693 MILDURA AP
94711 COBAR
94719* DUBBO
94784* TAREE
94802 ALBANY AP
94805 CAPE BORDA
94821 MT GAMBIER AP
94842 CAPE OTWAY
94869* DENILIQUIN
94907 EAST SALE AD
94910 WAGGA AP
94916 CABRAMURRA
94937 MORUYA HEADS
94965 LOW HEAD
94967 CAPE BRUNY
94995 LORD HOWE ISLAND
94996 NORFOLK ISLAND
94998 MACQUARIE ISLAND
95314 NEWMAN
95574 TEWANTIN
95646 FORREST AIRPORT AWS
95753 RICHMOND AWS

Stations operated by Australia
96995 CHRISTMAS ISLAND CXR
96996 COCOS ISLAND AMO CCK

Cook Islands
91801* PENRHYN AWS
91811* PUKAPUKA
91831* AITUTAKI
91843* RAROTONGA

Fiji
91650 ROTUMA
91652 UNDU POINT
91680 NANDI
91699 ONO-I-LAU

Stations operated by France
91753* HIHIFO

Kiribati
91490 CHRISTMAS ISLAND
91533* BANABA
91610* TARAWA
91701 CANTON ISLAND

New Caledonia
91577 KOUMAC
91592 NOUMEA

New Zealand
93012 KAITAIA
93292 GISBORNE AD
93309 NEW PLYMOUTH AWS
93417 PARAPARAUMU AD
93615 HOKITIKA AD
93747 OMARAMA TARA HILLS
93845 INVERCARGILL AP AWS
93947 CAMPBELL ISLAND
93987 CHATHAM ISLAND
93994 RAOUL ISL KERMADEC

Niue
91822* ALOFI

Papua New Guinea
92014 MADANG WO
92035 PORT MORESBY WO
92044 MOMOTE MO

French Polynesia
91925 ATUONA
91930 BORA-BORA
91938 TAHITI-FAAA
91943 TAKAROA
91945 HEREHERETUE
91948 RIKITEA
91949 REAO
91954 TUBUAI
91958 RAPA

Solomon Islands
91503 MUNDA
91517* HONIARA

Tokelau
91724* NUKUNONO

Tonga
91780 VAVAU
91788 NUKUALOFA

Tuvalu
91631* NANUMEA
91643 FUNAFUTI

Station operated by United Kingdom
91960 PITCAIRN

United States of America
91165 LIHUE , KAU, HW
91285 HILO GEN LYMAN, HAW, HW

Stations operated by the USA
91212 NWSO TIYAN, GUM
91334 TRUK, CRL
91348 PONAPE, CRL
91366 KWAJALEIN, MHL
91376 MAJURO, MHL
91408 KOROR, PLW
91413 YAP, CRL
91765 PAGO PAGO AP, ASM

Vanuatu
91554* PEKOA AIRPORT
91568* ANEITYUM

ANNEX X

STATUS AND NEEDS OF HYDROLOGICAL AND RAINFALL MONITORING NETWORKS OF THE SOUTH WEST PACIFIC REGION

Charles Pearson, National Institute of Water and Atmospheric Research New Zealand

Summary

Introduction

A hydrological network aims to provide information for a multitude of purposes on the state of water (quantity and quality) storage and flux within catchments and aquifers for a region. A network can comprise stations with recorders for atmospheric processes (rainfall, air temperature, evaporation, wind - thus overlapping with traditional meteorological stations for weather and climate purposes), soil moisture content, ground water levels, surface water levels and streamflows. Collected data need to be transmitted to a centre, checked and entered onto a database, converted to hydrological information about the catchments and aquifers, and presented to network stakeholders and water resource decision makers, in forms that they can understand.

At a recent World Meteorological Organization (WMO) Commission for Hydrology regional meeting held in Fiji ("Meeting of experts on hydrological needs of small islands," 4-6 October 1999), hydrological monitoring networks of the South West Pacific region were discussed. As a follow-up to this meeting, the WMO commissioned a thorough needs analysis of these networks. Paul Mosley (New Zealand) and Rishi Raj (Fiji) undertook this project and have, after wide consultation, produced a report on a "hydrological cycle observing system for Pacific countries, Pacific-Hycos."

Using the Fiji meeting and Pacific Hycos reports, this paper presents a review of the status and priority needs of hydrological monitoring networks (including rainfall) of the South West Pacific region.

Status of Hydrological and Rainfall Networks

Hydrological and rainfall networks of the island states of the South West Pacific have been established to varying degrees and for a variety of purposes. Typically, networks of rain gauges and river water-level recorders have been established. Responsibility for the networks and monitoring is sometimes that of water using agencies such as water supply authorities and hydro-electricity generators. Most countries do not have formal national hydrological services. Such units that do exist are normally located in a ministry for the environment, public works, or natural resources. Rainfall networks, however, fare better in that they tend to fall under the auspices of the national meteorological services, which exist in most countries.

Regional organisations such as SOPAC and SPREP, with their links with WMO, UNESCO, and aid donors, provide regional support for the hydrological units of each Pacific Island country. As the hydrological needs and capabilities of the countries are quite variable, regional organisations play an important role in coordinating hydrological training, leadership, and communication, and in communication with aid donors.

Despite these efforts, the hydrological (including rainfall) networks in the region are generally in a poor state of repair and operation. There are many difficulties, mainly being faced in

isolation, in maintaining networks in working order. In many cases, monitoring has ceased. In some countries, bilateral aid projects have commenced to rejuvenate networks. This approach benefits the recipient country, but it is more beneficial to all when it is part of a wider regional plan or project.

Network Needs

Identified needs of those responsible for operating hydrological networks within the region include:

- Greater agency cooperation and communication within countries, especially between meteorological and hydrological services, and with data users and decision-makers.
- Regional training in all operational aspects of hydrological networks, database management, and hydrological modelling; and retention of trained staff.
- Funding for replacement of obsolete instruments and equipment.
- Real-time rainfall and streamflow information for flood forecasting.
- A drought forecasting capability – an area for stronger links with climate forecasters.
- Baseline information on the water resource in waterways having hydropower potential, most of which would be at the micro- or mini-hydro scale.
- Baseline information on surface waters likely to be affected by agricultural, mining or forestry development, and subsequent monitoring.
- Water resource information, including streams, springs, and aquifers, at a reconnaissance scale, in support of rural water supply projects.
- Baseline and ongoing monitoring information on the quality of groundwater, particularly in the low islands and atolls where aquifers are subject to contamination by human and animal wastes, and saltwater intrusion.

Addressing these Needs: a Pacific Hycos

A likely overall goal of a Pacific Hycos project is that the participating Pacific island countries will:

- Attain a common level of ability (capacity) to assess and monitor the status and trend of their water resources, and to provide the water-related information and hazard warnings needed to support national social and economic development and environmental management.
- Have established databases and information archives, maintained to acceptable standards, that form the basis for sustained future data capture and information processing and dissemination.

A Pacific Hycos project would have three main purposes that contribute to achieving the above goal:

- To assist the participating countries to establish the human and institutional capacity to assess the status and trend of national water resources and to provide adequate warnings of water-related hazards.
- To establish basic hydrological monitoring and data capture systems, using technology that balances modernity, economy, robustness, and suitability for Pacific Island circumstances.
- To establish hydrological databases and information systems that provide users with the information they require, to the standards (including accuracy, timeliness, usability, etc.) they need, and that provide a secure repository of information for the indefinite future.

Conclusions

Regional coordination and overview of focused, long-term South West Pacific hydrological monitoring networks, such as a Pacific Hycos project, is required to revitalise the existing networks and provide the training needed by hydrological personnel. The strong overlap of hydrology and water resources with climate and meteorology means that effective communication amongst hydrologists and meteorologists of the region is essential, so that timely hydrological (and climate) information is presented to each country's governments and decision makers.

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ANNEX XI

REALIZING THE POTENTIAL OF OCEAN OBSERVING NETWORKS A PACIFIC ISLAND REGIONAL PERSPECTIVE

Neville R. Smith, Bureau of Meteorology Research Centre, Australia

Summary

Introduction

This paper focuses on the relevance of the ocean climate observing system to the Pacific Island region and the strategies that might be employed to enhance the provision and application of ocean data. The scope is limited to physical data and, for the most part, to climate applications. While the Decision of the Conference of the Parties that led to this workshop specifically refers to "participation in systematic observation," this paper will adopt a broader view, seeking some understanding of how the ocean observing system can best be operated in the service of the Pacific Island region.

The fundamental issue is one of enabling participation and collaboration. We cannot approach this region as we do, say, the North Atlantic, where the majority of the interested parties are relatively resource rich and capable, and the critical challenge is to encourage joint stewardship of the ocean observing system and agreement on a cost-effective method for sharing responsibility for sustained operation. The capacity to apply data to, say, climate research or operational ocean forecasting, is well developed, though there remain many scientific and technical challenges. Moreover, the size of the user constituency relative to the area of interest is relatively large. In the Pacific Island region, the situation is different. The size of the user community relative to ocean area is small, the ability to apply ocean information is not well developed, and the region is not resource rich.

What can we expect from the ocean observing network?

The present represents perhaps one of the more exciting periods in the history of oceanography, particularly in respect of oceanographic observations. Scientific and technical advances and a growing and more mature user community have led to substantial investments in measurement systems, many with a long-term view, particularly in aspects related to climate. We are contemplating an exciting future that includes:

- Global surface topography measurements from space and *in situ* with high accuracy and the potential to resolve ocean "weather," but at the same time capable of monitoring subtle climate changes;
- High-resolution, high quality sea surface temperature measurements, delivered from a range of *in situ* and remote instruments, and serving a broad user constituency;
- An El Niño observing system comprising fixed moorings, volunteer observing ships and autonomous surface and subsurface floats, making possible useful seasonal-to-interannual predictions;
- Remotely sensed surface wind data, capable of daily near-global resolution near 25 km, complemented by high-quality *in situ* data and numerical weather prediction model analyses and forecasts;
- A global array of profiling floats (*Argo*) returning order 3000 profiles of temperature and salinity every 10 days; and
- A range of other remote and *in situ* measurements to complement and add to the above.

This system is underpinned by a sound scientific rationale, a well-identified user community, and a feasible and affordable implementation strategy.

Why do we place such emphasis on observations? In a paper to the CLIVAR Conference in 1998 I expressed it thus:

> *You can observe, but not understand.*
> *You cannot understand if you do not observe.*

In the context of climate research, the message was that a properly planned and implemented sustained ocean observing system was fundamental and essential. It was not a research plan option. It is not a Pacific Island region option. In the present context we might also add the following:

> *You cannot use information that you do not have.*

The role of the ocean observing system does not end with the measurement. We must bring the data and the knowledge of how to use it within the scope of the target user communities, in a way that engenders real societal and economic value. It is within the "S" of GCOS that we strive to deliver full functionality to the end users. It is the responsibility of GCOS, the organism, to ensure that appropriate value accrues to all participants. For the Pacific Island region there would seem to be two key aspects:

(1) *The regional data requirements must be assessed and systems designed and implemented to enhance the provision and availability of such data; and*

(2) *Knowledge of the significance and potential benefits of ocean observations must be developed*

Both (1) and (2) will require careful thought and analysis since the total volume of data and knowledge can be overwhelming, even for the more sophisticated users. It is not immediately obvious how much emphasis should be given to the Region's participation in the gathering of data. Certainly, because of the vast extent of territorial waters, those involved in taking observations will seek the cooperation and involvement of island nations, to the extent that resources permit.

How is this information used?

As suggested above, there are many, many applications of ocean data ranging from El Niño prediction to ocean and marine forecasts. Through a series of studies and a major international conference, we are now confident that such applications provide more than enough justification to sustain the observing network. The broad user base is seen as an essential strength of the observing system. Multiple use delivers cost-efficiency through enhanced effect. A distinction is often drawn between *research* and *applied* use; for the first, the goal is knowledge while for the latter the goal is societal utility. In the present context this distinction is of limited relevance since the target community rarely has the luxury of optional pathways for participation. The key application areas are:

- Construction of climatologies;
- Climate change;
- Slow climate variations (decadal oscillations)
- Forecasts for El Niño and other interannual variability
- Intra-annual to seasonal variability (eg, monsoons)
- Ocean forecasting
- Surface marine and NWP

The importance attached to any one of these application areas varies from region to region, from nation to nation and, in some cases, within nations. The observing system has been designed and is being implemented taking into account the (perceived) overall relative priority of these application areas. The observing system is sufficiently comprehensive that, when fully implemented, it should be more than capable of meeting the Pacific Island regional needs, at least to the extent those needs have been articulated and comprehended.

It is imperative that a fresh dialogue be opened with the Island States to better understand the pressing issues and regional impacts and to identify those aspects that might be usefully developed or enhanced.

(3) *The potential of observing system applications and products should be exposed to the region and their participation sought in decisions on prospective applications that are likely to yield long-term benefits for the region.*

The approach from the Global Climate Observing System must not be to ask what you (the Pacific Island region) can and should do for GCOS, but what can we (GCOS) do for you.

Toward implementation

As we have labored toward implementation of the global climate and ocean observing systems we have learned many things. First, we have learned that implementation requires more than a well-written document and good plans. It needs participation at the "grass roots," and it needs strong consensus among the community on the intent and the method. If we are weak in any one of these areas, there are many other worthy causes more than willing to exploit our indecision and lack of community support. This is no less true for the Pacific Islands than it is for the well-developed oceanographic nations.

A second lesson has been in the approach to implementation. There have been, and continue to be, challenging issues related to the transition of observing elements from research support to sustained (operational) support. We should expect this to be rapid and so must devise techniques whereby research is able to relinquish control and responsibility at a pace that does not threaten the quality or scientific utility of the system while at the same time developing operational applications and supporting infrastructure that ensure the lasting value of the data sets.

The transition of knowledge and capacity to the Pacific Island region must also be managed carefully. Great care is being taken to ensure consistent and appropriate standards are adopted throughout the climate observing system and it is in everyone's interest, particularly those with an interest in the UNFCCC, to see these maintained and kept uniform. The expectations for regional participation must also be kept realistic and feasible and there must be a commitment for the long-term. It is not in the Pacific Island region's interest, nor that of GCOS, to build unreasonable expectation, especially in regard to commitment of local resources. For regional participants, this will only be successful if those brought into the system are fully involved in the decision making process, including assessment of the long-term prospects. This strategy should apply whether it is in the taking of observations, the reception of data, the building of analysis/display systems, or in the development of region-specific applications. The thesis of this paper is that greatest emphasis should be given to the development of useful, region-specific applications.

(4) *Develop a number of focussed "pilot" projects that (a) have clearly articulated and focussed objectives, (b) have been identified as high priority at the regional level, (c) build on the strengths of the ocean observing system, (d) are known to be feasible and practical given resource constraints and the existing regional capacity, and (e) include a workable schedule.*

Note the strong dependence of (4) on (1) - (3). Too often, in similar situations and with fine intent, inadequate attention is given to the total requirements. It is counter-productive to encourage participation in the gathering of particular observations if there is not strong regional need and an identified capacity to sustain involvement. The complexity of the observing system and of the many processing and modeling components means it is all too easy to arrive at a mismatch between the provided volume of information and the regional/local ability to use it (this remains true in general). Care must be taken to tailor the projects to end-user requirements and capacity.

What can the Pacific Island region bring to the process?

Through their participation, the Pacific Island region adds strength to the observing system, not only in the form of whatever measurements they might contribute, but also through the extension and enhancement of the net value derived from the effort. This strengthening of the partnership is not an inconsequential factor in the process of arguing for long-term, sustained commitments from the developed nations. The contest for resources is very competitive, and rightly so, and the climate community must work together to ensure their case is seen as compelling, whether the view be political, environmental or science. We must continually promote the case for investment in our area and the extent to which GCOS enjoys wide subscription will be a key metric.

As noted above, for this to be effective, we must have a full understanding and comprehension of how projects will be implemented, both at the "pilot" phase and for the long-term. This must be a two-way dialogue. There is rich potential in the GCOS for the region but GCOS needs assistance to find the right targets and the right working relationships. For the ocean component, we need agreement on the level of information that would be most effective, on the quality and complexity required, and on the methods for delivery. Establishing such a dialogue delivers enormous benefit to GCOS, both through the enhanced constituency and through the enhanced knowledge of the way GCOS information can be applied.

Conclusion

This paper had two purposes. The first was to briefly acquaint the Pacific Island regional community with the potential benefits of the global ocean observing system for climate. The potential benefits are manifold but realizing such benefits for the region is not straightforward. Knowledge of data requirements, of the potential applications and of the agreed focus would be required. The second purpose was to describe a possible implementation process, not focussed on the generic, global applications but directed at specific regional activities or "pilot" projects tailored to high-priority issues. Wide regional participation would be needed to ensure cost-effective implementation. The "tailoring" would almost inevitably require a graduated process whereby capacity was developed in a sustainable way.

ANNEX XII

DEVELOPING AN ACTION PLAN FOR IMPROVED CLIMATE MONITORING IN THE PACIFIC

A Discussion Paper for the
Pacific GCOS Regional Implementation Workshop
Apia, Samoa 14-15 August 2000

CONTENTS **Page**

DEVELOPING AN ACTION PLAN FOR IMPROVED CLIMATE MONITORING IN THE PACIFIC

A Discussion Paper

Executive Summary

The purpose of this paper is to form a basis for discussion at the Pacific GCOS Regional Implementation Workshop of an action plan to improve systematic monitoring of climate in the region. Climate change poses a major threat to the people and economies of the South Pacific because of the potential for significant sea level rise and changes to the patterns of seasonal precipitation.

As a starting point for discussion at the Workshop, the paper outlines the global response to inadequacies in climate monitoring systems particularly in the context of the UN FCCC and GCOS. The GCOS has been established to monitor and assess changes that are taking place within the climate system and to provide data for the initialisation and validation of climate models, as well as to provide data for national applications. The Conference of the Parties (COP) to the UN FCCC, recognising the need for an urgent response at a national level, has formed a partnership with GCOS to provide a framework for Parties to meet their commitments in systematic observations under the Convention. To underpin the urgency of improved monitoring of global climate, the COP has provided explicit guidance to the Global Environment Facility (GEF) to support capacity building for systematic observations.

Within a context provided by the current status of climate monitoring and data management systems in the Pacific and the strong regional links that have developed on environmental and climate issues, the paper puts forward a possible strategy for improving monitoring systems in the region. The key to the proposal is a regional approach underpinned by strong national commitments by the Pacific Island Countries. The principal elements of the proposed strategy are:

- Preparation of national climate monitoring plans, closely linked to an overall regional plan, to provide a structured basis for identification of gaps and deficiencies and to underpin the development of capacity building funding proposals;
- Network upgrade and operation and maintenance of observing systems required for climate monitoring;
- Establishment of a cooperative regional centre for climate to support the National Meteorological and Hydrological Services of the region, closely linked to the WMO regional infrastructure, and which could:

    - Provide high quality management of regional data;
    - Provide assistance for operations, maintenance and staff training of national climate observing stations within the GCOS networks;
    - Maintain a central archive of regional climate data that is directly accessible for national purposes and for regional and global climate change purposes;
    - Generate routine products (based on global analyses and regional data) for regional climate monitoring and regional climate change detection; and
    - Be a centre of expertise in regional climate matters.

The paper provides guidance in the preparation of national plans and explores the benefits of a regional approach in some detail, including the potential for optimising data availability from all climate system regimes, including the atmosphere and the ocean. The elements of a funding strategy are outlined and built into a proposed Action Plan.

A GCOS Action Plan for the Pacific

The objective of a GCOS Action Plan for the Pacific is to set out a framework and implementation timetable for improving climate monitoring in the region and regional access to global climate data and products. The primary outcome following implementation of the Action Plan should be an accessible database of climate data from a comprehensive network of Pacific stations, supported by access to externally collected data and products relevant to the region. The regional data would be available for a range of applications at a national and regional level, including climate applications, climate change assessment, modelling and impact studies, and the development of national and regional response strategies to climate change.

At the GCOS Implementation Workshop it will be necessary to:

- Identify deficiencies in the currently designated GCOS networks;
- Establish a strategy for coordinating National Climate Monitoring Plans as the basis for preparing national reports to the UNFCCC and ongoing management of GCOS stations;
- Explore the concept of a regional approach to climate data management;
- Agree in principle to a coordinated approach to the GEF to fund a cooperative regional climate centre for better management and utilisation of Pacific climate data.

Following the Workshop, SPREP, in close consultation with WMO, the GCOS secretariat and traditional funding agencies, should make application to GEF for:

- An Enabling Grant to assist in the preparation of national monitoring plans (and subsequent national reports to the UNFCCC) as requested by the UNFCCC; and
- A Block B grant under the Project Preparation and Development Facility to enable SPREP to develop specifications and coordinate political requirements in preparation for an application to the GEF for a Full-Sized Project. Consultations should also engage potential donor countries. The objective of the project would be to establish a cooperative regional climate centre under the framework of WMO and based on the work of the individual NMHSs of the SPREP member countries. The centre would be the focus for regional data management, for improving climate observing systems in the Pacific region, and for better regional use of climate information for climate change policies.

DEVELOPING AN ACTION PLAN FOR IMPROVED CLIMATE MONITORING IN THE PACIFIC

A Discussion Paper

Introduction

The key goals of the Pacific Island Regional Implementation Workshop are to identify deficiencies and needs in atmospheric, oceanographic and terrestrial observing systems for climate monitoring in the Pacific region and to guide participants in the process of developing plans and funding proposals to address the identified priority needs. To facilitate this process, this discussion paper aims to outline the elements of plans and proposals that need to be considered and to specify the features of an action plan that will lead to climate observing system improvements.

The context for the paper is set with a brief outline of the climate change issue, particularly from a monitoring perspective, as it impacts on the Pacific region and identification of some of the key institutions relevant to the Workshop, namely the UN Framework Convention on Climate Change (UNFCCC), the Global Climate Observing System (GCOS) and the Global Environment Facility (GEF). Other key players include the World Meteorological Organization (WMO) and its GCOS co-sponsors (Intergovernmental Oceanographic Commission (IOC) of UNESCO, United Nations Environment Programme (UNEP) and the International Council for Science (ICSU)), regional bodies such as the South Pacific Regional Environment Programme (SPREP) and, of course, the countries of the region. The development of climate monitoring activities in the Pacific region is summarised and the key issues in the preparation of national climate monitoring plans, within the context of a regional climate monitoring framework, are addressed. A particular focus of planning is initially on meteorological systems, but the importance and integration of other observing systems is highlighted.

A key element in mapping out the way forward towards implementing a Pacific GCOS is development of the regional framework and the paper suggests a possible approach for further discussion at the Workshop. The rationale for the regional approach, its relation to national approaches and underlying funding issues are addressed in some detail. Finally, the paper puts forward the essential elements of a possible GCOS action plan for the Pacific for consideration by Workshop participants.

A Global Response to Climate Monitoring

Background

The global average surface temperature has increased by between 0.4^{o}C and 0.8^{o}C since 1860, when sufficient worldwide data for global estimates became available. During that period, at least in the Northern Hemisphere, the 1990s was likely the warmest decade. Tide gauge data show a rise in sea level during the 20th century of between 10 and 20 centimetres and the rate of sea level rise may have been faster than at any time over the past 6,000 years. These trends provide evidence that the earth is warming and suggest the likelihood of other systematic changes taking place in the climate system. Rising sea level and the possibility of changed seasonal rainfall patterns pose a significant threat globally, and especially to the countries of the South Pacific.

Since pre-industrial times the concentrations in the atmosphere of a range of greenhouse gases and aerosols have increased as a result of human activity. The rise in concentration of the main anthropogenic greenhouse gases in the lower atmosphere (carbon dioxide, methane and oxides of nitrogen) impact on the earth's radiation budget and lead to a warming of the surface, while increased concentrations of aerosols lead to its cooling.

Overall, the increasing concentrations of anthropogenic greenhouse gases and aerosols contribute to a rise in equilibrium global mean temperature and appear to be responsible for at least part of the observed global warming.

Climate models currently used to project global warming trends have only a limited capacity to predict regional variations in the response of the climate system. Several climate models that incorporate the time-dependent changes in concentration of greenhouse gases and aerosols over the past 150 years are able to approximately simulate global temperature trends over the period. However, data used to assess recent climate change and to validate the models are mainly from the Northern Hemisphere. It is crucial that there is better monitoring and prediction of both global and regional climate and that a comprehensive and integrated global network of observing sites is established.

There are expected to be different responses between the hemispheres to greenhouse gas forcing of the climate system because of the global distribution of land, permanent ice and sea ice. Also, regional differences in response are expected because of complex interactions within the climate system and the impact of those interactions on the seasonal forcing of regional weather systems. The current global coverage of climate data is not sufficiently comprehensive to validate many characteristics of model-simulated seasonal weather patterns, nor is it possible to be confident about the details of many regional trend patterns observed. For Pacific Island Countries (PICs), it is vitally important to anticipate the magnitude of sea level rise and any changes to climatic controls over seasonal rainfall, such as shifts in the South Pacific Convergence Zone and changes to the frequency and intensity of El Niño events.

UN Framework Convention on Climate Change

The WMO, ICSU and UNEP convened a meeting of scientists at Villach, Austria in 1985 to assess the role of carbon dioxide and other greenhouse gases in climate variations and the associated impacts. This meeting of international experts concluded that, "… if present trends continued, a global warming of 1.5^{o}C to 4.5^{o}C would be likely by the middle of the next century, resulting in a rise in sea level of between 20 and 140 centimetres". WMO and UNEP established the Intergovernmental Panel on Climate Change (IPCC) to assess the state of understanding on many aspects of climate change. This action was endorsed by the United Nations General Assembly in its resolution of 1988 entitled "Protection of global climate for present and future generations of mankind".

The IPCC First Assessment Report of 1990 involved more than a thousand scientists from around the world. It confirmed that emissions of greenhouse gases resulting from human activities were increasing the atmospheric concentrations of those gases. The IPCC was certain that the increased concentrations would enhance the so-called greenhouse effect and on average would lead to additional warming of the earth's surface. There was, however, uncertainty about the timing, magnitude and regional characteristics of human induced climate change.

The IPCC First Assessment Report was endorsed at the Second World Climate Conference in Geneva in October 1990 and became the scientific basis for negotiating the United Nations Framework Convention on Climate Change (UNFCCC). The Second World Climate Conference also called for enhanced observational systems to better monitor the climate system and underpin research into climate change.

The UNFCCC was signed by 154 countries at the United Nations Conference on Environment and Development (UNCED) at Rio de Janeiro in June 1992. The ultimate objective of the UNFCCC is to achieve "… stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. ...". The Kyoto Protocol of 1997, when ratified, will require each developed

country to limit anthropogenic emissions of greenhouse gases to an amount relative to 1990 levels, and will require Parties to contribute to the protection and enhancement of greenhouse gas sinks and reservoirs.

The IPCC Second Assessment Report of 1995, the latest published assessment, concluded that for an equivalent doubling of the concentration of carbon dioxide the global mean temperature would rise between 0.9°C and 3.5°C above 1990 levels. Depending on the rate of increase of concentrations and the delay in stabilisation, sea level was expected to rise between 15 and 95 centimetres above 1990 levels by 2100 with a similar rate of rise for several centuries thereafter.

Responding to concerns raised by the climate research community regarding the status of global climate observing systems and their ability to monitor climate systematically and to reliably identify changes in climate variables, the third session of the Conference of the Parties (COP3) to the UNFCCC requested a report on the adequacy of the global observing systems. The GCOS Secretariat, on behalf of organisations participating in the Climate Agenda, coordinated the review and reported to COP4 at Buenos Aires in 1998. The report concluded that:

> *"… many of the observational requirements are generally known and documented and that many of the observing components are in place, but need substantial augmentations and enhancements to fully serve climate purposes. Fortunately many of the techniques needed to obtain the measurements are currently available and cost-effective, and an appropriate international infrastructure has been identified to facilitate the collection and distribution of climate-related observations.*
>
> *What is urgently needed is a commitment by nations to provide global coverage for key variables, to halt and reverse the degradation of existing observing systems, and to exchange information more effectively. Specific improvements are needed in atmospheric, oceanic and terrestrial systems. It is recommended that each Party should undertake programmes of systematic observations in accordance with national plans, which they should develop in concert with the overall strategy of climate observations*. …"

The report to COP4 had six major recommendations, three in relation to general principles and one each to the atmospheric, oceanic and terrestrial regimes. The three general principles related to:

- the need for programmes of systematic observations based on national plans but within the overall framework of GCOS,
- the need to exchange climate data and the elimination of internal barriers to exchange, and
- the need for capacity building programmes to assist countries to acquire and use climate data.

Through its Decision 14, COP4 accepted the recommendations and requested Parties, as an element of national communications as required under the Convention, to submit information on national plans and programmes in relation to their participation in global observing systems for climate. COP5 in 1999 built on these decisions further and adopted guidelines for reporting on national commitments relating to systematic observations. COP5 also encouraged GCOS, in consultation with relevant regional and international bodies, including the Global Environment Facility (GEF), to conduct a series of regional implementation workshops to assist countries in the process of identifying their priority capacity building needs.

Global Climate Observing System

GCOS was established in 1992 as a joint initiative of WMO, UNEP, IOC and ICSU. The objectives of GCOS are to provide the data necessary for:

- Climate system monitoring, climate change detection and response monitoring, especially for terrestrial ecosystems and mean sea level;
- Application to the development of national economies; and
- Research toward improved understanding, modelling and prediction of the climate system.

The Joint Scientific and Technical Committee of GCOS established five expert panels covering Atmospheric Observations, Oceanic Observations, Terrestrial Observations, Space-Based Observations, and Data and Information Management. When fully implemented, GCOS will provide all countries with access to global data sets. It will allow nations to obtain the data (both *in situ* and satellite) they need to improve their own short-term and long-term climate prediction services, improve mitigation planning for climate disasters, and better utilise climate change information in planning sustainable long-term development.

GCOS works in partnership with the Global Terrestrial Observing System and the Global Ocean Observing System. Recently, for example, formal discussions were launched to establish a Global Hydrological Network for Climate Monitoring. This network will be implemented jointly by GCOS, GTOS and WMO's Hydrology and Water Resources department. Moreover, the climate component of GOOS is the same as the ocean component of GCOS, and a Joint Commission on Oceanography and Marine Meteorology has been established to, among other things, coordinate and manage the observing system elements common to both GCOS and GOOS.

GCOS builds on existing and developing networks in three domain-specific observing systems. Within the atmospheric domain, the principal global networks related to climate are the GCOS Surface Network (GSN), the GCOS Upper Air Network (GUAN) and the Global Atmosphere Watch (GAW). GSN and GUAN are part of WMO's World Weather Watch and provide data on meteorological parameters, including temperature, pressure, precipitation, wind velocity and humidity, relevant to climate change and variability. To qualify as GSN or GUAN stations, specified GCOS observing standards must be met to ensure a high quality global data set for monitoring and detecting climate trends and changes. The GAW is an international programme to collect, provide quality control for, distribute, and archive observations of atmospheric constituents, including greenhouse gases and aerosols. In the oceanographic domain, both space-based and *in situ* networks measure sea surface temperature, winds, waves, salinity, sea level, sea ice properties, surface and sub-surface currents, and other observations. In the terrestrial domain, important global networks are being developed to provide permafrost, glacier, terrestrial carbon and hydrology observations for climate. Networks that were established specifically for research, such as the Tropical Atmosphere-Ocean (TAO) array of moored buoys of the World Climate Research Programme, also contribute to GCOS.

The distribution of GSN and GUAN sites is relatively dense in the developed countries, particularly in the Northern Hemisphere. The uneven distribution of data will provide a bias to the performance of climate models and inhibit validation over data-sparse regions. It is vital that good representation is achieved of GSN and GUAN sites across the island countries of the Pacific Ocean. These data would be the basis for research into regional climate processes and assist in the development of credible regional predictions for future strategic planning.

GCOS will allow participating nations to:

- *Detect climate change on a regional basis at the earliest possible time;*
- *Document natural climate variability and extreme events;*
- *Model, understand and predict climate variability and change;*
- *Assess the potential impact on eco-systems and socio-economic systems;*
- *Develop strategies to diminish potential harmful effects;*
- *Provide services and applications to climate-sensitive sectors; and*
- *Support sustainable development.*

A GCOS meeting in September 1997 at Geneva reviewed *in situ* measurements of the Earth system. It proposed an integrated strategy and identified priorities for the implementation of a global observing system. Of particular concern was the inadequacy of *in situ* measurements on a global scale, with serious decline in the acquisition of *in situ* observations in some areas over the previous decades. Although technical deficiencies were recognised as significant factors, an underlying concern was the inadequacy of data management at local, national and international levels.

Since COP3 in December 1997, GCOS has worked closely with the Convention bodies, in particular the Subsidiary Body for Scientific and Technological Advice (SBSTA), to implement COP decisions on systematic observations and to provide assistance to countries in meeting their commitments on climate monitoring, through, for example, drafting of reporting guidelines and initiation of a series of regional implementation workshops.

Global Environment Facility

The Global Environment Facility (GEF) was initially established as a pilot funding programme within the framework of the World Bank to assist in the protection of the global environment and to promote environmentally sound and sustainable economic development. In 1994, the GEF was restructured and expanded as a mechanism to achieve agreed environmental benefits in the four focal areas of climate change, biological diversity, international waters and ozone layer depletion.

The GEF is the designated “financial mechanism” for the UNFCCC and receives guidance from the COP on programmes and projects eligible for funding. As of May 2000, funds provided through the GEF for climate change purposes have mainly been in the areas of energy conservation, renewable energy and low greenhouse gas emitting technologies.

Through its Decision 2, COP4 decided that GEF should provide funding to developing country Parties to, *inter alia*:

- Build capacity for participation in systematic observation networks to reduce scientific uncertainties relating to the causes, effects, magnitudes and timing of climate change (1c); and
- Support capacity building for facilitating national/regional access to the information provided by international centres and networks, and for working with those centres for the dissemination of information, information services, and transfer of environmentally sound technologies and know-how in support of the Convention (1g(iv)).

Through its Decision 5, COP5:

- invited the GCOS secretariat, in consultation with relevant regional and international bodies, including the GEF, to organise regional workshops with the objective of identifying the priority capacity building needs related to participation in systematic observations (1 and 2);
- urged countries to actively support and participate in the regional workshops (3); and
- urged Parties to address deficiencies in the climate observing networks and invited them, in consultation with the GCOS secretariat, to bring forward specific proposals for that purpose.

Decision 5/CP.5 also urged Parties to identify the capacity building needs and funding required in developing countries to enable them to collect, exchange and utilise data on a continuing basis in pursuance of the Convention (6).

The GEF identifies four forms of funding:

1. *Project Preparation and Development Facility*: Block A grants (up to $25,000) fund very early stages of project or programme identification; Block B grants (up to $350,000) fund information gathering necessary to complete project proposals and provide necessary supporting documentation; Block C grants (up to $1 million) provide additional financing where required for larger projects to complete technical design and feasibility work.
2. *Medium-Sized Projects*: Grants of less than $1 million encourage a wider range of interested parties to propose and develop project concepts.
3. *Full-Sized Projects*: GEF implementing agencies (UNEP, UNDP and World Bank) work with country focal points to develop projects that are consistent both with the country's national programs and priorities and with GEF's operational strategy and programs. Regional or global programs and projects may be developed in all countries that endorse the proposed activity.
4. *Enabling Activities*: Grants to help countries prepare national inventories, strategies and action plans and identify the most promising opportunities for project development. In this context, the UNFCCC Decision 2/CP.4 provided specific guidance to the GEF to support capacity building for systematic observation networks.

How the GEF chooses to interpret the UNFCCC guidance depends on many factors not always obvious to the applicant. GEF support for activities which appear to fall within the guidelines should not therefore be taken for granted and full consideration should be given to alternative funding options. This is particularly the case for any support required to fund ongoing operations.

National Climate Monitoring Plans

Need for a National Plan

Each government has the responsibility to protect its citizens from climate-related natural disasters and to promote their well-being through climate services and the application of climate information. A National Climate Monitoring Plan establishes a shared responsibility and a multi-dimensional approach to identifying and managing climate risk.

A National Climate Monitoring Plan provides the essential framework for fulfilling country commitments to the UNFCCC, as identified in Article 5 of the Convention (Research and Systematic Observation), and for preparing national reports to the UNFCCC, as requested through Decision 14(8) of COP4 and in accordance with UNFCCC reporting guidelines as adopted in Decision 5 of COP5.

Within the context of national commitments under the UNFCCC, Decision 14/CP.4 urged Parties to actively support:

- national meteorological and atmospheric (sic) observing systems, including measurement of greenhouse gases, in order to ensure that stations identified as elements of the GCOS networks, based on the World Weather Watch and Global Atmosphere Watch, and underpinning the needs of the UNFCCC are fully operational and use best practices;
- national oceanographic observing systems, in order to ensure that the elements of GCOS and GOOS in support of ocean climate observations are implemented; and
- national terrestrial networks, including observational programmes to collect, exchange and preserve terrestrial data according to GCOS and GTOS climate priorities.

The national plan for each country should reflect political commitment and identify priority tasks, including the requirements for network development, instrumentation, training, communications and data management, as well as the requirements for ongoing operation of all system components.

Importantly for the developing countries, the national plan provides a coherent basis for the identification of capacity building needs within a clearly identified long-term climate monitoring strategy, and strengthens the confidence of donors and partners that resources are being applied effectively and strategically.

Regional cooperation in planning climate monitoring requirements is of particular importance for a region such as the Pacific, where many countries, each of relatively small land area, are scattered across a wide oceanic expanse. Regional cooperation, within a structure such as that provided by GCOS, provides benefits in terms of commonality of systems as well as sharing of expertise and experience. It also offers synergies for accessing other climate information relevant to the region, such as oceanographic data and products, remotely sensed data, and numerical model analyses and projections.

Climate data from the Pacific do not just serve the immediate needs of the region. The data are essential to systematic monitoring of global climate and to ensuring full global data coverage necessary for operation and validation of global climate models. They are therefore of value to all countries. Large, sparsely populated ocean areas have traditionally been data sparse, and so a coordinated regional program of climate observations in the Pacific is of special importance.

As for GCOS on its global scale, many of the basic building blocks of a national monitoring plan lie in the systems already operational or accessible within a country to serve the needs of a National Meteorological and Hydrological Service.

Features of a National Plan

Compiling a National Climate Monitoring Plan requires a multi-disciplinary approach. It requires an understanding of the need for systematic, long-term observations of a sufficiently high standard to identify and characterise trends and changes in climate, as well as of the potential uses and users of that information. The plan should clearly identify objectives, assign responsibility between agencies for action, and specify coordination arrangements.

Elements to be addressed in compiling a National Climate Monitoring Plan include:

- Systematic collection of meteorological, oceanographic and terrestrial observations to appropriate standards, including those relating to temporal and spatial distribution and data quality;
- Access to externally collected data and products to supplement data collected locally;

- Establishment and operation of data management facilities to ensure effective quality control, archival and exchange of climate data and data access systems necessary to underpin research, impact assessment and services;
- Identification of the skills required and training needs for implementation of the plan, including scientific, technical and management skills;
- Identification of resource requirements both to establish and to maintain the components of the plan;
- Inter-agency coordination mechanisms to ensure that the climate information and prediction needs of all sectors, including industry, the environment, public infrastructure and community safety, are recognised;
- Research programs to improve the applications of climate information and services.
- Multidisciplinary studies to establish national risk and vulnerability and to formulate appropriate response strategies;
- Provision of information and prediction services to meet community and sectoral needs.
- Linkages to regional and international programmes relevant to national objectives and capable of providing national benefits.

Specific consideration should be given, *inter alia*, to:

- Identification of those elements that already exist;
- Gaps, deficiencies and barriers, both in respect of observing networks and the other aspects of the plan, such as data management facilities and training;
- Priorities for action and relevant timing considerations;
- Identification of capacity building needs.

Any proposal to upgrade the climate monitoring systems of a country must have a sound data management strategy as its focus. Without such a focus data will be lost, records will be discontinuous, and the climate value of the investment in equipment, training and communications will be severely diminished.

The data management facility should also be linked to a reliable telecommunications system to ensure the regular collection, quality control and archival of observations at a central facility and for distribution of service products. An important part of the data management strategy is near real-time analysis of climate data which, as well as enabling routine provision of a range of climate service products appropriate to national needs, also provides an ongoing check of the overall system integrity.

Meteorological Observing Systems

At this time, the observing systems that are most extensively implemented and which enjoy the most rigorously defined standards and guidelines, are meteorological systems, particularly those of the WMO World Weather Watch and Global Atmosphere Watch. It is critical, for high quality climate data, that the exposure, layout, instrumentation and practices of these systems meet the international standards agreed through the WMO. These standards ensure that data collected by individual countries are compatible between all countries, are consistent over time and therefore provide a basis for monitoring climate and assessing climate change. A changed exposure, different observing times, replacement of instrument type or a shift in the site can each lead to spurious signals and false conclusions.

The Changing Climate in Paradise (Bureau of Meteorology, 1991) report and the *Strategic Action Plan* (SPREP, 1999) for the development of meteorology in the Pacific region, augmented by the forthcoming SPREP *Needs Analysis* for each of the countries, provide a framework of actions to be undertaken to improve national meteorological services. The assessments also provide estimates of costs involved in upgrading the observing networks, telecommunications systems, buildings and associated infrastructure. The implementation

of these proposals to upgrade the capability of NMHS will require additional funding for equipment, maintenance and training.

National requirements for climate data will extend beyond the specifications of the GSN and GUAN because of the need for increased network density to service local and regional objectives, such as monitoring and predicting regional climate variability on seasonal timescales, and the need for oceanographic and terrestrial data.

Other Climate Observing Systems

GCOS encompasses the totality of observing systems for monitoring climate, including the atmosphere, the oceans and the terrestrial components. While a comprehensive understanding of the characteristics and interactions of all elements of the climate system is important to the Pacific region, it is not anticipated that all the PICs will be actively committed to participating in all the relevant programs. For example, only one GAW station is operated within the PIC region, although a regional assessment of national monitoring plans may identify the need for additional stations and/or a different strategy for monitoring atmospheric chemistry and aerosols. However, it is important that all countries have the facility and opportunity to access up-to-date GAW data and products relevant to the region.

Similarly, broadscale oceanographic monitoring systems are largely operated by the developed countries but provide substantial benefits to developing countries. Such programs are more likely to seek the cooperation of the PICs, for example in instrument deployment, than their active investment and participation. However, the data and products from such systems are of considerable importance to understanding the climate variability of the region and to interpreting the possible extent and impact of present and future climate change. The network of very accurate tide gauges for sea level monitoring is one area of oceanographic monitoring where the countries of the region can and do make an active contribution.

Pacific Climate Monitoring Activities

Regional Coordination

The countries of the South Pacific cooperate in meteorological matters within the overall framework of WMO Regional Association V, which covers southeast Asia and the South West Pacific. The Regional Specialised Meteorological Centre (RSMC) at Nadi, Fiji provides a regional telecommunications hub for the collection and exchange of data between the countries of the South Pacific and also has the responsibility for tropical cyclone watch and warning for the region. Each country making meteorological observations retains responsibility for quality control and archival of its own data.

The South Pacific Regional Environment Programme (SPREP) is an autonomous regional organisation consisting of 22 Pacific Island Countries and Territories, and four developed countries (Australia, New Zealand, France and the United States of America) with direct interests in the region. One objective of SPREP is “to provide an understanding of, and a capacity to respond to, climate change and sea level rise, particularly through adaptation strategies”. As a consequence, SPREP is closely involved in regional meteorological matters.

WMO and SPREP have a Memorandum of Understanding and, with the support of the Government of Samoa, the WMO Sub-Regional Office for the South Pacific is co-located within the SPREP headquarters in Apia, Samoa.

A major stimulus for regional cooperation in climate matters came from the 19th meeting of the South Pacific Forum, 1988 that "expressed concern about climate changes in the South Pacific and their potential for serious social and economic disruptions to countries in the region". In response, the Australian Government funded a network of very accurate sea level monitoring stations and commissioned a feasibility study to further examine climate monitoring and assessment needs in the region. The report of the feasibility study, *The Changing Climate in Paradise* (Bureau of Meteorology, 1991), proposed a series of projects covering seven areas to improve monitoring of climate change. Action has proceeded in many areas, including climate observations, climate data management and infrastructure support for climate monitoring. A specific recommendation was for holding an annual meeting of Directors of Pacific Meteorological Services, and SPREP has obtained funding support and organised such annual events since 1993. SPREP also facilitates the participation of meteorological service personnel in international climate change and WMO meetings.

The fifth annual meeting of the Directors of Pacific Meteorological Services, held in November 1998 at Hawaii, agreed for SPREP to broaden its scope of work to cover meteorology and climate matters in addition to its climate change programmes. The meeting also urged SPREP to develop a long term strategic plan for the development of meteorology in the Pacific region, taking into account the WMO Fifth Long Term Plan and the priority areas agreed to at the WMO Regional Association V meeting held in Bali, Indonesia in September 1998. SPREP published the *Strategic Action Plan* for the development of meteorology in the Pacific region in December 1999.

The *Strategic Action Plan* called for a "needs analysis" of all the Pacific Island Meteorological Services. SPREP commissioned the *Needs Analysis* in early 2000 and the report is nearing completion. The objective of the analysis is to identify the requirements of the 20 Pacific Island Meteorological Services, package the requirements for aid consideration, and further, to coordinate and administer any consequential aid projects.

Status of Climate Monitoring Systems[1]

There are vastly different levels of development among the NMHSs of the Pacific Islands, related directly to the disparate levels of resource allocation. American Samoa, the Federated States of Micronesia, Commonwealth of the Northern Mariana, French Polynesia, Guam, New Caledonia, Republic of the Marshall Islands, Republic of Palau and Wallis and Futuna all receive full funding from external sources and are relatively well equipped. However, apart from Fiji, the independent Pacific Island NMHSs have not been able to carry out their roles and responsibilities because of lack of resources, skills and expertise. This has particular implications for the ongoing maintenance and long-term operation of monitoring systems in the region.

The analysis of needs has identified common themes across the PICs. Most independent countries are not capable of providing even a minimum level of essential services. The inadequacy of severe weather warnings and the deficiencies of climate information and prediction services are related directly to inadequate observational networks, poor telecommunications systems, and the need for infrastructure and institutional strengthening. Unless the decline in capability that has occurred over the past few decades is reversed, the countries, and the region as a whole, will find it impossible to address the issues of climate change and variability.

In the area of meteorological observations it will be necessary to:

[1] This section includes preliminary findings from the SPREP *Needs Analysis*

- Restore and upgrade surface observation networks, including the deployment of automated meteorological observing stations;
- Restore and upgrade the regional upper air observational network;
- Establish marine meteorological observing systems;
- Introduce basic meteorological observer training; and
- Provide technical maintenance backup.

The designated GSN and GUAN stations for WMO RAV are shown in Figures 1 and 2 respectively. For comparison, the extent of the underlying World Weather Watch Surface and Upper Air networks in the region are illustrated in Figures 3 and 4.

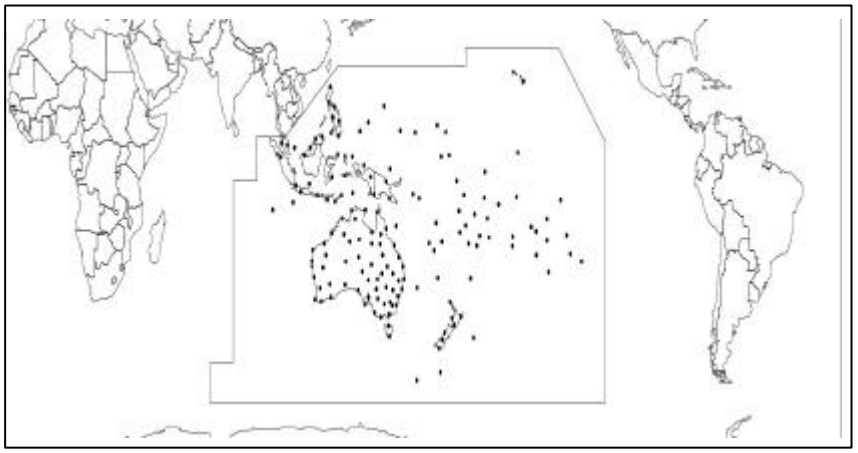

Figure 1. Designated GCOS Surface Network (GSN) stations in WMO RAV.

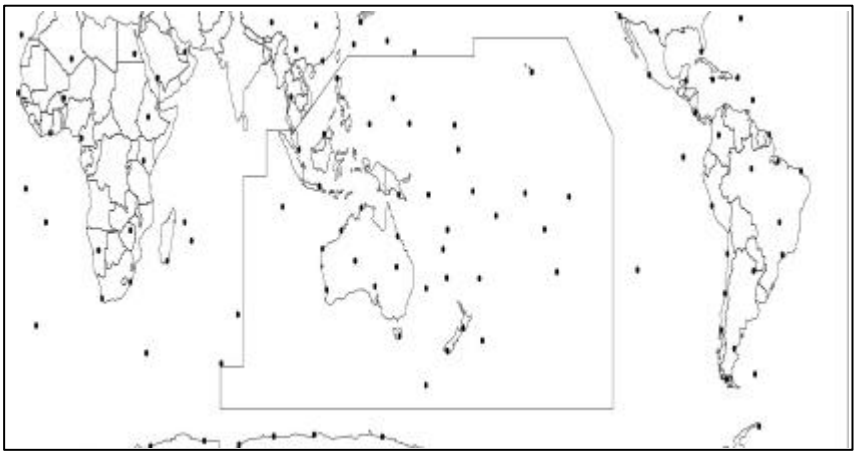

Figure 2. Designated GCOS Upper Air Network (GUAN) stations in WMO RAV.

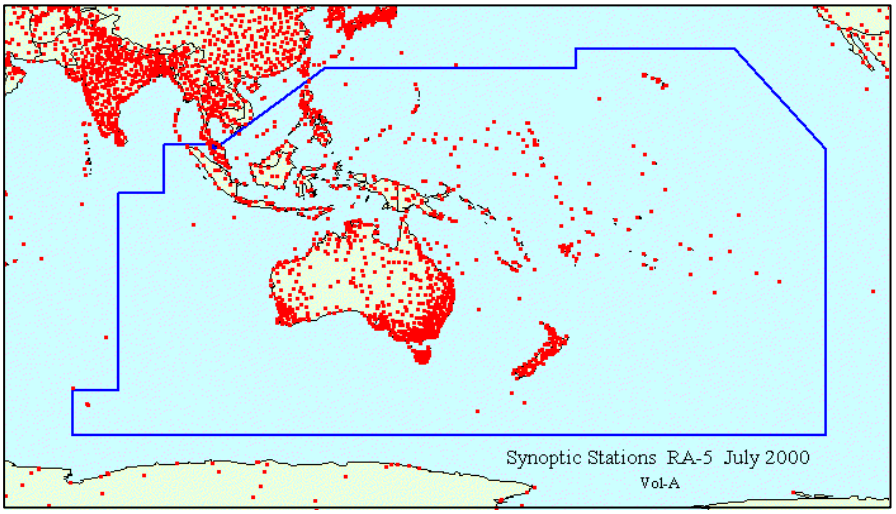

Figure 3. The WWW Surface Synoptic network in the WMO RAV region.

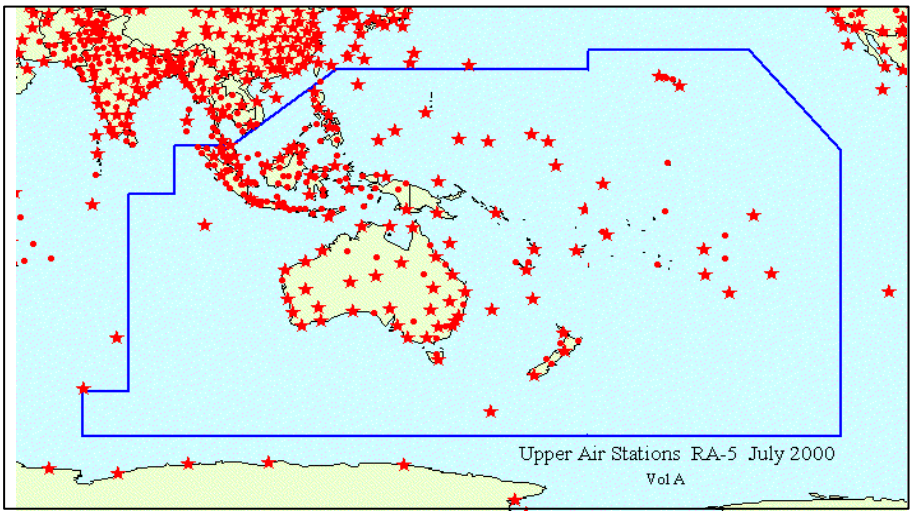

Figure 4. The WWW Upper Air network in the WMO RAV region. Radiosonde stations are indicated by stars and wind only stations by dots.

Not all of the designated GSN stations routinely transmit monthly reports to the World Data Centres for archival. A significant proportion of the stations report intermittently or have ceased reporting. The reasons for the failure to report are not identified but may relate, *inter alia*, to a problem with the station's observing programme, an inability of the local observer to code the monthly (CLIMAT) report, or a problem with the communications link. A priority action is to ensure that all designated GSN stations report routinely.

The SPREP *Strategic Action Plan* identified in-country telecommunications as a major problem area in the region. Modern telecommunications systems are necessary for the collection of data from across the national networks and for providing all countries with access to routine analyses based on the regional climate observations. It is fundamental to the operation of each national observing network and must be addressed in any strategy for development assistance. Needs include:

- High frequency radio receivers for collection of data from outstation observing sites;
- Local Area Networks (LAN) at NMHS for efficient data management and utilisation; and

- An Intranet connecting the Pacific NMHS in order to provide efficient data exchange and service product distribution.

The implementation of modern data management systems is an essential requirement for the utilisation of climate data for essential services, applications and the development of national policies and strategies appropriate to climate change. Security of data is the highest priority, but data also have to be readily accessible for national, regional and global benefits.

Problems associated with managing the data stream from the meteorological observing networks are a major weakness in the climate capability of many countries of the Pacific. Normal practice has been for observations to be recorded in journals and the data analysed at various intervals, usually on a monthly and annual basis. WMO has established the Data Rescue (DARE) and Computers for Climatology (CLICOM) projects to assist countries to microfilm deteriorating manuscript records and to implement modern data management technologies. Funding for DARE and CLICOM is by voluntary contributions from developed countries and falls well short of actual needs. The historical climate data of the Pacific region are at risk and current data are often not being safely archived. Moreover, the historical data of many countries are still held as manuscript records and are not readily accessible for analysis and research.

The Changing Climate in Paradise report and the SPREP *Strategic Action Plan*, augmented by the forthcoming SPREP *Needs Analysis* for each of the countries, provide a framework of actions to be undertaken to improve national meteorological services. The assessments also provide estimates of costs involved in upgrading the observing networks, telecommunications systems, buildings and associated infrastructure. The implementation of these proposals to upgrade the capability of NMHSs will require additional funding for equipment, maintenance and training.

Observations of trace gases, atmospheric radiation, total ozone and atmospheric aerosols are made at a single GAW station in the PIC region, Cape Matatula in American Samoa.

A variety of systems currently provide oceanographic data for the region, including:

- The equatorial array of 70 moored buoys established under the Tropical Ocean Global Atmosphere (TOGA) project and providing surface meteorological and subsurface temperature, salinity and current data;
- Long-term tide gauge networks operated by the University of Hawaii and the more recent high quality tide gauge network established by the National Tidal Facility, Adelaide with Australian government funding (Figure 5);
- Expendable bathythermographs deployed by merchant vessels of the Volunteer Observing Ships programme; and
- Drifting ocean buoys deployed by various countries.

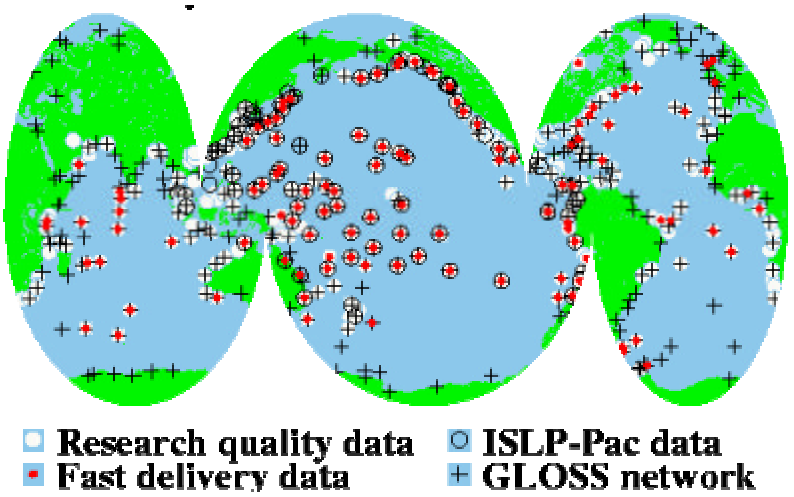

Figure 5. Global distribution of sea-level monitoring stations, with a focus on the Pacific Ocean and including the IGOSS (Integrated Global Ocean Services System) Sea level Programme for the Pacific and the Global Sea Level Observing System (GLOSS) network. The long-term network operated by the University of Hawaii and the high quality stations established by the Australian National Tidal Facility are represented.

Towards a Pacific GCOS

In planning a strategy for the improvement of climate observing systems and climate data utilisation in the Pacific region, the preceding discussion highlights the importance of addressing three key issues:

- *National Climate Monitoring Plans*. For maximum regional impact each national plan should set out national capabilities and needs within a regional framework. The coordinated preparation of national plans would assist in the preparation of national reports to the UNFCCC.
- *Network Upgrade and Operation and Maintenance of Climate Monitoring Systems*. In the past, funding assistance has been provided to developing countries for infrastructure equipment and training for meteorological observing, in recognition of the wider benefits that flow. Coordinated funding assistance for upgrading networks relevant to monitoring all aspects of climate and ongoing assistance for operations and maintenance are recognised and distinct needs.
- *Climate Data Management*. All aspects of climate data management, including collection, archival, and utilisation for national, regional, and global purposes need to be improved. Routine reporting of CLIMAT messages from designated GSN stations is a requirement.

A possible approach to developing a regional framework for national monitoring plans and to ensuring effective climate data management in the Pacific might involve a cooperative regional centre to coordinate climate data management and provide a focus for technical assistance in the operation and maintenance of national observing systems.

A Cooperative Regional Centre for Climate

A cooperative regional centre for climate, established primarily for regional climate data management, could give oversight to the Pacific GCOS and provide a focus for scientific and technical expertise. To be most effective and to operate most efficiently, the cooperative regional centre for climate should be closely aligned with existing WMO regional facilities including Global Telecommunication System (GTS) infrastructure.

Such an arrangement would in no way diminish the authority and responsibility of NMHSs to maintain observing networks at the highest possible standards for their own national purposes. Countries with existing meteorological observing stations, data collection and data archival systems would continue to maintain them and provide a range of local services. However, if a regional climate centre is established some smaller countries may find it more efficient to forward their climate data to the regional centre rather than duplicate the data management and archival facility.

In order to carry out its data management functions it would be necessary for the regional climate centre to establish an archive for the storage of collected climate information. Electronic storage of the data in an on-line database that was accessible by each participating NMHS would be a valuable resource for the region. Routine analysis of the data and the distribution of climate anomaly tables and maps would contribute to regional climate monitoring and assist with assessment of the strength and spatial impact of monthly and longer period climate anomalies and climate trends.

A regional approach to better management and use of existing data would provide the basis for future improvement to the regional GCOS network. Once the infrastructure for regional collection, archival and analysis of GSN data has been established, then expansion of the regional reporting networks is straightforward. If further review identifies suitable sites that would improve the regional density, then these could be added to the GSN with relative ease. The regional centre could also provide support to those designated GSN stations that are currently not functioning adequately or at all.

Currently, there is limited communication on operational performance between the World Data Centres and the more than 150 countries contributing data. If a country fails to make a routine CLIMAT report, there is no direct follow-up to implement corrective action. A cooperative regional approach to overall management of network performance, including monitoring the exchange of CLIMAT and other routine climate data, could identify non-reporting stations, facilitate technical support to the responsible NMHS, and recommend on corrective action.

A regional climate centre could also facilitate information flow from the various global centres and provide a range of integrated products for regional use. Such products would have applications for climate monitoring and the provision of early warning of such phenomena as El Niño and La Niña. A wide range of monitoring products that, for reasons of cost, expertise and opportunity, are beyond the active participation of PICs could be effectively accessed through the regional centre. These might include oceanographic data and products such as those derived from the Argo program. The regional focus may in some cases enhance opportunities for regional participation in international programs. Figure 6 shows the regional centre both as a shared central resource for regional climate data management and as a conduit for distributing regional data to world centres and integrating global products for regional use.

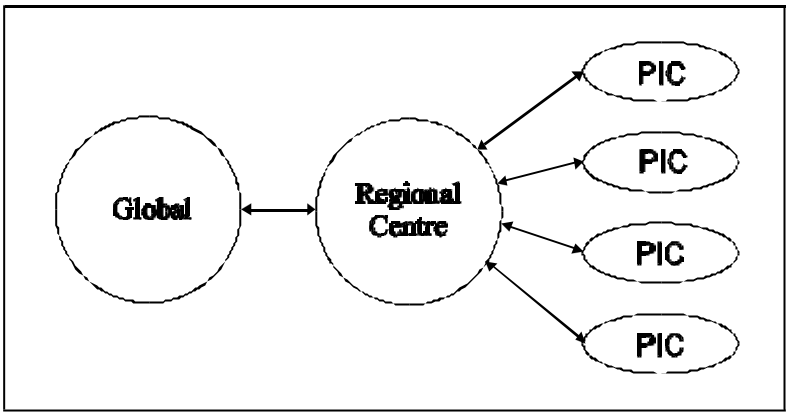

Figure 6. A schematic representation of the role of a regional climate centre for data management and information flow. Climate data are collected from the national observing networks in each of the Pacific Island Countries (PICs) and distributed to global centres. Data sets and products (both from in situ networks and satellite systems) are collected from global centres and specialised regional products made available to countries for climate applications and assessments.

A fundamental decision for each NMHS will be the extent to which it will maintain independent climate data management infrastructure and capability, or utilise the facilities of the regional cooperative facility for its climate data management requirements.

Funding Climate Monitoring Improvements

Background

Although national socio-economic development has been the primary goal of development assistance in meteorology, it is widely recognised that assistance for the upgrading of national meteorological infrastructure provides significant additional regional and global benefits. National meteorological data have global applications and benefits, and it is likely that traditional developed country donors will continue to participate in specific bilateral development projects and in regional projects coordinated through SPREP because of the wider benefits that flow.

In the recent past the NMHSs of many developing countries of the Pacific have received funding assistance through bilateral grants for capital projects, training and institutional support. Bilateral funding involves development of project plans for each country and separate approaches to the funding agencies. The past support has led to uneven development of the networks and capabilities of NMHSs and the recent *Strategic Action Plan* highlights the continuing deficiencies. Also, the overall outcomes for climate purposes would have been improved if more attention had been given to the necessary data management and information utilisation functions.

The GEF, as the funding mechanism for UNFCCC projects, is a potential source of funding for climate change related capacity building projects in the Pacific region. The decisions of COP4 and COP5 provide new guidance to GEF in providing support to developing countries, particularly on a regional basis. Decision 5/CP.5 invites Parties to bring forward proposals to address deficiencies in climate observing networks, especially as they relate to systematic observations, collection, exchange and utilisation of data on a continuing basis in pursuance of the Convention.

Regional Approach

It is yet to be established how the Decisions of COP4 and COP5 will be interpreted and acted upon by the GEF. However, a regionally coordinated project that has the Pacific GCOS as its focus fits well within the guidelines advised by the COP. Given the limitations of GEF funding, particularly in relation to capacity building, it is most likely that full implementation and operation of a regional centre will require the financial support of national donors as well.

A regional approach, involving the establishment of a cooperative regional climate centre for managing climate data, would provide a sound basis for the development of a wider range of regional climate monitoring, assessment and research activities and the better applications of new climate information. Such a project recognise the roles and responsibilities of individual NMHSs in the region and should initially build on the designated network of GSN, GUAN, GAW and other climate observing sites. It should specifically emphasise regional data collection, analysis and archival to ensure that data are available for regional and global assessments and for input to global climate models.

A **first stage** in the initiation of a funding proposal for a Pacific GCOS improvement project would be to reach regional agreement at the scientific and technical level, and later at the political level, on the objectives and outcomes to be achieved. The suggested approach is to focus the proposal on a cooperative regional centre for collection, management and utilisation of current and historical data flows from the designated GCOS networks of the Pacific region. An essential outcome would be for these data to be widely available as the basis for regional assessments of climate change and provide input to impact studies and the development of long-term response strategies.

The components of the regional climate centre project would be a facility to house the electronic database and data management staff, access to the WMO regional telecommunications hub and a technical unit for assisting in the maintenance of appropriate observational standards and practices across the network. The individual NMHSs would continue to operate the observing stations but could expect technical assistance and guidance from the regional centre.

A major advantage of a regional climate centre model is that the concepts fit within the framework of COP guidance to the GEF. The regional climate centre would provide the focus to ensure quality data are available for regional use and for wider application in global assessments and climate models. Thus, maximum utility is obtained from available data and there is a focus for the rescue and processing to computer form of the historical data stored in manuscript form. A well supported centralised data management system gives a high probability that deficiencies of the regional network are identified and that these will be specifically addressed to improve the overall regional climate observing capability. In addition, many smaller countries could make use of the capacity to store their climate data holdings electronically without duplication of the complex infrastructure.

The **second stage** in the development of a funding proposal would require a regional entity, such as SPREP, to make application for a Block B grant under the Project Preparation and Development Facility of the GEF. Such a grant would enable detailed specification of the project in consultation with GEF and traditional funding agencies. Part of the second stage would also involve detailed negotiation with international coordinating agencies, including WMO and the GCOS secretariat, and negotiation with countries of the region on the scientific and technical infrastructure details of the project.

The **third stage** of the project would be application to the GEF for a Full-Sized Project grant to undertake the actions necessary to establish a regional climate centre, including training

and the necessary scientific, technical and management infrastructure. The support of a consortium of donor countries would also be required at this stage.

National Approach

Decision 14/CP.4 requested Parties to submit national plans and programmes in relation to their participation in GCOS as part of their national communications, as required under the Convention. A coordinated regional approach through the formulation of National Climate Monitoring Plans would provide a framework for the national reports. Guidance in reporting on systematic monitoring within the national communications is provided as part of Decision 5/CP.5.

The GEF provides grants as Enabling Activities to assist developing countries prepare national plans and reports. Individual countries are able to apply to the GEF for a grant but there is also the option of a regional application with the national plans for each country forming the components of a regional plan. Individual countries may apply for up to $100,000 for 5 activities, including observations, from overall funds of $450,000 available per country for expedited activities related to the UNFCCC. A SPREP initiative for a GEF grant to coordinate the national monitoring plans would ensure a degree of consistency in the presentations of the national plans and reports. The SPREP application to the GEF would draw on the *Needs Analysis,* and liaison with the GCOS secretariat would identify the current adequacy and performance of designated GCOS stations.

Long-term Support for Climate Monitoring

In preparing national monitoring plans and addressing the possible establishment of a cooperative regional centre for climate, it is vital that consideration be also given to funding the long-term operation of national and regional monitoring infrastructure. Countries need to consider their own capabilities to fund these important monitoring systems. In addition, they should explore all available options, such as traditional and new partnerships, on a regional and national basis, potential access to funds through the UNFCCC Clean Development Mechanism, as well as possible linkages to other elements of the global environmental agenda.

A GCOS Action Plan for the Pacific

The objective of a GCOS Action Plan for the Pacific is to set out a framework and implementation timetable for improving climate monitoring in the region, both within the immediate context of country commitments to the UNFCCC and in respect of specific national and regional systematic monitoring priorities.

The primary outcome following implementation of the Action Plan should be an accessible database of climate data from a comprehensive network of Pacific stations, supported by access to externally collected data and products relevant to the region. The regional data would be available for a range of applications at a national and regional level, including climate applications, climate change assessment, modelling and impact studies, and the development of national and regional response strategies to climate change.

The following is a proposed sequence and framework for the Action Plan.

1. At the GCOS Implementation Workshop

- Based on the SPREP *Needs Analysis* and any other available information, identify deficiencies in the climate monitoring capabilities of the region, with a particular focus on the designated GCOS networks. Activities assessed would include:

- the adequacy of the designated network for regional climate purposes,
- the operational status of designated GCOS stations,
- other potential GCOS stations,
- the compliance of procedures and practices at the stations with WMO and other appropriate standards,
- facilities for recording and archiving observations,
- technical capability of staff at stations,
- access to the data, and routine transmission of monthly reports (eg, CLIMAT messages) to World Data Centres.

- Establish a strategy for a coordinated approach through SPREP to the GEF for an Enabling Activities grant to assist with preparation of National Climate Monitoring Plans as the basis for both the national communications (national reports) for the Convention and as a focus for systematic climate observations for GCOS.

- Discuss the concept of a regional approach to climate data management, such as through the establishment of a Cooperative Regional Centre for Climate, noting the need for it to operate under the WMO framework and be based on the work of the individual NMHSs of the SPREP member countries, as well as being closely aligned with existing WMO regional infrastructure.

- Agree on the scientific and technical aspects of a coordinated approach to the GEF for a Block B Project Preparation and Development Facility grant. The purpose of the grant would be to fund information gathering and coordination necessary to complete proposals and provide necessary supporting documentation for a regional climate centre as the focus for GCOS data management. (The COP guidelines to the GEF stress meeting capacity building needs of developing countries, particularly to collect, exchange, and utilise data on a continuing basis.)

2. Following the GCOS Implementation Workshop

- *Reporting to the UNFCCC:* SPREP, in consultation with Member countries, could make application to the GEF for an Enabling Activities grant to assist with the preparation of national reports on systematic and continuing observations for GCOS. National Climate Monitoring Plans would provide the framework for the national reports to the UNFCCC.

- *A Regional Climate Centre:* SPREP could, in close consultation with WMO, the GCOS secretariat and potential developed country donors, make an application to the GEF for a Block B grant under the Project Preparation and Development Facility for the establishment of a regional climate centre. The size of the project development grant would need to cover:

- A roving mission, taking account of the SPREP *Needs Analysis*, to fully document deficiencies in the designated GCOS network stations, including data management and telecommunications systems, and recommend remedial action;
- Negotiation with Member countries, especially those hosting GCOS stations, seeking agreement to participate in the regional climate facility;
- Presentation of a proposal to the South Pacific Forum to establish a cooperative regional climate facility, including its management structure and recommended location;
- Preparation of specifications and costs for telecommunications to link all designated GCOS stations and the regional climate facility to the WMO GTS through the WMO Regional Telecommunications Hub at Nadi, Fiji;
- Preparation of specifications and costs for a cooperative regional climate facility, including:
  - Building space and computing infrastructure;

- Telecommunications to link GCOS observing sites for data collection and to ensure that national agencies, especially the NMHSs, have remote access to the regional GCOS climate database; and
- Skilled staff for data management and to provide technical support in the operation of GCOS observing stations;

– Preparation of the stage 2 proposal to the GEF for a Full-Size Project to fund the establishment and ongoing assistance for operations of a regional climate centre for regional climate data management and utilisation.

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UNFCCC, 1999b. Report of the Conference of the Parties on its Fifth Session, Held at Bonn from 25 October to 5 November 1999. Part Two: Action Taken by the Conference of the Parties at its Fifth Session.

WMO, 1996. WMO and Climate Change. Geneva. WMO No 848.

ANNEX XIII

LIST OF ACRONYMS

AOPC	Atmospheric Observation Panel for Climate
APN	Asia-Pacific Network
CBS	Commission for Basic Systems
CCl	Commission for Climatology (of WMO)
CLICOM	CLImate COMputing
CLIMAT	Monthly surface climate summary report
CLIVAR	Climate Variability and Predictability (study of WCRP)
COP	Conference of the Parties (to UNFCCC)
CROP	Council of Regional Organizations in the Pacific
DARE	Data Rescue
DWD	Deutscher Wetterdienst
ECMWF	European Centre for Medium-Range Weather Forecasts
EEZ	Exclusive Economic Zone
ENSO	El Niño/Southern Oscillation
FAO	Food and Agriculture Organization of the United Nations
FORSEC	Forum Secretariat
GAW	Global Atmosphere Watch
GCOS	Global Climate Observing System
GEF	Global Environment Facility
GLOSS	Global Sea Level Observing System
GOOS	Global Ocean Observing System
GOS	Global Observing System
GSN	GCOS Surface Network
GTOS	Global Terrestrial Observing System
GTS	Global Telecommunication System
GUAN	GCOS Upper-Air Network
HYCOS	Hydrological Cycle Observing System
ICSU	International Council for Science
IGOSS	Integrated Global Ocean Services System
IGY	International Geophysical Year
IMO	International Meteorological Organization
IOC	Intergovernmental Oceanographic Commission (of UNESCO)
IPCC	Intergovernmental Panel on Climate Change
IPO	Inter-decadal Pacific Oscillation
ISLP-Pac	IGOSS Sea Level Programme for the Pacific
JMA	Japan Meteorological Agency
NCDC	National Climatic Data Center (USA)
NIWA	New Zealand National Institute of Water and Atmospheric Research Ltd.
NMHS	National Meteorological and Hydrological Service
NMSs	National Meteorological or Hydrometeorological Services
NOAA	National Oceanic and Atmospheric Administration
NTF	National Tidal Facility
P-HYCOS	Pacific - Hydrological Cycle Observing System
PIC	Pacific Island Country
PICCAP	Pacific Islands Climate Change Assistance Programme
PMSNAP	Pacific Meteorological Services Needs Analysis Project
RBSN	Regional Basic Synoptic Network (WWW)
RCS	Reference Climatological Station
RSMC	Regional Specialised Meteorological Centre
SBSTA	Subsidiary Body for Scientific and Technological Advice (of UNFCCC/COP)
SIDS	Small Island Developing States

SOPAC	South Pacific Geoscience Commission
SPCZ	South Pacific Convergence Zone
SPREP	South Pacific Regional Environment Programme
TAO	Tropical Atmosphere Ocean (TOGA)
TOGA	Tropical Ocean Global Atmosphere (project of WCRP)
TOPEX	Ocean Topography Experiment
UN	United Nations
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
WB	World Bank
WCASP	World Climate Applications and Services Programme
WCDMP	World Climate Data and Monitoring Programme
WCIRP	World Climate Impacts and Response Strategies Programme
WCP	World Climate Programme
WCRP	World Climate Research Programme
WHYCOS	World Hydrological Cycle Observing System
WMO	World Meteorological Organization
WWW	World Weather Watch

LIST OF GCOS PUBLICATIONS*

GCOS-1 (WMO/TD-No. 493)	Report of the first session of the Joint Scientific and Technical Committee for GCOS (Geneva, Switzerland, April 13-15, 1992)
GCOS-2 (WMO/TD-No. 551)	Report of the second session of the Joint Scientific and Technical Committee for GCOS (Washington DC, USA, January 11-14, 1993)
GCOS-3 (WMO/TD-No. 590)	Report of the third session of the Joint Scientific and Technical Committee for GCOS (Abingdon, UK, November 1-3,1993)
GCOS-4 (WMO/TD-No. 637)	Report of the fourth session of the Joint Scientific and Technical Committee for GCOS (Hamburg, Germany, September 19-22, 1994)
GCOS-5 (WMO/TD-No. 639)	Report of the GCOS Data System Task Group (Offenbach, Germany, March 22-25, 1994)
GCOS-6 (WMO/TD-No. 640)	Report of the GCOS Atmospheric Observation Panel, first session (Hamburg, Germany, April 25-28, 1994)
GCOS-7 (WMO/TD No. 641)	Report of the GCOS Space-based Observation Task Group (Darmstadt, Germany, May 3-6, 1994)
GCOS-8 (WMO/TD No. 642) (UNEP/EAP.MR/94-9)	Report of the GCOS/GTOS Terrestrial Observation Panel, first session (Arlington, VA, USA, June 28-30, 1994)
GCOS-9 (WMO/TD-No. 643)	Report of the GCOS Working Group on Socio-economic Benefits, first session (Washington DC, USA, August 1-3, 1994)
GCOS-10 (WMO/TD-No. 666)	Summary of the GCOS Plan, Version 1.0, April 1995
GCOS-11 (WMO/TD-No. 673)	Report of the GCOS Data and Information Management Panel, first session (Washington DC, USA, February 7-10, 1995)
GCOS-12 (WMO/TD-No. 674)	The Socio-economic Benefits of Climate Forecasts: Literature Review and Recommendations (Report prepared by the GCOS Working Group on Socio-economic Benefits), April 1995
GCOS-13 (WMO/TD-No. 677)	GCOS Data and Information Management Plan, Version 1.0, April 1995
GCOS-14 (WMO/TD-No. 681)	Plan for the Global Climate Observing System (GCOS), Version 1.0, May 1995
GCOS-15 (WMO/TD-No. 684)	GCOS Plan for Space-based Observations, Version 1.0, June 1995
GCOS-16 (WMO/TD-No. 685)	GCOS Guide to Satellite Instruments for Climate, June 1995
GCOS-17 (WMO/TD-No. 696)	Report of the GCOS Atmospheric Observation Panel, second session (Tokyo, Japan, March 20-23, 1995)

*GCOS publications may be accessed through the GCOS World Wide Web site at:
http://www.wmo.ch/web/gcos/gcoshome.html

GCOS-18 (WMO/TD-No. 697) (UNEP/EAP.MR/95-10)	Report of the GCOS/GTOS Terrestrial Observation Panel, second session (London, UK, April 19-21, 1995)
GCOS-19 (WMO/TD-No. 709)	Report of the GCOS Data Centre Implementation/Co-ordination Meeting (Offenbach, Germany, June 27-29, 1995)
GCOS-20 (WMO/TD-No. 720)	GCOS Observation Programme for Atmospheric Constituents: Background, Status and Action Plan, September 1995
GCOS-21 (WMO/TD-No. 721) (UNEP/EAP.TR/95-07)	GCOS/GTOS Plan for Terrestrial Climate-related Observations, version 1.0, November 1995
GCOS-22 (WMO/TD-No. 722)	Report of the fifth session of the Joint Scientific and Technical Committee for GCOS (Hakone, Japan, October 16-19, 1995)
GCOS-23 (WMO/TD-No. 754) (UNEP/DEIA/MR.96-6) (FAO GTOS-1)	Report of the GCOS/GTOS Terrestrial Observation Panel for Climate, third session (Cape Town, South Africa, March 19-22, 1996)
GCOS-24 (WMO/TD-No. 768) (UNESCO/IOC)	Report of the Joint GCOS/GOOS/WCRP Ocean Observations Panel for Climate, first session (Miami, Florida, USA, March 25-27, 1996)
GCOS-25 (WMO/TD-No. 765) (UNEP/DEIA/MR.96-5)	Report of the GCOS Data and Information Management Panel, second session (Ottawa, Ontario, Canada, May 14-17, 1996)
GCOS-26 (WMO/TD-No. 766)	Report of the Joint CCl/CBS Expert Meeting on the GCOS Surface Network (Norwich, UK, March 25-27, 1996)
GCOS-27 (WMO/TD-No. 772) (UNEP/DEIA/MR.96-7)	Report of the Expert Meeting on Hydrological Data for Global Observing Systems (Geneva, Switzerland, April 29-May 1, 1996)
GCOS-28 (WMO/TD-No. 793) (UNEP/DEIA/MR.97-3)	*In Situ* Observations for the Global Observing Systems (Geneva, Switzerland, September 10-13, 1996)
GCOS-29 (WMO/TD-No. 794) (UNEP/DEIA/MR.97-4)	Report of the Global Observing Systems Space Panel, second session (Geneva, Switzerland, October 16-18, 1996)
GCOS-30 (WMO/TD-No. 795)	Report of the sixth session of the Joint Scientific and Technical Committee for GCOS (Victoria, British Columbia, Canada, October 28-November 1, 1996)
GCOS-31 (WMO/TD-No. 803)	Proceedings of the fifth meeting of the TAO Implementation Panel (TIP-5) (Goa, India, November 18-21, 1996)
GCOS-32 (WMO/TD-No. 796)	GCOS/GTOS Plan for Terrestrial Climate-related Observations, version 2.0, June 1997

*GCOS publications may be accessed through the GCOS World Wide Web site at:
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GCOS-33 (WMO/TD-No. 798)	GHOST - Global Hierarchical Observing Strategy, March 1997
GCOS-34 (WMO/TD-No. 799)	Initial Selection of a GCOS Surface Network, February 1997
GCOS-35 (WMO/TD-No. 839)	Report of the second Joint CCl/CBS Meeting on the GCOS Surface Network (De Bilt, The Netherlands, June 25-27, 1997)
GCOS-36 (WMO/TD-No. 844) (UNESCO/IOC)	Report of the Joint GCOS/GOOS/WCRP Ocean Observations Panel for Climate, second session (Cape Town, South Africa, February 11-13, 1997)
GCOS-37 (WMO/TD-No. 845) (GOOS-10) & (GTOS-9)	Report of the Global Observing Systems Space Panel, third session (Paris, France, May 27-30, 1997)
GCOS-38 (WMO/TD-846) (GTOS-10)	Report of the Meeting of Experts on Ecological Networks (Guernica, Spain, June 17-20, 1997)
GCOS-39 (WMO/TD-No. 847) (GOOS-11) & (GTOS-11) (UNEP/DEIA/MR.97-8)	Report of the GCOS/GOOS/GTOS Joint Data and Information Management Panel, third session (Tokyo, Japan, July 15-18, 1997)
GCOS-40 (WMO/TD-No. 848)	Report of the GCOS/WCRP Atmospheric Observation Panel for Climate, third session (Reading, UK, August 19-22, 1997)
GCOS-41 (WMO/TD-No. 849) (GOOS-33)	Report of the Joint GCOS/GOOS/WCRP Ocean Observations Panel for Climate (OOPC) Ocean Climate Time-Series Workshop, (Baltimore, MD, USA, March 18-20, 1997)
GCOS-42 (WMO/TD-No. 857)	Report of the seventh session of the Joint Scientific and Technical Committee for GCOS (Eindhoven, The Netherlands, September 22-26, 1997)
GCOS-43a (GOOS-36)	TAO Implementation Panel, sixth session (Reading, U.K., November 4-6, 1997)
GCOS-43b (GOOS-55)	International Sea Level Workshop (Honolulu, Hawaii, USA, June 10-11, 1997)
GCOS-44 (GOOS-61)	Report of the Joint GCOS/GOOS/WCRP Ocean Observations Panel for Climate (OOPC), third session (Grasse, France, April 6-8, 1998)
GCOS-45 (WMO/TD-No. 922) (GOOS-58) & (GTOS-16) (UNEP/DEIA/MR.98-6)	Report of the Joint Meeting of the GCOS/WCRP Atmospheric Observation Panel for Climate and the GCOS/GOOS/GTOS Joint Data and Information Management Panel, fourth session (Honolulu, Hawaii, USA, April 28-May 1, 1998)
GCOS-46 (GTOS-15)	Report of the GCOS/GTOS Terrestrial Observation Panel for Climate, fourth session (Corvallis, USA, May 26-29, 1998)

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http://www.wmo.ch/web/gcos/gcoshome.html

GCOS-47 (WMO/TD-No. 941) (GOOS-67) (GTOS-20)	Report of the Global Observing Systems Space Panel, fourth session, (College Park, Maryland, USA, October 22-23, 1998)
GCOS-48	Report on the Adequacy of the Global Climate Observing Systems (United Nations Framework Convention on Climate Change, November 2-13 1998, Buenos Aires, Argentina)
GCOS-49 (GOOS-64)	Implementation of Global Ocean Observations for GOOS/GCOS, first session (Sydney, Australia, March 4-7, 1998)
GCOS-50 (GOOS-65)	Implementation of Global Ocean Observations for GOOS/GCOS, second session (Paris, France, November 30, 1998)
GCOS-51 (GOOS-66)	Global Ocean Observations for GOOS/GCOS: An Action Plan for Existing Bodies and Mechanisms
GCOS-52 (GOOS-68)	TAO Implementation Panel, 7th Session (Abidjan, Ivory Coast, November 11-13, 1998)
GCOS-53 (WMO/TD-No. 958)	GCOS Surface Network (GSN) Monitoring Centre Implementation Meeting (Offenbach, Germany, January 19-20, 1999)
GCOS-54 (WMO/TD-No. 953)	Report of the eighth session of the WMO-IOC-UNEP-ICSU Steering Committee for GCOS (Geneva, Switzerland, February 9-12, 1999)
GCOS-55	Report of the GCOS/WCRP Atmospheric Observation Panel for Climate (AOPC), fifth session (Silver Spring, MD, USA, April 20-23, 1999)
GCOS-56 (GOOS-75)	Special Report of the Joint GCOS/GOOS/WCRP Ocean Observations Panel for Climate (OOPC), fourth session (May 17, 1999); The CLIVAR Upper Ocean Panel (UOP), fourth session (May 21, 1999); A Joint Planning Meeting of the OOPC and the UOP for the OCEANOBS99 Conference (Woods Hole, MA, USA, May 18-20, 1999)
GCOS-57 (WMO/TD-No. 978) (GOOS-79)	Report of the OOPC/AOPC Workshop on Global Sea Surface Temperature Data Sets (Palisades, N.Y., USA, November 2-4, 1998)
GCOS-58 (GOOS-71**)**	Report of the 6th Session of the IOG Group of Experts on the Global Sea Level Climate Observing System (GLOSS)
GCOS-59 (GTOS-22)	Report of the GCOS/GTOS Terrestrial Observation Panel for Climate, fifth session (Birmingham, UK, July 27-30, 1999)
GCOS-60 (WMO/TD-No. 1004) (GOOS-70)	GCOS/GOOS/GTOS Joint Data and Information Management Plan, Version 1.0, May 2000
GCOS-61 (WMO/TD-No. 1031)	Report of the ninth session of the WMO-IOC-UNEP-ICSU Steering Committee for GCOS (Beijing, China, September 12-14, 2000)
GCOS-62 (WMO/TD-No. 1038)	Report of the Pacific Islands Regional Implementation Workshop on Improving Global Climate Observing Systems (Apia, Samoa, August 14-15, 2000

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