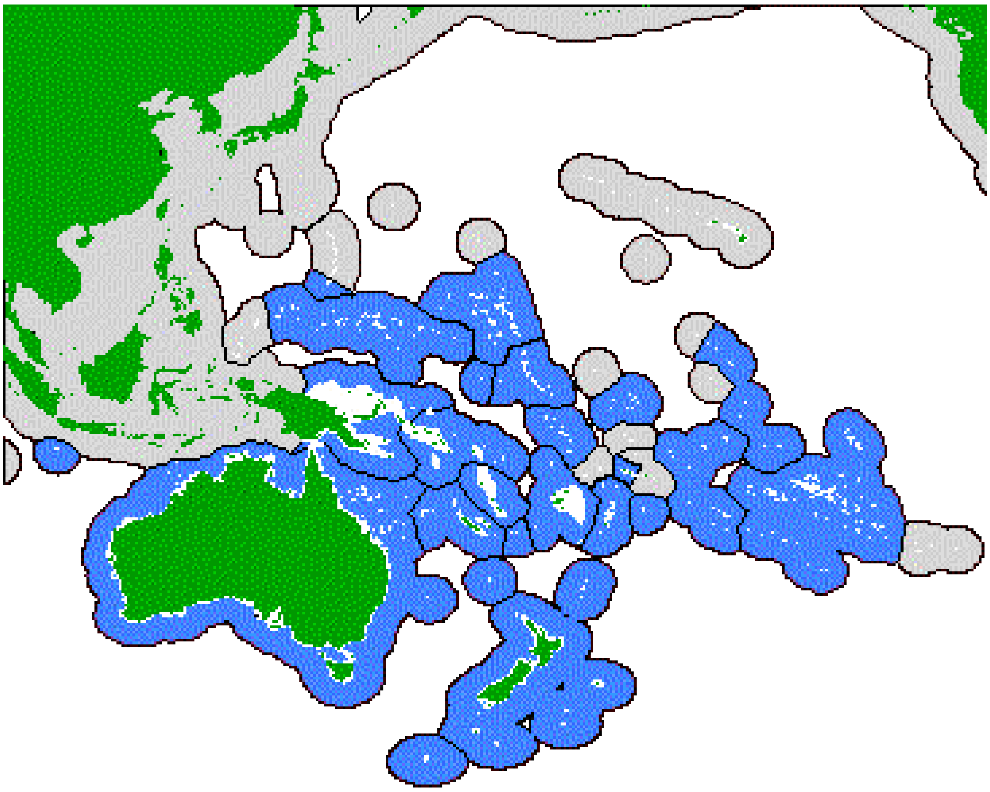
GLOBAL CLIMATE OBSERVING SYSTEM

SPREP
South Pacific Regional Environment Programme

PROE
Programme régional océanien de l'environnement



Pacific Island GCOS Action Plan

26 March 2002

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Foreword

Background

Long-term, high-quality observations of the global environmental system are essential for defining the current state of the Earth's system, and its past history and variability. This task requires both space- and surface-based observation systems. The term "climate observations" encompasses a broad range of environmental observations. These observations include the following elements

(1) Routine weather observations, which, collected over a long enough period, can be used to help describe the climatology of a region.

(2) Observations collected as part of research investigations to elucidate chemical, dynamical, biological, or radiative processes that contribute to maintaining climate patterns or to their variability.

(3) Highly precise, continuous observations of climate system variables collected for the express purpose of documenting long-term (decadal to centennial) change.

(4) Observations of climate proxies, collected to extend the instrumental climate record to remote regions and back in time to provide information on climate change for millennial and longer time scales.

Since 1998, Parties to the United Nations Framework Convention on Climate Change(UNFCCC) have noted with concern the mounting evidence of a decline in the global observing capability and have urged Parties to undertake programs of systematic observations and to strengthen their capability in the collection, exchange, and utilisation of environmental data and information. It has long been recognised that the range of global observations needed to understand and monitor Earth processes contributing to climate and to assess the impact of human activities cannot be satisfied by a single program, agency, or country.

What is GCOS?

The Global Climate Observing System (GCOS) was established in 1992 to ensure that the observations and information needed to address climate-related issues are obtained and made available to all potential users. While the GCOS Secretariat is housed at the World Meteorological Organisation (WMO), it is not a solely meteorological endeavour and it is in fact co-sponsored by three other organisations in addition to the WMO. These are the (a) Intergovernmental Oceanographic Commission (IOC) of UNESCO; (b) United Nations Environment Programme (UNEP); and (c) International Council for Science (ICSU). Therefore, GCOS is intended to be a long-term, user-driven operational system capable of providing comprehensive observations across domains that are required for monitoring the climate system. The applications associated with this involve the detection and attribution of climate change, for assessing the impacts of climate variability and change, and for supporting research toward improved understanding, modelling and prediction of the global climate system. It should be important to note that there has to be close consultation and collaboration among the various organisation and programmes.

GCOS addresses the total climate system across a number of scientific disciplines including physical, chemical and biological properties, and atmospheric, oceanic, hydrologic, cryospheric and terrestrial processes. While it neither makes direct observations nor generates data products, its purpose is to stimulate, encourage, coordinate and otherwise facilitate the taking of the needed observations by national or international organisations in support of their own requirements as well as of common goals. It provides an operational framework for integrating, and enhancing as needed, the observational systems of participating countries and organisations into a comprehensive system focussed on the requirements for climate issues. GCOS builds upon, and works in partnership with, other existing and developing observing systems such as the Global Ocean Observing System, the Global Terrestrial Observing System, and the Global Atmospheric Watch network of observatories.

GCOS focuses on *in-situ* measurements as satellite observations alone are not sufficient for the total global climate picture. Satellite observations require *in-situ* measurements for calibration and validation, and i*n-situ* observations are required for the measurement of parameters that cannot be estimated from space platforms (e.g., biodiversity, groundwater, carbon sequestration at the root zone, and subsurface ocean parameters). These *in-situ* measurements also provide long time series of observations required for the detection and diagnosis of global change. These parameters include surface temperature, precipitation and water resources, weather and other natural hazards, the emission or discharge of pollutants, and the impacts of multiple stresses on the environment due to human and natural causes.

Why a Pacific Island GCOS (PI-GCOS) Action Plan?

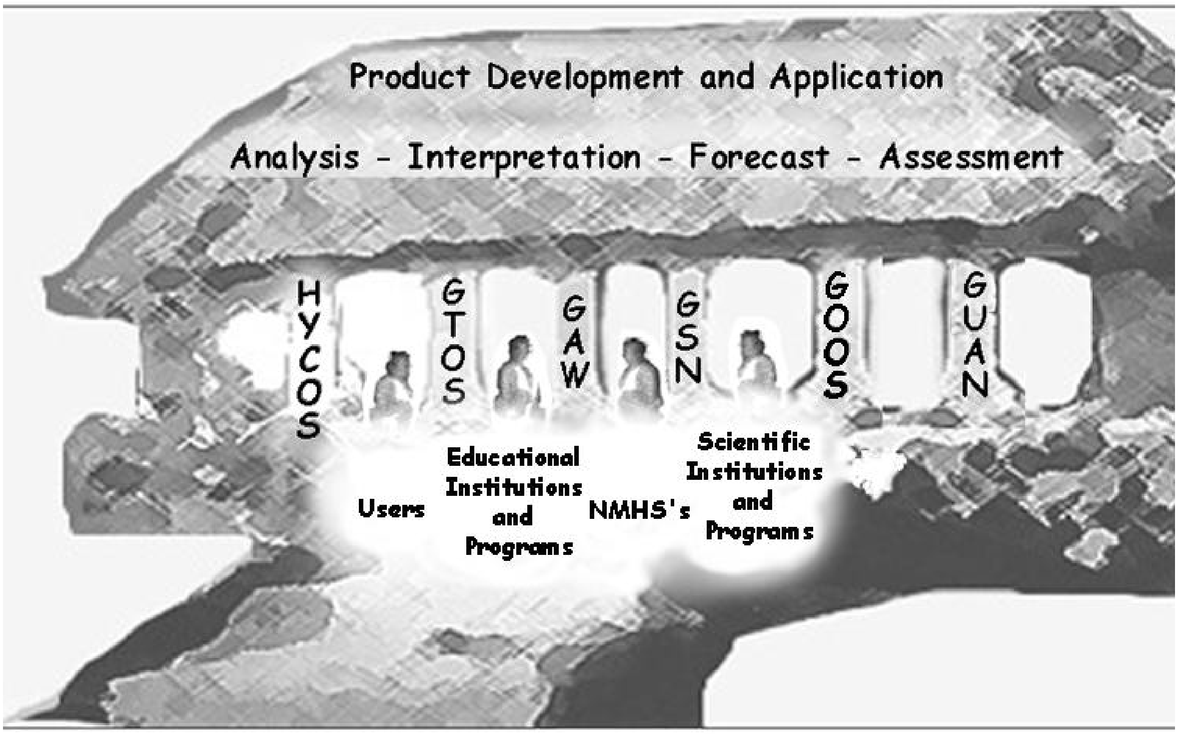
In 1999, the UNFCCC, noted with concern the report made by Professor Bert Bolin, in "The Report to the Seventh Session of the Subsidiary Body for Scientific and Technical Advice on behalf of the IPCC", October 1997; in that report he stated that "*The current global observational network is declining. If this decline is not stopped we may, say, twenty years from now, be in a worse situation than today, when trying to determine to what extent and how climate is changing. We will have less capability of clarifying to what extent an ongoing climate change might be the result of human activities or be an expression of natural variability in the climate system. A continuous close observation of the climate system is an absolute requirement for dealing adequately with the climate issue*."

In response to this recognised decline in observing networks, the UNFCCC directed the GCOS secretariat to begin staging a series of regional workshops for developing nations in order to see what actions could be taken to stem the decline. The first such regional workshop was conducted in August 2000 in Apia, Samoa. That workshop was jointly organised by GCOS and the South Pacific Regional Environment Programme. An important outcome of the Apia workshop was a formal resolution in which participants agreed to develop a Pacific Island GCOS Regional Action Plan to address priority climate observing system needs for the region that included not only atmospheric observations, but also the vital oceanographic and terrestrial components that comprise GCOS. The intent of this action plan is to frame the goal and objectives for an improved Pacific GCOS. It sets the stage and develops a roadmap for the newly formed Pacific Island GCOS Working Group to use with a set of five specific objectives that include actions, projects, improvements, and the identification of resources that should lead to an improved GCOS system in the Pacific.

How Does P-GCOS Fits in with Previous Regional Observing Planning?

Due to some very good planning on the part of SPREP related to meteorological observations, the Pacific region, unlike other developing regions, has developed an excellent framework that should allow GCOS to become a robust and sustainable system. Key among these planning efforts are the *Strategic Action Plan for the Development of Meterology in the Pacific Region for 2000-2009* (SPREP, 1999) and *The Needs Analysis Final Re*port (Krishna et al., 2001) that was commissioned by SPREP in early 2000. The Krishna report, termed PMSNAP, forms part of SPREP's initiative to identify the requirements of the National Meteorological Services (NMS) of twenty Pacific Island SPREP member countries and territories, and, amongst other assessments, recommend projects for aid consideration. The central goal of the PMSNAP project was to support continued strengthening of the capability of NMSs in the Pacific region to meet growing public demand for improved weather and climate services and products.

While this Pacific Island GCOS Action Plan draws heavily on those important planning documents, as stated earlier atmospheric or meteorological observations alone form only one part of the overall GCOS Fale.



PI-GCOS Fale. Joint Exploration and Shared Problem SolvingToward Sustainable Development.

The previous regional planning will go a long way to achieving the goal of an improved regional GCOS by outlining specific projects (with accompanying resource requirements) that can be presented to funding agencies for action. However, while the oceanographic and terrestrial elements of GCOS are less developed in the region, this action plan includes activities and elements that not only recognise their importance, but allow them to get wider review across the region and involve other parts of national governments, as well as other CROP organisations such as SOPAC in the overall Pacific GCOS planning process.

It must be recognised that while regional organisations such as SPREP and SOPAC, as well as global organisations such as the UNFCCC and the various G^3OS have been involved in the planning for GCOS, that the ownership of the component systems is the purview of the various national governments. This is evidenced by the call for national GCOS status reports by the UNFCCC that need to be fully coordinated throughout the governments. Meteorological agencies alone cannot be expected to carry the burden of fostering an improved GCOS. It is vital that linkages within each government's oceanographic and terrestrial focal points be made. In addition there must be a strong linkage between the national GCOS focal points and the policy makers of their national governments in order for the importance of climate observing to socio-economic applications (e.g., sea-level rise, severe weather, water quality) to be more fully realised. The policy makers are usually in control of the necessary resources that can help to improve GCOS and they should thus be made knowledgeable of the importance that climate observing issues have on higher-level policy issues within the various governments. An improved Pacific GCOS will have great benefits to each national government's environmental planning process, the overall well being of the Pacific region, and ultimately to the better understanding of the global climate system.

Executive Summary

1. This draft Pacific Island GCOS Action Plan (PI-GCOS) was prepared by the PI-GCOS Action Plan Writing Group during its meeting in Auckland, New Zealand, from 26-28 February 2002 in response to a recommendation from the Pacific GCOS expert working group meeting held in Honolulu, Hawaii in October 2001. The Pacific IslandGCOS Plan Writing Group was requested to:

- Identify GCOS requirements in the region and outline an approach to address these needs in a short strategy document;
- Provide progress into an expanded Pacific Island GCOS Working Group. This group will commence its work in March 2002 by the preparation of a Pacifi Island GCOS implementation plan in time for the input by the GCOS secretariat to the UNFCCC SBSTA for consideration at its sixteenth session.

This draft Pacific GCOS Action Plan a living document. Further input from all Pacific Island GCOS partners is required to further enhance the development of the Plan particularly on means of implementation, a task being allocated to the expanded Pacific GCOS Implementation Working Group.

2. The goal of the action plan is to establish a robust and sustainable PI-GCOS that meets the long-terms climate observation needs of the region and the world. The following objectives have been identified around which to projects and activities can be established and implemented in the action plan.

2.1 To continually advocate the importance of GCOS observing systems to policy applications on the part of national governments and other interested users (e.g. social, cultural and economic implications).

2.2 To fully support and operate ALL identified GCOS stations (e.g. GSN, GTOS, GUAN, etc.) in the region by 2005 and according to best practices by 2008.

2.3 To work with the AOPC to re-examine the spatial-distribution, criteria and coverage of GSN and GUAN stations in the region by 2003 and adjust the networks as appropriate by 2005.

2.4 To respond to the September 1999 WMO request for the provision of historical GSN and GUAN (when requested), metadata and data by 2003, and to rescue all existing climate data for the region by 2005 fully archive quality controlled climate data in digital form for the Pacific region by 2008.

2.5 To establish a permanent GCOS infrastructure by the end of 2002 with professional capacity within the region as appropriate (e.g. National GCOS Coordinator, Regional or National Climate Centres, etc)

3. In response to the recognized decline in observing networks that originally led to the first GCOS regional workshop in Apia in August 2000, all participants in the region have agreed that the development of a Pacific Island GCOS Regional Action Plan is required. This plan is intended to point the way for a comprehensive PI-GCOS that addresses the priority climate observing system needs for the region that include the atmospheric, oceanographic, and terrestrial components that comprise P-GCOS. The audience for this action plan is initially for the Pacific Island Regional GCOS Implementation Team (PIRGIT). The PIRGIT may choose to take some of the ideas in this action plan and transform them into some scaled down pilot projects and risk reduction exercises in

order to demonstrate some immediate successes, but it is not the intent of this plan to limit how the PIRGIT decides to address implementation issues.

4. The intent of this action plan is to frame the main goal and five objectives for an improved PI-GCOS that have been identified by the Pacific Island GCOS Working Group writing team in meetings in Honolulu in October 2001 and in Auckland in February 2002. In addition to the core GCOS systems themselves, this plan recognises the key roles played by data management, telecommunications, training and education, and infrastructure. By their nature, these elements are of an integrated and multi-sectoral nature and require good coordination across various GCOS domains in the region.

5. The P-GCOS action plan is outlined in section 9, with relevant developed projects to PI-GCOS in Appendix 2. The action plan has identified activities and developed projects. The latter have been derived from the Needs Analysis for the Strengthening of Pacific Islands Meteorological Services (Krishna et al., 2001), the Hydrological Cycle Observing System for the Pacific Island Countries (WMO, May 2000) and the hydrological training needs for small island states identified by SOPAC (2001). There are also proposed projects that will require development.

6. Other sections contain background and rationale and a summary of previous analysis of climate systems in the Pacific. The Report gives background and discussion on the core systems (GSN, GUAN, GOOS and GTOS). Later sections are on cross cutting issues: data management, communications, infrastructure for P-GCOS, training, education and capacity building.

7. This action plan is now for the Pacific Island Regional GCOS Implementation Team (PIRGIT) to progress. This team has the responsibility through August 2002 for developing the actual implementation planning for the actions in this plan that are necessary to improve PI-GCOS. Other interested parties for this action-planning document include the GCOS Secretariat, the four international sponsors of GCOS, the Subsidiary Body for Scientific and Technological Advice to the UNFCCC, funding agencies such as the Global Environment Facility (GEF), and donor nations with a vested interest in moving towards a robust and sustainable PI-GCOS.

CONTENTS

Pacific Island GCOS Action Plan

1 Background and Purpose.

The Global Climate Observing System (GCOS) launched a regional workshop programme in 2000 at the request of the Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC). The overall aim of the programme is to assist countries in developing regions to improve their observing systems for climate. The first of ten planned workshops in developing regions was held in Apia, Samoa in August 2000 for the countries of the Pacific Island region. This workshop was jointly organized by GCOS and its partner in the region, the South Pacific Regional Environment Programme (SPREP). An important outcome of the Apia workshop was a formal resolution (Appendix 1) in which participants agreed to develop a Pacific GCOS Regional Action Plan to address priority climate observing system needs for the region. Workshop participants further agreed that SPREP would coordinate the development of the Action Plan.

SPREP organized as an initial follow-up activity to the Apia workshop at the East-West Center in Honolulu, Hawaii, in October 2001 a meeting to discuss how to proceed with the development of the Action Plan. The U.S. National Oceanic and Atmospheric Administration (NOAA) and the East West Center provided support for the meeting. During the 2-day meeting, the participants reviewed the outcome of the Apia workshop, identified elements that need to be part of an Action Plan, and planned the next steps toward its development and implementation. The meeting identified the outline of elements to be addressed in a Pacific Island GCOS Action Plan.

This report has arisen out of one of the key recommendations to draft an Action Plan. The purpose of it is to:

- Identify GCOS requirements in the region and outline an approach to address these needs in a short strategy document;
- Provide progress into an expanded Pacific Island GCOS Working Group. This group will commence its work in March 2002 by the preparation of a Pacific-GCOS implementation plan in time for the input by the GCOS secretariat to the UNFCCC SBSTA for consideration at its sixteenth session

Goal:

- To establish a robust and sustainable Pacific Island GCOS that meets the long-terms climate observation needs of the region and the world.

Objectives

- To continually advocate the importance of GCOS observing systems to policy applications on the part of national governments and other interested users (e.g. social, cultural and economic implications).
- To fully support and operate ALL identified GCOS stations (e.g. GSN, GTOS, GUAN, etc.) in the region by 2005 and according to best practices by 2008.
- To work with the AOPC to reexamine the spatial-distribution, criteria and coverage of GSN and GUAN stations in the region by 2003 and adjust the networks as appropriate by 2005.
- To respond to the September 1999 WMO request for the provision of historical GSN and GUAN (when requested), metadata and data by 2003, and to rescue all existing climate data

for the region by 2005 fully archive quality controlled climate data in digital form for the Pacific region by 2008.

- To establish a permanent GCOS infrastructure by the end of 2002 with professional capacity within the region as appropriate (e.g. National GCOS Coordinator, Regional or National Climate Centers, etc)

2 Rationale.

The Pacific Islands, occupying a vast area of mainly ocean (about 38 million km^2) experiences patterns of climate variability and change that are significant on both global and regional scales.

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. Major climatic anomalies occur both globally and regionally during El Niño and La Niña events. During an El Niño, the trade winds weaken. 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, whilst the central and eastern Pacific 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 feature, 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. Finally, observed trends and variability in the region show that mean island near-surface air temperatures increased by between 0.3 to 0.8 ^{o}C during the 20^{th} century.

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 trends and extremes of climate (cyclone-induced 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.

Therefore climate plays a vital and crucial role in the social, environmental and economic well-being of any country, and particularly in the South Pacific. Understanding and acquiring advanced warnings of impending climate change and variability can assist countries minimise the impacts due to these changes.

The key action area recommended by the Intergovernmental Panel on Climate Change (Albritton et al.,2001) was to reverse the decline of observation networks in many parts of the world, and sustain and expand the observational foundation for climate studies by providing accurate, long-term, consistent data including implementation of a strategy for integrated global observations.

Strengthening the GCOS capacity will accomplish these and provide the necessary data and capacity for the preparation of advanced warnings. These will greatly assist Pacific Islands in meeting their social, environmental and economic needs. An improved Pacific GCOS system provides the ability to prepare for and minimize impacts on the social, environmental and economic sectors that are vital to achieving sustainable development. Climate data are needed to support the development and application of a variety of climate information products and services in the Pacific region, including:

- Seasonal-to-Interannual forecasts and other aspects of climate variability;
- Derived products;
- Climate change monitoring;
- Climate change assessment;
- Climate variability;
- Enhanced information on extreme events;
- Indicators of environmental quality and vulnerability;
- Advice to governments (e.g., on sustainable development and support for international obligations);
- Information to assist industry and communities address the consequences of climate variability and change.

3 Previous Analysis.

Four earlier studies in the last decade have been made on assessing resources, climate monitoring and the needs of strengthening of various aspects of the climate observing system in the Pacific Islands (Basher et al., 1990; Brook et al., 1991; WMO/SPREP/BoM 1999., Krishna et al., 2001). Hence the work on assessments should be limited and translated into action plans in preparation for implementation.

The first report (Basher et al., 1990) provided a useful appendix of where larger data sources for South Pacific climate data are held (New Zealand, Australia, Fiji, French Polynesia, New Caledonia) and made several important recommendations including:

1. Quality upgrading of past climate data for the region should be continued;
2. Current quality assurance procedures used in the region should be reviewed to ensure that data required for climate research are obtained with a suitably high quality and high reliability;
3. Existing support by developed countries for climate data collection in the Pacific islands, instrument supply and calibration, personnel training, and data archiving, should be maintained and, where necessary, strengthened;
4. A regional network of Reference Climate Stations, based on existing quality stations with long records, and operating to specific higher standards, should be established;
5. Steps should be taken by countries in the region to integrate climate data resources useful for climate change research. It was suggested that New Zealand undertake to provide a regional archive to facilitate this.

The report of Brook et al (1991) examined, amongst other aspects, climate monitoring in fifteen independent states in the South Pacific region. One of the three goals of this study was to determine the requirements for strengthening the capacity of countries in the region to monitor climate. It recognized that in 1991 only one or two nations have enough resources to become fully self-sufficient. Most countries, to a significant degree, rely on aid and cooperative programs. These are bilateral, multilateral and regional with donors from individual countries, groupings of countries or international organizations. It was concluded that the climate monitoring was barely sufficient in 1991 to maintain a level of meteorological observations for climate purposes, and that these fell short of meeting long-term requirements. The needs identified are regional, operational and strategic in nature and ongoing in type. The long-term maintenance of systems, supply of consumables and operational activities are often not included in aid projects. During the latter part of the 20th century there has been strong international support for climate services in the region particularly by New Zealand, Australia, the United States, France and the United Kingdom. This support has historical origins dating back to colonial times. The long-term commitment in some cases has now become fragile which has put the climate observing systems in jeopardy. The report noted that institutional support from WMO, UNDP, UNEP, SPREP and others from EEC and Japan was of variable quality and effectiveness.

A number of projects were recommended to develop climate monitoring: climate monitoring, climate data management, climate data and analysis and infrastructure support for climate monitoring. The first function, climate monitoring, required upgrading and replacement of basic instrumentation, upgrading of telecommunications facilities and assistance with maintenance of services and staff training. In some countries basic climate monitoring network has been badly resourced for many years resulting in significant deficiencies in the climate record. Climate data management was found to be very undeveloped, with a traditional reliance on outside agencies to assist in this activity. Climate data analysis and applications follows on from the first two activities, and development of knowledge and techniques is required to make use of the climate information. Human resource development is required for this aspect.

The Brooks et al (1991) report concluded that the climate monitoring networks are only marginally adequate because of physical limitation on available sites in this oceanic region and inability of local meteorological services to maintain the quality of data over many years. They concluded that the monitoring system is minimal to requirements and is in jeopardy of failing. The study also identified deficiencies in the provision of climate data management and analysis services by the national meteorological services. The critical long-term issue is to maintain adequate climate monitoring.

The third report (WMO/SPREP/BoM., 1999) was a strategic action plan for the development of meteorology in the Pacific region for decade 2000. This identified that Pacific Island Meteorological Services collected basic data for climate monitoring but that climate services were generally poorly developed or nonexistent. In many instances, these countries relied on external support to provide basic climatological services. Infrastructure was variable. Needs were growing in various countries for the provision of climate services. In the areas of concern to GCOS, strategies were proposed for meteorological observing systems, telecommunications, infrastructure, climate, climate and hydrological applications, technology transfer and capacity building. A needs analysis was proposed which was implemented and resulted in the fourth publication.

The final report (Krishna et al., 2001) was commissioned by SPREP in early 2000, termed PMSNAP, forms part of SPREP's initiative to identify the requirements of the National Meteorological Services (NMSs) of twenty Pacific Island SPERP member countries and territories, and, amongst other assessments, recommend projects for aid consideration. The central goal of the PMSNAP project was to support continued strengthening of the capability of NMSs in the Pacific region to meet growing public demand for improved weather and climate services and products.

All the countries surveyed have a NMS. In the post-colonial era, as countries gained independence, most took over full management responsibilities for managing climate observing systems. However France and the United States continue to provide assistance to some islands and territories. The realignment of resources in response to poor economic performance reduction in the 1990s has led to a serious decline in standards, communications and services. The report included 21 national country reports with detailed information. These all clearly highlight that local climate observing systems are certainly failing badly. One of the two clear common priority areas of need that emerged for all countries was seasonal and climate prediction services, especially for drought. The identified areas of investment of funding in climate that is expected to provide the greatest returns were:

1. Climate observational networks;

2. Telecommunications networks; and
3. Physical infrastructure and institutional strengthening.

Five key regional projects have been recommended for implementation. Those pertaining to GCOS are:

1. Strengthening observing systems ($US 19 million);
2. Strengthening telecommunications networks ($US 6 million);
3. Climate data management, analysis and application ($US 1 million); and
4. Institutional strengthening including infrastructure support ($US 7 million).

The projects identified are aimed at assisting NMSs to further strengthen their capacities to fulfil, amongst other obligations, national GCOS requirements. The projects recommended are both short-term, to ensure basic systems are sustained, and long-term to reinforce and develop the benefits obtained from short-term assistance. The report did note that there had been a significant improvement in some services, although the climate observing system has not improved and is still in a parlous state.

This current short strategic report builds on the four previous assessments and need analyses. It will highlight the regional GCOS requirements and outline an approach to address these needs. This report will be used to provide progress into an expanded Pacific GCOS Working Group, which commences its work in March 2002 for the input by GCOS into the sixteenth session of the UNFCCC SBSTA by April 2002.

4 Core Systems.

4.1 GCOS Surface Network.

4.1.1 Introduction

One of the key components of GCOS is the GCOS Surface Network (GSN). The network currently consists of 989 surface observation stations worldwide and is designed to provide sufficient data to detect the global and hemispheric patterns of temperature and atmospheric circulation changes at the surface. The initial selection of the stations included in the GSN is described by Peterson et al. (1997).

Despite progress in the development of the GSN, concerns remain over the adequacy of the existing meteorological observation networks to satisfy the needs of GCOS. An urgent commitment is required to halt and reverse the decline of existing observation systems and to exchange information more effectively (GCOS 1998).

4.1.2 Assessment of current state

Current network

SPREP (2001) reported that the existing meteorological observation systems in the Pacific are primarily for weather and warning purposes. Those climate observation systems that do exist are generally for short-term research purposes, rather than long-term climate monitoring. Nevertheless, these existing meteorological observations stations in the Pacific must form the basis on which the GSN is built.

This report is based on the official GSN station list found on the GCOS website: http://www.wmo.ch/web/gcos/gsnlist.htm. According to this list there are currently 46 GSNs being operated by Pacific Island Countries and Territories. The names, WMO numbers and co-ordinates of these stations are listed in Appendix 3. Ten Pacific GSN stations are yet to be approved for GSN status by the respective Permanent Representative.

Despite 46 stations being named on the current GSN list, some sources (eg. SPREP 2001) identify 48 or 50 stations being operated by the members of SPREP. This suggests that there are outdated lists of GSN stations in circulation and reflects poor communication on the status of the network. It is appropriate that the list on the GSN website be regarded as the official list. Any inaccuracies in this list should be corrected to allow meaningful performance assessments to be undertaken. DWD and JMA (2001) suggest that some of the apparent non-reporting of expected CLIMAT messages could be due to out of date station details.

Given the global density of the GSN, the Pacific GSN stations give a reasonable coverage of the region. However, some remote ocean parts are poorly sampled. Given the difficulties with access to these regions it is likely to be some time before these regions have observation stations suitable for inclusion in the GSN.

Comparison against GSN best practices

SPREP (2001) assessed the current Pacific GSN stations against the climate monitoring principles defined by Karl et al. (1995). These are listed in Appendix 2. Generally the monitoring principles are poorly met by the Pacific GSNs. Some of the most significant findings of the SPREP report include a lack of comparison observations for changes in site location and instrumentation, poorly recorded metadata, lack of homogeneity assessments, equipment being provided on an ad-hoc basis rather than part of a long-term plan, and little co-ordination at a regional level.

The Atmospheric Observation Panel for Climate (AOPC) defined the requirements for meteorological observations for GCOS (WMO 1981). Pacific GSN stations are assessed against these "best practices" below.

(1) transmitting monthly CLIMAT messages on the Global Telecommunications System (GTS) in an accurate and timely manner

CLIMAT messages are required to be exchanged internationally in the new code format. The GSN monitoring centres in the Deutscher Wetterdienst (DWD) and Japan Meteorological Agency (JMA) are routinely monitoring the performance of the GSN by assessing the availability, timeliness, completeness and correctness of CLIMAT reports collected from the GTS.

The latest published GSN Monitoring Report (DWD and JMA, 2001) for the period January to June 2001 indicates that only 20% of Pacific Island GSN stations reported the six expected monthly CLIMAT messages in the correct format over this period. Another 30% of stations reported some of the messages correctly with the remaining 50% reporting none of the six expected messages correctly. The status of the CLIMAT messages received for each of the Pacific GSN stations is summarised in Appendix 5.

Some of these non-reports are likely to be due to out of date information on CLIMAT reporting stations in WMO Volume A, and some countries not reporting in the “new” CLIMAT format. SPREP (2001) suggests more fundamental reasons for these results, such as a lack of ongoing financial support for equipment and infrastructure, and inadequate training and capacity building.

(2) carefully archiving observational and related metadata (i.e. station history information) in the country of origin in both the original and digital forms

All Pacific countries archive climate data within their own country or arrange for it to be archived elsewhere. However, metadata is not routinely archived (SPREP 2001).

(3) providing up-to-date digital copy of the historical climate data and metadata to the designated GSN data depository

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. So far data for only 8 of the 46 Pacific GSN stations has been submitted. SPREP (2001) lists the reasons for this as lack of personnel and resources. Onerous data formats may also be preventing compliance. The procedures and data format to use in providing this data can be found at: http://www.eis.noaa.gov/gcos/gsn_format/gcos_dfsd.pdf.

(4) establishing a period of overlap when there are significant changes in sensor devices or station location

According to SPREP (2001) this is generally not done throughout the Pacific Islands due to a lack of available instrumentation.

(5) accompanying installation of automatic instrumentation with accurate calibration and intercomparison tests

This is generally not done despite the number of AWSs gradually increasing throughout the Pacific GSN network. Of particular concern is the increasing number of AWS-only sites where no manual back-up is provided. AWS-only stations are often noted as being the poorest performing stations in terms of data continuity.

4.1.3 Strategies to address critical deficiencies

The above discussion identifies many deficiencies relating to the operation of GSN stations in the Pacific. Several of these are regarded as being critical:

Discrepancies in network details
Poor data exchange nationally and internationally
Lack of data quality control procedures
Inadequate training
Metadata not routinely archived
Lack of parallel observation programs for site moves and instrument changes
Increasing numbers of AWS-only stations
Few countries providing historical data and metadata for GSN database
Few countries submitting GCOS National Reports

Activities and projects to address these critical deficiencies are outlined in Section 9.

4.1.4 Strategies for long-term sustainability

The long-term sustainability of the Pacific GSN network depends not only addressing the critical deficiencies but also changing the culture of NMSs and governments in the region to recognise the needs of the GSN. SPREP (2001) reported that many Pacific governments have resorted to re-directing assistance funding to other critical areas such as health and education. However, GSN needs should not be seen as being in competition with other development needs, rather as an essential component of sustainable development. Possible strategies for achieving long-term sustainability of the GSN include:

Raise GSN profile within NMSs and governments
Increase co-ordination within region
Increase feedback to station operators
Maximise use of assistance funding
Site security

4.1.5 Summary

Several significant deficiencies associated with the Pacific Island GSN stations have been identified. Very few, if any, of these stations are currently meeting the defined best practices for the network. A number of potential activities have been proposed to address these deficiencies. Many of these will only be achieved over a long period of time. However, there are a number of activities that could be implemented relatively quickly, to at least start addressing some of the needs of the GSN in the region such as each NMS reviewing the GSN stations it operates and completing as much as possible of the national GCOS reports.

4.2 GCOS Upper Air Network.

4.2.1 Introduction

The GCOS Upper-Air Network (GUAN) consists of approximately 150 upper-air stations selected from the Global Observing System of the World Weather Watch. The purpose of the network is to ensure a relatively homogenous distribution of upper-air stations suitable for detecting patterns of climate change in the upper atmosphere. The selection criteria for stations in the network included location, and the length and quality of historical records.

4.2.2 Assessment of current state

Current network

There are several different versions of the GUAN station list in circulation. This report is based on the official GUAN station list at http://www.wmo.ch/web/gcos/guanstationslist.htm. According to this list there are currently 15 GUAN stations being operated by Pacific Island Countries and Territories. The names, WMO numbers and co-ordinates of these stations are listed in Appendix 1. All but one of these stations (Bauerfield Airport) are co-located with GSN stations.

Given the overall density of the GUAN, the current Pacific GUAN stations provide a reasonable coverage of the region. However, this coverage would be compromised by any reduction in station numbers. Some data voids could be filled using existing upper-air stations. However, the lack of inhabited land with sufficient infrastructure means that there are few options for filling some voids in remote ocean parts.

Comparison against GUAN best practices

The Atmospheric Observation Panel for Climate (AOPC) defined the requirements for meteorological observations for the GUAN (WMO 1981). Pacific GUAN stations are assessed against these "best practices" below.

(1) Long-term continuity - minimal changes, parallel observations for significant changes

The long-term continuity of upper-air stations in the Pacific is compromised by the lack of a permanent source of reliable funding. As for the GSN, parallel observation programs are generally not undertaken for changes in instrumentation (SPREP 2001).

(2) Soundings made twice per day and reach height of 5hPa

Upper-air stations that remain open are gradually reducing their observation programs (SPREP 2001). Very few perform two sounding per day. Traditional 350g weather balloons tend to burst between the atmospheric levels of 25hPa and 15hPa, lower than the required height of 5hPa. To increase the height achieved at GUAN stations 800g balloons need to be introduced to the network. Most Pacific stations currently use the smaller balloons due to cost constraints.

(3) CLIMAT TEMP data provided in an accurate and timely manner

The latest available analyses of GUAN performance by the Hadley Centre (http://www.metoffice.gov.uk/research/hadleycentre/guan/repmap.html) indicate that during the period March to August 2001 only 8 of the 15 Pacific GUAN stations provided the expected monthly CLIMAT TEMP messages correctly. Another one provided some of the messages correctly but 6 stations provided none of the expected messages. These results are summarised in Appendix 2, along with reasons for the non-reports. Nearly all stations reported either 0% or 100% of expected messages suggesting that the non-reporting stations were closed during the period, rather than having communication difficulties.

(4) Rigorous quality control - periodic calibration, validation and maintenance

Limited checks are performed on-site. At some sites this is due to a lack of training, at others upper-air data is not archived locally and hence quality control is seen as a low priority. However, for those stations exchanging data via the GTS, the GCOS Upper-Air Data Analysis Centres located in the Hadley Centre and NCDC undertake quality checking of the data before it is archived. Inspection and maintenance costs are generally prohibitive for Pacific NMSs, causing them to rely on external funding.

(5) Basic checks made before each sounding - errors corrected before transmission

Generally data from Pacific GUAN stations undergoes only limited checks due to lack of training.

(6) Back-up radiosondes released in cases of failure

The high costs of equipment means that generally a second flight is not performed after a failure.

(7) Detailed metadata for each GUAN station provided

As for the GSN, detailed metadata is currently not archived routinely (SPREP 2001).

4.2.3 Strategies to address critical deficiencies

The above discussion identifies some deficiencies relating to the operation of GUAN stations in the Pacific. Several of these can be regarded as being critical and some proposals to address these critical deficiencies are outlined below.

Station closures and downgrading of observation programs
Poor data exchange nationally and internationally
Inadequate quality checking and maintenance
Metadata not routinely archived

4.2.4 Strategies for long-term sustainability

The long-term sustainability of the Pacific GUAN network depends on addressing the critical deficiencies described above. However, the single greatest issue in doing this seems to be identifying a source of reliable, ongoing funding.

4.2.5 Summary

Many deficiencies have been identified in the current operation of Pacific Island GUAN stations. Very few, if any, are currently meeting the defined best practices for the network. Of particular concern are station closures and the gradual downgrading of observation schedules. The highest priority for the Pacific GUAN stations should be to arrest this decline through the identification of a reliable funding source. This needs to be achieved before considering how to meet best practices such as parallel observation programs for instrument changes and radiosonde flights that reach the 5hPa level.

4.3 Global Ocean Observing System

4.3.1 Background

This section focuses on the relevance of the ocean observing system to the Pacific region and the strategies that should 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 (GCOS). While the Decision of the Conference of the Parties that led to this Plan specifically refers to "participation in systematic observation", a broader view is adopted providing some guidance of how the ocean observing system can best be applied in the service of the Pacific Island region.

The fundamental issue is one of enabling participation and collaboration. The regional approach can not adopt, for example, that of 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 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. Also, per capita, the potential impact and importance of the ocean and climate on society, culture, the economy and even survival is much higher than elsewhere.

4.3.2 Rationale and Objectives

Unlike the atmospheric components of GCOS, the oceanographic components have a relatively short history and the rationale for investment is not driven by length and quality of records. Issues of climate and climate change are not always unravelled by time, but by improved understanding of processes and attention to the spatial gaps – climate change is a manifestly complicated four-dimensional process, not just a temporal phenomenon.

For the Pacific Island region, these actions are not for the basis of climate change and variability only. There are many other environmental and societal issues that can be addressed, at least in part, by the same observing networks that are supporting monitoring and detection of climate change and variability. Indeed it seems likely that, for oceanography at least, these rationales are of at least equal if not greater importance.

The strategy outlined here is founded on the belief that the potential of observing system applications and products should be exposed to the region as a whole and that their participation should be sought in decisions on prospective applications that are likely to yield long-term benefits for the region. There are thus two broad objectives that should be pursued.

1. Review potential applications of ocean observations that can be of benefit to the Pacific Islands. Applications include climate variability and extremes, seasonal-to-interannual climate forecasting, monitoring and predicting sea level change, operational ocean and marine services, assessment/prediction of the health of coral reefs, fisheries population modelling and management, water quality and management, coastal change, basic research in ocean variability and air-sea interaction, and secondary education.

2. Identify data product and timeliness requirements that are needed for each of these applications, and assess the extent to which these requirements are presently being met. In the case of needed improvements establish linkages between those who will develop the enhanced products and services, those who will routinely create them, and those who will use them.

This strategy is not unlike that developed for atmospheric observations in Sections 4.1 and 4.2. Both the surface and upper air networks were supported principally for numerical weather prediction but have since taken on key roles for climate monitoring. The above objectives embrace climate change but recognize that it is more efficient to seek a general solution and broad participation.

4.3.3 Key Climate Applications of Global Ocean Observing System initiatives

Seasonal-to-Interannual Climate Forecasts Seasonal forecasts are produced using coupled ocean/atmosphere models. The ocean is initialized from a previous forecast, but corrected using available surface and subsurface datasets. Successful forecasts are not possible without accurate initialization. Subsurface data from the ENSO Observing System (OS) (including the tropical moored buoy network, volunteer observing ships, surface drifters, and sea level gages) has been a critical element in observing ENSO evolution and in producing successful ENSO forecasts – because of the long time-scales of the ocean and the importance of equatorial ocean dynamics. Argo will expand the domain of subsurface temperature measurements and will add subsurface salinity—which has not been regularly measured until now—thus enabling an assessment of its impact on forecasts.

Sea-level Change Sea level in the Pacific islands is subject to large seasonal-to-inter-annual fluctuations due to ENSO and related variability as well as variations related to climate change. Typical island sea level anomalies are 10 - 20 cm, lasting for several months. Changes on time-scales from months to a decade or longer are dominated by water column temperature variability (thermal expansion). Understanding these changes is critical to addressing climate change on time scales from decades to a century or more. Since 20 cm is equivalent to 100 years of the present global sea level trend, the short-term variability is highly significant. When added to the slow sea level trend, faster variability becomes the direct cause of coastal inundation. Systematic collection of subsurface temperature and salinity will allow interpretation of the underlying causes of seasonal-to-decadal sea level variability, and hence of the long-term prospects for sea level rise.

Ocean and Marine Prediction The Pacific Islands and their Exclusive Economic Zones occupy a vast area of the Pacific Ocean. Sustainable development and management of exploitation and risk are important considerations for the region, and each is dependent to some extent upon access to ocean data and information. There are also common issues concerning marine biodiversity, regulation of shipping and transport, and safety—particularly for recreation and tourism. Access to timely ocean and marine products and forecasts is important.

A system for providing such products capable of meeting regional requirements but at the same time underpinning the needs of climate change is critical (the equivalent of “reanalyses for atmospheric climate). The creation of PacificGOOS is intended to provide the region with a mechanism for supporting the development of observing systems in the region and the complementary delivery systems for applications and products to the region’s user community.

Health of Coral Reefs Coral bleaching occurs when sea surface temperature is elevated above historical highs for a prolonged period—typically when the SST is warmer than the maximum monthly SST by 5-deg C weeks (that is, 1-deg C for 5 weeks or 5-deg C for 1 week). Satellite-derived SST observations are routinely used to provide a warning for those locations when bleaching is likely to occur. However, there is at present no capability to predict such events for the future (in advance of temperature rises) or to assess likely impacts of climate change.

There is some potential predictability to sustained high temperature patterns, strongly paralleling that associated with ENSO. Heat content of the water column and ocean circulation will both be important factors in characterizing broad-scale SST patterns and their evolution, and ocean observations will contribute to such a characterization.

Fisheries Population Monitoring and Modeling Long-term changes in fisheries, whether from anthropogenic climate change or long-term climate variability is of first order interest to the Pacific Island region. While the issue stretches beyond the remit of GCOS, at least some of the factors that are thought to be involved have a strong dependence on changes in the physical state and circulation of the ocean.

Recent advances in coupling ocean general circulation models to bio-geochemical models have enabled prediction of forage distribution for pelagic species such as tuna. In turn, forage distribution is a major factor in explaining the basin-scale distribution of fishing stock. To date, these models have relied on satellite and surface data sets, due to the lack of regular subsurface data. Availability of systematic ocean data presents an opportunity for advances in this area. In other research, subsurface temperature profiles together with population/temperature correlation data and catch statistics have been shown to produce improved estimates of billfish population distribution.

Oceanographic Research Just as the prototypical operational applications described above rest on results from past basic research, future gains in operational capability will be dependent on research carried out now. The World Climate Research Programme Climate Variability and Predictability (WCRP-CLIVAR) program will include comprehensive and sustained basin-wide observations of the ocean, built on a foundation that includes the ENSO Observing System and the International Argo Programme. Systematic measurements of the oceans will reveal previously unknown patterns and physical mechanisms of oceanic variability, leading to better understanding, modeling and prediction of climate variability in the future.

In addition to climate, the ocean observing system will also provide information on air-sea interaction on shorter time-scales. For example, Argo profiles collected in the path and the wake of tropical cyclones provide estimates of air-sea exchanges of heat, moisture, and momentum under extreme conditions—and new insight on how the ocean’s heat fuels the growth of tropical storms. Without basic research today, there can be no operational successes and economic gains tomorrow.

Advocacy through Education and Awareness In island communities, the ocean provides natural and vital opportunities for classroom study, enabling students to learn that science is inquiry into the workings of the real world, with value and relevance in everyday life. Relevance has been a serious issue in science curricula in the region. With the advent of information becoming available in near real-time for the world's oceans through initiatives such as ENSO OS, Argo, conditions in the Pacific can be related to variability in other oceans or on a global scale. A secondary education pilot program called SEREAD (Scientific Educational Resources and Experience Associated with the Deployment of Argo drifting floats), sponsored by among others UNESCO, SOPAC, IOC and managed by USP, is being developed to satisfy this need. With an initial focus on Argo floats and data, SEREAD can develop to include other elements of the observing system. SEREAD will assist in educating today's students and tomorrow's leaders on the important connections between the local island environment, the surrounding sea, and the global ocean.

4.3.4 Elements of the existing network

The most exciting time for Pacific Ocean oceanography is being witnessed, 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. These include:

- 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
- A global array of autonomous profiling floats (known as the International Argo Program (Argo)) returning about 3000 profiles of temperature and salinity every 10 days
- 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 drifters, 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 range of other remote and in situ measurements, which complement and compliment the above initiatives.

The role of the ocean observing system does not end with the measurement. The data and the knowledge of how to use it within the scope of the target user communities must be 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.

For the Pacific Island region three key aspects are apparent. They include:

(1) Regional data requirements, which must be assessed and systems designed and implemented to enhance the provision and availability of such data
(2) Knowledge with respect to the significance and potential benefits of ocean observations, which need to be developed
(3) Data products and services of value to the regional user community, which must be identified and delivered.

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. (3) will require extensive capacity building to ensure timely and efficient distribution of the products and their easy and full use.

4.3.5 Toward Implementation

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 any one of these areas are weak, there are many other worthy causes more than willing to exploit the indecision and lack of community support. This is no less true for the Pacific Islands than it is for the well-developed oceanographic nations.

There have been, and continue to be, challenging issues related to the transition of observing elements from research support to sustained (operational) support. This will be rapid and so must devise techniques whereby research is able to share control and responsibility without threatening 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 Pacific Island 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 section is that greatest emphasis should be given to the development of useful, region-specific applications through the development of a number of focussed « pilot » projects that are:

a. Clearly articulated and have focussed objectives
b. Identified as high priority at the regional level
c. Built on the strengths of the ocean observing system
d. Known to be feasible and practical given resource constraints and the existing regional capacity; and,
e. Have a workable schedule.

An initial GOOS pilot project is the Argo, which will enable continuous real-time observations of heat and freshwater storage in the oceans, as well as their large-scale transport by ocean circulation. Closure of the oceanic branch of the heat and hydrological cycles is central to better understanding of the climate system and to improved prediction of climate variability. The high regional priority of Argo stems from its contributions to all of the key application areas listed above in Section 4.3.3.

Support for Argo by Pacific nations has been demonstrated through resource commitments by float-providers and through logistical support and concurrence for float deployments within the EEZ's of a wide spectrum of Pacific nations. Argo strongly complements the existing ENSO OS and the remotely sensed observations of sea surface height, SST, and winds.

Implementation of Argo has begun, including many floats now operating in the Pacific, with sufficient commitments from 14 float-providing nations to complete the global float array by late 2005.

Argo/Pacific is "owned" by all nations of the Pacific, and the continuing evolution of the float array, its data system and products should be crafted to benefit all.

Argo, together with the ENSO OS and the remote sensing elements of the observing system, do not satisfy all of the requirements for a comprehensive ocean observing system. Other elements are needed to observe the critical western boundary current systems, the deep-ocean, and ocean-atmosphere exchanges. In essence, these additional measurements satisfy criteria (a), (b), and (c) above, but not yet (d) and/or (e). They are being undertaken as research initiatives, requiring additional instrumentation development, network design, and demonstration of practicality and feasibility, or of value in sustained modes of operation. As research programs, their Pacific Ocean implementation is in the hands of the CLIVAR Pacific Panel and its contributing nations.

As these observing system elements mature individually, they too should transition as GOOS pilot projects to operational support and management. Even as research programs they will require regional support and careful attention to identify regional value. It is only by carrying through with this process to completion that a comprehensive ocean observing system for climate will be developed and maintained to serve Pacific regional as well as global needs.

As an example of a 'next step' toward the definition and development of enhanced oceanographic and climate services for this region, the South Pacific Applied Geoscience Commission (SOPAC) is working with a number of sponsoring agencies in Argo float-providing countries to organize a workshop entitled, "Potential Applications of Ocean Observations for the Pacific Islands." This workshop, to be held in Fiji later in 2002, will review potential applications of ocean observations that can benefit the Pacific Islands and identify data product requirements needed for each application. To the extent that improvements are needed, it will establish linkages between those who will develop the enhanced products, those who will routinely create them, and those who will use them.

This workshop will include the identification of policy makers and end users requirements and the role of ocean observing system measurements and products and services to meet these requirements, then to assist with the knowledge of how to use these factors to have tangible socio-economic effects.

4.4 Global Terrestrial Observing System

Introduction

The market for hydrological information in the region, particularly small island countries, is poorly developed. Although there are some applications they are limited to large industrial sectors such as hydropower generation and water supply systems. In recent years the extreme peaks of shortage and excess of water appears to be increasing. For example the 1997/98 drought in Papua-New Guinea (PNG) and Fiji were the worst experienced. PNG was affected with a famine and Fiji suffered a large reduction in its GDP.

Information on the onset of the wet and dry seasons would be of significant assistance for agriculture, particularly in the timing of sowing or planting of crops (sugarcane, rice pasture). Most countries are dependent on subsistence crops with short storage life. Forecasts of droughts and delays in the onset of the wet season are required for frugal operation of reservoirs, both for water supplies and energy generation. Astute management can be of considerable saving. These are of significant economic importance for Pacific Island States that already have a fragile environment, weak economies and limited resources.

The impact of climate variation and change on hydrology and water resources impacts directly or indirectly on all sectors ranging from health to food security.

Assessment of current state of NHS systems

The National Hydrological Services (NHS) of small Pacific Island Countries (PICs) were developed to meet the immediate needs for national development such as water supplies, hydropower generation and irrigation. Plentiful supply and limited or no competition for water resources did not warrant legislation and institutional organizations are weak with inadequate resources.

Most of the NHSs are poorly structured with limited staff and capabilities. They are attached as support agency to departments like Mineral Resources, Mines, Irrigation and Drainage, Public Works and Water Supply. Work related to hydrology takes a low priority in the face of other national social demands.

Applications of hydrological data and information are limited to support the demands of these activities. Application of hydrology into other peripheral areas such as climate, health and agriculture and long term implications cannot be undertaken with the available resources.

Many hydrology stations are project related with no intentions or plans for long-term data collection. In many cases data collection ends with the completion of the construction and commissioning of projects. Rarely the stations are continued for significant periods even if it is desirable. Equipment supplied under projects fails through age and replacement costs are high, consumables and spare parts lacking or difficult to procure. There is limited, if any, long-term commitment either by the project or government for continuity of monitoring. To a large extend this is necessary as available resources are required elsewhere with great urgency.

Infrequent visits to stations in remote locations in rough terrain involve high costs in travel, which, in itself, is a serious constraint that affects data continuity. It demoralizes staff and data quality suffers further.

Lack of in-country analytical expertise for application of hydrological data for value added products under value the data and has negative implications.

Capital infrastructure and maintenance

There are a number of medium to long term hydrology stations that are operated as basic national networks. The installations are equipped with simple traditional recorders with data loggers or chart recorders. They can be upgraded with a range of robust and affordable sensors for sampling specific parameters discharges,water quality, temperature, sediment and so on.

In many cases these stations are in remote areas but strategically located for capturing useful data. It offers potential for capturing additional useful climate related data with only minimum costs. A range of hydrological and meteorological parameters can be captured from a single platform/site. Sharing of costs and maximizing benefits for both NMS and NHS are indeed attractive, while at the same time there is potential to develop specialist skills for NMHSs e.g. communications, electronics, etc.

Telecommunications

Except for one catchment in Fiji, none of the small PICs have real time data capture systems. All data is collected manually from the stations or sites on charts, tapes or electronic (ROMs) data-loggers. Unlike the meteorological stations they do not have observers, site visits are irregular and access can be difficult.

Meteorologists prefer to have their data at specific times of the day for the next day's weather forecast or immediately at the end of each calendar month for future climate outlook preparation. Hydrologists on the other hand are interested in the longer-term information such as the behavior of storage reservoirs, lakes and rivers. This is the principal reason for limited to almost non-cooperation between meteorologists and hydrologists in many countries. In many cases long journeys under difficult conditions and involving considerable costs has to be undertaken. Sometimes helicopters are utilized and the stations visited once in a quarter even a longer period.

Data Management

While the NMSs use common software (CLICOM) for data storage, retrieval and analysis the NHSs use a range of software, often obtained from different sources, particularly donors. They have in place quality checks before archiving. It may require some formalities for safeguarding. Data captured by GCOS system for the NMS can be made available to the NHS by a suitable communication system viz. Internet.

With a little effort and a reliable communication links data from NHS can be made readable for NMS and vice versa.

Training and Capacity-building

Training needs have been identified by WMO and a proposal for a training programme has been developed already. Additional training can be accommodated within the program. It is anticipated that the training will be scheduled this year in collaboration with SOPAC and UNESCO. Additional training will be undertaken with the development of a Pacific HYCOS - again a proposal has been developed and circulated.

The development of Pacific HYCOS has a component that will address any deficiencies including operation, maintenance, communications and management.

Comparison against best standards and practices

All countries use WMO Guide to Hydrological Practice. Apart from meeting the basic requirements weather forecasts additional data will meet the requirements for better forecasting of floods and droughts. With additional data and information climate prediction can be made with higher degree of confidence and greater accuracy.

Automatic sensors will transmit data from the platforms to the national center and the time of each transmission can be made to coincide with that required by the NMS. This data will be cross checked with previous records and neighboring stations.

Identification of critical deficiencies

NHSs do not have access to real time data, or data transmission networks or access to GTS telecommunication. They will need a base station similar to the NMS, which will involve costs.

There will be a need for building up expertise in calibration, operation and maintenance of electronic sensors, communication systems and network development. Intensive training will be required.

Deficiencies within the system will be identified as early as the last transmission of data. Identification of cost effective approaches to address critical deficiencies

Identification of cost effective approaches to addressing deficiencies

Each individual NHS and NMS will need to identify the best option for communication making maximum use of any available national system that is compatible and in place or could be put in place with minimum of effort and costs.

All real time data can be channeled to the NMS as a master base and redirected to NHS via a suitable network e.g. internet facilities. A robust and affordable communication system between the NMS and NHS will need to be established.

Scheduling of station visits will coincide with requirements of the station which will reduce costs in travel and time. The requirements at the remote platform will be identified by technicians before the visit; spares and accessories will be taken to the remote location on that one trip.

Mechanisms to monitor performance and ensure quality control

Have in place project management system to monitor the timeliness and accuracy of data capture, enable the reporting to respond promptly to changing requirements, facilitate the participation of stakeholders (NMss and NHSs) and ensure that the outputs are delivered on time, to standard and within budget.

Data captured will be monitored for quality and checked against standard loggers for at least two seasons. Checks against data collected earlier where available will be used.

Long-term sustainability of the system

Use of real time data for the development of products directly of use and benefit to the public will create a demand (market) for information. This demand will in itself support sustainability. An appetite for the information will have to be developed with products that are for regular and beneficial use across all sectors. It will meet the needs of international conventions and protocols that are obligatory e.g. UNFCC.

Training and capacity building

The training components will be of benefit across the region. Exchange of staff within the region and between the Meteorological and hydrological services will create additional opportunities that are currently lacking. Training within the region will bring about uniformity while meeting the specific requirements and needs of the region. Mounting of a training programme on a regional scale will be cost effective with participants coming from within the region.

Consideration of opportunities for regional logistical support (e.g., bulk buys)

Currently there is a range of equipment used many supplied as aid from different donors and different parts of the world. It will encourage the establishment of basic hydrological monitoring and data capture systems, using technology that balances modernity, economy, robustness, and suitability for Pacific Island environment and circumstances.

Opportunities for bulk purchase of suitable equipment for quantity discounts and distribution to Members in the region has merit. Additional advantage will be uniformity of data, standardization of equipment, group training programmes and sharing of expertise in maintenance and servicing within the countries and the region. The proposal for a Pacific-HYCOS has a similar proposal and encourages this opportunity.

5 Data Management Systems and Issues.

5.1 Data Management Systems

Achieving the goals of a global climate observing program will require multidisciplinary analysis of data and information to an extent never before attempted. This includes the analysis of interlinked environmental changes that occur on multiple temporal and spatial scales that is very challenging both technically and intellectually. For example, many types of satellite and *in situ* observations at multiple scales need to be integrated with models and the results presented in understandable ways to all levels of the research community, decision makers, and the public. Additionally, very large volumes of data from a wide variety of sources and results from many different investigations need to be readily accessible to scientists and other stakeholders in an easily usable form.

Over the past decade the meteorological community has witnessed an ever increasing demand for current and historical data related to extreme weather and climate events. Such data are necessary for seasonal and interannual climate predication as well as for climate research, monitoring of climate variability, and detecting climate change. Governments have recognized the importance of these activities on numerous occasions at various meetings, and in particular by the Intergovernmental Panel for Climate Change (IPCC) and by the Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC).

The provision of data and information in forms needed for cross-disciplinary analysis and projections remain a challenge even as the increasing focus of various environmental agencies remains on investigating the impacts and consequences of change heightens the need for multidisciplinary research. Physical and biological data will need to be related to data on environmental conditions and socioeconomic trends originally compiled by agencies and groups primarily for purposes other than global change research. This is a particularly important challenge in addressing potential regional consequences of multiple stresses and determining the vulnerability of different resources and communities.

Similarly, the need to effectively link the global observation data activities supported by GCOS' international partners that provide critical measurements from around the world to local and regional measurements produced by observational programs both inside and outside the global change research community is increasing. Further, observational data on individual variables must be combined into long-term, integrated measures of environmental changes. Both need to be coupled with modeling efforts at multiple scales to provide the synergy necessary to understand the relationships between complex variables, such as the relationships between air and water quality and human health.

In general international data centres, which are the repositories of climate and environmental data and information, are experiencing either flat or declining budgets while their workload from data and user volume is increasing. For example, in the U.S. during the past five years, the volume of data at Federal data centres has increased by two- to six-fold and this growth rate is expected to grow at even higher rates in the next decade. As examples, NASA's Earth Science data holdings increased by a factor of six from 1994 to 1999 and the total amount of data then doubled between 1999 and 2000. NOAA's data center holdings are expected to increase by more than ten times by the year 2012.

The National Climatic Data Center (NCDC) in Asheville, North Carolina, is responsible for building a permanent data base of GSN daily and monthly data submissions, along with the appropriate station metadata history, and for providing free and open user access to this information via the World Wide Web. This site contains all of the historical daily and monthly CLIMAT-formatted GSN data received (as of December 2001) at NCDC from 321 of these surface stations in 30 nations. As more data is received they will be integrated into the system and made available for use. The visitor may view data in both textual and graphical form, and, through the use of copy and paste, can download subsets of the database to their own system for later use and analysis. As new station information is made available to NCDC, the GSN database will be updated and this information will be noted on their web site at http://lwf.ncdc.noaa.gov/servlets/gsn.

The WMO Secretary-General issued a request for GSN historical data and metadata in September 1999 to all WMO member states. As of January 2002 three SPREP members, USA, New Caledonia, Australia have provided this information. It is imperative that these data be added to the holdings in the GSN historical database. A list of regional GSN sites can be found in Appendix A of this chapter or at the GSN Monitoring Centre at http://www.dwd.de/research/klis/gsn_mc/. The compilation of the configuration of GSN sites was accomplished by the GCOS Atmospheric Observations Panel for Climate (Peterson, 1997). While a call for GUAN data has not yet been made, plans are in the works to address that at some time.

The need for monitoring the performance of the GSN was recognized and formulated by the Second Joint CCL/CBS Meeting on GSN in 1997 in GCOS Publication 35. The participants considered it essential that the operational exchange of the GSN temperature and pressure data via CLIMAT messages on the GTS be monitored routinely. At the third session of the Joint Data and Information Management Panel (JDIMP) (GCOS Publication 39) the Deutscher Wetterdienst (DWD) offered to monitor the GSN data flow, data availability, and data quality with special regard to precipitation. In August 1997 the CCL agreed that the availability and quality of CLIMAT messages being distributed over the GTS be globally monitored by monitoring centers, with the assistance of regionally-designated focal points (WMO, 1997). Following this agreement, Germany and Japan officially offered to serve as GSN Monitoring Centres.

In January 1999, the GSN Monitoring Centre Implementation Meeting was held in Offenbach, Germany (GCOS-53, 1999). This was the official start of the monitoring activities. The proposed tasks of the GSN Monitoring Centres (GSNMC) were documented in 1999 in GCOS Publication 53. The tasks of the GSNMCs are to: (1) monitor the availability, timeliness and completeness of the CLIMAT messages distributed via the Global Telecommunication System (GTS) to improve the performance of the GSN; and (2) to perform basic quality control and assurance procedures for GSN stations to obtain high quality and completeness of the data set. These GCOS publications can be found at http://www.wmo.ch/web/gcos/gcoshome.html.

The data format and supporting documentation for members to use when providing digital historical data for GSN sites for inclusion in the NCDC GSN historical database can be found at http://www.eis.noaa.gov/gcos/gsn_format/gcos_dfsd.pdf. The information can be submitted as an e-mail attachment (e.g., Word format) and sent to the U.S. GCOS Program Manager, Howard Diamond, at howard.diamond@noaa.gov. From there the data will be transmitted to the appropriate personnel at NCDC for processing.

The Global Observing System Information Center (GOSIC) web site located at http://oceanic.cms.udel.edu/gos/ is a data and information management facility established by the Joint Data and Information Management Panel (JDIMP) of the GCOS program. The JDIMP no longer exists, but a GOSIC advisory group has taken its place to guide the requirements for the GOSIC. This site provides additional information on the observing requirements, the operational data systems, and the access procedures for finding and obtaining data and products of what is known as the G^3OS. The G^3OS consists of GCOS, the Global Ocean Observing System (GOOS), and the Global Terrestrial Observing System (GTOS). The University of Delaware, with funding and support from NOAA, currently operates GOSIC. The GOSIC is going through a new 3-year developmental effort that will be followed by a two-year transition period to an operational agency.

An important international data management activity related to ocean observations is the Global Ocean Data Assimilation Experiment (GODAE). GODAE is an initiative of the GCOS, Global Ocean Observing System, and World Climate Research Program (WCRP) jointly sponsored Ocean Observations Panel for Climate; reference http://www.bom.gov.au/bmrc/ocean/OOPC/index.html. The objective of GODAE is to demonstrate the practicality and feasibility of routine, real-time global ocean data assimilation and prediction. GODAE was founded on the belief that such a demonstration is vital for the realization of a permanent, global ocean observing network and prediction system, with all components functional and operating on a global domain, and delivering useful products in a timely manner. GODAE emphasizes integration of the remote and direct data streams, and the use of models and data assimilation to draw maximum benefit from the observations (Smith, 1999).

Detailed information on the conception of GODAE, an initial "prospectus", and a draft "Strategy" can be accessed on the Internet at http://www.bom.gov.au/bmrc/ocean/GODAE/homepage.html. The general objective of GODAE is to provide a practical demonstration of real-time global ocean data assimilation in order to provide regular, complete depictions of the ocean circulation, at high temporal and spatial resolution, and consistent with a suite of space and direct measurements and appropriate dynamical and physical constraints. GODAE is not a research program, but a practical test of the oceanographic community's ability to deliver useful products, derived from a global ocean data set and assimilated into a skillful model in order to extract greater benefit from the information, and delivered in a timely manner

5.2 Issues

With comprehensive climate data sets describing the Earth comes a new set of challenges in managing and using these data. The size and diversity of databases describing climate processes makes it difficult to effectively and efficiently access multidisciplinary data sets. The development of national and international spatial data infrastructures, which convey standards, procedures, formats, etc., can be confusing, intimidating and, at times, a liability. Data originally collected for thematic studies can be reapplied many times in an interdisciplinary framework resulting in sometimes questionable and inappropriate interpretations of the data. The adoption of national, international and commercial data policies is debated for its economic, scientific and social priorities. Finally, addressing the challenge to effectively and intelligently use emerging technology may be the most difficult task. (Clark, 2001)

Large and diverse spatial databases

A daunting challenge of the 21st century is the management of the large volume and highly diverse data describing the Earth's climate. These data are a result of comprehensive observing and monitoring systems implemented by the scientific community, governmental agencies and private industry. Extensive observing systems are measuring the climate from a number of different domains. The diversity of the types of data, from satellite imagery to *in-situ* atmospheric and oceanographic observations will make compilation and interpretation of climate database very complex. As result of this diverse observation of the Earth, the volume of data describing the

Earth's climate system is increasing with the advent of new, high resolution observing systems, including satellite remote sensing, and *in-situ* monitoring systems. Furthermore, analyses and models using these data are producing even more new data sets from the observed climate parameters. The size of the data archives is growing faster than we can derive information from it. For example, it is estimated that by 2010, the size of a major U.S. data archive for NOAA, the National Aeronautics and Space Administration (NASA), and the United States Geological Survey (USGS) will be 18,000 terabytes or 10^{18} bytes of data. There are numerous issues regarding these vast and diverse archives that include storage (archival), access, quality, documentation (metadata), and associated costs, which must be addressed. However, these issues are beginning to be addressed and should begin to be solved in the years to come, partly by applying technology, partly by new and innovative procedures and methods, partly by the years of experience being gained by the data management experts, and partly by sensitising policy makers and resource managers to the critical role that data management plays in climate observing. However, the global outlook is not very good at this time.

Data Policy

Data policy, which is described as the set of rules, regulations, laws or agreements governing the access and use of data, will have a major impact on climate datasets in the 21st century. There are numerous data policies currently in effect or being developed for virtually all types of data and information present in our society today. These policies cover not only the natural and physical sciences but the financial, cultural, and political aspects of our society as well.

Data policies are currently implemented or are being developed in all the countries of the world. In Europe, the European Union (EU) has issued the EU Directive on the Legal Protection of Databases, which provides strong property rights in public and private sector databases (European Union 1996). Internationally, the WMO has issued several resolutions, which set out data policy for the exchange of environmental data (WMO 1995, WMO 1999). The U.S. maintains several types of data policies within its governmental, academic and commercial communities. The commercial sector also has its international policy efforts. Ultimately, many of these data policy issues are connected to policies implemented by the World Intellectual Property Organization (WIPO) which is an international organization dedicated to helping ensure that the rights of creators and owners of intellectual property are protected worldwide. WIPO policies regarding the ownership and/or use of data base information could affect the full and open exchange of environmental data and therefore must be considered an issue to consider in the area of global climatic data bases.

Many of these policies are in conflict with each other and the challenge will be to understand these conflicts and chart a course that benefits all. This will take the close interaction and negotiation of the database rights holders and users to strike the balance between protection and fair use (NRC 1999). The question of data access, copyrights and restrictions could make the "fair use" of climate data much more complicated. Compiling long-term climate data sets from which long-term climate trends can be derived will be greatly impacted by future data policy of national and international bodies.

Diverse Global Applications

As we enter the 21st century, many national and international research, monitoring and observation activities will need climate data to address the requirements of their programs. Many scientific programs, such as the International Geosphere Biosphere Program (IGBP) and the WCRP, will have very different needs for data obtained by these programs. The study of global change will necessitate the collection and analysis of a wide range of data (Townshend and Rasool 1993), and therefore any restrictions on the “fair use” of such data could pose significant problems in the study of global climate change.

The diversity and volume of the collected data has already been noted. The application of these data will dictate the numerous ways that they will have to be managed. As an example of one way of dealing with the diversity in environmental measurements and as an effort to coordinate observing systems, many of the global programs and organizations have formed a partnership to address environmental issues, research and provision of Earth observations. The Integrated Global Observing Strategy (IGOS) is made up of representatives from the national space agencies, many United Nations organizations, major international scientific organizations such as IGBP and World Climate Research Program, and the international observing programs, GCOS, GTOS and GOOS. Many of the various environmental initiatives and treaties implemented over the last few decades call for systematic observations of the Earth, and the IGOS will provide the necessary links in support of the international initiatives. IGOS may be a good paradigm to consider for addressing climate database problems.

Rapidly Advancing Technology

There is a down side to rapidly advancing technology. Rapidly advancing technology can give rise to a "digital divide." This is a gap between those who are technologically capable and those who cannot, for economic or cultural reasons, implement this technology. We must pose the question about whether this is happening in the Pacific, and if so, what effect does that have upon GCOS? This challenge is significant because of the climate database issues discussed above, technology will be critical in addressing these problems. In addition to the digital divide, the sheer magnitude of technological advances is making it difficult for efficient assimilation of the technology and some programs are lagging behind.

There are many bits and pieces of historical data that are in a variety of formats and media. Some of this material is in danger of being lost and must be preserved. We look to these historical records to aid in providing the missing pieces of the overall climate puzzle from which we can derive long-term trends. The issue of data rescue or climate database modernization will be an important component of improving the overall quality of climate databases. It is this context of historical data that makes the integration and blending of paleoclimate data with historical instrumental data so important. The paleoclimate data extends the overall climate record, and hence the data base, back in time, and thus allows conclusions on climate change and variability to be made well into the past hundreds and thousands of years prior to the time of human instrumentation.

While it is an on-going effort, there has not been the big push for quality control that is required, and better quality control procedures are required. Examples of deficiencies requiring such quality control include the discontinuity and non-homogeneity of data that result from changes in the location of observing locations, the elimination of observing locations, a degradation of observing equipment, changes in the types of observing equipment used, and a lack of proper training and documentation in taking observations.

One of the prime purposes of GCOS is to monitor climate changes and thus the need for long-term homogeneous records are of vital importance. In line with this changes in site locations, instrumentation, observation practices, and environmental exposure can jeopardise the continuity of these records. Therefore, there is a great need for accurate metadata documentation in order to keep track of these changes for data acquisition and rescue, as well as the need to look at a homogenisation of records in order to assure as continuous a historic record as possible.

6 Communications Systems and Issues.

There are three processes that are vital to the successful operation of a meteorological/climatological service in any country. These are timely data collection, analysis and dissemination.

Without these three processes operating in a timely manner any efforts made to collect and use meteorological/climatological data will be a failure.

Without adequate data being collected regularly and transmitted to a central point for analysis there is little hope of knowing the prevailing conditions in the area and even less likelihood of forecasting future conditions.

If this data cannot be analyzed for one reason or another then the data collected is of no practical use. For climatological purposes data which has missed operational meteorological deadlines is still important and should be transmitted when available for inclusion into the national/regional climate databases.

If the resulting analysis is not conveyed to end users in the form of understandable forecasts, warnings or other useful information, the preceding efforts have largely been wasted. It is only when these three processes work together, quickly and smoothly that the final outcome is productive.

It was only after rapid means of communications, like the electric telegraph, were developed in the mid 1800s that synoptic/climatological forecasting became practical. A quick and reliable means of gathering synoptic/climate observations to a central point for analysis was essential for producing a timely forecast and that is still the case even today.

In spite of rapid advances in technology some small island states experience problems of one kind or another in reliably communicating their weather information both within the country and externally.

Not all meteorological/climatological services are operating with very minimal budgets and so any solutions that are proposed must be cost effective and not too costly to operate and maintain.

In many countries telecommunications costs are a major component of their budget. Maintenance funds are usually very limited and emphasis should be placed on low maintenance equipment.

6.1 Data Collection.

Traditionally meteorological/climatological data has been collected by people located at strategic locations throughout a country and relayed by some means to a central facility for onward transmission or analysis.

This practice still continues in many countries and is successful to varying degrees.
Depending on reliability of staff, communications systems and so on synoptic/climate data may or may not reach its destination in a timely manner.

Unless data is collected and transmitted reliably at the correct times the collection process has failed.

In the Pacific Islands various means are used to transmit data and these range from HF radio links, voice telephony, facsimile and email to satellite data transmissions.

Many stations still use manual data collection, and in general this provides more useful information than fully automated stations in terms of cloud observations, present weather and so on. However it is sometimes difficult or nearly impossible to maintain observers at remote, isolated locations and it is in these locations places that automatic stations can be useful. They continue to operate year round in fine weather or adverse sending data on time to the central collection point. The use of a datalogger with sufficient storage to be able to recover data unable to be transmitted due to communications outages is invaluable to complete climatic records for a site.

With the declining use of HF radio in many countries and the increasingly high levels of electrical interference prevailing around typical urban area meteorological stations, HF radio has been considered a less viable option than it was in past days. However by utilizing emerging Digital Signal Processing (DSP) techniques digital data can be transmitted very reliably and at low cost even in adverse radio conditions using very narrow bandwidth low power HF transceivers. Existing HF facilities can be adapted for digital HF communication with the addition of a data entry terminal and an HF DSP modem. Because the data is in digital form it can be processed automatically by communications software. An HF digital network could provide a very cost effective communications solution for backup or if necessary primary data dissemination.

Public telecommunications links such as telephone and facsimile are used regularly throughout the region to transmit synoptic data and are generally reliable, but somewhat expensive to operate. Especially in these times of cost cutting and with reduced budgets available to the meteorological/climatological services lower cost means of communications need to be found.

These services are frequently disrupted after severe storms, due to fallen lines, prolonged power outages etc.

Internet based Email is used fairly successfully in a number of countries for sending routine observations and generally works well. However difficulties are experienced when there is an outage of the Internet system or during high usage periods especially in those countries that have fairly low speed links to the worldwide network. It cannot be relied on in times of emergency.

Satellite data transmission as used by a number of automatic stations throughout the region could be a viable option even for the manual observation stations provided reliable and reasonably priced transmission equipment is available and it is suggested that this method be explored more in the future. Whereas direct satellite transmission via geostationary satellites is desirable for operational meteorological data, climatological data could be transmitted using forward and store transmission protocols used on low earth orbit satellites (LEOS) such as the VITASAT system that has been used in Africa to transmit climate data from remote sites.

The transmission of synoptic/climate data through GOES and GMS satellites DCP / DCS is technically feasible using manual data entry terminals and after the initial purchase of the transmission equipment the ongoing costs are very low as the transmission medium is made available at no cost to end user.

In some countries there is still a lack of synoptic/climate stations and this could be filled by introducing more automatic stations. These would particularly help in areas of cyclone genesis and where synoptic/climate stations have not yet been established due to cost and / or logistics problems.

There is a need for an effective backup communications system for each meteorological service that is portable and can be setup with little difficulty following a natural disaster event such as a tropical cyclone during which the primary communications system has been stowed to prevent damage or has suffered damage.

As mentioned emerging digital HF radio techniques offer a very cost effective backup communications solution. If the service can afford a commercial portable satellite system using either the Inmarsat or Iridium satellites voice and data solutions these can be employed. However the provision of Inmarsat systems by the EU to some of the regions meteorological services proved these were too costly for most services to consider using.

With the purchase of the Iridium network by the Boeing Corporation costs for the use of this service continue to fall with service providers currently providing a connection for USD 20 per month that includes unlimited SMS messaging. SMS is suitable for the transmission and collection of coded meteorological observations. Voice and data is charged at USD 0.50 per minute charged in intervals of 20 seconds after the first minute. Capital costs of a new Iridium phone with data connector is approximately USD 1500 making an Iridium system an affordable reliable backup facility.

6.2 Summary

1. There is a need to improve “on time” collection of meteorological/climatological data using cost effective reliable communications.
2. There is a need to install more data collection stations in some areas
3. There is a need for more reliable distribution of data and warnings to end users and remote communities.
4. Internet Services should not be regarded a reliable primary source of data.
5. Transmission of synoptic/climate data through reliable GOES and GMS satellites DCP / DCS is technically feasible using manual data entry terminals and is free of airtime costs. This offers the most promising solution for primary communications of observational data.
6. Cost effective portable backup communications systems are required to maintain communications during a primary system outage. Digital HF radio transceivers and Iridium phones could provide this backup facility.

7 Pacific Global Climate Observing System Infrastructure

7.1 Designation of National GCOS Coordinators

The involvement of small island states in the monitoring of climate change has never been more important than today. The role that National Meteorological and Hydrological Services (NMHSs) play is crucial in the coverage of the Pacific Region as far as climate information is concerned. Due to their relative obligations under the various conventions (WMO, SPREP, SOPAC, etc), NMHSs can enhance their contribution to GCOS through the designation of a GCOS coordinator. This coordinator would be required to pursue the requirements of GCOS as part of the NMHSs day-to-day task.

As a Coordinator, other tasks would involve other agencies and partners that are involved in climate change and sea level rise issues. It would be the responsibility of the Coordinator to facilitate a work-plan for all these agencies so as not to re-invent the wheel through duplication of work. As other agencies have Coordinators (such as the PICCAP Coordinator), these would the people that would be required to be acquainted with the GCOS Coordinator.

7.2 Pacific GCOS Website

The availability of Information Technology nowadays can be fully utilized by Pacific Island GCOS so as to monitor the current situation in the Pacific. As most NMHSs in the region has internet capability, the development of a Pacific Island GCOS website would be the ideal medium for the distribution of information to all stakeholders. Although some of the NMHSs in the region do have a web-page of some sort, data is being transmitted via the Internet through electronic mail (e-mail) by most, if not, all of the NMHSs. The smaller NMSs has also shown a tendency to go along transmitting data on GTS via internet due to the cheaper cost compared to other communication medium such as AFTN.

This website can also be complemented by other NMSs within as well as outside of the region as part of their contribution to GCOS. Through this means of information availability, other stakeholders can contribute to the objective of GCOS.

7.3 Requirement for a Regional Support Structure (through CROP and other agencies)

Considering that several meetings are held annually by regional agencies such as SPREP, SOPAC and others, support structures maybe requested to such agencies that could support the work programme of GCOS. With the inclusion of the GOOS through SOPAC and the continued support by SPREP for the RMSD annual meetings, other agencies can also be included to cater for the long-term work-plan of Pacific Island GCOS. CROP agencies can be effective in this instance whereas contacts can be extended to anyone that is associated with them.

Other agencies that be considered are the ones that has projects that are up and running within the region. A good example of this is the National Tidal Facility and Flinders University. The data they produce and the product they distribute annually from the Tide Gauges on 11 islands in the Pacific, is an excellent way of promoting the findings of climate change and sea level rise. The information is made available to all member countries as well as to any scientific body that requires the information for research purposes.

WMO has been considering the development of Regional Climate Centres (RCCs). The proposed role of these new centres is to have a primary focus on climate, and can include both centralised and distributed functionalities, the latter being met by a network of existing centres (a virtual centre) each contributing within their resources. The requirements of NMHSs for RCC functions will vary from Region to Region, and may comprise only a subset of the following list. The required activities may be undertaken within a single centre or distributed amongst NMSs. Functions include operational activities (seasonal to interannual climate forecasts for a region, product verification and distribution, exchange of data) coordination functions (collaboration between NMSs, harmonisation of regional climate forecasts, workshops, public awareness) data services (climate data rescue, provision of a regional climate database, software for applications, data quality assurance), training and capacity building (training of both NMS staff and end-users of climate products) and research and development (coordination of research, studies on regional climate variability, predictability and impacts, applications research). The development of RCC(s) in the Pacific would dramatically strengthen regional climate services and P-GCOS infrastructure.

7.4 Identification of a regional technical expert's group

In the last decade, capacity building has been of importance to the smaller NMSs especially in terms of technical skills. Although not all small NMS has that capability, it should be borne in mind that there are skills in some of these NMS that can contribute a great deal to the operations of such small NMS. In this respect, there ought to be technical expert's group that needs to be identified in the region so as to assist all NMSs. Such a group may not be required to meet together but they maybe able to diagnose problems from their respective stations with the availability of modern technology and the usage of the Internet.

Such a technical expert group may also be requested to present case studies to annual meetings of Directors and even have a recommendation by the Directors to ensue that such a group is given the opportunity to efficiently utilize the scarce resources they have in their respective stations. As more modern technology come to the fore, these new skills need to be conveyed to such a group.

As a technical expert is usually a "one-man-band" in the case of small NMSs, dialogue is required with other experts from the region so as to solve a common problems. As SIDS go through reforms nowadays, the tendency for NMS is to go for Automatic Weather Stations (AWS) which also require special skills from technical experts. There is a huge responsibility bestowed on the technical expert in terms of maintenance, travel and calibrating these AWSs.

7.5 Support for participation at meetings of national GCOS coordinators

As the awareness of Climate Change and Variability and Sea Level Rise is enhanced in this part of the world due to the vast ocean areas, meetings of key agencies and stakeholders are of importance to all. Support for participation at meetings of National GCOS Coordinators maybe requested through international and regional agencies. Care must however be taken as funding agencies nowadays are specific in their support for any forum. In this case, tentative agenda which focuses on actions and results to move the score forward maybe prepared by a regional agency who has been involved in the work of Climate Change before. This could be SPREP or SOPAC.

7.6 Identify shared resources (e.g. regional logistical support)

With the limited resources and the unavailability of some basic infrastructure, SIDS need to identify resources that can be shared so as to maximize their efficiency in operating the Pacific Island GCOS project. Such resources can be identified through current shared facility by NMSs.

A good example of this is GUAN where instead of each NMS obtaining consumables for their upper air flights, these maybe purchased by a NMS that has a GUAN and can also sell consumables to other GUAN Stations at a very reasonable price.

A system can be put into place whereby such logistics and resources can be monitored and evaluated on its effectiveness as well as its efficiency.

8 Training, Education and Capacity Building

8.1 Introduction

This section concentrates on capacity building, training and education and; and for the purpose of PI-GCOS, capacity building is defined as actions needed to create and/or enhance the capability of the Pacific region to meet PI-GCOS goal. It encompasses improvements in human resources and institutions, through education, training, and management. These include improvement in physical infrastructure and introduction of appropriate technology, such as distance learning capabilities, as well as improvement of environment in which people and institutions function (law and regulation).

It recognizes special skills and unique capabilities of existing institutions, programmes, mechanisms, structure, and combined activities at national, regional and international level; and harnesses and utilizes existing potential of the Pacific region to implement PI-GCOS. Building on these potential, it will further strengthen institutions' mechanisms, procedures, linkages and coordination; increasing knowledge of systematic observations for the atmosphere, terrestrial and ocean and climatology, and increase the number of professional climatologists in the Pacific Island Countries.

8.2 Assessment of current status of capacity building

There have been in the past and existing capacity building, education and training activities either related or contributing to systematic observations for the atmosphere, terrestrial and ocean. These include;

- A number of Regional Meteorological Training Centers were established under the WMO framework for education and training. These centers provide training in the different field of meteorology (weather and climate).
- The Australian Bureau of Meteorology Training Center provides a post graduate diploma in meteorology at WMO Class I Level.
- The University of Wellington also provides a post graduate diploma on meteorology at WMO Class I Level.
- Fiji Meteorological Service Training Center provides meteorological training in the field of weather observations (WMO Class IV and III) Level and hopefully technical maintenance (WMO Class II) in the future.
- USP also has a science degree programme, geography degree programme, and environment programme.
- The USA DOE ARM established 3 stations in the Pacific to monitor the outgoing radiation from the cloud and surface of the earth; and also has a training programme.
- The South Pacific Sea Level and Climate Monitoring Project monitors the sea level and enable the Pacific region to understand the long-term implication of changing seas level and climate variability induced by global warming.
- A secondary education pilot programme called the Scientific Educational Resources and Experience Associated with the Deployment (SEREAD) of Argo drifting floats; sponsored by among others, UNESCO, SOPAC, IOC and managed by USP.

Lessons learned from implementation efforts related to the climate change convention and other environment conventions have revealed that many common obligations exist under these conventions. These include for example requirement for research; systematic observations for the atmosphere, terrestrial and ocean, including data collection and analysis; reporting; capacity building, including training, public education and awareness; and exchange of information. Lessons learned from these past efforts suggest a need for capacity building activities to coordinate environmental policy formulation and implementation among sectoral authorities. These includes, for example, development of capacity building activities to implement the climate convention and other environmental conventions; integrating systematic observations for the atmosphere, terrestrial and ocean, including data collection and analysis; reporting; and enhance research activities that meet the needs of more than one environmental conventions and increasing understanding of linkages; and strengthening regional cooperation.

There is a considerable importance and value in taking a holistic (i.e crosscutting) approach to capacity building; and understanding the synergies among the environmental conventions, and finding ways to coordinate and harmonize overlapping activities among them, are becoming increasingly important.

Krishna et al (2000) reported that in the past 15 to 20 years, there has bee a decline in support to meteorological activities in the Pacific region. This situation resulted in significant deterioration on the quality, regularity, availability and exchange of data and information within the region and with the international communities. The challenges of climate change and variability require that this situation be reserved, as a priority.

It can be equally said for the terrestrial and oceanographic activities, and to be more precisely, very low support to terrestrial and oceanographic activities in the Pacific region. Training needs have been identified by WMO and a proposal for a training programme has been developed already, titled "Programme to Meet Hydrological Training Needs of Small Island Countries in the Pacific." Consideration should be given to on site and distance learning and training methods.

8.3 Issues related to capacity building, including education and training

The above discussion identifies a number of issues and regarded as very critical to success of PI-GCOS.

- Lack of or very little knowledge of policy makers and public communities of the importance and value of systematic observations and roles and responsibilities of institutions responsible for systematic observations for the atmosphere, terrestrial and ocean.
- Lack or very low number of professionals at all levels in the field of sciences relating to climate. Hydrology and oceanography.
- Very little coordination among institutions responsible for systematic observations for the atmosphere, terrestrial and ocean.
- No means of supporting training activities in and for the Pacific Island Countries that developed countries considered necessary to support systematic observations.
- Large reduction in resources available to national institutions, which are responsible for systematic observations for the atmosphere, terrestrial and ocean.
- Lack of specific legislation in many Pacific Island Countries, prescribing the functions and responsibilities related to systematic observations for the atmosphere, terrestrial and ocean.
- Lack of coordination among institutions responsible for the climate change convention and other environmental conventions.
- To demonstrate now PI-GCOS observations and products can be used by policy makers to make decisions to improve socio-economic aspects of their countries.

Activities and projects to address these issues are outlined in Section 9.

8.4 Strategies for long-term sustainability

The long-term sustainability of PI-GCOS depends on changing the culture of governments of the Pacific Island Countries and their relevant institutions to recognize the needs for PI-GCOS. Krishna et all (2000) reported that many Pacific Island Countries have resorted to re-directing assistance funding to other critical areas such as health and education. However, PI-GCOS needs should not be seen as being in competition with other development needs, rather as an essential component of sustainable development. Possible strategies for achieving long-term sustainability of PI-GCOS include;

- To raise the profile of PI-GCOS and institutions responsible for systematic observations for the atmosphere, terrestrial, and ocean among policy makers and the public communities.
- To strengthen mechanisms, procedures, linkages and coordination for and among relevant stakeholders and government departments and ministries.
- To promote cooperation and coordination of all relevant development assistance agencies.
- To increase number of professionals at all levels in the field of science relating to climate, hydrology and oceanography in the Pacific Island Countries.

9 Pacific Island GCOS Action Plan (PI-GCOS)

In response to the recognised decline in observing networks that originally led to the first GCOS regional workshop in Apia in August 2000, all participants in the region have agreed that the development of a Pacific Island GCOS Regional Action Plan is urgent. This plan is intended to point the way for a comprehensive PI-GCOS that addresses the priority climate observing system needs for the region that include the atmospheric, oceanographic, and terrestrial components that comprise P-GCOS. The audience for this action plan is initially for the Pacific Island Regional GCOS Implementation Team (PIRGIT). This team has the responsibility through August 2002 for developing the actual implementation planning for the actions in this plan that are necessary to improve PI-GCOS. Other audiences for this action planning document include the GCOS Secretariat, the four international sponsors of GCOS, the Subsidiary Body for Scientific and Technological Advice to the UNFCCC, funding agencies such as the Global Environment Facility (GEF), and donor nations with a vested interest in moving towards a robust and sustainable PI-GCOS and NMS.

Therefore, the intent of this action plan is to frame the main goal and five objectives for an improved PI-GCOS that have been identified by the Pacific Island GCOS Working Group writing team in meetings in Honolulu in October 2001 and in Auckland in February 2002. In addition to the core GCOS systems themselves, this plan recognises the key roles played by data management, telecommunications, training and education, and infrastructure. By their nature, these elements are of an integrated and multi-sectoral nature and require good coordination across various GCOS domains in the region.

The following action plan is organised along the five objectives identified for an improved PI-GCOS. Each objective consists of recommended activities for the PIRGIT to pursue, developed projects from planning already done in the Pacific by SPREP, and proposed projects which were put on the table by the PI-GCOS action plan writing team. The identified activities which are relatively low cost and developed projects present some low hanging fruit for the PIRGIT to take advantage of, and that if fully implemented, would show immediate benefits to PI-GCOS. The developed projects already being contacted as planned are listed in Appendix 2. The proposed projects are a bit longer term in nature and require development of details and required resources. However, these longer-term proposals will give PI-GCOS the robust and sustainable nature that is required for it to succeed. The PIRGIT may choose to take some of the ideas in this action plan and transform them into some scaled down pilot projects and risk reduction exercises in order to demonstrate some immediate successes, but it is not the intent of this plan to limit how the PIRGIT decides to address implementation issues.

9.1 Advocacy

To continually advocate the importance of GCOS observing systems to policy applications on the part of national governments and other interested users (e.g. social, cultural and economic implications

9.1.1 Activities:

(i) SPREP/WMO SRO to request members at minimum, complete the tables in their national GCOS report.

(ii) SPREP/WMO SRO to encourage each government to establish a Meteorological Act recognising climate needs, as well as an Activity Plan to develop both GCOS and national climate networks.

(iii) All P-GCOS partners establish a regional and national advocacy programme to promote and raise awareness of the benefits of Pacific Island GCOS:

- o Develop and disseminate relevant information products;
- o Convene a regional GCOS workshop to evaluate potential applications of GCOS outputs for the Pacific Islands;
- o Establish a PI-GCOS Coordinator;
- o Establish the terms of reference for National GCOS Coordinators;
- o National GCOS Coordinator communicates with relevant stakeholders and across government departments and ministries;

(iv) PI-GCOS partners to encourage increased interaction between climate and observation sections of NMHSs.

(v) PI-GCOS partners to develop a communications strategy for an established and sustainable Pacific Island GCOS Regional Alliance:

- o Identify and establish partnerships and key interdependencies [national, regional and international] to ensure a well managed and integrated observing system;

9.1.2 Developed Projects:

Project 1: Expanding and enhancing the prudent use of climate predictions.

Project 2: Pacific Regional Climate Bulletin.

9.1.3 Proposed Projects:

Project A: Demonstration project for Pacific Island GCOS

9.2 Core Systems

To fully support and operate ALL identified GCOS stations (e.g. GSN, GTOS, GUAN, etc.) in the region by 2005 and according to best practices by 2008

9.2.1 Activities:

(i) Assess performance of manual versus automated observation sites for meeting GSN purposes in the region.

(ii) BOM and NIWA to homogenise some climate records for GSN stations, demonstrating the benefit of parallel observation periods.

(iii) Ensure that access to relevant data, products and services are free and unrestricted to user communities in the Pacific

9.2.2 .Developed Projects:

Project 3: Restore and upgrade manual observation stations.

Project 4: Provide Data Collection Platforms.

Project 5: Restore and upgrade upper-air observation stations.

Project 6: Provide high-frequency radio transceivers.

Project 7: Regional Pacific Intranet

9.2.3 Proposed Projects:

Project B: Develop a web-based CLIMAT submission form.

Project C: Develop a pilot project to assess the impacts of climate on coastal environments

Project D: Install data loggers on AWSs and multi-sensor redundancy at GSN stations.

Project E: Provide spare equipment to be used specifically for periods of parallel observation.

Project F: Develop a manual for routine management of GCOS stations, including procedures to notify the GCOS Secretariat of changes to GCOS stations.(e.g GSN, GUAN, GTOS, etc.)

Project G: Undertake a needs analysis to identify established (oceanographic and hydrology systems, GTOS and GOOS stations) and establish the data, products and services demands of the region, of relevance to Pacific GCOS.

9.3 Strengthening existing networks

To work with the AOPC to re-examine the spatial-distribution, criteria and coverage of GSN and GUAN stations in the region by 2003 and adjust the networks as appropriate by 2005

9.3.1 Activities:

(i) Review the current Pacific Island GCOS stations and address metadata inconsistencies between WMO Volume A, GSNMC and internal databases.

(ii) WMO to encourage countries to apply for world heritage protection at key GSN stations. (e.g. Apia, Rarotonga, etc.)

(iii) Make provision for upgrading and improving existing GTOS and GOOS stations identified as benefiting GCOS.

9.3.2 Developed Projects

Project 4: Provision of Data Collection Platforms (DCP)/Automatic Weather Stations (AWS).

Project 6: Provision of High Frequency Radio Transceivers for the collection of weather reports from outstations.

Project 7: Regional Pacific Intranet (RPI).

Project 8: Upgrade and improve GTOS stations in the Region [GTOS]

9.3.3 Proposed Projects

Project H: Project Upgrade and improve GOOS stations in the Region

9.4 Climate Data Management

To respond to the September 1999 WMO request for the provision of historical GSN and GUAN (when requested), metadata and data by 2003]. To rescue all existing climate data for the region by 2005 fully archive quality controlled climate data in digital form for the Pacific region by 2008

9.4.1 Activities:

(i) WMO to follow up on the September 1999 request for historical data and metadata and target the audience to ensure that it is received and acted upon by the appropriate climate and/or national GCOS coordinator.

(ii) WMO to define standard climate metadata requirements and formats.

(iii) Request that the GOSIC facility investigate the development of a common Pacific Island GCOS portal that brings together the data management activities for the atmospheric, oceanographic and terrestrial elements of PI-GCOS into a common interface that can be accessed thru the proposed Regional Pacific Intranet system (reference PI-GCOS project 7).

(iv) BOM/NIWA to promote the use of homogeneity software (e.g., MASH, CLIMDEX, and possibly others to be developed) to ensure the continuity of historical datasets.

(v) NIWA to submit proposal to APN to hold a workshop devoted to metadata requirements and management in 2003.

(vi) SOPAC to strengthen relationships with the IODE (Metadata policy and standards for oceanographic data) and other international oceanographic data centres.

(vii) The WMO Inter-Commission Task Team on Regional Climate Centres to consider regional data exchange arrangements for the Pacific (develop memorandums of understanding between national and regional climate data centres).

9.4.2 Developed Projects:

Project 9: Provide training in all aspects of data management.

9.4.3 Proposed Projects:

Project I: Develop a regional climate database (both data and metadata) with centralised quality control.

Project J: Develop, in conjunction with the GOSIC, a regional Pacific GCOS database that includes atmosphere, ocean and terrestrial components.

Project K: Recruit roving experts to audit existing data holdings and provide recommendations for data rescue and computerising in each NMS.

9.5 **Institutional Strengthening and Capacity Building**

To establish a permanent GCOS infrastructure by the end of 2002 with professional capacity within the region as appropriate (e.g. National GCOS Coordinator, Regional or National Climate Centres, etc)

9.5.1 Activities

(i) PI-GCOS partners to ensure Pacific HYCOS proposals compliment Pacific GCOS activities

9.5.2 Developed Projects:

Project 10: Strengthen basic meteorological observer training.

Project 11: Provide technical maintenance back-up.

Project 12: Marine meteorological and climate data reporting, collection, dissemination and training.

Project 9: Climatology Training

Project 13: Hydrological Training Needs of Small Island Countries of the Pacific

9.5.3 Proposed Projects:

Project L: Establish Regional Climate Centre(s), including the following activities

- Pacific Island GCOS co-ordinator who could co-ordinate activities such as bulk-buys, inspections and maintenance.
- Develop data monitoring and reporting systems that integrate with information flowing from the GCOS Monitoring Centres to assess the networks against GSN Best Practices and Monitoring Principles
- Evaluate and strengthen the human capacity of the region and explore the feasibility of pooling of technical skills.

Project M: Combine available resources for each NMS upper-air programme and manage a regional upper-air network from a central location.(e.g. expendables, sparing and inspections)

Project N: Pacific Regional integrated observing system with the goal to increase efficiencies and effectiveness through sharing of resources, skills, knowledge, and avoid duplication of effort

Project O: Enhance the use of Information Communications Technology in the region

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10 Appendices

10.1 Appendix 1. Resolution concerning P-GCOS, Apia, Samoa, August 2000.

GLOBAL
CLIMATE
OBSERVING
SYSTEM

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Resolution Concerning the Improvement of Global Climate Observing Systems in the Pacific Region
14-15 August 2000, Apia, Samoa

The participants[12] in the GCOS Pacific Island 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);

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[12] 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 Oceanic Commission (IOC) Perth Office, Food and Agriculture Organization (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.

(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);

(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;

(4) The role and importance of the Global Climate Observing System (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 Nino and other natural phenomenon, as well as to detect and better prepared 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;

(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 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 program:

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 programs in participating countries. *All* SPREP members should strive to develop these reports in the context of national implementation programmes pursuant to the UNFCCC guidelines and making use of the "elements" paper prepared by the workshop, as well as guidelines contained in the FCCC/CP/1999/L4/Add.1 and submitted them to SPREP.

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

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, April 3-7 2000 and the findings of the Pacific Islands GCOS workshop held in Apia, Samoa, August 14-15, 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 (COP7) 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; and

(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 the COP and its Subsidiary Bodies.

(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.

10.2 Appendix 2. Projects appropriate to P-GCOS developed by Krishna et al (2001), WMO (2000) and SOPAC (2001).

Project 1 (DP1) Expanding and enhancing the prudent use of climate predictions

Background: The capacity to predict seasonal to interannual rainfall and other climate anomalies (largely based on the El-Niño Southern Oscillation/La-Niña phenomena) in the Pacific region emerged as a high priority for SPREP members. Experience has shown that statistical predictions can work well for the coming season (0-3 months) whereas forecasts from climate models become more useful at longer lead times. Unfortunately statistical predictions are not made for or by all members, nor is the web-based information from climate models readily available for members who do not have web access and there is little guidance on how this broader picture relates to specific locations within the region. While both statistical and climate model forecasts together can provide the basis for a very useful climate prediction service in all member countries there are a range of issues that need to be addressed in producing a successful system. This project proposes a system which is best developed employing a joint/community strategy with each of the NMSs playing a pivotal role in their region.

Recently the Australian Bureau of Meteorology (through its National Climate Centre) in conjunction with the Fiji Meteorological Service used *Aus*AID funds to develop a PC-based stand-alone statistical prediction scheme for seasonal rainfall in Fiji. A comprehensive assessment of the skill of the scheme was also produced. The Fiji Meteorological Service is now using this scheme operationally in their monthly climate outlook.

The only on-going input required for this scheme is the latest monthly value of the Southern Oscillation Index or SOI - a readily available, single number. This scheme therefore provides an extremely simple but highly useful starting point and potential back bone for seasonal forecasting operations, especially in countries with limited staff resources and/or experience in interpreting output from more complicated systems.

The project proposes similar schemes for other countries in the region, giving them the capacity to perform seasonal forecasts or at least to have access to forecasts specifically tailored to their regions/countries. During the first few months statistical schemes have demonstrable skill in the region (as has been the experience in Australia, Fiji, U.S. and French affiliates) and very likely have skill in the those countries in the region which do not currently have a capacity in this area.

While there is work being done in assessing the accuracy of climate predictions from climate models in other parts of the world, there is currently no initiative specifically focussed on downscaling (ie refining and directing) information from coupled atmosphere-ocean model seasonal to interannual forecasts in our region on a near real-time basis for use by NMSs.

Another obstacle to the widespread and prudent use of seasonal to interannual forecasts in our region is that their availability and potential usefulness is not widely appreciated by the general public. There is therefore a strong need for education and training in a wide range of issues both within our NMSs and amongst the broader community. The production of a new climate prediction service is of limited value if it is not used in decision making by governments and industry in the region or if the results are not used properly due to an imperfect understanding of the advice provided.

Project description: The project is therefore aimed at: -

- developing systems to downscale forecast information from coupled atmosphere-ocean general circulation models for our region;
- increasing the capacity of NMSs in the region to produce their own outlooks using in-house, stand-alone systems and to integrate this with the information from the coupled atmosphere-ocean models to produce a coherent whole;
- raising the awareness of the new products amongst the wider community as they become available;
- liaising with potential users (individual users, government agencies, and a range of industries) to ascertain what information and what formats will be of most use to them, to develop dissemination strategies and to increase awareness of their probabilistic nature and to assist in the incorporation of the forecasts into decision-making.

These aims are to be achieved as follows:

1. Training workshops (approximately 2 weeks duration) in the region possibly in Fiji ideally prior to a 2 day climate outlook forum) after the statistical schemes have been developed) in 2001/2002, with the participation of lecturers from SPREP member nations and other centres around the world. This is aimed at training participants on how to use the schemes developed and on accessing and interpreting material from centres around the world and on devising an actual outlook for the region. Specifically it will aim to:-

* raise appreciation of factors affecting climate on large-scale and on a regional/national scale;
* enhance ability of NMSs to interpret forecasts from centres around the world and incorporate information into NMS outlook statements;
* develop capacity to make statistical forecasts using proposed scheme;
* ability to access and understand additional information from overseas on an ongoing basis;
* an appreciation of the relative skill of the various methods to ensure that consensus forecasts are on as objective a footing as possible ; build an informal self-support network in the region to support the more formal structure (see below);
* increase understanding of the basis for statistical and numerical prediction;
* building links with users - demystifying the forecasts, tailoring forecasts;
* increase appreciation of psychological and sociological pitfalls that can be associated with subjective consensus forecasting;
* provide an operational climate outlook for subsequent dissemination

Cost: $40, 000 per workshop

2. Professional Officer to build schemes, document schemes, verify schemes and provide supporting explanatory reference material. Roving training work, education, implementation, liaison as required ($150,000)
3. Support for longer term training attachment of key staff at centres where the method is well established (e.g. Fiji). ($30, 000)
4. A trainer/technician perhaps based in Fiji, Australia or at SPREP to follow up on trainees to answer any further queries to ensure smooth running of systems for 12 months or longer, to explain and assist with implementation of new services as they become available ($50,000).
5. The use of consistent PCs in all centres would be an advantage for follow up, so that centres can exchange information on smooth running of packages ($30,000).
6. See project 4.3. Person to assist with collation and dissemination in the region making full use of existing channels and modern methods where possible but ensuring that all participating nations receive timely information.
7. A person to develop and implement a marketing strategy - to gauge what products are most needed and in what format and by what channels, to promote services as they are developed, to

provide advice on promotion and media liaison, to assist with ongoing improvement of systems ($60,000).

8. Two post-doctoral fellows to investigate the feasibility, and if feasible, develop real-time systems to downscale forecasts from coupled atmosphere ocean models and to develop an objective consensus system incorporating climate forecasts from more than one system to enhance accuracy ($260,000)).

Objective: To enhance the ability of NMSs in the region to produce, interpret, disseminate and explain climate prediction information using modern techniques, to raise the awareness of the availability and potential usefulness of the information, to enhance the ability of potential users to incorporate the predictions into their decision making.

Location: Australian Bureau of Meteorology, SPREP, Fiji Meteorological Service, and NMSs throughout the region.

Duration: Three years.

Expected outcome: Increased ability of companies, government agencies and individuals to factor climate prediction information into their decision making which will assist in the better management of activities (e.g. government, business, health, agriculture) related to climate variability in the region.

Project implementation: Australian Bureau of Meteorology, SPREP, Fiji Meteorological Service

Risks and sustainability:

It has been assumed that the observational data needed to develop prediction schemes (both stand-alone and downscaled) are made available by the individual NMSs. All of the initiatives are aimed at capacity building in the individual centres and to provide systems that will be of use for extended periods beyond the project life-time within the various NMSs.

Indicative budget: US$620,000

Project 2 (DP2) Pacific Regional Climate Bulletin

Background: In 1996, SPREP commissioned a feasibility study to look at ways of developing a Regional Climate Bulletin. The idea for a regional bulletin came out of the third SPREP Meeting of RMSD in 1995. The study concluded that there was urgent need to establish a regional climate bulletin to disseminate climate information and predictions to all people in the region. At present, only a quarterly newsletter produced by the Pacific ENSO Application Center (PEAC) in Honolulu, Hawaii is serving as a source of climate predictions. This newsletter only covers US affiliated countries and territories. A detailed proposal for a regional bulletin came out of the 1996 feasibility study. SPREP submitted this detailed proposal to various donors and as of this year, the Italian government has agreed to provide limited funds to kick-start the bulletin

Project description: A regional climate bulletin catering for the needs of all SPREP Pacific Island members will be produced. Ideally. It could be hosted in a web page. However, hard copies still need to be produced and circulated.

Objective: To develop a regional climate bulletin serving the needs of PICs

Location: SPREP Web page, or Fiji Meteorological Service, PEAC, NIWA, BoM

Duration: Three years.

Expected outcome: Timely and wider dissemination of climate information and predictions.

Project implementation: SPREP/WMO jointly with PIC NMSs and advanced climate centres.

Risks and sustainability:

The main risks are the lack of committed funding, which this proposal is seeking to address.

Indicative budget: US$300,000

Project implementation: The project is envisaged to span 5 years, implemented in the following phases; Phase 1: Procurement of Equipment, Phase 2: Installation and Commissioning and Phase 3:Training and on-going maintenance

Risks and sustainability: The main risks are likely to be inadequate commitments from partner countries resulting in insufficient funding for spare parts and on-going maintenance. This can be addressed by ensuring prior commitment to funding of parts and maintenance by partner countries, and ultimate replacement by charges to end-users of the information, or by inclusion in government budgets.

Indicative budget: US $ 430, 000

Phase 1:	30,000
Phase 2:	250,000
Phase 3:	150,000
Total	430,000

It is envisaged that as far as possible, recurrent costs such as system maintenance, would be capitalized and funded through advance or progressive payments to the regional network maintenance center. By this approach, the individual NMSs would not be liable for the network running costs. This phase will take about one to two years for completion, with most installations being completed by the end of year 2 and the project completed by year 3.

Project 3 (DP3): Restore and upgrade the human-operated surface observational network

Background: Observations from existing manual surface observing networks within the region are inadequate to meet the requirements of NMSs on all levels. The deficiencies in surface observing systems are due to the lack of appropriate equipment, training & quality control management (i.e. observations not taken or not taken on time, or not taken accurately), and on-going maintenance. The problem is compounded by the large gaps within the present networks. These gaps need to be narrowed by installing additional human-operated observing stations.

Project description: Specifically, source and supply standard surface meteorological instrumentation (Stephenson Screens, recording rain gauges, solar radiation measuring equipment, anemometers, etc, including spare parts) required to upgrade country networks to meet user needs for services of international standards. The project will ensure equipment provided under past programs (e.g. the Pacific Meteorological Services Project (PMSP) completed in 1997) continue operating. The equipment will be procured through a central facility in SPREP or through a contractor. Equipment standards should be confined to WMO standards. A Project Co-ordinator will manage the implementation, and where necessary, arrange for further training of key technical staff.

Objective: To restore and upgrade human-operated surface observing networks in the region to provide quality meteorological and climate data

Location: All NMS of Pacific Island Countries and Territories

Duration: Five years.

Expected outcome: Operational equipment and human-operated weather stations restored and in full operation again; and installation of new human-operated surface observing stations in strategic locations to better understand the climatology of the region, and provide improved services.

Expected impacts: Increase in more accurate data from human-operated surface observing stations leading to better warnings and climate predictions for the Pacific Islands, better understanding of the climatology of the region for planning purposes, and safe marine and aviation operations in particular.

Implementation: A meteorological technical specialist with experience in the region will be contracted to undertake maintenance of existing equipment and installation of new equipment. The specialist will be contracted to SPREP, which will manage funds allocated for the project. The funds for this project should be put under the SPREP Special Purpose Fund already set up for this purpose.

Risks and sustainability: No funding committed from development partners and individual governments. No commitments and support from local governments. The WMO Technical Cooperation Program could assist in this project.

Indicative budget: US$750,000

Instrumentation and installation:	700,000
Training	50,000.
Total	750,000.

Project 4 (DP4) Provision of Data Collection Platforms (DCP)/Automatic Weather Stations (AWSs)

Background: A continual problem experienced by all Pacific Island NMSs is the difficulty in the timely collection and distribution of surface observations. The analysis, as well as periodic surveys carried out by WMO highlighted this issue as a major problem which needs to be addressed. A major factor contributing to the belated transfer of data is poor or unserviceable telecommunication links from remote stations, particularly from outer islands. Unless observations are collected and put onto the GTS (Global Telecommunication Systems) promptly, they are of very little use. If the data are not received on time, then the efforts of individual observing stations are largely wasted. By using simple and relatively low cost satellite based transmission equipment, which has a proven record in the region, the collection and dissemination of data would be vastly improved.

Description of Project: The project seeks to identify simple and reliable equipment for use in these applications and to ensure its correct installation, use and maintenance. Three types of DCP equipment will be assessed and implemented using GOES - WDCS system as the transmission medium with the following basic characteristics. Where access is not available through GOES-W, access through the Japanese GMS (Geostationary Meteorological Satellite)/MTSAT (Multifunctional Transport Satellite) will be sought. This technology is successfully used world wide to collect data from many different sensors. Systems envisaged include a simple keyboard entry, store and forward system to transmit manual observations, a combination of human-operated entry and automatic entry (where human-operated observations can be entered into the data stream for additional parameters not collected by a normal automatic weather station) and a fully automatic station capable of making standard observations of wind speed and direction, temperature, dew point/relative humidity and atmospheric pressure. About 70 manual entry DCPs will installed at remote stations.

Objective: The prime objective of this project is to ensure quick, reliable and accurate data transmission from meteorological observing stations in to the GTS. The distribution of the data to various analysis centres is crucial for the provision of better and improved services. The project also seeks to provide additional observation points from strategic remote areas where no observations are currently available. This will be particularly important in countries within the tropical cyclone belt.

Expected impacts: The major impact of this project will be to make a dramatic improvement in the reliability of meteorological data collection throughout the Pacific area. It will enable forecasters to use accurate and timely data to prepare forecasts, provide accurate and timely data input to models for developing longer term forecasts, and provide more accurate input to climate databases throughout the region. It will also provide early warnings of possible cyclone genesis in areas where synoptic data is currently unavailable. This in turn will contribute to the improved safety of life and property in those areas. The use of DCP technology will reduce the recurring costs of data collection.

Locations: All Pacific Islands Countries and Territories.

Duration: 2 - 3 years.

Expected outcome: The proposed project will provide for much improved data collection and distribution. It will provide collection points in strategic areas where they do not exist at present and will enhance the tropical cyclone warning system throughout the Pacific region. It will also result in reduced ongoing telecommunication costs.

Project implementation: It is envisaged that the project will be implemented in two parts. Due to the harsh environment and the need for appropriate reliable equipment, it is desirable that a survey be undertaken to identify the shortcomings, if any, of existing DCP installations and prepare a detailed design document which will set out the requirements in detail. Once a detailed design and procurement document is available, tenders would be called for the supply, delivery and installation of suitable equipment. The installation phase would see the delivery, installation and commissioning of the equipment using local meteorological staff as much as possible, or involving them as trainees or counterparts in the process, to give them the opportunity to become familiar with the equipment, its operation and maintenance.

Procurement: Procurement would be by international tender after a suitable tender document has been prepared. If it is possible under agency contracting procedures, it would be desirable that the person who prepares the initial contract documentation be appointed as the project manager to ensure continuity and sharing of local knowledge.

Management: As described in the above sections it will be desirable to appoint a project manager to oversee the project design and implementation.

Risk and Sustainability:
Appropriateness of equipment for harsh environment. Equipment failure resulting in non-transmission of information. Equipment may not be maintained regularly and appropriately and fail, and so information flow will fail. Equipment should be robust, accepting that value-for-money may involve purchase of more expensive equipment but which remains reliable in the long-term. Equipment should, as far as possible, be compatible throughout the region. NMS staff should be involved as counterparts during the installation and commissioning phase to improve understanding/familiarity with equipment.

Indicative budget: $3,160,000

Initial Project Design	100,000
Procurement and Installation.	2,100,000
Civil Works	150,000
Spares	210,000
Training	200,000
Project Supervision	400,000

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Project 5 (DP5) Restore and upgrade the regional upper air networks

Background: Upper air observations are essential for understanding atmospheric processes driving weather and climate. Data from upper air observations allow forecasters to assess the development and movement of weather systems. These observations are also very important in understanding changes in the regional climate (of the scale of climate variability and change). The observations are particularly important for the prediction of the development and movement (paths) of tropical cyclones. In the South Pacific region, upper air reports have declined significantly in the last 10 to 20 years. Many of the upper air stations with long history of excellent records have been closed down. The upper air network in some critical areas has wide gaps in it, often resulting in a tropical cyclone slipping through the network, without any information being available on it in the upper atmosphere. There are two main reasons for this decline: a) lack of on-going funding for expensive radiosondes (electronic equipment released attached to balloons); and b) failure of hydrogen generating systems (for filling the balloons) due to age. The current hydrogen generators are also very dangerous to operate due to age, and are environmentally damaging.

Project Description: The project will supplement about half the total cost for radiosondes over 5 years for countries with critical shortage of operational funds, procure and install new radiosounding ground systems (including GPS receivers) and modern hydrogen generators to replace failed systems as necessary (including the necessary maintenance training). Supplementary funding support for radiosondes is included in this project because of the crucial importance of upper air observations in particular for tropical cyclone warnings, aviation forecasts, and better definition of regional/global scale computer models for the benefit of the whole regional/global community. These models are also used jointly with global ocean models, to understand ocean-atmosphere interaction, and are being refined using the Pacific network of sea level gauges provided under a separate AusAID project. A Proton Energies system, a generator based on electrolysis, which has no moving parts, and is virtually maintenance free, is recommended. The US NWS has installed a Proton Energies systems and plans to replace existing generators at its Pacific Region upper air stations with the same model. The hydrogen generating systems supplied must meet any relevant regulations for each respective country since hydrogen is a highly dangerous, inflammable gas. Moreover, during the life t To understand ocean-atmosphere interaction,ime of the project, it is expected that wind profilers will begin to offer a more cost effective alternative to the conventional systems, and this option kept in mind in

Objectives: To provide regular, uninterrupted flow of upper air meteorological data with adequate spatial coverage to support the provision of high quality cyclone warnings, and weather and climate prediction for various purposes.

Location: Cook Islands (2), Fiji, Kiribati, Solomon Islands, Tonga, Tuvalu, Vanuatu, Papua New Guinea.

Duration: 5 years

Expected outcome: Uninterrupted flow of upper air meteorological data with adequate spatial coverage contributing to improved weather services, in particular cyclone warnings, aviation weather services, and seasonal/climate prediction.

Expected impacts: Positive impact on social and economic development, through improved weather and climate services.

Project implementation: The hydrogen generators will be procured and installed by contract with the supplier, and coordinated by SPREP/WMO. Radiosondes will be bulk purchased from the suppler.

Indicative budget: US$ 2.6 million

Hydrogen Generators:	500,000
Radiosondes (bulk purchase):	1,500,000
Radiosonde ground systems (9)	600,000

Risks and sustainability:

Risks: National inability to fund spares for maintenance of equipment. Provision of equipment and materials should be conditional on government-endorsed take-over plans, and agreed gradual increase in PIC government funding of the upper air measurement programs to 100% after 5 years.

Sustainability: Upper air systems have been operating in many Pacific Islands NMSs so the technology is well known, and is almost a certainty that they can be sustained.

Project implementation: The hydrogen generators will be procured and installed by contract with the supplier, and coordinated by SPREP/WMO. Radiosondes will be bulk purchased from the suppler.

Indicative budget: US$ 2.6 million

Hydrogen Generators:	500,000
Radiosondes (bulk purchase):	1,500,000
Radiosonde ground systems (9)	600,000

Risks and sustainability:

Risks: National inability to fund spares for maintenance of equipment. Provision of equipment and materials should be conditional on government-endorsed take-over plans, and agreed gradual increase in PIC government funding of the upper air measurement programs to 100% after 5 years.

Sustainability: Upper air systems have been operating in many Pacific Islands NMSs so the technology is well known, and is almost a certainty that they can be sustained.

Project 6 (DP6) Provision of high frequency radio transceivers for the collection of weather reports from outstations.

Background: Many countries use transceivers to collect weather observations and reports from outer stations at a central NMS location. In some countries, these are old and difficult to maintain, resulting in frequent and lengthy interruptions in the collection of weather reports, especially in times of stormy weather. The transceivers also provide backup to other available means of communication (including of warnings), and are the only means for the relay of administrative messages to isolated weather stations. Without effective communication systems, forecasts and warnings systems, however accurate, are worthless, as warnings and advice cannot be passed on to affected communities.

Project description: The project involves the procurement and installation of high frequency radio transceivers to replace existing systems, including the aerial system, solar power supplies, and an adequate supply of spare parts. Procurement will be done regionally (for ease of purchase, cost effectiveness and to assist NMS mutual support networks) and implementation will be the responsibility of individual NMSs. An estimated 45 systems will be required.

Objective: To improve the communication and collection of weather reports from outstations and to provide better severe weather warnings and advice to outlying stations/communities.

Location: Cook Islands, Fiji, Kiribati, Papua New Guinea, Tuvalu and Solomon Islands. (Kiribati and Tuvalu to receive only solar power supplies and aerial systems)

Expected outcome: Regular uninterrupted availability of essential weather reports at the national collection centres for NMS use and for regional and global dissemination.

Expected impacts: Improved weather and climate services for the economic and social benefit of the region

Implementation: Complete systems will be bulk purchased and implementation will be co-ordinated by SPREP/WMO.

Risks and sustainability: Risks: SPREP should ensure that all recipients can install and test the equipment, and provide support for this if individual NMSs cannot undertake the installation.

Sustainability: The systems will be sustainable if NMS users are familiar with installation and maintenance protocols, if problem identification manuals are available at all locations, and if there is a regularly replenished store of standard spare parts in each location. SPREP should co-ordinate the provision of manuals and spare parts.

Project 7 (DP7) Regional Pacific Intranet (RPI)

Background: Communications links to most Pacific NMSs are based on low speed Aeronautical Fixed Telecommunications Network links supplemented by special purpose systems such as satellite based EMWIN and the geo-stationary satellite Data Collection Service (DCS). While these systems serve their specific purpose well, they do not offer a simple but versatile communication capability to enable NMSs easy access to neighboring countries, the WMO GTS or the global Internet. This project seeks to fulfil this need.

Project description: The project entails an 'intranet' for the Pacific states, implemented through a satellite based Very Small Aperture Terminal (VSAT) network. The Regional Pacific Intranet (RPI) would allow each Pacific NMS to have reliable and high capacity access to the Internet. This would allow access to the vast range of scientific and information resources as well as access to services and NWP output of leading centres. In addition, it will facilitate exchange of information, and routine forecasts and warnings among the Pacific Islands.

Objectives: To provide a facility which will enable efficient communications between Pacific NMSs, a high capacity connection to the global Internet, and improve the operation of real time exchange of meteorological data and enhance the Global Telecommunications System (GTS) in the Pacific.

Locations: All Pacific Island NMSs. This amounts to approximately 21 countries or territories, subject to refinement of numbers after a detailed project design study.

Duration: The project is expected to have a duration of four years for implementation and an overall minimum lifetime of 10 years.

Expected outcomes: Improved forecast and warning services to local communities, aviation, agriculture and marine sectors, through timely access to regional data and information sources; advancement of the understanding of the climatology of the Pacific by improving and facilitating exchange of scientific data and research collaborations; strengthened cooperation between states through ease of communication and mutual assistance, particularly during severe weather events; and mitigation of the risk of small Pacific states becoming 'information poor' as information technology continues to advance in the developed world.

Project implementation: The project is envisaged to span 4 years, implemented in the following phases:

Phase 1: Network feasibility and design study, to determine local requirements, regulatory constraints and site-specific factors which might limit the effective operation of such a facility. From this study, a network design would evolve, from which procurement specification would be prepared. This phase may take six months.

Phase 2: Implementation. This phase will involve the procurement and installation of the VSAT network through open tendering. The contractor selected would be required to provide, install, commission and maintain the network for its operational life. It is envisaged that as far as possible, recurrent costs, such as space segment lease costs and system maintenance, would be capitalised and funded through advance or progressive payments to the network contractor on a regional network basis. With this approach, individual NMSs would not be liable for network running costs. This phase will take about one to two years for completion, with most installations being completed by the end of year 2 and the project completed by year 3.

Risks and sustainability:

Risks: The main risks and difficulties may be the project magnitude associated with geographic extent of areas and diversity of countries. This will mean that project coordination and management will be a large and complex task and great care will be required in selecting a contractor with the necessary organizational skills, technical experience and political/institutional credentials. Possible difficulties with the telecommunications regularity regime in each country, which may impede approval for establishing communication networks independent of the national telecommunications carrier. This risk may be addressed by emphasizing the benefits flowing back to the country through improved services, combined with assurances that the system will be used only for bona fide meteorological purposes (although the difficulty of policing this assurance must be acknowledged). Alternatively an agreement may be reached by convening a series of in-country inter-agency workshops, to consider the national implications of the NMS having access to such a facility.

Sustainability and support: VSAT systems are a very reliable and mature technology. The best maintenance strategy would be to contract with the system vendor to provide maintenance services for the life of the network, as part of the purchase cost. In this way, the users of the system could treat it as a 'black box' and need not become involved with its internal working or support. This type of arrangement is normal, even in developed countries, because the specialised nature of the VSAT equipment usually does not lend itself to user maintenance.

Indicative budget: US$3,600,000

The total budget is estimated at $US 3.6M apportioned as follows:
Phase 1: 100,000
Phase 2: 3,500,000 (includes capital and recurrent costs for 8 years capitalised)

Project 8 (DP8): Upgrade and improve GTOS stations in the region

Recent analyses carried out by South Pacific Island hydrologists in the framework of WMOs Southwest Pacific Regional Association have indicated that improvements in the availability of water-related information are needed to support sustainable water resources management. The WHYCOS (World Hydrological Cycle Observing System) concept might provide a vehicle, with modification, to build regional capacity in this area, and WMO has commissioned a thorough needs analysis as a basis for a Pacific-HYCOS project design. The project design considers the group of Pacific Island developing states that stretches from Papua New Guinea to French Polynesia, and that has Melanesian or Polynesian indigenous populations. As in many developing countries, their governments tend to focus attention on health, education, and basic infrastructure (telecommunications, transport, energy), and water is of significance principally in the context of public health (that is, water supply and sanitation) and energy supply.

In summary, the main requirements for water-related information that are indicated by the needs analysis are:

- Real-time rainfall and streamflow information for flood forecasting: six countries.
- A drought forecasting capability: all countries.
- Baseline information an the water resource in waterways having hydropower potential, most of which would be at the micro- or mini-hydro scale: five countries. Baseline information on surface waters likely to be affected by mining or forestry development, and subsequent monitoring: four countries.
- Water resource information, including streams, springs, and aquifers, at a reconnaissance scale, in support of rural water supply projects: all countries.
- 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: about ten countries.

Each of these is a requirement only in a subset of the Pacific Island countries. The needs analysis also assessed capacity building requirements in the region. In some countries there is effectively no national hydrological service, and water-related information is collected, if at all, by the water using agencies - usually the water supply authority. In the others, there is some form of national hydrological service, normally located in a ministry for the environment, public works, or natural resources. However, in most cases it is under-resourced, sometimes with demoralized staff who have have vision for the future, and in several cases it has all but ceased to function. Only in Fiji and the French territories could the national ability to collect and archive water- related information be regarded as meeting national needs.

On the basis of the analysis of needs, a Project concept is proposed that takes the WMO's WHYCOS concept and reshapes it for Pacific Island circumstances. The project will involve a number of elements, in different combinations in each participating country, that together build national capacities to obtain and manage information about their water resources. The principal direct beneficiaries of the Project's outputs are envisaged to be officials of Pacific Island government agencies and NG0s, who have some responsibility for water resources planning and management, environmental monitoring and management, education, hazard mitigation, andlor national development. The ultimate beneficiaries, with whom the officials have direct contact, include elected representatives and leaders, and the general public.

The overall Project goal 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.

The Project has three main purposes that contribute to achieving the above goal:

1 . 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.
2. To establish basic hydrological monitoring and data capture systems, using technology that balances modernity, economy, robustness, and suitability for Pacific Island circumstances.
3. 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.

It has six “output delivery" components, and one "management" component:

Component 1: Flood forecasting capability. *Objective:* To develop a methodology for flood forecasting and implement it in 15 selected critical catchrnents in the participating countries.

Component 2: Water resources assessment in major rivers. Objective: That participating countries with significant surface water resources have in place a basic network of near-real time hydrological observing stations and the capability to securely archive incoming data.

Component 3: Water resources databases. Objective: That participating countries will have national hydrological databases that are secure and meet agreed data quality standards, and the capability to maintain them and generate information products that meet users' needs.

Component 4: Drought forecasting. Objective: To develop and implement a common approach to drought forecasting in participating countries.

Component 5: Groundwater monitoring and assessment. *Objective:* To establish in participating countries a basic capability in monitoring and assessment of groundwater resources.

Component 6: Water quality monitoring and assessment. *Objective:* TO establish in participating countries a basic capability in monitoring and assessment of water quality and chemistry.

Component 7: Project management. *Objective:* To have Project management systems in place and implemented that (1) ensure that contracted outputs are delivered on time, to standard, and within budget; (2) enable the Project to respond promptly to changing requirements; (3) facilitate the participation of stakeholders in Project affairs; (4) provide timely and accurate reporting.

The responsibilities of the Supervising Agency, Executing Agency and the participating countries are outlined in the document; a Regional Centre will be required, and a Regional Steering Committee will play a key role in Project oversight and monitoring. The Project is costed at almost A$2.2 million; it is recommended to have a duration of five years, with the several components being implemented in a staged manner to spread the cost and to avoid overloading the very limited capacity of the participating countries to absorb Project activities.

The Project will need to place emphasis on monitoring performance against a set of indicators, which are proposed in the logical framework. Because this is a development project that assists small island developing states, it is inherently a high risk project. The proposed design aims to minimise risk of Project failure and to maximize the likelihood of post-Project sustainabiiity. The Executing Agency will need, during implementation, to:

1. demonstrate to participating country governments, NHSs and other stakeholders the benefits of the Project (which is best done as early as possible);
2. maintain very effective relationships and communication channels with the Project Steering Committee, participating country governments, and stakeholders, especially those involved in public sector institutional strengthening;
3. Update the analysis of NHS needs annually, as a basis for including capacity building in the annual plans;
4. incorporate into the annual plans a regularly updated risk management strategy;
5. carefully monitor during years 1 to 4 the progress of each NHS in establishing and sustaining the desired capabilities, and identify any under-achievement;
6. target capacity building at the areas and participating countries where there is greatest need.

An impact assessment indicates that the Project will have positive impacts in economic, environmental, and social areas, principally by improving the quality of information on which resource management, hazard mitigation, and economic development planning is based.

Project 9 (DP9) Climatology training

Background: Climate information and prediction services was identified as one of the key priority needs of users, particularly in the forestry, fisheries and agriculture sectors, and for disaster management. Most users wanted to see more regular updates and accurate predictions of the El-Niño/La-Niña and associated weather and climate extremes (e.g. probability of tropical cyclones occurrence). Despite this high priority need, there are very few qualified climatologists in the region. This project aims at developing university level knowledge and skills in climatology, develop the capability to carry out climatological analysis and interpret these to users including policy makers.

Project description: Interest in hosting this program was expressed by the University of the South Pacific, as a part of the Pacific Islands Climate Change Diploma Course, initiated under the PICCAP program.

Objective: To develop university level knowledge and skills in climatology.

Location: USP

Duration: Three years.

Expected outcome: More qualified climatologists in the region.

Project implementation: USP, SPREP and WMO.

Risks and sustainability: The main risks are the lack of committed funding, which this proposal is seeking to address.

Indicative budget: US$250,000

Project 10 (DP10) Basic meteorological observer training

Background: New recruits to a NMS whose jobs involve acquisition and processing of different kinds of weather data require training before operating independently. The training involves a basic knowledge of meteorology and methods and procedures for making observations in conformity with prescribed WMO standards, maintenance of basic instrumentation, and transmission of data. The nature and level of training required is not available within most PICs. The FMS will run the Basic Observer Training Course, which it has conducted in the past for its own recruits, as required for trainees from other PIC NMSs.

Description: High school graduates with good backgrounds in math/physics/computer basics who are new entrants to a Meteorological Service will be provided training at the Fiji Meteorological Service, in Nadi. FMS will take 5-10 trainees in to this course, depending on demand. It is proposed that 5-10 trainees from PIC NMSs will be trained during alternate years in the next 5 years, starting in 2001. The project will benefit Cook Islands, Fiji, Kiribati, Niue, PNG, Palau, Samoa, Solomon Islands, Tokelau, Tonga, Tuvalu, and Vanuatu, as required.

Objective: To improve and maintain weather-observing standards through the provision of appropriate training to weather observing personnel entering an NMS.

Location: Fiji

Duration: The training course is of about 2-month duration. The duration of the project will be 5 years.

Expected outcome: Availability of quality observations to meet the requirements for providing useful weather and climate services.

Expected impact: Social and economic benefits due to improved weather and climate services

Estimated Budget: **$110,000**

Implementation: The project will be implemented through co-operative arrangements with the Fiji Meteorological Service, co-ordinated by SPREP/WMO.

Risks and sustainability: None identified.

Project 11 (DP11) Technical maintenance back-up

Background: Specialized meteorological maintenance services are generally not available in the Pacific Islands. In the past, many countries relied on the former New Zealand Meteorological Services (now MetService New Zealand Ltd.) and other advanced NMSs through bilateral or multilateral development assistance for such services. Changes in the policies of these development partners saw technical assistance discontinued. At the 1998 SPREP Meeting of RMSD in Honolulu, the 26 Directors recommended the establishment of the SPREP Special Purpose Fund (Trust Fund). The idea is to attract funding from external sources to support on-going maintenance of equipment and to fill gaps left by New Zealand and others. The need to maintain a technical back-up maintenance program is urgently needed.

Project description: The project seeks to provide specialist maintenance, maintenance advice and calibration services including the necessary spare parts not available locally. The project will also seek to procure better deals with manufacturers of meteorological equipment through bulk purchase agreements of consumable items (radiosondes, balloons, etc). The project will also provide advice on requirements for monitoring and maintenance, including those required for all stations throughout the region. The project will also encourage annual inspection visits as requested by countries and promote the development of technical maintenance skills within countries.

Objectives: To provide external specialist and back up services required to maintain weather and climate monitoring to WMO specified calibration standards as well as securing funding for the Special Purpose Fund.

Expected impacts: Continuous full operations of observing stations throughout the region and procurement of advantageous purchase deals with manufacturers of meteorological equipment through the negotiation of bulk purchases on behalf of the countries.

Location: All SPREP Pacific Island members in Categories B, C, D, E.

Duration: Total support time of six months per year, over five years but with expectation of longer term support beyond this period.

Expected outcome: Secure cost-effective purchase agreements with manufacturers of meteorological equipment and continuous operation of the observing networks.

Project implementation: Technical specialists will be recruited by SPREP under contracts. SPREP/WMO will manage the contracts and disbursement of the funds.

Risks and sustainability: Development partners do not have the funds to contribute to the SPREP Special Purpose Fund. Recipient countries do not provide on-going support. SPREP is already undertaking this task with financial contributions from new development partners.

Indicative budget: US$500,000

Project 12 (DP12) Marine meteorological data reporting, collection, dissemination, and training.

Project Title: Provision of a Marine Meteorological Reporting Network for the collection and dissemination of marine meteorological reports from small boat operators, and expanded participation in the WMO Voluntary Observing Ships (VOS) Program for medium and large ships by Pacific Island NMSs

Background: A major problem for regional forecasting centres and most NMSs with forecasting capability is the lack of meteorological reports over open waters of the Pacific. At present, there is a lack of VOS meteorological reports in many sections of the tropical Pacific. These reports provide critical data in support of operational meteorology to meet the needs of marine meteorological services, including those for the GMDSS, and those issued specifically for the marine communities, as well as global climate studies. The project will identify resources (i.e. marine meteorological observing equipment) needed for Pacific Island NMSs to increase participation from vessels operating between the island nations. There is an even greater need to obtain marine meteorological reports from small craft operating within the region, particularly out from shore to 150 km, in support of marine forecasts and warnings for near shore and coastal waters.

Project description: This project proposes to train small and medium crafts operators in the region, on how to take, record, and transmit marine weather reports to NMSs. It also proposes to establish marine radio station operators to collect marine weather reports and to disseminate marine forecasts and warnings to near shore crafts operators. A similar network called the 'Caribbean Regional Meteorological Emergency Network (CARMEN)' is successfully operating at present in the Caribbean.

Objectives: To provide a simple and reliable marine weather report collection network in the region and within islands, particularly for those islands with vast exclusive economic zones (EEZ). The network will collect and disseminate real time marine weather reports from small and medium craft (boats) operators to the region's NMSs and regional forecast centres, The project further aims to increase the number of Pacific Island registered ships participating in the WMO VOS Program. The project also aims to conduct seminars for recruiting and training marine boat operators to take and disseminate marine weather reports, including the provision of marine radios and marine meteorological equipment to facilitate report collection and dissemination.

Expected impacts: The provision of this equipment will contribute to the safety and well being of the marine community within PICs and Territories by providing the means to increase marine weather reports and improve the accuracy of marine weather forecasts and warnings.

Locations: About 50 locations throughout the Pacific Islands (about two coastal radio stations per country/territory).

Duration: 2 – 3 years.

Expected outcome: Greatly improved receipt of marine meteorological reports to NMSs and regional forecast centres. This will result in improved marine forecasts and warnings to island communities, improved safety of life and property and enhancement of the critical marine transportation sector of island economies.

Project implementation:

Schedule: The first phase of this project will be to write a detailed specification for the equipment required, identification of participating coastal radio station operators, and the identification of training resources and meteorological equipment needed for recruitment and training of boat operators.

At this stage there will also be a need to consider social/community participation aspects of the design, to engage and motivate stakeholders, including small-scale fishing boat operators. The services of a community development specialist/facilitator will be necessary for short-term implementation. Expressions of interest can then be obtained from prospective manufacturers. They will then be given the opportunity to competitively bid for the supply of the equipment and if they have the necessary resources, to provide installation and commissioning supervision.

It is desirable that the project manager should participate in both the design and installation / commissioning of the equipment, and plan/conduct marine workshops in major ports to recruit and train new boat operators on procedures for taking and transmitting marine meteorological reports. It is expected that the design/testing phase could take up to 12 months and that the installation of coastal radio stations, which would be identified by the Pacific Island NMSs in partnership with their national marine agency, would then proceed in the next phase.

Installations should be carried out as much as possible by Pacific Islands' Meteorological staff under the supervision of a contractor or the project manager. Adequate training in the use and maintenance of the equipment will be required. Because of the simple design, it is expected that operational training will be minimal.

Procurement: There are two phases to this project. The first phase involves the procurement of appropriate equipment. The second is the implementation phase, including adequate training in the operation and maintenance of the equipment. The supplier will be expected to manufacture suitable terminal equipment to meet the specifications laid down. The equipment at each coastal radio station will consist of two VHF and two HF radios, two antennas, mounts, power supplies, two PCs with modems, printers, printer supplies, scanners, and CD and CD write drives. The procurement will also include a supply of anemometers, barometers, and thermometers for use on boats and ships. Each coastal radio station will also receive a complete EMWIN system, to insure receipt of marine forecasts and warnings, and marine weather maps from regional centres, and verify that the reports collected were received by the Pacific Island NMSs and disseminated. The prime requirement will be for simple and robust equipment that will operate satisfactorily in the tropical maritime environment prevailing in the Pacific Islands. Care must be taken to ensure long operating life with minimal maintenance.

Management: It will be necessary to provide project oversight to ensure that the equipment provided meets the requirements of the project and that it is installed and operating satisfactorily. It will also be necessary to insure marine training workshops are conducted and reinforced, and NMS personnel are trained on installation and preventative maintenance for all marine radios and meteorological equipment, including a reliable supply of replacement instruments.

Risks and sustainability: As with any project being carried out in remote areas there are always a number of risks attached to this project. Risks will include lack of interest within the affected community, unless the benefits are explained clearly, failure of equipment and difficulty in ensuring maintenance and repairs, and loss/theft of equipment unless training in care and maintenance is adequate. With careful and adequate project design and implementation these risks can be minimized.
Indicative budget: US$530,000

Design Phase	20,000
Manufacture and Testing	210,000
Installation and Commissioning	100,000
Training Workshops	100,000
Project Supervision.	100,000
Total	530,000

Project 13 (DP13) Hydrological Training Needs of Small Island Countries of the South Pacific (SOPAC/WMO/UNESCO)

The South Pacific Applied Geoscience Commission (SOPAC), in collaboration with the World Meteorological Organization (WMO) and the United Nations Educational, Scientific and Cultural Organization (UNESCO), is pleased to submit this proposal for your consideration.

Issue

At a number of regional meetings including the:

- UNESCO/SOPAC/UNDDSMS workshop 'Pacific Water Sector Planning, Research and Training' (UNESCO 1995);
- UNESCO/SOPAC/USP Water Resources Workshop (Suva, Fiji, July 1997);
- Twelfth Session of WMO Regional Association V (South-West Pacific) (RA V) (Bali, 1998); and,
- WMO Expert Meeting on Hydrological Needs of Small Islands (Nadi, Fiji, October 1999),

small island countries in the Pacific have identified a lack of training as being an inhibiting factor in water resources development and management in their countries.

Proposal

A programme to develop and strengthen the basic hydrological training needs of small island countries in the Pacific.

Outcome

Increased national capacity to meet the challenges of development by implementation of water resources monitoring and information systems to enable the sustainable management of water resources in the small island countries of the Pacific.

Specific Benefits

The programme will result in:

- Provision of (basic) hydrological training at the regional level in a region where it is not viable to undertake a training programme in each individual country;
- Increased skill and technical capacity in hydrology for the staff attending the training;
- A consistent and practical approach to water resources monitoring and information systems in the region which will provide the basis for sustainable management of the resource;
- Additional expertise and knowledge base in hydrology and water resources management within SOPAC (aimed at ensuring the programme is sustainable);
- Hydrological training material that is tailored to meet the needs of the small island countries in the Pacific;
- Further transfer of hydrological skills within the participating agencies;
- A pool of hydrological expertise within the region; and
- Improved communication and information sharing between the participating agencies.

Strategies

The programme will apply the following strategies in undertaking its activities:

- Training will be undertaken within the region and respond to identified needs from within the region;
- The programme will be partnership focussed and thus make use of an existing regional body (SOPAC) and it's existing training infrastructure;
- The training will target basic skills courses of a few weeks duration, rather than training over a long period;
- Where practical, training will take the form of "train-the-trainer" exercises so that knowledge and experience can be further disseminated;
- Where practical, the gender balance will be addressed through selection of female participants;
- By using an existing regional body (SOPAC), all attempts will be made to enable the programme to be both practically orientated and sustainable into the future;
- By incorporating a training on hydrological databases in the framework of the International Hydrological Programme (IHP) funded through UNESCO Apia Office overlap of activities is avoided;
- Participation of all small island countries will be promoted;
- Trainers with knowledge of small island country hydrology and related issues will be selected;
- Training material will be Pacific Island focussed; and
- Ongoing monitoring and evaluation together with end of project report which ensures a record of benefits gained is kept.

Resources Required

Summary of Funding Requirements

Year	Year 1	Year 2	Year 3	Total
Resources (US$)	$50,900	$69,700	$56,800	$177,400

10.3 Appendix 3 List of WMO Region V GSN Stations.

Appendix A- List of WMO REGION V GSN Stations

(Last update: 15 August 2001)

Source: GSN Monitoring Centre (http://www.dwd.de/research/klis/gsn_mc/)

Australia

Station Index	Station Name	Latitude** (°,')	Longitude** (°,')
94101	KALUMBURU	-14° 18’	126 38
94120	DARWIN AIRPORT	-12 24	130 52
94131*	TINDAL AWS	-14 31	132 22
94150	GOVE AIRPORT	-12 16	136 49
94170	WEIPA AMO	-12 41	141 55
94203	BROOME AIRPORT	-17 57	122 13
94212	HALLS CREEK	-18 13	127 39
94238			

TENNANT CREEK
-19 38
134 10

94259
BURKETOWN
-17 44
139 32

94275*
GEORGETOWN
-18 18
143 33

94287
CAIRNS AIRPORT
-16 53
145 45

94299
WILLIS ISLAND
-16 18
149 59

94300
CARNARVON AIRPORT
-24 52
113 40

94302
LEARMONTH AIR
-22 14
114 05

94312
PORT HEDLAND AMO
-20 22
118 38

94317
NEWMAN AERO
-23 21
119 43

94326
ALICE SPRINGS
-23 48
133 53

94332
MT ISA AIRPOR
-20 40
139 29

94340
RICHMOND
-20 43

143 08

94346
LONGREACH AIRPORT
-23 26
144 16

94367
MACKAY
-21 07
149 13

94380
GLADSTONE
-23 51
151 15

94403
GERALDTON AP
-28 47
114 42

94430
MEEKATHARRA AP
-26 36
118 32

94461
GILES
-25 02
128 17

94476
OODNADATTA AP
-27 35
135 27

94480
MARREE
-29 39
138 03

94482
BIRDSVILLE
-25 54
139 21

94485
TIBOOBURRA
-29 25
142 01

94492*
THARGOMINDAH
-28 00
143 49

94510
CHARLEVILLE AP
-26 24
146 16

94517
ST GEORGE
-28 02
148 35

94541*
INVERELL
-29 46
151 06

94570
TEWANTIN
-26 23
153 02

94589
YAMBA
-29 26
153 21

94601
CAPE LEEUWIN
-34 22
115 07

94626
CUNDERDIN
-31 39
117 14

94637
KALGOORLIE BOULDER AMO
-30 47
121 27

94638
ESPERANCE
-33 49
121 53

94653
CEDUNA AP
-32 07
133 42

94670
SNOWTOWN
-33 47
138 13

94689*
BROKEN HILL

-31 58
141 28

94693
MILDURA AP
-34 13
142 05

94711
COBAR
-31 29
145 49

94784*
TAREE
-31 54
152 29

94802
ALBANY AP
-34 56
117 48

94805
CAPE BORDA
-35 45
136 35

94821
MT GAMBIER AP
-37 44
140 47

94842
CAPE OTWAY
-38 51
143 30

94869*
DENILIQUIN
-35 33
144 56

94907
EAST SALE AD
-38 06
147 08

94910
WAGGA AP
-35 09
147 27

94937
MORUYA HEADS
-35 54
150 09

94967
CAPE BRUNY
-43 30
147 09

94995
LORD HOWE ISLAND
-31 32
159 04

94996
NORFOLK ISLAND
-29 02
167 56

94998
MACQUARIE ISLAND
-54 29
158 57

95322
RABBIT FLAT
-20 11
130 00

95646
FORREST AIRPORT AWS
-30 50
128 07

95719*
DUBBO
-32 12
148 34

95753
RICHMOND AWS
-33 36
150 47

95916
CABRAMURRA
-35 56
148 23

95964
LOW HEAD
-41 03
146 48

Stations operated by Australia

Station Index
Station Name
Latitude**
(°,')
Longitude**
(°,')

96995
CHRISTMAS ISLAND CXR
-10 26
105 41

96996
COCOS ISLAND AMO CCK
-12 11
96 50

Cook Islands

Station Index
Station Name
Latitude**
(°,')
Longitude**
(°,')

91801*
PENRHYN AWS
-9 00
-158 03

91811*
PUKAPUKA
-10 53
-165 49

91831*
AITUTAKI
-18 50
-159 46

91843*
RAROTONGA
-21 12
-159 49

Fiji

Station Index
Station Name

		Latitude** (°,')	Longitude** (°,')
91650	ROTUMA	-12 30	177 03
91652	UNDU POINT	-16 08	-179 59
91680	NANDI	-17 45	177 27
91699	ONO-I-LAU	-20 40	-178 43

Stations operated by France

Station Index	Station Name	Latitude** (°,')	Longitude** (°,')
91753*	HIHIFO	-13 14	-176 10

Indonesia

Station Index	Station Name	Latitude** (°,')	Longitude** (°,')
96073	SIBOLGA PINANGSORI, SUM	1 33	98 53

96145
TAREMPA, SUM
3 12
106 15

96163
PADANG TABING, SUM
-0 53
100 21

96745
JAKARTA OBS, JAW
-6 11
106 50

96805
CILACAP, JAW
-7 44
109 01

96925
SANGKAPURA, JAW
-5 51
112 38

97014
MENADO, SUL
1 32
124 55

97146
KENDARI WOLTERMONGI SUL
-4 06
122 26

97240
AMPENAN SELAPARANG, NUS
-8 32
116 04

97340
WAINGAPU MAU HAU, NUS
-9 40
120 20

97372
KUPANG EL TARI, NUS
-10 10
123 40

97395
BAUCAU, NUS
-8 30
126 24

97502

SORONG JEFMAN, IRJ
-0 56
131 07

97560
BIAK MOKMER, IRJ
-1 11
136 07

97686
WAMENA, IRJ
-4 04
138 57

97690
JAJAPURA SENTANI, IRJ
-2 33
140 33

97724
AMBON PATTIMURA, MAL
-3 42
128 05

97900
SAUMLAKI, MAL
-7 59
131 18

97980
MERAUKE MOPAH, IRJ
-8 28
140 23

Kiribati

Station Index
Station Name
Latitude**
(°,')
Longitude**
(°,')

91490
CHRISTMAS ISLAND
1 59
-157 29

91533
BANABA
-0 54
169 32

91610
TARAWA

1 21
172 55

91701
CANTON ISLAND
-2 46
-171 43

Malaysia

Station Index
Station Name
Latitude
(°,')
Longitude
(°,')

48620
SITIAWAN
4 13
100 42

48657
KUANTAN
3 47
103 13

96413
KUCHING
1 29
110 20

96441
BINTULU
3 12
113 02

96465
LABUAN
5 18
115 15

96491
SANDAKAN
5 54
118 04

New Caledonia

Station Index
Station Name

Latitude**
(°,')
Longitude**
(°,')

91577
KOUMAC
-20 34
164 17

91592
NOUMEA
-22 16
166 27

New Zealand

Station Index
Station Name
Latitude**
(°,')
Longitude**
(°,')

93012
KAITAIA
-35 06
173 16

93292
GISBORNE AD
-38 39
177 59

93309
NEW PLYMOUTH AWS
-39 01
174 11

93417
PARAPARAUMU AD
-40 54
174 59

93615
HOKITIKA AD
-42 43
170 59

93747
OMARAMA TARA HILLS
-44 31
169 54

93844
INVERCARGILL AP AWS
-46 42
168 33

93945
CAMPBELL ISLAND
-52 33
169 09

93987
CHATHAM ISLAND
-43 57
-176 34

93994
RAOUL ISL KERMADEC
-29 15
-177 55

Niue

Station Index
Station Name
Latitude
(°,')
Longitude
(°,')

91822*
ALOFI
-19 04
-169 55

Papua New Guinea

Station Index
Station Name
Latitude
(°,')
Longitude
(°,')

92014
MADANG WO
-5 13
145 47

92035
PORT MORESBY WO
-9 23
147 13

92044
MOMOTE MO
-2 04
147 26

Philippines

Station Index
Station Name
Latitude
(°,')
Longitude
(°,')

98232
APARRI
18 22
121 38

98429
NINOY AQUINO
14 31
121 00

98444
LEGASPI
13 08
123 44

98637
ILOILO
10 42
122 34

98653
SURIGAO
9 48
125 30

98836
ZAMBOANGA
6 54
122 04

98851

GEN. SANTOS
6 07
125 11

French Polynesia

Station Index
Station Name
Latitude**
(°,')
Longitude**
(°,')

91925
ATUONA
-9 48
-139 02

91929
BORA-BORA
-16 27
-151 45

91938
TAHITI-FAAA
-17 33
-149 37

91943
TAKAROA
-14 29
-145 02

91945
HEREHERETUE
-19 52
-145 00

91948
RIKITEA
-23 08
-134 58

91949
REAO
-18 28
-136 28

91954
TUBUAI
-23 21
-149 29

91958
RAPA

-27 37
-144 20

Solomon Islands

Station Index
Station Name
Latitude**
(°,')
Longitude**
(°,')

91503
MUNDA
-8 20
157 16

91517*
HONIARA
-9 25
159 58

Tokelau

Station Index
Station Name
Latitude**
(°,')
Longitude**
(°,')

91724
NUKUNONO
-9 12
-171 55

Tonga

Station Index
Station Name
Latitude**
(°,')
Longitude**
(°,')

91780
VAVAU
-18 39
-173 59

91788

NUKUALOFA
-21 08
-175 12

Tuvalu

Station Index
Station Name
Latitude****
(°,')
Longitude****
(°,')

91631
NANUMEA
-5 04
176 08

91643
FUNAFUTI
-8 31
179 13

Station operated by United Kingdom

Station Index
Station Name
Latitude****
(°,')
Longitude****
(°,')

91960*
PITCAIRN
-25 04
-130 06

United States of America

Station Index
Station Name
Latitude****
(°,')
Longitude****
(°,')

91165
LIHUE , KAU, HW
21 59
-159 21

91285
HILO GEN LYMAN, HAW, HW
19 43
-155 04

Stations operated by USA

Station Index
Station Name
Latitude**
(°,')
Longitude**
(°,')

91212
NWSO TIYAN, GUM
13 29
144 48

91334
TRUK, CRL
7 28
151 51

91348
PONAPE, CRL
6 58
158 13

91366
KWAJALEIN, MHL
8 44
167 44

91376
MAJURO, MHL
7 05
171 23

91408
KOROR, PLW
7 20
134 29

91413
YAP, CRL
9 29
138 05

91765
PAGO PAGO AP, ASM
-14 20

-170 43

Vanuatu

Station Index	Station Name	Latitude** (°,')	Longitude** (°,')
91554*	PEKOA AIRPORT	-15 31	167 13
91568*	ANEITYUM	-20 14	169 46

10.4 Appendix 4 GCOS Monitoring Principles.

1. The impact of new systems or changes to existing systems should be assessed prior to implementation.

2. A suitable period of overlap of new and old observing systems should be required.

3. The results of calibration, validation and data homogeneity assessments and assessments of algorithm changes should be treated with the same care as data.

4. A capability to routinely assess the quality and homogeneity of data on extreme events, including high-resolution data and related descriptive information, should be ensured.

5. Consideration of environmental climate-monitoring products and assessments, such as IPCC assessments, should be integrated into national, regional and global observing priorities.

6. Uninterrupted station operations and observing systems should be maintained.

7. A high priority should be given to additional observations in data-poor regions and regions sensitive to change.

8. Long-term requirements should be specified to network designers, operators and instrument engineers at the outset of new system design and implementation.

9. The carefully planned conversion of research observing systems to long-term operations should be promoted.

10. Data management systems that facilitate access, use and interpretation should be included as essential elements of climate monitoring systems.

10.5 Appendix 5 CLIMATs received at GSN Monitoring Centres, January – June 2001.

WMO No.	NAME	JAN	FEB	MAR	APR	MAY	JUN	Reason *(to be completed)*
91212	GUAM NWSO AGANA	NIL	NIL	NIL	NIL	NIL	NIL	
91334	TRUK	OK	OK	OK	OK	OK	OK	
91348	PONAPE	OK	OK	OK	OK	OK	OK	
91366	KWAJALEIN BUCHOLZ	OK	OK	OK	OK	OK	OK	
91376	MAJURO AP	OK	OK	OK	OK	OK	OK	
91408	KOROR ISL	OK	OK	OK	OK	OK	OK	
91413	YAP	OK	OK	OK	OK	OK	OK	
91490	CHRISTMAS ISL	NIL	NIL	NIL	NIL	NIL	NIL	
91503	MUNDA	NIL	NIL	NIL	NIL	NIL	NIL	
91517	HONIARA	NIL	NIL	NIL	NIL	NIL	NIL	
91533	BANABA	NIL	NIL	NIL	NIL	NIL	NIL	
91554	PEKOA AP	NIL	NIL	NIL	NIL	NIL	NIL	
91568	ANEITYUM	NIL	NIL	NIL	NIL	NIL	NIL	
91577	KOUMAC	OK	OK	OK	OK	OK	OK	
91592	NOUMEA	ERR	ERR	ERR	ERR	ERR	ERR	
91610	TARAWA	NIL	NIL	NIL	NIL	NIL	NIL	
91631	NANUMEA	NIL	NIL	NIL	NIL	NIL	NIL	
91643	FUNAFUTI AP INT	NIL	NIL	NIL	NIL	NIL	OK	
91650	ROTUMA	NIL	ERR	OK	OK	ERR	ERR	
91652	UNDU POINT	NIL	ERR	OK	OK	ERR	ERR	
91680	NANDI AP	NIL	ERR	OK	OK	ERR	ERR	
91699	ONO I LAU	NIL	ERR	OK	OK	ERR	ERR	
91701	KANTON ISL	NIL	NIL	NIL	NIL	NIL	NIL	
91724	NUKUNONO	NIL	NIL	NIL	NIL	NIL	NIL	
91753	HIHIFO	NIL	NIL	NIL	NIL	NIL	NIL	
91765	PAGO PAGO	OK	OK	OK	OK	OK	OK	
91780	VAVAU	NIL	NIL	NIL	NIL	NIL	NIL	
91788	NUKUALOFA	NIL	NIL	NIL	NIL	NIL	NIL	
91801	PENRHYN	NIL	NIL	NIL	NIL	NIL	NIL	
91811	PUKAPUKA	NIL	NIL	NIL	NIL	NIL	NIL	
91822	ALOFI NIUE	NIL	NIL	NIL	NIL	NIL	NIL	
91831	AITUTAKI AUT	NIL	NIL	NIL	NIL	NIL	NIL	
91843	RAROTONGA	ERR	ERR	ERR	ERR	NIL	ERR	
91925	ATUONA	OK	NIL	NIL	ERR	OK	OK	
91930	BORA BORA	NIL	NIL	NIL	NIL	NIL	NIL	
91938	TAHITI FAAA	OK	OK	NIL	ERR	OK	OK	
91943	TAKAROA	OK	NIL	NIL	ERR	OK	OK	
91945	HEREHERETUE	OK	NIL	NIL	ERR	OK	OK	
91948	RIKITEA	OK	NIL	NIL	ERR	OK	OK	
91949	REAO	NIL	NIL	NIL	NIL	NIL	NIL	
91954	TUBUAI	OK	NIL	NIL	ERR	OK	OK	
91958	RAPA	OK	OK	NIL	ERR	ERR	ERR	
91960	PITCAIRN	NIL	NIL	NIL	NIL	NIL	NIL	
92014	MADANG WO	OK	OK	OK	OK	OK	OK	
92035	PORT MORESBY WO	OK	OK	OK	NIL	OK	OK	
92044	MOMOTE WO	OK	NIL	OK	NIL	NIL	OK	

OK = CLIMAT received in correct format

ERR = CLIMAT received but incorrect format
NIL = No CLIMAT received

10.6 Appendix 6 Current Pacific GUAN stations.

WMO No.	NAME	Operator	LAT (° ')	LON (° ')	ELEV (m)	Start year
91217	GUAM WSMO AGANA	USA	13 33	144 50	110	1947
91334	TRUK	USA	7 28	151 51	2	1951
91376	MAJURO AP	USA	7 05	171 23	3	1952
91408	KOROR ISL	USA	7 20	134 29	29	1950
91517	HONIARA	SLB	-9 25	159 58	55	1959
91557	BAUERFIELD	VUT	-17 42	168 18	20	1985
91592	NOUMEA	NCL	-22 16	166 27	69	1960
91610	TARAWA	KIR	1 21	172 55	2	1958
91643	FUNAFUTI	TUV	-8 31	179 13	1	1973
91765	PAGO PAGO AP	USA	-14 20	-170 43	3	1966
91801	PENRHYN	COK	-9 00	-158 03	1	1973
91925	ATUONA	PYF	-9 48	-139 02	51	1968
91938	TAHITI FAAA	PYF	-17 33	-149 37	2	1966
91958	RAPA	PYF	-27 37	-144 20	1	1966
92035	PORT MORESBY WO	PNG	-9 23	147 13	38	1946

10.7 Appendix 7 CLIMAT TEMP messages received at GCOS Upper-Air Data Analysis Centre, UKMO during March - August 2001.

WMO No.	NAME	MAR	APR	MAY	JUN	JUL	AUG	Reason *(to be completed)*
91217	GUAM WSMO AGANA	NIL	NIL	NIL	NIL	NIL	NIL	Closed (?)
91334	TRUK	OK	OK	OK	OK	OK	OK	
91376	MAJURO AP	OK	OK	OK	OK	OK	OK	
91408	KOROR ISL	OK	OK	OK	OK	OK	OK	
91517	HONIARA	NIL	NIL	NIL	NIL	NIL	NIL	Closed (?)
91557	BAUERFIELD	NIL	NIL	NIL	NIL	NIL	NIL	Closed (?)
91592	NOUMEA	OK	OK	OK	OK	OK	OK	
91610	TARAWA	NIL	NIL	NIL	NIL	NIL	NIL	Closed (?)
91643	FUNAFUTI	OK	NIL	NIL	NIL	OK	NIL	Communication problems (?)
91765	PAGO PAGO AP	OK	OK	OK	OK	OK	OK	
91801	PENRHYN	NIL	NIL	NIL	NIL	NIL	NIL	Closed (?)
91925	ATUONA	OK	OK	OK	OK	OK	OK	
91938	TAHITI FAAA	OK	OK	OK	OK	OK	OK	
91958	RAPA	OK	OK	OK	OK	OK	OK	
92035	PORT MORESBY WO	NIL	NIL	NIL	NIL	NIL	NIL	Closed (?)

10.8 Appendix 8. Commonly used acronyms

AOPC – Atmospheric Observation Panel for Climate

APN – Asia Pacific Network

AWS – Automatic Weather Station

BOM – Australian Bureau of Meteorology

CLICOM – Climate Computing (WMO software)

COP – Conference of the Parties to the United Nations Framework Convention on Climate Change

CROP – Council of Regional Organizations and Programmes

DWD – Deutscher Wertterdienst

EEZ – Exclusive Economic Zone

ENSO – El Nino Southern Oscillation

EU - European Union

GAW- Global Atmosphere Watch

GCOS – Global Climate Observing Systems

GEF – Global Environment Facility

GMS – Geostationary Meteorological Satellite

GSN – Global Surface Network

GSNMC – GSN Monitoring Centers

GUAN – Global Upper Air Network

GTOS – Global Terrestrial Observing Systems

GOSIC – Global Observing System Information Center

GODAE – Global Ocean Data Assimilation Experiment

GTS – Global Telecommunications Network

GOOS – Global Ocean Observing Systems

ICSU – International Council for Science

IGBP – International Geosphere Biosphere Programme

IGOS – Integrated Global Observing Strategy

IPCC – Intergovernmental Panel on Climate Change

IPO – Interdecadal Pacific Oscillation

IOC – International Oceanographic Commission

JDIMP – Joint Data and Information Management Panel

JMA – Japan Meteorological Agency

NCDC – US National Climatic Data Center in Asheville, North Carolina

NIWA – National Institute of Water and Atmospheric Research

NMHS – National Meteorological and Hydrological Services

PIRGIT – Pacific Island Regional GCOS Implementation Team

PI-GCOS – Pacific Island Global Climate Observing System

PICCAP – Pacific Islands Climate Change Assistance Programme

PMSNAP – Pacific Meteorological Services Needs Analysis Project

RCC – Regional Climate Centers

SBSTA – Subsidiary Body for Scientific and Technical Advice to the UNFCCC

SDMP – Strategic Action Plan for the Development of Meteorology

SEREAD – Scientific Educational Resources and Experience Associated with the Deployment of Argo drifting floats

SPREP – South Pacific Regional Environment Programme

SOPAC – South Pacific Geoscience Commission

UNDP – United Nations Development Programme

UNESCO – United Nations Education, Scientific Commission

UNEP – United Nations Environment Programme

UNFCCC – United Nations Framework Convention on Climate Change

US NOAA – United States National Oceanic and Atmospheric Administration

US NASA – United States National Aeronautics and Space Agency

USGS – United States Geological Survey

USP – University of the South Pacific

WCRP-CLIVAR – World Climate Research Programme Climate Variability and Predictability

WIPO – World Intellectual Property Organization

WMO – World Meteorological Organization