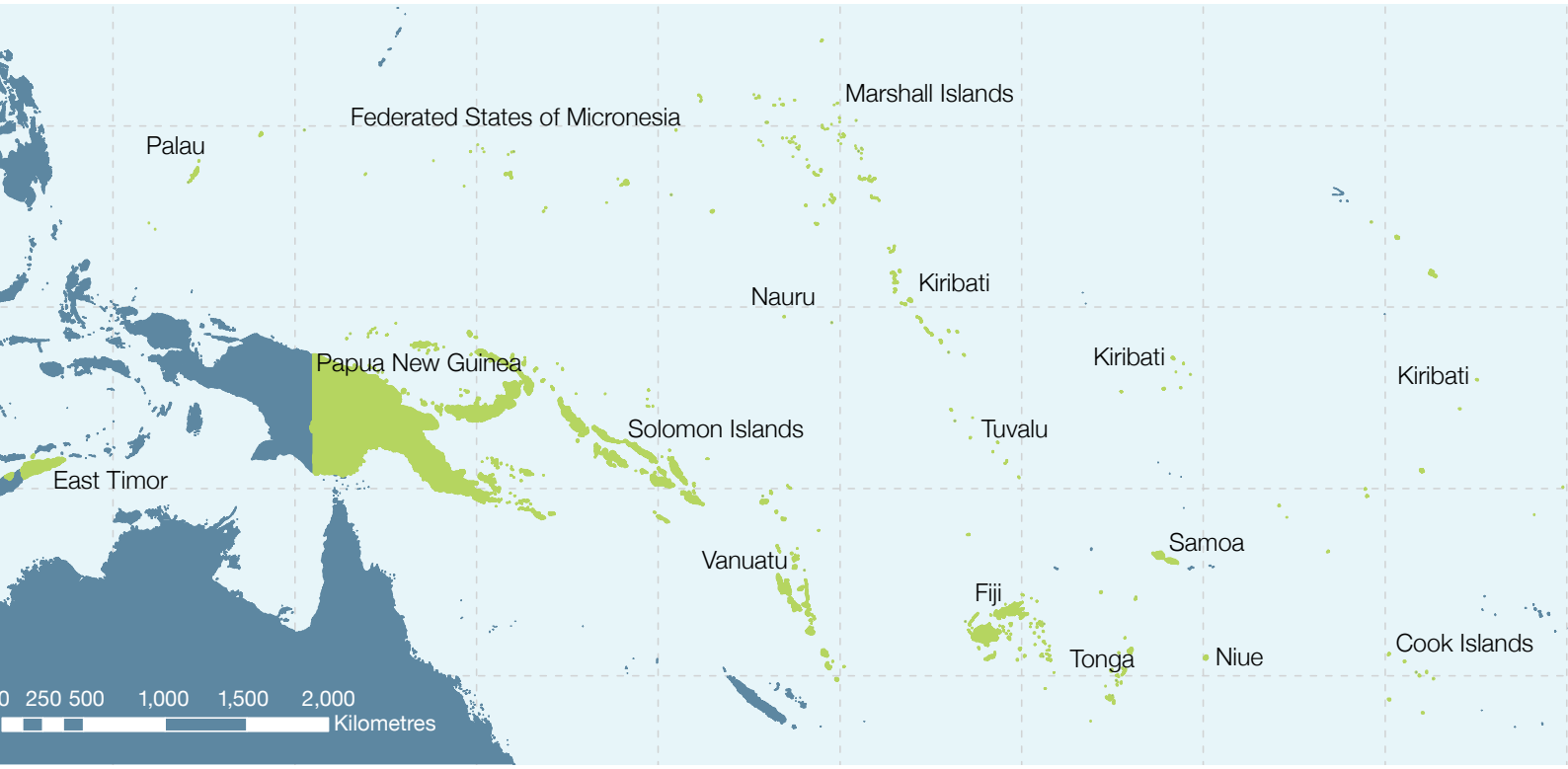
International CLIMATE CHANGE ADAPTATION Initiative

Pacific Climate Change Science Program



Annual Report 1 2009 - 2010

Australian Government

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Executive summary

The **Pacific Climate Change Science Program (PCCSP)** has been developed to assist decision makers and planners in 14 Pacific island countries and East Timor better understand how their climate and oceans have changed and how they may change in the future. The Program has been set up to deliver early results in priority knowledge areas while providing the base upon which longer-term climate change science outcomes can be delivered. It is part of the larger International Climate Change Adaptation Initiative.

The 15 PCCSP partner countries are Cook Islands, East Timor, Federated States of Micronesia, Fiji, Kiribati, Marshall Islands, Nauru, Niue, Palau, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu and Vanuatu.

This report is the first Annual Report for the PCCSP and summarises progress in delivering the PCCSP over the period 1 July 2009 to 30 June 2010. The PCCSP consists of five components, four of which cover research:

- **Component 1:** Current and recent climate;
- **Component 2:** Regional drivers;
- **Component 3:** Climate change projections;
- **Component 4:** Oceans and sea level rise; and
- **Component 5:** Science information synthesis and communication.

The components interact with each other and involve research, training and capacity building, and information sharing. On average across the five components, at least 40% of the work has been completed making the PCCSP on schedule to deliver all the final products by 31 December 2011. As the PCCSP embarks on its second year of

implementation, there will be a greater focus on in-country activities to engage many more stakeholders in the partner countries.

This Annual Report presents the progress made towards each of the PCCSP's three main objectives. The first objective seeks to provide meteorological, climatological and oceanographic (physical and chemical) information, particularly in areas where there are identified gaps in partner country knowledge. In the PCCSP's first year, significant research has been undertaken on the analysis of current climate trends and the large-scale climate features that drive climate variability. The reliability of the Global Climate Models used in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change has been evaluated in the region and interim projections prepared. Work on downscaling climate model outputs to 60 km is underway to provide more detailed information for each partner country. In addition, downscaling to 8 km is being undertaken for selected countries. Analysis of the regional changes in sea level and extreme sea level events has been advanced, together with an improved understanding of trends and future projections for ocean acidification and ocean properties and processes.

Recognising the urgent need for country specific climate and ocean projection information to inform adaptation planning, the PCCSP has revised its schedule and advanced the preparation of some of the planned peer reviewed journal papers. The full results of the research will be available by November 2011.

The second major objective of the PCCSP is to build the capacity of partner country scientific organisations, where feasible, to undertake scientific research to support the provision of this information. This objective has also been a major focus in the first year. Activities have included three regional workshops, and several in-country visits. These have all been extremely successful in building the knowledge base for climate science in the partner countries and in sharing information about the PCCSP with partner countries

Executive summary

and regional organisations. Ongoing communication with identified focal points, technical representatives and other stakeholders is a regular part of the PCCSP's engagement process.

Dissemination of the climate science information to partner countries and other stakeholders, the third objective of the PCCSP, has been conducted using a variety of delivery modes guided by the PCCSP Communication Plan, revised in May 2010. Sharing of information with partner country stakeholders has been a focus during the three regional workshops and several in-country visits. Four new climate science software tools have been developed and demonstrated to partner countries and feedback obtained. A number of presentations on the PCCSP have been made at international and regional meetings and conferences. Two peer reviewed journal papers have been published and eleven others are under preparation. A detailed outline of the final technical report has been prepared and circulated widely, and the zero order (first) draft of this report has been compiled. Finally, a general brochure on the PCCSP has been prepared and was printed in time for distribution at the Pacific Islands Forum in August 2010.

Partner countries, regional organisations and PCCSP researchers have also contributed to an analysis of the gaps in climate change science that need to be filled. Among the identified gaps are: broader communication and capacity building of partner country stakeholders in climate change science; improved monitoring of climate and oceanic variables; robust attribution of climate change to natural and/or anthropogenic factors; updated atmospheric and oceanic projections using the new emissions scenarios and models for the Fifth Assessment Report of the Intergovernmental Panel on Climate Change; detailed projections for extreme events including co-incident events; and impact of improved atmospheric and ocean projections on selected sectors and regions.

The PCCSP presents a unique and challenging opportunity to provide partner countries with a solid scientific foundation on which to base their adaptation responses. All the scientific and support staff working on the PCCSP are dedicated to meeting this challenge.

List of abbreviations

AusAID	Australian Agency for International Development
BoM	Bureau of Meteorology
CAWCR	Centre for Australian Weather and Climate Research
CCAM	Conformal-Cubic Atmospheric Model
CDMS	Climate data management system
COP	Conference of Parties to the United Nations Framework Convention on Climate Change
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DCCEE	Department of Climate Change and Energy Efficiency
ENSO	El Niño-Southern Oscillation
ERA	European Centre for Medium-range Weather Forecasts Reanalysis
GA	Geoscience Australia
GCM	Global Climate Model
GCOS	Global Climate Observing System
ICCAI	International Climate Change Adaptation Initiative
IPCC	Intergovernmental Panel on Climate Change
IPCC AR4	Intergovernmental Panel on Climate Change Fourth Assessment Report
IPCC AR5	Intergovernmental Panel on Climate Change Fifth Assessment Report
ITCZ	Inter-Tropical Convergence Zone
LSE	Large Scale Environment
MIT	Massachusetts Institute of Technology
MSLP	Mean sea level pressure
NCEP	National Centre for Environmental Prediction
NIWA	National Institute of Water and Atmospheric Research (New Zealand)
NMS	National Meteorological Service
NMHS	National Meteorological and Hydrological Service
NOAA	National Oceanic and Atmospheric Administration (USA)
PACC	Pacific Adaptation to Climate Change Project
PASAP	Pacific Adaptation Strategy Assistance Program
PCCSP	Pacific Climate Change Science Program
SOI	Southern Oscillation Index
SPC	Secretariat of the Pacific Community
SPCZ	South Pacific Convergence Zone
SOPAC	Pacific Islands Applied Geoscience Commission
SPREP	Secretariat of the Pacific Regional Environment Programme
SST	Sea surface temperature
TCLV	Tropical cyclone-like vortex
TCRM	Tropical Cyclone Risk Model
USP	University of the South Pacific
WMO	World Meteorological Organisation
WPM	West Pacific Monsoon

1 Introduction

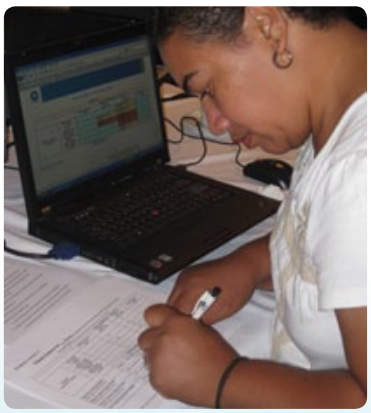
The Pacific Climate Change Science Program (PCCSP) has been developed to **assist decision makers and planners in 14 Pacific island countries and East Timor better understand how their climate and oceans have changed and how they may change in the future.** The Program has been set up to deliver early results in priority knowledge areas while also providing the base upon which longer-term climate change science outcomes can be delivered. It is part of the International Climate Change Adaptation Initiative (ICCAI).

The ICCAI is jointly managed by the Australian Agency for International Development (AusAID) and the Department of Climate Change and Energy Efficiency (DCCEE). The objectives of the ICCAI are to:

- Establish a sound policy, scientific and analytical basis for long-term Australian action to help partner countries adapt to the impacts of climate change;
- Increase understanding in partner countries of the impacts of climate change on their natural and socio-economic systems;
- Enhance partner country capacity to assess key climate vulnerabilities and risks, formulate appropriate adaptation strategies and plans, and mainstream adaptation into decision making; and
- Identify and finance priority adaptation measures that can immediately increase the resilience of partner countries to the impacts of climate change.

1.1 Vision statement

The PCCSP is a partnership between Australian science agencies and Pacific island countries and East Timor, carried out in collaboration with Pacific regional organisations, with the objective of conducting a comprehensive climate change science research program to provide better information about the likely impacts of climate change to stakeholders in participating countries.



1.2 Objectives

The objectives of the PCCSP are to:

- Provide meteorological, climatological and oceanographic (physical and chemical) information, particularly in areas where there are identified gaps in partner country knowledge;
- Build the capacity of partner country scientific organisations, where feasible, to undertake scientific research to support the provision of this information; and
- Disseminate the information to partner countries and other stakeholders.

1.3 Partner countries

The 15 PCCSP partner countries are:

Cook Islands	Marshall Islands	Samoa
East Timor	Nauru	Solomon Islands
Federated States of Micronesia	Niue	Tonga
Fiji	Palau	Tuvalu
Kiribati	Papua New Guinea	Vanuatu

1.4 Program components

The PCCSP consists of five components, four of which cover research, and the fifth focuses on science information synthesis and communication:

- **Component 1:** Current and recent climate;
- **Component 2:** Regional drivers;
- **Component 3:** Climate change projections;
- **Component 4:** Oceans and sea level rise; and
- **Component 5:** Science information synthesis and communication.

1 Introduction

The components interact with each other and involve research, training and capacity building, and information sharing. **Figure 1** shows a framework for how the components work together towards producing the final outputs.

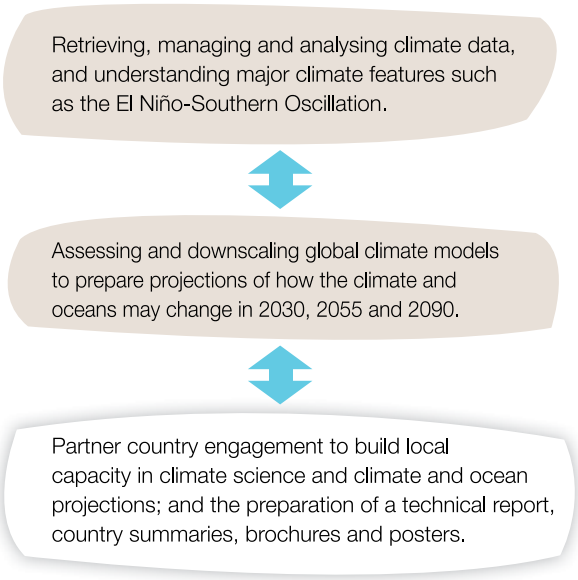
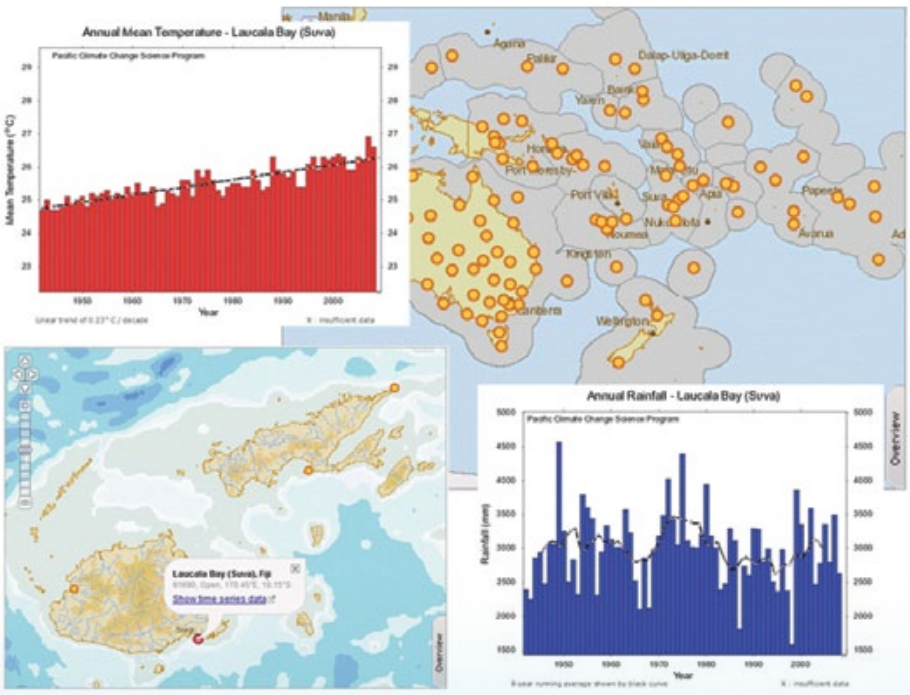


Figure 1: *Framework for the Pacific Climate Change Science Program.*



The PCCSP's new station data portal provides partner countries with interactive access to historical climate series and a suite of data analysis tools to enhance the understanding of climate variability and change over recent decades.

PCCSP researchers discuss cross component issues at the PCCSP Internal Workshop, 22-24 February 2010.

2 Addressing the Program's Objectives.

This section discusses how PCCSP activities in 2009-2010 have addressed the three objectives: (a) filling identified scientific gaps in the existing knowledge base; (b) building capacity of partner countries in climate change science; and (c) disseminating the information.

2.1 Provision of scientific information

The PCCSP was designed to address the following major gaps in climate change science in the partner countries:

- Management of climate data and analysis of data trends;
- Extreme events, including tropical cyclones;
- Understanding of large-scale climate features in the Pacific region, including the main driver of climate variability – the El Niño-Southern Oscillation (ENSO);
- Climate projections in the region and for specific countries; and
- Understanding of ocean processes and how they may change in the future under global warming, especially sea level rise and ocean acidification.

Two scientific papers presenting results have already been published in academic journals and eleven others have been submitted for publication or are close to submission, see list in Annex 1. All findings will be included in a technical report *Climate change in the Pacific* and the first (zero-order) draft of this report was compiled in June 2010.

In 2009-2010 representatives from partner countries, regional organisations and other projects have emphasised an urgent need for specific climate and ocean projection information to inform adaptation planning. Recognising this urgent need, the Program's schedule has been revised to advance the preparation of some planned peer reviewed journal papers to provide regional and national partners with verifiable projection information as early as possible.

Progress up to June 2010 in providing the scientific information is described in general terms in sections 2.1.1 to 2.1.5, while section 2.1.6 focuses on further gaps that need to be filled after the PCCSP. Section 3 of this report describes progress component by component.

2.1.1 Management of climate data and analysis of data trends

The climate of the Pacific is changing. Scientific studies show an increase in average temperatures throughout the region during the second half of the 20th century. Changes in rainfall over recent decades are more varied than those of temperature. Over the period 1960-2000 most locations northeast of a line drawn from the Solomon Islands to the Cook Islands recorded increased rainfall, contrasting with declines to the southeast of this line. Changes in extreme rainfall have tended to mirror the shifts in total rain. All rainfall trends display great natural variability associated with climate phenomena such as ENSO. Unfortunately little data and few sound studies exist for other climate variables, such as solar radiation. Many of the existing studies are out-of-date and rely on incomplete and inconsistent data records, creating serious problems given the need for enhanced scrutiny of historical observational records.

Scientists from the PCCSP are working closely with partner countries to address these problems and rescue, collate and analyse existing climate records from observational stations in the region. This involves improving methods of storage and management of data. A customised climate database management system has been designed as part of the Program and will be tested and installed in partner countries in 2011. The provision of the database, together with appropriate training in its use, will support National Meteorological Services (NMS) and enable them to improve their climate data storage, climate services and undertake more climate research work in the future.

Many climate data records in the partner countries contain inconsistencies associated with changes in instrumentation and recording methods. A new web-based climate data portal that incorporates a range of interactive navigation controls and geospatial information has been developed. This will enable NMS to check for errors and inconsistencies in their data records, thereby improving the quality of their data trends and analyses and identify patterns of change.

2 Addressing the Program's Objectives.

2.1.2 Extreme events

Photo: *Courtesy of the Climate Change Office, Ministry of Environment, Conservation and Meteorology, Solomon Islands.*

Tropical cyclones are among the most destructive natural hazards affecting millions of people around the world each year. There is some uncertainty as to how climate change influences tropical cyclones. Detecting trends in tropical cyclones requires long, accurate data records. Changes in recording practices can influence the analysis of tropical cyclone trends. For example, since the early 1970s there has been an increase in available data with the introduction of satellites. A rigorous analysis of the data is being undertaken by the PCCSP. This includes a detailed investigation into the influence of large-scale climatic features, e.g. ENSO, on tropical cyclone variability. In addition, a web-based portal 'Tropical cyclones in the southern hemisphere' is being further developed as a tool for NMS to access and analyse tropical cyclone historical data.

Storm surges cause elevated sea levels which can result in flooding and coastal erosion. As sea level rises, the impact of extreme sea level events, due to storm surges and high tides, will become more severe. PCCSP scientists are working to develop a better understanding of the regional pattern of sea level rise in the region and to quantify the likelihood of extreme sea level events. This will provide information needed by partner countries to plan coastal development, as well as safeguarding existing coastal infrastructure, agriculture, water resources and sites of cultural significance.

2.1.3 Understanding large-scale climate features

The climates in partner countries are strongly influenced by one or more of the following features of the climate: the South Pacific Convergence Zone (SPCZ), the West Pacific Monsoon (WPM), the Inter-Tropical Convergence Zone (ITCZ) and ENSO. These features can 'drive' rainfall, winds, tropical cyclone tracks, ocean currents, nutrients and many other aspects of the environment. Despite their fundamental importance to the region, there are still major deficiencies in

PCCSP scientist and NMS representatives discuss climate drivers at the PCCSP Technical Workshop, Vanuatu, 12-16 October.

understanding their properties and impacts. PCCSP scientists are addressing this significant knowledge gap by working with partner countries' NMS to increase the understanding of the impact of these drivers on their countries. This research includes examining how well the climate models simulate the drivers, and how these drivers might change in the future under global warming. For example, a rainfall projection in one country might be explained as a shift in the position of the SPCZ and therefore a result of natural variability in the climate.

2.1.4 Climate projections

Limited information is currently available on climate projections for the Pacific. The IPCC Fourth Assessment Report (AR4) provides annual and seasonal average temperature and rainfall projections for the whole Pacific divided into only two regions (north and south) and projections of global average sea-level. The PCCSP will provide more detailed atmospheric and ocean projections for each partner country.

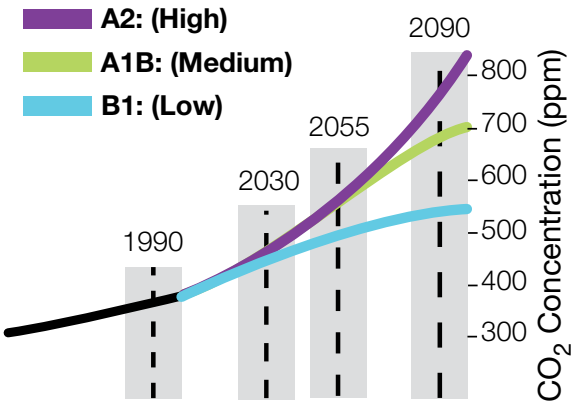


Figure 2 | *Carbon dioxide (CO2) concentrations (parts per million, ppm) associated with the three IPCC emission scenarios (B1, A1B and A2). The PCCSP will analyse climate model results for periods centred on 1990, 2030, 2055 and 2090 (shaded).*

Twenty-three global climate models used by the IPCC, plus an additional model from CSIRO, have been evaluated by comparing the present-day climate simulations against historical observations. The most realistic models have been used to create projections for each country for time periods centred on 2030, 2055 and 2090 for three different greenhouse gas and aerosol emissions scenarios **(Figure 2)**. Dynamical downscaling (using finer resolution climate models), combined with statistical downscaling for selected regions, is being undertaken to provide more detailed information. Atmospheric projections for each country are being prepared for temperature, rainfall, humidity, wind, evaporation, solar radiation and extreme weather events.

The PCCSP is applying a new approach called Climate Futures to develop projections for partner countries. This approach groups the projections from individual models to form a set of internally consistent climate futures, e.g. grouping the models that show a warmer and wetter climate for a particular country and developing projections using that group of models, then following the same procedure for models that show a hotter and drier future climate, and so on. This is a more scientifically robust method than mixing projections from different models. A web-based Climate Futures tool is being developed by the PCCSP to help partner countries access national climate projections. This tool has already been demonstrated to partner countries and valuable feedback obtained.

2 Addressing the Program's Objectives.

The PCCSP has provided advice on the most robust and up-to-date projections available for the development of AusAID's country-specific climate change profiles. Many of the partner countries are preparing their Second National Communications (SNC) to the United Nations Framework Convention on Climate Change. Advice has been provided to several partner countries on how to access country specific information from the IPCC AR4. The PCCSP is collaborating closely with the United Nations Development Programme (UNDP) to ensure that the new projection information, once it has been peer reviewed, will be made available to partner countries for use in their SNCs.

2.1.5 Ocean processes and changes

The atmosphere and the ocean are closely linked so it is vital to understand the nature of the interaction and how it will change with global warming. Changes in the ocean will also directly impact biological systems including fisheries and coral reefs. The PCCSP is working with partner countries to understand how the increased heat entering the ocean will change ocean currents, salinity, temperatures and the supply of nutrients.

Many partner countries are already experiencing sea level rise. Projections for sea level rise from the IPCC AR4, including an allowance for a dynamic ice-sheet response, are about 18 to 80 cm by 2100. However, the IPCC cautioned a larger rise was possible but the likelihood could not yet be assessed. More recent projections suggest that a rise of up to one metre or more is possible by 2100. Significant uncertainties are still present in important aspects of sea level science. PCCSP scientists are mapping regional distributions of sea level rise for recent decades and for the 21st century.

The ocean is a major sink for atmospheric carbon dioxide. It absorbs about one quarter of the carbon dioxide emissions resulting from human activities each year. This helps to slow the rate of atmospheric carbon dioxide increase but results in ocean acidification. This in turn decreases the capacity of reef building corals, calcareous algae and many other key species in tropical ecosystems to grow calcium carbonate skeletons and shells. The research being undertaken in the PCCSP aims to understand how ocean acidification

impacts the Pacific region. Scientists are analysing regional measurements and ocean carbon cycle models to project future changes under different greenhouse gas emissions scenarios. This research will provide a solid foundation for assessing the risk of acidification to the many reef systems throughout the region.

2.1.6 **Remaining scientific gaps**

During 2009-2010, a gaps and needs analysis of climate change science in the region was conducted. This was based on feedback from partner countries and regional organisations during three regional workshops and several in-country visits. The analysis showed gaps that need to be addressed after the PCCSP has been completed:

- Broader communication of climate change science to partner country stakeholders;
- Further capacity building and education;
- Reducing uncertainty in atmospheric and oceanic projections;
- Robust attribution of climate change to natural and/or anthropogenic factors;
- Updated regional and country specific atmospheric and ocean projections for 2020 to 2100 and beyond for the new Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment emissions scenarios and climate simulations;
- More detailed projections for extreme events including co-incident extreme events; and
- Detailed atmospheric and oceanic projections for selected economic sectors and regions.

Communication and capacity building are key objectives of the PCCSP and are being delivered and undertaken in a variety of ways (these will be discussed in detail in the following sections). Particularly since climate change science is a relatively new field, and is perceived as a very relevant area among partner countries, there is a huge demand for increased efforts in communication and capacity building.

2 Addressing the Program's Objectives.

2.2 Building capacity of partner countries in climate change science

2.2.1 Process for engagement

With a Program involving more than 60 research scientists, and stakeholders in 15 partner countries, it was first important to establish a clear path of communication. PCCSP Focal Points were established in each country, these are for the most part representatives from agencies charged with the environment portfolio. PCCSP Technical Representatives were also identified and these are generally from the NMS. The communication process works well and has been endorsed by each country.

Ongoing engagement with the partner countries and regional organisations is an important part of capacity building. Direct engagement takes place during in-country visits and regional workshops. The focus for partner countries during 2009-2010 has been on regional workshops, but this will shift to a focus on capacity building during in-country visits in the second year of the PCCSP. The countries are kept informed about significant milestones in the Program and their feedback is actively encouraged.

Recognising that air travel contributes a significant amount of carbon dioxide into the atmosphere, the additional carbon generated by all PCCSP related air travel and events is offset through tree planting programs in Western Australia. Similar programs have not yet been identified in the partner countries.

Collaboration with regional organisations has been another major focus during the first year of the PCCSP. This is extremely important for building sustainability and regional ownership of the outcomes of the PCCSP. During the second half of 2009, meetings were held with the Pacific Islands Applied Geoscience Commission (SOPAC), Secretariat of the Pacific Community (SPC), Secretariat of the Pacific Regional Environment Programme (SPREP), UNDP, University of Hawai'i, and the University of the South Pacific (USP). This resulted in specific collaboration on PCCSP activities, in particular with SPREP, UNDP and USP (direct collaboration with SPC had commenced before July 2009).

Within the framework of the ICCAI, the PCCSP has also collaborated directly with Pacific Adaptation Strategy Assistance Program (PASAP), e.g. in the implementation of the PCCSP Climate and Ocean Projections Workshop, held in Cairns, 22-26 March 2010.

PCCSP Climate Data, Variability and Change, Research and Training Workshop 31 May – 9 June 2010: Darwin Convention Centre, Darwin, Australia.

The PCCSP is represented on the PASAP Management Committee and this has improved connections between the two Programs, highlighted synergies and limitations, and led to modification of some PCCSP milestones so that the scientific findings can better inform adaptation.

PCCSP Technical Workshop, 12-16 October, 2009, Vanuatu.

The PCCSP has also been represented at several international events, e.g. the Pacific Climate Change Round Table held in the Marshall Islands, 19-21 October 2009. A list of PCCSP presentations at international events is presented in Annex 2.

Developing fair and secure data sharing arrangements between PCCSP scientists and partner countries has been a key priority that was first discussed at the PCCSP Regional Workshop held in Vanuatu, 12-16 October 2009. As a result of those discussions, an Interim Agreement on Data Security Arrangements was prepared and sent to partner countries in November 2009. As of 30 June 2010, six of the 15 partner countries have signed the Agreement.

2.2.2 **Regional workshops**

Three PCCSP regional workshops have been conducted:

- PCCSP Regional Workshop, Vanuatu, 12-16 October 2009;
- PCCSP Climate and Ocean Projections Workshop, Cairns, 22-26 March 2010; and
- PCCSP Climate Data, Variability and Change Research and Training Workshop, Darwin, 31 May – 9 June 2010.

2 Addressing the Program's Objectives.

The workshop in Vanuatu was attended by 35 participants, of which 16 were from PCCSP's partner countries' NMS. Representatives from DCCEE, SPC and the World Meteorological Organisation (WMO) also attended. The workshop achieved its three main objectives:

- Partner country representatives described their country's current climate, how their climate is changing, climate data management status, and climate change issues;
- PCCSP scientists introduced the detailed components of the PCCSP and obtained feedback; and
- Progress was made on creating a sense of ownership of the PCCSP among partner countries so as to encourage their active and ongoing participation.

The workshop in Cairns was conducted in partnership with SPREP and PASAP. This five-day workshop was attended by a total of 63 participants, of which 25 were from the PCCSP's 15 partner countries. The majority of the partner country representatives came from their country's administration engaged in national planning, resource allocation, and/or mainstreaming of climate change and environment issues across government.

Climate and Ocean Projections Workshop Report, 22-26 March 2010 – Cairns, Australia.

Representatives from AusAID, DCCEE, National Institute of Water and Atmospheric Research (NIWA) New Zealand, SPC and SPREP also attended the meeting. The first four days of the program were devoted to PCCSP and the fifth day to PASAP. The workshop achieved its three main objectives:

- Participants' knowledge was enhanced about observed climate trends, drivers of climate variability, global climate model applications and their reliability, and the benefits of downscaling;
- Interim projections for climate and ocean changes across the whole PCCSP region were presented and feedback received; and
- The prototype of the Climate Futures software tool for creating projections at the national level was tested and feedback received.

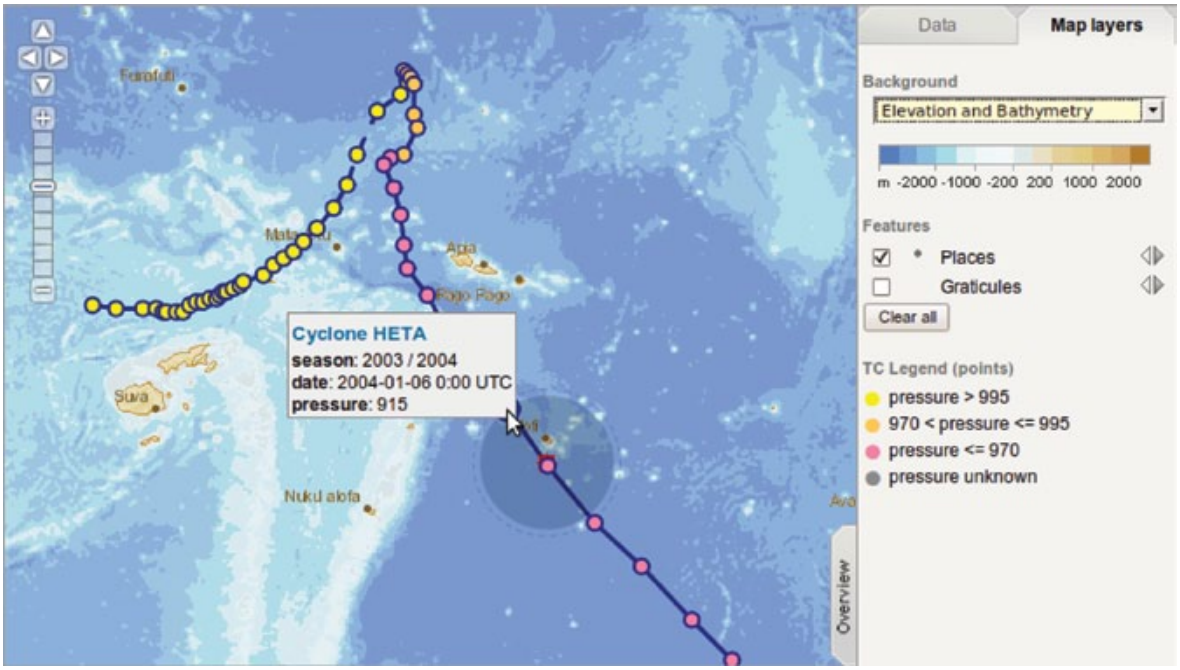
The workshop in Darwin was attended by 54 participants, 29 of whom were from NMS and related agencies in all 15 partner countries. This workshop was also attended by representatives from DCCEE, Environment Canada, the US National Oceanic and Atmospheric Agency (NOAA), NIWA and SPREP.

Stakeholders from Samoa, together with PCCSP scientist, Yuriy Kuleshov (left), test the tropical cyclone web portal at the Climate Data, Variability and Change Research and Training Workshop, held in Darwin, 31 May – 9 June 2010.

The workshop program introduced concepts relating to climate data management, data quality control, trend analysis and correlation with climate driver indices. Participants were introduced to a newly designed climate database management system and two data analysis web portals, and feedback was obtained. Global climate models, and climate and ocean projections were also introduced and the Climate Futures tool for

2 Addressing the Program's Objectives.

country-specific projections was demonstrated. The highlight of the last three days of the workshop was the preparation of country climate summaries, accompanied by PowerPoint presentations by each partner country. During the coming months, partner countries and PCCSP scientists will further develop these summaries to form the basis of part of an appendix in the PCCSP final technical report. The high standard of these summaries is a clear indication of the benefits of the PCCSP's capacity building and training activities. Based on detailed evaluations conducted by the partner country participants, these three workshops have been highly successful in building the knowledge base of climate science in the partner countries and information sharing. Full reports have been prepared and distributed for the first two workshops, and a similar report is being finalised for the workshop held in Darwin.



Screenshot of the tropical cyclone portal interface showing detailed information about Tropical Cyclone Heta.

After the success of the workshop in Cairns, partners at SPREP invited the PCCSP to give a one-day presentation on climate and ocean projections at the Pacific Adaptation to Climate Change (PACC) Project Workshop held in Samoa from 10-14 April 2010. Three PCCSP scientists conducted the session and again there was considerable interest among the Pacific country representatives in the preliminary climate and ocean projection information that was presented.

2.3 Information dissemination

Dissemination of information is an important part of the PCCSP. Specific ways in which information has been disseminated in the first full year of the Program are listed below (many of these items have been mentioned in section 2.1 and 2.2):

- In-country visits have been undertaken to raise awareness about the PCCSP and gain insight into stakeholder needs. This has included visits to Marshall Islands in October 2009, Fiji and Samoa in November 2009, Noumea in December 2009 and East Timor in February 2010. In each country PCCSP staff gave presentations and held discussions with colleagues in ministries responsible for agriculture, environment, infrastructure, NMS, planning and water. Meetings were also held with regional organisations including SOPAC, SPC, SPREP, UNDP, and USP;
- Four software tools (climate database management system; climate portal; tropical cyclone web portal; Climate Futures tool) have been developed (see sections 2.1.1 and 2.1.4) and demonstrated to partner countries and regional organisations at the regional workshops and feedback obtained;
- Two peer reviewed papers have been published in scientific journals and eleven others are under preparation or have been submitted (Annex 1);
- Presentations about the PCCSP have been made at international and regional events and meetings (Annex 2);
- Reports on the regional workshops in Vanuatu and Cairns have been prepared and sent to partner countries and regional organisations (the report on the Darwin workshop is in final preparation); information sheets and handouts have been provided at, and following, the four regional workshops;
- A six-page brochure on the PCCSP, targeting leaders of the partner countries, was distributed at the Pacific Islands Forum, 3-6 August 2010;
- Work is underway on a more substantive brochure detailing some interim findings in preparation for the Conference of Parties to the United Nations Framework Convention on Climate Change (COP) 16 in November 2010; and
- A detailed outline of the final technical report has been prepared and sent to partner countries for comment; material for the first (zero order) draft of the final technical report was compiled by end June 2010.

3 Progress

This section summarises progress in delivering the PCCSP over the period July 2009 to June 2010. For each component, there is a brief description and summary of the progress to date.

3.1 Component 1: Current and recent climate

3.1.1 Description of Component 1

A rigorous assessment of recent climate variability and change will underpin a better understanding of the likely climate change in the region and is essential for interpreting and validating projections from global climate models. Assessments of recent climate will include analysis of existing meteorological records and augment existing ocean observation programs. In some cases rehabilitation and digitisation of records will be required. Documentation of trends will significantly improve knowledge of the extent to which global warming is already affecting the region. Quality observations are also essential for improving long-term projections of climate and for seasonal and inter-annual predictions of the likelihood of droughts, floods and other climatic extremes.

There are three inter-related projects in this component:

- Data rescue and management;
- Rehabilitation of meteorological data; and
- Improving the understanding of tropical cyclone climatology.

3.1.2 Summary of progress to date in Component 1

Project	% complete	Comments
Data rescue and management	40	Project is on schedule and will meet milestones.
Rehabilitation of meteorological data	53	Project is on schedule and will meet milestones. Obtaining data has been somewhat challenging.
Improving the understanding of tropical cyclone climatology	50	Project is on schedule and will meet milestones.

Significant progress has been made in component 1 and all the projects are on schedule, with some ahead of schedule. Three web-based tools: a climate database management system, climate data portal, and a tropical cyclone portal, have been developed. These will support the improvement of climate data storage, climate services and climate research work undertaken by partner countries. Input on user needs from partner countries has been crucial for the successful development of these tools, which have all been demonstrated during regional workshops. The stage is now set for these tools to be installed in NMS and training in their use provided.

Some valuable scientific findings are already emerging from the analytical work. Temperatures show substantial warming which has continued into the 21st century at most locations. There is also some evidence of a reversal of the rainfall trends observed over the last few decades of the 20th century.

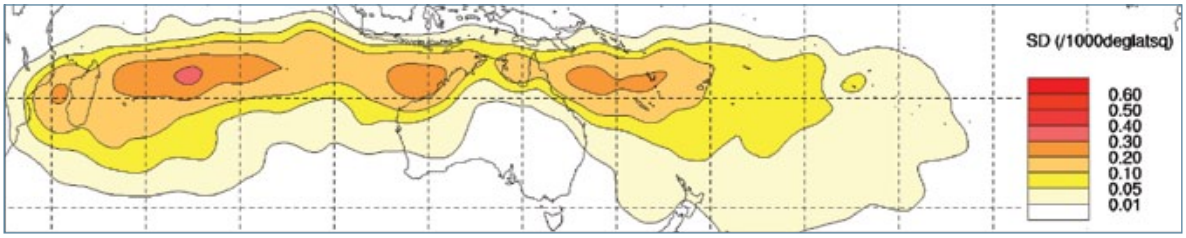


Figure 3a: *Average annual cyclone densities for all seasons;*

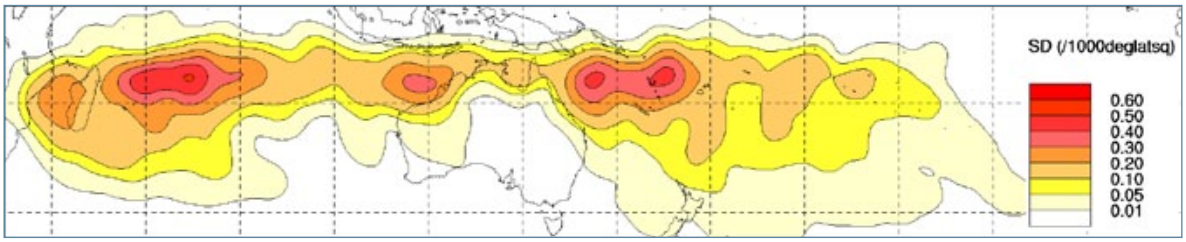


Figure 3b: *Average annual cyclone densities for El Niño seasons, and;*

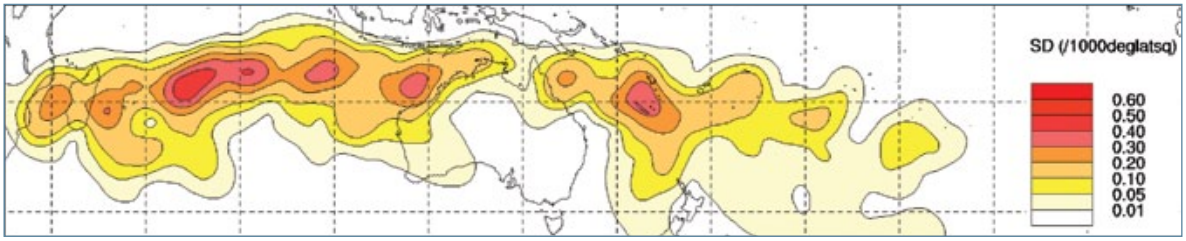


Figure 3c: *Average annual cyclone densities for La Niña*

3 Progress

3.2 Component 2: Regional drivers

3.2.1 Description of Component 2

ENSO, SPCZ, ITCZ and the WPM are important 'drivers' of climate in the region. The three inter-related projects in this component are focusing on gaining a better understanding of the four main drivers, in particular how they are controlling seasonal and large-scale changes in rainfall, winds and tropical cyclones now, as well as how this will be altered by global warming in the future.

There are three inter-related projects in this component:

- Climate change and ENSO impact;
- SPCZ; and
- WPM and ITCZ.

3.2.2 Summary of progress to date in Component 2

Project	% complete	Comments
Climate change and ENSO impact	40	Project is on schedule and will meet milestones.
SPCZ	40	Project is on schedule and will meet milestones.
WPM and ITCZ	35	Project has had some delays due to recruitment difficulties. This has now been addressed and milestones are being met.

Extensive work has been conducted on the main 'drivers' of Pacific climate and their impacts. This includes literature reviews and assessments of how the four 'drivers' are represented in the global climate models. Diagnostic and analytical tools have been developed to assess the models. Collaborative work is underway together with the other components to evaluate the models and work is progressing on journal publications.

Planning has been advanced for the first international meeting on the SPCZ. This meeting has been endorsed by the World Climate Research Programme on Climate Variability and Predictability, International Pacific Implementation Panel. The meeting, planned for August 2010, will bring together a number of the world's SPCZ experts, as well as several representatives from PCCSP partner countries.

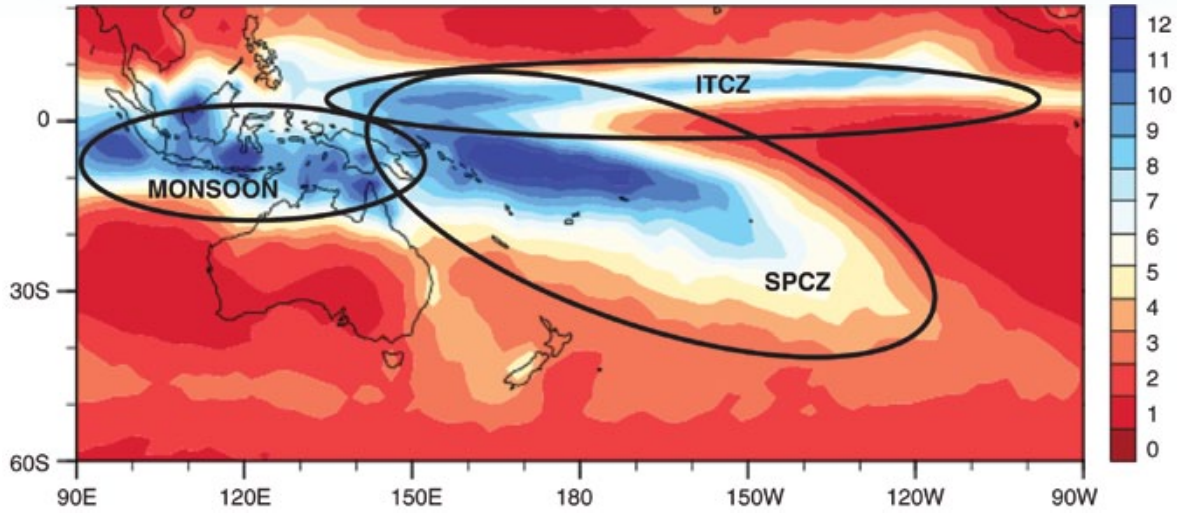


Figure 4: *Position of the Monsoon, the SPCZ and the ITCZ shown by the rainfall they produce on average during December to February. The WPM is the eastern part of the Monsoon shown on this map.*

3.3 Component 3: Climate change projections

3.3.1 Description of Component 3

Regional projections of likely changes to mean and extreme weather conditions (including tropical cyclones) are needed to assess vulnerability to potential climate change impacts and plan adaptation responses. This component will provide comprehensive and up-to-date projections, with some products tailored for use in impact studies and awareness-raising.

Key variables to be considered are surface air temperature, sea surface temperature, rainfall, wind speed and direction, evaporation, humidity, and solar radiation. Analysis of extremes will focus on temperature, rainfall and winds, as well as tropical cyclones.

Collaboration with universities and research institutions with expertise in delivering research outputs relevant to the PCCSP is an important feature of this component. In particular, the PCCSP is collaborating with four other institutions (The University of Melbourne, The University of New South Wales, NIWA and Iowa State University) to undertake additional dynamical downscaling to complement the CSIRO downscaling.

There are six inter-related projects in this component:

- Climate projections;
- Tropical cyclones;
- Statistical downscaling;
- Additional downscaling;
- Dynamical downscaling;
- Tailored projects.

3 Progress

3.3.2 Summary of progress to date in Component 3

Project	% complete	Comments
Climate projections	50	Project is ahead of schedule and will meet milestones.
Tropical cyclones	40	Project is on schedule and will meet milestones.
Dynamical downscaling	40	Project on schedule, and will meet milestones.
Additional downscaling	35	Project is slightly behind schedule due to delays in signing contracts, but will meet milestones.
Statistical downscaling	40	Project on schedule, and will meet milestones.
Tailored products	40	Project on schedule, and will meet milestones.

The reliability of the GCMs used in the IPCC-AR4 to simulate key climate processes and average climate patterns has been evaluated together with other components. Six models were judged to have inadequate reliability and have not been used in the preparation of the PCCSP climate projections. The selected models have been used to prepare projections of key climate variables: temperature, rainfall, wind, humidity, solar radiation and drought for each country for two emissions scenarios (A2 and A1B) centred on 2030, 2055 and 2090.

Karen Kalayer Hiawalyer from Papua New Guinea and Netatua Pelesikoti from SPREP put the Climate Futures tool to the test at the Climate and Ocean Projections Workshop Report 22-26 March 2010 – Cairns, Australia.

To further complement the projections from the GCMs, dynamical and statistical downscaling work is being conducted. Six GCMs have been downscaled at 60 km resolution over the whole PCCSP region from 1961-2100 for the A2 emission scenario. A set of criteria was used to select seven regions (each measuring about 500 x 500 km) for downscaling at 8 km resolution. Downscaling to 8 km will be conducted in the second year of the PCCSP and will provide more detailed projection

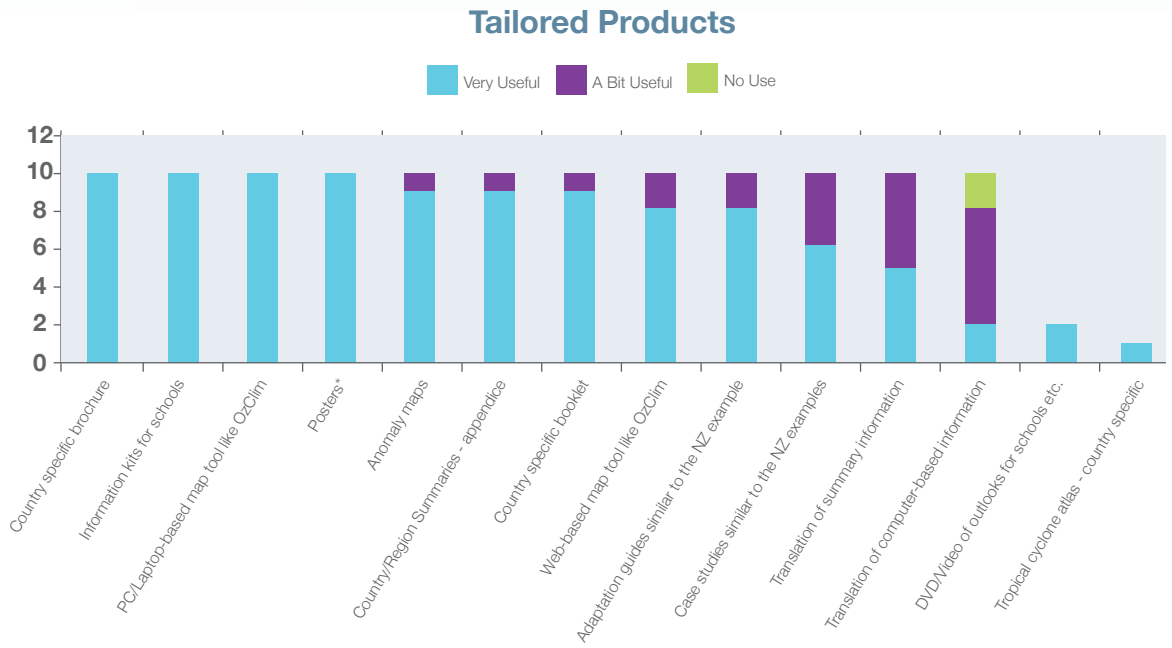


Figure 5: *Potential climate projection products identified at PCCSP Technical Workshop,Vanuatu, 12-16 October 2009.*

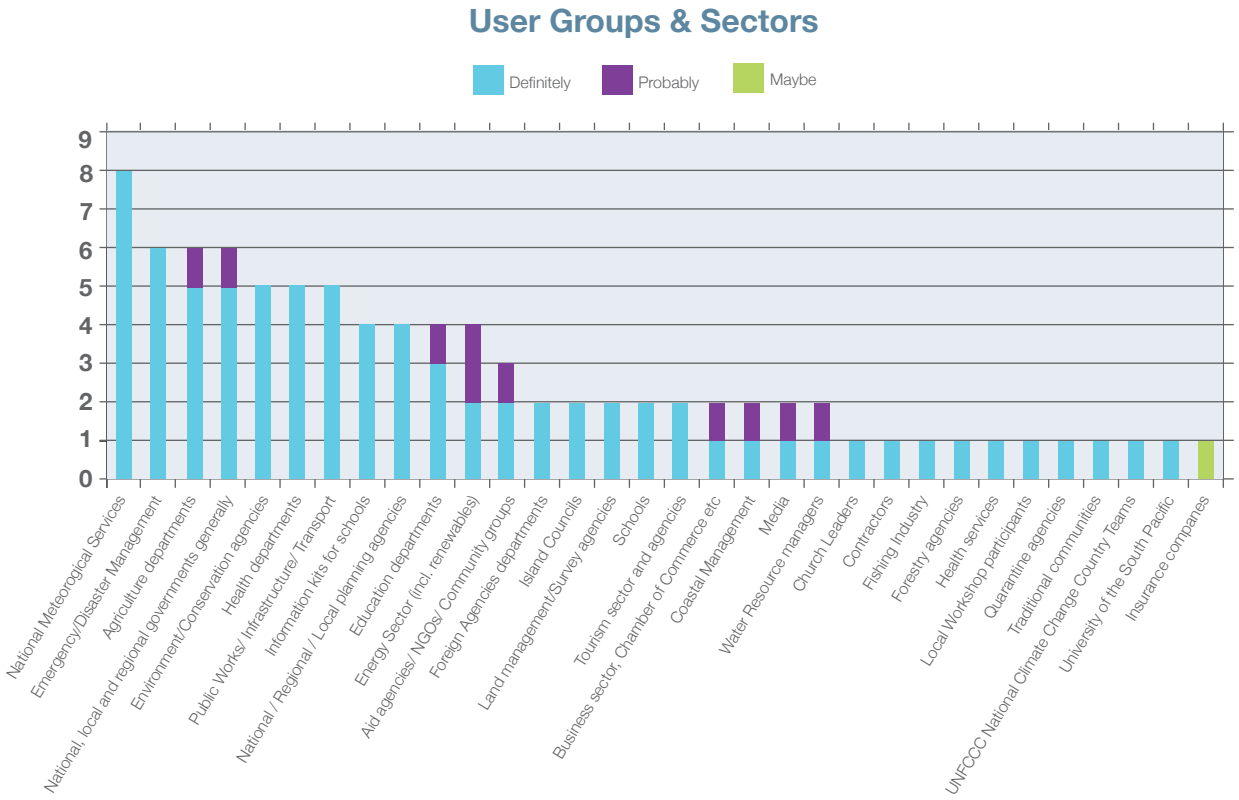


Figure 6: *Groups and sectors identified as users of climate projection products, PCCSP Technical Workshop, Vanuatu, 12-16 October 2009.*

information for the partner countries. The additional downscaling work being done by partner institutions is on schedule and will be completed in the second year of the PCCSP. The statistical downscaling work is on schedule despite some challenges with poor data quality for some countries.

Work on climate projections for tropical cyclones is on schedule and a new index for tropical cyclone genesis and intensification based on large-scale environmental factors has been developed.

A web interface for creating climate futures for all 15 countries has been developed and tested in four workshops with partner country representatives (three PCCSP regional workshops and one PACC workshop). Positive feedback and suggestions for improvement were received. The web interface is underpinned by data from 24 GCMs, with variables including annual-average and seasonal-average changes in temperature, rainfall, wind-speed, solar radiation, potential evaporation, extreme rainfall, extreme wind-speed and rain-days. Further enhancements to the web interface and supporting guidance material are underway.

3.4 Component 4: Oceans and sea level rise

3.4.1 Description of Component 4

Changes in sea level and ocean processes are particularly significant for island nations in the Pacific region. This research component, in close collaboration with the other three components, is aiming to improve understanding of these changes. Specifically they will examine the regional distribution of sea level changes and the effects of climate variability and climate change on extreme sea levels caused by extreme weather events. They are also investigating the relationship between complex ocean dynamics in the western equatorial Pacific and ENSO; and ocean acidification which is expected to cause a decline in the health and sustainability of reef ecosystems.

There are four inter-related projects in this component:

- ENSO variability and climate change;
- Effect of climate variability and climate change on extreme sea level events;
- Ocean acidification; and
- Sea level projections.

3.4.2 Summary of progress to date in Component 4

Project	% complete	Comments
ENSO variability and climate change	40	This project is on schedule. Initial staff shortages were addressed by drawing on capability from the University of New South Wales.
Effect of climate variability and climate change on extreme sea level events	30	This project has suffered delays due to recruitment difficulties. This has now been addressed and all milestones are likely to be met.
Ocean acidification	50	This project is well on schedule.
Sea level projections	25	This project was delayed due to recruitment difficulties. The schedule for project outputs has been revised and under the new plan milestones will be met.

Analysis of changes in temperature and salinity over the past 60 years show the surface ocean beneath rainfall-dominated regions has freshened, whereas ocean regions dominated by evaporation are saltier. Furthermore, results confirm that the surface warming of the world's oceans over the past 50 years has penetrated into the oceans' interior changing deep-ocean salinity patterns. Analysis of model drift for the 20th century runs of the IPCC simulations is well-advanced and contributes to the work of the other components on model evaluation.

Tropical cyclone occurrences for selected locations in the region have been analysed under average conditions and ENSO extremes and hydrodynamic model simulations for extreme sea level events in selected locations is underway.

Historical data on carbonate chemistry for the study region have been compiled and analysed. Along with data from mooring and shipboard sampling these will form the basis for determining the drivers of acidification in the region and for testing biogeochemical models. Model simulations are underway to assess current variability in carbonate chemistry with validation against historical data.

Work is ongoing on the time series and maps of the regional distribution of sea level rise for recent decades. This work includes analysis of the regional distribution of sea level rise from glacier contributions and from ocean thermal expansion.

3 Progress

3.5 Component 5: Science information synthesis and communication

3.5.1 Description of Component 5

This component supports project management, international and national coordination, outreach activities and workshops to be undertaken through the four research components. In addition, the component is responsible for synthesising the science outputs and making them available to planners and decision makers in the region and more broadly.

There are three main activities in this component:

- Domestic coordination;
- International coordination; and
- Information synthesis.

3.5.2 Summary of progress to date in Component 5

Project	% complete	Comments
Domestic activities	40	All domestic coordinating activities are well in hand and progressing satisfactorily. This project is on schedule.
International activities	40	This project is on schedule: effective engagement with partner countries and regional organisations is progressing very well.
Science information synthesis & communication	23	This project depends to a large extent on the completion of the PCCSP research components, so whilst showing only 23% complete, it is, nevertheless on schedule.

This component is on schedule and provides the coordination and project management to support the other components. A revised management structure for the Project Management Team has been put in place and is functioning effectively. Progress and budgetary oversight is provided by the PCCSP Management Committee based on bi-monthly traffic light reporting, six-monthly and annual reporting. One internal meeting for

all PCCSP researchers was held in February 2010 to share research findings and conduct a gaps and needs analysis of climate change science in the region.

PCCSP Internal Workshop, 22-24 February 2010.

Three PCCSP regional workshops have been coordinated and evaluations show they were extremely successful in building the knowledge-base of climate science in the partner countries. Specific modes of communication with the partner countries have been established and are proving effective. Several in-country visits have been important for information sharing with partner country stakeholders and regional organisations. An Interim Agreement on Data Security Arrangements has been put in place and has been endorsed by six countries.

Internal PCCSP monthly meetings are held to plan the final technical report and a detailed outline has been prepared and endorsed by the partner countries. All input to the first (zero-order) draft of the final technical report has been compiled. A six-page brochure on the PCCSP was prepared and circulated at the Pacific Islands Forum in August 2010 and planning has started for a second more substantive brochure. Work on the PCCSP website is advancing.

Climate observational station in the Marshall Islands.

4 Concluding remarks

The PCCSP is on schedule and expected to deliver all final products on time.

Research work is progressing with the full engagement of the partner countries and regional organisations and already some interesting results are emerging. Several scientific papers have been prepared and presentations made at international events.

As the Program progresses, there will be an increasing trend towards in-country activities which will allow for the engagement of many more stakeholders in the partner countries.

The PCCSP presents a unique and challenging opportunity to provide partner countries in the Pacific region with a solid scientific foundation on which to base their adaptation responses. All the scientific and support staff working on the Program are dedicated to meeting this challenge.

Annex 1

Annex 1 PCCSP Publications

Published papers

Kuleshov, Y., R. Fawcett, L. Qi, B. Trewin, D. Jones, J. McBride, and H. Ramsay (2010), Trends in tropical cyclones in the South Indian Ocean and the South Pacific Ocean, J. Geophys. Res., 115, D01101, doi:10.1029/2009JD012372

Durack, P.J., Wijffels, S. 2010. Fifty-year trends in global ocean salinities and their relationship to broad-scale warming, American Meteorological Society, Journal of Climate, doi: 10.1175/2010JCLI3377.1/

Papers in preparation

Papers submitted to Journals

Brown, J. et al. Evaluation of the South Pacific Convergence Zone in WCRP CMIP3 climate model simulations of the 20th century, submitted to Journal of Climate, June 2010

Kokic, P. et al. Forecasting climate variables using a mixed-effect state-space model, submitted to Environmetrics

Papers in draft stage

Chattopadhyay, M., Abbs, D. Brown, J. and Lavender, S. Tropical cyclone indices and in relation to the SPCZ in current and future climates, to be submitted to Journal of Climate

Irving, D. et al. GCM evaluation paper, to be submitted to the Open Atmospheric Science Journal

Katzfey, J. et al. CCAM 60 km evaluation of present climate for the globe, Journal yet to be selected

Kuchinke, M., Tilbrook, B., Lenton, A. The carbonate chemistry response to natural drivers in the Pacific Island regions, Journal yet to be selected

Annex 1

McInnes, K., McBride, J., Walsh, K. Climate change impacts on tropical cyclones and extreme sea level in the south Pacific, Journal yet to be selected

Nguyen, K. et al. CCAM 60 km evaluation of present climate for the tropical Pacific, Journal yet to be selected

Nguyen, K. et al. CCAM 60 km climate projections for the tropical Pacific, Journal yet to be selected

Perkins, S. et al. GCM atmospheric projections paper, to be submitted to the Open Atmospheric Science Journal

Sen Gupta, A. Climate drift in the CMIP 3 coupled climate models, to be submitted to Journal of Climate or Climate Dynamics

Annex 2

Annex 2 Presentations on PCCSP and PCCSP Science at Meetings and Conferences

2009

20-24 April 2009, Discussion of PCCSP at Meeting of Technical Working Group/SPC Project on Assessing the Vulnerability of Fisheries and Aquaculture to climate change, Noumea, New Caledonia, Susan Wijffels, Component 4 scientist

August 2009, Meeting at University of Hawai'i, Presentation on PCCSP, by Scott Power Component 2 scientist

August 2009, Meeting with NIWA and NZAID, Presentation on PCCSP by Scott Power, Component 2 scientist

21-23 October, 2009, Pacific Climate Change Roundtable, Republic of the Marshall Islands. Presentation on PCCSP: Advancing the scientific basis for adaptation by Gillian Cambers, Program Manager

21-25 October, 2009, SOPAC Science and Technology and Resource Network (STAR), Vanuatu. Presentation on Ocean acidification in the South Pacific region by Mareva Kuchinke, Component 4 Research Scientist

20 November, 2009, Delegation from Philippines National Economic Development Authority visited BoM. Presentation on PCCSP by Gillian Cambers, Program Manager

23-24 November, 2009, Presentations on PCCSP to SOPAC, SPREP, USP in Fiji by Elizabeth Boulton, Gillian Cambers, John Clarke and Kevin Hennessy, representatives of Components 3 and 5

25-26 November, 2009, Presentations on PCCSP to SPREP and UNDP in Samoa by Elizabeth Boulton, Gillian Cambers, John Clarke and Kevin Hennessy, representatives of Components 3 and 5

25 November 2009, Presentation on PCCSP to National Environment Conference in Samoa, Kevin Hennessy, Component 3 scientist

Annex 2

7 December 2009, Group undertaking SPREP Review of Meteorological Services visited BoM. Presentation on PCCSP by Elizabeth Boulton, International Liaison Officer

8 December, 2009, Delegation from China Meteorological Administration visited CSIRO. Presentation on PCCSP by Gillian Cambers, Program Manager

2010

27-29 January 2010, Australian Meteorological and Atmospheric Society (AMOS) National Conference, Canberra, 2010:

Paul Durack, Component 4 scientist: Fifty-year changes in the hydrological cycle expressed in ocean salinity

Alex Sen Gupta, Component 4 scientist: Projected changes to the tropical Pacific Ocean in the CMIP3 models

12 February, 2010, BoM Regional Office in Darwin, Presentation on PCCSP, Rod Hutchinson and Aurel Moise, Component 1 and Component 2 scientists

13-14 April 2010, Sea Level Data Applications Workshop, BoM, Presentation on Sea level monitoring and applications by Gillian Cambers, Program Manager

13 May 2010, Pacific Adaptation to Climate Change (PACC) Workshop, Apia, Samoa, series of presentations on PCCSP work on Climate and Ocean Projections, by Sarah Perkins and John Clarke, Component 3 scientists, and Les Muir, Component 4 scientist

24 May 2010, Pacific Island Climate Change Prediction Project, Melbourne, Presentation on Key climate drivers in the Pacific region, Brad Murphy, Component 2 scientist

29 June – 1 July 2010, National Climate Change Adaptation Research Facility Conference:

Dean Collins, David Jones, Simon McGree and John Phan, Component 1 scientists: A new climate change monitoring website for the South Pacific

W.J. Wright, R. Hutchinson and A. Howard, Component 1 scientists, Data in support of climate change adaptation in the Pacific.

International CLIMATE CHANGE ADAPTATION Initiative

For more information please contact:

Dr Gillian Cambers – Program Manager
Pacific Climate Change Science Program
• Phone: +61 3 9239 4400 • Email: gillian.cambers@csiro.au
Private Bag 1, Aspendale VIC 3195 Australia

For communications or media enquiries please contact:

Jill Rischbieth – Communications Officer
Pacific Climate Change Science Program
• Phone: +61 3 9239 4400 • Email: jill.rischbieth@csiro.au
Private Bag 1, Aspendale VIC 3195 Australia

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