



Koror, Palau

Chapter 8

Conclusions and Further Research to Advance Pacific Climate Science

8.1 Introduction

While there has been progress on many fronts to monitor, document, understand and project climate change relevant to the Pacific Climate Change Science Program's (PCCSP) Partner Countries, there are still many challenges. Further work to strengthen the scientific understanding of Pacific climate change is required to inform adaptation and mitigation strategies. Ongoing research in the following areas can contribute to the advancement of climate science in the PCCSP region.

8.1.1 Expand Ocean and Atmosphere Measurements in the Pacific Climate Change Science Program Region

There has been a marked decline in the total number of land based climate observation (measurement) stations in Partner Countries over the past few decades. These climate measurement stations need to be re-opened and upgraded, and the network needs to be expanded. The increased exchange of data between nations of the region will strengthen the ability of Partner Countries to monitor climate.

There is also a need to increase and recover meteorological and oceanographic data in the PCCSP region. The quality of historical climate observations in some countries is not high enough to reliably document variability or trends, and, despite improvements in ocean and satellite observations of the Pacific over the past few decades, the longer climate record of the Pacific region is generally sparse compared to other parts of the globe.

To this end, the rescue and rehabilitation of observational climate data, including the identification of new data sources and digitisation of hard copy data, is expanding the availability of climate data in Partner Countries, but requires continuing effort. The collation of other forms of historical data such as photographs, newspaper records and anecdotal evidence of change, is required to complement the instrumental monitoring of climate change. Given the relatively short duration of the instrumental records, palaeoclimate data also have an important role in extending the climate and sea-level records of this region.

Apart from the regional sea-level network, data documenting ocean changes are sparse, particularly regarding the sub-surface properties of the ocean, ocean chemistry and biological productivity changes. Greater use of ships of opportunity (volunteer merchant ships which routinely transit strategic shipping routes and carry instruments to measure ocean variables), or ocean gliders (remotely operated underwater vehicles, also carrying sensors to measure ocean characteristics) in the region will be beneficial. Expanded monitoring of ocean chemistry including acidification is urgent. Further analysis of historical sea-level observations is also required to provide a more continuous record of sea-level change.

A greater understanding of the role of tides, storm surges and waves in sea-level extremes would be facilitated by the addition of in situ wave observations throughout the region. This would include strategically located wave buoys and tide gauges. In quantifying the impacts of climate change on the coast in terms of both inundation and erosion, more comprehensive monitoring of shoreline changes and high resolution elevation surveys are needed throughout the region.

8.1.2 Advance the Understanding of Current Climate, Climate Variability and Climate Trends

A better understanding of climate features and patterns of variability in the PCCSP region is needed. For example, despite the key role of the South Pacific Convergence Zone in the climate of many Partner Countries, the processes governing it are still not fully understood. Issues such as this can be addressed through the continued use of observations and climate models. The imminent arrival of many new climate models through the international Coupled Model Intercomparison Project Phase 5 (CMIP5), and use of the Australian Climate Community Earth-System Simulator (ACCESS) for experimentation specifically targeted to issues of importance to the PCCSP region, provide exciting new opportunities on this front.

Trends in climate are evident over the Pacific as a whole, including the PCCSP region, however the extent to which these trends are attributable to natural variability and to human activities is not yet well understood. Greater clarity on this issue, and more reliable estimates of past variability in the atmosphere and the ocean – including extreme events – will help strengthen the credibility and communication of future climate projections in the region.

8.1.3 Improve Climate Models and Climate Change Projections

Models from the Coupled Model Intercomparison Project Phase 3 (CMIP3) have several limitations that restrict a full understanding of the past and projection of the future climate. The new set of global model projections from CMIP5 and the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (due 2014) will provide new information about past and future climate, with a wider range of emissions scenarios and improved models.

CMIP5 will provide a standard set of model simulations to: (1) evaluate how realistic the models are in simulating the recent past, (2) provide projections of future climate change on two time scales, near-term (out to about 2035) and long-term (out to 2100 and beyond), and (3) explore the role of different factors and feedbacks such as clouds and the carbon cycle.

The ability of these next generation climate models to simulate climate in the PCCSP region needs to be assessed, and ongoing work to improve climate models needs to continue. Future model evaluation should also take advantage of the new enhanced regional climate dataset obtained from station records through the PCCSP.

Updating future climate projections for the PCCSP region using these new CMIP5 climate models is a priority. These projections need to be integrated more closely in specific case studies examining the impacts of climate change and developing adaptation strategies.

Greater attention needs to be given to assessing how statistical and dynamical downscaling can complement the global climate models. Downscaling of ocean projections is also required to understand changes to biological systems and impacts on fisheries and aquaculture.

One of the greatest sources of uncertainty in climate projections is the lack of consistency in projected El Niño-Southern Oscillation changes. Uncertainty can be better quantified and possibly reduced through closer study of systematic biases in the climate models associated with the El Niño-Southern Oscillation, the cold tongue and the South Pacific Convergence Zone. These model issues are likely to be interrelated and will require improvements to cloud physics, increased ocean resolution, and better representation of sub-annual atmospheric variability.

Uncertainty in sea-level projections is dominated by the future dynamic response of the Greenland and Antarctic ice sheets. Reducing uncertainty will require ongoing in situ and satellite observations, process studies and improved ice sheet (cryosphere) models, and the evaluation of climate models and their ability to simulate steric sea-level rise, as well as glacial and ice cap changes.

More detailed and rigorous testing of sea level and ocean heat content simulated by climate models is required, including the inter comparison of models and understanding the reasons for the differences between them. The models need to be critically compared with the available historical observations so as to improve understanding of interannual and decadal variability.

Regional projections of ocean acidification are based on coarse resolution climate models, so they do not represent localised changes in carbonate chemistry that result from net calcification and production within reefs, which can feedback to the acidification response. In order to reduce uncertainties of how reef systems will respond to acidification, a hierarchy of models and observations at reef and regional scales will be required. These models will also need to include ecological responses to other stressors including coral bleaching and pollution.

Climate models provide credible quantitative estimates of future climate change, particularly at larger scale, however some deficiencies remain at smaller scales. There will always be a range of uncertainty in climate projections. It is important that this uncertainty is understood and incorporated into any future impact assessments based on climate model projections.

8.1.4 Improve Understanding of Tropical Cyclones and Extreme Events

Continued use of climate models to make projections of tropical cyclone behaviour including frequency, location, intensity, rainfall and movement remains a high priority for the PCCSP region. Projections of changes in tropical cyclone intensity and extreme rainfall require the use of fine-resolution (less than 5 km) non-hydrostatic models which are able to represent small-scale features of the cyclone eye wall. The current methods used to predict the number of cyclones often provide conflicting results, reflecting a poor understanding of the relationship between cyclone activity and the surrounding large-scale circulation. A better understanding of the reasons why tropical cyclone activity varies from year to year will improve understanding and possibly lead to more robust projections. Projections of tropical cyclone activity in the future would also be more robust if the theoretical understanding of cyclone formation, intensity and frequency is enhanced.

To date there has been no systematic documentation of the effects of tropical cyclones in the PCCSP region. Daily time series of rainfall, sea level and wind need to be examined in order to document the contribution of tropical cyclones to extreme events in the current climate.

8.2 Conclusions

The IPCC Fourth Assessment Report (2007) concluded that a renewed international agenda to assess the vulnerability of small islands is needed, based on the most recent projections and newly available tools, to provide small islands with a firmer basis for future planning. The work of the PCCSP has addressed some of the key areas identified in the IPCC report as they relate to the Pacific islands and East Timor and has sought to enhance the capacity of the Partner Countries to collaborate in this research.

While some shortcomings, primarily in data availability and resolution of regional models, still remain, the PCCSP represents a coordinated, regionally focused research effort to directly address these issues.

There are many important steps to be taken on the way to implementing sound adaptation measures. An understanding of past and future climate change is fundamental, but it is only one step. This information has to be applied in impact models, vulnerability assessments, and ultimately long-term planning and decision support services.

Scientific research and capacity building have to proceed hand in hand. A long-term, inter-agency coordinated effort is required to further understand climate change science in the PCCSP region and to deliver the information in a manner that can inform and help shape adaptation strategies. This will assist the region in implementing the Pacific Islands Framework for Action on Climate Change and subsequent policies, and contribute to the sustainable development of the Partner Countries.