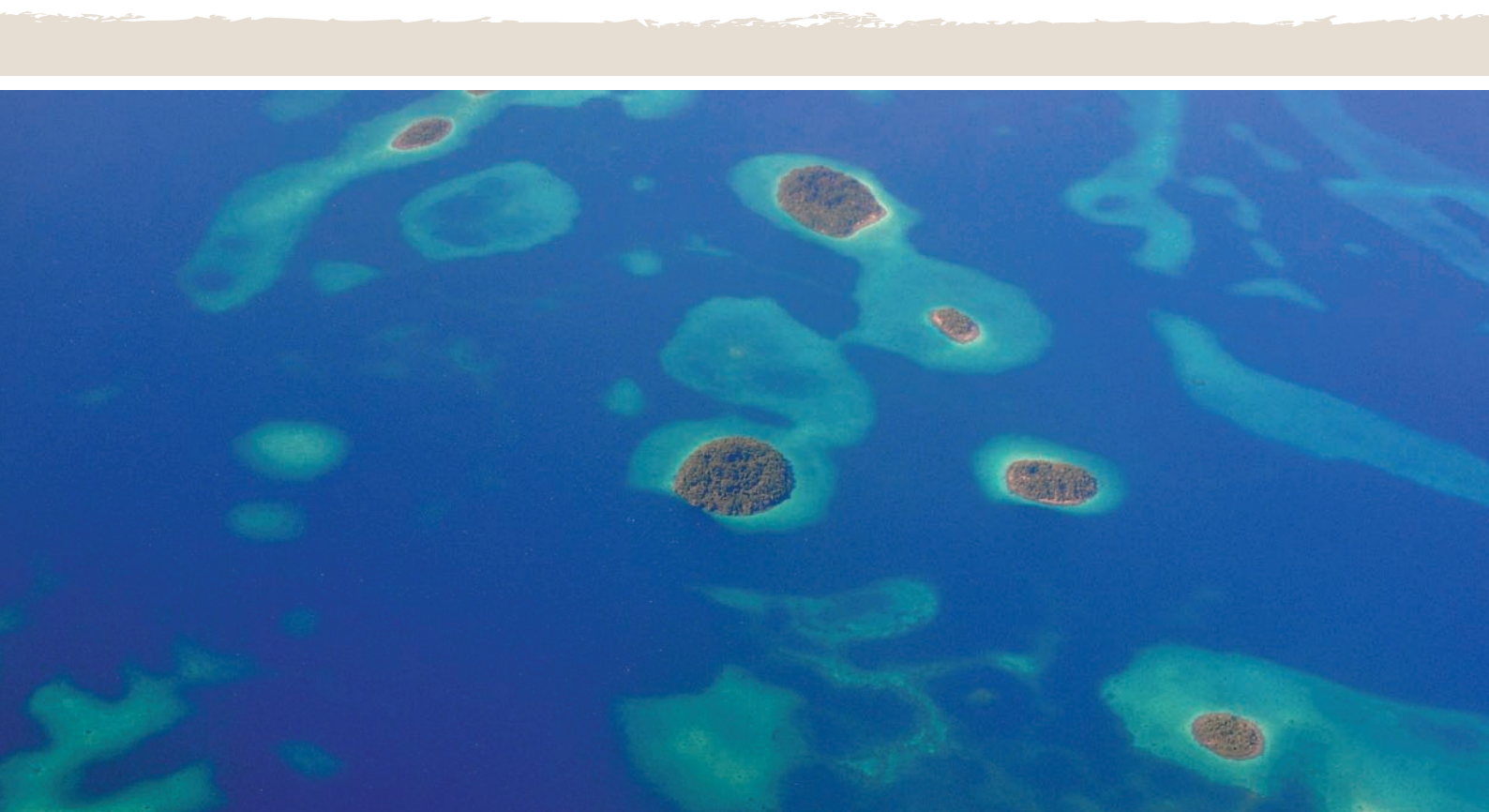


Pacific Climate Change Science Program



Climate variability and change in the Pacific islands and East Timor



Australian Government

Living with climate variability and change

Many people living in the Pacific islands and East Timor report their climate is changing. Climate variability and change present challenges for major economic activities, such as agriculture and tourism, as well as individual livelihoods.

These changes are being felt in a variety of ways, as described by a representative from East Timor attending a climate science workshop in 2010:

“People in agriculturally-dependent rural areas suggest the rainfall pattern has changed. Those living in the highlands report increased winds, and fishermen in coastal areas say they are noticing more frequent large waves.”

Only limited scientific research about climate variability and change has been undertaken in the region. The Pacific Climate Change Science Program (PCCSP) is helping 14 Pacific island nations and East Timor better understand their current and future climates and is providing information critical to adaptation planning.

The PCCSP is part of the Australian Government's International Climate Change Adaptation Initiative which commenced in 2008 to help meet high-priority adaptation needs of vulnerable countries in the Asia-Pacific region, especially Pacific island countries and East Timor.

Perceptions of a changing climate

Representatives from PCCSP partner countries described their communities' experiences of climate change during a PCCSP workshop held in 2010.

They highlighted changes in weather and climate and how these were affecting their islands, including:

- > Shifts in seasonal patterns of rainfall and tropical cyclone tracks
- > More frequent and more intense rainfall causing flooding and mudslides
- > More frequent and longer droughts
- > More hot days
- > Sea-level rise leading to increased coastal erosion and risks to important crops such as taro through salt water contaminating freshwater supplies
- > Coral bleaching

But it was not all bad news. Others said higher temperatures were increasing the yields of some crops. For example, grapefruit is now found year-round in Samoa, and in Vanuatu coconut trees are bearing more fruit.



Flooding in Teuma, Vanuatu
(Courtesy of Vanuatu Meteorological Service)

Understanding the **climate** of the region

The climate of the Pacific islands and East Timor is particularly influenced by three large-scale features: the South Pacific Convergence Zone, the Intertropical Convergence Zone and the West Pacific Monsoon.

These features influence rainfall, winds, tropical cyclones, ocean currents and other aspects of the weather and climate. Despite their importance to the region, there are still significant gaps in our understanding of them.

PCCSP scientists have been working with partner countries to improve the understanding of the current and possible future effects of these features. Figure 1 shows a map of these climate features. This map has been developed in consultation with partner countries and as a result of research being undertaken by PCCSP scientists.

Causes and impacts of climate features

The South Pacific Convergence Zone, the Intertropical Convergence Zone and the Monsoon are all caused by winds converging over warm water, producing thunderstorm activity and high rainfall. These prominent, large-scale climate features drive seasonal variations in rainfall in Pacific countries resulting in wet seasons (November to April in the Southern Hemisphere, May to October in the Northern Hemisphere) and dry seasons. These features meet over the West Pacific Warm Pool, which comprises some of the warmest open ocean waters on Earth.

The South Pacific Convergence Zone is a band of heavy rainfall extending from near the Solomon Islands to east

of the Cook Islands. It is strongest in the Southern Hemisphere wet season.

The Intertropical Convergence Zone stretches across the Pacific just north of the equator and is strongest in the Northern Hemisphere wet season.

The West Pacific Monsoon (eastern part of the Monsoon on the map) is driven by large differences in temperature between the land and the ocean. It moves north to mainland Asia during the Northern Hemisphere summer and south to Australia in the Southern Hemisphere summer. The seasonal arrival of the Monsoon usually brings a switch from very dry to very wet conditions.

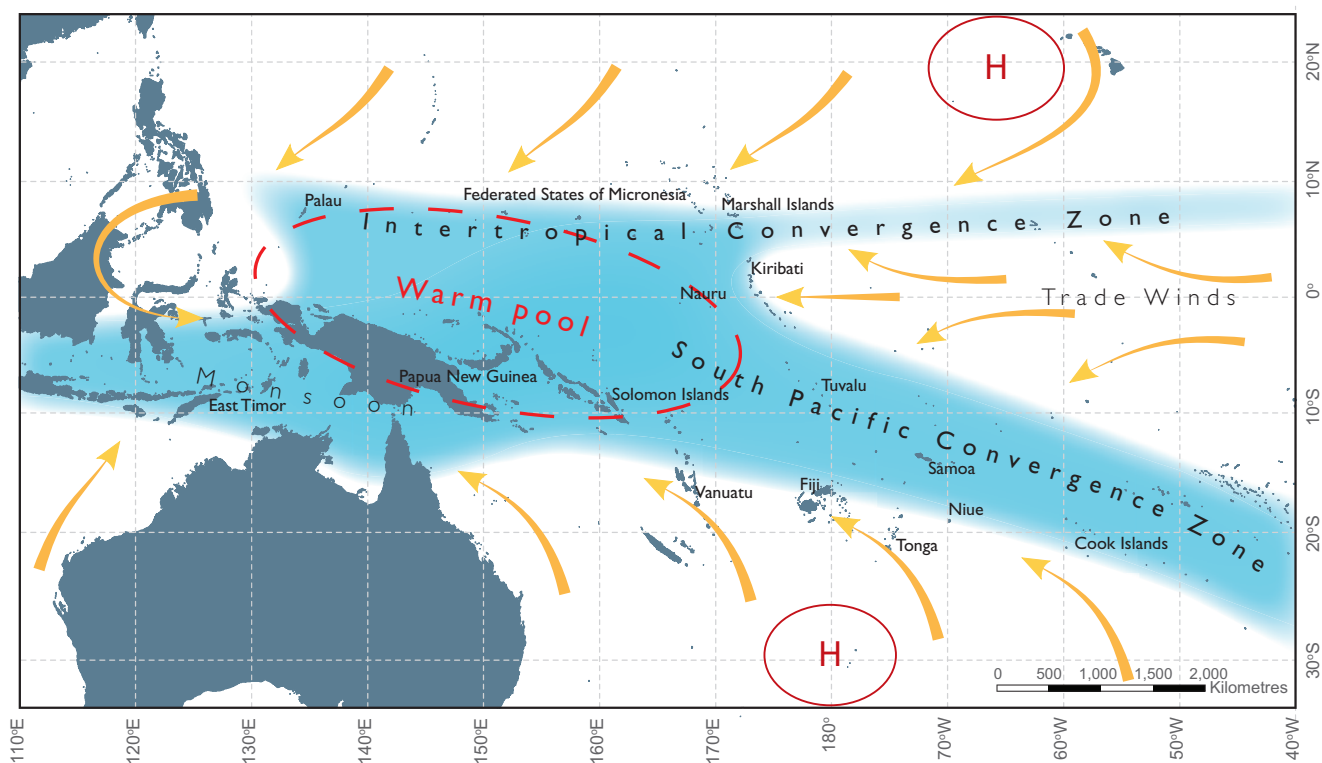


Figure 1: The average positions of the climate features in November to April. The arrows show near surface winds, the blue shading represents the bands of rainfall convergence zones, the dashed oval shows the West Pacific Warm Pool and H represents typical positions of moving high pressure systems.

Temperature variation

In the tropics, air temperatures are strongly driven by ocean temperatures. In countries close to the equator, little change in temperature occurs throughout the year. Away from the equator, seasonal variations in temperature are greater due to changes in sunlight and ocean temperature, as well as the impact of sub-tropical high-pressure systems and cold fronts. The direction and strength of the Trade Winds also affect temperatures in most tropical countries.

El Niño-Southern Oscillation and year-to-year variability

The climate in all PCCSP countries varies from one year to the next largely due to the El Niño-Southern Oscillation. An El Niño event is one extreme of the El Niño-Southern Oscillation and occurs every two to seven years. An El Niño brings weaker Trade Winds and warming of the central and eastern tropical Pacific Ocean. These changes alter the strength and position of the Intertropical Convergence Zone and the South Pacific Convergence Zone and the timing of the Monsoon. During an El Niño year some countries experience different rainfall and temperatures to their “normal” climate. The opposite extreme of the El Niño-Southern Oscillation is called La Niña. Between the extremes of El Niño and La Niña, there are neutral phases of the El Niño-Southern Oscillation when the climate is close to “normal”.

Seasonal cycles

The wet and dry seasons of Pacific island countries and East Timor are caused by the large-scale climate features such as the South Pacific Convergence Zone. For example, in the Solomon Islands the wet season arrives in late December as the Monsoon moves south. But some rain falls throughout the year as the South Pacific Convergence Zone and thunderstorm activity over the West Pacific Warm Pool continue year-round. Temperatures change little, as the amount of sunlight and the sea surface temperature remain fairly constant throughout the year.

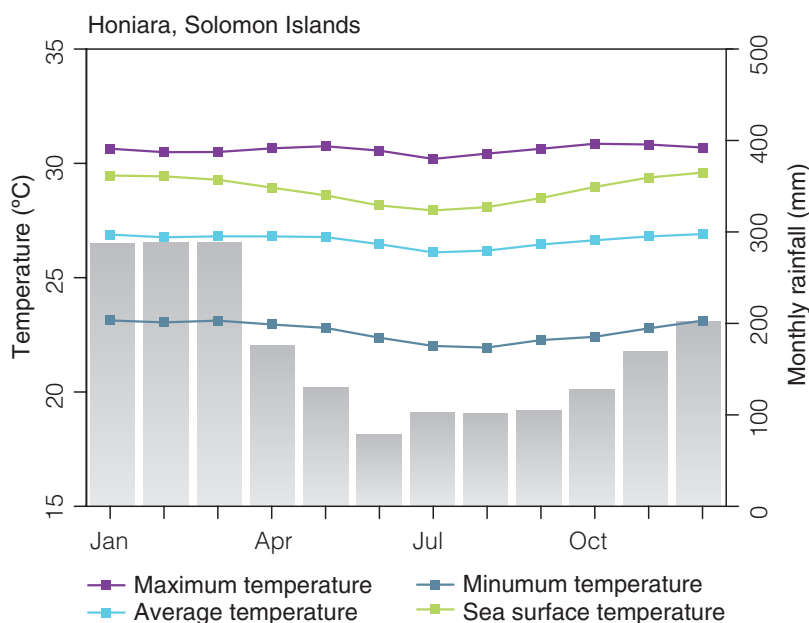


Figure 2: Monthly average rainfall (grey bars); maximum, minimum and average air temperatures; and sea surface temperature in Honiara, Solomon Islands.



The climate has **changed**

Based on existing studies, together with some initial findings from the PCCSP, it is clear that the climate in the region has changed over recent decades.

The PCCSP is working with National Meteorological Services to collate and analyse historical climate records. This work is improving the scientific understanding of past changes and underpins analysis of future climate change.

Average temperatures have increased

Global temperature datasets show strong warming in the Pacific region since the mid-1970s (Figure 3). Most of the warmest years on record have occurred in the last decade. In much of the region, average temperatures have increased by 0.1-0.2°C per decade since 1970. However, the warming has not been consistent everywhere. Since 1970, the areas of greatest warming in the region are mostly located near the equator, west of longitude 180°E.

Rainfall patterns are changing

Changes in rainfall over recent decades are more varied than those of temperature. Over the past 50 years, there has been a trend of increased rainfall northeast of the South Pacific Convergence Zone and decreased rainfall southwest of the South Pacific Convergence Zone. Rainfall trends show great natural variability associated with the climate features such as the El Niño-Southern Oscillation.

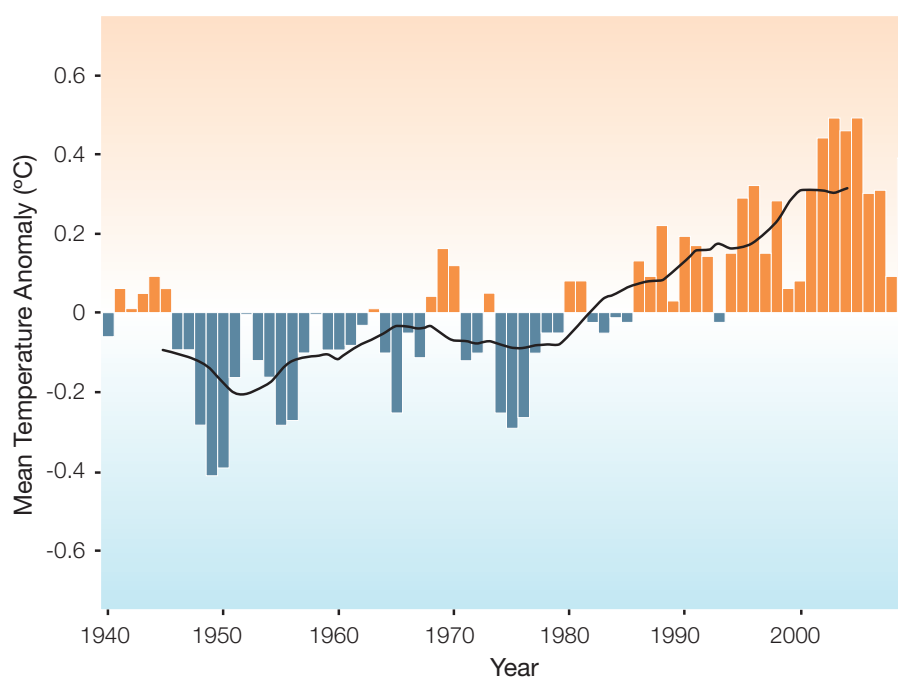


Figure 3: Change in annual mean surface temperature compared to a 1961-1990 base period for the region (120°E-150°W; 25°S-20°N). Solid line indicates 11-year running mean. Based on the Climatic Research Unit/ Hadley Centre global gridded surface temperature dataset (HadCRUT3v).

The ocean has changed

The PCCSP is working with regional organisations and partner countries to improve understanding of oceanic changes including temperature, salinity, circulation, sea-level rise and acidification.

Ocean temperature is rising

Most of the heat due to increased emissions of greenhouse gases has been absorbed by the oceans. Increased ocean temperatures cause a variety of impacts. These include sea-level rise and incidents of coral bleaching which stress coral reef ecosystems. New research by PCCSP scientists shows average sea surface temperatures have increased by 0.7°C from 1950 to 2000 across the tropical Pacific.

Ocean salinity is changing

Changes in ocean salinity are driven by rainfall and evaporation. In areas of high rainfall, salt in the seawater becomes more diluted, and in areas of high evaporation the salt becomes more concentrated. Changes in salinity are important in understanding changes in rainfall patterns over the ocean.

Research by PCCSP scientists shows that over the period 1950-2000, the West Pacific Warm Pool has freshened due to increased rainfall. In the southeast Pacific region, enhanced evaporation has caused increased salinity.

Sea level continues to rise

Long-term measurements of sea level depend on tide gauges. Prior to the late 19th century these were all located in the Northern Hemisphere. Since then, the number of gauges has increased both globally and in the Southern Hemisphere. In recent decades, satellite instruments have also provided sea-level data.

Analysis of global tide gauge data shows that the rate of sea-level rise increased in the late 19th and early 20th century, with a global-average rate of about 1.7 mm/yr over the 20th century (Figure 4).

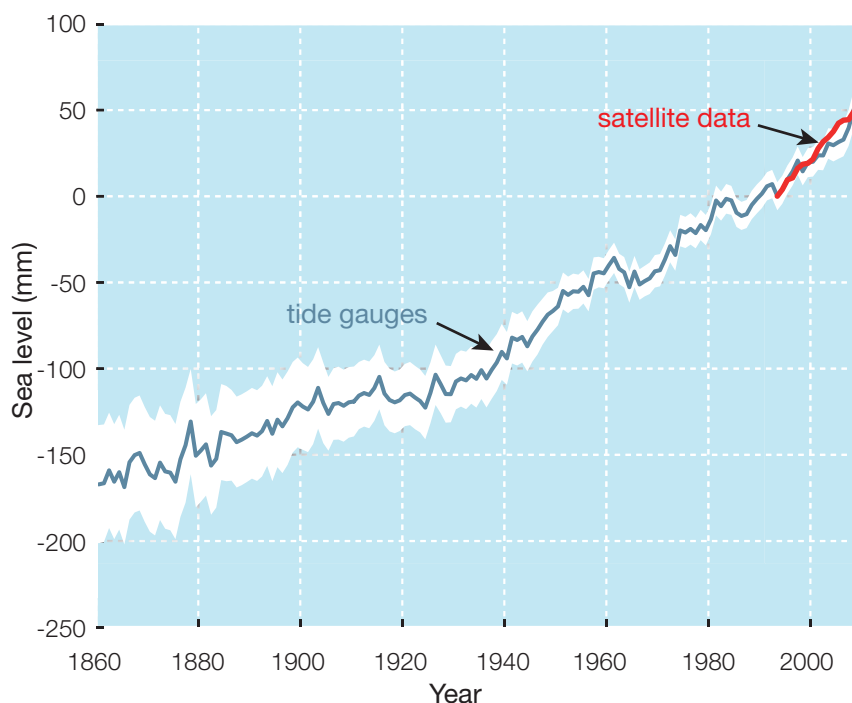


Figure 4: Global averaged sea-level changes since 1860 compared to the 1990 average. The solid blue line is estimated from tide gauges and the red line represents sea level measured by satellite altimeters. The average rate of rise from 1900 to 2000 was about 1.7 mm/yr . The rate of rise measured by satellite altimeters since 1993 has been about 3.2 mm/yr and the rate measured by tide gauges was slightly smaller.



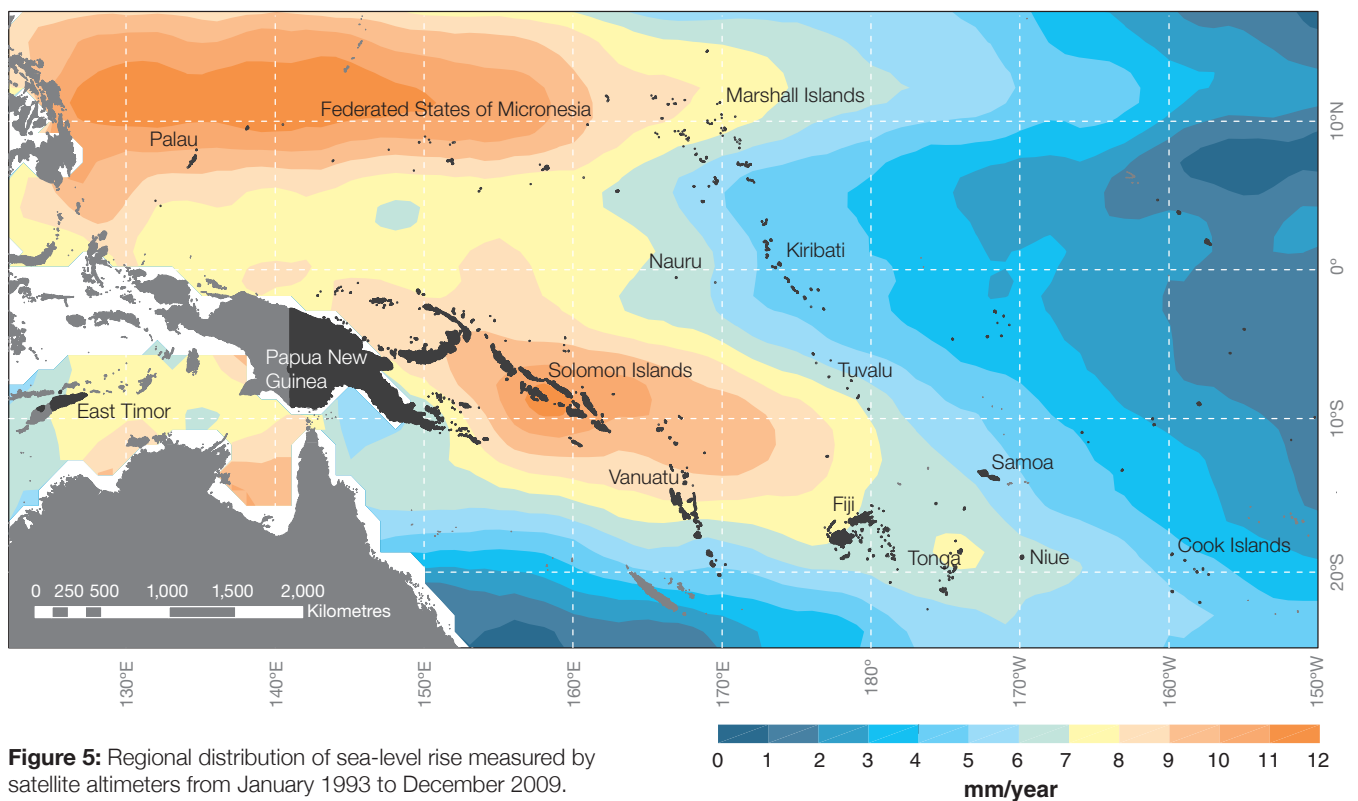
Bleached coral

Globally, satellite data indicate average sea level rose at a rate of about 3.2 mm/year since 1993. Tide gauge data indicate a slightly smaller rate of rise over the same period.

But sea level has not risen uniformly (Figure 5). Since 1993, the largest rise was over 10 mm/year in the western Pacific Ocean near latitudes 10°S and 10°N. In contrast, in the central equatorial Pacific the rise was much smaller. This regional pattern is largely a result of natural climate variability caused by the El Niño-Southern Oscillation. However, on a global level, some of this pattern of change may also be related to longer-term changes in wind patterns, possibly associated with climate change.



Sea defences under construction in Kiribati



How the climate may change in the future

In addition to examining historical climate change, PCCSP scientists are developing projections for how climate in the region may change in the future. This information will be provided to partner countries to inform their adaptation initiatives and development planning.

The PCCSP will produce detailed national and regional projections. These are being developed from climate models that have been rigorously assessed by PCCSP scientists. Projections will be developed for air temperature, rainfall, wind speed, humidity, sunshine, evaporation and extreme weather events, as well as ocean temperature and salinity. These

projections will show how the climate may look under three different greenhouse gas emissions scenarios (low, medium and high) around 2030, 2055 and 2090. Additional projections will be developed for acidification and sea-level rise in the region.

Country-specific projection information will be accessible to partner countries via an interactive web-based tool called Climate Futures. It will have three levels of detail to cater for different user needs. The advanced level will allow people to explore projections from different climate models and download data for use in adaptation planning. Training and guidance material will be provided.

Sharing the findings

Final results from the PCCSP will be available in November 2011 in a technical report – Climate Change in the Pacific. This extensive, peer-reviewed report will be complemented by 15 short brochures providing summaries of each partner country's current and projected future climate.

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Further reading

Church, John A., Philip L. Woodworth, Thorkild Aarup and W. Stanley Wilson (Eds) 2010. Understanding Sea-level Rise and Variability, Wiley-Blackwell Publishing, Chichester, UK. 427 pp; ISBN: 978-1-4443-3452-4.

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