Pacific-Australia Climate Change Science and Adaptation Planning Program

Current and future climate of **Papua New Guinea**

> Papua New Guinea National Weather Service
> Australian Bureau of Meteorology
> Commonwealth Scientific and Industrial Research Organisation (CSIRO)

Australian Government

Papua New Guinea's current climate

Temperature

The temperature of the ocean surrounding Papua New Guinea has a strong influence on average monthly air temperatures. Changes in the temperature from season to season are small but more marked around Port Moresby than further to the north.

Rainfall

Papua New Guinea has a wet season from November to April and a dry season from May to October (Figure 1), but these seasons are only noticeably different in Port Moresby, where about 78% of the yearly average rainfall comes in the wet season. Due to their location in the West Pacific Warm Pool, islands in the north of Papua New Guinea experience rain throughout the year. As a result, Kavieng's average annual rainfall (3150 mm) is much higher than Port Moresby's (1190 mm).

Most of the rainfall in Port Moresby comes from the West Pacific Monsoon. Large differences in temperature between the land and the ocean drive the monsoon, and its seasonal arrival usually brings a switch from very dry to very wet conditions. In the north of the country rainfall is more consistent year-round, although the peak in rainfall corresponds to the monsoon season.

Rainfall in the north of Papua New Guinea is also affected by the Intertropical Convergence Zone and, to a lesser extent, the South Pacific Convergence Zone. These bands of heavy rainfall are caused by air rising over warm water where winds converge, resulting in thunderstorm activity. The South Pacific Convergence Zone extends across the South Pacific Ocean from the Solomon Islands to east of the Cook Islands, whilst the Intertropical Convergence Zone lies across the Pacific just north of the equator (Figure 2).

Year-to-year variability

Papua New Guinea's climate varies considerably from year to year due to the El Niño-Southern Oscillation. This is a natural climate pattern that occurs across the tropical Pacific Ocean and affects weather around the world. There are two extreme phases of the El Niño-Southern Oscillation: El Niño and La Niña. There is also a neutral phase. Generally in Papua New Guinea El Niño years are usually drier than normal while La Niña events are usually wetter. La Niña-associated prolonged rainfall has led to flooding and landslides, whilst El Niño-associated droughts have also taken their toll on Papua New Guinea. During El Niño events the monsoon season also starts later. The dry season at Port Moresby is cooler than normal in El Niño years and warmer than normal in La Niña years, while the wet season tends to be warmer and drier than normal during an El Niño event.

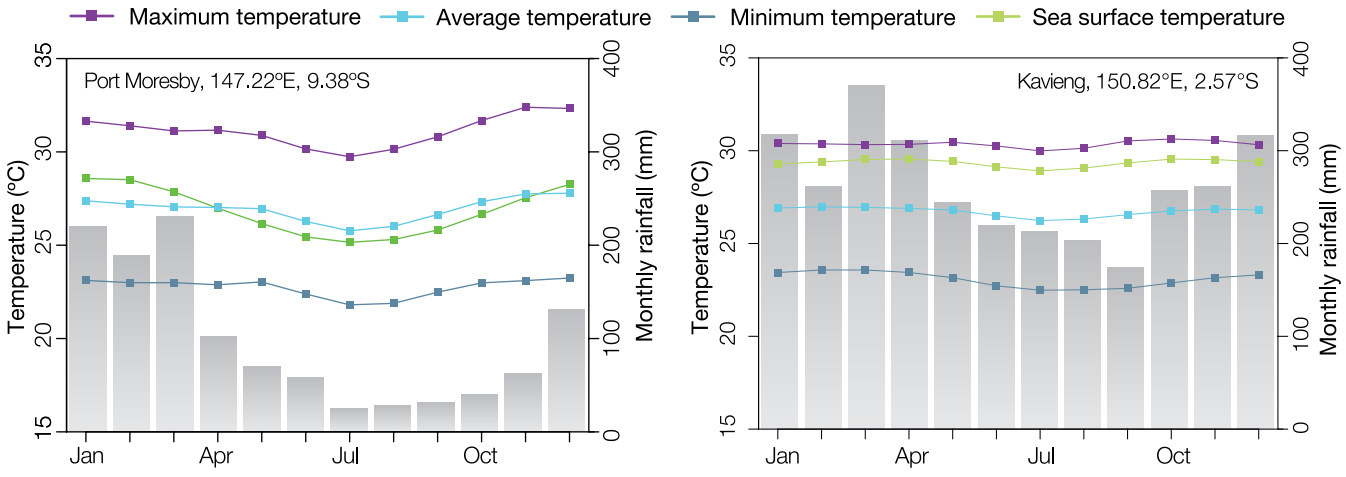


Figure 1: Seasonal rainfall and temperature at Port Moresby and Kavieng.

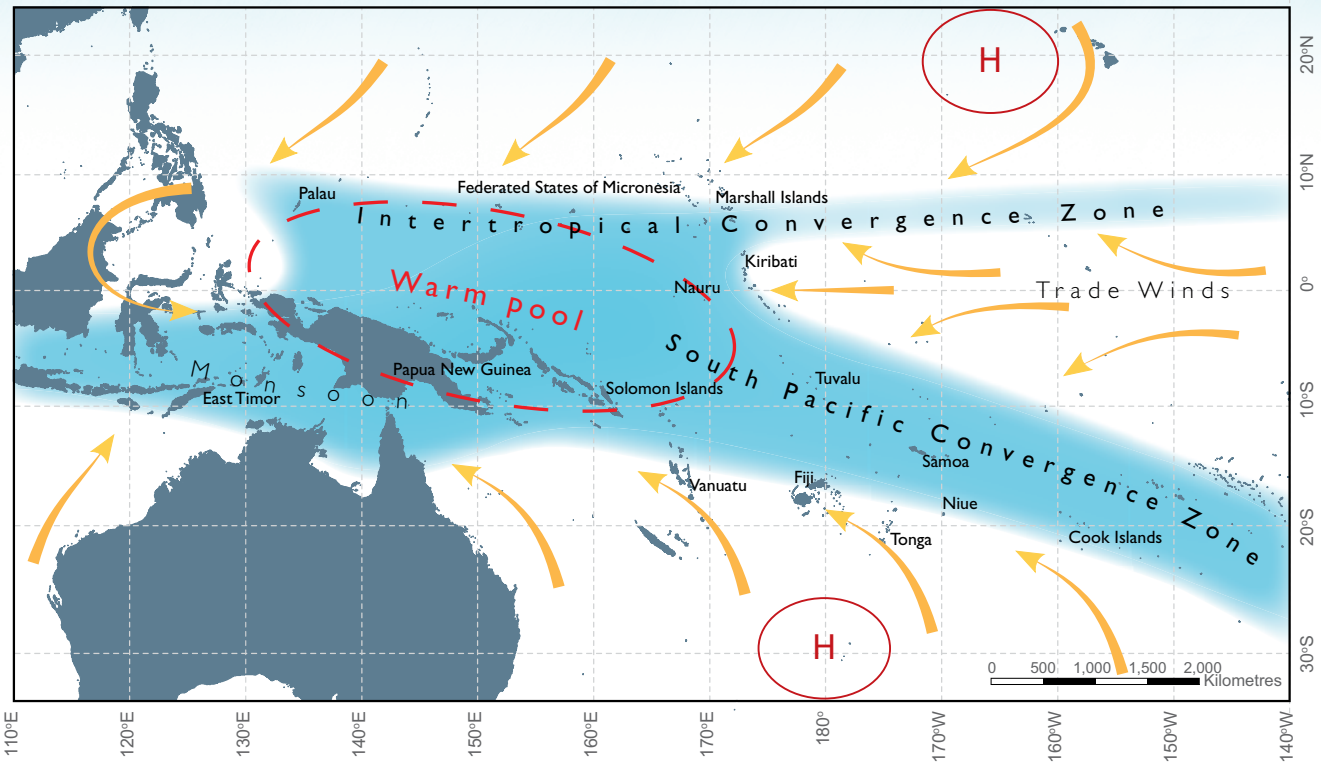


Figure 2: Average positions of the major climate features in November to April. The arrows show near surface winds, the blue shading represents the bands of rainfall convergence zones, the dashed oval shows the West Pacific Warm Pool and H represents typical positions of moving high pressure systems.

Tropical cyclones

Tropical cyclones tend to affect southern Papua New Guinea between November and April. In the 42-year period between the 1969 and 2010 seasons, 64 tropical cyclones developed in or crossed into the Papua New Guinea Exclusive Economic Zone, an average of 15 cyclones per decade (Figure 3). The number of cyclones varies widely from year to year, with none in some seasons but up to six in others. Over this period cyclones occurred in El Niño, La Niña and neutral years.

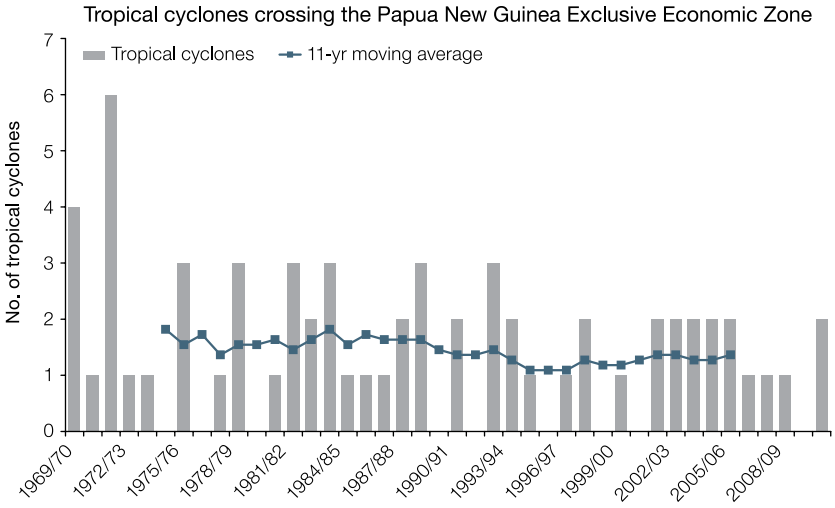


Figure 3: Number of tropical cyclones developing within and crossing the Papua New Guinea Exclusive Economic Zone per season. The 11-year moving average is in blue.

Wind-driven waves

Wind-waves around Papua New Guinea are typically not large, with markedly different behaviour on the north and south coasts. Waves are seasonally influenced by the trade winds, the West Pacific Monsoon and the location of the Intertropical Convergence Zone. From year to year they vary with the El Niño–Southern Oscillation. On the south coast waves are predominantly directed from the south-east throughout the year, but display strong seasonal variability with the largest waves during June to August (Figure 4, top). On the northern coast waves are characterised by the variability of trade winds and monsoon systems with the largest waves occurring during from December to March (Figure 4, bottom).

Taking weather observations, Papua New Guinea Weather Service.

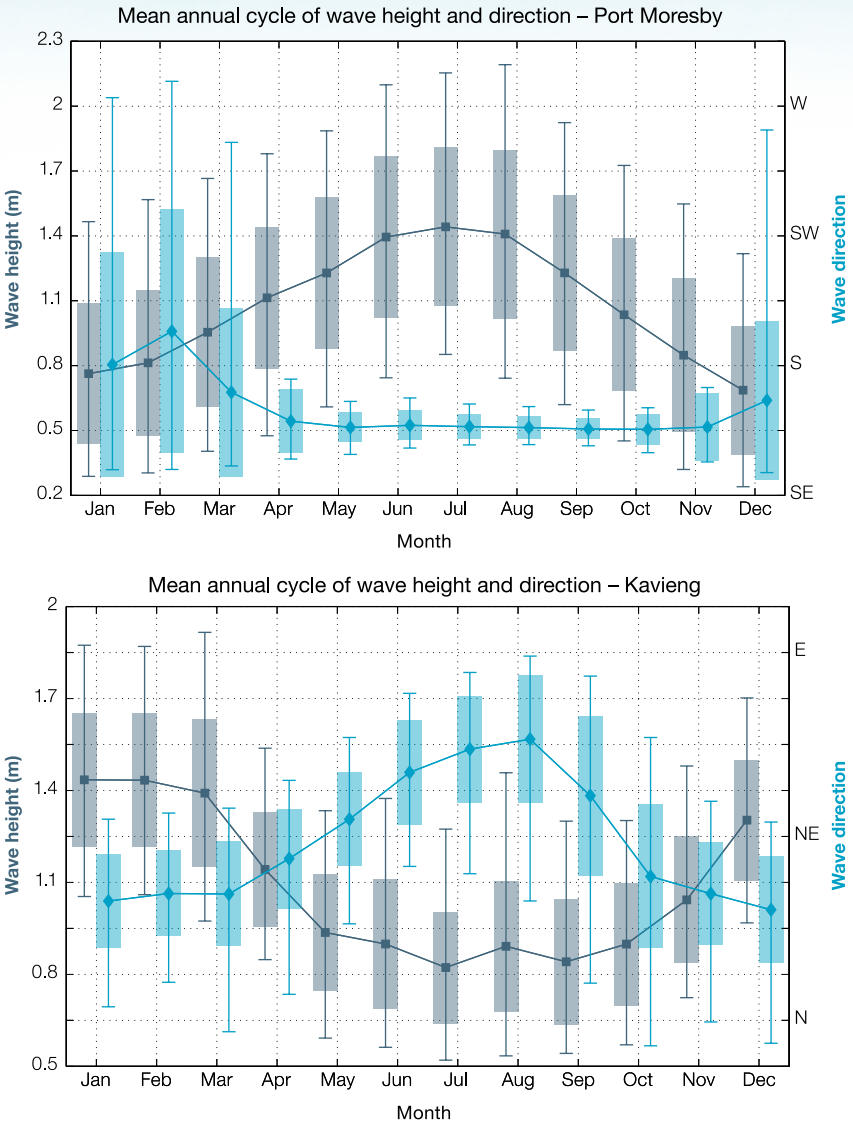


Figure 4: Annual cycle of wave height (grey) and wave direction (blue) at Port Moresby (top) and Kavieng (bottom) based on data from 1979–2009. The shaded boxes represent one standard deviation around the monthly means, and the error bars indicate the 5–95% range, showing the year-to-year variability in wave climate. The direction from which the waves are travelling is shown (not the direction towards which they are travelling).

Papua New Guinea's changing climate

Temperatures have increased

Annual mean temperatures at Port Moresby have increased since 1943 at the rate of 0.22ºC per decade (Figure 5). Maximum annual temperatures have increased at a rate of 0.13°C per decade and minimum annual temperatures have increased at 0.3ºC per decade. The number of warm days and warm nights has also increased since 1943 at both Port Moresby and Kavieng. Over the same period the number of cool days and cool nights (Figure 6) has decreased. These temperature increases are consistent with the global pattern of warming.

Rainfall varies from year to year

There are no clear trends in rainfall over Papua New Guinea since 1945 (Figure 5). Over this period, there has been substantial variation in rainfall from year to year. There has been little change in extreme daily rainfall over the same period.

Sea level has risen

As ocean water warms it expands causing the sea level to rise. The melting of glaciers and ice sheets also contributes to sea-level rise.

Instruments mounted on satellites and tide gauges are used to measure sea level. Satellite data indicate the sea level has risen near Papua New Guinea by about 7 mm per year since 1993. This is larger than the global average of 2.8–3.6 mm per year. This higher rate of rise may be partly related to natural fluctuations that take place year to year or decade to decade caused by phenomena such as the El Niño-Southern Oscillation. This variation in sea level can be seen in Figure 7 which includes the tide gauge records since 1966 and the satellite data since 1993.

Ocean acidification has been increasing

About one quarter of the carbon dioxide emitted from human activities each year is absorbed by the oceans. As the extra carbon dioxide reacts with sea water it causes the ocean to become slightly more acidic. This impacts the growth of corals and organisms that construct their skeletons from carbonate minerals. These species are critical to the balance of tropical reef ecosystems. Data show that since the 18th century the level of ocean acidification has been slowly increasing in Papua New Guinea's waters.

Papua New Guinea National Weather Service

A coastal village near Port Moresby completely destroyed by Tropical Cyclone Justin in 1992.

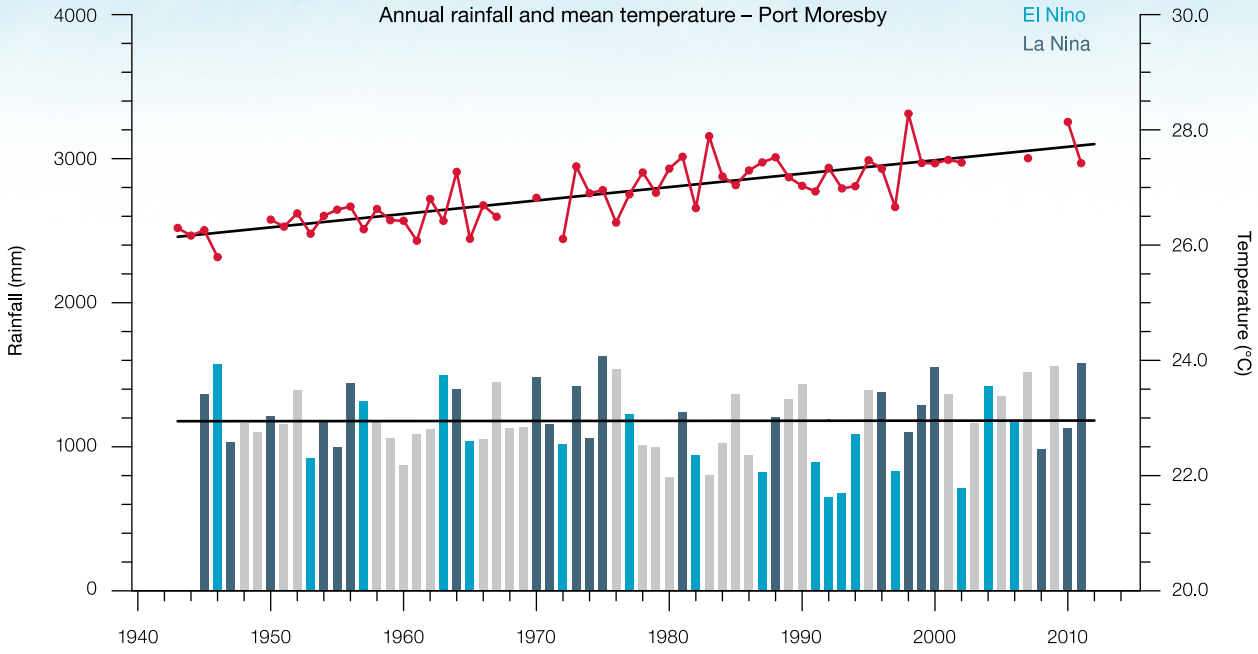


Figure 5: Annual average air temperature (red dots and line) and total rainfall (bars) at Port Moresby. Light blue, dark blue and grey bars indicate El Niño, La Niña and neutral years respectively. The solid black lines show the trends.

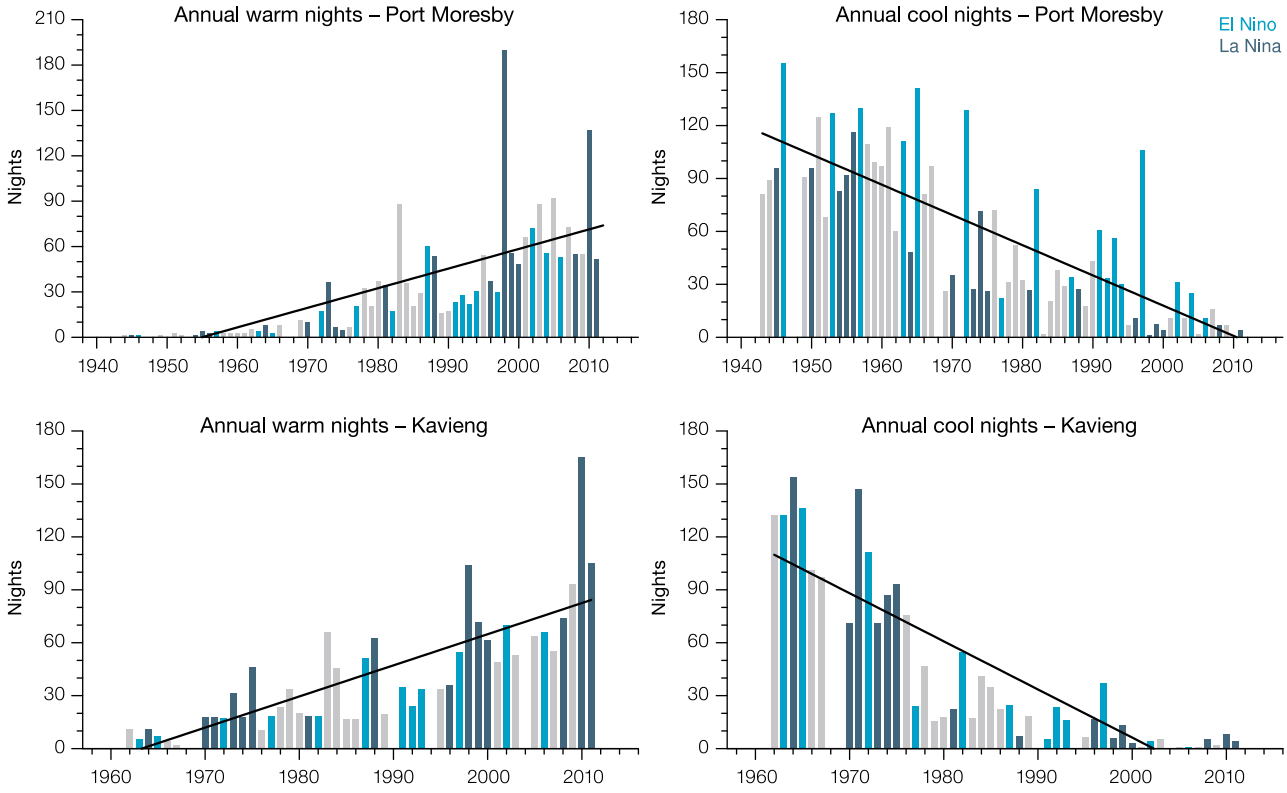


Figure 6: Annual total number of warm nights (left) and cool nights (right) at Port Moresby (top) and Kavieng (bottom). Light blue, dark blue and grey bars indicate El Niño, La Niña and neutral years respectively. No bars indicate that data is not available. Solid black lines show the trends.

Papua New Guinea's future climate

Climate impacts almost all aspects of life in Papua New Guinea. Understanding the possible future climate of Papua New Guinea is important so people and the government can plan for changes.

At a glance

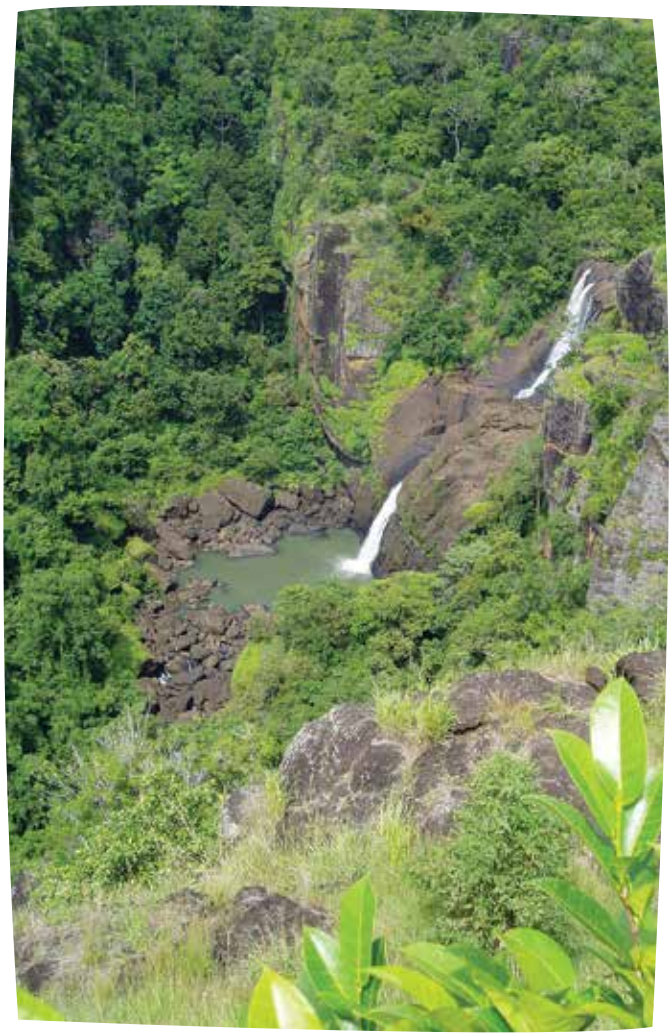
- El Niño and La Niña events will continue to occur in the future, but there is little consensus on whether these events will change in intensity or frequency.

- Annual mean temperatures and extremely high daily temperatures will continue to rise.

- Average rainfall is projected to increase in most areas, along with more extreme rain events.
- Droughts are projected to decline in frequency

- Sea level will continue to rise.
- Ocean acidification is expected to continue.
- The risk of coral bleaching is expected to increase.
- No changes in waves along the Coral Sea coast are projected, while on the northern coasts, December–March wave heights and periods are projected to decrease.

- Tropical cyclones are projected to be less frequent but more intense.



Rouna Falls, Sogeri Road, Port Moresby.

Temperatures will continue to increase

Projections for all emissions scenarios indicate that the annual average air temperature and sea-surface temperature will increase in the future in Papua New Guinea (Table 1). By 2030, under a very high emissions scenario, this increase in temperature is projected to be in the range of 0.5–1.1°C. Later in the century the range of the projected temperature increase under the different scenarios broadens.

Table 1: Projected changes in the annual average surface air temperature for Papua New Guinea. Values represent 90% of the range of the models and are relative to the period 1986–2005.

	2030 (°C)	2050 (°C)	2070 (°C)	2090 (°C)
Very low emissions scenario	0.5–0.9	0.6–1.2	0.5–1.3	0.4–1.3
Low emissions scenario	0.4–1.0	0.8–1.5	0.9–1.9	1.0–2.2
Medium emissions scenario	0.5–0.9	0.7–1.4	1.1–2.0	1.4–2.7
Very high emissions scenario	0.5–1.1	1.0–2.0	1.6–3.2	2.1–4.2

More very hot days

Increases in average temperature will also result in a rise in the number of hot days and warm nights, and a decline in cooler weather.

Changing rainfall patterns

Average annual and seasonal rainfall is projected to increase over the course of the 21st century. Projected increases are consistent with the expected intensification of the West Pacific Monsoon and the Intertropical Convergence Zone. However, there is some uncertainty in the rainfall projections and not all models show consistent results. Drought frequency is expected to decrease by the end of the century.

More extreme rainfall days

Projections show extreme rainfall days are likely to occur more often and be more intense.

Less frequent tropical cyclones

On a global scale, the projections indicate there is likely to be a decrease in the number of tropical cyclones by the end of the 21st century. But there is also likely to be an increase in the average maximum wind speed of cyclones by between 2% and 11% and an increase in rainfall intensity of about 20% within 100 km of the cyclone centre.

In the Papua New Guinea region, projections tend to show a decrease in the frequency of tropical cyclones by the late 21st century.

Weather balloon launch, Papua New Guinea National Weather Service.

Sea level will continue to rise

Sea level is expected to continue to rise in Papua New Guinea (Table 2 and Figure 7). By 2030, under a very high emissions scenario, this rise in sea level is projected to be in the range of 8–17 cm. The sea-level rise combined with natural year-to-year changes will accentuate the impact of storm surges and coastal flooding. As there is still much to learn, particularly how large ice sheets such as Antarctica and Greenland contribute to sea-level rise, scientists warn larger rises than currently predicted could be possible.

Ocean acidification will continue

Under all four emissions scenarios the acidity level of sea waters in the Papua New Guinea region will continue to increase over the 21st century, with the greatest change under the very high emissions scenario. The impact of increased acidification on the health of reef ecosystems is likely to be compounded by other stressors including coral bleaching, storm damage and fishing pressure.

Northern coast wave climate will change

No changes in waves along the Coral Sea coast of Papua New Guinea are projected. On the northern coasts, December to March wave heights and periods are projected to decrease.

Table 2: Sea-level rise projections for Papua New Guinea. Values represent 90% of the range of the model results and are relative to the period 1986–2005.

	2030 (cm)	2050 (cm)	2070 (cm)	2090 (cm)
Very low emissions scenario	8–17	14–30	19–44	24–58
Low emissions scenario	7–17	14–31	22–47	29–66
Medium emissions scenario	7–16	14–29	21–46	30–67
Very high emissions scenario	8–17	17–34	28–57	41–87

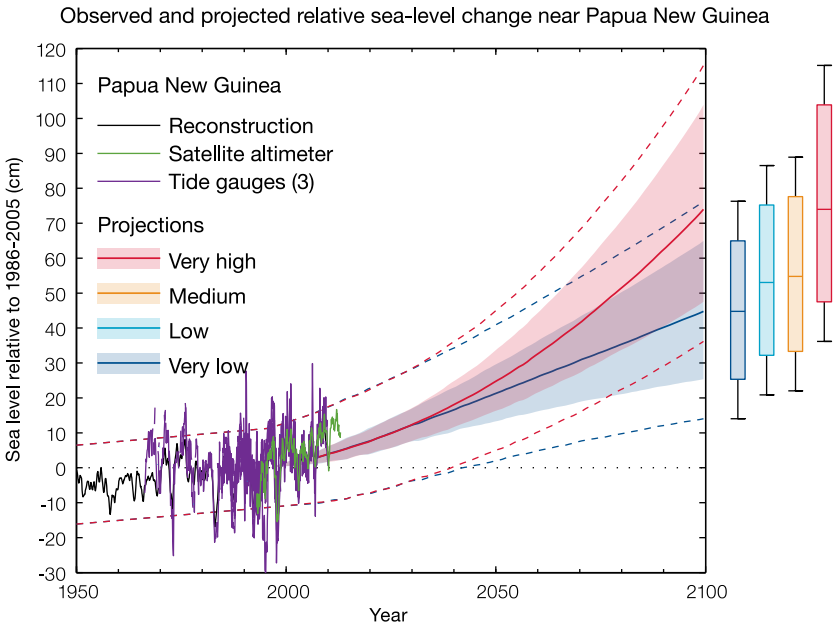


Figure 7: Tide-gauge records of relative sea level (since 1966) are indicated in purple, and the satellite record (since 1993) in green. The reconstructed sea level data at Papua New Guinea (since 1950) is shown in black. Multi-model mean projections from 1995–2100 are given for the very high (red solid line) and very low emissions scenarios (blue solid line), with the 5–95% uncertainty range shown by the red and blue shaded regions. The ranges of projections for the four emissions scenarios by 2100 are also shown by the bars on the right. The dashed lines are an estimate of year-to-year variability in sea level (5–95% uncertainty range about the projections) and indicate that individual monthly averages of sea level can be above or below longer-term averages

How do scientists develop climate projections?

Global climate models are the best tools for understanding future climate change. Climate models are mathematical representations of the climate system that require very powerful computers. They are based on the laws of physics and include information about the atmosphere, ocean, land and ice.

There are many different global climate models and they all represent the climate slightly differently. Scientists from the Pacific Climate Change Science and Adaptation Planning Program have evaluated 26 models from around the world and found that 24 best represent the climate of the Papua New Guinea region of the western tropical Pacific. These 24 models have been used to develop climate projections for Papua New Guinea.

The future climate will be determined by a combination of natural and human factors. As we do not know what the future holds, we need to consider a range of possible future conditions, or scenarios, in climate models. Greenhouse gas and aerosol emissions scenarios are used in climate modelling to provide projections that represent a range of possible futures. The Intergovernmental Panel on Climate Change (IPCC) has developed four greenhouse gas and emissions scenarios, called Representative Concentration Pathways (RCPs). These scenarios cover a broad range of possibilities. For example, the lowest scenario shows the likely outcome if global emissions are significantly reduced, while the highest scenario shows the impact of a pathway with no policy of reducing emissions.

The climate projections for Papua New Guinea are based on the four IPCC RCPs: very low emissions (RCP2.6), low emissions (RCP4.5), medium emissions (RCP6.0) and very high emissions (RCP8.5), for four 20-year time periods centred on 2030, 2050, 2070 and 2090, relative to a 20-year period centred on 1995 (Figure 8). Since individual models give different results, the projections are presented as a range of values. When interpreting projected changes in the mean climate in the Pacific, it is important to keep in mind that natural climate variability, such as the state of the El Niño-Southern Oscillation, strongly affects the climate from one year to the next.

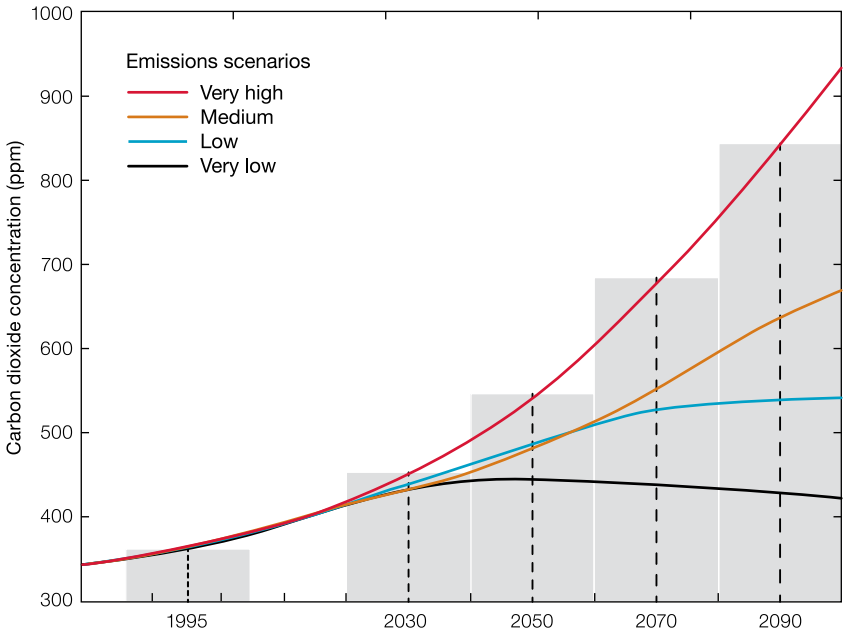


Figure 8: Carbon dioxide concentrations (parts per million, ppm) associated with the very low (RCP2.6), low (RCP4.5), medium (RCP6.0) and very high (RCP8.5) emissions scenarios for 20-year time periods (shaded) centred on 1995 (the reference period), 2030, 2050, 2070 and 2090.

This brochure contains a summary of climate projections for Papua New Guinea. For more information refer to the technical reports *Climate Change in the Pacific: Scientific Assessment and New Research (Volume 2)* and *Climate Variability, Extremes and Change in the Western Tropical Pacific: New Science and Updated Country Reports.*

These reports are available at **www.pacificclimatechangescience.org**.

Climate projections are also available through the web-based Pacific Climate Futures tool at **www.pacificclimatefutures.net**.

Changes in
Papua New Guinea's climate

> Temperatures have warmed and will continue to warm with more very hot days in the future.

> Rainfall shows no clear trend since 1945. Annual and seasonal rainfall is projected to increase by the end of the century, along with extreme rainfall events. Drought frequency is projected to decrease by the end of the century.

> By the end of this century projections suggest decreasing numbers of tropical cyclones.

> Sea level near Papua New Guinea has risen and will continue to rise throughout this century.

> Ocean acidification has been increasing in Papua New Guinea's waters. It will continue to increase and threaten coral reef ecosystems.

> December to March wave heights and periods are projected to decrease on the northern coasts by the end of the century.

This publication updates the original *Current and future climate of Papua New Guinea* brochure published in 2011.

The content of this brochure is the result of a collaborative effort between the Papua New Guinea National Weather Service and the Pacific-Australia Climate Change Science and Adaptation Planning (PACCSAP) Program – a component of the Australian Government's International Climate Change Adaptation Initiative. The information in this publication, and research conducted by PACCSAP, builds on the findings of the 2013 IPCC Fifth Assessment Report, and uses new emissions scenarios and climate models.

For more detailed information on the climate of Papua New Guinea and the Pacific see *Climate Variability, Extremes and Change in the Western Tropical Pacific: New Science and Updated Country Reports* (2014) and *Climate Change in the Pacific: Scientific Assessment and New Research. Volume 1: Regional Overview. Volume 2: Country Reports* (2011).

www.pacificclimatechangescience.org

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