

Pacific Climate Change Science Program



Current and future climate of **Palau**



- > Palau National Weather Service Office
- > Australian Bureau of Meteorology
- > Commonwealth Scientific and Industrial Research Organisation (CSIRO)



Australian Government

Palau's current climate

The average daily temperature in Palau is 82.4°F (28°C) throughout the year. Changes in the temperature from season to season are relatively small (1.5°F or 0.8°C) and strongly tied to changes in the surrounding ocean temperature. The main wet season is from May to October, while the driest months are February to April (Figure 1).

On average Palau receives more than about 8 inches (200 mm) rainfall every month. This is due to Palau's location on the edge of the Pacific Warm Pool and the year-long influence of the Intertropical Convergence Zone. This band of heavy rainfall is caused by air rising over warm water where winds converge, resulting in thunderstorm activity. It extends across the Pacific just north of the equator and is most intense in the Northern Hemisphere wet season (Figure 2).

Between June and August the West Pacific Monsoon brings heavy rainfall to Palau. The Monsoon 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 Northern Hemisphere winter.

Palau's climate is also influenced by the trade winds. From December to March the winds come from the

north-east. During April, the frequency of the trade winds decreases. In May, the winds are predominantly from south-east to north-east.

Palau'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. In Koror, El Niño events tend to bring dry seasons that are drier and cooler than normal, while La Niña events usually bring wetter than normal conditions.

During the strong 1997/98 El Niño event Palau experienced severe drought and the increase in sea surface temperatures caused widespread coral bleaching and impacted subsistence fishing.

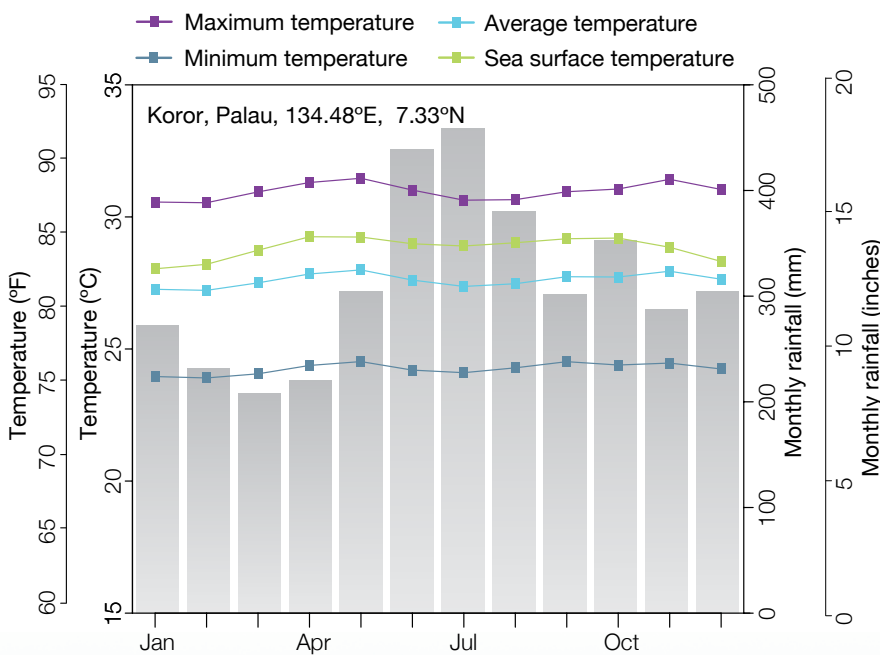


Figure 1: Seasonal rainfall and temperature at Koror.



Palau National Weather Service Office

Ngerimel Water Reservoir in Airai State during the 1998 drought.

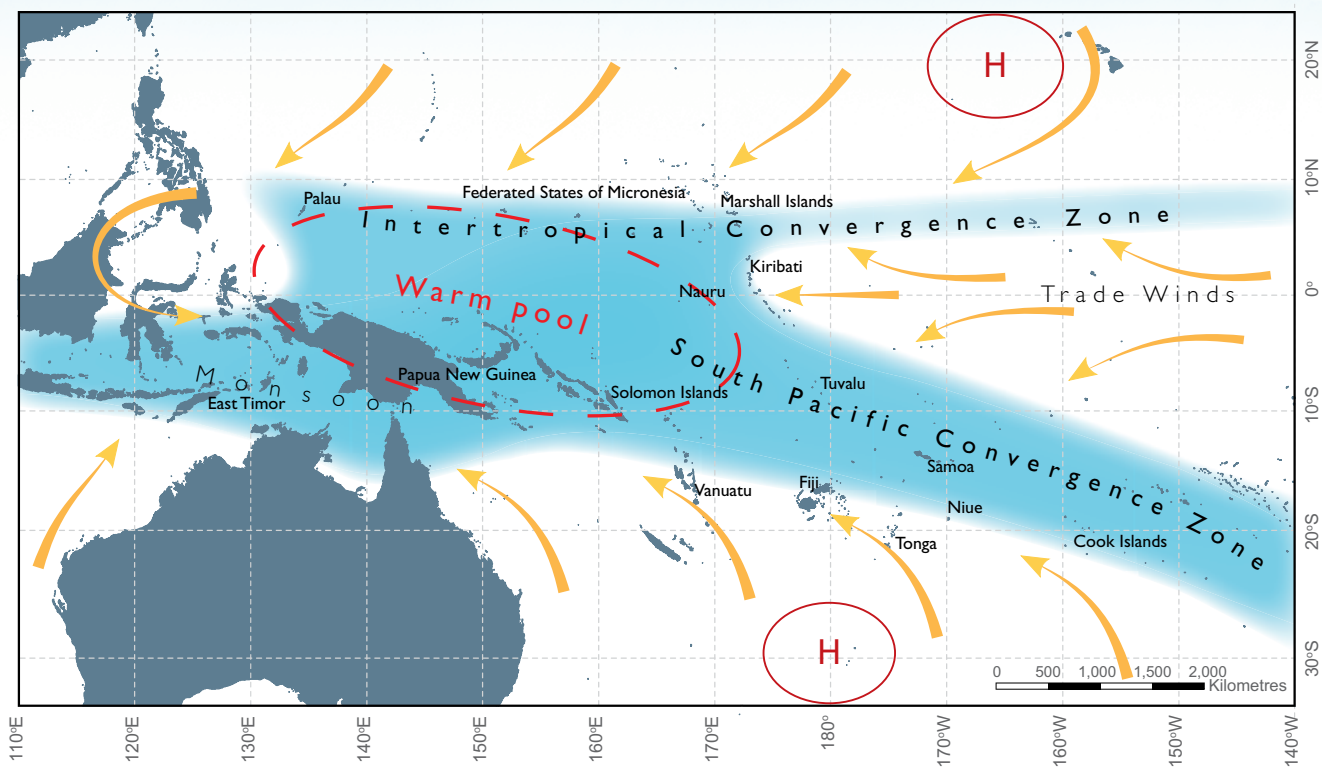


Figure 2: The average positions of the major climate features in November to April. The arrows show near surface winds, the blue shading represents the bands of rainfall convergence zones, the dashed oval shows the West Pacific Warm Pool and H represents typical positions of moving high pressure systems.



Rock Islands, Palau.

Typhoons

Palau is south of the main typhoon zone, so tropical cyclones (or typhoons as they are known in this region) are rare. However, Palau does experience heavy rains and strong winds from tropical storms and typhoons which pass to the north. Large typhoons or tropical storms that pass between Guam and Yap typically generate heavy swells that can damage reefs.

Palau's changing climate

Temperatures have increased

Annual and seasonal maximum and minimum temperatures have increased at Koror since 1953 (Figure 3). In Koror, maximum temperatures have increased at a rate of 0.2°F (0.11°C) per decade. These temperature increases are consistent with the global pattern of warming.

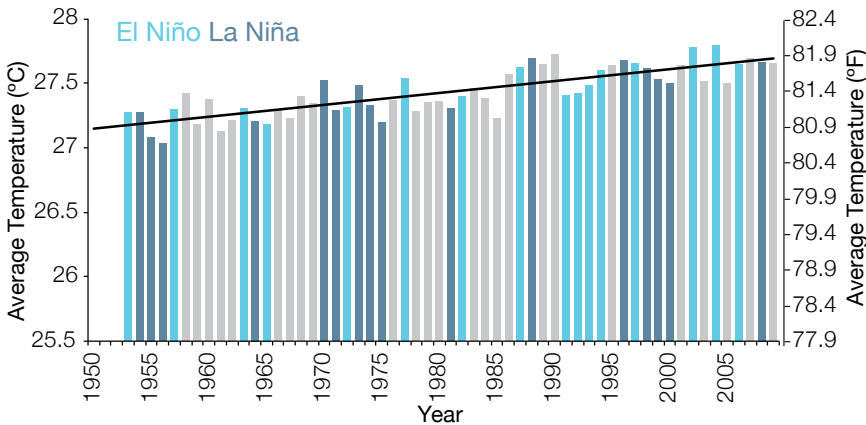


Figure 3: Annual average temperature for Koror. Light blue indicate El Niño years, dark blue bars indicate La Niña years and grey bars indicate neutral years.

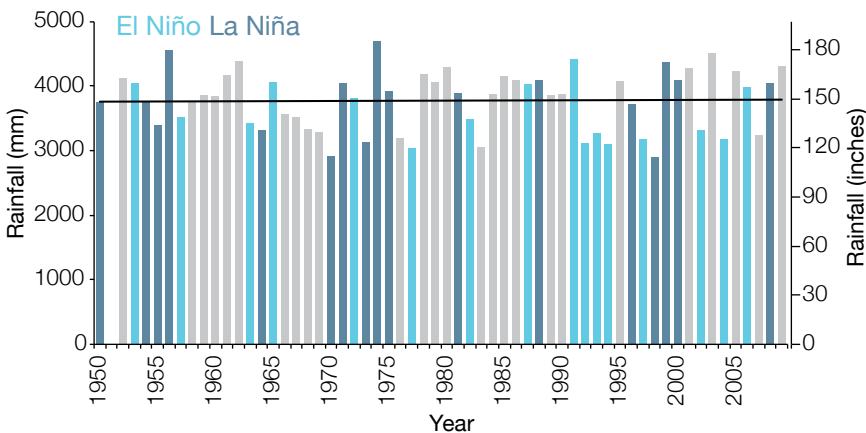


Figure 4: Annual rainfall for Koror. Light blue bars indicate El Niño years, dark blue bars indicate La Niña years and grey bars indicate neutral years.

Koror's rainfall unchanged

Data since 1950 for Koror show no clear trends in annual or seasonal rainfall (Figure 4). Over this period there has been substantial variation in rainfall from year to year.

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 in Palau by about 0.35 inches (9 mm) per year since 1993. This is larger than the global average of 0.11–0.14 inches (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. The natural variation in sea level can be seen in Figure 6 which includes the tide gauge record since 1969 and the satellite data since 1993.

Ocean acidification

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 Palau's waters.



Weather balloon launch, Palau National Weather Service.

Palau's future climate

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

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 Program (PCCSP) have evaluated 24 models from around the world and found that 18 best represent the climate of the western tropical Pacific region. These 18 models have been used to develop climate projections for Palau.

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. The

Intergovernmental Panel on Climate Change (IPCC) developed a series of plausible scenarios based on a set of assumptions about future population changes, economic development and technological advances. For example, the A1B (or medium) emissions scenario envisages global population peaking mid-century and declining thereafter, very rapid economic growth, and rapid introduction of new and more efficient technologies. Greenhouse gas and aerosol emissions scenarios are used in climate modelling to provide projections that represent a range of possible futures.

The climate projections for Palau are based on three IPCC emissions scenarios: low (B1), medium (A1B) and high (A2), for time periods around 2030, 2055 and 2090 (Figure 5). Since individual models give different results, the projections are presented as a range of values.

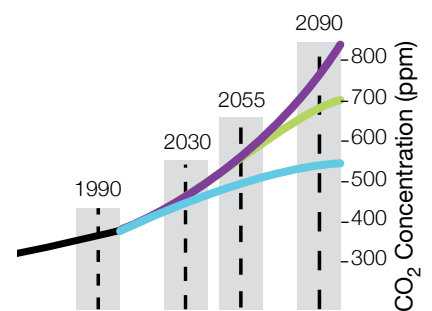


Figure 5: Carbon dioxide (CO₂) concentrations (parts per million, ppm) associated with three IPCC emissions scenarios: low emissions (B1 – blue), medium emissions (A1B – green) and high emissions (A2 – purple). The PCCSP has analysed climate model results for periods centred on 1990, 2030, 2055 and 2090 (shaded).



Sea defences Ngeruling, Babeldaob.



Coral reef, Rock Islands.

Palau's future climate

This is a summary of climate projections for Palau. For further information refer to Volume 2 of *Climate Change in the Pacific: Scientific Assessment and New Research*, and the web-based climate projections tool – *Pacific Climate Futures* (available at www.pacificclimatefutures.net).

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 Palau (Table 1). By 2030, under a high emissions scenario, this increase in temperature is projected to be in the range of 0.7–1.7°F (0.4–1.0°C).

More very hot days

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

Table 1: Projected annual average air temperature changes for Palau for three emissions scenarios and three time periods. Values represent 90% of the range of the models and changes are relative to the average of the period 1980–1999.

	2030		2055		2090	
	(°F)	(°C)	(°F)	(°C)	(°F)	(°C)
Low emissions scenario	0.4–1.8	0.2–1.0	1.1–2.7	0.6–1.6	1.5–3.9	0.9–2.1
Medium emissions scenario	0.7–2.1	0.4–1.2	1.7–3.5	1.0–2.0	2.6–5.6	1.5–3.1
High emissions scenario	0.7–1.7	0.4–1.0	1.7–3.3	1.0–1.8	3.6–6.2	2.0–3.4

Changing rainfall patterns

Rainfall during the wet season is projected to increase over the course of the 21st century. Wet season increases are consistent with the expected intensification of the West Pacific Monsoon and the Intertropical Convergence Zone. Projections for dry season rainfall also suggest a general increase. However, there is some uncertainty in the rainfall projections and not all models show consistent results. Droughts are projected to become less frequent throughout this century.

More extreme rainfall days

Model projections show extreme rainfall days are likely to occur more often.

Less frequent typhoons

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

Palau is in a region where projections tend to show a decrease in typhoon frequency by the late 21st century, and a decrease in the proportion of the more intense storms.



Landslide during Tropical Storm Utor in June 2001.

Palau National Weather Service Office

Sea level will continue to rise

Sea level is expected to continue to rise in Palau (Table 2 and Figure 6). By 2030, under a high emissions scenario, this rise in sea level is projected to be in the range of 1.6-5.9 inches (4-15 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 about sea level, 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.

Table 2: Sea-level rise projections for Palau for three emissions scenarios and three time periods. Values represent 90% of the range of the models and changes are relative to the average of the period 1980-1999.

	2030		2055		2090	
	(in)	(cm)	(in)	(cm)	(in)	(cm)
Low emissions scenario	1.6-5.1	4-13	3.1-10.2	8-26	5.9-18.1	15-46
Medium emissions scenario	1.2-5.9	3-15	3.5-12.2	9-31	7.1-23.2	18-59
High emissions scenario	1.6-5.9	4-15	4.3-11.4	11-29	8.3-24.0	21-61

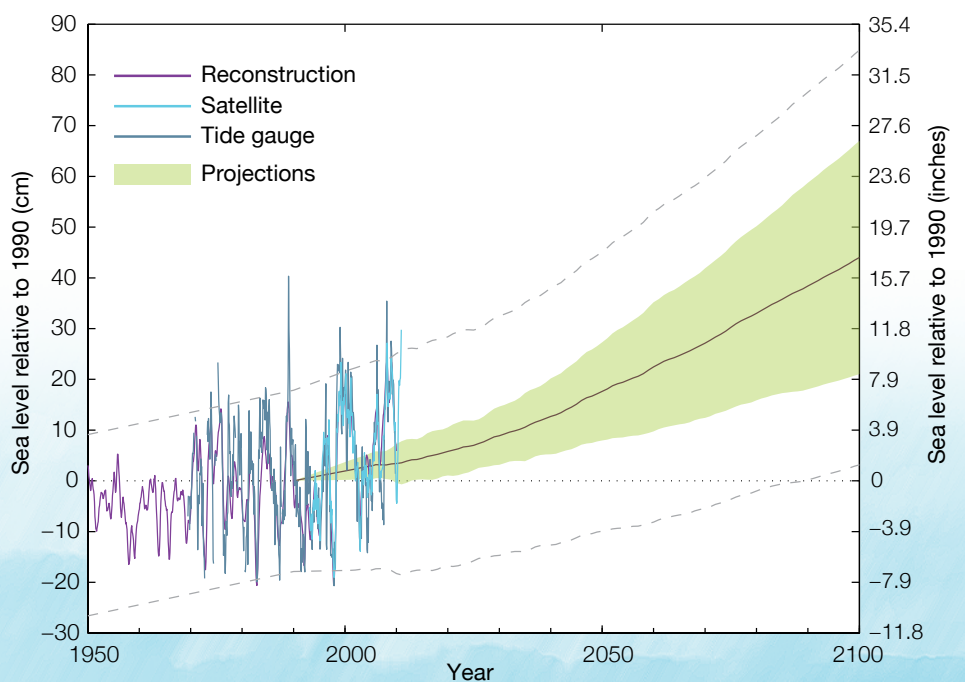
Ocean acidification will continue

Under all three emissions scenarios (low, medium and high) the acidity level of sea waters in the Palau region will continue to increase over the 21st century, with the greatest change under the 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.



Coral reef, Rock Islands.

Figure 6: Observed and projected relative sea-level change near Palau. The observed sea-level records are indicated in dark blue (relative tide-gauge observations) and light blue (the satellite record since 1993). Reconstructed estimates of sea level near Palau (since 1950) are shown in purple. The projections for the A1B (medium) emissions scenario (representing 90% of the range of models) are shown by the shaded green region from 1990 to 2100. The dashed lines are an estimate of 90% of the range of natural year-to-year variability in sea level.



Changes in Palau's climate

- > Temperatures have warmed and will continue to warm with more very hot days in the future.
- > Rainfall at Koror shows no clear trend since 1950. Wet season rainfall is generally projected to increase over this century with more extreme rainfall days and less droughts.
- > By the end of this century projections suggest decreasing numbers of typhoons and a possible shift towards less intense categories.
- > Sea level near Palau has risen and will continue to rise throughout this century.
- > Ocean acidification has been increasing in Palau's waters. It will continue to increase and threaten coral reef ecosystems.

The content of this brochure is the result of a collaborative effort between the Palau National Weather Service Office and the Pacific Climate Change Science Program – a component of the Australian Government's International Climate Change Adaptation Initiative. This information and research conducted by the Pacific Climate Change Science Program builds on the findings of the 2007 IPCC Fourth Assessment Report. For more detailed information on the climate of Palau and the Pacific see: *Climate Change in the Pacific: Scientific Assessment and New Research. Volume 1: Regional Overview. Volume 2: Country Reports.* Available from November 2011.

www.pacificclimatechangescience.org

Contact the Palau National Weather Service Office:

web: www.prh.noaa.gov/koror
phone: +680 488 1034

© Pacific Climate Change Science Program partners 2011.

