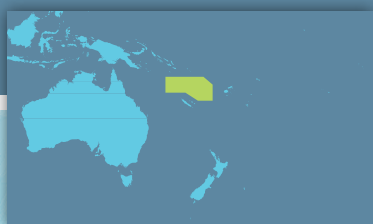


Pacific-Australia Climate Change Science and Adaptation Planning Program



Current and future climate of **Vanuatu**



- > Vanuatu Meteorology and Geo-hazard Department
- > Australian Bureau of Meteorology
- > Commonwealth Scientific and Industrial Research Organisation (CSIRO)



Australian Government

Vanuatu's current climate

Temperature

Across Vanuatu the annual average temperatures are between 23.5–27.5°C. Changes in the temperature from season to season are strongly tied to changes in the surrounding ocean temperature. The country has two distinct seasons – a warm wet season from November to April and a cooler dry season from May to October (Figure 1).

Rainfall

Rainfall in Vanuatu is affected by the South Pacific Convergence Zone. This band of heavy rainfall is caused by air rising over warm waters where winds converge, resulting in thunderstorm activity. It extends across the South Pacific Ocean from the Solomon Islands to east of the Cook Islands (Figure 2). During the wet season the South

Pacific Convergence Zone intensifies and moves further south, bringing higher rainfall to Vanuatu. Low pressure systems embedded in this band of heavy rainfall often become tropical cyclones during the cyclone season.

Mountains also play a role in the variations in rainfall across some islands. During the wet season, rainfall is particularly high on the windward (south-east) side of the mountain ranges of the bigger islands, and scarce on the leeward (north-west) sides, especially during the dry season.

Year-to-year variability

Vanuatu's climate varies considerably from year to year due to the El Niño-Southern Oscillation. This is a 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 both Port Vila and Aneityum El Niño events tend to bring drier conditions as well as a late start to the wet season and cooler than normal dry seasons. The opposite occurs during La Niña events.

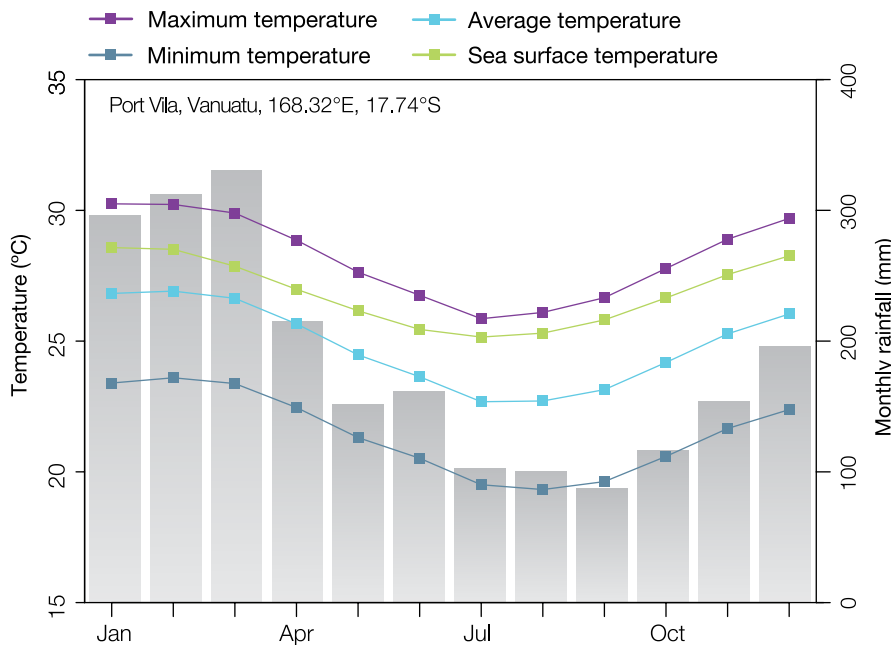


Figure 1: Seasonal rainfall and temperature at Port Vila.



Flooding in Teuma, Vanuatu.

Vanuatu Meteorology and Geo-hazard Department

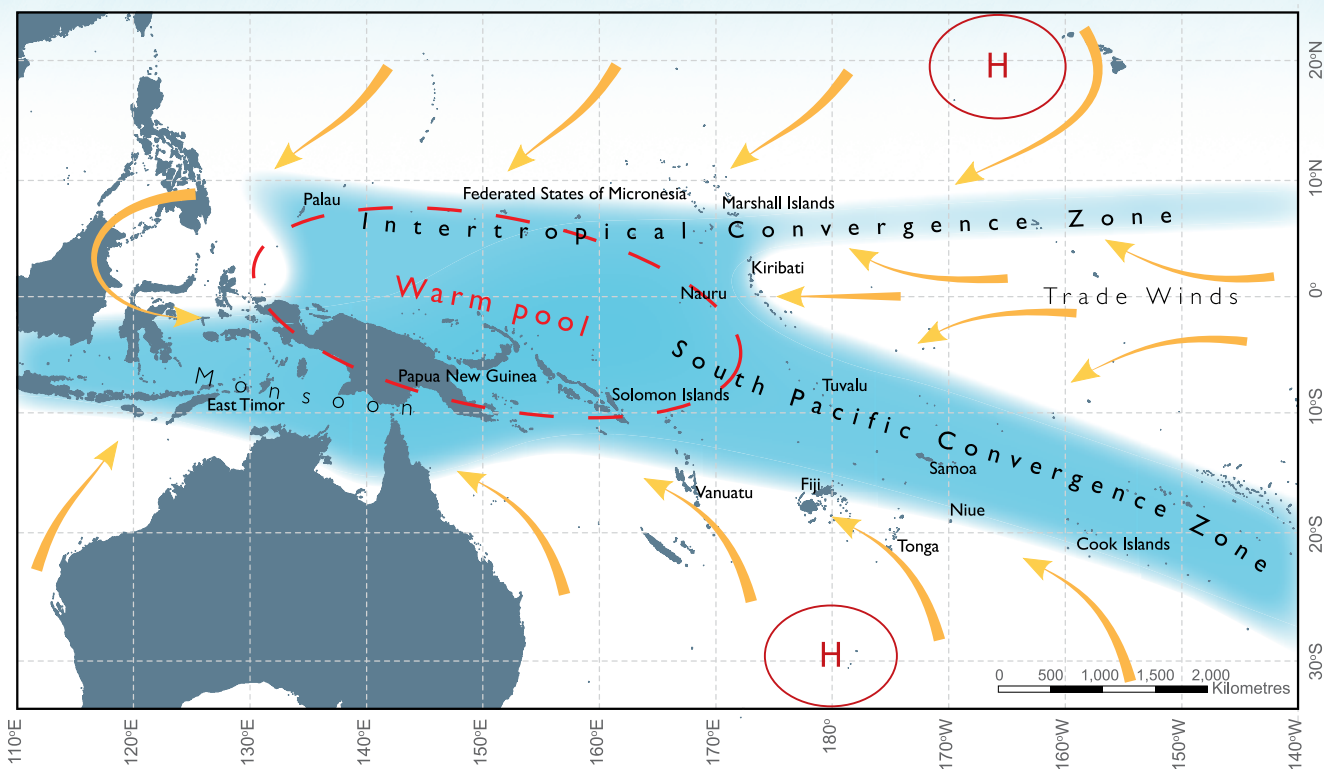


Figure 2: Average positions of the major climate features in November to April. The arrows show near surface winds, the blue shading represents the bands of rainfall convergence zones, the dashed oval shows the West Pacific Warm Pool and H represents typical positions of moving high pressure systems.

Tropical cyclones

Tropical cyclones tend to affect Vanuatu between November and April. In the 42-year period between the 1969 and 2010 seasons, 101 tropical cyclones developed or crossed into the Vanuatu Exclusive Economic Zone, an average of 24 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.

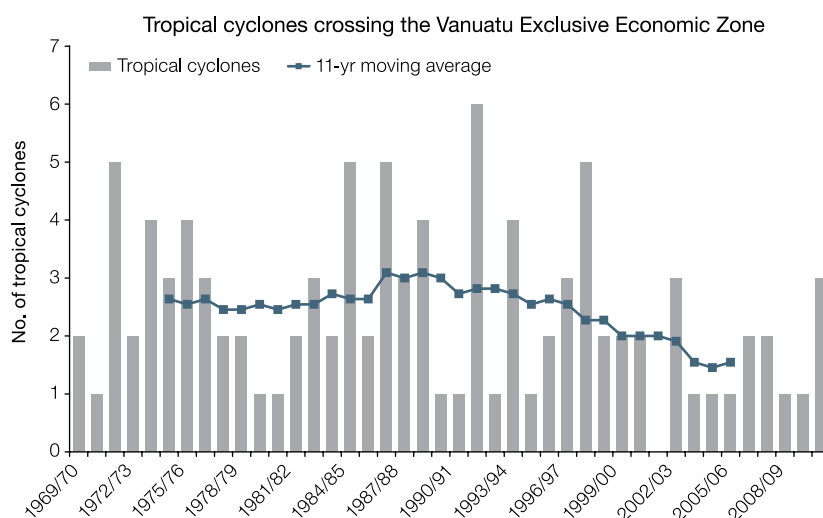


Figure 3: Number of tropical cyclones developing within and crossing the Vanuatu Exclusive Economic Zone per season. The 11-year moving average is in blue.

Wind-driven waves

Wind-waves around Vanuatu do not vary significantly throughout the year, having fairly constant wave heights and periods. Waves are influenced by the southern trade winds and movement of the South Pacific Convergence Zone. They display some variability from year to year with the El Niño–Southern Oscillation and Southern Annual Mode. Waves come mainly from the south-east, consisting of trade wind generated waves and a component of swell propagated from storm events in the Southern Ocean. Wave heights are typically greater in the south at Aneityum (Figure 4, bottom) than at Port Vila in the north (Figure 4, top).



Climate data management training, Vanuatu Meteorology and Geo-hazard Department.

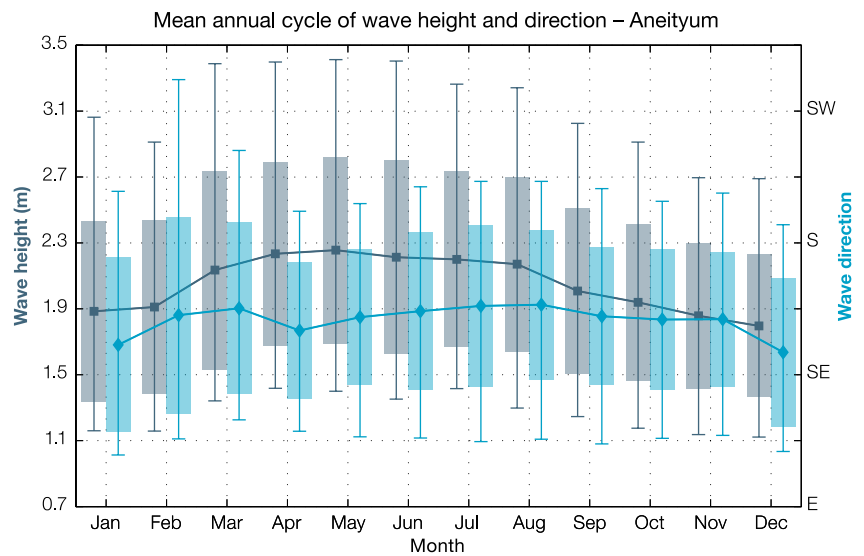
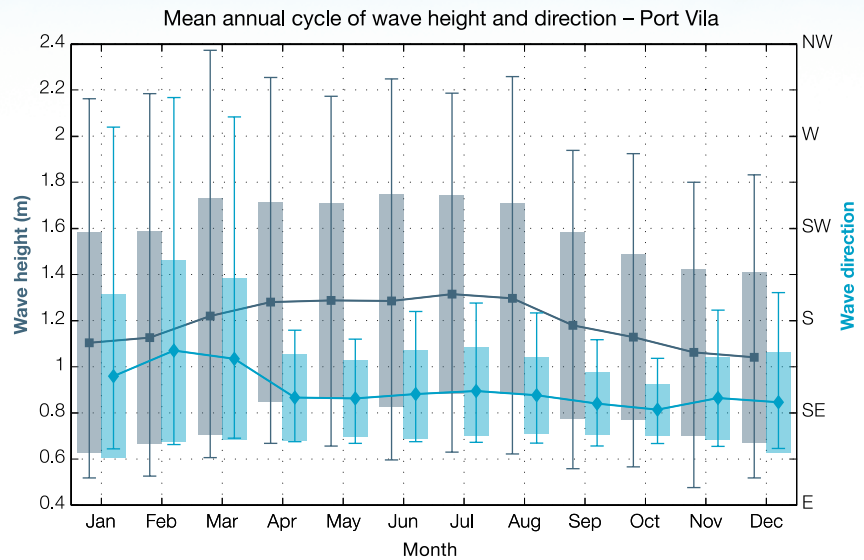


Figure 4: Annual cycle of wave height (grey) and wave direction (blue) at Port Vila (top) and Aneityum (bottom) based on data from 1979–2009. The shaded boxes represent one standard deviation around the monthly means, and the error bars indicate the 5–95% range, showing the year-to-year variability in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

Vanuatu's changing climate

Temperatures have increased

Annual and seasonal mean, maximum and minimum temperatures have increased at Bauerfield Airport since 1948 (Figure 5, top). Seasonal maximum and minimum temperatures at Aneityum have also increased over the same period (Figure 5, bottom). Annual and seasonal mean temperatures at Bauerfield Airport have increased at a rate of 0.14°C per decade. These temperature increases are consistent with the global pattern of warming.

Rainfall varies from year to year

There are no clear trends in seasonal or annual rainfall over Vanuatu since 1907 (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 Vanuatu by about 6 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 6 which includes the tide gauge record 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 Vanuatu's waters.



Eton Beach, West Efate.

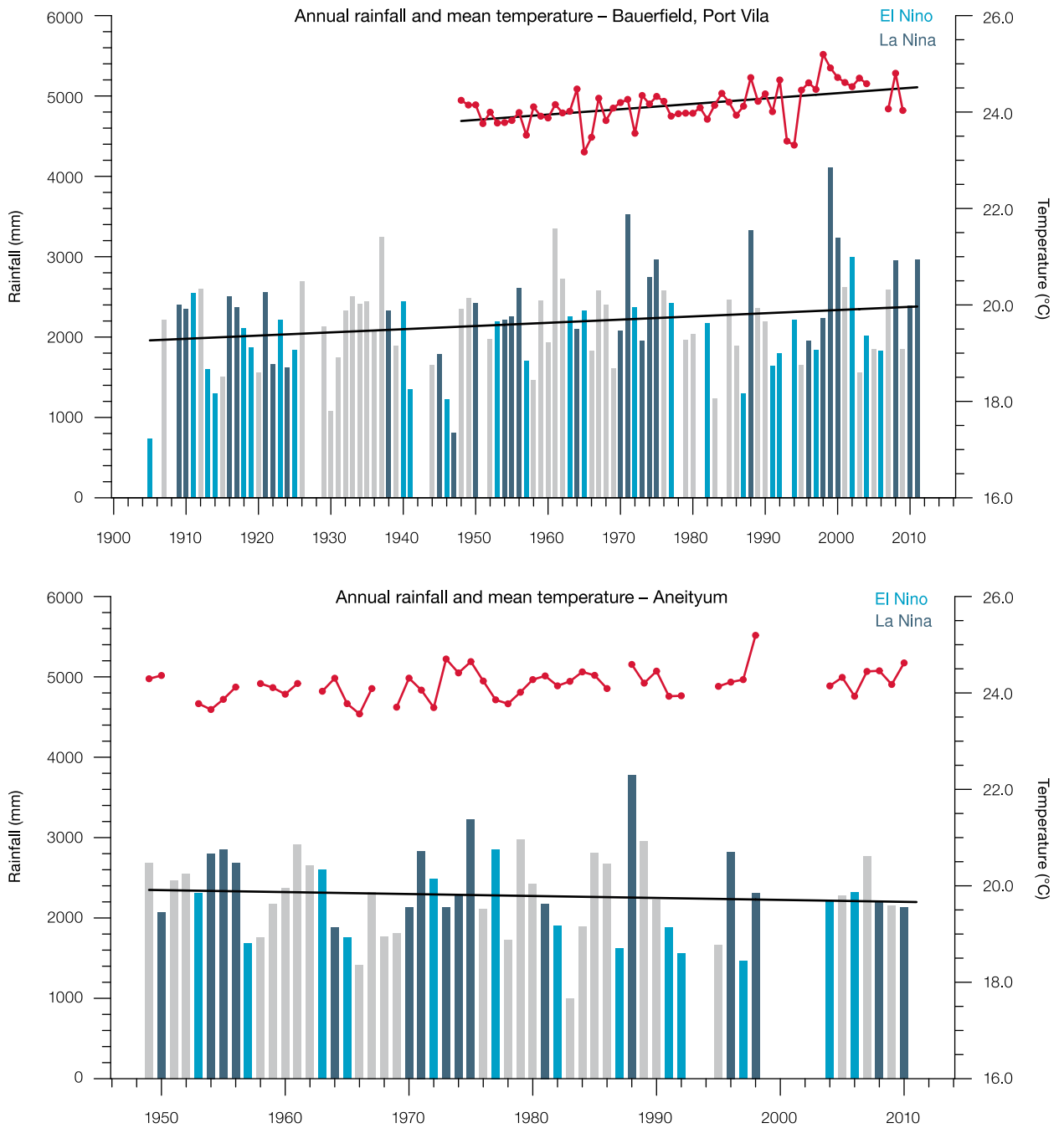


Figure 5: Annual average air temperature (red dots and line) and total rainfall (bars) at Bauerfield Airport, Port Vila (top) and Aneityum (bottom). Light blue, dark blue and grey bars indicate El Niño, La Niña and neutral years respectively. No bars indicate that data is not available. The solid black lines show the trends.

Vanuatu's future climate

Climate impacts almost all aspects of life in Vanuatu. Understanding the possible future climate of Vanuatu 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.



- Mean annual rainfall could increase or decrease with the model average indicating little change, with more extreme rain events.
- Incidence of drought is projected to decrease slightly under the high emission scenario and stay approximately the same under the other emissions scenarios.



- Sea level will continue to rise.
- Ocean acidification is expected to continue.
- The risk of coral bleaching is expected to increase.
- Wet season wave heights and periods are projected to decrease slightly, with no significant changes projected in the dry season.



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



Eton Beach, West Efate.

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 Vanuatu (Table 1). By 2030, under a very high emissions scenario, this increase in temperature is projected to be in the range of 0.5–1.0°C. Later in the century the range of the projected temperature increase under the different scenarios broadens.

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.

Changing rainfall patterns

There is uncertainty around rainfall projections for Vanuatu as model results are not consistent. Some models suggest a slight increase in wet season rainfall and a decrease in dry season rainfall, however the overall projection is for little change. Wet and dry years will still occur in response to natural variability. Drought frequency is expected to decrease slightly by the end of the century.

More extreme rainfall days

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

Table 1: Projected changes in the annual average surface air temperature for Vanuatu. 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	0.4–0.9	0.5–1.1	0.4–1.1	0.3–1.2
Low emissions scenario	0.3–1.0	0.6–1.5	0.7–1.8	0.8–2.0
Medium emissions scenario	0.4–1.0	0.6–1.3	1.0–1.9	1.2–2.5
Very high emissions scenario	0.5–1.0	0.8–2.0	1.5–2.9	1.9–4.0

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



Damage to a house from Tropical Cyclone Gene, January 2008.

Vanuatu Meteorology and Geo-hazard Department

Sea level will continue to rise

Sea level is expected to continue to rise in Vanuatu (Table 2 and Figure 6). By 2030, under a very high emissions scenario, this rise in sea level is projected to be in the range of 8–18 cm. The sea-level rise combined with natural year-to-year changes will increase 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 Vanuatu 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.

Wet season wave climate will change

Wet season wave heights and periods are projected to decrease slightly, with no significant changes projected in the dry season.

Table 2: Sea-level rise projections for Vanuatu. 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	8–19	15–31	20–45	25–59
Low emissions scenario	8–18	15–32	23–49	30–67
Medium emissions scenario	8–18	15–31	23–48	32–69
Very high emissions scenario	8–18	17–35	29–59	42–89

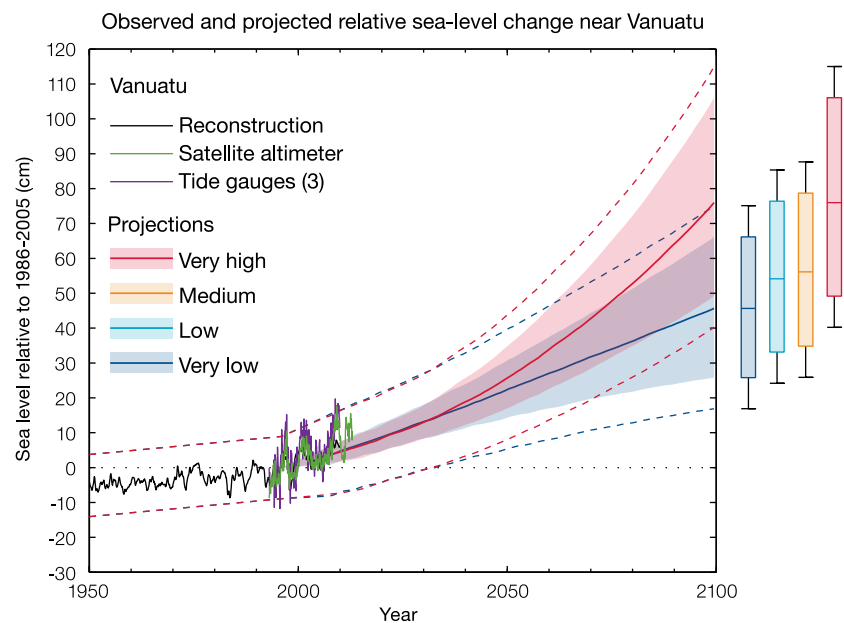


Figure 6: Tide-gauge records (purple) of relative sea level and the satellite record (green) since 1993. The reconstructed sea level data at Vanuatu (since 1950) is shown in black. Multi-model mean projections from 1995–2100 are given for the very high (red solid line) and very low emissions scenarios (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 Vanuatu region of the western tropical Pacific. These 24 models have been used to develop climate projections for Vanuatu.

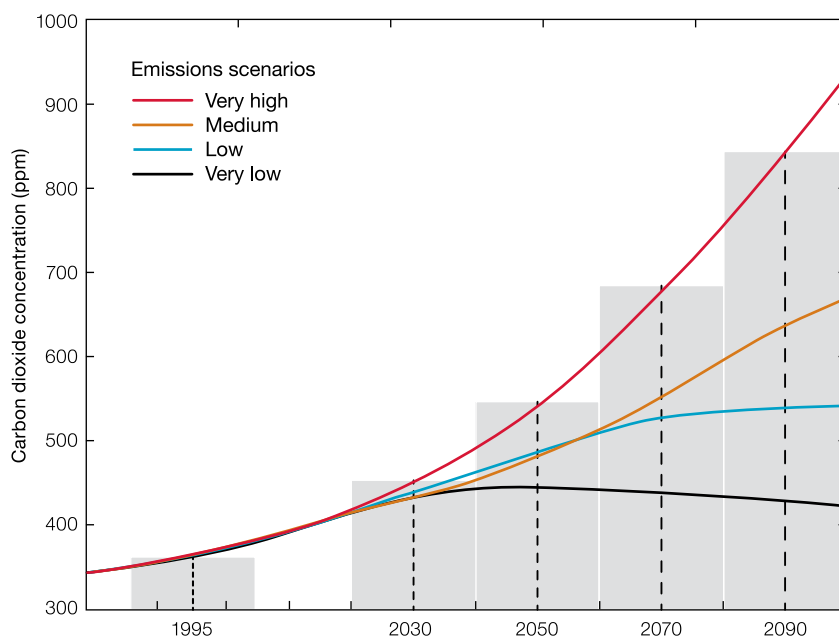
The future climate will be determined by a combination of natural and human factors. As we do not know what the future holds, we need to consider a range of possible future conditions, or scenarios, in climate models. Greenhouse gas and aerosol

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 Vanuatu 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 7). 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 7: 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 Vanuatu. 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 Vanuatu's climate

- > Temperatures have warmed and will continue to warm with more very hot days in the future.
- > Rainfall shows no clear trend since the 1907. Projections of annual rainfall are unclear, with models indicating little change. However, wet and dry years will still occur as a result of natural variability. Extreme rainfall events are projected to become more frequent and more intense. Drought frequency is projected to decrease by the end of the century.
- > By the end of this century projections suggest tropical cyclones will be less frequent.
- > Sea level near Vanuatu has risen and will continue to rise throughout this century.
- > Ocean acidification has been increasing in Vanuatu's waters. It will continue to increase and threaten coral reef ecosystems.
- > Wet season wave heights and periods are projected to decrease slightly by the end of the century.

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

The content of this brochure is the result of a collaborative effort between the Vanuatu Meteorology and Geo-hazard Department 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 Vanuatu 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).

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