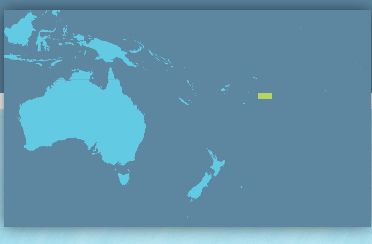
Pacific-Australia Climate Change Science and Adaptation Planning Program



Current and future climate of **Niue**

> Niue Department of Meteorology and Climate Change
> Australian Bureau of Meteorology
> Commonwealth Scientific and Industrial Research Organisation (CSIRO)

Australian Government

Niue's current climate

Temperature

The annual average temperature on Niue is around 24°C. Changes in the temperature from season to season are relatively small (4°C difference between the warmest and coolest months) and strongly tied to changes in the surrounding ocean temperature. The country has two distinct seasons – a warm wet season from November to May and a cooler dry season from June to October (Figure 1).

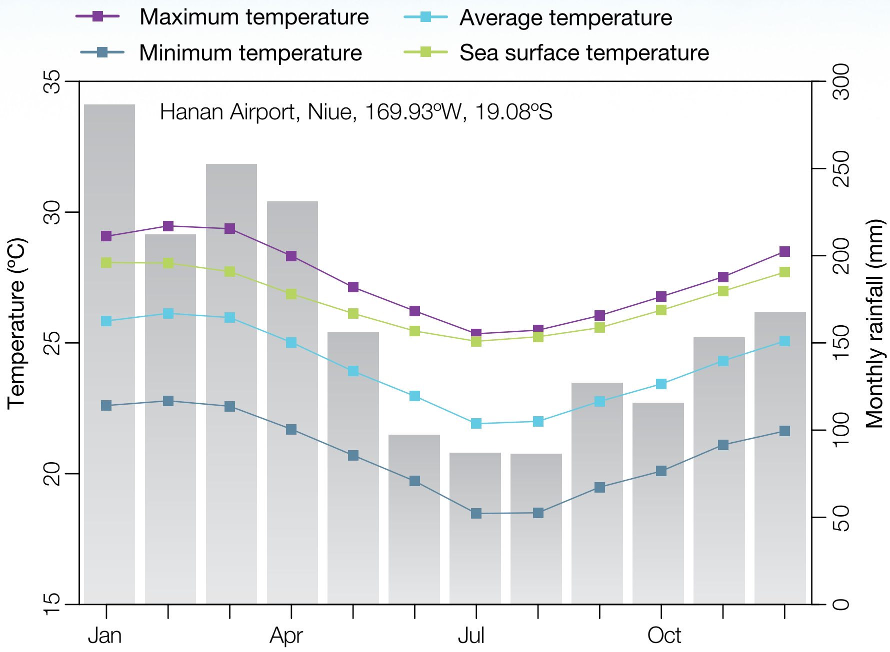


Figure 1: Seasonal rainfall and temperature at Hanan Airport.

Rainfall

Niue's wet season is affected by the movement of the South Pacific 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 South Pacific Ocean from the Solomon Islands to the Cook Islands (Figure 2).

Annual rainfall in the wettest years can be almost four times the rainfall in the driest years. Severe droughts have occurred in Niue, most recently in 1983, 1991 and 1998.

Niue's climate is also influenced by sub-tropical high pressure systems and the trade winds, which blow mainly from the south-east.

Year-to-year variability

Niue'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. El Niño events tend to bring drier than normal conditions to Niue, particularly in the wet season. They also bring cooler conditions during the dry season. La Niña events usually bring wetter conditions. The drier conditions in El Niño years are often caused by the South Pacific Convergence Zone moving away to the north-east. In La Niña years the South Pacific Convergence Zone moves south-east, bringing more rainfall.

Cliffs and reef flat at Tamakautoga.

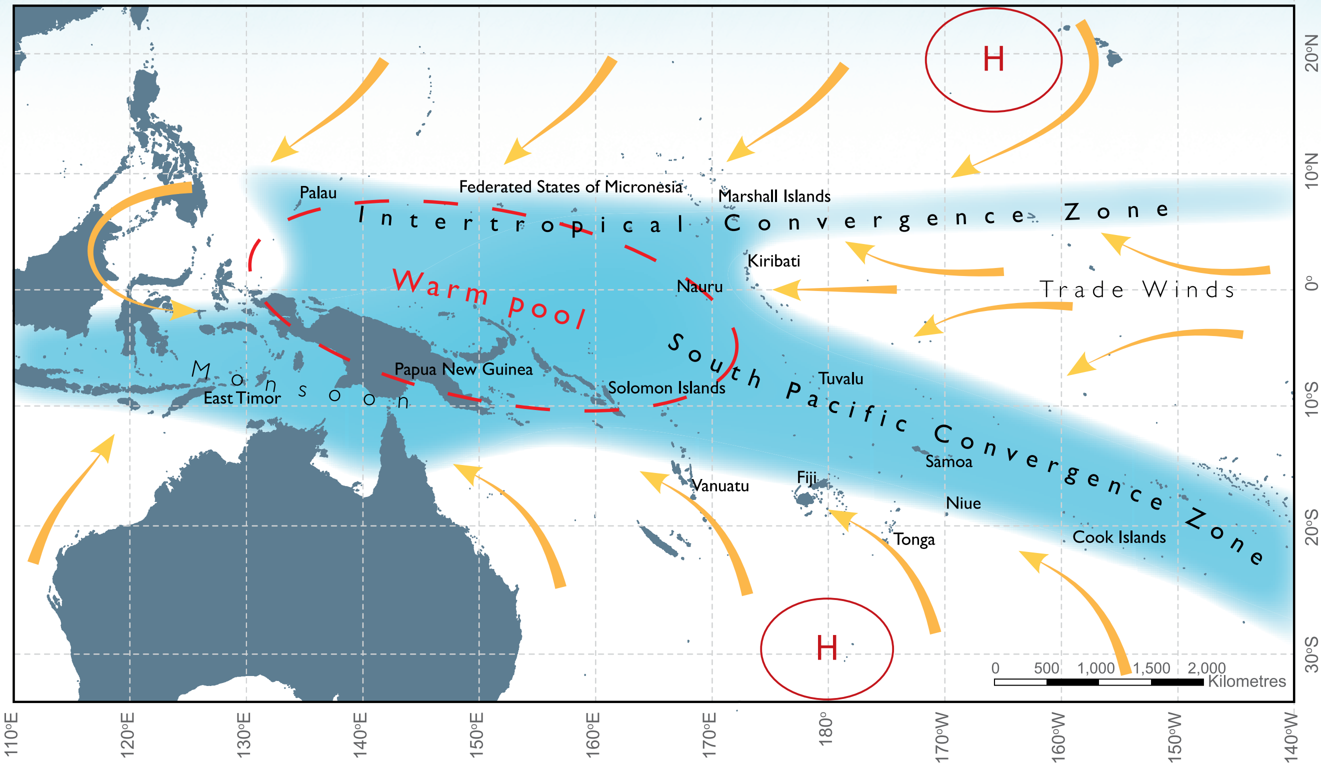


Figure 2: Average positions of the major climate features in November to April. The arrows show near surface winds, the blue shading represents the bands of rainfall convergence zones, the dashed oval shows the West Pacific Warm Pool and H represents typical positions of moving high pressure systems.

Wind-driven waves

Wind-waves at Niue have a nearly constant height, period and direction throughout the year, with a slight seasonal increase in wave height and period with southern trade winds during June to September (Figure 3). Waves are characterised by trade winds seasonally and the El Niño–Southern Oscillation and Southern Annular Mode from year to year.

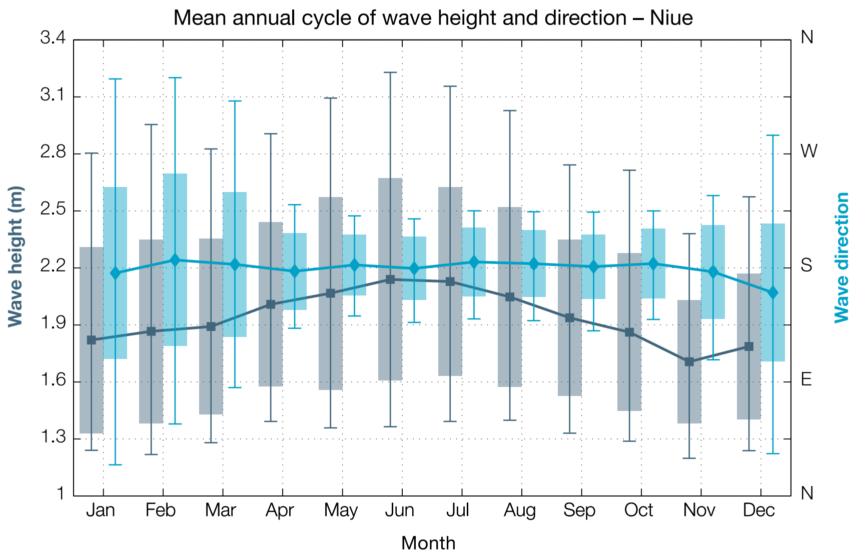


Figure 3: Annual cycle of wave height (grey) and wave direction (blue) at Niue based on data from 1979–2009. The shaded boxes represent one standard deviation around the monthly means, and the error bars indicate the 5–95% range, showing the year-to-year variability in wave climate. The direction from which the waves are travelling is shown (not the direction towards which they are travelling).

Tropical cyclones

Tropical cyclones affect Niue between November and April. In the 42-year period between the 1969 and 2010 seasons, 41 tropical cyclones developed or crossed into the Niue Exclusive Economic Zone, an average of 10 cyclones per decade (Figure 4). The number of cyclones varies widely from year to year, with none in some seasons but up to four in others. Over this period cyclones occurred in El Niño, La Nina and neutral years. Niue's economy suffered significantly from high winds, storm surge and intense rainfall associated with Tropical Cyclone Heta on 4 January 2004. In all, it caused over NZ$37.7 million damage, three times Niue's annual Gross Domestic Product.

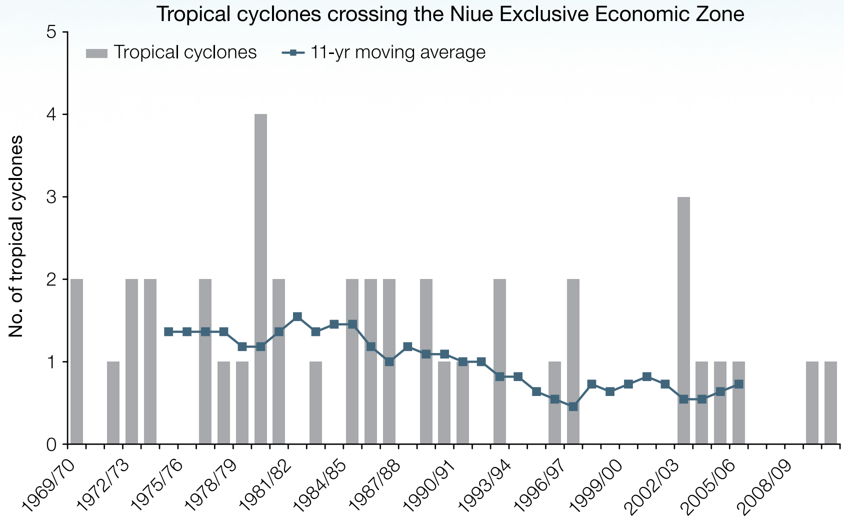


Figure 4: Number of tropical cyclones developing within and crossing the Niue Exclusive Economic Zone per season. The 11-year moving average is in blue.

House damaged by Tropical Cyclone Heta, January 2004.

Niue's changing climate

Temperatures have increased

Wet season maximum and minimum temperatures at Alofi-Hanan Airport have increased since 1940. Maximum wet season temperatures have increased at a rate of 0.06ºC per decade and minimum wet season temperatures have increased at 0.12ºC per decade.

There are no clear trends in annual or seasonal mean temperature (Figure 5). The number of warm days (Figure 6) and warm nights has increased. 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 Niue since 1905 (Figure 5). Over this period, there has been substantial variation in rainfall from year to year. There has also been little change in extreme daily rainfall since 1915.

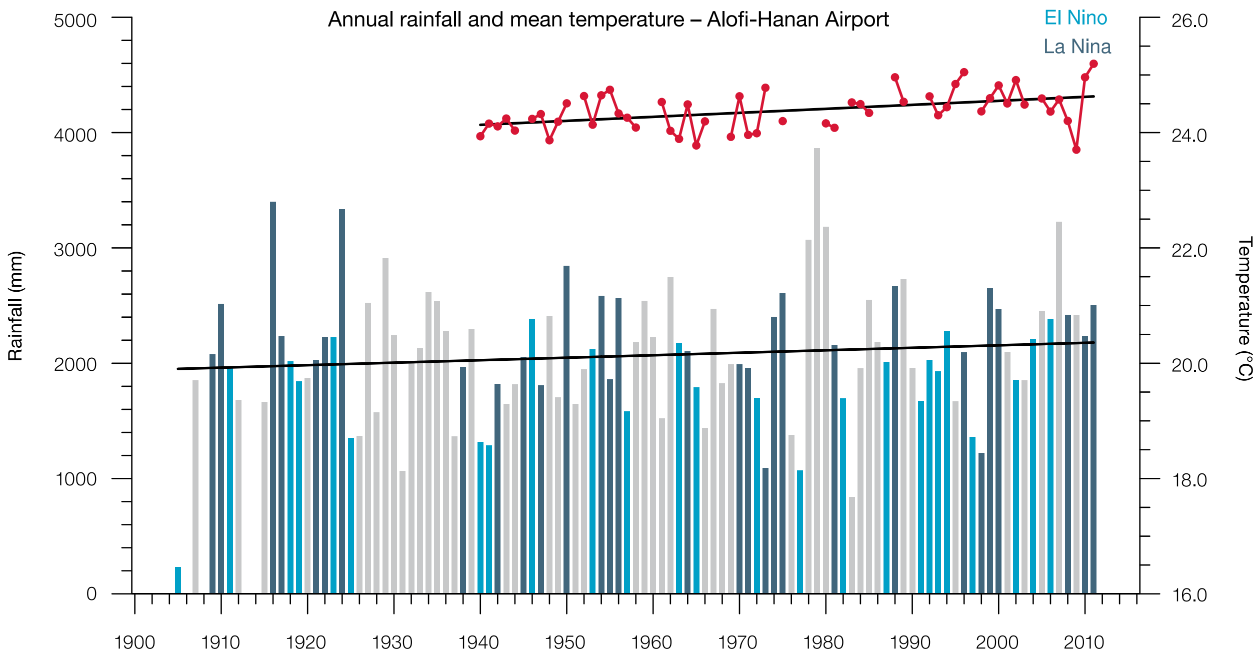


Figure 5: Annual average air temperature (red dots and line) and total rainfall (bars) at Alofi-Hanan Airport. Light blue, dark blue and grey bars indicate El Niño, La Niña and neutral years respectively. No bars indicate that data is not available. The solid black lines show the trends.

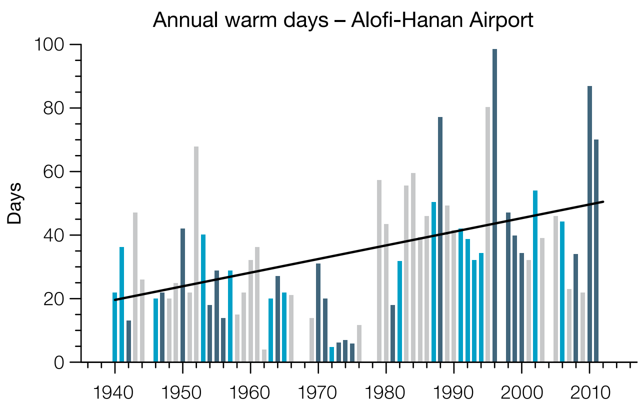


Figure 6: Annual total number of warm days at Alofi-Hanan Airport. Light blue, dark blue and grey bars indicate El Niño, La Niña and neutral years respectively. The solid black line shows the trend.

Sea level has risen

As ocean water warms it expands causing the sea level to rise. The melting of glaciers and ice sheets also contribute 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 Niue by about 5 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 from 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 record since 1974 and 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 Niue's waters.

Cliffs and reef flat near Alofi.

Niue's future climate

Climate impacts almost all aspects of life in Niue. Understanding the possible future climate of Niue 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.
- The proportion of time in drought is projected to decrease or stay approximately the same.

- Sea level will continue to rise.
- Ocean acidification is expected to continue.
- The risk of coral bleaching is expected to increase.
- Wave heights may decrease in December–March, with no significant changes projected in June–September waves.

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

Reef flat at Tamakautoga.

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 Niue (Table 1). By 2030, under a very high emissions scenario, this increase in temperature is projected to be in the range of 0.4–1.1°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 Niue as model results are not consistent. However, projections suggest a general increase in wet season rainfall over the course of the 21st century. Wet season increases are consistent with the expected intensification of the South Pacific Convergence Zone. The proportion of the time in drought is projected to stay the same or decrease.

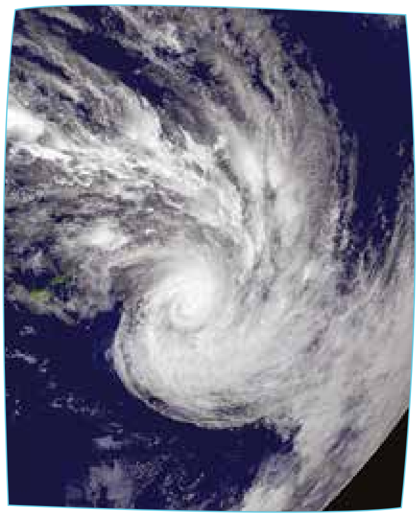
More extreme rainfall days

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



Category 5 Tropical Cyclone Heta hit Niue in January 2004 causing catastrophic damage. Satellite image originally processed by the Australian Bureau of Meteorology from the geostationary meteorological satellite GOES-9 operated by the National Oceanic and Atmospheric Administration for the Japan Meteorological Agency.

Table 1: Projected changes in the annual average surface air temperature for Niue. 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	0.3–0.9	0.3–1.0	0.3–1.0	0.2–1.1
Low emissions scenario	0.3–0.9	0.6–1.5	0.7–1.8	0.7–2.1
Medium emissions scenario	0.3–0.9	0.5–1.4	0.8–1.9	1.1–2.5
Very high emissions scenario	0.4–1.1	0.8–2.0	1.3–3.0	1.7–4.2

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Damage from Tropical Cyclone Heta, January 2004.

Sea level will continue to rise

Sea level is expected to continue to rise in Niue (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 8–18 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 Niue 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.

Wave climate will change

Wave heights may decrease in December to March, with no significant changes projected in June to September waves. Wave period may also decrease slightly in December to March.

Coast at Limu Pools.

Table 2: Sea-level rise projections for Niue. Values represent 90% of the range of the models and are relative to the period 1986–2005.

	2030 (cm)	2050 (cm)	2070 (cm)	2090 (cm)
Very low emissions scenario	7–17	13–30	18–43	23–57
Low emissions scenario	8–17	14–31	22–47	29–66
Medium emissions scenario	7–17	13–30	21–47	29–67
Very high emissions scenario	8–18	16–34	27–57	41–87

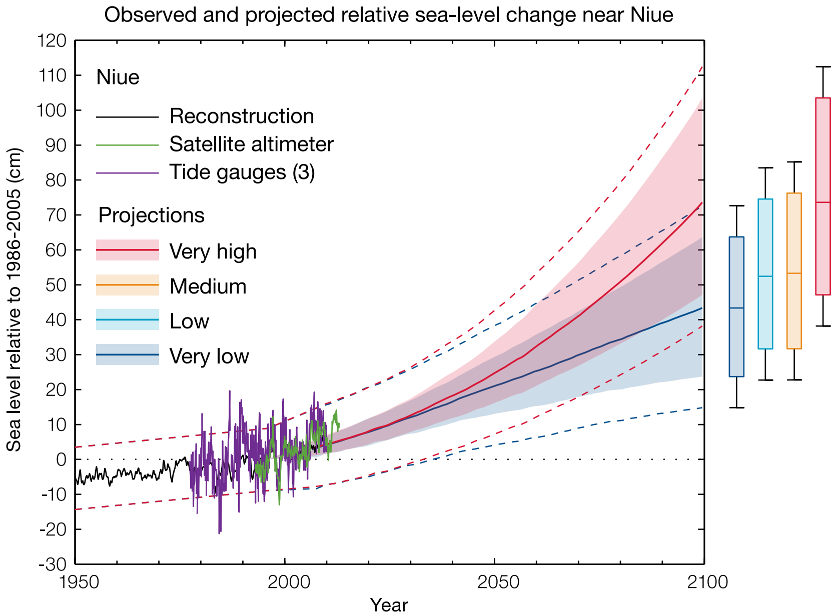

Figure 7: Tide-gauge records of relative sea level (since 1974) are indicated in purple, and the satellite record (since 1993) in green. The reconstructed sea level data at Niue (since 1950) is shown in black. Multi-model mean projections from 1995–2100 are given for the very high (red solid line) and 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 Niue region of the western tropical Pacific. These 24 models have been used to develop climate projections for Niue.

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 gobal emissions are significantly reduced, while the highest scenario shows the impact of a pathway with no policy of reducing emissions.

The climate projections for Niue 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.

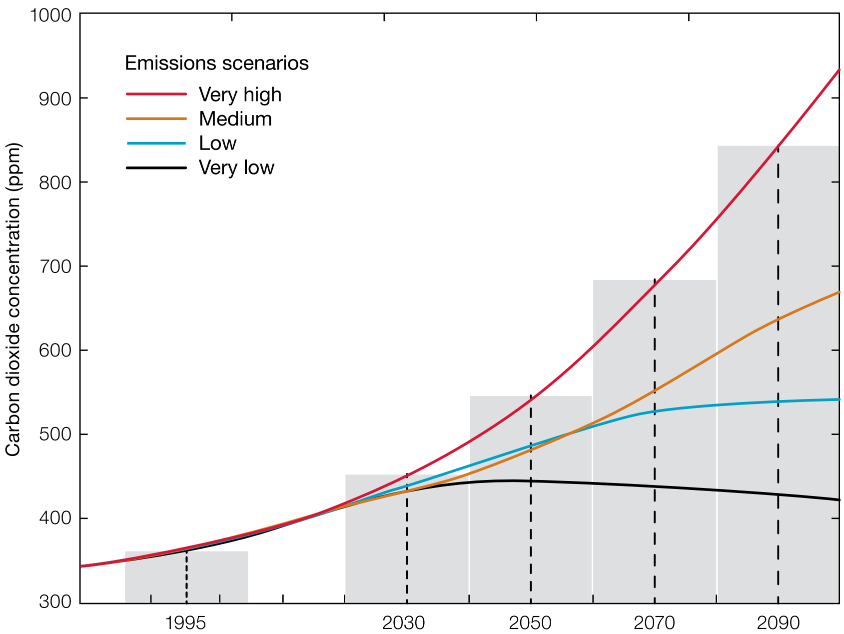

Figure 8: Carbon dioxide concentrations (parts per million, ppm) associated with the very low (RCP2.6), low (RCP4.5), medium (RCP6.0) and very high (RCP8.5) emissions scenarios for 20-year time periods (shaded) centred on 1995 (the reference period), 2030, 2050, 2070 and 2090.

This brochure contains a summary of climate projections for Niue. 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 Niue's climate

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

> Rainfall data since 1905 show no clear trends. Wet season rainfall is generally projected to increase over this century with more extreme rainfall days and fewer droughts.

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

> Sea level near Niue has risen and will continue to rise throughout this century.

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

> Wave heights may decrease in December to March.

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

The content of this brochure is the result of a collaborative effort between the Niue Department of Meteorology and Climate Change 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 Niue 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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