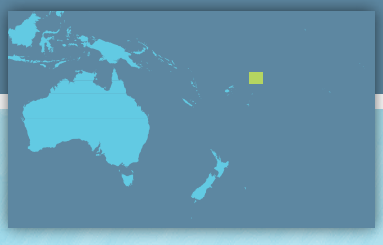
Pacific-Australia Climate Change Science and Adaptation Planning Program



Current and future climate of **Samoa**

> Samoa Meteorology Division, Ministry of Natural Resources and Environment
> Australian Bureau of Meteorology
> Commonwealth Scientific and Industrial Research Organisation (CSIRO)

Australian Government

Samoa's current climate

Temperature

Temperatures in Samoa are generally consistent throughout the year, with only very small seasonal differences (Figure 1). Average temperatures are coolest in July, when the cool, dry south-east trade winds are strongest. The warmest month is March. The country has two distinct seasons – a wet season from November to April and a dry season from May to October. On average 75% of Samoa's total annual rainfall occurs in the wet season.

Rainfall

Samoa's rainfall is greatly influenced by the position and strength 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 and lies between Samoa and Fiji during the wet season (Figure 2).

Samoa's mountains have a significant effect on rainfall distribution. Wetter areas are located in the south-east and relatively sheltered, drier areas in the north-west.

Year-to-year variability

Samoa'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 Samoa, El Niño events tend to bring wet seasons that are drier than normal, while La Niña events usually bring wetter and cooler than normal conditions.

Checking the automatic weather station, Samoa Meteorology Division.

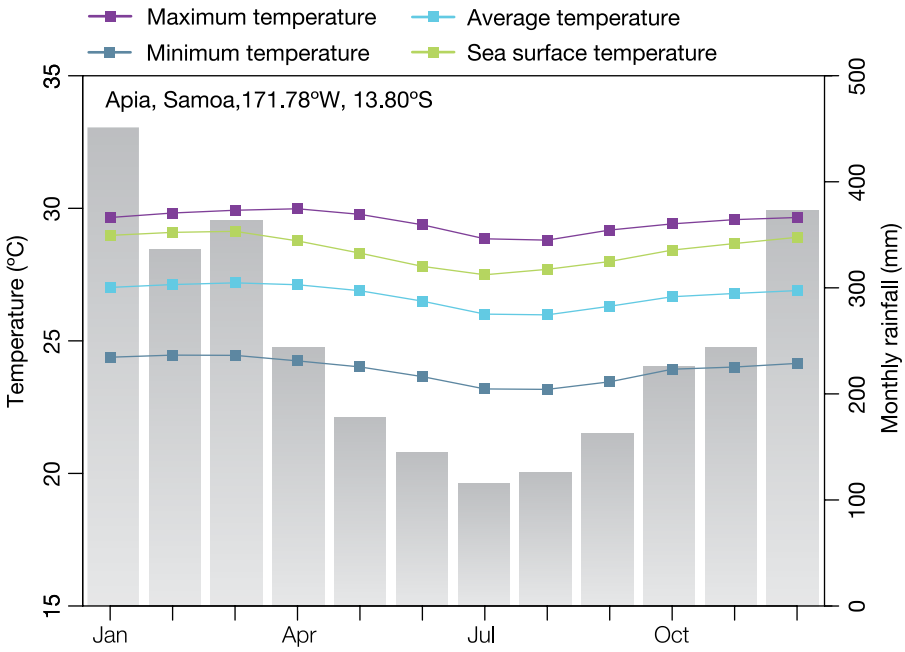


Figure 1: Seasonal rainfall and temperature at Apia.

Taking temperature observations, Samoa Meteorology Division.

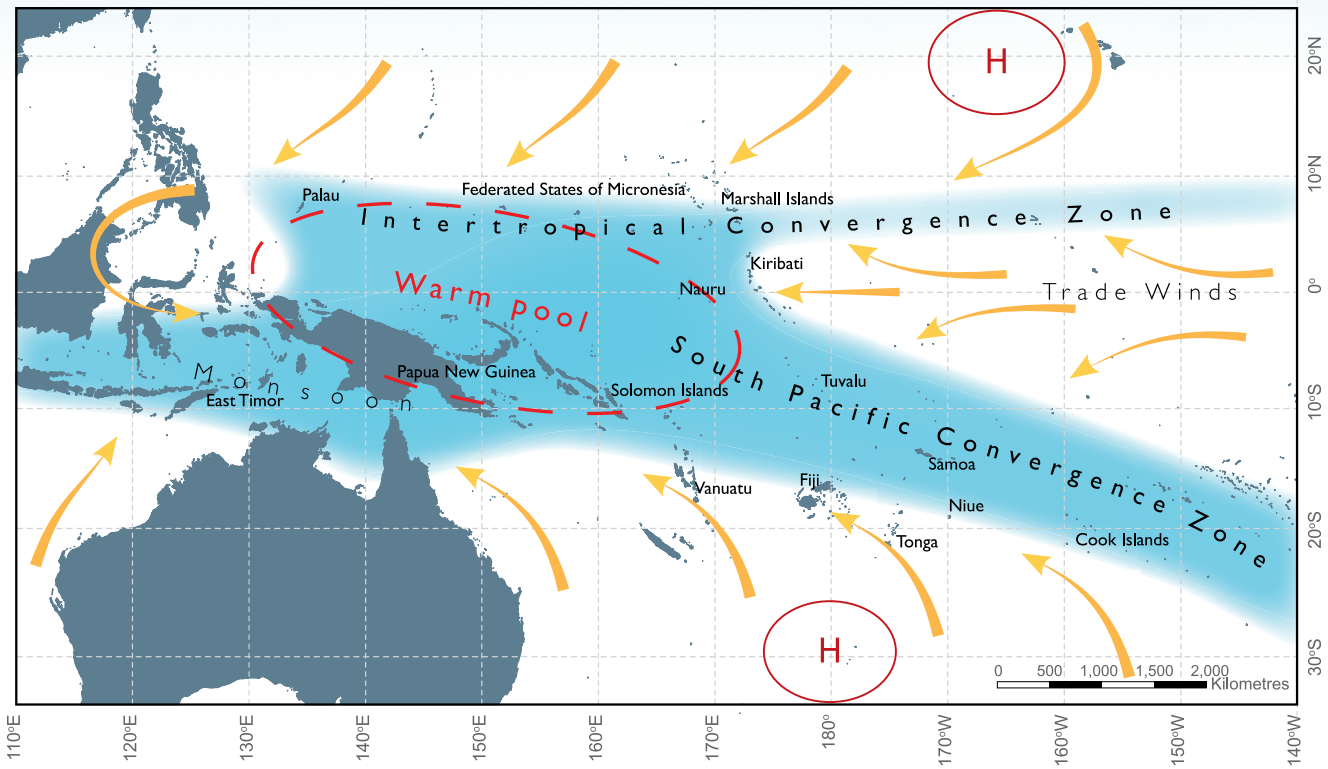


Figure 2: Average positions of the major climate features from November to April. The arrows show near surface winds, the blue shading represents the bands of rainfall convergence zones, the dashed oval shows the West Pacific Warm Pool and H represents typical positions of moving high pressure systems.

Tropical cyclones

Tropical cyclones tend to affect Samoa between November and April. In the 41-year period between 1969 and 2009 seasons, 26 tropical cyclones developed in or crossed into the Samoa Exclusive Economic Zone, an average of six cyclones per decade (Figure 3). The number of cyclones varies greatly from year to year, with none in some seasons but up to three in others. Over this period, cyclones occurred in El Niño, La Niña and neutral years.

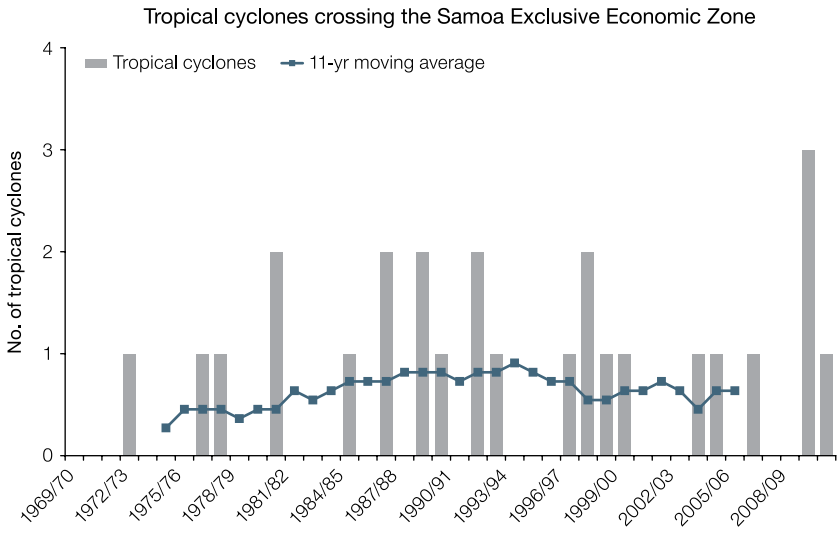


Figure 3: Number of tropical cyclones developing within and crossing the Samoa Exclusive Economic Zone per season. The 11-year moving average is in blue.

Wind-driven waves

Variability of wind-waves at Samoa is characterised by trade winds and location of the South Pacific Convergence Zone seasonally, and the El Niño–Southern Oscillation and the Southern Annular Mode from year to year. There is little variation in wave height throughout the year. Waves from southerly directions due to south-easterly trade winds or Southern Ocean storm swell are blocked on the north coast near Apia (Figure 4). Waves at this location are directed predominantly from the east to north-east during June to September have smaller heights and shorter wave periods than December to March. From December to March waves are directed mostly from the north-east and north.

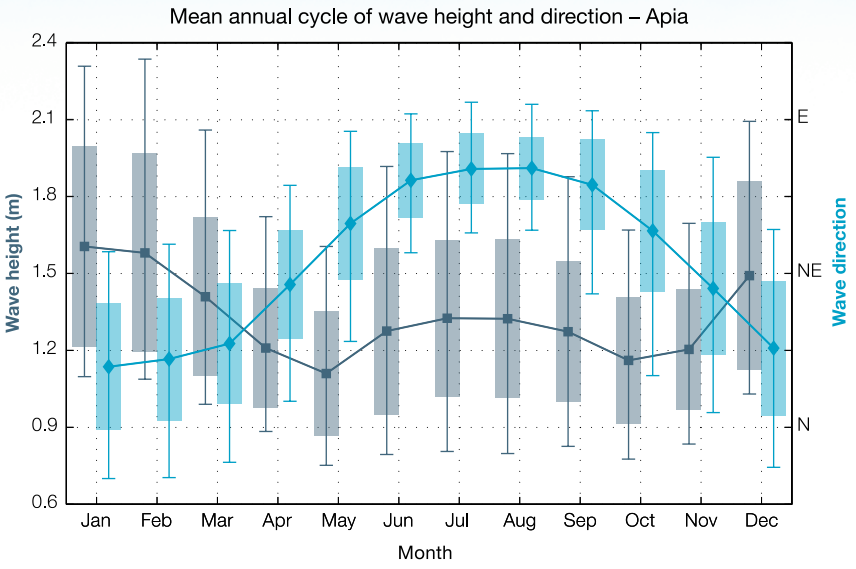


Figure 4: Annual cycle of wave height (grey) and wave direction (blue) at Apia based on data from 1979–2009. The shaded boxes represent one standard deviation around the monthly means, and the error bars indicate the 5–95% range, showing the year-to-year variability in wave climate. The direction from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

Floods and droughts

Droughts and flooding associated with the El Niño-Southern Oscillation have impacted the socio-economic livelihoods of the Samoan people on many occasions in the past.

Flooding associated with tropical cyclones and strong La Niña events has caused widespread damage in Samoa in the past, particularly in Apia. In early 2008 and 2011, for example, transportation infrastructure and water supplies were severely damaged.

Drought impacts are most notable in the north-west regions of the main islands and at times are associated with forest fires. In Asau, there were major forest fires during the dry seasons of 1982-83, 1997-98, 2001-02 and 2002-03.

Sunny Seuseu, Meteorology Division, Ministry of Natural Resources and Environment

2008 flood, Apia.

Samoa's changing climate

Temperatures are unchanged

There are no clear trends in the temperature records at Apia since 1957 (Figure 5). Over the same period the annual number of cool days has decreased, however trends in other temperature extremes are unclear. Despite missing data it is probable that over the past half-century there has been a warming air temperature trend at Apia in line with regional and global trends, partly due to the warming ocean temperatures around Samoa.

Rainfall has increased

Annual and dry season rainfall has increased at Apia since 1890 (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 across Samoa by about 4 mm per year since 1993. This is slightly 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 since 1950 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 Samoa's waters.

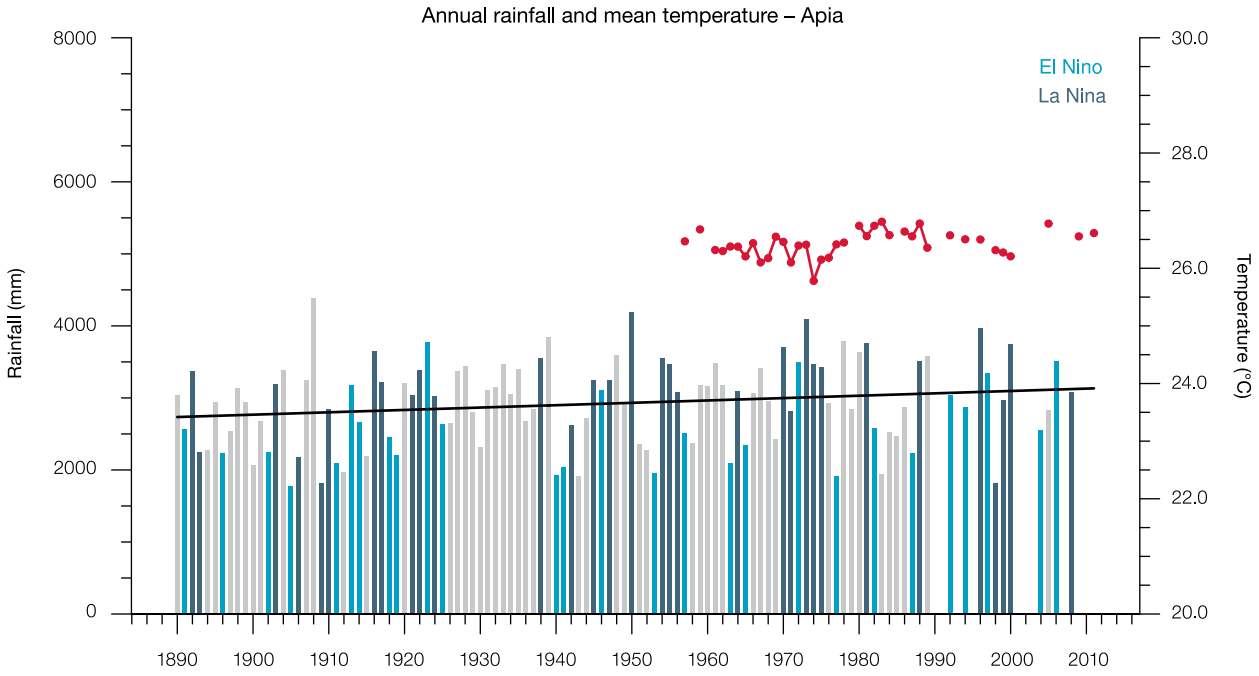


Figure 5: Annual average air temperature (red dots and line) and total rainfall (bars) at Apia. Light blue, dark blue and grey bars indicate El Niño, La Niña and neutral years respectively. No bars indicate that data is not available. The solid black line shows the trend.

Samoa's future climate

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

At a glance

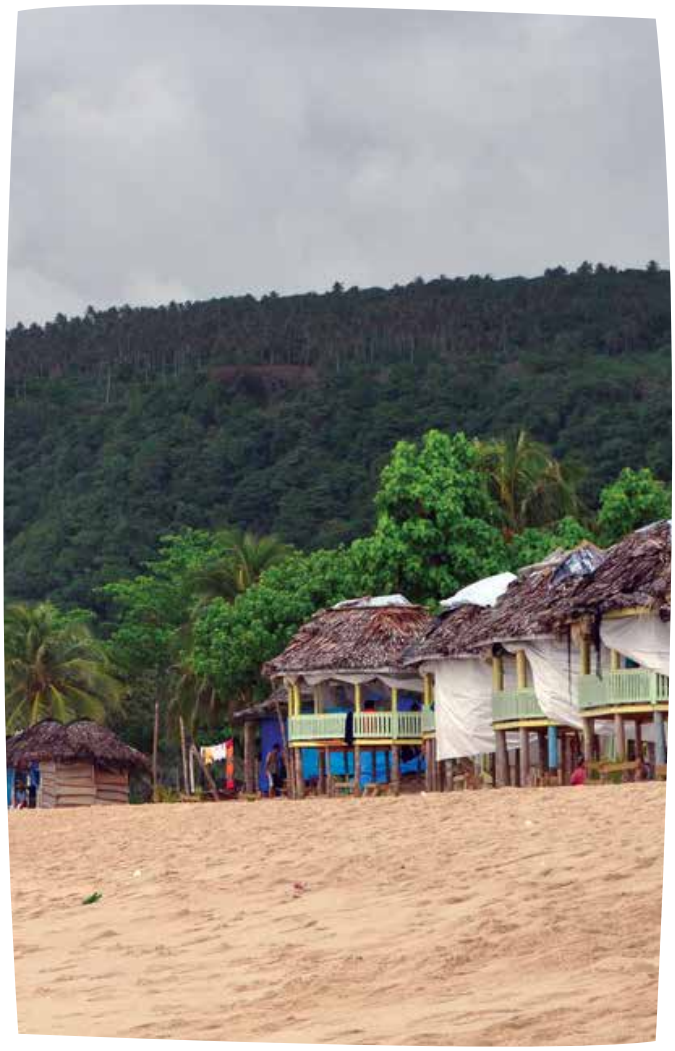
- El Niño and La Niña events will continue to occur in the future, but there is little consensus on whether these events will change in intensity or frequency.

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

- Little change in mean annual rainfall is projected, with more extreme rain events.
- Incidence of drought is projected to decline 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.
- A reduction of wave period in December–March is projected with no change in wave height, while no change is projected in June–September.

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



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 Samoa (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 Samoa. 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	0.4–1.0	0.7–1.4	0.9–1.8	0.9–2.1
Medium emissions scenario	0.4–0.9	0.6–1.4	0.9–1.9	1.1–2.5
Very high emissions scenario	0.5–1.1	1.0–1.9	1.5–2.9	2.0–4.0

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 Samoa as model results are not consistent. However, projections generally suggest little change over the course of the 21st century. Increased dry season rainfall is possible due to the projected intensification of the South Pacific Convergence Zone. Wet and dry years will still occur in response to natural variability. Drought projections are inconsistent for Samoa. 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 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 Samoa region, projections tend to show a decrease in the frequency of tropical cyclones by the late 21st century.

Taking rainfall observations, Samoa Meteorology Division.

Thunderstorm activity, Upolu.

Sea level will continue to rise

Sea level is expected to continue to rise in Samoa (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 7–17 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 Samoa 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 period in December to March is projected to decrease, with no change in wave height. No change is projected in June to September.

Taufua Beach, Upolu.

Tabl2: Sea-level rise projections for Samoa. 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	13–30	18–44	23–59
Low emissions scenario	7–17	13–30	21–47	28–66
Medium emissions scenario	7–17	13–29	21–46	29–67
Very high emissions scenario	7–17	16–33	27–56	40–87

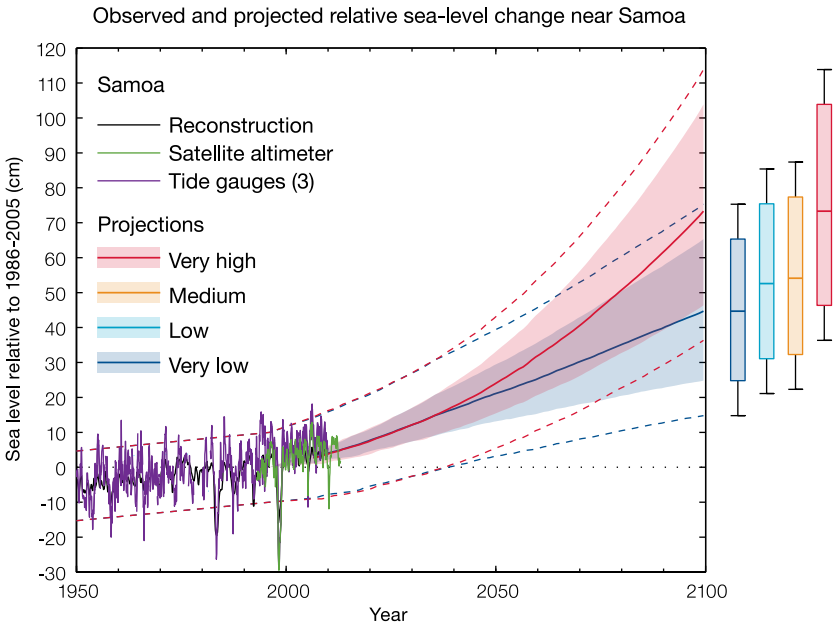


Figure 6: Tide-gauge records of relative sea level (since 1950) are indicated in purple, and the satellite record (since 1993) in green. The reconstructed sea level data at Samoa (since 1950) is shown in black. Multi-model mean projections from 1995–2100 are given for the very high (red solid line) and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

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 Samoa 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.

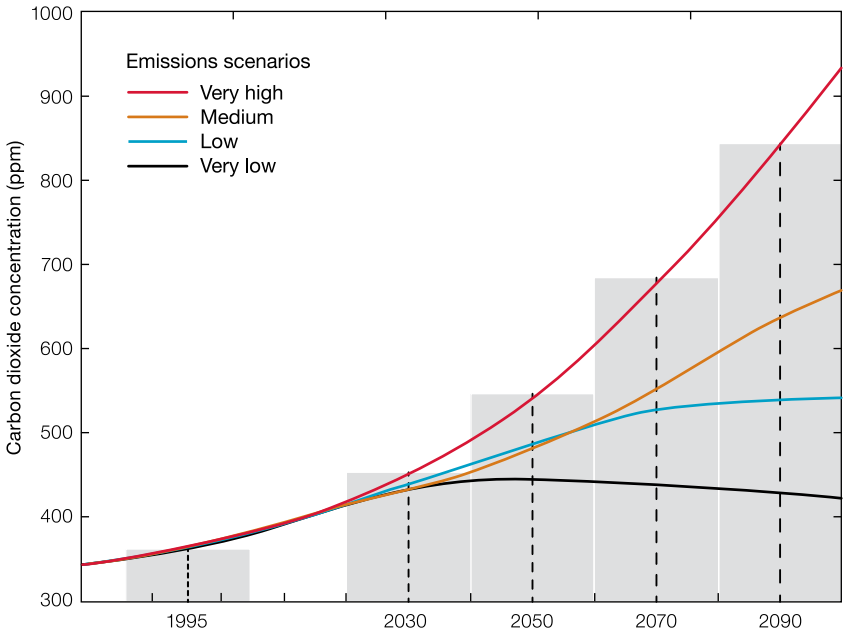


Figure 7: Carbon dioxide concentrations (parts per million, ppm) associated with the very low (RCP2.6), low (RCP4.5), medium (RCP6.0) and very high (RCP8.5) emissions scenarios for 20-year time periods (shaded) centred on 1995 (the reference period), 2030, 2050, 2070 and 2090.

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

> Temperatures show no clear trend but are projected to warm with more very hot days in the future.

> Rainfall has increased since 1890 at Apia. Projections show little change in annual or seasonal rainfall, with more extreme rainfall events. 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 Samoa has risen and will continue to rise throughout this century.

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

> Wave period in December to March is projected to decrease by the end of the century.

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

The content of this brochure is the result of a collaborative effort between the Samoa Meteorology Division 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 Samoa 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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