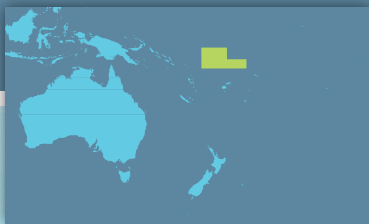
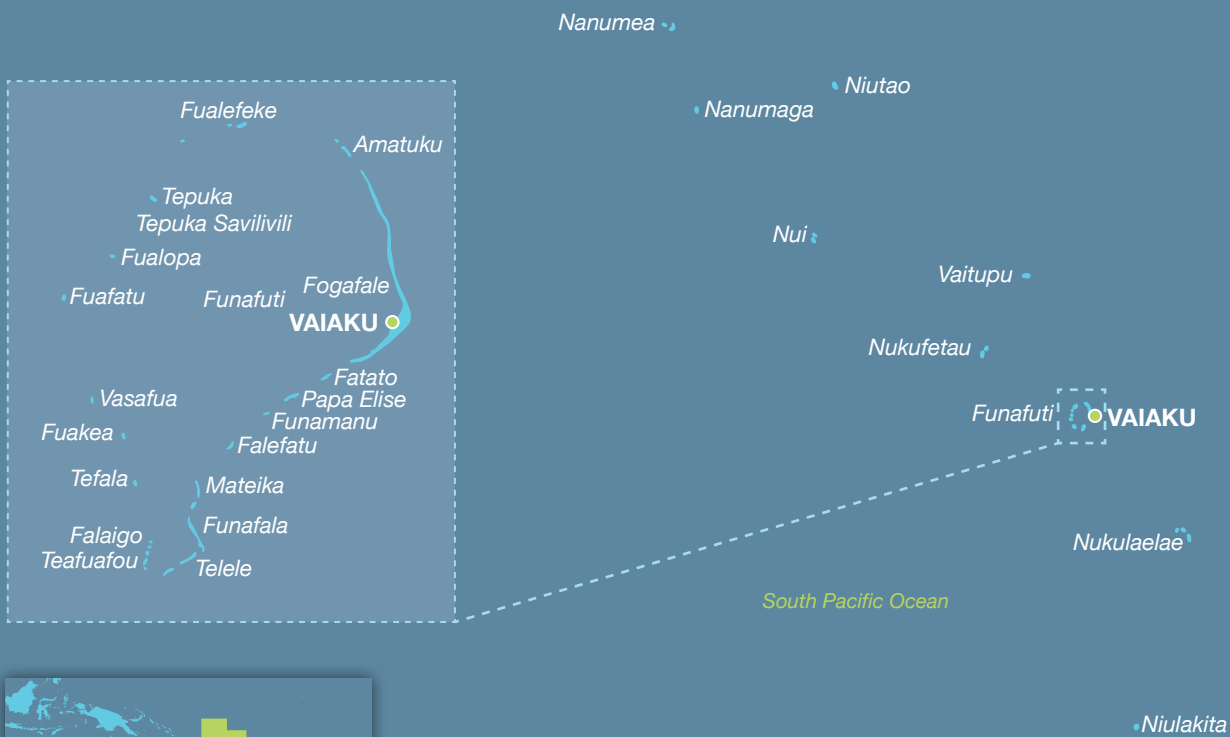


Pacific Climate Change Science Program



Current and future climate of **Tuvalu**



- > Tuvalu Meterological Service
- > Australian Bureau of Meteorology
- > Commonwealth Scientific and Industrial Research Organisation (CSIRO)



Australian Government

Tuvalu's current climate

In Funafuti, the capital of Tuvalu, there is little variation in temperature throughout the year. The maximum temperature is between 31–32°C and the minimum temperature between 25–26°C all year round. Air temperatures are strongly tied to the ocean temperatures surrounding the islands and atolls of the country.

The country has two distinct seasons – a wet season from November to April and a dry season from May to October (Figure 1), however rainfall averages more than 200 mm each month of the year in Funafuti and more than 160 mm in Nanumea. This is due to the location of Tuvalu near the West Pacific Warm Pool (Figure 2), where thunderstorm activity occurs year round.

Tuvalu's wet season is affected by the movement and strength of the South Pacific Convergence Zone (Figure 2). 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 is most intense during Tuvalu's wet season.

The West Pacific Monsoon can also bring heavy rainfall to Tuvalu during the wet season. The Monsoon is driven by large differences in temperature between the land and the ocean, and its arrival usually brings a switch from very dry to very wet conditions.

Tuvalu'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 Funafuti, El Niño events tend to bring wetter, warmer conditions than normal, while La Niña events usually bring drier, cooler than normal conditions. This is likely due to the warmer ocean temperatures around Tuvalu in El Niño years.

extreme weather events

Spring tides and tropical cyclones are among the main extreme events that affect Funafuti. As well as high winds and rainfall, tropical cyclones also cause storm surges and swells. The resulting flooding causes agricultural losses, particularly of taro crops and damage to buildings and roads along the coast.



Tuvalu Meteorological Service

Flooding in front of the Meeting Place (Lotonui Falekaupule), Tuvalu.

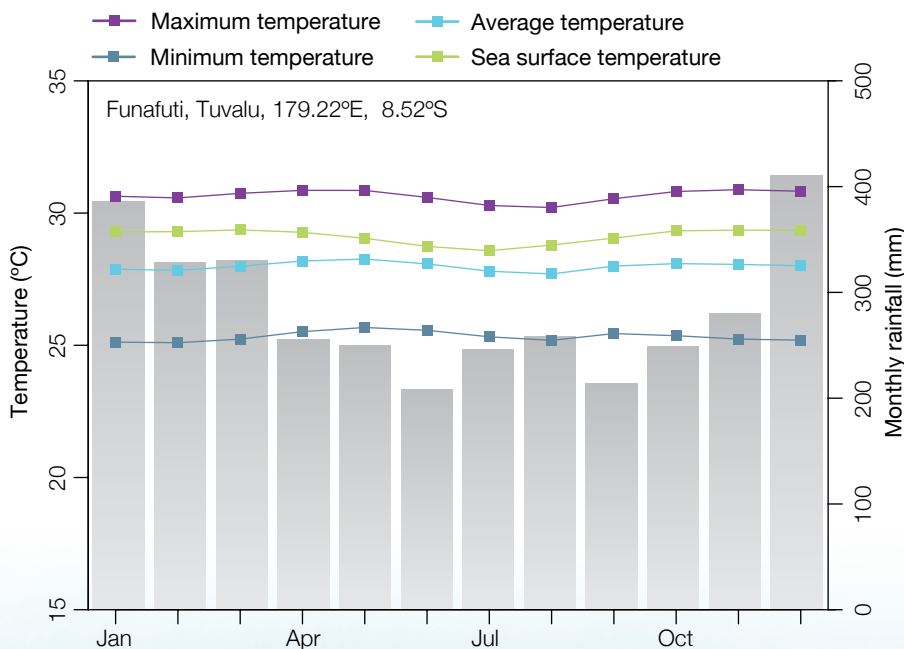


Figure 1: Seasonal rainfall and temperature at Funafuti.

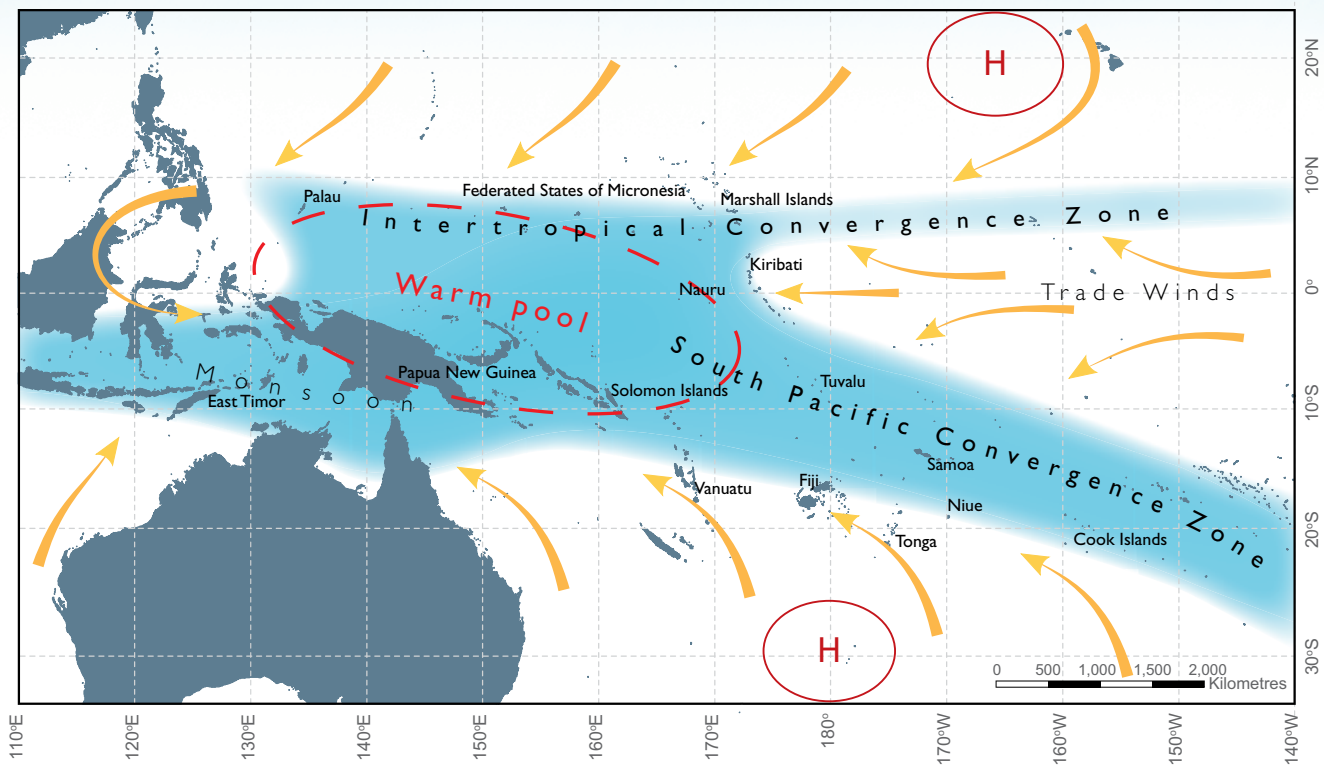


Figure 2: The average positions of the major climate features in November to April. The arrows show near surface winds, the blue shading represents the bands of rainfall convergence zones, the dashed oval shows the West Pacific Warm Pool and H represents typical positions of moving high pressure systems.

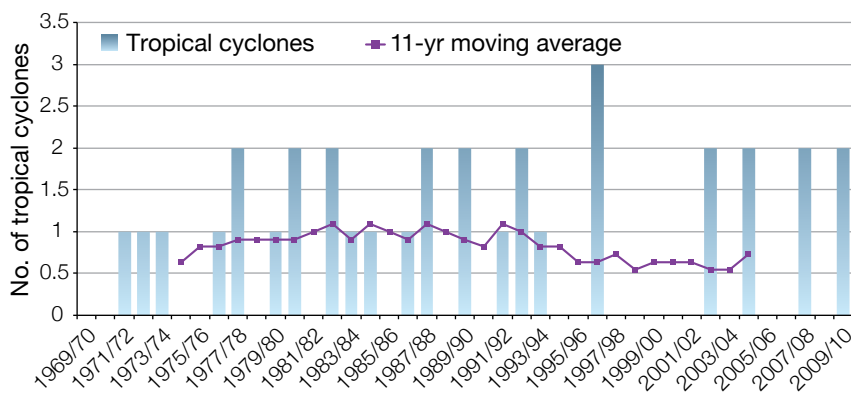


Figure 3: Number of tropical cyclones passing within 400 km of Funafuti. Eleven-year moving average in purple.

Tropical cyclones

Tropical cyclones affect Tuvalu between November and April. In the 41-year period between 1969 and 2010, 33 tropical cyclones passed within 400 km of Funafuti, an average of just under one cyclone per season (Figure 3). The number of cyclones varies widely from year to year, with none in some seasons but up to three in others. Over this period, cyclones occurred more frequently in El Niño years.

Tuvalu's changing climate

Temperatures have increased

Annual and seasonal maximum and minimum temperatures have increased in Funafuti since 1950 (Figure 4). In Funafuti maximum temperatures have increased at a rate of 0.21°C per decade. These temperature increases are consistent with the global pattern of warming.

No rainfall change

Data for Funafuti (Figure 5) and Nanumea since 1950 show no clear trends in annual or seasonal rainfall. However, 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 near Tuvalu by about 5 mm per year since 1993 (a total of 9 cm over this period). 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 record since 1977 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 Tuvalu's waters.

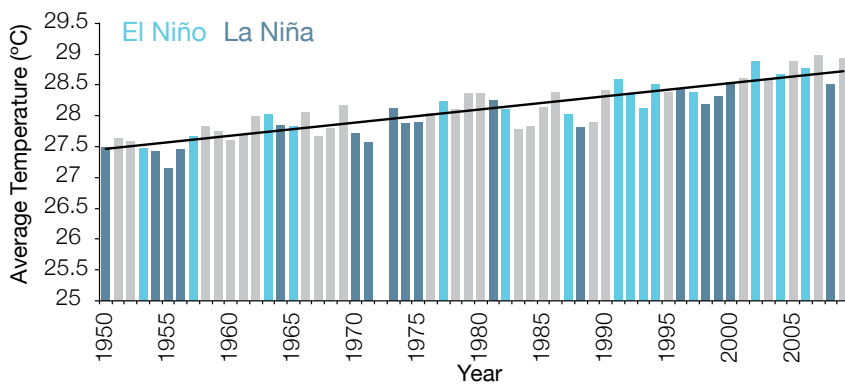


Figure 4: Annual average temperature for Funafuti. Light blue bars indicate El Niño years, dark blue bars indicate La Niña years and grey bars indicate neutral years.

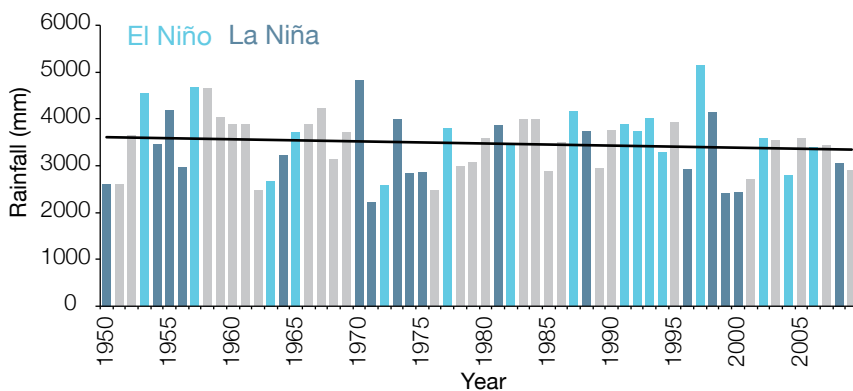


Figure 5: Annual rainfall for Funafuti. Light blue bars indicate El Niño years, dark blue bars indicate La Niña years and the grey bars indicate neutral years.



Aerial view of Funafuti Airport, Vaiaaku.

Tuvalu's future climate

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

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 Tuvalu are based on three IPCC emissions scenarios: low (B1), medium (A1B) and high (A2), for time periods around 2030, 2055 and 2090 (Figure 6). Since individual models give different results, the projections are presented as a range of values.

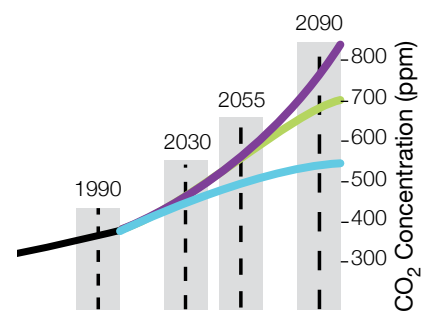


Figure 6: Carbon dioxide (CO₂) concentrations (parts per million, ppm) associated with three IPCC emissions scenarios: low emissions (B1 – blue), medium emissions (A1B – green) and high emissions (A2 – purple). The PCCSP has analysed climate model results for periods centred on 1990, 2030, 2055 and 2090 (shaded).



Coral reef, Funafuti.



Taking temperature observations, Tuvalu Meteorological Service.

Tuvalu's future climate

This is a summary of climate projections for Tuvalu. 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 Tuvalu (Table 1). By 2030, under a high emissions scenario, this increase in temperature is projected to be in the range of 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 Tuvalu 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 (°C)	2055 (°C)	2090 (°C)
Low emissions scenario	0.3–1.1	0.7–1.5	0.9–2.1
Medium emissions scenario	0.4–1.2	1.0–2.0	1.5–3.1
High emissions scenario	0.4–1.0	1.0–1.8	2.1–3.3

Changing rainfall patterns

Almost all of the global climate models project an increase in average annual and seasonal rainfall over the course of the 21st century. Wet season and dry season increases are expected mainly due to the projected intensification of the South Pacific Convergence Zone. However, there is some uncertainty in the rainfall projections and not all models show consistent results. Drought projections are inconsistent across Tuvalu.

More extreme rainfall days

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

Less frequent but more intense 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 Tuvalu region, projections tend to show a decrease in the frequency of tropical cyclones by the late 21st century and an increase in the proportion of the more intense storms.



Inundation during spring tide in front of Tuvalu Meteorological Service.



Funafuti Lagoon.

Sea level will continue to rise

Sea level is expected to continue to rise in Tuvalu (Table 2 and Figure 7). By 2030, under a high emissions scenario, this rise in sea level is projected to be in the range of 4-14 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.

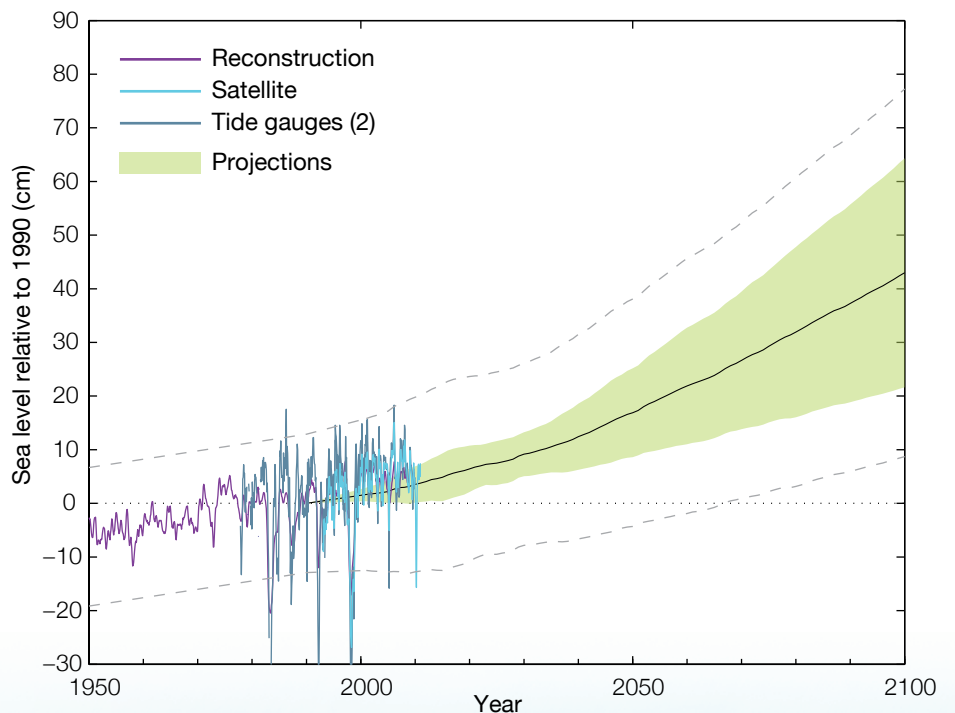
Table 2: Sea-level rise projections for Tuvalu for three emissions scenarios and three time periods. Values represent 90% of the range of the models and changes are relative to the average of the period 1980-1999.

	2030 (cm)	2055 (cm)	2090 (cm)
Low emissions scenario	4-14	9-25	16-45
Medium emissions scenario	5-14	10-29	19-56
High emissions scenario	4-14	9-28	19-58

Ocean acidification

Under all three emissions scenarios (low, medium and high) the acidity level of sea waters in the Tuvalu 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.

Figure 7: Observed and projected relative sea-level change near Tuvalu. 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 Tuvalu (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 Tuvalu's climate

- > Temperatures have warmed and will continue to warm with more very hot days in the future.
- > Rainfall shows no clear trend since 1950 at Funafuti and Nanumea. Rainfall is generally projected to increase over this century with more extreme rainfall days expected.
- > By the end of this century projections suggest decreasing numbers of tropical cyclones but a possible shift towards more intense categories.
- > Sea level near Tuvalu has risen and will continue to rise throughout this century.
- > Ocean acidification has been increasing in Tuvalu'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 Tuvalu Meteorological Service 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 Tuvalu 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

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