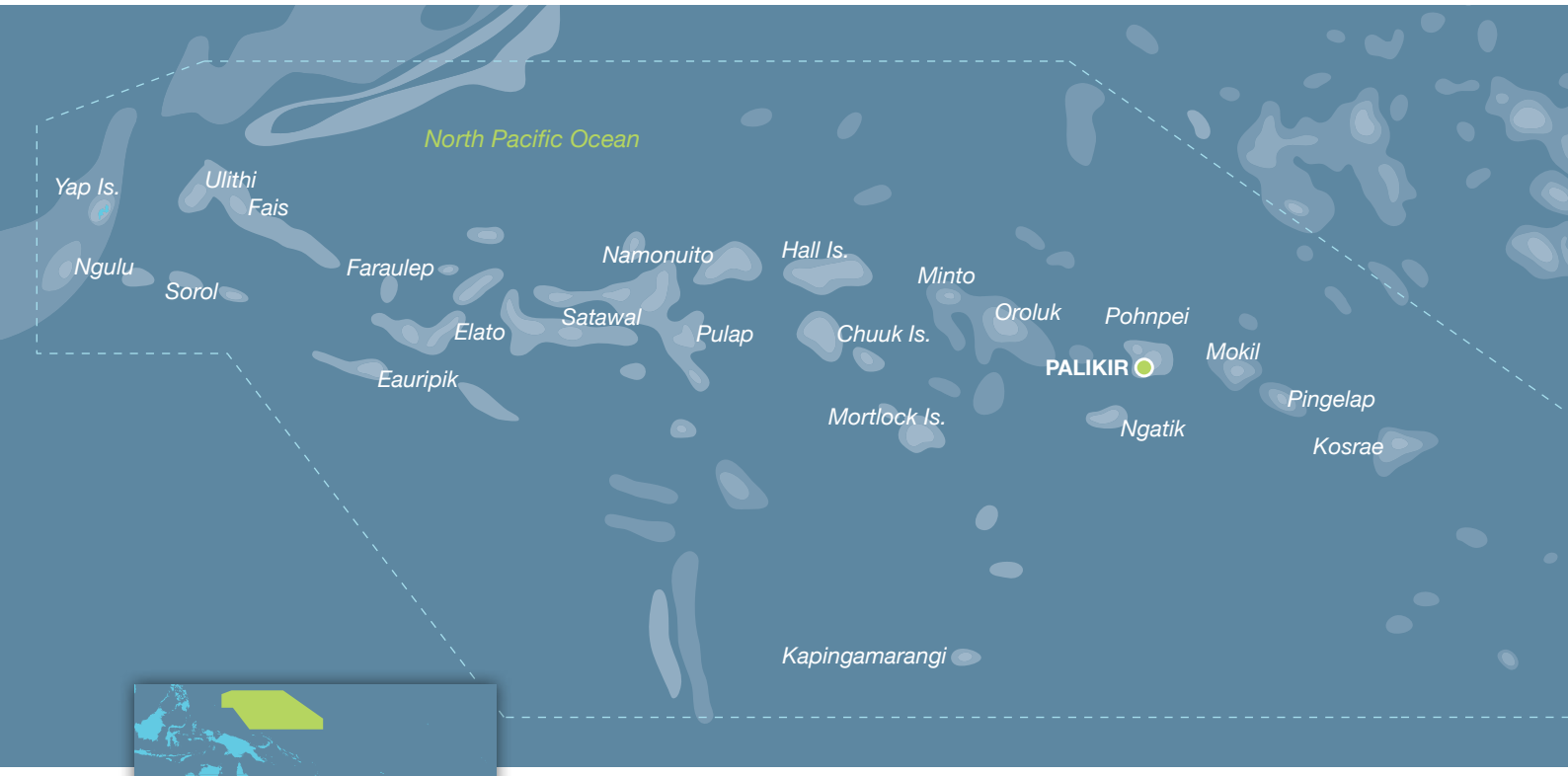
International CLIMATE CHANGE ADAPTATION Initiative

Pacific Climate Change Science Program



Current and future climate of the **Federated States of Micronesia**

> Federated States of Micronesia National Weather Service Office
> Australian Bureau of Meteorology
> Commonwealth Scientific and Industrial Research Organisation (CSIRO)

Australian Government

Current climate
of the Federated States of Micronesia

In the Federated States of Micronesia there is little seasonal variation in temperature, with less than 3°F (1.5°C) between the average hottest and coolest months. The country has two seasons – a dry season from November to April and a wet season from May to October (Figure 1).

Rainfall in the Federated States of Micronesia is affected by the movement 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 (Figure 2). The wet season occurs when the Intertropical Convergence Zone strengthens and moves north close to the Federated States of Micronesia. The West Pacific Monsoon also impacts rainfall, bringing additional rain during the wet season. The Monsoon is driven by large differences in temperature between the land and the ocean, and its seasonal arrival usually brings a switch from very dry to very wet conditions.

The Federated States of Micronesia'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 Pohnpei, El Niño tends to result in drier conditions during the dry season, but higher than average rainfall during the wet season. La Niña tends to bring above average rainfall in the dry season. The West Pacific Monsoon affects the western states of Chuuk and especially Yap more than the eastern states of Pohnpei and Kosrae. It tends to be farther east during El Niño, bringing higher rainfall, and in a more western position during La Niña, resulting in less rainfall. The Intertropical Convergence Zone results in less rainfall during El Niño events and more during La Niña.

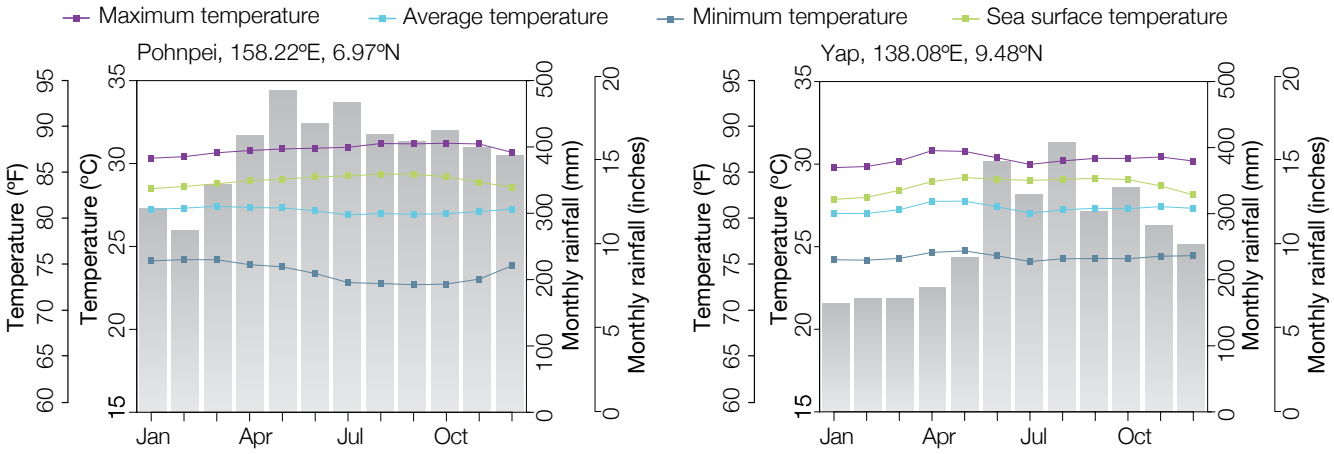


Figure 1: Seasonal rainfall and temperature at Pohnpei and Yap.

Kolonia Harbour, Pohnpei.

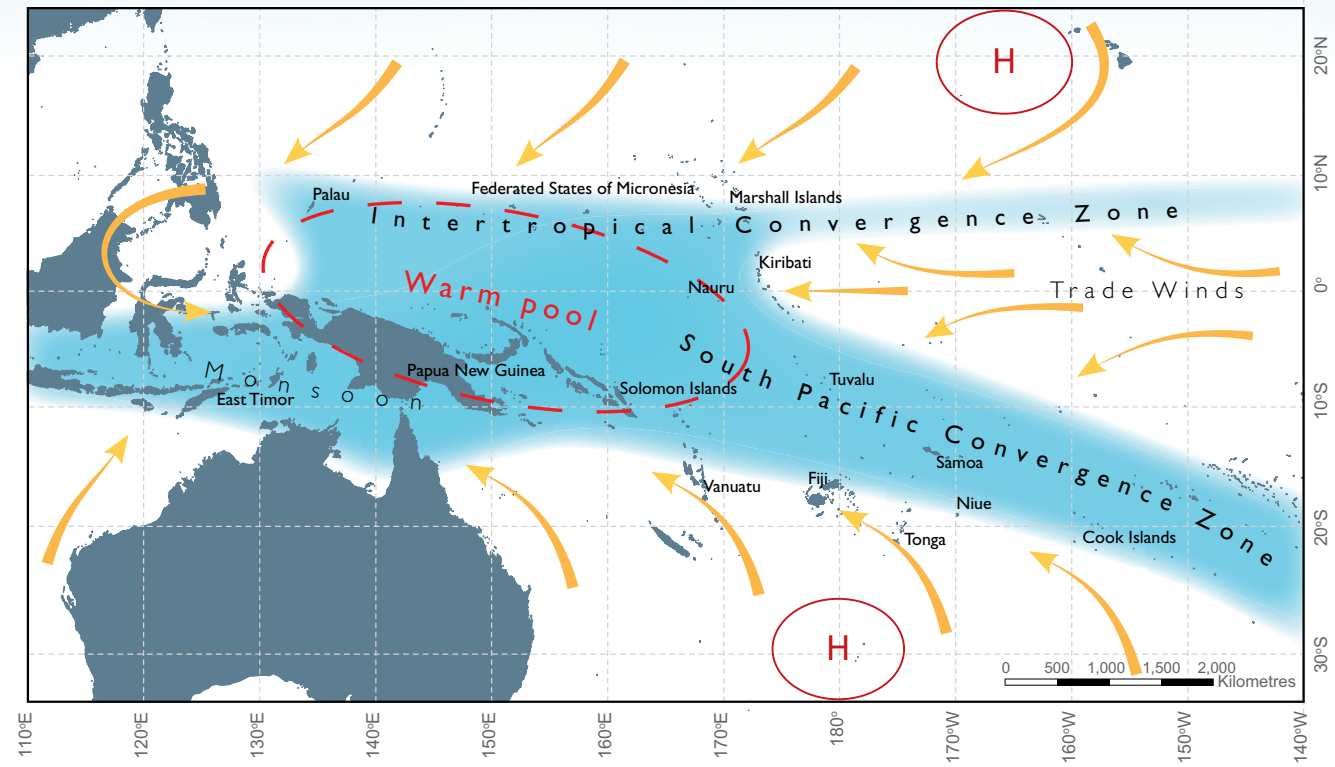


Figure 2: The average positions of the major climate features in November to April. The arrows show near surface winds, the blue shading represents the bands of rainfall convergence zones, the dashed oval shows the West Pacific Warm Pool and H represents typical positions of moving high pressure systems.

extreme weather events

Droughts, typhoons, storm waves, flooding and landslides all affect the Federated States of Micronesia. El Niño events are associated with drier conditions and occasional droughts. Fires, water shortages and food shortages have occurred during severe dry events. During La Niña events above-average numbers of tropical storms occur in the Federated States of Micronesia region.

Johannes Berdon, National Weather Service Office

Damage from high sea surge, Oneop, Chuuk.

Changing climate
of the Federated States of Micronesia

Temperatures have increased

Annual and seasonal maximum and minimum temperatures have increased in Pohnpei since 1952 (Figure 3). Maximum temperatures have increased at a rate of 0.19ºF (0.10°C) per decade. These temperature increases are consistent with the global pattern of warming.

Pohnpei's annual rainfall has decreased

Data since 1950 for Pohnpei show a clear decreasing trend in annual and wet season rainfall (Figure 4), but no clear trend in the dry season. There are no clear rainfall trends at Yap. Over this period, there has been substantial variation in rainfall from year to year at both sites.

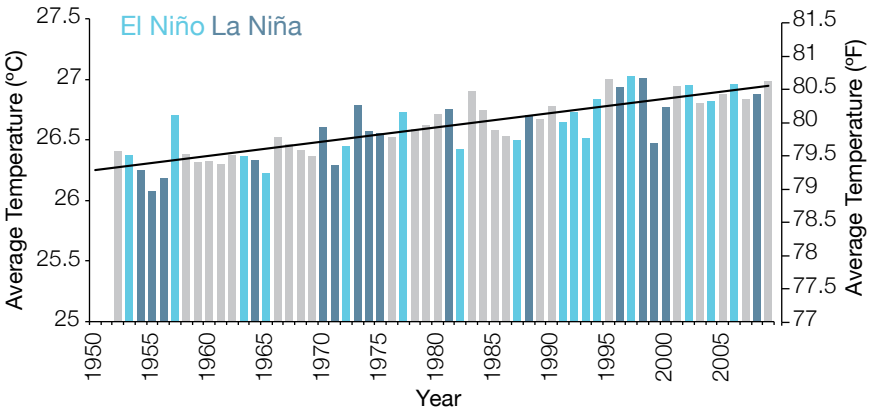


Figure 3: Annual average temperature for Pohnpei. Light blue bars indicate El Niño years, dark blue bars indicate La Niña years and the grey bars indicate neutral years.

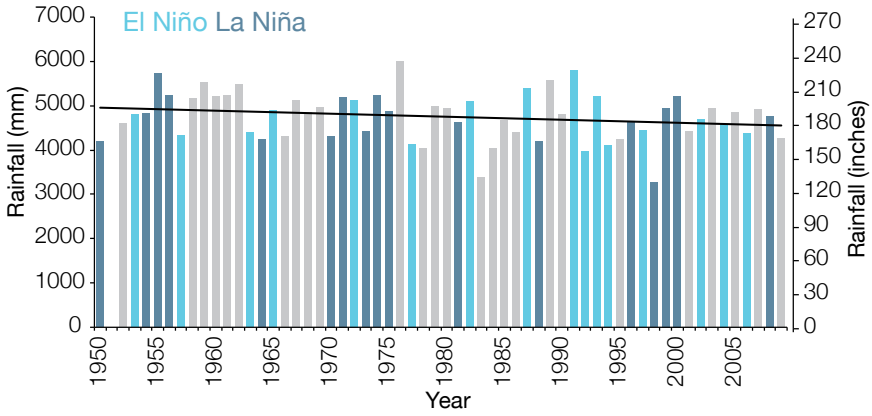


Figure 4: Annual rainfall for Pohnpei. Light blue bars indicate El Niño years, dark blue bars indicate La Niña years and the grey bars indicate neutral years.

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 sea level has risen in the Federated States of Micronesia by over 0.39 inches (10 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. This year-to-year 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 the Federated State of Micronesia's waters.

Taking temperature observations, Pohnpei Weather Service Office.

Future climate
of the Federated States of Micronesia

Climate impacts almost all aspects of life in the Federated States of Micronesia. Understanding the possible future climate of the Federated States of Micronesia 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 the Federated States of Micronesia.

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 the Federated States of Micronesia 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.

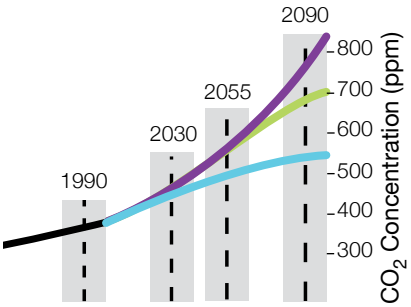


Figure 5: Carbon dioxide (CO_2) concentrations (parts per million, ppm) associated with three IPCC emissions scenarios: low emissions (B1 – blue), medium emissions (A1B – green) and high emissions (A2 – purple). The PCCSP has analysed climate model results for periods centred on 1990, 2030, 2055 and 2090 (shaded).

Climate projections training, Pohnpei Weather Service Office.

Johannes Berdon, National Weather Service Office

Damage from high sea surge, Lekinioch, Chuuk.

Future climate of the Federated States of Micronesia

This is a summary of climate projections for the Federated States of Micronesia. 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 the Federated States of Micronesia (Table 1). By 2030, under a high emissions scenario, this increase in temperature is projected to be in the range of 0.7–1.9ºF (0.4–1.0°C) in eastern Federated States of Micronesia and 0.8–1.8ºF (0.4–1.1ºC) in western Federated States of Micronesia.

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

Almost all the global climate models project an increase in average annual and seasonal rainfall over the course of the 21st century. 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. There is also 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.

The Federated States of Micronesia 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.

Table 1: Projected annual average air temperature changes for the Federated States of Micronesia (FSM) 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)	(ºC)	(°F)	(ºC)	(°F)	(ºC)
Eastern FSM						
Low emissions scenario	0.4–2.0	0.1–1.1	1.1–2.9	0.6–1.6	1.5–4.1	0.9–2.3
Medium emissions scenario	0.5–2.3	0.3–1.3	1.6–3.8	0.9–2.1	2.7–5.9	1.5–3.3
High emissions scenario	0.7–1.9	0.4–1.0	1.8–3.4	1.0–1.8	3.9–6.3	2.2–3.4
Western FSM						
Low emissions scenario	0.4–1.8	0.2–1.0	1.0–2.8	0.6–1.6	1.4–4.0	0.8–2.2
Medium emissions scenario	0.6–2.2	0.4–1.2	1.7–3.7	0.9–2.1	2.6–5.8	1.4–3.2
High emissions scenario	0.8–1.8	0.4–1.1	1.7–3.3	1.0–1.8	3.8–6.2	2.1–3.5

Kepirohi Falls, Pohnpei.

Sea level will continue to rise

Sea level is expected to continue to rise in the Federated States of Micronesia (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 1.2-5.9 inches (3-15 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, 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 three emissions scenarios (low, medium and high) the acidity level of sea waters in the Federated States of Micronesia 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.

Johannes Berdon, National Weather Service Office

Damage to taro crop from salt water inundation, Lekinioch, Chuuk.

Table 2: Sea-level rise projections for the Federated States of Micronesia 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	1.2–5.5	3–14	3.5–10.2	9–26	6.3–18.1	16–46
Medium emissions scenario	1.2–5.9	3–15	3.5–12.6	9–32	7.5–23.6	19–60
High emissions scenario	1.2–5.9	3–15	3.9–11.8	10–30	8.3–24.4	21–62

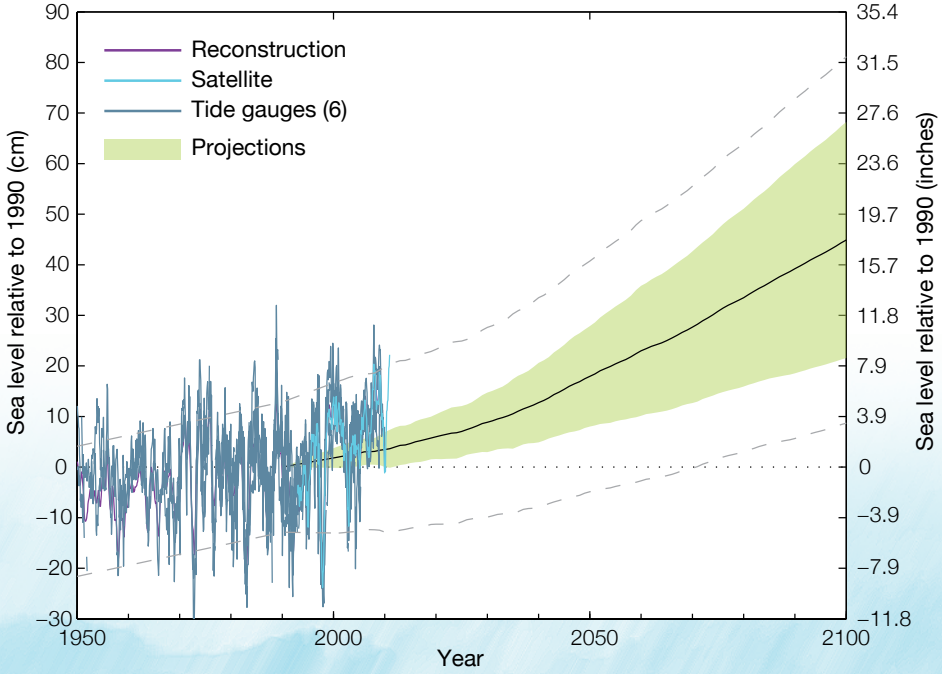


Figure 6: Observed and projected relative sea-level change near the Federated States of Micronesia. The observed sea-level records are indicated in dark blue (relative tide-gauge observations) and light blue (the satellite record since 1993). Reconstructed estimates of sea level near the Federated States of Micronesia (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 the climate of the **Federated States of Micronesia**

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

> Annual and wet season rainfall since 1952 has decreased at Pohnpei but at Yap there has been no clear change. 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 the Federated States of Micronesia has risen and will continue to rise throughout this century.

> Ocean acidification has been increasing in the Federated States of Micronesia'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 National Weather Service Offices of the Federated States of Micronesia 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 the Federated States of Micronesia 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.

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