Executive summary

About this report

This report presents key scientific findings from the second phase of the Climate and Oceans Support Program in the Pacific (COSPPac, July 2018–June 2023), Seasonal Prediction and the Pacific Sea Level and Geodetic Monitoring (PSLGM) projects. The report contributes to COSPPac's aim for Pacific Island national meteorological services to understand and use climate, ocean and sea level data and information to develop and disseminate useful products and services to Pacific Island governments and communities, building resilience against the impact of climate change, climate variability and disasters.

The report also provides an update of scientific understanding of large-scale climate processes, variability and extremes in the western tropical Pacific first presented in the Pacific Climate Change Science Program (PCCSP) *Climate Change in the Pacific: Scientific Assessment and New Research, Volume 2, Country Reports* (2011) and the Pacific–Australia Climate Change Science and Adaptation Planning (PACCSAP) Program *Climate Variability, Extremes and Change in the Western Tropical Pacific: New Science and Updated Country Reports* (2014).

The work is designed to complement the recently released 'NextGen' Projections for the Western Tropical Pacific country reports and provide finer-scale partner country historical climate change information not presented in the Intergovernmental Panel on Climate Change (IPCC)'s Sixth Assessment Report (AR6), *Climate Change 2021: The Physical Science Basis,* and World Meteorological Organization (WMO) Regional Association Five (RA-V) Pacific Regional Climate Centre (RCC) Network's *Pacific Climate Change Monitor* (PCCM) Report (2022).

Chapter 1 provides a general introduction to the content, structure and methods used for each country report in subsequent chapters. Each subsequent country chapter has nine sections that provide: (1) a climate and ocean summary; (2) country description; (3) data availability; (4) rainfall seasonal cycle and observed trends; (5) air temperature seasonal cycle and observed trends; (6) tropical cyclone seasonal cycle and observed trends; (7) sea surface temperature (SST) seasonal cycle and observed trends; (8) sea level seasonal cycle and observed trends; and (9) wave climate, seasonal cycle, trends, and extreme value analysis. Trend lengths vary depending on data availability and quality.

It is anticipated that this report, associated products and capacity-building activities will provide decision-makers and other stakeholders in the partner countries, as well as the wider scientific community, with up-to-date, robust climate change science information for the region and the individual countries.

While producing this report, the authors identified a decline in the quality and quantity of Pacific Island climate data and metadata beginning in the 1990s. Few Pacific national meteorological services are documenting equipment maintenance/change, calibration, exposure and site changes. More than half of the countries represented in this report currently have less than two stations with near-complete maximum and minimum temperature time series from the 1980s to 2020. In some cases, this represents a national network decline of greater than 80% in 30 years. Pacific Island governments and donors are requested to prioritise climate and ocean observations for the purposes of ongoing climate change monitoring in the Pacific.

Regional summary

Climate variability and current climate

Communities in COSPPac partner countries and territories experience climate and ocean variability at weekly, seasonal and longer timescales. They also experience extreme events such as droughts, tropical cyclones, coastal and river flooding, and coral bleaching. The occurrence of extreme events, and in some cases multiple events simultaneously, as well as global warming, can have devastating impacts.

An important aspect of understanding and adapting to climate change in the region is being able to differentiate between climate variability and long-term change and being able to correctly attribute extreme events to climate variability or anthropogenic climate change. This report provides communities in COSPPac partner countries and territories with information on seasonal cycles and the impact of the major modes of variability and long-term change for key variables at a country scale, expanding on information provided in the WMO RA-V Pacific RCC Network PCCM (2022).

El Niño and La Niña have perhaps the strongest influence on year-to-year climate variability in the Pacific. These phenomena are a part of a natural cycle known as El Niño–Southern Oscillation (ENSO) and are associated with a sustained period (many months) of warming (El Niño) or cooling (La Niña) in the central and/or eastern tropical Pacific. The ENSO cycle operates over timescales from two to seven years.

ENSO is strongly linked with variations in other climate features, such as the Pacific Warm Pool, Intertropical Convergence Zone (ITCZ), South Pacific Convergence Zone (SPCZ), West Pacific Monsoon (WPM) and trade winds associated with the subtropical belt. During La Niña events, the SPCZ is displaced southwest of its normal position, while the ITCZ moves further north of the equator. These variations influence the amount of rainfall countries in the vicinity receive. Sea level, SST, ocean waves and currents, air temperature and tropical cyclone genesis are also impacted. All COSPPac partner countries and territories experience climate and ocean variability due to ENSO, although the magnitude and timing of this influence varies.

ENSO behaviour is modified at decadal timescales by the Interdecadal Pacific Oscillation, which includes the closely related Pacific Decadal Oscillation (PDO). Understanding decadal variability is important as some Pacific climate data records are short, such as tropical cyclones and sea level, making the detection of long-term trends difficult.

The following is a summary of climate and ocean trends presented in this report that are based on updated or improved datasets.

Rainfall

- Station records show large year-to-year and decade-to-decade variability. However, long-term trends in total annual and seasonal rainfall show little change at most locations over the last 70 years.
- Trends in the extreme rainfall indices, including the standardised rainfall evapotranspiration index (drought) and maximum one-day rainfall indices, also show little change at most locations.

Air temperature

- Station records show notable warming of mean maximum daytime and mean minimum night-time temperatures over the last 70 years (and over shorter periods). There have been significantly more warm days and nights, and fewer cool days and nights.
- There have been strong increases in the cooling degree day index across the region, suggesting that energy requirements for air conditioning have increased significantly over the last 70 years.

Tropical cyclones

- There has been little change in the total number of tropical cyclones occurring in the Southwest Pacific over the last 40 years. Over the same period, there has been a decline in the total number of severe tropical cyclones and a marginal decline in the proportion of tropical cyclones reaching severe status.
- The decline in the total number of severe tropical cyclones identified in this report differs from that for the same region and period in the WMO RA-V Pacific RCC Network PCCM (2022). The PCCM reports that trends in severe tropical cyclones in the Southwest Pacific are not statistically significant. This report uses The Bureau's Southern Hemisphere Tropical Cyclone (SHTC) archive, while the PCCM uses the International Best Track Archive for Climate Stewardship. Reasons for the notable difference in severe tropical cyclone numbers in these datasets are unclear at this time. Further research is required to resolve this issue. The key message from both reports is that trends in severe tropical cyclones in the Southwest Pacific have not increased over the last 40 years.
- In the Northwest Pacific, there has been little change in the total number of tropical cyclones, severe tropical cyclones and proportion of tropical cyclones reaching severe status.

Sea surface temperature

- Satellite observations show rapid warming of sea surface temperatures over the last 40 years in COSPPac partner countries and territories in the western tropical Pacific.

Sea level

- Sea level observations from satellite altimetry over the last 30 years show increases across the western tropical Pacific, but these rates vary due to large-scale climate processes. In many countries, the rate of sea-level rise is higher than the global average for the same period.
- Tide-gauge observations show higher rates of sea-level rise where land subsidence is occurring, including New Guinea Islands (PNG), Samoa, Tonga, Federated States of Micronesia (FSM), Kiribati and Nauru.

Waves

- Mean annual wave height has remained unchanged at most locations over the last 44 years. Waves change from month to month with the seasons, but they also change from year to year with climate oscillations such as ENSO.
- Extreme wave analysis was undertaken for selected locations by defining a severe height threshold and fitting a generalized Pareto distribution. The number of wave events reaching or exceeding a particular threshold is reported over a 42-year wave record for each selected location. Average recurrence (1–100-year) interval wave heights are also presented.