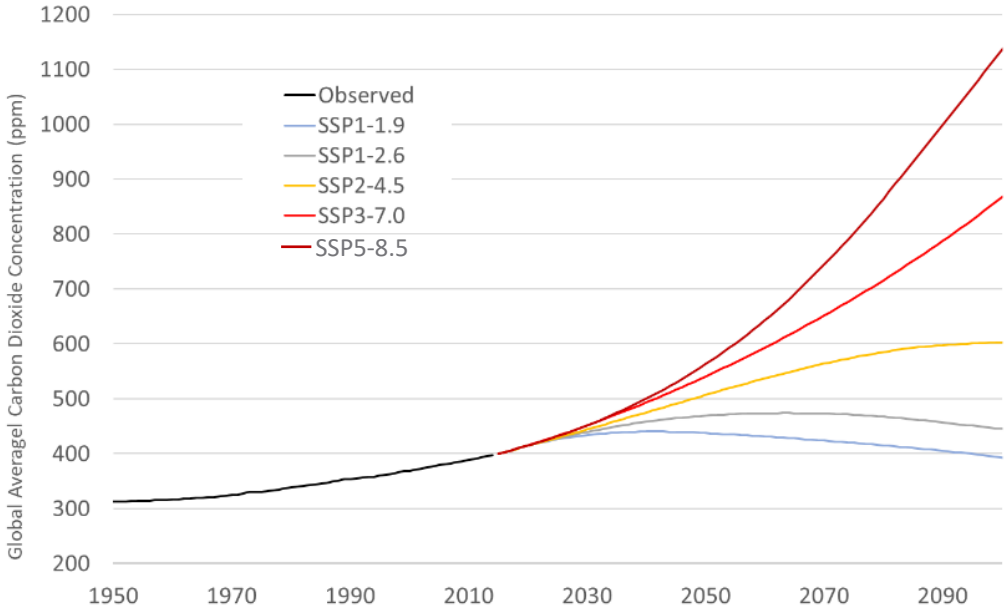
Pacific rainfall and sea surface temperature projections

Kevin Hennessy, 25 October, 2022

PICOF-11 Session 6

Introduction

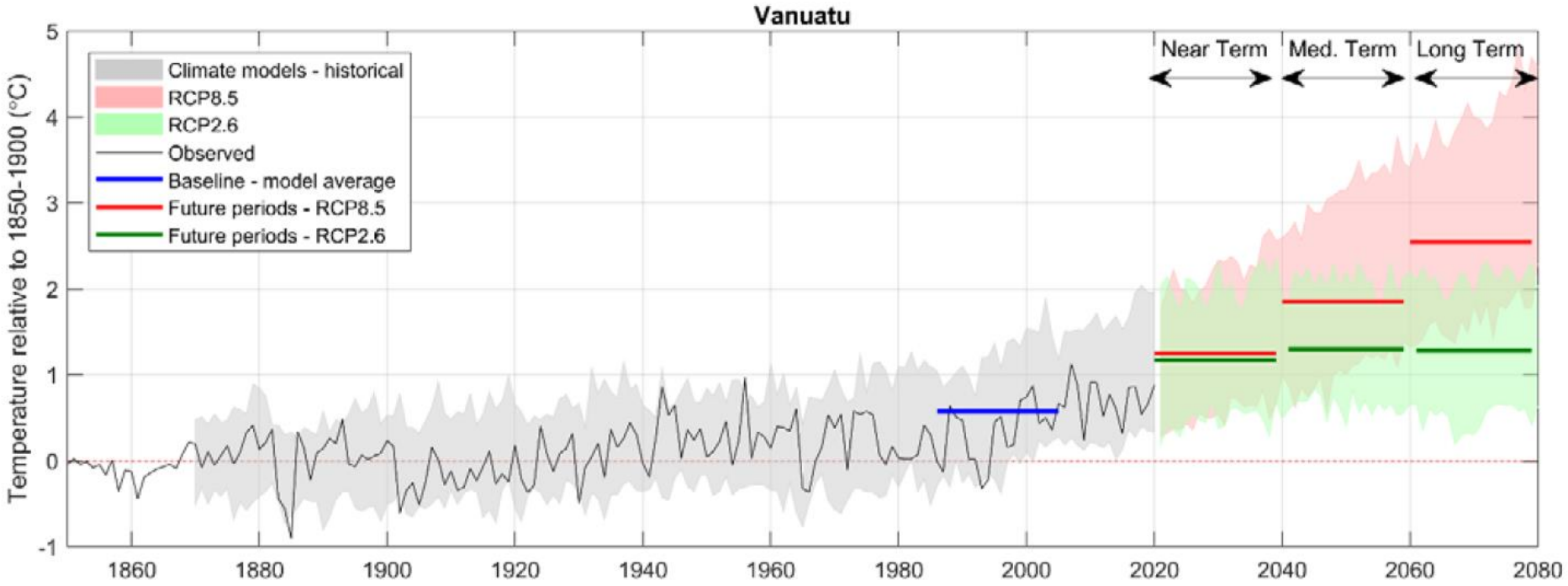


The direction and magnitude of climate projections are affected by:

1. Greenhouse gas concentration pathways: based on assumptions about future demographic change, economic development, energy use and land use
2. Regional climate responses to each concentration pathway: based on simulations from up to 40 climate models
3. Natural variability: from local weather variability and large-scale factors such as El Niño, La Niña, and the Pacific Decadal Oscillation

CSIRO & SPREP (2021), Grose et al (2022)

Bringing it all together: an example

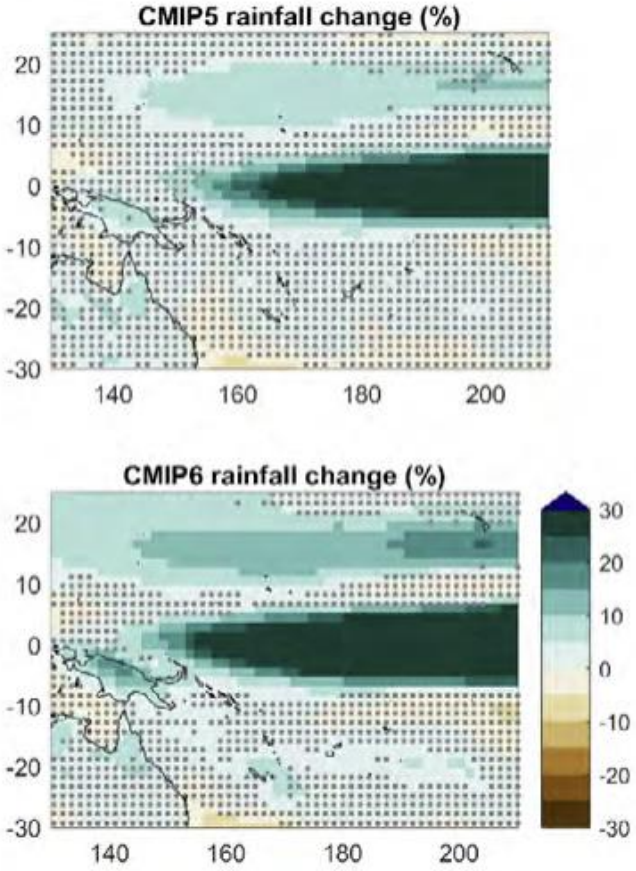


Each climate projection includes a central estimate and a range of uncertainty (CSIRO & SPREP, 2021)

Rainfall

- In the Pacific Islands, rainfall is strongly affected by El Niño, La Niña and the Pacific Decadal Oscillation
- While cyclone contributions to extreme rainfall have decreased over most of the region due to fewer cyclones over the past few decades, the intensity of extreme rainfall events associated with cyclones has increased (Deo et al., 2021)
- Over the last 70 years, there has been little change in annual total rainfall or dry spells at most locations, with mixed evidence for changes in heavy rainfall (Session 4)

Rainfall projections



Projected changes for 2050-2099

- Short-term trends (e.g., 2021–2030) will be strongly affected by natural variability
- Longer-term trends include an increase along the equator linked to enhanced warming
- Outside the equator, the direction of change is less certain (dots indicate where less than 2/3 of climate models agree on the direction of change), so a range of possibilities should be considered

CSIRO & SPREP (2021). ‘NextGen’ Projections for the Western Tropical Pacific

Rainfall projections

RCP2.6

RCP8.5

		2030	2050	2070
Palau	Annual rainfall from 1986-2005 (%)	2 (-8 to 10)	3 (-4 to 10)	2 (-5 to 9)
			4 (-7 to 13)	6 (-2 to 16)
Cook Is (South)	Annual rainfall from 1986-2005 (%)	1 (-10 to 10)	0 (-6 to 5)	1 (-3 to 6)
			1 (-10 to 9)	2 (-11 to 20)
Vanuatu	Annual rainfall from 1986-2005 (%)	1 (-9 to 13)	1 (-6 to 9)	0 (-10 to 9)
			0 (-12 to 14)	2 (-16 to 15)
Marshall Is (North)	Annual rainfall from 1986-2005 (%)	2 (-6 to 11)	3 (-2 to 8)	1 (-4 to 4)
			8 (-2 to 26)	8 (-4 to 16)
PNG	Annual rainfall from 1986-2005 (%)	4 (-1 to 9)	4 (0 to 9)	5 (-1 to 9)
			7 (-1 to 15)	10 (-1 to 20)
Solomon Is	Annual rainfall from 1986-2005 (%)	3 (-2 to 9)	3 (-1 to 7)	3 (-3 to 8)
			3 (-3 to 9)	5 (-3 to 14)

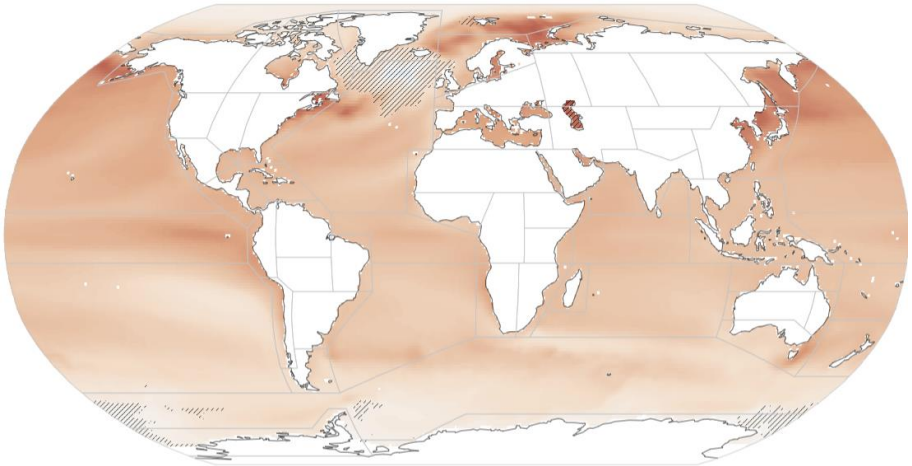
CSIRO & SPREP (2021)

Rainfall projections

- Warmer conditions increase the intensity of heavy rainfall
- This can lead to flash floods
- Maximum 1-day rainfall is projected to increase almost everywhere by a minimum of 5–7% per degree of warming

Grose et al (2022)

Sea surface temperature (SST)



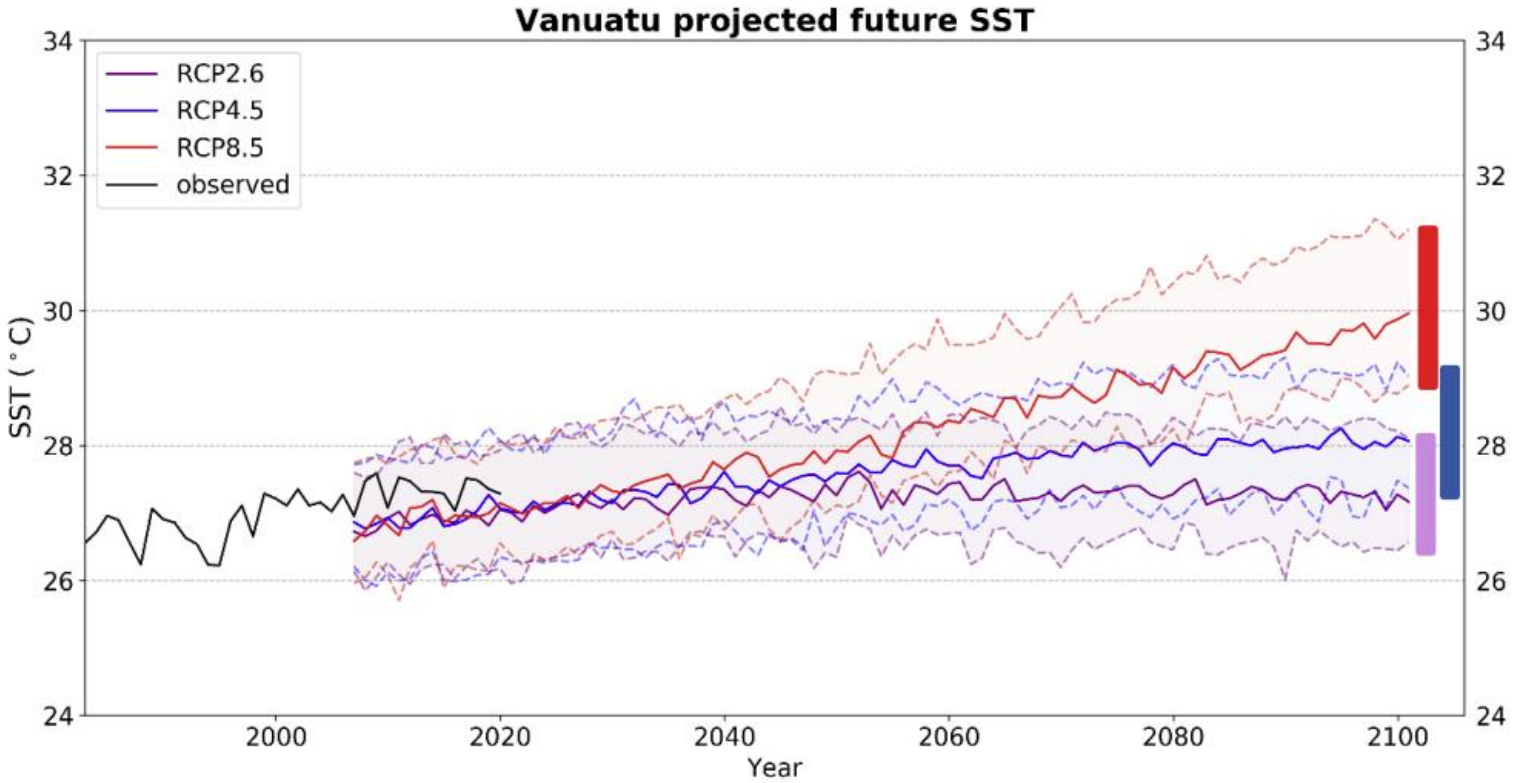
SST warming for 2041-2060, under a high concentration pathway (SSP5-8.5) relative to 1995-2014, based on 27 CMIP6 climate models

Averaged over the South Pacific Ocean, the projected SST warming is:

- 0.4°C by 2021-2040, 0.6°C by 2041-2060, and 0.7°C by 2081-2100, relative to 1995-2014, for a low concentration pathway (SSP1-2.6)
- 0.4°C by 2021-2040, 1.0°C by 2041-2060, and 2.4°C by 2081-2100, relative to 1995-2014, for a high concentration pathway (SSP5-8.5)

IPCC Interactive Atlas (2022)

Sea surface temperature (SST)

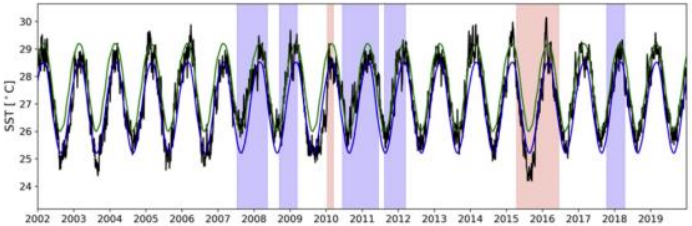


Van KIRAP workshop (2021)

Marine heatwaves

- Heatwaves can cause devastating impacts to marine species and habitats, e.g. coral reefs, kelp, seagrass, fisheries and aquaculture
- Fish food-poisoning through ciguatera has been linked to warmer sea surface temperatures
- The average duration of heatwaves in the 1980s to 2000s was 5 to 16 days. However, during the 2010s, this increased to 8 to 20+ days (Session 4, Holbrook et al, 2022)

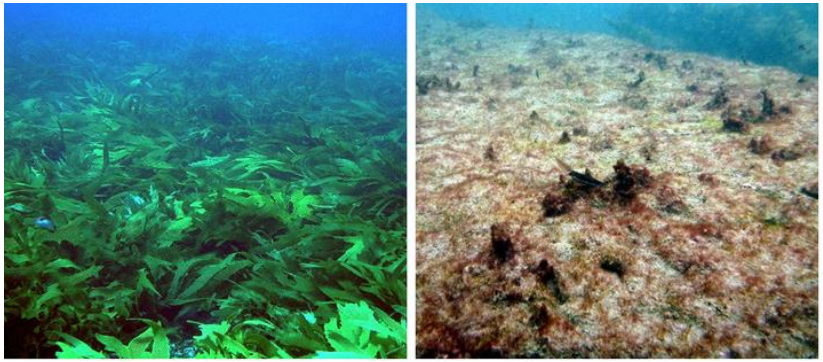
Marine heatwaves: Fiji example



a. Observed SST (black line), monthly average SST (blue line), 90th percentile threshold (green line), El Niño (pink shading), La Niña (blue shading)
b. Dead fish on a beach on 8 Feb 2016
c. SST anomaly on 8 Feb 2016
d. SST timeseries of the 2016 event showing observed SST (black line), monthly average SST (blue line), 90th percentile threshold (green line), 2 x threshold (dotted line: Moderate event), and 3 x threshold (dashed line: Strong event)

Holbrook et al (2022)

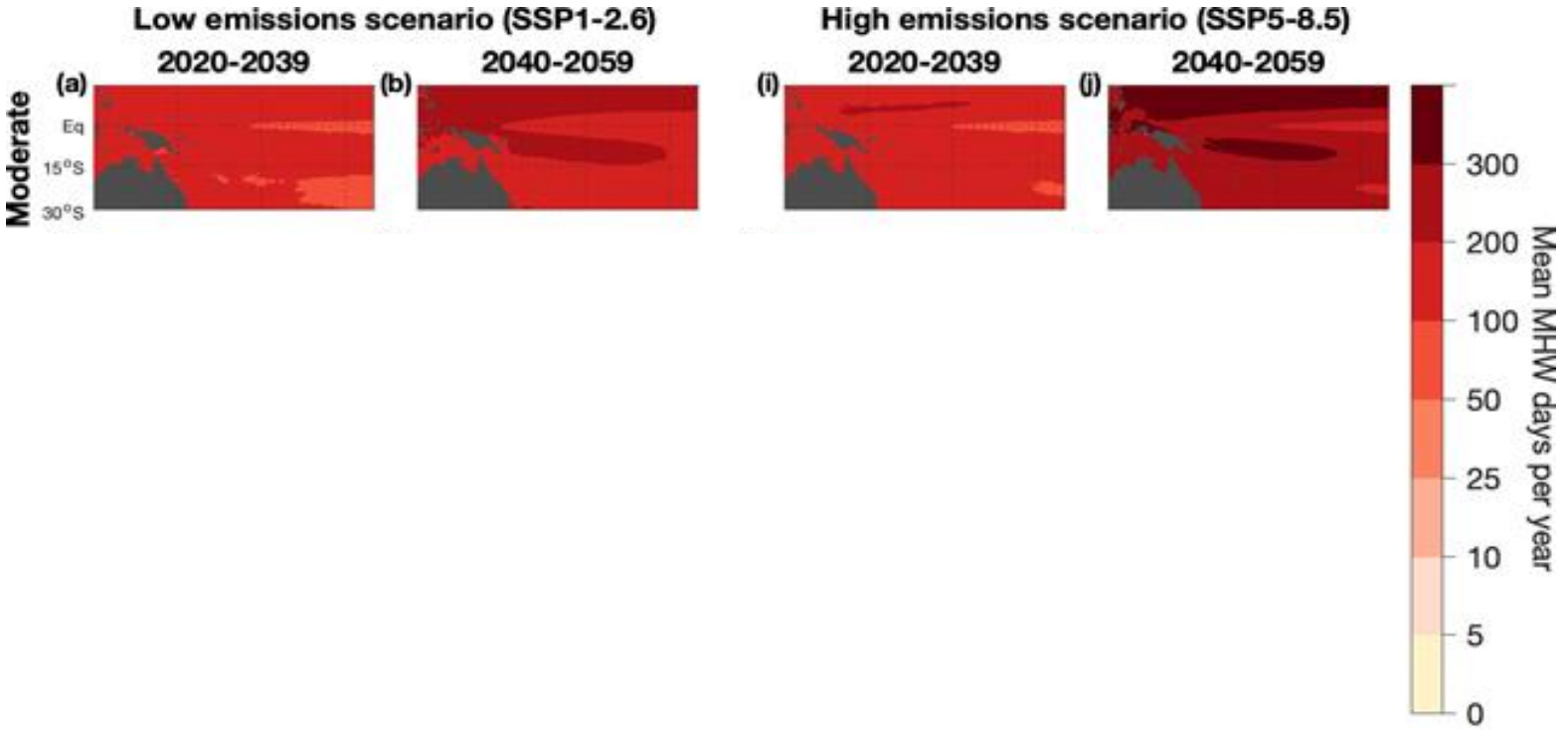
Marine heatwaves: projections



- For a low concentration pathway (SSP1-2.6), the number of “Moderate” marine heat waves increases from recent (1995–2014) values of 10–50 days/year to over 100 days/year by 2050, with over 200 days/year nearer the equator
- For a high concentration pathway (SSP5-8.5), the number of “Moderate” marine heat waves increases to 100-200 days/year by 2050, with over 300 days/year nearer the equator

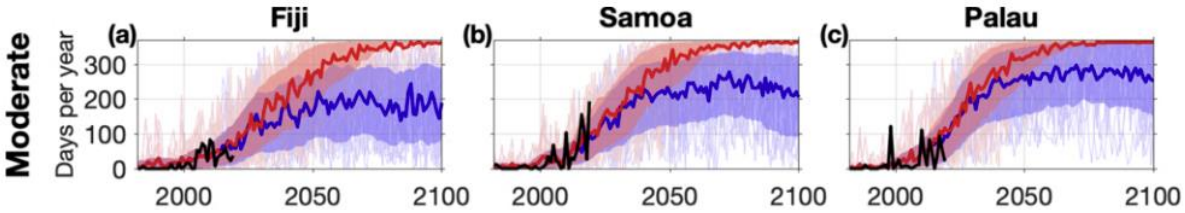
Holbrook et al. (2022)

Marine heatwaves: projections



Projected increase in the mean number of marine heat wave (MHW) days per year for four intensity categories (Moderate, Strong, Severe and Extreme) by 2020-2039 and 2040-2059 averaged over 18 CMIP6 climate models under low (SSP1-2.6) and high (SSP5-8.5) concentration pathways, relative to a baseline of 1995–2014. Source: Holbrook et al. (2022)

Marine heatwaves: projections



- Small differences between the low and high concentration pathways before 2040
- Big differences between the low and high concentration pathways after 2050
- Fiji is slightly less sensitive than Samoa, which is slightly less sensitive than Palau
- Larger differences for Strong-Extreme heatwaves

Annual marine heatwave days in four intensity categories under low (SSP1–2.6: blue) and high (SSP5–8.5: red) concentration pathways. Source: Holbrook et al (2022)

Summary

- Short-term rainfall projections will be strongly affected by natural variability
- Longer-term rainfall projections indicate an increase near the equator, but the direction of change is uncertain outside the equator
- A warmer atmosphere will cause an increase in heavy rainfall and flash flooding
- Warmer sea surface temperatures will increase the frequency and intensity of marine heat waves
- Future greenhouse gas concentrations will heavily influence what happens after mid-century

Further reading

CSIRO and SPREP (2021). 'NextGen' Projections for the Western Tropical Pacific.
https://www.pacificmet.net/rcc/climate-projections
https://www.rccap.org/climate-change-update-for-the-pacific
https://www.rccap.org/regional-research-insights

Deo et al (2021). Tropical cyclone contribution to extreme rainfall over southwest Pacific Island nations. *Climate Dynamics*. https://doi.org/10.1007/s00382-021-05680-5

Grose, M., Chand, S., Hernaman, V., Webb, L. (2022). *Future Climate*. In: Marra et al. (Eds.), Pacific Climate Change Monitor: 2021. The Pacific Islands-Regional Climate Centre Network (PI-RCC) Report to the Pacific Islands Climate Service (PICS) Panel and Pacific Meteorological Council (PMC). DOI:10.5281/zenodo.6965143

Holbrook et al (2022). Impacts of marine heatwaves on tropical western and central Pacific Island nations and their communities. https://doi.org/10.1016/j.gloplacha.2021.103680

Thank you

For more information

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