Vanuatu North

Sub-national historical and projected climate overview

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Vanuatu North:
sub-national historical and projected climate overview

SUB-NATIONAL SUMMARY

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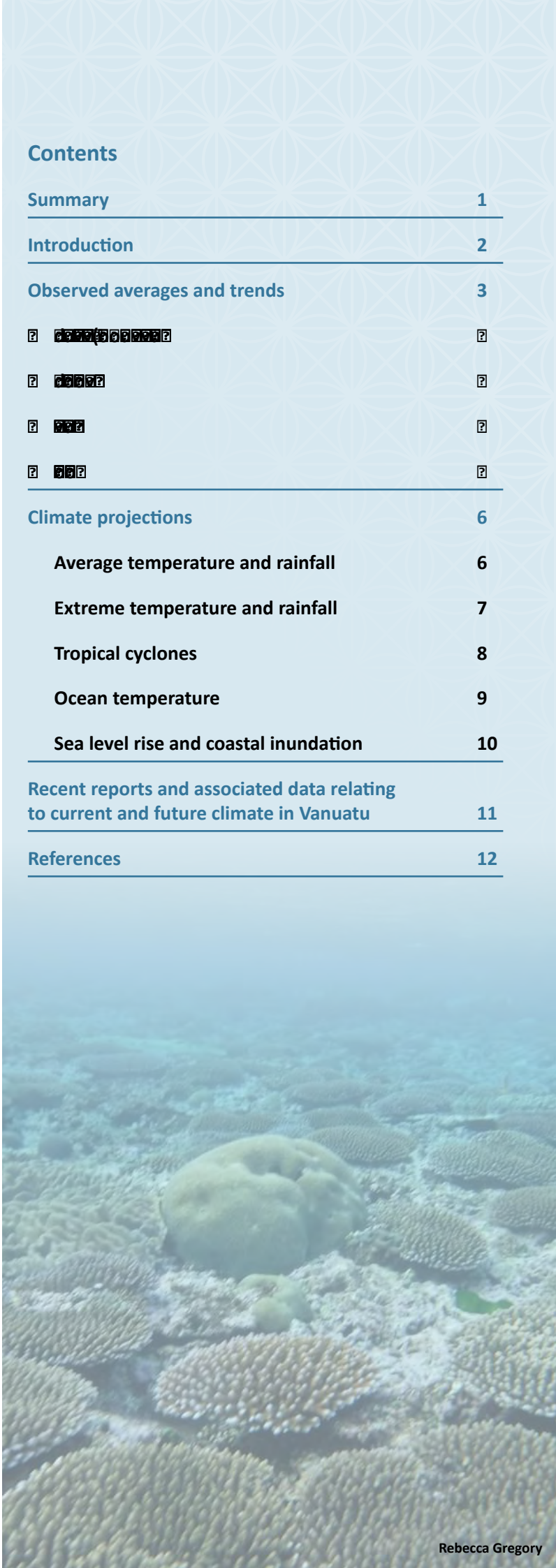
Contents

The project team would li e to ac nowledge Geo Gooley, Rebecca Gregory and Gina Ishmael for images used on the front cover



Rebecca Gregory

Summary

Vanuatu has a warmer and wetter season from November to April and a slightly cooler and drier season from May to October.

Variability in rainfall and cyclone activity is strongly a ected by the South Pacific Convergence one (SPC) and the El Ni o Southern Oscillation (ENSO). In El Ni o years, the SPC moves north-east in the western tropical Pacific, leading to drier conditions and fewer cyclones over Vanuatu. In La Ni a years, the SPC moves south-west, leading to wetter conditions and more cyclones over Vanuatu.

The climate is changing. Vanuatu has warmed by 0.7 °C since the pre-industrial period (1850 1900), hot days have increased, cold days have decreased, marine heatwaves have become more fre uent and sea level has risen. However, there has been little change in annual average rainfall or extreme daily rainfall. The number of cyclones has decreased since 1971 but the intensity has increased.

Climate projections for the 21st century are derived from climate model simulations driven by di erent greenhouse gas emissions scenarios. Temperature is projected to continue increasing, with little change in seasonal average rainfall, and an increase in extreme daily rainfall (Table 1). Sea level is projected to continue rising, with more marine heatwaves, fewer cyclones but slightly increased cyclone intensity (Table 2). Extreme La Ni a and El Ni o events are projected to increase in future.

2070 and 2090, relative to a 20-year period centred on 1995, for two greenhouse gas emissions scenarios (low RCP2.6 and high RCP8.5).
The median value is given with the 10th to 90th percentile range of uncertainty in brac ets. Source: irono et al (2023).

PERIODS	EMISSIONS	TEMPERATURE (°C)	RAINFALL NOV-APR (%)	RAINFALL MAY-OCT (%)	EXTREME RAINFALL (%)
2020-2039	[illegible]	[illegible]	[illegible]	[illegible]	
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2040-2059	[illegible]	[illegible]	[illegible]	[illegible]	
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2060-2079	RCP2.6	0.6 (0.5 to 1.0)	-1 (-10 to 7)	-1 (-22 to 8)	
	RCP8.5	1.9 (1.4 to 2.4)	1 (-13 to 9)	0 (-25 to 16)	3 (-17 to 28)
2080-2099	[illegible]	[illegible]	[illegible]	[illegible]	
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]
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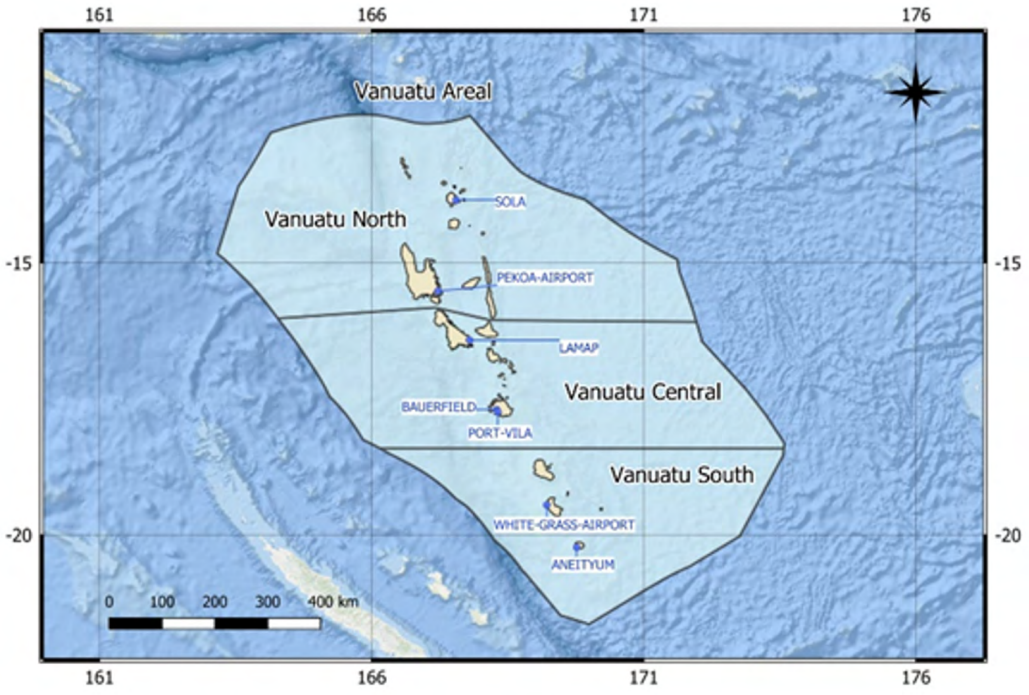
[illegible]
[illegible] [illegible] [illegible]

PERIODS	EMISSIONS	SEA LEVEL (M)	CYCLONE INTENSITY (%)	CYCLONE FREQUENCY (%)	MARINE HEATWAVES (DAYS)
2020-2039	[illegible]	[illegible]			
	[illegible]	[illegible]			
2040-2059	[illegible]	[illegible]			[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2060-2079	RCP2.6	0.32 (0.24 0.43)			
	RCP8.5	0.48 (0.37 0.64)			
2080-2099	[illegible]	[illegible]			[illegible]
	[illegible]	[illegible]	[illegible]		[illegible]

Introduction



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Observed averages and trends

Temperature and rainfall

Vanuatu's climate has two distinct seasons: a warmer, wetter season from November to April and a slightly cooler, drier season from May to October [2].

For Pe oa (Santo airport), mean monthly temperatures ranged from around 24 to 26.5 °C during the period 1971 2000 [1]. Seasonal rainfall is strongly a ected by the South Pacific Convergence one (SPC), while air temperatures are strongly connected with surrounding ocean temperatures [2].

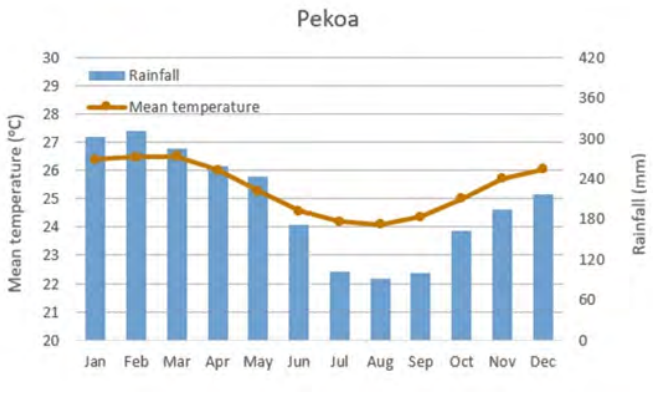


Figure 2 Mean monthly rainfall (bars) and temperature (dots and lines) for Pe oa for 1971 2000. ata source: [3].

Increasing concentrations of greenhouse gases are changing the climate. Vanuatu has warmed by 0.7 °C since the pre-industrial period (1850 1900) [4], hot days have increased, cold days have decreased, and sea level has risen. However, there has been little change in annual average rainfall, or dry spells [2]. Past mean annual temperature and rainfall variability are shown in Figure 3 [2].

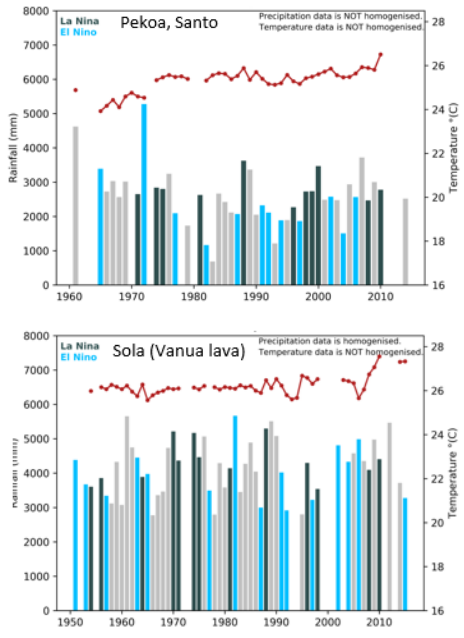


Figure Annual mean temperature red line with mar ers and rainfall bar in Pe oa and Sola see Figure 1 for the period 1 50 2017. Light blue dar blue and grey bars denote El Ni o La Ni a and neutral years respec vely. Informa on regarding whether the data has been homogenised or not is also shown. Data source: .

There has been a clear warming of the hottest day and hottest night of the year since 1950, though little change in the coldest night of the year [1] (Table 1). Increasing interannual variability for the number of warm nights and cold days since 1988 has also been detected [2]. Consistent with mean rainfall, maximum daily rainfall is highly variable year-to-year [1], with trends in annual total rainfall and extreme rainfall being small and statistically non-significant (Figure 3) [2]. The occurrence, duration and intensity of droughts (see Drought explainer varies with loca on with Sola showing a non-signi cant decrease in drought occurrence 5 .

Table 1 Daily extremes from weather sta on data. Average annual values are given with the minimum and maximum annual values in brac ets calculated over the 1 2005 baseline period. Unless otherwise noted the values are from unhomogenised data. Data source: .

Station	Annual hottest day (°C)	Annual hottest night (°C)	Annual coldest night (°C)	Annual maximum daily rainfall (mm)
Sola#	32.7 (31.5 33.2)	26.4 (25.7 27.8)	18.4 (17.0 19.9)	204 (106 301)
Pekoa Airport	32.7 (32.0 34.0)	25.4 (24.5 26.5)	15.0 (12.6 16.9)	162 (79 267)

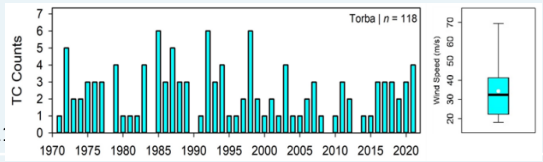
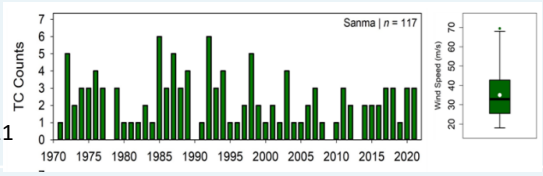
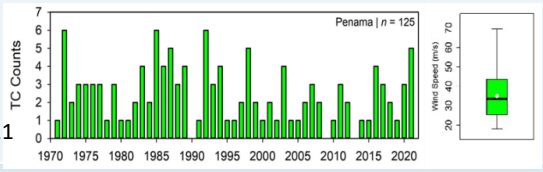
#Rainfall data for Sola are homogenised. Additionally, years with more than 10 missing data were removed and manual uality control was applied to remove obvious data errors.

The El Ni o Southern Oscillation (ENSO) is a natural, large-scale driver of climate variability in the Pacific, a ecting rainfall and temperature [2]. The El Ni o phase of ENSO is associated with droughts [5, 6]. This is because in El Ni o years the SPC moves north-east in the Pacific, leading to drier conditions over Vanuatu. In La Ni a years the SPC moves south-west, leading to wetter conditions over Vanuatu [7]. Monthly mean historical data presented as maps, with a focus on ENSO in uences on temperature and rainfall, have recently been prepared [8] (also see Climate variability explainer .

Tropical cyclones

The fre uency of tropical cyclones (TCs) a ecting the whole Vanuatu Archipelago has declined by 28 over the period 1996 2021 compared with 1971 1995 [9]. Cyclone attributes for Vanuatu North are presented in Table 2. Observed cyclone numbers have been higher in the south than the north of Vanuatu [9].

Table 2 Observed number (n) of cyclones that have occurred within 500 m of selected provinces in Vanuatu North (1971 2021). Wind speed distributions (boxplots) for the same period are also shown, where the blac line represents the median and white dot is the mean. (ata source: SPEArTC [10]).

Province	TCs/ season	Average wind speed (m/s)
Torba	2.31	34.29
fre uency for 1 71 202		
Sanma	2.30	35.01
fre uency for 1 71 2021		
Penama	2.45	35.00
fre uency for 1 71 2021		

The proportion of severe tropical cyclones (winds greater than 17.5 m/s) has increased over recent decades in Vanuatu, consistent with expectations due to climate change [11]. The severity (i.e. wind speed intensities) of TCs passing near Vanuatu has increased by 15 over the period 1996 2021 compared with 1971 1995 [9], due to an increase in greenhouse gases [12].

The TC-related, mean seasonal, maximum daily rainfall has increased considerably over recent decades (i.e. 20 mm per day between the periods 1970 1993 and 1994 2018) [13].

TCs within 500 m of Vanuatu have been more fre uent during La Ni a years (13 cyclones per decade) than during El Ni o and neutral years (9 cyclones per decade) [9].

For more details, see the Tropical cyclone explainer.

Ocean temperature

In Vanuatu, annual average sea surface temperatures (SST) range from about 25.5 °C to 28.5 °C, from south to north (Figure 4). For Vanuatu North, which is the warmest of the 3 sub-national climate ones, SST ranges from 27.5 to 28.5 °C.

Through the period 1982 2021 the SST has been warming in Vanuatu North, with Sola, Vanua Lava shown here as an example (Figure 4 top). While the number of marine heatwaves (MHWs) is around 25 per year on average, the total number and severity of MHW events has been increasing (Figure 4 third from top), and this is evident across the region more generally (Figure 4 bottom). For more information on MHW categories see theMHW explainer.

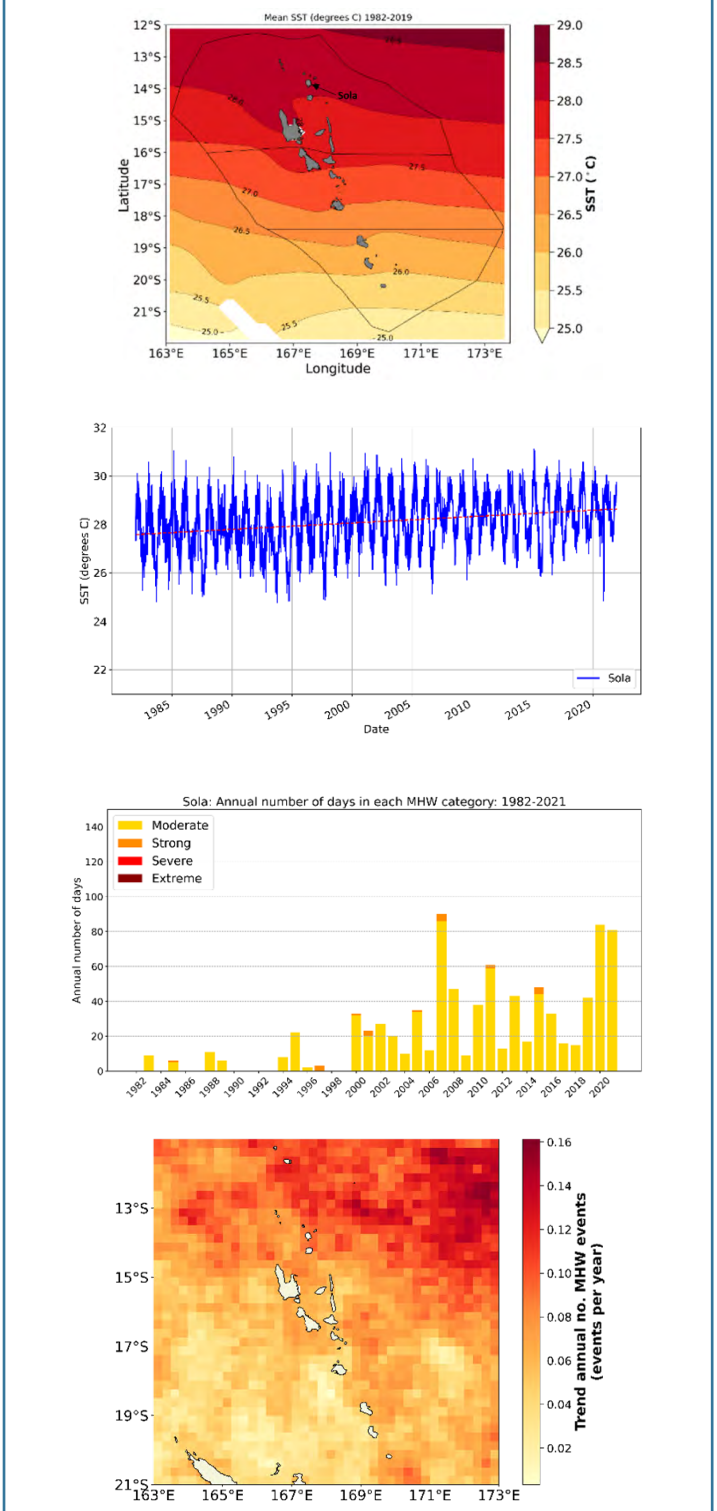


Figure Vanuatu mean SST C 1 2 201 top . SST C from 1 2 2021 for Sola blue line second from top . Annual number of days in each marine heatwave category over the period 1 2 2021 third from top . Trend in annual number of MHW events bo om . Events are de ned as: a discrete prolonged and anomalously warm water event which lasts for ve or more days with temperatures warmer than the 0th percen le. MHWs are considered as separate events if they are separated from a previous MHW by more than two days Hobday et al. 1 15 . Source data: NOAA OISST v2-1 SST 1 .

For Vanuatu North Sola was assessed for heatwave characteris cs through the period 1 2 2021. Most sites experienced MHWs that were in the Moderate or Strong category. All sites showed higher incidence of MHW days in later years compared to earlier years. See MHW explainer .

Sea level

In the western tropical Pacific, including around Vanuatu, sea levels measured by satellites have risen faster than in the central and eastern parts of the tropical Pacific [17], by about 10 15 mm since 1993 [18] (Figure 5).

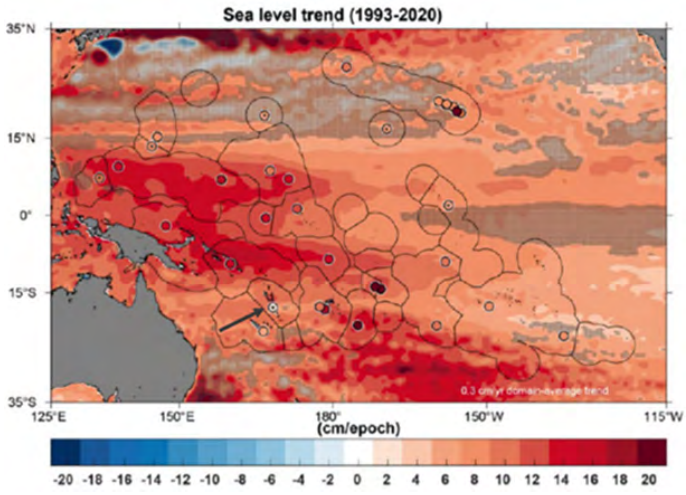


Figure 5 Sea level trends (cm) from satellite altimetry (shaded contours) and sea level trends from tide gauges (circles) during 1993 2020. Trends that are less than interannual variability, which is determined by the standard deviation of monthly anomalies, are indicated by hatching and circles with dots for the altimetry and tide gauges respectively. An arrow points to Port Vila in Vanuatu. Source: [18]

Port Vila has experienced less sea level rise relative to the land because vertical land motion due to earth ua es, around 2008, o set some of the e ect of sea level rise [19]. For the period 1993 2020 the Port Vila tide gauge, which measures water levels relative to land, indicates no long-term trend in sea level (Figure 5, arrow). The coastal ood fre uency has not increased for Port Vila, counter to the overall increasing ood fre uency trends for the Pacific region. This countertrend may change in the future depending on whether local vertical land motion eeps pace with sea level rise.

The interannual-to-multidecadal variability of SST, rainfall, and relative sea level around Vanuatu is in uenced by ENSO. Above normal sea levels were recently observed during the prolonged 2020 2023 La Ni a event [20] (see Climate variability explainer .

[redacted]

Climate projections

Climate projections for the coming decades are a ected by uncertainty about future greenhouse gas concentrations, regional climate responses to those gases, and natural climate variability. Emissions pathways (see Greenhouse gas emissions factsheet range from very low to very high and are based on plausible assump ons about future demographic change socio-economic development energy use land use and air pollu on. Climate models see Climate models factsheet are driven by projected changes in greenhouse gas and aerosol concentra ons to es mate future changes in regional climate. There are do ens of climate models each of which produces a uni ue simula on of future climate. The simula ons include natural climate variability see Climate variability explainer on a range of spa al and temporal scales including daily/local weather and yearly/regional climate extremes due to factors such as ENSO.

Average temperature and rainfall

The mean annual temperature for Vanuatu North is projected to increase (Figure 6, top three plots), adding to the historical warming. The projections are similar for all three sub-national ones and across the wet and dry season. The magnitude of warming is highly dependent on the greenhouse gas emissions pathways, with the largest temperature increase under a high emissions pathway (RCP8.5) [1].

There is significant uncertainty about projected change in annual average rainfall for Vanuatu including Vanuatu North (Figure 6, bottom three plots). Some climate models show an increase, others show a decrease. There is a slight tendency for the multi-model median to show a reduction in rainfall in the dry season, and this tendency becomes more pronounced in the latter part of the 21st century under all emissions pathways [1].

Figure 6 Vanuatu North average temperature (top three plots) and rainfall (bottom three plots) for 1910 2090 as simulated by up to 38 global climate models relative to the 1986 2005 baseline. The thic line is the multi-model median value, and the shading is the 10th and 90th percentile range of 20-year running means (inner) and single year

simulation, while the future scenarios are shown with colour-coded shading: high RCP8.5 (purple), medium RCP4.5 (blue) and low RCP2.6 (green). An example of a climate model annual time series is shown as the thin purple line. See irono et al. [1] for associated data.

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