Marine Thermal Stress in French Polynesia: Historical Trends and Future Projections of Sea Surface Temperature and Marine Heatwaves Across Five Island Groups

the climate centre

Marine Thermal Stress in French Polynesia: Historical Trends and Future Projections of Sea Surface Temperature and Marine Heatwaves Across Five Island Groups

Introduction

- French Polynesia comprises more than 120 islands and atolls across approximately 2000 kilometres in the South Pacific Ocean, and is divided into five island groups: the Austral Islands (including the Bass Islands); the Gambier Islands; the Marquesas Islands; the Society Islands (comprising the Leeward and Windward Islands); and the Tuamotus.
- These five island groups are classified somewhat differently according to their administrative divisions: Austral Islands, Leeward Islands, Marquesas Islands, Tuamotu-Gambier Islands, and the Windward Islands.
- French Polynesia is known for its extensive coral reef systems and its rich marine biodiversity, including more than 1000 fish species, approximately 1500 varieties of mollusk, almost 1000 crustaceans, and approximately 200 coral species, with animals such as whales, turtles, rays, sharks and dolphins using archipelago lagoons and surrounding open ocean for feeding, breeding, and migration corridors (Palomares et al 2021; Purkis et al 2017).
- Some of the species endemic to the area include the Tuamotu sandpiper, the Mangareva kingfisher, the Tahiti butterflyfish, the Marquesas surgeonfish, and the Conasprella pepeiu, with many of these species sensitive to ocean stressors such as elevated temperatures and ocean acidification, as well as overfishing and negative impacts from tourism and coastal development.
- Sea surface temperatures (SSTs) in French Polynesia, measured at Tahiti and Moorea, have historically been within 25 °Cto 30 °C (Penin et al 2007), with notable coral bleaching events occurring in 1991, 1994, 2002, 2007, 2016 and 2019 (Pratchett et al. 2013; NCCOS 2025). Even modest marine heatwaves can trigger coral bleaching and disrupt the life cycles of endemic species.
- Conservation initiatives such as Marine Protected Areas (MPAs) aim to safeguard biodiversity hotspots, and ongoing scientific programs such as the Pacific Islands Global Ocean Observing System (PIGOOS) and ReefTEMPS, combine satellite data, autonomous buoys, and community-based monitoring to track ocean metrics including SST and provide essential inputs for adaptive management and climate-adaptation planning (Pacific Community, n.d.; ReefTEMPS, 2025).
- While operational monitoring networks provide ongoing SST observations, targeted studies are needed to analyse spatial and temporal patterns in warming rates across the archipelago's diverse reef environments, and also under future climate scenarios, with consideration to geographies that relate to administrative areas and not only physical geographic features.

Fig. 1 Habitats and life found in French Polynesia: Pink whipray and reef sharks (top left), Green turtle (top middle), Antler coral and blue damselfish (top right), islands, coral reefs and lagoons (bottom left), Tahiti butterflyfish (bottom middle), and the Mangareva kingfisher (bottom right).

Methods

- This study used reanalysis SST data to determine thermal historical conditions and warming trends, and CMIP6 model data to infer potential future sea surface temperature states under a SSP5-8.5 scenario, across areas of ocean around islands and atolls with respect to administrative divisions of the Austral Islands, Leeward Islands, Marquesas Islands, Tuamotu-Gambier Islands, and Windward Islands.
- 5-kilometre resolution SST data from Coral Reef Watch (NOAA Coral Reef Watch, 2019), and SST data from the ERA5 reanalysis dataset (Hersbach et al. 2018), was used for historical conditions from 1985 to present, and 1940 to present, respectively; while CMIP6 data from HadGEM3 was used to infer potential future sea surface temperature states under a SSP5-8.5 scenario (Roberts, 2019).
- Data was masked geographically to within a 1-degree radius around islands and atolls as defined by geographic shapefile data from the Database of Global Administrative Areas for the administrative subdivisions of French Polynesia (GADM, 2025) and spatially averaged.
- ERA5 data was compared to Coral Reef Watch data to assess the margin of difference between the two datasets over the period 1985 to 2024; while overlap in datasets between these reanalysis products and CMIP6 data over the period 2015 to 2024 was also investigated to assess accuracy of CMIP6 modelling. Comparisons were achieved through linear regression and calculating statistical differences.
- Rate of change in the average SST for each administrative division was determined based on linear regression, and extreme value analysis was used to characterise ocean temperatures across various return periods (10, 20, 50 and 100 years), while correlation analysis was undertaken using the Southern Oscillation Index to understand climate teleconnections (Bureau of Meteorology, 2025).

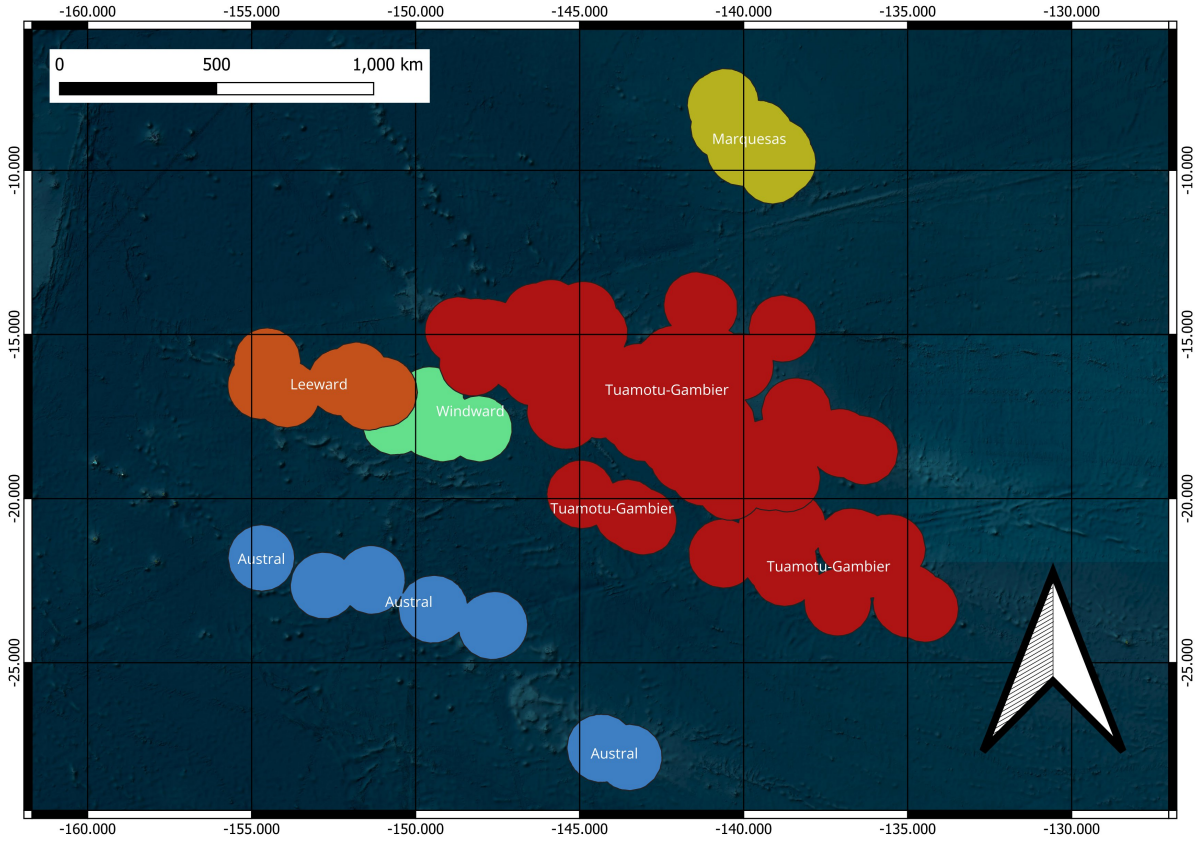

Fig. 2 Geographical masking was applied to datasets within a 1-degree radius around islands and atolls for each of the five administrative areas to calculate average sea surface temperatures (SSTs).

Results

Austral Islands

- According to analysis of ERA5 data the rate of change of mean sea surface temperatures (SSTs) in the Austral Islands from 1940 to 2024 was 0.0061 °C per annum (R^2=0.175, p=0.0001), while that rate was lower for minimum temperatures (0.0055 °C yr^{-1}, R^2=0.074, p=0.0118), but higher for maximum temperatures (0.0117 °C yr^{-1}, R^2=0.216, p=0.0000).
- The rate from 1985 to 2024 based on ERA5 data for mean temperatures was higher at 0.0131 °C per annum (R^2=0.195, p=0.0043), and also higher for maximum and minimum temperatures (0.0094 °C yr^{-1}, R^2=0.038, p=0.2256, and 0.0167 °C yr^{-1}, R^2=0.208, p=0.0031, respectively).
- The rate from 2015 to 2024 based on ERA5 data was higher again for mean temperatures at 0.0383 °C per annum (R^2=0.097, p=0.3811), and also higher for maximum and minimum temperatures (0.0492 °C yr^{-1}, R^2=0.075, p=0.4432, and 0.0426 °C yr^{-1}, R^2=0.110, p=0.3497, respectively). The low sample size of this period may be responsible for the low confidence in these values.
- According to analysis of Coral Reef Watch (CRW) data the rate of change of mean sea surface temperatures in the Austral Islands from 1985 to 2024 was 0.0175 °C per annum (R^2=0.316, p=0.0001), while that rate was higher for

minimum temperatures (0.0277 °C yr^{-1}, R^2=0.395, p=0.0000), but lower for maximum temperatures (0.0132 °C yr^{-1}, R^2=0.068, p=0.1000).

- The rate from 2015 to 2024 based on CRW data was higher for mean temperatures at 0.0455 °C per annum (R^2=0.166, p=0.2131), and also higher for maximum and minimum temperatures (0.0806 °C yr^{-1}, R^2=0.211, p=0.1552, and 0.0291 °C yr^{-1}, R^2=0.067, p=0.4416, respectively). The low sample size of this period may be responsible for the low confidence in these values.
- ERA5 and CRW data was well-correlated for the Austral Islands over the period 1985 to 2024 (max R = 0.9348, mean R = 0.9778, min R = 0.9469, all p=0.0000), and there were no significant differences between the values (max: t=0.168, p=0.8674, d=0.037; mean: t=0.629, p=0.5309, d=0.141; min: t=0.906, p=0.3678, d=0.204).
- According to HadGEM3 data, temperatures over the period 2025 to 2050 increased at a rate of 0.0443 °C per annum for mean temperatures (R^2=0.541, p=0.0000), with maximum temperatures increasing at an even greater rate (0.0502 °C yr^{-1}, R^2=0.339, p=0.0018), and minimum temperatures increasing at a lower rate (0.0403 °C yr^{-1}, R^2=0.364, p=0.0011). These rates were somewhat comparable to those already observed in ERA5 and CRW data in the period 2015 to 2024.
- While CRW and HadGEM3 data overlapped during the period 2015 to 2024, values were significantly differently for mean and minimum temperatures (CRW mean: 24.71 °C, 95% CI: ±0.27, HadGEM3 mean: 23.48 °C, 95% CI: ±0.25, t=7.591, p=0.0000, d=3.396; CRW min: 22.42 °C, 95% CI: ±0.28, HadGEM3 min: 21.09 °C, 95% CI: ±0.22, t=8.404, p=0.0000, d=3.785). Average temperatures for the Austral Islands in CMIP6 data was below those values observed in both ERA5 and CRW data over the period 2015 to 2024 (Figure 3).

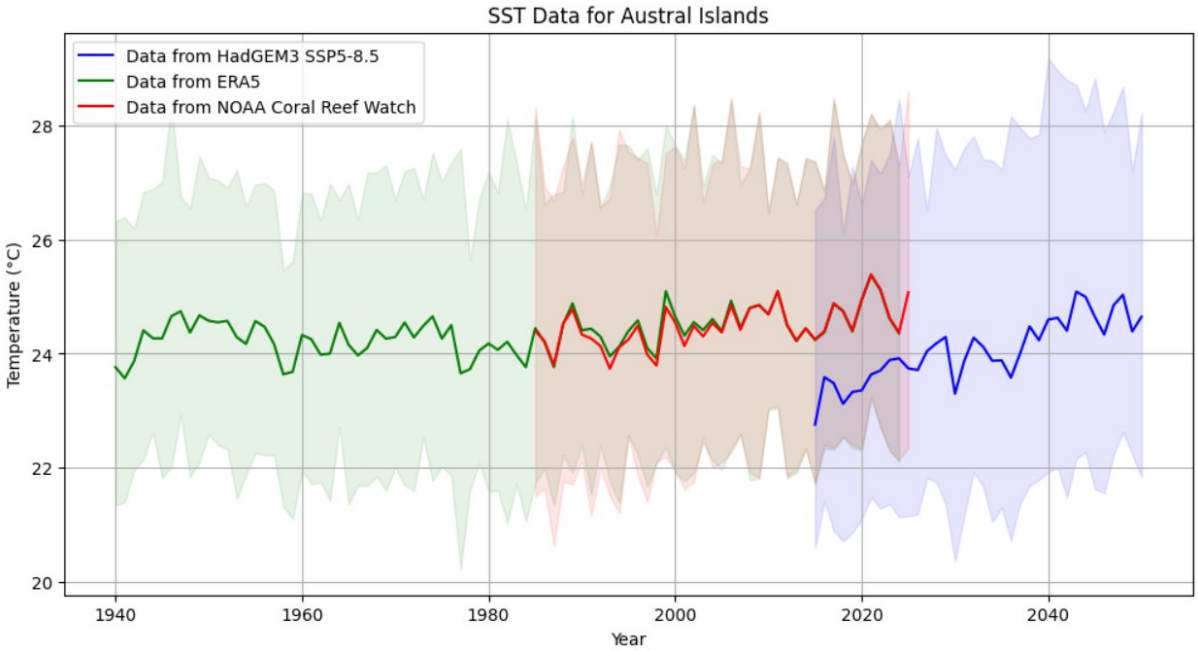

Fig. 3 SST data for the Austral Islands in the ERA5, CRW, and HadGEM3 datasets. Mean values are represented by solid colour lines while maximum to minimum ranges are represented by shaded areas.

Leeward Islands

- According to analysis of ERA5 data the rate of change of mean sea surface temperatures in the Leeward Islands from 1940 to 2024 was 0.0037 °Cper annum (R^2=0.122, p=0.0011), while that rate was lower for minimum temperatures (0.0009 °C yr^{-1}, R^2=0.004, p=0.5530), but higher for maximum temperatures (0.0081 °C yr^{-1}, R^2=0.199, p=0.0000).
- The rate from 1985 to 2024 based on ERA5 data for mean temperatures was higher at 0.0121 °C per annum (R^2=0.291, p=0.0003), and also higher for maximum and minimum temperatures (0.0109 °C yr^{-1}, R^2=0.082, p=0.0731, and 0.0134 °C yr^{-1}, R^2=0.291, p=0.0003, respectively).
- However, the rate from 2015 to 2024 based on ERA5 data was not only lower, but trending down for mean temperatures at -0.0277 °C per annum (R^2=0.169, p=0.2380), and also for maximum and minimum temperatures (-0.0284 °C yr^{-1}, R^2=0.036, p=0.6013, and -0.0010 °C yr^{-1}, R^2=0.000, p=0.9685, respectively). The low sample size of this period may be responsible for the low confidence in these values.
- According to analysis of Coral Reef Watch (CRW) data the rate of change of mean sea surface temperatures in the Leeward Islands from 1985 to 2024 was 0.0141 °C per annum (R^2=0.366, p=0.0000), while that rate was higher for minimum temperatures (0.0270 °C yr^{-1}, R^2=0.509, p=0.0000), but lower for maximum temperatures (0.0024 °C yr^{-1}, R^2=0.004, p=0.6864).
- The rate from 2015 to 2024 based on CRW data was not only lower for mean temperatures, but also negative at -0.0089 °C per annum (R^2=0.020, p=0.6769), and so were for maximum temperatures (-0.0214 °C yr^{-1}, R^2=0.025, p=0.6411), while minimum temperatures had increased, but at a lower rate than for the previous period (0.0183 °C yr^{-1}, R^2=0.065, p=0.4488). The low sample size of this period may be responsible for the low confidence in these values.
- ERA5 and CRW data was well-correlated for Leeward Islands over the period 1985 to 2024 (max R = 0.8598, mean R = 0.9599, min R = 0.8252, all p=0.0000), and there were no signficant differences between the values (max: t=-0.855, p=0.3949, d=-0.191; mean: t=0.113, p=0.9103, d=0.025; min: t=0.692, p=0.4913, d=0.158).
- According to HadGEM3 data, temperatures over the period 2025 to 2050 increased at a rate of 0.0529 °C per annum for mean temperatures (R^2=0.741, p=0.0000), with maximum temperatures increasing at a lower rate (0.0478 °C yr^{-1}, R^2=0.332, p=0.0021), and minimum temperatures increasing at a greater rate (0.0562 °C yr^{-1}, R^2=0.454, p=0.0002).
- CRW and HadGEM3 data was significantly differently over the period 2015 to 2024 for all temperatures (CRW max: 29.77 °C, 95% CI: ±0.34, HadGEM3 max: 30.19 °C, 95% CI: ±0.28, t=-2.162, p=0.0443, d=-0.971; CRW mean: 28.16 °C, 95% CI: ±0.15, HadGEM3 mean: 27.73 °C, 95% CI: ±0.20, t=3.849, p=0.0012, d=1.744; CRW min: 26.67 °C, 95% CI: ±0.14, HadGEM3 min: 26.04 °C, 95% CI: ±0.27, t=4.695, p=0.0002, d=2.200).

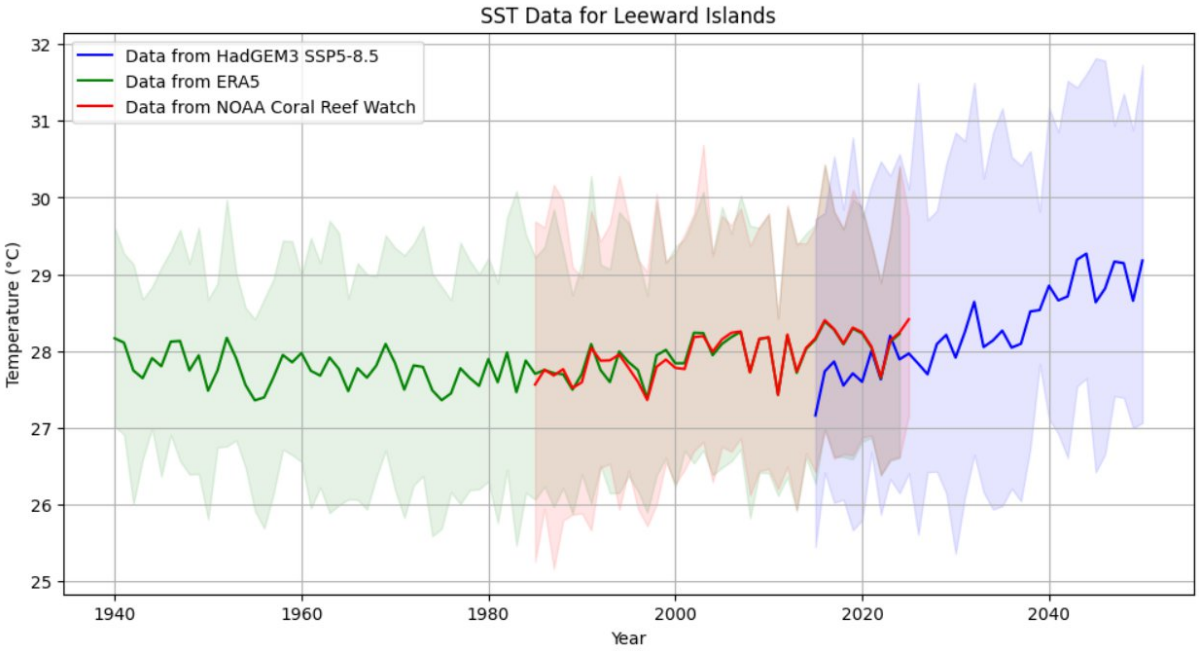

Fig. 4 SST data for the Leeward Islands in the ERA5, CRW, and HadGEM3 datasets. Mean values are represented by solid colour lines while maximum to minimum ranges are represented by shaded areas.

Marquesas Islands

- According to analysis of ERA5 data the rate of change of mean sea surface temperatures in the Marquesas Islands from 1940 to 2024 was 0.0039 °C per annum (R^2=0.046, p=0.0480), while that rate was higher for minimum temperatures (0.0057 °C yr^{-1}, R^2=0.079, p=0.0093), and also higher for maximum temperatures (0.0050 °C yr^{-1}, R^2=0.040, p=0.0681).
- The rate from 1985 to 2024 based on ERA5 data for mean temperatures was lower and negative at -0.0028 °C per annum (R^2=0.005, p=0.6521), and also loewr and negative for both maximum and minimum temperatures (-0.0046 °C yr^{-1}, R^2=0.007, p=0.5952, and -0.0031 °C yr^{-1}, R^2=0.006, p=0.6315, respectively). However, there was a low confidence in all these values.
- The rate from 2015 to 2024 based on ERA5 data was also negative for mean temperatures at -0.0601 °C per annum (R^2=0.112, p=0.3440), and also for maximum and minimum temperatures (-0.0974 °C yr^{-1}, R^2=0.139, p=0.2891, and -0.0301 °C yr^{-1}, R^2=0.060, p=0.4953, respectively). The low sample size of this period may be responsible for the low confidence in these values.
- According to analysis of Coral Reef Watch (CRW) data the rate of change of mean sea surface temperatures in the Marquesas Islands from 1985 to 2024 was 0.0021 °C per annum (R^2=0.003, p=0.7240), while that rate was higher for minimum temperatures (0.0190 °C yr^{-1}, R^2=0.189, p=0.0045), but lower and negative for maximum temperatures (-0.0152 °C yr^{-1}, R^2=0.077, p=0.0792).
- The rate from 2015 to 2024 based on CRW data was negative at -0.0381 °C per annum (R^2=0.060, p=0.4691), and similarly negative for maximum temperatures (-0.0659 °C yr^{-1}, R^2=0.088, p=0.3766), and minimum temperatures (-0.0272 °C yr^{-1}, R^2=0.065, p=0.4488). The low sample size of this period may be responsible for the low confidence in these values.

- ERA5 and CRW data was well-correlated for Marquesas Islands over the period 1985 to 2024 (max R = 0.9327, mean R = 0.9820, min R = 0.7260, all p=0.0000), and there were no signficant differences between the values (max: t=-0.681, p=0.4976, d=-0.152; mean: t=0.413, p=0.6806, d=0.092; min: t=1.745, p=0.0849, d=0.391).
- According to HadGEM3 data, temperatures over the period 2025 to 2050 increase at a rate of 0.0486 °Cper annum for mean temperatures (R^2=0.323, p=0.0024), with maximum temperatures increasing at a lower rate (0.0462 °C yr^{-1}, R^2=0.279, p=0.0055), and minimum teperatures increasing at a greater rate (0.0555 °C yr^{-1}, R^2=0.339, p=0.0018).
- CRW and HadGEM3 data was significantly differently over the period 2015 to 2024 for all temperatures (CRW max: 29.15 °C, 95% CI: ±0.56, HadGEM3 max: 30.01 °C, 95% CI: ±0.38, t=-2.881, p=0.0099, d=-1.311; CRW mean: 27.94 °C, 95% CI: ±0.39, HadGEM3 mean: 28.51 °C, 95% CI: ±0.25, t=-2.807, p=0.0117, d=-1.287; CRW min: 26.92 °C, 95% CI: ±0.27, HadGEM3 min: 27.52 °C, 95% CI: ±0.34, t=-3.124, p=0.0059, d=-1.407).

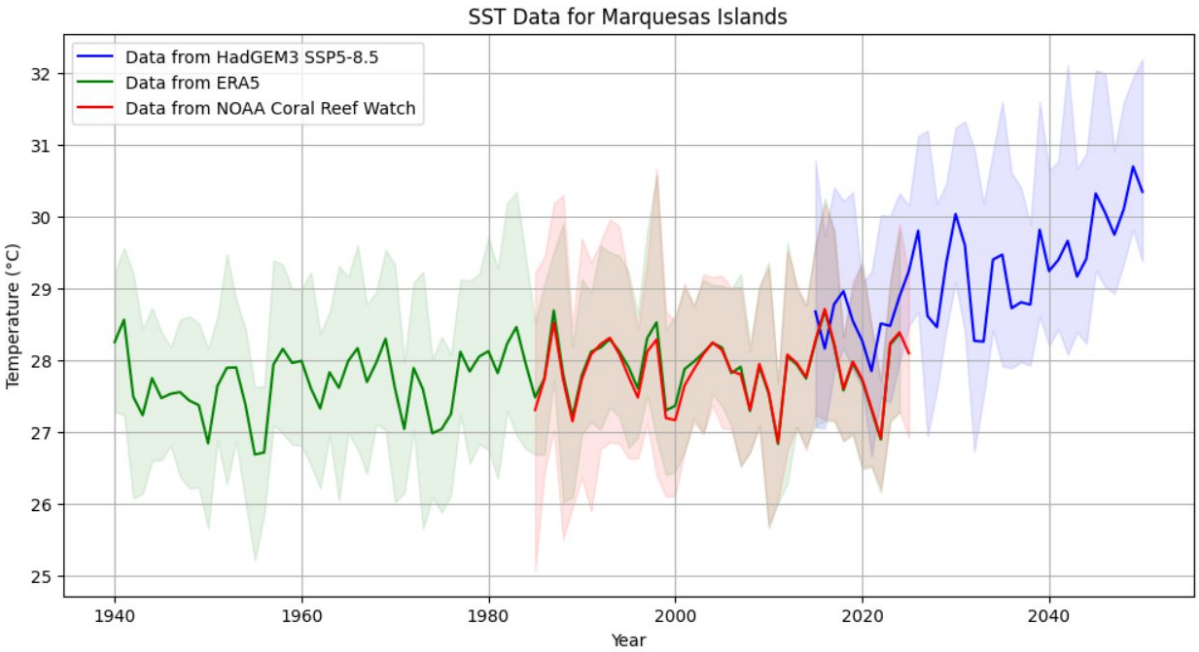

Fig. 5 SST data for the Marquesas Islands in the ERA5, CRW, and HadGEM3 datasets. Mean values are represented by solid colour lines while maximum to minimum ranges are represented by shaded areas.

Tuamotu-Gambier Islands

- According to analysis of ERA5 data the rate of change of mean sea surface temperatures in the Tuamotu-Gambier Islands from 1940 to 2024 was 0.0036 °C per annum (R^2=0.152, p=0.0002), while that rate was lower for minimum temperatures (0.0021 °C yr^{-1}, R^2=0.034, p=0.0903), and higher for maximum temperatures (0.0059 °C yr^{-1}, R^2=0.162, p=0.0001).
- The rate from 1985 to 2024 based on ERA5 data for mean temperatures was lower at 0.0025 °C per annum (R^2=0.018, p=0.4048), with differing trends for maximum and minimum temperatures (0.0044 °C yr^{-1}, R^2=0.017, p=0.4278,

and -0.0003 °C yr^{-1}, R^2=0.000, p=0.9287, respectively). However, there was a low confidence in all these values.

- The rate from 2015 to 2024 based on ERA5 data was also negative for mean temperatures at -0.0164 °C per annum (R^2=0.069, p=0.4623), with differing trends for maximum and minimum temperatures (0.0036 °C yr^{-1}, R^2=0.001, p=0.9445, and -0.0333 °C yr^{-1}, R^2=0.315, p=0.0912, respectively). The low sample size of this period may be responsible for the low confidence in these values.
- According to analysis of Coral Reef Watch (CRW) data the rate of change of mean sea surface temperatures in the Tuamotu-Gambier Islands from 1985 to 2024 was 0.0080 °C per annum (R^2=0.165, p=0.0084), while that rate was higher for minimum temperatures (0.0168 °C yr^{-1}, R^2=0.314, p=0.0001), but lower and negative for maximum temperatures (-0.0005 °C yr^{-1}, R^2=0.000, p=0.9276).
- The rate from 2015 to 2024 based on CRW data was 0.0038 C per annum (R^2=0.004, p=0.8580), with differing trends for maximum and minimum temperatures (0.0210 °C yr^{-1}, R^2=0.027, p=0.6287, and -0.0009 °C yr^{-1}, R^2=0.000, p=0.9721, respectively). The low sample size of this period may be responsible for the low confidence in these values.
- ERA5 and CRW data was well-correlated for Tuamotu-Gambier Islands for maximum and mean temperatures over the period 1985 to 2024, while only moderately correlated for minumum temperatures (max R = 0.8774, mean R = 0.9357, min R = 0.6635, all p=0.0000), and there were only signficant differences for minimum temperature values (max: t=-0.428, p=0.6700, d=-0.096; mean: t=1.276, p=0.2056, d=0.285; min: t=2.217, p=0.0295, d=0.500, ERA5 min: 25.39 °C, 95% CI: ±0.08, CRW min: 25.24 °C, 95% CI: ±0.11).
- According to HadGEM3 data, temperatures over the period 2025 to 2050 increase at a rate of 0.0550 °Cper annum for mean temperatures (R^2=0.805, p=0.0000), with maximum temperatures increasing at a lower rate (0.0491 °C yr^{-1}, R^2=0.400, p=0.0005), and minimum teperatures increasing at a greater rate (0.0600 °C yr^{-1}, R^2=0.614, p=0.0000).
- CRW and HadGEM3 data was significantly differently over the period 2015 to 2024 for mean and minimum temperatures (max: t=-1.677, p=0.1107, d=-0.763; CRW mean: 27.15 °C, 95% CI: ±0.13, HadGEM3 mean: 26.80 °C, 95% CI: ±0.15, t=3.993, p=0.0009, d=1.788; CRW min: 25.44 °C, 95% CI: ±0.13, HadGEM3 min: 24.85 °C, 95% CI: ±0.18, t=5.979, p=0.0000, d=2.704).

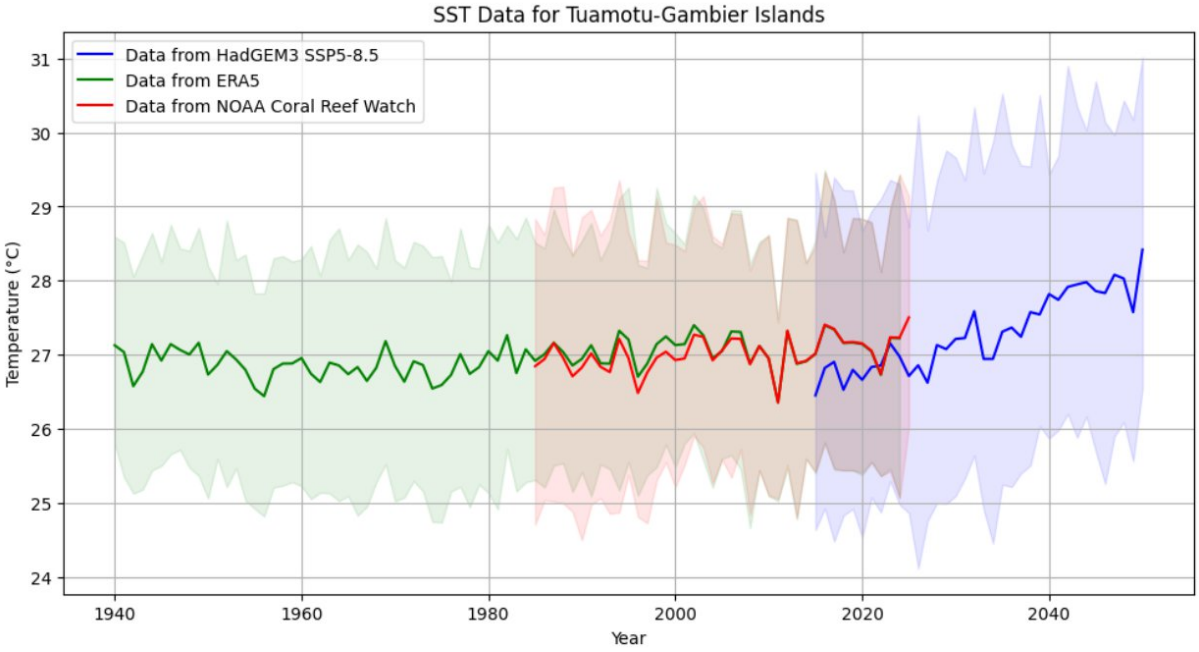

Fig. 6 SST data for the Tuamotu-Gambier Islands in the ERA5, CRW, and HadGEM3 datasets. Mean values are represented by solid colour lines while maximum to minimum ranges are represented by shaded areas.

Windward Islands

- According to analysis of ERA5 data the rate of change of mean sea surface temperatures in the Windward Islands from 1940 to 2024 was 0.0050 °C per annum (R^2=0.202, p=0.0000), while that rate was lower for minimum temperatures (0.0030 °C yr^{-1}, R^2=0.038, p=0.0733), and higher for maximum temperatures (0.0089 °C yr^{-1}, R^2=0.257, p=0.0000).
- The rate from 1985 to 2024 based on ERA5 data for mean temperatures was higher at 0.0119 °C per annum (R^2=0.288, p=0.0004), and also higher both for maximum and minimum temperatures (0.0112 °C yr^{-1}, R^2=0.104, p=0.0428, and 0.0141 °C yr^{-1}, R^2=0.276, p=0.0005, respectively). However, there was a low confidence in all these values.
- The rate from 2015 to 2024 based on ERA5 data was negative for mean temperatures at -0.0229 °C per annum (R^2=0.188, p=0.2106), also negative for maximum and minimum temperatures (-0.0341 °C yr^{-1}, R^2=0.080, p=0.4290, and -0.0068 °C yr^{-1}, R^2=0.011, p=0.7735, respectively). The low sample size of this period may be responsible for the low confidence in these values.
- According to analysis of Coral Reef Watch (CRW) data the rate of change of mean sea surface temperatures in the Windward Islands from 1985 to 2024 was 0.0119 °C per annum (R^2=0.306, p=0.0002), while that rate was higher for minimum temperatures (0.0288 °C yr^{-1}, R^2=0.468, p=0.0000), but lower for maximum temperatures (0.0018 °C yr^{-1}, R^2=0.002, p=0.7632).
- The rate from 2015 to 2024 based on CRW data was -0.0033 °C per annum (R^2=0.004, p=0.8561), with differing trends for maximum and minimum temperatures (-0.0215 °C yr^{-1} , R^2=0.042, p=0.5471, and 0.0228 °C yr^{-1}, R^2=0.083, p=0.3891, respectively). The low sample size of this period may be responsible for the low confidence in these values.

- ERA5 and CRW data was well-correlated for Windward Islands for temperatures over the period 1985 to 2024 (max R = 0.7999, mean R = 0.9412, min R = 0.8366, all p=0.0000), and there were no signficant differences between datasets (max: t=-1.248, p=0.2159, d=-0.279; mean: t=-0.428, p=0.6700, d=-0.096; min: t=0.990, p=0.3250, d=0.227).
- According to HadGEM3 data, temperatures over the period 2025 to 2050 increase at a rate of 0.0525 °Cper annum for mean temperatures (R^2=0.726, p=0.0000), with both maximum and minimum temperatures increasing at a lower rate (0.0434 °C yr^{-1}, R^2=0.369, p=0.0010, and 0.0492 °C yr^{-1}, R^2=0.471, p=0.0001, respectively).
- CRW and HadGEM3 data was significantly differently over the period 2015 to 2024 for all temperatures (CRW max: 29.56 °C, 95% CI: ±0.26, HadGEM3 max: 30.02 °C, 95% CI: ±0.29, t=-2.643, p=0.0165, d=-1.184; CRW mean: 27.77, 95% CI: ±0.11, HadGEM3 mean: 27.28 °C, 95% CI: ±0.20, t=4.695, p=0.0002, d=2.180; CRW min: 26.14 °C, 95% CI: ±0.14, HadGEM3 min: 25.45 °C, 95% CI: ±0.27, t=5.035, p=0.0001, d=2.356).

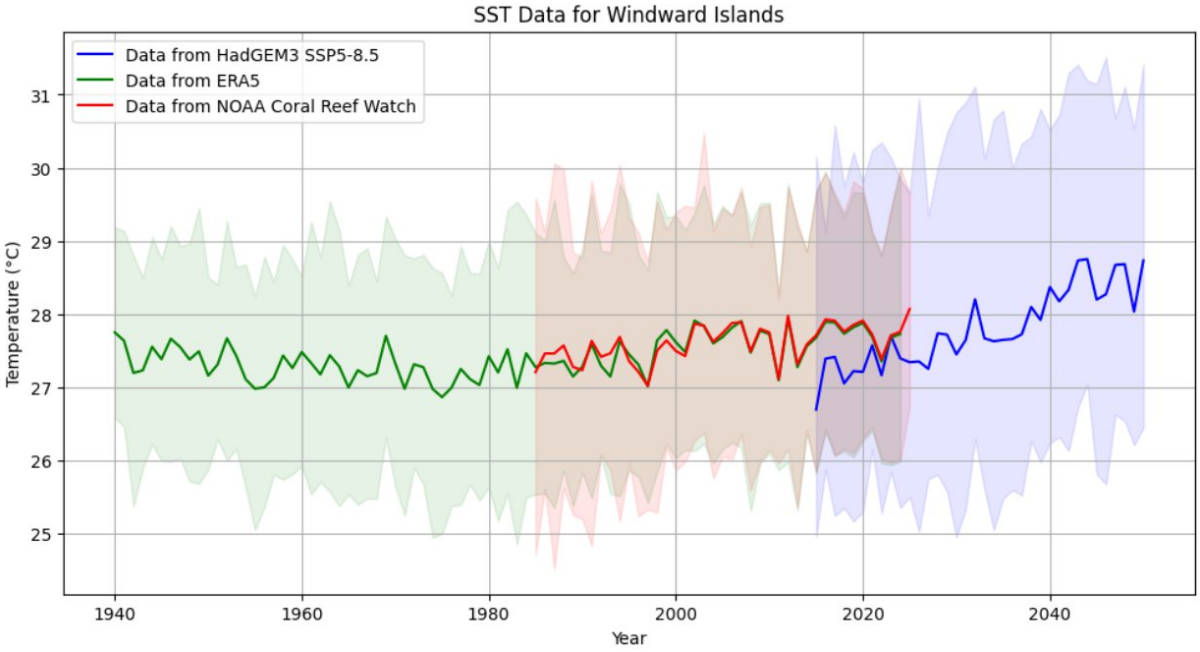

Fig. 7 SST data for the Windward Islands in the ERA5, CRW, and HadGEM3 datasets. Mean values are represented by solid colour lines while maximum to minimum ranges are represented by shaded areas.

SOI Comparison and Return Period Analysis

- Both ERA5 and CRW data was compared against the Southern Oscillation Index on a monthly basis, revealing only Marquesas Islands having any notable correlation (R = -0.49 for CRW data, and R = -0.48 for ERA5 data), with a majority of locations being poorly correlated (ranging from R = -0.03 for Windward Islands based on CRW data to R = 0.20 for Austral Islands also based on CRW data).

- Results from return period analysis is shown below indicating locations may experience a 0.3 – 0.6 °C greater temperature in extremes calculated over a 100 year return period when compared to a 10 year return period.
- The Austral Islands experienced the coolest extreme SSTs (~ 28.6 °C for a 100-yr event), implying that even the most severe heatwaves here remained below other thresholds elsewhere in French Polynesia.
- The Leeward, Marquesas, and Windward islands showed 100-yr extreme SSTs in excess of 30 °C, indicating that a centennial-scale heatwave would likely push more sensitive species to thermal limits.
- The Tuamotu-Gambier Islands sit in the middle of the analysis (~ 29.5 °C for a 100-yr event), which is likely reflective of their broad geographic scale.

	Administrative division				
Return period	**Austral**	**Leeward**	**Marquesas**	**Tuamotu-Gambier**	**Windward**
			CRW SST data (°C)		
10-year	28.2	30.2	30.0	29.2	30.0
20-year	28.4	30.4	30.3	29.3	30.1
50-year	28.6	30.5	30.5	29.4	30.3
100-year	28.7	30.6	30.6	29.5	30.4
			ERA5 SST data (°C)		
10-year	27.9	29.9	29.8	29.0	29.6
20-year	28.2	30.1	30.0	29.2	29.8
50-year	28.4	30.3	30.3	29.3	29.9
100-year	28.5	30.4	30.4	29.4	30.0

Fig. 8 Return period analysis for CRW and ERA5 SST data for all administrative areas over 10, 20, 50, and 100 year periods.

Discussion

- All regions showed SST increases over the long term, however, particularly in the short term, the magnitude differed. The Austral Islands exhibited the steepest recent rise (~ 0.04 °C yr^{-1}) in the 2015-2024 window. While other islands displayed SST increases over the longer term, the trends were weaker or even negative in the last decade, however it should be noted that negative trends were typically associated with low confidence, potentially due to low sample sizes.
- ERA5 and Coral Reef Watch datasets were highly correlated (R ~ 0.9) for most areas and measures.
- Under the SSP5-8.5 pathway, CMIP6 HadGEM3 simulations forecast continued SST increase (~ 0.04–0.06 °C yr^{-1} across all administrative divisions through 2050, indicating the potential for >1 °C additional heating by mid century). Even the current potentially cooler regions (e.g., Marquesas Islands) are projected to experience comparable rates, suggesting that current potential "cool spots" may lose their relative refuge value.
- Some areas (e.g. Austral Islands) showed recent observations (2015 – 2024) from ERA5 and CRW datasets significantly greater than those predicted by

HadGEM3 (>1 °C difference for mean and minimum temperatures), i.e. HadGEM3 SST predictions underestimated recent warming trends.

- While the analysis did not consider marine heatwaves from a traditional perspective (that incorporating both duration and intensity), extreme value analysis revealed that 100-yr extreme SSTs in excess of 30 °C would be seen based on historical data for the Leeward, Marquesas, and Windward islands, while the Austral Islands would experience the coolest extreme SSTs (28.5 °C). This may reflect a north-south gradient in heat-wave severity across French Polynesia, however further work would be required to properly characterise the data in terms of marine heatwaves reflecting both intensity and duration. The Austral Islands may also potentially act as a refuge in future marine heatwaves.
- Endemic marine species already face thermal stress. Projected SST rises, which maybe potential underestimates, could push many habitats beyond thermal thresholds, intensifying bleaching risk and potentially reshaping species distribution across the archipelago.

References

Bureau of Meteorology. 2025. Southern Oscillation Index (SOI) since 1876 - Monthly data. https://www.bom.gov.au/climate/enso/soi/

GADM, 2025. Database of Global Administrative Areas: Download GADM data (version 4.1).
https://gadm.org/download_country.html

Hersbach, H., Bell, B., Berrisford, P., Biavati, G., Horányi, A., Muñoz Sabater, J., Nicolas, J., Peubey, C., Radu, R., Rozum, I., Schepers, D., Simmons, A., Soci, C., Dee, D., Thépaut, J-N. (2018): ERA5 hourly data on single levels from 1940 to present. Copernicus Climate Change Service (C3S) Climate Data Store (CDS), DOI: 10.24381/cds.adbb2d47 , (Accessed on 07-MAR-2023)

NCCOS, 2025. Long-distance Reefs May Be Key to Coral Recovery From Bleaching in Moorea and Tahiti. https://coastalscience.noaa.gov/news/long-distance-reefs-may-be-key-to-coral-recovery-in-moorea-and-tahiti-from-bleaching/

NOAA Coral Reef Watch. 2019, updated daily. NOAA Coral Reef Watch Version 3.1 Daily 5km Satellite Regional Virtual Station Time Series Data for Southeast Florida, Mar. 12, 2013-Mar. 11, 2014. College Park, Maryland, USA: NOAA Coral Reef Watch. Data set accessed 2020-02-05 at
https://coralreefwatch.noaa.gov/product/vs/data.php.

Pacific Community, n.d. Pacific Islands Global Ocean Observing System.
https://www.spc.int/pigoos

Palomares, M.L.D. , N. Bailly, E. Bato, E. Capuli, J.C. Espedido, R. Gallano, C. Hoornaert, S. Luna, R. Polido, K. Reyes, R.R. Valdestamon, P.M.S. Yap and D. Pauly. 2021. Some aspects of the marine biodiversity of French Polynesia, p. 45-56. In: D. Pauly and Elaine Chu (eds). Marine and Freshwater Miscellanea III. Fisheries Centre Research Reports. 29(1).

Penin, L, Adjeroud, M., Schrimm, M. & Lenihan, H. S. (2007) High spatial variability in coral bleaching around Moorea (French Polynesia): patterns across locations and water depths. Ecology. C. R. Biologies 330 (2007) 171–181.
http://france.elsevier.com/direct/CRASS3/

Pratchett MS, McCowan D, Maynard JA, Heron SF. Changes in bleaching susceptibility among corals subject to ocean warming and recurrent bleaching in Moorea, French Polynesia. PLoS One. 2013 Jul 29;8(7):e70443. doi: 10.1371/journal.pone.0070443. PMID: 23922992; PMCID: PMC3726623.

Purkis, S., Dempsey, A., Carlton, R.D., Andréfouët, S., Samaniego, B., Rauer, E.M., and Renaud, P.G. (2017) Global Reef Expedition: French Polynesia. Final Report. Khaled Bin Sultan Living Oceans Foundation, Annapolis, MD. Vol 5: 80p. ISBN: 978-0-9975451-1-1

ReefTEMPS. 2025. ReefTEMPS network information portal. https://www.reeftemps.science/en/home/#infos

Roberts, Malcolm (2019). MOHC HadGEM3-GC31-HH model output prepared for CMIP6 HighResMIP highres-future. Version YYYYMMDD[1].Earth System Grid Federation. https://doi.org/10.22033/ESGF/CMIP6.5982

Photos

All images contained within this document are published under a creative commons license. Figures are made by the author.

https://commons.wikimedia.org/wiki/File:Pink_whipray_(Pateobatis_fai)_Moorea.jpg

https://commons.wikimedia.org/wiki/File:Antler_coral_(Pocillopora_grandis)_with_blue_damselfish_(Pomacentrus_pavo)_Moorea.jpg

https://commons.wikimedia.org/wiki/File:Chaetodontidae_-_Chaetodon_trichrous.JPG

https://commons.wikimedia.org/wiki/File:BoraBora_SEtienne.jpg

https://commons.wikimedia.org/wiki/File:Green_sea_turtle_(Chelonia_mydas)_Moorea.jpg

https://commons.wikimedia.org/wiki/File:Niau_Kingfisher,_%C3%8Eles_Tuamotu-Gambier,_PF_imported_from_iNaturalist_photo_395655001.jpg

Ownership

Creative commons licence

Attribution

Goodsell, B. (2026). Marine Thermal Stress in French Polynesia: Historical Trends and Future Projections of Sea Surface Temperature and Marine Heatwaves Across Five Island Groups. The Climate Centre.

Cover image attribution: French Polynesia by Sophie Hurel, 2010. https://commons.wikimedia.org/wiki/File:French_Polynesia_(29482135).jpeg

About this document

The information in this document was presented as part of the Ocean Sciences Meeting 2026 in an interactive poster. It is being republished as a hard copy digital version to allow for viewing in a static format. The interactive poster can be viewed here:

https://osm26.ipostersessions.com/default.aspx?s=F7-A5-9F-E9-33-36-6C-D3-84-E5-E7-EA-B1-3B-62-B3