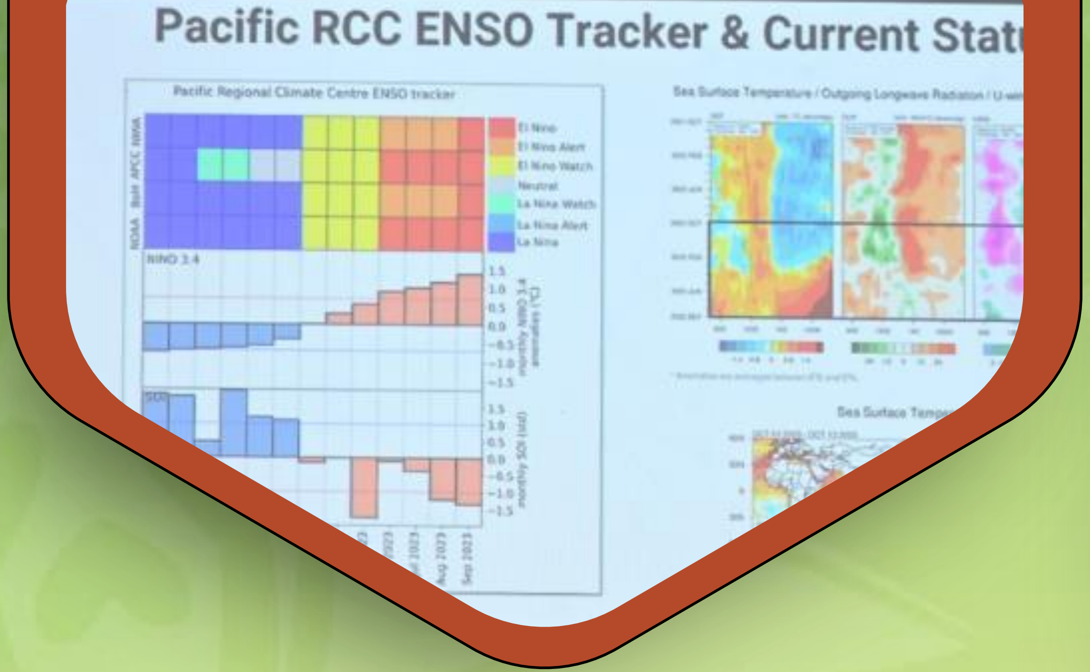

17th SESSION
PACIFIC ISLANDS CLIMATE OUTLOOK FORUM (PICOF-17)

22 - 23 October, 2025

Port Vila, Vanuatu

WMO · PACIFIC REGIONAL CLIMATE CENTRE NETWORK · COSPPac Climate and Oceans Support Program in the Pacific · ClimSA · SPREP Secretariat of the Pacific Regional Environment Programme · Pacific Community Communauté du Pacifique · Australian Government Bureau of Meteorology · CSIRO · NIWA Taihoro Nukurangi · APCC · NOAA · METEO FRANCE

Tropical Cyclone Projections

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Overview

Global Perspective

- TC Future Projections
- Challenges

Case study for Vanuatu

- TC risks and economic impacts
- Coastal inundation

Summary

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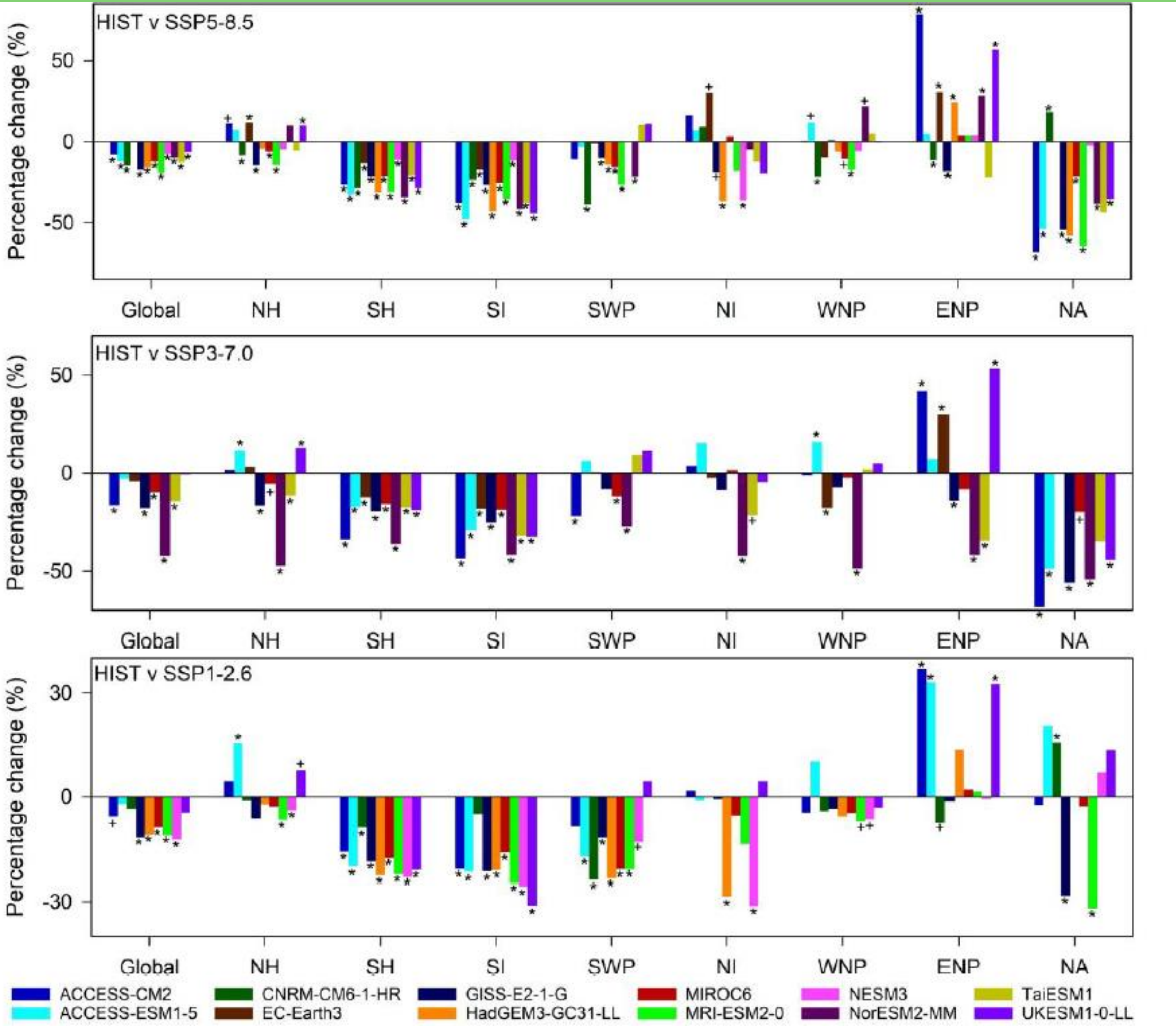
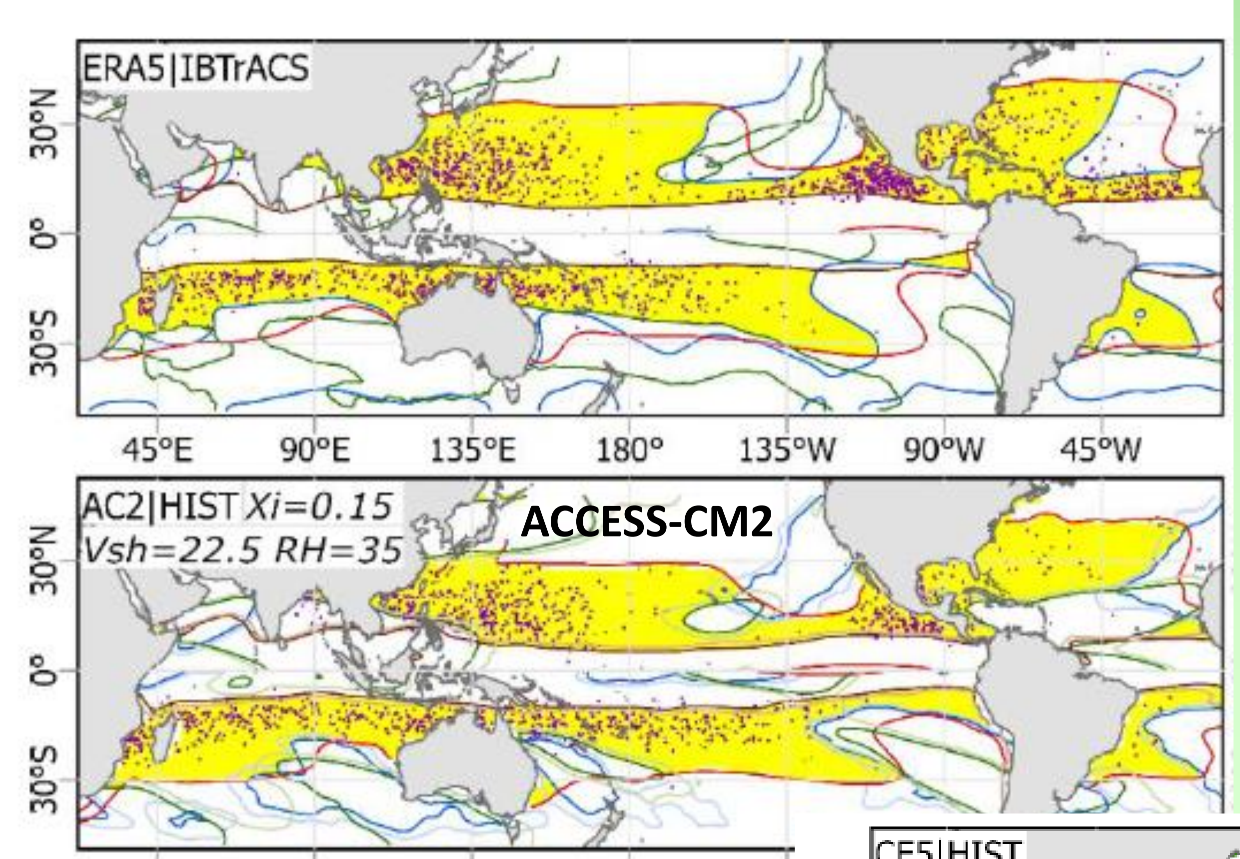
TC Frequency

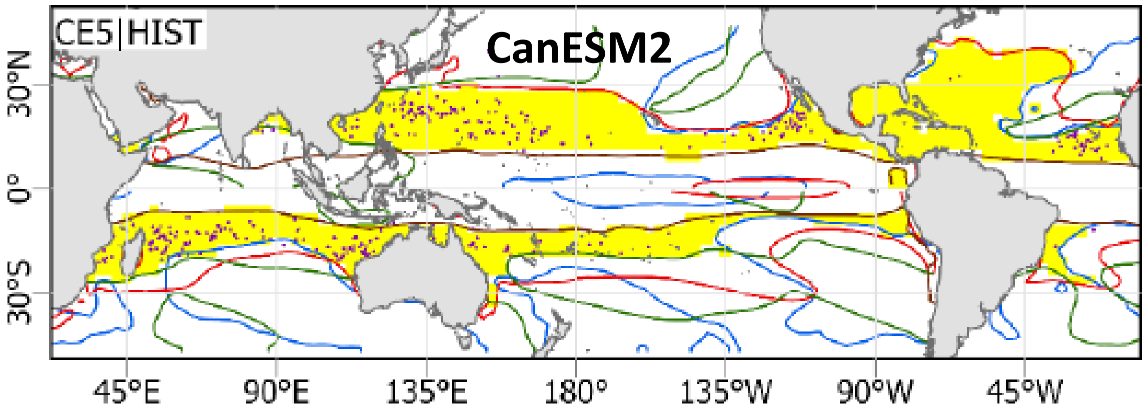


Projected changes in TC frequency between the historical (1970-2000) and future-climate (2070-2100) simulations using CMIP6 models under three SSPs: SSP1-2.6, SSP3-7.0 and SSP5-8.5

Source: Sharma et al. 2025, submitted to *Climate Dynamics*



Robust model verifications and validations undertaken. An example for a better (ACCESS-CM2) and a poor (CanESM2) performing model



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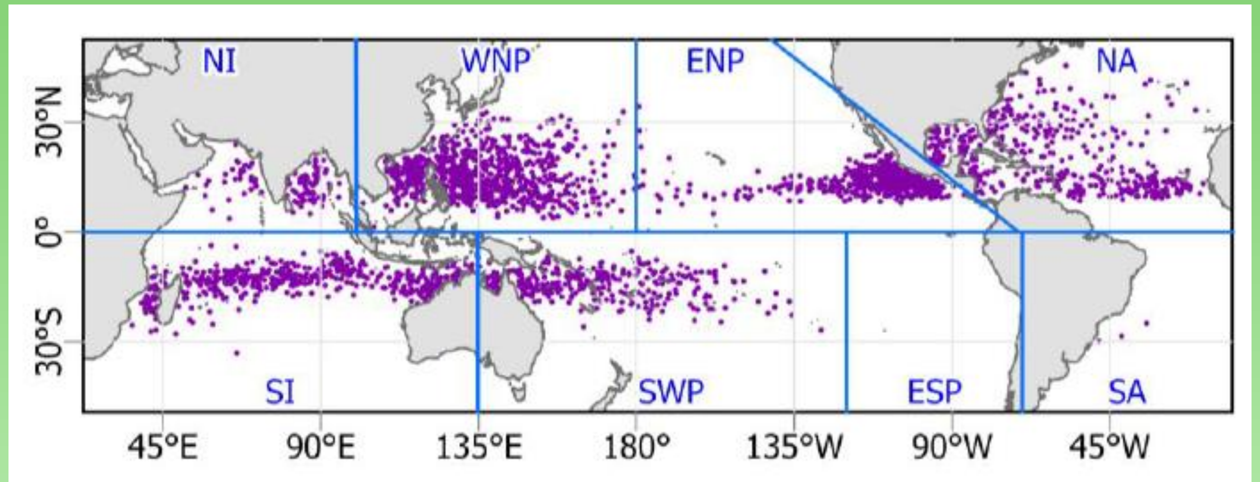
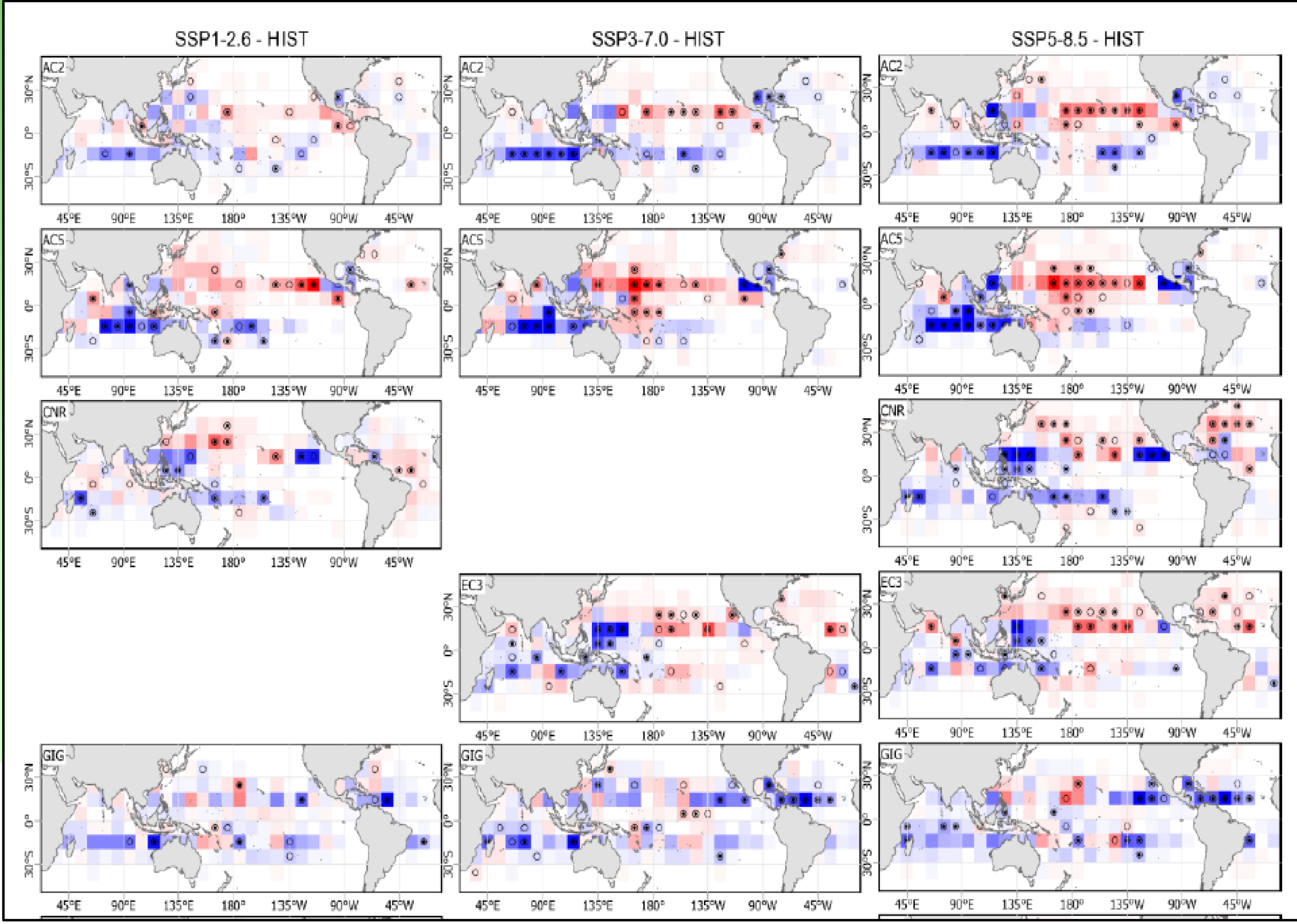
TC Density Spatial Patterns: All TCs



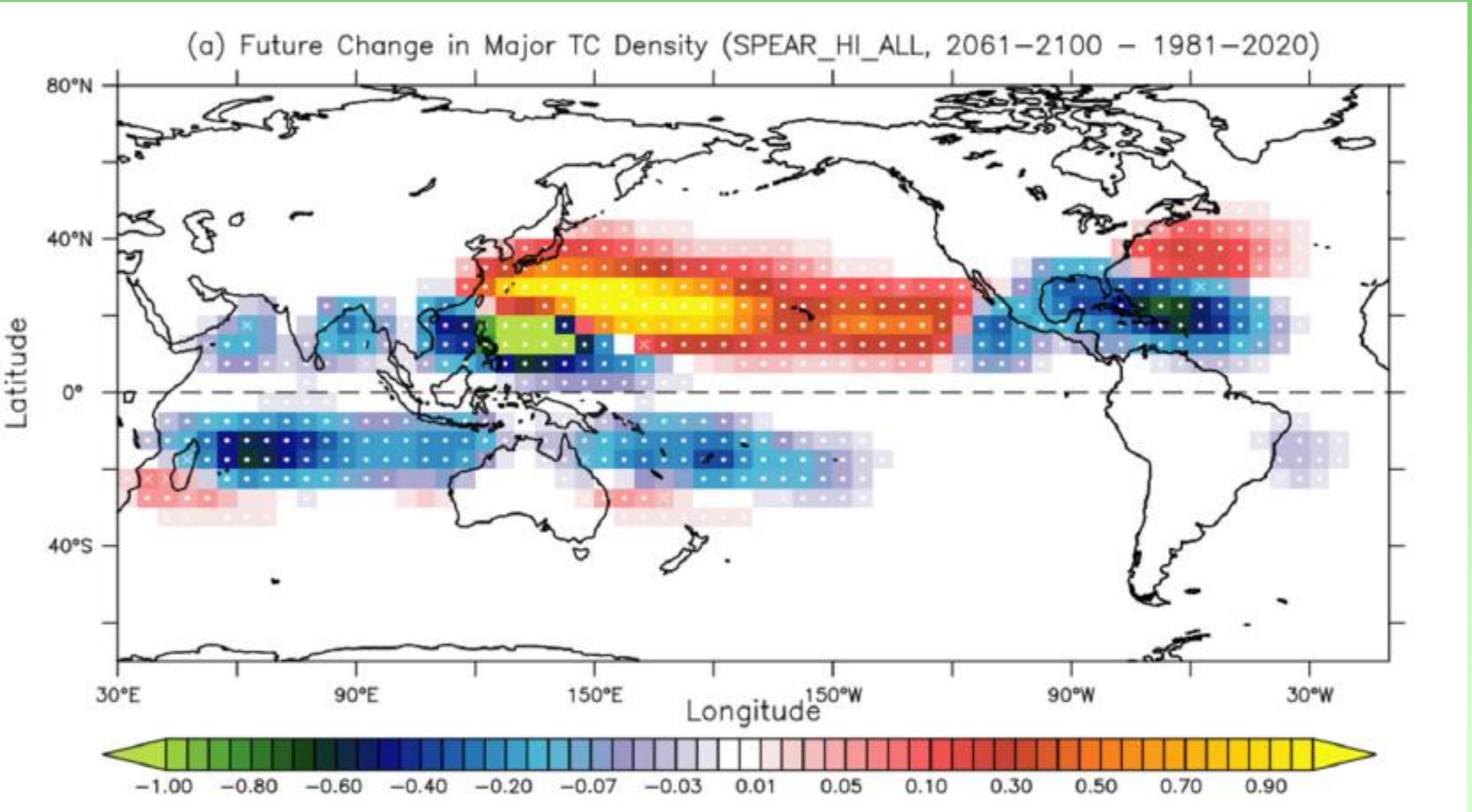
Distribution of TC genesis positions in IBTrACS for the period 1984–2014 among the TC basins

Projected changes in spatial patterns is VERY important!



Source: Sharma et al. 2025, submitted to *Climate Dynamics*

TC Density Spatial Patterns: Major TCs



Notable increase in TC density in the Central North Pacific under SSP5-8.5.

Projected changes in major hurricane (Cat 3-5 on Saffir- Simpson’s scale) under SSP5-8.5:

Source: Murakami et al. 2024, *Nature Communications*

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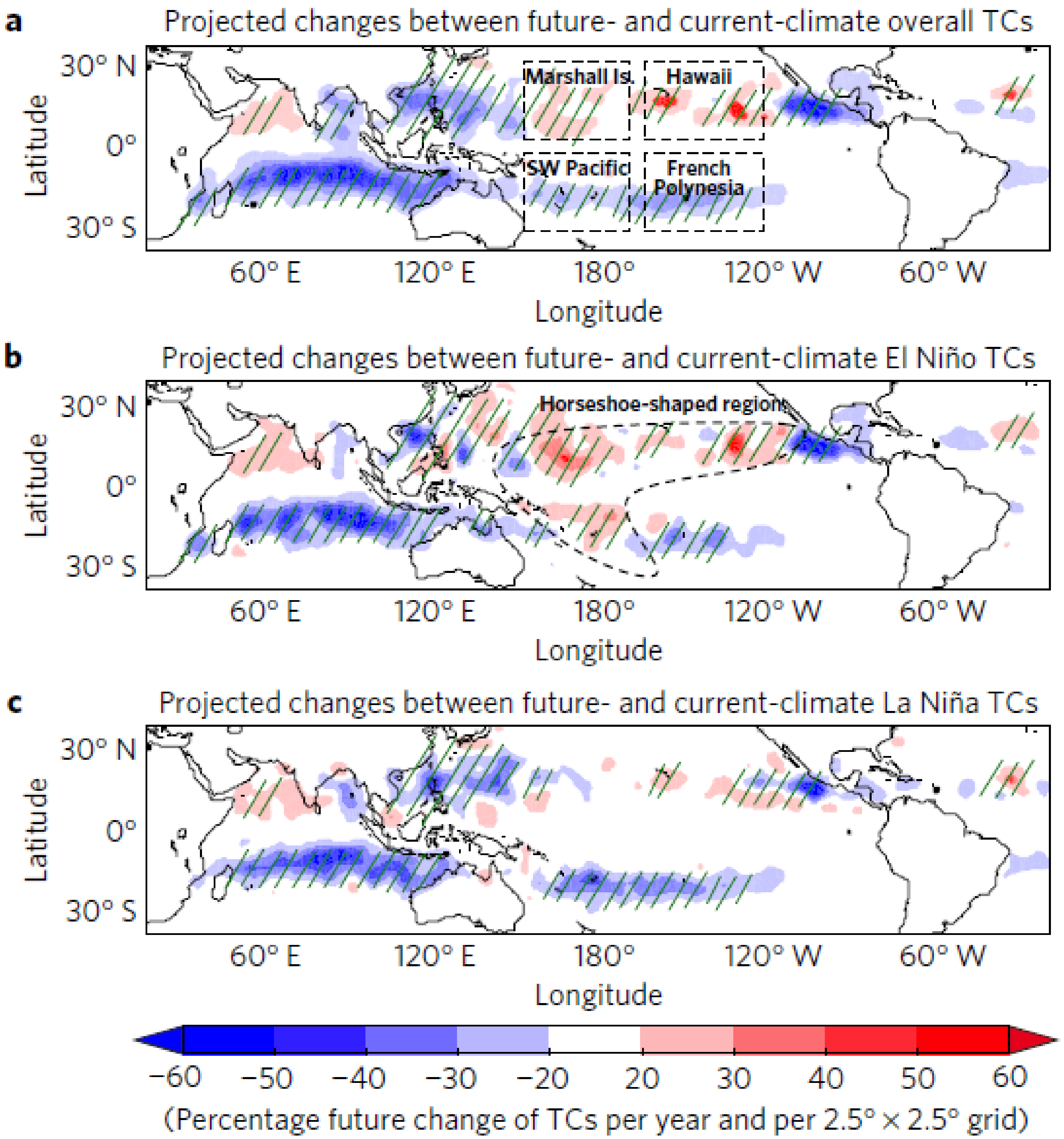
TC and ENSO

Is the Projected increase in Central Pacific El Niño-driven (e.g., Chand et al. 2017)

How confident are we in these projections, given existing CMIP models drift more towards simulating El Niño-like conditions, but observations for the past few decades indicate otherwise?

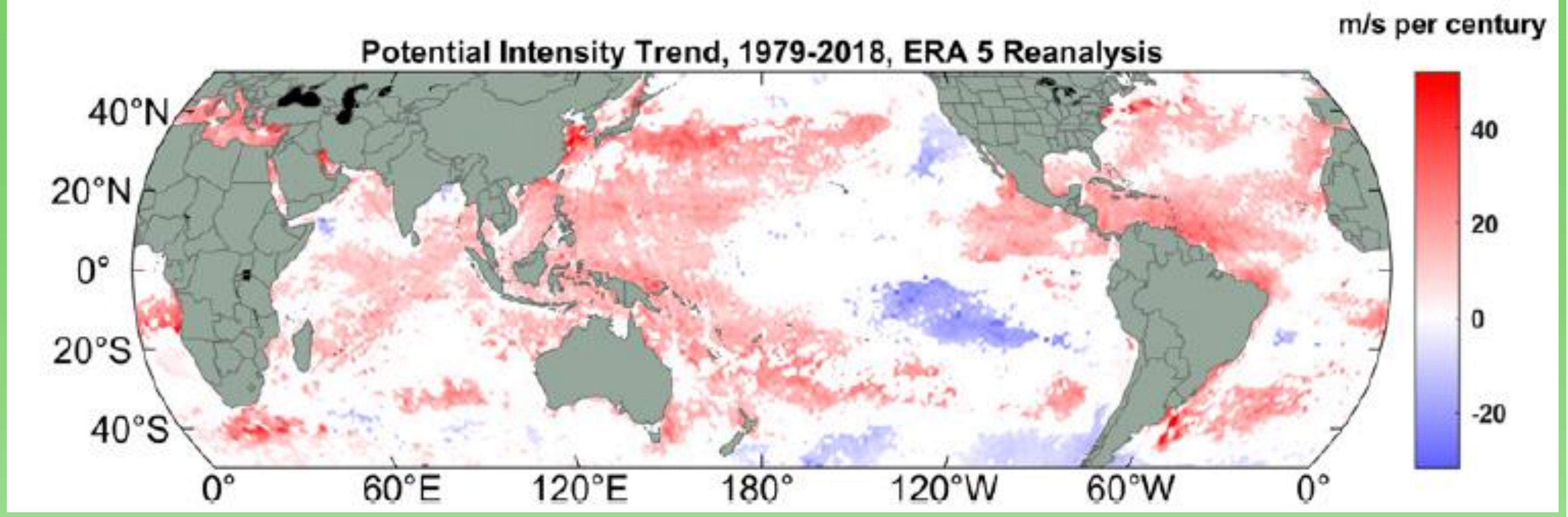
ENSO: A recent study indicates changes from a moderate-amplitude irregular regime, as observed in the current climate, to a highly regular oscillation with intensifying amplitude (Stuecker et al. 2025, *Nature Communications*) … how does this change affect TCs?



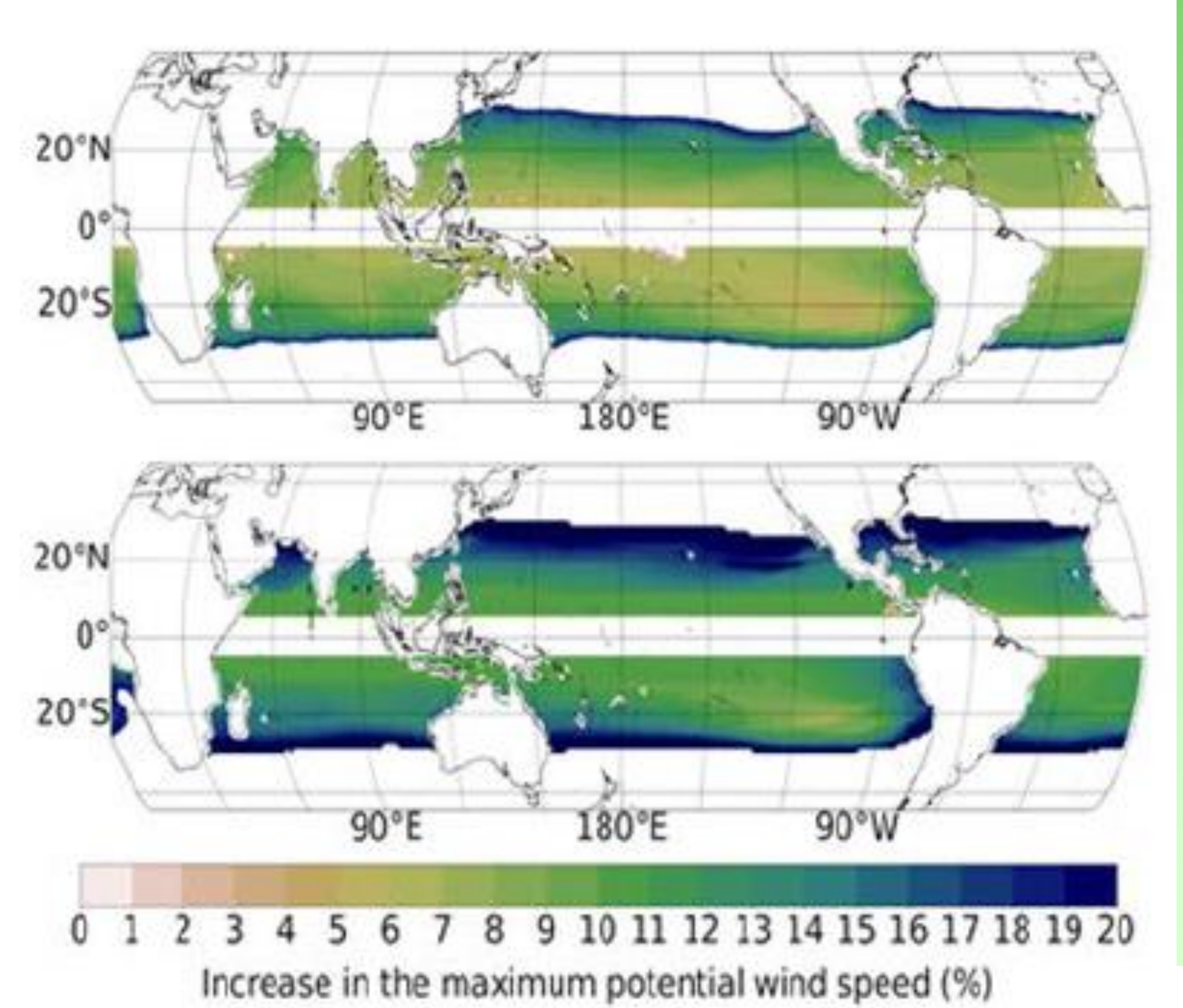
Projected changes in El Niño-driven TC frequency in the Pacific under SSP5-8.5

Source: Chand et al. 2017, *Nature Climate Change*

TC Intensity



Historical trend in maximum potential intensity (1979-2018).
Source: Emanuel 2020, *PNAS*



There is a consensus from theory and climate modeling that the strongest TCs will get stronger in the future, and will at least become a larger fraction of total TC frequency.

Projected increase (%) in the maximum potential wind speed between historical (1985-2014) and (a) MID (2041-2070) and END (2071-2100) CMIP6 simulations under RCP5-8.5.

Source: Perez-Alarcon et al. 2020, *Environmental Process*

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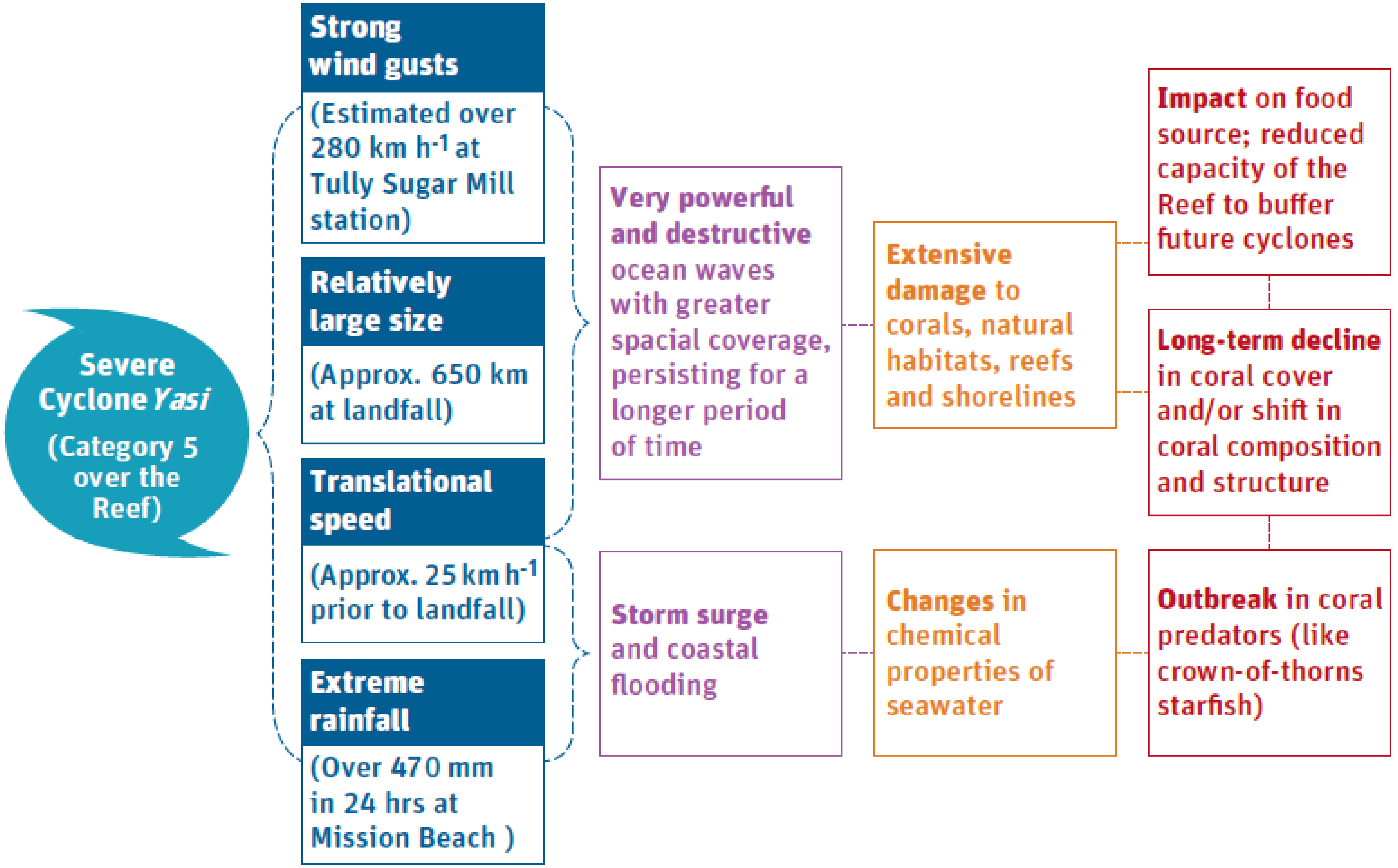
TC Risks

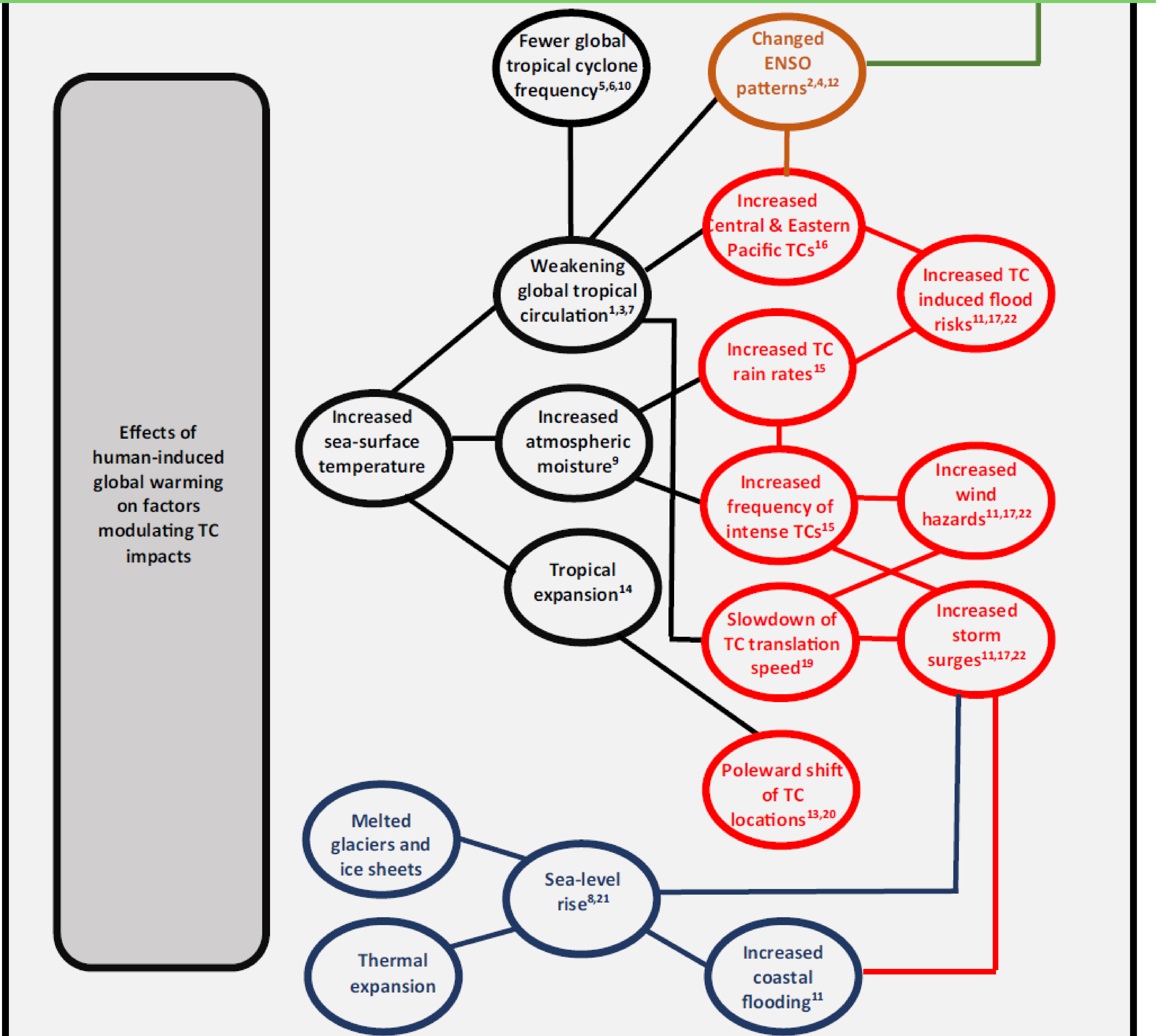


This schematic illustrates the widespread destruction across the GBR caused by severe tropical cyclone Yasi (February 2011)

Source: National Environmental Science Program

TC Risks - PICs

Schematic representation of the linkages between human-induced global warming and tropical cyclones. Note that this diagram is not exclusive and does not quantify the changes, but instead demonstrates how different climatic factors may interact to affect TC characteristics and associated impacts over the SWP region.



Source: Deo et al. 2022, *Climatic Change*

Case for Vanuatu

This study examines the impact of climate change on tropical cyclones (TCs) in Vanuatu, one of the world's most disaster-prone countries.

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RESEARCH ARTICLE OPEN ACCESS

Impact of Climate Change on Tropical Cyclones Over Vanuatu: A Case for Informing Disaster Planning and Adaptation Strategies

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Keywords: Climate change | CMIP5 | Decision-makers | Mitigate | Projections | SPEArTC | Tropical cyclones | Vanuatu

ABSTRACT

This study examines the impact of climate change on tropical cyclones (TCs) in Vanuatu, one of the world's most disaster-prone countries. Here, TCs often result in costly outcomes to the national economy, such as damage to buildings and critical infrastructure, disruptions to livelihoods, food security, health and economic sectors such as tourism and agriculture. The severity of TCs in Vanuatu—such as severe TC Kevin and Judy, the two back-to-back TCs that impacted the country in March 2023—is expected to worsen, compromising the nation's ability to manage such future events. A comprehensive understanding of current and future TC impacts is essential to inform disaster management and adaptation planning strategies across different sectors and enhance the country's economic and community resilience. Reliable historical TC data from the South Pacific Enhanced Archive of Tropical Cyclones (SPEArTC) database were analysed from 1970 to 2021. Results show a ~28% decrease in TC frequency and ~15% increase in mean TC intensity (maximum sustained wind speed) between 1971-1995 and 1996-2021; changes in both metrics are statistically significant (at the 90% significance level). Future TC data from climate model experiments, such as those from the Climate Model Intercomparison Projects (CMIP), are at a relatively coarse resolution and substantially underestimate metrics like TC intensity required for decision-making purposes at finer spatial scales. Nonetheless, we developed a method that utilises TCs detected and tracked using the Okubo-Weiss-Zeta (OWZ) scheme to demonstrate the feasibility of assessing TC impacts for Vanuatu. This study uses consolidated climate

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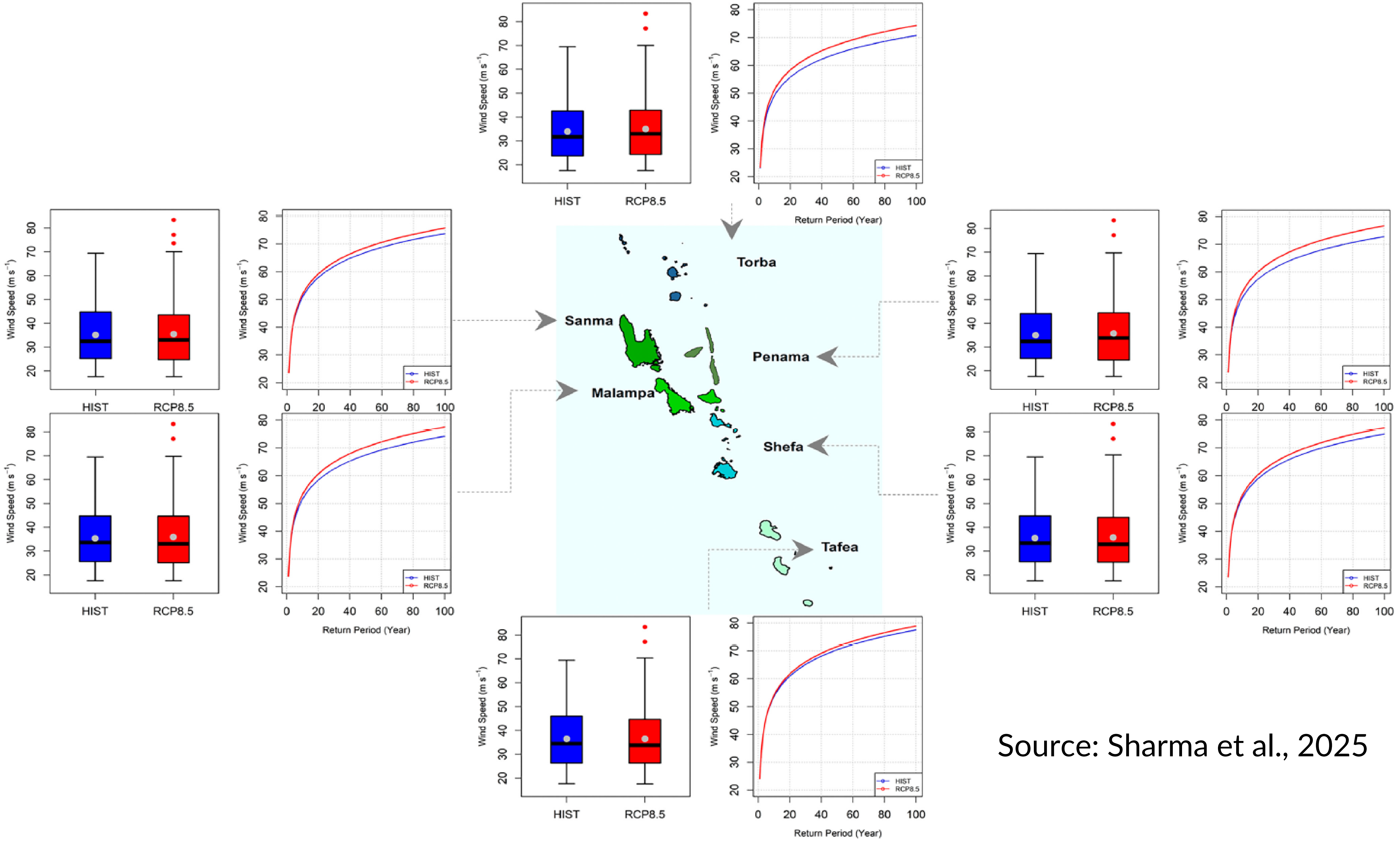
Case for Vanuatu

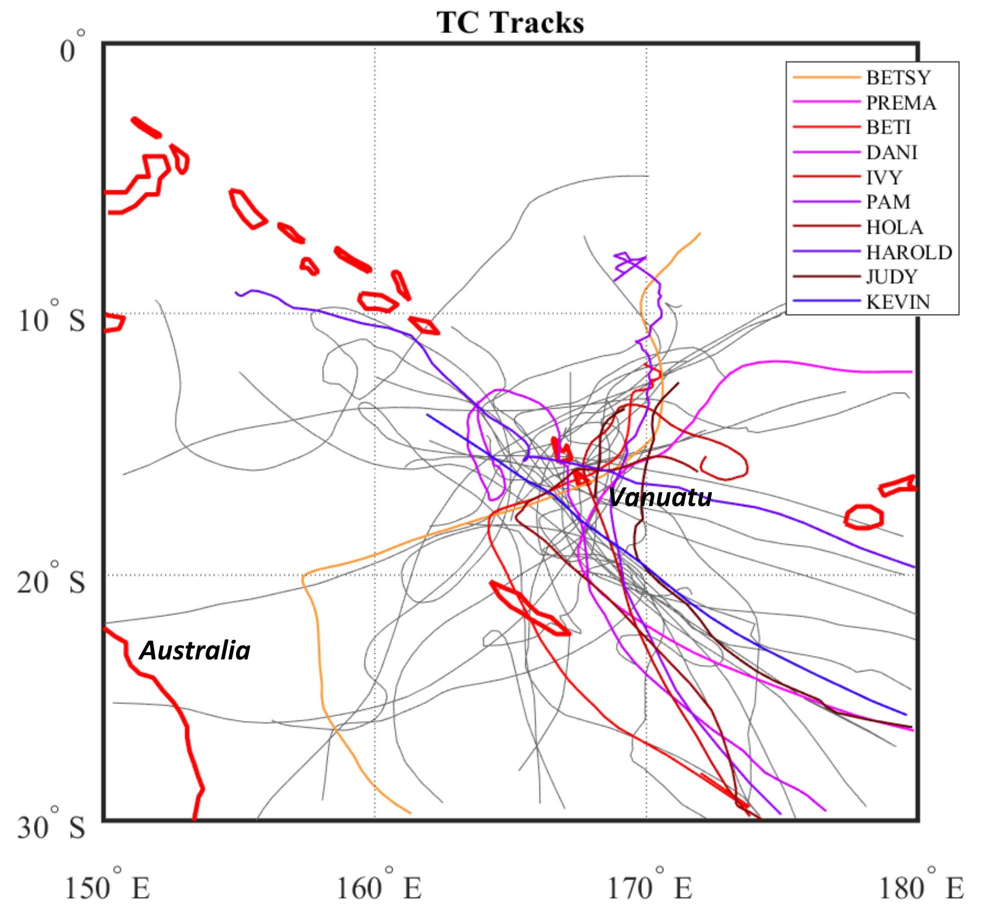


Source: Sharma et al., 2025

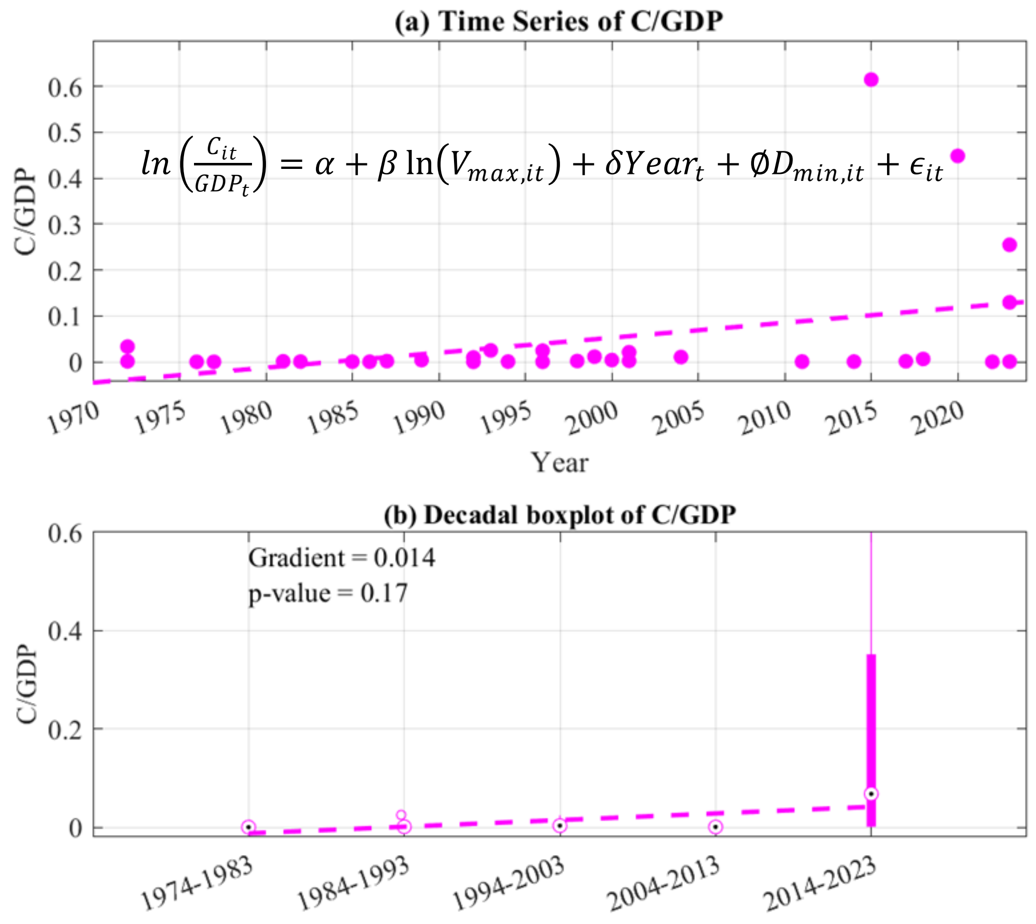
Summary of projected changes in the TC intensity and their respective return periods of 'All TCs' between the current climate (blue: 1971–2000) and the future climate (red: 2071–2100) across each province of Vanuatu.

Case for Vanuatu: Economic Impacts

Case	1981-2023			2040-2059						2080-2099					
				Estimated cost per TC			Difference			Estimated cost per TC			Difference		
	% of GDP	Billions of VT (2023 levels)	Millions of USD (2023 levels)	% of GDP	Billions of VT (2023 levels)	Millions of USD (2023 levels)	% of GDP	Billions of VT (2023 levels)	Millions of USD (2023 levels)	% of GDP	Billions of VT (2023 levels)	Millions of USD (2023 levels)	% of GDP	Billions of VT (2023 levels)	Millions of USD (2023 levels)
a.	5.25	6.53	56.02	6.06	7.53	64.66	0.81	1.01	8.63	6.06	7.53	64.66	0.81	1.01	8.63
b.	5.25	6.53	56.02	6.98	8.67	74.41	1.72	2.14	18.38	9.79	12.17	104.44	4.54	5.64	48.41
c.	5.25	6.53	56.02	6.57	8.16	70.09	1.32	1.64	14.06	6.57	8.16	70.09	1.32	1.64	14.06
d.	5.25	6.53	56.02	8.16	10.14	87.06	2.91	3.62	31.04	13.65	16.96	145.58	8.40	10.43	89.56
e.	5.25	6.53	56.02	6.33	7.87	67.55	1.08	1.34	11.52	6.33	7.87	67.55	1.08	1.34	11.52
f.	5.25	6.53	56.02	7.61	9.45	81.13	2.35	2.92	25.11	11.84	14.71	126.27	6.59	8.18	70.25



Estimates using the above power law show that by late-century (2090), the mean expected cost per TC could increase to 6.1 – 6.6 % of GDP (an increase of VT 1.01 – 1.64 billion) under a low emissions scenario or 9.8 – 13.7 % of GDP (an increase by VT 5.64 – 10.43 billion) under a high emissions scenario.



Time series and (b) decadal boxplot of normalised cost (C/GDP) using reported values combined with estimates.

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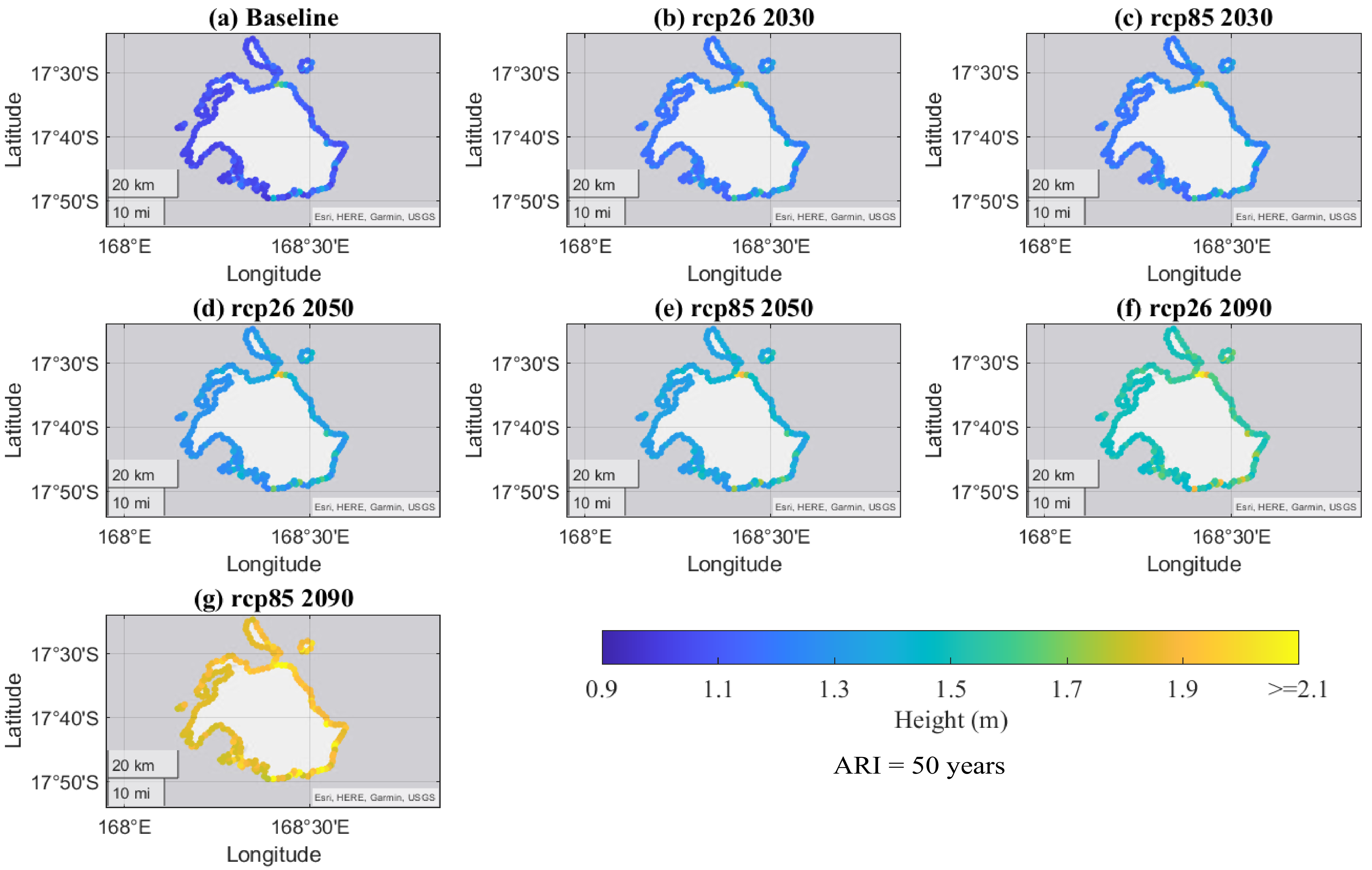
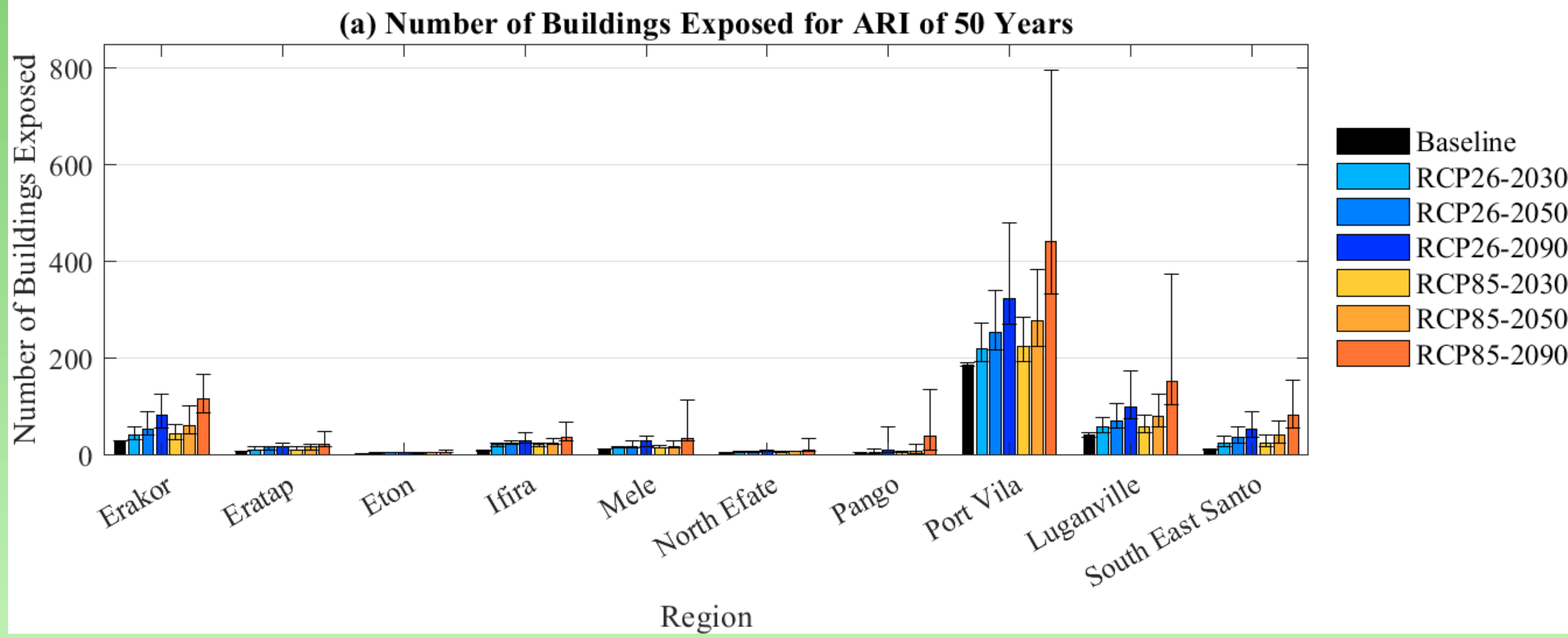
Source: Deo et al., 2025, under review.

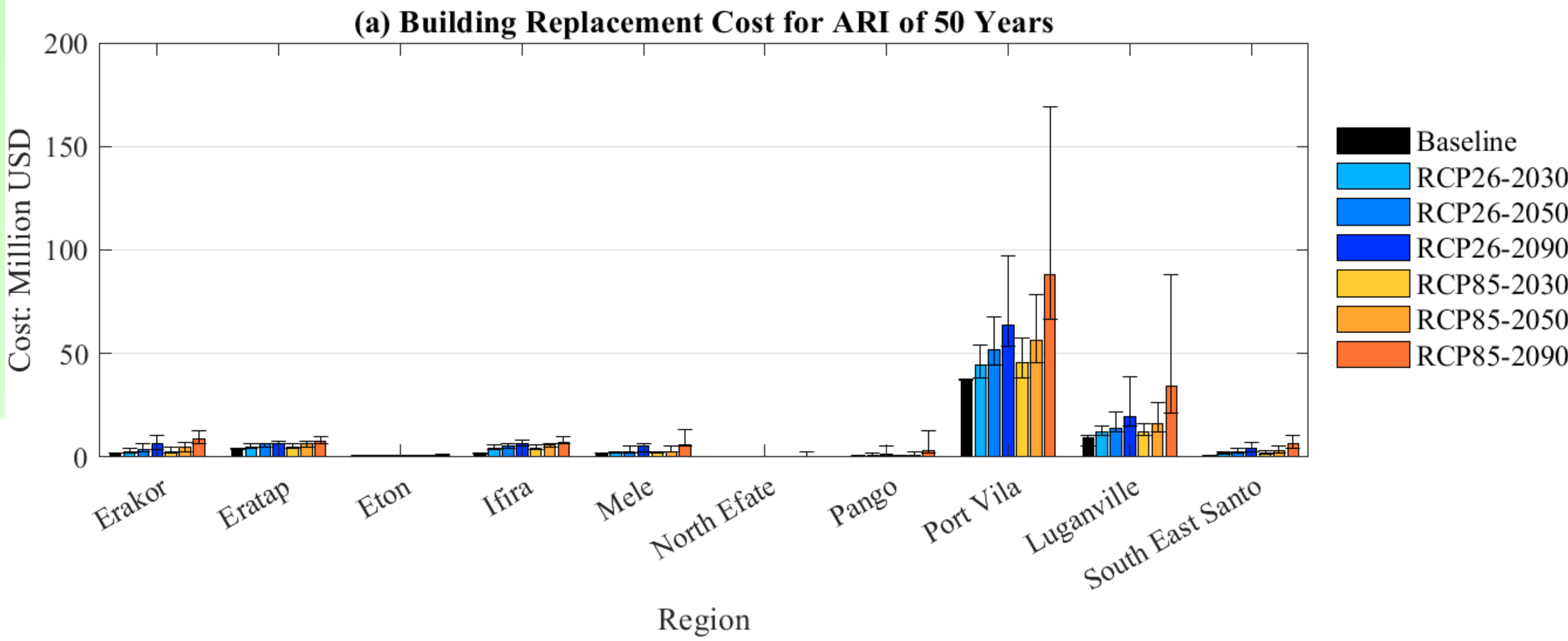
Case for Vanuatu: Coastal Inundation



Extreme Sea Level heigh (metres) for ARI of 50 years over Efate for baseline (1981-2020) and future (2030, 2050, 2090) conditions for low (RCP2.6) and high (RCP8.5) emissions scenarios.



Number of buildings exposed for 50-year and ARIs stratified by LGA region, for the baseline period (1981-2020) and low (RCP2.6) and high (RCP8.5) emissions scenarios for 2030, 2050 and 2090.



Building replacement cost for 50- year ARIs grouped by LGAs, for low (RCP2.6) and high (RCP8.5) emissions scenarios for 2030, 2050 and 2090.

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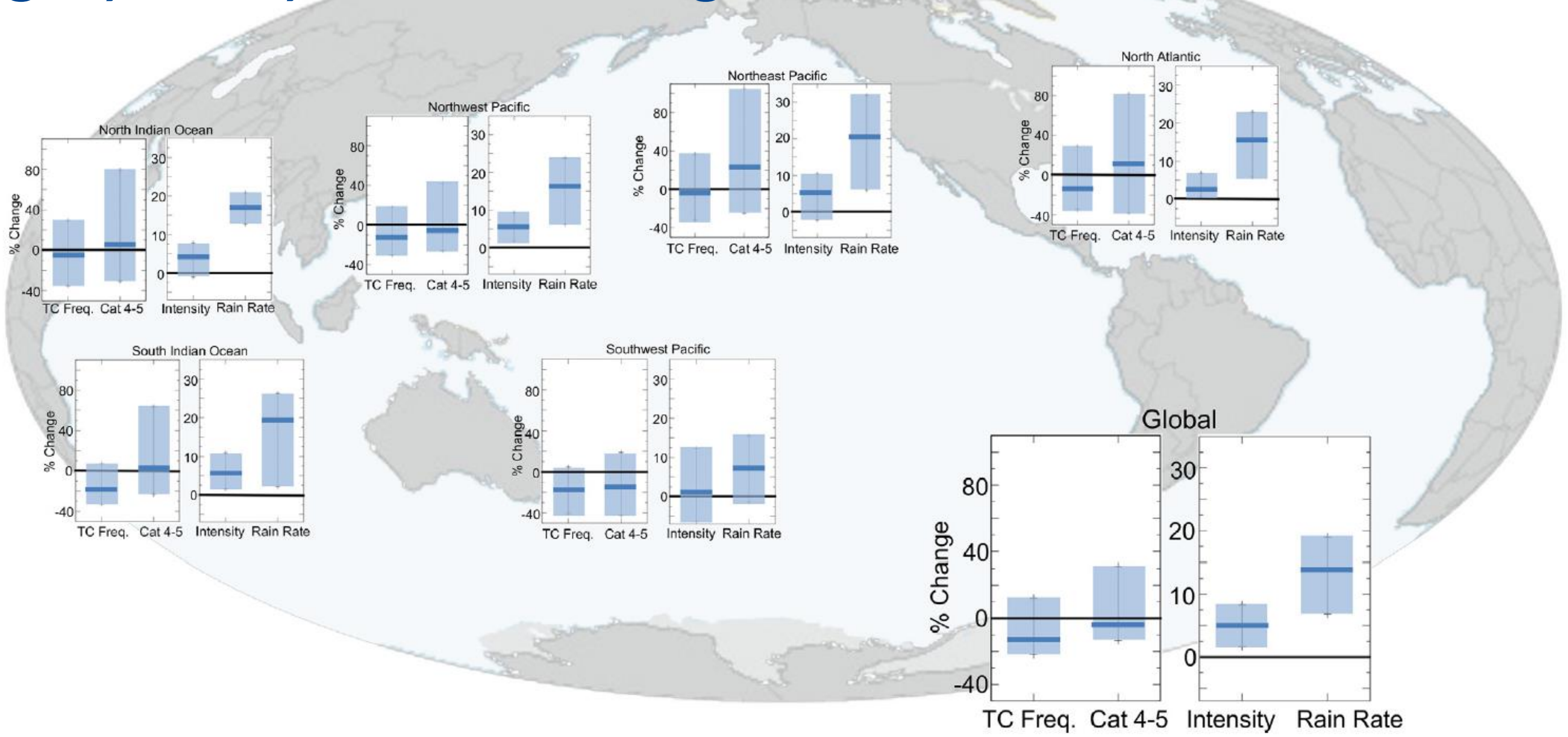
Source: Deo et al., 2025, under review.

Summary

Regional-scale TC projection is still a challenge due to many reasons, including model limitations in simulating various drivers that modulate TC activity (see Schematic from Knutson et al. 2020, *BAMOS*):

- TC numbers are likely to decline due to warming in the SH basins (medium confidence) while there is a large variability in NH basins (low confidence)
- TC intensity is highly likely increase in future due to warming (high confidence).
- TC-induced rainfall highly likely increase (high confidence).



THANK YOU!

Savin Chand, Federation University Australia