



The Effect of Projected Sea Surface Temperature (SST) Pattern Changes on Tropical Precipitation using CESM 1

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Introduction

Decadal variability in the climate system causes the strength of SST gradients to vary across the tropical Pacific that can cause precipitation patterns to transition from one decade to the next

In the CESM1 Large Ensemble (Kay et al. 2015), each member uses different initial conditions that can be used to examine climate projections on short term (e.g. weeks, years) through long term (e.g. century) time scales

Because climate models contain climate variability such as the Madden Julian Oscillation (MJO), El Niño Southern Oscillation (ENSO), and Pacific Decadal Oscillation (PDO), each ensemble member can have diverse projection outcomes in a given decade

Research Questions:

- How uncertain are the patterns of SST change in the future on decadal timescales?
- To what extent does the pattern of projected SST change influence precipitation change in the Tropics?
- What are the implications for precipitation on islands in the Pacific?

Methodology

Data

NCAR CESM RCP8.5 scenario precipitation and surface temperature from 1920-2100.

Ensembles 6, 7, 8, 9, 10, 11, 12, & 15 (8)

Methods

- Python used to analyze and present visualization of data
- All future changes assessed relative to 1985-2005

Analysis

- Compare and contrast different ensemble members to identify those with the most prominent Eastern, Central or Western Pacific SST changes
- Identify patterns of SSTs and precipitation change in different future 20-yr periods
- Calculate trends in the 10-yr running mean of ENSO 3.4 SST and the East-West Pacific temperature gradient
- Spearman's correlation between Pacific SST gradient and station precipitation

Results

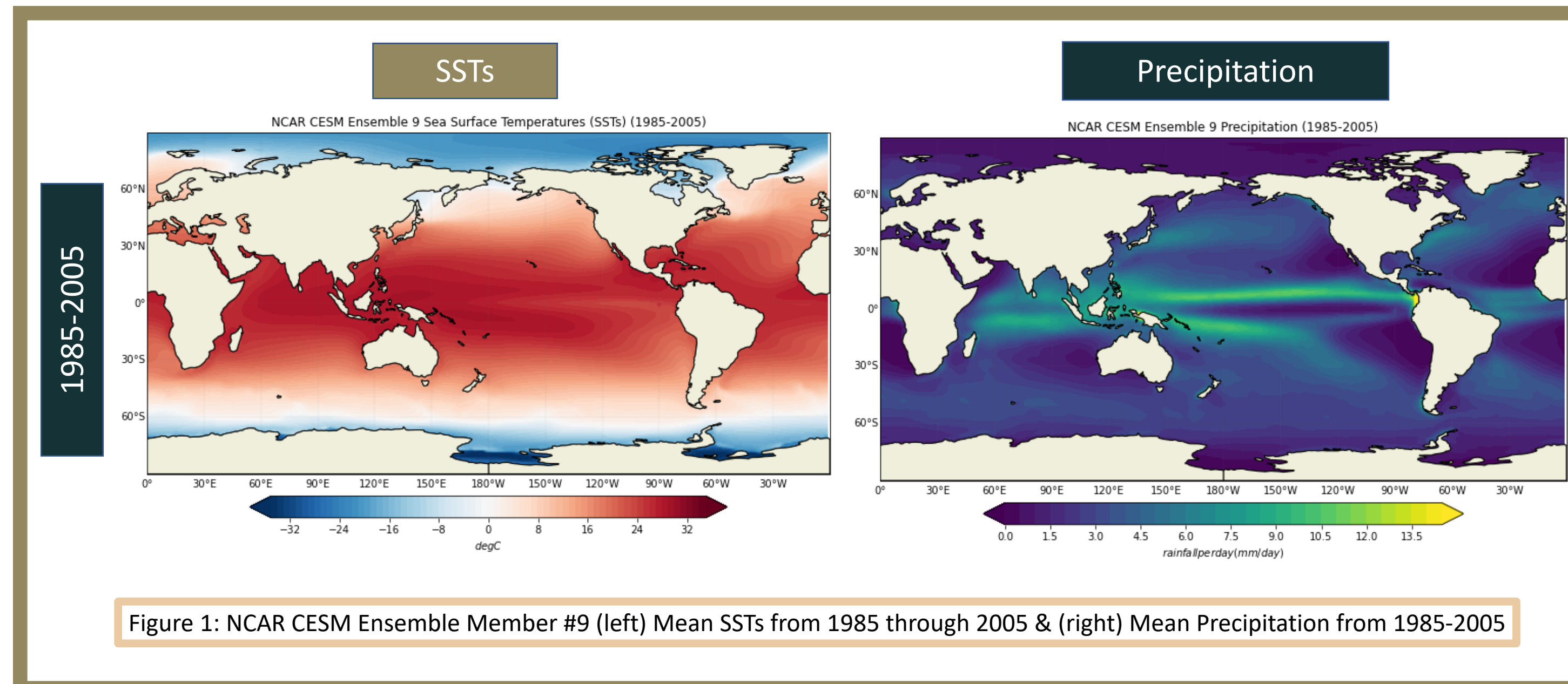


Figure 1: NCAR CESM Ensemble Member #9 (left) Mean SSTs from 1985 through 2005 & (right) Mean Precipitation from 1985-2005

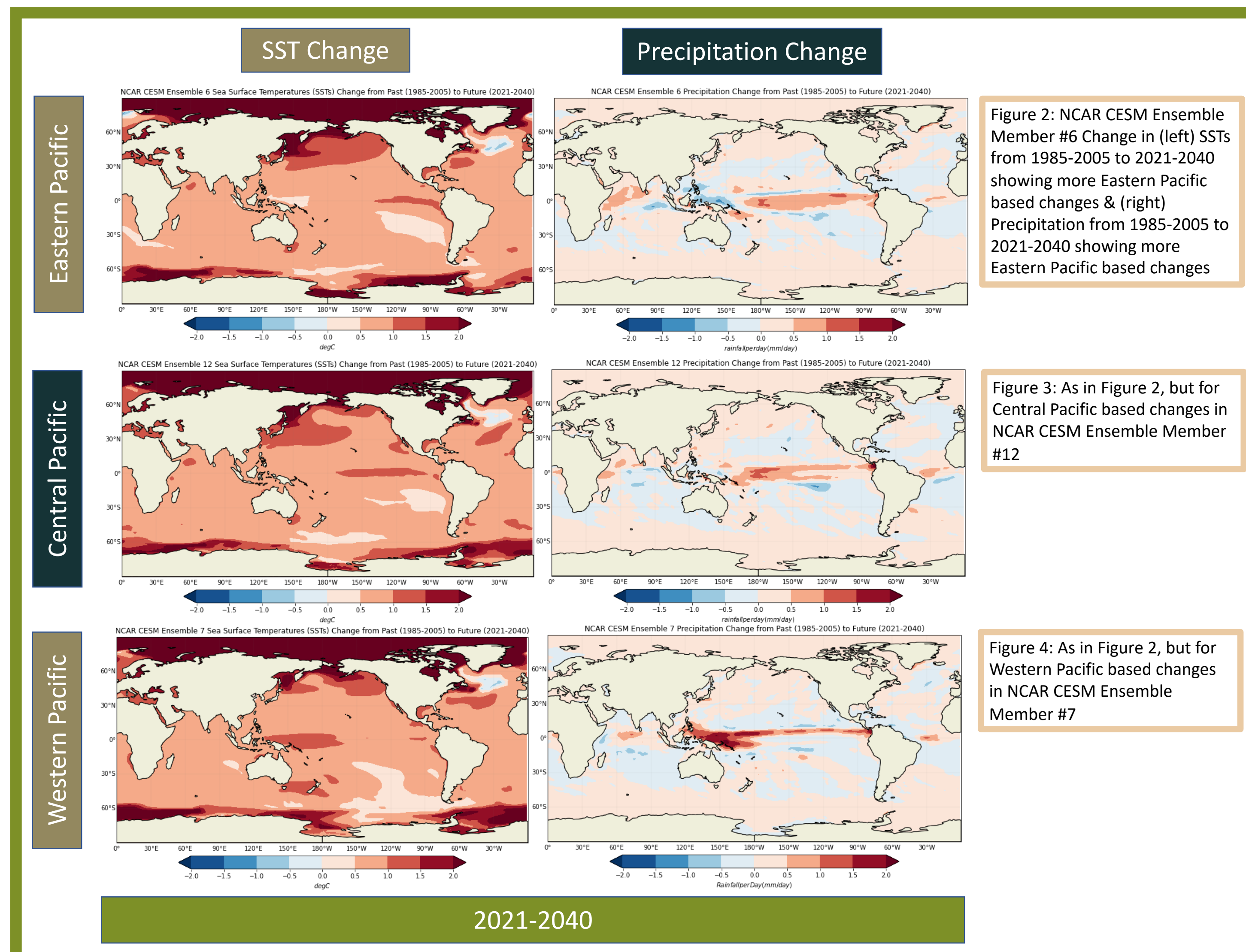


Figure 2: NCAR CESM Ensemble Member #6 Change in (left) SSTs from 1985-2005 to 2021-2040 showing more Eastern Pacific based changes & (right) Precipitation from 1985-2005 to 2021-2040 showing more Eastern Pacific based changes

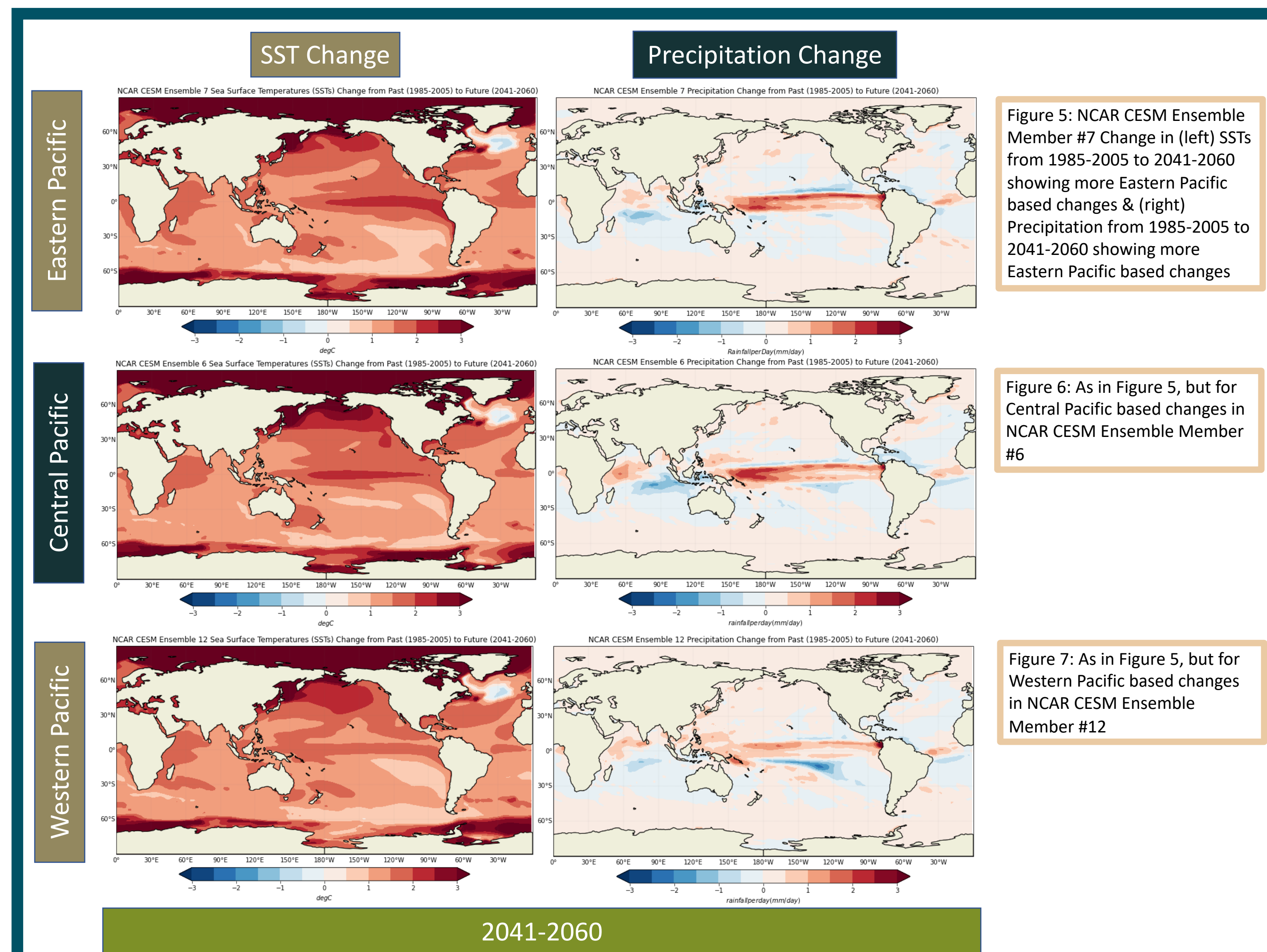


Figure 5: NCAR CESM Ensemble Member #7 Change in (left) SSTs from 1985-2005 to 2041-2060 showing more Eastern Pacific based changes & (right) Precipitation from 1985-2005 to 2041-2060 showing more Eastern Pacific based changes

Figure 7: As in Figure 5, but for Western Pacific based changes in NCAR CESM Ensemble Member #12

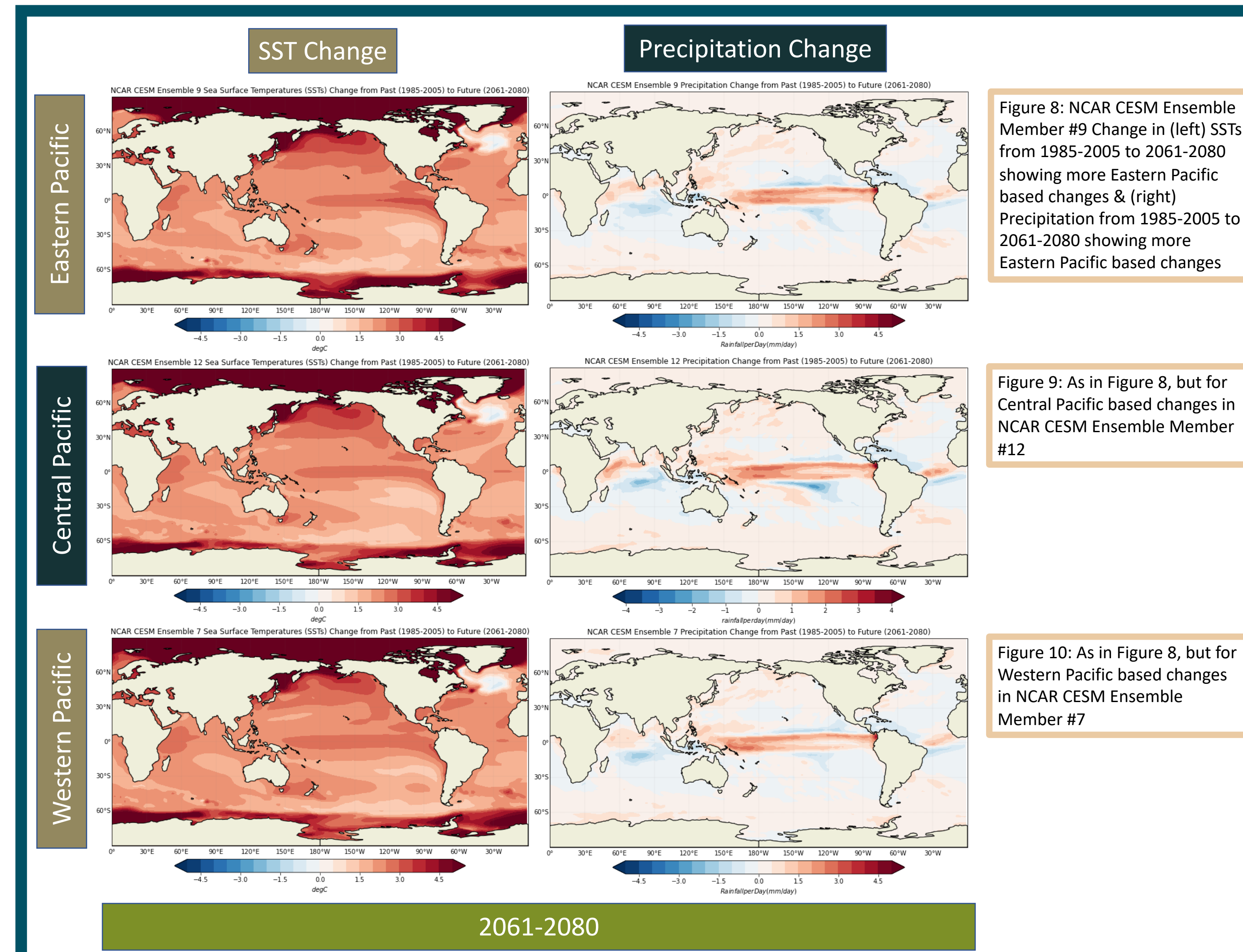


Figure 8: NCAR CESM Ensemble Member #9 Change in (left) SSTs from 1985-2005 to 2061-2080 showing more Eastern Pacific based changes & (right) Precipitation from 1985-2005 to 2061-2080 showing more Eastern Pacific based changes

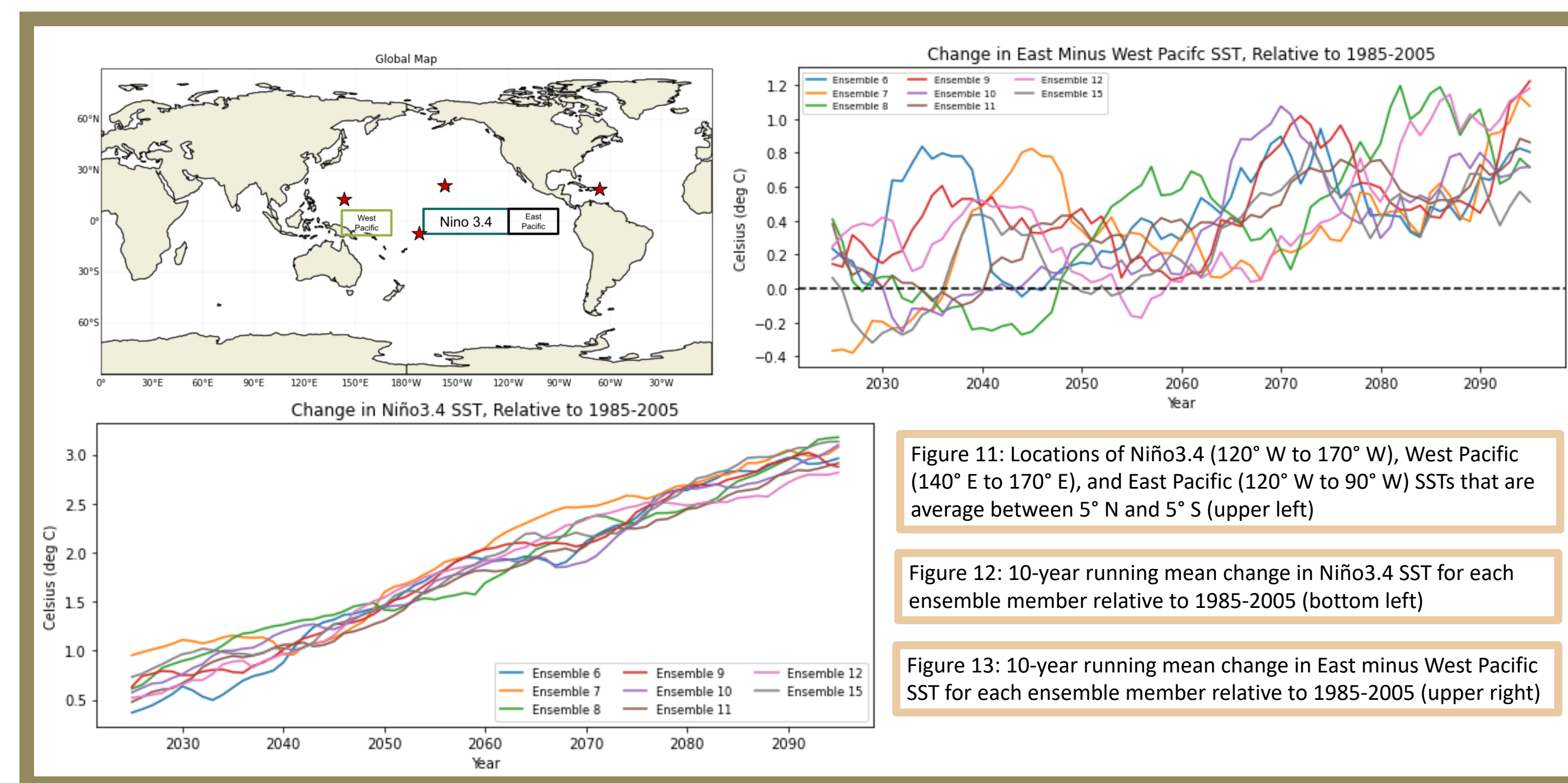


Figure 11: Locations of Niño3.4 (120° W to 170° W), West Pacific (140° E to 170° E), and East Pacific (120° W to 90° W) SSTs that are average between 5° N and 5° S (upper left)

Figure 12: 10-year running mean change in Niño3.4 SST for each ensemble member relative to 1985-2005 (bottom left)

Figure 13: 10-year running mean change in East minus West Pacific SST for each ensemble member relative to 1985-2005 (upper right)

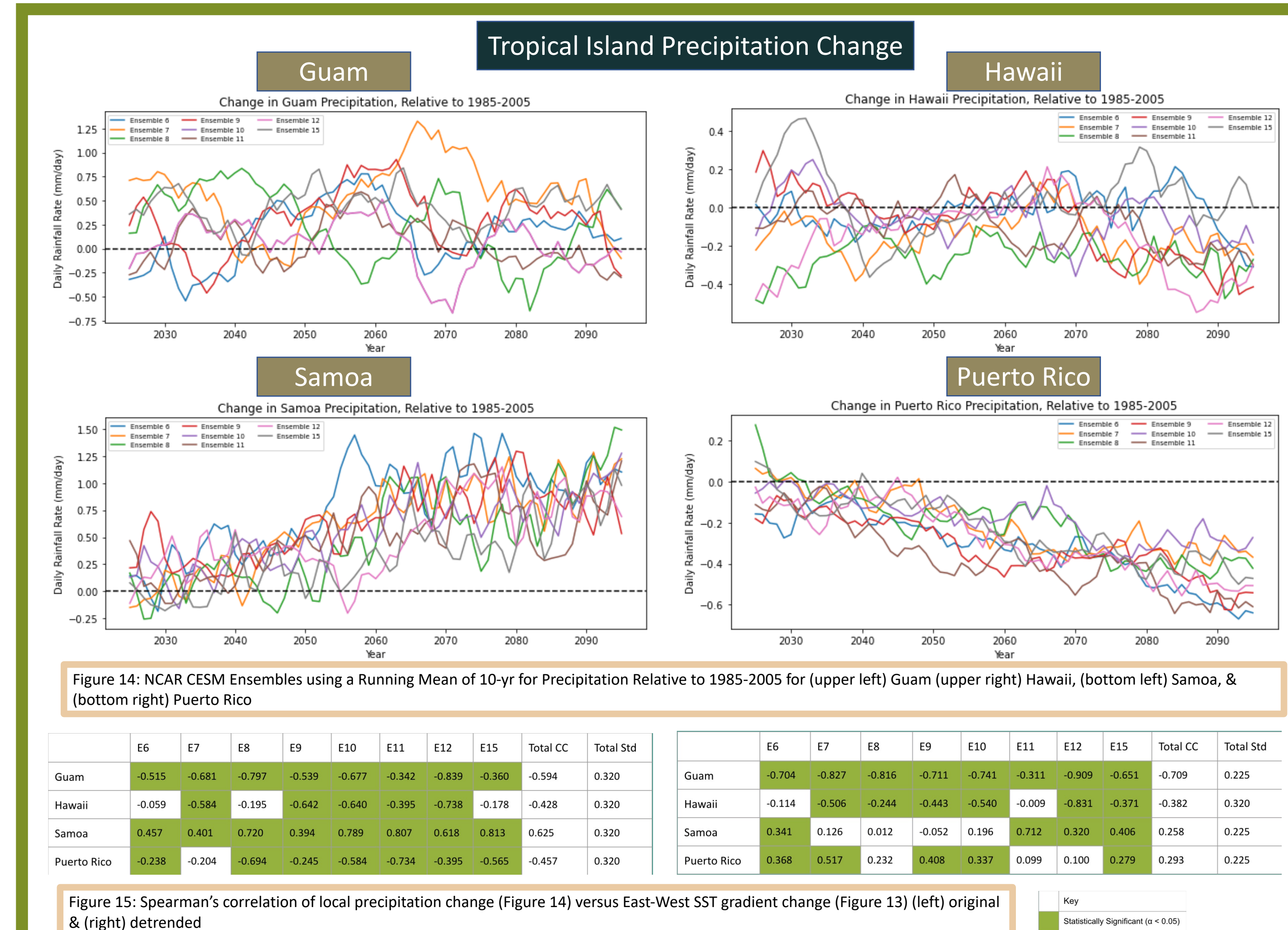


Figure 14: NCAR CESM Ensembles using a Running Mean of 10-yr for Precipitation Relative to 1985-2005 for (upper left) Guam (upper right) Hawaii, (bottom left) Samoa, & (bottom right) Puerto Rico

Figure 15: Spearman's correlation of local precipitation change (Figure 14) versus East-West SST gradient change (Figure 13) (left) original & (right) detrended

Conclusions

All ensemble members eventually show an El Niño-like warming pattern by 2100

In earlier decades, different ensemble members show preferential SST warming shifted either toward the west, central, or east Pacific in a given 20-year period

These SST shifts strongly influence the patterns of precipitation change during any given period

While Niño3.4 SST general go up relative to 1985-2005, the tropical Pacific East-West Temperature gradient change does not show a consistent upward trend

The precipitation change at Guam in a given 20-year period relative to 1985-2005 shows a strong negative correlation with the Pacific temperature gradient change that in some decades goes against the long term trend

Samoa has a high positive correlation with the SST gradient change, consistent with the long term trend in projected Central and Eastern Pacific warming that can also be temporarily enhanced in earlier decades

This makes it challenging to predict future changes in water resource availability for tropical islands.

Future Work

Examine Projected SST and precipitation trends using the CESM2 ensemble, which includes more ensemble members and a better representation of the MJO

Analyze the influence of wind changes on SSTs and precipitation patterns

Explore the impact of projected SSTs changes on the MJO

Observe the effect of projected SSTs and precipitation change on water resources, fire weather, and other societal impacts on Tropical Pacific islands, which are vulnerable communities

References

- Kay, J. E., C. Deser, A. Phillips, A. Mai, C. Hannay, G. Strand, J. Arblaster, S. Bates, G. Danabasoglu, J. Edwards, M. Holland, P. Kushner, J. Lamarque, D. Lawrence, K. Lindsay, A. Middleton, E. Munoz, R. Neale, K. Oleson, ... M. Vertenstein, 2015: The Community Earth System Model (CESM) Large Ensemble Project: A Community Resource for Studying Climate Change in the Presence of Internal Climate Variability. *Bulletin of the American Meteorological Society*, 96(8), 1333–1349, doi: 10.1175/bams-d-13-00255.1

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