Tropical Pacific Climate Predicted By DJF Climatological Cooling Rate

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Motivation

- The response of tropical Pacific sea surface temperatures (SST) to climate change is highly debated
- Historical observed trend is a strengthening zonal SST gradient, which climate models have poorly captured

DJF Climatological Cooling Rates

- Over long time-periods,

$$\gamma \Delta T = \Delta \mathcal{F}$$

- γ is defined as the cooling from longwave radiation, sensible heat flux, and latent heat flux.

Largest Term

$$\gamma = \underbrace{\varepsilon \sigma \overline{T}^3}_{LW} + \underbrace{\rho_a c_p C_{SH} \overline{U}}_{SH} + \underbrace{\rho_a L_v C_{LH} \epsilon \alpha \beta \overline{U}}_{LH}$$

$$\alpha = \frac{\overline{p}_s + 2\overline{e}_s(1-\epsilon)}{\overline{p}_s^2}; \beta = \frac{L_v e_s(\overline{T})}{R_v \overline{T}^2}$$

ε: Emissivity | ϵ: ratio of gas & vapor constants | $\overline{x}$: Climatological mean of x

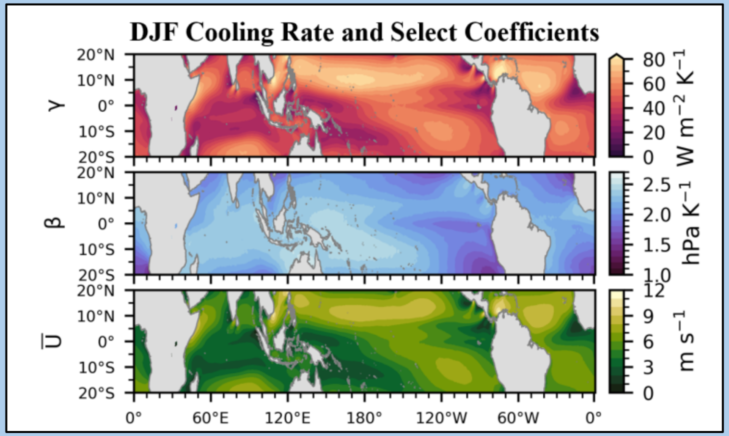

Figure 1: Maps of γ, the coefficient β, and climatological wind speed ($\overline{U}$)

- Wind more important than temperature in determining γ
- Central and Eastern Pacific are damped more

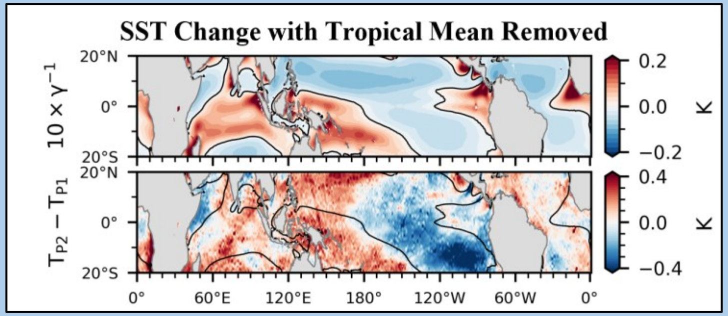

Figure 2: Response to uniform 10 W m^{-2} forcing (top) and the difference between the 1979-1999 and 2000-2020 average ENSO- and PDO-removed SST (bottom). Both panels have the 20°S-20°N average removed with the black contour representing the average response.

SST Response to a Uniform Forcing of 10 W m^{-2}

- Using the ENSO- and PDO-removed SST change between 1979-1999 and 2000-2020, the tropical averaged $\gamma\Delta T$ is 10 W m^{-2}
- Response to uniform forcing shows less warming in the eastern and central Pacific
- The pattern of relative SST matches similarly to the observed change between 1979-1999 and 2000-2020, but magnitudes are different
- Feedbacks such as the Bjerknes feedback could lessen the magnitude differences

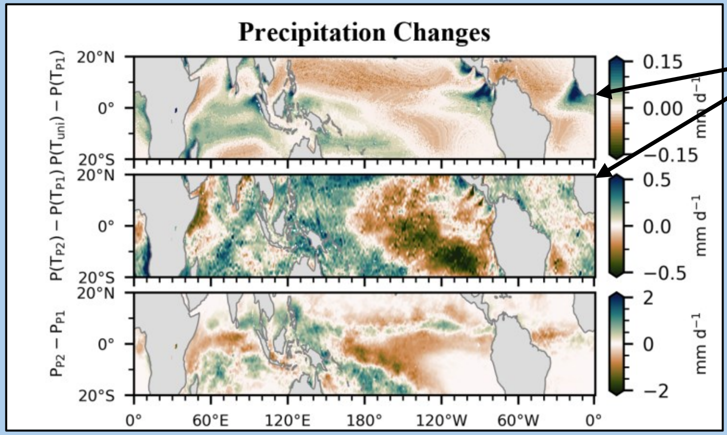

Figure 3: Changes in precipitation given the SST response (top), the observed change in SST (middle), and the observed change in ENSO- and PDO-removed precipitation between 1979-1999 and 2000-2020 (bottom).

Response of Precipitation

- Binned precipitation by relative SST and used the function to map the SST response and observed SST changes shown above to precipitation changes
- The response and the change from the observed SST change have the same differences as the SST response and changes
- Less similarity between the response and actual change in precipitation
- Convection is a complex process, so considering only SST changes leaves room for large differences with the observed changes

Summary

- Wind speed most important for the distribution of γ
- A uniform forcing results in a La Niña-like response
- Precipitation follows a warmer-get-wetter pattern
- Results not sensitive to reanalysis used (ERA5 shown)

Discussion and Conclusions

- Conflicts with the evaporative damping theory which says the western Pacific is damped more because SST is higher
- Results suggest Greenhouse Gas warming has contributed to the La Niña-like trend
- Damping from entrainment is maximized in a similar location as γ which could further intensify the gradient in the response