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Tropical SST Impacts on the Subtropical Atmospheric Circulation and Regional Precipitation

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The tropical Pacific Ocean hosts the Earth's most prominent year-to-year climate fluctuation, the El Niño-Southern Oscillation (ENSO), which exerts strong impacts on remote regions of the globe through atmospheric teleconnection. In this study, we use reanalysis data and Coupled Model Intercomparison Project Phase 6 (CMIP6) historical simulations to investigate the relationship between tropical and subtropical atmospheric circulation, and the tropical SST patterns and regional precipitation.

We find dynamical relationships between subtropical high intensity, the Hadley and Ferrel Circulation intensity, and the Eady Growth Rate from the reanalysis. A poleward shift of the maximum in Eady Growth Rate is associated with a strengthening of the descending branches of the Ferrel and Hadley Cells, with subtropical troposphere adiabatic warming and an increased intensity and poleward movement of the subtropical highs. Shifts in the poleward Eady Growth Rate are dominated by changes in vertical wind shear which, in turn, are in thermal wind balance with variations and trends in temperature. The mechanism for the intensification of the subtropical highs involves feedbacks from high-frequency transient eddies. Strong North Pacific and South Pacific Subtropical highs are associated with La-Niña conditions. We also show that the mechanisms for interannual variations are similar to those for trends in the highs.

We further analysed the performance of the coupled models in reproducing the trends (1979-2014) of the tropical zonal wind and regional precipitation. The CMIP6 historical simulations do not capture the intensification of trade winds within the Niño 4 region, and they also fail to reproduce the statistically significant precipitation trends over the Southern North America and the Amazon. However, a linear adjustment, based on ENSO teleconnections, can be applied to the coupled models to make the precipitation trends much closer to observations. The relationship between SST patterns and precipitation trends are confirmed by looking at atmosphere-only simulations. This study provides further evidence of the importance of reconciling observed and modelled SST patterns in the tropical Pacific.