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A Critical Role for Meridional Modes in Determining the Equatorial Pacific Response to Orbital Precession

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Understanding external drivers of the El-Nino Southern Oscillation (ENSO) is essential for predicting its future evolution. Orbital precession has been identified as a driver of ENSO variability through both proxy records and climate model simulations, yet the exact mechanics remain unclear. This orbital cycle moderates the seasonal timing of insolation relative to Earth's revolution around the Sun, thereby adjusting the magnitude of the seasonal cycle experienced by each hemisphere. Here, we analyze output from a suite of simulations in NCAR CESM 2.1.1 designed to analyze ENSO under different precessional extremes that significantly modify the meridional temperature gradients and the cold tongue seasonal cycle in the Pacific ocean. Variations in orbital precession have a strong impact on the magnitude, periodicity, and spatial expression of tropical Pacific variability. We find a critical role for both the North and South Pacific Meridional Modes (NPMM and SPMM) in explaining changes in ENSO and decadal variability by propagating subtropical anomalies to the equatorial Pacific along with a shift in the meridional structure of equatorial winds. As an example, when the perihelion of orbit occurs during boreal winter creating a dampened (strengthened) seasonal cycle in the Northern (Southern) Hemisphere, the SPMM becomes significantly more active while the NPMM weakens. This precessional state experiences a shift toward amplified decadal variability and a greater prevalence of Eastern El Nino events in comparison with the other orbital configurations tested. Understanding the precessional control of tropical variability via subtropical pathways may help explain developments that have occurred in the past, as well as future changes which may be observed due to shifts in meridional temperature gradients.