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Prediction and Predictability of Persistent Cool States of the Tropical Pacific

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The Tropical Pacific Ocean displays persistently cool sea surface temperature (SST) anomalies that last several years to a decade, with either no El Niño events or a few weak El Niño events. These cause large-scale droughts in the extratropics, including major North American droughts such as the 1930s Dust Bowl, and also modulate the global mean surface temperature. Here we show that two models with different levels of complexity—the Zebiak–Cane intermediate model and the Geophysical Fluid Dynamics Laboratory Coupled Model version 2.1—are able to produce such periods in a realistic manner. We then test the predictability of these periods in the Zebiak–Cane model using an ensemble of experiments with perturbed initial states. Our results show that in most cases the cool mean state is predictable. We then apply this method to make retrospective forecasts of shifts in the decadal mean state and to forecast the mean state of the Tropical Pacific Ocean for the upcoming decade. Our results suggested that the Pacific would undergo a shift to a warmer mean state after the 2015–2016 El Niño.
Based on the result that the long-term statistics of the $NINO_3$ index are modestly predictable where the short-term (interannual) variations are not, we use an attractor reconstruction method to examine the predictability of the Zebiak-Cane model on decadal timescales. We find that high- and low- variance states of the Tropical Pacific as determined by the $NINO_3$ index appear as separate regimes of behavior in the system's state space, and that the system spends over a third of the time in states from which the ENSO variance of the following 15 years is predictable. We characterize the states of the Zebiak-Cane model from which reliable predictions of the long-term variability can be made, and explore similarities between this system and the observations.