A study of decadal variability for El Nino-Southern Oscillation

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The observed El Nino events are generally stronger than the La Nina events. This property of ENSO is termed as ENSO asymmetry. Evidence is presented to show that this asymmetry has changed since the famous 1976 climate shift. Along the thinking of how the tropical background field modulates ENSO cycle, we explore the effect of the climatological basic-state change on the ENSO asymmetry by applying the approach of conditional nonlinear optimal perturbation (CNOP) in a theoretical coupled model. CNOP is the initial anomaly pattern that evolves into ENSO event most probably. Observation shows that from the pre-shift (1961-1975) to the post-shift (1981-1995) period, significant changes have occurred in climatological background state, i.e., the mean temperature difference between the equatorial eastern and western Pacific basins and between the mixed-layer and subsurface-layer water, which control the ENSO oscillation in the theoretical coupled model. By computing the CNOPs of the climatological basic state corresponding to the 1961-1975 (1981-1995) epoch, we reproduce the observed decadal change of ENSO asymmetry qualitatively. Based on the physics described by the model, the mechanism of ENSO asymmetry change in interdecadal scale is explored in depth. It is shown that the decadal change of ENSO asymmetry is induced by the change of nonlinear temperature advection, which is closely related to the decadal change of the tropical background state. These indicate that the decadal change of ENSO asymmetry results from the collective effect of the changes of the tropical background state and the nonlinearity. These findings in this study also suggest that the nonlinearity can explain not only the asymmetry of interannual ENSO, but also that of interdecadal ENSO, which may present a powerful evidence to the ENSO chaotic theory.