ENSO diversity caused by mean state-dependent ENSO modes resulting from an intermediate coupled model

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ENSO diversity is referred to the event-to-event differences in the amplitude, longitudinal location of maximum sea surface temperature (SST) anomalies and evolutional mechanisms, as manifested in both observation data and climate model simulations. Previous studies argued that ENSO diversity is associated with westerly wind burst (WWB) or subtropical forcing in the northeastern Pacific. Here, we bring evidences, from a modified intermediate complexity Zebiak-Cane (MZC) coupled model, to illustrate that the ENSO diversity is also determined by the mean states. Stabilities of the linearized MZC model reveal that the mean state with weak (strong) wind stress and deep (shallow) thermocline prefers ENSO variation in the equitorial eastern (central) Pacific with a four-year (two-year) period. Weak wind stress and deep thermocline make the thermocline (TH) feedback the dominant contribution to the growth of ENSO SST anomalies, whereas the opposite mean state favors the zonal advective (ZA) feedback as the key one. Different leading dynamical contributor and pacemaker make ENSO display its diversity in spatial pattern and period. In a mean state that resembles the tropical Pacific climate after 2000, the four-year and two-year ENSO variations coexist with similar growth rate. Even without WWB forcing, the nonlinear integration results with adjusted parameters in this special mean state also present at least two types of El Niño, in which the maximum warming rates are contributed by either TH or ZA feedback. The consistency between linear and nonlinear model results indicates that the ENSO diversity depends on the mean state.

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