A new intermediate coupled model for improved SST variability and predictability in the tropical Pacific climate system

Rong-Hua Zhang and Stephen E. Zebiak
International Research Institute for climate prediction,
Columbia University

Richard Kleeman
Courant Institute for Mathematical Sciences, New York University

A new intermediate coupled model (ICM) is developed and used to simulate and predict sea surface temperature (SST) variability in the tropical Pacific. The ocean component is based on an intermediate complexity ocean model developed by Keenlyside and Kleeman (2000) that is an extension of the McCreary (1981) baroclinic modal model with the further inclusion of varying stratification and nonlinearity effects, and of a SST anomaly model. One crucial component with such an ICM is the parameterization of subsurface entrainment temperature (Te) into the surface mixed layer within which the SST is computed; several schemes have been tested. The most realistic results were achieved by using a singular value decomposition (SVD) of the covariance between simulated ocean surface pressure from the model and the estimated Te from the inversion of the SST anomaly equation using observed (SST fields and their tendency) and model (mean and anomaly currents) data. The improved ocean model is then coupled to a statistical atmospheric model that estimates wind stress anomalies based on a SVD analysis between observed SST anomalies and wind stress anomalies from the ECHAM4.5 AMIP run (24 member ensemble mean). The coupled system exhibits a variety of behavior for a range of parameters. Four versions of the ICM, differing from each other in the details of the statistical formulations for Te and wind stress (annual invariant vs. monthly varying models reconstructed from data), show different coupled variability (e.g., oscillation periods and SST propagation feature). They are used to conduct a series of hindcast and forecast experiments. Extensive analyses have been performed to examine the sensitivity of prediction skill to model formulations.