A MARCH model for ENSO decadal variability

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Abstract

Linear stochastic ENSO models for the prediction of the EL Nino Southern Oscillation (ENSO) demonstrate comparable forecast skill to global climate models of intermediate complexity. Yet ENSO displays inherently non-linear characteristics such as skewness, and decadal variability than cannot be explained by white noise forcing. These nonlinearities have a large effect on long-term ENSO behavior even though the short-term variability is well approximated by a linear dynamical system. The decadal variability is observed as heteroskedasticity in the uncorrelated Gaussian residual of a SSTA only Vector Autoregressive (VAR) model. The Multivariate Autoregressive Conditional Heteroskedasticity (MARCH) model generalizes the VAR to enable time dependent variation in residual amplitude, but a physical parametrization is necessary to determine an appropriate noise decomposition. Kirtman and Schopf (1998) calculated that the decadal climatology during more predictable (unpredictable) regimes exhibits a warmer (colder) tropical pacific anomaly with more westerly (easterly) windstress anomalies. The strength of Walker circulation is an important aspect of ENSO predictability as increased reliability of the prevailing easterlies leads greater thermocline depression and longer more predictable advection due to sustained Rossby waves. The basin-wide windstress anomaly is in-fact westerly during these periods, because the increased wind-gravity imbalance and WP heat content leads to stronger El Nino during fall and winter months causing a strong reversal in Walker circulation. Conversely during colder regimes the temperature gradient between the western and eastern pacific is lessened and the strength of Walker circulation is weaker leading to less reliability of the prevailing easterlies and greater randomness in the trade winds. Smaller central pacific ENSO events can occur if equatorial Kelvin waves begin prior to the western pacific thermocline reaching its maximal depression. We explore the use of basin-wide SSTA as a parametrization of the noise model in a MARCH model in order to better approximate the decadal variability of ENSO.