Diagnosis of ENSO Variability in Coupled CAM/HYCOM Model

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1. Introduction

For my research I have examined two coupled general circulation models for El Niño/Southern Oscillation (ENSO). This research has the potential to make important contributions to the forefront of climate research. ENSO continues to be the core issue even in the current debate of climate change. The distinction between "Modoki" or central Pacific warming ENSO versus eastern Pacific warming ENSO is being touted as a possible global warming signal of ENSO. Its impact on Atlantic and eastern Pacific hurricane seasons is one of great socio-economic interest.

2. Data Sources

Two state-of-the-art climate models CCSM3.0 and CAM3.0/HYCOM (hereafter referred to as CAM/POP and CAM/HYCOM) have been compared to our best climate observational records, the former being one of the IPCC-AR4 models and the later developed by researchers at the Center for Ocean-Atmospheric Prediction Studies (COAPS). Monthly averages of model integrations for a 1000-year control run of CAM/POP are available from earthsystemgrid.org. At the time of this paper, 300 years of CAM/HYCOM control run have been completed. To neglect data during the period of initialization shock, 200 years of model data starting with year 101 will be compared to observational data. Observations used consist of 100 years (1909-2008) of Extended Reconstruction SST version 3b (ERSSTv3b) for SSTs, 60 years (1948-2007) of NCEP-NCAR Reanalysis data.

3. Results

Figure 1 shows the apparent variance associated with the first PC which is physically interpreted as ENSO over this domain. CAM/HYCOM (b) has a tendency to under represent modeled ENSO events compared to CAM/POP (c) but has a zonal extent closer to observations. Figure 2 shows that both models have zonal pattern of ENSO as compared to the horseshoe observed. CAM/HYCOM (b) shows stronger-than-observed variance off the coast of Peru. Figure 3 shows the effects of ENSO on precipitation. The well-established Hadley cell mutes the effects of ENSO in both models. Figure 4 shows the sample spectra for observations, CAM/HYCOM, and CAM/POP with climatological mean removed. Observations show ENSO period around 4.5 years. Relative amplitudes of the models' formed ENSO is much lower with the weakest amplitude in CAM/HYCOM. Notably, CAM/HYCOM has corrected the erroneous biennial cycle found in CAM/POP. To investigate the effects of the biennial cycle on our findings, a new noise-assisted data analysis method, Ensemble Empirical Mode Decomposition, is used. For our purposes, we have extracted two Intrinsic Mode Functions (IMFs): one containing the biennial cycle of the Niño 3 Index and one containing the ENSO cycle of the Niño 3 Index. The relative magnitudes of each IMF can be obtained from Figure 4. Figure 5 shows the effects of biennial cycle on SST. The relative effects of observations and models are weighted equally, however, with the exception of CAM/POP, contribute only slightly to the total time series. Figure 6 shows regression of IMF2 for comparison with Figures 1 and 2.

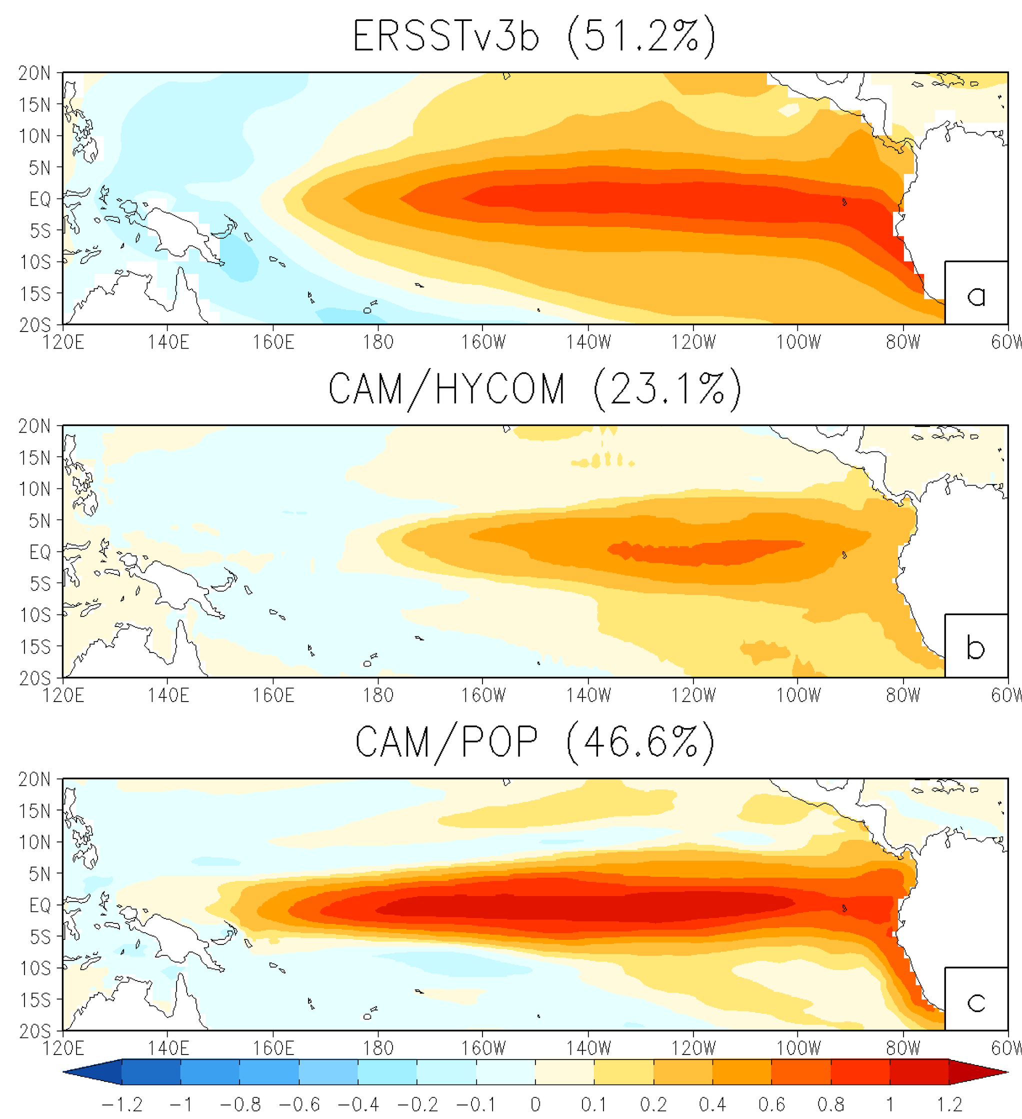

Figure 1. EOF1 for Equatorial Pacific; percentages are variance explained by the PC.

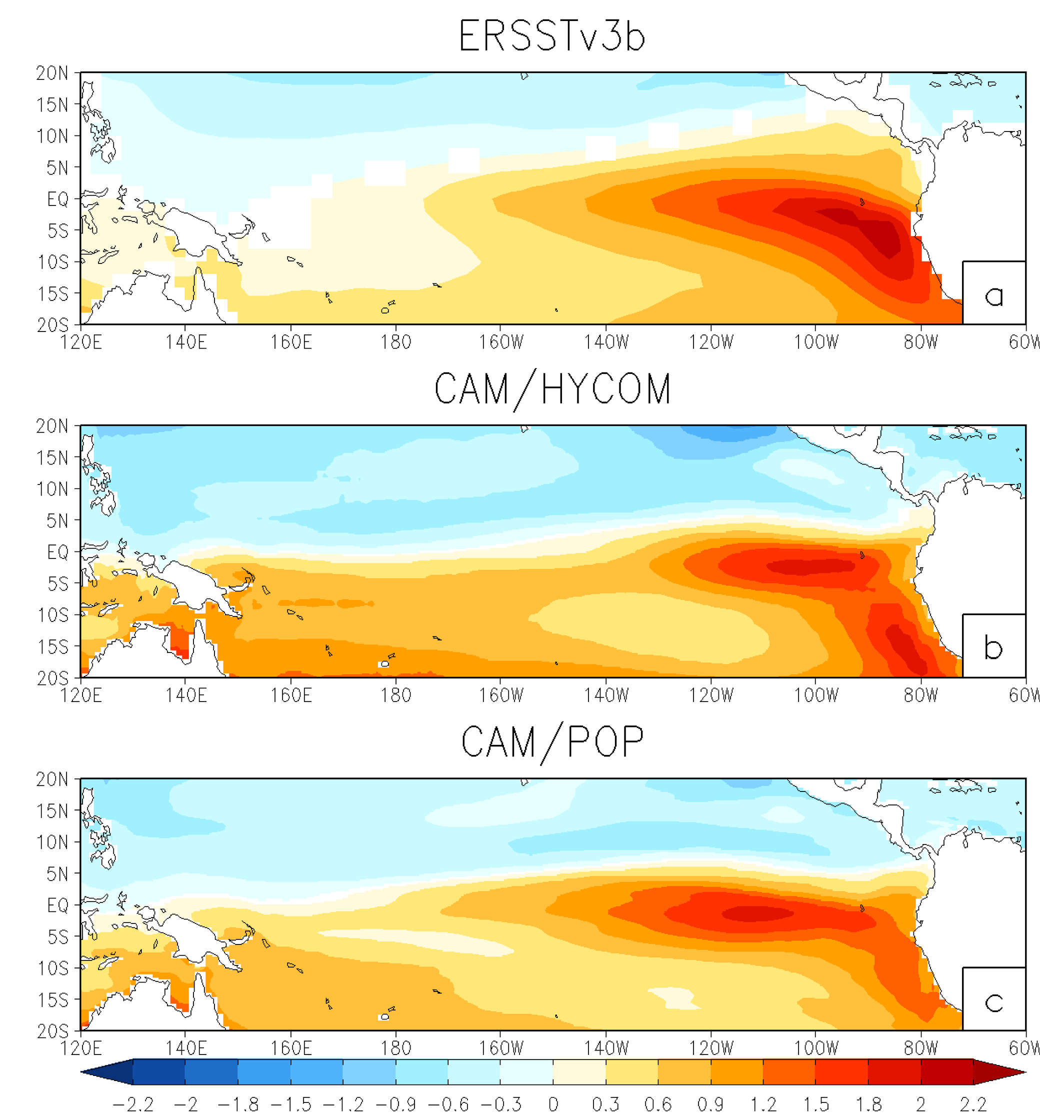

Figure 2. Regression of normalized Niño3 Index on equatorial Pacific SST; values significant at 95% confidence limit are shown.

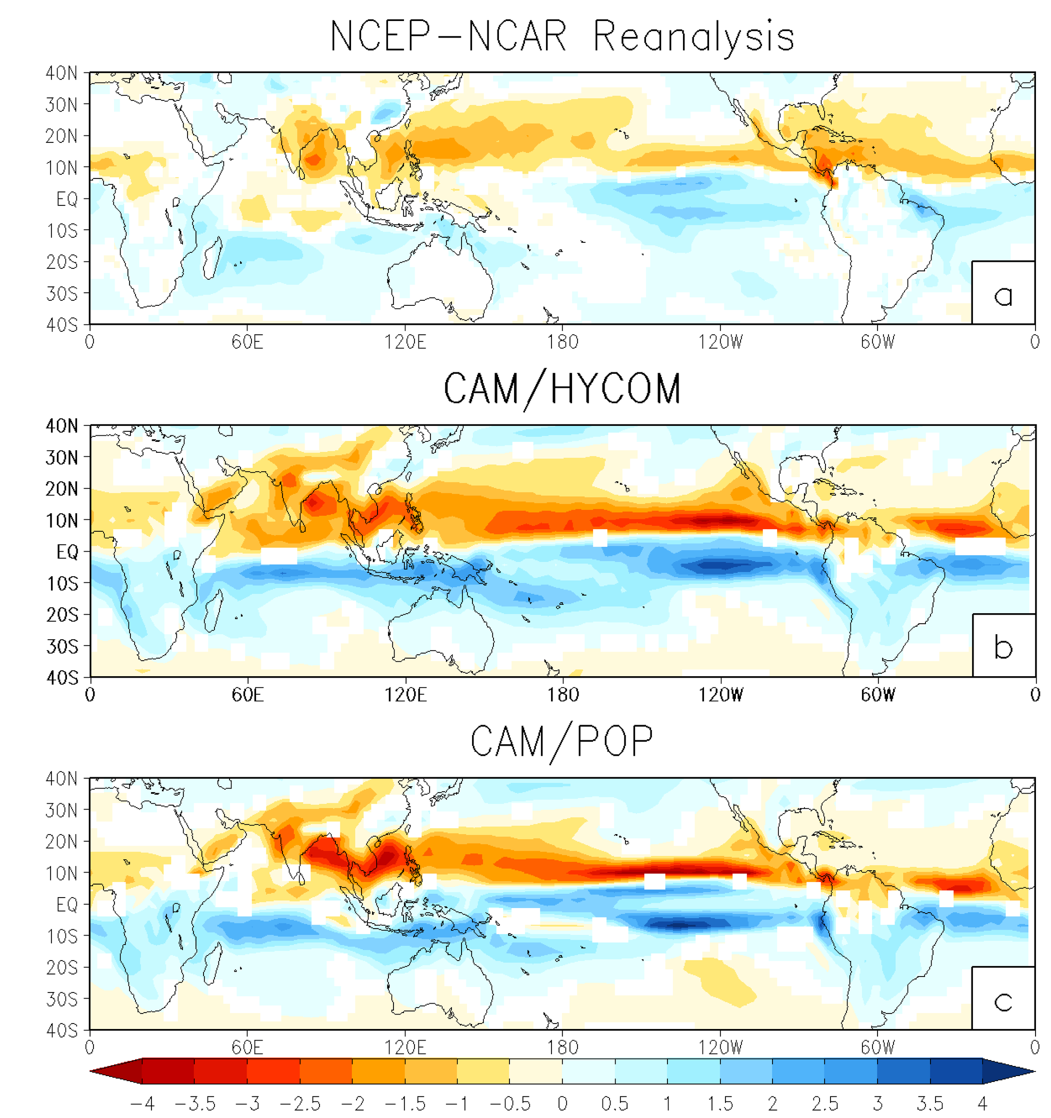

Figure 3. Regression of normalized Niño3 Index on precipitation; values significant at 95% confidence limit are shown.

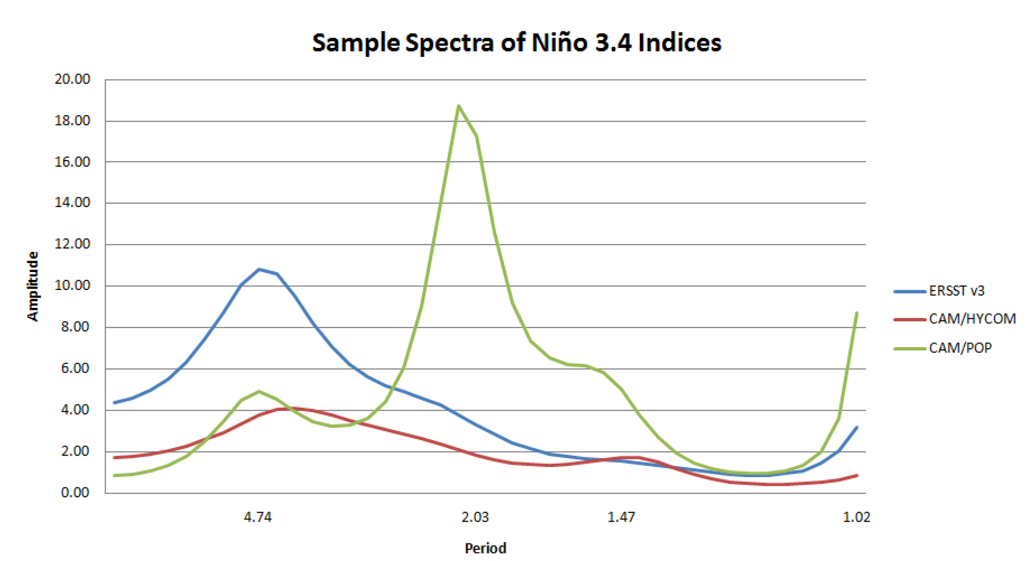

Figure 4. Sample Spectra generated using Maximum Entropy Method; ENSO signal is weaker than observations for both models CAM/POP has strong erroneous biennial cycle.

4. Conclusions

CAM/HYCOM and CAM/POP vary only in the ocean model used, however, this has shown to alter the ENSO variability significantly. CAM/HYCOM exhibits weaker ENSO variability compared to its counterpart but successfully removed the unphysical biennial pattern. While CAM/HYCOM has not improved the strength of ENSO variability or the split ITCZ phenomenon, it has improved the spatial pattern of warming associated with ENSO.

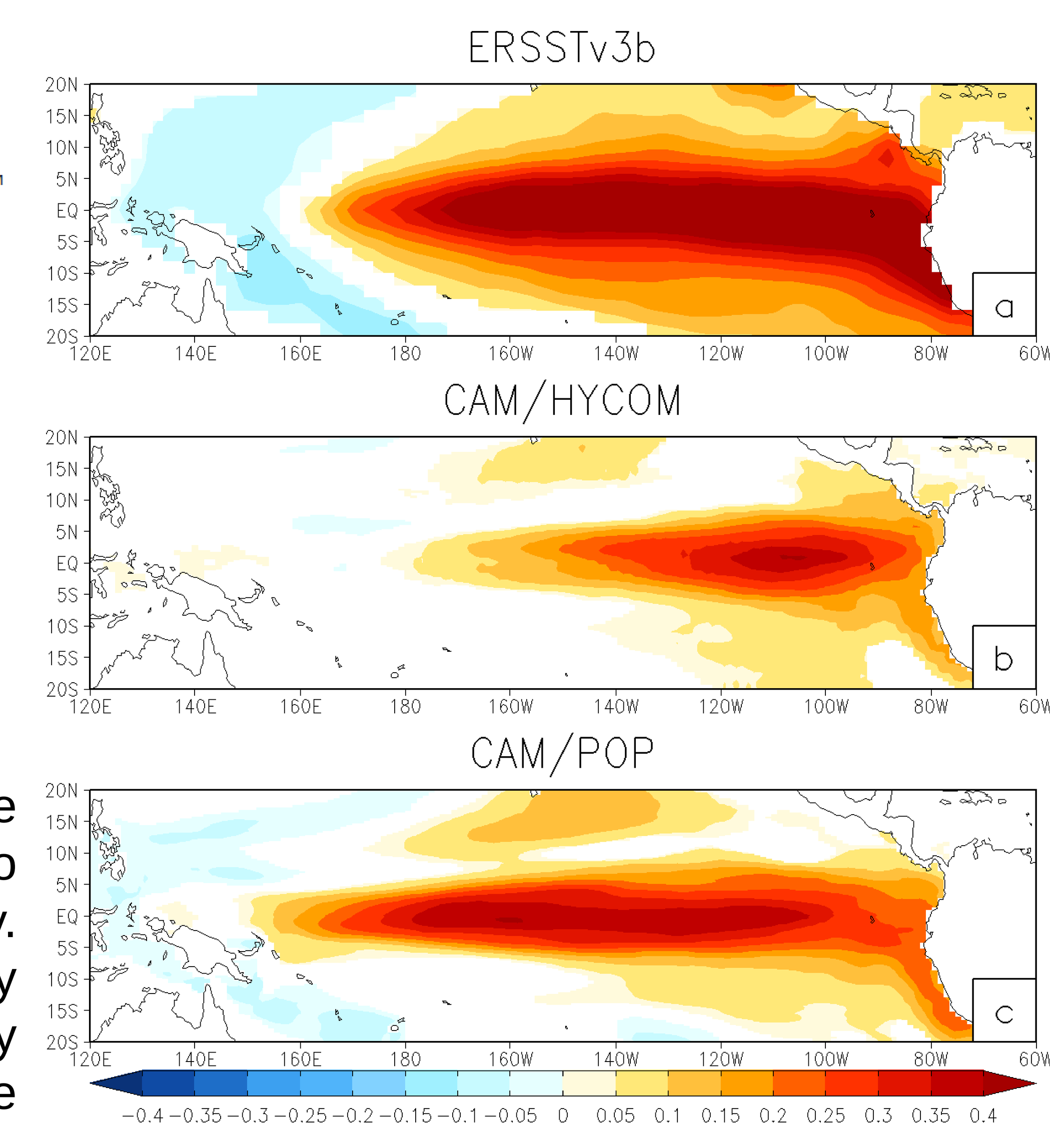

Figure 5. Regression of IMF1 (biennial cycle) on equatorial Pacific SST; values significant at 95% confidence limit are shown.

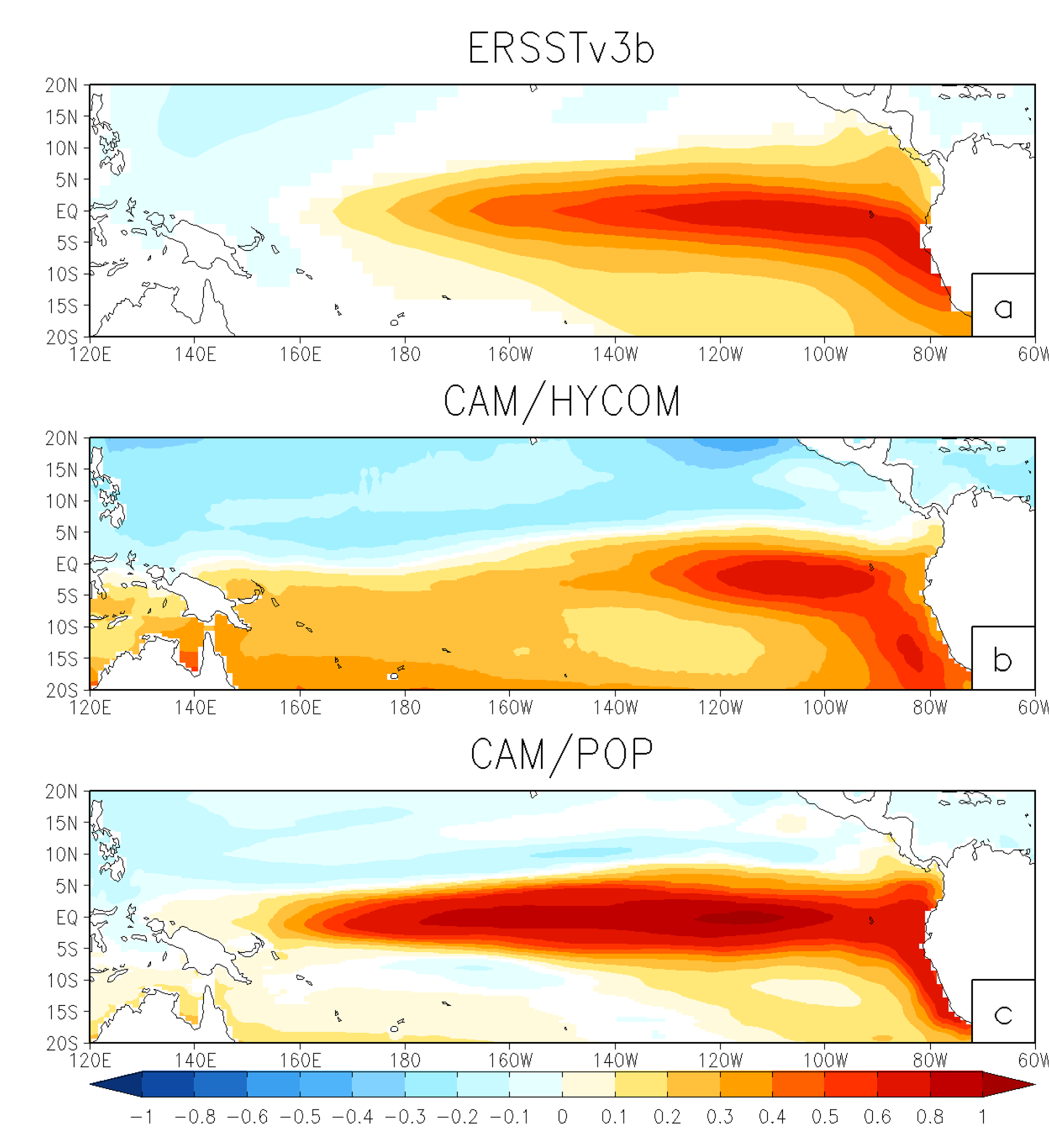

Figure 6. Regression of IMF2 (ENSO cycle) on equatorial Pacific SST; values significant at 95% confidence limit are shown.

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