Response of El Niño Events to Higher CO_2 Forcing: Role of Nonlinearity

De-Zheng Sun[1], Shao Sun[2], & Jin Liang[3]
[1]*University of Colorado, Colorado, USA*
[2] *China Meteorological Administration, Beijing, China*
[3]*Nanjing University, Nanjing, China*

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As El Nino—Southern Oscillation (ENSO) affects climate worldwide, how ENSO events respond to higher CO2 forcing is a critical question in the science of climate change. Theory based on a nonlinear, analytical model predicts an increase in the level of ENSO activity in response to higher CO2 forcing even when the level of activity is gauged by the traditional measure—the variance of Nino3 SST. This contrasts the average results from the state-of-the art climate models collected by CMIP5 that suggest a largely muted response. However, we find that that CMIP5 models have a common deficiency in simulating ENSO—an underestimate of the asymmetry between the two phases of ENSO. The nonlinear model that the theoretical prediction is based on, in contrast, does simulate this fundamental aspect of the observed ENSO. We further find that the number of models that project a consistent positive response of ENSO (i.e., an increase in the level of ENSO activity) to higher CO2 forcing under two different rates of CO2 increases is comparable to the number of models that give a consistent muted response of ENSO activity of CO2. More importantly, ENSO simulated in the historical runs of the models that predict a consistent positive response in the level of ENSO activity are found to be more comparable to the observations in amplitude and asymmetry than ENSO in the runs that project a muted response. These findings suggest a critical role of nonlinear dynamics in the response of ENSO events to higher CO2 forcing. The results also suggest that the theoretical prediction from a nonlinear, analytical model is not necessarily in consistent with projections by the state-of-the-art climate models.