GFDL One-Page Research Summary

A method for disentangling El Niño-mean state interaction

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Tropical rainfall plays a fundamental role in global climate, driving a global circulation that shapes weather and climate patterns. The El Niño / Southern Oscillation (ENSO) -- rooted in the tropical Pacific -- is Earth's largest interannual climate fluctuation, and impacts weather, ecosystems, and economies around the world. Understanding ENSO's interaction with tropical rainfall is thus highly relevant to society and to NOAA's mission.

A long-standing problem has been to understand why the climatological tropical rainfall differs among different coupled general circulation models (CGCMs), between models and observations, or between simulations with differing parameter settings or climate forcings. This study introduces a new method for understanding connections between ENSO variability and tropical rainfall, by decomposing climatological rainfall differences into components driven by changes in (1) mean SST, (2) SST variability, and (3) how rainfall responds to absolute SST.

The technique is demonstrated using 4 simulations from the MIROC5 CGCM, in which the level of lateral entrainment in the cumulus convection scheme was systematically increased -- resulting in decreased rainfall over the eastern equatorial Pacific. The analysis shows that the reduced rainfall is not the result of changes in the local rainfall sensitivity to absolute local SST, since those changes actually oppose the reduction in mean rainfall. Rather, the reduced mean rainfall results from cooler and less variable SSTs over the eastern equatorial Pacific, which generates fewer heavy-rainfall events in the region.

The method is then applied to 16 pre-industrial control runs from the Coupled Model Intercomparison Project Phase 5 (CMIP5). The results reveal that the inter-model diversity in eastern equatorial Pacific mean rainfall arises mainly from the inter-model diversity of both the mean SSTs and the precipitation sensitivities to absolute SST; the diversity in ENSO SST variability is only a minor contributor.

Future work could build upon these results, by applying the method to (1) additional models; (2) additional climate variables, such as winds and subsurface temperatures; (3) differences between models and observations; and (4) simulated anthropogenic changes in the climate system.