Understanding ENSO Diversity

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Summary:

1) The article reviews the current state of understanding of diversity among El Niño / Southern Oscillation (ENSO) events, which differ from event to event in their amplitude, spatial pattern, temporal evolution, dynamical mechanisms, and impacts.

2) ENSO diversity is apparent in historical climate records, paleo proxy records, and model simulations. There appear not to be distinct "types" of ENSO events, but rather a continuum of variability with some interesting extremes.

3) ENSO warm events (El Niños) are more diverse than cold events (La Niñas). Compared to weaker El Niños, stronger El Niños tend to exhibit their peak warm sea surface temperature (SST) anomalies farther east, with a relatively greater role in the ocean mixed layer heat budget for thermocline motions, as opposed to oceanic zonal advection and air-sea heat fluxes.

4) El Niño events of all types are often preceded (and in part triggered) by westerly wind events (WWEs) in the western and central equatorial Pacific, which are in turn favored by relaxation of the equatorial zonal SST gradient, recharge of the equatorial ocean heat content, and equatorward propagation of off-equatorial disturbances via wind-evaporation-SST feedbacks. The initial heat content of the tropical Pacific ocean influences the subsequent development of ENSO flavors.

5) Prediction systems can skillfully distinguish flavors of ENSO up to six months in advance, although model forecasts tend to warm too much in the eastern Pacific for those observed flavors that peak farther west. On longer time scales, simulations suggest that multi-decadal prevalence of a given ENSO flavor can occur at random, even in the absence of external changes in radiative forcings. Future anthropogenic forcings are expected to increase the intensity of ENSO rainfall anomalies in the central equatorial Pacific.

Relevance to NOAA science, and to society: The El Niño / Southern Oscillation (ENSO) is Earth's strongest interannual climate fluctuation, impacting weather, ecosystems, and economies around the world. Understanding the range of ENSO variation is thus highly relevant to society and to NOAA's mission.

Unique aspects of the study: The article draws from community discussions that took place at the U.S. CLIVAR Workshop on ENSO Diversity, held in Boulder, Colorado during February 2013.

Remaining uncertainties: Future work will focus on (a) understanding how ENSO diversity relates to decadal- and longer-term variations in the background climate state; (b) clarifying the sources and limits of predictability for different ENSO events; (c) improving the representation of ENSO diversity in climate models and observational and paleo reconstructions; and (d) improving operational forecasts of ENSO diversity.