# El Nino and the tropical Eastern Pacific annual cycle run to the same beat

September 22 2011

This is an image of rain clouds over the Pacific. Credit: International Pacific Research Center

Phase synchronization is a phenomenon in which separate oscillatory systems develop joint coherent behavior by some nonlinear mechanism. First described in 1673 by Dutch scientist Christiaan Huygens, this phenomenon occurs for instance when an applauding audience suddenly starts to clap in unison or when human breathing patterns lock to multiples of the heart beat.

Two climate modes dominate the temperature variability in the eastern equatorial Pacific. Generated through air-sea interactions, the El Niño-Southern Oscillation is the tropical Pacific climate mode that disrupts

weather patterns world wide about every 2 to 7 years. The seasonal cycle of temperature off Ecuador and the Galapagos Islands emerges through coupled air-sea interactions in response to off-equatorial solar radiation and can vary substantially from year-to-year in amplitude and phase with respect to the calendar, depending on the state of the El Niño system.

The interaction between El Niño events and the seasonal cycle of sea surface temperatures in the eastern equatorial Pacific can be described through such a nonlinear phase synchronization mechanism, according to a study published in the September issue of *Physical Review Letters* by University of Hawaii Manoa (UHM) Ph.D student Karl Stein and by Niklas Schneider and Axel Timmermann, professors at the International Pacific Research Center and the Department of Oceanography, UHM.

The team of climate scientists analyzed decades of temperature observations to detect evidence for phase synchronization among these two dominant tropical climate modes. Their extensive and complex mathematical computations showed that El Niño events and the annual temperature cycle in the eastern equatorial Pacific synchronize their common dynamics in what scientists call a "2:1 Arnold Tongue," after the famous Russian mathematician Vladimir Arnold (1937-2010). This partial synchronization indicates that at certain times El Niño and the annual cycle run according to the same beat, while at other times the phases of the two climate modes "slip past" each other.

The newly discovered sporadic phase-locking behavior of El Niño and the annual cycle will have significant impacts on current understanding of the seasonal predictability of large El Niño events. The scientists are eager to test how well state-of-the art climate models reproduce the nonlinear interaction between these two dominant modes of climate variability.

**More information:** Karl Stein, Axel Timmermann, and Niklas

Schneider, 2011: Phase Synchronization of the El Niño-Southern Oscillation with the Annual Cycle, Physical Review Letters 107, issue 12.

Provided by University of Hawaii