ENSO variability from mid- to late Holocene and the Seasonal Cycle of SST off Peru

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The El-Nino Southern Oscillation impacts environmental conditions across the tropical Pacific and, via teleconnection, feeds into climate across the globe. The degree to which ENSO is variable, and how this relates to global climate conditions, is a key issue for regional climate dynamics, marine biological resources and feedback analysis within the planetary climate system. The response of ENSO to global warming remains an open question. ENSO variability has been linked, in theoretical work, to both atmospheric dynamics and thermocline circulation in the eastern equatorial Pacific. Key factors are the seasonal cycle in strength of the meridional SST gradient in the eastern equatorial Pacific, and temperature and depth of the thermocline. These feed into an annual cycle which provides the trigger for ENSO state switching. There are various theories about the way that the key factors interact to control ENSO activity. We test these theories with an analysis of upwelling temperatures, and their seasonal cycle, for selected time intervals from the mid-Holocene of Peru. Lake records of El Nino frequency from Ecuador indicate that ENSO activity has varied on the millennial to centennial timescale from the mid-Holocene to the Present. We identify three time periods when ENSO variability was apparently minimized, in an intermediate state, and maximized. We examine these time intervals using sub-annual sampling of the stable isotopes of mollusk shell growth bands. We test whether the changes in El Nino frequency inferred from the lake deposits are supported by independent records from coastal Peru, and we test whether changes in annual cycle of SST and/or thermocline temperatures can account for the differences in El Nino activity as expected from theoretical considerations.