El Niño-Southern Oscillation (ENSO) phenomenon – event reconstruction and analysis over the past 2000 years

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A two-step modeling approach is used to reconstruct and analyze conditional trends in the number of annual Neutral, El Niño, and La Niña events over the past two millennia. First, annual data are extended from the century to millennial scale using a self-organizing map (SOM) technique. The SOM estimates the number of events by exploiting the underlying nonlinear multivariate relations among modern observations (< 150 years) of presence or absence of ENSO events, surface temperature (sea and land), oceanic teleconnections (Arctic, Antarctic, Atlantic, and Pacific), external solar forcing (sunspots and irradiance); and paleoclimatic (0-2000) land-based Palmer Drought Severity Index (PDSI) data. Cross-validation indicates that reconstructions of ENSO events are unbiased over the global region, and various regions of the northern and southern hemispheres. Second, quantile modeling reveals that neutral events appear on-the-average constant over the 2000 year period, whereas trends are opposite for El Niño and La Niña events. The number of La Niña events is lowest from 0 to about 800, and highest from about 800 to 1800, whereas the number of El Niño events is highest from 0 to about 1300, and lowest from about 1300 to 1800. The most significant rates of event change occur during the modern period beginning about 1800 with decreasing La Niña and increasing El Niño events that are reach about half their historic maximum numbers. The differences in numbers, timing, and duration among quantile models offer alternative interpretations that otherwise are not available when using traditional empirical smoothing.