

Timmermann, Axel, University of Hawaii

Changes in the Tropical Pacific Climate Variability During the Last Millennium:
External Forcing Versus Internal Variability

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Abstract: Paleo proxies, documentary research and instrumental data, all capture variations in ENSO behavior over the past centuries and throughout the Holocene. Much of this variability appears to be internal to the earth's climate system, but there is evidence from intermediate coupled models and coupled general circulation models that orbital variations have been responsible for systematic changes of ENSO statistics throughout the Holocene. Recently, also volcanic aerosol forcing as well as changes in the solar irradiance have been suggested as potential drivers for low-frequency changes of ENSO. Separating externally forced signals in tropical Pacific climate reconstructions and model simulations from the ones that are generated by internal instabilities is a fundamental problem, which will be addressed in our proposed research. Using several existing climate model simulations of the last 500-1000 years, we will elucidate the physical mechanisms responsible for long-term changes of tropical Pacific climate during the last millennium. Questions to be addressed specifically are: • What is the degree of consistency between different paleo-ENSO reconstructions during the last millennium? • What is the range of internally generated ENSO variability on decadal and centennial time scales in comparison with the externally-induced low-frequency modulation of ENSO? • What are the mechanisms of internally generated and externally-induced long-term changes of ENSO?

These questions will be addressed by a careful statistical analysis of existing paleo-proxy data for ENSO and by using coupled-atmosphere ocean general circulation model simulations for the last 500-1000 years.

Our proposed research will reassess existing paleo-proxy data, provide rigorous uncertainty estimates, and might eventually contribute to a better understanding of ENSO's sensitivity to climate change, with important implications for society.