

## PROJECT SUMMARY

### Investigation of a Dynamical Response of the Tropical Pacific to Orbital and Solar Forcing during the Holocene (PI: T. Marchitto)

Numerical models of varying complexity simulate an orbitally-forced ‘La Niña-like’ state in the tropical Pacific during the mid-Holocene that is generally, though not universally, supported by paleoclimate proxy data. The intermediate-complexity Zebiak-Cane model of El Niño – Southern Oscillation (ENSO) dynamics produces a similar response to enhanced solar irradiance at shorter (multi-centennial/millennial) timescales, a behavior that is not exhibited by global general circulation models (GCMs). Proxy evidence in support of the solar response is thus far equivocal and limited to the past 1000 yr. Initial results from Soledad Basin off the west coast of Baja California Sur appear to support both orbital and solar forcing of the ENSO system during the Holocene. Interannual variations in sea surface temperature (SST) at this site are dominated by ENSO today. Paleo-SSTs based on planktonic foraminiferal Mg/Ca exhibit orbital-scale cooling during the early to middle Holocene and millennial-scale cooling during early Holocene solar maxima, in accordance with the so-called ‘ocean dynamical thermostat’ mechanism inherent to the Zebiak-Cane model.

The work proposed here will build upon initial Soledad Basin observations and test the idea that this site provides unprecedented insight into the behavior of the ENSO system during the Holocene. The past 11.6 kyr will be spanned by a Soledad Basin box core, gravity core, and piston core of exceptional quality. Mg/Ca will be measured in three species of planktonic foraminifera, supplemented by  $\delta^{18}\text{O}$ , to capture past seawater temperatures in different seasons and water depths. The proposed work is divided into the testing of five interrelated hypotheses: (1) Holocene orbital-scale cooling off Baja California Sur was caused by a La Niña-like response of the equatorial Pacific to enhanced boreal summer/fall insolation; (2) Spring SSTs on the Baja California Sur margin cooled in response to positive solar forcing at multi-centennial/millennial timescales during the Holocene; (3) These millennial-scale SST oscillations reflect shifts in the ENSO system, and not local upwelling strength; (4) The Medieval Warm Period was colder in the eastern tropical Pacific (more La Niña-like) and the Little Ice Age was warmer (more El Niño-like); and (5) Early Holocene millennial-scale cold intervals in the eastern tropical Pacific were characterized by reduced ENSO variance.

**Intellectual Merit:** This work promises to add materially to the understanding of a system (ENSO) that is of great interest to paleoclimatologists, modern climatologists, and society at large. It will test the hypothesis that a major mode of the climate system is more sensitive to solar forcing than is currently simulated by GCMs. If the data generated here support that assertion, they will provide a crucial target for modeling by IPCC-class GCMs. The proposed use of single-specimen Mg/Ca measurements to assess past SST variance is novel and could become a valuable tool for paleoceanographers.

**Broader Impacts:** This project will provide extensive learning and training experiences for a new PhD student, including the presentation of results at two international meetings. It will also expose an undergraduate geology major to cutting-edge research, likely leading to an Honors Thesis. Existing collaborations between the PI and colleagues at other institutions will be strengthened (van Geen, Thunell) and new ones will be developed (Berelson, Moy, Zhao). Data that result in critical tests for GCMs could ultimately lead to more robust predictions of future climate change, particularly for a system that results in economically and societally important impacts on agriculture, fisheries, and natural disasters.