Abstract: The climate of the last 1,000 years was punctuated by two prominent events: the Medieval Warm Period (MWP) from 1000-1300 A.D. and the Little Ice Age (LIA) from 1400-1850. The impact of, and evidence for these events derives almost exclusively from the middle latitudes of the Northern Hemisphere continents, largely from tree rings (Jones & Mann, 2004) and mountain glaciers (Grove, 1988). Remarkably little attention has been given to the tropical climate of the last millennium and its potential impact on the middle and high latitudes even though massive fluxes of latent heat, moisture and momentum originate there (Peixoto & Oort, 1992). Indeed, records of the ENSO system, the monsoons of Asia and India, and the position of the Intertropical Convergence Zone (ITCZ) indicate that the last 1,000 years were a time of profound changes in the tropical climate globally. During the LIA the East Asian (Wang et al., 2005) and Indian (Anderson et al., 2002) monsoons plumbed their weakest intensity and, at least regionally, the ITCZ reached its southern-most position of the entire Holocene (Haug et al., 2001; Newton et al., 2006), ENSO intensity and frequency may have been higher than any time in the last 1,000 years (Cobb et al., 2003), and the Gulf Stream transport may have declined by 10-15% (Lund et al., 2006).

More recently, the intensity and frequency of El Niño events appears to have increased during the last 25 years relative to the prior 110 years. Judging whether this recent increase in El Niño activity is historically significant or within the normal range for the last millennium is still not possible owing to a scarcity of climate time series longer than 150 years. Indeed, most instrumental records of temperature and rainfall from the tropics are much shorter than that, and are often on the periphery of the tropical Pacific Ocean where rainfall and temperature are influenced by monsoon circulations and continental climates. In order to evaluate with confidence whether the more frequent and intense El Niño events of the last 25 years are anomalous relative to the last thousand years—a period sufficiently long to include forty 25-year intervals, plus the Little Ice Age and Medieval Warm Period—we propose to extend the record of tropical Pacific climate back to 800 A.D. using marine and lake sediments, corals, and mollusks to produce a robust record of the mean state of the tropical Pacific and variations in ENSO against which the changes of the recent decades can be rigorously evaluated.

The focal point of our approach is to reconstruct climate on time scales from 10-1 to 102 yr across the entire tropical Pacific, 135°W to 80°E and 20°S to 20°N, using multiple sites, archives and proxies from Palau, Papua New Guinea and northeast Australia in the west, the Northern Line Islands and Tahiti in the center, and the Galapagos, Clipperton Atoll, and Peru in the east (Fig. 1). We will combine records of seasonal, annual and inter-annual climate variations from mollusks (by Dr. Matthieu Carre, a JISAO Postdoctoral Fellow in my laboratory) and corals (by Dr. Sandy
Tudhope at the University of Edinburgh and Dr. Janice Lough of the Australian Institute of Marine Science) with records of inter-annual, decadal and centennial climate variations from sediments. We believe this multiple-archive, multiple-proxy approach across a wide swath of the tropics is the only way to produce climate time series of sufficient temporal and spatial resolution to meaningfully test and help improve models that are being used for predicting the response of ENSO and the global climate to increasing greenhouse gas forcing.

Our study is thus motivated by the following hypotheses: 1. Tropical climate reached extremes during the last millennium unmatched during the rest of the Holocene. 2. Tropical climate changes of the past millennium are linked with, and may have been drivers of significant regional and hemispheric changes in Northern Hemisphere air temperature that occurred during the MWPLIA period. 3. The 17th century marked an inflection point during the last millennium for the position of the ITCZ (southernmost), the Asian and Indian monsoons (weakest), and ENSO (most intense and frequent).

In order to test these hypotheses a robust climatology is required that spans the entire tropical Pacific Ocean and extends back in time to 800 A.D. This proposal seeks to produce that product. The project addresses the scientific objectives of the "Climate Change Data and Detection Paleoclimatology" element of the NOAA Climate Program Office. Specifically, we will produce a robust record of ENSO and the climatic mean state of the tropical Pacific since 800 A.D. by applying multiple proxies in multiple archives that have monthly-to-decadal resolution in those regions most strongly impacted by El Niño. Thus this project will provide an urgently needed data product that the climate modeling community can use for validation purposes. Finally, it will provide a sound basis for evaluating whether the late 20th-century increase in the strength and frequency of El Niño events is anomalous. All data generated from this project will be archived at the Paleoclimatology Branch of the National Climatic Data Center (NCDC).