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Collaborative Research: Extracting Multi-Century Low-Latitude Sea Surface temperatures from coral Skeletons Using Replicated Records of Annual Growth: Method Refinement & Application

Intellectual Merit: Northern hemisphere (NH) reconstructions suggest that the late 20th century was warmer than any other time during the last 500 years, and, with decreasing confidence, any time during the last 1,300 years. Global temperature reconstructions have greater uncertainties because there are fewer data sets from the southern hemisphere and low latitudes. Moreover, these reconstructions are based largely on terrestrial records from extra-tropical or high elevation sites. Temperature changes of the earth’s surface, however, most closely follow those of the global tropics, which are ~75% ocean. Improving global temperature reconstructions and reducing uncertainties, therefore, requires the development of well-replicated, well-dated, multi-century long records from the low-latitude oceans. With such records, we can provide a better context for understanding recent warming trends, provide better estimates of the temperature response to natural (volcanic/solar) and anthropogenic (greenhouse gas and aerosol) external forcing, and provide a better assessment of the persistence of internal modes of climate variability with changing background climate.

We have recently applied a method to reconstruct annual SST using the demonstrated relationship between the skeletal growth of corals and water temperature. We show in multiple records generated from 3 coral species at Bermuda, Bahamas, Belize and Fiji, that in these species, skeletal growth captures up to 85% of the variability in the instrumental record on multi-annual (>6yr) and longer timescales. Applying our method to a ~440-year long slow-growing coral collected from the Bahamas suggests that SSTs were within error of modern at ~ AD1550, that Little Ice Age SSTs were about 1°C cooler than today, and that there is a strong anthropogenic signal in the SSTs of the last 50 years. Here, we outline a research program that builds on this initial work, focusing on refining our method of extracting SST from coral growth records and applying it to generate multi-century long proxy SST records for the low-latitude Atlantic and Pacific Oceans. Data acquisition is relatively rapid and inexpensive, enabling us to generate many records of varying lengths from multiple colonies at each site, and, using techniques applied in dendrochronology, provide realistic error estimates on our reconstructed SSTs. Specifically, we propose:

1. To collect multiple new, long (>250 yrs) and short (50-70 yrs) cores from massive, slow-growing, long-lived corals in the US Virgin Islands, Belize, and Micronesia that will supplement a collection of cores already in hand from the Bahamas, Bermuda, the Red Sea, and Fiji,

2. To systematically assess the temperature-dependent response of skeletal growth in these massive, slow growing species, including the range over which the response is linear and possible ontogenetic effects (for which there is no evidence in these species),

3. To generate error estimates using several approaches, including those applied in dendrochronology,

4. To generate multiple, multi-century length, annually resolved records at several sites across the tropical/subtropical Atlantic and Pacific Oceans,

5. A significant data analysis effort to generate an SST stack, including error estimates, since at least AD1750 that tracks the global tropics, evaluating the persistence of climate modes such as the North Atlantic Oscillation, the Atlantic Multidecadal Oscillation, and the Interdecadal Pacific Oscillation, and detection and attribution analysis, and

6. To make our data available to, and collaborate with, modelers on a number of questions related to improving estimates of climate response to external forcings, and internal ocean variability.

Broader Impacts

This project includes funding for a postdoctoral investigator, a graduate student, and for undergraduate research training. Because the proposed method of generating mean annual SST is considerably less expensive than geochemical methods, we anticipate that a successful outcome will promote additional collection of similar data from other regions, by ourselves and others, so that ultimately a community-wide effort will result in the acquisition of a “network” of such SST records from the low-latitude oceans, enabling a better characterization of SST and climate trends and variability during the last 500 years. All data will be made available on NOAA’s NCDC website. All research will be presented at national and international meetings and at public venues; results will be summarized on our websites, and will be integrated into our undergraduate and graduate courses.