

Reconstructing Multi-Decadal to Centennial-Scale Variations of the Indian Ocean Dipole During the Last Two Millennia

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What were the primary questions you were trying to address with this research? (Or, if more appropriate, was there a hypothesis or theory that you were trying to prove or disprove?)

Our primary goals were to ascertain whether eastern Indian Ocean sea surface temperatures (SST) were unprecedented during the last two millennia and to use the geochemistry of depth-stratified planktonic foraminifera to reconstruct centennial-scale changes in Indian Ocean interannual variability. For a variety of reasons, work on these specific questions has gone slower than planned. Although we did carry out a core-top calibration to verify that our multi-species approach will work, we focused our temperature reconstruction of the last 2,000 years on a core from Indonesia, in the westernmost tropical Pacific.

What have you discovered or learned that you didn't know before you started this work?

Our work suggests that in the Indonesian region of the western Pacific, sea surface temperatures during the last 2000 years were within error of today during the peak of the so-called Medieval Warm Period, a warm period that occurred from ~ 900-1300 AD at high northern latitudes, but whose global extent is uncertain.

What is the significance of your findings for others working in this field of inquiry and for the broader scientific community?

We find this result surprising, especially because SST in this part of the ocean closely follows northern hemisphere and global temperatures. Reconstructions of northern hemisphere temperatures based on terrestrial archives (mostly tree ring records from high latitudes) suggest that recent temperatures are ~ 0.5 °C warmer than the Medieval Warm Period. Therefore, our results suggest that either one of the two temperature reconstructions is in error, or that the relationship between Indonesia and global SST's changed over the course of the last two millennia.

What is the significance of this research for society?

In my opinion, it is too early to tell. There are sources of uncertainty with all proxy reconstructions. In our case, I generated data that suggest that the season that the planktonic foraminifera we used for our reconstruction may change through time, and this may influence the amplitude of our temperature reconstruction in unexpected ways.

I have just written a proposal to the NSF, in part to follow through on this question.

What were the most unusual or unexpected results and opportunities in this investigation?

The evidence that the foraminifera changed seasonality was unexpected, though not startling. It prompted me to think about other ways to reconstruct SST, one aspect of my pending NSF proposal.

What were the greatest challenges and difficulties?

Foraminifera were not very plentiful in the top of the Indian Ocean core we had originally hoped to work on. This prompted us to work on the Pacific Ocean (Indonesian) core to address this question. Core-top data are needed to compare modern to past conditions.

When and where was this investigation conducted? (For instance, did you conduct new field research, or was this a new analysis of existing data?)

We had the samples in hand, but most of these were new analyses.

What were the key tools or instruments you used to conduct this research?

Geochemistry of planktonic foraminifera.

Is this research part of a larger project or program?

Yes, this work represents a larger effort by my colleagues and I to characterize and understand mechanisms of past climate change in the region, and the relationship of such climate changes to global climate.

What are your next steps?

My hope is to use the geochemistry of a foraminifera whose seasonality we know better, to reconstruct SST of the last 2,000 years. I have also proposed measurements to identify the specific mechanisms of sea surface temperature change (e.g., advection of waters with different temperature, changes in the intensity of upwelling of cold subsurface waters, etc.).

We are planning to pursue our original goal of reconstructing long-term trends in Indian Ocean interannual variability during the next several months. The sediments available to us will enable us to reconstruct changes over the last 10,000 years, but probably not a direct comparison to modern sediments.

Have you published findings or web pages related to this research? Please provide a citation, reprint, and web link (when available).

Paper will be published Aug 27th in Nature. The uncorrected proof is attached in this e-mail.