Statement of Research Interests

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Background

My research interests are varied but can be broadly categorized under the aegis of the oceans' role in regulating and determining regional and global climate change. In particular of late, I am focusing on climatic variability in the North Atlantic region on decadal-to-millennial time scales over the Holocene Epoch. In this and all my graduate research activities since earning my B.S. in applied mathematics from Towson University (1991), I have had the intention of employing a combination of observational studies and computer modeling in an environmental study, because far too often these complementary approaches are kept separate, which can lead to frustration for both camps. However, throughout my endeavors in this realm, achieving a real balance between modeling and observation has proved to be much easier envisioned than realized. My M.S. in environmental science from Florida Tech (1995) and my M. Phil. in ocean and climate physics from Columbia U. (2003) were both centered exclusively on computer model development and refinement. Never quite happy being entirely computer-based, I moved away from modeling for my Ph.D. research in geosciences at UMass-Amherst (degree expected August 2010), with an observation-based approach that involves extensive field and lab work while including only model results.

Because my most recent career history, and my continuing career goal, involves teaching at a small liberal arts college rather than working in a large research-based university setting, the approach I have taken to my Ph.D. research fits well with the direction I am moving. Generally speaking, it should prove easier to get large numbers of geosciences undergraduates involved in and excited about field-based research than computer modeling. This may be especially true for me, considering that my current research is based in Bermuda and that my future research ideas involve other remote island settings.

Current research

Before discussing future plans in detail, a bit of information on my current research is in order. The island of Bermuda, located in the Sargasso Sea of the subtropical North Atlantic Ocean, is a unique laboratory for analyzing the ocean's role in climate change. As a remote island (the nearest point of land is Cape Hatteras, NC, ~1000 km distant), Bermuda represents a small landmass whose climate responds directly to changes in the surrounding Atlantic Ocean. A wealth of terrestrial and historical climate data can be found there, providing a truly unique view of oceanic changes over time. In my case, I am utilizing a newly-digitized set of historical weather data dating to 1852 and the isotope geochemistry of a number of several-thousand year old stalagmites from Bermuda caves, to investigate climatic changes in this area over the late Holocene. I am using a combination of spectral and cross-correlational statistics to look for patterns, relationships, and trends in these data.

Specifically, I am investigating late-Holocene changes in the two leading modes of low-frequency variability in North Atlantic climate, namely the North Atlantic Oscillation (NAO) and the Atlantic Multidecadal Oscillation (AMO). These modes have profound influence on regional climate variability on different time scales, and Bermuda's subtropical setting, which lacks a strong seasonal cycle, is an ideal place to look for such variability.

My approach involves three main phases:

- digitization and statistical analysis of 150+ years of historical weather data from Bermuda (temperature, precipitation, sea level pressure, wind speed and direction), to establish modern conditions and provide a basis for calibration and comparison to stalagmite stable isotope and trace element data.
- stable isotope ($\delta^{18}O$, $\delta^{13}C$) analysis of a number of Holocene-age Bermuda stalagmites, to calibrate against the observational data and to combine with other proxy data from Bermuda and other North Atlantic region locations.
- stable oxygen isotope ($\delta^{18}O$) analysis of cave dripwater and rainwater from Bermuda, to establish a relationship between precipitation and dripwater $\delta^{18}O$ and to help interpret the stalagmite $\delta^{18}O$ results.

Among the more interesting initial results from this analysis are that Bermuda air temperature corresponds roughly to both the NAO and the AMO on different time scales, one stalagmite contains a signal that may correspond to a hemisphere-wide drought around 4200 years ago, and Bermuda cave dripwater exhibits a positive $\delta^{18}O$ spike in response to the rainfall from the passage of a hurricane over the island, which was opposite to our expectations as hurricane rainfall tends to be ^{18}O-depleted).

Future research ideas and goals

An important future direction for my research will involve education/outreach tied to Bermuda and its caves. I have made preliminary plans with scientists at the Bermuda Aquarium Museum and Zoo (BAMZ) for setting up a display at their facility based on my climate research. Also, I have personal and professional ties with several scientists at the Bermuda Institute for Ocean Sciences (BIOS) and have begun discussing possibilities for collaboration with them on student research through the NSF's Research Experience for Undergraduates (REU) program, with which BIOS is actively involved on several fronts, and for a short course on Bermuda cave geology and biology.

While the field and lab work portion of my dissertation study is coming to an end, a future direction for this project could involve computer modeling, which would bring my enduring aspiration of combining field work and modeling to fruition. The idea would be to employ isotope tracer modeling (i.e., an isotope-enabled tracer model coupled to a GCM) to strengthen the isotope-climate relationship, to analyze interannual climate variability, and to investigate future regional climate scenarios. This type of modeling tool would also prove useful in locations where there is a lack of observational data on stable isotopes of precipitation.

I view computer modeling as an essential process in climate research, and I hope to never completely abandon it. In fact I plan to take full advantage of my modeling background by incorporating a climate modeling component in the courses I teach and, if given the opportunity, formulating an introductory course dedicated to the subject. But in terms of research applications, sophisticated climate modeling is beyond the scope of most undergraduate students' abilities. Hence, because I will need to get students involved in my research, my future plans will be focused on field studies.

I have what I feel is an exciting, unique, and potentially far-reaching idea for investigating paleoceanography and paleoclimate in various locations around the world. The project would be called Terrestrial and Historical Records from Remote Island Locations (THRRIL), and it would consist of the same type of study that I am performing for my Ph.D. That is, historical weather data and terrestrial climate proxies (e.g., stalagmites, marsh and lake sediments, tree rings, submerged remains of past ecosystems, etc.) from small remote islands far from major land masses, would be utilized to provide a terrestrial-based dataset for marine climate-related changes over the Holocene. Certainly the most obvious way to investigate oceanic changes is to analyze marine records such as corals or marine sediments, but the THRRIL project would complement those data and provide independent means of comparison, perhaps revealing previously unseen changes or patterns as well since many terrestrial proxies have very high temporal resolution and lengthy temporal coverage.

There is a socially relevant potential aspect to this idea as well, one that would lend the project an added sense of purpose as well as a sense of urgency. As global sea level rises with the onset of global warming, some island nations' peoples are literally losing the land from under their feet. Assuming it gets started relatively quickly, the THRRIL project would obtain terrestrial information from these sites before they become submerged. Perhaps even more importantly, it could bring attention to the plight of the people living in these nations and provide a venue for students interested in the sociopolitical as well as the geological consequences of climate change and sea level rise.

Some locations that may work well for this project include the following:

- Azores
- Bahamas
- Cape Verde
- Faroe Islands
- Fiji
- French Polynesia (Tahiti)
- Galapagos Islands
- Maldives
- Mauritius
- Micronesia
- Niue Island
- Norfolk Island
- Pitcairn Island
- Samoa
- Seychelles
- St. Helena

While the availability of historical weather data from these locations is not guaranteed, they have all been inhabited for some time, and in many cases ships' logs can be utilized to broadly reconstruct weather variability in the proximity of the islands. As for climate proxies, many of these are carbonate islands with abundant cave stalagmites, and those that are volcanic will contain marshes, lakes, or trees that could yield good paleoclimate proxy data. I would plan to work in collaboration with other investigators on this, and getting students involved should be fairly easy for obvious reasons. I feel there is real potential with this project, to add several unique, valuable datasets from remote islands to help explore the oceans' role in regulating and determining climate over a wide variety of regional and temporal scales.