Multi-scale analysis of stable isotope – climate relationships in tropical proxy records

8/2010 - 7/2013 (AGS-1003690)

Mathias Vuille Dept. of Atmospheric & Environmental Sciences, Univ. at Albany

In collaboration with
Allegra LeGrande NASA/GISS, New York

In this project we propose to merge recent advances in forward modeling of stable isotopic proxies with new intriguing records of tropical Holocene climate variability from speleothems, lake records and ice cores to better constrain the interpretation of terrestrial stable isotopic proxies ($\delta^{18}O$ and δD) at interannual to millennial timescales. Given the rapid pace at which new high-resolution stable isotopic proxy records have become available recently, and the lingering uncertainty surrounding their interpretation at low latitudes, we believe this proposal to be very timely. Specifically we propose to:
- Evaluate the ability of GISS ModelE-R with stable isotopic tracer capabilities to reproduce Holocene climate variability in the tropics. We intend to synthesize, in close collaboration with a number of research groups, existing isotopic records into a spatio-temporal network that can be compared with GISS ModelE-R output at ~1000 yr time steps to obtain a dynamically consistent and physically plausible picture of changes in the tropical hydrological cycle throughout the entire Holocene.
- Diagnose the climatic controls on isotopic variations in the model throughout the Holocene at the various tropical proxy sites. We will focus on the influence of orbital forcing on the location of the ITCZ, changes in the Hadley and Walker circulation and the intensity of monsoons in each hemisphere and their respective imprint on $\delta^{18}O$ and δD in model and proxy data.
- Use SWING (Stable Water Isotope iNtercomparison Group) model output to assess the high-frequency (interannual- to decadal) isotopic variability related to tropical modes of ocean-atmosphere interactions. By employing spectral and empirical orthogonal function analyses we will determine the spatio-temporal isotopic variability associated with monsoon systems and modes of interannual climate variability such as the El Niño - Southern Oscillation (ENSO) phenomenon.
- Diagnose the relative importance of local versus large-scale upstream climatic effects on the $\delta^{18}O$ and δD composition in different parts of the tropics at different timescales. This decomposition will better constrain the uncertainties surrounding the use of isotopic proxies for climate reconstructions.

Our proposal intersects several areas of emphasis of the P2C2-NSF 08-505 program solicitation. Its **intellectual merit** is related to our attempt to "*improve understanding in the large-scale hydrological variability of tropical….regions* and to *"developing spatial-temporal networks needed to understand variability in ENSO, monsoons, Inter Tropical Convergence Zone (ITCZ) position, and regional hydrologic variability (e.g., droughts and floods) in….the tropics";* and finally to study *"modes of atmospheric variability and how they are altered by changes in mean climate conditions*" (P2C2-NSF 08-505 program solicitation). By focusing on model-data integration through forward modeling in a dynamically consistent and physically plausible framework we anticipate to gain new insight into past variations of the tropical climate system, its mechanisms and sensitivities. Our approach, focusing on stable isotope modeling is ideally suited to study past variations in the tropical hydrologic cycle, given the integrative character of $\delta^{18}O$

and δD and its much more homogeneous spatial characteristics when compared to precipitation. Isotope tracer models further allow for a direct comparison between the model output and the measured isotopic signal in proxy data, without additional error-prone conversion of simulated temperature or precipitation data into a proxy signal.

The **broader impacts** are guaranteed by the education and training of two graduate students at the University at Albany and Columbia University and dissemination of our results through publications, media, conferences, and integration of several research aspects into the classroom. Assessing the models ability to reproduce past variations in the tropical hydrologic cycle also has ramifications for future anthropogenic climate change projections as the model physics we rely on is essentially the same as in the next generation models used for the IPCC-AR5 report, to be released in 2013.