The Hadley Circulation and the Monsoon System Past and Present – A Stable Oxygen Isotope Modeling Perspective

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Low latitude ice core sites in Tibet, the Andes and East Africa are all to some extent influenced by the monsoon system under modern climatic conditions. It is therefore very likely that these sites have recorded past changes in the intensity, variability and location of the summer monsoon and the Hadley circulation as well.

Stable isotopes (δD and $\delta^{18}O$) from ancient precipitation preserved in ice cores are a commonly used proxy to describe climatic conditions at the drill site at the time of snow deposition. Long records of $\delta^{18}O$ in particular, may thus provide us with a past history of paleo-monsoon intensity. However many different factors, such as seasonality of precipitation, changes in the atmospheric circulation and related shifts in the relative contribution of various moisture sources to the total precipitation at the site, and changes in air temperature and precipitation amount can influence the stable isotope signal. Unfortunately it is very difficult to individually account for all these different factors acting upon the stable isotope composition at any given location over the course of thousands of years. This limitation clearly restricts our capability of correctly interpreting tropical ice core paleorecords. Simulations with Atmospheric General Circulation Models (AGCMs) on the other hand, which include stable isotopic tracers, have a big advantage over conventional observational methods, since all factors influencing the fractionation process are explicitly known, which allows testing of their relative importance.

Here we present evidence that two of these AGCM's, the ECHAM-4 (in T30 and T106 resolution) and the GISS II model, are able to quite accurately simulate both climate and stable isotopic variability under modern conditions in the tropical Andes. Based on both observational data and model simulations, the dominant climatic controls on the stable isotopic composition are evaluated, and ramifications for the interpretation of tropical Andean ice cores are discussed.

Finally potential applications of this modeling approach to other proxies (e.g. speleothems); to other sites, which are influenced by the summer monsoon (e.g. Tibet, East Africa and Arabia); and for times with different boundary conditions (mid-Holocene, LGM), when the monsoon system and the Hadley circulation operated very differently, will be discussed.