Reconstructing the Isotopic Composition of Past Precipitation from Continental Archives

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The distribution of stable isotopes in precipitation provides crucial quantitative information about the global water cycle. Increasing use of the water isotope tracers ^{18}O and ^{2}H in the atmospheric general circulation models that mimic Earth's climate processes has especially highlighted the need for better documentation and understanding of the distribution of isotopes in both past and present precipitation.

Thirty-two participants gathered in Vienna for the first ISOMAP workshop, held in cooperation with the Isotope Hydrology Section of the International Atomic Energy Agency, at IAEA headquarters in Vienna. ISOMAP is the central element of PAGES Focus 5 on Isotope Calibration (Activity 2, Task 1), and the primary goal of this inaugural workshop was to enunciate the transfer functions linking the isotopic data recorded in a given continental archive to the precipitation from which it was originally derived. This is an essential step in efforts to compile and manage isotopic data for data-model comparison, in order to clearly define the potential to estimate or constrain the isotopic composition of paleoprecipitation.

The discussions began by reviewing existing knowledge about the distribution of isotopes in modern precipitation, gained in large part from the IAEA/WMO Global Network for Isotopes in Precipitation (GNIP). This long-running program was recently strengthened by the signing of a Memorandum of Understanding between the two agencies, including establishment of formal PAGES representation on the Scientific Steering Committee. Although originally intended only to define what were thought to be essentially stationary input functions for hydrologic studies, the GNIP data base has proven to be a key source of information about contemporary global climate dynamics and change. Other related activities, especially the new science initiative ISOHYC (Isotopes in the Hydrologic Cycle) will build on the GNIP foundation to forge more sophisticated understanding of isotope-climate linkages.

The state of understanding about the fundamental physical processes controlling the natural isotopic labeling of water in the hydrologic cycle was also addressed, and the introductory session ended with a call for careful re-appraisal of such fundamental considerations as the kinetic behavior of deuterated water molecules during evaporation under various conditions, which remains surprisingly ill-defined.

ISOMAP Working Groups

The remainder of the workshop was devoted to plenary presentations by five previously established proto-working groups and subsequent break-out sessions. The first presentation dealt with the current abilities of general circulation models to depict the distribution of isotopes in global precipitation at different times, including the present. In spite of the relatively coarse (but continually improving) spatial resolution of current model runs, it is clear that the major features of the distribution of isotopes globally can be reproduced with some fidelity. The situation for the past is less clear, in significant part because of the sparse paleo-isotope data that are readily available.

The other four working group presentations focused on the major types of continental isotopic archives, including glacier ice, groundwater and speleothems, lake sediments, and terrestrial organic archives. For some archives, such as glacier ice and groundwater, the link to the original precipitation is very direct, and can potentially provide both $\delta^{18}O$ and $\delta^{2}H$ values, as well as the *d*-excess parameter ($d = \delta^{2}H - 8\,\delta^{18}O$), whereas other archives, including carbonate lake sediments, for example, may only support estimation of precipitation $\delta^{18}O$ indirectly via isotopic transfer functions linking both the archive to the lake water and the lake water to local precipitation.

Climate modelers are currently looking to paleoscientists for data of two types, the more familiar **time-slice** reconstructions of the isotopic composition of paleoprecipitation, for validation of equilibrium climate scenarios for key times in the past, including past extremes (e.g. Last Glacial Maximum and 6 ky BP), as well as a growing interest in **time-interval** reconstructions, to examine features of transient climate variability over selected periods. The former approach requires absolute constraints to be placed on estimates of the isotopic composition of paleoprecipitation for a given time and place, akin to estimates of paleotemperature or other climate parameters derived from different proxies. A prominent question addressed by modelers has been the robustness of spatial and temporal isotope-temperature relations in the past, because of their importance in the calibration of isotope paleothermometers. In contrast to such point-in-time isotopic reconstructions, validation of model-generated estimates of past climate variability, currently focused on the last millennium, depends on sub-decadally resolved paleo-isotope time-series, generally limited to archives like tree-rings and annually laminated lake sediments.

Paleo-Isotope Data

The presentations and discussions demonstrated that a high level of sophistication already exists in the development of transfer functions between measured parameters and precipitation, as a result of the extensive use of water isotope tracers in paleo-environmental investigations, but a major challenge facing both producers and users of paleo-isotope data is the effective management of data and meta-data, to permit ready retrieval of raw and inferred data for comparison and reinterpretation. This will be an important goal of future ISOMAP activities. Though the workshop was not focused on the problems of data compilation, the critical need for more paleodata from low latitudes was clearly recognized. Paradoxically, low-latitude glaciers, which constitute one of the best sources of paleo-isotope data in regions such as the Andes and Himalayas, are particularly poorly represented by (or even invisible to) current GCM's.

The primary outcome of this workshop will be a collection of peer-reviewed articles to appear in *Quaternary Science Reviews*, documenting the current state-of-the-art of continental isotope paleoclimatology, from the viewpoints of both paleodata production and use.

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