CLIMATE VARIABILITY FROM ISOTOPE RECORDS IN PRECIPITATION

H. GRASSL
Max-Planck-Institut für Meteorologie and Meteorologisches Institut, Universität Hamburg, Hamburg, Germany

M. LATIF
Meteorologisches Institut, Universität Hamburg,
Hamburg, Germany

U. SCHOTTERER
Physics Institute and Department of Chemistry, University of Bern,
Berne, Switzerland

L. GOURCY
Isotope Hydrology Section,
International Atomic Energy Agency,
Vienna

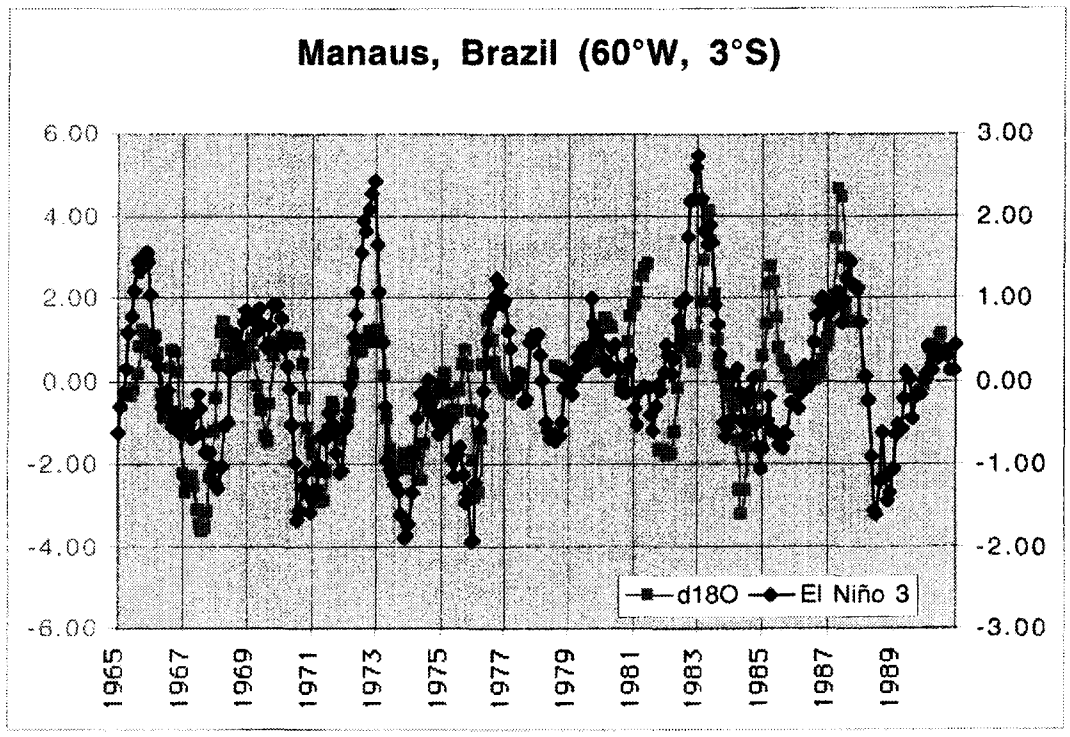
Abstract. Selected time series from the Global Network for Isotopes in Precipitation (GNIP) revealed a close relationship to climate variability phenomena like El Niño – Southern Oscillation (ENSO) or the North Atlantic Oscillation (NAO) although the precipitation anomaly in the case studies of Manaus (Brazil) and Groningen (The Netherlands) is rather weak. For a sound understanding of this relationship especially in the case of Manaus, the data should include major events like the 1997/98 El Niño, however, the time series are interrupted frequently or important stations are even closed. Improvements are only possible if existing key stations and new ones (placed at "hot spots" derived from model experiments) are supported continuously. A close link of GNIP to important scientific programmes like CLIVAR, the Climate Variability and Predictability Programme seems to be indispensable for a successful continuation.

1. MOTIVATION

The quantitative reconstruction climate history became possible largely by the measurement of isotopic composition in layered deposits. For example, the high correlation between greenhouse gas concentration in the atmosphere and atmospheric temperature from gas bubbles in ice cores and the ice itself is one of the pillars of the anthropogenic climate change debate and it is relying totally on isotopic composition records. The close relationship between atmospheric temperature and the composition of stable isotopes of the water molecule in precipitation (hence in ice) was one of the major earlier findings of the Global Network for Isotopes in Precipitation (GNIP), as reviewed in the 1960s by Dansgaard [1].

On the other hand, the understanding of climate variability on interannual to decadal time scales is a prerequisite for the separation of natural and anthropogenic climate change. As GNIP is now operating since four decades it should be possible to look for climate variability signals in its longest station records. In other words: Do isotopes in precipitation show strong climate variability phenomena like El Niño or the North Atlantic Oscillation (NAO)? A first attempt to answer this question was started some years ago by Hans Oeschger's Isotopes in the Hydrological Cycle (ISOHYC) Initiative.

Observations:



ECHAM-4:

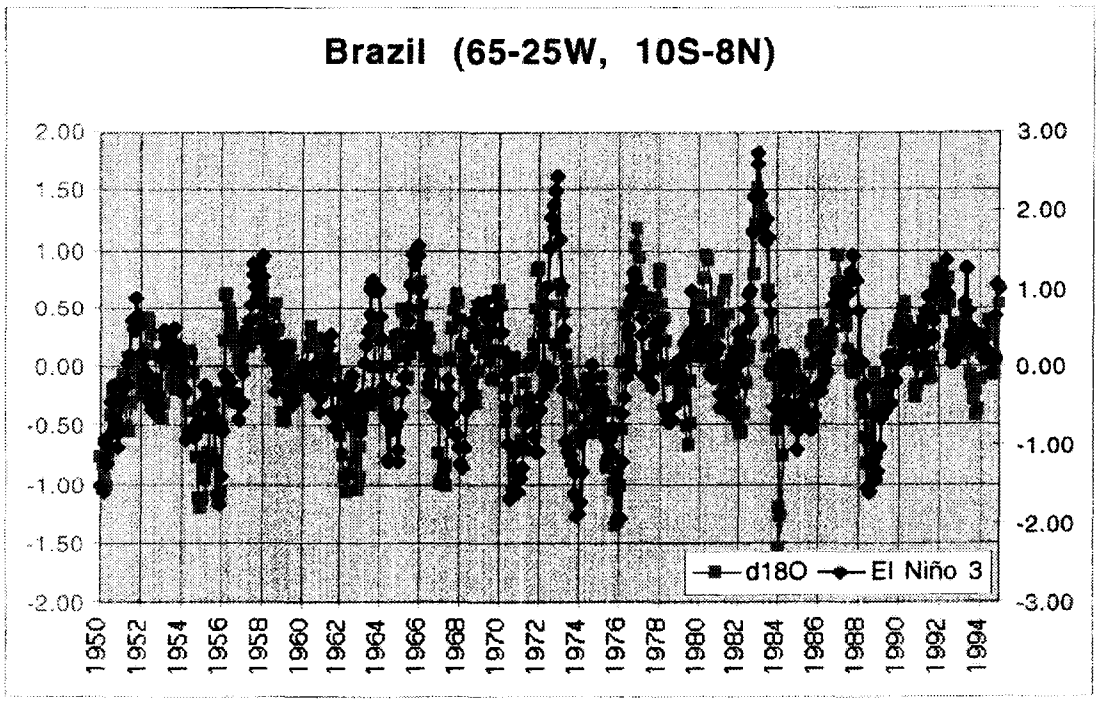


FIG. 1. Correlation of $\delta^{18}O$ from monthly composites of precipitation in Manaus with sea surface temperatures from the Niño 3 area; upper panel: observations, lower panel: modelling result.

2. FIRST RESULTS

As GNIP was not meant for climate variability studies, there exist only very few continuous records in areas sensitive to El Niño. Although the station Manaus, in the Amazon basin, Brazil, does not represent a key area of ENSO-related precipitation anomalies due to the intensive water recycling [2], which may overprint this anomaly a first statistical treatment of the available isotope data between 1965 and 1989 [3] shows a close correlation to SST anomalies in the central Pacific Ocean (Fig. 1).

Unfortunately, the data collection stopped in 1989 and the major 1997/98 El Niño was not included. However, a reconstruction of El Niño events in natural archives (ice cores, tree rings, corals, lake deposits) close to strong impacts of El Niño (hot spots) seems feasible.

The denser isotope network in Europe opens a much better opportunity to look for even weaker climate anomalies like the NAO. For example, despite the weak precipitation anomaly related to NAO in Groningen (The Netherlands) the isotope anomaly is significantly correlated to NAO (Fig. 2).

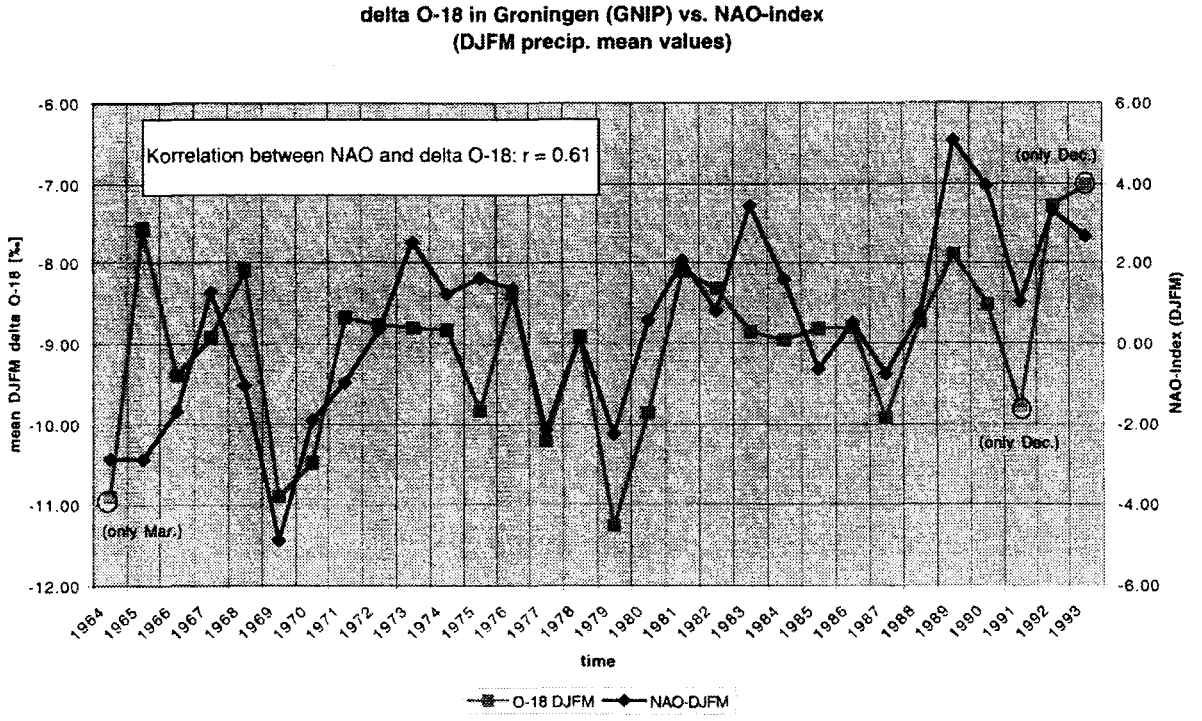


FIG. 2. Time series of winter (DJFM) North Atlantic Oscillation (NAO) index (blue) and the $\delta^{18}O$ measurements at Groningen. Both time series are highly correlated.

The high correlation of $\delta^{18}O$ may be addressed to ocean-atmosphere interactions within the source area of atmospheric moisture during a specific NAO situation and the rain-out history of the air masses precipitating at Groningen. Improvements in the connection between isotopic composition and changes in the atmosphere/ocean-interaction, on which they are based, can be achieved by model experiments. These models have to contain balance equations for the stable isotopes oxygen-18 and deuterium as well.

These improvements will remain wishful thinking if no new data from stations in "hot spot" areas are initiated, continuously supported and evaluated (extended GNIP).

3. FURTHER INITIATIVES NEEDED

The science initiative ISOHYC, together with the GNIP sponsoring agencies IAEA and WMO, already could halt the further decay of the GNIP. A memorandum of understanding between IAEA and WMO led to:

- Scientific Steering committee of the GNIP,
- revival of stations
- event-based sampling at a few stations in order to follow climate anomalies
- stronger integration of national networks, and
- the strengthening of the open-access GNIP database.

Although this has strengthened GNIP as a whole, it is, however, still not suited to fulfil its role in an isotope climatology as envisaged by Hans Oeschger, when he - together with the Beatenberg Group- started the ISOHYC Initiative in 1997.

A prominent example, where a science initiative has led to intergovernmental support is the World Climate Research Programme's (WCRP) study on Climate Variability and Predictability (CLIVAR [4]), that now has started to implement a global upper ocean observing system called ARGO, jointly with another science initiative GODAE (Global Ocean Data Assimilation Experiment) with the financial support of most OECD countries.

If a CLIVAR question like "Do we intensify El Niño events or influence monsoonal variability by an enhanced greenhouse effect?" has to be answered convincingly, we need to extend the instrumental record into the recent past by isotope-based quantitative reconstruction of the relevant climate parameters. An Isotope Climatology, therefore, would be a proper module within CLIVAR. This would then give the push for a further strengthening of GNIP by the synergy of scientific and intergovernmental support.

REFERENCES

[1] DANSGAARD, W. Stable isotopes in precipitation, Tellus **16** (1964) 436-468.

[2] GAT, J.R., MATSUI, E. Atmospheric water balance in the Amazon Basin: an isotopic evapotranspiration model, J. Geophys. Res., **96 (D7)** (1991) 13179-13188.

[3] WERNER, M. Private Communication.

[4] CLIVAR EXCHANGES No. **19, 20, 21** (2001) http://www.clivar.org/