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Interpretation of Water Isotope Signals in paleo archives covering the last 20.000 years

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Water isotope records from various paleo archives are among the most important climate archives of Quaternary climate variability. The advantage of these records is often their extremely high resolution (in particular the various ice core records from the southern and northern hemisphere ice shields) and that the quantity reconstructed from the different archives, i.e. the water isotope signal of paleo precipitation δ^{18}O and δD, is a purely physical quantity of the hydrological cycle (in contrast to the many biological tracers). However, this physical quantity is in fact influenced by many possible complications: The isotopic composition of precipitation is affected by source conditions of the final water vapour forming the precipitation, its trajectory and mixing along the trajectory, the seasonality of precipitation and many other factors. Many of these factors can be addressed within a GCM framework. Therefore the physics of water isotopes have been introduced into a number of atmospheric GCMs which were finally run under different boundary conditions. Here I present results of a number of time slice experiments throughout the Holocene to the last glacial maximum with the isotope version of the ECHAM model. Results are analysed with respect to high latitude records and their relationship with simulated temperature changes to explore the validity of the often used assumption of a stable temperature/isotope relation (temperature effect). In fact the model can faithfully mimic the bias in the Greenland isotope/temperature relation under glacial conditions which was found in observational studies. Key factors responsible for the bias of about 50% of the isotopic paleothermometer over Greenland are the seasonality of precipitation and shifts in source temperature conditions. Over Antarctica, the simulation in fact confirmed a

more stable paleothermometer with however some non-negligible spatial variability. This variability is mainly the result of differences between diverging condensation and surface temperature shifts. These shifts are in fact triggered by the imposed orography changes of the Antarctic ice sheet. These model results point to two major problems in the interpretation of Quaternary isotope signals: A) the Deuterium excess signal (i.e. the scaled difference between precipitation δ^{18}O and δD) under glacial conditions. This signal is classically interpreted as a tracer of water vapour source conditions and could not be reproduced by the GCM whatever were the chosen glacial boundary conditions. B) The observed depletion of tropical water isotope record was not simulated by the model. Again (like for the deuterium excess) this indicates major problems in our understanding of the glacial hydrological cycle.