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Stable isotope composition of carbonate and fluid inclusions in Holocene stalagmites from the Amazon Basin

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The paleoclimate of Amazonia has been the topic of considerable debate over the past decades. Particularly the climatic and environmental changes that accompany Glacial-Interglacial transitions were the focus of attention. However, also in the Holocene, significant climate change was recorded in various studies (e.g. Hooghiemstra and van der Hammen, 1998; and references therein). The Andean highlands contain good climate records in lake sediments (e.g. Baker et al., 2001) and ice cores (Thompson et al., 1998), while lowland paleoclimate data mostly hinge on pollen records. Lowland isotope records, comparable to the Andean ice cores, are scarce, although several speleothem records have been published recently (e.g. Cruz et al., 2005).

Here, we present high-resolution Holocene stable isotope records from stalagmites collected in lowland Peruvian Amazonia. These records show a long Holocene trend with more than 2 permil oxygen isotope variation. This trend compares relatively well to the January (wet season) insolation curve calculated for this latitude.

Since temperature is thought to have varied little in this area during the Holocene, the significant trend in δ^{18}O data most likely derives from isotope variation in rainwater. In Amazonia a strong amount effect, regulated by the shifting Intertropical Convergence Zone (ITCZ), exerts the dominant control on rainwater isotope composition. Over the Holocene, ITCZ migration over Amazonia was forced by insolation. Therefore, the isotope pattern observed in our speleothems likely reflects insolation-forced ITCZ migration over Amazonia. A good case for such a general relationship was already given by Cruz et al. (2005) who showed that the isotope pattern of a 116ka speleothem from Brazil is in phase with Milankovitch-driven insolation of that time

interval.

To verify this hypothesis for the Holocene, we analysed the isotope composition (δ^2H and δ^{18}O) of fluid inclusion water in our speleothems. Cave drip water usually is isotopically very similar to the rainwater from which it originates. Some drip water is trapped as fluid inclusions in the stalagmite where its original isotopic signal remains undisturbed. We applied the technique developed by Vonhof et al. (2006) to analyse the oxygen and hydrogen isotope composition of the fluid inclusions, resulting in a record of Holocene rainwater isotope variation in Amazonia. Oxygen and hydrogen isotope values of these inclusion water samples generally plot close to the Global Meteoric Water Line, and their temporal variation indeed lines up with isotope variation in speleothem carbonate, and the January insolation curve.

In conclusion, fluid inclusion stable isotope data support that Milankovitch-forced insolation has an important control on rainfall patterns in Holocene Amazonia. In a broader sense, this study shows how fluid inclusion stable isotope analyses can drastically improve paleoclimatic interpretation based on speleothem records.

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