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The variability of the North Atlantic Oscillation throughout the Holocene

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The North Atlantic Oscillation (NAO) has a major impact on Northern Hemisphere winter climate. Trouet et al. (2009) reconstructed the NAO for the last millennium based on a Moroccan tree ring PDSI (Palmer Drought Severity Index) reconstruction and a Scottish speleothem record. More recently, Olsen et al. (2012) extended the NAO record back to 5.2 ka BP based on a lake record from West Greenland. It is, however, well known that the NAO exhibits non-stationary behavior and the use of a single location for a NAO reconstruction may not capture the complete variability. In addition, the imprint of the NAO on European rainfall patterns in the Early and Mid Holocene on (multi-) centennial timescales is still largely unknown. This is related to difficulties in establishing robust correlations between different proxy records and the fact that proxies may not only reflect winter conditions (i.e., the season when the NAO has the largest influence).

Here we present a precisely dated, high resolution speleothem δ^{18}O record from NW Morocco covering the complete Early and Mid Holocene. Carbon and oxygen isotopes were measured at a resolution of 15 years. A multi-proxy approach provides solid evidence that speleothem δ^{18}O values reflect changes in past rainfall intensity. The Moroccan record shows a significant correlation with a speleothem rainfall record from western Germany, which covers the entire Holocene (Fohlmeister et al., 2012). The combination with the extended speleothem record from Scotland, speleothem records from north Italy and the NAO reconstruction from West Greenland (Olsen et al., 2012) allows us to study the variability of the NAO during the entire Holocene. The relation between West German and Northwest Moroccan rainfall has not been stationary, which is evident from the changing signs of correlation. The Early Holocene is characterized by a positive correlation, which changes between 9 and 8 ka BP into a negative correlation. Simulations with the state-of-the-art earth system model COSMOS for the Early and Mid Holocene (Wei and Lohmann, 2012) indicate that this change in the NAO teleconnection is related to large-scale circulation changes due to the ice sheet configuration and deglaciation.

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