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Late Holocene climate oscillations and ^{14}C fluctuations in speleothem calcite: constraints on models for solar forcing

A.S. Jackson (1), **F. McDermott** (1) and A. Mangini (2)

(1) UCD School of Geological Sciences, University College Dublin, Belfield, Dublin 4, Ireland, (2) Institut für Umweltphysik, Heidelberger Akademie der Wissenschaften, Im Neuenheimer Feld 229, D-69120 Heidelberg, Germany

frank.mcdermott@ucd.ie

Links between Holocene climate variability and changes in solar irradiance remain controversial. The initial ^{14}C activity of calcite deposited in a late Holocene stalagmite (a$^{14}C_{stal}$) from Attahöhle (Sauerland, Germany) varies synchronously with changes in atmospheric ^{14}C activity (a$^{14}C_{atm}$). This observation provides independent chronological support for the correlation between a solar forcing proxy (atmospheric ^{14}C production rate, a$^{14}C_{prod}$) and a climate proxy ($\delta^{18}O_{stal}$) in this stalagmite, and eliminates the need to 'tune' the chronology. A Monte Carlo randomisation in which 100,000 synthetic $\delta^{18}O_{stal}$ datasets indicates that the strong correlation between a$^{14}C_{prod}$ and $\delta^{18}O_{stal}$ is statistically robust. The absence of a significant time lag between the $\delta^{18}O_{stal}$ and a$^{14}C_{prod}$ datasets implies tight coupling at this site between a climate-sensitive proxy and atmospheric radiocarbon production. The transmission of the a$^{14}C_{atm}$ profile to STAL-AH-1 also implies rapid carbon cycling in the soil/epikarst zone above Attahöhle, and a 'dead carbon' proportion that remained relatively constant during 2.7-2.2 ka. Taken together with evidence from Holocene lake cores and ^{14}C 'wiggle-matched' peat bog sequences, the data for STAL-AH-1 are interpreted to indicate cold-wet conditions (and an increase in effective summer precipitation) during late Holocene solar minima. These conditions are difficult to reconcile with the predictions of atmospheric amplification models [cold-dry, e.g. Shin-

dell et al., 2001], pointing to possible deficiencies in the physics of these models (e.g. absence of cosmic-ray modulated cloud formation processes).

Shindell, D.T., Schmidt, G.A., Mann, M.E., Rind, D. and Waple, A. (2001) *Science* **294**, 2149-2152.