Solar forcing of Holocene climate; where are the amplifiers?

FRANK MCDERMOTT

Department of Geology, University College Dublin, Belfield, Dublin 4, Ireland. (frank.mcdermott@ucd.ie)

It is generally accepted that climate variability on time-scales of 10^3 to 10^5 years is driven primarily by orbital forcing. By contrast, the cause of high-frequency variability on decadal to millennial timescales during the Holocene remains highly contentious. Cosmogenic isotope fluxes (e.g. ^{10}Be, ^{14}C) provide proxies for solar irradiance, and several recent studies have highlighted the correlation between total irradiance and variations in climatic conditions in the Holocene. Thus, there is increasing evidence that solar variations may have had a significant impact on Holocene climates. Examples include an association between southward expansions of ice-bearing cold surface waters in the N. Atlantic and inferred minima in solar output, a correlation between monsoonal rainfall and atmospheric Δ^{14}C in Oman, and evidence that the European terrestrial biota of may respond, via climate change, to variations in atmospheric Δ^{14}C.

An important issue in palaeo-climatology therefore is how seemingly small changes in solar output are amplified to produce detectable climate signals. Recently two positive feedback models have been proposed, involving atmospheric (stratospheric ozone changes) and oceanic amplifiers (reduced NADW) respectively. Fortunately, each predicts a distinctive pattern of circum N. Atlantic regional cooling during times of low solar irradiance, allowing an assessment of their relative effects on different timescales.

A high resolution terrestrial δ^{18}O data-set from a mid-latitude speleothem (Crag Cave, S.W. Ireland) indicates that multiple cooling events during the early to mid-Holocene are synchronous with those in the high-latitude ice-cores on centennial to millennial time-scales. This indicates broad regional cooling and favours an oceanic rather than an atmospheric amplifier. By contrast, historical and proxy climate data for the so-called Maunder Minimum indicate regional cooling patterns that are consistent with a low Arctic Oscillation/North Atlantic Oscillation index. This suggests that an atmospheric amplifier may dominate on shorter, decadal to centennial timescales.

Palaeohydrology in the Eastern Mediterranean from speleothem fluid inclusion D/H analyses

S. MCGARRY[1,2], M. BAR-MATTHEWS[2], A. MATTHEWS[1] AND A. AYALON[2],

[1]Institute of Earth Sciences, The Hebrew University of Jerusalem, 91904, Israel (smcgarry@vms.huji.ac.il; alan@vms.huji.ac.il)

[2]Geological Survey of Israel, 30 Malchei Israel St., Jerusalem 95501, Israel (matthews@mail.gsi.gov.il; ayalon@mail.gsi.gov.il

The Eastern Mediterranean region is located in a climate transition zone and was very sensitive in the past to environmental changes such as temperature, amount of rainfall, pattern and origin of storm tracks and changes in the desert boundary. Thus, Israel is an ideal location for the study of palaeoclimate change. The aim of this study is to gain an understanding of the palaeohydrological conditions in different climatic zones in this region at various times in the past. This has been achieved by the analysis of the δ^{18}O of the speleothem calcite and the D/H ratios of the coeval speleothem fluid inclusions, which act as a proxy for the isotopic composition of the palaeo-rainwater from which the inclusion originated.

The speleothems chosen for this study cover a variety of climatic regimes in Israel and formed during distinct time periods during the past 130 ka, including 3 marine isotopic glacial and 2 interglacial periods. The fluid inclusions were extracted and analysed by thermal decrepitation method (Matthews et al., 2000). The results show a significant δD range varying from *ca* -40‰ to 0‰. These changes broadly parallel δD variations observed in present-day rain and cave waters. Correspondingly, calculated δ^{18}O paleo-water values vary from –3‰ to -7‰. δD vs. δ^{18}O variations generally fall along the present-day Mediterranean Meteoric Line relationship (characterized by higher D-excesses than the global MWL).

The isotopic compositions show climatic zoning. The samples taken from northern Israel have the lowest δD and δ^{18}O values reflecting the high elevation and rainfall at this site. The isotopic compositions become progressively heavier in samples taken in central Israel, and samples taken at the desert boundary have the highest values, which clearly reflect the high evaporation and low precipitation in this climate. A temporal trend is also seen in which speleothems formed during interglacial sapropel periods have low δ^{18}O and δD values, indicating markedly higher rainfall during these periods. Samples that formed during glacial conditions are exceptional in that their isotopic compositions fall near the global MWL and possibly reflect low relative humidity gradients above the Mediterranean Sea source of the rainfall.

References

Matthews A., Ayalon, A. and Bar-Matthews, M., (2000), *Chem. Geol.* **166**, 183-191.