



An investigation of Cl-36 as a novel solar irradiance proxy in speleothems: preliminary results from European rainfall and shallow karst systems.

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An improved understanding of solar forcing of Holocene climate requires that solar irradiance proxies (e.g. cosmogenic isotope production rates) be linked to climate proxies (e.g. $\delta^{18}\text{O}$) within the same palaeoclimate archives (e.g. ice cores, speleothems). Previous studies of solar forcing based on speleothems have relied on comparisons between their $\delta^{18}\text{O}$ values and variations in $\Delta^{14}\text{C}$ activity inferred from contemporaneous tree-rings. Such comparisons are hampered by uncertainties in the chronology of speleothem O isotope time-series. In addition, temporal variations in atmospheric $\Delta^{14}\text{C}$ may be compromised by climate-driven changes in the carbon cycle. The ultimate goal of this project is to investigate the use of $^{36}\text{Cl}/\text{Cl}$ as an alternative solar irradiance proxy in speleothems by combining it with $\delta^{18}\text{O}$ variations measured in the same calcite. Cl-36 is a cosmogenic isotope formed in the atmosphere predominantly by bombardment of Ar-40 with cosmic rays. During episodes of high solar activity, magnetic fields of the solar wind deflect incoming galactic cosmic rays, resulting in lower production of Cl-36. Thus, Cl-36 production is inversely proportional to the sun's activity. In this preliminary study we report the variability of $^{36}\text{Cl}/\text{Cl}$ in European rainfall and its behaviour in shallow karst systems and selected speleothems.

Cl-36 is potentially superior to other cosmogenic isotope solar proxies since radiocarbon is incorporated into the biosphere and Be-10 can become adsorbed onto surficial deposits, complicating their transfer to speleothem archives. By contrast, the inert and hydrophilic nature of chloride enables Cl-36 to become rapidly washed out of the

atmosphere and transferred through the soil into caves.

The distribution of atmospheric chloride and Cl-36 were studied in rainwater across Europe during Spring 2007. Chloride concentrations ranged between 0.2 and 18.6 ppm, decreasing from maximal values at the coast to lower values inland, consistent with a marine source. The primary control on the spatial variability of the $^{36}\text{Cl}/\text{Cl}$ ratio is the deposition of stable chloride, where an inverse relationship exists. Highest $^{36}\text{Cl}/\text{Cl}$ ratios within Europe are associated with Alpine regions (c. 400×10^{-15}), compared with c. 20×10^{-15} in coastal locations. However, when this water percolates down to the cave only a small amount of total chloride is trapped in the speleothem calcite ($<10 \mu\text{g Cl}^-/\text{g calcite}$). In addition, the extremely low concentrations of ^{36}Cl ($<20,000$ atoms/g) and the current precision of the accelerator mass spectrometer measurements require us to maximise the ratio of $^{36}\text{Cl}/\text{Cl}$ to gain high resolution archives. Therefore, Alpine regions are target areas for pioneering this new technique.