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Pollen chemistry as a tool for reconstructing past solar and ultraviolet irradiance

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Despite the importance of solar irradiance as a dominant control on Earth's energy budget, no proxy has been developed that can provide records on timescales of over 10 000 years. No independent empirical record of solar irradiance therefore exists prior to the Holocene, limiting our understanding of the relationships between solar energy inputs, global climate and biotic change over longer timescales.

Here, we present a novel proxy based on the chemical composition of sporopollenin, the primary component of the outer walls of pollen and spores (sporomorphs). Sporopollenin chemistry is responsive to levels of ultraviolet-B (UV-B) radiation exposure, via a concomitant change in the concentration of phenolic compounds. This relationship offers the possibility of using fossil sporomorph chemistry as a proxy for past UV-B flux, and by extension total solar irradiance (TSI). Fourier Transform infrared (FTIR) spectroscopy provides an efficient, economical and non-destructive method for measuring phenolic compound concentration on small sample sizes ($\leq$30 sporomorphs/sample). The high preservation potential of sporomorphs in the geologic record, and the conserved nature of sporopollenin chemistry and UV-B response across the Embryophyta, means that this new proxy has the potential to reconstruct UV-B and TSI flux over much longer timescales than has previously been possible.

We demonstrate the utility of this proxy with two chemopalynological datasets. Orbital cyclicity is reconstructed using grass pollen from a 150 000 year long sediment record from Lake Bosumtwi in Ghana, and changes in solar output over the last 600 years are reconstructed using pine pollen from Nar Lake in Turkey. This proxy provides a new approach for quantifying and understanding the relationship between UV-B flux, solar insolation and past climate. The unpicking of this information offers the tantalising potential to determine how changes in solar irradiance have driven long-term changes in vegetation assemblages.