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Interrogating trees as archives of sulphur deposition

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A principal driver of climatic variability over the past 1,000 years and essential forcing mechanism for climate, are the changes in atmospheric composition resulting from sulphur aerosols. Natural and anthropogenic aerosols released into the atmosphere disrupt the radiative balance through backscattering and absorption of incoming solar radiation and increase cloud albedo by acting as condensation nuclei. Understanding the impact of sulphur emissions upon climate beyond the last few hundred years however is not straightforward and natural archives of environmental information must be explored. Tree-rings represent one such archive as they are widely distributed and preserve environmental information within a precisely dateable, annually resolved timescale.

Until recently the sulphur contained within tree-rings has largely remained beyond the reach of environmental scientists and climate modelers owing to difficulties associated with the extraction of a robust signal and uncertainties regarding post-depositional mobility. Our recent work using synchrotron radiation has established that the majority of non-labile sulphur in two conifer species is preserved within the cellular structure of the woody tissue after uptake and demonstrates an increasing trend in sulphur concentration during the 20th century and during known volcanic events. Due to the clear isotopic distinction between marine (+21‰), geological (+10 to +30‰), atmospheric pollution (-3 to +9 ‰) and volcanic sources of sulphur (0 to +5‰), isotopic ratios provide a diagnostic tool with which changes in the source of atmospheric sulphur can be detected in a more reliable fashion than concentration alone. Sulphur isotopes should thereby provide a fingerprint of short lived events including volcanic activity when extracted at high resolution and in conjunction with high resolution S concentrations defining the event. Here we present methodologies associated with extracting the sulphur isotopic signal from tree-rings using both elemental analyser isotope ratio mass spectrometry and ion probe technology. Preliminary data indicate success at extracting the sulphur isotopic signal from woody tissues at 2-3 year resolution. In conjunction with analytical developments in ion probe technology, high resolution records of localised sulphur forcing from tree-ring archives, including volcanic activity, no longer seem too far beyond the reach of climate scientists.