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EPICA Dome C ice core fire record demonstrates a major biomass burning increase over the past 500 years

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Natural factors and human activity influence fire variability including changes in temperature and precipitation, increasing greenhouse gas concentrations, altering ignitions, vegetation cover and fuel availability. Ice cores archive chemical signatures of both past climate and fire activity, and understanding this interaction is increasingly important in a warming climate. The specific molecular marker levoglucosan (1,6-anhydro-ß-D-glucopyranose) can only be produced by burning woody tissue at temperatures greater than 300°C. Levoglucosan is present in the fine fraction of smoke plumes, is transported distances of thousands of kilometers, is deposited on glacier surfaces, and is detectable in both polar and mountain ice cores providing an unambiguous fire history. Here, we present a high-resolution 10,000-year levoglucosan record in the EPICA Dome C (75°06'S, 123°21'E, 3233 masl) ice core and implications for determining natural and human-caused fire variability.

A recent provocative hypothesis by Ruddiman suggests that humans may have had a significant impact on the Earth's climate thousands of years ago through carbon and methane emissions originating from biomass burning associated with early agriculture. This hypothesis is centered on the observation that atmospheric carbon dioxide and methane levels recorded in ice cores increased irrespective of insolation changes beginning 7,000 to 5,000 years before present. The EDC levoglucosan record does not demonstrate augmented fire activity at 5000 and/or 7000 years ago in the Southern Hemisphere. We are currently determining Holocene levoglucosan concentrations in the NEEM, Greenland (77°27' N; 51°3'W, 2454 masl) ice core to provide a Northern Hemisphere comparison at 5000 and/or 7000 years ago.

The highest EDC Holocene fire activity occurs during the past 500 years. Mean levoglucosan concentrations between 500 to 10,000 BP are approximately 50 ppt, but rise to 300 ppt at present. This substantial increase is not present in NEEM. Unlike methane and its isotopic signatures, levoglucosan is not a globally mixed marker, and these hemispheric differences are consistent with the atmospheric lifetime, sources, and transport of levoglucosan. This considerable increase in fire activity over the past 500 years is also present in Southern Hemisphere compilations of charcoal records. The EDC levoglucosan profile is most similar to regional charcoal compilations from New Zealand and southeastern Australia. Transport models demonstrate the possibility of New Zealand and Australia as major levoglucosan sources to EDC. This contemporary biomass burning increase is likely due to human activity as opposed to the Holocene background levels between 500 to 10,000 BP.