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Fire in Ice: Glacial-Interglacial biomass burning in the NEEM ice core

Piero Zennaro (1), Natalie Kehrwald (2), Roberta Zangrando (1), Andrea Gambaro (2), Carlo Barbante (1,2)
(1) Institute for the Dynamics of Environmental Processes - National Research Council, Venice, Italy, (2) Department of Environmental Sciences, Informatics and Statistics - University Ca' Foscari of Venice, Venice, Italy

Earth is an intrinsically flammable planet. Fire is a key Earth system process with a crucial role in biogeochemical cycles, affecting carbon cycle mechanisms, land-surface properties, atmospheric chemistry, aerosols and human activities. However, human activities may have also altered biomass burning for thousands of years, thus influencing the climate system. We analyse the specific marker levoglucosan to reconstruct past fire events in ice cores. Levoglucosan (1,6-anhydro-β-D-glucopyranose) is an organic compound that can be only released during the pyrolysis of cellulose at temperatures > 300°C. Levoglucosan is a major fire product in the fine fraction of woody vegetation combustion, can be transported over regional to global distances, and is deposited on the Greenland ice sheet.

The NEEM, Greenland ice core (77 27'N, 51 3'W, 2454 masl) documents past fire activity changes from the present back to the penultimate interglacial, the Eemian. Here we present a fire activity reconstruction from both North American and Eurasian sources over the last 120,000 yrs based on levoglucosan signatures in the NEEM ice core. Biomass burning significantly increased over the boreal Northern Hemisphere since the last glacial, resulting in a maximum between 1.5 and 3.5 kyr BP yet decreasing from $\sim$2 kyr BP until the present. Major climate parameters alone cannot explain the observed trend and thus it is not possible to rule out the hypothesis of early anthropogenic influences on fire activity.

Over millennial timescales, temperature influences Arctic ice sheet extension and vegetation distribution at Northern Hemisphere high latitudes and may have altered the distance between NEEM and available fuel loads. During the last Glacial, the combination of dry and cold climate conditions, together with low boreal insolation and decreased atmospheric carbon dioxide levels may have also limited the production of available biomass. Diminished boreal forest extension and the southward shift of taiga may have reduced the levoglucosan flux over Greenland during the Glacial, thus limiting the biomass burning signatures in the glacial NEEM section.

Eemian biomass burning would be expected to be greater than that of the last Glacial due to incresed temperatures and the lack of continental ice sheets. However, NEEM Eemian levoglucosan concentrations are unexpectedly low, and are lower than any other climate period including the last Glacial. We propose that microbial activity in melting ice layers is a potential explanation for the low observed Eemian levoglucosan values.