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CARBONACEOUS AEROSOL TRACERS IN ICE-CORES RECORD MULTI-DECADAL CLIMATE OSCILLATIONS

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A deeper understanding of the forcing and feedback mechanisms that drive decadal to centennial climate variability is vital to improve the accuracy of near future climate projections by model simulations. Solar irradiance and volcanic aerosol forcings account for a significant degree of the natural (non-anthropogenic) component of temperature anomalies over decadal to centennial timescales. However, model simulations, which attempt to incorporate the known principle forcings (solar, volcanic, inorganic aerosols, greenhouse gases etc), tend to underestimate the amplitude of historical temperature fluctuations. This suggests that the models are either relatively insensitive to the known principle forcings, or there are, hitherto undiscovered, climatic forcings or feedback mechanisms in operation in the real world.
Better constraints on historical changes in carbonaceous aerosols may help to resolve such proxy-model amplitude mismatches since, along with clouds, their microphysical processes and transport mechanisms constitute the greatest uncertainty in both models and observations. Carbonaceous aerosols include a mix of light absorbing Black Carbon (BC), Brown Carbon (BrC) and light-scattering organic matter and influence the global climate via direct and indirect effects on radiative balance. However, the factors controlling their emissions and transport remain highly uncertain both for the past and future, leaving its role in the climate system unclear.
In this study, we apply organic tracers to ice-cores collected from Greenland and Kamchatka to reconstruct variability of carbonaceous aerosol loadings in the northern high latitudes. Our ice core data revealed that, throughout the period covered by the records (1460 to 2000 CE), the concentrations and composition of biomass burning- and soil-derived carbonaceous aerosol tracers are well correlated primarily with temperatures in the summer Arctic Oscillation (AO). Order of magnitude increases (decreases) in abundance are observed during warm (cold) phases of the summer AO. This result suggests emission and transport of the carbonaceous aerosols to the Arctic are tightly linked to the multidecadal climate oscillation, implying potential role of carbonaceous aerosol in climate system as a positive feedback mechanism, yet the degree of its impact on climate remains uncertain at this stage.