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Multiple fire proxy records from Lake El'gygytgyn sediments reveal glacial to interglacial fire history of northeastern Siberia

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Long-term fire regime shifts are major unknowns in the prediction of future environmental change in the high northern latitudes. Lake El'gygytgyn (ICDP Site 5011-1), northeastern Siberia, provides the only continuous Pliocene-Pleistocene sediment record of environmental conditions in the Arctic. Several proxies suggested prominent climate and biome shifts in the past under different boundary conditions – beyond human influence. Hence, El'gygytgyn sediment cores are unique archives to analyze high northern fire regime shifts on long time scales and during different climate states, with some past interglacials serving as natural analogues of predicted future climate change.

Here, we study the long-term fire regime history of Chukotka, and focus on two intervals of the last 270,000 years that are characterized by similar summer insolation, but different global ice volume, and different vegetation composition (i.e. MIS 5e and MIS 7e). We aim to test (i) how far varying climate conditions and biome configurations are reflected in multiple fire regime proxies that are fire-intensity and severity specific, and (ii) how far external feedbacks as determined from climate and ice volume relationships and/or internal vegetation-permafrost feedbacks drive fire regime shifts in the high-northern latitudes.

We present centennial and millennial scale records of multiple fire proxies from the same samples of core PG1351 that allow to characterize past fire regimes. Charcoals and spores of Gelasinospora (a fire disturbance indicator) were microscopically analyzed from pollen slides, whereas ultra-high performance liquid chromatography-high resolution mass spectrometry was used to determine, for the first time, records of the low-temperature biomass combustion residues levoglucosan, mannosan and galactosan. We find significantly different fire proxy ranges, variability and ratios that allow characterizing different fire regimes during the two interglacials and their preceding glacials. The comparison with climate and vegetation reconstructions from the same lake and same samples, respectively, suggests that not only temperature, but also internal vegetation-permafrost feedbacks determine the specific configuration of fire regime parameters such as fire intensity, severity, type and amount of biomass burnt, on long time scales. These new results provide a step forward to understanding long-term feedbacks that are crucial for model predictions of future fire regime shifts in the high northern latitudes.