Nov.26
08:30 – 14:40h Knight Hall

2.1 Alpine Geomorphology and AK Permafrost - Orals

8:40 – 09:20h

Towards quantifying long-term fire-vegetation feedbacks in Eastern Siberia: what we learn from sediment

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The ongoing intensification of forest fires in the Arctic raises concerns if fires might lead to biome shifts from tundra to boreal forest – with consequences for biophysical land properties and biogeochemical cycles. Given short instrumental observations, it is unknown if fire can initiate or support biome shifts under amplified warming or if climate drives fire regime and biome changes independently. Lake El'gygytgyn, NE Siberia, is surrounded by tundra on permafrost, but during "superinterglacial" MIS 11, c. 375-440 kyrs ago, pollen data suggests that biome composition changed several times, from a glacial steppe to various interglacial boreal forest types. The overall question is if and which type of fire regime shifts accompanied these biome shifts and if we can quantify the impact of fire on biome shifts.
In this talk, I reflect on what we can learn from the principles of sediment transport, unraveled by grain size end-member modelling, for quantitative reconstructions of past fire regimes. We analyzed multiple fire proxies in interglacial El'gygytgyn sediments, but also in modern lake surface sediments from three lakes in Eastern Siberia, as a space-for-time analogue, to link fire proxy amounts and composition with fire regime properties. Then, we assessed modern charcoal source areas by simulating charcoal transport using data from modern fires and wind fields.
We find clear differences in fire proxy composition depending on source area of charcoals and anhydrosugars. Modern relationships between fire regime parameters, fire proxy composition and pollen-based vegetation are comparable to past interglacial relationships indicating that fire regime change did play a role during some, but not all interglacial biome shifts. Overall, we provide new understanding of sedimentary fire proxies, crucial for a quantitative reconstruction of long-term fire regime change, that allows to assess the role of fire regime intensification in biome changes during periods of stark warming.

09:20 – 09:40h

More than carbon: Frozen element inventories in ice-rich Yedoma permafrost

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Soils of the permafrost zone store globally relevant reservoirs of frozen matter, such as organic matter, mineral elements as well as other biogeochemical relevant compounds like contaminants. Besides well-studied organic carbon (OC), other compounds can become available in active biological and hydrological element cycling as global climate change is warming northern permafrost regions nearly four times faster than the global average. Current heating in Siberia is unprecedented during the past seven millennia, triggering widespread permafrost degradation and collapse.
This is especially relevant for our study region, the Yedoma domain. In this region, a large amount of belowground ice is present and the ground can become unstable with warming, allowing the mobilisation of previously frozen sediments with their geochemical element contents. With this presentation, we want to synthesise recent studies, which have improved the understanding of various frozen stocks. Here, we estimated that the Yedoma domain contains 41.2 Gt of nitrogen, which increases the previous estimate for the circumpolar permafrost zone by ~46%. The highest element stock within the Yedoma domain is estimated for r Si (2739 Gt), followed by Al, Fe, K, Ca, Ti, Mn, Zr, Sr, and Zn. The stocks of Al and Fe (598 and 288 Gt) are in the same order of magnitude as OC (327–466 Gt). Concerning contaminants, we focused on mercury. Using the ratio of mercury to OC (RHgC, our found value: 2.57 μg Hg g C−1) and the OC levels from various studies for a first rough estimation of the Hg reservoir, we estimate the Yedoma mercury pool to be ~542000 tons.
In conclusion, we find that deep thaw of the Yedoma permafrost domain and its degradation will bear the potential to change the availability of various elements in active biogeochemical and hydrological cycles, which will have the potential to change crucial ecosystem variables and services.

09:40 – 10:00h

Temperature and Microcracks control Frost Cracking in Alpine Rockwalls

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The dominant process of rockwall erosion in high alpine environment is frost weathering. Low-porosity alpine rockwalls are characterized by cracks instead of pores and higher rock strength than high-porosity sedimentary rocks. Frost weathering is controlled by permeability and water distribution inside the cracks. In this study, we use comparable Wetterstein limestone rock samples with different cracking historicity to (1) test the influence of initial crack patterns in combination with different saturation levels. We (2) quantify temperature dependent cracking efficacy and evaluate driving processes by measuring acoustic emissions. Our results show that saturation levels in low porous alpine rocks have a minor impact on ice segregation as sufficient water supply is enabled through cracks (capillary rise) and pores (absorption). Ice segregation shows for alpine rocks a higher efficacy at colder temperatures between -10 °C to -8 °C independent from the sample cracking historicity. At north- or south-facing rockwalls water distribution and temperatures are varying. Our results suggest that frost weathering is mainly prone to cold.