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Severe winter cooling during the Younger Dryas in northern Alaska - evidence from the stable isotope composition of a buried ice-wedge system

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The Younger Dryas (YD) interval, from approximately 12.9 to 11.5 kyr cal BP, a rapid reversion to glacial climate conditions at the Pleistocene-Holocene transition, has generally been attributed to the release of meltwater from the Laurentide Ice Sheet to the North Atlantic or Arctic oceans. The reaction of the North Pacific region to this „shutdown“ of the thermohaline circulation in the North Atlantic during Younger Dryas is, however, little understood. The YD cold interval is of great interest for understanding rapid natural climate change, especially with regard to recent global warming scenarios. Various archives such as glacier ice, tree rings, lacustrine and marine sediments provide evidence for strong climate variability during the Late Glacial-Holocene transition.
In our study, we investigated a relict, buried ice-wedge system within the continuous permafrost zone near Barrow, northern Alaska (71°18'N, 156°40'W). The Barrow ice-wedge system is buried under about three meters of Late Glacial/early Holocene ice-rich sediments. The ice wedges are accessible through a shaft which extends into an underground excavation, where a detailed description and sampling with an electrical chain saw were carried out. Permafrost is not only susceptible to recent climate change, it also may store evidence of these changes in ground ice, especially in ice wedges. Ice wedges can be assessed by stable water isotope methods similar to glacier ice climate reconstructions. Ice wedges are assumed to be indicative of winter climate conditions, because the seasonality of thermal contraction cracking and of the infill of frost cracks are generally related to winter and spring, respectively.
In this paper, we present a winter climate record from ice wedges in permafrost of northern Alaska, a region, where paleoclimate records extending beyond the Late Glacial-Holocene transition are generally rather sparse, often restricted to lake sediments and rely mostly on summer indicators such as pollen. This reconstruction is the first radiocarbon-dated centennial-scale stable water isotope record from permafrost at all. The Late Glacial winter climate reconstruction from Barrow ice wedges clearly demonstrates the existence of a Younger Dryas cold event, formerly believed to be reduced or absent in this area. Comparing the Barrow ice-wedge record to Greenland ice cores (such as N-GRIP), we observe similar and contemporaneous isotopic variations in the same order of magnitude, underpinning the climatic relevance of our ice wedge data. The Barrow ice-wedge stable isotope record additionally displays a gradual change of the atmospheric moisture source conditions during the Younger Dryas reflected in a shift of the d excess, potentially being associated with the successive opening of the Bering Strait.