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Late Holocene stable-isotope based winter temperature records from ice wedges in the Northeast Siberian Arctic

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The Arctic is currently undergoing an unprecedented warming. This highly dynamic response on changes in climate forcing and the global impact of the Arctic water, carbon and energy balances make the Arctic a key region to study past, recent and future climate changes. Recent proxy-based temperature reconstructions indicate a long-term cooling over the past about 8 millennia that is mainly related to a decrease in solar summer insolation and has been reversed only by the ongoing warming. Climate model results on the other hand show no significant change or even a slight warming over this period. This model-proxy data mismatch might be caused by a summer bias of the used climate proxies. Ice wedges may provide essential information on past winter temperatures for a comprehensive seasonal picture of Holocene Arctic climate variability.

Polygonal ice wedges are a widespread permafrost feature in the Arctic tundra lowlands. Ice wedges form by the repeated filling of thermal contraction cracks with snow melt water, which quickly refreezes at subzero ground temperatures and forms ice veins. As the seasonality of frost cracking and infill is generally related to winter and spring, respectively, the isotopic composition of wedge ice is indicative of past climate conditions during the annual cold season (DJFMAM, hereafter referred to as winter). δ18O of ice is interpreted as proxy for regional surface air temperature. AMS radiocarbon dating of organic remains in ice-wedge samples provides age information to generate chronologies for single ice wedges as well as regionally stacked records with an up to centennial resolution.

In this contribution we seek to summarize Holocene ice-wedge δ18O based temperature information from the Northeast Siberian Arctic. We strongly focus on own work in the Laptev Sea region but consider as well literature data from other regional study sites. We consider the stable-isotope composition of wedge ice, ice-wedge dating and chronological approaches as well as the stratigraphic context of the studied ice wedges in terms of suitability for reconstruction of high-quality records.

Our Mid to Late Holocene ice-wedge δ18O records show a marked variability with long-term increasing trends and an unprecedented recent maximum. The derived winter temperature records are discussed considering other Arctic paleoclimate records, climate forcing factors as well as climate-model results. We show that ice-wedge δ18O records contribute unique and highly relevant winter information on past Arctic temperatures. However, the generation of high-quality reconstructions depends on careful selection of study sites and ice wedges, the availability of suitable organic matter for AMS radiocarbon dating, a high sampling resolution and suitable chronological approaches.