Permafrost, landscape and ecosystem responses to late Quaternary warm stages in Northeast Siberia

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BACKGROUND

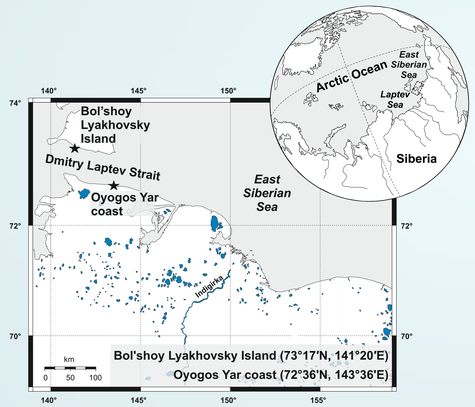
South coast of Bol'shoy Lyakhovsly Island at the Dmitry Laptev Strait

Perennially frozen ground is widely distributed in Arctic lowlands and beyond. Permafrost responds sensitive to changes in climate conditions. Climate-driven dynamics of landscape, sedimentation and ecology in periglacial regions are frequently recorded in permafrost deposits. The study of late Quaternary permafrost can therefore reveal past glacial-interglacial and stadial-interstadial environmental dynamics. One of the most striking processes under warming climate conditions is the extensive thawing of permafrost (thermokarst) and subsequent surface subsidence. Thermokarst basins promote the development of lakes, whose sedimentological and paleontological records give insights into past interglacial and interstadial (warm) periods.

INTENTION

In this poster we present results of qualitative and quantitative reconstructions of climate and environmental conditions for the last Interglacial (ca. 130 to 115 ka ago), the lateglacial Allerød Interstadial (ca. 13 to 11 ^{14}C ka BP), and the early Holocene (ca. 10.5 to 8 ^{14}C ka BP).

The study was performed in course of the IPY project #15 'Past Permafrost' with permafrost deposits exposed at the coasts of the Dmitry Laptev Strait (East Siberian Sea).



METHODS

The reconstruction is based on fossil-rich findings of plants (pollen, macro-remains) and invertebrates (beetles, chironomids, ostracods, gastropods), and completed by cryostratigraphic data.

Pollen-based reconstructions of mean temperatures of the warmest month (MTWA, T_{July}) refer to the best modern analogue (BMA) method (*Andreev et al.* 2011). T_{July} reconstructions by plant macro-fossils employed the coexistence interval approach for modern species (*Kienast et al.* 2008, 2011), while a transfer function was used for chironomid-based T_{July} (*Nazarova et al.* 2011). Proxy-based paleoclimate and paleoenvironmental reconstructions were finally compared with simulations produced by an earth system model (ESM) of intermediate complexity, CLIMBER-2 (*Andreev et al.* 2011).

RESULTS

The here presented palaeoclimate data focus on T_{July} as reconstructed by pollen spectra, and for the Last Interglacial additionally by plant macrofossils and chironomids:

Early Holocene (ca. 10.3 to 8 ^{14}C ka BP)
- shrub-tundra
- intense thermokarst
- T_{July} up to 4 °C warmer than today

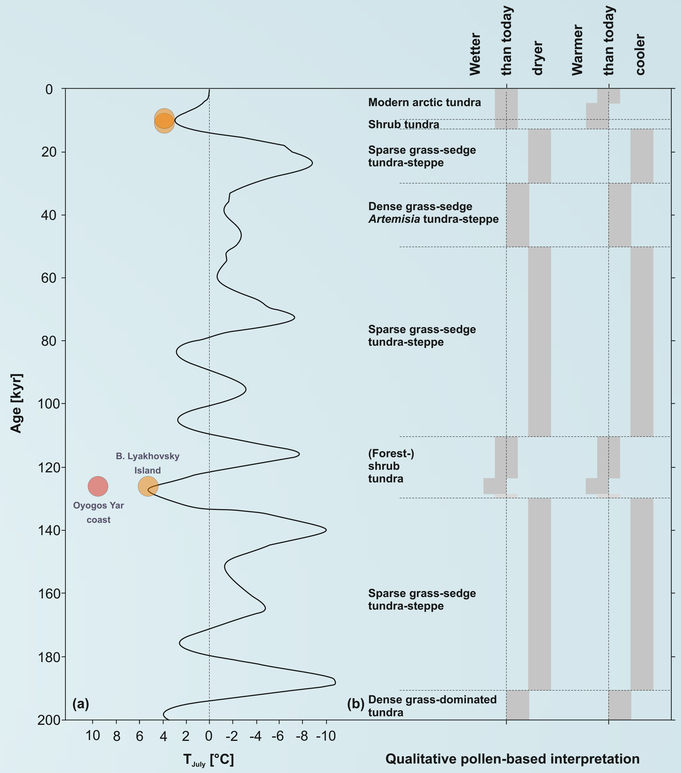
Last Interstadial (ca. 13 to 11 ^{14}C ka BP)
- tundra-steppe with few shrubs
- intense thermokarst
- T_{July} up to 4 °C warmer than today

Last Interglacial (ca. 130 to 115 ka ago)
- shrub-tundra and open forest-tundra
- intense thermokarst
- T_{July} up to 10 °C warmer than today

  pollen-based T_{July}: 11 to 17.6°C

  plant macrofossil-based T_{July}: 12.7 to 13.6°C

  chironomid-based T_{July}: 12 to 13.8 °C



Comparison of CLIMBER-2 model-based and pollen-based paleoclimate reconstructions for the Laptev Sea region over the last ca 200 kyr:
(a) simulated summer temperature variations relative to control value from pre-industrial simulation. Note circles that show quantitative pollen-based temperature estimations on Oyogos yar coast (red) and Bol'shoy Lyakhovsky Island (orange);
(b) pollen-based qualitative reconstructions of vegetation cover are presented as descriptions of dominant vegetation type and in comparison to modern conditions shown as gray bars.

Exemplarely plant macrofossils of last Interglacial forest tundra.

CONCLUSIONS

Warmer-than-present stages occurred several times during the late Quaternary. Arctic permafrost lowlands responded with intense thermokarst. Vegetation changed from tundra-steppe to shrub tundra or forest tundra communities as reflected by pollen and plant macrofossils. Independent temperature reconstructions mirror quantitative and qualitative ecosystem response to a warming Arctic, especially for the last Interglacial. Comparisons to climate model results are appropriate to understand dynamics of so far less studied periods.

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