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Arctic shelf flooding: a negative feedback on climate warming during terminations

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Glacial terminations are characterized by a strong rise in sea level related to melting ice sheets. This rise in sea level is not uniform all over the world, because regional effects (uplift and subsidence of coastal zones) are superimposed on global trends. For the Laptev Sea, Bauch et al. (2001) have shown that during the early Holocene the shelf area became flooded from 8.9 ka BP (-31 m) to 7.5 ka BP (-7 m, close to modern day coastline). An extrapolation of this result on the basis of modern bathymetry suggests that a far bigger area, covering the entire East Siberian Sea, became flooded at that time. This area is currently known as a sea-ice production zone (Tamura and Ohshima, 2010) and contributes significantly to the sea-ice exported from the Arctic through the Fram Strait ($\sim$20% of annual sea-ice area passing Fram Strait, Rigor and Colony, 1997).
This leads to the following hypothesis: during times of lower sea levels, the coastline advances closer to the shelf break and reduces the amount of sea-ice production on these shelves, reducing sea-ice volume and export through Fram Strait and causing the sea-ice extent to retreat in the Nordic Seas, yielding warmer and saltier sea surface conditions.
We have tested this hypothesis in a ocean-sea-ice-atmosphere coupled model of intermediate complexity (LOVE-CLIM), thereby focusing on an early Holocene (9 ka BP) test case. We use the results of 9 snapshot simulations with different model configurations, differing in land-sea-mask, manually prescribed ice sheets and melt fluxes from the Laurentide Ice sheet and the Greenland Ice sheet. Simulations with an unflooded East Siberian shelf show lower sea-ice production, a retreat of the sea-ice extent in the Nordic Seas and an increase in temperature and salinity on the northern East Greenland Current. Together with the retreating sea ice cover, local deep convection shifts from south of the Denmark Strait up to 9 degrees north, following the sea ice edge and resulting in heat release and surface warming during the entire year. Our analysis exhibits a surprising connection between increased sea-ice export through Fram Strait and changes in atmospheric winds that result from modifications in the atmospheric circulation, that are forced by changes in differential heating over the East Siberian Shelf and the Nordic Seas. This atmospheric teleconnection clearly shows that regional changes can affect hemispheric changes. In a first comparison with available sea-ice proxy reconstructions our results do not disagree, but show the necessity of increased temporal and spatial coverage of proxy reconstructions for future investigations.
Our results indicate that shelf flooding had a significant impact on the climate during the early Holocene, namely reducing sea-ice cover and affecting atmospheric circulation. During terminations this can be considered to be a negative feedback on the progress of the termination, as a shelf area becomes flooded, sea-ice production and extent are likely to increase and reduce high latitude intake of orbitally-forced insolation, slowing down the warming trend. This can be the cause of observed cold reversals during warming phases in the continuous transformation of a glacial to an interglacial climate. This implies that shelf flooding should be taken into account when studying the climate dynamics during all glacial terminations.

References

Bauch, H.; Mueller-Lupp, T.; Taldenkova, E.; Spielhagen, R.; Kassens, H.; Grootes, P.; Thiede, J.; Heinemeier, J. & Petryashov, V. Chronology of the Holocene transgression at the North Siberian margin, Global and Planetary Change, 2001, 31, 125 - 139

Rigor, I. & Colony, R., Sea-ice production and transport of pollutants in the Laptev Sea, 1979–1993, Science of The Total Environment, Environmental Radioactivity in the Arctic, 1997, 202, 89-110

Tamura, T. & Ohshima, K. I., Mapping of sea ice production in the Arctic coastal polynyas, J. Geophys. Res., AGU, 2011, 116, C07030-