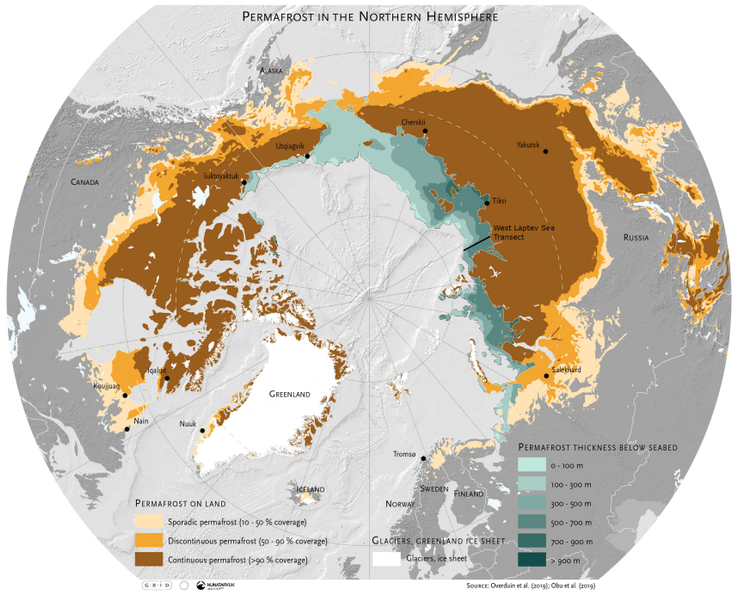
Submarine Permafrost as a Long-term Late Quaternary Carbon Sink

F. Miesner[1*], P. P. Overduin[1], G. Grosse[1,2], J. Strauss[1], M. Langer[1,3], S. Westermann[4], T. Schneider von Deimling[1], V. Brovkin[5,6], S. Arndt[7]

Frederieke Miesner
Alfred-Wegener-Institute
Helmholtz Center for Polar and Marine Science
frederieke.miesner@awi.de

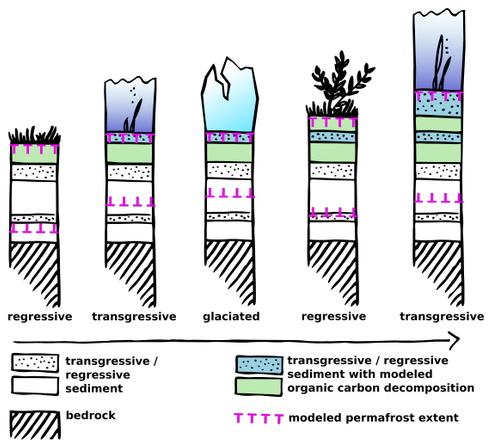
Background and Aims

- Organic carbon (OC) in sediments on the Arctic continental shelf is climate-sensitive but poorly quantified
- Most shelf permafrost is warmer than -2 C, and therefore even small additional warming may result in thaw
- We model permafrost as well as the sedimentation and decomposition of organic matter (OM) to estimate how submarine permafrost interacts with Arctic shelf carbon



Subsea permafrost (thickness below seafloor in green) underlies an area equivalent to approx. 18% that of terrestrial permafrost (permafrost extent zonations in brown-orange)

Modeling Carbon Burial

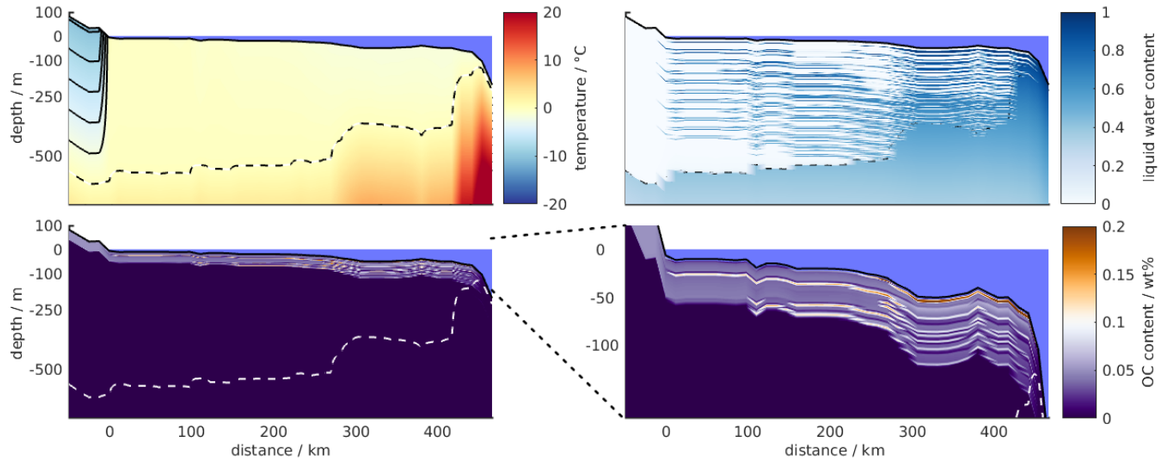


Modeled sedimentation over multiple glacial cycles (schematic)

- Simplified sedimentation scheme with different sedimentation rates, grain size, salinity and OC content for regressive (first and fourth columns), transgressive (second and last columns) and glaciated (third column) periods
- 1D heat flow model over multiple glacial cycles (450 kyr), calculating permafrost extent (lower boundary shown as dashed magenta lines)
- Neglecting *older* material (uncoloured sediment), i.e. stocks deeper than approx. 100 m, and any gas hydrates

Modeling Carbon Decomposition

- We use a reactivity continuum model for OM decomposition, using observed terrestrial and marine OM reactivities
- We further restrict decomposition to the liquid habitat for microbial activity



Temperature (upper left), ice content (upper right) and OC content (lower) along a transect in the West Laptev Sea. OC decomposition was restricted by liquid water content.

Results

- Permafrost below the Arctic Shelf stores at least as much OC as its terrestrial counterpart at pre-industrial time, and likely up to 2-3 times as much
- Sensitivity of our results to variations in OC reactivity suggest that we need to improve our understanding of in-situ OM reactivity
- Higher reactivity and lower ice content in marine sediments lead to a relatively higher preservation effect

Conclusions

Our modeling shows that

⇒ a significant amount of OC is stored in subsea permafrost; its validation requires a targeted scientific drilling campaign

⇒ more research is needed to understand microbial OM decomposition in cold but not necessarily frozen sediments

⇒ already warm subsea permafrost carbon is potentially susceptible to deep thaw in a rapidly warming Arctic

This project is funded by the European Union

1 - Alfred Wegener Institute for Polar and Marine Research, Telegrafenberg A45, 14473 Potsdam, Germany
2 - Geoscience Institute, University of Potsdam, Potsdam, Germany
3 - Department of Geography, Humboldt-Universitt zu Berlin, Berlin, Germany
4 - Department of Geosciences, University of Oslo, Oslo, Norway
5 - Max Planck Institute for Meteorology, Hamburg, Germany
6 - CEN, University of Hamburg, Hamburg, Germany
7 - Department of Geosciences, Environment and Society, Université libre de Bruxelles, Brussels, Belgium