LowPerm: quantifying thaw-driven biogas production and nutrient export from Eurasian Arctic lowlands

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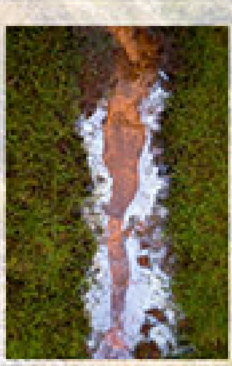
Project rationale

The importance of the oceans for heat transfer into the Arctic means that the low altitude and very extensive permafrost lowlands here can respond quickly and significantly to climate change. In the Eurasian Arctic this causes the early onset of melt, increasing active layer thickness and enhanced microbial activity. It is now known that the vast soil carbon stocks of Arctic permafrost are vulnerable to these changes, but accurate forecasting of its influence on the global climate system cannot be achieved until key knowledge gaps are addressed.

In the extensive Arctic sedimentary lowlands, two crucial weaknesses undermine our understanding of biological and physical drivers of regional greenhouse gas fluxes:

- poor quantitative understanding of how intrinsic hydrological, geomorphological and ecological factors influence biogas and nutrient recycling/release in the active layer and its interface with the upper permafrost;

- poor knowledge on how such changes in permafrost characteristics and function of the active layer influence the adjacent coastal marine ecosystems.



Figures 1 and 2. Ice-wedged polygonal landscape of Adventdalen (left) and ochreous precipitate in surface water between ice-wedged polygons (right) indicating iron rich environment.

Project objectives

1. Microbially mediated processes at the interface between active layer and permafrost will control the autochthonous production and release of biogases and nutrients as active layer depths increase. However, the inherent hydrological, geomorphological, and ecological drivers that govern these crucial biogeochemical processes are not yet fully understood and require *in-situ* investigation before they can be incorporated into regional models.

2. Runoff from permafrost lowlands in the Eurasian Arctic is a quantitatively important source of Fe, N, P, and organic matter, to already highly productive high-latitude marine ecosystems. The impacts of changes in the runoff chemistry and the consequent fertilisation potential must be quantified, as they will influence the CO_2 budget of the ocean and thus potentially initiate marine ecosystem change.

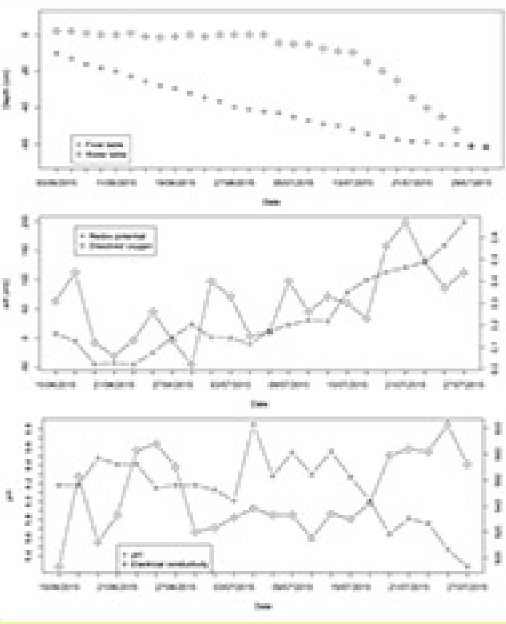
3. With increases in Arctic air temperature, it is vital to understand if permafrost wetlands and tundra environments can remain carbon sinks or if these will become net sources of carbon. Quantifying changes in carbon accumulation rates over time as well as estimating total permafrost carbon stocks is therefore an urgent research priority. Temperatures during the Holocene Thermal Maximum exceeded those of today by up to 3°C and studying the palaeo-record will provide insights into likely ecosystem responses to temperature increases.

2015 Field campaign

- Hydrochemical and discharge monitoring of Endalen Bolterdalen, Todalen, Gruvedalen, and Advent River
- Collection of four 2-m long permafrost cores from Adventdalen
- *In-situ* monitoring of soil pore-water chemistry in Adventdalen
- Ecological habitat monitoring for testate amoebae
- Collection of sea water from Isfjorden for incubations

Figure 3. Study area in Adventdalen and Bohemanflya. Red dots indicate permafrost coring locations; green dots mark hydrochemical work; purple dots mark in-situ measurement locations.

Initial results



Figures 4-6. Results from soil pore water analyses of ice-wedged polygon in Adventdalen

Upcoming work

- Anaerobic and aerobic incubation of permafrost and sea water samples
- *In-situ* monitoring of biogas production and nutrient fluxes
- Run-off hydrochemistry and discharge monitoring (2016)
- Extraction of >10 m-long permafrost core from Adventdalen
- Palaeoenvironmental (C:N, pollen) and ecological (testate amoebae) analyses

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