High-Resolution insights into permafrost thaw: Remote Sensing and Geochemical Techniques for Understanding Carbon Cycle Feedbacks

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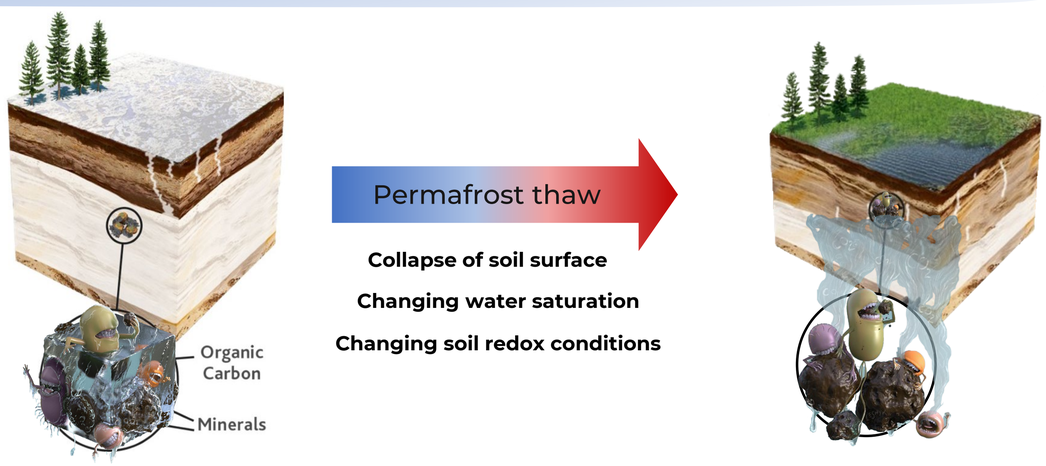
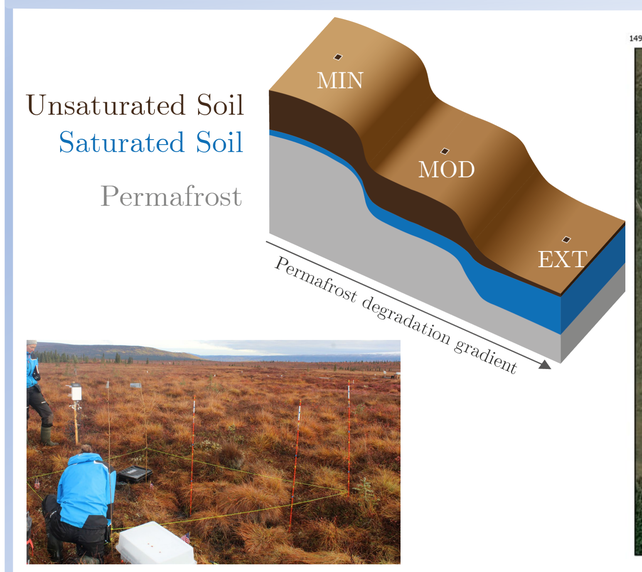
Climate change causes permafrost thaw, altering the physicochemical conditions of Arctic soils, potentially emitting greenhouse gases

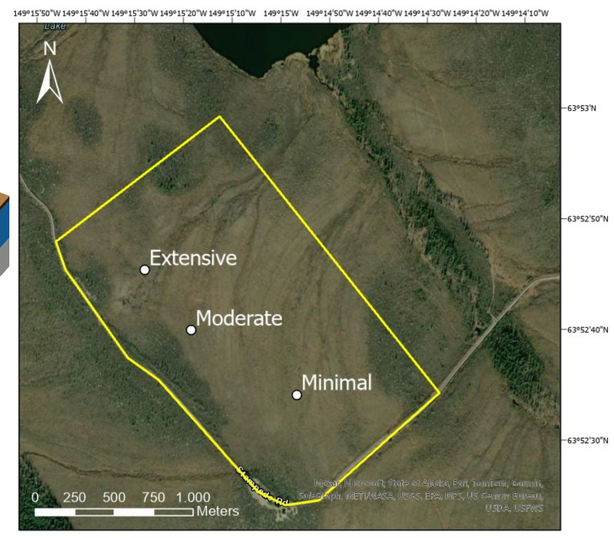


[1,2,3]

→ How do hydrological and topographical variations resulting from permafrost thaw impact the release of Dissolved Organic Carbon (DOC) in soil pore water?

Study case of an Arctic peatland with a natural permafrost thawing gradient in Eight Mile Lake in late summer of 2023 (Alaska (USA))





Combining geochemical and very-high resolution remote sensing techniques to better understand the impact of permafrost thaw and resulting thaw depth increase at the profile scale and at the site scale

Site scale: prediction of the thaw depth across the site

4 sensors

7 indices

LiDAR → DEM; Canopy Height Model (CHM); Slope angle; Terrain wettness Index (TWI)

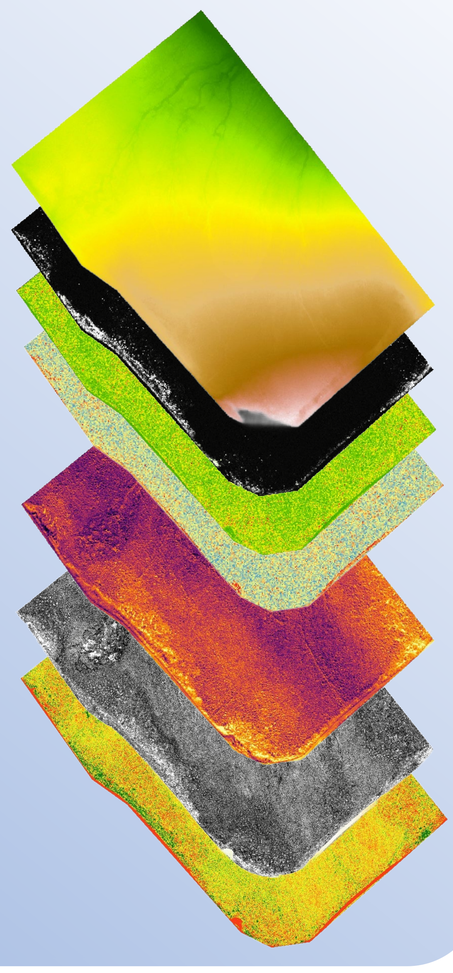
Thermal → Land Surface Temperature (LST)

Multispectral → Normalized Difference Red Edge Index (NDRE); Normalized Difference Water Index (NDWI)

RGB

DJI M 300

13, 16, and 19th of Sept



Profile scale: impact of the thaw depth increase on the geochemistry of soil pore water

17 days of sampling: 16th Sept- 2nd Oct

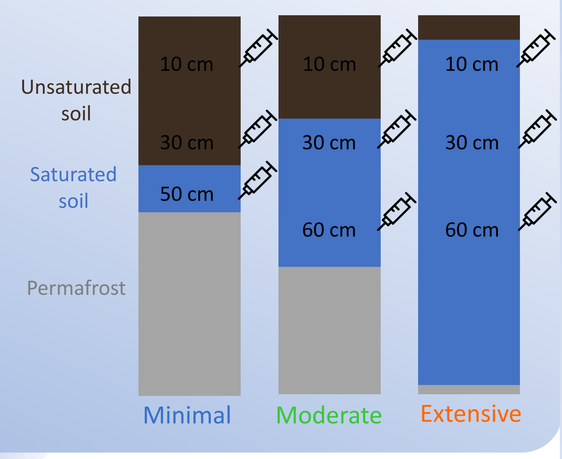
In 1 bottle: 3-days water collection

3 sites with triplicates at each site

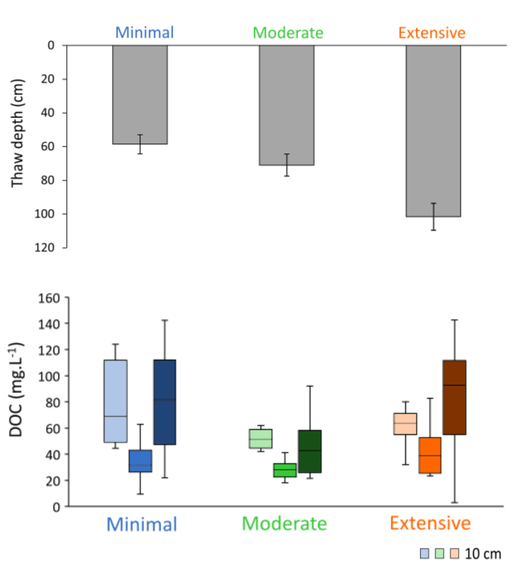
3 depths

+

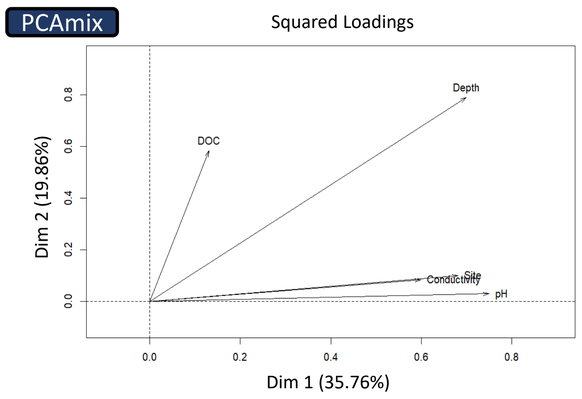
39 Thaw Depth measurements

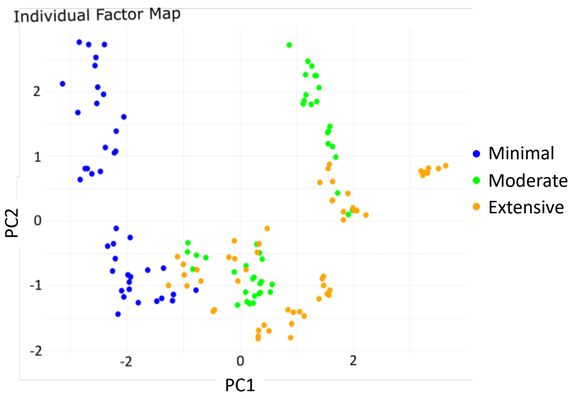


39 Thaw Depth measurements



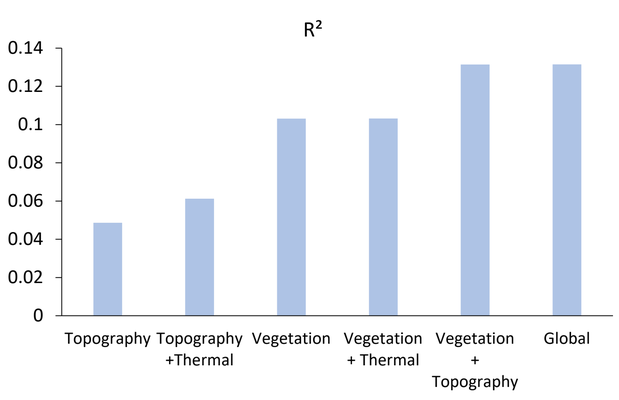
PCAmix

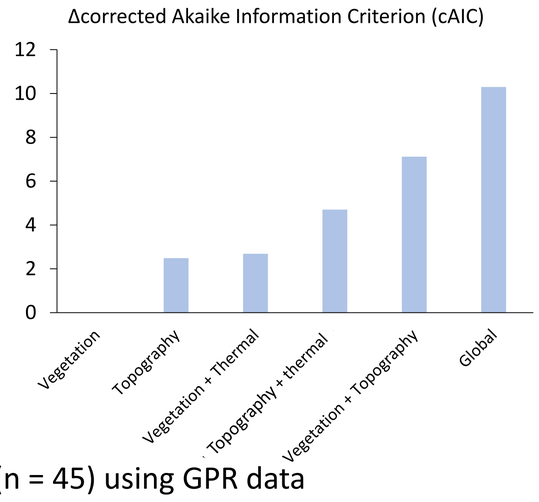




Linear Regressions

- **Topography:** Thaw Depth ~ DEM + TWI + SLOPE
- **Topography + Thermal data :** Thaw Depth ~ DEM + TWI + SLOPE +LST
- **Vegetation** : Thaw Depth ~ NDRE + NDWI + CHM
- **Vegetation + Thermal data**: Thaw Depth ~ NDRE + NDWI + CHM + LST
- **Vegetation + Topography**: Thaw Depth ~ NDRE + NDWI + CHM + DEM + TWI + SLOPE
- **Global**: Thaw Depth ~ DEM + TWI + SLOPE + NDRE + NDWI + CHM + LST





- Need to increase number of observations (n = 45) using GPR data
- Test other topography indices (e.g., subsidence [3]), multispectral indices
- Produce land cover classification map (Random Forest)

Take home messages and perspectives

- DOC concentrations do not seem to increase in the soil pore water although there might be masking effects with depths (influence of the type of horizon which is thawing : organic vs. mineral)
- DOC concentrations are mainly correlated with depth but seem to be independent from the Site, the pH, and the conductivity. DOC seem to stay in the same range of values while conditions change (pH and conductivity).

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[2] Illustration of organic matter by Victor Leshyk
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