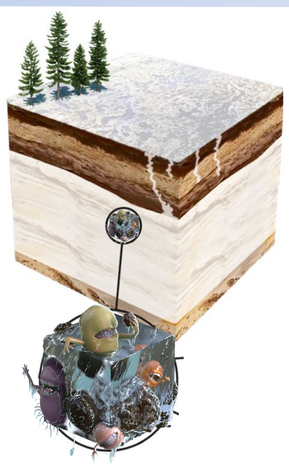
Investigating the role of changing permafrost hydrology on carbon and nutrient fluxes using very-high resolution remote sensing and geochemical techniques (Stordalen, Sweden)

Eléonore DU BOIS D'AISCHE[1,2], *François JONARD*[2], *Sébastien LAMBOT*[1], *Kristof VAN OOST*[1], *Veerle VANACKER*[1], *Maëlle VILLANI*[1], *Maxime THOMAS*[1], *Catherine HIRST*[3], *Sophie OPFERGELT*[1]

[1]*Earth and Life Institute, Université catholique de Louvain, Louvain-la-Neuve, Belgium*
[2]*Earth Observation and Ecosystem Modelling Laboratory, SPHERES Research Unit, Université de Liège, Liège, Belgium*
[3]*Department of Earth Sciences, Durham University, Durham, United Kingdom*
**email: eleonore.dubois@uclouvain.be*

European Research Council
Established by the European Commission

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

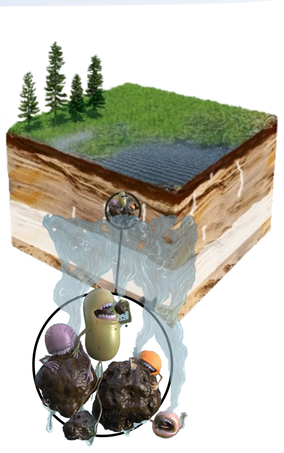


Permafrost thaw

Collapse of soil surface

Changing water saturation

Changing soil redox conditions



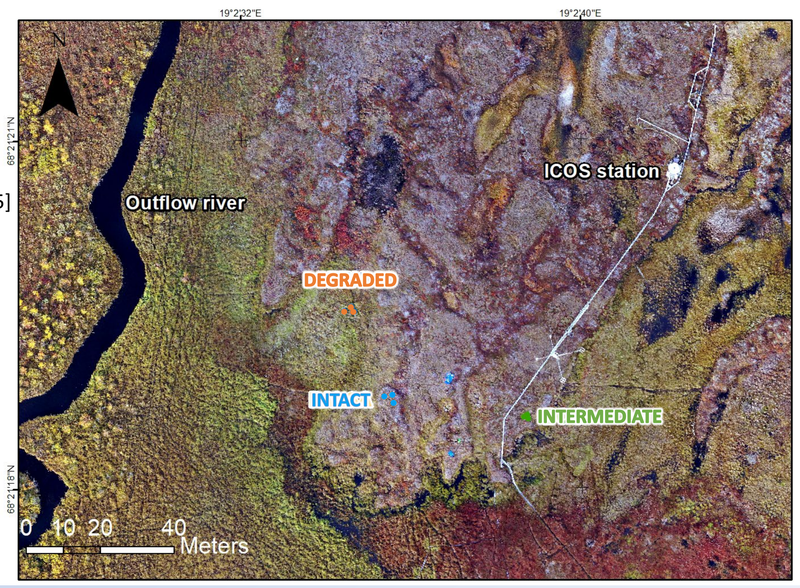
~ 30-80% soil OC stabilized by interactions with mineral elements (e.g. Fe)[3,4]

↑ OC vulnerability [1,2]

→ **Do hydrological and topographical variations resulting from permafrost thaw induce co-solubilization of iron and carbon?**

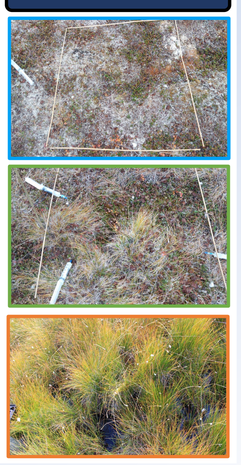
Study case of a permafrost degradation gradient in Stordalen mire in late summer of 2021 (Abisko, Sweden)

[5]



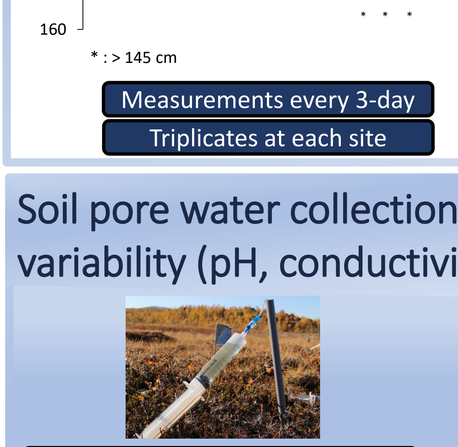
3 sites

3 vegetation communities



Identification of three stages of permafrost degradation (intact, intermediate, fully degraded permafrost) using geophysics and remote sensing techniques

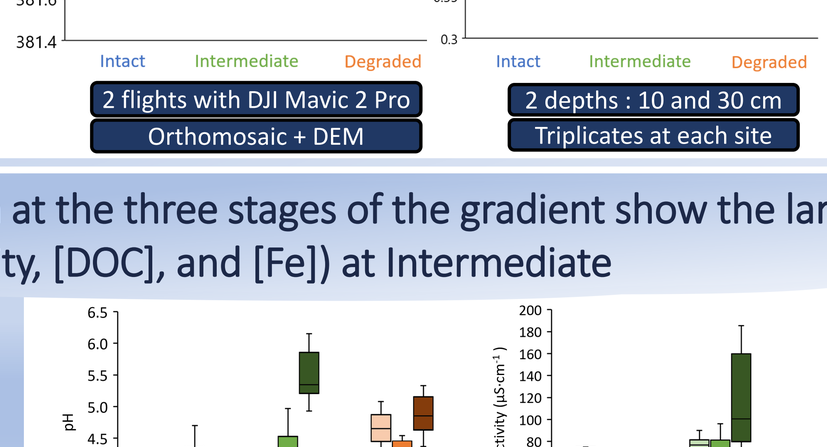
Thaw depth (cm)



Measurements every 3-day

Triplicates at each site

Elevation (cm)



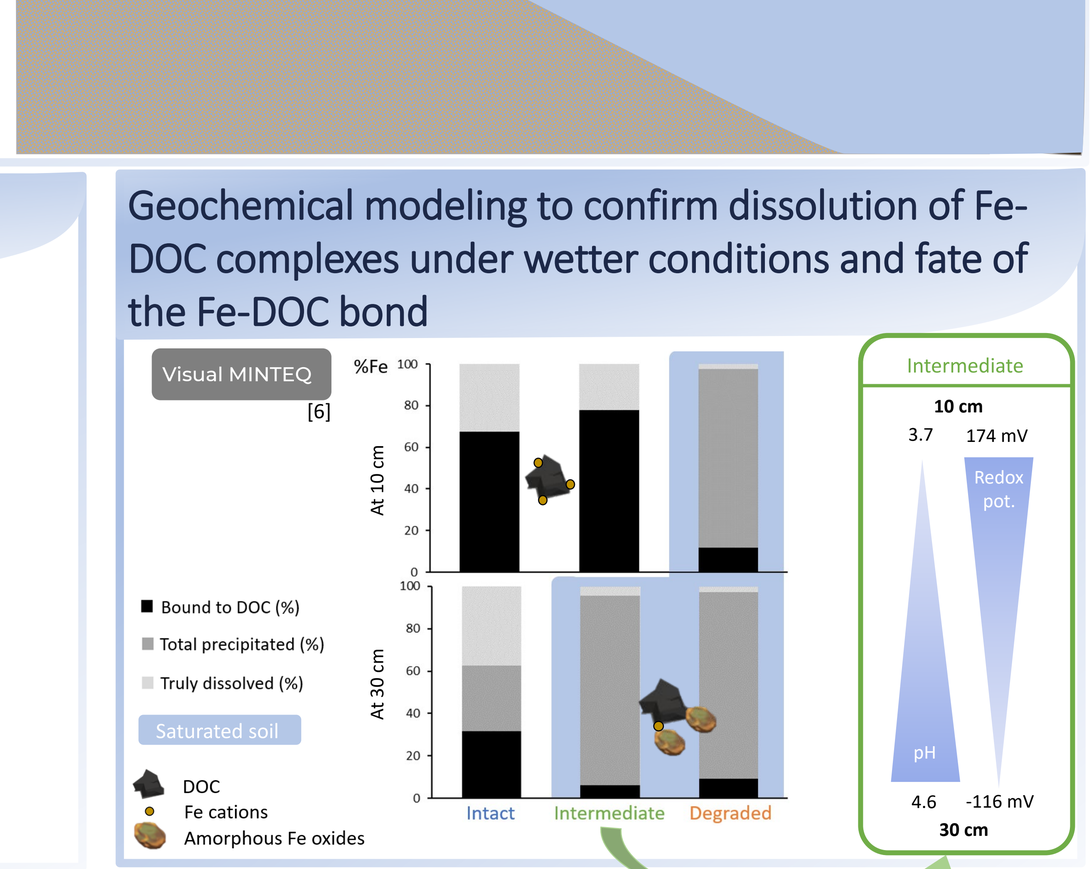
2 flights with DJI Mavic 2 Pro

Orthomosaic + DEM

Soil water content ($m^3.m^{-3}$)

2 depths : 10 and 30 cm

Triplicates at each site



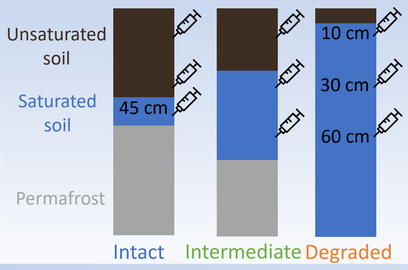
Soil pore water collection at the three stages of the gradient show the largest variability (pH, conductivity, [DOC], and [Fe]) at Intermediate

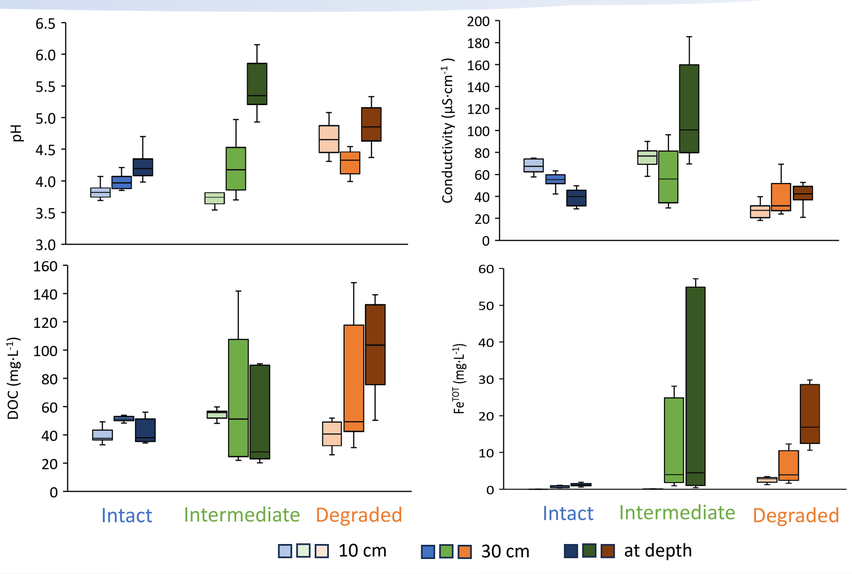
18 days of sampling

In 1 bottle: 3-days water collection

3 sites with triplicates at each site

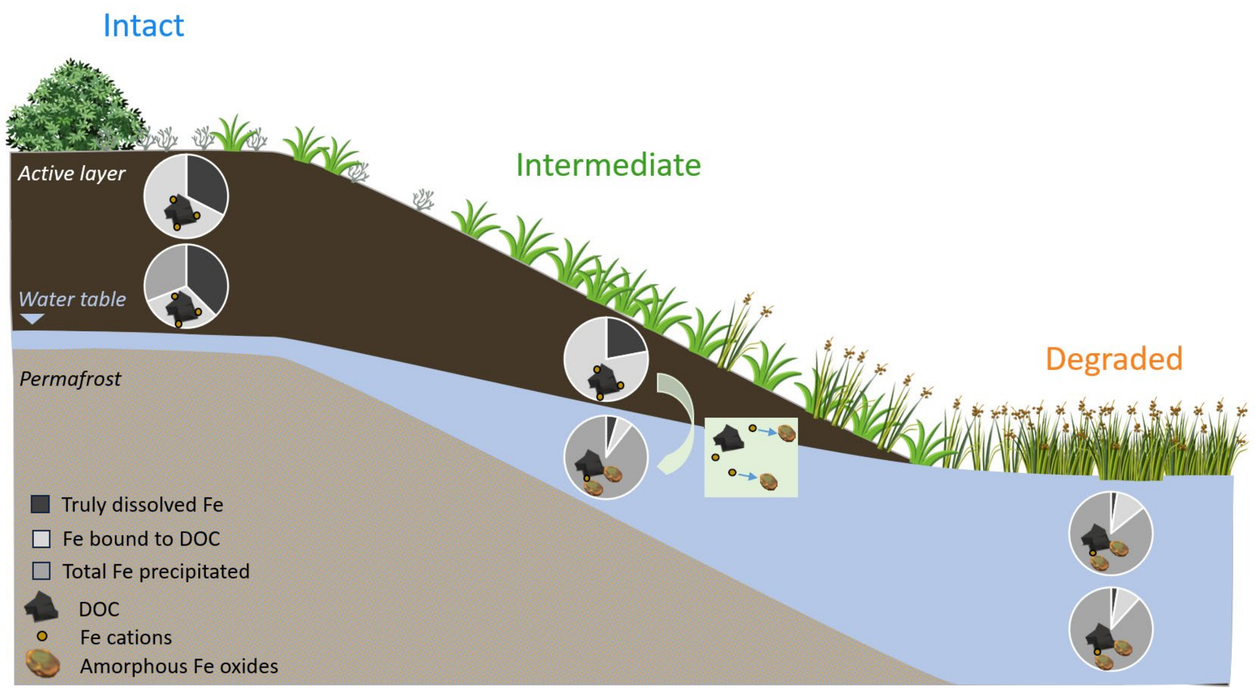
3 depths





Geochemical modeling to confirm dissolution of Fe-DOC complexes under wetter conditions and fate of the Fe-DOC bond

Visual MINTEQ [6]



Take home messages and perspectives

- Intermediate is the **key step** in the permafrost degradation process : location of **highest variability** (elevation, soil water content, Thaw depth, pH, conductivity, [DOC], [Fe])
- **Hydrology** drives the type of bond between iron and organic carbon in the soil
- When soil water content increases, redox conditions become reductive resulting in the dissolution of **Fe-DOC complexes**. Newly formed amorphous Fe oxides offer sites on which **DOC** can be **adsorbed**.
- When the bond between iron and DOC changes, **DOC** is **highly vulnerable** to mineralization

→ How does the nature of the link between iron and carbon affect the vulnerability of carbon to mineralization when these Fe-DOC end up in rivers and may undergo photodegradation?

Acknowledgements

We thank A. Monhonval, M. Villani, M. Thomas, E. Mauclet, C. Hirst, R. Giesler, and M. Mörth for their help during the fieldwork mission in Abisko (Sweden). We thank the Swedish Polar Research Secretariat and SITES for the support at the Abisko Scientific Research Station. We thank Laurence Monin, Elodie Devos, Claudine Givron, Hélène Dailly and the MOCA plateform for their analytical help.

Funding

This project received funding from FWB for the LandSense project and from the EU (ERC) for the WeThaw project. E.DBDA acknowledges funding from the Fund for Scientific Research FNRS in Belgium.

References

[1] Opfergelt, S. Environ. Res. Lett. 15, 091003 (2020).
[2] Illustration of organic matter by Victor Leshyk
[3] Dutta, K. et al. Glob. Change Biol. 12, 2336–2351 (2006).
[4] Mueller, C. W. et al. Glob. Change Biol. 21, 2804–2817 (2015).
[5] Patzner, M. S. et al. Nat. Commun. 11, 6329 (2020).
[6] Gustafsson, J. P. (2011). Visual MINTEQ Version 3.1: A windows version of MINTEQA2.