ROLE OF MICROORGANISMS IN GREENHOUSE GAS FLUXES IN WETLANDS IN ARCTIC DEGRADED PERMAFROST

Project overview

Recent air temperature increases in Arctic and sub-Arctic regions significantly exceed global average trends (IPCC, 2019). As a result, permafrost (ground with a temperature ≤0 °C for at least two consecutive years) in these regions is experiencing significant warming (Biskaborn et al., 2019). Climate simulations predict a rapid warming of the Arctic by 2100, and permafrost thawing is expected to expand and intensify (IPCC, 2019). Degradation of the frozen ice-rich ground leads to thawing and subsequent ground subsidence (Fig. 1), typically forming thermokarst lakes (formed by melting permafrost) and thaw slumps (French, 2007). Permafrost degradation is mainly driven by climate change (at regional or global scale), but can also be the result of local environmental factors (e.g. destruction of vegetation cover, localised erosion, forest fires and land-use changes). Permafrost soils store about 50% of the global soil organic carbon stock (1300 Pg C; Schuur et al., 2015). Permafrost covers 20-25% of the Northern Hemisphere land surface. Organic carbon released from permafrost degradation is mineralised by microorganisms (bacteria and archaea) and released as greenhouse gases (e.g. CO_2, CH_4), feeding a positive global warming loop. Despite their importance, the key conditions and actors that make this process possible are not yet well defined. Small watersheds remain little studied.

This thesis project will focus on the role of microorganisms in greenhouse gas fluxes within the PRISMARTCYC project (https://www.belmontforum.org/archives/projects/permafrost-degradation-impacts-on-soils-human-societies-water-resources-and-carbon-cycle).

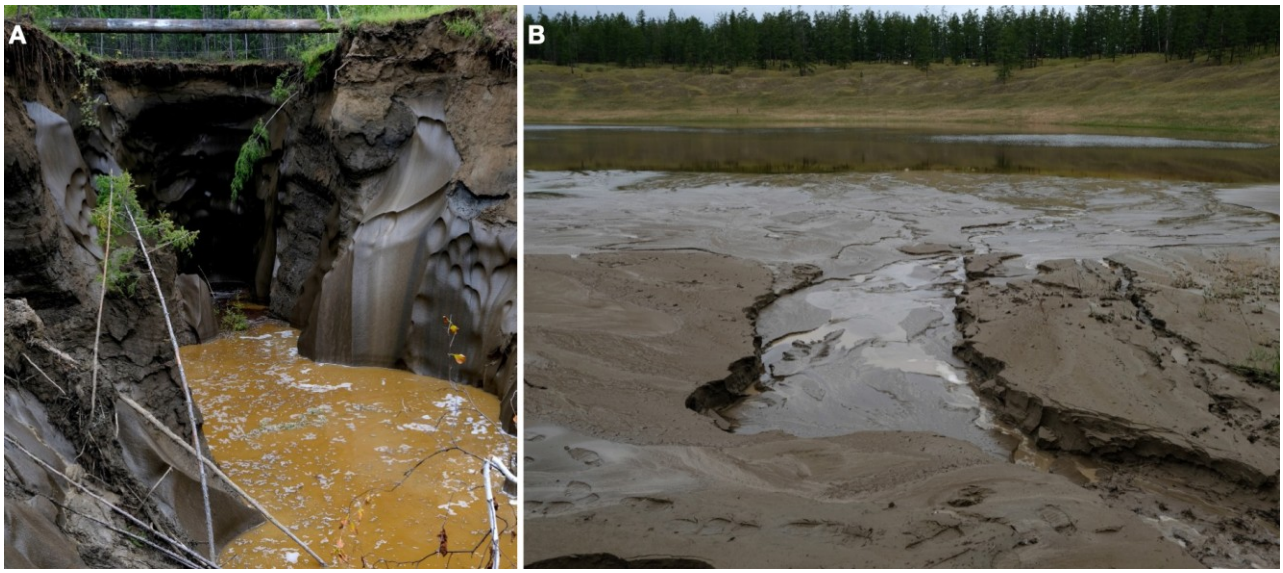

Figure 1 : example of A- melting permafrost in Yakutia (Siberia) leading to B- a large input of organic matter into a lake (source: L. Jardillier).

Objectives

This thesis project aims to characterise the microbial processes controlling the magnitude, rate and seasonal dynamics of greenhouse gas emissions from permafrost ecosystems. To this end, the project will aim to determine: 1- the phylogenetic diversity and potential metabolic activity of microbial communities in these wetlands formed by permafrost melt, 2- the identity of microorganisms involved in CO_2 and CH_4 fluxes and the quantification of their contributions to these fluxes, and 3- the links between spatio-temporal variations in microbial communities and CO_2 and CH_4 fluxes.

Methods

Greenhouse gas fluxes and the origins of the carbon in these gases will be measured by members of the PRISMARTYC consortium. To explore the seasonality of greenhouse gas production and emission, samples will be collected during 4 field missions spread over a full annual cycle (2022-2023). Due to current geopolitical problems, new study sites similar to those initially planned in Siberia are being identified, in Alaska for example.

The thesis project will aim to characterise the composition and potential functions of prokaryotic communities and to identify the main microorganisms responsible for CO_2 and CH_4 fluxes and to measure the contribution of prokaryotes (bacteria and archaea) to these fluxes using combined metabarcoding, qPCR, metagenomic, Flow-FISH and NanoSIMS approaches.

This project is also based on collaborations with French public laboratories (Université Paris-Saclay (GEOPS, CEARC), Université du Littoral Côte d'Opale (LOG), Unité EcoLab de Toulouse, Institut Méditerranéen d'Océanologie (MIO, Marseille) through the PRIMSARCTYC project. A close collaboration will be carried out for this thesis project with U. Christaki (LOG, Wimereux), Léa Cabrol (MIO, Marseille) and Maïalen Barret (ECOLAB, Toulouse). M. Barret and L. Cabrol will carry out the qPCR analyses. The Georgia Institute of Technology (USA) will provide training in metagenomic analyses.

References

Biskaborn BK, Smith SL, Noetzli J, Matthes H, Vieira G, Streletskiy DA, et al. (2019) Permafrost is warming at a global scale. Nat Commun 10:264
French HM (2017) The Periglacial Environment, 4th ed.Wiley
Schuur EAG, McGuire AD, Schädel C, Grosse G, Harden JW, Hayes DJ, et al. (2015) Climate change and the permafrost carbon feedback. Nature 520:171

Fundings

The PRISMARTCYC project (2021-2024, funded by the Belmont International Forum) will only cover the costs of fieldwork and sample analyses. The candidate will therefore have to apply to doctoral school grant to fund the salary (see application section below for more details). All the equipment necessary for the successful completion of the project is available at the ESE and at the collaborators.

Essential and desirable criteria

Applicants will ideally have skills in microbiology, microbial ecology, molecular biology and bioinformatics. Experience in field sampling is desirable. Due to international collaborations, the candidate will have a good English level. The candidate will be expected to organise and carry out short stays in France and abroad.

To apply

Applications must be submitted on the ADUM website (https://www.adum.fr/index.pl?site=adumR) for the doctoral schools SDSV n°577 of the Université Paris-Saclay and STS n°585 of the Université du Littoral Côte d'Opale.
The deadline for applications is 17 April 2022. Short-listed candidates will then be interviewed by L. Jardillier, U. Christaki, M. Barret and L. Cabrol by 10th May 2022. The selected candidate will be auditioned by the doctoral school end of June 2022.

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