Past, present and future of permafrost peatlands

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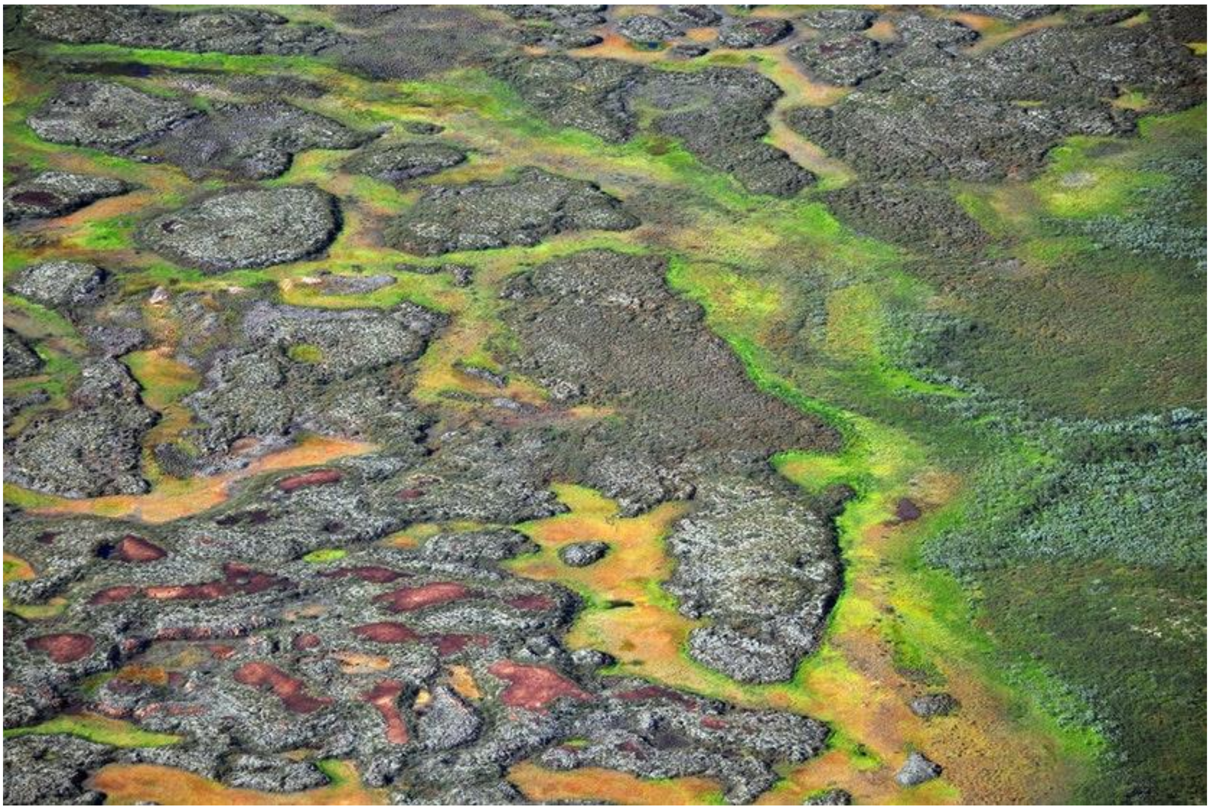
The Arctic is experiencing more rapid warming than anywhere else on the planet (Cohen et al., 2014), and this trend is projected to accelerate in coming decades, even under modest emissions scenarios (Collins et al., 2013). This warming is already having marked effects on high-latitude ecosystems, stimulating biological processes and biochemical cycles. The result is rapidly changing landscapes on globally-important scales, particularly through the loss of permafrost (Chadburn et al., 2017). Some of the most important, and potentially fragile, ecosystems in the arctic are permafrost peatlands, which have been estimated to store 277 Pg of carbon, equivalent to more than 8% of the entire global belowground carbon pool (Tarnocai et al., 2009). Until recently this huge carbon store has been rendered effectively inert due to frozen conditions. Recent work, including by Leeds researchers (e.g., Swindles et al., 2015; Taylor, 2018), indicates that high-latitude peatlands are already experiencing dramatic changes in ecosystem structure and function in response to recent warming. The complexity of these ecosystems means that it is currently unclear whether thawing permafrost peatlands will become net sources (through enhanced respiration) or sinks (through enhanced plant productivity) of carbon (Ciais et al., 2013; Treat & Frolking, 2013). This PhD project will make a major contribution to this important question.

Down-core studies of past changes in permafrost peatlands are relatively limited, and the project will see the student filling important spatial gaps in existing knowledge about these systems. The student will combine their new data with a comprehensive database of published information on past changes in important aspects of permafrost peatland development (e.g., carbon accumulation regimes, surface wetness, plant communities, trophic status) in study sites across the arctic. The student will use state-of-the-art palaeoclimate simulations from the HadCM3 Earth system model to establish the long-term climatic controls on permafrost peatland development (see Morris et al., 2018), before making informed projections about the likely fate of these important ecosystems under future climate change scenarios. There is scope for flexibility in the project, which may focus on permafrost peatland carbon budgets, plant communities and biodiversity, or other aspects of these ecosystems' development according to the interests and experience of the student.

There will be exciting opportunities for the student to visit permafrost peatlands in the Arctic to collect cores, and to build collaborations with the broad group of international experts working in this topical area.



Seen from the air, permafrost peatlands often display a colourful patchwork of vegetation cover and micro-relief that disguise an enormous and potentially fragile carbon store just below the surface (photo credit: Tarmo Virtanen, University of Helsinki).

Objectives

This project will use a powerful combination of palaeoecology, database analysis and climate simulations from a cutting edge Earth system model to investigate the past, present and future of permafrost peatlands across the Arctic. More specifically, the project has the following objectives:

1. Undertake detailed analysis of peat palaeoenvironmental proxies in cores from the Toolik Lake area of Alaska's North Slope.
2. Construct and analyse a comprehensive catalogue of published data on the past developmental behaviour of permafrost peatlands.
3. Use palaeoclimate simulations from the HadCM3 Earth system model to investigate the climatic controls on permafrost peatland development.
4. Use this new understanding to make informed forecasts about the fate of these important ecosystems under a range of projected climate scenarios.

Fit to NERC Science

This project is closely aligned with two NERC research areas: 1) Climate & Climate Change, including using model simulations of past, present and future climate, and in understanding drivers of change in palaeoenvironments; and 2) Terrestrial & Freshwater Ecosystems, particularly peatland carbon budgets, land-atmosphere interactions, and ecosystem-scale processes.

Potential for high impact outcome

The project will contribute to one of the most pressing environmental issues of our time – the fate of permafrost peatland ecosystems and their huge carbon store under likely future climate scenarios. The research has been designed so that each of the objectives (above) will lead directly to an important, high-profile journal article that the student will lead. They will be guided in this endeavour and all other aspects of the project by the supervisors, who have a track record of publishing in some of the world's most prestigious journals.

Training

The student will work under the supervision of Dr. Paul Morris and Dr. Graeme Swindles in the School of Geography, where they will become a member of the River Basins Processes and Management research cluster; Dr. Ruza Ivanovic in the Institute for Climate and Atmospheric Science, School of Earth and Environment; and Dr. Sarah Chadburn, University of Exeter. The project will provide the student with high-level training in (i) peatland science; (ii) Quaternary climate and environmental change; (iii) leading-edge climate model simulations; (iv) advanced data analysis skills. The student will be supported throughout by a comprehensive PGR skills training programme that follows the VITAE Research Development Framework and focuses on knowledge and intellectual abilities; personal effectiveness; research governance and organisation; and engagement, influence and impact. Training needs will be assessed at the beginning of the project and at key stages throughout the project and the student will be encouraged to participate in the numerous training and development course that are run within the university to support PGR students, including statistics training (e.g. R, SPSS), academic writing skills, grant writing etc (http://www.emeskillstraining.leeds.ac.uk/). Supervision will involve regular meetings between all supervisors and further support of a research support group.

Student profile:

The student should have a keen interest in climate science and environmental change, and a strong background in a physical geography, Earth sciences, plant sciences, environmental sciences or a related discipline. Strong skills and an enthusiasm for microscopy and palaeoecological techniques, data handling, and numerical methods are also desirable. Some basic skills in R would be an advantage, but are not essential.

References

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