How are our peatlands eroding? Using fine scale 'roughness signatures' to quantify soil and carbon losses via different erosion mechanisms

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Project summary

Peatlands form an important terrestrial carbon store, comprising 30-50% of all carbon stored in soils worldwide (Gorham, 1991) much of which is at risk of degradation through climate change (Gallego-Sala and Prentice, 2013), increasing its susceptibility to erosion. When peat is eroded, this carbon is released into the atmosphere and contributes to global greenhouse gas emissions. Blanket peat in the British Isles makes up a highly significant 15% of the global total and recent efforts have been directed towards mapping the extent of peat erosion in Britain from satellites and aircraft. These surveys can detect large changes over the course of decades. In contrast, many studies focus on studying short-term erosion rates at the field scale, using point measurements of erosion. Although recent studies have shown that peat erosion and transport is an important component of the carbon budget, this process is rarely investigated in detail. In general, there are few direct measurements of peat erosion processes.

Recent advances in geomatics present exciting new opportunities by offering unprecedented resolution topographic data. We now have the opportunity to observe mm to cm-scale changes in bare peat surfaces and quantify erosion and carbon loss over small scales. High resolution topographic data contain a wealth of hitherto untapped information; the fine-scale topographic variability acts as a 'roughness signature' of the dominant processes operating on peat (demonstrated recently by Smith & Warburton, 2018). By integrating detailed small-scale observations of erosion processes as a connected mosaic within the larger catchment erosion and sediment yield models can be developed.

The aim of this project is to couple event-scale monitoring of surface change using Structure-from-Motion photogrammetry with observations of meteorological and hydrological drivers of that erosion. Using roughness analysis and machine-learning algorithms, the project will identify roughness signatures of peat weathering and erosion processes, thereby attributing volumetric peat and carbon losses to a particular driving process. Finally, for a broader impact, the project will seek to upscale this mechanistic quantification of peat erosion to larger catchment scales to inform and help target future restoration practices.

Objectives

In this project, you will work with scientists in both the University of Leeds and Durham University with close ties to peatland managers and restoration practitioners of the North Pennines AONB Peatland Programme. The exact nature of the project can be adjusted to suit your individual research interests (including experiments in the environmental laboratory and potentially modelling); however, the studentship will involve the following core objectives:

1. To quantify peat erosion volumes and carbon loss estimates at the plot and small catchment scale over a range of surface types;
2. To measure fine scale peat topographic roughness using Structure-from-Motion photogrammetry over a range of surface types;
3. To establish quantitative 'roughness signatures' of different peat surface processes using machine learning techniques;
4. To produce the first mechanistic segregation of peat erosion volumes and carbon loss through application of these roughness signatures;
5. To upscale these relationships to the management scale and inform targeted peatland restoration campaigns.

While the majority of the research is planned for UK uplands, the methods are transferrable to other areas of eroding peatland and the supervision team has extensive experience studying peatlands worldwide. Furthermore, the members of the supervision team were recently awarded a research grant to investigate geomorphological responses to the Saddleworth Moor wildfires; the successful candidate may wish to interrogate the high spatial and temporal resolution topographic dataset to investigate peatland responses to wildfire and/or investigate any further such fires should they arise.

Fit to NERC Science

This project is aligned with the NERC terrestrial research area, covering Earth surface processes, Soil Science, and quantifying fluxes of carbon within the physical environment.

Potential for high impact outcome

The project will apply cutting-edge geomatic survey techniques and machine learning algorithms to address longstanding questions relating to the relative importance of different surface processes in eroding peatlands. A recent publication by two members of the supervisory team (Smith and Warburton, 2018) has demonstrated that this approach has potential, but requires validating and upscaling to be effective. In doing so, this studentship would produce several outputs. While peatlands are ideally suited to the proposed method, the approach would be generalizable to soil erosion more broadly and hence, there is potential for impactful and highly cited research outputs.

Training

The student will work under the supervision of Dr Mark Smith and Prof Andy Baird within the River Basin Processes & Management research cluster in the School of Geography at the University of Leeds. An active network of peatland scientists works within this research cluster. Furthermore, via the supervision of Prof. Jeff Warburton at Durham University, the successful candidate will have access to a broader network of peatland researchers across the north of England. The project provides a high-level of training in (i) photogrammetric techniques for monitoring surface changes; and (ii) field monitoring methods in upland environments. Moreover, the student will be supported throughout the studentship 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, MATLAB), 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

Applicants should have a strong background in physical geography and an interest in geomorphology. Knowledge of remote sensing and GIS-based analysis is essential. Strong fieldwork skills are desirable but not essential, as full training will be provided during the PhD.

References

Gorham E. 1991. Northern peatlands: role in the carbon cycle and probable responses to climatic warming. Ecological Applications 1: 182–195.

Gallego-Sala AV, Prentice IC. 2013. Blanket peat biome endangered by climate change. *Nature Climate Change* 3: 152–155.

Smith, M.W. and Warburton, J., 2018. Microtopography of bare peat: a conceptual model and objective classification from high-resolution topographic survey data. *Earth Surface Processes and Landforms* 43, 1557–1574.