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Fully-funded MSc by Research –

Cold humid Islands: peatlands as tools for cooling the climate

1. Background

Different environments will partition the solar energy that falls upon them in different ways. Comparing a dry and wet environment, the dry environment would partition incoming energy in favour of sensible heat relative to the wet environment where the presence of more water means that incoming energy is more likely to be partitioned in favour of latent heat, i.e. more of the energy can be used for evaporating water. This relative behaviour between dry and wet environments means that the drier environment would produce more warmer air and thus increase air temperature above them whereas for the wetter environment more energy is dissipated as latent heat and so gives rise to relatively cold humid air. ***These effects of land use on changing energy balance means that we could have a way of manipulating landscapes to mitigate climate change impacts.***

Worrall et al. (2019) showed that peatland restoration (revegetation and raising water tables) led to a 1.7 °C decrease in air temperature. Subsequently, Worrall et al. (2022) found that cooling by the landscape is a competition between albedo, Bowen ratio (i.e. the ratio between surface energy and latent heat flux) and surface roughness. ***Therefore, to understand how a landscape impacts air temperature we need to understand how energy partitions across different landscapes.***

2. Methods

It is complex to predict air temperature from the surface energy balance because of interacting effects, circular assumptions and complex feedbacks. Therefore, we need to predict air temperature from independent measurable variables such as albedo, water table depth, surface roughness, and time of year. The Bowen ratio is not independent of surface energy balance, but it is commonly measured in environments and commonly discussed as a control on surface energy budgets. The Bowen ratio could be linked to measured independent variables. We have been measuring the range hydrometeorological parameters at Thorne Moors in Yorkshire (Figure 1). At the Thorne Moors site we have been measuring both the independent and dependent variables that will allow us to study the link between land surface factors and air temperature. There are then 3 questions that this project will address:

Figure 1: Restored peatland at the Thorne study site.

i) *What controls the Bowen ratio?* - Bowen ratio is the ratio of surface energy to latent heat fluxes. Because the Bowen ratio is not independent of controls on sensible and latent heat fluxes, it is not a control in itself but we can consider possible controls upon it. The approach will be to compare measured independent variables to measured Bowen ratio.

ii) *What controls air temperature?* - it is possible to conceptualise the controls on air temperature and this project will use this conceptual network to predict air temperature and the importance of the components of the network. The method used will be Bayesian networks, these have the advantage over neural networks as the nature of connections can be both specified and learnt thus avoiding the black box problem of many neural network approaches. The developed Bayesian networks will be used to predict the impact of management, for example if albedo was decreased by the addition of biochar to the surface.

iii) Can results for Thorne Moors be generalised? - The advantage of the methods chosen above is that they can show what relationships are significant, but the methods rely on empirical relationships and so could be site specific. However, we have access to data from a range of locations across UK peatlands. Therefore, we can check findings from Thorne Moors for other sites.

3. Scientific benefits

The project has a number of important benefits.

i) *Increasing resilience* - if we can show that air temperature can be linked to independent variables that can be controlled by management then we have the opportunity to increase resilience

ii) *Reverse climate change* – if we can increase resilience we can also use the landscape to cool the air and so combat climate change.

iii) *Increase benefits of restoration* – peatlands have often been thought of as acting as a sink of greenhouse gases and so to act as a means of mitigating climate change. With this project we could also show that peatlands act to directly cool a landscape, thus creating another reason for funding peatland restoration.

4. Training

The project is fully-funded and will cover the costs of tuition fees; research and include a stipend. The project will use a range of machine learning techniques and the student will receive training in all data science methods. The project will include fieldwork at Thorne Moors to collect data and maintain the monitoring equipment. The training in such data science methods and Earth observation methods will position the student well for a range of future careers.

5. Further information

Worrall, F., et al. (2019). The Impact of Peatland Restoration on Local Climate: Restoration of a Cool Humid Island. *Journal of Geophysical Research - Biogeosciences 124, 6, 1696-1713.*

Worrall, F., et al. (2022). Local climate impacts from ongoing restoration of a peatland. *Hydrol. Process. 36, 3 DOI10.1002/hyp.14496.*

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