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Finding hotspots and coldspots - mitigating climate change through land use

1. Background

Different environments will partition the solar energy that falls upon them in different ways. For example, comparing dry and wet environments, 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 used for evaporating water. Equally, changes in the land surface alter the albedo (reflection of energy) and the changes in vegetation alter the surface roughness. Therefore, different land uses will impact the air temperature in different ways. If the reasons for different air temperatures can be identified then we can exploit this to improve resilience to climate change. This project has two hypotheses:

i) That there will be land management and land use changes that lead to cooling of air temperature.
ii) That it is possible to identify rural areas with land use that gives rise to cooler air temperatures.

2. Methods

The approach of this study will be to use NASA MODIS (Moderate Resolution Imaging Spectroradiometer) satellite data. The satellite has been operated by NASA since the year 2000, twice a day it passes over each part of the globe and records 36 wavelengths. These wavelengths have been associated with a range of properties that mean we are able to monitor a range of important climate properties (eg. temperature, albedo and vegetation cover – Figure 1) at a landscape scale. In addition to MODIS data there are a considerable range of spatial datasets that can provide essential covariate data, for example land use, soil type and air temperature. Using the MODIS and covariate datasets the project will consider two experiments:

i) English fenlands – a preliminary examination of land surface temperature (Figure 1) shows there are relative hot and cold areas across the landscape that are not urban centres, i.e. landscape is controlling the surface temperature.

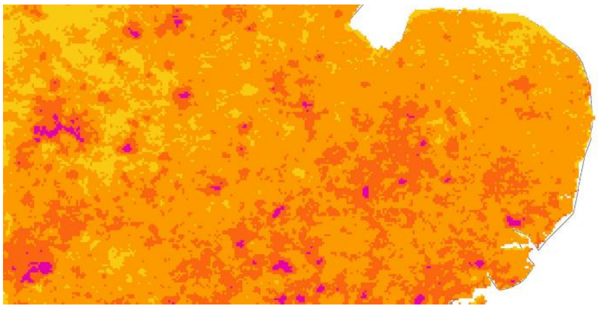

Figure 1. The average land surface temperature of eastern England for 2015-2017. Most hotspots (purple) are urban centres but not all.

The fenlands have both peat and sandy soils as well as intensive arable and forestry land use. The remote sensing and land use information will enable us to test what is controlling air temperature.

ii) The Onlanden – an area of the north east Netherlands where a large tract of land was taken into public ownership and rewetted. The area lies upwind of the city of Groningen. This landscape and land use change means that there are pre- and parallel controls for a large-scale landscape intervention. Furthermore, the area lies upwind of the city of Groningen and so there is potential to test the impact of the land use change on the climate of the city.

3. Scientific benefits

The project has a number of important benefits.

i) *Improving impact assessment* – New developments and land use changes are commonly now assessed for their impact on greenhouse gas emissions, but why are they not assessed for their direct impact on climate? This project provides a means of assessing the direct climate impact of land use and land use changes, and therefore creates a novel means of assessing direct climate impact.
ii) *Increasing resilience* - if we can show that air temperature can be linked to land management

then we have the opportunity to increase resilience.

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

4. Training

The project will use remote sensing and data science techniques to test the hypotheses. The student will receive training in all the required techniques. The training in such data science methods and Earth observation methods will position the student well for a range of future careers.

5. Further reading & 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. (2020). Are peatlands cool humid islands in a landscape? *Hydrological Processes* DOI: 10.1002/hyp.13921.

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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