Project Title | Transport of climate active trace gases between the atmosphere and biosphere
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Host University | University of Warwick
Themes | Climate & Environmental Sustainability, Organisms & Ecosystems
Supervisory team | Professor Robert M Kerr, Department of Mathematics/School of Engineering, University of Warwick, [R.M.Kerr@warwick.ac.uk](mailto:R.M.Kerr@warwick.ac.uk)  
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Project Highlights

- Model horizontal transport of trace gases through soils
- Observe and model the vertical exchange and transport of trace gases between soil horizons and the atmosphere in preparation for new parameterisations
- Determine how soil community metabolisms impact the net production and consumption of trace gases from soils

Overview

Soils both produce and degrade/consume trace volatile gases, as such they are a critical component of global cycling for all greenhouse and climate affecting gases. The biosphere-atmosphere rates of exchange across the terrestrial surface-atmosphere boundary \(^1\) are strongly affected by boundary-layer wind speeds, which affect rates of mixing; a factor taken into account in ocean-atmosphere exchange and incorporated into climate models \(^2\). However, at this time, no corrections are currently made to modelled, diffusive exchanges rates used at soil surfaces in coupled global climate models.

As the terrestrial ecosystem-atmosphere gas fluxes \(^4\) are projected to be a major determinant of future climate, and considering that climate change also has a strong effect on average wind speeds across the planet, addressing these uncertainties will require a multi-disciplinary approach that uses modelling to provide a way to interpolate over a broad range of soil types, winds and soil saturation levels once their assumptions, parameters and predictions have been validated using field-based measurements. This work done under this PhD would be a significant contribution to those efforts.

Importance. Volatile compounds pass through soils, with impacts on climate (through greenhouse gases), local ecology (through signalling and defense compounds) and the local soil environment. Concentrations of these volatile gases in soils is heavily dependent upon their soil residence time, which depends substantively on surface wind speeds and porosity. Increased surface winds enhance the movement of volatile compounds from the soil to the atmosphere (and vice versa when soils consume the compound of interest, like methane in forest soils) as well as driving horizontal movement within the soils. These impacts have only recently been explored and there remains substantial uncertainty over the distance important ecological chemical signals can travel in upper soil horizons, as well as the degree of influence surface winds have on the release of greenhouse gases to the atmosphere.
Methodology
1) A community atmospheric mesoscale code. I currently have a student using this in the Cities CDT to understand the effect of hurricanes on city infrastructures.
2) An in-house multi-particle collision model (Garcia-Gutiérrez et al, 2015) that was previously developed for the flow of red blood cells through capillaries, but with particle numerics more appropriate for flow through porous media.
3) Access to and training in the use of archived and ongoing environmental data from observations of trace gases by Redeker obtained using closed headspace sampling over soil surfaces, analyzed using gas chromatography and mass spectrometry.

Training and skills
CENTA students are required to complete 45 days training throughout their PhD including a 10 day placement. In the first year, students will be trained as a single cohort on environmental science, research methods and core skills. Throughout the PhD, training will progress from core skills sets to master classes specific to CENTA research themes.
Experience in using three-dimensional numerical codes with applications to biology, porous materials and atmospheric dynamics.
Experience in collecting and using observational data to validate numerical codes and then making new predictions.
If the focus will be on the atmospheric code, a week should be spent at one the training workshops for use of the WRF mesoscale code staffed by members of the National Center for Atmospheric Research. Either in Boulder, Colorado or the biennial workshop run in the UK for European users.
In the last phase, experience in developing the types of models and parameterisations used by most modern predictive models.

Partners and collaboration
Partner for Professor Kerr on mesoscale modelling is with the Met Office branch at Reading University group on Convective-scale Modelling Research.
Partners for Dr Redeker- Dr Redeker engages with RSPB, Natural England and the Environment Agency to assess ecosystem function in a number of UK ecosystems (including peat bogs, agricultural soils and salt marshes).

Possible timeline
Year 1: CENTA training plus additional training for using the codes. If the focus will be on the atmospheric code, a week should be spent at one the training workshops for use of the National
Center for Atmospheric Research’s WRF mesoscale code, either in Boulder, Colorado or the biennial workshop run in the UK for European users. Then running example calculations to gain familiarity with the capabilities of the codes.
Year 2: Apply the codes to the archived and ongoing data of environmental trace gas fluxes obtained by Redeker’s York group using canisters sampling static chambers and examined using GC-MS. Included would be accessing data at national centres for local variations in greenhouse gases.
Year 3: Once the results are known, the next step would be to consider how the results should be used for parameterising the surface fluxes in larger scale atmospheric models. First mesoscale (regional) models, then perhaps global models. Whilst finishing the analysis and writing the results.

Further reading


*Web page with an author:*
https://warwick.ac.uk/fac/sci/maths/people/staff/robert_kerr/r2_garcia_kerr_somfai_singer.pdf