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\(^1\) 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 the sub-surface 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:**

There would be three interwoven themes in the proposed study of the exchange of the gaseous volatiles between the atmosphere and soils. 1) Atmospheric forcing. 2) Transport through the soils. 3) Comparisons with observational data.

1) WRF, a community atmospheric mesoscale code, would provide the atmospheric forcing. By nesting domains, horizontal scales down to a few 10s of metres, with the true underlying fine-scale soil-type/vegetation, can be represented.

2) The subsurface motion and exchange would be modelled using either the commercial RANS code taught in Engineering or my own boundary-layer/convection code (Kerr, 1996) when run in Stokes mode, with analytic models representing the volatile exchange (Massman, 2006) and WRF providing the atmospheric surface forcing and turbulence levels.

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.

To understand the origins of the small-scale reanalysis data to be used, which would be blended from mesoscale-numerics plus global observations, 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, the learnt experience of using observational data combined with numerical predictions would be applied during a placement with a water treatment agency.

**Partners and collaboration:**
Partner for Prof. Kerr on mesoscale modelling is with the Met Office branch at Reading University group on Convective-scale Modelling Research.

For 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. In addition, 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:**

*Journal:*


**Further details:**

For further details about this project please contact Prof Robert M Kerr, R.M.Kerr@warwick.ac.uk