Projects available for Research Experience Placements 2022

1. Investigating observations from a network of boundary layer scintillometers in Berlin

<u>Supervisors: William Morrison, Sue Grimmond (University of Reading)</u>

Scintillometers are novel and exciting ground-based instruments that measure the intensity of turbulent eddies in the atmosphere across distances up to around 10 km. The scintillation phenomena - which explains the "twinkling" of stars - is observed by boundary layer scintillometers to infer boundary layer turbulence and heat fluxes.

The student will collect and use ongoing observations from six pairs of scintillometers in Berlin, Germany, and will benefit from having the opportunity to work on a range of different questions:

- are there characteristic temporal and spatial variations in the turbulent intensity (the structure parameter of temperature - Cn2) across the city?
- what steps are needed to separate good and bad quality data (quality control)?
- how do the observations compare to results from numerical weather prediction models?
- based on any of the above points, how can the current observation network be improved and/or applied in other cities?
- how can the current tools available be made more accessible to future users (e.g. help develop python package and repository)?

This is an excellent opportunity to be part of modern, real-time field operations. If future in-situ fieldwork opportunities arise, funds are available to support this. The student will also benefit from access to a large research group of postdocs, PhD, MSc and visiting students/scientists, not just at the host institution Reading (UK), but also from collaborating teams across Europe (e.g. Germany, France, Greece).

2. Transforming Research Visualisation in Ecology with Interactive Graphics

Supervisors: Becks Spake, Manuela Gonzalez, Tom Oliver (University of Reading),

External collaborators: James Bullock (UKCEH), Tom August (UKCEH), Diana Bowler (UKCEH), Matthew Grainger (Norwegian Institute for Nature Research (NINA)

Brief description

While ecological modelling has increased in complexity over recent decades, the way that model results are presented in journals, as static 2D images, has not kept pace. Statistical interactions, which are ubiquitous in ecological analyses, are prone to misinterpretation in this format. Ecologists have yet to capitalise on the opportunities provided by online interactive graphics (IG), which could greatly enhance interpretation by providing users with options to visualise different aspects of models and data.

Objective: To explore how IG can be harnessed to improve the interpretability of statistical interactions.

Methods:

1) Systematically map the literature to document current practice in the presentation and interpretation of interactions:

Following established protocols, the student will search and collate studies that investigated interactions in a specific topic, biodiversity responses to climate and land-use change, published in select ecological journals within the past five years. The student will extract and code simple methodological details regarding e.g., data transformation, results visualisation.

2) Design IG application that improves interaction interpretability:

The student will improve on current practice and develop an open-source analysis and data-visualization web-app (R Shiny). The app will enable users to upload models fitted in R, and display relevant quantities, uncertainty, and interrogate the marginal predictions. This will draw on practices already established in other disciplines (psychology, public health), but yet to become common in ecology. For demonstration, the student will work with an already-published model (e.g.,https://doi.org/10.1111/1365-2664.13945).

Benefits: Exposure to hot ecological topic and systematic mapping methodology, collaborations with multiple research groups, presentation at group meetings, report writing and potential contribution to a publication, opportunities to assist PhD fieldwork.

Supervision:

University of Reading: Becks Spake (systematic map, app development), Manuela Gonzalez (app development), Tom Oliver (systematic map)

James Bullock (UKCEH, systematic map), Tom August (UKCEH, app development), Diana Bowler (UKCEH, systematic map), Matthew Grainger (NINA, app development)

3. Integrating meteorological factors for better modelling urban air quality using mobile monitoring

Supervisors: Hong Yang, Janet Barlow, Marta O'Brien, University of Reading

Introduction: Air pollution, especially particulate matter ($PM_{2.5}$), is the most significant environmental health risk globally. However, the sparse nature of the stationary air quality monitoring network makes it challenging to quantify intra-urban air pollution. With the advent of Internet of Things technology, mobile monitoring has increasingly been used to characterise intra-urban air pollution. Meteorological factors, particularly wind, can significantly influence ambient $PM_{2.5}$ levels by impacting ventilation rates, dry deposition, and chemical reactions. Urban forms, such as land use, population distribution, and transportation networks, can also affect the spatiotemporal dynamics of air quality. Previous studies that captured the impact of meteorology on the urban-form−air-quality relationship tended to rely on linear models and measurements from stationary monitors.

Objectives: This project will quantify the importance of meteorological factors on urban-form−air-quality relationships using mobile monitoring data with machine learning models.

Methods: The project will construct and test both linear (Multiple Linear Regression) and nonlinear models (Machine Learning Random Forest and Artificial Neural Network) with both tenfold cross-validation and field $PM_{2.5}$ data in Reading measured from a mobile sensor, Flow 2. Temperature and relative humidity will be included as control variables.

Benefits: The student will benefit from (1) exposure to atmospheric composition modelling, (2) analysing and visualising data using various programming languages such as Python and R with guidance and support, (3) meeting our current PhD students, and (4) writing report and potentially contributing to a publication.

External collaborator: Prof. Jianlin Hu, NUIST, China, collaboration through the Royal Society International Exchange Grant

4. Species' capacities for sustained adaptation in response to climate change

Supervisor/Host: Professor Mark Pagel, School of Biological Sciences, University of Reading
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Earth is now warming at rates faster than it has for millions of years, and is at its warmest point of the past 125,000 years. The most recent report from the United Nation's climate scientists warns that some environmental changes in response to this warming could become self-sustaining, amplifying their own effects. This new climate, and the many environmental changes it brings, mean that the plants and animals are going to have to adapt to survive, and do so over timescales of potentially many hundreds to thousands of years. Already Australia's corals are in severe decline.

For how long and at what rates can species maintain sustained bouts of adaptation? Our current views on this question are probably wildly optimistic. The work on this placement would be to participate in the development of a new way to estimate long-term sustainable adaptation over thousands of years. We anticipate that this new methodology could provide a valuable corrective to the received wisdom and be of interest to environment, conservation and climate scientists, governments and conservation organisations.

The placement work would involve obtaining data on natural variation from published studies (large database already identified), and for a variety of different species. Then, in combination with information on species' generation times, the individual would develop predictions of long-term sustainable change over thousands of years.

The project will benefit students interested in quantitative approaches to the environmental sciences and conservation, and those interested in climate change and its effects. It will provide a front-row experience on how to develop scientific predictions from combining evidence and theory. Prior knowledge of methods is not necessary. Supervision is provided at every step, and the research environment is a lively and welcoming open-plan office with PhD students, postdoctoral researchers and academic staff.

5. Assessment of thermobaric energy in the ocean

Supervisor: Rémi Tailleux (University of Reading)

An important feature of the ocean is that its equation of state for density is a strong nonlinear function of three variables: salinity, temperature and pressure. One particularly important aspect of the nonlinearity is related to 'thermobaricity', that is the strong pressure dependence of the thermal expansion coefficient (which controls the response of sea level to global warming, among other things). Thermobaricity, when coupled with density-compensated temperature/salinity anomalies created by the surface patterns of heat and freshwater fluxes, introduces a new form of energy in the system, called thermobaric energy. Most of the time, thermobaric energy represents a 'dormant' form of energy that most often plays little role in ocean dynamics. It has been hypothesized, however, that circumstances may occasionally arise that would cause thermobaric energy to be suddenly released, thus potentially explaining some past abrupt climate change induced by changes in the ocean circulation. Progress in our understanding has been limited, however, by the lack of an appropriate theoretical framework to define and quantify thermobaric energy precisely. The main objective of this project will be to test a couple of possible definitions of thermobaric energy arising from the analysis of the problem in terms of the theory of available potential energy developed by the supervisor. The next step will be for the student to collect climatological data of temperature and salinity from existing sources (from the web) in order to quantify thermobaric energy in the actual ocean and its temporal variations in the past 50 years or so. In addition, an afternoon will be devoted to visit Reading university weather station in order for the student to better appreciate what kind of variables are measured, the physical principles underlying such measurements, and where the data are collected and analysed.