Research experience placements at the University of Reading, summer 2020

The Natural Environment Research Council has a scheme aimed at encouraging undergraduate students who are doing a degree in a quantitative discipline to consider a career in environmental research.
http://www.nerc.ac.uk/funding/available/postgrad/advanced/experience/

The SCENARIO DTP https://research.reading.ac.uk/scenario/
has three placements in this scheme this year, based at the University of Reading. This scheme is therefore an excellent opportunity to get experience of working in a thriving research environment before considering applying for a PhD next year (whether with SCENARIO or elsewhere).
Students would receive £9.10/hr, 25 hours per week for 7 weeks of work this summer. The eligibility criteria are strict. They must:

- Be studying for a degree in a quantitative discipline (e.g. mathematics, statistics, computing, engineering, physics)
- Be undertaking the placement in a different department to their undergraduate degree
- Be in the middle of their first degree studies (or integrated Masters)
- Be expected to obtain a first or upper second class UK honours degree
- Be eligible for subsequent NERC PhD funding (UK, EU or right to remain in the UK)

Five possible areas of study are given on the following pages. Please note that all of these topics will require computing skills to perform, in terms of data handling and presenting your results. These projects will all be run remotely. Supervision, including guidance in using software, will be provided online by the supervisors.

If you are interested in applying for one of these placements, please email Prof Bill Collins (w.collins@reading.ac.uk) by **Friday 22nd May 2020**, providing a brief application (no more than 2 sides of A4) that should include information on:

(a) How you meet all of the above criteria
(b) A-levels grades (or equivalent), and on the marks you have received on your University course so far,
(c) Any experience with data processing software (Python, Matlab, R, etc.)
(d) The topics you would like to work on in order of preference.
(e) Provide a short statement, in around 250 words, on the origin and nature of your interest in environmental science. Include any relevant work or project experience.

1. **Surface-atmosphere exchanges in urban and rural areas: how variable should the model parameters be?**

Hamid Omidvar, Ting Sun, Sue Grimmond. Department of Meteorology

Site specific parameters such as Land cover (LC), surface albedo and Leaf area index (LAI) are essential inputs for atmospheric simulations to model surface energy fluxes and drive atmospheric dynamics. Derivation of these parameters is critical to study energy and water balance both over urban and rural areas.

We have recently developed a framework to derive various model parameters for different urban and non-urban areas. This helps us calculate albedo, LAI, surface resistances and LC for different types of surfaces and to use them as input to urban land surface models e.g. Surface Urban Energy and Water balance Scheme (SUEWS) and JULES. The framework includes working with flux observations (FLUXNET) and satellite imagery (Sentinel 2).

Activities will involve (i) using the developed framework and observational data to calculate site parameters and land covers for new flux sites and cities (ii) assessing the conditions where the model works well and where improvements are needed (e.g. collecting more observational data) (iii) proposing and undertaking improvements.

The student will (1) gain experience with working with satellite/EO and flux data and analysing such data; (2) become familiar with the importance of model parameters for atmospheric models, (3) improve python programming, standard software development, and report-writing skills, (4) be part of an active (virtual) group working on boundary layer meteorology.

2. **Poor man's vs. rich man's Navier-Stokes simulations**

Omduth Coceal, Department of Meteorology

Turbulence is ubiquitous in nature, yet is notoriously difficult to simulate accurately. Direct numerical simulations (DNS), which solve the Navier-Stokes equations governing fluid motion, typically require many thousands of cpu-hours even for simple flows in modest domains. Turbulent flows are unsteady, stochastic and multi-scale, characteristics that result from the underlying non-linearity of the Navier-Stokes equation. Understanding the physics of such flows is crucial for developing simpler models in a number of applications such as dispersion and air quality modelling. A novel approach has recently been proposed to represent local turbulent time series by means of a discrete dynamical system. Such "poor man's Navier-Stokes" models employ very simple mathematical methods and can therefore be easily coded and run extremely cheaply. This project will investigate which aspects of the turbulence these simple models can or cannot capture, by comparing them against existing data generated by DNS. The project will involve data analysis and coding in Python or Matlab. It will give the student an opportunity to develop their mathematical and numerical modelling skills and will cultivate a deep physical understanding of complex turbulent flows, which underlie many natural phenomena

3. Flash droughts and their forecast

Liang Guo, Amulya Chevuturi, Fangxing Tian, Department of Meteorology

Compared to traditional meteorological and agricultural droughts, lasting from few months to years, flash droughts could be as short as 1-2 weeks. Since their recognition in 2002, it has been revealed that flash droughts have severe repercussions on agricultural yield and water supply. However, these types of droughts haven't been studied in much detail. Further, under the changing climate, with accelerating temperature rise, the flash droughts are expected to occur more frequently and with longer duration in the future. Thus, identifying flash droughts and their timely forecasts should be the utmost priority for both the scientific community and relevant stakeholders. In this project, we will first identify flash droughts using two state-of-the-art reanalyses: European Centre for Medium-Range Weather Forecasts (ECMWF) Re-Analysis version 5 (ERA5) and Global Land Data Assimilation System (GLDAS). We aim to identify flash drought hotspots in terms of frequency and persistency using weekly mean surface air temperature, evapotranspiration and soil moisture. Applying the same metric, we will evaluate the forecast capability of flash droughts in three major subseasonal—to—seasonal (S2S) forecasting systems, UKMO, NCEP and ECMWF. Prediction performance will be evaluated for the different forecast lead time, to establish the skilful early-warning period for each forecasting system over the flash drought hotspots. Time permitting, we also aim to understand the reason behind successful/failed forecasts. Successful outcomes of this project, in future can be developed into operational early warning system for flash droughts.

The student will have an opportunity to be part of impactful and service driven scientific research and will gain experience in analysing model and reanalyses data, collaborating with others, presenting scientific findings and potentially contributing to a publication.

4. **Trace-element impurities in stalagmites as paleo-volcanic records: quantum-mechanical computer simulations**

Dr. Ricardo Grau-Crespo, Scott Midgley, Department of Chemistry

Trace-elements contained in stalagmites have been shown to provide reliable long-timescale records of volcanic activity. The history of these significant geological events is a vital input parameter climate models, because volcanic eruptions can affect global temperatures for years following an eruption by disrupting solar radiation transfer in the atmosphere. At present, interpretation of experimental detection by x-ray fluorescence spectroscopy (Prof. Dominik Fleitmann, University of Basel) is hindered by limited understanding of the atomic-level structural and thermodynamic aspects of incorporation.

This 10-week summer project will employ computer simulations based on quantum mechanics, to understand the incorporation of bromine and sulphur containing anionic impurities in the crystalline and surface regions of calcite and aragonite; which are common minerals comprising calcium carbonate stalagmites. We will make use of the research group's subscription to the national scientific supercomputing facility, ARCHER, as well as the UoR Academic Computing Cluster, to run simulations.

The student will be trained (remotely) in state-of-the art atomistic and molecular simulation methods (no previous knowledge in this area is required). Computing jobs, data analysis and postprocessing will be performed using the Unix operating system and there will be opportunities to learn and use programming languages like Python. Training will be supervised by Dr. Ricardo Grau-Crespo and Scott Midgley, whose Scenario DTP funded research is also in computational investigation of stalagmite geochemistry. We anticipate that successful completion of the proposed project will lead to a publication in a scientific journal, for example *Geochimica et Cosmochimica Acta* or *Chemical Geology.*

5. A meta-analysis on the effects of mixture and on soil functions and microbial community in agroecosystem

Xin Shu and Tom Sizmur, Department of Geography and Environmental Science

The interaction of aboveground plants and belowground microbial communities plays an important role in recycling nutrients across atmosphere, pedosphere and hydrosphere. Inputs of plant residues benefits microbial communities that favours specific plant-associated nutrients, and thus facilitate the microorganisms to occupy niches and increase their growths. This relationship is closely related to the species and functional diversity, and resource heterogeneity coming from plant residues. In nature, plants rarely grow in monoculture. Even in agricultural systems, crops are usually grown in a rotation of species or intercropped with cover crops, such that plant residues with different biochemical traits are mixed in the soil. In a null model, the effects of plant residues consisting of divergent plant species can be expected to be equal to the sum of individual species resulting in an additive effect. However, interactions of plant residues with contrasting biochemical compositions could lead to non-additive synergistic (the effects from mixture is greater than the sum of individual species) or antagonistic (the effects from mixture is smaller than the sum of individual species) effects. There is growing interests on detecting the factors that determine either additive or non-additive effect following the incorporation of mixture of plant residues.

This project will conduct a meta-analysis to investigate the differences between applying a mixture of different plant residues and the sum of the individual parts of the mixture in terms of their impact on soil carbon and nitrogen cycling and the underpinning microbial communities in agroecosystem. The overarching aim is to quantify what parameters control the size and direction of litter mixing effects. The student will search peer reviewed published research in the ISI-Web of Science core collection with the subject on plant residues mixture studies to date to collect relevant data and build a database which could be published in a data repository. The student and the team will define equation and select statistical approach (e.g. analysis of variance) that will be suitable to compare the effects of mixture and the effects of the sum of individuals. A statistical model (e.g. linear mixed effects model) will be applied to determine the explanation of environmental variables (e.g. precipitation and temperature), soil physicochemical properties (e.g. soil organic carbon), and plant physiological traits (e.g. lignin and cellulose content) on the non-additive or additive effects from the mixture. The student will use different packages in R programming or Genstat to conduct statistical analysis. The student will also use software such as MatLab, Origin, and R to produce graphs to visualize the research findings. The outcome of this research will contribute the understanding of plant-soil feedback, and help to predict carbon and nitrogen cycling in agricultural ecosystem with higher plant species diversity.