University of Reading
UNIVERSITY OF SURREY
Scenario DOCTORAL TRAINING PARTNERSHIP
UKRI Natural Environment Research Council

Projects available for Research Experience Placements 2024

1 Evaluating UKESM by comparison model output to gas phase chemistry observations using a state-of-the-art flight track simulator

Supervisor: James Weber (Department of Meteorology, University of Reading)

Project Description

Climate change is driven by changes to the composition of our atmosphere. Therefore, to make accurate predictions of future climate change, atmospheric composition, largely controlled by the emissions and chemical reactions of key gases, must be well simulated in models such as the United Kingdom Earth System Model (UKESM). However, no model is perfect, and a model's strengths and weaknesses must be understood so its predictions can be viewed in context and efforts to improve the model can be targeted to maximise impact. The best way to assess strengths and weaknesses is by comparing model output to measurements taken in the real world, in this case, measurements of key atmospheric gases. This project will compare UKESM output to measurements taken during multiple aircraft campaigns which sampled different regions and altitudes of the atmosphere. You will use the output from a new tool which interpolates model output directly on to aircraft flight tracks to perform the most faithful comparison between the model and real-world measurements to date. This analysis will improve our understanding of how well UKESM simulates certain important atmospheric gases and how its performance varies with altitude and region. The findings will help inform efforts for further targeted model development. For example, should further work be undertaken into refining emissions of a key gas or must the simulation of its chemistry be improved? Ultimately, this will help UKESM produce ever more accurate predictions of future atmospheric composition and climate change with real world implications for climate change policy.

.Benefits To Students

This project will introduce the student to atmospheric chemistry modelling, model-observation comparison, and model evaluation. Beyond this, the student will also learn about the wider field of Earth system modelling and how experiments to predict future climate change are performed, allowing them to make a well-informed decision about whether they would like to pursue further research in this area. In addition to this conceptual introduction, the project will involve challenging but impactful data analysis. The student will develop skills in data processing (e.g. combining multiple datasets along a time axis or binning data by altitude) and 2 of 2 assessing the influence of different factors (e.g. altitude, latitude/longitude) on model performance. Particular focus will be paid to a "question first approach" where the key questions to answer are first defined and the specific data analysis approach developed from there. The student will drive the project and propose how they want to analyse the data with justification, rather than being told how to do it. The student will write a short report summarising their findings which will be presented to colleagues in the ACRC group in Reading and to UKESM developers at the Met Office and relevant academic at other institutions. Effective researchers in the environmental sciences need to have a keen interest and understanding of the underlying science, strong data analysis skills, and the ability to summarise and present work to other scientists. This project provides all of these aspects

Student Profile

This project would suit students with an interest in climate change and/or data analysis and visualisation. Knowledge of atmospheric chemistry is not required but a bonus. The project is entirely computational and some experience with analysing NetCDF, csv files or numpy arrays in Python or R is recommended.

Remote Working – NO

2 Exploring smoothing to improve an ocean reanalysis for climate studies

Supervisor: Keith Haines (Department of Meteorology, University of Reading)

Project Description

In this project the student will get to learn about data assimilation techniques by applying new simplified Kalman smoothing algorithms developed in Reading to ocean reanalysis products produced by Italian collaborators as part of the EU Copernicus program. Historical reanalyses of atmospheric or ocean states are datasets over decades of complete gridded products of temperature and circulation made by combining (assimilating) sparse observations with a computer model of the system. Reanalyses should be able to generate better states by making more use of future observations not available to data assimilation systems developed for forecasting although this is not usually done operationally. Assimilation methods called “smoothers” can do this. You will explore whether smoothing could improve a new long ocean climate reanalysis (http://cigar.ismar.cnr.it/). This would be a pilot for an EU Copernicus project which may start later this year. You will experiment using the stored data increments and apply them to earlier periods using algorithms developed in Reading. You will validate results with available observations as well as assess climate metrics such as ocean heat content changes and trends.

Benefits To Students

You will take part in meetings in the department within the Data Assimilation Research Centre colleagues including PhD students and you will have some online meetings with colleagues in Italy who have produced the original ocean reanalysis. A visit to ECMWF to discuss with their Ocean reanalysis group will be arranged. You will also have a chance to tour the Reading University observatory where atmospheric instruments deployed by the Met Office collect data that are assimilated for operational weather forecasts.
You will benefit from seeing how research is carried out both in academia and in operational centres like ECMWF. You will learn about both observations and numerical models and appreciate the importance of their uncertainties and errors and how these are treated in forecasting situations.

Student Profile

Strong physics background including some fluid dynamics experience and some vector calculus. No model code running will be required but good Python knowledge for plotting and statistical analysis of large geospatial datasets will be needed. Would suit student with at least 2 years UG experience.

Remote Working – YES

Remote Working Details

Some remote working may be possible but good internet connection will be vital. We would expect to have meetings and work in the department at least twice each week

3 Using Earth Observation data to explore novel approaches in the downscaling of sectoral water demands

Supervisor: Nathan Rickards (Department of Water Resources, UK Centre for Ecology & Hydrology)

Project Description

In a world where a changing climate and growing population is placing increasing pressure on water resources, it is vital to be able to accurately model water demand and availability into the future. However, water demand data is often difficult to access at a fine spatial scale due to its sensitive nature and challenges in data collection.

Earth Observation datasets have recently gained greater momentum in the fields of hydrology and environmental science, by providing valuable insights into environmental changes and natural resource management. In this project, we will utilise various Earth Observation datasets (e.g. urban extent, night-time lights, heat) to downscale coarse-resolution water demands data (e.g. ISIMIP water abstractions) for a range of water use sectors (e.g. domestic, industrial, agricultural, etc.). There's potential for various methods of downscaling to be explored, from relatively simple scaling approaches (e.g. Tethys, as used for GCAM outputs), through to more advanced machine learning methods. Downscaling will be implemented over England, where in-situ abstraction data is available for validation at a 1 km resolution through the CS-N0W project. This comparison will gauge the suitability and accuracy of the refined water demand data and the effectiveness of employed downscaling methods for potential application over other geographical regions

Benefits To Students

The student on this project will explore downscaling methodologies appropriate for large-scale EO datasets, as applicable for environmental research. They will be guided in the acquisition, manipulation, and analysis of large spatial datasets via appropriate methodologies and software, and will gain experience in the use of programming in a scientific context. Through this, they will build upon key research skills such as reviewing literature, working with big data, and communicating their science with peers and the wider scientific community.

The candidate will also gain an understanding of water resources modelling both in the UK and internationally, and will contribute to the current research ongoing in the Water Resources group at UKCEH.

Student Profile

A successful candidate will have:

- Experience in a scientific programming language such as Python and/or R.
- Some experience in data handling and visualisation.
- Good numerical, oral and written communication skills.
- An awareness of machine learning/data-driven methodologies would be an advantage.

Remote Working – YES

Remote Working Details

Although the successful candidate is expected to be on site at UKCEH Wallingford throughout the placement, there will be opportunity for hybrid working as appropriate to the requirements of both the student and UKCEH..

4 Investigating Earth's Global Electric Circuit.

Supervisor: Keri Nicoll (Department of Meteorology, University of Reading

Project Description

Introduction: Earth's atmosphere is continuously electrified due to the presence of ions which are constantly generated by cosmic rays. A well-established feature of Earth's electrical environment is the Global Atmospheric Electric Circuit (GEC), within which current flows around the planet, sustained by global thunderstorm activity. Ongoing research at Reading is investigating how the GEC links to climate change (both in terms of using the GEC to monitor climate, but also how the GEC may vary in response to changes in climate).

Objectives and methods: In this project the student will help to compare different sources of atmospheric electricity data (specifically measurements of the atmospheric electric field) to investigate how the GEC can be measured from different locations simultaneously. The student will have an opportunity to perform the first detailed analysis of a newly digitised historical dataset of electric field from Lerwick Observatory in the Shetland Isles, to investigate how well this site can be used to study the GEC. The hourly electric field measurements from Lerwick will be compared with electric field measurements made by the Carnegie research ship, which is widely regarded as having generated one of the definitive datasets underpinning the GEC concept. As local weather can mask the GEC effects, the student will also help develop methods to select days on which GEC signals could exist in both datasets, using meteorological measurements and reanalysis data.

Benefits To Students

The student will gain valuable data analysis skills by working with a variety of real-world datasets, made by different instruments and at different locations. The novelty of this research means that there is a good chance that the student may also get to contribute to research paper publications. The student will have the opportunity to learn about meteorological instrumentation and, specifically, measurements of atmospheric electricity. These are made at the university atmospheric observatory (which hosts a number of different atmospheric electricity instruments) which will be visited with the supervisors. Finally, they will have the opportunity to get involved with radiosonde balloon launches from the observatory, which will carry cutting edge atmospheric electricity sensors developed in the supervisors' research group.

Student Profile

This project would suit a student with a physics, or meteorology background, with some basic programming skills and an interest in working with atmospheric data obtained from field instruments and observatory sites. Prior knowledge of atmospheric electricity is not necessary.

Remote Working – Yes

Remote Working Details

Remote working is possible but in person visits to the department will be expected at least several times during the project. Good internet connection will be essential for remote working to enable meetings to take place on line.

5 Environmental Impacts of Funerary Practices

Supervisor: Eugene Mohareb (School of Construction Management & Engineering, University of Reading

Project Description

The net-zero agenda is touching all sectors of our society, with the need to understand how each contributes to our global impact and find ways to reduce associated greenhouse gas (GHG) emissions. This project will develop a knowledgebase on diverse funerary rituals and practices (including different forms of ritual, burial, cremations, alternative technologies, coffin/ shroud type, grave markers, material and virtual memorials, floral tributes, patterns of grave visiting etc.) for investigating the environmental impact of these by collecting, compiling, and analysing data from life cycle assessment (LCA) studies and databases. 2 of 2 Our understanding of the environmental impact of funerals and disposition of the dead in the UK is limited but growing. LCA is a systematic framework for quantifying the environmental impacts associated with processes, products, or services from cradle (i.e., raw material extraction) to end of life (i.e., material disposal). Further analysis of the environmental impacts of the various funerary practices is needed to understand how these might be mitigated.

This project will begin with a hotspot analysis to determine the most impactful elements across funerary practices. This preliminary analysis will include consideration of impacts from both direct and indirect resource inputs; for example, direct energy inputs include site operations and maintenance, cremation, as well as ritual and grave attendance, whilst indirect energy inputs would include those associated with grave markers, coffins/urns, embalming, floral tributes, and water abstraction/treatment. Additionally, alternative site management practices (e.g., integration of onsite combined heat and power, greenhouses, virtual memorials) will also be considered.

Benefits To Students

- Students will gain an understanding of life cycle assessment through engagement with the databases and the literature; life cycle assessment is becoming an increasingly common tool within sustainability professions
- Students will engage with academic literature and apply it, develop research and analysis skills
- Students will learn about funerary services and develop their systems thinking around how these may impact the built and natural environment

Student Profile

- Quantitative skill
- Experience working with MS Excel
- Comfortable reading academic literature
- Analytic skills

Remote Working – Yes

Remote Working Details

- As students will likely be at a different university, we are happy for them to conduct work from home, assuming that they will be able to access their University's library
- We will have regular meetings on Teams (at least once per week)