University of Reading
UNIVERSITY OF SURREY

Scenario
DOCTORAL TRAINING PARTNERSHIP

UKRI Natural Environment Research Council

Projects available for Research Experience Placements 2023

1 The kernowite-liroconite mineral series: computer simulations (at Reading) and experimental characterisation (at the Natural History Museum).

Supervisor: Dr Ricardo Grau-Crespo (Department of Chemistry, University of Reading)

Project Description

In 2020, the new mineral kernowite, with composition Cu2Fe(AsO4)(OH)4•4H2O, was discovered by a team from the Natural History Museum (https://www.bbc.com/news/uk-england-cornwall-55396421). The mineral is analogous to liroconite, Cu2Al (AsO4) (OH)4•4H2O, but with iron replacing aluminium. These minerals are not well understood but, as secondary minerals from the alteration of primary copper and tin deposits, they can provide insights into the geochemical processes controlling the formation and evolution of mineral deposits. Environmentally, they are important to understand the presence of arsenic in groundwaters derived from old mine dumps/tailings.

In this project we will perform computer simulations, based on quantum-mechanical molecular modelling techniques, of the structural and thermodynamic properties of kernowite, liroconite, and their solid solutions. We are initially seeking to establish a) the detailed crystal structures of these minerals, b) the thermodynamics of mixing and the existence or absence of miscibility gaps, and c) the variation in properties (structural, optical, morphological) with the Fe/Al content in the series.

The simulations will be performed using the national supercomputing facilities ARCHER and Young, for which we have guaranteed access for this project. The simulations will be complemented by a wide range of mineral characterisation experiments using state-of-the-art facilities at the National History Museum. The student will mainly execute the computational work, but they can be more or less involved in the experimental side of the project depending on interest and on whether the project is conducted in person or remotely.

Benefits To Students

The student will benefit from learning about the molecular modelling of minerals, a technique that can provide insights into many geochemical processes of interest in environmental sciences (e.g., stable isotope fractionation between minerals, impurities in minerals as temperature proxies in paleoclimatic reconstructions, etc - see recent work by supervisor). The student will acquire experience using high-performance computer facilities and many transferrable skills in terms of data processing and visualisation.

Student Profile

The project is ideally suited for a Physics/Chemistry/Materials student who wants to apply their existing knowledge to a geochemistry problem. Full training will be provided, so strong computing skills, while advantageous, are not a prerequisite.

Remote Working – YES

The project can be carried out in person or remotely. Remote work is perfectly ok as simulations will be carried out via remote connection to computing facilities. But if the student prefers to attend in person to facilitate discussions etc. that's also fine.

2 Climate Change, Floods, and Mould Risk.

<u>Supervisor: Prof Hong Yang (Department of Geography and Environmental Science, University of Reading)</u>

Project Description

According to the UK Climate Change Projections (UKCP18), South England is at an increased risk of flooding due to rising sea levels and more frequent heavy rainfall. The flooding can lead to water damage and mould growth on building surfaces. Previous studies have identified temperature, moisture, substrate, and exposure time, particularly the standardised Relative Humidity, as the main factors influencing mould growth. Dampness and mould in buildings have been linked to respiratory symptoms, asthma, and respiratory infections, with children under eighteen being particularly vulnerable to these health impacts. Unfortunately, there have been cases where mould exposure has resulted in fatalities, such as the case of two-year-old Awaab Ishak, who died from a respiratory condition caused by "extensive" mould at a flat in Greater Manchester in 2020. Despite efforts to improve building energy performance through retrofitting and refurbishment, these activities can increase the risk of condensation, dampness, and mould growth in buildings, with impacts that are often under-reported and can occur long after the flood or storm event

This placement aims to model flood risk using the UKCP18 model and predict the risk of mould growth using the Heat, Air, and Moisture (HAM) model. The student will also measure the mould risk using an Airthings Air Quality Monitor. To predict mould severity levels, the student will develop machine learning models including Random Forest (RF) and Artificial Neural Network (ANN). By conducting this study, we hope to contribute to a better understanding of the risks of mould growth under climate change.

Benefits To Students

The proposed placement presents an opportunity for the student to acquire a range of valuable skills and knowledge in the field of climate change, flood, and mould research. Specifically, the student will benefit from:

1) Exposure to advanced modelling techniques for climate change and mould, providing a comprehensive understanding of the complex interplay between these phenomena.

2) The opportunity to develop machine learning models, including Random Forest (RF) and Artificial Neural Network (ANN), with guidance and support from the project team. This will allow the student to gain practical experience with cutting-edge tools and techniques used in climate change research.

3) Experience in analysing and visualising data using programming languages such as Python and R, under the guidance of the project team. These skills are highly valuable in a wide range of research fields and will provide the student with a competitive edge in future research endeavours.

4) The opportunity to meet and work alongside our current PhD students, providing valuable networking opportunities and exposure to diverse research perspectives.

5) The chance to write a report and potentially contribute to a publication, providing an opportunity for the student to gain experience in scientific writing and publishing.
In particular, the project team includes PhD student Nick Aifuwa-Morgan, whose experience and expertise will provide valuable guidance and support to the student throughout the project. The working experience with the current PhD student will also provide inspiration and motivation for the student to pursue further research opportunities, such as a SCENARIO PhD.

Student Profile

The ideal candidate for this project would have a background in meteorology, environmental science or engineering, geography, mathematics, computer science, or a related discipline. The successful candidate should possess the ability to work both independently and as part of a team, with a strong motivation to learn and contribute to the project. The candidate should possess good quantitative skills and have a good foundation in programming, specifically in R or Python. While knowledge of meteorology and machine learning would be an asset, it is not a requirement as training will be provided to the candidate, as necessary.

Remote Working – YES

3 Quantifying the value of observations in convection-permitting Numerical Weather Prediction.

Supervisor: Alison Fowler (Department of Meteorology, University of Reading)

Project Description

Every hour ~45000 observations are assimilated into the Met Office's UK convection-permitting forecast system (UKV). The output of the assimilation, known as the 'analysis,' is used to initialise the numerical weather prediction (NWP) forecast model. Achieving an accurate analysis is fundamental to the skill of modern-day weather forecasting. The assimilated observations include those from relatively straightforward sources, e.g., instruments onboard weather balloons, or can be far more complex, e.g., winds derived from satellite images of clouds. Given the diverse nature of the observations assimilated it is essential to understand their relative value in creating an accurate analysis. This information may then be used to inform advances to the observing network as well as improvements to the way the data are assimilated. This knowledge is all the more crucial in the UKV system, which is relatively immature compared to global NWP.
The aim of this project is to quantify and contrast the value of observations obtained from weather balloons and satellite-derived winds assimilated into the UKV. If the observations are not assimilated correctly then their influence may be much larger or smaller than it should be, potentially either degrading the forecast or underutilising the information available. Using statistical metrics based on the degrees of freedom for signal we will simultaneously assess this influence and determine if it is optimal. It is expected that this approach will highlight large differences between the two observation types, which will then be fed back to the Met Office to enable future improvements to the UKV.

Benefits To Students

The student will learn how to conduct research studies (under detailed supervision), including identifying research questions, performing mathematical analysis, designing, and performing numerical experiments (writing own code) and discussing the result. Joint supervision with the Met Office will allow the student to discuss the experimental design and results with practitioners working in different research areas, including observing systems, data assimilation and modelling. The student will also benefit from joining a large research group at the University of Reading, which is located within a thriving Meteorology department, giving the student the opportunity to interact with a wide range of researchers including current PhD students.

Student Profile

This project would suit a student working towards a quantitative degree with an interest in environmental forecasting. A good knowledge of linear algebra and statistics is desirable. To investigate this problem the student will modify pre-written code in python applied to archived output from the UKV. Prior knowledge of Python or similar coding environment would therefore be greatly beneficial.

Remote Working – YES

Ideally the project would be in person to get the greatest benefit but, if necessary, the majority of the work and supervision could be performed remotely.

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4 Investigating Saharan dust aerosol size using drone measurements.

<u>Supervisor: Claire Ryder (Department of Meteorology, University of Reading</u>

Project Description

During June 2022, instrumented uncrewed aerial vehicles (UAVs, commonly known as drones) were flown over the Cape Verde Islands, in the path of the Saharan dust plume. (https://blogs.esa.int/campaignearth/2022/08/03/delving-deep-into-dusty-skies-on-the-askos-aeolus-field-campaign/). The instruments took measurements of how dust particle size changed with altitude, up to 5 km in some flights. The purpose of the measurements was to investigate whether dust size near the top of a dust layer changes between night and day, due to the presence or absence of solar heating and resultant mixing within the dust layer. This theory has been proposed as a possible explanation for the 'mystery' of how large dust particles are transported over long distances, such as across the Atlantic. In this project, the student will analyse the size measurements from the UAVs to determine whether there are differences between day and night. Different altitude dust layers and different size ranges will be compared. Comparisons with other ground-based instruments which operated during the field campaign, such as lidars, and/or operational dust forecast models may also be carried out. The student may have the opportunity to discuss measurements and findings with collaborators involved in the field campaign from other institutions (e.g., Cyprus Institute, National Observatory of Athens). In addition, the student may have the opportunity to be involved in the launching of specially instrumented radiosonde balloons from the University of Reading, as part of a separate project which may take place during summer 2023 to examine electric charging of cloud and aerosol layers.

Benefits To Students

This project offers an excellent opportunity to explore cutting edge research observations. It offers a chance to analyse new in-situ dust measurements from lightweight aerosol size sensors mounted on UAVs, a growing field in atmospheric and environmental sciences. It offers the chance to address currently unanswered questions and contribute to new research. There is also a potential opportunity to obtain hands-on experience with launching radiosondes and observe lightweight charge and cloud sensors developed at the Meteorology department, offering valuable skills in fieldwork and instrument operation.

Student Profile

The student should have an interest in atmospheric science and how aerosols are important in weather and climate. The student will use code such as Python or IDL for data analysis. Support and existing code will be provided but the student should be open to developing these skills. Students should be willing to engage with fieldwork (occasional radiosonde launches).

Remote Working – NO

The student should be based in Reading to allow involvement in the fieldwork. However, the occasional pre-arranged remote working day should be possible.

5 Fine-scale mapping of hedgerow canopy backscatter using a ground radar system.

Supervisor: Veronica Escobar Ruiz (Department of Meteorology, University of Reading)

Project Description

Satellite remote sensing is essential for earth observation, and radar systems are perhaps the most used technology, since (unlike optical sensors) they can “see” through clouds. However, radar remote sensing data has a limited spatial resolution of 20 m by 20 m, and in addition these data do not provide information on the vertical backscattering for biomass characterisation. An appropriate biomass profile characterisation is essential for better modelling. Hedgerows are natural structures in the UK landscape that can greatly influence different processes of the hydrological cycle (e.g., precipitation interception, infiltration, and soil moisture). Hence, fine-resolution canopy backscatter knowledge of these features can help to better understand the role of these structures in the hydrological process (hydrology connectivity).

Aim: High-resolution mapping of hedgerows using ground radar system methods: The student will:-

a) calibrate the Radar-Rig in lab and in-field,
b) scan hedgerows inside UoR campus,
c) collect soil moisture, GPS data in addition to vegetation characteristics along the track (e.g. high and other species in the hedgerow section)
d) reconstruct backscatter signal using the Tomographic profiling technique,

e) analyse relations between soil moisture and backscatter signal for each species (if found), and obtain 3D map of canopy backscatter of the hedgerows in the corresponding GPS location.

Benefits To Students

The student will benefit from:

a) exposure to earth observation using radar systems,
b) analysing and visualising data using various programming languages such as Python and Matlab,
c) meeting with PhD students and experience of scientific writing.

Student Profile

The student must be interested in the areas of remote sensing and earth observation. They should have basic programming skills and a good understanding of electromagnetism. Experience with instruments is not essential, but students with such interests are encouraged to apply.

Remote Working – NO

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6 EXPLORING CONSTRAINTS ON FUTURE MEDITERRANEAN RAINFALL.

Supervisor: Christopher O'Reilly (Department of Meteorology, University of Reading)

Project Description

The Mediterranean region is very sensitive to rainfall changes; however, climate model projections of future Mediterranean rainfall are very uncertain. Some of our recent work has shown that current methods for constraining future regional projections using observations struggle to provide useful information over the Mediterranean region. In this project we will examine the large-scale factors affecting changes in precipitation over the Mediterranean, such as changes in the large-scale atmospheric circulation and storm tracks, using climate model data and we will examine signatures of these future changes in the current climate period to try to develop potential signatures of future changes in Mediterranean. These constraints may be global features or features local to the Euro-Atlantic sector. We will also compare this behaviour to available observational data to assess how realistic the mechanisms underlying these constraints might be.

Benefits To Students

Learn about how to manipulate and analyse datasets and introduce them to some climate dynamics.

Student Profile

Any students with a background in mathematical/physical sciences. Some experience of scientific computing would be helpful.

Remote Working – YES
