

## INTERNSHIP 2: TOWARDS A UNIFIED APPROACH TO ENVIRONMENTAL MODELLING

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**Internship Location:** UKCEH Edinburgh, Bush Estate, Penicuik, Midlothian, EH26 0QB

### **Project Description:**

Models are an essential tool for understanding and predicting environmental change. There are usually several different approaches to modelling the same physical processes, each with their own strengths and weaknesses. For example, while essentially everyone agrees on the fundamental equations that describe atmospheric dynamics, there are many weather forecasting models that make different technical choices and produce different predictions.

Although diversity and competition among models is good for science in principle, the reality is that issues of a more practical nature prevent us from fully benefiting from this multiplicity of models. The problem is that different models are generally hard to *compare* (due to e.g. different inputs and outputs, spatio-temporal scales), hard to *combine* (e.g. due to differences in design, the choice of programming language and use of software libraries), and hard to *learn* (even for experienced researchers!).

This situation has led to increasing interest in more structured frameworks for model development that make models more comparable and interoperable by design. A good example of this is the so-called *Basic Model Interface* (BMI). In simple terms, the BMI enables models with different internal mechanisms to be operated through the same set of Python commands, allowing models to interface with analysis scripts and other models in a consistent way.

Several research-grade models have already been reformulated to adopt the BMI, but its potential as an educational scaffold has been under-explored. We (the supervisors) have proposed to lead the development of a collection of pedagogical numerical models that are operated through the BMI, accompanied by instructional resources such as notebooks and interactive dashboards.

The purpose of this internship is to contribute to this effort, primarily by developing models that adhere to the BMI, and by creating tutorial notebooks that use these models to demonstrate good scientific and software practices. The code and tutorials will be open-sourced and freely licensed for use or adaptation.

This internship would suit a student who is interested in the internal mechanics of numerical models (i.e. the equations and code) and the unifying principles of modelling. The student will be expected to take ownership of their development work, solve technical problems, discuss ideas and findings with the supervisors, and disseminate their outputs using appropriate channels.

### **Tasks:**

The first 2-3 weeks will be dedicated to a warm-up task. The student will implement the Basic Model Interface for a simple model written in Python and create instructional material in the form of executable notebooks (e.g. Jupyter, Rmarkdown, Pluto.jl or Quarto). In doing so they will gain familiarity with the BMI framework and core tools of modern scientific software.

At the half-way point the student will be in a good position to decide on the direction they would like to take in the second half of their internship. A student looking to improve their software development skills might choose to develop their own BMI-compliant model, chosen to match their scientific or other technical interests. A student interested in education and community building would be encouraged to develop additional learning resources such as interactive dashboards using BMI models. A third, more research-oriented option would be to investigate the possibility of implementing the BMI for one of the flagship scientific models developed by UKCEH scientists.

### Expected Outcomes:

1. At **least** one fully developed and documented model implementing the BMI, accompanied by a collection of tutorial notebooks, published online (e.g. using GitHub) and freely available for anyone to use and extend.
2. The student will be expected to join and engage with the [CSDMS community discussion forum](#), a resource which they will be able to draw on during and after the internship.
3. The student's contributions will be credited on GitHub, the CSDMS Community Model Repository, and any other forums where the model appears, allowing them to highlight their achievements on their CV.
4. The student should produce a technical report of their work, and a short blog post reflecting on their experiences during the internship.

### Required Skills and Background:

#### Essential:

- Currently in undergraduate or postgraduate (including PhD) education at university or have graduated within the six months prior to the start of the internship (30th June 2025)
- Intermediate level programming skills, including some experience with Python
- Some familiarity with the principles of modelling and the underlying mathematics; preferably the student has taken a course in numerical methods or computer modelling. However, the student need not have experience with environmental models specifically.
- An enthusiasm for learning and, importantly, sharing knowledge with others, e.g. through teaching, participation in learning communities, or contributing to open-source software. (Note *enthusiasm* does not require previous experience).

#### Desirable:

- Experience with git and GitHub, either via the command line, through editor integrations or GitHub desktop.
- Some experience with Linux and knowledge of basic shell commands (to change directory, copy files etc).
- Experience with any of R, Julia, C, C++ or FORTRAN. Familiarity with a compiled language would be helpful for a conceptual understanding of research models.