Evaluation of Land Biosphere Processes in the new UK Climate Model

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This project will evaluate the performance of the new UK climate model (UKESM) with a specific focus on the terrestrial biosphere and using satellite data from NASA and the European Space Agency. It will make an important contribution to the development of the model by providing confidence in its predictions. The project represents an exciting opportunity for a talented individual to become part of the climate modelling community and to contribute to the science of the IPCC reports.

Rigorous evaluation of climate models against observations is vital to provide confidence in future predictions of climate change. The new UK Earth System Model (UKESM) will be the UK’s contribution to CMIP6, the next phase of the Coupled Model Intercomparison Project which contributes to the Assessment Reports of the Intergovernmental Panel on Climate Change (the IPCC). A key innovation in the UKESM, and many of the other of the climate models contributing to CMIP6, is the inclusion of biogeochemical cycles. With this addition the role of the terrestrial biosphere has become increasingly important for making well founded climate predictions. Consequently evaluating the biosphere processes in UKESM is a required part of the development of the model.

One of the most important and yet least well understood model components needed to represent biogeochemical cycles in Earth System Models is the growth of plants and their interaction with the physical climate system. Currently the terrestrial biosphere is responsible for sequestering around 25% of anthropogenic fossil fuel emissions. This proportion has remained roughly constant over recent decades, despite the increasing concentration of carbon dioxide in the atmosphere. In other words the total amount of carbon dioxide sequestered by the land surface is increasing – and it is keeping pace with the rate of increase in the atmosphere. Whether this mitigating effect will continue into the future as the climate changes is unknown and the focus of much debate; if the strength of the biospheric sink decreases, as many models predict, climate change will be accelerated.

The biosphere plays another very important role: the majority of our food is grown there. To understand the impacts of climate change on humans it is necessary to understand its impact on food production. The UKESM has recently had crop models added which allow the prediction of yields for a number of key global crops (rice, wheat, maize and so on). However this new component of the model has undergone very little testing on large scales.

Earth Observation data from satellites is one of the most important sources of information for testing Earth System Models because they are available globally on spatial scales that are appropriate to ESMs. There are now records of up to forty years length for some key variables and such long time series allow us to start to untangle the climate signal from natural variability. The relationship between a satellite derived variables and their counterparts predicted by an ESM can be complex however and understanding why a model differs from observations typically requires detailed investigation.

This project will use a range of long time series variables, such as albedo and land surface temperature as well as newer data sets such as solar induced fluorescence (a direct proxy for photosynthesis, see Fig. 1). A key
component of the research will involve designing novel diagnostics to test the interaction between the physical climate and vegetation productivity. The goal will be to diagnose the specific processes that are in error in the model (rather than simply to state that there exists a difference). Both natural and agricultural components of the biosphere will be investigated to address the questions of (a) how well the feedbacks between the biosphere and the physical climate are represented and (b) whether the model correctly represents the impact on human society in terms of food production. A final stage will examine whether it is possible to apply empirical corrections (known as bias correction) to the model outputs to improve its predictions.

![Image: Solar induced fluorescence, as measured by NASA’s Orbiting Carbon Observatory.](image)

**Figure 1.** Solar induced fluorescence, as measured by NASA’s Orbiting Carbon Observatory.

**Training opportunities:**
The studentship is attached to two NERC centres: The National Centre for Earth Observation (NCEO) and the Centre for Ecology and Hydrology (CEH). The student will spend approximately 3 months per year at CEH in Wallingford where are large component of the UKESM land-surface team are based and will receive bespoke training on relevant parts of the model. Training in the use of Earth Observation data will be provided by the lead supervisor. There will also be the possibility to attend relevant summer schools.

**Student profile:**
This project would be suitable for students with a degree in physics or a closely related environmental or physical science. Some existing experience of computer programming is essential. We will also consider applicants with a background in computer science if they are able to demonstrate sufficient knowledge of remote sensing and/or the climate system.

**Funding particulars:**
The studentship has CASE sponsorship from the NERC Centre for Ecology and Hydrology (CEH).

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