Scenario DOCTORAL TRAINING PARTNERSHIP

NERC SCIENCE OF THE ENVIRONMENT

Turbulence and Clouds

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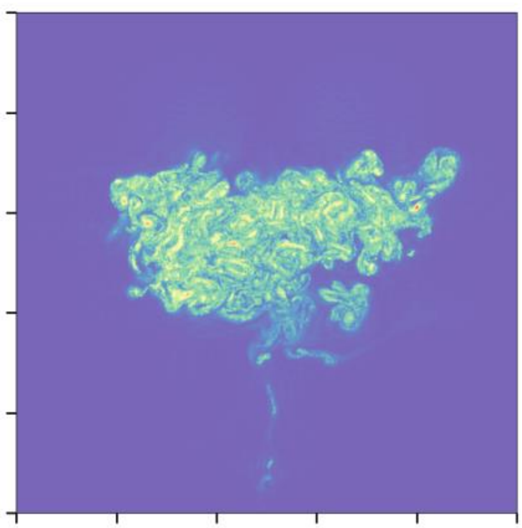
The representations of clouds and associated buoyant atmospheric convection are arguably the weakest aspects of weather and climate models, leading to poor forecasts and unreliable projections of the regional impacts of climate change. At the resolutions used for climate and global weather prediction, much convection and turbulence are sub-grid-scale, meaning that their behaviour must be estimated from larger scale features (or parameterised). This proposal aims to improve these parameterisations. The interaction between turbulence and convection is currently either missing or poorly represented in weather and climate prediction models.



Simulation of a turbulent cloud from Dritchel et al, Quart. J. Royal Meteor. Soc, 2018

Cumulus Congestus

Boundary layer turbulence (near the ground) is estimated using simple relationships with the resolved flow and no account is taken of growth and decay of turbulence – it is assumed to be in equilibrium. Clouds and convection are often initiated in the boundary layer but the turbulence of the boundary layer is not used in models to estimate when convection will occur or how it will grow. Convection generates more turbulence and transports it upwards which influences the growth of further convection. These processes are not represented in atmosphere models.

In this project, we plan to use established mathematical methods for predicting turbulent statistics that haven't before been used for atmospheric modelling. These will need to be optimised for conditions with temperature and density gradients as occur in the atmosphere. We will simulate the atmospheric boundary layer and a detailed, high resolution simulation of a cloud and we will compare with simulations in which the turbulence is (nearly) resolved. These techniques will then be combined with new methods of representing sub-grid-scale clouds and convection in order to lead to dramatic improvements in simulation at resolutions where turbulence, clouds and convection are not resolved.

Model development will be done using the OpenFOAM C++ library for solving partial differential equations. This will enable rapid progress without the student needing to implement spatial and temporal discretisation. This will enable the student to focus on the atmospheric dynamics and finding the most suitable equations to represent the turbulence and convection. The lead supervisor is expert in simulating atmospheric dynamics using OpenFOAM and ample support will be given.

Training opportunities:
The student will be able to take graduate courses in meteorology at Reading, including atmospheric dynamics and physics. An external training course on using OpenFOAM will also be available.
The student will benefit from a three month placement at the Met Office, working with the Met Office supervisors.

Student profile:
This project would be suitable for students with a degree in physics, mathematics or a closely related environmental or physical science. Good programming skills and a desire to write excellent code will be required, using object-oriented techniques and version control to create reproducible science. Knowledge of fluid dynamics and modelling are essential.

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