Simulation in the terra incognita

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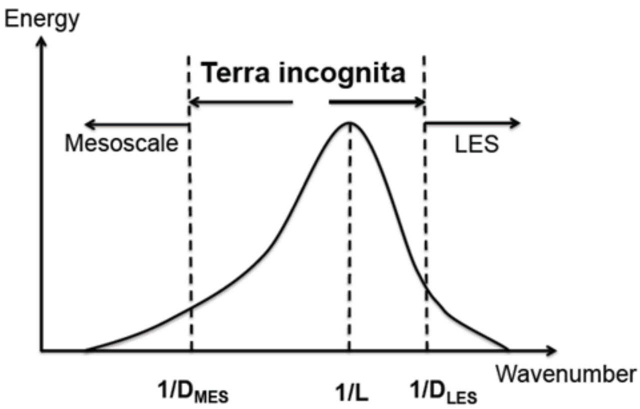
The atmospheric boundary layer is the region of the atmosphere next to the surface which is characterised by the continuous presence of turbulence. It mediates between the earth's surface and the rest of the atmosphere and so is strongly coupled to many important pheonmena such as large-scale weather systems and convective storms. Simulating the boundary layer thus plays a key role in many high-impact aspects of weather forecasting and climate such as: surface temperature, the dispersion of pollutants and chemical species, low level cloud and fog, and the onset of thunderstorms.

The figure shows the form of the spectrum of turbulent energy. The peak energy occurs at a lengthscale L which gives an idea of a typical size of a turbulent eddy. In the atmosphere, this varies over the course of the day but is typically between a few tens of metres up to a kilometre. Now, suppose for the moment that the resolution of our simulations for the atmosphere was really very good. In other words, suppose the smallest lengthscale D that we simulate is much smaller than L. In that case we are simulating all the turbulence explicitly in our model. All is well, except that such a model is simply nowhere near being practical for weather forecasting. At the other extreme, suppose that D is very large compared to L. Then we would have to find some way of representing the effects of all of the atmospheric turbulence on the large-scale part of the flow that we do actually simulate. Actually, there are well-established ways of doing just that and that's how a weather forecast or climate model works.



Schematic of the energy spectrum as a function of wavenumber.

The smaller the value of D in our weather forecast, the more accurate the forecast, so we like to use the smallest possible D that the computer can handle. At the moment, the available computer resources are getting to the stage where $D \approx L$. So how should we be modelling things then? Quite honestly, we don't know what to do any more, and that's why it's called the terra incognita.

This project aims to find out, and to develop some new techniques that are going to be in greater and greater demand. What we do expect is that these new modelling techniques will have to be 3D not 1D and stochastic not deterministic. You can expect to be doing a lot of state-of-the-art numerical modelling across a range of D and to be building theoretical frameworks to support a careful analysis of the results. Better modelling in the terra-incognita will lead to improved high resolution forecasts at the Met Office.

Student profile:
Suitable for candidates with a degree in mathematics, physics or a closely related physical or environmental science. Those with specific interests in numerical modelling and turbulence are strongly encouraged to enquire further.

Funding particulars:
A funding decision for this project is not expected before June 2012. If funded, it will be part of a wider collobaration on the terra incognita with Exeter University and the UK Met Office.