Raising the roof

Supervisors

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Project description

An exciting extension of modern meteorological forecasting is the development of a coupled Sun to Earth modeling system for improved forecast capability. An important part of this system is an accurate representation of the coupling between the thermospheric and ionosphere and the lower levels of the atmosphere (the troposphere, stratosphere and mesosphere). This will lead to improved forecasts of the thermosphere and ionosphere, which will benefit satellite operators, and users of High Frequency radio communications and Global Navigation Satellite System (GNSS)-based positioning, timing and navigation,as well as improving the safety of passengers of high altitude jet aircraft.

In the project we aim for the student to work in a collaboration between Bath, Exeter and the Met Office to develop, test, analyse and apply **ExUM**; a stable version of the Unified Model (UM), the main model used by the Met Office for weather forecasting. The student will develop a model which has an upper boundary at around 120 km. By doing this they will '**raise the roof**' of the current weather forecast and allow us to study the interaction between earth and space weather both theoretically and through experiments linked to Radar and satellite observations of the upper atmosphere. The student will work in the rich interdisciplinary interface between mathematical modelling, scientific computing, atmospheric modelling and experiment, and the results of their work will be of direct relevance to policy makers.

Phase one:

The student will develop a stable numerical model of the upper atmosphere which can also represent high-frequency and other waves in the atmosphere. This is highly novel as current simulations with the 120 km upper boundary are not yet stable. Studying this will involve a strong interaction between mathematics, numerical analysis, computation and atmospheric modelling. The project will experiment with the inclusion of more realistic physical processes (and, if necessary, adjust the numerical schemes used) in order to make ExUM stable and accurate. The calculations required for the ExUM involve integration over long time periods. This imposes an important stability constraint on the methods used to do these computations. The UM is now using semi-Lagrangian, semi-implicit (SISL) code as its dynamical core. We will analyse and extend the SISL methods and will investigate the effects on model stability and accuracy of the methods of including vertical damping and the use of a sponge layer at the upper boundary to damp vertical velocities. Further, we will investigate the effects of tuning the off-centering parameter for the SISL step and, more generally, the use of several different forms of interpolation in this step, investigating both dissipative and ENO (essentially non-oscillatory) forms of interpolation as means of improving stability.

Phase Two:

Having developed ExUM it will be used to explore a number of important meteorological phenomena in the upper atmosphere which are beyond the reach of current forecasts. In particular we will study the mean zonal temperatures and also the nature and behaviour of gravity waves and tidal waves. Both of these types of wave are known to have an important effect on both weather and climate, and understanding them will give insights into both.

Phase Three:

At a high altitude meteor Radar observations obtained by Prof Mitchell combined with satellite observations, provide a potentially rich source of information on mean winds, tides and gravity wave momentum fluxes. The student will use these observations to validate the ExUM results. This will be novel and important work as by running the ExUM with a lid at 120 km, the comparison between predicted value of these physical predictions and radar fields will be easier much to interpret than the current UM, as adverse effects related to the model upper boundary will be reduced.