Formulating and applying high resolution AGCMs for climate prediction

Richard Jones, James Murphy, David Hassell and Keith Williams
Met Office, Hadley Centre for Climate Prediction and Research, U.K.

Most assessments of regional climate change have been obtained directly from simulations using coupled atmosphere-ocean general circulation model (AOGCM). Their horizontal resolution is typically ~300km which is acceptable for the simulation of climate over the global domain. However, regionally errors can be large, often in excess of predicted climate changes which are therefore unlikely to be regarded as reliable. This points to a requirement for AOGCMs with higher resolution and improved representations of physical processes. However, as a comprehensive set of AOGCM experiments to characterise 21st century climate change involves many months to years of computer time, even a doubling of resolution will not be practical for several years. One alternative is to use the AOGCM to characterise the oceanic response for a set of important time-periods and atmospheric emissions scenarios and then use this to drive an improved higher resolution AGCM.

This talks then explores two important issues relating to the use of high resolution AGCMs to predict climate change. The first is the importance of formulating the AGCM to give improved performance in comparison with lower resolution AOGCMs. The second is an examination of the consistency between the response to climate change of a high resolution AGCM with its driving coupled AOGCM.

The process of providing an AGCM with improved performance is demonstrated by examining the formulation of HadAM3H, an AGCM with a resolution of ~150km based on the current Hadley Centre AOGCM, HadCM3. This shows that many aspects of the model configuration, from its representation of clouds to the accuracy of sea-surface temperatures at the lower boundary, had to be changed leading to a model which better represents the atmospheric general circulation and the surface climatology over land.

The use of this model in predicting climate changes is then demonstrated with predictions for 2070-2100 resulting from the A2 and B2 emissions of the IPCC Special Report on Emissions Scenario (SRES) A2. These are compared with the corresponding HadCM3 predictions from which the sea-surface forcing was derived. To investigate whether the use of HadAM3H as the atmospheric component of the AOGCM would give consistent results at the global scale, it has been coupled to a simple mixed layer (or slab) ocean model. Comparisons of climate predictions with this model and a slab-ocean model version of HadCM3 indicate that the atmospheric response of HadAM3H is consistent with its driving sea-surface boundary forcing.