

**UK-Japan Collaboration between the Hadley Centre, the NCAS Centre for Global Atmospheric Modelling and the Earth Simulator Centre**

Following the visit of Lord Sainsbury to Japan in April 2001, the Hadley Centre and NCAS/CGAM have established collaborations with scientists in Japan, which have provided access to the Earth Simulator. Through a joint project with the Centre for Climate Science Research (CCSR) at the University of Tokyo and through a wider Agreement with the Director of the Earth Simulator Centre, an ambitious programme of model integrations and climate research is planned. The formal Agreement with the Earth Simulator Centre, JAMSTEC, will provide access to the Earth Simulator for the next 5 years and will constitute a major collaboration between the UK and Japan.

The research proposed under the Agreement involves the development and use of a high-resolution, coupled climate-chemistry-ecosystem model based on the new Hadley Centre's global environment model, HadGEM1. The current, state-of-the-art coupled climate models have a typical resolution of  $\sim 3^\circ$  (N48) in the atmosphere and  $\sim 1^\circ$  in the ocean, but there is a strong case for high resolution in all components of the coupled system. The intention in this project is to develop a high resolution coupled model with a resolution of less than  $1^\circ$  in the atmosphere and  $1/3^\circ$  in the ocean. This will build on complementary work within the NERC UK-HiGEM Consortium on high resolution Global Environment Modelling being led by CGAM in collaboration with the Hadley Centre.

General Circulation Models (GCMs) still tend to concentrate on the physical aspects of the climate system (e.g. radiation balance, clouds, convection, atmospheric and ocean heat transports), and they most often treat the chemical and biological components of the Earth System as either fixed (e.g. vegetation) or time-varying boundary conditions (e.g. the concentrations of greenhouse gases). However, it is known that ecosystems and atmospheric chemistry are intricately coupled to the physical climate system, because they are sensitive to climate and because they control the concentrations of greenhouse gases and aerosols (which themselves affect climate). For this reason the extension of physical GCMs to include biological and chemical components is seen as a major frontier in climate modelling.

Under the UK-Japan Collaboration, we intend to produce a unique Earth System Simulation of the 21<sup>st</sup> century, initially utilising the GCM and sub-models already available at the Hadley Centre, but implemented at higher resolution and including fully coupled climate-ecosystem-chemistry processes. The full simulation will be the most complete model representation of the Earth System ever achieved, and will allow us to answer key scientific and policy questions, such as:

- How will the climate change in the 21st century and how will ecosystem-chemistry interactions affect this change?
- What are the critical feedbacks in the Earth System?
- What will be the wider changes in the life-support systems of the Earth (e.g. stratospheric ozone and UV, tropospheric ozone and human health, water availability)?
- Where are the dangerous thresholds in the Earth system?

The union of the Hadley Centre, NERC and Japanese capabilities in Earth System Modelling, combined with the Earth Simulator facility, should allow these questions to be addressed more thoroughly than ever before, and the combination of increased resolution with a far more complete representation of important climate processes can truly be said to bring about a 'next generation' climate model. It hardly needs to be stressed that this is an exceptional opportunity to work with the Earth Simulator that will allow us to advance our scientific and technical capabilities in comprehensive, coupled climate modelling and prediction at a critical point in their development.

The proposed project is very ambitious and will stretch both the technical and scientific limits of UK expertise in coupled climate modelling. The collaboration will need to be carefully managed to ensure that the model development is in line with the Hadley Centre's programme and NERC's plans, including the UK-HiGEM project. Furthermore, the effective use of the computing time available at the Earth Simulator will require careful planning of model integrations and diagnostics to ensure their maximum utility to the research programmes of the Hadley Centre and NERC. For these reasons, Senior Scientists at both the Hadley Centre and NCAS/CGAM will be appointed. They will represent the specific interests of the relevant programmes and, in the case of NCAS/CGAM, provide linkages with the wider NERC community. The Senior Scientists will be responsible for the running of the collaboration and will report to the Directors of the Hadley Centre and CGAM on a regular basis. They will be based at the Hadley Centre and CGAM, where they will work closely with core staff, but will also spend significant periods of time at the Earth Simulator Centre liaising with their Japanese counterparts. It is expected that the Senior Scientists will have significant opportunities to exploit the Earth Simulator integrations for their personal research.

In addition to the Senior Scientists, a core team of 4 scientists will be placed at the Earth Simulator Centre. These Project Scientists will be responsible for porting and optimising the model code in collaboration with computer specialists at the Earth Simulator Centre and under the direction of the UK/Japan Senior Scientists. Updates to the model will need to be carefully monitored and documented, ensuring that they comply with the coding standards set by the Hadley Centre and the Earth Simulator Centre. The Project Scientists will also be responsible for setting up and running model integrations, and for archiving the model output with the assistance of the British Atmospheric Data Centre (BADC) who are also funded under this collaboration. A significant programme of visits by Hadley Centre and NERC staff, to work on specific projects, is also supported by the UK-Japan Project. The Project Scientists will be expected to work with these staff and assist them in the use of the Earth Simulator.

The Project Scientists will also undertake their own research within the remit of the collaboration, working closely with scientists at the Earth Simulator Centre, the Frontiers Research Programme on Global Change (FRSGC) and the University of Tokyo. Since one of the aims of the UK-Japan programme is to work together on areas of climate research that are of mutual interest, staff located at the Earth Simulator Centre will be key players in fostering the active collaboration between UK and Japanese researchers. The establishment of the UK-Japan collaboration has benefited enormously from the involvement of the Science Attache at the British Embassy in Tokyo, and funds to support exchange visits have also been allocated by the Foreign and Commonwealth Office. UK scientists working at the Earth Simulator Centre are assured of the continuing support of the staff at the British Embassy.