

# NERC and Met Office Strategy for Earth System Modelling

## 1. Introduction

- 1.1. Society requires better predictions of the future state of the environment if it is to be able to develop effective mitigation and adaptation strategies. Earth system modelling (ESM) is an essential tool for providing these predictions and is critical to the delivery of the strategic objectives of both NERC and the Met Office.
- 1.2. The Met Office science strategy is entitled ‘Unified science and modelling for unified prediction’ and identifies four science imperatives:
  - forecasting hazardous weather from hours to decades;
  - water cycle and quantitative precipitation forecasting;
  - monthly to decadal prediction in a changing climate;
  - sensitivity of the Earth system to human activities.
- 1.3. NERC's strategic goal is:  
To deliver world-leading environmental research at the frontiers of knowledge:
  - enabling society to respond urgently to global climate change and the increasing pressures on natural resources;
  - contributing to UK leadership in predicting the regional and local impacts of environmental change from days to decades; and
  - creating and supporting vibrant, integrated research communities.
- 1.4. The complexity of ES models is increasing rapidly, and there are major drivers toward greater internationalisation of ESM activities. If we are to maintain UK leadership in this field it is essential that the UK ESM community works together in a coordinated way that more effectively exploits the strengths of the Met Office and the NERC community.
- 1.5. The 2010 review by the Government Office for Science of the Met Office Hadley Centre states:  
*The Hadley Centre cannot operate in isolation. It has a critical and co-dependent relationship with the UK climate science community, which is similarly world class. Neither could function as they do if the other did not exist. Whilst respective roles differ, there is significant advantage and opportunity to work increasingly closely to maximise the overall value of investments, improve outputs and generate efficiencies. **It will be important for the Met Office and the Research Councils to take forward discussions on how best to pursue opportunities for collaboration.***

### **Objective of this document**

- 1.6. The objective of this document is to define a joint National Strategy for Earth system modelling that will provide a framework for identifying and selecting the ESM activities that NERC and the Met Office will collaborate on.
- 1.7. The scope of this proposed strategy covers Earth system models of the physical climate system and biological and chemical feedbacks on to the climate. This strategy therefore does not include other important areas such as climate impacts, provision of operational weather forecasts, socio-economic modelling, Earth core/plate tectonics and the mesosphere.

## **2. Key principles**

- 2.1. In the context of evolving needs and changing technologies, NERC and the Met Office recognise the need to work together in two specific areas:
  - a) Scoping and development of a 10 year vision for UK capabilities in ESM, in an international context.
  - b) Significantly enhanced collaboration to continue the development and exploitation over the next 3-5 years of the UK's world leading brand of Earth system model.
- 2.2. Earth system modelling requires stably supported development and evaluation teams for both the component sub-models and the full ESM configurations. This support is critical if the ESMs are to be effective and widely used tools for the environmental science community.
- 2.3. There is a well-established shared commitment to the Unified Model, which is central to both operational weather forecasting and climate research. This will also remain a strategic tool for research at a wide range of temporal and spatial scales for many years. The principles are further strengthened by the increasingly blurred distinction between weather and climate scales.
- 2.4. For the most effective development of the ESM capability effort should be coordinated around specific sub-components as well as the integration of these sub-components together. The current sub-components of the UK Earth system model are detailed in Annex A.
- 2.5. Earth system modelling is a dynamic developing discipline. It is not the intention of NERC to prescribe a limited list of models that it will support; NERC will fund research using any model where there is a clear scientific justification for its use. However where the aim is to enhance the broader UK capability in Earth system modelling this joint strategy aims to provide a focus and clear direction for the development of this capability.
- 2.6. Development is needed of a software infrastructure that facilitates rapid progress by new users and assists innovation from national and international partners.
- 2.7. Earth system modelling requires access to High Performance Computing infrastructure to remain internationally competitive. The models themselves need to be developed so that they can fully exploit emerging supercomputer technologies.

## **3. Governance**

- 3.1. The UK Earth system model will be developed under the joint governance of the Met Office and NERC through the Joint Weather and Climate Research Programme (JWCRP see <http://www.jwcrp.org.uk/>).
- 3.2. The Strategic Programme Board of JWCRP will need to define the governance arrangements for the development of the UK's capability in Earth system modelling.
- 3.3. Some of the ESM sub- components have their own governance arrangements (see Annex A). Such arrangements should be continued, with appropriate links to the JWCRP.

- 3.4. Major new programmes of work will be developed and agreed through the existing processes within the two organisations.

#### **4. International engagement**

- 4.1. In the context of both 2.1 a) and 2.1b), NERC and the Met Office will engage with international partners in the development of future Earth system models.
- 4.2. The atmospheric dynamics and physics of the Unified Model will continue to be developed by the Met Office in collaboration both with NERC and international users of the Unified Model.
- 4.3. In the context of 2.1 b), in identifying the strategic sub-components of the UK Earth system model NERC and the Met Office will adopt the sub-component that is seen to deliver the best science for the UK community. For example the NEMO ocean model was originally developed outside the UK and is now managed by a consortium which includes the Met Office and the NERC. In other cases sub-component models developed in the UK will be used internationally. For example the GLIMMER ice sheet model was originally developed in the UK has been adopted by international partners who are contributing to the maintenance and development of the model.
- 4.4. In the context of 2.1a) NERC and the Met Office will work together to position the UK to take a leading and coordinated role in international initiatives related to Earth system modelling.

#### **5. Agreed shared objectives of the National Strategy**

- 5.1. NERC and the Met Office will establish a joint working group to address 2.1a)
- 5.2. To address 2.1b) NERC and the Met Office will work together through JWCRP, and using both Met Office and NERC resources, to:
- improve the usability, flexibility and portability of the Unified Model system for research in weather and climate.
  - develop, evaluate and exploit the next UK Global Environmental Model (“UK-GEM”), based on the HadGEM3 model.
- 5.3. NERC will contribute to sub-component model development in its Centres through long term National Capability funding. NERC is developing a strategic approach to the ESM activity that it supports through its integrated National Capability Strategy.
- 5.4. NERC and the Met Office will adopt a common approach to model evaluation using shared tools and observational databases.
- 5.5. NERC and the Met Office will continue to invest in the shared computer platform MONSooN which is seen as a key tool to facilitate closer collaboration.

## Annex A - Development of component sub-models

To maintain and develop the UK's world leading Earth System Model there is a need to foster innovation and improvements to the ESM, and also provide a focus on those elements that contribute to the UK's ESM. It is not the intention that this strategy prescribes a limited list of models that it will support; NERC will fund research using any model where there is a clear scientific justification for its use.

This Annex defines those components of the Earth System Model that NERC will support through National Capability funding and also in Research Programmes which have a specific aim of improving the UK capability in Earth System Modelling through the development of the component sub-models. The component sub-models will change over time as new and better models are developed. Recommendations to change the strategic component will be made through the Joint Weather and Climate Research Programme (JWCRP).

The following section defines the component sub-models of the Earth System Model that it is recommended should be supported through National Capability and the priorities for future development.

	<b>ESM element</b>	<b>Strategic component sub-model</b>	<b>UK lead and governance</b>	<b>Priorities for future development</b>
<b>1.</b>	<b>Atmospheric dynamics</b>	The Unified Model	The Met Office in collaboration with the NERC community and a range of international partners.	The development of a new dynamical core to improve both the performance and resolution of the model in order to exploit emerging supercomputer technologies.
<b>2.</b>	<b>Atmospheric physics</b>	The Unified Model	The Met Office in collaboration with the NERC community and a range of international partners.	The atmospheric physics element of the Unified Model should continue to be developed and enhanced in order to ensure that full advantage is taken of the potential for increased resolution, including the resolution of processes not previously modelled.
<b>3.</b>	<b>Atmospheric composition</b>	The UK Chemistry and Aerosol (UKCA) model	Community model developed and maintained by a consortium of the Met Office and the Universities of Cambridge,	The development of well-founded surface exchange schemes for both the land and ocean interfaces. Whole-atmosphere chemistry. Consolidation of current effort on off line chemical

	<b>ESM element</b>	<b>Strategic component sub-model</b>	<b>UK lead and governance</b>	<b>Priorities for future development</b>
			Leeds, Oxford and Reading. Supported by NCAS Computational modelling support.	transport models (CTMs) to produce a single UK CTM that would be traceable to UKCA.
<b>4.</b>	<b>Land surface</b>	Joint UK Land Environment Simulator (JULES)	Community model owned collectively by 9 UK institutions (Met Office, CEH, Universities of Aberdeen, Exeter, Edinburgh, Reading, Leeds and Sheffield, Rothamsted Research). JULES management committee meets twice a year and decides on operational and science issues. JULES science steering committee advises on science issues.	The interface of JULES to the other components of the Earth Include/develop further components for permafrost, groundwater, macronutrients, vegetation dynamics and climate impacts. New global and regional datasets are needed to develop and benchmark JULES. Link to other components (notably atmospheric chemistry and land ice) needs to be developed. A 10-yr strategy is currently being developed.
<b>5.</b>	<b>Ocean dynamics and physics</b>	NEMO (Nucleus for European Modelling of the Ocean)	The NEMO model is governed through a consortium agreement with partners CNRS, MERCATOR, the Met Office and NERC.	A 10 year roadmap of requirements for ocean modelling is currently under development by NOC. There is a longer term requirement to develop a model that can be applied seamlessly to open ocean and coastal seas.
<b>6.</b>	<b>Ocean biogeochemistry</b>	There is currently no common model within the UK ESM for ocean biogeochemistry.		The UK ocean biogeochemistry community needs to develop a common model for ESM activity building on the strengths of the existing UK models.
<b>7.</b>	<b>Sea floor</b>	There is no specific sea floor component within the UK ESM.	Work in this area would need to be prioritised against the development of other components.	There is a potential requirement to develop seabed process models of carbon burial, nutrient cycling in shelf seas, methane hydrates and other climatically active gases.
<b>8.</b>	<b>Sea ice</b>	CICE	CICE is developed by Los Alamos National Laboratory and is freely available.	The horizontal grid for CICE should be developed to assist with its coupling to major ocean models, specifically NEMO.
<b>9.</b>	<b>Ice sheets</b>	GLIMMER CISM	Community model under active	Future developments should build on the existing collaborations

	<b>ESM element</b>	<b>Strategic component sub-model</b>	<b>UK lead and governance</b>	<b>Priorities for future development</b>
			development in the UK (Universities of Bristol, Edinburgh and Swansea) and US (Montana State University and Los Alamos National Laboratory). Development overseen by international steering committee.	with BAS and international partners to enhance the model.