The European Network for Earth System Modelling

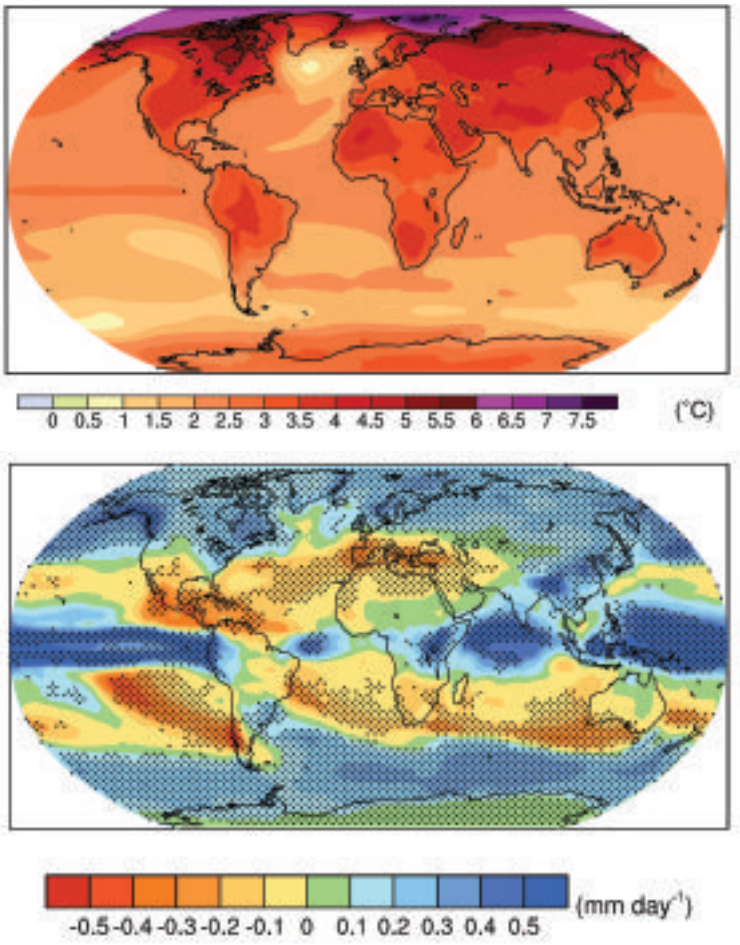
Predicting climate change…

Global climate models are at the basis of climate change science and of the provision of information to decision-makers and a large range of users. Within Europe, the European Network for Earth System Modelling (ENES, www.enes.org) gathers together the European climate/Earth system modelling community, which is working on understanding and prediction of future climate change. This community is strongly involved in the assessments of the Intergovernmental Panel on Climate Change and provides the predictions on which EU mitigation and adaptation policies are elaborated. Several EU projects, such as the FP6 large Integrated Project ENSEMBLES (http://ensembles-eu.metoffice.com) that provides climate change projections for Europe, have emerged from the ENES community.

Challenges

Climate change raises several challenges for the ENES scientific community:

- To improve our understanding and prediction of future climate changes requires the analysis of the full complexity of the Earth system, ie. the physical, biological and chemical dimensions coupled together, and the development of comprehensive Earth system models capable of simulating natural climate variability and human-induced climate changes;
- To improve our understanding and prediction of climate change impacts in all socioeconomic dimensions requires better accounts of climate change on regional scales and enhanced interactions with the climate change impact community. This will be particularly required to prepare for adaptation to climate change.



Projections for the end of the 21th Century (2080-2099) for the A1B scenario (medium range of greenhouse gases future emission scenarios) of surface warming and precipitation changes obtained from an average of global climate models as displayed in the last IPCC report (2007, http://www.ipcc.ch). Anomalies are relative to the period 1980-1999. Consistently in all climate models, surface warming is stronger in high latitudes and over continents. For precipitation, models produce an increase in high latitudes and a decrease in the Mediterranean region and subtropical areas. Regions that are stippled correspond to a consistency in the sign of change of 80% of the models

In order to improve European competitiveness and expertise, there is also a need to:

- Better integrate countries that are new to the subject and that want to be involved in the study of climate change. Indeed, with the increasing threat of climate change, more countries want to develop their own expertise on climate change prediction to prepare for adaptation;
- Perform the most up-to-date and accurate climate simulations. This requires sophisticated models, world-class, high-performance computers, and state-of-the-art software infrastructures to make efficient use of the models and the hardware.

Developing an infrastructure for ENES

Under FP7, ENES has just launched an Integrated Infrastructure project (2009-2013), IS-ENES (Infrastructure for ENES), in order to develop a virtual

Earth System Modelling Resource Centre, integrating the European Climate/Earth system models and their hardware, software, and data environments, and addressing the above challenges. IS-ENES gathers 18 partners from 10 European countries and includes the six main European Global Climate models (see box). IS-ENES will follow four main objectives:

- Foster the integration of the European climate and Earth system modelling community;
- Foster the development of Earth system models for the understanding of climate change;
- Foster high-end simulations enabling better understanding and prediction of future climate change;
- Foster the application of Earth system model simulations to better predict and understand future climate change impacts.

The IS-ENES e-infrastructure will deliver a service on climate models and support the dissemination of model results, especially model projections for the next IPCC assessment. The IS-ENES service is directed towards both modelling groups and users of model results, especially the impact community. IS-ENES will improve access to model documentation, access to model results, and prototype climate services for the impact community. Networking activities will increase the cohesion of the European ESM community and advance a coherent European Network for Earth system modelling. IS-ENES will use the standards developed by the FP7 ENES METAFOR project 'Common Metadata for Climate Modelling Digital repositories' (http://ncas-cms.nerc.ac.uk/METAFOR). IS-ENES will provide a prototype for a web service interface to bridge the gap between the climate modelling community, the climate impact community and decision-makers for developing adaptation and mitigation policies. A set of use cases will be documented as well as tools and methodologies gathered.

Central to climate change predictions is the need to access to high-performance computing (HPC) facilities. An effective European computing infrastructure for climate/Earth system modelling requires a full HPC-ecosystem: from Tier-0 world-class facilities allowing high-end simulations at the top to properly nested and scaled Tier-1 national facilities. Tier-0 facilities are needed to run model simulations at the highest possible resolution and improve the study of climate change impacts whereas Tier-1 allows models to be developed and optimised, and many lighter experiments to be run. ENES expects the European project 'Partnership for Advanced Computing in Europe' (PRACE) to provide the top of the pyramid of the HPC-ecosystem and has been recognised by the 'Distributed European Infrastructure for Supercomputing Applications' project (DEISA), as the virtual community for climate research. IS-ENES will organise the interface with these large infrastructure projects and help prepare for the future generation of computing architectures and facilities.

IS-ENES will also engage a dialogue between the top-edge European climate research community, and the relevant climate policy-making European Directorates and related institutions on issues such as 'Climate data needs in support of the EU Climate Adaptation Strategy' and 'The ENES strategy and its Implementation'.

Six European climate/ Earth system models for the next IPCC report

Earth system models include a full representation of the atmosphere circulation coupled to the oceans, sea ice and land surfaces. Such models are based on the fundamental laws of physics and include representations of clouds, radiation, surface flux exchanges. Full Earth system models include a modelling of the carbon cycle within the atmosphere, ocean and land, which requires adding biological processes. Chemistry and aerosols cycles are also included to account for their impact on radiation and cloud microphysics.

The six models are:

- ARPEGE-NEMO is the coupled model from Meteo-France;
- C-ESM is the new model developed at the Centro Euro-Mediterraneo per i Cambiamenti Climatici in Italy;
- COSMOS is a community effort by the Max Planck Institutes from Hamburg, Mainz and Jena and the Finnish Meteorological Institute;
- EC-Earth is developed by a consortium, gathering a number of national weather services and universities currently from 11 countries in Europe, the Koninklijk, Netherlands Meteorological Institute, the Swedish Meteorological and Hydrological Institute, and other partners in Ireland, Denmark, Norway and Switzerland;
- HadGEM3 is developed by the Hadley Centre at the UK MetOffice;
- IPSLCM is developed by Institut Pierre Simon Laplace in France.

Sylvie Joussaume is the Coordinator of the IS-ENES FP7 project and Chair of ENES Scientific Board. The ENES Scientific Board includes: Jean-Claude André (CERFACS), Reinhard Budich and Jochem Marotzke (MPI Hamburg), John Mitchell (Hadley Centre), Antonio Navarra (CMCC), Tim Palmer (ECMWF), and Pavel Kabat (Wageningen University).

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