SPECIAL PROJECT PROGRESS REPORT

Progress Reports should be 2 to 10 pages in length, depending on importance of the project. All the following mandatory information needs to be provided.

Reporting year	2018
Project Title:	EC-EARTH: developing a European Earth System model based on ECMWF modelling systems
Computer Project Account:	SPNLTUNE
Principal Investigator(s):	Dr. Ralf Döscher
Affiliation:	Rossby Centre, SMHI
Name of ECMWF scientist(s) collaborating to the project (if applicable)	Dr. Glenn Carver
Start date of the project:	2018
Expected end date:	2020

Computer resources allocated/used for the current year and the previous one
(if applicable)
Please answer for all project resources

		Previous year (2017)		**Current year (2018)**	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)	25000000	25000000	50000000	30923451
Data storage capacity	(Gbytes)	70000	?	70000	?

Summary of project objectives

(10 lines max)

The development of Earth System Model EC-Earth needs a major effort in tuning and testing of its components. During this phase of the project, main objectives were further tuning of the physical and earth system components in various configurations. The goal was to achieve a well-tuned Earth-System-Model suitable for performing Coupled Model Intercomparison project (CMIP6) simulations and studying a wide range of scientific questions. Special attention was given to the tuning of the global energy balance and mass conservation in the model and achieving realistic radiative fluxes (TOA and surface, cloud forcing).

Summary of problems encountered (if any)

(20 lines max)

We did not experience major technical problems with the computing environment.

Summary of results of the current year (from July of previous year to June of current year)

This section should comprise 1 to 8 pages and can be replaced by a short summary plus an existing scientific report on the project

Model development

SPNLTUNE resources have been essential to perform continuous tuning of the EC-Earth model. During the past few months, the EC-Earth consortium did a significant amount of work and launched simulations within the framework of CMIP6 including the mandatory DECK simulations and several Model Intercomparison Projects (MIP) simulations. A large set of necessary simulations were performed in the past year using the project resources. The standard model resolution T255L91 was mainly used, and the work has primarily focused on atmospheric tuning with AMIP runs. In this period, the rapid development of the model and investigating the solution of several different issues required us to perform more than 80 tuning runs of each 20-model years long at T255L91 resolution. This allowed exploring the impact of several important changes in the model and determining their impact on the global energy budget of the model.

To tune the global model energy balance, a bulk of tuning work was performed by modifying a set of tuning parameters (mainly convective and microphysical parameters). The sensitivity of these parameters in terms of impact on global energy fluxes (such as TOA and Surface net, SW and LW fluxes, cloud forcing) was determined in the past with a series of short AMIP runs, as already reported. The known parameter sensitivities were used in a tuning simulator, based on a linear assumption, to estimate the impact of linear combinations of parameter modifications. This allowed to easily determine the new tuning parameter sets for achieving a realistic global energy fluxes in the model and to test them in the 20-year long standard model experiments (typically 1990-2009 runs, with averages over the 1995-2009 period).

Below we show selected examples of specific tuning and testing works. These experiments were essential to check global energy budget implications of the following model changes and to tune the model accordingly (a well-tuned version of the model has always been kept during the past year, as soon as a new model change was implemented in the trunk):

1) Linking land albedo and vegetation

In order to allow using the model for the preindustrial, historical of future projection experiments, a new parameterization had to be developed linking land vegetation parameters (high and low vegetation cover fraction, type of vegetation and leaf-area index) and background albedo. This parametrization was then used for IFS instead of using fixed background climatological albedo maps. Visible/UV and Near Infra-red, direct and diffuse albedo needed to be reproduced. Total land albedo was written as a linear combination of background soil albedo and of vegetation albedo (function of vegetation type), weighted with effective vegetation cover fraction. The obtained solution is based on an existing background soil albedo map (from Rechid et al. 2009 and Otto et al. 2011) and vegetation albedo coefficients determined by linear regression from observed MODIS albedo climatologies and IFS vegetation type maps.

2) Vegetation fields derived from LPJ-Guess and ERA-20C

The impact of vegetation type and cover maps, which was obtained from different sources (coupled runs with IFS+LPJ-Guess or LPJ-Guess forced by ERA20C), on model tuning was explored and different tuning configurations were developed. This was done both for the consistency with the Earth-System Model configuration of EC-Earth with dynamical LPJ-Guess vegetation as well as producing future projections of land albedo to be used with the model.

3) Different boundary and initial conditions

Those experiments which were comparing the initial and boundary conditions in 1950 to 1990, revealed that the model internal energy production in particular (TOA-SRF net flux difference, currently -0.27 W/m2 at T255L91) was sensitive to the smoothness of the imposed orography. Furthermore, the sensitivity of tuning statistics in the period 1995-2009 (used as a standard for tuning) to the initial conditions used for the experiments was determined (we found impacts of order of up to 0.2 W/m2 comparing experiments starting in 1990 or 1950).

4) Full versus simplified stratospheric aerosols

Two implementations of CMIP6 stratospheric aerosol forcing were developed for EC-Earth (a simplified one, vertically integrated at 550nm, and a full version using the vertically dependent information provided by the forcing files). The impact in terms of global energy fluxes tuning was verified and appropriate model tuning parameters sets were determined.

5) Conservation issues and options in coupling atmosphere and ocean

An extensive investigation of energy and mass conservation implications of different OASIS coupling interpolation options were explored. Additionally different energy conservation assumptions in EC-Earth, NEMO and LIM3 were compared (LW flux over ice, sensible heat contributions of runoff, snowfall and rainfall).

6) High-resolution tuning

High resolution tuning runs at T511L91 were performed, particularly in the HighResMIP setup (tuning the model for 1950 conditions in a series of AMIP experiments)

7) Different cloud activation schemes (ACI)

The use of ACI, which represents the indirect effects of clouds, has been recently adopted as a default in the standard model configuration and is being developed for CMIP6. The non-negligible tuning impact of different schemes (Menon, Fountoukis & Nenes, Abdul-Razzak and Ghan) was evaluated and sensitivity to internal parameters of the schemes (mainly the critical radius parameter RLCRIT_UPHYS) was determined. Exploration of different schemes is still work in progress.

8) Effective radiative forcing associated with anthropogenic aerosol changes

A number of AMIP simulations were also carried out to estimate the effective radiative forcing (ERF) associated with anthropogenic aerosol changes from the pre-industrial (1850) to the present day (2010). ERF was estimated by comparing top of atmosphere (TOA) and surface radiative flux fields in

21-year simulations with aerosols being set to 2010 and 1850 levels, respectively. The contributions to the ERF from aerosol-radiation interactions (i.e. direct radiative effects and semi-direct effects) and aerosol-cloud interactions (indirect effects) were estimated separately. In the analysis, our standard EC-Earth3 version with anthropogenic aerosols being prescribed by the MACv2-SP simple plume model, was compared to a configuration in which the aerosol distributions are prescribed based on climatologies derived from TM5. The latter configuration is a simplified version of EC-Earth3-AerChem, in which TM5 simulates tropospheric aerosols interactively. The contribution from aerosol-radiation interactions to the ERF was found to be similar in both configurations. However, a ~0.9 W/m2 weaker contribution from aerosol-cloud interactions was obtained in the version with MACv2-SP. As the analysis were performed before completion of the tuning for CMIP6, the results should be considered preliminary.

List of publications/reports from the project with complete references

A paper describing tuning of EC-Earth for CMIP6 is in preparation.

Summary of plans for the continuation of the project

(10 lines max)

The EC-Earth consortium has applied for a new SP.