# 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** | 2017 |
| **Project Title:** | EC-Earth climate simulation for AerChemMIP |
| **Computer Project Account:** | SPNLNOIJ |
| **Principal Investigator(s):** | Dr. T.P.C. van Noije |
| **Affiliation:** | Royal Netherlands Meteorological Institute (KNMI) |
| **Name of ECMWF scientist(s) collaborating to the project** (if applicable) | Not applicable |
| **Start date of the project:** | January 2017 |
| **Expected end date:** | December 2019 |

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

| | | Previous year | | Current year | |
|---|---|---|---|---|---|
| | | Allocated | Used | Allocated | Used |
| **High Performance Computing Facility** | (units) | 0 | 0 | 38,000,000 | 5,473,482 |
| **Data storage capacity** | (Gbytes) | 0 | 0 | 40,000 | 3,000 |

## Summary of project objectives
(10 lines max)

Within this special project, we will carry out climate simulations with the global climate model EC-Earth within the context of the Coupled Model Intercomparison Project Phase 6 (CMIP6). The simulations will be done with a model configuration with interactive aerosols and atmospheric chemistry, and will be part of the consortium's contribution to the Aerosols and Chemistry Model Intercomparison Project (AerChemMIP). The set of simulations will also include a selection of the CMIP DECK simulations (Diagnostic, Evaluation and Characterization of Klima) and the CMIP6 historical simulation for this model configuration.

## Summary of problems encountered (if any)
(20 lines max)

The development and tuning of the physical model configuration (EC-Earth3) has been delayed by several months. The first DECK simulations with the physical model are now expected to start in October 2017. The implication for this project is that the tuning of the model configuration with interactive aerosols and chemistry (EC-Earth3-AerChem) will also be delayed. The pre-industrial control spin-up simulation and first DECK simulations, which were scheduled to start towards the end of summer 2017, will have to be postponed. Thus, we expect to spend only a small part of the resources assigned for this year. To be able to complete the simulations, it will be necessary to move resources from the first to the third year of the project (see project amendment sent to together with this report).

## 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

Simulations completed during the first months of the project have focused on three activities, which are part of the final development of EC-Earth3-AerChem:

1) Improved description of secondary organic aerosols and boundary layer nucleation
2) Implementation of CMIP6 forcing data sets and options
3) Improved computational performance

A short summary for each of these activities is given below.

*Improved description of secondary organic aerosols and boundary layer nucleation*

The representation of secondary organic aerosol (SOA) in TM5 has been improved. The simple representation using surrogate emissions has been replaced by an explicit scheme in which SOA is formed in the atmosphere as presented by Jokinen et al. (Proc. Natl. Acad. Sci., 2015). The new scheme is a two-product model where isoprene and monoterpene are oxidized by ozone and hydroxyl radical to produce semi-volatile organic compounds (SVOC) and extremely volatile compounds (ELVOC). Together with the new scheme we also implemented a new particle formation mechanism as a function of ELVOC and sulfate concentrations (Paasonen et al., Atm. Chem. Phys, 2010; Riccobono et al., Science, 2014) and condensation of ELVOCs and SVOCs. A set of sensitivity simulations has been carried in off-line mode to test the new secondary organic aerosol (SOA) formation scheme, and prepare for a model description and evaluation paper. Figure 1 shows the impact of these model improvements on the organic aerosol mass distribution. The simulations performed for this part costed 757 kSBU.

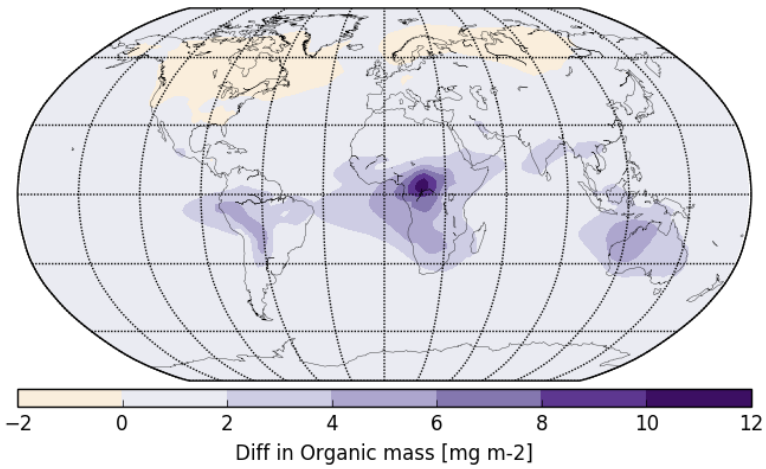


Figure 1. Difference in organic aerosol mass density compared to the earlier model version.

*Implementation of CMIP6 forcing data sets and options*

New CMIP6 forcing data sets for the pre-industrial and historical periods (1850-2014) have been implemented in TM5. These include data sets describing the evolution of the mixing ratios of stratospheric ozone, methane and carbon dioxide since 1850, as well as updated versions for the historical emissions of aerosol and ozone precursors from both anthropogenic and biomass burning sources. In addition, new output routines have been implemented in TM5 to provide the aerosol data required for AerChemMIP.

Because the model does not include a comprehensive stratospheric chemistry scheme, ozone mixing ratios are nudged towards their desired zonal mean values, which can now be chosen to be based on the CMIP6 pre-industrial climatology or historical time series. Methane mixing ratios in the model are constrained both at the surface and in the stratosphere. At the surface, mixing ratios are nudged to concurrent zonal means from the CMIP6 data set, while in the stratosphere the annual global mean mixing ratio from CMIP6 is used with a one-year delay for scaling a present-day climatology from the HALOE (Halogen Occultation Experiment) satellite instrument. Global mean mixing ratio of carbon dioxide is used in TM5 to calculate the acidity of cloud droplets, which is relevant for aqueous phase chemistry.

For anthropogenic emissions, a more detailed sector dependence of the size distribution and solubility of primary emissions of carbonaceous particles has been introduced, e.g. by making explicit use of the supplementary information on solid biofuel combustion emissions, provided as part of the CMIP6 anthropogenic emissions from the Community Emissions Data System (CEDS). The test simulations associated with this part of the development costed 378 kSBU.

*Improved computational performance*
Work has been done to improve the model's computational performance. The exchange of non-spectral fields between IFS and TM5 now involves all cores of TM5 instead of one. This has reduced the MPI communication, and has substantially increased the scalability of the model. A number of test simulations have been performed to estimate the effects on model performance. We estimated that the use of multi-core coupling increases the speed of the model in atmosphere-only configuration from about 1.4 to slightly more than 2.0 simulation years per day (see Figure 2). These test simulations costed 4,339 kSBU.

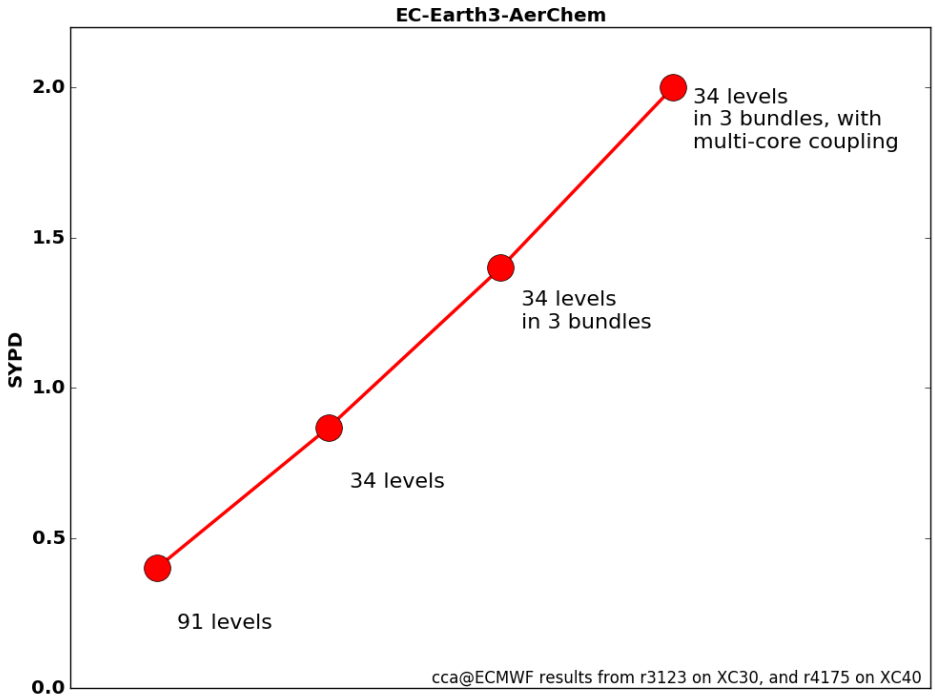


Figure 2. Model speed in simulation years per day (SYPD) obtained in various development stages of EC-Earth3-AerChem in atmosphere-only configuration.

## List of publications/reports from the project with complete references

Bergman, T., T. van Noije, et al., in preparation.

## Summary of plans for the continuation of the project

(10 lines max)
We will continue the project as outlined in the amendment.