SPECIAL PROJECT PROGRESS REPORT

All the following mandatory information needs to be provided. The length should *reflect the complexity and duration* of the project.

Reporting year	2019
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)	41,000,000	17,179,037	50,000,000	21,317,141
Data storage capacity	(Gbytes)	43,000	18,000	60,000	25,600

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 (10 lines max)

Besides the delays mentioned in the last report, we've encountered no further problems.

Summary of plans for the continuation of the project (10 lines max)

We will start the EC-Earth3-AerChem pre-industrial control simulation (piControl) as soon as the spinup simulations that are currently running have sufficiently stabilized and we can decide on the final parameter settings to be used for AerChemMIP (see Summary of results). The piControl of at least 206 years long was not part of the original project request, but was moved from FMI/UHEL to KNMI. At the same time we will start running the EC-Earth3-AerChem DECK and tier-1 AerChemMIP production runs listed in the project request.

List of publications/reports from the project with complete references

Bergman, T., R. Makkonen, R. Schrödner, and T. van Noije, Description and evaluation of a new secondary organic aerosol scheme within TM5, in preparation.

Van Noije, T., T. Bergman, P. Le Sager, et al., EC-Earth3-AerChem, a global climate model with interactive aerosols and atmospheric chemistry participating in CMIP6, in preparation.

Fanourgakis, G., M. Kanakidou, A. Nenes, T. Bergman, T. van Noije et al., Evaluation of global simulations of aerosol particle and cloud condensation nuclei number, and implications for cloud droplet formation, Atmos. Chem. Phys., accepted.

Summary of results

If submitted **during the first project year**, please summarise the results achieved during the period from the project start to June of the current year. A few paragraphs might be sufficient. If submitted **during the second project year**, this summary should be more detailed and cover the period from the project start. The length, at most 8 pages, should reflect the complexity of the project. Alternatively, it could be replaced by a short summary plus an existing scientific report on the project attached to this document. If submitted **during the third project year**, please summarise the results achieved during the period from July of the previous year to June of the current year. A few paragraphs might be sufficient.

Earlier this year, we have started spinning up a near-final version of EC-Earth3-AerChem in ocean-atmosphere coupled mode using pre-industrial emissions and other forcing data sets. Initially we used the same settings of tuning parameters as used in the standard version of EC-Earth3, i.e. the version with aerosols and greenhouse gases, including ozone and methane, prescribed. Starting from an initial state from the EC-Earth3 pre-industrial control simulation, the model configuration with interactive aerosols, ozone and methane, started to warm, especially in the Northern Hemisphere. To reduce the NH warm bias obtained with these parameter settings, we started two additional spinup simulations with slightly changed values of three atmospheric tuning parameters (part of IFS). The behaviour of these two configurations was as expected, resulting in a global cooling of a few tenths of degrees compared to the original run (see Figure 1).

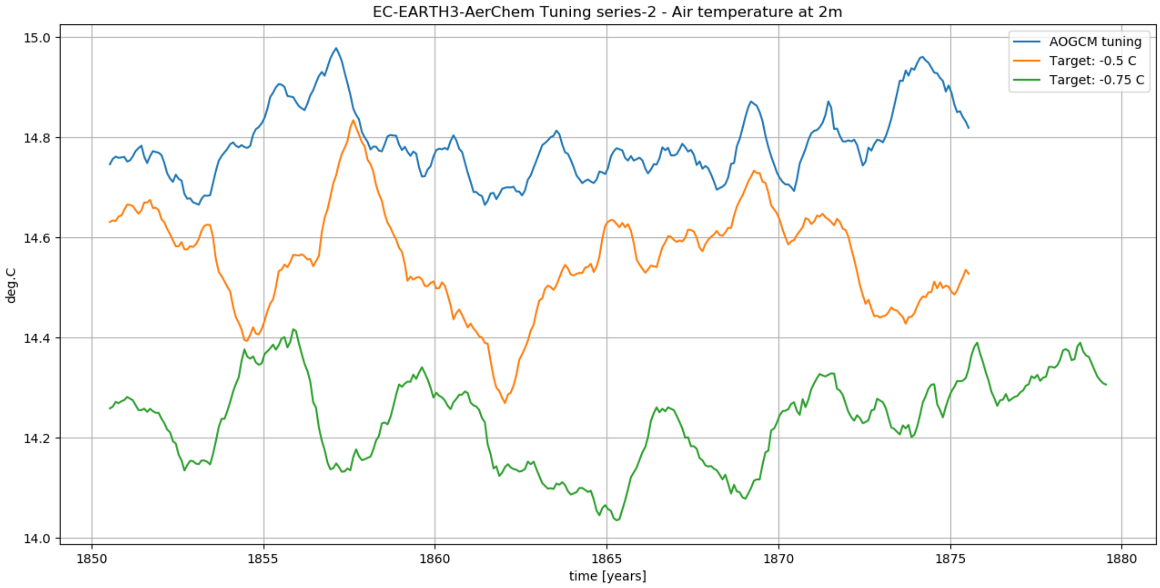

Figure 1. Global mean surface air temperature in the three EC-Earth3-AerChem pre-industrial spinup runs, which are currently running. The three model configurations differ only in the values of three atmospheric tuning parameters: the blue curve is produced using the standard settings from EC-Earth3, while the orange and green curves are obtained after re-tuning the model, where the target was to cool the model by about 0.5 K and 0.75 K, respectively, compared to the configuration with standard settings. Note that all simulations were started from the same initial state obtained with EC-Earth3; the first 120 years of the simulations are not shown.

The largest impact is realized in the NH. The top panel in Figure 2 shows the multi-annual zonal mean surface temperatures from the three EC-Earth3-AerChem spinup simulations, the EC-Earth3 pre-industrial control simulation (blue line), and from the ERA5 reanalysis for the 1980s (purple line); the bottom panel shows the differences between the simulated zonal means and the reanalysis data set. These differences give an idea of the temperature biases in the simulations, but for a quantitative comparison one would need to account for the warming already realized in the 1980s. It can be seen that the different pre-industrial simulations all have similar warm biases over the Southern Ocean. Moreover, whereas EC-Earth3 is generally too cold in the NH, using the same set of tuning parameters EC-Earth3-AerChem tends to be too warm. Finally, by changing only two or three of the standard tuning parameters used in the tuning of EC-Earth3, more realistic NH temperatures can be obtained.

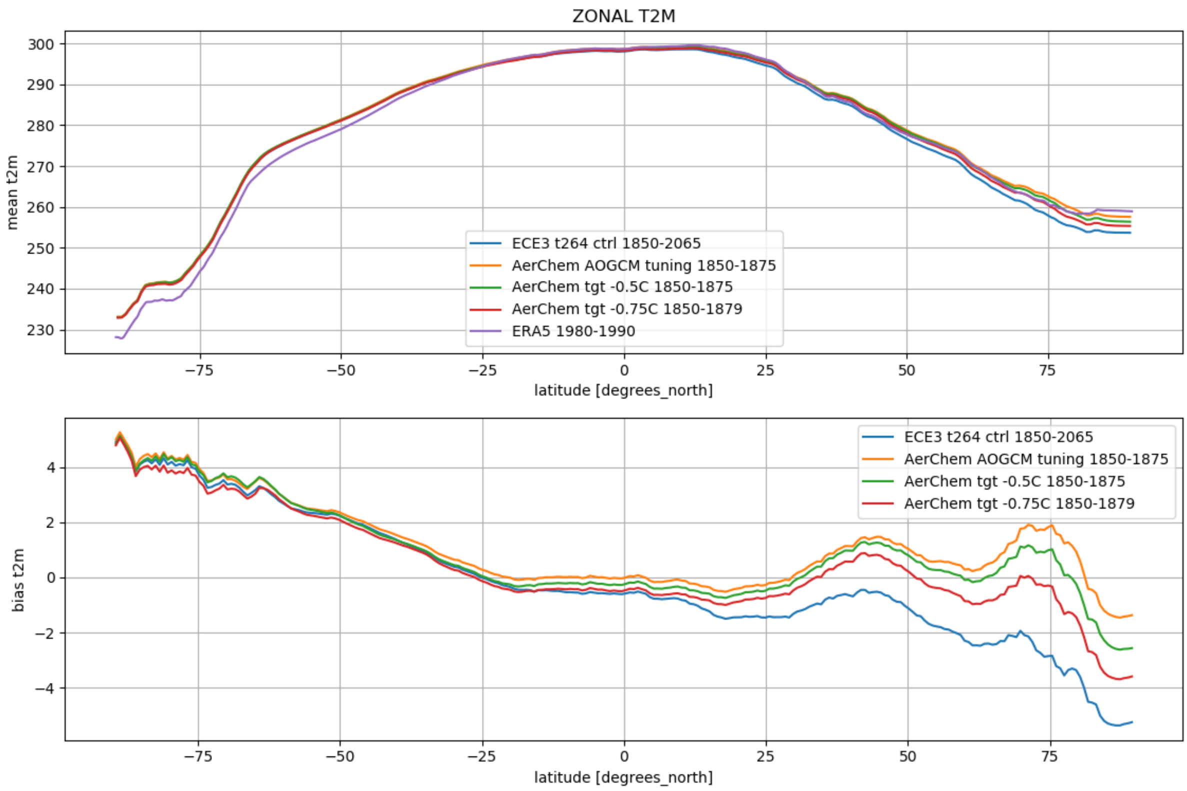

Figure 2. The top panel shows the multi-annual zonal mean surface temperatures from the three EC-Earth3-AerChem spinup simulations (orange, green and red curves) for the periods presented in Figure 1, from the EC-Earth3 pre-industrial control simulations (averaged over more than 200 years), and from the ERA5 reanalysis for the 1980s. The differences between the simulations and the reanalysis are shown in the bottom panel.

Whereas EC-Earth3 produces a pre-industrial climate with large long-term variations in, e.g., NH temperatures and sea ice, and Atlantic Meridional Overturning Circulation (AMOC), likely triggered by a cold bias in the Northern Atlantic, our spinup simulations with interactive aerosols and atmospheric chemistry do not show this behaviour. This suggests that the variability in the EC-Earth3-AerChem pre-industrial and historical runs will be more realistic in this respect. Note that the resources for running these spinup simulations have been shared with the SPNLTUNE special project. Further details about these runs are given in the accompanying annual report.