Report for project 854 “Erdsystemmodellevaluierung”

Project: **854**
Project title: **Erdsystemmodellevaluierung**
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Aerosol-chemistry-cloud-climate interactions (ESA CMUG)

Because of unexpected problems encountered during the development of the new model version (EMAC 2.52 with MADE3 coupled to radiation and new cloud scheme with ice phase clouds) that are mostly related to problems with the coupling to the scavenging module SCAV, the model runs planned for 2016 could not be performed in time.

These problems have now been solved. The new model system is now fully operational and is currently being evaluated against observations including the newly available ESA CCI satellite data. As an example, Figure 1 shows a comparison of the aerosol optical depth at 550 nm simulated by EMAC-MADE3 in comparison with the ESA CCI satellite data. We expect to be able to start the proposed production runs in the beginning of 2017.

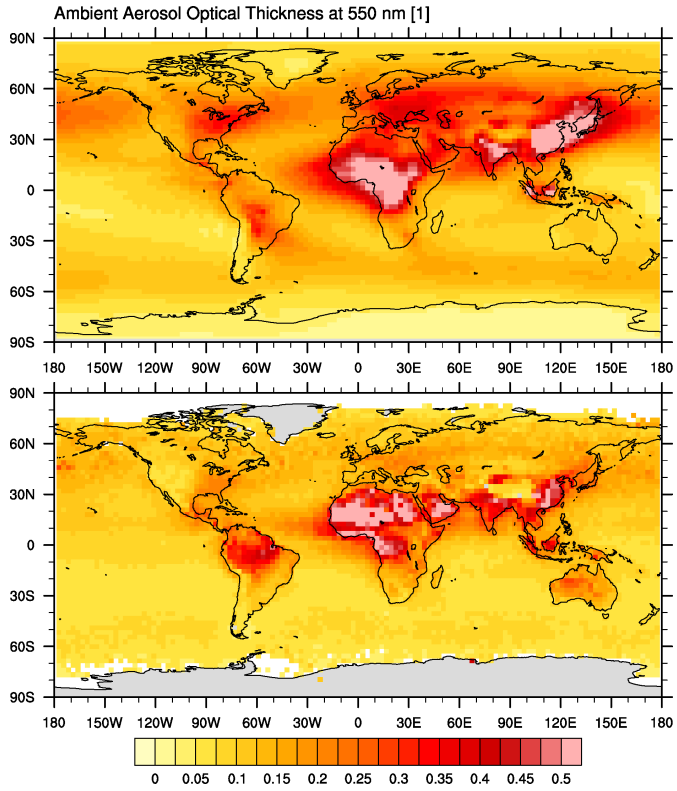

Figure 1: Aerosol optical depth at 550 nm simulated by EMAC-MADE3 (top) and from the ESA CCI satellite product (bottom).

As the model was not ready to perform the aerosol simulations initially planned for 2016, we used part of the granted node-hours for tuning experiments to adjust the non-orographic wave parameter in EMAC. The main results of these tuning experiments are summarized in the following section.

Non-orographic gravity wave parameter tuning

We performed 5 time slice simulations in order to receive a first impression of the model behavior regarding the adjustment of non-orographic gravity wave parameters. Each model simulation (meteorology only) covers 25 years including a 5-year spin-up phase. The boundary conditions of each model simulation

were kept constant only allowing a seasonal cycle. Greenhouse gas concentrations (i.e. CO_2, N_2O, CH_4, O_3) were prescribed according to conditions in the year 2000. The horizontal resolution of the model is T42 corresponding to an approximately 2.8°x2.8° Gaussian grid. The vertical extend from surface to middle atmosphere with an upper model lid centered at 0.01 hPa is distributed into 90 levels.

The model experiments consisted of a number of sensitivity simulations with different settings of the parameter "rmscon". The rmscon parameter is a tuning parameter, which controls the wave activity of non-orographic waves. We named our simulations as follows: G1 (rmscon = 0.88); G2 (rmscon = 0.92); G3 (rmscon = 1.00); G4 (rmscon = 1.04); G5 (switch off non-orographic gravity waves); REF (rmscon = 0.96).

In order to analyze the temporal evolution of the southern hemispheric polar vortex, the annual cycle of mean Antarctic polar cap temperature anomalies of the individual simulations calculated using ERA-Interim as a reference. Figure 1 shows exemplary the deviation of the temperature anomalies from the REF model simulation compared with ERA-Interim. In contrast to the SST sensitivities, the anomaly patterns of the gravity wave sensitivity simulations differ distinctly from each other. In the simulations with a smaller rmscon parameter, namely G1 and G2, the stratospheric warm bias during Austral winter and spring season is less pronounced compared to the REF simulation. Deviations from ERA-Interim are smaller than 4 K and never exceed 8 K. The warm bias in G1 tends to be bounded to the lower stratospheric levels around 50 hPa to 30 hPa. However, in the case of G2 positive anomalies can reach stratopause levels in late winter to early spring term. For the stratopause level the simulated warm biases of G1 and G2 are less than in REF or even negative anomalies can arises (e.g. in June at 5 hPa). With a larger rmscon parameter, in particular in the sensitivity run G3 the model warm bias is increased towards the REF simulation. For both of these sensitivity simulations the stratospheric warm bias amplifies in the course of the winter months reaching a relative maximum in the transition from winter to spring with values of about 10 K. In spring anomalies propagate from upper stratospheric levels at 1 hPa to tropopause level at 100 hPa. The overall absolute maximum positive anomaly in both sensitivity simulations can reach 12 K. Analogue to the REF simulation a continuous stratopause warm bias can be found roughly from March to September.

With regard to G5, the simulation without non-orographic gravity wave parametrization, a so called cold-pole bias can be observed. Negative anomalies, which can drop below -18 K, occur during March to September and vertically extend through the whole middle atmosphere. Broadly speaking simulations taking the effects of non-orographic gravity waves into account, suffer all together from a stratospheric warm bias in the Austral winter and spring season. Furthermore, it should be noted that with an increased rmscon parameter this model warm bias intensifies. As shown earlier, raising the rmscon parameter enhances at the same time the gravity wave dissipation, reflected in the gravity wave drag at stratospheric levels.

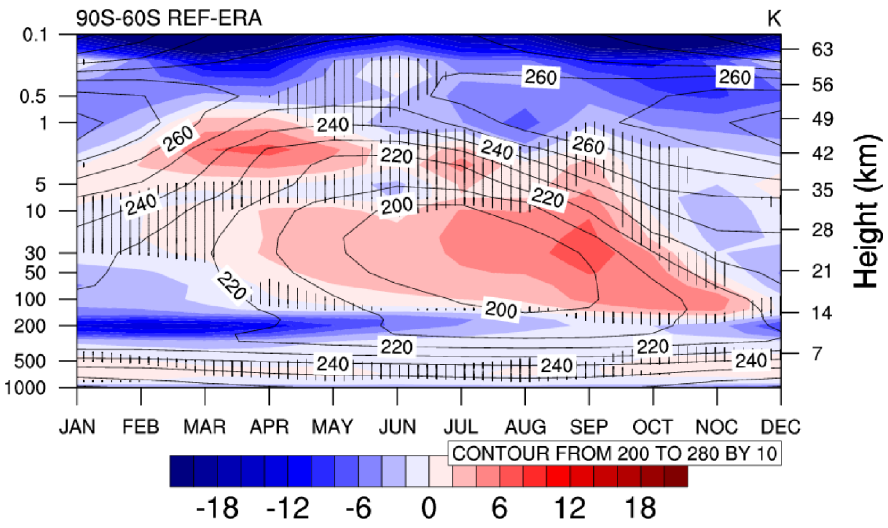

Figure 2: Annual cycle climatology of 90°S – 60°S mean temperature differences REF – ERA-Interim in K. Solid contour lines refer to the absolute values from ERA-Interim.