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Response to Tropospheric Aerosol Changes in a Fully Coupled Ocean Troposphere Stratosphere Model (EGMAM)

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Many of the global models used for IPCC simulations do not account for middle atmosphere dynamics (IPCC AR4, 4 models of 23 have a top above 1 hPa). The response of new components, like aerosols, in such models can be affected by the missing link to the middle atmosphere. On the other hand, in models with vertical high resolution up to the mesosphere, the feedback to the underlying ocean is neglected, due to prescribed sea surface temperatures. In our testcase tropospheric aerosols were implemented in the coupled ocean atmosphere model EGMAM (ECHAM4 with HOPE, top is 0.01 hPa) and sets of pairwise experiments were performed.

The first series of experiments was foccused on the effect of the vertical extension of the model. Two experiment pairs one with the tropospheric model version and one with the additional middle atmosphere were simulated. For each experiment the same warmstart conditions were used, that were generated from a longer coupled control simulation. The experiment pairs were running 50 years with and without aerosols. The overall background conditions were prescribed following the AMIP mean period, except the sea surface conditions which followed the interactive ocean.

In the second series of experiments the coupled model with the middle atmosphere was used for two equilibrium simulation pairs. The conditions were based on the IPCC specifications. For the first pair the 1860 and for the 2nd 1990 conditions were used. In both cases the model was running with and without tropospheric aerosols.

The simulated aerosol distribution in all simulations was realistic and comparable with the observations. However the simulated atmospheric response was changed, when the middle atmosphere switched on in the model. The radiation net flux change for the troposphere due to the aerosols was ten times larger in the experiments with the middle atmosphere and the dynamical feedback to the Hadley circulation was much stronger. The cooling effect near the surface due to aerosols is much weaker under 1860 conditions. However the aerosol effect in the precipitation response in the tropics is nearly unchanged, when comparing 1860 with 1990 conditions and higher than the effect due to the changes in the greenhouse gas and solar background conditions.