Impacts of Mt. Pinatubo Volcanic Aerosol on the Tropical Stratosphere in Chemistry-Climate Model Simulations using CCMI and CMIP6 Aerosol Data

Andrea STENKE[1], Laura E. REVELL[2], Beiping LUO[1], Stefanie KREMSER[2], Eugene ROZANOV[1,3], Timofei SUKHODOLOV[3] and Thomas PETER[1]

[1] *Institute for Atmospheric and Climate Science, ETH Zurich, Zurich, Switzerland*

[2] *Bodeker Scientific, Alexandra, New Zealand*

[3] *Physikalisch-Meteorologisches Observatorium Davos and World Radiation Center, Davos, Switzerland*

For phase 6 of the Coupled Model Intercomparison Project (CMIP6) and the Chemistry-Climate Model Initiative (CCMI), two stratospheric aerosol data sets were compiled for use by chemistry-climate models without an online aerosol module. The data sets provide temporally and spatially resolved aerosol size parameters for heterogeneous chemistry and aerosol radiative properties as a function of wavelength. Both data sets are based on SAGE (Stratospheric Aerosol and Gas Experiment) II satellite measurements. The "SAGE-4λ" data set was compiled for CCMI, and the "SAGE-3λ" data set for CMIP6. Following the Mt. Pinatubo eruption in 1991, when the stratosphere was too optically opaque for SAGE II, the SAGE-4λ data set was gap-filled with ground-based Lidar measurements, while satellite measurements from CLAES (Cryogenic Limb Array Etalon Spectrometer) were used for the SAGE-3λ gap-filling. Here we performed SOCOLv3 (Solar Climate Ozone Links version 3) chemistry-climate model simulations to investigate the impact of the Mt. Pinatubo eruption in 1991 on stratospheric temperature and ozone and how this response differs depending on which aerosol data set is applied.

In the simulations using SAGE-4λ aerosols, heating is overestimated in the post-eruption period in the tropical lower stratosphere by approximately 3 K compared to observations. Using SAGE-3λ aerosols less heating occurs, despite an overall enhanced stratospheric aerosol burden compared to SAGE-4λ. Tropical temperature anomalies in these simulations are in good agreement with MERRA and ERA-Interim reanalyses. Evaluations of short- and longwave aerosol heating rates indicate a longwave cooling in the tropical stratosphere above approximately 40 hPa in the simulations using SAGE-3λ aerosols, which is significantly less pronounced and occurs only at higher altitudes in the simulations using the SAGE-4λ data set. In case of SAGE-3λ, infrared emission by the aerosol itself, which is proportional to the fourth power of the ambient temperature, can overcompensate the absorption of outgoing terrestrial radiation. This holds in particular for cloudy conditions with reduced longwave emission from the lower parts of the atmosphere.

Finally, in the simulations using SAGE-4λ aerosols ozone loss in the tropical lower stratosphere is overestimated following the Mt. Pinatubo eruption compared to observations by about 0.2 ppmv. Differences in tropical upwelling and ozone destruction cycles means that, in the SAGE-3λ simulations, ozone is in better agreement with observations from the SWOOSH record.

Key words: Mt. Pinatubo, Stratospheric Aerosol, Temperature, Ozone, Longwave Cooling