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Modelling study of Mt. Pinatubo eruption and applications to geoengineering

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So far suggested geoengineering measures are largely unexplored ideas that require careful inspections before they might become options. In order to evaluate the effectiveness and safety of geoengineering by injection of sulfur containing gases into the stratosphere, a particle-size resolving model is required to obtain reliable results. Here we study the Mt. Pinatubo eruption as an analogue for the geoengineering. We compare two methods to retrieve spectrally resolved optical properties. Both methods consider a unimodal lognormal size distribution. In the first method, we use the gap-filled SAGE II data sets (SPARC, 2006). The number density (N) is determined using surface area density (SAD) and effective radius (R) data, and assuming a particle distribution width (s = 1.8). SAD and R are based on a principal component analysis using four wavelengths (Thomason et al., 1997; Schraner et al., 2008). The second method is described by Stenchikov et al. (1998) in which an older version of SAGE II is applied and assuming s=1.25. Both methods fit the vertical distribution of extinction with their data sets very well, however there are strong discrepancies in the gap-filled regions, i.e. where the stratosphere was opaque for SAGE II and lidar measurements from ground stations had to be used as filling data. We also perform Pinatubo eruption simulations by using the AER 2-D sulfate aerosol model (Weisenstein et al., 1997). The eruption is modelled assuming 9 Mt sulfur injected between 23 and 25 km. The AER model was the best model in the SPARC aerosol assessment (SPARC, 2006), but nevertheless overestimated the extinction with respect to satellite measurements in all wavelength regimes during the year of the Pinatubo eruption. We have developed new coagulation and growth/evaporation schemes, which fit the extinction at 1020 nm at 20 km much better, largely correcting the previous deficits. The results presented here constitute also an important step towards a proper judgement of considered geoengineering measures. Further experiments are required to fully establish the aerosol optical and microphysical properties with a reasonable level of certainty. References: Schraner, M., Rozanov, E., Schnadt Poberaj, C., Kenzelmann, P., Fischer, A. M., Zubov, V., Luo, B. P., Hoyle, C. R., Egorova, T., Fueglistaler, S., Brˆnnimann, S., Schmutz, W., and Peter, T.: Technical Note: Chemistry-climate model SOCOL: version 2.0 with improved transport and chemistry/microphysics schemes, Atmos. Chem. Phys., 8, 5957-5974, 2008. Thomason, L. W., L. R. Poole, and T. Deshler, A global climatology of stratospheric aerosol surface area density deduced from Stratospheric Aerosol and Gas Experiment II measurements: 1984-1994, J. Geophys. Res., 102(D7), 8967-8976, 1997. Stenchikov, G. L., I. Kirchner, A. Robock, H.-F. Graf, J. C. Antuna, R. G. Grainger, A. Lambert, and L. Thomason, Radiative forcing from the 1991 Mount Pinatubo volcanic eruption, J. Geophys. Res., 103(D12), 13,837-13,857, 1998 Weisenstein, D., G. Yue, M. Ko, N. D. Sze, J. Rodriguez, and C. Scott, A two dimensional model of sulfur species and aerosols, J. Geophys. Res., 102(D11), 13019-13035, 1997. SPARC: SPARC Assessment of Stratospheric Aerosol Properties, L. Thomason and T. Peter (eds.), SPARC Report No. 4, World Climate Research Programme WCRP- 124, WMO/TD No. 1295, 2006