Geophysical Research Abstracts
Vol. 12, EGU2010-5779, 2010
EGU General Assembly 2010

Stratospheric changes caused by geoengineering aerosols

P. Heckendorn (1), T. Peter (1), D. Weisenstein (2), B. P. Luo (1), E. Rozanov (1,3), S. Fueglistaler (4), and L. W. Thomason (5)

(1) ETH, IACETH, Zurich, Switzerland (patricia.heckendorn@env.ethz.ch), (2) AER, Lexington MA, USA, (3) PMOD-WRC, Davos, Switzerland, (4) DAMTP, U. of Cambridge, UK, (5) NASA Langley Research Center, Hampton, VA, USA

Anthropogenic greenhouse gas emissions are warming the global climate at an unprecedented rate. Significant emission reductions will be required soon to avoid a rapid temperature rise. One of the most prominent geoengineering ideas to counteract global warming is the increase of Earth's albedo by artificially enhancing stratospheric sulphate aerosols. This idea is based on the observed increase of atmospheric optical thickness after volcanic eruptions. The most straightforward method, from a technical point of view, is to inject sulphur in the tropical stratosphere.

We use a 3D chemistry climate model, fed by aerosol size distributions from a zonal mean aerosol model, to simulate continuous injection of 1–10 Mt/a sulphur in form of SO2 into the lower tropical stratosphere. The volcanic and geoengineering forcings differ in terms of their radiative, chemical and dynamical impact on climate, mainly because the geoengineering forcing has to be continuously applied over a long period of time, whereas volcanic eruptions are single events, leading to a non-linear relationship between annual sulphur input and stratospheric sulphur burden. The reason is the continuous supply of sulphuric acid and hence freshly formed small aerosol particles, which enhance the formation of large aerosol particles by coagulation and, to a lesser extent, also by condensation. This shows the importance of investigating carefully the microphysics of the sulphate aerosols. The growth of the particles is sensitive to the injection region and the sulphur loading per injection time.

The consequences of the formation of large particles lead to notable disadvantages. Larger particles are less efficient in cooling than small particles with the same mass. Furthermore, a large fraction of the emitted sulphur is lost rapidly by gravitational settling and subsequent tropospheric washout. Hence, larger sulphur amounts are needed to achieve a targeted cooling.

Some particles are trapped in the tropopause region and lead to heating; as a consequence the entry mixing ratio of water vapour increases. We show that this may have significant impact on radiative forcing and total ozone, because of several effects: the higher temperatures lead to a general acceleration of ozone loss cycles; faster heterogeneous chemistry on the aerosol surfaces lead to a deceleration of NOx-induced ozone loss, but to an acceleration of HOx and ClOx-induced ozone loss; the increased water vapour intensifies the HOx-induced ozone loss cycle. Furthermore, the stratospheric circulation is affected by the strong heating of the lower stratosphere, intensifying the meridional temperature gradient and the polar vortices. As a consequence, PSC formation and polar ozone depletion are enhanced.

In addition, further ozone depletion will result from the emissions of aircraft or rockets that need to be operated to establish the sulphur injection.