STRATOSPHERIC SOLAR GEOENGINEERING WITH THE USE OF SULFATE AEROSOLS

Anthony Ntampos1,2, Robyn Schofield1,2, Kane Stone1,2, David Karoly1,2, Matthew Woodhouse3 and Anne Kubin4

1School of Earth Sciences, University of Melbourne, Australia, 2Centre of Excellence for Climate System Science, 3Commonwealth Scientific and Industrial Research Organisation, Australia 4Freie Universität Berlin, Institute of Meteorology Atmospheric Dynamics, Berlin

Introduction
Anthropogenic climate change due to the emissions of greenhouse gases from fossil fuel combustion is a global threat. Mitigation of emissions is the only viable and permanent solution to the problem, although it is considered to be costly and difficult to implement efficiently worldwide. Therefore, Solar Radiation Management (SRM) has been proposed as an alternative to alter the climate to counteract the consequences of anthropogenic global warming. Solar geoengineering, also called solar radiation management, is the deliberate reflection of sunlight back to space, which has been proposed as a means of temporarily altering some of the effects of anthropogenic greenhouse gas emissions (Budyko, 1974). It is therefore considered to be a tool for stabilising climate in the near term by reducing the warming caused by stratospheric aerosol cooling. Nevertheless, stratospheric aerosol cooling has a feedback mechanism that decreases the albedo of the Earth's surface, leading to an increase in surface temperature.

ACCESS
The ACCESS model is based on the UK Met Office Unified Model. The stratosphere within ACCESS is simulated by the UKCA (UK Chemistry and Aerosols) module. Within GLOMAP-mode, the aerosol size distribution is represented within assumed log-normal modes, tracking both number and mass. Aerosol species represented by GLOMAP-mode are sea-salt, sulphate, black and organic carbon and dust.

ACCESS Run
- All vertical levels with a ceiling at 10km
- A 1.25 x 1.875 horizontal resolution
- 1 month, December 1999

Figure 1. The four proposed GeoMIP experiments. RCP4.5 (representative concentration pathway resulting in 4.5 Wm−2 radiative forcing) is a “business-as-usual” scenario used to force climate models in recent standardized experiments. G1: The experiment is started from a control run. The instantaneous quadrupling of CO2 concentration from pre-industrial levels is balanced by a reduction in the solar constant until year 50. G2: The experiment is started from a control run. The positive radiative forcing of an increase in CO2 concentration of 15% year−1 is balanced by a decrease in the solar constant until year 50. G3: The experiment approximately balances the positive radiative forcing from the RCP4.5 scenario by an injection of SO2 into the tropical lower stratosphere. G4: This experiment is based on the RCP4.5 scenario, where immediate negative radiative forcing is produced by an injection of SO2 into the tropical lower stratosphere at a rate of 5 Tg year−1. Figures 1–4 from Kravitz et al., 2011.

CONCLUSIONS
This study uses GeoMIP data that shows that the 10% solar cycle signal is mostly captured over the Equatorial South Pacific region. Specifically, the incident solar radiation decreases over this region and increases at higher latitudes. A 4% less bright sun is sufficient to balance the increase in CO2 concentration of 15% year−1. This study also demonstrates that the reduction in the solar constant until year 50 is balanced by a decrease in the solar constant until year 50. The impact of the solar constant is considered to be the highest uncertain variable in such models, in a world with increasing atmospheric concentrations of greenhouse gases. This reduces the radiative fluxes and cloud cover, leading to higher surface temperatures.

REFERENCES

Figure 2. Top row refers to all-sky radiation, whereas the bottom plot depicts clear sky radiation. The total reduction of radiation on the surface can be attributed to the reduction of the reflectivity of the clouds or the reduction of the global cloud cover, but the response of the global cloud cover in the future is considered to be the highest uncertain variable in such models, in a world with increasing atmospheric concentrations of greenhouse gases. The clear sky radiation levels show a decrease after 2015, which can only be attributed to the future increase of the total CO2 column, diminishing the absorption in the visible and near IR (IPCC, 2007) and concluding to the total reduction of radiation on the surface. According to the EMAC-D52 data, 1.5 Wm−2 less reach at the surface of the planet on 2100 in comparison to 1960. A reduction of 17% is quite significant, considering that it represents the whole globe.