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What Is The Optimal Level of Solar Radiation Management?

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Solar radiation management (SRM), achieved by stratospheric aerosol injections or by placing a sunshade in orbit, has the potential to cool the Earth's climate to pre-industrial temperatures even with large quantities of CO2 in the atmosphere. Many authors have observed that in such a geoengineered world there would be an undesirable reduction in the intensity of the hydrological cycle. With a large geoengineering intervention in the climate there are many known issues, and potentially some unexpected issues, which could arise as a result. If climate geoengineering is to be conducted, what is the optimal level of solar radiation management?

Here we present the results from a set of experiments using the UK Met Office HadCM3L coupled GCM to simulate the effect of reductions in insolation on the climate of a world with four times the pre-industrial CO2 level. We consider 10 levels of SRM geoengineering from 100% application, returning global average temperature to pre-industrial levels, to 10% of this reduction in insolation. A pre-industrial control, two and four times pre-industrial CO_2 experiments were also conducted. All the simulations were run for 400 years to allow the climate to reach a new equilibrium, with the last 100 years used for the climatological averages. In addition the Glimmer Ice Sheet model was used to simulate the viability of the Greenland ice sheet in each of these climates, the results of this section of the work are already published.

We assess the effects of different levels of geoengineering on a high CO_2 world by a number of different methods, including: temperature and precipitation changes and the stability of the Greenland Ice-Sheet. We include a measure of the change in the climate due solely to the geoengineering intervention, accounting for imperfect mitigation. We combine these variables to find a first estimate of the optimal level of solar radiation management for a high CO_2 world.

Global average temperature and precipitation have been shown to drop with increasing levels of SRM geoengineering, however our results show that levels of crought may remain constant or even decrease relative to the unmitigated, high CO_2 world. We show that the Greenland ice sheet remains stable, in its preindustrial state, with a reduction in insolation of 60% of that required to cool the Earth to pre-industrial temperatures. We also find that the mitigation of global warming at low levels of geoengineering has few imperfections but that at higher levels of geoengineering there are profound imperfections.

We combine these results to determine a subjective optimal level of geoengineering. Our results show that to minimize the level of undesired geoengineering-induced climate changes and reductions in global precipitation, whilst preserving the Greenland ice sheet, 60% of the full reduction in insolation would be required. This partial geoengineering would be cheaper to implement and would be less likely to produce unexpected side-effects.