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Stripy Sunshades: the impact of latitudinal variations in stratospheric aerosol geoengineering on regional weather patterns and climate.

Thomas Hornigold (1), William Ingram (2), Myles Allen (3), and Sarah Sparrow (4)

(1) Atmospheric, Oceanic and Planetary Physics, University of Oxford, Oxford, United Kingdom (thomas.hornigold@linacre.ox.ac.uk), (2) Met Office, Exeter, United Kingdom (william.ingram@metoffice.gov.uk), (3) Environmental Change Institute, University of Oxford, Oxford, United Kingdom (myles.allen@ouce.ox.ac.uk), (4) Oxford E-Research Centre, Oxford University, Oxford, United Kingdom (sarah.sparrow@oerc.ox.ac.uk)

Of the various techniques proposed for solar geoengineering, stratospheric aerosol injection (SAI) has received the most attention in the scientific community.

Studies such as the Geoengineering Model Intercomparison Project (GEOMIP) used uniform distributions of aerosol, or simple injection strategies at a single point on the globe. These studies have shown that this technique can compensate for global mean temperature increases, even in high-emissions scenarios, but that it will likely also disrupt regional rainfall patterns, damaging agriculture and natural ecosystems.

However, the frequency, altitude, latitude, and type of aerosol injections could all be tuned to optimize a solar geoengineering programme, if the response to these variations were well enough understood.

We have therefore run an ensemble with the HadCM3 GCM, exploring the impacts on weather extremes and climate of idealised latitudinal variations in the stratospheric aerosol optical depth (AOD). In addition, we have run experiments using the distribution of AOD that results from injections at various latitude bands in the stratosphere in CESM-WACCM; the aim is to explore the linearity of the system's response to latitudinal and temporal variations in AOD. This is very relevant to constructing an "optimal" distribution that minimises negative global impacts.

HadCM3s implements stratospheric aerosol geoengineering via an AOD which can be set in each of 71 latitude bands. In our idealised experiments, AOD is increased in ten adjacent latitude bands, spanning latitudinal regions of around 25°, as well as experiments where the AOD is increased in selected individual model rows. (As winds in the stratosphere are predominantly zonal, to a first approximation aerosol distributions vary only as a function of latitude.)

These localised perturbations to the surface radiation balance are analogous to those which could be created by regular injections of an aerosol with a short residence time in the stratosphere, and illustrate potential consequences of such an implementation of SRM. Examining the response of weather and climate patterns and extremes to this idealised, latitudinally-confined aerosol, and the resulting changes to radiative forcing, will provide insight into the regime where stratospheric aerosol geoengineering meets weather modification.

Preliminary analysis shows that significant localised reductions in temperature can be achieved, especially over land. However, perturbing the radiation balance drives shifts in cloud and the intertropical convergence zone, at least in this model, making the impacts on precipitation less clear. Analysis of these experiments will explore the impacts of regional geoengineering, including trade-offs between local temperature reduction and shifts in regional precipitation. In particular, any impacts on monsoons due to shifting land-sea temperature contrasts will be explored. We hope to examine what zonally confined AOD can and cannot achieve for particular regions, and the possible side-effects on non-targeted regions.