Geophysical Research Abstracts
Vol. 19, EGU2017-4660, 2017
EGU General Assembly 2017

Detecting the global and regional effects of sulphate aerosol geoengineering

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Climate warming is unequivocal. In addition to carbon dioxide emission mitigation, some geoengineering ideas have been proposed to reduce future surface temperature rise. One of these proposals involves injecting sulphate aerosols into the stratosphere to increase the planet's albedo. Monitoring the effectiveness of sulphate aerosol injection (SAI) would require us to be able to distinguish and detect its cooling effect from the climate system's internal variability and other externally forced temperature changes.

This research uses optimal fingerprinting techniques together with simulations from the GeoMIP data base to estimate the number of years of observations that would be needed to detect SAI's cooling signal in near-surface air temperature, should 5 Tg of sulphur dioxide be injected into the stratosphere per year on top of RCP4.5 from 2020-2070.

The first part of the research compares the application of two detection methods that have different null hypotheses to SAI detection in global mean near-surface temperature. The first method assumes climate noise to be dominated by unforced climate variability and attempts to detect the SAI cooling signal and greenhouse gas driven warming signal in the "observations" simultaneously against this noise. The second method considers greenhouse gas driven warming to be a non-stationary background climate and attempts to detect the net cooling effect of SAI against this background. Results from this part of the research show that the conventional multi-variate detection method that has been extensively used to attribute climate warming to anthropogenic sources could also be applied for geoengineering detection.

The second part of the research investigates detection of geoengineering effects on the regional scale. The globe is divided into various sub-continental scale regions and the cooling effect of SAI is looked for in the temperature time series in each of these regions using total least squares multi-variate detection. Results show that surface temperature observations would be most useful for SAI detection in the Northern Hemisphere mid-latitudes, especially in East Asia. This can be used to indicate the optimal observational network for monitoring the effectiveness of SAI in the future, should that be needed.