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Global and Regional Climate Responses Solar Radiation Management: Results from a climateprediction.net Geoengineering Experiment

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To date modeling studies suggest that, while significant hydrological anomalies could result from the artificial addition of reflecting aerosols in the stratosphere for the purpose of solar radiation management (SRM), even at the regional level such a geoengineered world would bear a much closer resemblance to a low CO2 world, than to an unmodified high CO2 world. These previous modeling studies have generally compared one or two SRM forcing scenarios to various business-as-usual controls. However, such approaches cannot provide much information about regional sensitivities to the levels of SRM that might realistically result. Should engaging in SRM every be seriously contemplated, such regional analysis of a range of realistic scenarios will be an essential input to any process of geopolitical decision-making.

Here we present the results from a large-ensemble experiment that used the HadCM3L GCM, implemented through climateprediction.net. The analysis examines 135 globally-uniform stratospheric optical depth modification scenarios designed to stabilize global temperatures under SRES A1B. Scenarios were tested using ten-member subensembles which made small perturbations to initial conditions. All simulations use identical standard settings of model physics parameters and are initiated from historically-forced runs from 1920-2005. A total of 7,331 simulations of the years 2000-2080 were performed for this experiment using computing resources donated by the general public.

Our analysis of regional temperature and precipitation anomalies, normalized to account for variability, shows that SRM compensations for anthropogenic greenhouse gas forcing do generally return regional climates closer to their baseline climate states than the no-geoengineering, business-as-usual scenarios. However, we find that the magnitudes and sensitivities of regional responses to this type of activity, as modeled in HadCM3L, are highly variable. As the amount of SRM increases to compensate for rising greenhouse gas concentrations in the atmosphere, regions, such as Eastern China and India, migrate away from their baseline climate states in different ways, illustrating the impossibility of simultaneous stabilization of regional climates.

A number of policy-relevant questions about SRM activities have not yet been addressed in the literature. These include whether regional climate factors become more or less variable under SRM as compared to no-geoengineering and how long after deployment of geoengineering forcings it may be before one can determine the global and regional effects with some confidence. We present new analyses in which we exploit our large ensemble to explore several such questions.