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Simulation of how a geo-engineering intervention to restore arctic sea ice might work in practice

Piers Forster and Lawrence Jackson
School of Earth and Environment, University of Leeds, Leeds, UK (p.m.forster@leeds.ac.uk)

The declining trend in annual minimum Arctic sea ice coverage and years of more pronounced drops like 2007 and 2012 raise the prospect of an Arctic Ocean largely free of sea ice in late summer and the potential for a climate crisis or emergency. In a novel computer simulation, we treated one realisation of a climate model (HadGEM2) as the real world and tried to restore its Arctic sea ice by the rapid deployment of geo-engineering with emission of SO_2 into the Arctic stratosphere. The objective was to restore the annual minimum Arctic sea ice coverage to levels seen in the late twentieth century using as little geo-engineering as possible. We took intervention decisions as one might do in the real world: by committee, using a limited set of uncertain "observations" from our simulated world and using models and control theory to plan the best intervention strategy for the coming year - so learning as we went and being thrown off course by future volcanoes and technological breakdowns. Uncertainties in real world observations were simulated by applying noise to emerging results from the climate model. Volcanic radiative forcing of twenty-first century climate was included with the timing and magnitude of the simulated eruptions unknown by the "geo-engineers" until after the year of the eruption. Monitoring of Arctic sea ice with the option to intervene with SO_2 emissions started from 2018 and continued to 2075. Simulated SO_2 emissions were made in January-May each year at a latitude of 79o N and an altitude within the range of contemporary tanker aircraft. The magnitude of emissions was chosen annually using a model predictive control process calibrated using results from CMIP5 models (excluding HadGEM2), using the simplified climate model MAGICC and assimilation of emerging annual results from the HadGEM2 "real world". We found that doubts in the minds of the "geo-engineers" of the radiative effect of their interventions, the side effects of their past interventions, and the veracity of the models used for planning intervention were a constant feature of the simulation. As a result, their assumptions and intervention approaches were considerably revised as the simulation progressed. We also found that side effects of the geo-engineering were difficult to explicitly determine without a control experiment.