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Marine Cloud Brightening

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The idea behind the marine cloud brightening (MCB) geoengineering technique is that seeding marine stratocumulus clouds with copious quantities of roughly monodisperse sub-micrometre seawater particles, of sufficiently large salt-mass to be activated on entry to the clouds, could significantly enhance the cloud droplet number concentration, thus increasing the cloud albedo and longevity – thereby producing a cooling, which computations suggest could be adequate to balance the warming associated with a doubling of the atmospheric carbon dioxide (CO2) concentration.

We present a review of recent research into a number of critical issues associated with MCB: (1) general circulation model (GCM) studies, which are our primary tools to evaluate globally the effectiveness of MCB and to assess its impacts on rainfall amounts and distribution, as well as on polar sea-ice cover and thickness. This GCM work indicates that if the cloud condensation nucleus (CCN) seeding affects the clouds in the manner described above – an issue which requires considerable further research – a technologically feasible amount of seeding could produce sufficient globally averaged negative forcing to balance the positive forcing produced by CO2-doubling. If so, the globally averaged surface temperature and sea-ice cover at both poles could be maintained at roughly current values. GCM studies by others and ourselves indicate that the influence of MCB on rainfall amounts is very sensitive to seeding amounts and locations, an important topic which needs to be researched further: (2) high resolution modeling of the effects of seeding on marine stratocumulus, which is required to understand the complex array of interacting cloud processes involved in cloud brightening. Early results from these studies indicate that the efficacy of the seeding is very sensitive to the strategy employed: (3) microphysical parcel-modelling sensitivity studies, examining the influence of seeding amount, seed-particle salt-mass, air-mass characteristics, updraught speed and other parameters on cloud-albedo change; this work being stimulated in part by the need to ascertain the range of conditions for which spray technologies under investigation can be utilized efficaciously: (4) sea-water spray production by (a) spraying of saltwater at or near its critical temperature through simple orifices, and (b) by microfabrication lithography. In the former case, results suggest that this method will be suitable, both in terms of the particle distributions generated and the implementation of a manageable scale-up effort. It is hoped to conduct tests of the latter technique in the near future. Substantial progress has been made regarding the crucial problem of adequate filtration of the seawater from which the drops are formed: (5) computational fluid dynamics studies of air-flow around spinning Flettner rotors, in order to examine the possible occurrence of large-scale periodicities which could produce instabilities in the performance of unmanned, wind-powered Flettner vessels, which have been suggested as suitable vehicles for the dissemination of the proposed seawater aerosol: (6) planning of a three-stage limited-area field research experiment, which has the objective of developing our fundamental knowledge of marine stratocumulus clouds, testing the technology developed for the MCB geoengineering application, and ultimately, if deemed justifiable, field-testing the idea quantitatively, on a limited spatial scale, estimated to be about 100km.