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Stratospheric geoengineering with black carbon aerosols

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We used ModelE2, a general circulation model of Earth's climate developed by the NASA Goddard Institute for Space Studies, to simulate stratospheric geoengineering with black carbon aerosols. We used fixed sea surface temperatures and sea ice coverage for our simulations and ran them for ten years, averaging over the last three years of simulation. We varied the altitude of injection (lower vs. middle stratosphere), initial particle size (0.03, 0.08, and 0.15 μm), and whether the deposited black carbon modifies ground albedo. 1 Tg of black carbon aerosols injected into the stratosphere each year will cause variable surface air temperature effects, with globally averaged cooling by ~0.8^{o}C if small particles are used, ~0.4^{o}C if a high altitude of injection is used, or negligible cooling if a larger particle size (0.08 or 0.15 μm) in the lower stratosphere is used. In some cases, there are large annually averaged regional cooling effects, sometimes up to 7^{o}C, which would be catastrophic to agriculture. The aerosols cause significant stratospheric heating, often exceeding 40^{o}C, resulting in stratospheric ozone destruction and circulation changes, most notably an increase in the Northern Hemisphere winter polar jet, which forms an Arctic ozone hole and forces a positive mode of the Arctic Oscillation. The hydrologic cycle is perturbed, specifically the summer monsoon system of India, Africa, and East Asia. By the tenth year of simulation, globally averaged precipitation is reduced by ~0.25 mm/day in the high altitude case and up to 0.8 mm/day in the small radius case, although evaporation is reduced by similar amounts, resulting in a slight increase in soil moisture in many areas. Our choice of using fixed sea surface temperatures affected these results, but we are uncertain of the sign of this effect. The modification of ground albedo by the soot particles slightly perturbs the radiative budget but does not cause any distinguishable climate effects, although this is likely due to our choice of simulation using fixed sea surface temperatures and sea ice coverage.