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Moving toward a conceptual design for moderating global warming with polar shielding

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Model simulations carried out with the NCAR CAM3.1 atmospheric model coupled to a slab ocean indicate that limiting solar radiation incident on the Earth's polar regions will not only limit cooling in the high latitudes, but will cool middle and lower latitude regions by drawing heat from these regions. We have carried out model simulations in which, in each hemisphere separately and then also together, we impose reductions in solar radiation of 6% poleward of 51° latitude (equivalent to a reduction in global average solar insolation by ~0.75 W/m2), 10% poleward of 61° latitude (~0.55 W/m2), or 25% poleward of 71° latitude (~0.5 W/m2) starting from equilibrium conditions for a CO2 doubling. For comparison with the responses of a global reduction in solar radiation, an additional simulation was made with a global reduction of 1.8% (~4.1 W/m2), which roughly matches the increase in trapping of infrared radiation caused by a CO2 doubling in this model. Both the northern and southern polar shielding simulations were able to offset the warming in the regions where the reductions in solar radiation were imposed, and, not surprisingly given the relative flux reduction, exerted only a modest suppressing effect on the warming in mid-latitudes in the hemisphere of the perturbation. When the reductions in solar radiation were simultaneously imposed on both polar regions, the temperature increases in both polar regions were nearly fully offset, and the reductions in temperature change over mid-latitude land areas were roughly halved. The results for precipitation exhibited a different pattern. For the polar perturbations, as found for the Northern Hemisphere simulation by Caldeira and Wood (2008), the precipitation increases in high latitudes caused by the doubling of the CO2 concentration were only modestly reduced. At lower latitudes, the northern shielding simulation also did not significantly alter the southward shift of the ITCZ precipitation caused by the CO2 doubling, whereas the southern shielding appeared to push the ITCZ northward, thus tending to moderate the effect of the CO2 increase. Carried out together, especially when kept poleward of 61° latitude, the polar perturbations tended to generally moderate the precipitation changes induced by the CO2 doubling, although not erasing some of the regional continental dryings that have been projected. Recognizing the important shortcomings of counterbalancing human-induced climate change via an increase in the global stratospheric sulfate layer, polar perturbations appear capable of exerting a significant moderation of CO2-induced warming without fewer adverse impacts. While achieving the required levels of solar radiation reduction in high latitudes would require creation of a stratospheric or tropospheric sulfate and/or cloud or surface brightening, the solar reduction need only be created during the few sunlit months, placed either in the lower stratosphere or even in the troposphere.