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Engineering the climate with polar-only solar radiation management

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Important shortcomings of counterbalancing human-induced climate change via an increase in the global stratospheric sulfate layer include the worldwide conversion of direct to diffuse radiation and the likelihood of weakening the hydrological cycle and summer monsoons relative to the high-CO2 climate in the absence of added aerosols. We explore the potential for an alternative approach that only reduces incoming solar radiation over the polar regions. To explore this proposal, we conducted simulations with reduced solar insolation over high latitudes and over the globe using the NCAR CAM3.1 atmospheric model coupled to a slab ocean. Global and high-latitude responsiveness (i.e., climate sensitivity) were calculated, accounting for changes in meridional energy transport. Our results indicate that reductions in solar radiation over the southern high-latitudes would lead to a larger response than would globally uniform or high-northern-latitude reductions. This higher sensitivity is a result of stronger sea-ice albedo amplification and a larger increase in cloud fraction. The atmospheric response to high latitude reductions increases meridional energy transport from lower latitudes, thus extending the cooling influence to global scales without significantly affecting the global hydrological cycle or the direct flux of solar radiation to the surface. While achieving the required levels of solar radiation reduction in polar regions would require a significant sulfate loading, the aerosol layer need only be present for the sunlit months, so the injection can be into the lower stratosphere or upper troposphere and the regional extent can be relatively limited, thus likely reducing the spread of significant sulfate to mid-latitudes where the monsoon could be affected.