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Modeling of Solar Radiation Management: A comparison of simulations using reduced solar constant and stratospheric aerosols

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The climatic effects of Solar Radiation Management (SRM) geoengineering have been often modeled by simply reducing the solar constant. This is most likely valid only for space sunshades and not for atmosphere and surface based SRM methods. In this study, a global climate model is used to test if the climate response to SRM by stratospheric aerosols and uniform solar constant reduction are equivalent. Our analysis shows that when global mean warming from a doubling of CO_2 is nearly cancelled by both these methods, they are equivalent when important surface and tropospheric climate variables are considered. However, a difference of 1 K in the global mean stratospheric (61-9.8 hPa) temperature is simulated between the two SRM methods. Further, while the global mean surface diffuse radiation increases by about 15-20% and direct radiation decreases by about 8% in the case of sulphate aerosol SRM method, both direct and diffuse radiation decrease by similar fractional amounts ($\sim$ -1.5%) when solar constant is reduced. Though the contribution from shaded leaves to gross primary productivity (GPP) increases by 6% in aerosol SRM because of increased diffuse light this increase is almost offset by a 7% decline in sunlit contribution due to reduced direct light. Hence, in the aerosol SRM there is a slight net reduction ($\sim$ 1%) in total GPP which is close to the decrease due to solar constant reduction. Based on our results we conclude that the climate states produced by a reduction in solar constant and addition of aerosols into the stratosphere can be considered almost equivalent except for two important aspects: stratospheric temperature change and the partitioning of direct versus diffuse radiation reaching the surface.