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Supporting Information for:

Potential ecological impacts of climate intervention by reflecting sunlight to cool Earth

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Fig. S1. Appendix S1.

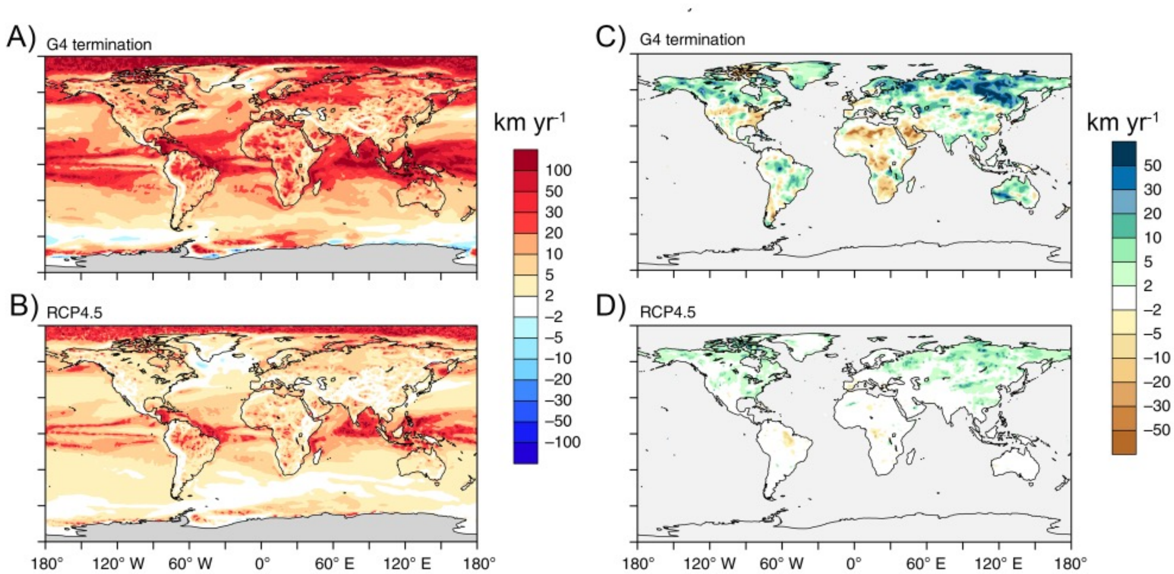

Fig. S1: Climate velocities differ between implementing vs. not implementing an SAI scenario, during an intermediate climate change scenario. Climate velocities indicate the speed and direction that organisms or systems would have to move to remain in the same climate envelope. Assuming an intermediate climate change scenario (RCP4.5 (representative concentration pathway, with a radiative forcing of 4.5 W m^{-2} in the year 2100 (1), temperature velocity (A, B) and precipitation velocity (C, D) are shown for two cases: implementing the SAI G4 scenario with sudden termination ('G4 termination'; (2)), and not implementing SAI. The change in sign between termination of SAI G4 and a future with RCP4.5 indicates a 180^{o} change in the direction that climate moves. Positive values indicate a warmer climate and a need to move poleward or higher in elevation (A,B), or a wetter climate and a need to move to a drier site (C,D). Negative values indicate a cooler climate and a need to move towards the tropics or lower in elevation (A,B), or a drier climate and a need to move to wetter sites (C,D). The termination of SAI can cause dramatically different temperature and precipitation velocities when compared with future projected climate change scenarios. For example, in many parts of the world, climate intervention termination in the SAI G4 scenario (2) would result in larger velocities in (A) temperature and (C) precipitation than velocities in (B) temperature and (D) precipitation of the RCP4.5 scenario. Adapted from Figure 3 of (3).

Appendix S1. How SAI might affect ecosystem processes other that primary productivity

Much of the uncertainty about the ecological effects of SAI is rooted in key differences between the ways that GHGs and SAI affect climate, the disconnect between temperature and CO_2 that SAI would produce, and the effects that this would have on hydrologic and biogeochemical processes. The effects of SAI on radiation input (4, 5), acid precipitation (6) and air quality (7) would form the platform for ecological impact analysis. Although these basic mechanistic effects have begun to be addressed, they have not been well explored or considered in SAI models that will potentially be used for making decisions about implementation.

Some of the potential consequences of different SAI scenarios for ecosystem processes are better understood than others. We would expect that additional sulfuric acid deposition from some SAI scenarios could negatively impact particular ecosystems by increasing acid precipitation, although this effect might be small, as deposition from SAI would be a small fraction of surface deposition from anthropogenic sources (8, 9). Given the buffering capacity of many soils, the additional deposition is unlikely to overcome the critical load for most regions (6). In particularly vulnerable soils, however, it could potentially induce aluminum dissolution, resulting in increased toxicity (10), both for soils that are currently less affected and for areas where the potential buffering capacity of soils has been depleted in the past due to high levels of sulfate deposition. Freshwater systems could also potentially experience acidification both from CO_2 emissions and from acid precipitation, which would aggravate the effects of current anthropogenic sources like tropospheric SO_2 (11, 12). With increased acidification, freshwater systems are expected to decline in acid-neutralizing capacity and may experience shifts in food webs, especially declines in taxa at lower trophic levels (13). There is a long history of assessment and management of atmospheric sulfur, acid precipitation and ozone that provides a basis for assessing the effects of SAI (6, 14), but the effects would depend on the SAI scenario and the amount of sulfate deposition that results.

Under current and future anthropogenic climate change, global vegetation growth is thought to be constrained by increasing atmospheric vapor pressure deficit (VPD; (15, 16)). The reason VPD has increased globally is because warmer temperatures have increased saturated water vapor pressure, while actual water vapor pressure has decreased due to recent changes in oceanic evaporation (15). Together, SAI-induced cooling, altered global precipitation regimes, changes in global VPD, UV, and diffuse radiation, along with persistently high CO_2, would create novel conditions that would affect biogeochemical processes and productivity in unpredictable ways.

In addition to CO_2, biological processes produce and consume other greenhouse gases (methane, nitrous oxide), and SAI-induced cooling will affect the dynamics of these gases (17). Consequences of potential changes in the diurnal cycle on soil microbial processes are unknown and require further research but are also expected to vary with the SAI scenario and specific ecosystem. It is possible that the limited cooling at night resulting from SAI would keep soil microbial respiration high, increasing decomposition and the cycling of the brown food web, and adding to atmospheric CO_2 (18).

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