Climate response to Pulse versus Sustained Stratospheric Aerosol Forcing

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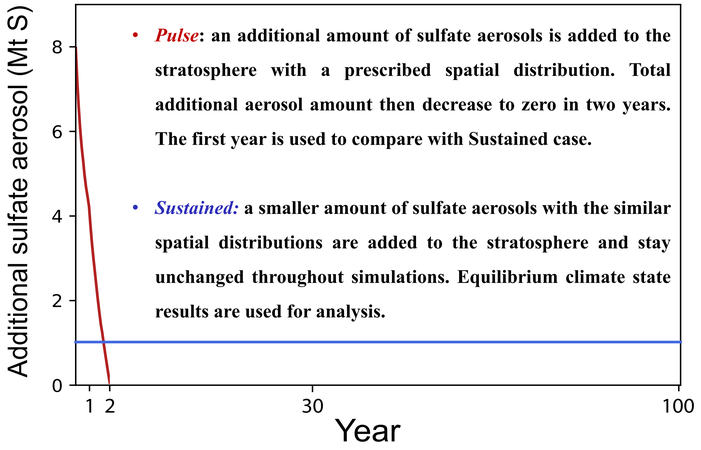
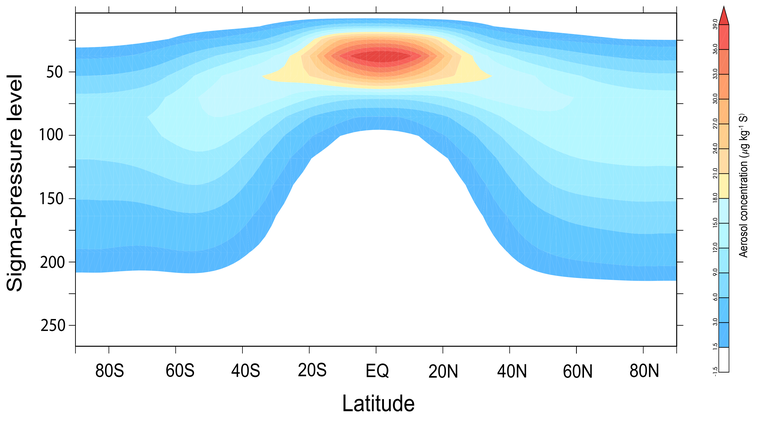
Key Points

- We used NCAR CESM to simulate the climate impact of a volcanic-like pulse and a geoengineering-like sustained stratospheric sulfate aerosol forcing
- For the same global mean cooling, decrease in land temperature, precipitation, and runoff is much larger under the pulse forcing
- Different timescales of aerosol forcing related to volcanic eruptions and geoengineering would produce quite different climate outcomes

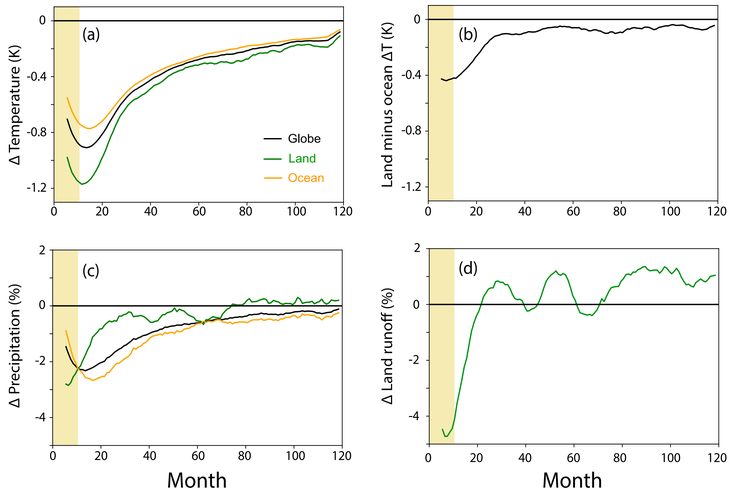
Stratospheric sulfate aerosol forcing



- *Pulse*: an additional amount of sulfate aerosols is added to the stratosphere with a prescribed spatial distribution. Total additional aerosol amount then decrease to zero in two years. The first year is used to compare with Sustained case.
- *Sustained:* a smaller amount of sulfate aerosols with the similar spatial distributions are added to the stratosphere and stay unchanged throughout simulations. Equilibrium climate state results are used for analysis.

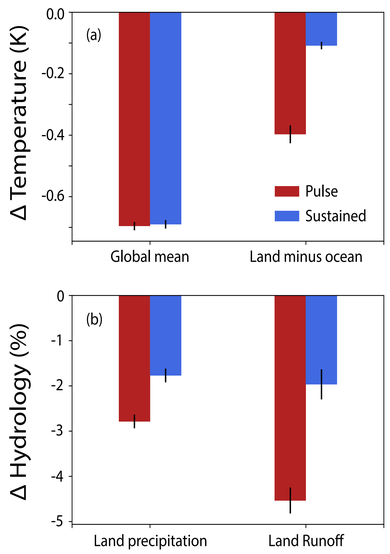


Time series responses



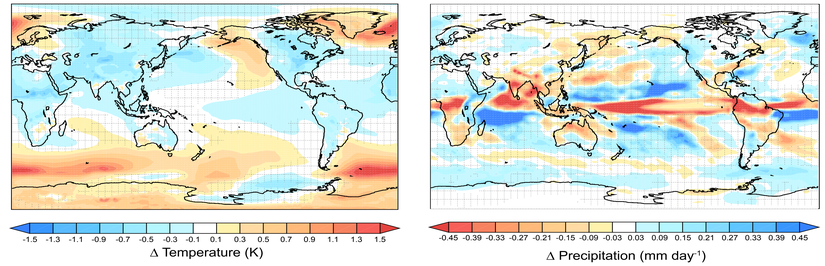
- For the *Pulse* case, the land cools much quicker than the ocean leading to a large land-sea temperature difference;
- Difference in surface cooling in these cases would lead to different hydrological cycle response and thus the land precipitation and runoff.

Global and land mean responses

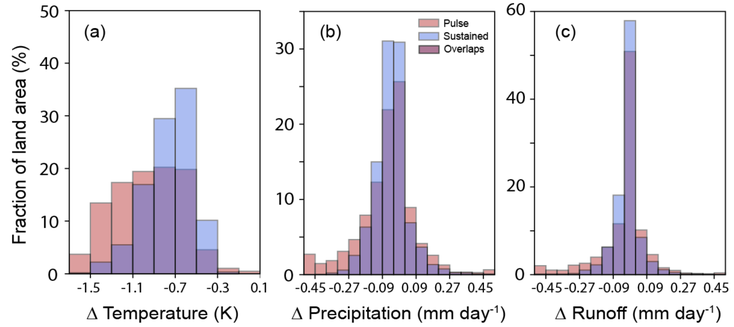


- When producing similar global mean surface temperature change, the land cools more in the *Pulse* case which leads to a larger land-sea surface temperature difference;
- Compared to *Pulse*, precipitation and surface runoff over land decreases less in the *Sustained* case. Decrease in runoff over land, which represents the water resource availability, is two times larger in the *Pulse* case than that in the *Sustained* case.

Spatial pattern of *Pulse* minus *Sustained*



- When producing the similar global mean temperature change, the *Pulse* case leads to more cooling over land and less cooling over the ocean compared to the *Sustained* case;
- The precipitation response is difference over both land and ocean for these cases, which is related to more cooling over land in the *Pulse* case and different land-sea temperature change contrast.



- For the similar global mean temperature change, more grid cells in the *Pulse* case have extreme temperature, precipitation, and runoff changes over the land;

Main conclusions

- Relative to the *Sustained* case, the *Pulse* case has much larger reductions in surface temperature over land, leading to a larger decrease in the upward motion of air over land in lower atmosphere, and reduces water vapor transport from the ocean to land.
- For similar amounts of cooling, the decrease in land runoff caused by a short-term pulse aerosol forcing is about twice as large as that caused by a sustained aerosol forcing.
- We demonstrate difference in the climate response to volcanic-like and geoengineering-like stratospheric aerosol forcings, and suggest that cares should be taken when extrapolating results from volcanic eruptions to the aerosol geoengineering deployments.

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