Brightening Clouds with Stratospheric Aerosols

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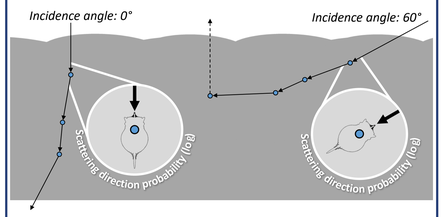
Motivation

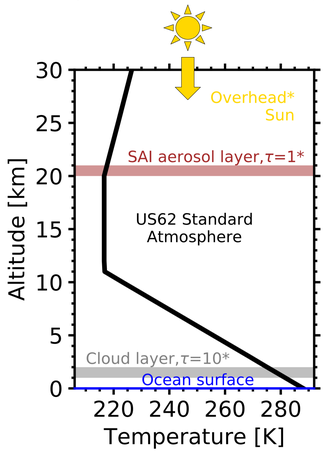
- Emission reductions alone are unlikely to limit global warming to 1.5°C or 2°C (Paris Agreement).
- Climate intervention approaches are gaining increased attention but need to be better understood.
- One potential approach – SAI – would diffuse the radiation field, thereby changing the angle that sunlight enters clouds (below).



- **Cloud brightness depends on the angle that sunlight enters: how important is this effect?**

Method

- A radiative transfer model – SBDART – is run with and without stratospheric aerosol (below).



*sensitivity shown in publication.

- Aerosol model: "fresh volcanic".

Key Points

#1

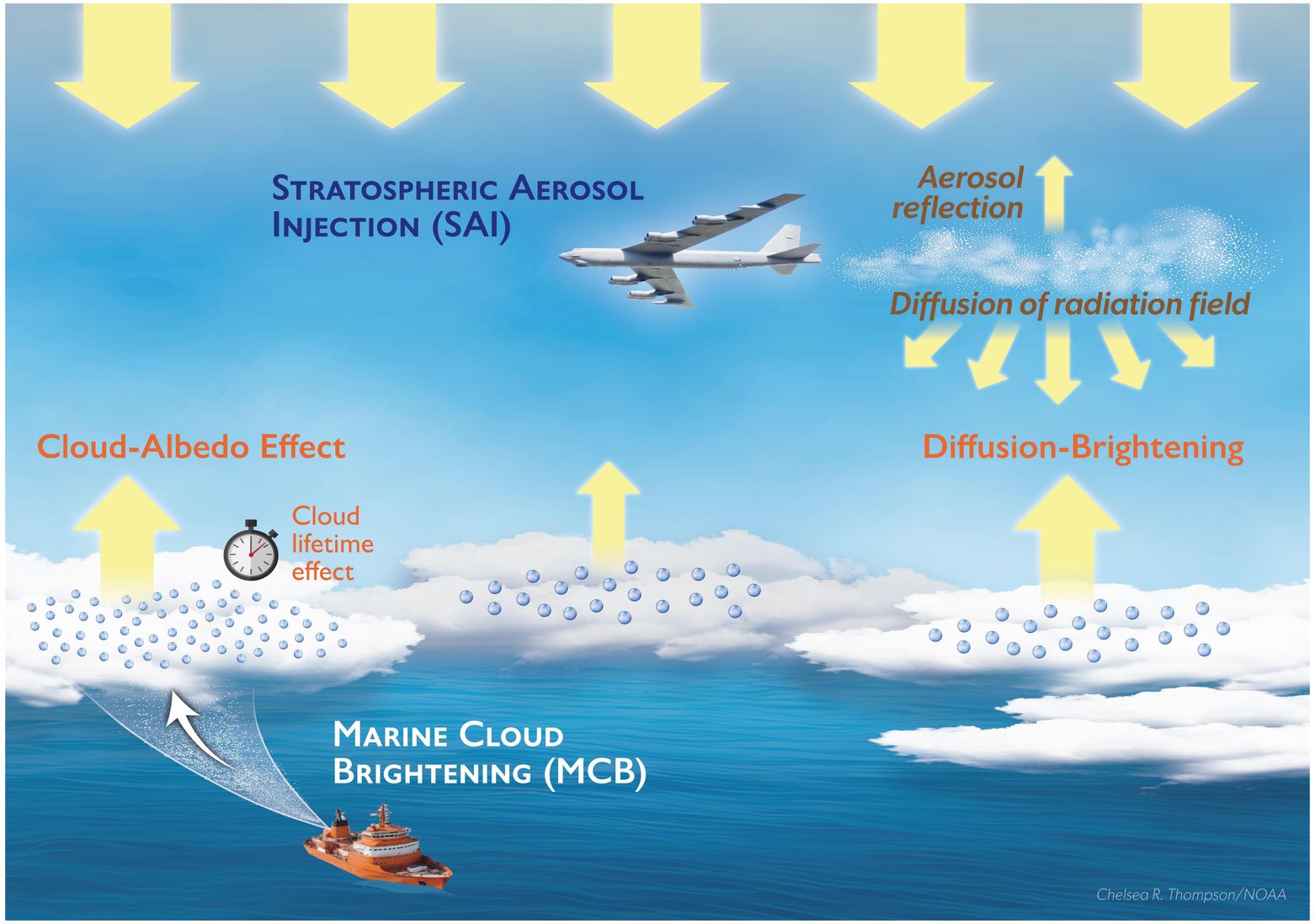
Diffusion of sunlight by stratospheric aerosols can increase cloud albedo by as much as 10% without changing the cloud properties.

#2

The overall cooling effect of SAI would be dominated by inadvertent cloud brightening at many locations and times.

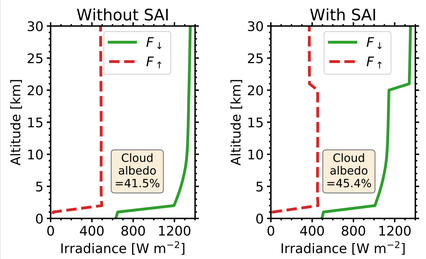
#3

This diffusion-brightening effect has important implications for solar radiation management.

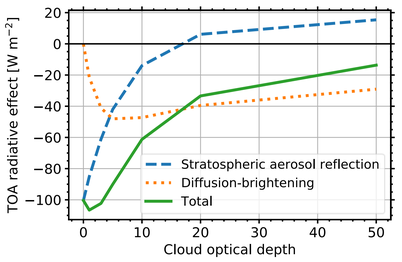


Results

- Cloud albedo increased by ~10% in the idealized SAI scenario (below).



- The overall top-of-atmosphere radiative effect of SAI would be dominated by cloud brightening for cloud optical depths above ~4 (below).



- Since clouds cover around two-thirds of the Earth, and 80% of daytime clouds have optical depths above 3, cloud brightening caused by SAI could be substantial.

References

- Gristey J. J. and G. Feingold (2025): Stratospheric Aerosol Injection Would Change Cloud Brightness. *Geophys. Res. Lett.*, doi.org/10.1029/2024GL113914

Published study:

CIRES profile: