# **Can we cool the Arctic?**

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# NULLUNIVER CONTROLOGY

# **Solar Radiation Modification**

- Reflecting sunlight would cool the climate
- Two questions:
  - High-latitude impacts of SRM applied globally?
  - Can one specifically target high latitudes?



Marine cloud brightening (MCB)

Cirrus cloud Thinning (CCT)

7.2

5.4

3.6

·1.8



# Can we cool the Arctic? Yes, but...

- CO<sub>2</sub> and other greenhouse gases warm the climate
  - Loss of Arctic sea ice, permafrost thaw, Greenland melt, have both local and global implications

Climate Impacts

- Reducing emissions to zero stops the problem from getting worse... (?)
- "Negative" emissions technologies give a long-term solution, but slow
- There is one "fast" option: it is possible to deliberately reflect sunlight
  - Could be "global" or Arctic-focused
  - There is no technology barrier for Arctic-focused
  - We know it would cool
  - We don't know the details
  - Can focus in the Arctic but the effects would still be global
- There is no "ideal" solution. We may need a portfolio of options





#### ARTICLE

https://doi.org/10.1038/s41467-020-16357-8 OPEN

Mitigation of Arctic permafrost carbon loss through stratospheric aerosol geoengineering

Yating Chen₀<sup>1</sup>, Aobo Liu₀<sup>1</sup> & John C. Moore<sup>1,2,3 ⊠</sup>

 Permafrost carbon release roughly halved for GeoMIP scenario G4 compared with RCP4.5

Check for updates

- 5 Tg SO<sub>2</sub>/yr
- Equatorial injection





### **Geophysical Research Letters**

#### **RESEARCH LETTER** 10.1029/2019GL085758

#### Key Points:

- We use a large ensemble of simulations to explore high-latitude climate seasonal shifts under stratospheric aerosol geoengineering
- Stratospheric aerosol geoengineering would alter seasonal cycle of temperature, snow depth, and sea ice at high latitudes

#### Stratospheric Sulfate Aerosol Geoengineering Could Alter the High-Latitude Seasonal Cycle

Jiu Jiang<sup>1</sup>, Long Cao<sup>1</sup>, Douglas G. MacMartin<sup>2</sup>, Isla R. Simpson<sup>3</sup>, Ben Kravitz<sup>4,5</sup>, Wei Cheng<sup>2</sup>, Daniele Visioni<sup>2</sup>, Simone Tilmes<sup>6</sup>, Jadwiga H. Richter<sup>3</sup>, and Michael J. Mills<sup>6</sup>

- Analysis of the Geoengineering Large Ensemble (GLENS; Tilmes et al 2018)
  - Injection at 30°S, 15°S, 15°N, 30°N, designed to keep global mean temperature and high-latitude temperature constant under RCP8.5 (requires much more than 5 Tg SO<sub>2</sub>/yr)
  - Only looked at soil temperature





## **Stratospheric Aerosols at high latitude**

- Nearly all research has been into "global" strategies
  - Requires new aircraft to reach >20km altitude (and ~\$5B, 5 years)
- The tropopause is much lower at high latitude
  - Could use existing aircraft
- Only need to add aerosols in spring
  - Broad cooling at high latitudes
  - Quick
- This could be done...
- This may be the only option to quickly stop permafrost thaw



Lee, MacMartin, Visioni and Kravitz (in review)



## How would SRM affect the Arctic?

- Reduce incoming sunlight  $\rightarrow$  cools the climate  $\rightarrow$  increase sea ice  $\sim$  tent, etc.
- With Arctic-only SRM, changes in heat transport  $\rightarrow$  effects  $\rightarrow$  1 titudes
- Changes to precipitation patterns and clouds
  - While sign of effect on Greenland ice sheet is clear, de
- Changes to seasonal cycle; relative to no construction of the seasonal cycle; relative to no cycle; relative to no construction of the seasonal cycle; relative to no cycle; relativ
  - Could influence snow depth, insur
- Changes to ocean circula
- SAI: Depositive for the state of the second state of the second
- Possible surp



### **Summary**

- "We" may need to think about all of the options...
  - Some form of SRM is likely the *only* way to quickly reduce temperatures
- We should do the research *before* we get to a point where we are facing hard choices
- The hardest part will be how to decide...
  - Whose voices are heard?
  - How confident do we need to be?