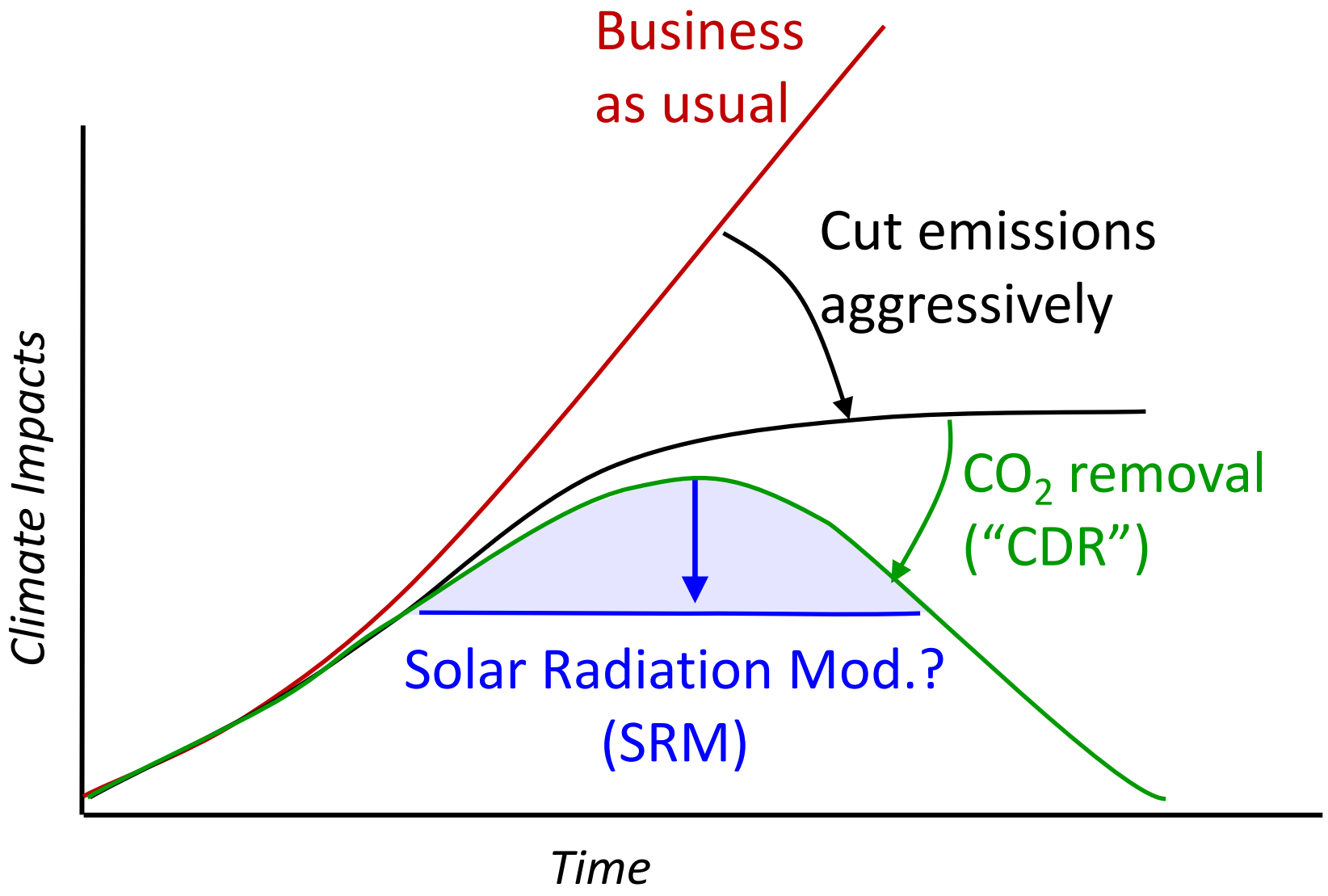
Climate-altering approaches & the Arctic: Carbon-dioxide removal (CDR) & Solar Radiation Modification (SRM)

Douglas MacMartin
Mechanical & Aerospace Engineering,
Cornell University

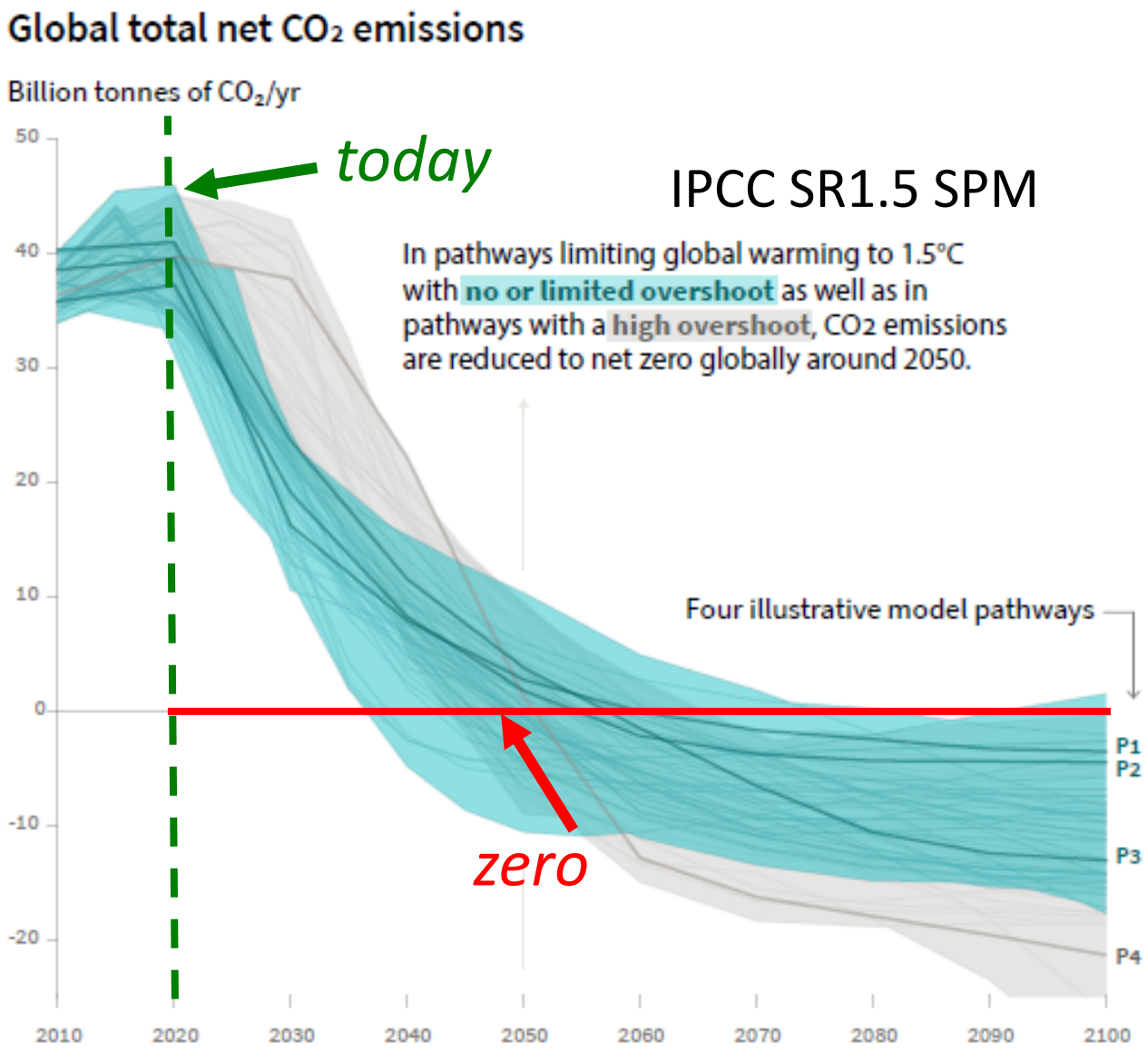
What is the role for CDR & SRM?



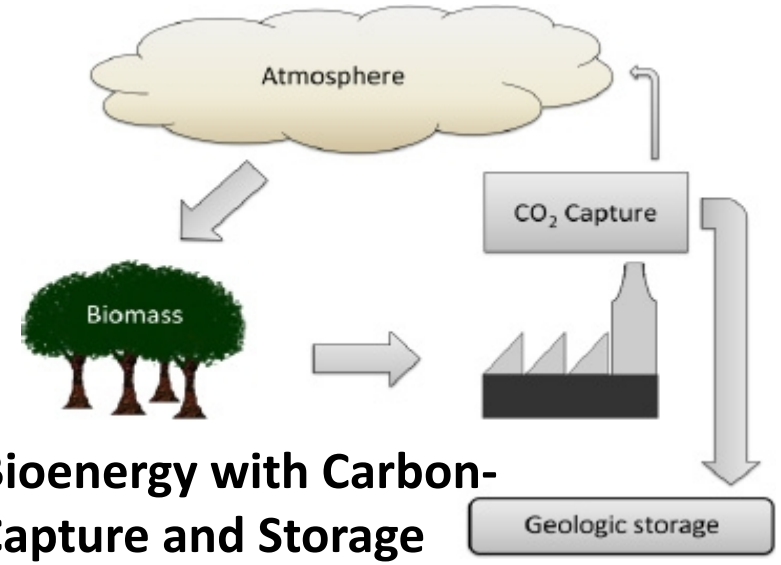
1.5°C and CO_2 removal

- To stay below 1.5°C, need to rapidly ramp down CO_2… ***and then go negative***

- Lots of ideas for how, but
  - Typically either
    - Expensive
    - Hard to scale
    - Significant local impacts



Carbon dioxide removal (CDR)



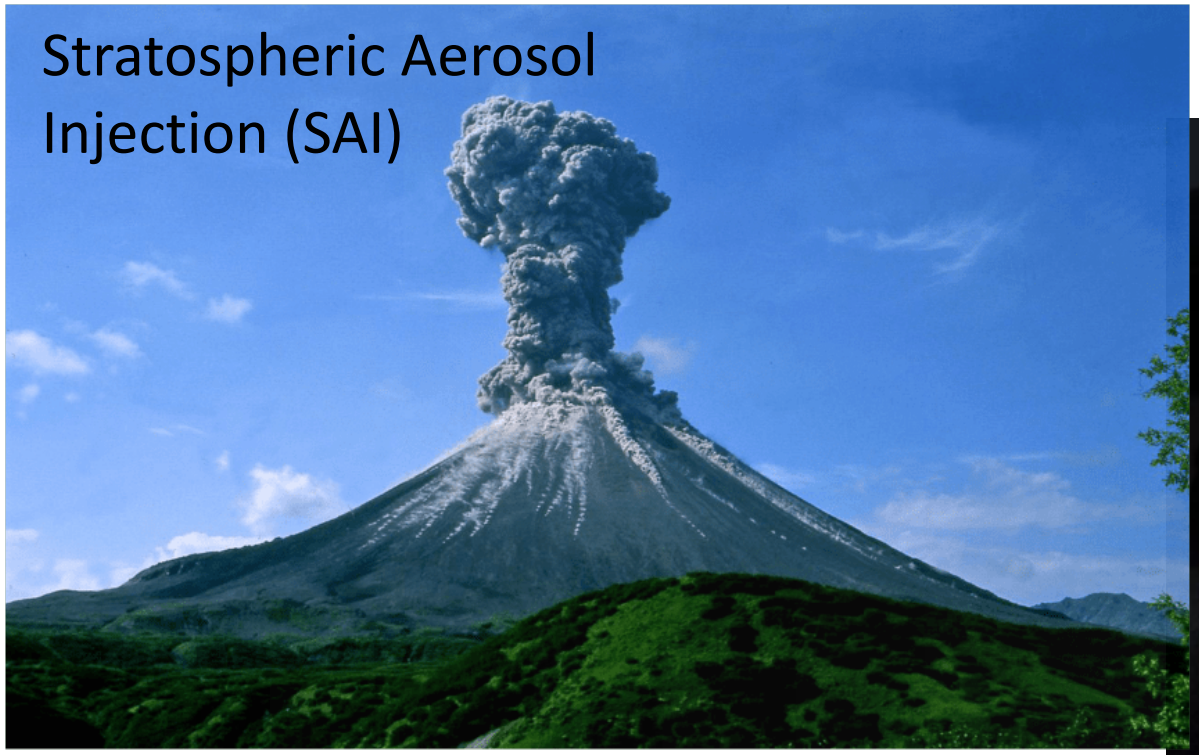
Bioenergy with Carbon-Capture and Storage ("BECCS")

- Ocean iron fertilization
- Enhanced weathering
- Sequestration in soils (e.g., biochar)
- Etc…

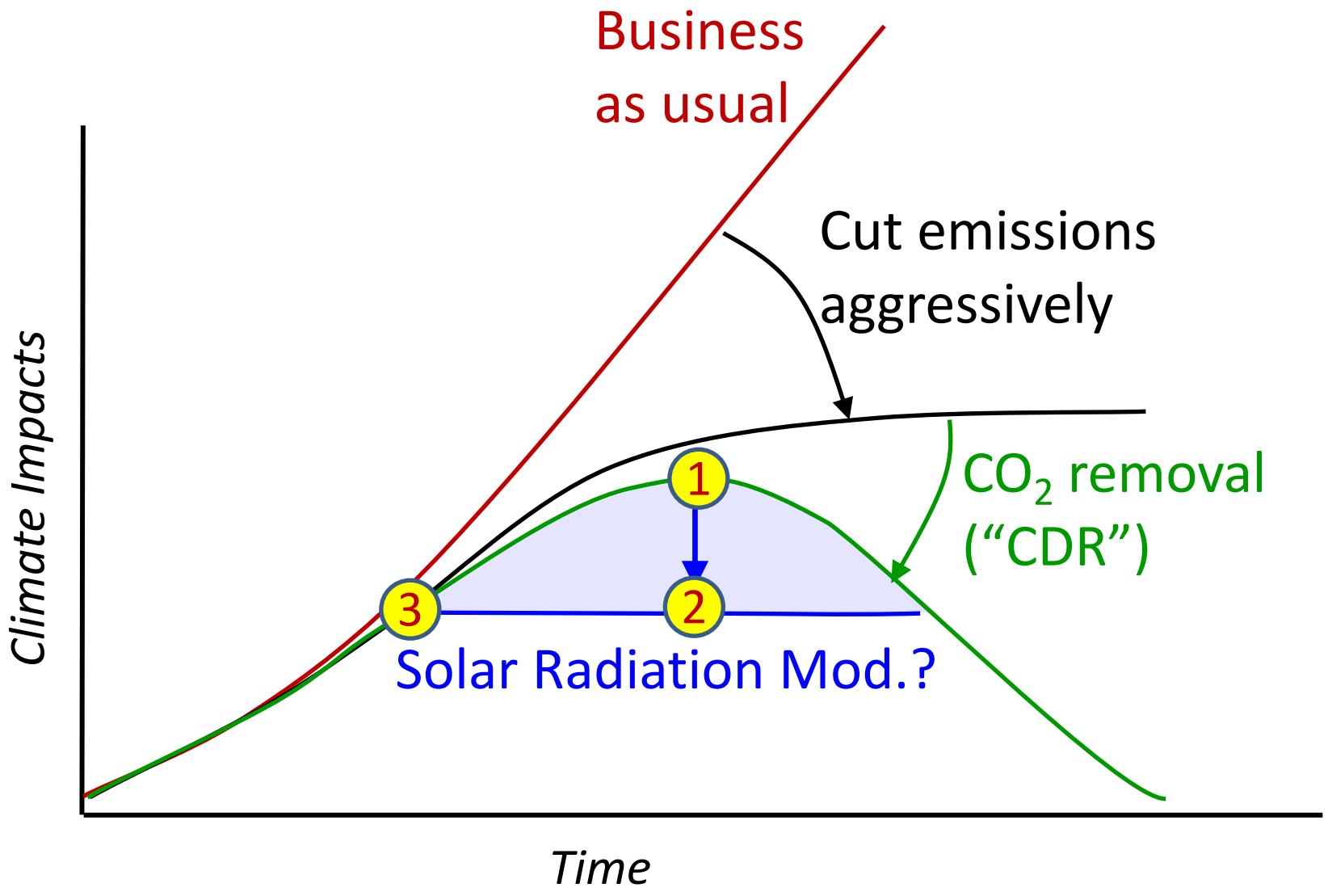
- Doesn't matter where the CDR is done
- For most, not likely to take place in the Arctic
- **Relevant question on reversibility?**

Solar Radiation Modification

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



What is the role for CDR & SRM?



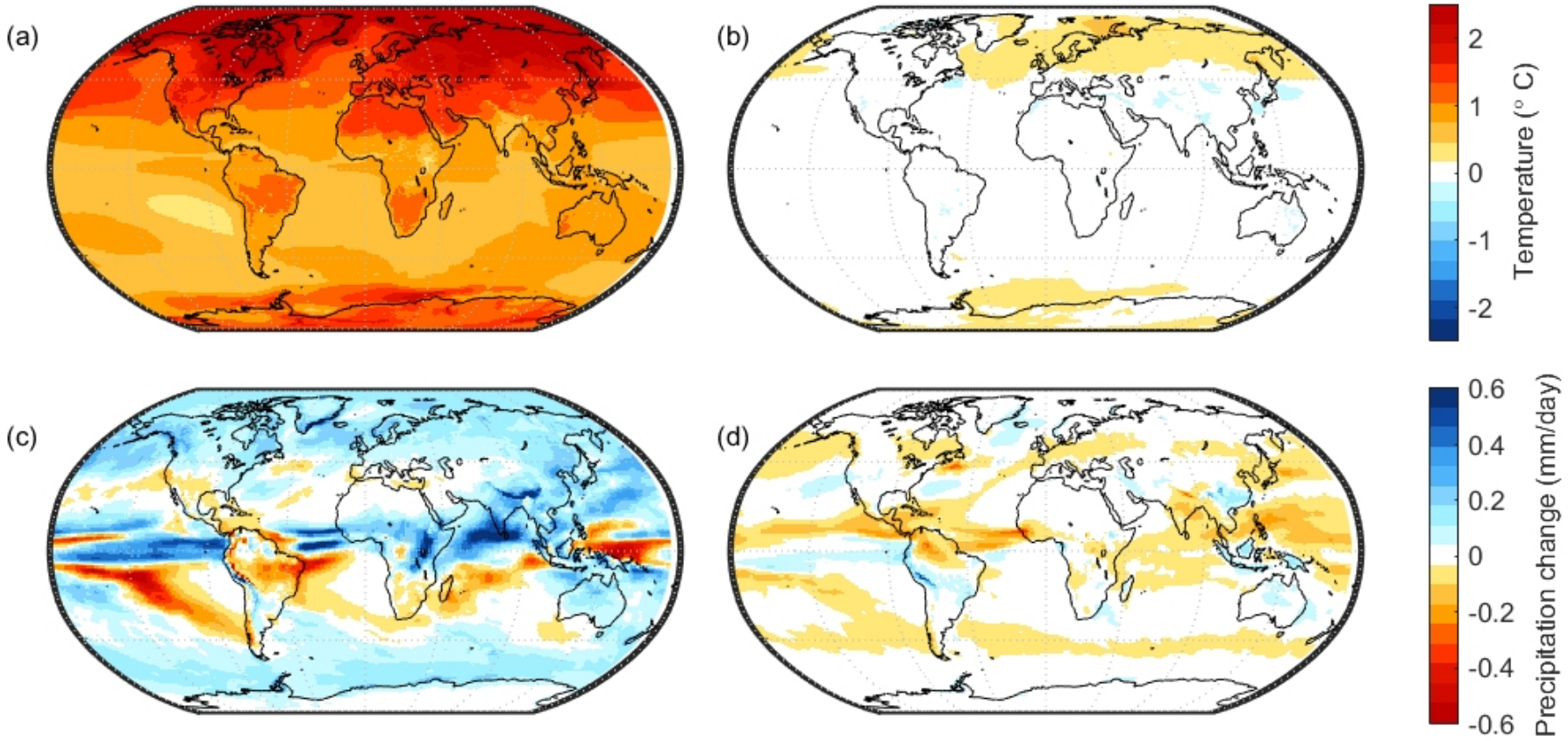
Climate Model Simulations (of global SAI)

1° warming from CO_2

1° warming from CO_2
offset by
1° cooling from strat. aer.

Temperature (per degree)

Precipitation (per degree)



MacMartin et al, JGR 2019

How would SRM affect the Arctic?

- Reduce incoming sunlight → cools the climate → increase sea ice extent, etc.
- With Arctic-only SRM, changes in heat transport → effects at lower latitudes
- Changes to precipitation patterns and clouds
  - While sign of effect on Greenland ice sheet is clear, details aren't
- Changes to seasonal cycle; relative to no CO_2 and no SRM, t[illegible] mer winter and cooler summer (probably irrelevant comp[illegible] $_2$ only)
  - Could influence snow depth, insulation over permafro[illegible]
- Changes to ocean circulation
- SAI: Ozone loss (with sulfate aeroso[illegible]
- SAI: Deposition – overall qua[illegible] compared with industrial pollution, but industrial pollution falls not i[illegible]ere it is emitted
- Possible surprises?

NEEDS MORE RESEARCH!

Governance

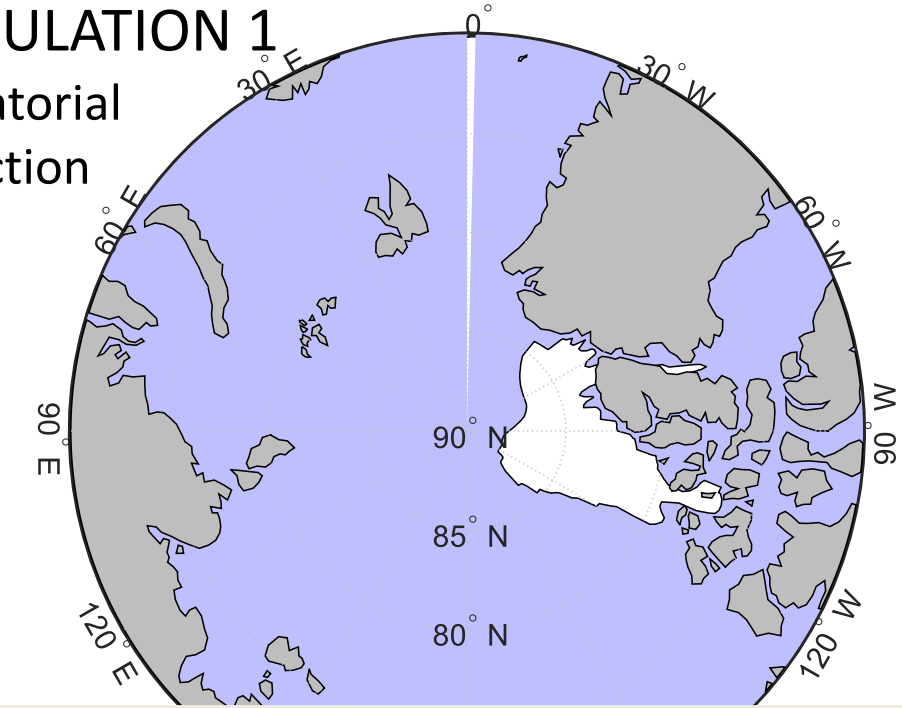
- A “globally-focused” strategy (with SAI, MCB) introduces a number of concerns
  - Who decides; whose voices are at the table
  - What happens if some people or places are harmed
  - How do you ensure that this isn’t taken as an excuse not to mitigate
  - How do you manage deployment for centuries
- Arctic-focused strategies share some of these concerns
  - Potential for action by a small set of nations / actors
  - Technically feasible: Arctic-focused SAI, for example could be deployed almost immediately
    - We don’t have the scientific research to inform responsible decisions
    - We don’t have the capacity to make responsible decisions

- CDR: ensure Arctic impacts are considered

SAI is *not* "one thing": Impacts depend on how it is deployed

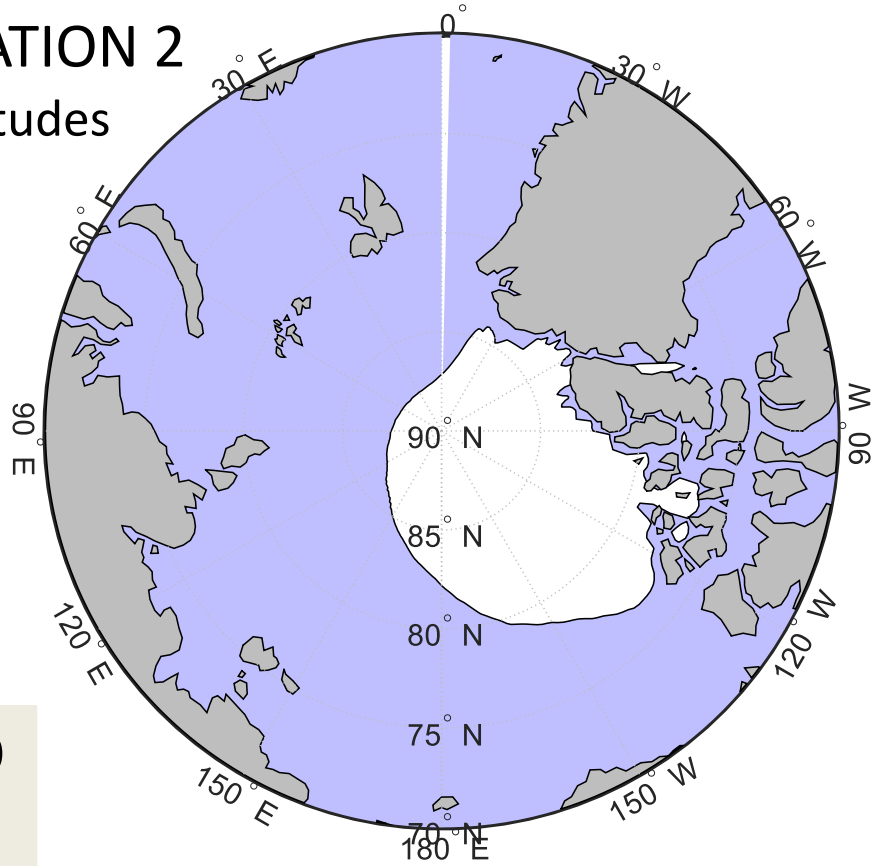
SIMULATION 1

Equatorial Injection



SIMULATION 2

Four-latitudes Injection



SEPTEMBER ARCTIC SEA ICE (75% extent) UNDER TWO STRATOSPHERIC AEROSOL INJECTION STRATEGIES

- This makes it hard to talk about "the" impacts of SAI
- Decisions aren't just yes/no

Questions

- How confident do we need to be?
  - Some uncertainty will not be resolvable
- Who gets to decide?
  - Everyone is affected… whose voices are at the table?
- What happens if some people/places are harmed?
  - Or are perceived to be harmed?
- How do you ensure that this isn't taken as an excuse not to mitigate?
- How do you manage deployment for centuries?
  - Without any interruption…