

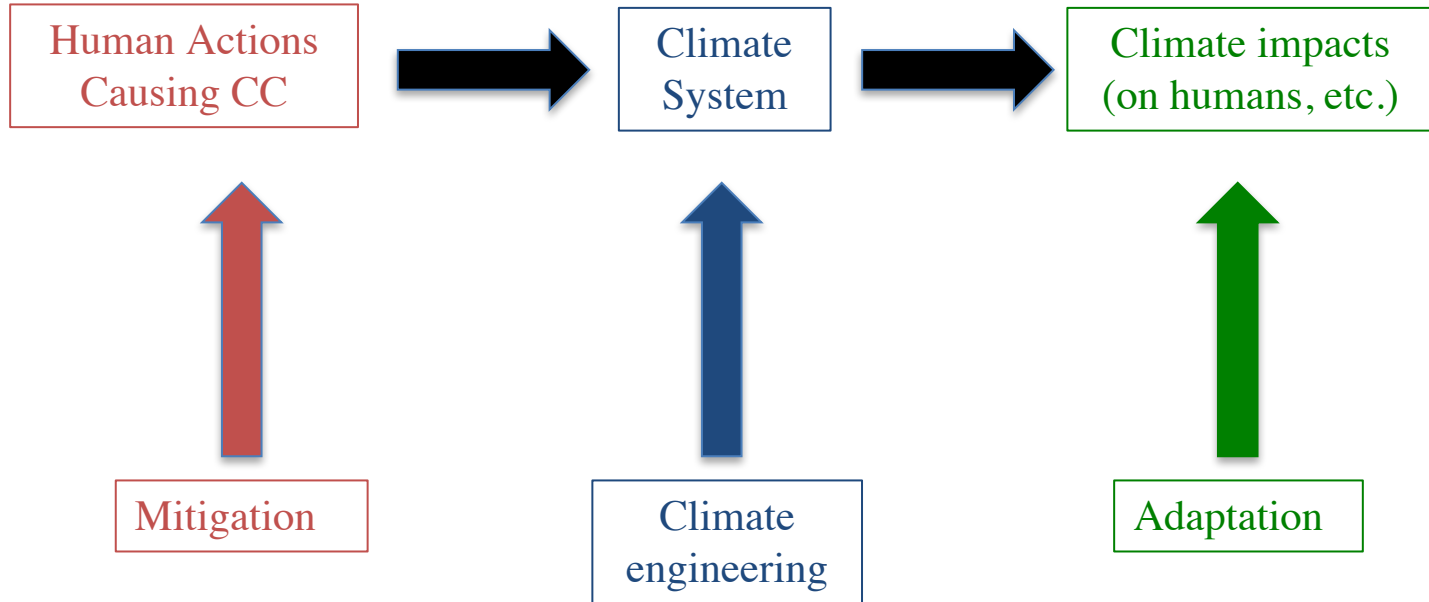
A Strategy for the Use of Solar Climate Engineering

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Rossow Symposium



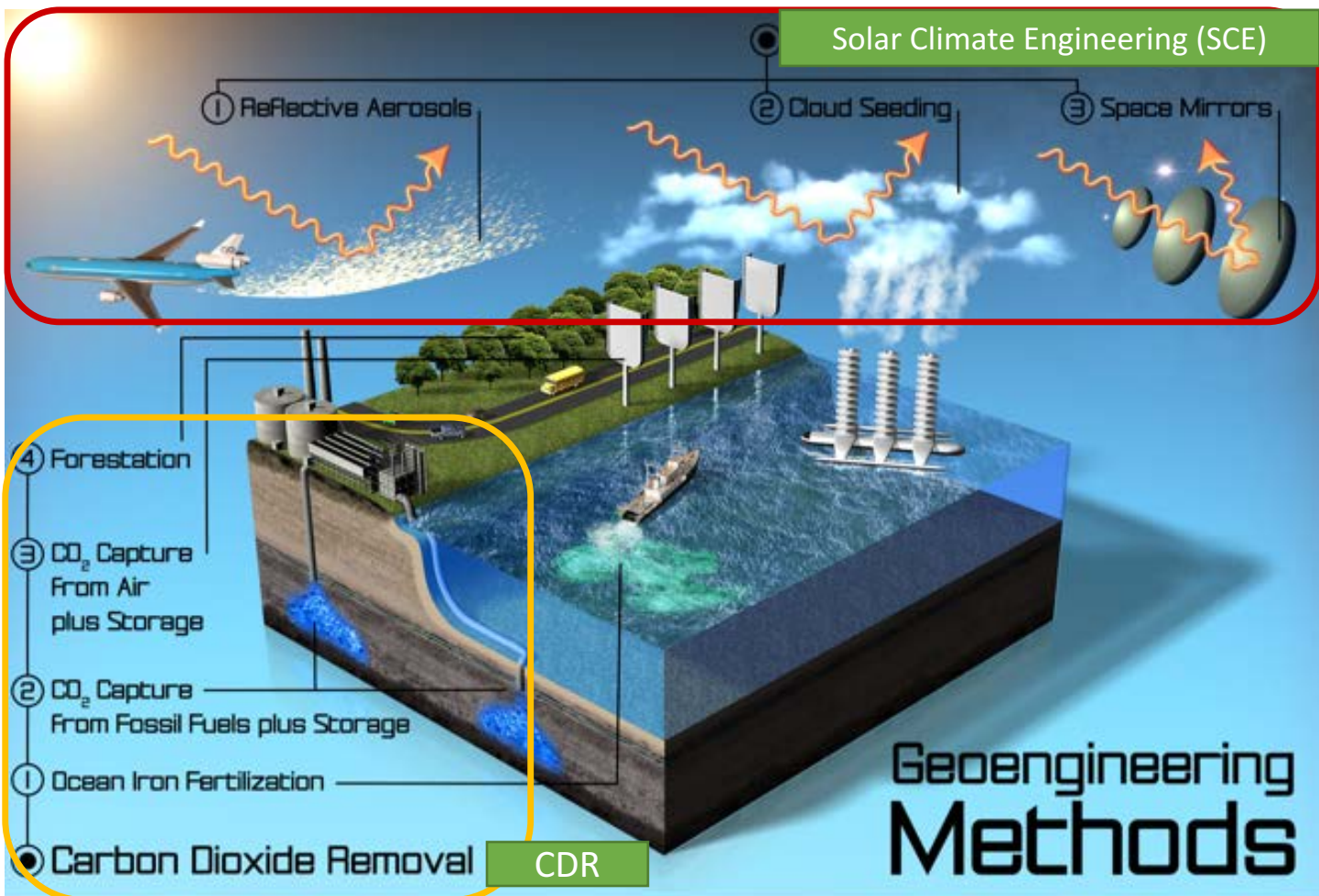
Addressing the climate change problem



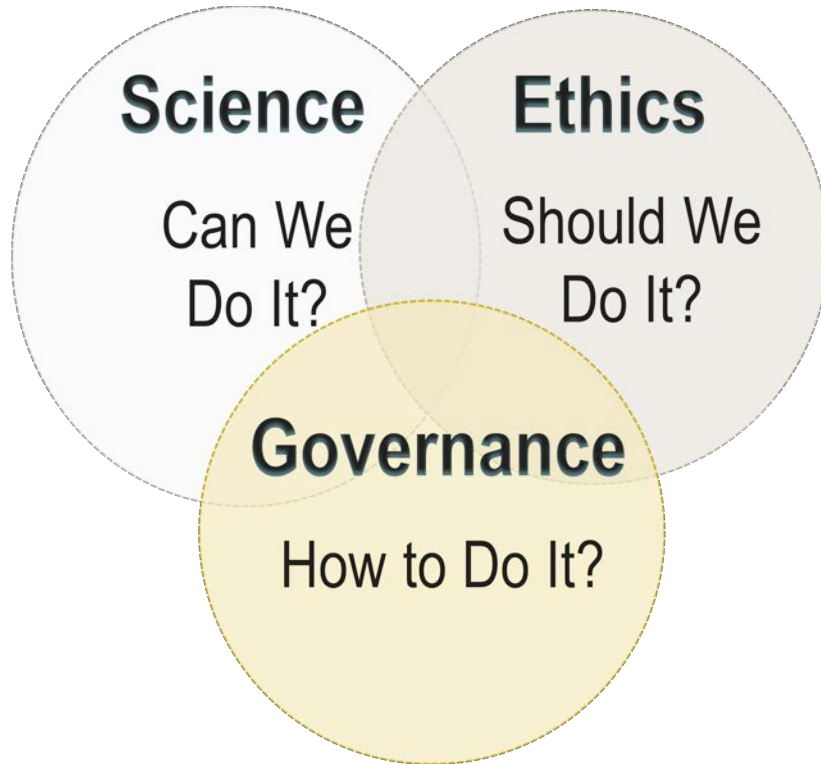
Climate engineering

- Deliberate modification of climate system to prevent global warming
- Two approaches
 - Carbon dioxide removal (CDR)
 - Solar climate engineering (SCE)
- Why would we think about doing this?
 - Limit (temporarily) warming due to increasing CO₂

Solar Climate Engineering (SCE)



Framing the climate engineering problem



UW (and partners) Research Program

Science

- Global models: is there a useful way to think about using SCE?
- Marine Cloud Brightening: how would you cool a planet?

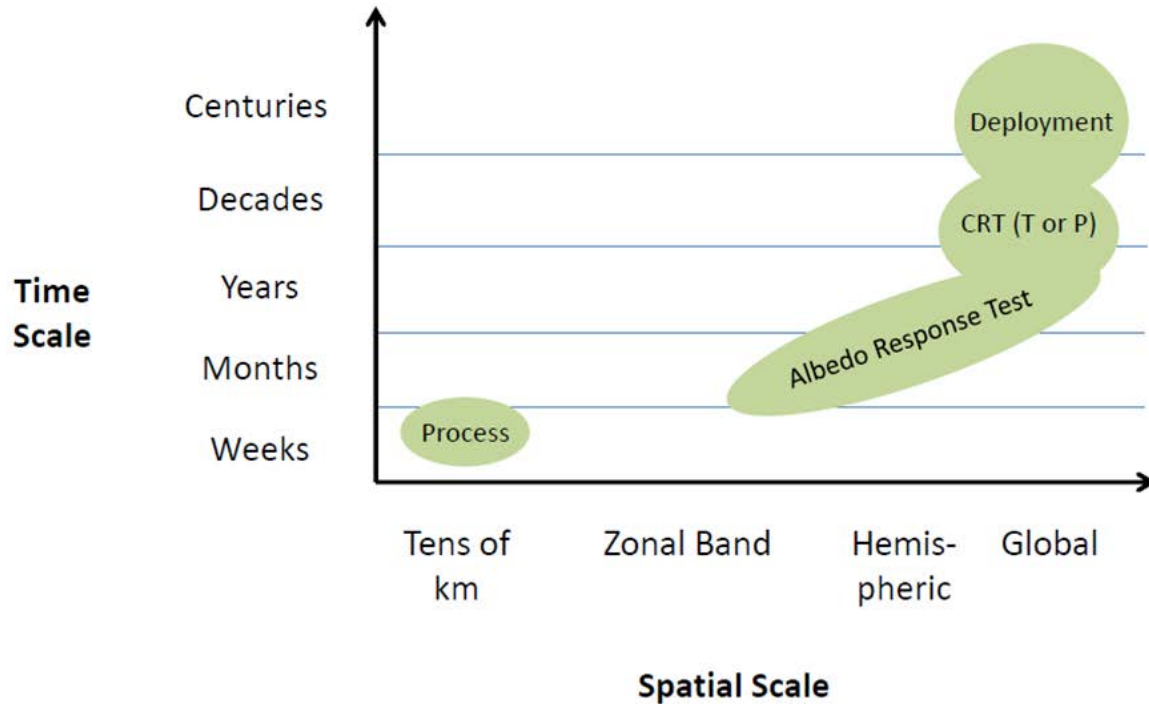
Ethics

- Is SCE research ethically defensible?
How does it differ ethically from deployment?

Governance

- How do you govern (regulate?) SCE?
What are the national and international considerations?

Focus of this talk: deployment



BUT
Responsible deployment
is 20 years away at best

What will the future look like?

One possible view

- Assume that CDR will be available in the future
 - CO₂ concentrations increase for now (next 50 to 75 years)
 - Then emissions go to zero and then we start removing CO₂
- Will use SCE to reduce the radiative forcing of CO₂
 - Reduce amount of solar radiation to compensate for CO₂ global warming until CO₂ concentrations can be reduced
- What would climate look like under these assumptions?

Model

- CESM v1.2.0
- Fully coupled atmosphere-ocean GCM
- 2° horizontal resolution
- Runs all initiated from same 20th century historical run
- 200 year runs: 2000 - 2200

Forcing Scenarios

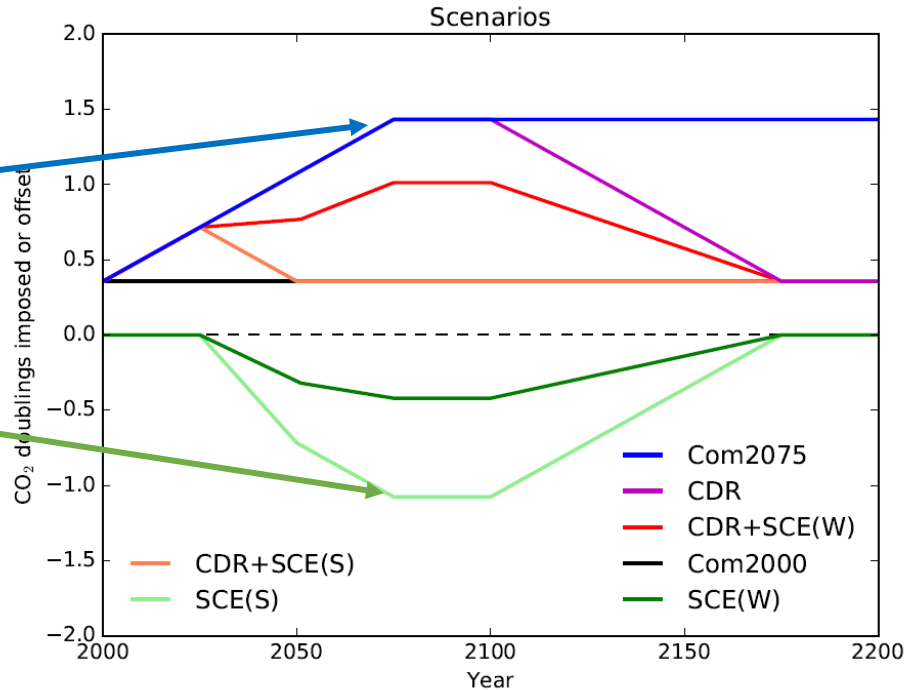
| Run name | CO2 forcing | Solar forcing | Rationale |
|------------|---|--|---|
| Com2000 | Constant at 2000 concentration | None | Control case |
| Com2075 | Increase at 1%/year until 2075, then constant | None | Global warming with no climate engineering |
| CDR | Same as Com2075 until 2100, decrease at 1%/year until 2175, then constant | None | Study reversibility of climate system; isolate effects of SCE in other runs |
| CDR+SCE(S) | Same as CDR run | Ramp up from 2025 to 2075, ramp down to zero from 2100 to 2175 | Maintain global mean temperature at ~2000 levels |
| CDR+SCE(W) | Same as CDR run | Same as CDR+SCE(S) but ~60% weaker | Intermediate SCE case |

Forcing scenarios

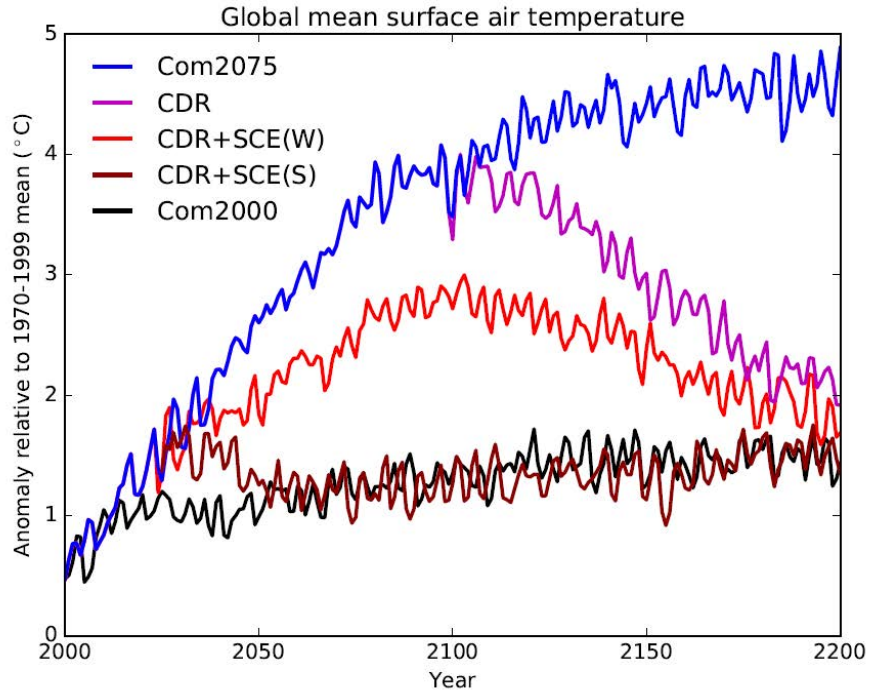
Max. CO₂ concentration
= 778 ppm

Max. solar reduction =
2.5% (Strong case)

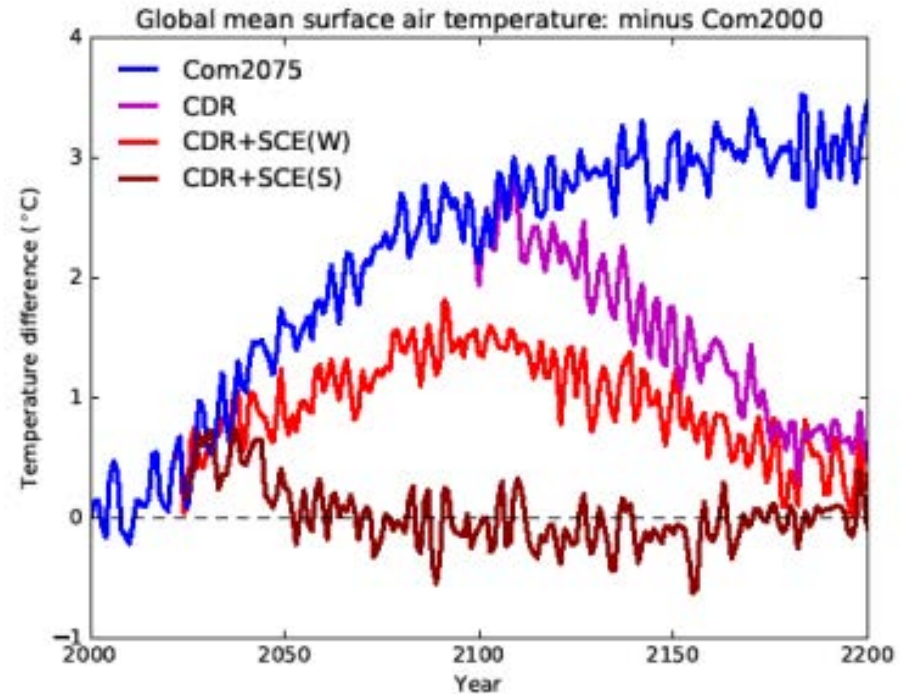
Max. solar reduction =
1.0% (Weak case)



Global mean temperature



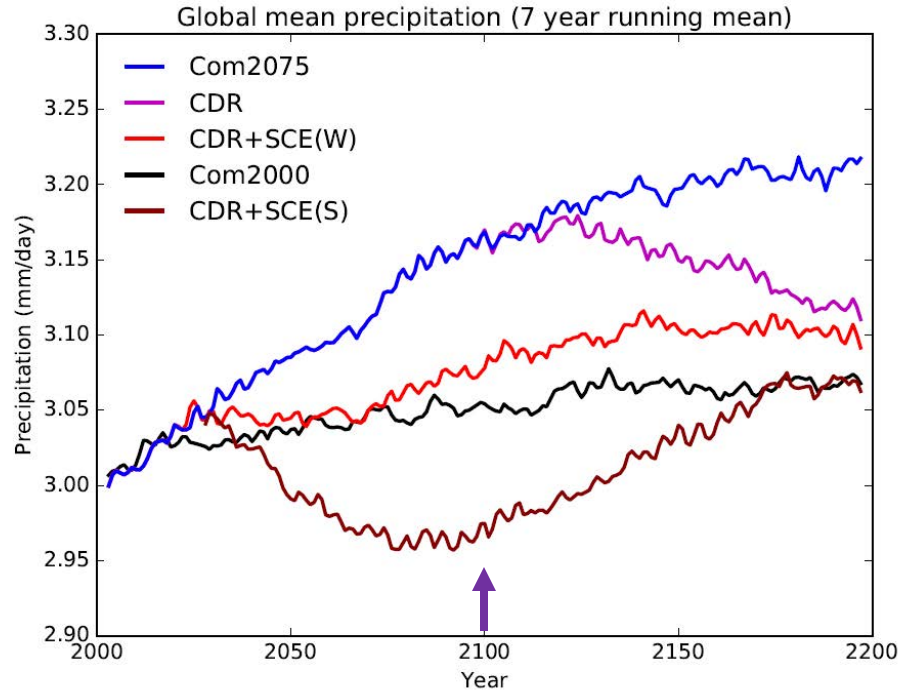
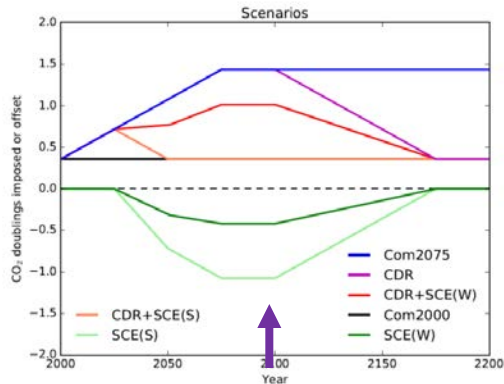
T_{sfc} as anomaly relative to 1970-99 mean



$T_{\text{sfc}} - T_{\text{sfc}}(\text{Com2000})$

Global mean precipitation

- Precipitation increases with increased CO₂
- SCE *overcompensates* – slows hydrologic cycle even though T_{sfc} same



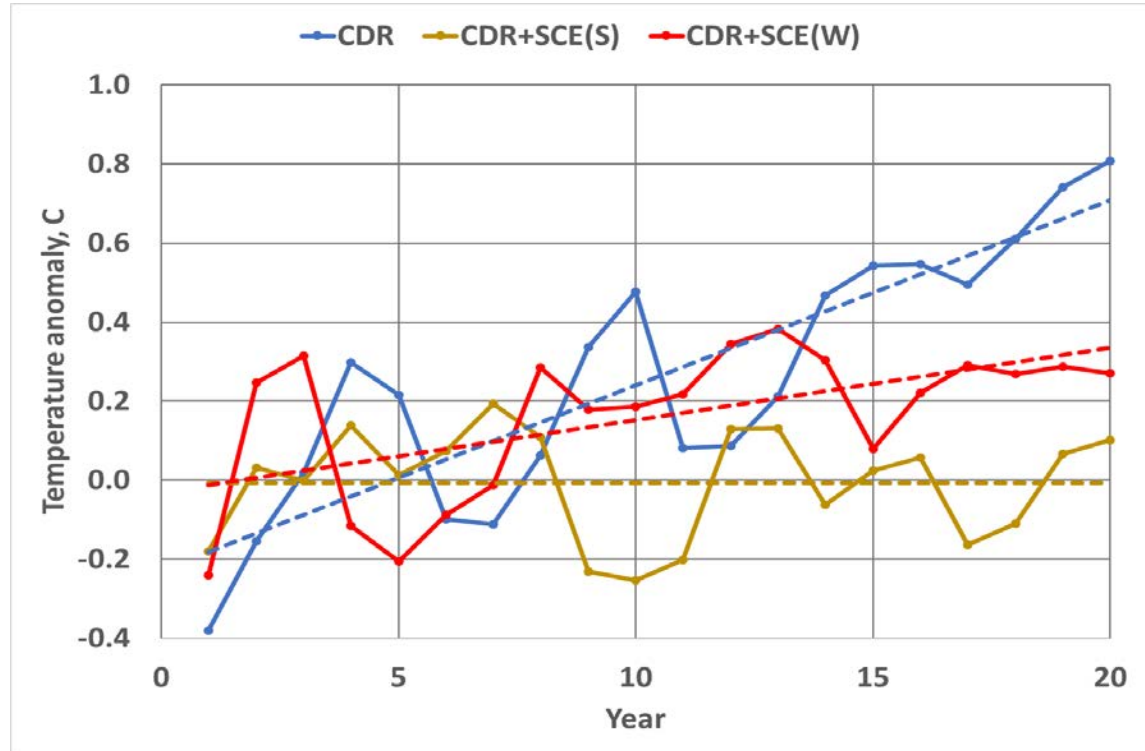
Detection: an initial condition problem

- Decide to start SCE
- Pick a value to balance increasing CO₂ forcing
- How long do we have to wait to decide that we have picked the right amount of SCE?
- What do we have to measure?
 - Global-average Tsfc
 - Global-average precipitation
 - TOA radiation budget

T_{sfc} time series – model world (2025 start)

GCM 20-year
anomaly time
series

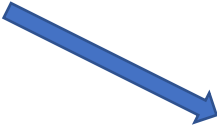
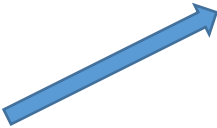
- Referenced to
average of first
5 years



Possible role for SCE
Reduce climate impacts while waiting for CDR

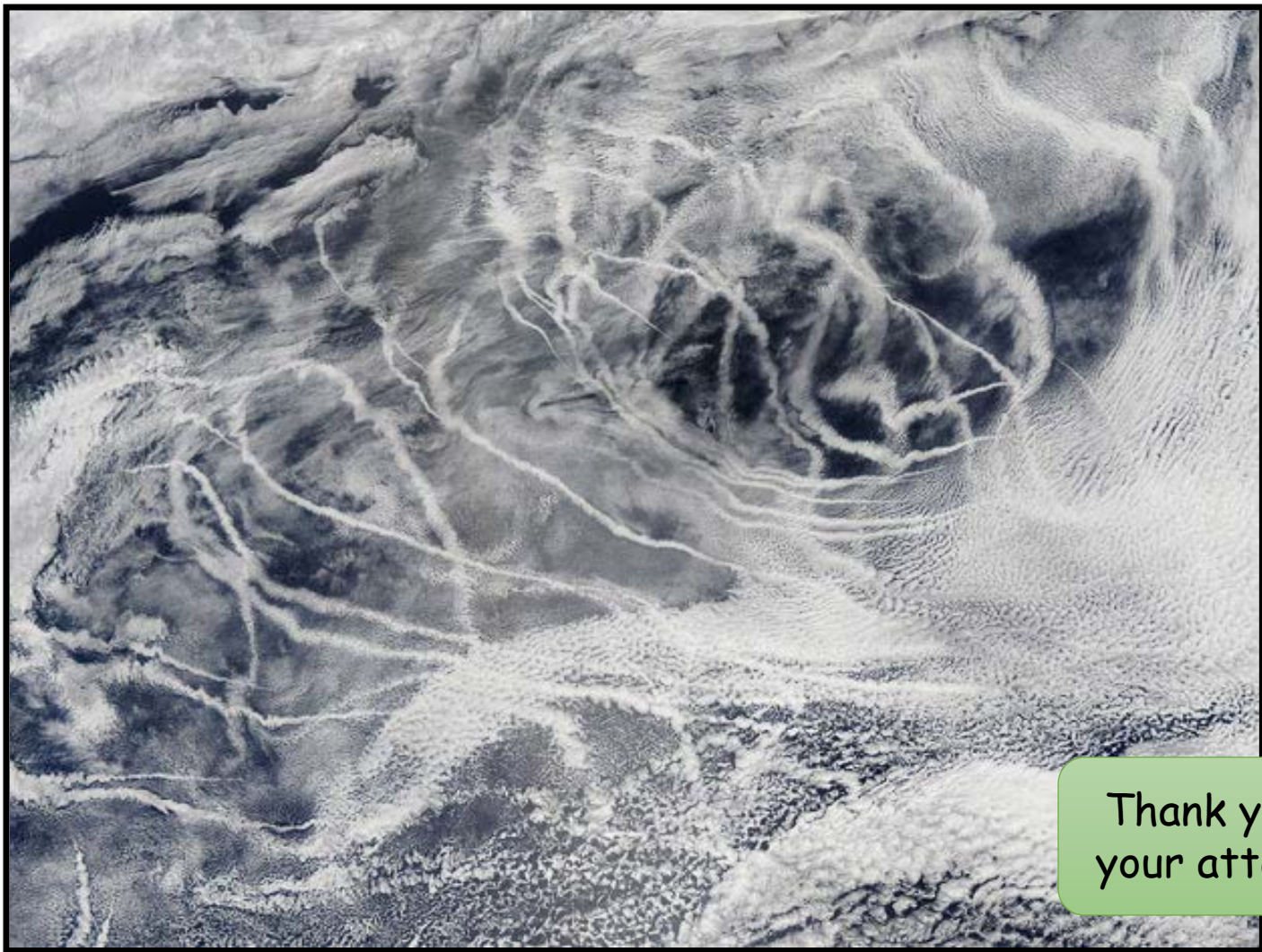
Picking the “right” climate is complicated
*Current global T or P?
Regional “winners” and “losers”?*

Lessons and Questions



Starting SCE will be challenging
*What level do we apply?
How long do we have to wait to determine the effect on climate?*

GCM has ~linear global response to forcings
*Not true for zonally averaged results
What are regional responses?
How certain can we be about these responses?*



Thank you for
your attention!