

Geoengineering 1: Solar Radiation Management

EES 3310/5310

Global Climate Change

Jonathan Gilligan

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Geoengineering

Scope of Problem

- After 10,000 years:
 - High-level nuclear waste: about 0.03% of excess radioactivity remains
 - CO₂: about 25% remains in atmosphere (for release of 4,000–5,000 GTC)
- Consequences uncertain
 - Possible catastrophic consequences lasting thousands of years
 - Experts think “business as usual” has high probability (>50%) of tipping point to disaster
- Eliminating fossil fuels quickly looks very challenging, expensive

Comparing imperfect solutions

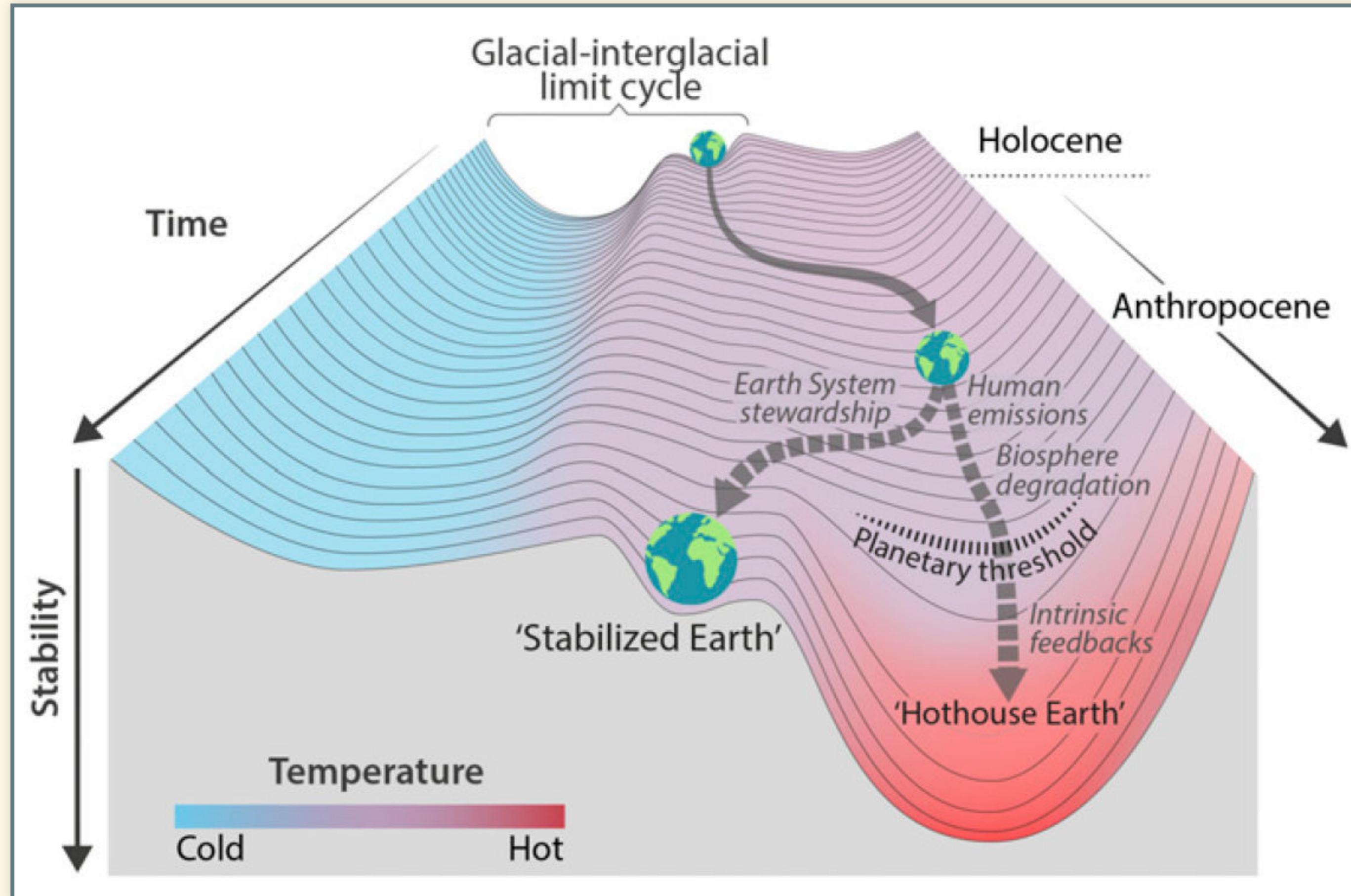
- Mitigation:
 - Cut emissions
 - Geoengineering
- Adaptation
 - Manageable, unmanageable, and unmanaged systems
- Do nothing

*"We have three options:
mitigation, adaptation, and suffering."*

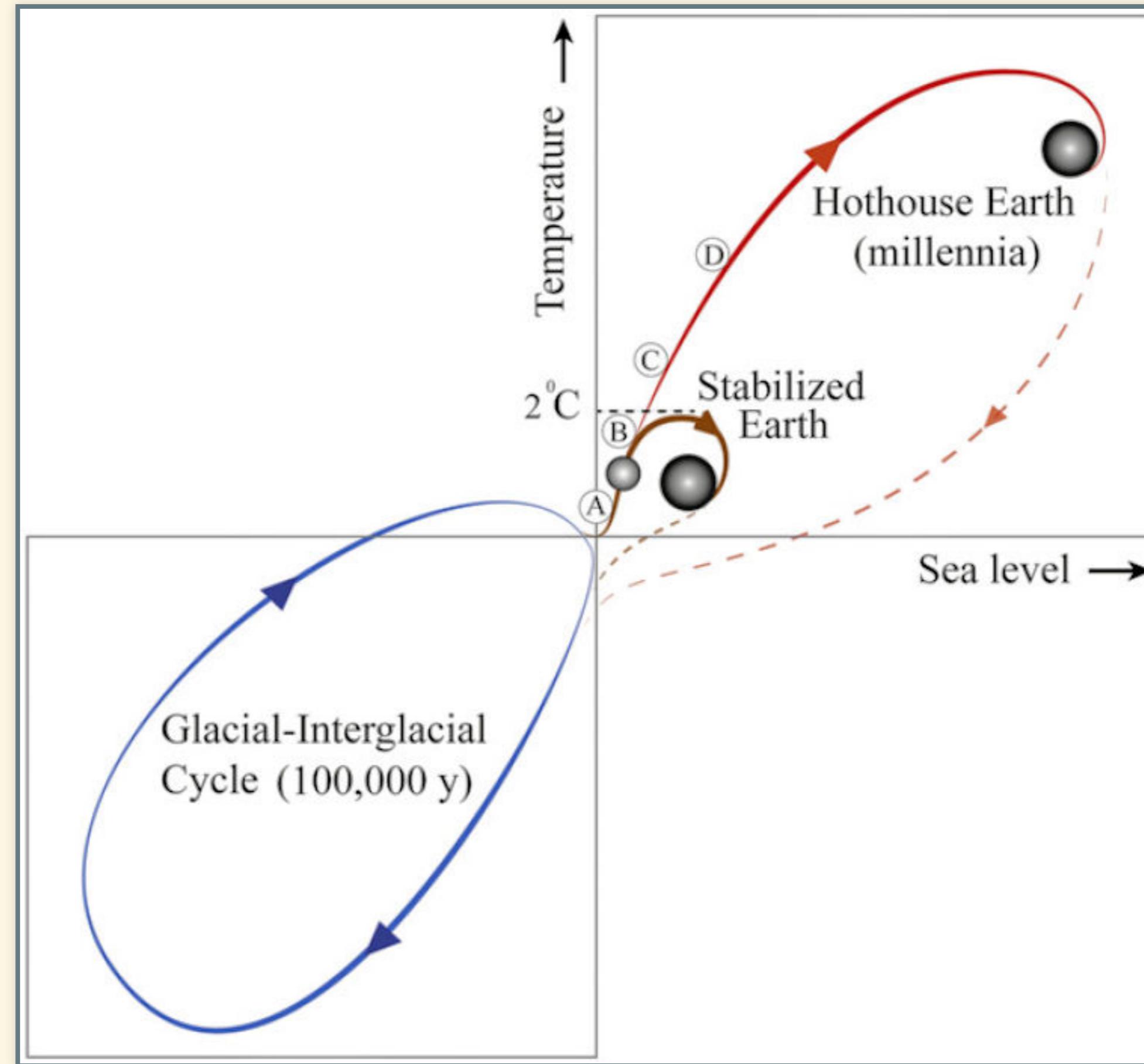
— Prof. Lonnie Thompson

New Challenges

Stability of the Climate



Pathways for Climate System



Defining Geoengineering

Defining Geoengineering

- Scale and Intent
 - Intent without scale: *ornamental gardening*
 - Scale without intent: *pollution, global warming*
 - **Scale with intent: geoengineering**

Basic Concepts

- Wicked problem
- Technological fix
- Geoengineering:
 - Albedo engineering
 - Pielke: Doesn't work as technological fix
 - Nordhaus:
 - Reflecting 2% of sunlight cancels doubling CO₂
 - Costs 1-10% as much as reducing emissions
 - "Fire truck" vs. "Fire insurance"
 - "Salvage therapy"
 - Air capture of CO₂
 - Pielke: Worth considering
 - Nordhaus:
 - All geoengineering poses a moral hazard problem

Criteria for Technological Fix

1. Cause-effect relationship
 - Can it work in theory?
2. Assessable effects
 - Can we tell whether it's working?
3. Established technological base
 - Research and development needs somewhere to start
 - Beginning from scratch takes too long to be useful.
 - Focus on incremental improvements
 - Don't bet on big breakthroughs



SPL

Who Controls the Thermostat?



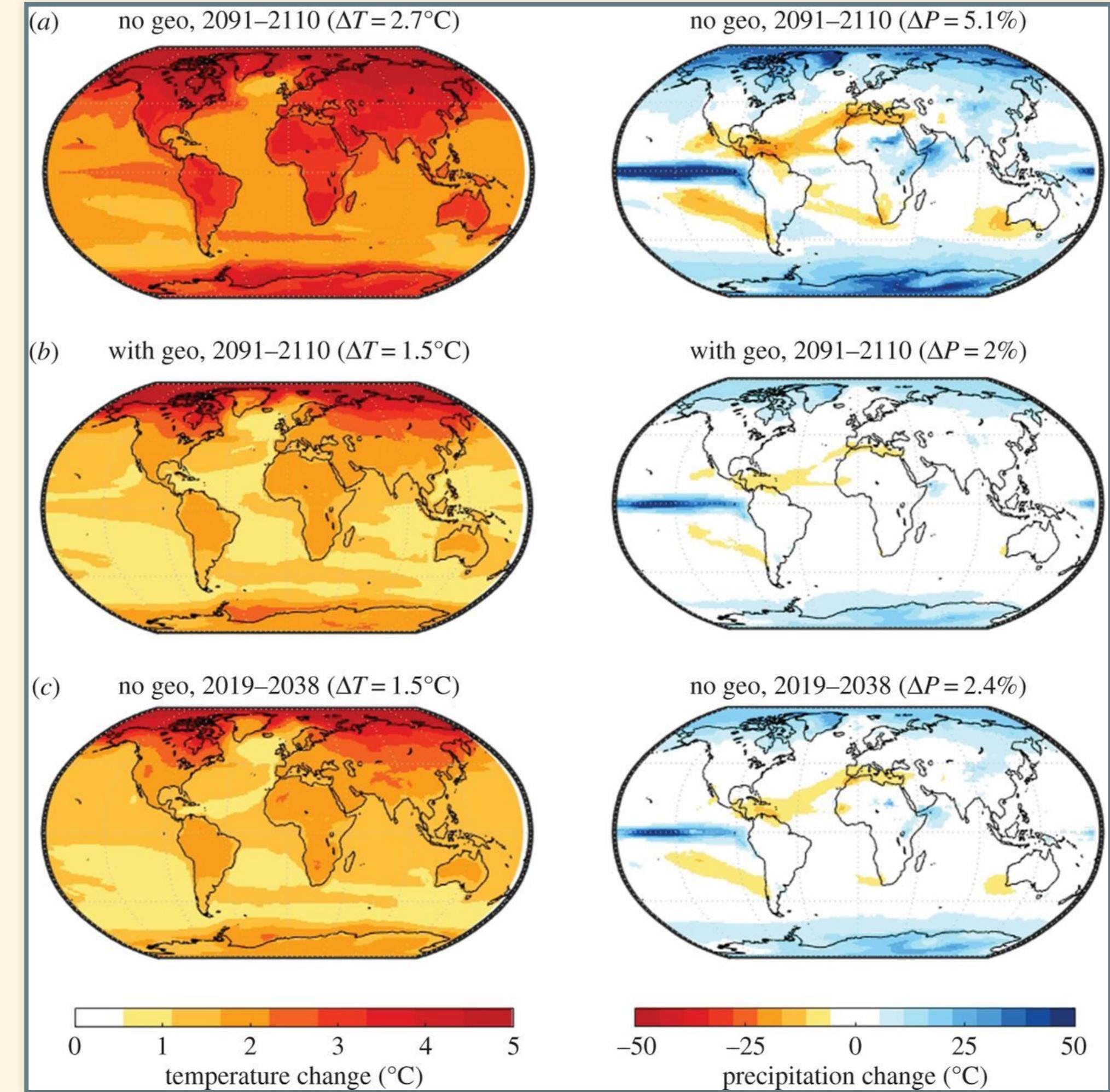
*Regional diversity in the response to different levels of solar-radiation management **could make consensus about the optimal level of geoengineering difficult, if not impossible, to achieve***

K.L. Ricke *et al.* Nature Geosci. **3**, 537 (2010).

It's not just about
global average temperature

It's not just about global average temperature

- Can geoengineering manage all parts of the planet at once?
- Can we manage both temperature and precipitation?
- What about other effects of CO₂?
 - Ocean acidification?
- However...
 - It looks likely that it could reduce the harm from climate change.
 - Can't return planet to pre-industrial climate, but:
 - Can probably *reduce changes* in both temperature and precipitation
 - Can probably *reduce changes* across the whole planet
 - The same climate models we use to study climate change say SRM should work



Who's responsible for
unintended consequences?

Who's responsible for unintended consequences?



Geoengineering Litigation

THE LEGAL ASPECTS

Since the first successful experiments in laboratories of the General Electric Company in 1946, the artificial precipitation by means of such experiments involves the use of similar cooling materials.

HARVARD LAW REVIEW

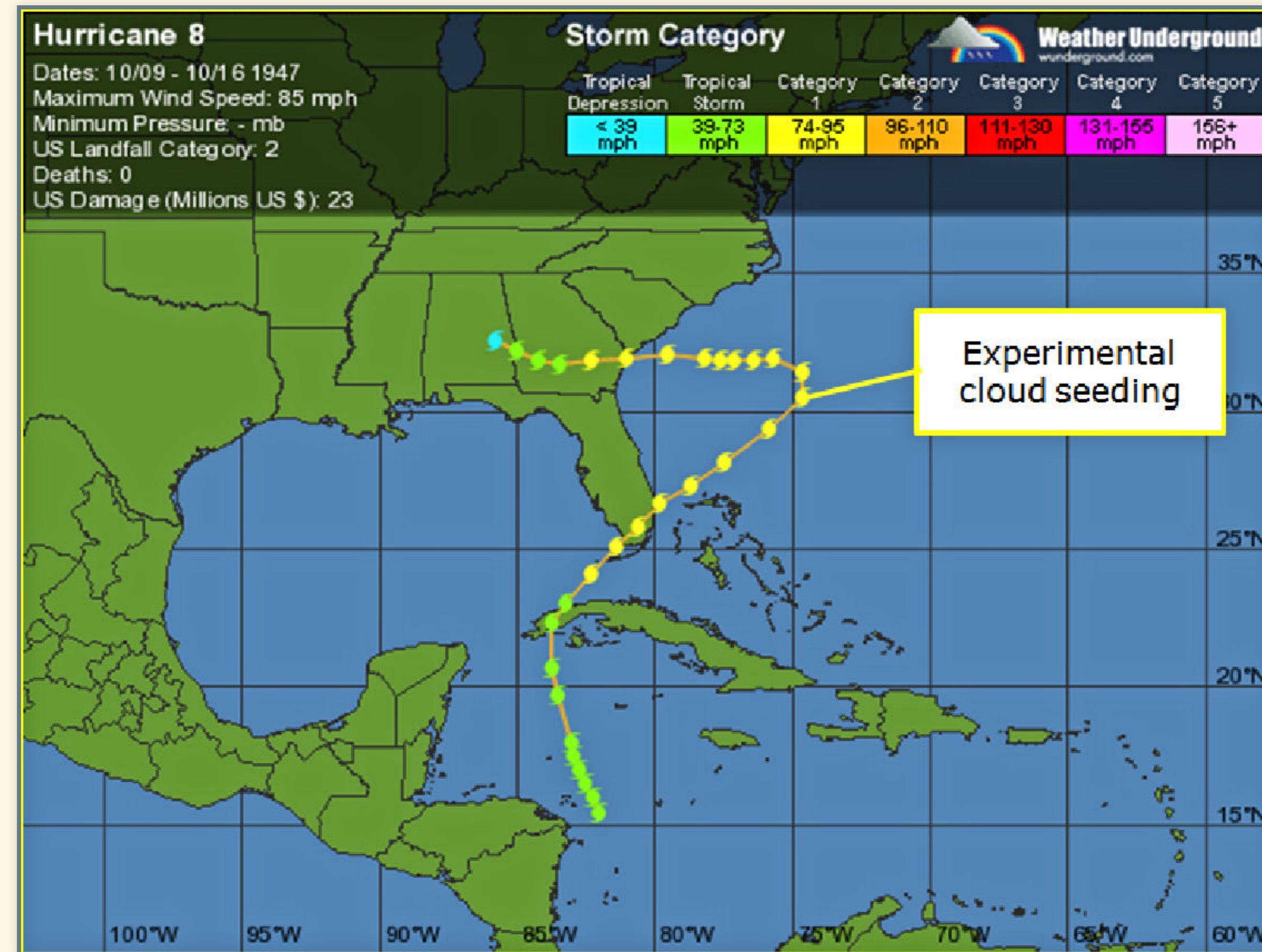
Property— Property Rights Incident to Ownership of Land—Cloud Seeding Infringes Property Rights of Subadjacent Landowners — *Southwest Weather Research, Inc., v. Rounsville* (Tex. Civ. Appl. 1958)

73 Harvard L. R. 790 (1958)

LEGAL REMEDIES FOR “CLOUD SEEDING”

The important question of liability for “cloud seeding” has been decided at the highest level for the first time. The decision in *Southwest Weather Research, Inc., v. Rounsville* added significance in that it defines the scope of a landowner’s rights in the air over his land and circumscribes the

Hurricane #8, Oct. 1947



In North Carolina, hurricanes did what scientists could not: Convince Republicans that climate change is real

"I always thought climate change was a bunch of nonsense, but now I really do think it is happening," said [Margie] White, a 65-year-old Trump supporter.

Washington Post, Oct. 18, 2018

Yes, Climate Change Made Harvey and Irma Worse

... the consensus among scientists is that the effects of climate change ... made these storms far more destructive.

CNN, Sept. 19, 2017

Are Tornadoes More Powerful Due to Climate Change?

AccuWeather, June 15, 2012

Links between More Extreme Weather and Climate Change

... the key thing, then is that all of the weather that is occurring, all of the storms are occurring in an environment that is simply different than it used to be.

NPR Science Friday, Apr. 5, 2012

Colorado Flooding: Did Climate Change Play A Role in Recent Disaster?

Huffington Post, Sept. 14, 2013

- **Most scientific reviews on link between climate change and extreme weather are inconclusive**
- **But public, media jump to conclusions**
- **Will they also blame geoengineering?**

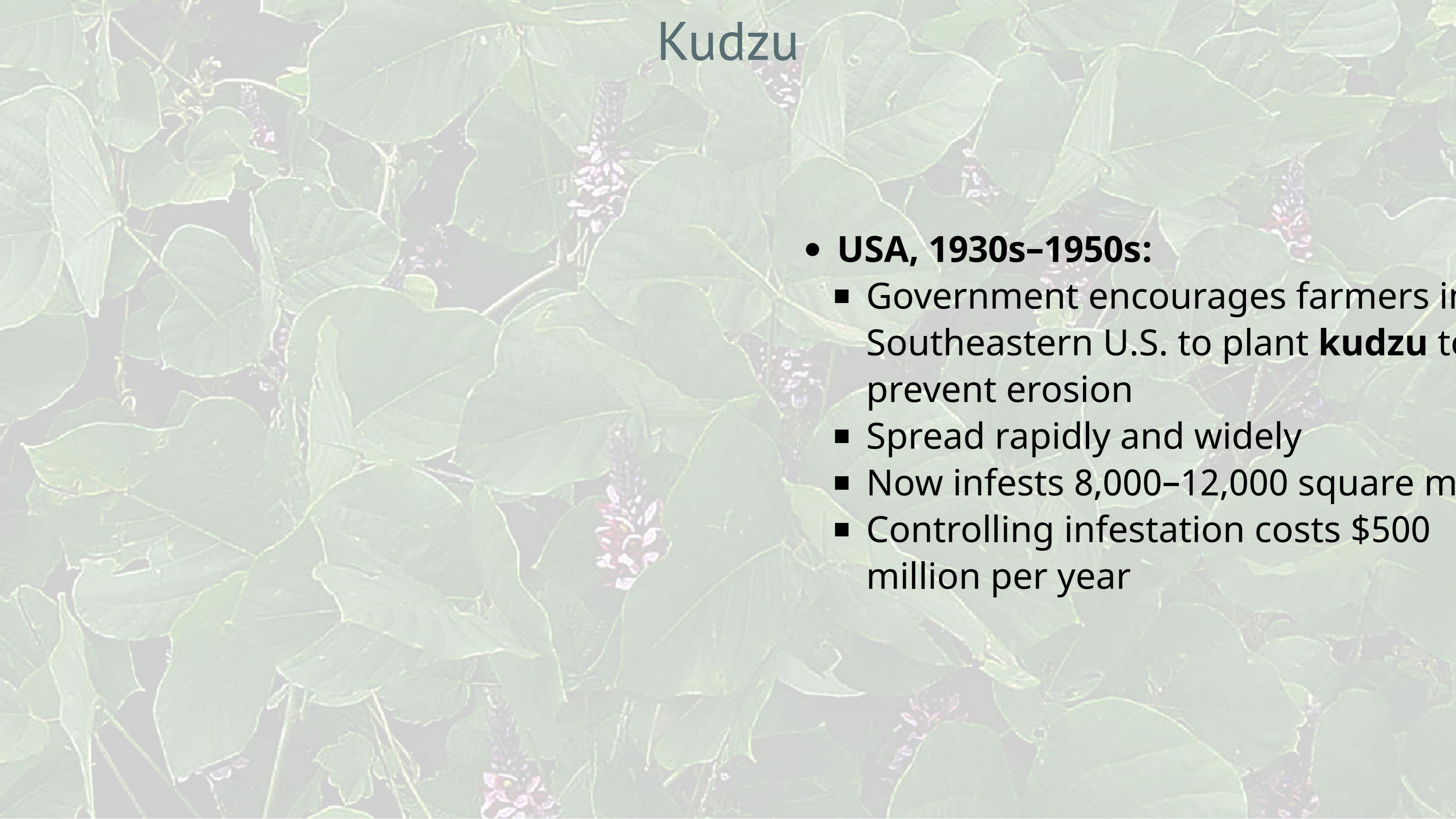
Cane Toad

- Australia, 1933:
 - Beetles infesting sugarcane
 - 102 toads imported from Hawaii to eat beetles
 - Toads eat other bugs, leave beetles alone
 - No predators: toad population out of control

Mongoose



- Hawaii, 1883:
 - Mongoose introduced to control rats
 - Predates on lizards, insects
 - Spreads disease leptospirosis



Kudzu

- **USA, 1930s–1950s:**
 - Government encourages farmers in Southeastern U.S. to plant **kudzu** to prevent erosion
 - Spread rapidly and widely
 - Now infests 8,000–12,000 square miles
 - Controlling infestation costs \$500 million per year





Maintenance

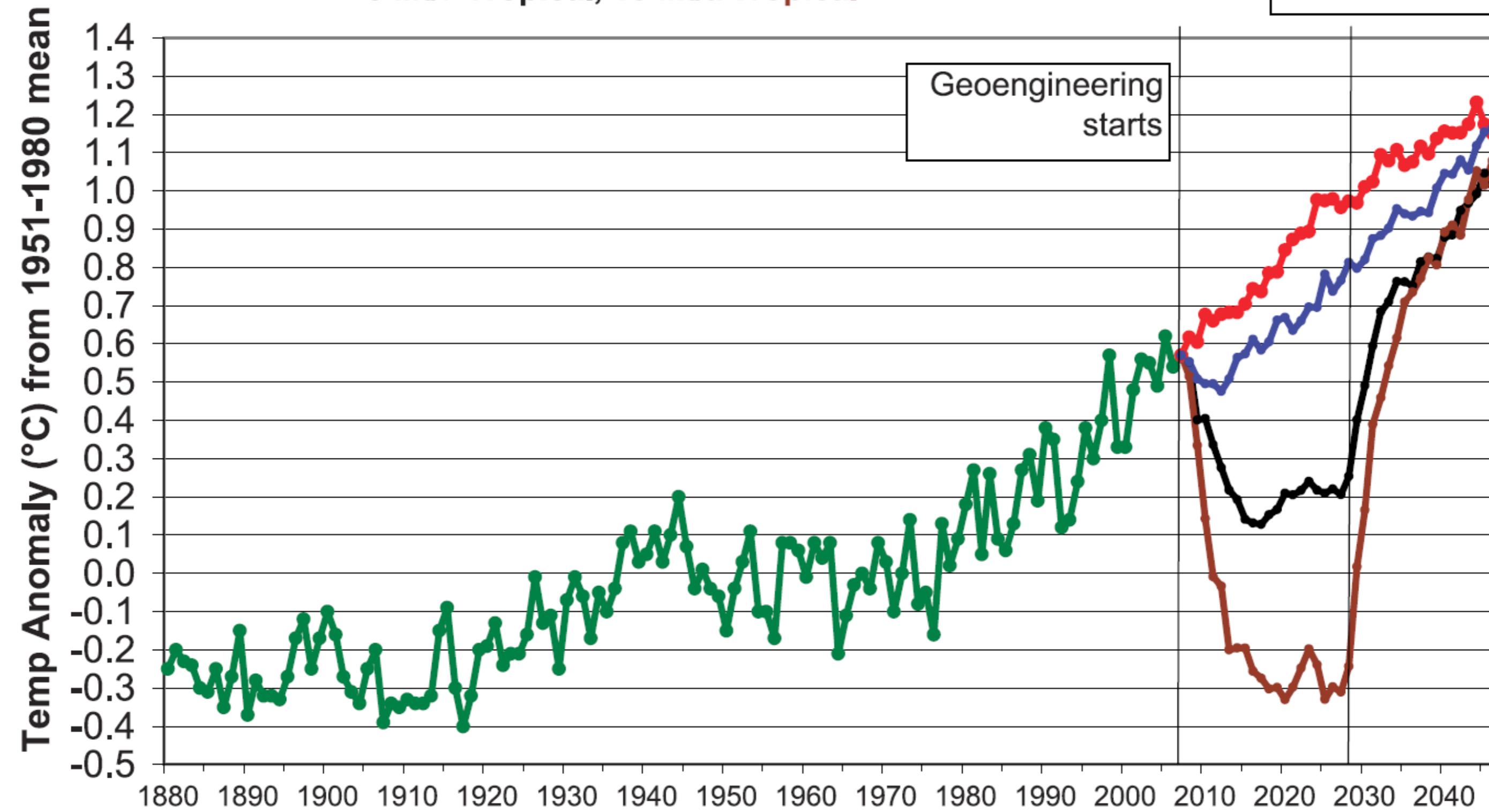


GISS Global Average Temperature Anomaly

+ Anthro Forcing, 3 Mt/a Arctic,

5 Mt/a Tropical, 10 Mt/a Tropical

Geoengineering
ends



Summary

Summary

- Is Solar-Radiation Management a Feasible Technological Fix?
 - Pielke says no
 - Relation between cause and effect is complex and uncertain
 - Can't assess the effects without a full-scale global experiment
 - Doesn't build off existing technology
 - Others say maybe
 - It can't cancel out global warming, but it could make it much less bad.
 - It's quickly reversible so we could adjust as we learn more
 - It doesn't need fancy technology.
 - Many problems are more political than scientific:
 - How should decisions about geoengineering be made?
 - Who should participate in decision-making?