

Risks from Geoengineering (Solar Radiation Management)

Alan Robock

Department of Environmental Sciences
Rutgers University, New Brunswick, New Jersey

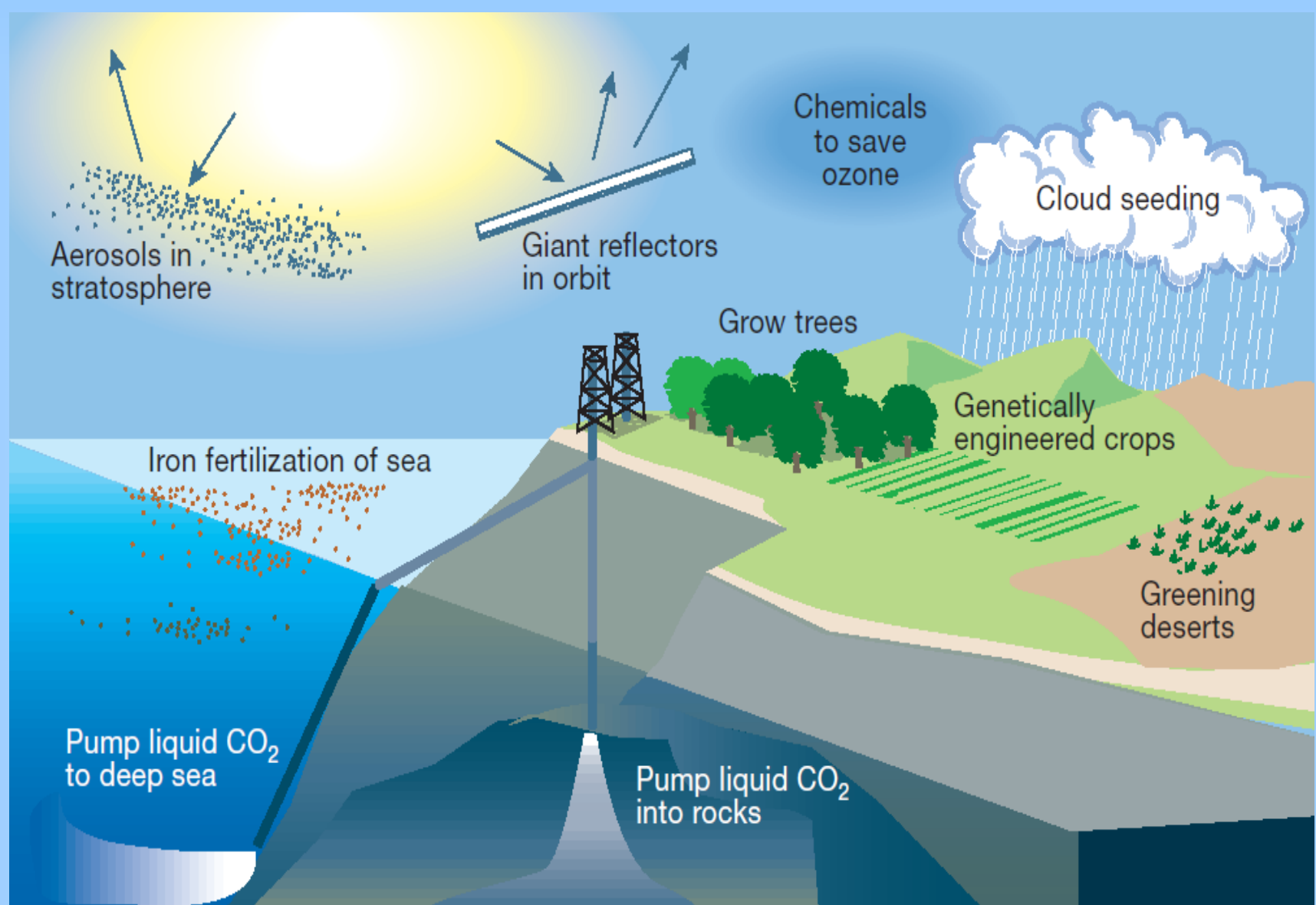
robock@envsci.rutgers.edu

<http://envsci.rutgers.edu/~robock>

Geoengineering is defined as

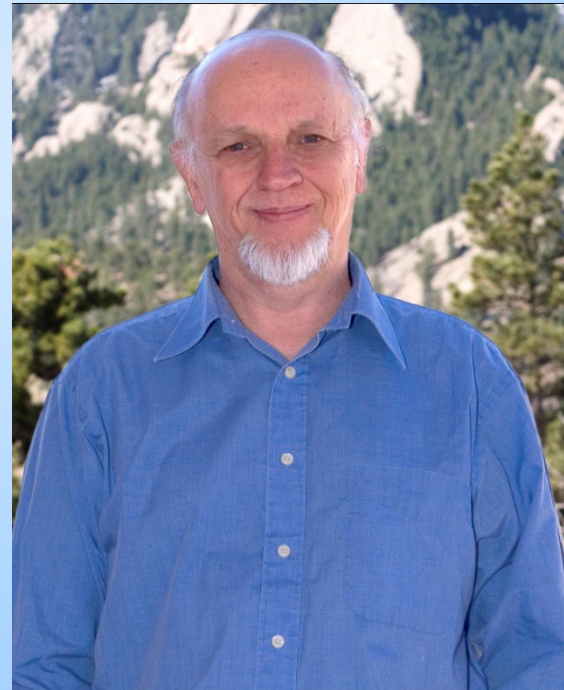
**"deliberate large-scale
manipulation of the planetary
environment to counteract
anthropogenic climate change."**

Shepherd, J. G. S. et al., 2009: *Geoengineering the climate: Science, governance and uncertainty*, RS Policy Document 10/09, (London: The Royal Society).



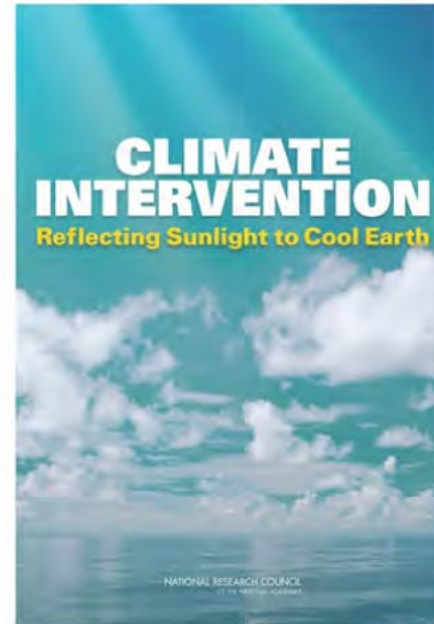
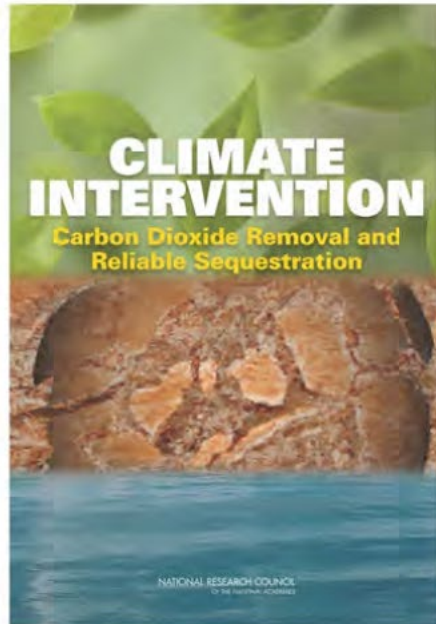
Schematic representation of various climate-engineering proposals (courtesy B. Matthews).

Despairing of prompt political response to global warming, in August and September 2006, Paul Crutzen (Nobel Prize in Chemistry) and Tom Wigley (NCAR) suggested that we consider temporary geoengineering as an emergency response.



CLIMATE INTERVENTION

Carbon
Dioxide
Removal
(CDR)



Solar
Radiation
Management
(SRM)

Released February 14, 2015

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NATIONAL RESEARCH COUNCIL
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WHY “CLIMATE INTERVENTION”?

There are several meanings to the term “geoengineering”

In general, the term “engineering” implies a more precisely tailored and controllable process than might be the case for climate interventions

Intervention is an action intended to improve a situation



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9

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THERE IS NO SUBSTITUTE FOR MITIGATION AND ADAPTATION

Recommendation 1:

Efforts to address climate change should continue to focus most heavily on

- **mitigating greenhouse gas emissions**
- **in combination with adapting to the impacts of climate change**

because these approaches

- **do not present poorly defined and poorly quantified risks and**
- **are at a greater state of technological readiness**

CARBON DIOXIDE REMOVAL READY FOR INCREASED RESEARCH AND DEVELOPMENT

Recommendation 2:

The Committee recommends research and development investment to

- **improve methods of carbon dioxide removal and disposal at scales that matter**

in particular to

- **minimize energy and materials consumption**
- **identify and quantify risks**
- **lower costs, and**
- **develop reliable sequestration and monitoring**

ALBEDO MODIFICATION POSES SIGNIFICANT RISKS

Environmental risks – both known and poorly known

- Decreases in stratospheric ozone
- Changes in the amount and patterns of precipitation
- No reduction of root cause of climate change (greenhouse gases)
- Poorly understood regional variability
- Potential risk of millennial dependence

Significant potential for unanticipated, unmanageable, and regrettable consequences

- Including political, social, legal, economic, and ethical dimensions

Recommendation 3: Albedo modification at scales sufficient to alter climate should not be deployed at this time

ALBEDO MODIFICATION RESEARCH

Research needed to determine if albedo modification could be viable climate response

- If there were a climate emergency
- Could it be key part of a portfolio of responses?

Better understanding of consequences needed if there were an action by a unilateral / uncoordinated actor

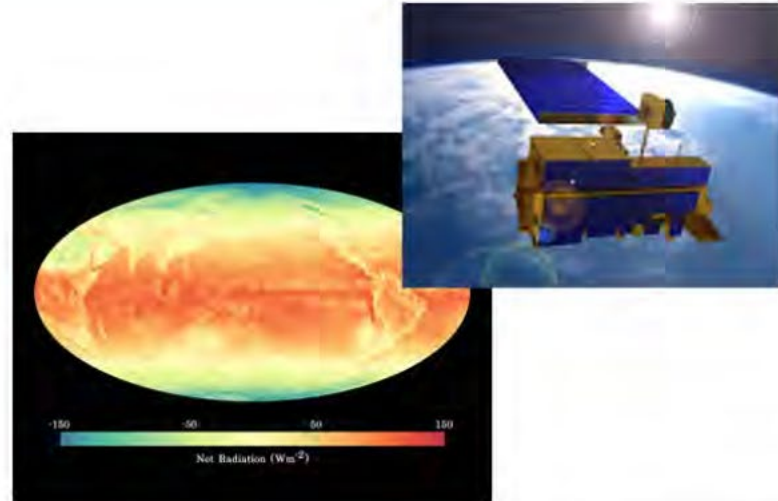
Recommendation 4:

The Committee recommends an albedo modification research program be developed and implemented that emphasizes multiple benefit research that furthers

- **basic understanding of the climate system**
- **and its human dimensions**

ALBEDO MODIFICATION RESEARCH

Current observational capabilities lack sufficient capacity to detect and monitor environmental effects of albedo modification deployment



Recommendation 5: The Committee recommends that the United States improve its capacity to detect and measure changes in radiative forcing and associated changes in climate

GOVERNANCE CONSIDERATIONS

Recommendation 6:

The Committee recommends the initiation of a serious deliberative process to examine:

- (a) what types of research governance, beyond those that already exist, may be needed for albedo modification research, and**
- (b) the types of research that would require such governance, potentially based on the magnitude of their expected impact on radiative forcing, their potential for detrimental direct and indirect effects, and other considerations**

My IPCC participation

6 meetings:

Synthesis Report Scoping Meeting, Liege, Belgium

WG I LA Meeting, Kunming, China

WG I, II, and III Geoengineering Meeting, Lima, Peru

WG I LA Meeting, Brest, France

WG I LA Meeting, Marrakech, Morocco

WG I LA Meeting, Hobart, Australia

Lead Author, WG I, Chapter 8

Contributing Author, WG I, Chapter 5

Contributing Author, WG I, Chapter 7

Contributing Author, WG I, Chapter 11

Contributing Author, WG II, Chapter 19

Reviewer, many drafts of WG I, II, and III

My IPCC participation

6 meetings:

Synthesis Report Scoping Meeting, Liege, Belgium

1.26 tons CO₂

WG I LA Meeting, Kunming, China

2.68 tons CO₂

WG I, II, and III Geoengineering Meeting, Lima, Peru

1.24 tons CO₂

WG I LA Meeting, Brest, France

1.40 tons CO₂

WG I LA Meeting, Marrakech, Morocco

2.42 tons CO₂

WG I LA Meeting, Hobart, Australia

3.50 tons CO₂

Total: 12.50 tons CO₂

(My annual emissions from driving is 2.2 tons CO₂.)

My IPCC geoengineering participation

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WG I LA Meeting, Kunming, China

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Anthropogenic and Natural Radiative Forcing

Coordinating Lead Authors:

Gunnar Myhre (Norway), Drew Shindell (USA)

Lead Authors:

François-Marie Bréon (France), William Collins (UK), Jan Fuglestad (Norway), Jianping Huang (China), Dorothy Koch (USA), Jean-François Lamarque (USA), David Lee (UK), Blanca Mendoza (Mexico), Teruyuki Nakajima (Japan), Alan Robock (USA), Graeme Stephens (USA), Toshihiko Takemura (Japan), Hua Zhang (China)

Contributing Authors:

Borgar Aamaas (Norway), Olivier Boucher (France), Stig B. Dalsøren (Norway), John S. Daniel (USA), Piers Forster (UK), Claire Granier (France), Joanna Haigh (UK), Øivind Hodnebrog (Norway), Jed O. Kaplan (Switzerland/Belgium/USA), George Marston (UK), Claus J. Nielsen (Norway), Brian C. O'Neill (USA), Glen P. Peters (Norway), Julia Pongratz (Germany), Michael Prather (USA), Venkatachalam Ramaswamy (USA), Raphael Roth (Switzerland), Leon Rotstayn (Australia), Steven J. Smith (USA), David Stevenson (UK), Jean-Paul Vernier (USA), Oliver Wild (UK), Paul Young (USA)

Review Editors:

Daniel Jacob (USA), A.R. Ravishankara (USA), Keith Shine (UK)

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Box 8.3 | Volcanic Eruptions as Analogues

Volcanic eruptions provide a natural experiment of a stratospheric aerosol cloud that can serve to inform us of the impacts of the proposed production of such a cloud as a means to control the climate, which is one method of geoengineering (Rasch et al., 2008); see Section 7.7. For example, Trenberth and Dai (2007) showed that the Asian and African summer monsoon, as well as the global hydrological cycle, was weaker for the year following the 1991 Mt Pinatubo eruption, which is consistent with climate model simulations (Robock et al., 2008). MacMynowski et al. (2011) showed that because the climate system response of the hydrological cycle is rapid, forcing from volcanic eruptions, which typically last about a year, can serve as good analogues for longer-lived forcing. The formation of sulphate aerosols, their transport and removal, their impacts on ozone chemistry, their RF, and the impacts on whitening skies all also serve as good analogues for geoengineering proposals. Volcanic impacts on the carbon cycle because of more diffuse radiation (Mercado et al., 2009) and on remote sensing can also be useful analogues, and the impacts of contrail-generated sub-visual cirrus (Long et al., 2009) can be used to test the long-term impacts of a permanent stratospheric cloud.

Smoke from fires generated by nuclear explosions on cities and industrial areas, which could be lofted into the stratosphere, would cause surface cooling and a reduction of stratospheric ozone (Mills et al., 2008). Volcanic eruptions that produce substantial stratospheric aerosol clouds also serve as an analogue that supports climate model simulations of the transport and removal of stratospheric aerosols, their impacts on ozone chemistry, their RF, and the climate response. The use of the current global nuclear arsenal still has the potential to produce nuclear winter, with continental temperatures below freezing in summer (Robock et al., 2007a; Toon et al., 2008), and the use of only 100 nuclear weapons could produce climate change unprecedented in recorded human history (Robock et al., 2007b), with significant impacts on global agriculture (Ozdogan et al., 2013; Xia and Robock, 2013).

IPCC Working Group I, Fifth Assessment Report

Stratospheric Geoengineering

Benefits

1. Reduce surface air temperatures, which could reduce or reverse negative impacts of global warming, including floods, droughts, stronger storms, sea ice melting, land-based ice sheet melting, and sea level rise
2. Increase plant productivity
3. Increase terrestrial CO₂ sink
4. Beautiful red and yellow sunsets
5. Unexpected benefits

Each of these needs to be quantified so that society can make informed decisions.

Robock, Alan, 2008: 20 reasons why geoengineering may be a bad idea. *Bull. Atomic Scientists*, **64**, No. 2, 14-18, 59, doi:10.2968/064002006.

Robock, Alan, Allison B. Marquardt, Ben Kravitz, and Georgiy Stenchikov, 2009: The benefits, risks, and costs of stratospheric geoengineering. *Geophys. Res. Lett.*, **36**, L19703, doi:10.1029/2009GL039209.

Robock, Alan, 2014: Stratospheric aerosol geoengineering. *Issues Env. Sci. Tech.* (Special issue "Geoengineering of the Climate System"), **38**, 162-185.

Risks

1. Drought in Africa and Asia
2. Perturb ecology with more diffuse radiation
3. Ozone depletion
4. Continued ocean acidification
5. Will not stop ice sheets from melting
6. Impacts on tropospheric chemistry
7. Whiter skies
8. Less solar electricity generation
9. Degrade passive solar heating
10. Rapid warming if stopped
11. Cannot stop effects quickly
12. Human error
13. Unexpected consequences
14. Commercial control
15. Military use of technology
16. Societal disruption, conflict between countries
17. Conflicts with current treaties
18. Whose hand on the thermostat?
19. Effects on airplanes flying in stratosphere
20. Effects on electrical properties of atmosphere
21. Environmental impact of implementation
22. Degrade terrestrial optical astronomy
23. Affect stargazing
24. Affect satellite remote sensing
25. More sunburn
26. Moral hazard - the prospect of it working would reduce drive for mitigation
27. Moral authority - do we have the right to do this?

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**Mentioned in Chapter 19,
AR5 WG II report**

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The United Nations Framework Convention On Climate Change 1992

Signed by 194 countries and ratified by 188
(as of February 26, 2004)

Signed and ratified in 1992 by the United States

The ultimate objective of this Convention ... is to achieve ... stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.

The UN Framework Convention on Climate Change thought of "dangerous anthropogenic interference" as due to the inadvertent effects on climate from anthropogenic greenhouse gases .

We now must include geoengineering in our pledge to "prevent dangerous anthropogenic interference with the climate system."



© New York Times, Henning Wagenbreth, Oct. 24, 2007

IPCC is policy-relevant,
but not policy-prescriptive.

But personally,
I feel obligated to recommend
policy responses.

