

# The Asilomar International Conference on Climate Intervention Technologies: Minimizing the Potential Risk of Research to Counter-balance Climate Change and its Impacts

March 22-26, 2010, Asilomar Conference Center, Pacific Grove, California



CLIMATE RESPONSE FUND



# The Conference goal was to establish a framework for possible research

Quoted from the invitation letter:

The goal of the Conference will be to propose strategies to minimize risk associated with scientific experimentation and research on approaches for climate intervention. The specific objectives of the conference will be to:

- 1) identify the potential risks associated with climate intervention experiments;
- 2) propose a system to assess experiments for their potential categorical risks and suggest precautions necessary for the experiments; and
- 3) propose research standards and guidelines for use by the international science community.

**The need for consideration of guidelines, protocols, and governance mechanisms for research has recently been increasing**

**The Asilomar International Conference on Climate Intervention Technologies has been motivated by the many calls for research on geoengineering during the past two years:**

- **The American Meteorological Society statement**
- **The UK Royal Society report**
- **The American Geophysical Union statement**
- **The Novim report**
- **Additional reports from the NAS and NCEP**

**Organization of the Conference benefitted from the insights of Dr. Paul Berg, organizer of the 1975 Asilomar Conference on Recombinant DNA**



Dr. Paul Berg, Stanford University

# Members of the Scientific Organizing Committee

**Dr. Michael MacCracken**, Climate Institute (Chair)

**Dr. Paul Crutzen**, Max Planck Institute, and Scripps Institution of Oceanography (corresponding member)

**Dr. Scott Barrett**, Lenfest Professor of Natural Resource Economics, Columbia University

**Dr. Roger Barry**, Director of the World Data Center for Glaciology and Distinguished Professor of Geography, University of Colorado

**Dr. Steven Hamburg**, Chief Scientist, Environmental Defense Fund

**Dr. Richard Lampitt**, Senior Scientist, National Oceanography Center and Professor, University of Southampton

**Dr. Diana Liverman**, Director of the Institute of the Environment and Professor of Geography and Regional Development, University of Arizona, US. Senior Fellow in the Environmental Change Institute, Oxford University

**Dr. Thomas Lovejoy**, Heinz Center Biodiversity Chair at the Heinz Center for Science and the Environment

**Dr. Gordon McBean**, Professor, Departments of Geography and Political Science and Director of Policy Studies at the Institute for Catastrophic Loss Reduction, The University of Western Ontario

**Dr. John Shepherd**, Professorial Research Fellow in Earth System Science, School of Ocean and Earth Science, National Oceanography Centre, University of Southampton, and Deputy Director (External Science Coordination) of the Tyndall Centre for Climate Change Research

**Mr. Stephen Seidel**, Vice President for Policy Analysis and General Counsel at the Pew Center on Global Climate Change

**Dr. Richard Somerville**, Distinguished Professor Emeritus and Research Professor at Scripps Institution of Oceanography, University of California San Diego

**Dr. Tom M.L. Wigley**, Professor, University of Adelaide and Senior Scientist, National Center for Atmospheric Research

## The primary affiliations of the expert participants covered 14 nations\*

### International representation:

Australia	6	Japan	1
Austria	1	The Netherlands	3
Brazil	2	South Africa	2
Canada	3	Spain	2
Germany	3	Sweden	2
India	2	United Kingdom	16
Israel	1	United States	137

\* A number of the participants were multi-national, some holding more than one passport, and a number were based at institutions other than their likely citizenship

**The Conference was developed by the Climate  
Response Fund (CRF)  
under Dr. Margaret Leinen  
(<http://www.climateresponsefund.org/>)**

**Partners for the CRF included:**

- The Climate Institute
- The Environmental Defense Fund
- The Royal Society
- Guttman Initiatives

**Support for the CRF was provided by:**

- The State of Victoria, Australia
- The William K. Bowes, Jr. Foundation
- The Franklin P. and Catherine Johnson Family Foundation
- The Altman Family Foundation
- Danielle and Bob Klein
- The Qualcomm Matching Gift Program
- John Freidenrich
- Carin and Alan Trounson
- The Ueberroth Family Foundation

# Asilomar event troubling

By **RACHEL SMOLKER**  
*Guest commentary*

**T**his week, Asilomar is hosting the International Conference on Climate Intervention Technologies. Proposed technologies include dumping tons of iron particles into the ocean to stimulate carbon dioxide-absorbing plankton

organized by Margaret Leinen, who happens to be the mother and science adviser to Dan Whaley. His company, Climos, intends to use carbon-offset markets to profit from ocean iron fertilization, for which it has patents pending.

Such connections are questionable for a body

sensible to have a serious dialogue about this topic, and not leave it in the hands of a few connected people. A letter to the conferees, signed by dozens of groups, states: "The priority at this time is not to sort out the conditions under which this experimentation might take place but, rather, whether or

## Good and bad of science

By **PETER BREWER**  
*Guest commentary*

**T**he guest commentary Wednesday by Rachel Smolker criticizing the holding of the Asilomar International Conference on Climate Intervention

*Technology and Innovation*

climate problem. How valid are these? Should they be dismissed out of hand, or examined for clues to effectiveness? What may be the unintended consequences and how can we effectively diagnose

*the problem and the solution?*

reduce the noxious algal blooms that now plague the region — but it would release some of the stored CO<sub>2</sub> and create a complex aqueous chemistry chain that we think we understand. Is this geoengineering? A

*letter to the conference*





# The Good and Bad of Science

By PETER BREWER

*Guest commentary*

The guest commentary Wednesday by Rachel Smolker criticizing the holding of the Asilomar International Conference on Climate Intervention Technologies, and casting aspersions on participants and organizers, should not go unchallenged.

History shows that knowledge is better than ignorance, and openness is better than secrecy — that is what our culture is founded on. For some reason, people tend to be unusually complacent when very large-scale, uncontrolled experiments on the planet are carried out, but exceptionally nervous when small-scale, controlled experiments are discussed as a basis for understanding. That is where we get it wrong.

Governments come to scientists for factual knowledge about the impacts of our advanced industrial society on the environment. Scientists often cannot give adequate replies without some form of testing in a controlled manner.

The Asilomar meeting was designed to advance the dialog between scientists and policy experts to explore the most effective ways of addressing experiments and for bringing in wider communities to ensure full and open discussion before any action could be planned.

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- Geoen지니어ing versus
  - Research on geoen지니어ing

# The scientific (and public) discussion of geoengineering reignited in 2006



## ALBEDO ENHANCEMENT BY STRATOSPHERIC SULFUR INJECTIONS: A CONTRIBUTION TO RESOLVE A POLICY DILEMMA?

*An Editorial Essay*

Fossil fuel burning releases about 25 Pg of CO<sub>2</sub> per year into the atmosphere, which leads to global warming (Prentice et al., 2001). However, it also emits 55 Tg S per year (Stern, 2005), about half of which is converted to sub-micrometer sulfate particles, the remainder being dry deposited. Recent research has shown that the warming of earth by the increasing concentrations of CO<sub>2</sub> and other greenhouse gases is partially countered by some backscattering to space of solar radiation by the sulfate particles, which act as cloud condensation nuclei and thereby influence the micro-physical and optical properties of clouds, affecting regional precipitation patterns, and increasing cloud albedo (e.g., Rosenfeld, 2000; Ramanathan et al., 2001; Ramaswamy et al., 2001). Anthropogenically enhanced sulfate particle concentrations thus cool the planet, offsetting an uncertain fraction of the anthropogenic increase in greenhouse gas warming. However, this fortunate coincidence is "bought" at a substantial price. According to the World Health Organization, sulfate pollution particles affect health and lead to more than 500,000 premature deaths per year worldwide (Nel, 2005). Through acid precipitation and deposition, SO<sub>2</sub> and sulfates also cause various kinds of ecological damage. This creates a dilemma for environmental policy makers, because the required emission reductions of SO<sub>2</sub> and also anthropogenic organics (except black carbon), as dictated by health and ecological considerations, add to global warming and associated negative consequences, such as sea level rise, caused by the greenhouse gases. In fact, after early 1990s, global SO<sub>2</sub> emissions and thus sulfate loading have been declining at a rate of 2.7% per year, potentially explaining the observed reverse from dimming to brightening in surface solar radiation at many stations worldwide (Wild et al., 2005). The corresponding increase in solar radiation by 0.10% per year from 1990 to 2001 (Pinker et al., 2005) contributed to the observed climate warming during that

## GEOENGINEERING: ENCOURAGING RESEARCH AND OVERSEEING IMPLEMENTATION

*An Editorial Comment*

Research on how to engineer Earth's climate, or to modify the environment on large scales to counter human impacts, do not enjoy broad support from scientists. Refereed publications that deal with such ideas are not numerous nor are they cited widely. Paul Crutzen (2006) analyzes the idea of intentionally injecting sulfur into the stratosphere, to enhance the albedo of Earth, so as to slow the warming of the planet due to greenhouse gases. He notes that such an intervention might become necessary unless the world becomes more successful in limiting greenhouse gas emissions and/or if global warming should proceed faster than currently anticipated partly due to cleaning the lower atmosphere of sulfur pollution (Andreae et al., 2005; Charlson et al., 1991).

I am aware that various individuals have opposed the publication of Crutzen's paper, even after peer review and revisions, for various and sincere reasons that are not wholly scientific. Here, I write in support of his call for research on geoengineering and propose a framework for future progress in which supporting and opposing viewpoints can be heard and incorporated. I also propose that research on geoengineering be considered separately from actual implementation, and I suggest a path in that direction.

### 1. Geoengineering – Past Ideas and Their Results

Chelling (1996) has noted that while "geoengineering" is not fully defined, that "it seems to imply something global, intentional and unnatural". Thus, not all human-induced changes to Earth's surface, biota and flows of minerals and water would qualify. For example, Vitousek et al. (1986) and Pauly and Christensen (1995) have estimated that humans are using or diverting significant fractions of primary productivity on land and at sea, respectively, and Postel et al. (1995) have shown that humans are using significant fractions of the fresh water available globally on evapotranspiration and runoff, partly through damming of rivers to convert them from flowing water to electricity and for water management. Similarly, large

Since 2006 when Nobel Laureate Paul Crutzen called for study of climate intervention research, the scientific community and the community of concerned climate and environmental scientists have struggled with understanding whether to consider such research and how to approach it



# What is geoengineering?

From NAS workshop scope:

*"Approaches that attempt to diminish effects or concentrations of greenhouse gases*

*that have already been emitted to the atmosphere*

*and are not already well-covered  
by other parts of the ACC process  
(e.g., conventional afforestation)."*

From the AMS policy statement on geoengineering

“deliberately manipulating physical, chemical, or biological aspects of the Earth system”

TOP STORIES IN World



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China Trade Surplus Widens

EUROPE NEWS | JULY 8, 2010

# Report Backs Climate Data, Scolds Scientists

*U.K. Inquiry Concludes Researchers Didn't Skew Findings, but Says They Failed to Show 'Proper Degree of Openness'*

Article

Comments (281)

Email Print Save This Like 59 + More Text

By JEFFREY BALL And GUY CHAZAN

A U.K. investigation concluded Wednesday that researchers at a prominent climate-change institute didn't skew science to inflate evidence of man-made global warming, but it criticized them for not sharing data and, in one instance, for presenting information in a "misleading" way.

The report is the third and largest in recent months to reach the complex conclusion about the conduct of climate scientists at the Climatic Research Unit of the U.K.'s University of East Anglia.

Taken together, the reports are in line with the 2007 conclusion by the United Nations' Intergovernmental Panel on Climate Change that global warming is "unequivocal" and is "very likely" caused by human activity. But the reports collectively warn climate scientists to be more transparent in responding to critics and in explaining their methods. The latest report also notes

Highly charged background




# Geoengineering

- Focused almost exclusively on global warming
- Some discussion of ocean acidification



# Techniques

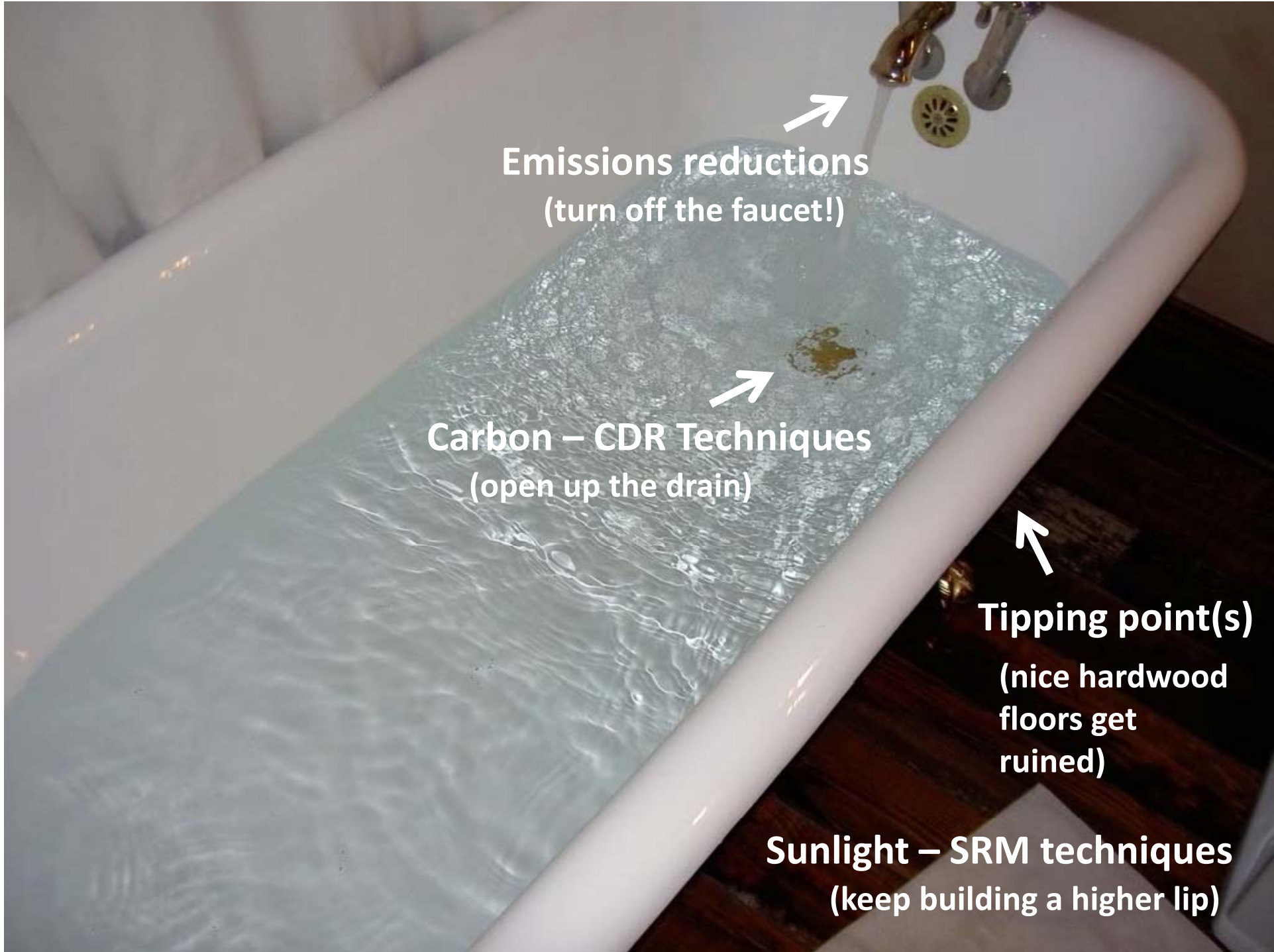
- Carbon Dioxide Removal (CDR)
- Solar Radiation Management (SRM)
- SRM techniques “assume” no impacts on the ocean when large changes in heat fluxes and irradiance expected



**Microbubbles ability to modulate albedo more rapidly and locally than stratospheric aerosols without chemical risks to the ozone layer or the color of the sky suggests a new approach to solar radiation management. Don't dim the sun. Brighten the water.**

Russell Seitz, Harvard, Journal of Climate in press





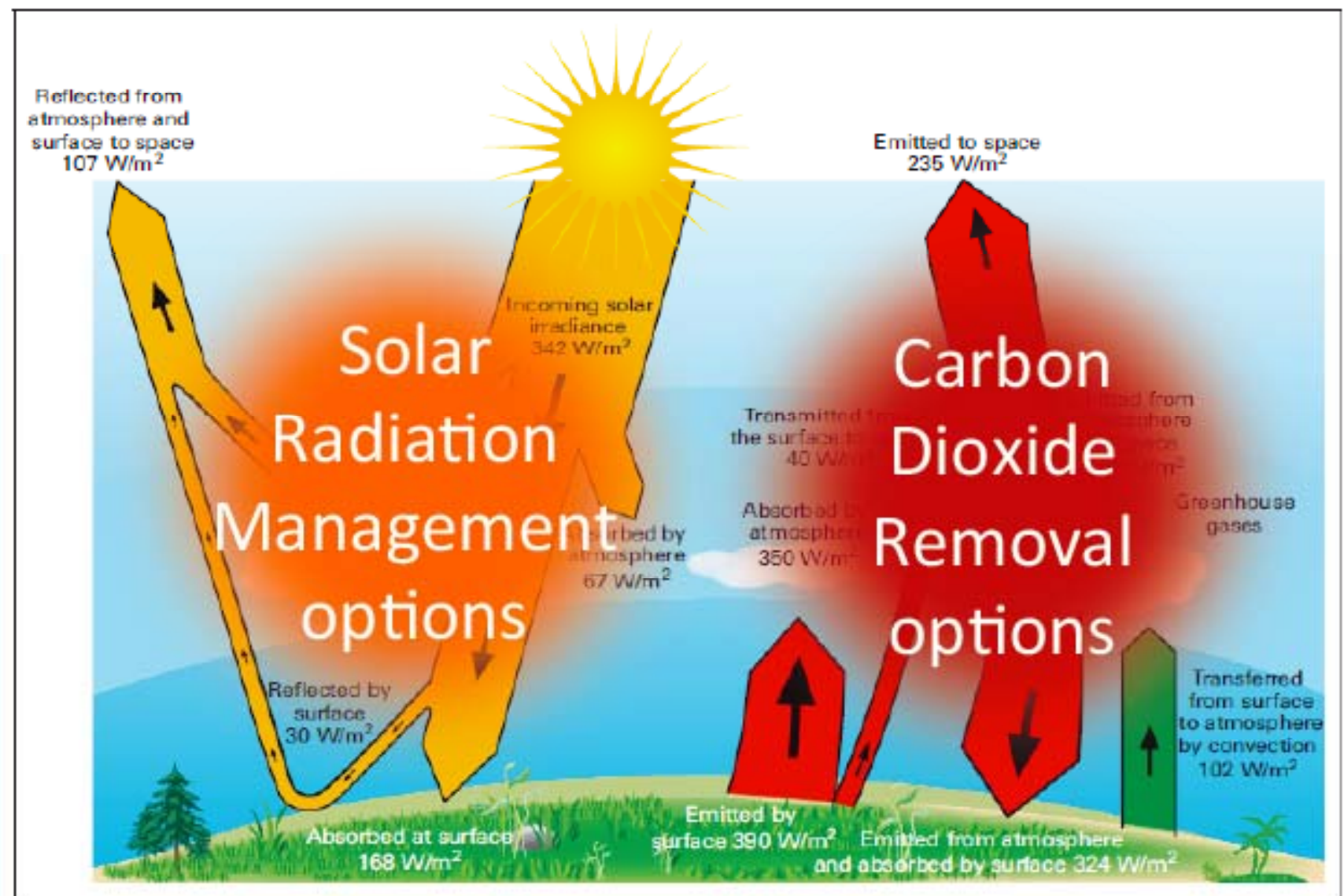
**Emissions reductions**  
(turn off the faucet!)

**Carbon – CDR Techniques**  
(open up the drain)

**Tipping point(s)**  
(nice hardwood  
floors get  
ruined)

**Sunlight – SRM techniques**  
(keep building a higher lip)

# Managing Earth's climate system: two basic methods: CDR & SRM



# Options

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graph TD; Options[Options] --- Gases[Remove greenhouse gases from atmosphere]; Options --- Sunlight[Reflect more sunlight to space]; Gases --- Biological[Biological approaches]; Gases --- Chemical[Chemical approaches];
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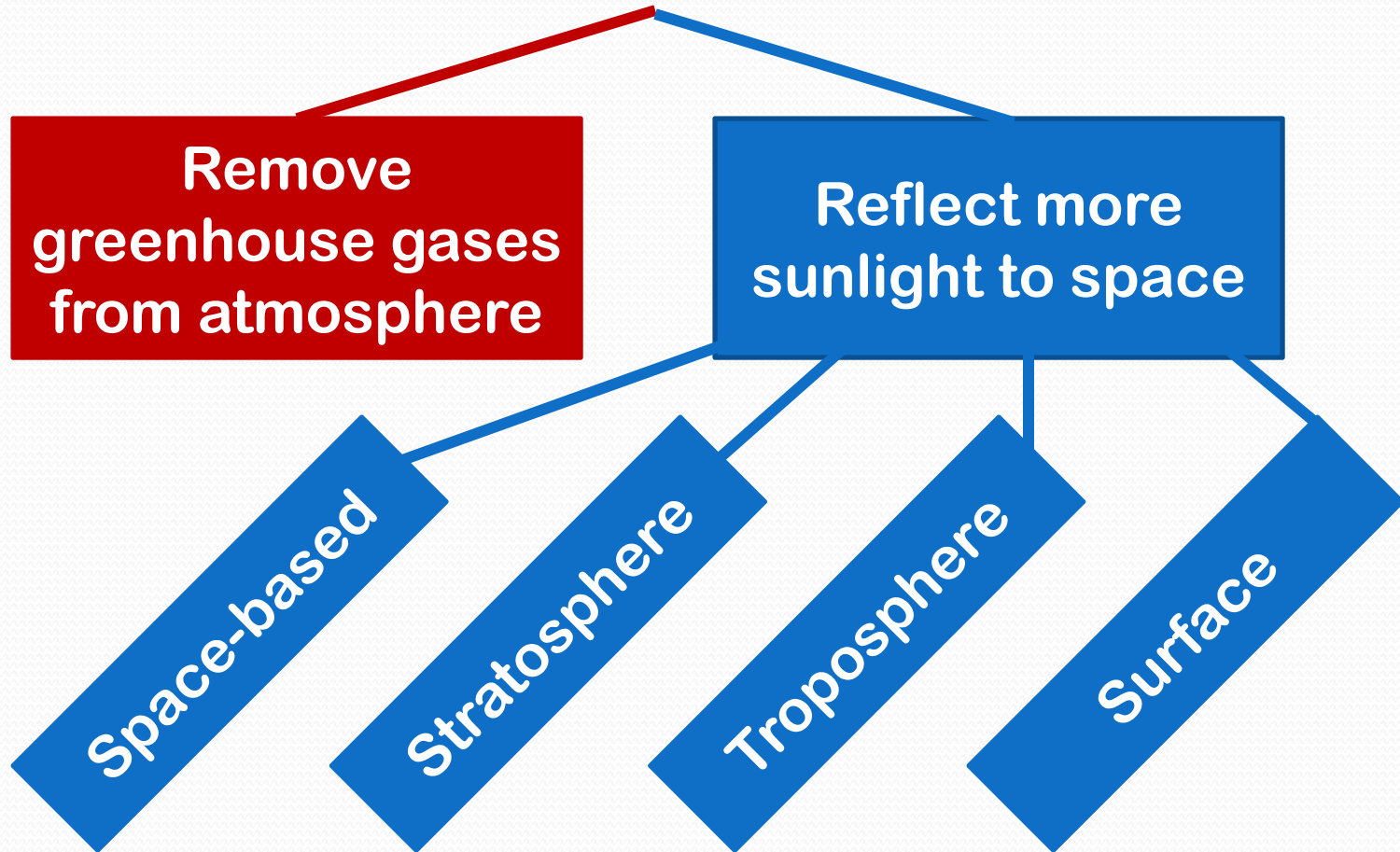
**Remove  
greenhouse gases  
from atmosphere**

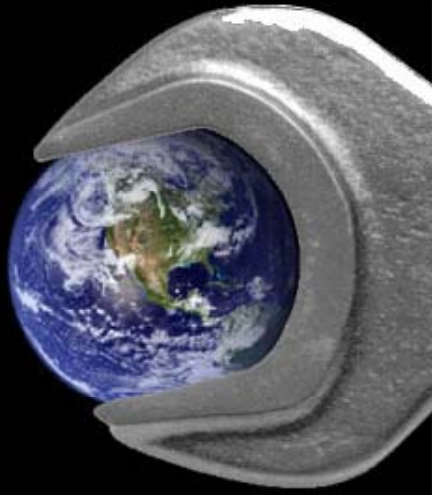
**Reflect more  
sunlight to space**

**Biological  
approaches**

**Chemical  
approaches**

# Options





**YOU CONTROL  
CLIMATE CHANGE.**

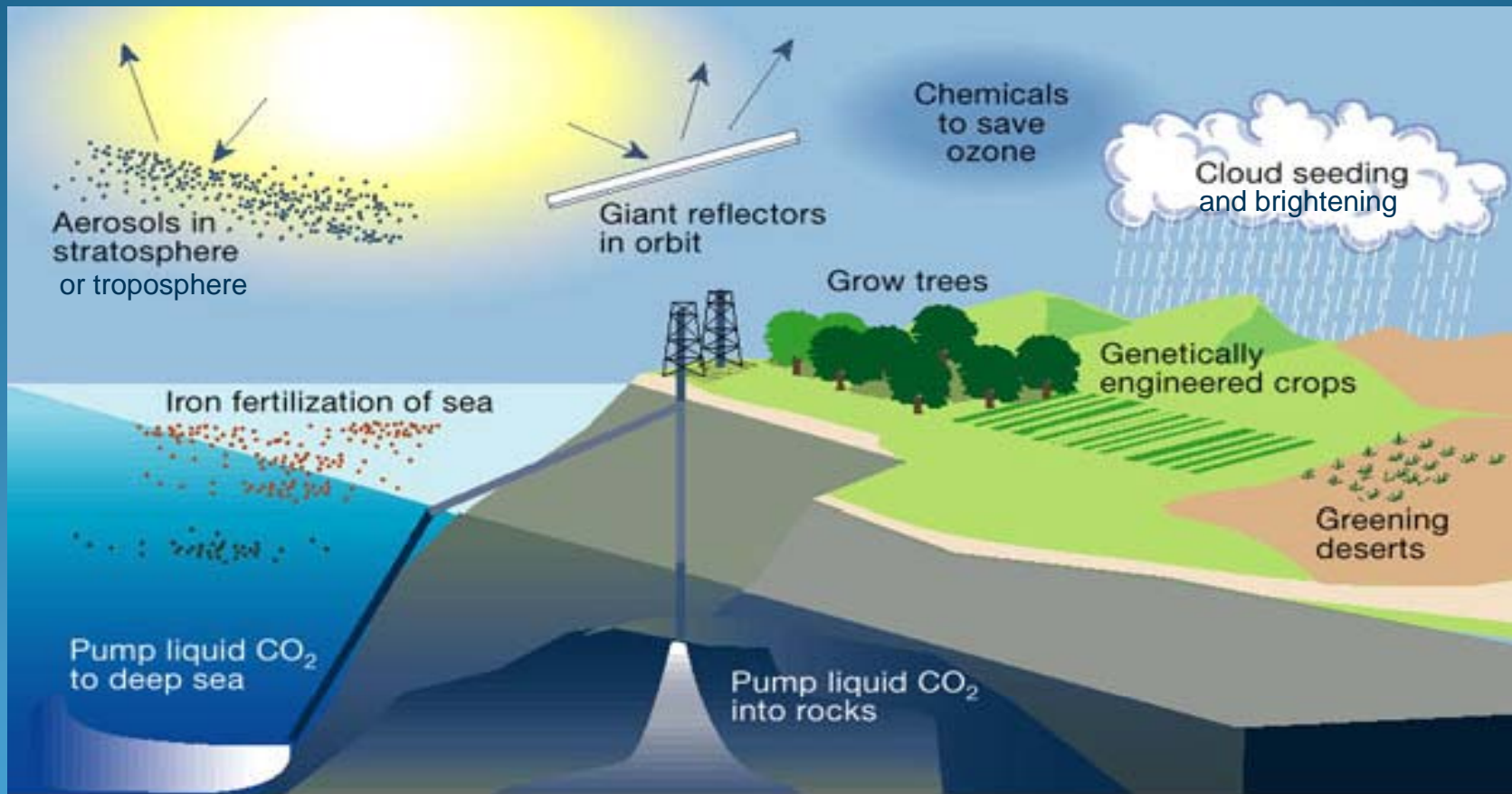


Two ways to geoengineer. High-altitude planes (*above*) might help study "climate intervention" techniques whereas CO<sub>2</sub>-suckers (*right*) involve "carbon remediation."



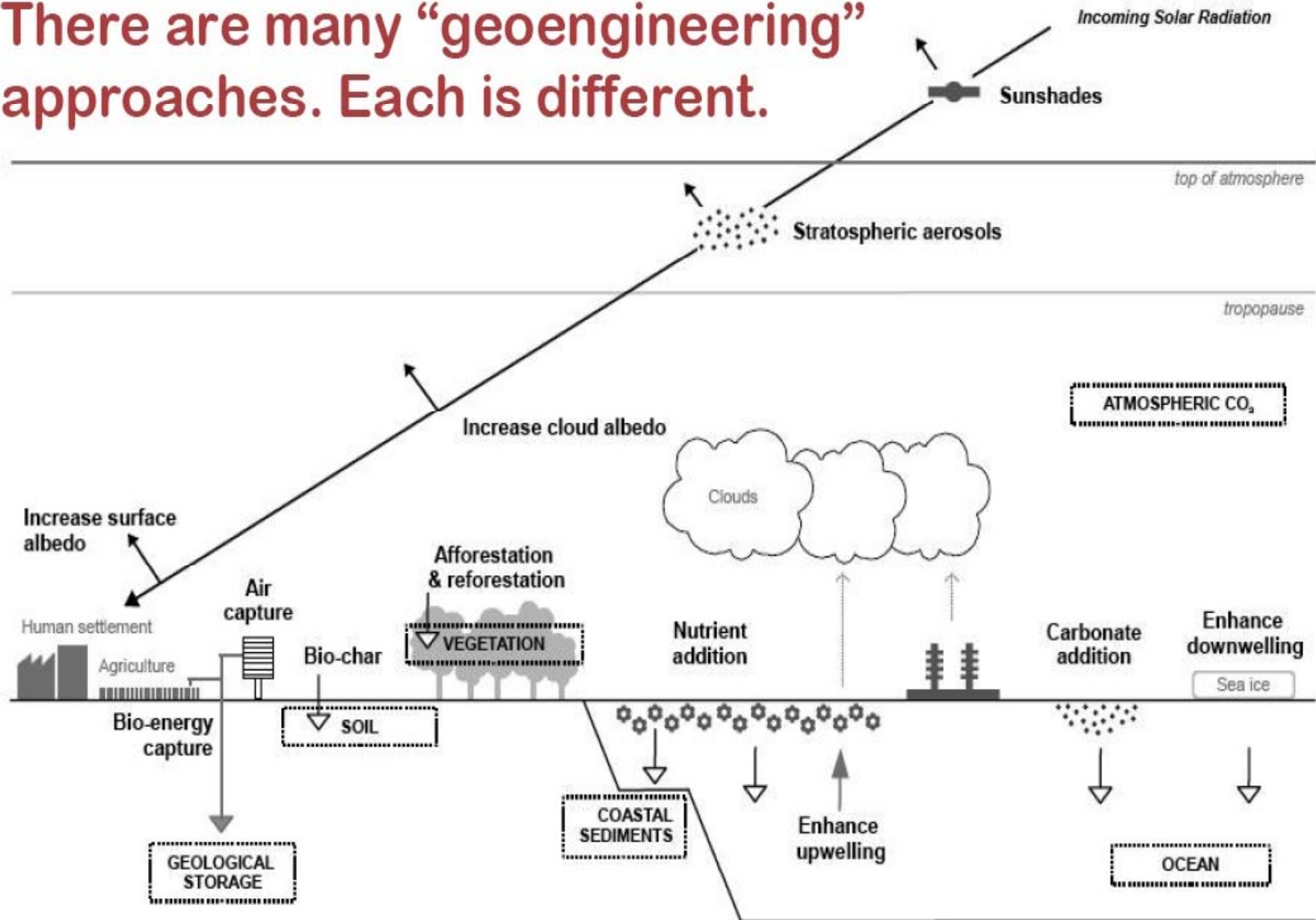
# There are three general approaches to Geoengineering

1. Reducing the quantities of greenhouse gases in the atmosphere
2. Reducing incoming solar radiation to counterbalance the warming influence of greenhouse gases
3. Altering the processes that lead to the climate change and impacts



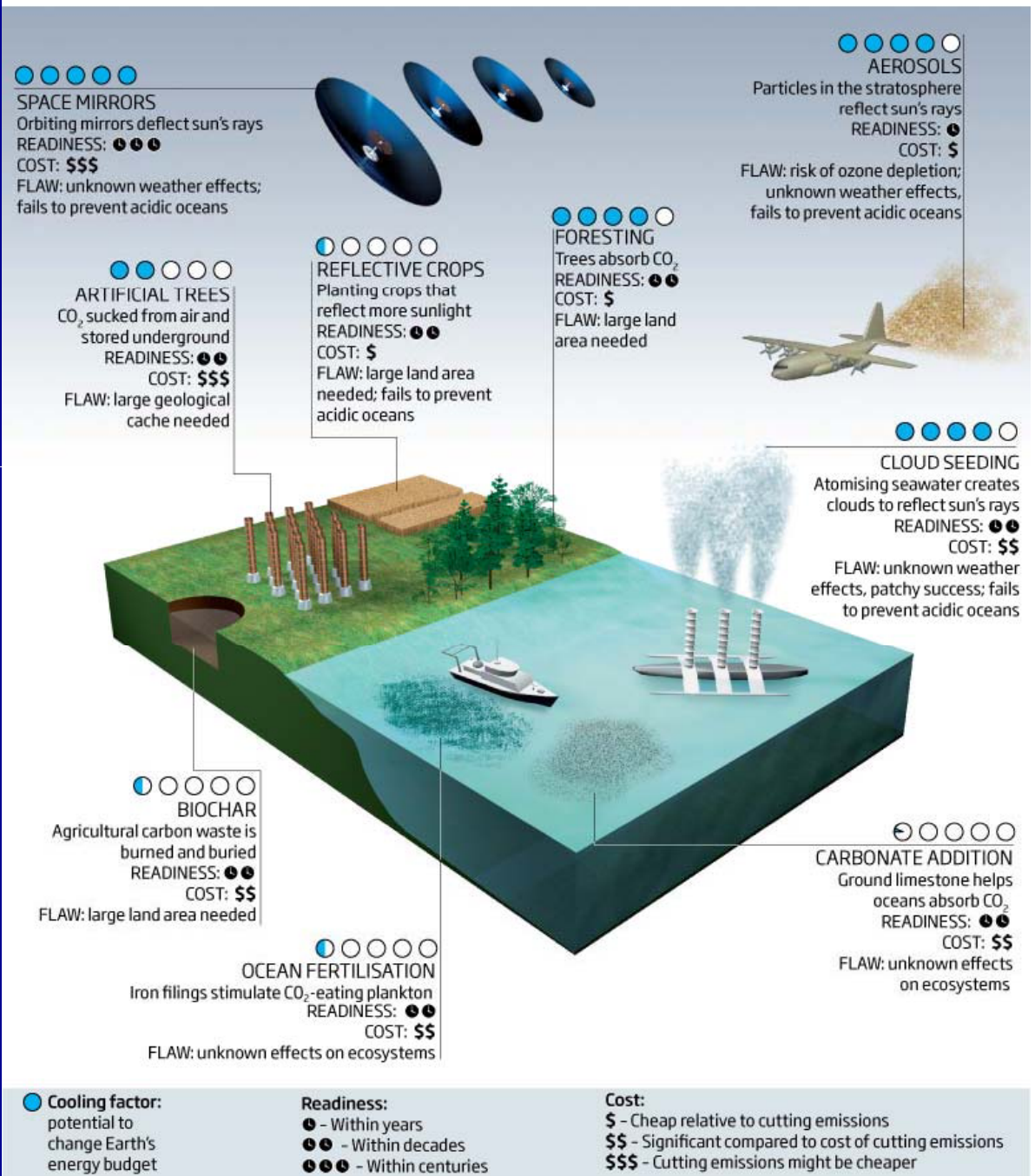
Schematic representation of various climate-engineering proposals (courtesy B. Matthews). (modified)

# There are many “geoengineering” approaches. Each is different.



Each of the approaches has a different potential cooling influence, readiness, and cost—all are in need of further research if they are to become potential options

## Geoengineering weighed up





## The Conference program\* was structured to generate discussion regarding potential guidelines for research activities, not deployment (1)

- **Monday evening:** Experiences with guidelines in other fields
- **Tuesday morning:** Plenary talks on approaches to climate and carbon intervention
- **Tuesday afternoon:** Plenary talks on legal, ethical, societal, economic, and governance issues
- **Tuesday evening:** Panel on actions/plans by governments
- **Wednesday morning:** Plenary talks introducing the notion of guidelines that might be applied to research on climate intervention

\* In addition to the time in the Conference sessions, that everyone had rooms on the grounds and ate meals together provided significant opportunities for interactions

## The Conference program was structured to generate discussion regarding potential guidelines for research activities, not deployment (2)

- **Wednesday and Thursday mornings:** Breakout groups on various types of approaches, focusing Wednesday on how to ensure a thorough scientific peer review and Thursday on how to ensure a responsible public and governmental review;
- **Wednesday and Thursday afternoons:** Parallel plenary sessions on Wednesday for solar radiation management and for carbon management; joint plenary on Thursday;
- **Wednesday evening:** Plenary presentations on results of surveys of the public and of studies of press coverage on climate change;
- **Thursday evening:** Plenary presentations on the possibilities and problems of considering climate intervention as part of the policy mix
- **Friday morning:** Discussion of the draft Conference statement

## The Breakout Groups were focused around potential objectives of climate intervention, rather than around technologies

- A. Reduce global average temperature (stratospheric aerosols, global cloud or surface brightening, etc.)
- B. Reduce specific (regional) impacts (e.g., cool the Arctic, moderate tropical cyclones, redirect storm tracks, etc.)
- C. Increase ocean uptake of CO<sub>2</sub> and limit pH change
- D. Increase terrestrial uptake and storage of CO<sub>2</sub>
- E. Destroy or geologically tie up CO<sub>2</sub> and other GHGs (e.g., scrub CO<sub>2</sub> and inject underground)

# The participants in the Conference represented an unprecedented set of experiences and backgrounds

Total of expert participants ~ 175; about 75-80% received support for travel and/or food and lodging at the Asilomar Conference Center; about 22% female

Academic institutions ~100 (including 10 young scientists who served as rapporteurs)

Non-governmental organizations = 40

Governments and government laboratories = 20

Other (retired, consultants, industry, etc.) = 15

## Participants included leading experts in the physical sciences



John Shepherd, FRS



Phil Rasch, PNNL



David Keith, Univ. of Calgary,  
and Alan Robock, Rutgers

...international legal scholars, energy experts, and experts in international climate policy



Catherine Redgewell, Cambridge



Jane Long, LLNL

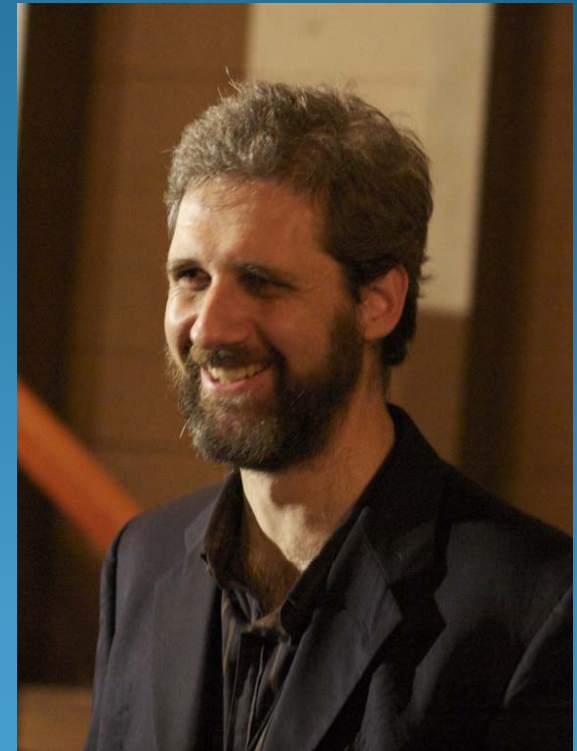


Diana Liverman, U. Arizona

# and experts from social sciences, diplomacy and international non-profits



Amb. Richard Benedick  
Chief US Negotiator, Montreal Protocol



Pablo Suarez  
Intl Red Cross/Red Crescent

# The Conference was open to the press under three limited rules

The three rules were:

1. **Chatham House Rule (modified)**—Information learned at Conference can be used, provided there is no quoting of or attributing statements to specific individuals without their specific permission (and speakers granted their permission on talks).
2. Information learned at Conference is embargoed until the end of the Conference.
3. Recording only allowed in plenary sessions, and subject to the Chatham House Rule (modified) shown above.

Under these rules, there have been quite a number of articles about the Conference coming out since it concluded.



# The media contingent included representatives of major media and scientific publications and documentaries



Jeff Tollefson, Nature



Oliver Morton, The Economist



Cheryl Hogue, C&E News

**Discussions at the Conference suggested five key principles for conducting and governing scientific research, modified from Rayner et al.**

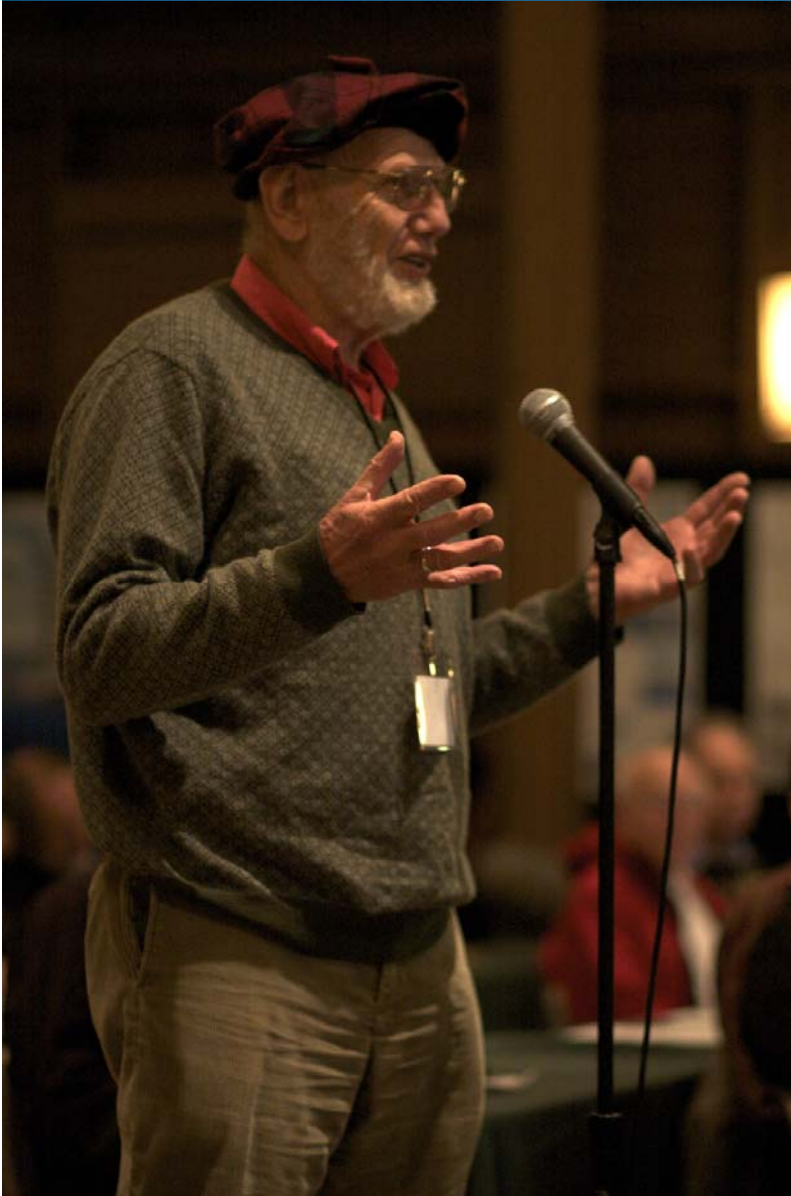
- 1. Conduct research to improve understanding of the potential for climate remediation for the collective benefit of humankind and the environment;**
- 2. Establish appropriate mechanisms and norms for research oversight and conduct;**
- 3. Ensure that research is coordinated, comprehensive, and transparent, with extensive and timely disclosure of results;**
- 4. Conduct independent, high-quality technical assessments of potential impacts and risks; and**
- 5. Promote adequate public participation and consultation in assessments and decision-making related to climate remediation.**

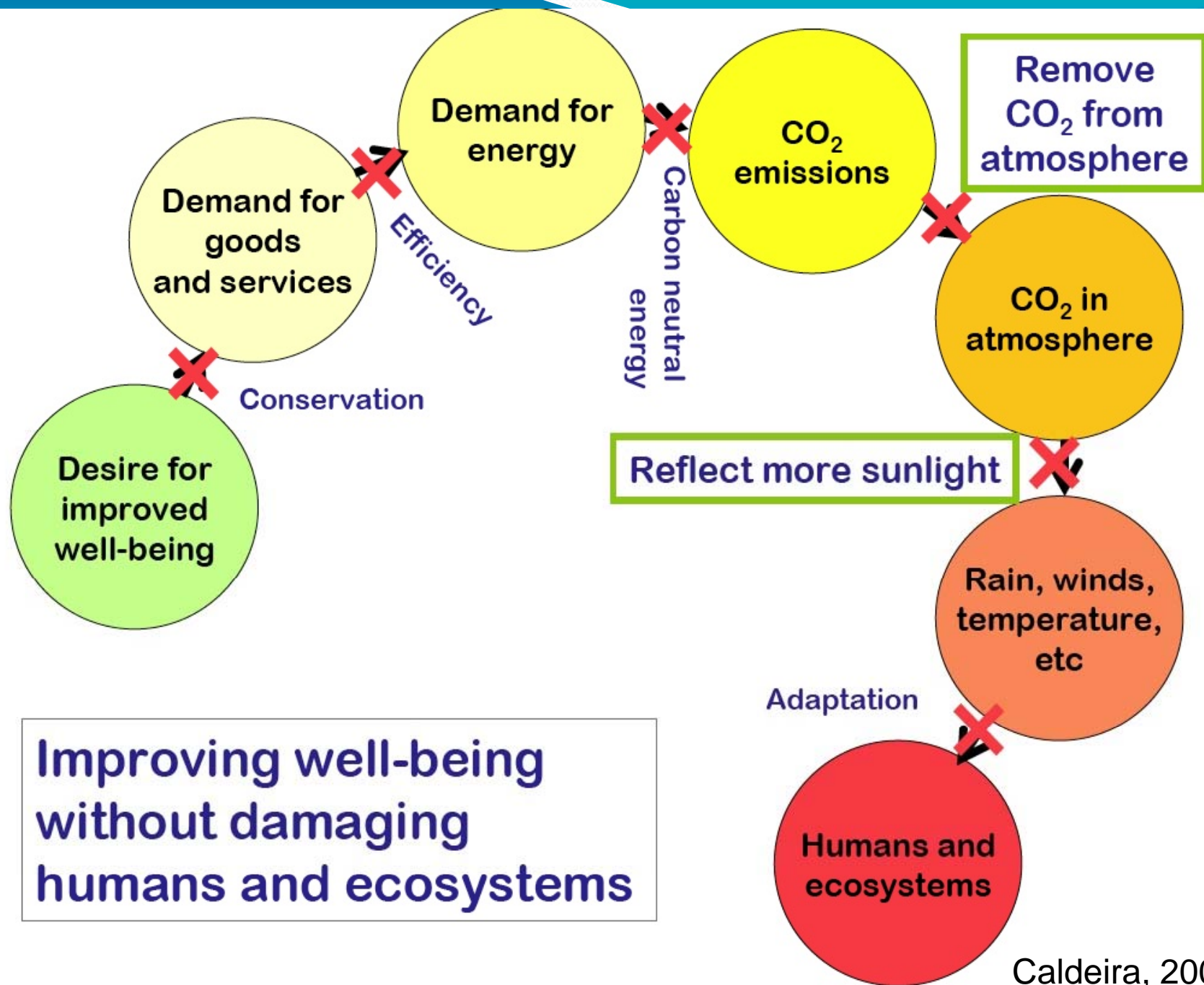
# Key points from the Conference Statement

- 1. MITIGATION AND ADAPTATION FIRST**--“Participants reaffirmed that the risks posed by climate change require a strong commitment to mitigation of greenhouse gas emissions, adaptation to unavoidable climate change, and development of low-carbon energy sources independent of whether climate intervention methods ultimately prove to be safe and feasible.”
- 2. SIGNIFICANT RISKS REMAIN**--“... uncertainties in the response of the climate system to increased greenhouse gases leave open the possibility of very large future changes. It is thus important to initiate further research in all relevant disciplines to better understand and communicate whether additional strategies to moderate future climate change are, or are not, viable, appropriate and ethical.”
- 3. RESEARCH ON CLIMATE INTERVENTION IS ESSENTIAL**--“We do not yet have sufficient knowledge of the risks associated with using methods for climate intervention and remediation, their intended and unintended impacts, and their efficacy in reducing the rate of climatic change to assess whether they should or should not be implemented. Thus, further research is essential.
- 4. CARE AND HUMILITY REQUIRED**—“Such discussions should be undertaken with humility and recognition of the threats posed by the rapid increase in atmospheric greenhouse gas concentrations.”

## Paul Craig, Sierra Club

“I came here expecting to find a bunch of engineers proposing to engineer the planet a la Edward Teller. Instead I found a conversation in which the word ‘humility’ appeared on their viewgraphs. I’m leaving here with a much different impression of what the geoengineers want to do.”







# OCEAN FERTILIZATION

a scientific summary for policy makers

## Contents

1. Ocean fertilization: context and key messages
2. Why fertilize the ocean?
3. How is the ocean fertilized and how is CO<sub>2</sub> sequestered?
4. What happens when the ocean is fertilized?
5. Are there unintended impacts of ocean fertilization?
6. How efficient is ocean fertilization for sequestering atmospheric carbon?
7. Monitoring for verification and reversibility
8. Governance and policy



# Workshop on Ocean Iron Fertilization Research, July 12-14, 2010, Woods Hole

- International group (Australia, China, Germany, Japan, UK, US) met to discuss the scientific motivation for future ocean iron fertilization (OIF) research
- Considered unresolved issues, possible experimental designs and organization strategies needed to improve our understanding of the effectiveness and impacts of ocean iron fertilization (OIF)
- Focus on the ability of OIF to sequester carbon at larger scales and how OIF can be used to test general hypotheses regarding oceanic carbon cycles and ecosystems