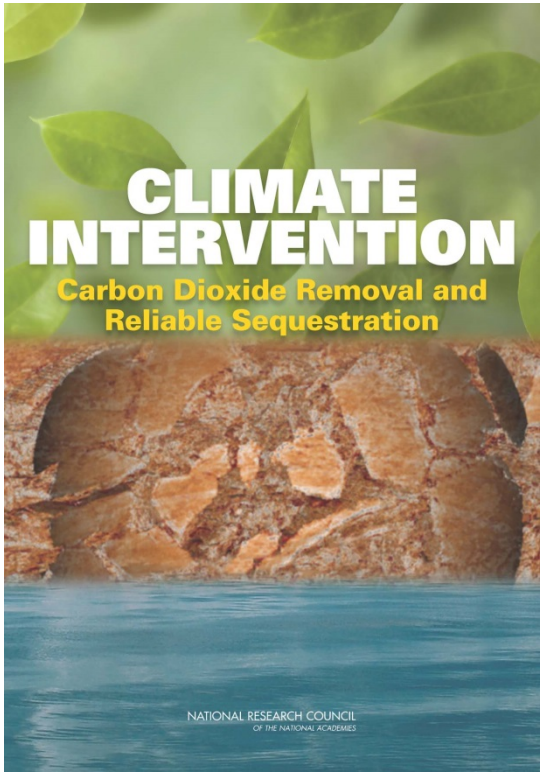
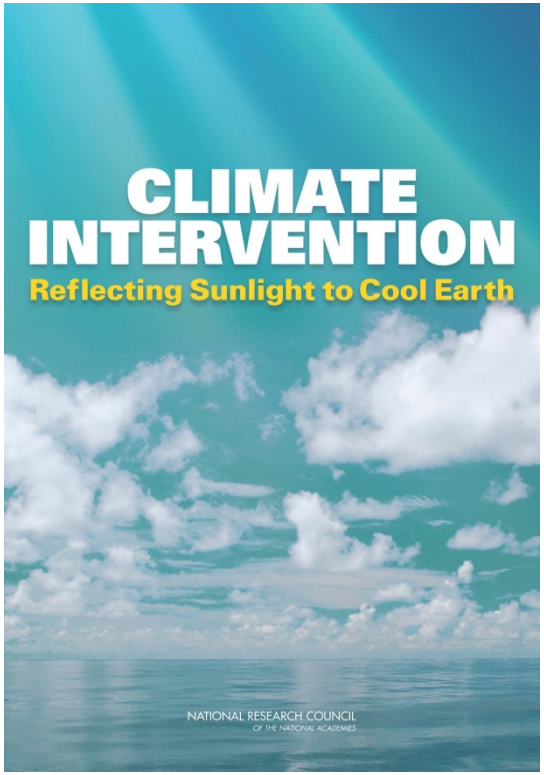
# CLIMATE INTERVENTION



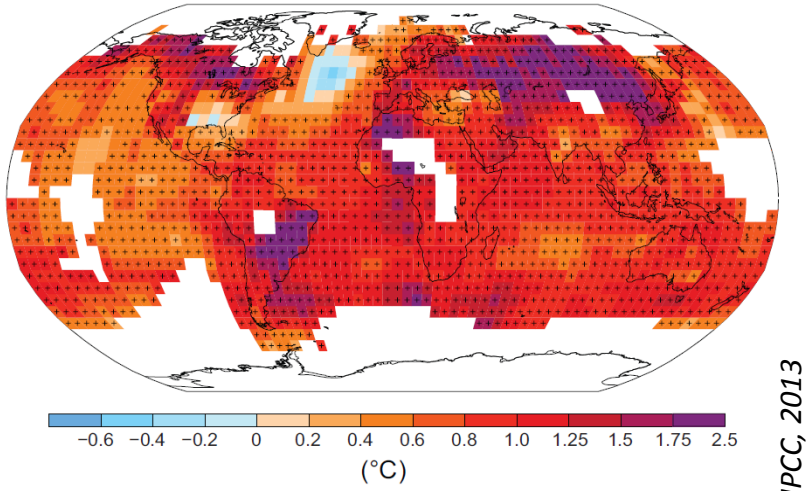




Marcia McNutt (Committee Chair)

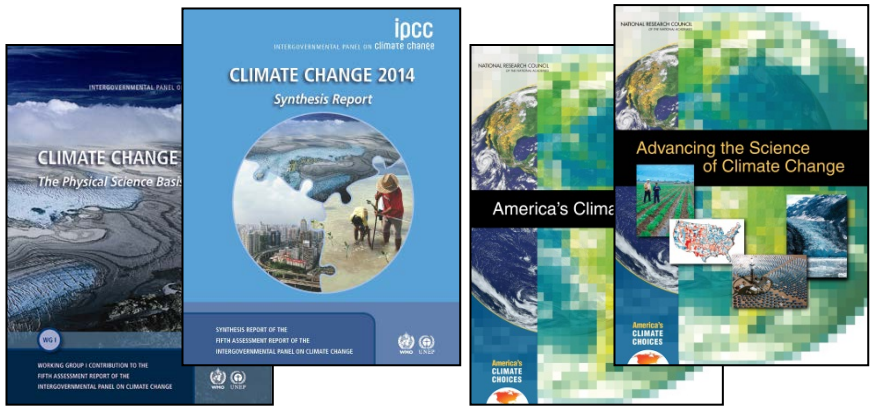
# CLIMATE IS CHANGING

- The signs of changing climate are all around us:
  - Greenhouse gases are increasing
  - Sea level is rising
  - Ice sheets and glaciers are melting
  - Global temperatures are increasing
- Climate change impacts people, ecosystems, and the economy

Observed Change in Surface Temperature




*IPCC, 2013*



# POSSIBLE CLIMATE RESPONSE OPTIONS

- Reducing greenhouse gas emissions
  - "Mitigation"
- Adapting to the impacts of climate change
  - "Adaptation"
- Climate Intervention???

# COMMITTEE ON GEOENGINEERING CLIMATE: TECHNICAL EVALUATION AND DISCUSSION OF IMPACTS

DOE, NASA, NOAA, U.S. intelligence community, and National Academy of Sciences supported this study

**Technical assessment** of two classes of climate intervention technologies

- Removing carbon dioxide from the atmosphere
- Reducing sunlight absorbed by Earth in order to cool planet's surface

- What is currently known
  - Science - risks and consequences
  - Viability for implementation
- Identify future research needed
- Comment generally on potential societal, legal, and ethical considerations

# COMMITTEE ON GEOENGINEERING CLIMATE: TECHNICAL EVALUATION AND DISCUSSION OF IMPACTS

**Marcia K. McNutt (Chair)**
Science / AAAS
**Waleed Abdalati**
University of Colorado, Boulder
**Ken Caldeira**
Carnegie Institution for Science
**Scott C. Doney**
Woods Hole Oceanographic Institution
**Paul G. Falkowski**
Rutgers, The State University of New Jersey
**Steve Fetter**
University of Maryland
**James R. Fleming**
Colby College
**Steven P. Hamburg**
Environmental Defense Fund
**M. Granger Morgan**
Carnegie Mellon University
**Joyce E. Penner**
University of Michigan
**Raymond T. Pierrehumbert**
University of Chicago
**Philip J. Rasch**
Pacific Northwest National Laboratory
**Lynn M. Russell**
Scripps Institution of Oceanography
**John T. Snow**
University of Oklahoma
**David W. Titley**
Penn State University
**Jennifer Wilcox**
Stanford University

- The Committee held four meetings and interacted with dozens of scientists
- Reports were reviewed by 16 outside experts

# 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 AND RELIABLE SEQUESTRATION

## Enhancing natural carbon sinks

- Changes in land use management
  - Reforestation / afforestation
  - Agricultural practices
- Accelerated weathering
  - Chemical reactions to form carbonate or silicate minerals
- Ocean iron fertilization
  - Adding iron to the ocean to boost the growth of phytoplankton

# CARBON DIOXIDE REMOVAL AND RELIABLE SEQUESTRATION

## Other technologies

- Direct Air Capture and Sequestration (DACS)
  - Chemical scrubbing processes
- Bioenergy with Carbon Capture and Sequestration (BECCS)
  - Use plants (biomass) to produce energy
  - Capture carbon dioxide from power plant and sequester underground

# 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**

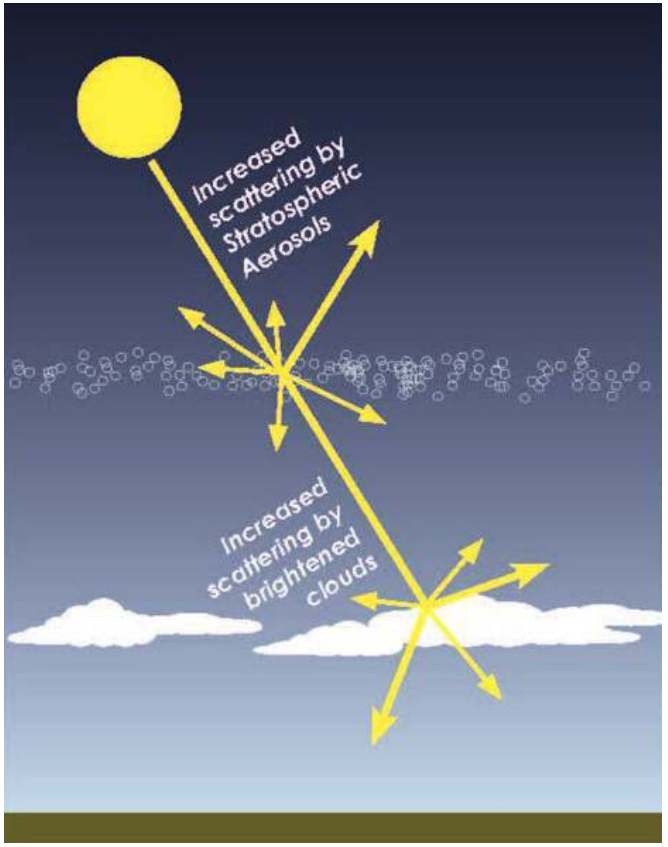
# ALBEDO MODIFICATION

Albedo modification could reduce amount of sunlight absorbed by Earth in order to cool planet's surface quickly

- The report considered two strategies:
  - Stratospheric aerosols
  - Marine cloud brightening

*Elsewhere referred to as "Solar Radiation Management"*

*"Albedo" is the proportion of incoming sunlight that is reflected back to space*



# 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

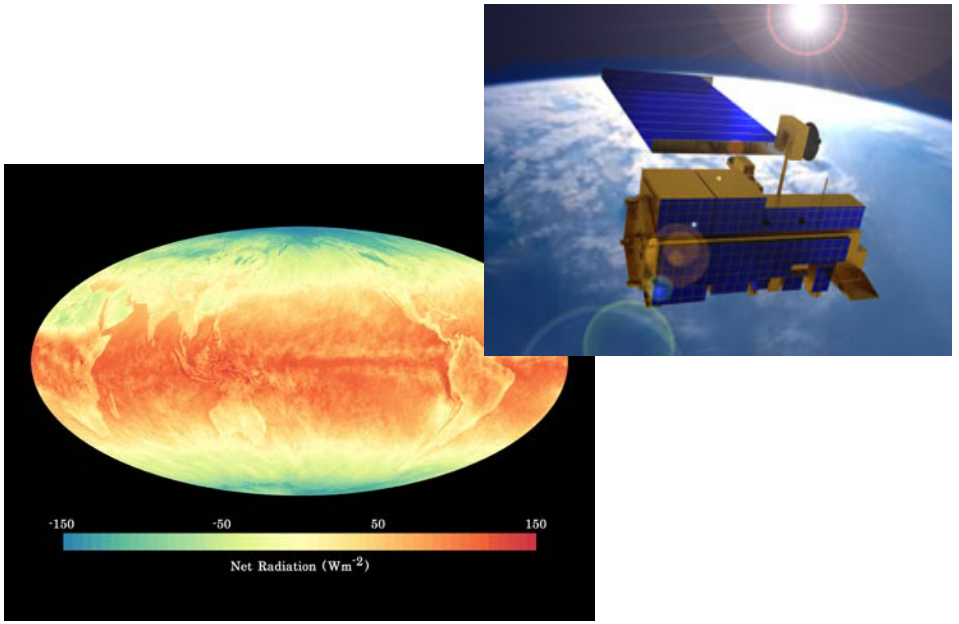
**Recommendation 4:**

**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

More than just science involved in decisions on research and deployment

- Governance
- Ethical & legal considerations

Albedo modification research is not specifically addressed by any federal laws or regulations

Need for transparent and inclusive conversations

Goal of governance should be to maximize benefits of research while minimizing risks

# GOVERNANCE CONSIDERATIONS

**Recommendation 6:**

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

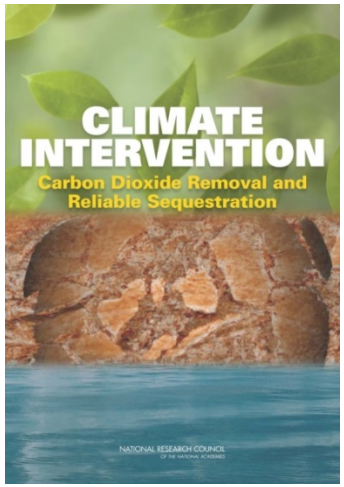
**(a) what types of research governance, beyond those that already exist, may be needed for albedo modification research, and**

**(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**

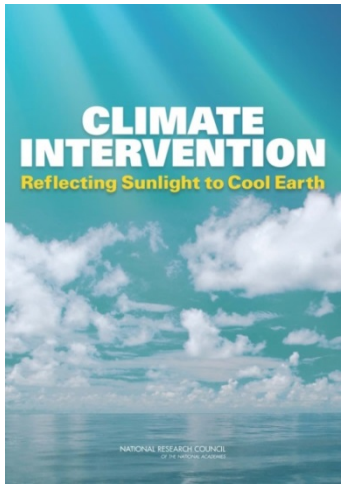
# CONCLUSIONS

- The challenges of climate change require a portfolio of actions with varying degrees of risk and efficacy
- There is no substitute for mitigation and adaptation
- Carbon dioxide removal strategies offer potential to decrease carbon dioxide concentrations in the atmosphere
- Albedo modification strategies currently limited by unfamiliar and unquantifiable risks and governance issues
- Any intervention in Earth's climate should be informed by a far more substantive body of scientific research than is available at present

# ACKNOWLEDGMENTS




Sponsors
Committee
Reviewers
NRC Staff
Numerous colleagues consulted during study




Please visit **americasclimatechoices.org** to find:

- Complete reports available for free PDF download
- Report in Brief (4-page lay summary)
- Press release
- Briefing slides and archived public release webcast

Join the conversation : #ClimateIntervention

| Carbon Dioxide Removal proposals… | Albedo Modification proposals… |
|---|---|
| **… address the cause of human-induced climate change (high atmospheric GHG concentrations).** | …do not address cause of human-induced climate change (high atmospheric GHG concentrations). |
| **…do not introduce novel global risks.** | … introduce novel global risks. |
| **…are currently expensive (or comparable to the cost of emission reduction).** | …are inexpensive to deploy (relative to cost of emissions reduction). |
| **…may produce only modest climate effects within decades.** | …can produce substantial climate effects within years. |
| **…raise fewer and less difficult issues with respect to global governance.** | …raise difficult issues with respect to global governance. |
| **…will be judged largely on questions related to cost.** | …will be judged largely on questions related to risk. |
| **…may be implemented incrementally with limited effects as society becomes more serious about reducing GHG concentrations or slowing their growth.** | …could be implemented suddenly, with large-scale impacts before enough research is available to understand their risks relative to inaction. |
| **…require cooperation by major carbon emitters to have a significant effect.** | …could be done unilaterally. |
| **…for likely future emissions scenarios, abrupt termination would have limited consequences** | …for likely future emissions scenarios, abrupt termination would produce significant consequences |

# DISSEMINATION ACTIVITIES

**Sponsor Briefings**
- Multi-Agency Sponsor Briefing (Feb. 9, 2015)
- NOAA Climate Goal Team Briefing (Feb. 13, 2015)

**Congressional Briefings**
- Senate Climate Clearinghouse (Feb. 9, 2015)
- Senate Environment and Public Works (Feb. 9, 2015)
- Senate Commerce (Feb. 9, 2015)
- House SEEC Coalition (Feb. 9, 2015)
- House Science, Space and Technology – Majority (Feb. 9, 2015)
- House Science, Space and Technology – Minority (Feb. 9, 2015)
- House Natural Resources Subcommittee on Energy & Mineral Resources (Feb. 9, 2015)

**Other Briefings**
- OSTP and OMB Briefing (Feb. 9, 2015)
- NGA (Feb. 11, 2014)
- Center for Climate & Security (Feb. 25, 2015)

**AAAS Annual Meeting**
- Feb. 14, 2015
- Two sessions
  - Going Negative: Removing Carbon Dioxide from the Atmosphere
  - Climate Intervention and Geoengineering: Albedo Modification

**Public Webinars**
- Public Release Event (Feb. 10, 2015)
- Resources for the Future Event (Feb. 24, 2015)
- Public NRC Webinar (Feb. 26, 2015)
- Union of Concerned Scientists Webinar (Feb. 27, 2015)
- Chevron Internal Seminar Series (March 17, 2015)
- World Resources Institute (March 19, 2015)
- US Energy Association (March 31, 2015)

# PUBLIC REACTIONS

**Media Coverage**

- New York Times
- Washington Post
- Associated Press
- Los Angeles Times
- The Guardian
- USA Today
- National Public Radio
- National Geographic
- Science
- Bloomberg Business
- Forbes
- National Monitor
- National Journal
- EcoWatch
- Eos
- Physics World
- E&E News
- … more…

**Statements / Reactions from Non-Governmental Organizations**

- Environmental Defense Fund
- ETC
- Friends of the Earth
- Natural Resources Defense Council
- Union of Concerned Scientists