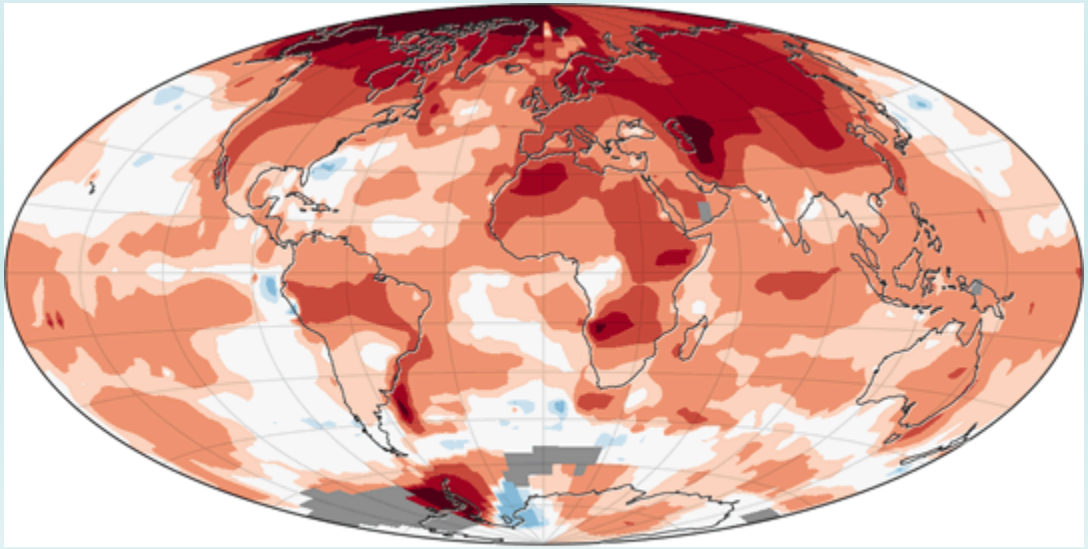
Climate Change and Geoengineering



Center for Environmental Stewardship
Thomas Jefferson Institute for Public Policy

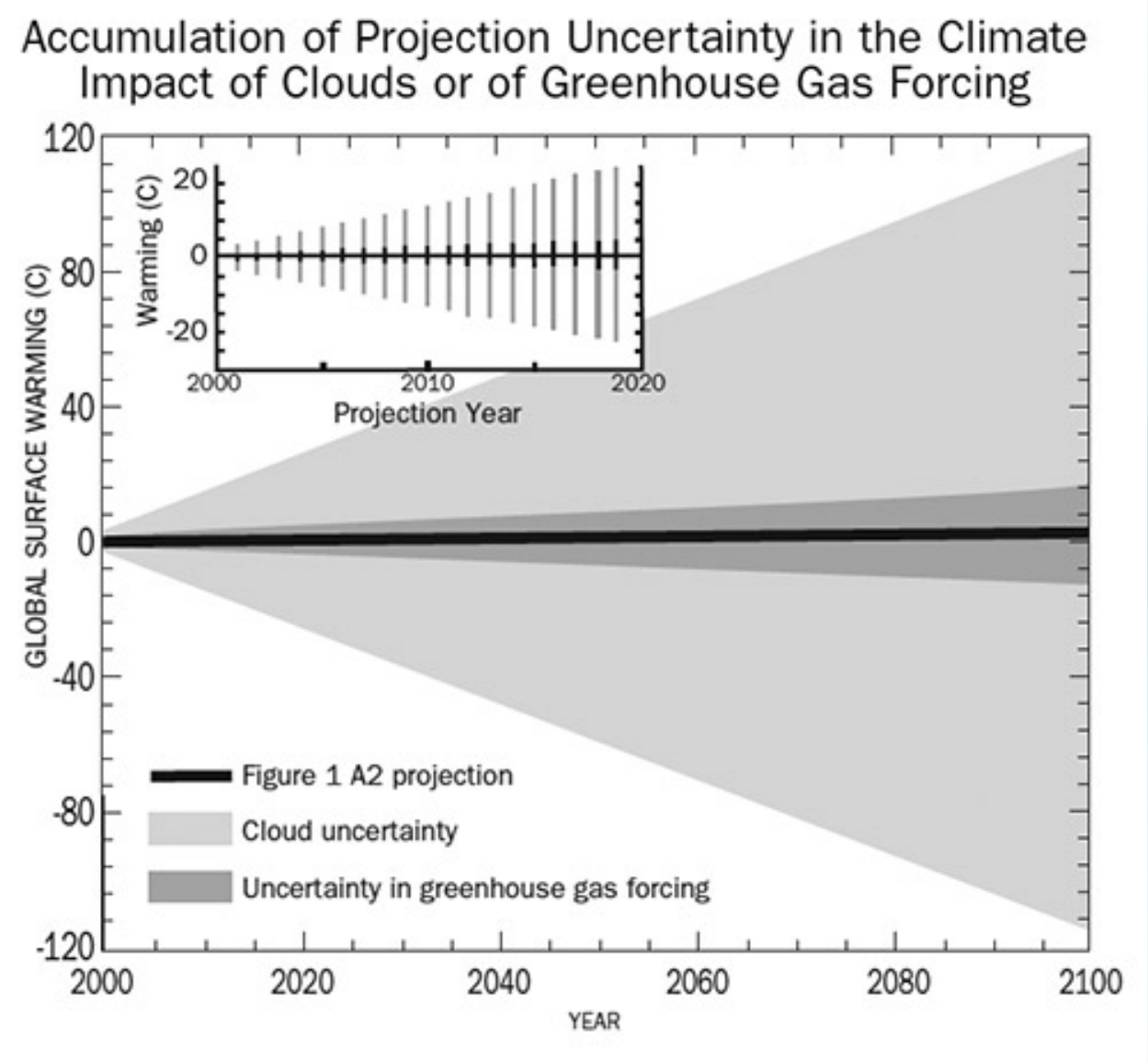
Mission Statements:

The mission of the Thomas Jefferson Institute for Public Policy is to provide Virginia's political, business, academic, community and media leadership with thoughtful, realistic, useful and non-partisan analysis of public policy issues confronting our Commonwealth.

The mission of the Center for Environmental Stewardship is to promote environmentalism within the context of meeting all human needs.

The Uncertain Basis of Climate Change Policy

- **As the following graph indicates, the IPCC estimates on whether emissions of greenhouse gases will warm or cool the planet is very uncertain, and the amount they will do so is very uncertain.**
- **Even more uncertain are the effects clouds have on warming and cooling.**
- **In light of this massive uncertainty, economic commitments to address climate change should be done in pieces and over several decades, depending on new knowledge from emerging science.**
- **In addition, emergency planning for rapid climate change demands special attention. This presentation introduces one "insurance policy" that is available for emergencies.**


Accumulation of Projection Uncertainty in the Climate Impact of Clouds or of Greenhouse Gas Forcing
GLOBAL SURFACE WARMING (C)
120
80
40
0
-40
-80
-120
2000
2020
2040
2060
2080
2100
YEAR
Warming (C)
20
0
-20
2000
2010
2020
Projection Year
Figure 1 A2 projection
Cloud uncertainty
Uncertainty in greenhouse gas forcing

Have we already reached an emergency?

According to the IPCC and its chairman, the answer is an unreserved

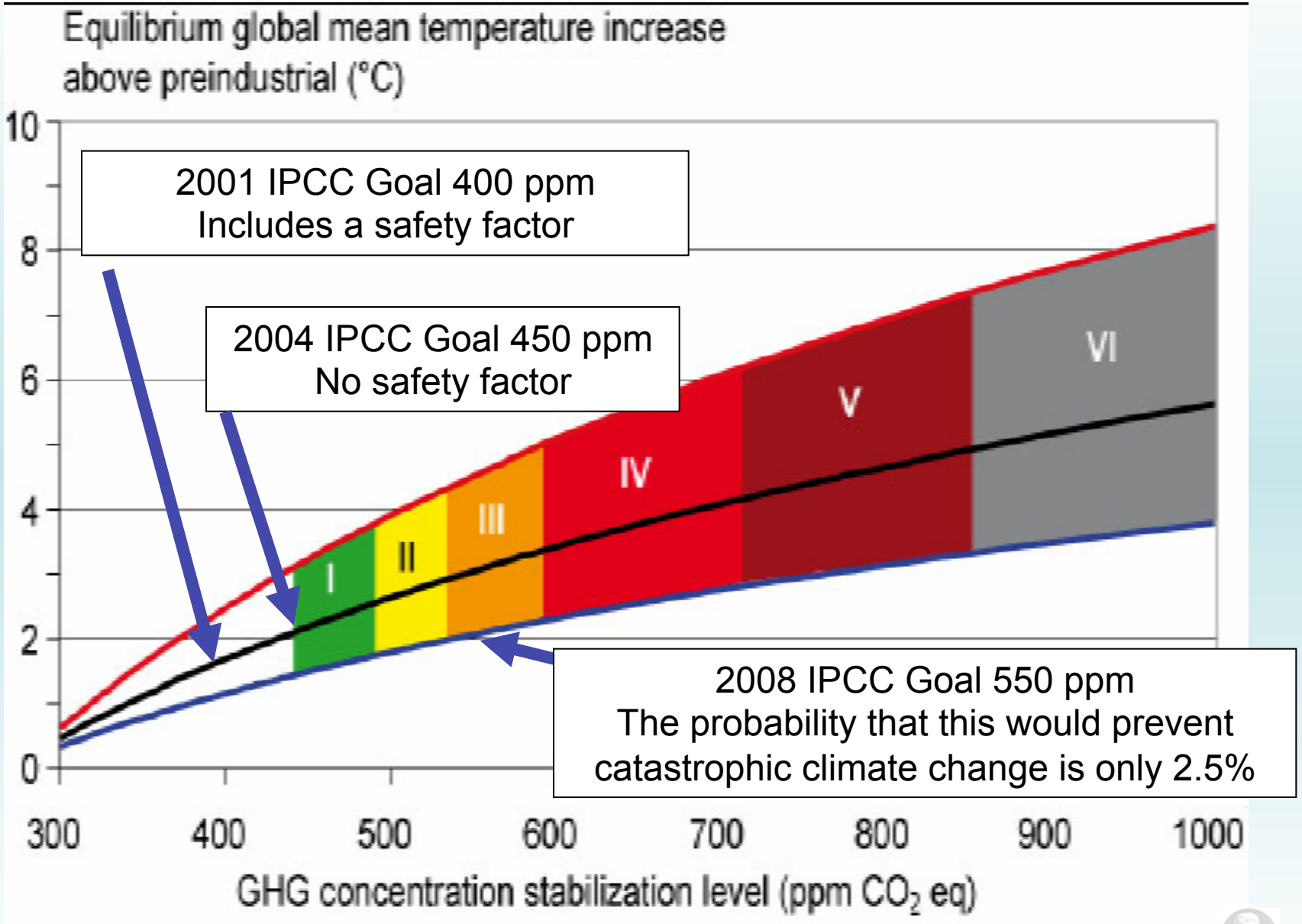
yes.

The IPCC chairman has recognized that the global community has failed to meet GHG emission reduction goals, and will have to go beyond mitigation that involves only emissions reductions.

Without expressly saying so, he has conceded that state, federal and international carbon reduction goals are[1]:

"Too little and too late".

- **The next chart shows how the IPCC has shifted its carbon emissions reduction goals, mainly because nations throughout the world simply refuse to reduce their emissions.**
- **In 2001, the IPCC goal included a safety factor.**
- **By 2004, their goal had no safety factor at all and there was a 50 % chance that meeting their goal would still lead to climate catastrophe.**
- **By 2008, the IPCC abandoned any pretense that it could stop unacceptable warming. Their goal has only a 2.5 percent chance of preventing a catastrophe.**
- **The reality is worse. Based on the best IPCC estimates, it is now too late to prevent catastrophic warming.**



Source: IPCC SPM[3]

A Harsh Reality:

- The atmosphere reached greenhouse gas concentrations of 450 ppm CO_2 eq in 2005.[2]
- Assuming the IPCC models are correct, catastrophic climate change will occur regardless of the emissions reductions we achieve over the next two decades.

There are three means to prevent catastrophic climate change:

1. Reduce GHG emissions (not sufficient alone)
2. Remove CO2 from the atmosphere (Geo-engineering)
3. Reduce Solar Radiation (Geo-engineering)

If we see significant temperature increases, we will need to use all three.[3]

Climate Change Activists Agree Geoengineering is a path we need to examine.

"There are good arguments for paying more attention to understanding geoengineering possibilities."[4]

David Hawkins,
Natural Resources Defense Council

"Yes, by all means, do all the [geoengineering] research."[5]

Rajendra K. Pachauri
IPCC Chairman

Who Supports Geoengineering Research?

- Paul Crudzen, *Nobel Laureate* (CFCs and the ozone hole)
- Thomas Schelling, *Nobel Laureate* (economics and international conflict theory)
- Ken Caldeira, *Nobel Laureate* – IPCC Team (Carnegie Institute)
- Tom Wigley, *Nobel Laureat* – IPCC Team (National Center for Atmospheric Research)
- Rajendra K. Pachauri, *Nobel Laureate* – IPCC Team (Chairman, IPCC)
- James Hansen, *Nobel Laureate* – IPCC Team (NASA)
- David Hawkins – Natural Resources Defense Council
- Alan Carlin – US Environmental Protection Agency
- Eugene I. Gordon – National Research Council/National Academy of Engineering

What is Geo-Engineering?

Geo-engineering is the deliberate modification of Earth's environment on a large scale "to suit human needs and promote habitability".

Geoengineering is at present the only economically competitive technology to offset global warming. The geo-engineering option may be considered costless.[6]

William Nordhaus, Yale

Five geo-engineering approaches have been seriously considered.

1. Whitening the Earth's Surface
2. Shading the Earth with Mirrors
3. Sequestering Carbon in the Ocean
4. Shading the Earth with Aerosols
5. Shading the Earth with Whiter Clouds

White Surface the Earth.

- White roofs in California would cost as much as would be saved in air conditioning costs.
- To cool the planet would require covering 30% of all land.
- It would also have to offset the warming caused by the increased canopy of arboreal forests (which are dark).
- It would require significant international cooperation.
- This was considered the solution to global warming during the Johnson administration.

Launch Space Mirrors

- We would need to launch 70 square kilometers of mirror every day for a year to build a sufficiently large mirror.
- The cost of this approach is equal to the cost of 90% carbon reduction through shifts to non-carbon energy
- No one nation could afford this, and it is not simple to "turn-on and off".

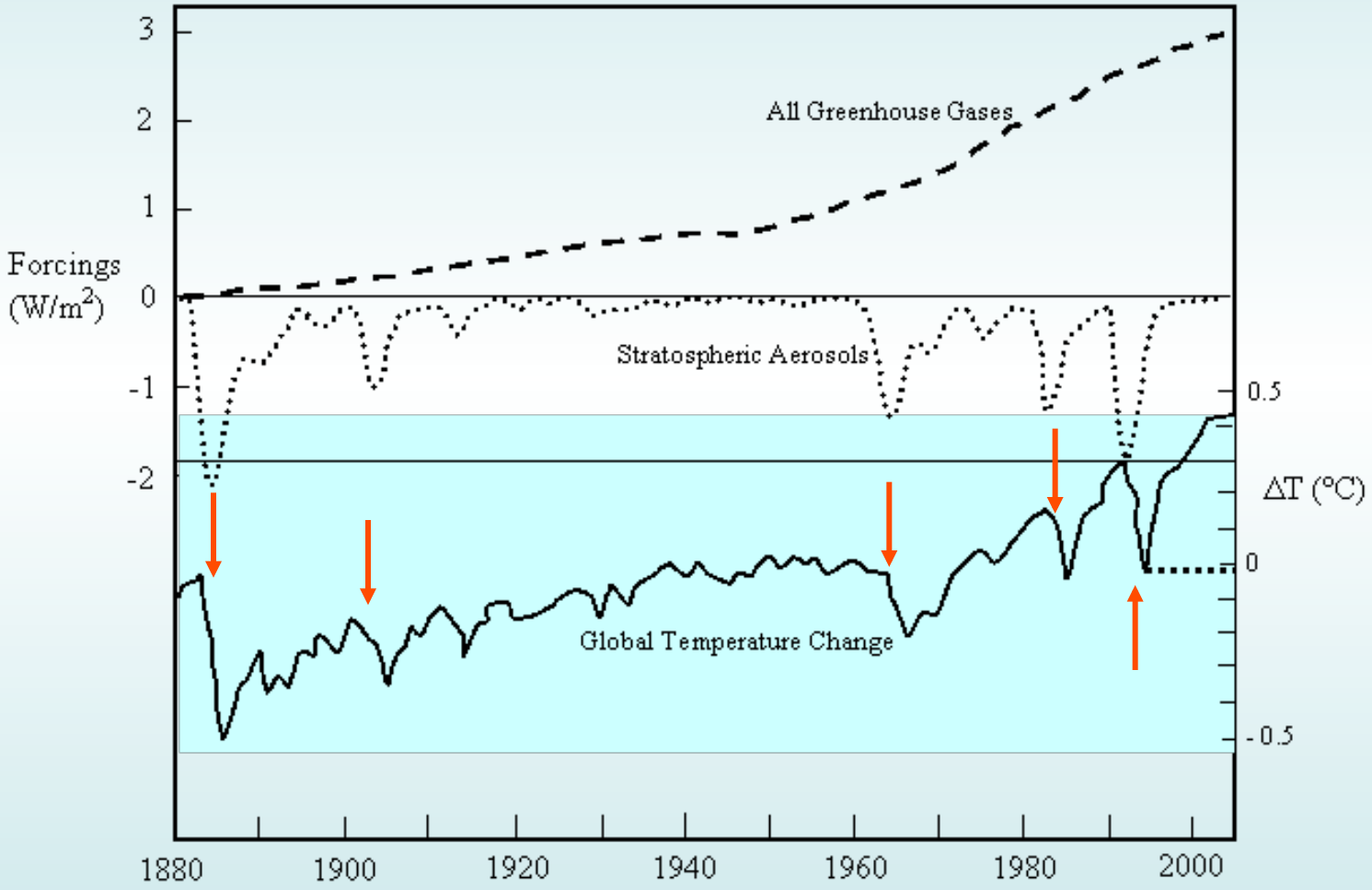
Ocean Iron Fertilization

- Would neutralize acid in the ocean, something no other approach would do.
- Is commercially available today.
- May not sequester carbon if organisms do not fall deep into the ocean upon their deaths.
- Can be turned on and off easily.
- Is low-cost sequestration, if it sequesters 35% of bio-extracted carbon.

A Stratospheric Aerosol Sun Shade

- **The most frequently discusses approach to geoengineering is to create an umbrella of small particles in the upper atmosphere to reflect heat away from the earth.**
- **As the next chart shows, this mimics volcano eruptions – and it works very well, very quickly.**
- **The arrows indicate large volcanic eruptions. Note the immediate and large reductions in global temperature.**

Stratospheric Aerosol Geoengineering Mimics Volcano Eruptions



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Launch Stratospheric Aerosols

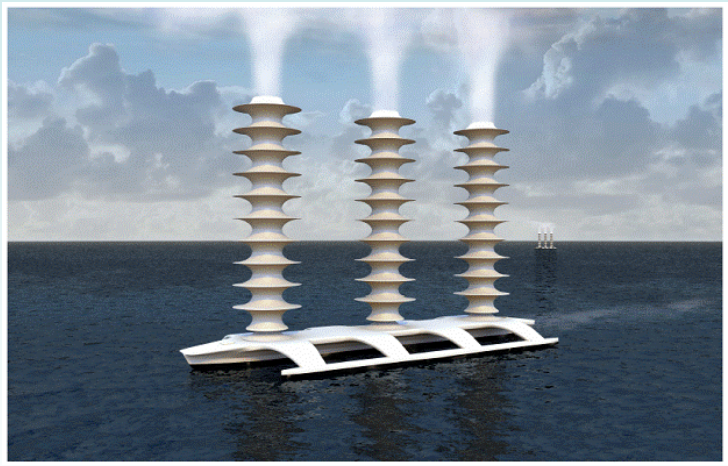
- Requires $200 Million to $2 Billion a year, an amount equal to $1 per ton of carbon emission reduction. (Current U.S. market price is $4.50/ ton.)
- Uses 10 747 aircraft operating continuously, discharging through the equivalent of a fire hose.
- Alternatively, tall insulated tubes from 4% of U.S. coal fired power plants could be used.
- Can design aerosols to prevent harm to the ozone or acid deposition.

Launch Stratospheric Aerosols (cont.)

- Can be turned on and off quickly.
- Has the side benefit of producing light that better penetrates tropical forests and thus increases carbon sequestration in forests.
- Could restore arctic ice cover within two years.
- Would take two decades to cool down the ocean heat sink.
- Extends the amount of time available to implement carbon reduction actions.

Whiten Clouds[7]

- Uses natural cloud reflectivity.
- Increases rainfall.
- Can be used geographically selectively to benefit local climates (*e.g.*, Southeastern US).
- Lowest Cost option.
- Can be turned on and off.



A Temperate (Phased) Strategy

- **Use every carbon reduction action that pays for itself in cost savings (*e.g.*, CFLs)**

- **Schedule state-based carbon emission reductions over a three to five decade period, reflecting the evolution of climate science and the inevitable use of geoengineering to mitigate catastrophic climate change.**

- **Invest in geoengineering research**

Notes:

1. Pachauri, R. (2007) The IPCC Chairman no longer discusses stabilizing greenhouse gases at 400 ppm CO_2 eq. His most optimistic scenario stabilizes GHGs at 467 ppm CO_2 eq and a global temperature rise above 2°C. See: http://gcep.stanford.edu/pdfs/kUXNHroC3cAssx6wJoz_Mg/Pachauri-20071001-GCEP.pdf

2. Flannery, T. "Greenhouse gas levels 'far worse than predicted '", ABC News, October 9, 2007 http://www.abc.net.au/news/stories/2007/10/09/2054191.htm. (Accessed 5-7-2008).

3. Wigley, T.M.L. (2006), "A Combined Mitigation/Geoengineering Approach to Climate Stabilization", Science 20 October 2006: Vol. 314. no. 5798, pp. 452 – 454, DOI: 10.1126/science.1131728 http://www.sciencemag.org/cgi/content/full/314/5798/452 (Accessed 5-8-2008)

4. Hawkins, David (2008). http://groups.google.com/group/geoengineering/browse_thread/thread/e0a4d648ad978032/627c2e5b864f68c6#627c2e5b864f68c6 (Accessed 5-7-2008)

5. "Yes, by all means, do all the [geoengineering] research," Indian climatologist Rajendra K. Pachauri told the AP. (2006), cited at http://www.iht.com/articles/ap/2006/11/16/africa/AF_GEN_Kenya_Saved_By_Haze.php

6. Nordhaus, W. "The Challenge of Global Warming: Economic Models and Environmental Policy" http://nordhaus.econ.yale.edu/dice_mss_072407_all.pdf (Accessed 5-7-2008)

7. Keith Bower, Tom Choularton, John Latham, Jalil Sahraei, Stephen Salter (2006), "Computational assessment of a proposed technique for global warming mitigation via albedo-enhancement of marine stratocumulus clouds", Atmospheric Research 82, 328–336, http://www.mmm.ucar.edu/people/latham/files/cloud_albedo_atmos_res_2006.pdf (Accessed 5-7-2008)