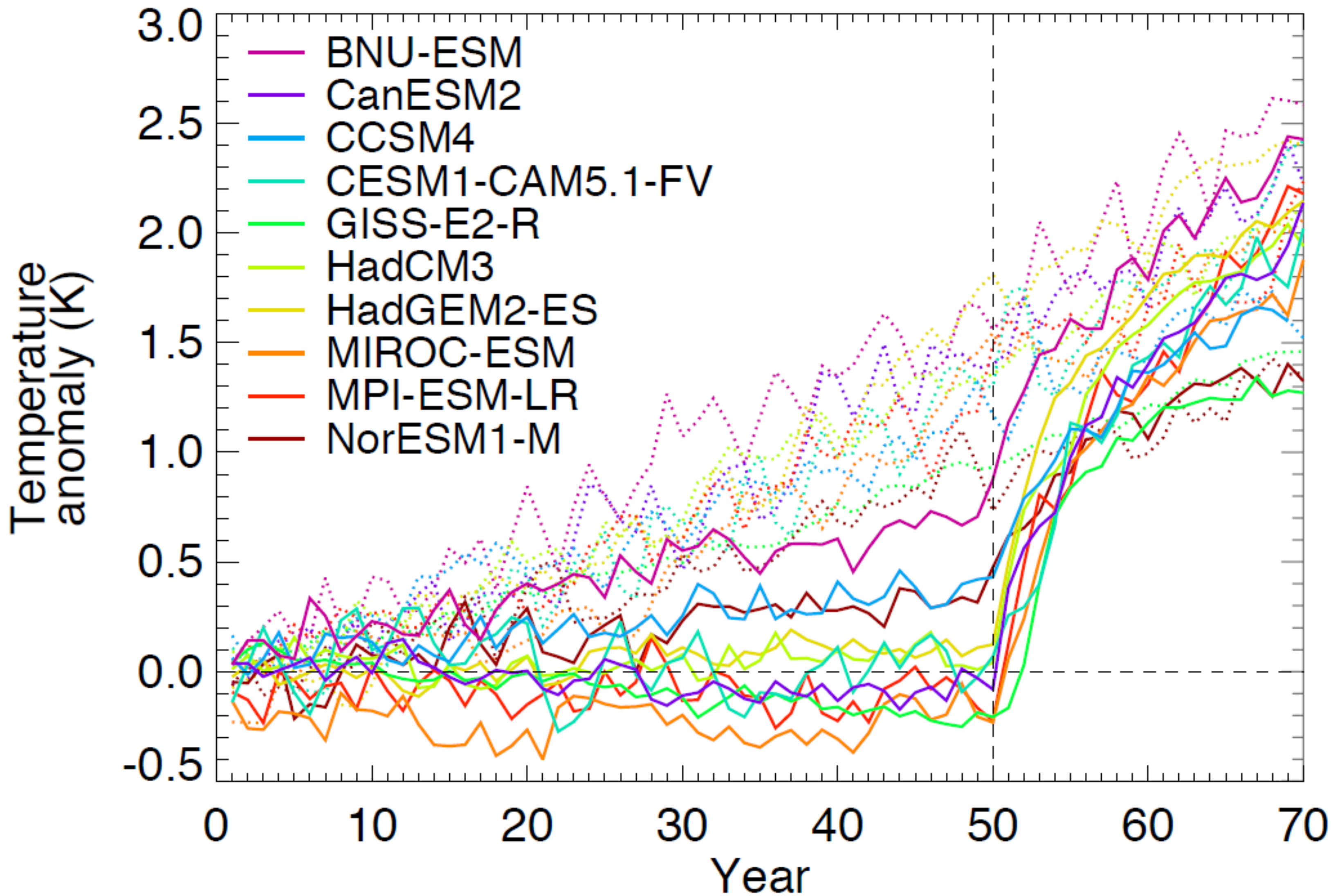
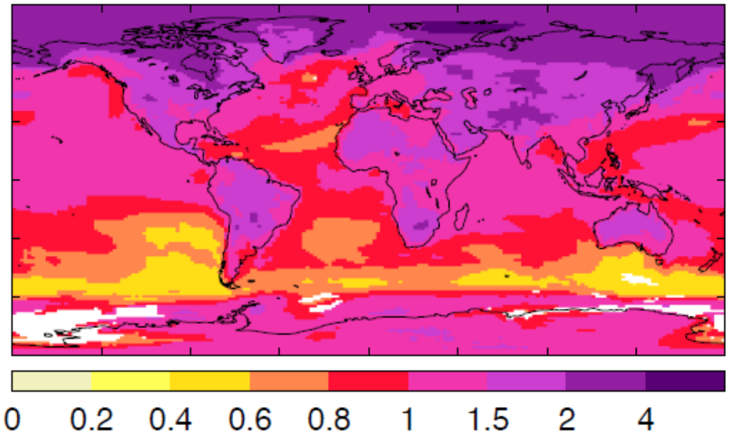
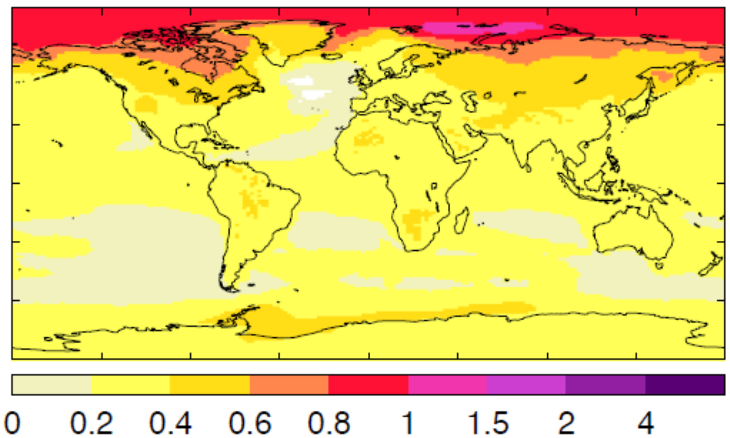


dotted lines are +1%/yr CO_2 solid lines are G2

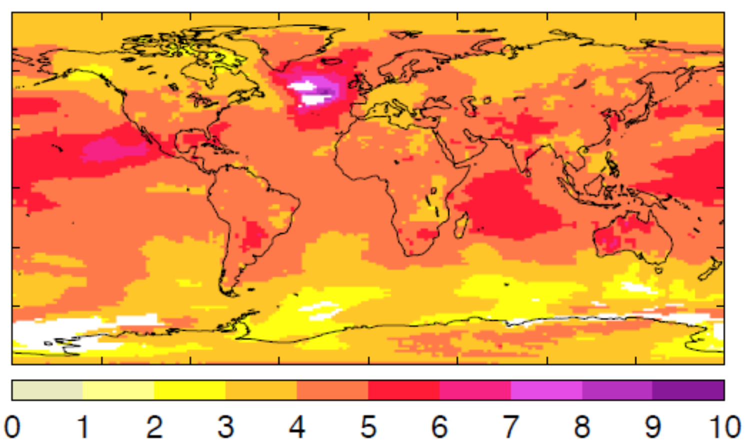
Alan Robock
Department of Environmental Sciences



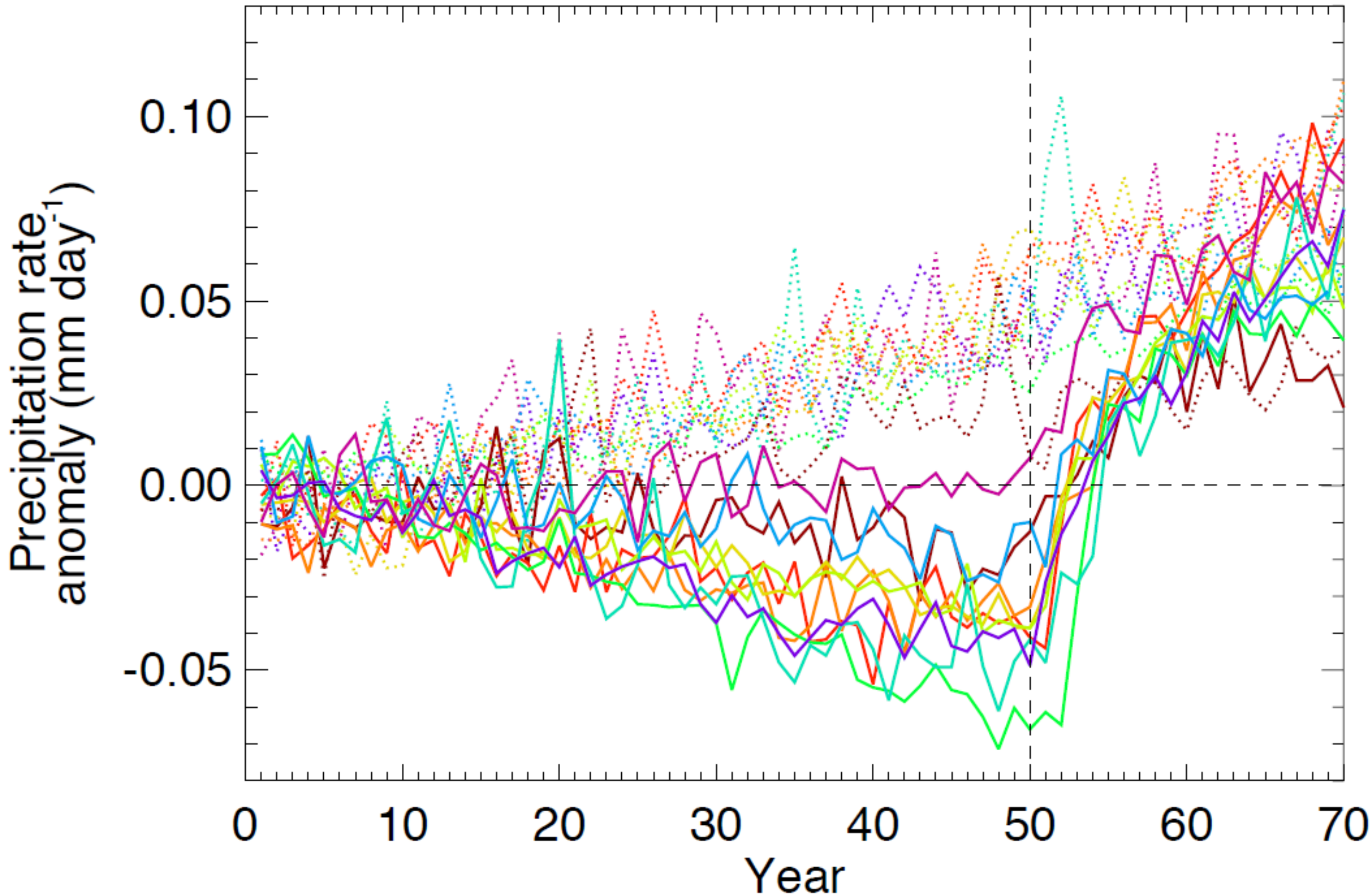
Rate of change of temperature in first 10 years of G2 (K/decade)



Rate of change of temperature in 70 years of +1%/yr CO_2 (K/decade)



Ratio of G2 to +1%/yr CO_2



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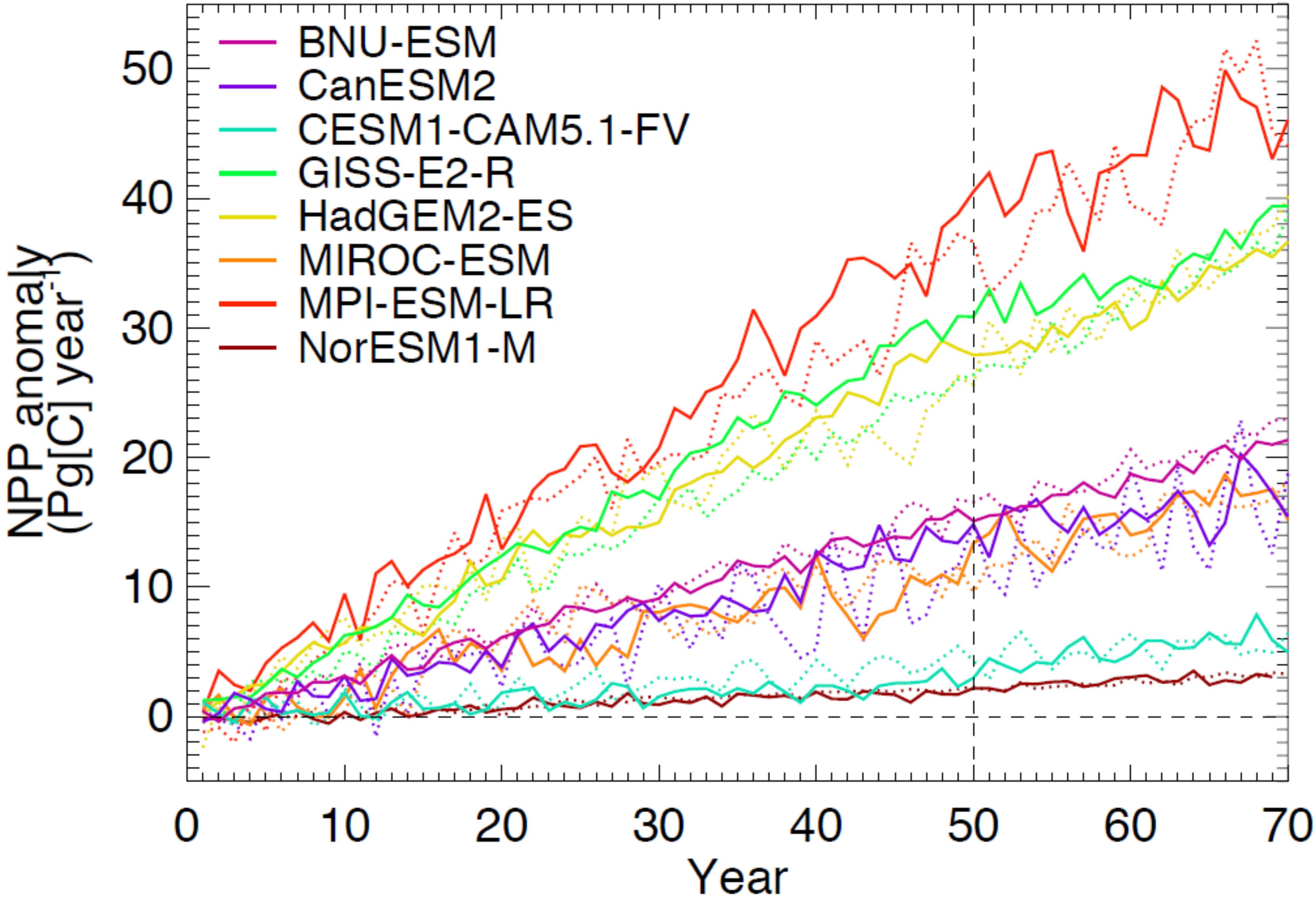

dotted lines are +1%/yr CO_2 solid lines are G2

Successes

20 participating modeling groups (and we expect more)

Gaining confidence in model response to geoengineering

Issues

Limited resources (all time spent on GeoMIP is currently voluntary)

Some of the experiments (particularly G3) are difficult to carry out and analyze

Alan Robock
Department of Environmental Sciences

Reasons geoengineering may be a bad idea

Climate system response

✓1. Regional climate change, including temperature and precipitation
✓2. Rapid warming when it stops
✓3. How rapidly could effects be stopped?
✓4. Continued ocean acidification
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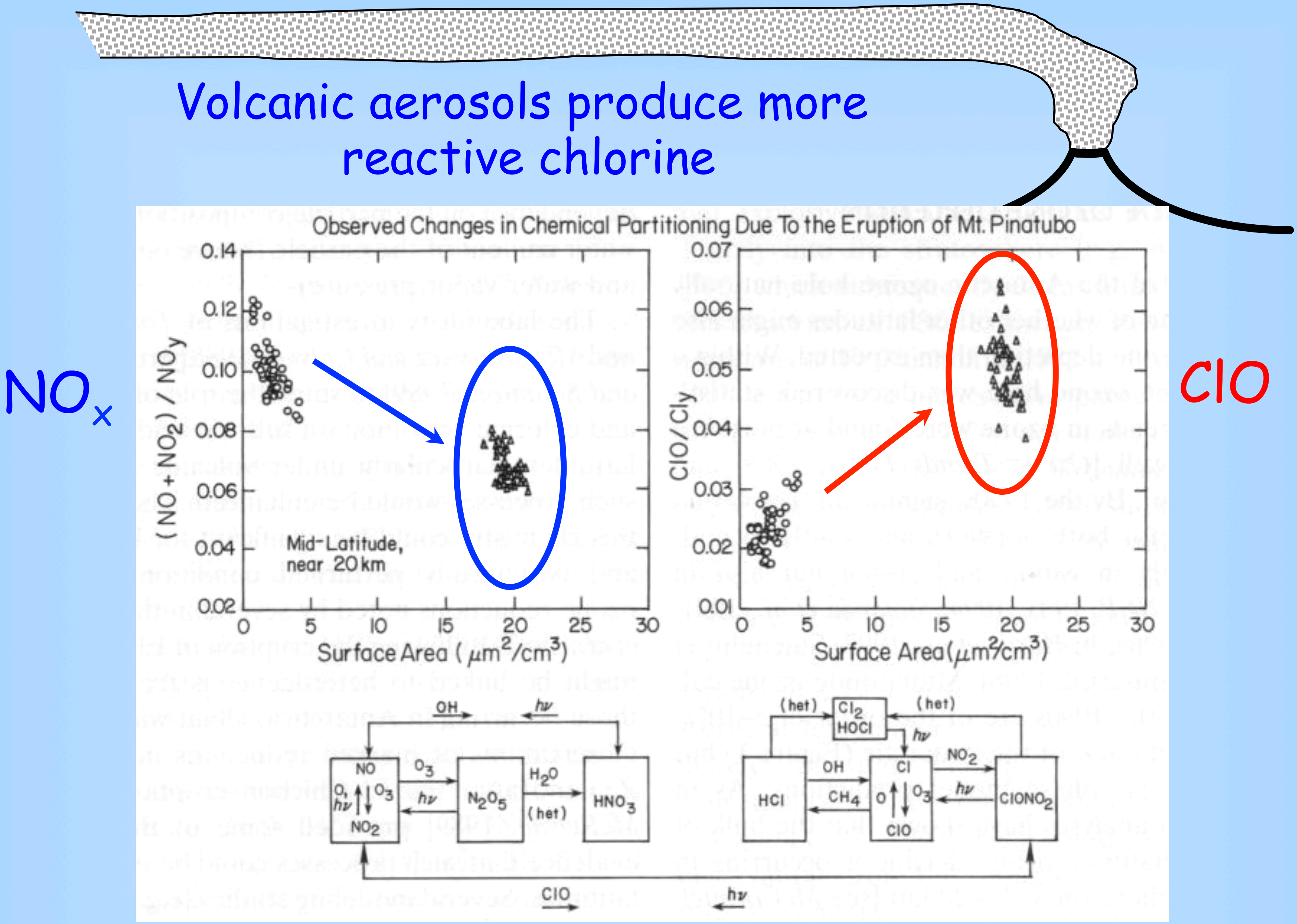
11. Environmental impacts of aerosol injection, including producing and delivering aerosols

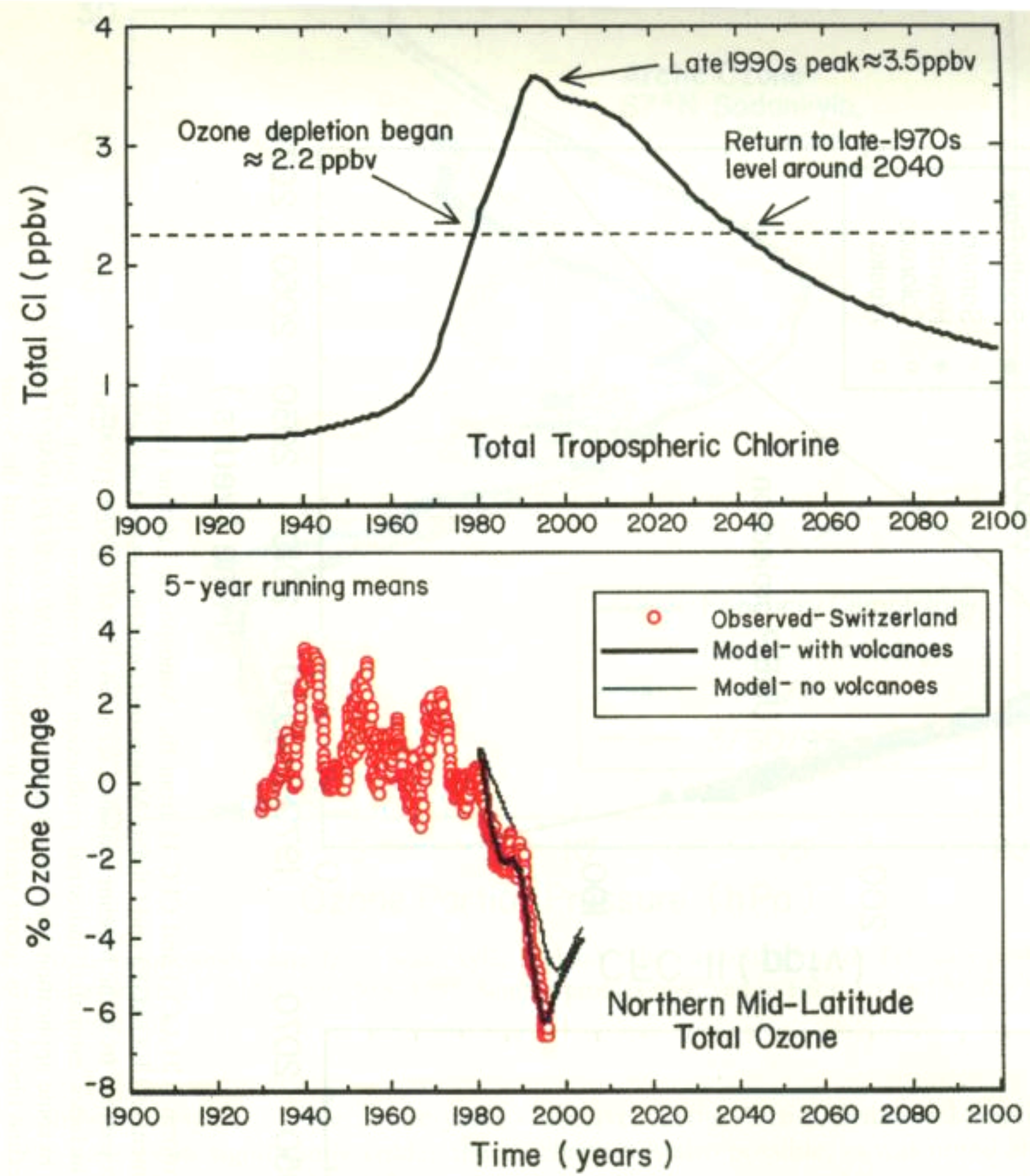
Volcanic aerosols produce more reactive chlorine



Tropospheric chlorine diffuses to stratosphere.

Volcanic aerosols make chlorine available to destroy ozone.

Solomon (1999)



RUTGERS

SH

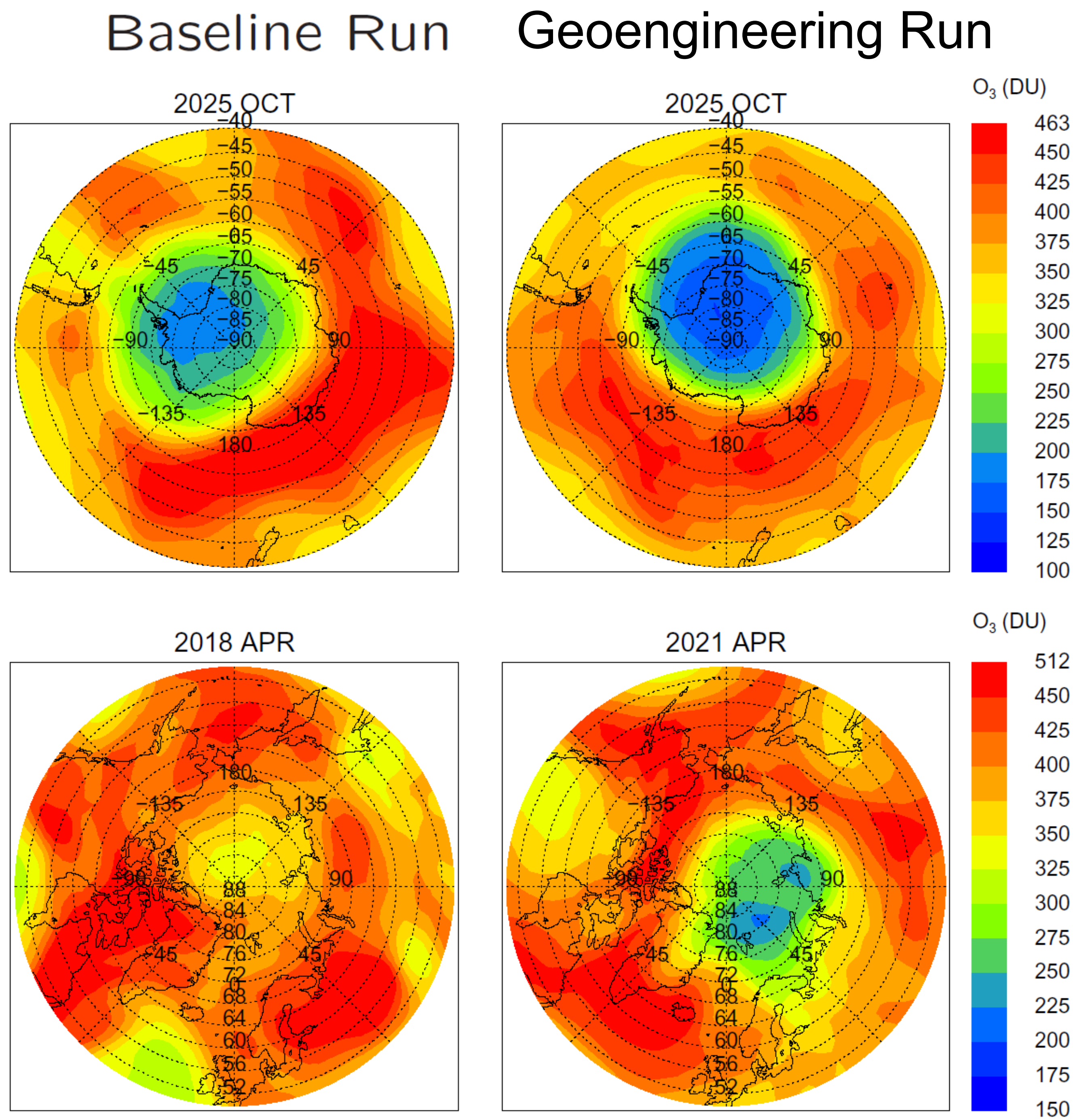
Rasch et al. (2008)

Ozone concentration for coldest winters with and without geoengineering

WACCM3 model runs by Tilmes et al. (2008) with 2 Tg S/yr

NH

RUTGERS



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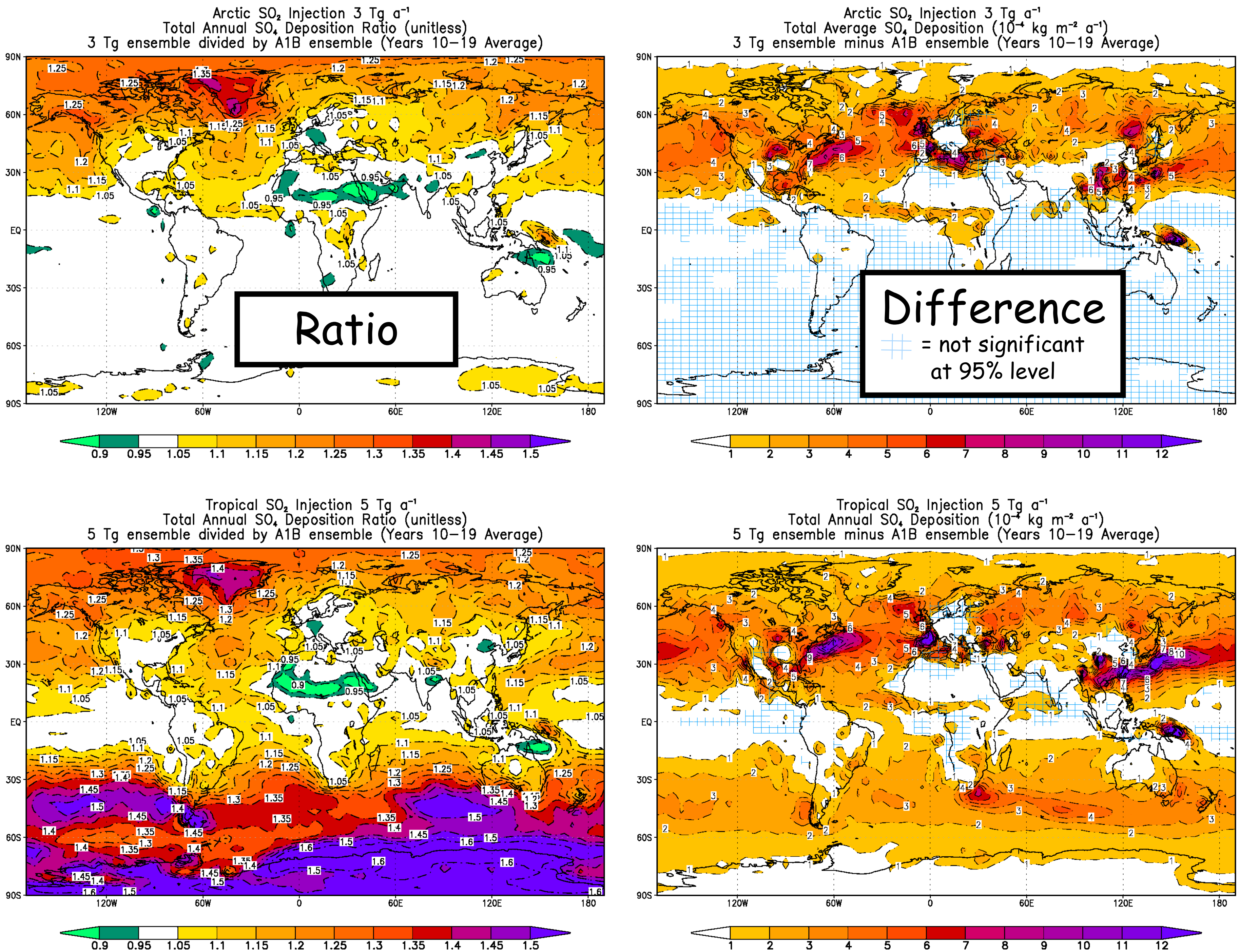
Robock, Alan, 2008: Whither geoengineering? *Science*, **320**, 1166-1167.

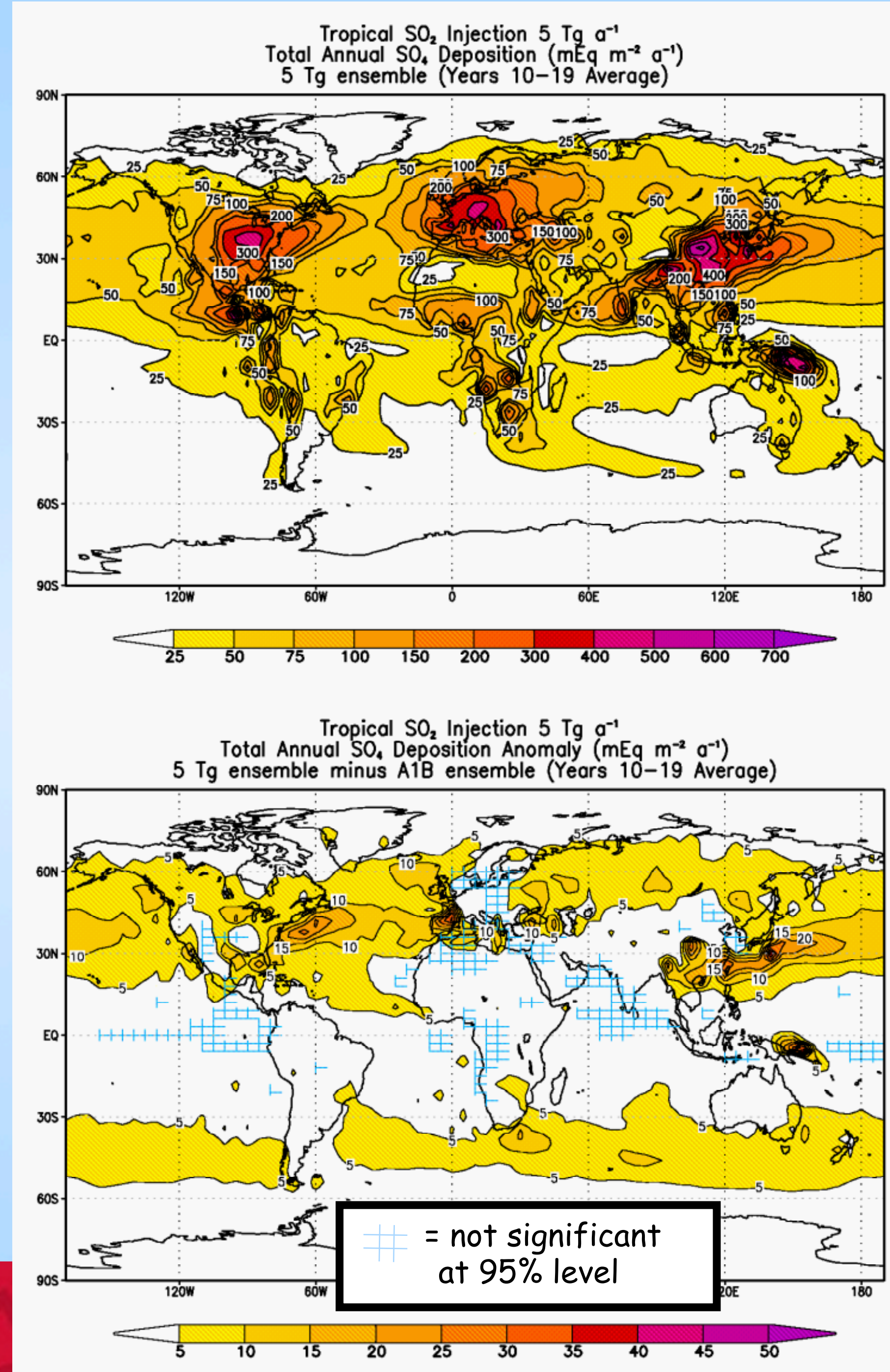
Alan Robock
Department of Environmental Sciences


Arctic SO2 Injection 3 Tg a-1
Total Annual SO4 Deposition Ratio (unitless)
3 Tg ensemble divided by A1B ensemble (Years 10–19 Average)
Ratio
0.9 0.95 1.05 1.1 1.15 1.2 1.25 1.3 1.35 1.4 1.45 1.5
Arctic SO2 Injection 3 Tg a-1
Total Average SO4 Deposition (10-4 kg m-2 a-1)
3 Tg ensemble minus A1B ensemble (Years 10–19 Average)
Difference
= not significant at 95% level
1 2 3 4 5 6 7 8 9 10 11 12
Tropical SO2 Injection 5 Tg a-1
Total Annual SO4 Deposition Ratio (unitless)
5 Tg ensemble divided by A1B ensemble (Years 10–19 Average)
0.9 0.95 1.05 1.1 1.15 1.2 1.25 1.3 1.35 1.4 1.45 1.5
Tropical SO2 Injection 5 Tg a-1
Total Annual SO4 Deposition (10-4 kg m-2 a-1)
5 Tg ensemble minus A1B ensemble (Years 10–19 Average)
1 2 3 4 5 6 7 8 9 10 11 12

Ranges of critical loading of pollutant deposition (including sulfur) for various sites in Europe [*Skeffington*, 2006]

Region	Critical Load ($mEq\ m^{-2}\ a^{-1}$)
Coniferous forests in Southern Sweden	13-61
Deciduous forests in Southern Sweden	15-72
Varied sites in the UK	24-182
Aber in North Wales	32-134
Uhlirska in the Czech Republic	260-358
Fårahall in Sweden	29-134
Several varied sites in China (sulfur only)	63-880
Waterways in Sweden	1-44

Excess deposition is too small to be harmful.



Kravitz, Ben, Alan Robock, Luke Oman, Georgiy Stenchikov, and Allison B. Marquardt, 2009: Sulfuric acid deposition from stratospheric geoengineering with sulfate aerosols. *J. Geophys. Res.*, **114**, D14109, doi:10.1029/2009JD011918, corrected.

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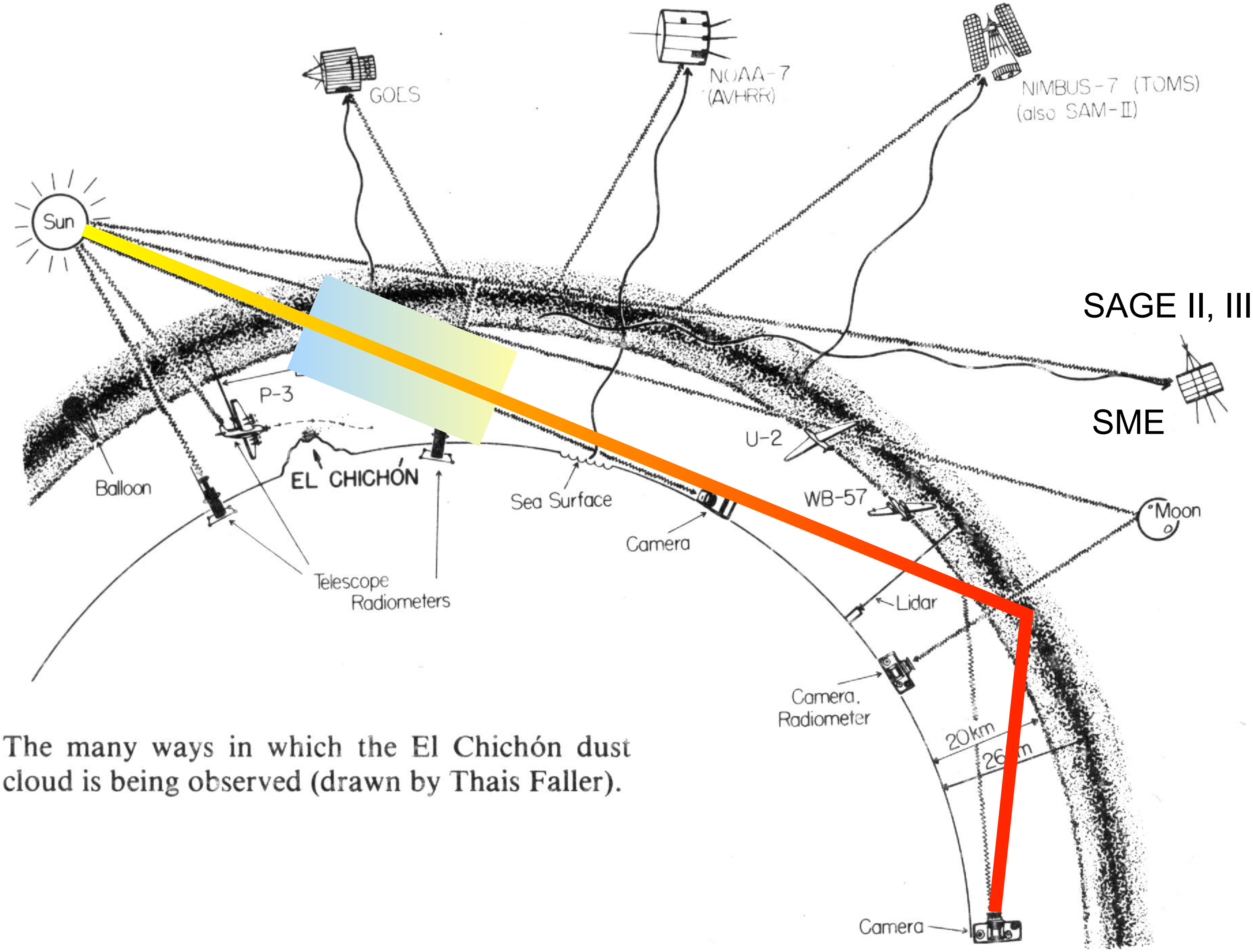


The many ways in which the El Chichón dust cloud is being observed (drawn by Thais Faller).

Robock (1983)

Krakatau, 1883
Watercolor by William Ascroft

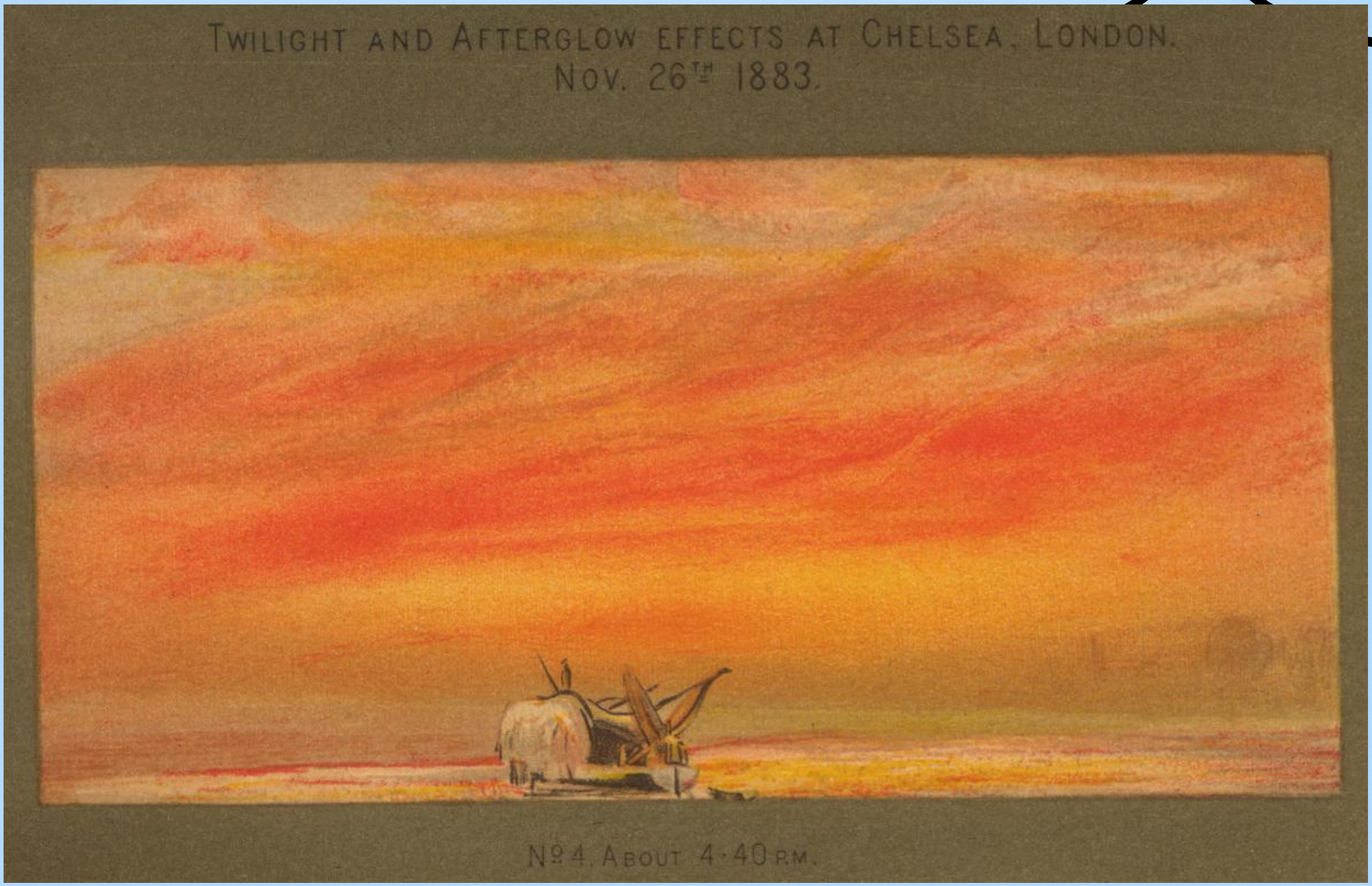
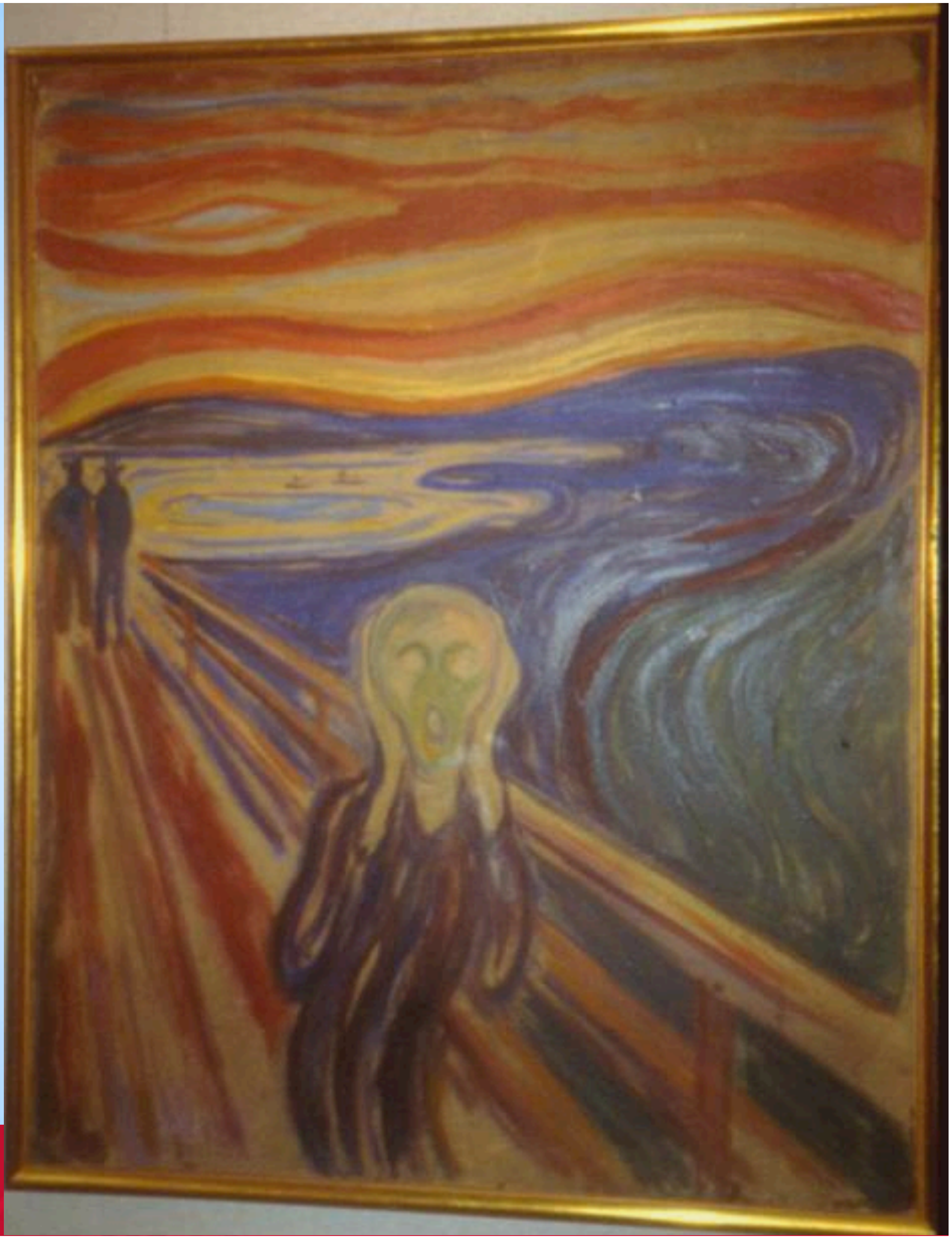


Figure from Symons (1888)

“The Scream”

Edvard Munch

Painted in 1893 based on Munch’s memory of the brilliant sunsets following the 1883 Krakatau eruption.



RUTGERS

Sunset over Lake Mendota, July 1982

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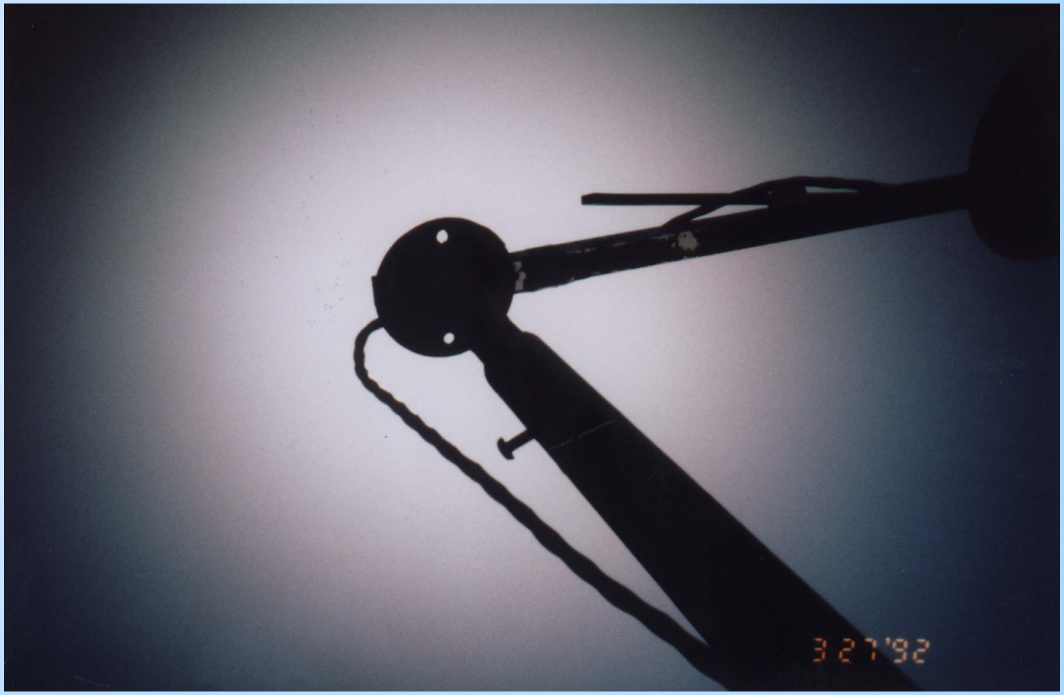
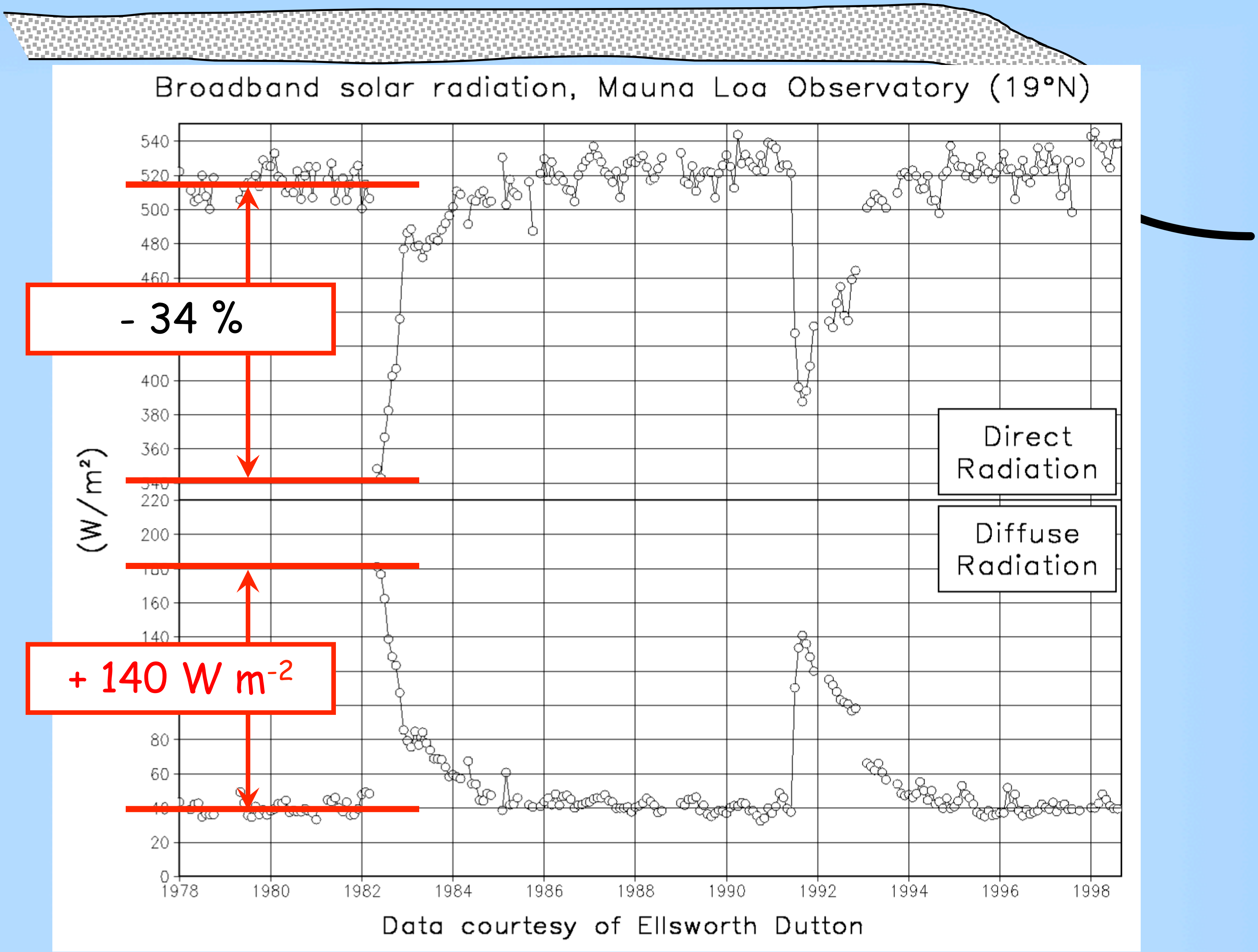
Alan Robock
Department of Environmental Sciences

Diffuse Radiation from Pinatubo Makes a Whiter Sky



Photographs by Alan Robock



Robock (2000), Dutton and Bodhaine (2001)

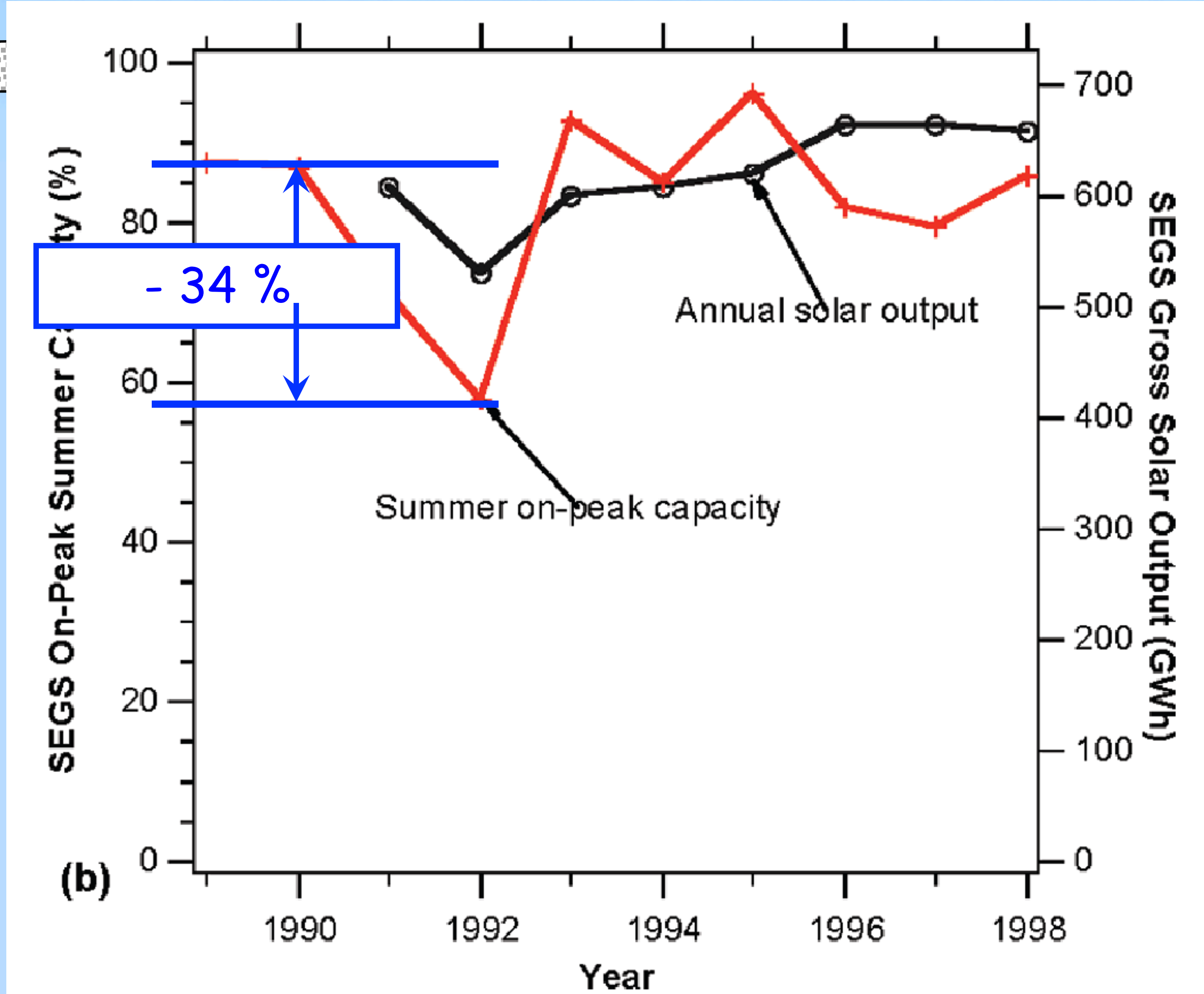
Nevada Solar One
64 MW

Solar steam generators requiring direct solar

Seville, Spain
Solar Tower
11 MW

http://www.electronichealing.co.uk/articles/solar_power_tower_spain.htm

http://judykitsune.wordpress.com/2007/09/12/solar-seville/



Output of solar electric generating systems (SEGS) solar thermal power plants in California (9 with a combined capacity of 354 peak MW). (Murphy, 2009, *ES&T*)

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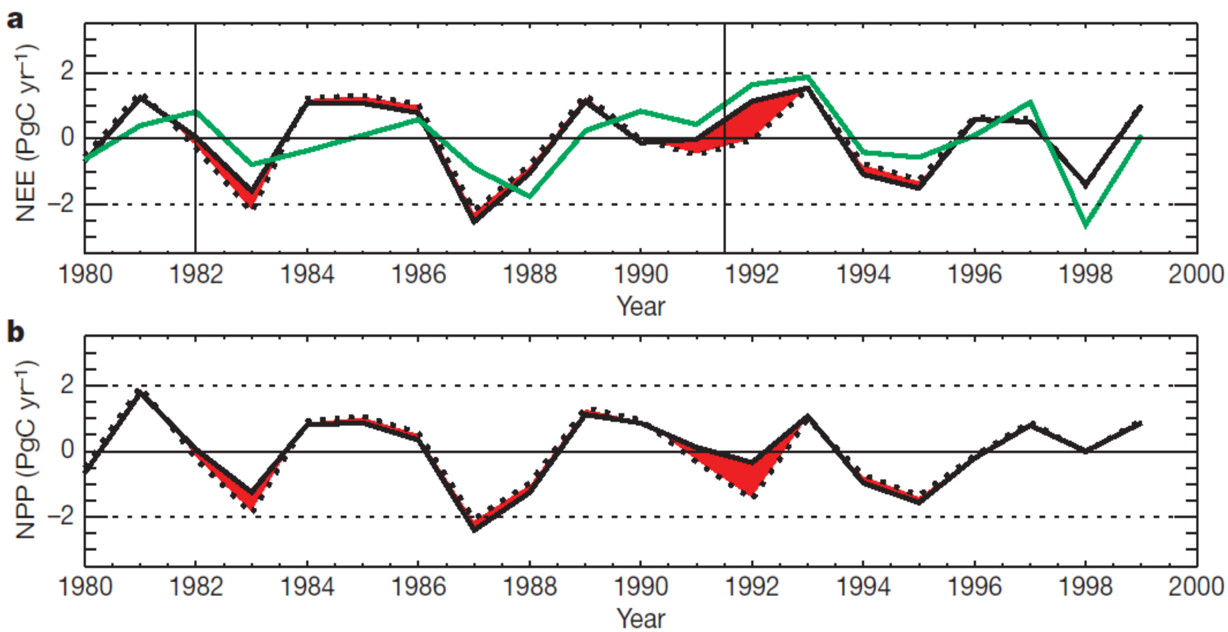

Figure 2 | Net ecosystem exchange (NEE) and net primary productivity (NPP). a, Inferred NEE values (derived from atmospheric CO_2 measurements[21] and simulated ocean flux[25]) are shown by the green line. Also presented are simulated global detrended flux anomalies of NEE (black) under varying (continuous line) and fixed (dashed line) diffuse fraction. The red shaded area corresponds to the contribution of the varying diffuse fraction to simulated NEE, calculated as the difference between the fluxes simulated under conditions of varying and fixed diffuse fraction. NEE is defined as the difference between net primary productivity (NPP) and heterotrophic respiration. Vertical lines correspond to the timing of the El Chichón (Mexico) and Pinatubo volcanic eruptions, respectively. **b**, Simulated NPP values for varying (continuous line) and fixed (dashed line) diffuse fraction, with the red shaded area again corresponding to the contribution of varying diffuse irradiance to simulated NPP.

nature Vol 458|23 April 2009|**doi:10.1038/nature07949**

LETTERS

Impact of changes in diffuse radiation on the global land carbon sink

Lina M. Mercado[1], Nicolas Bellouin[2], Stephen Sitch[2], Olivier Boucher[2], Chris Huntingford[1], Martin Wild[3] & Peter M. Cox[4]

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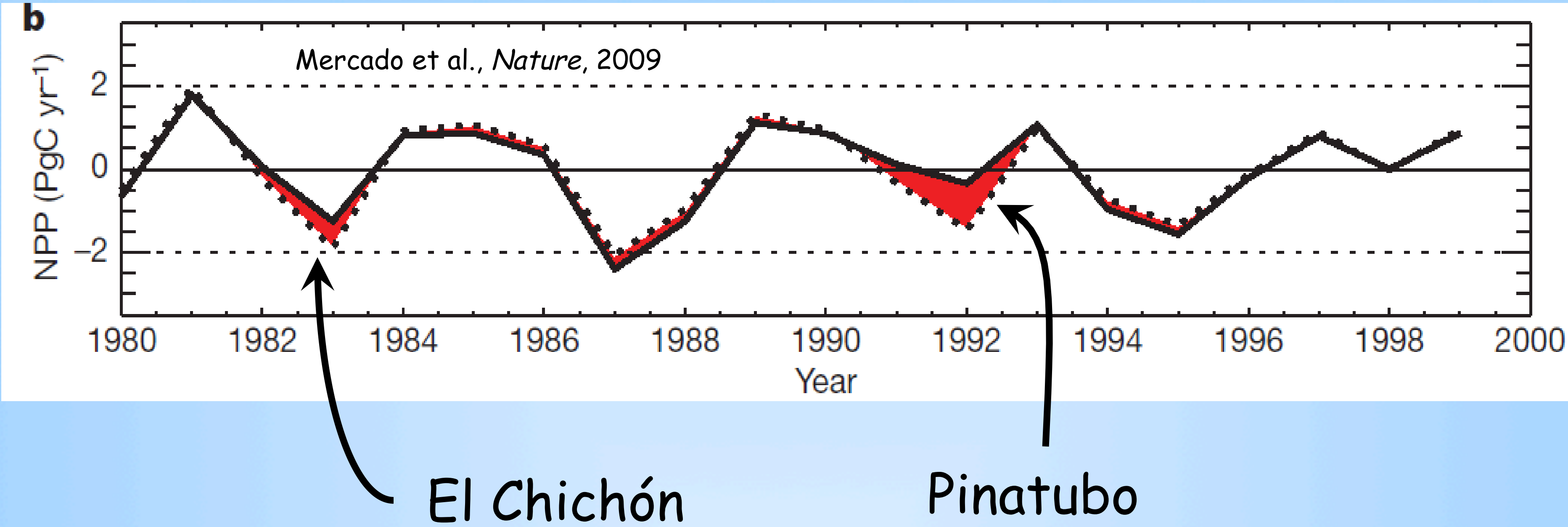
Alan Robock
nmental Sciences



Additional carbon sequestration after volcanic eruptions because of the effects of diffuse radiation, but certainly will impact natural and farmed vegetation.

nature Vol 458|23 April 2009|**doi:10.1038/nature07949**

LETTERS

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SMALL IMPACT ON CIRRUS CLOUDS

Complex compensating interactions between particle sizes and degree of troposphere – stratosphere mixing gives small impacts on cirrus, in one model study.

"The resulting mean impact on the northern midlatitudes by changes in cirrus is predicted to be low, namely < 1% of the intended radiative forcing by the stratospheric aerosols."

Cirisan, A., et al. (2013), Microphysical and radiative changes in cirrus clouds by geoengineering the stratosphere, *J. Geophys. Res. Atmos., 118, doi:10.1002/jgrd.50388.*

Reasons geoengineering may be a bad idea

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✓11. Environmental impacts of aerosol injection, including producing and delivering aerosols

Alan Robock
Department of Environmental Sciences

Reasons geoengineering may be a bad idea

Unknowns

✓12. Human error
✓13. Unexpected consequences (How well can we predict the expected effects of geoengineering? What about unforeseen effects?)

Political, ethical and moral issues

✓14. Schemes perceived to work will lessen the incentive to mitigate greenhouse gas emissions
✓15. Use of the technology for military purposes. Are we developing weapons?
✓16. Commercial control of technology
✓17. Violates UN Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques
18. Could be tremendously expensive
19. Even if it works, whose hand will be on the thermostat? How could the world agree on the optimal climate?
20. Who has the moral right to advertently modify the global climate?

Alan Robock
Department of Environmental Sciences

How could we actually get the sulfate aerosols into the stratosphere?

Artillery?

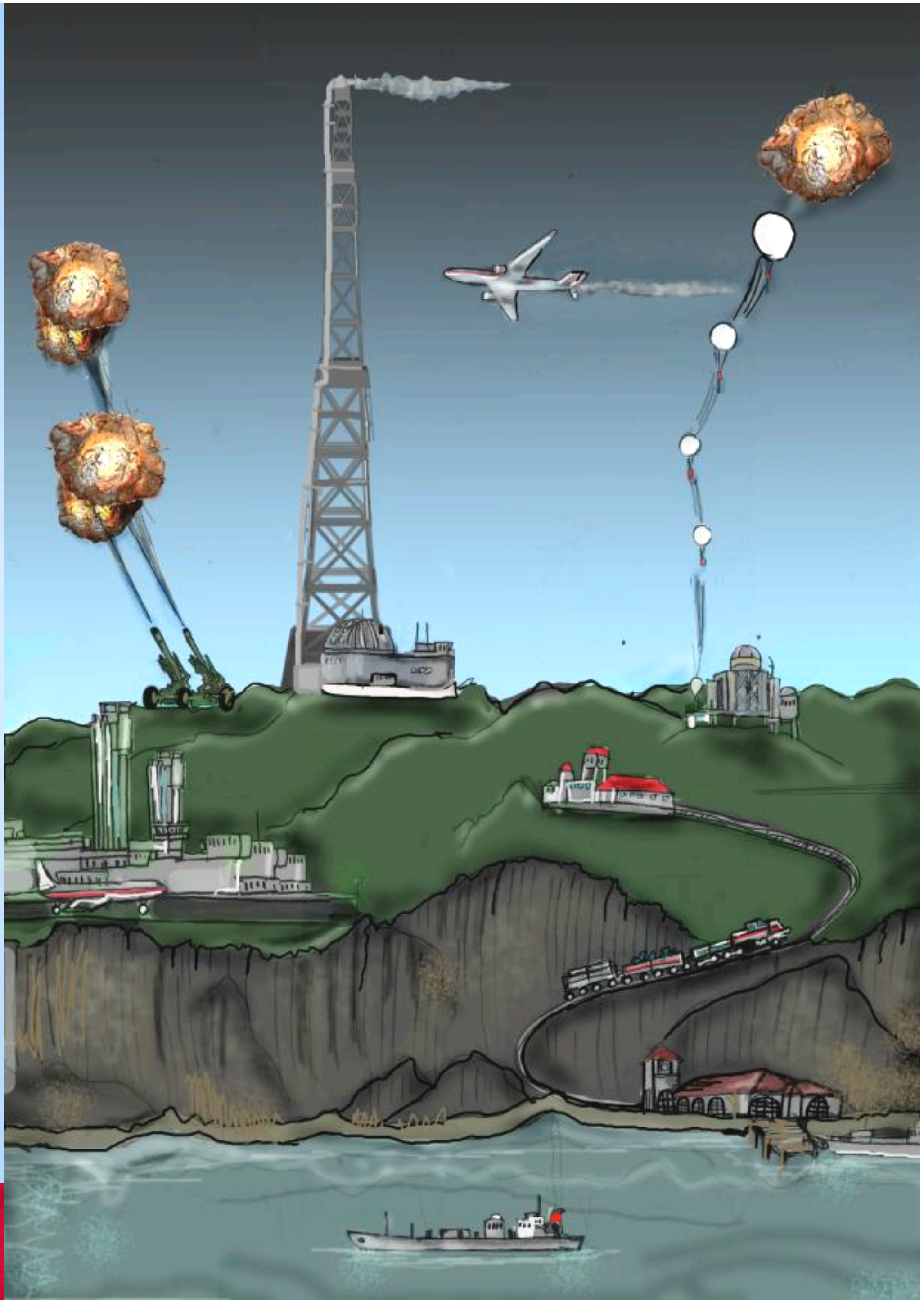
Aircraft?

Balloons?

Tower?

Starting from a mountain top would make stratospheric injection easier, say from the Andes in the tropics, or from Greenland in the Arctic.

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.



RUTGERS

Drawing by Brian West

- There is currently no way to do geoengineering. No means exist to inject aerosol precursors (gases).
- Even if we could get the gases up there, we do not yet understand how to produce particles of the appropriate size.
- Here we investigate only the problem of lofting precursors to the lower stratosphere.

Henning Wagenbreth
Oct. 24, 2007

H_2S would be lightest and cheapest precursor to produce stratospheric aerosols.

While volcanic eruptions inject mostly SO_2 into the stratosphere, the relevant quantity is the amount of sulfur. If H_2S were injected instead, it would oxidize quickly to form SO_2, which would then react with water to form H_2SO_4 droplets. Because of the relative molecular weights, only 1 Tg of H_2S would be required to produce the same amount of sulfate aerosols as 2 Tg of SO_2. However, H_2S is toxic and flammable, so it may be preferable to use SO_2.

Here we evaluate the cost of lofting 1 Tg of H_2S into the stratosphere per year.

The total cost of geoengineering would depend on the total amount to be lofted and on the gas.

The National Academy of Sciences (1992) study estimated the price of SO_2 to be $50,000,000 per Tg, and H_2S would be much cheaper, so the price of the gases themselves is not an issue.

How could we use <u>airplanes</u> to loft gas to the stratosphere?

- Put S back into the jet fuel.

  But, except for the Arctic, planes do not routinely fly that high.

- Have tanker aircraft carry it to the stratosphere.

  But they can only get into the stratosphere in the Arctic.

- Have fighter planes carry it to the stratosphere.

  But you would need many more planes.

- Have tanker aircraft carry it to the upper troposphere and have fighter jets carry it the rest of the way.

- Could you have a tanker tow a glider with a hose to loft the exit nozzle into the stratosphere?

F-15C Eagle

Ceiling: 20 km

Payload: 8 tons gas

Cost: $30,000,000
(1998 dollars)

http://www.af.mil/shared/media/photodb/photos/060614-F-8260H-310.JPG

http://www.fas.org/man/dod-101/sys/ac/f-15e-981230-F-6082P-004.jpg

With 3 flights/day,
operating 250 days/year

would need 167 planes
to deliver 1 Tg gas per year
to tropical stratosphere.

Alan Robock
Department of Environmental Sciences

KC-135 Stratotanker

Ceiling: 15 km

Payload: 91 tons gas

Cost: $39,600,000
(1998 dollars)

http://upload.wikimedia.org/wikipedia/commons/a/a8/Usaf.f15.f16.kc135.750pix.jpg

http://www.af.mil/shared/media/photodb/photos/021202-O-9999G-029.jpg

With 3 flights/day,
operating 250 days/year

would need 15 planes
to deliver 1 Tg gas per year
to Arctic stratosphere.

Alan Robock
Department of Environmental Sciences

KC-10 Extender

Ceiling: 12.73 km

Payload: 160 tons gas

Cost: $88,400,000
(1998 dollars)

http://www.af.mil/shared/media/factsheet/kc_10.jpg

http://www.af.mil/shared/media/photodb/photos/030317-F-7203T-013.jpg

With 3 flights/day,
operating 250 days/year

would need 9 planes
to deliver 1 Tg gas per year
to Arctic stratosphere.

Alan Robock
Department of Environmental Sciences

Costs of stratospheric aerosols (Aurora report, 2010)

(Robock et al., 2009)

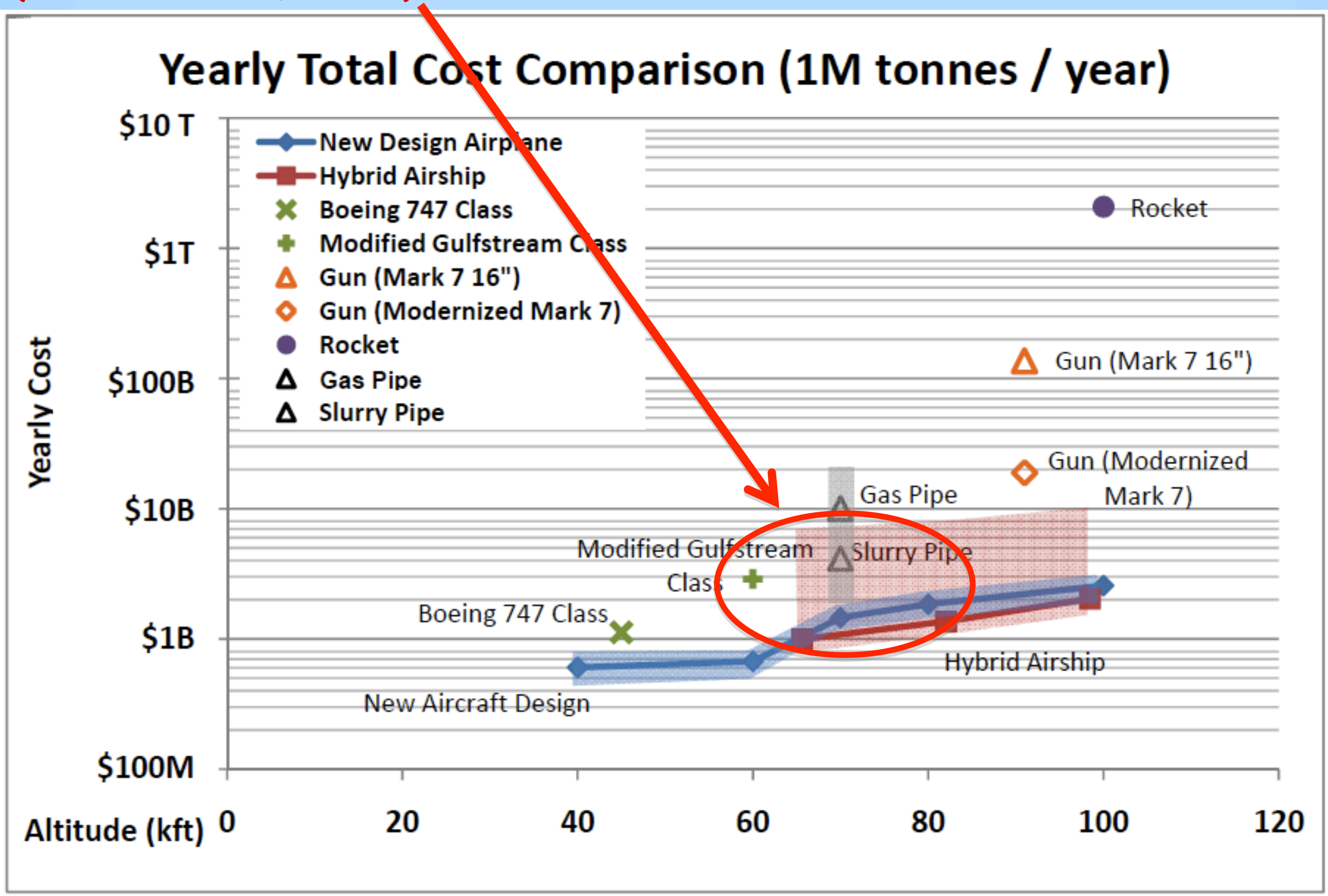


Figure 2: Yearly cost (including depreciation, interest, and operations costs) for 1M tonne per year geoengineering

Costs of personnel, maintenance, and CO_2 emissions would depend on implementation strategy.

Each KC-135 costs $4,600,000 per year for total operations and support costs, including personnel, fuel, maintenance, and spare parts.*

* http://www.gao.gov/new.items/d03938t.pdf

16" (41 cm) naval rifles (artillery) were evaluated by the National Academy of Sciences (1992).

The annual cost to inject 1 Tg (they used Al_2O_3 dust) into the stratosphere, including ammunition, gun barrels, stations, and personnel, was estimated to be $20,000,000,000.

"The rifles could be deployed at sea or in empty areas (e.g., military reservations) where the noise of the shots and the fallback of expended shells could be managed."

Alan Robock
Department of Environmental Sciences

Balloons could be used in several ways:

- To float in the stratosphere, suspending a hose to pump gas up there.
- Aluminized long-duration balloons floating as reflectors.
- To loft a payload under the balloon, in which case the additional mass of the balloon and its gas would be a weight penalty.
- To mix H_2 and H_2S inside a balloon. Maximize the ratio of H_2S to H_2, while still maintaining a buoyancy of 20%, standard for weather balloons. When the balloons burst the H_2S is released into the stratosphere.

Alan Robock
Department of Environmental Sciences

Large H_2 balloons lofting Al_2O_3 dust were also evaluated by the National Academy of Sciences (1992).

The annual cost to inject 1 Tg into the stratosphere, including balloons, dust, dust dispenser equipment, hydrogen, stations, and personnel, was also estimated to be $20,000,000,000. The cost of hot air balloon systems would be 4 to 10 times that of H_2 balloons.

"The fall of collapsed balloons might be an annoying form of trash rain."

Alan Robock
Department of Environmental Sciences

Plastic balloons (rather than rubber) would be required to get through the cold tropical tropopause or into the cold Arctic stratosphere without breaking. The largest standard weather balloon available is model number SF4-0.141-.3/0-T from Aerostar International, available in quantities of 10 or more for $1,711 each. I called, and there is currently no discount for very large numbers, but I am sure this could be negotiated. Each balloon has a mass of 11.4 kg. To fill it to the required buoyancy, would produce a mixture of 38.5% H_2, 61.5% H_2S, for a total mass of H_2S of 93.7 kg. The balloons would burst at 25 mb.

To put 1 Tg gas into stratosphere	**37,000**	**balloons per day**
	9,000,000	**balloons per year**
Total (balloons only)	**$16,000,000,000**	**per year**
	100,000,000	**kg (0.1 Tg) plastic per year**

According to NAS (1992), the additional costs for infrastructure, personnel, and H_2 would be $3,600,000,000 per year.

To inject 1 Tg S (as H_2S) into the lower stratosphere per year

Method	Maximum Payload	Ceiling (km)	# of Units	Price per unit (2007 dollars)	Total Purchase Price (2008 dollars)	Annual Operation Costs
F-15C Eagle	8 tons	20	167 planes 3 flights/day	$38,100,000	**$6,362,700,000** but there are already 522	**$4,175,000,000***
KC-135 Strato-tanker	91 tons	15	15 planes 3 flights/day	$50,292,000	**$755,000,000** but there are already more than 481, and they will become surplus	**$375,000,000**
KC-10 Extender	160 tons	13	9 planes 3 flights/day	$112,000,000	**$1,000,000,000** but there are already 59	**$225,000,000***
~~Balloons~~	4 tons	30	37,000 per day	$1,711		~~$30,000,000,000~~
~~Naval Rifles~~	500 kg	20	8,000 shots per day			~~$30,000,000,000~~

Conclusions

1. Using airplanes for geoengineering would not be costly, especially with existing military planes, but there are still questions about whether desirable aerosols could be created.
2. There are still many reasons not to do geoengineering.

RUTGERS

Alan Robock
Department of Environmental Sciences

Crude estimates show it would cost a few billion dollars to build a system, cost a few billion dollars per year to operate, and take less than a decade to implement.

Is this inexpensive?

Some say "yes" compared to other government expenditures or oil company profits.

Alan Robock
Department of Environmental Sciences

- There is currently no way to do geoengineering. No means exist to inject aerosol precursors (gases).
- Even if we could get the gases up there, we do not yet understand how to produce particles of the appropriate size.
- Putting sulfur gases into the lower stratosphere with existing military planes would cost a few billion dollars per year.

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.

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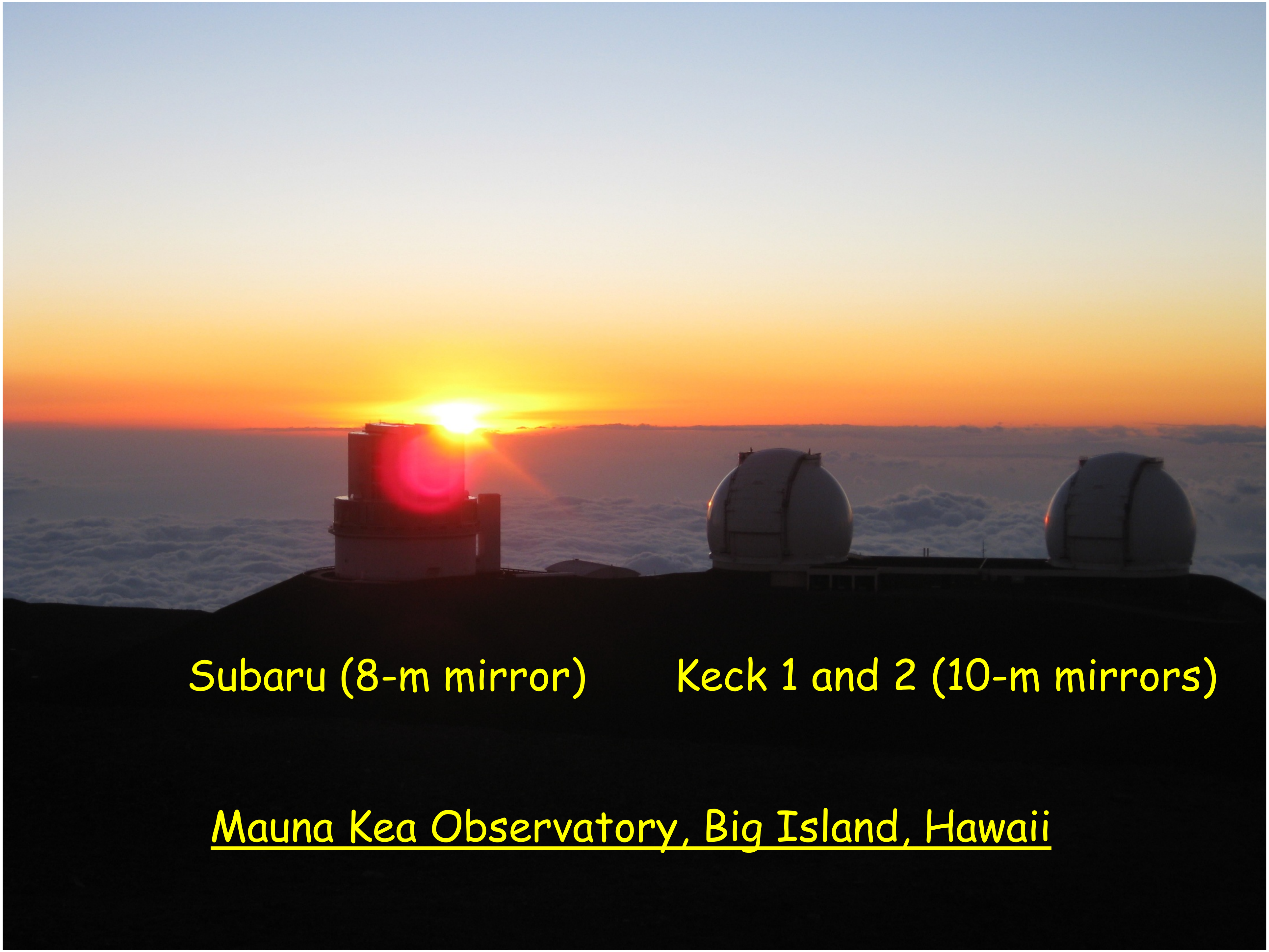
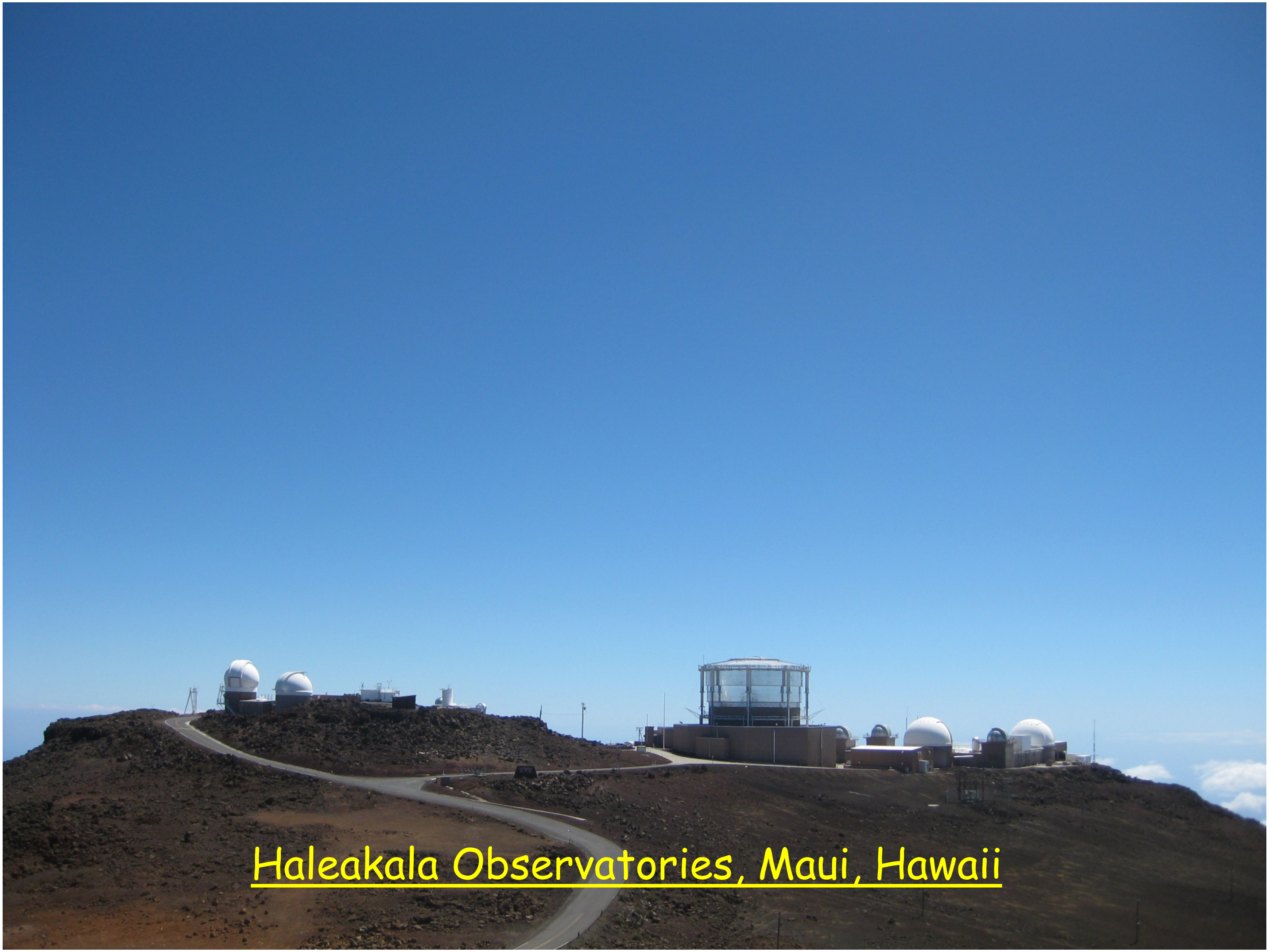
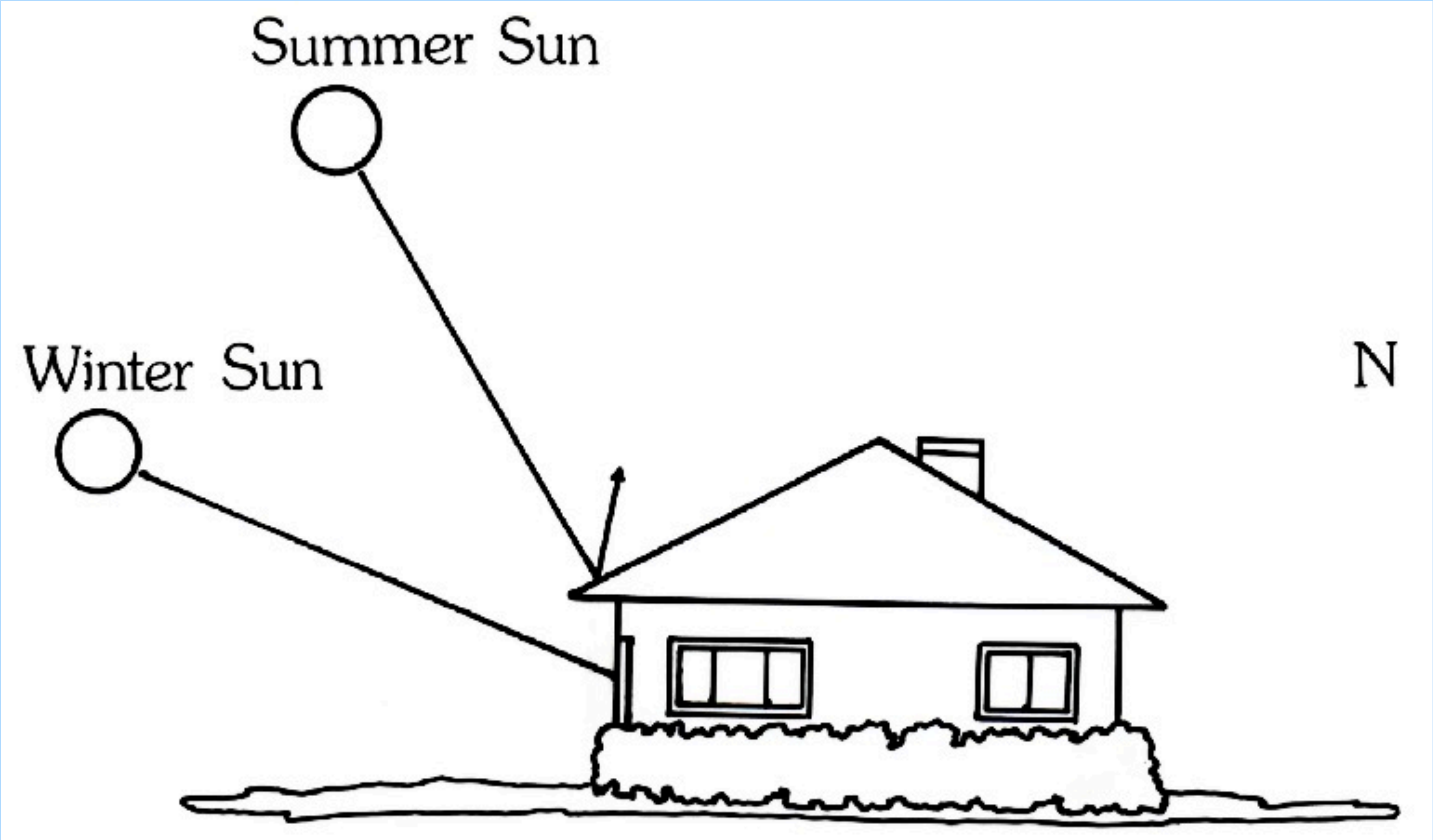

Subaru (8-m mirror)
Keck 1 and 2 (10-m mirrors)
Mauna Kea Observatory, Big Island, Hawaii


Haleakala Observatories, Maui, Hawaii

Passive solar homes require direct sunlight in winter.



ENERGY SMARTS: CHECKLIST TO DETERMINE ENERGY EFFICIENCY OF A HOME
Leona K. Hawks, Utah State University
http://www.builditsolar.com/Projects/SolarHomes/UtahExtFact_Sheet_3.pdf

Conclusions

Of the 20 reasons why geoengineering may be a bad idea:

17 ✓ 3 X

Since then I have added 9 more reasons:

✓It might mess up Earth-based optical astronomy.
✓It would affect nighttime stargazing.
✓It would mess up satellite remote sensing of Earth.
✓It would make passive solar heating work less well.
✓More sunburn from diffuse light and no sunscreen.
✓Effects on airplanes flying in stratosphere.
✓Effects on electrical properties of atmosphere.
✓Impacts on tropospheric chemistry.
✓Societal disruption, conflict between countries.

As of now, there are at least 26 reasons why geoengineering is a bad idea.

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Stratospheric Geoengineering

Benefits

1. Cool planet
2. Reduce or reverse sea ice melting
3. Reduce or reverse ice sheet melting
4. Reduce or reverse sea level rise
5. Increase plant productivity
6. Increase terrestrial CO_2 sink
7. Beautiful red and yellow sunsets
8. Control of precipitation?
9. Unexpected benefits

Risks

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

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.

Stratospheric Geoengineering

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IPCC

WG I

WG II

WG III

Risks

1. Drought in Africa and Asia
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American Meteorological Society and American Geophysical Union Policy Statement on Geoengineering

"The AMS and AGU recommend:

- "Enhanced research on the scientific and technological potential for geoengineering the climate system, including research on intended and unintended environmental responses.
- "Coordinated study of historical, ethical, legal, and social implications of geoengineering that integrates international, interdisciplinary, and intergenerational issues and perspectives and includes lessons from past efforts to modify weather and climate.
- "Development and analysis of policy options to promote transparency and international cooperation in exploring geoengineering options along with restrictions on reckless efforts to manipulate the climate system."

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Department of Environmental Sciences

A well-funded national or international research program, as part of the currently ongoing Intergovernmental Panel on Climate Change Fifth Scientific Assessment, would be able to look at several other aspects of geoengineering and provide valuable guidance to policymakers trying to decide how best to address the problems of global warming.

We currently lack the capability to monitor the evolution and distribution of stratospheric aerosol clouds. A robust space-based observing system would allow monitoring future volcanic eruptions or any geoengineering experiments.

Robock, Alan, 2008: Whither geoengineering? *Science*, **320**, 1166-1167.

Testing SRM in the stratosphere at less than full-scale will not allow the evaluation of cloud creation in the presence of a cloud nor of the climate response to the cloud.

Robock, Alan, Martin Bunzl, Ben Kravitz, and Georgiy Stenchikov, 2010: A test for geoengineering? *Science*, **327**, 530-531, doi:10.1126/science.1186237.

I don't think geoengineering will ever be implemented. How would the planetary governance decision be made as to whether to implement geoengineering, and if so how much? Whose hand would be on the planetary thermostat?

The principle of informed consent governs medical interventions. How could we get the informed consent of the entire planet?

Certainly the developed world is most capable of doing any geoengineering implementation. The history of colonialism will make the rest of the world wary of climate manipulations that are presumably for their benefit.

Robock, Alan, 2012: Will geoengineering with solar radiation management ever be used? *Ethics, Policy & Environment*, **15**, 202-205.

Indoor geoengineering research is ethical and is needed to provide information to policymakers and society so that we can make informed decisions in the future to deal with climate change.

Outdoor geoengineering research, however, is not ethical unless subject to governance that protects society from potential environmental dangers.

Robock, Alan, 2012: Is geoengineering research ethical? *Peace and Security*, **4**, 226-229.

Some advocate "small-scale" in situ cloud brightening or stratospheric injection experiments.

But what is "small-scale?" How large a region? For how long? How much material would be injected?

Until the governance issues are dealt with, the research needs to be limited to theoretical and laboratory work, with no in situ cloud brightening or stratospheric injection.

If there will be a significant reduction of Asian monsoon precipitation, how will this affect food production?

Reduced precipitation will be countered by two factors which would increase plant growth: increased CO_2 and increased fraction of diffuse radiation.

This needs studies with agricultural experts and models, driven by climate change scenarios from the standardized runs.

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Department of Environmental Sciences

The World's Largest Crops

China is largely self-sufficient in food production and doesn't export much. But it produces and consumes some of the world's largest crops by far. And if recent droughts in China force the country to begin importing on a large scale, it could push the already rising prices of commodities like wheat even higher.

2009 PRODUCTION OF:

RICE	Millions of tons	World share
China	**197**	**29%**
India	131	19
Indonesia	64	9
Bangladesh	45	7
Vietnam	39	6
Thailand*	31	5
Myanmar*	31	4
Philippines	16	2
Brazil	13	2
Japan	11	2
Pakistan	10	2
United States	10	1

WHEAT		
China	**115**	**17%**
India	81	12
Russia	62	9
United States	60	9
France	38	6
Canada	27	4
Germany	25	4
Pakistan	24	4
Australia	22	3
Ukraine	21	3
Turkey	21	3
Kazakhstan	17	3

CORN		
United States	333	41%
China	**163**	**20**
Brazil	51	6
Mexico	20	2
Indonesia	18	2
India	17	2
France	15	2
Argentina	13	2
South Africa	12	1
Ukraine	10	1
Canada	10	1
Romania	8	1

Source: United Nations Food and Agriculture Organization *2008 production.

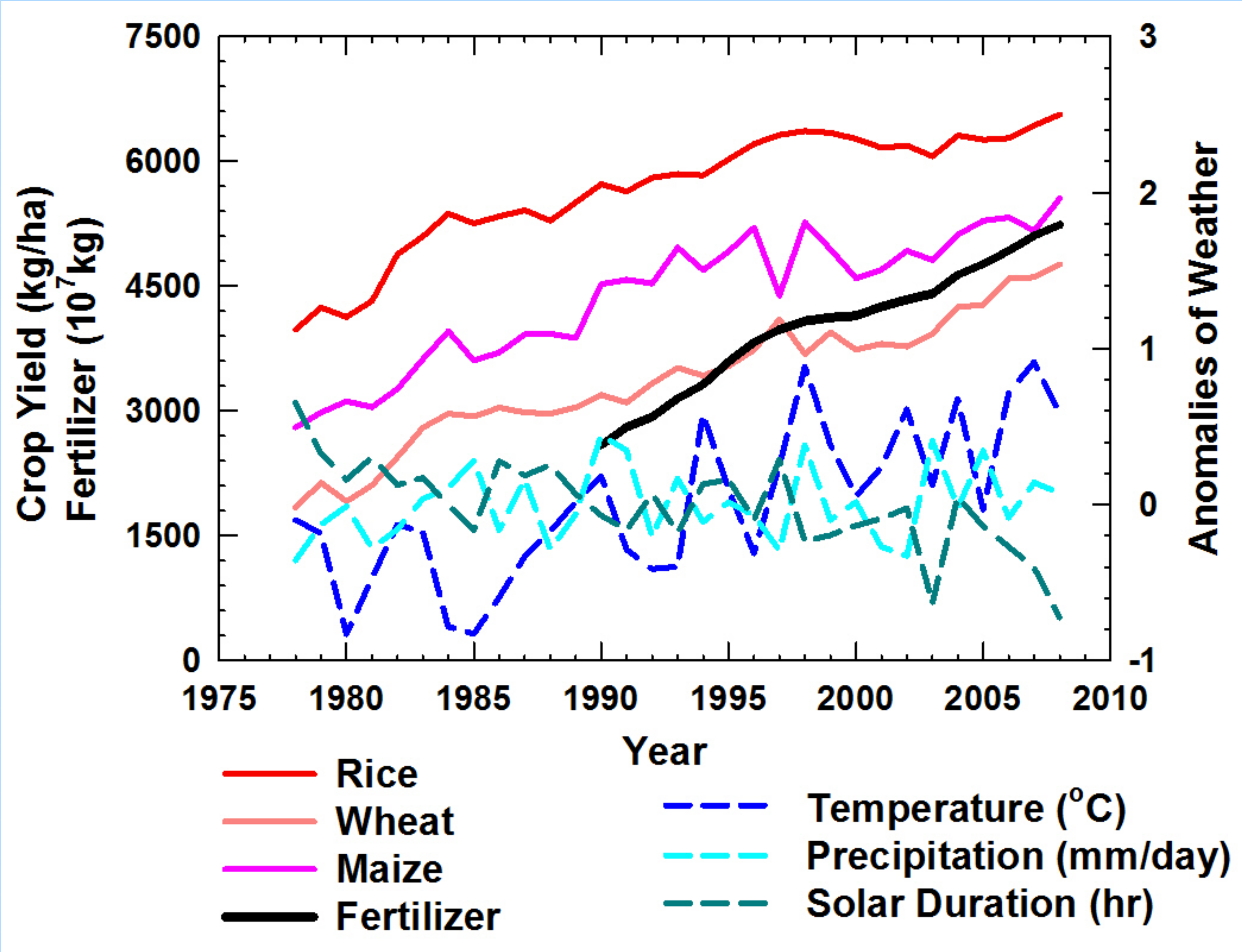
THE NEW YORK TIMES

New York Times, February 9, 2011

RUTGERS

Alan Robock
Department of Environmental Sciences

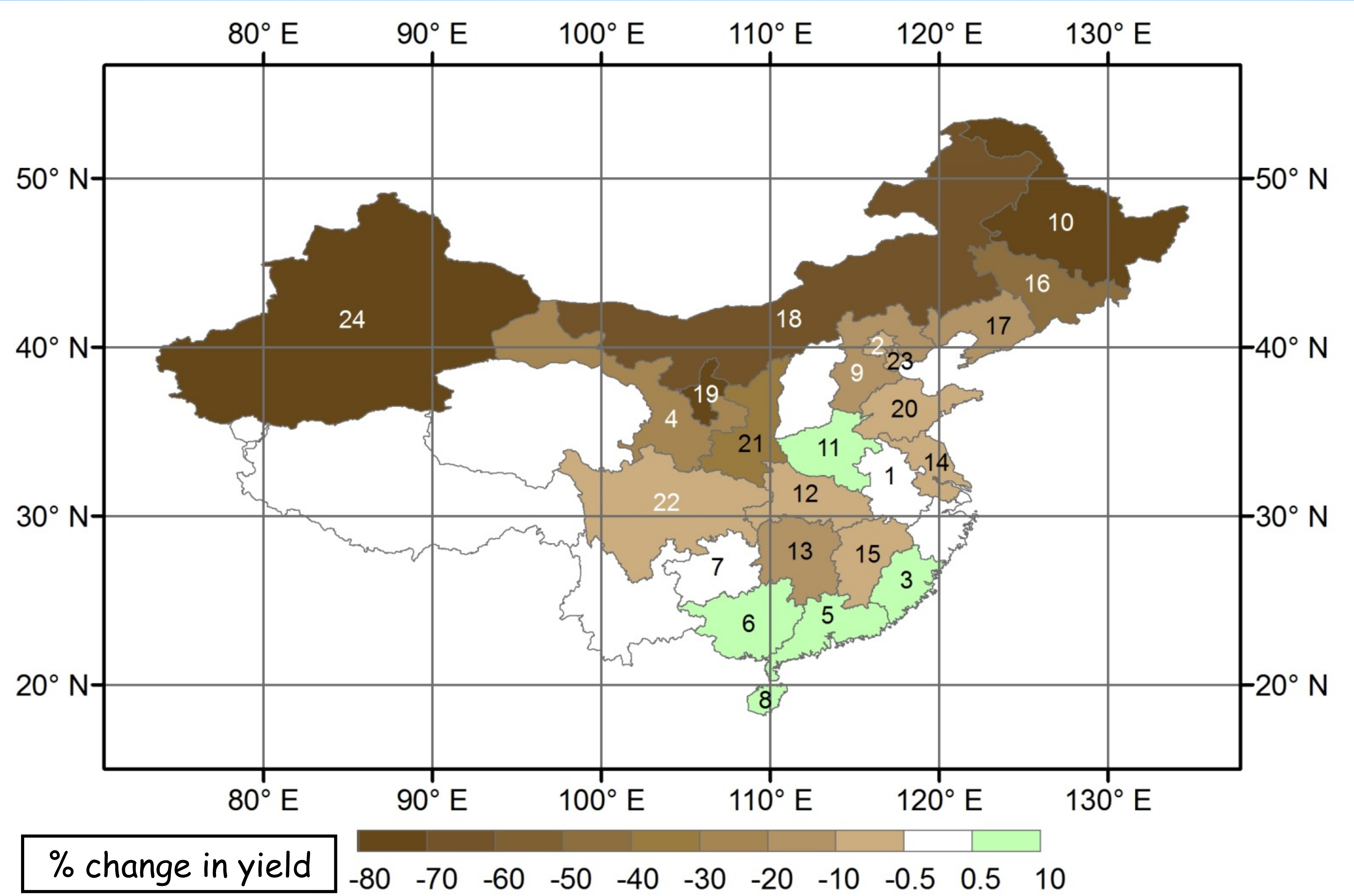
Yields of major crops and annual weather anomalies in mainland China



RUTGERS

Lili Xia and Alan Robock
Department of Environmental Sciences

Using the DSSAT crop model, rice production in China would decrease 11±3% (13±4 Mt) in response to a 5 Tg SO_2 per year stratospheric injection, averaged over the second decade of geoengineering.



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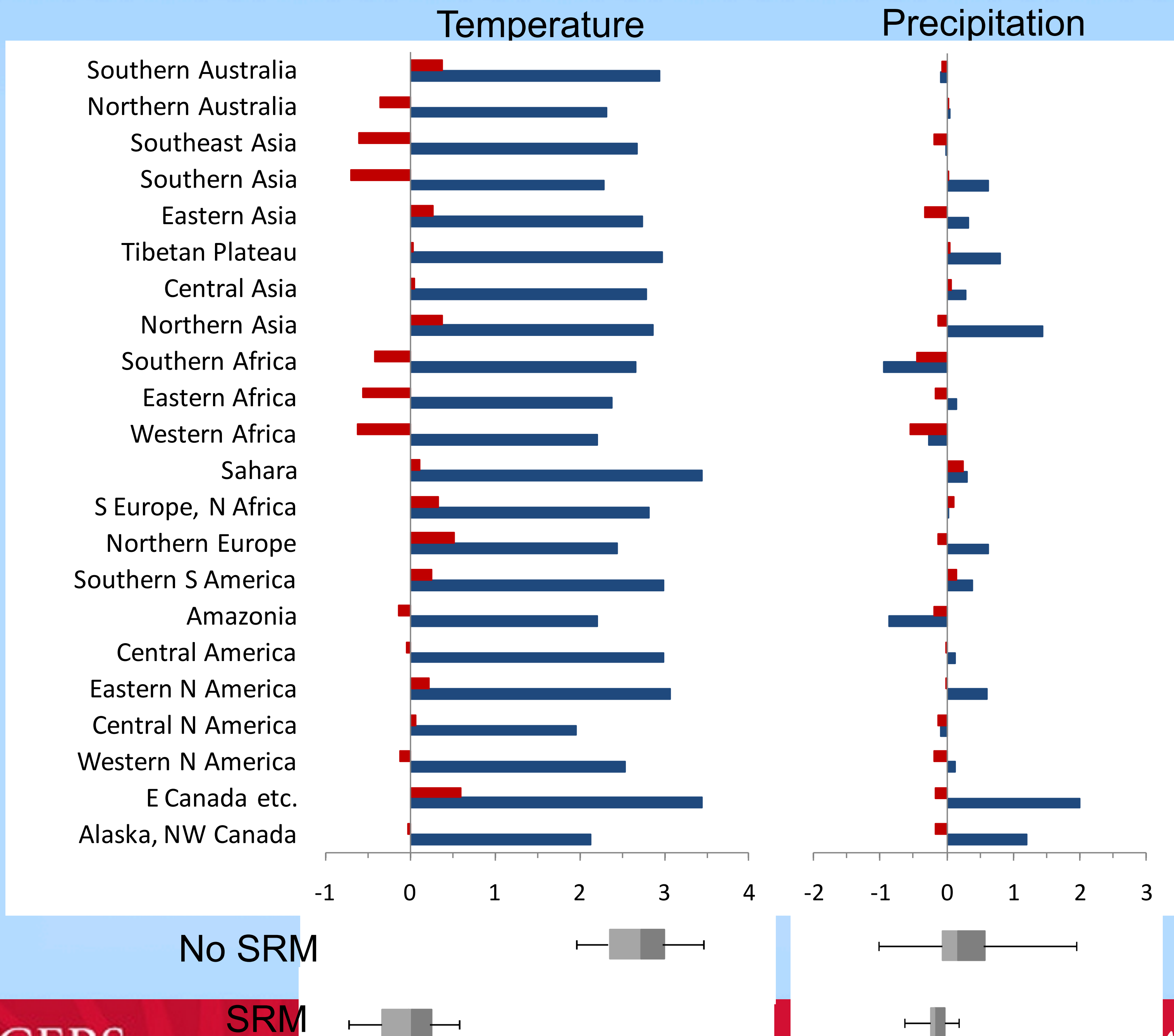


Moreno-Cruz, Ricke & Keith (2011)

Conclusions

A well-funded national or international research program, as part of the currently ongoing Intergovernmental Panel on Climate Change Fifth Scientific Assessment, would be able to look at several other aspects of geoengineering and provide valuable guidance to policymakers trying to decide how best to address the problems of global warming.

Such research should include theoretical calculations as well as engineering studies. Small-scale experiments could examine nozzle properties and initial formation of aerosols, but they could not be used to test the climatic response of stratospheric aerosols.

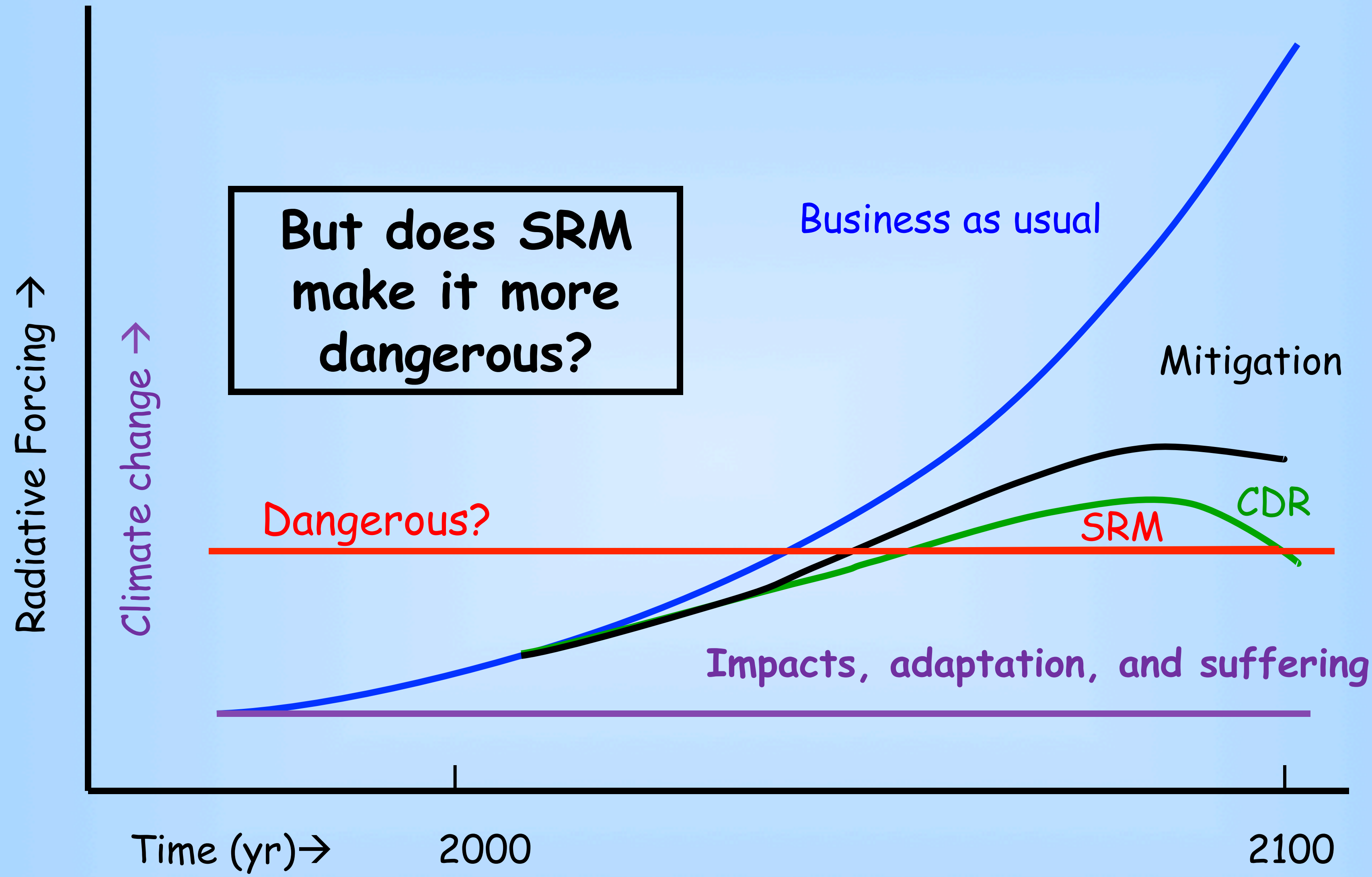
We currently lack the capability to monitor the evolution and distribution of stratospheric aerosol clouds. A robust space-based observing system would allow monitoring future volcanic eruptions or any geoengineering experiments.

Reasons mitigation is a good idea

Proponents of geoengineering say that mitigation is not possible, as they see no evidence of it yet. But it is clearly a political and not a technical problem.

Mitigation will not only reduce global warming but it will also

- reduce ocean acidification,
- reduce our dependence on foreign sources of energy,
- stop subsidizing terrorism with our gas dollars,
- reduce our military budget, freeing resources for other uses,
- clean up the air, and
- provide economic opportunities for a green economy, to provide solar, wind, cellulosic ethanol, energy efficiency, and other technologies we can sell around the world.



RUTGERS
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Department of Environmental Sciences

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.

Alan Robock
Department of Environmental Sciences

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.”

Alan Robock
Department of Environmental Sciences