



The Case for Anthropogenic Warming

Richard McGehee



Seminar on the Mathematics of Climate Change
School of Mathematics
September 9, 2008



The Case for Anthropogenic Warming

Is the globe warming?
What determines the Earth's temperature?
Did human activity cause the problem?
How big is the problem?
What's at stake?



The Case for Anthropogenic Warming

What's at stake?


- No ice fishing in Minnesota
- No polar bears in the Arctic
 - No ice in Antarctica
 - No Florida



The Case for Anthropogenic Warming

What's at stake?

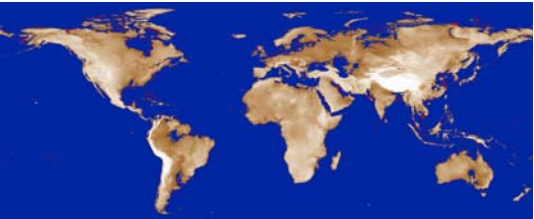
The USA in the Ice Free Earth
Computer Simulation, Clarence Lehman, Univ. Mn. 2006


The Case for Anthropogenic Warming

What's at stake?

The Modern Ice Free Earth
Computer Simulation, Clarence Lehman, Univ. Mn. 2006



Sea level rises 63 meters.



The Case for Anthropogenic Warming

Is the globe warming?
What determines the Earth's temperature?
Did human activity cause the problem?
How big is the problem?
What's at stake?

The Case for Anthropogenic Warming Is the Globe Warming?

Public Perception

Inside Washington National Journal
Congressional Insiders Poll

Q Do you think it's been proven beyond a reasonable doubt that the Earth is warming because of man-made problems?

Democrats (41 votes)		Republicans (31 votes)	
	(Now)	(April 2006)	
Yes	95 percent	93 percent	23 percent
No	2 percent	2 percent	84 percent
Scientific consensus (retaliated)	2 percent		3 percent
			Only part of the cause (retaliated)

National Journal, Feb 3, 2007
http://syndication.nationaljournal.com/images/203Insiderspoll_NJ1logo.pdf

The Case for Anthropogenic Warming Is the Globe Warming?

2007 Polar Sea Ice

Press Release, 1 October 2007, National Snow and Ice Data Center
http://nsidc.org/news/press/2007_seaiceminimum/20071001_pressrelease.html

The Case for Anthropogenic Warming Is the Globe Warming?

Polar Sea Ice

National Snow and Ice Data Center
 Press Release, 1 October 2007, National Snow and Ice Data Center
http://nsidc.org/news/press/2007_seaiceminimum/20071001_pressrelease.html

The Case for Anthropogenic Warming Is the Globe Warming?

Global Mean Temperature

Period (years)	Rate (°C per decade)
25	0.177 ± 0.052
50	0.125 ± 0.026
100	0.074 ± 0.019
150	0.045 ± 0.012

Technical Summary, IPCC AR4, p.37
http://ipcc-wg1.ucar.edu/wg1/Report/AR4WG1_Print_TS.pdf

The Case for Anthropogenic Warming Is the Globe Warming?

Northern Hemisphere Data

<http://www.ncdc.noaa.gov/paleo/globalwarming/paleoat.html>

The Case for Anthropogenic Warming Is the Globe Warming?

Lake Vostok

http://www.nsf.gov/news/mmg/media/images/lake_vostok_nsf_h.jpg

The Case for Anthropogenic Warming
Is the Globe Warming?

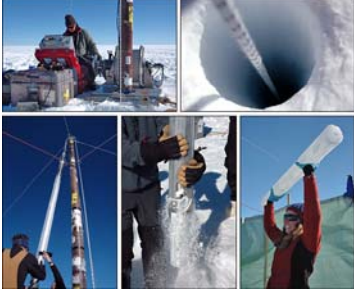
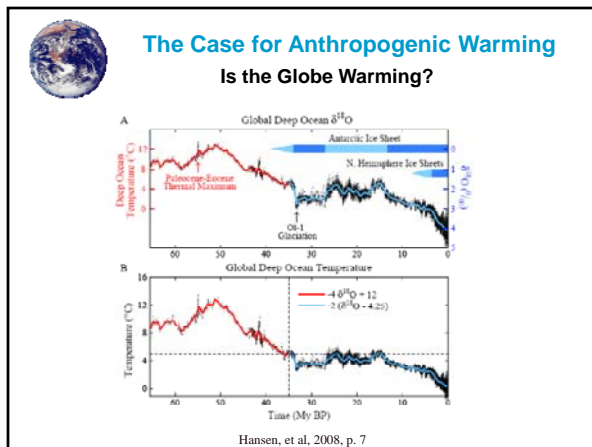
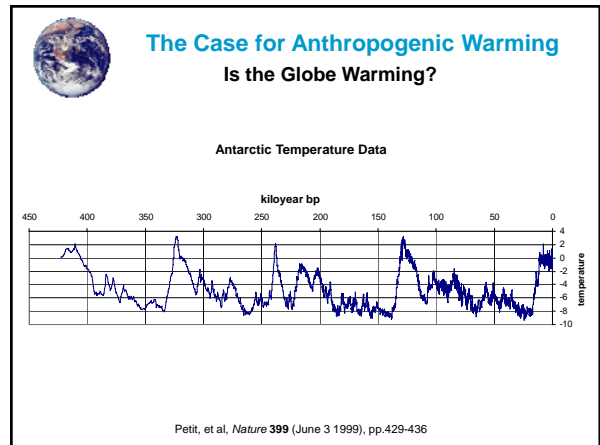
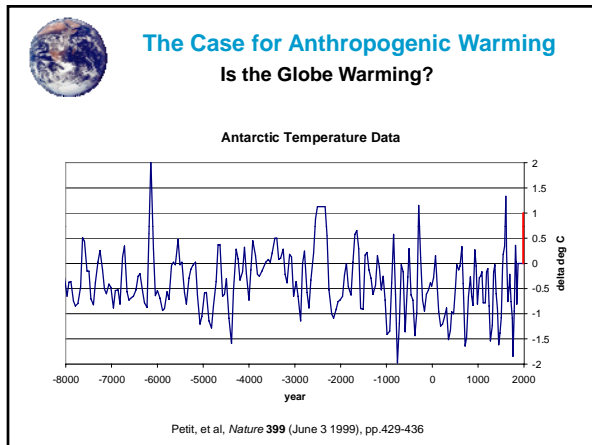
Lake Vostok



<http://svs.gsfc.nasa.gov/viz/a000000/a000900/a000996/index.html>

The Case for Anthropogenic Warming
Is the Globe Warming?

Core Samples
Photographs copyright Reto Stockli, NASA GSFC

The Case for Anthropogenic Warming

Is the globe warming?

What determines the Earth's temperature?

Did human activity cause the problem?

How big is the problem?

What's at stake?



The Case for Anthropogenic Warming

What Determines the Earth's Temperature?

Heat Balance

$$T^4 = kS$$

where T = surface temperature ($^{\circ}\text{K}$)

S = solar influx (W/m^2)

k = constant depending on reflectivity of the surface, emissivity of the surface, and the Stefan-Boltzmann constant.

For the current value of k , $T = 255^{\circ}\text{K} = -18^{\circ}\text{C} = 0^{\circ}\text{F}$

Why isn't the Earth a Snowball?

C.Lorius, The ice-core record: climate sensitivity and future greenhouse warming, *Nature* 347 (1990), pp.139-145



The Case for Anthropogenic Warming

What Determines the Earth's Temperature?

Why isn't the Earth a Snowball?

The Greenhouse Effect!

Joseph Fourier, *Mémoires de l'Académie des Sciences de l'Institut de France*, t. vii. 1827.



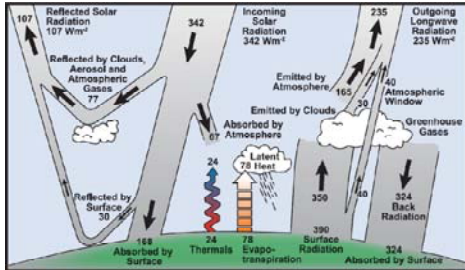
Svante Arrhenius, "On the Influence of Carbonic Acid in the Air upon the Temperature of the Ground," *Philosophical Magazine and Journal of Science (Fifth Series)* 41, pp. 237-276, 1896.



The Case for Anthropogenic Warming

What Determines the Earth's Temperature?

Heat Balance



Historical Overview of Climate Change Science, IPCC AR4, p.96
http://ipcc-wg1.ucar.edu/wg1/Report/AR4WG1_Print_CH01.pdf

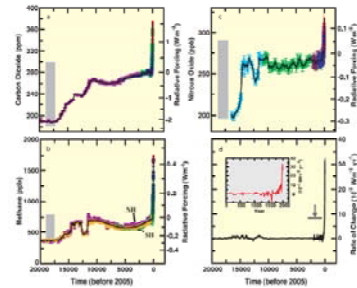


The Case for Anthropogenic Warming

What Determines the Earth's Temperature?

Radiative Forcing by Greenhouse Gases

CHANGES IN GREENHOUSE GASES FROM ICE CORE AND MODERN DATA



Technical Summary, IPCC AR4, p.25

http://ipcc-wg1.ucar.edu/wg1/Report/AR4WG1_Print_TS.pdf

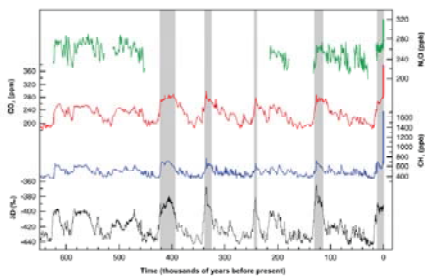


The Case for Anthropogenic Warming

What Determines the Earth's Temperature?

Greenhouse Gases

GLACIAL-INTERGLACIAL ICE CORE DATA



Technical Summary, IPCC AR4, p.24

http://ipcc-wg1.ucar.edu/wg1/Report/AR4WG1_Print_TS.pdf

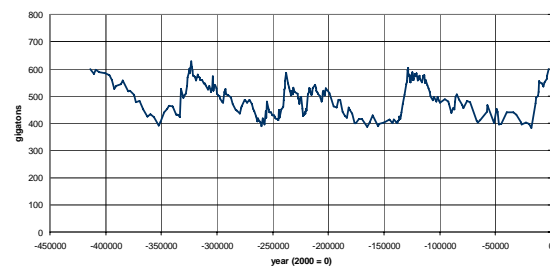


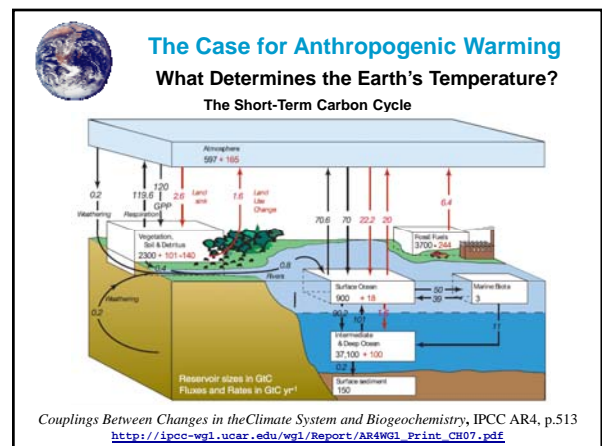
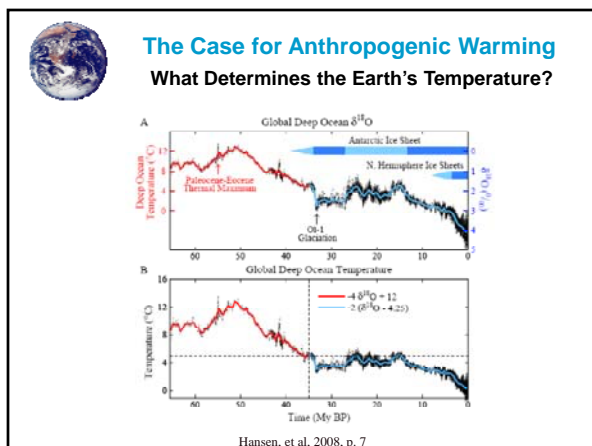
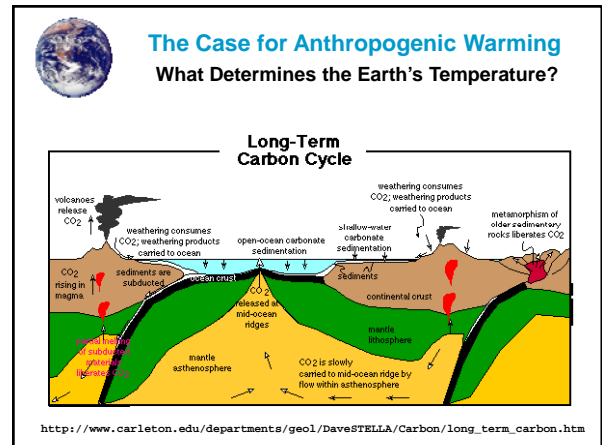
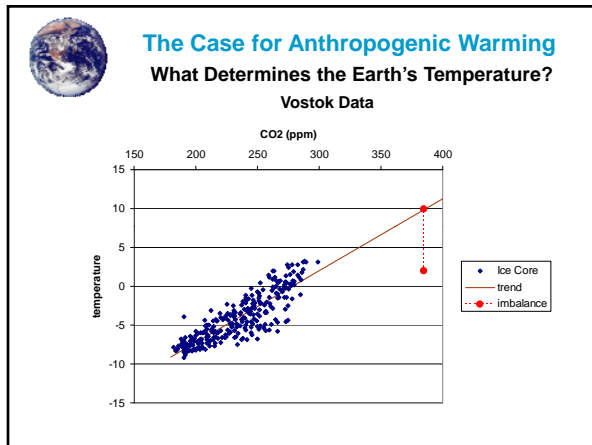
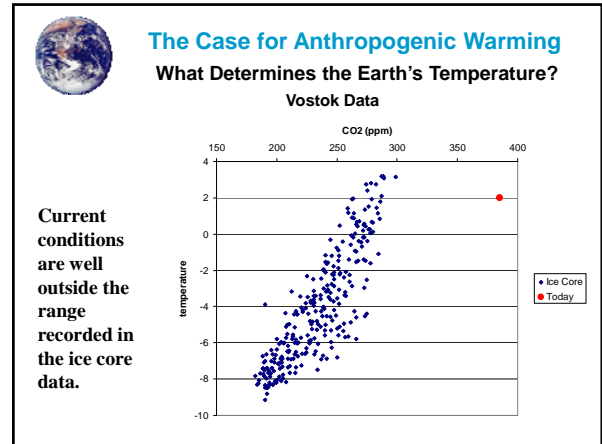
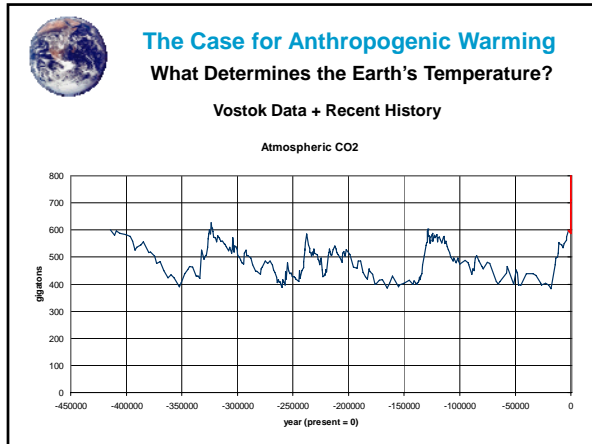
The Case for Anthropogenic Warming

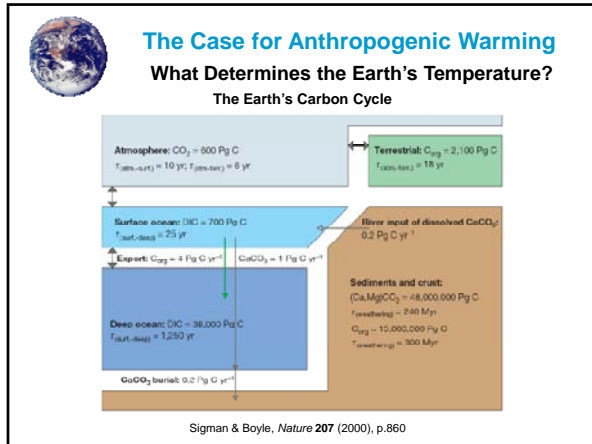
What Determines the Earth's Temperature?

Vostok Data

Atmospheric CO₂

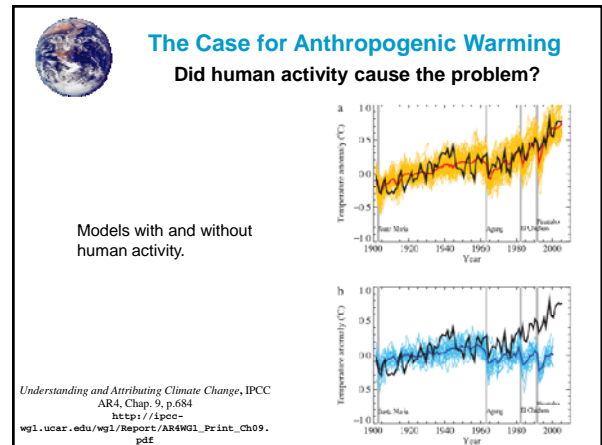
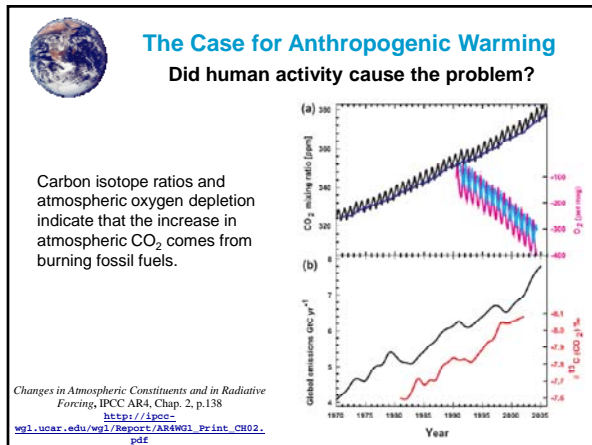






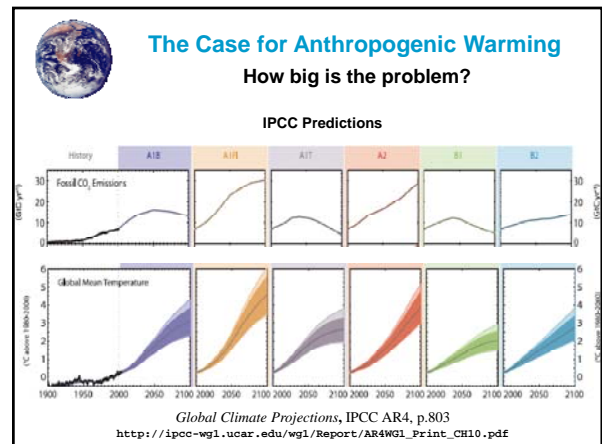
The Case for Anthropogenic Warming

Is the globe warming?
 What determines the Earth's temperature?
 Did human activity cause the problem?
 How big is the problem?
 What's at stake?



The Case for Anthropogenic Warming

Is the globe warming?
 What determines the Earth's temperature?
 Did human activity cause the problem?
 How big is the problem?
 What's at stake?

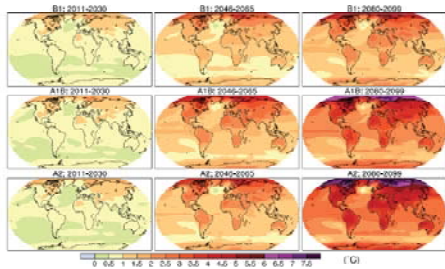




The Case for Anthropogenic Warming

How big is the problem?

Surface Temperature Predictions



Global Climate Projections, IPCC AR4, p.766
http://ipcc-wg1.ucar.edu/wg1/Report/AR4WG1_Print_CH10.pdf



The Case for Anthropogenic Warming

Summary

Is the globe warming?

Yes, but so far not much.

What determines the Earth's temperature?

Solar forcing plus the greenhouse effect.

Did human activity cause the problem?

Sure looks like it.

How big is the problem?

So far, not big. But it could become huge.