




Math and Climate Seminar IMA



Mathematics and Climate Research Network


Joint MCRN/IMA Math and Climate Seminar
 Tuesdays 11:15 – 12:05
 streaming video available at
 www.ima.umn.edu

MCRN  


www.mathclimate.org

The Scientific Case for Anthropogenic Warming, II

Richard McGehee



Seminar on the Mathematics of Climate
 IMA, MCRN, School of Mathematics
 September 10, 2013




Anthropogenic Warming

Where is Public Opinion?
Mired in politics.

Is the globe warming?
Yes, but, from a geologic perspective, not so much.

What determines the Earth's temperature?

What is the role of human activity?
 How big is the problem?



Anthropogenic Warming

What Determines the Earth's Temperature?


Heat Balance

outgoing (infrared) $\rightarrow \sigma T^4 = (1 - \alpha)S \leftarrow$ solar incoming (visible)

where T = surface temperature ($^{\circ}K$)
 S = solar influx (W/m^2)
 α = albedo (reflectivity)
 σ = the Stefan-Boltzmann constant

For current values , $T = 255K = -18^{\circ}C = 0^{\circ}F$

Why isn't the Earth a Snowball?




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.

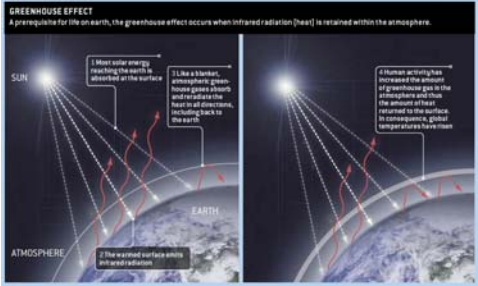


Svante Arrhenius, "On the Influence of Carbonic Acid in the Air upon the Temperature of the Ground," *Philosophical Magazine and Journal of Science (Fifth Series)* 41, pp. 237-276, 1896.

Anthropogenic Warming

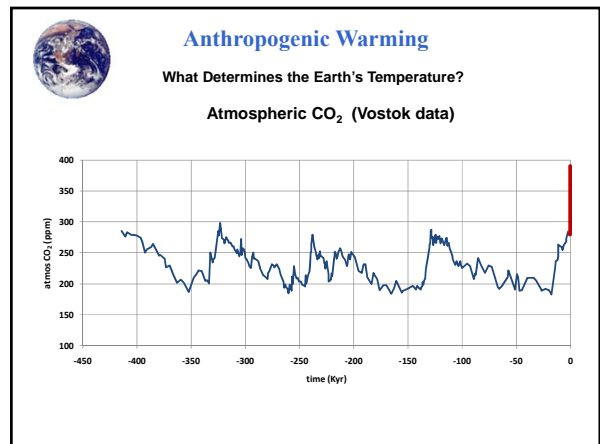
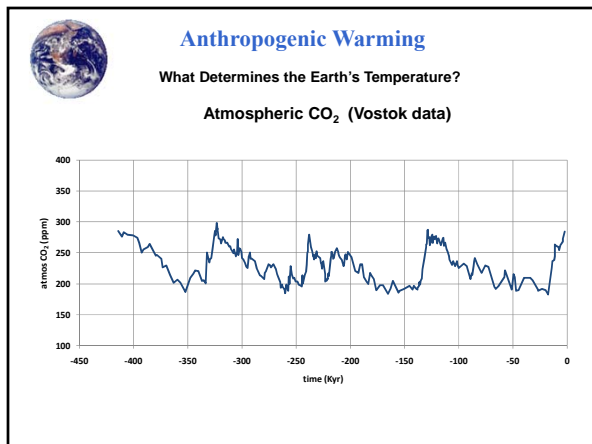
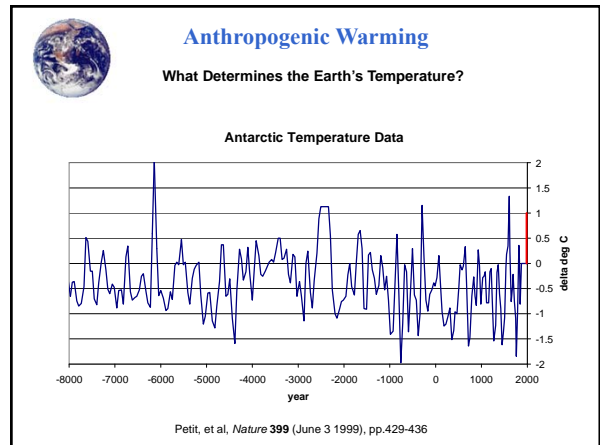
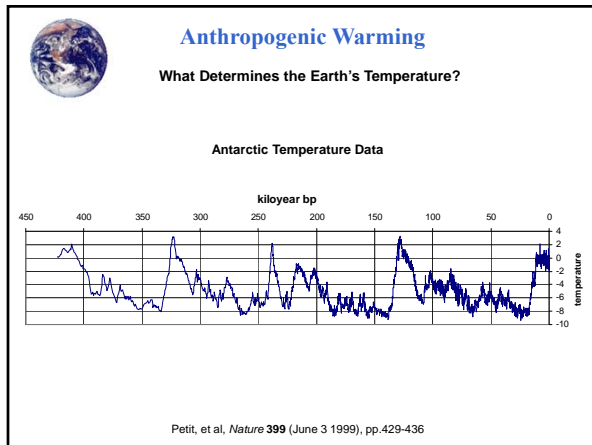
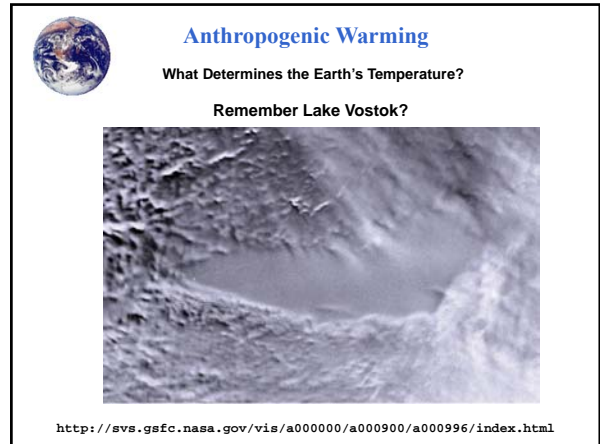
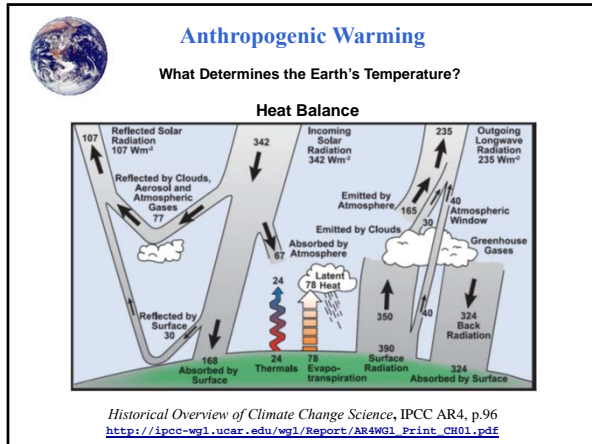
What Determines the Earth's Temperature?

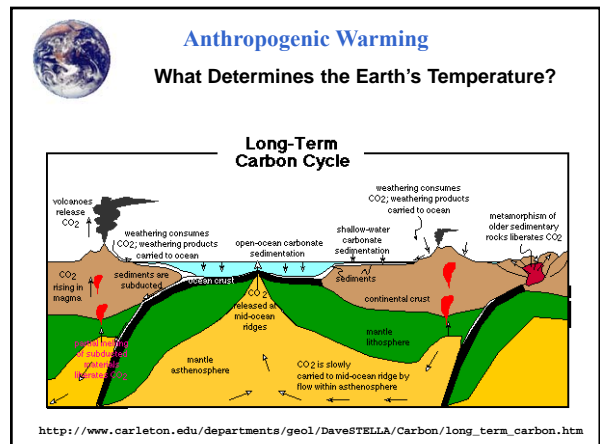
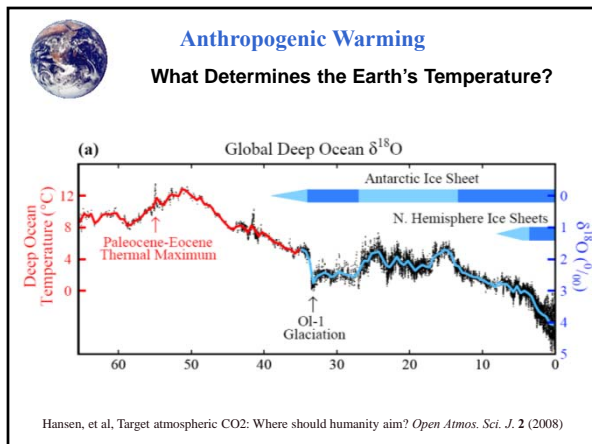
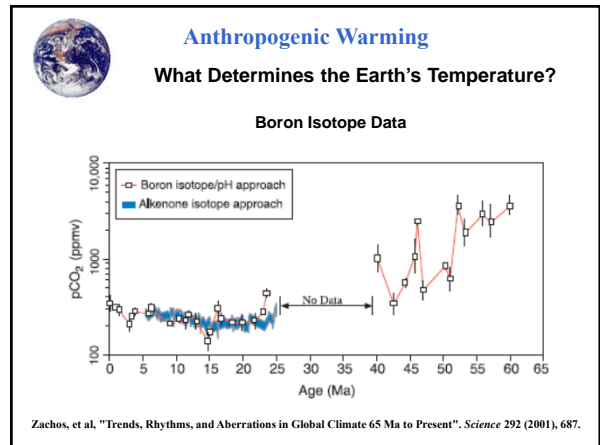
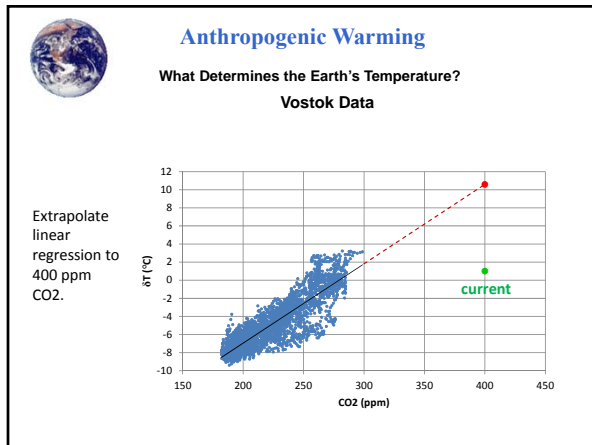
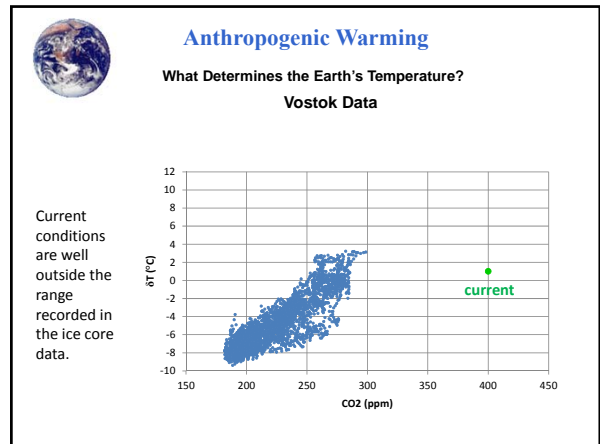
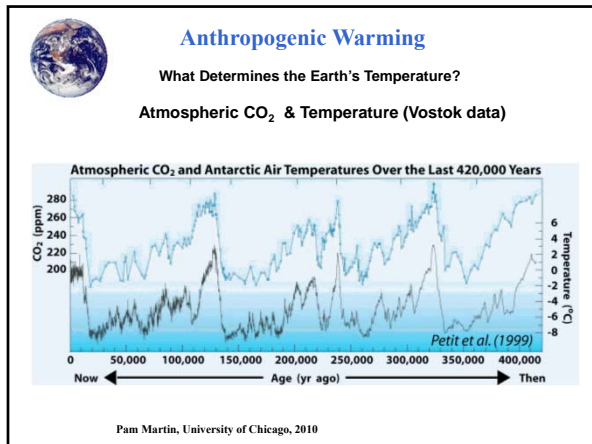


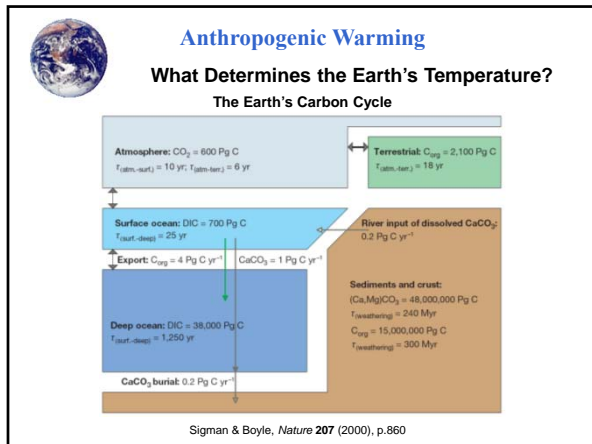
GREENHOUSE EFFECT
 A prerequisite for life on earth, the greenhouse effect occurs when infrared radiation (heat) is retained within the atmosphere.

1 Most solar energy reaching the earth is absorbed at the surface.
 2 The warmed surface emits infrared radiation.
 3 Like a blanket, atmospheric gases (being gases absorb and re-emit the heat in all directions, including back to the earth).
 4 Human activity has increased the amount of greenhouse gas in the atmosphere and that the amount of heat returned to the surface is increasing, global temperatures have risen.

Gary Stix, *Scientific American* September 2006, pp.46-49







Anthropogenic Warming

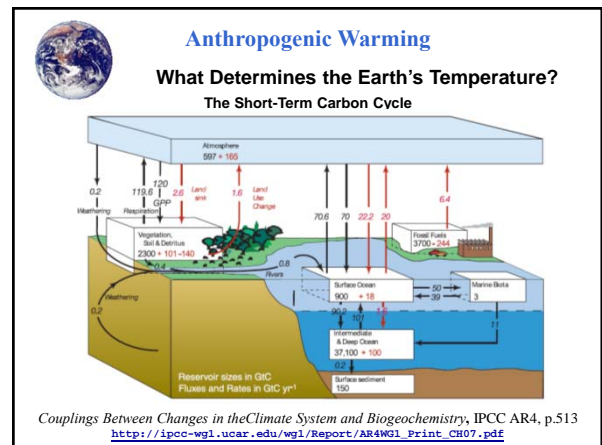
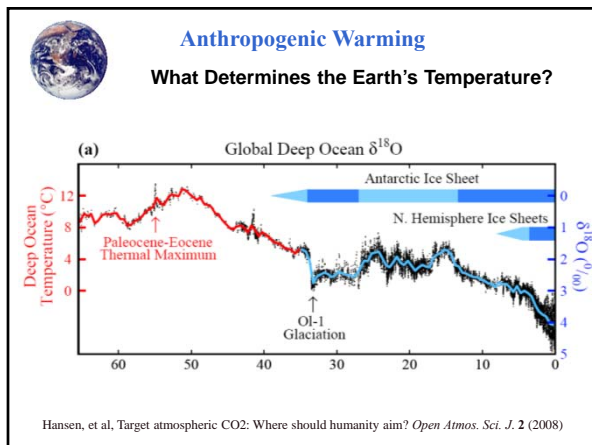
What Determines the Earth's Temperature?

Silicate Weathering

Rainwater containing dissolved CO_2 falling on silicate rocks replaces a silicon atom with a carbon atom, ultimately producing calcium carbonate (limestone) and silicon dioxide (quartz). For example, calcium silicate (Wollastonite):

$$\text{CaSiO}_3 + \text{CO}_2 \rightarrow \text{CaCO}_3 + \text{SiO}_2$$

Under volcanic conditions, the carbon atom is replaced by a silicon atom, completing the long term carbon cycle.

$$\text{CaCO}_3 + \text{SiO}_2 \rightarrow \text{CaSiO}_3 + \text{CO}_2$$


Anthropogenic Warming

Where is Public Opinion?

Mired in politics.

Is the globe warming?

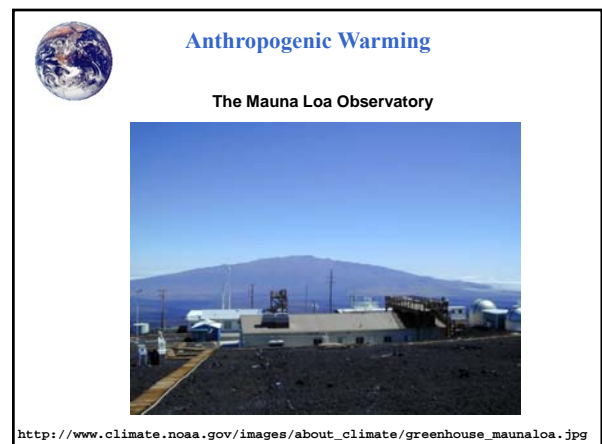
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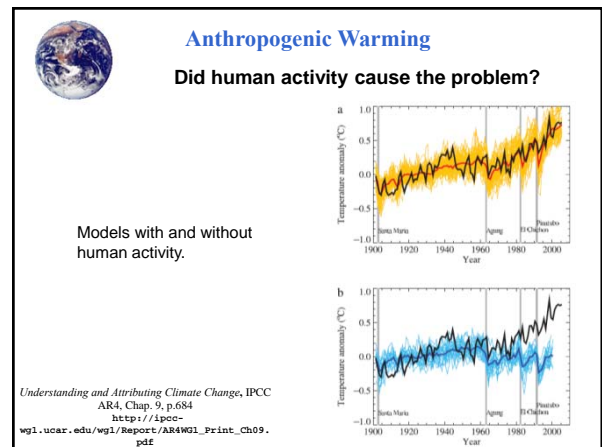
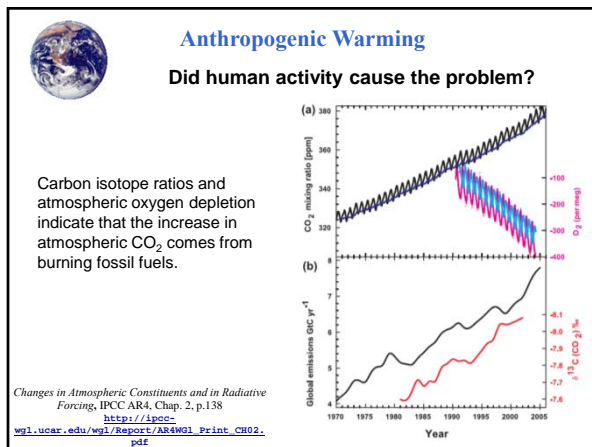
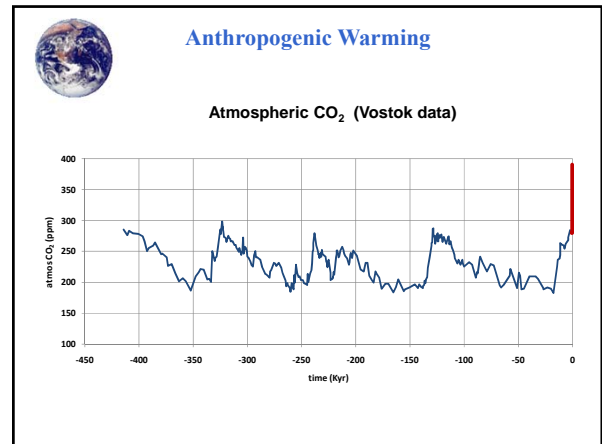
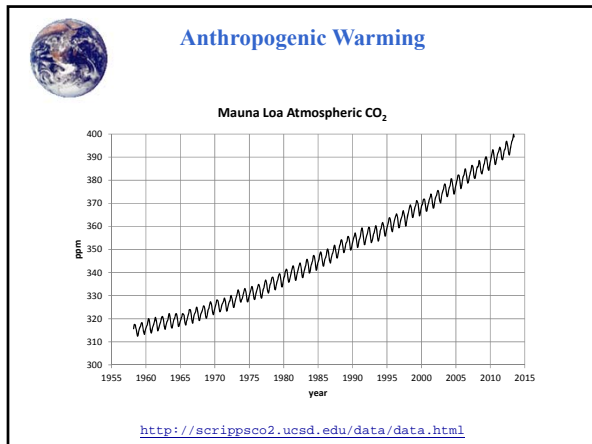
What determines the Earth's temperature?

Physics! Solar heating plus the carbon cycle.

What is the role of human activity?

How big is the problem?





Anthropogenic Warming

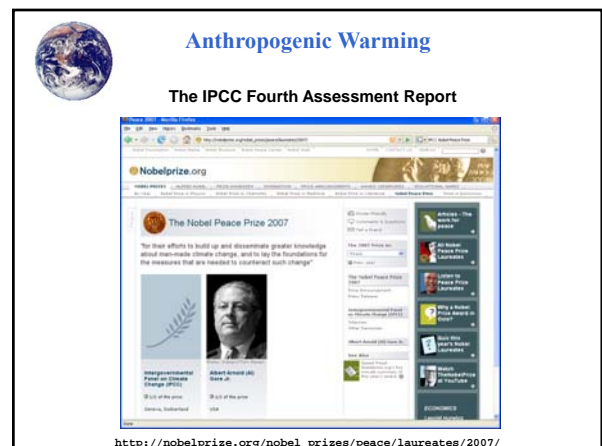
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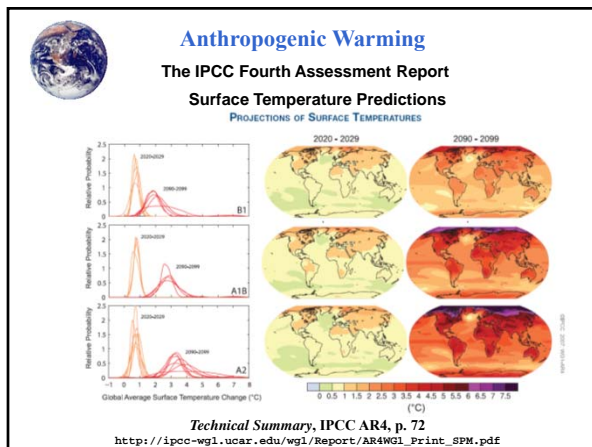
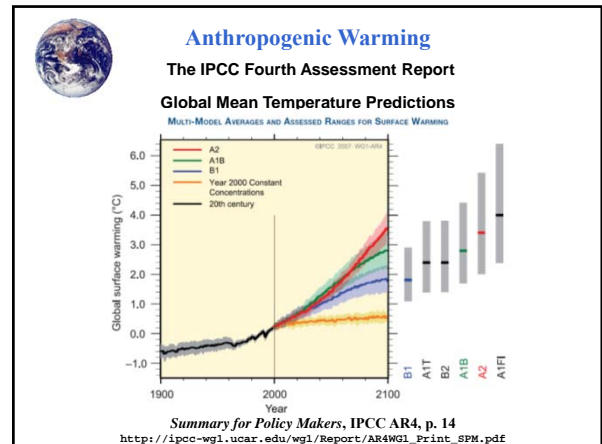
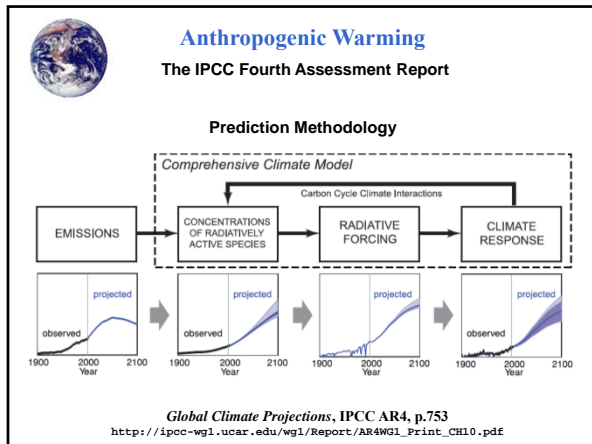
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How big is the problem?





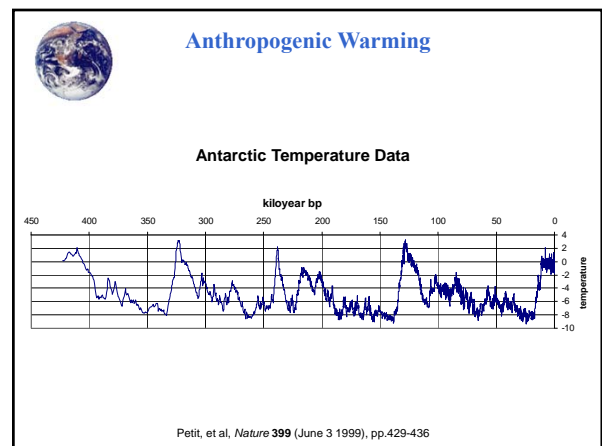
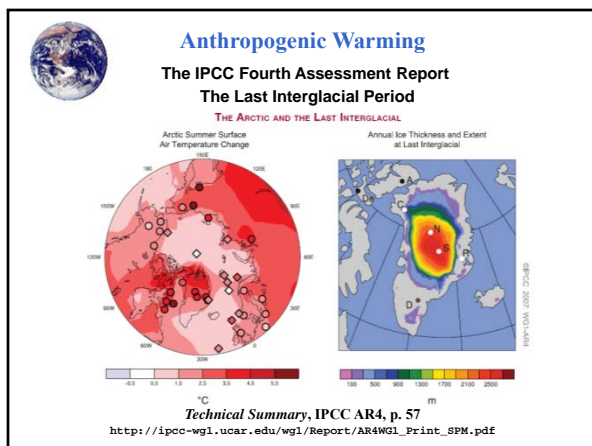
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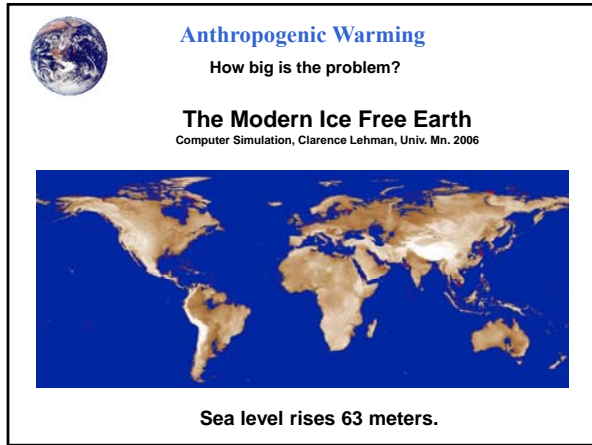
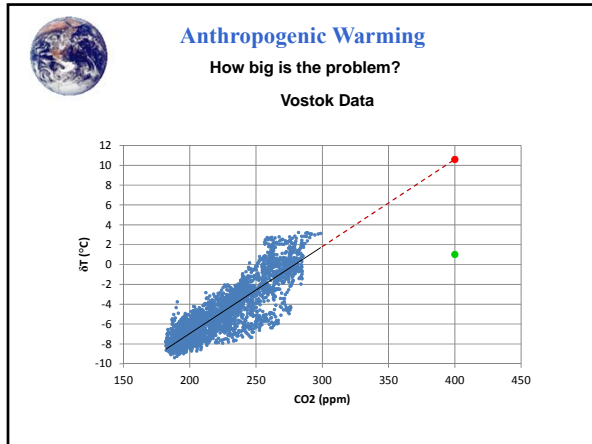
The IPCC Fourth Assessment Report

The Last Interglacial Period

Global average sea level was likely between 4 and 6 m higher during the last interglacial period, about 125,000 years ago, than during the 20th century, mainly due to the retreat of polar ice. Ice core data suggest that the Greenland Summit region was ice-covered during this period, but reductions in the ice sheet extent are indicated in parts of southern Greenland. Ice core data also indicate that average polar temperatures at that time were 3°C to 5°C warmer than the 20th century because of differences in the Earth's orbit. The Greenland Ice Sheet and other arctic ice fields likely contributed no more than 4 m of the observed sea level rise, implying that there may also have been a contribution from Antarctica.

Technical Summary, IPCC AR4, p. 58
http://ipcc-wg1.ucar.edu/wg1/Report/AR4WG1_Print_SPM.pdf





Anthropogenic Warming

Summary

Where is Public Opinion?
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Is the globe warming?
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What determines the Earth's temperature?
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What is the role of human activity?
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How big is the problem?
Not big. Yet. ...

