


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, I

Richard McGehee




Seminar on the Mathematics of Climate
 IMA, MCRN, School of Mathematics
 September 11, 2012



Anthropogenic Warming

Outline


- Where is Public Opinion?
- Is the globe warming?
- What determines the Earth's temperature?
- What is the role of human activity?
- How big is the problem?



Anthropogenic Warming

Where is Public Opinion?

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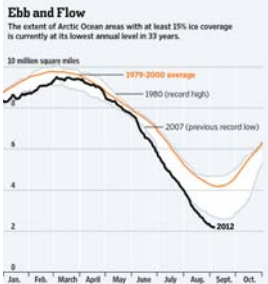


Anthropogenic Warming

Arctic Sea Ice Reaches New Low: August 2012

Ebb and Flow

The extent of Arctic Ocean areas with at least 15% ice coverage is currently at its lowest annual level in 33 years.

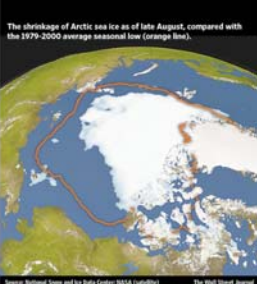


13 million square miles

1979-2000 average
 1980 (record high)
 2007 (previous record low)
 2012


Jan Feb March April May June July Aug Sept Oct

The shrinkage of Arctic sea ice as of late August, compared with the 1979-2000 average seasonal low. (orange line).



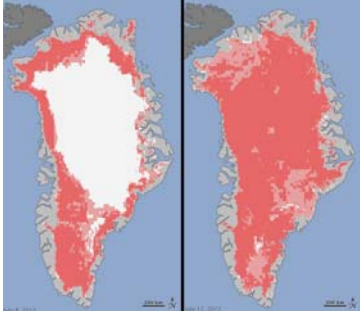
Source: National Oceanic and Ice Data Center (NOAA) (Landsat) The Wall Street Journal

<http://online.wsj.com/article/SB10000872396390444772804577621470127844642.html#articleTabs3Dinteractive>

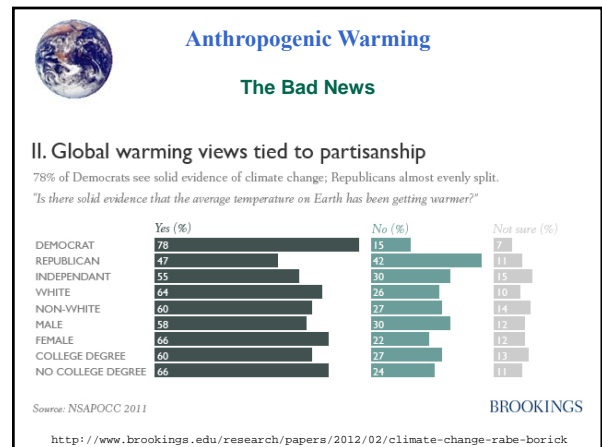
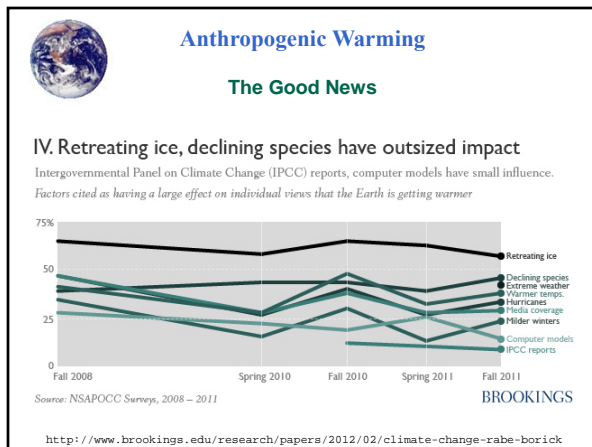
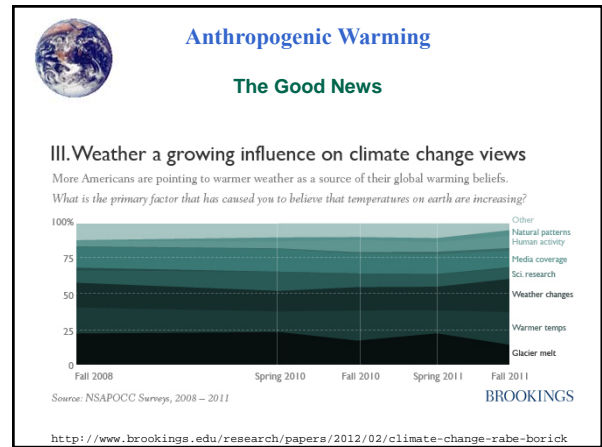
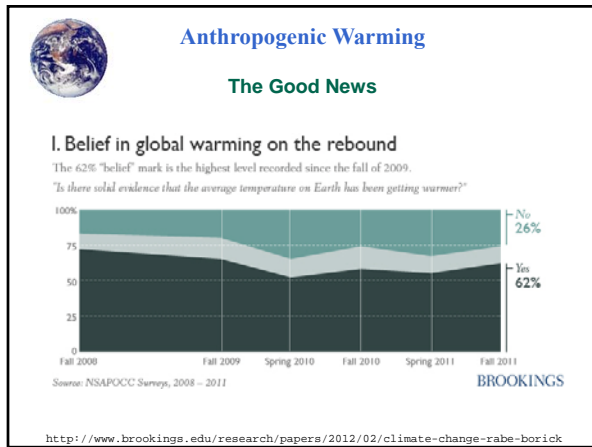
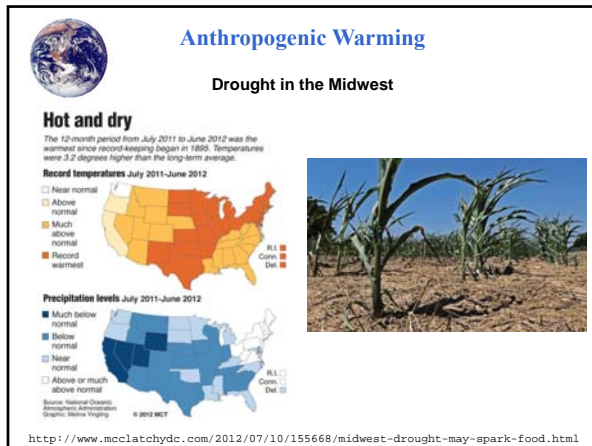


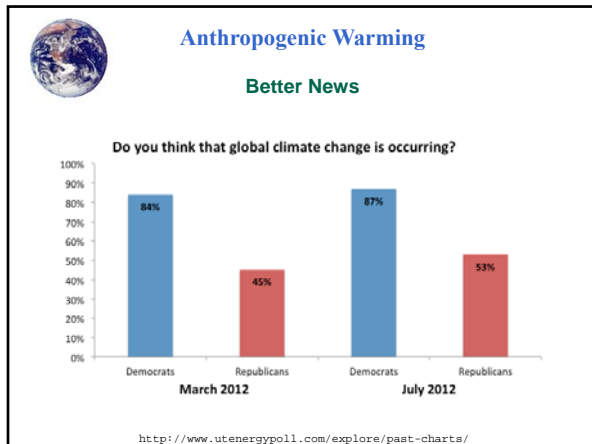
Anthropogenic Warming

The Great Greenland Thaw: July 2012



<http://www.jpl.nasa.gov/news/news.php?release=2012-217>





Anthropogenic Warming

Is the Globe Warming?

Public Perception

Opinions About Global Warming: 2006-2010

| | July 2006 | Jan 2007 | April 2008 | Oct 2009 | Oct 2010 |
|--|-----------|----------|------------|----------|----------|
| Is there solid evidence the earth is warming? | % | % | % | % | % |
| Yes | 79 | 77 | 71 | 57 | 59 |
| Because of human activity | 50 | 47 | 47 | 36 | 34 |
| Because of natural patterns | 23 | 20 | 18 | 16 | 18 |
| Don't know | 6 | 10 | 6 | 6 | 6 |
| No | 17 | 16 | 21 | 33 | 32 |
| Mixed/Don't know | 4 | 7 | 8 | 10 | 9 |
| | 100 | 100 | 100 | 100 | 100 |

The Pew Research Center for People and the Press, October 27, 2010
<http://people-press.org/2010/10/27/little-change-in-opinions-about-global-warming/>

Anthropogenic Warming

Is the Globe Warming?

Public Perception

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) | | (Now) | (April 2006) |
| Yes | 95 percent | 98 percent | Yes | 13 percent | 23 percent |
| No | 2 percent | 2 percent | No | 84 percent | 77 percent |
| Scientific consensus (unintended) | 2 percent | | Only part of the cause (unintended) | 3 percent | |

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

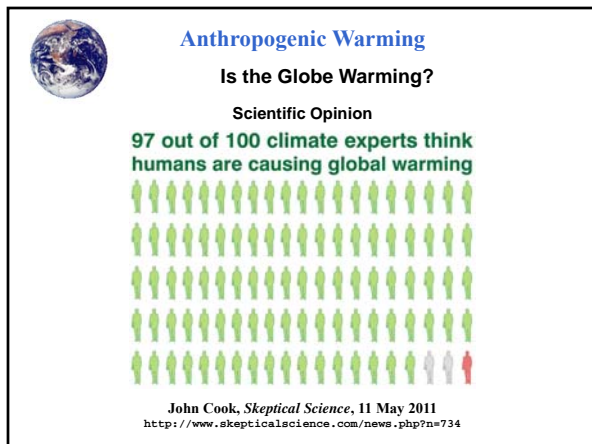
Anthropogenic Warming

Is the Globe Warming?

Public Perception

| | July 2006 | Jan 2007 | April 2008 | Oct 2009 | Oct 2010 |
|---|-----------|----------|------------|----------|----------|
| Do scientists agree the earth is getting warmer because of human activity? | % | % | % | % | % |
| Yes | 59 | -- | -- | -- | 44 |
| No | 29 | -- | -- | -- | 44 |
| Don't know | 12 | -- | -- | -- | 12 |
| | 100 | -- | -- | -- | 100 |

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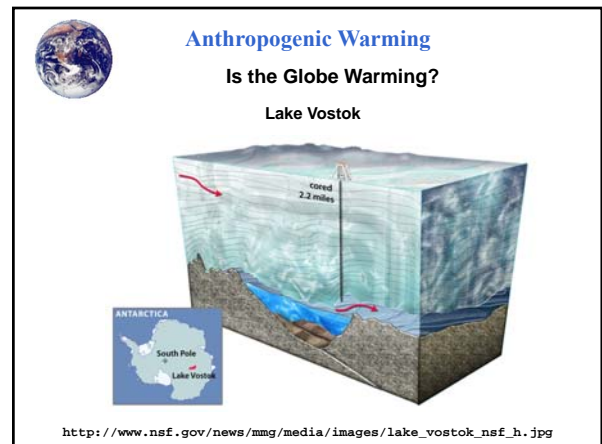
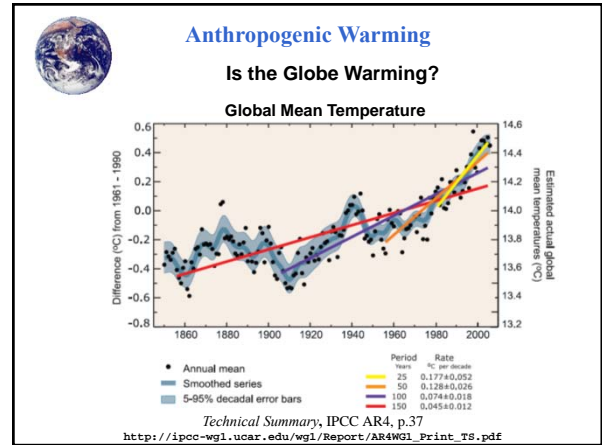
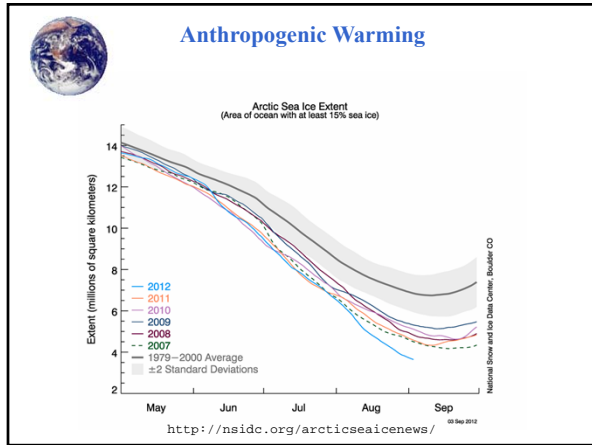
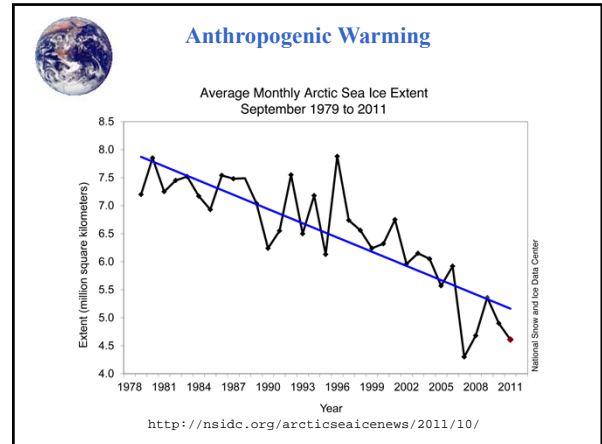
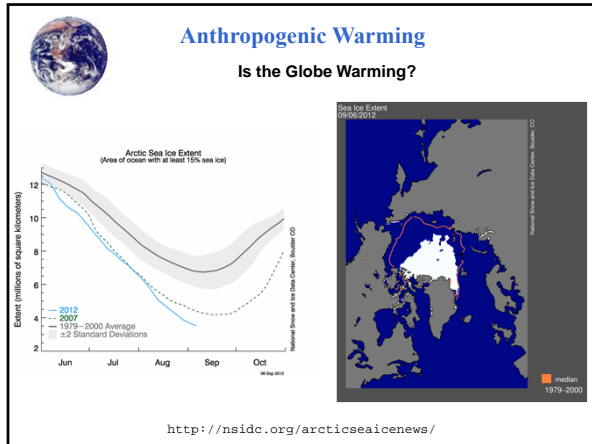
Anthropogenic Warming

Where is Public Opinion?

Mired in politics.

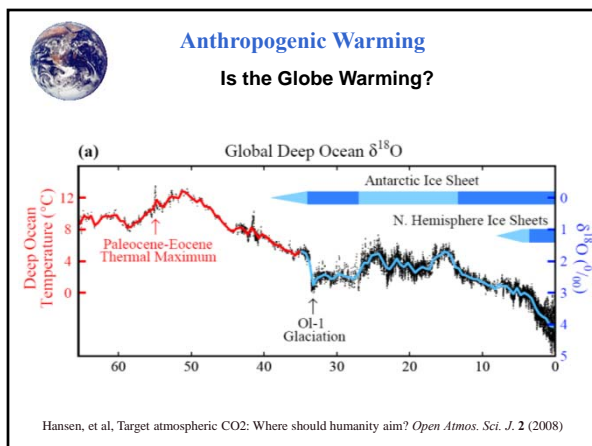
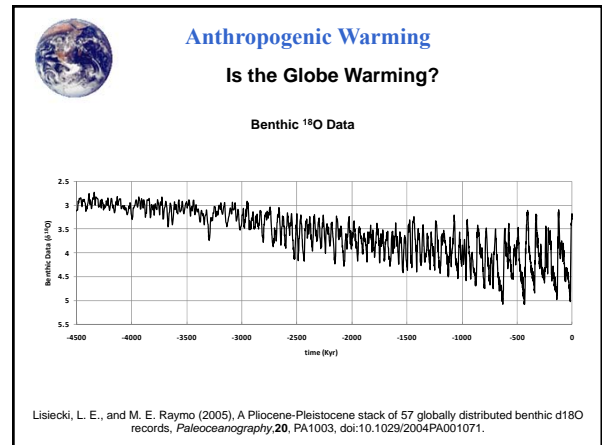
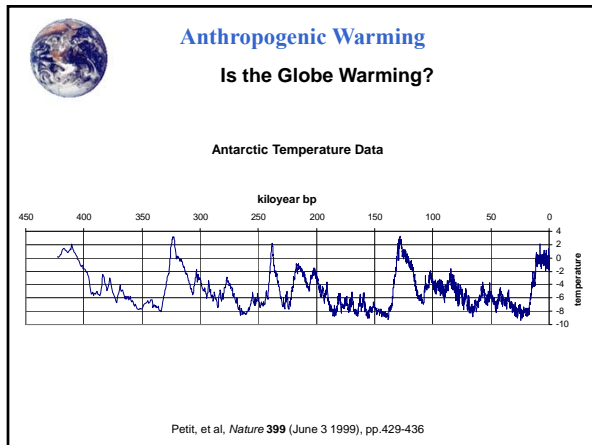
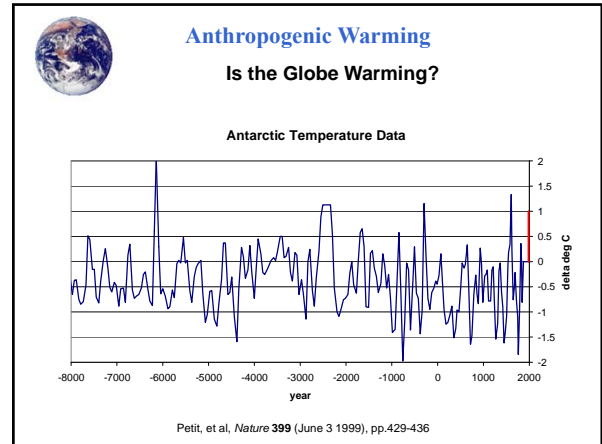
Is the globe warming?

What determines the Earth's temperature?
 What is the role of human activity?
 How big is the problem?



Anthropogenic Warming
Is the Globe Warming?

Core Samples
Photographs copyright Reto Stöckli, NASA GSFC



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

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

Why isn't the Earth a Snowball?

Anthropogenic Warming

What Determines the Earth's Temperature?

The Greenhouse Effect

Greenhouse gases (CO_2 , H_2O , CH_4) are transparent to visible light, but opaque to infrared light. The energy from the sun passes through the atmosphere and heats the surface. The surface radiates energy at a lower temperature (infrared), which is absorbed by the atmosphere.

Who discovered the greenhouse effect?

Anthropogenic Warming


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Who discovered the greenhouse effect?

Joseph Fourier (1827), *Mémoire sur les Températures du Globe Terrestre et des Espaces Planétaires*, *Mémoires de l'Académie Royale des Sciences*, t. vii., p. 569.




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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.

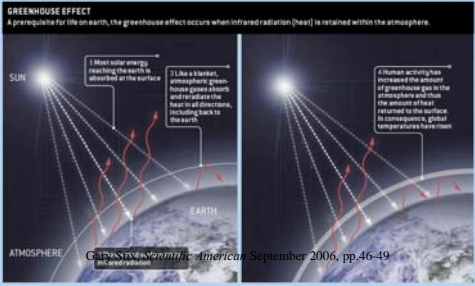


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What Determines the Earth's Temperature?

GREENHOUSE EFFECT

A prerequisite for the sun earth, the greenhouse effect occurs when infrared radiation [heat] is retained within the atmosphere.

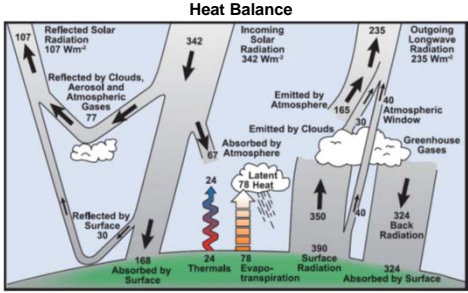


GREENHOUSE EFFECT *Scientific American*, September 2006, pp.46-49

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



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What determines the Earth's temperature?

Physics!

Tune in next week ...

What is the role of human activity?

How big is the problem?