



The Case for Anthropogenic Warming


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 Mathematics of Climate Seminar
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Anthropogenic Warming

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


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Anthropogenic Warming

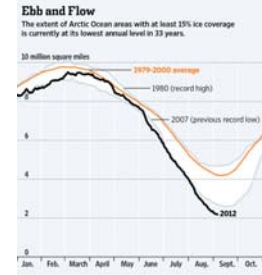
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Anthropogenic Warming

Arctic Sea Ice Reaches New Low: August 2012




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

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

Source: National Snow and Ice Data Center, NSIDC, satellite data. The Wall Street Journal.

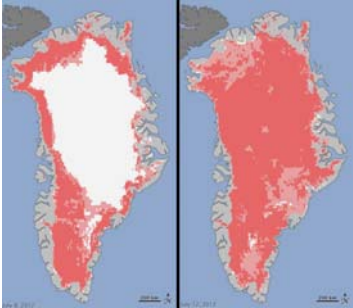
<http://online.wsj.com/article/SB10000872396390444772804577621470127844642.html#articleTabs=interactive>

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The Great Greenland Thaw: July 2012



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

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Anthropogenic Warming

Drought in the Midwest

Hot and dry
 The 12-month period from July 2011 to June 2012 was the warmest since record-keeping began in 1850. Temperatures were 3.2 degrees higher than the long-term average.



Record temperatures July 2011-June 2012

- Near normal
- Above normal
- Much above normal
- Record warmest



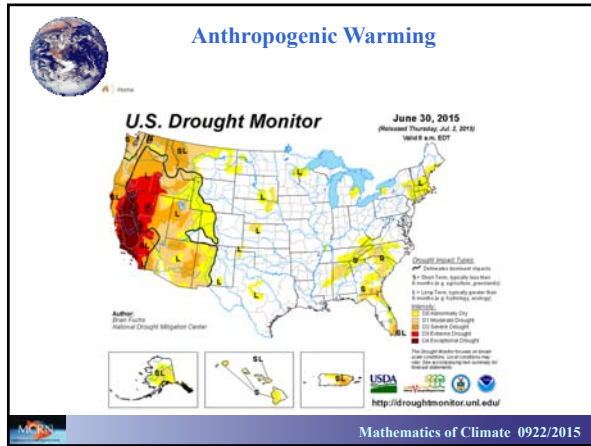
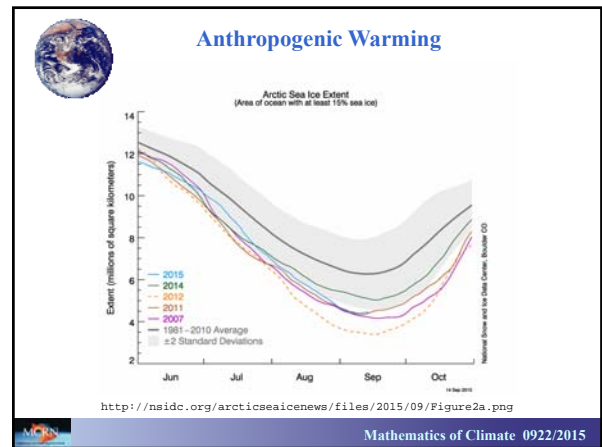
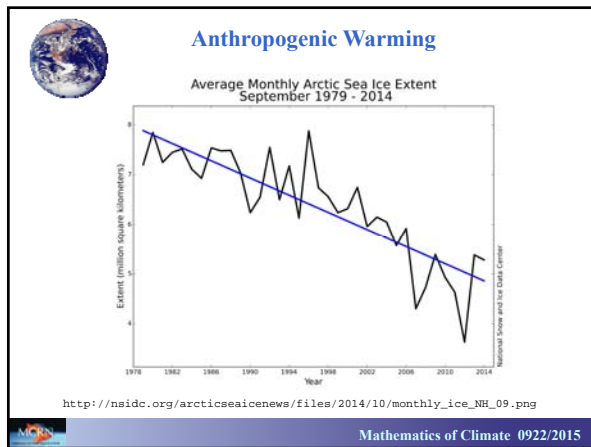
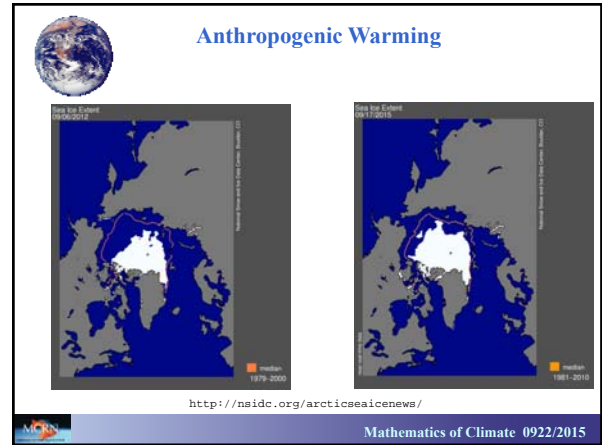
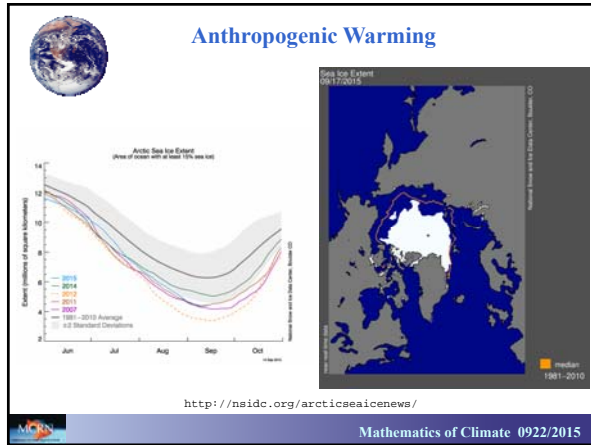
Precipitation levels July 2011-June 2012

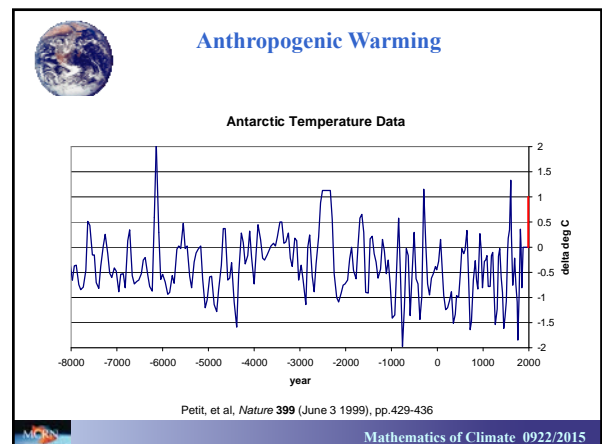
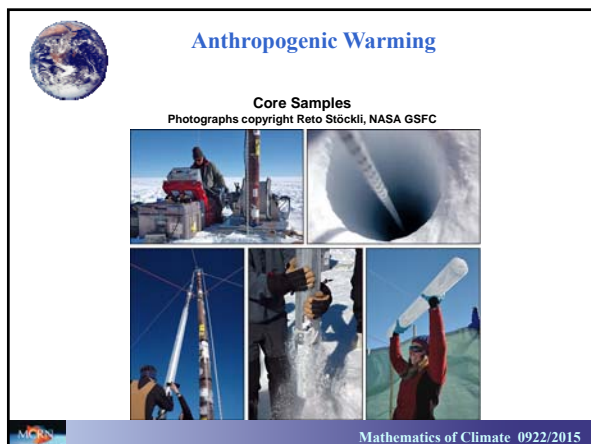
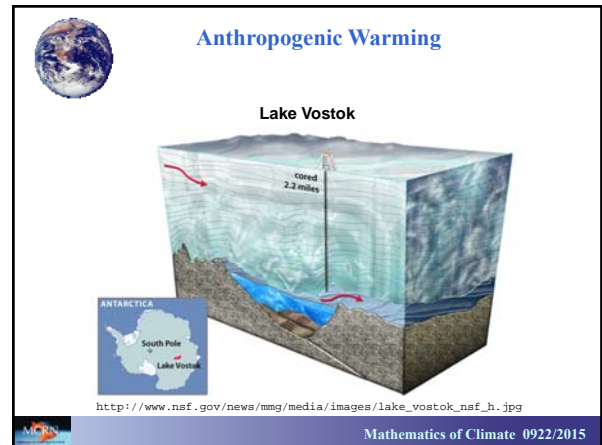
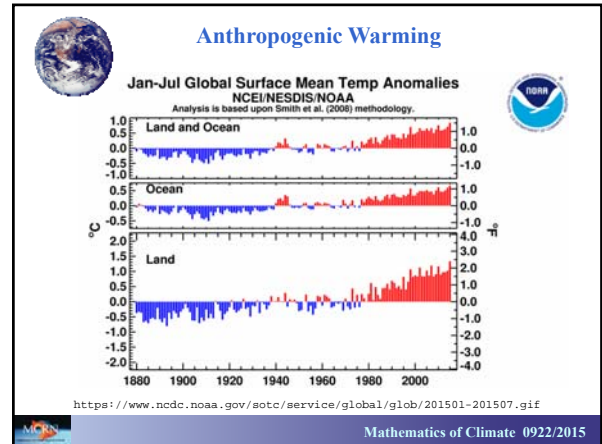
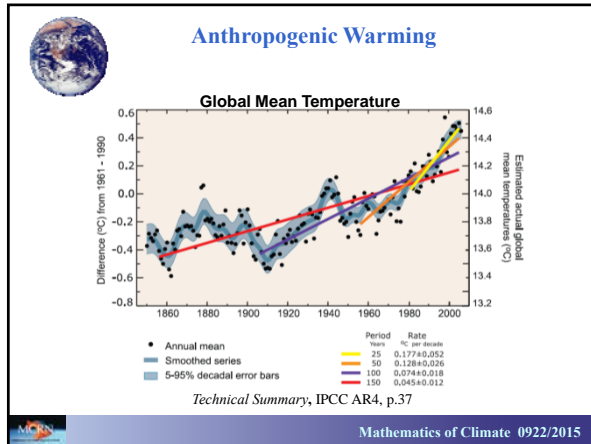
- Much below normal
- Below normal
- Near normal
- Above or much above normal

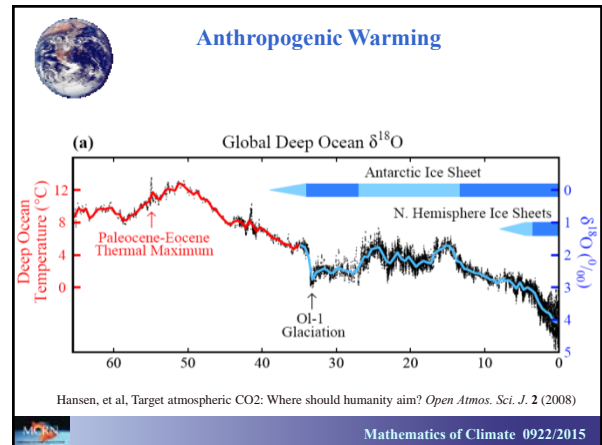
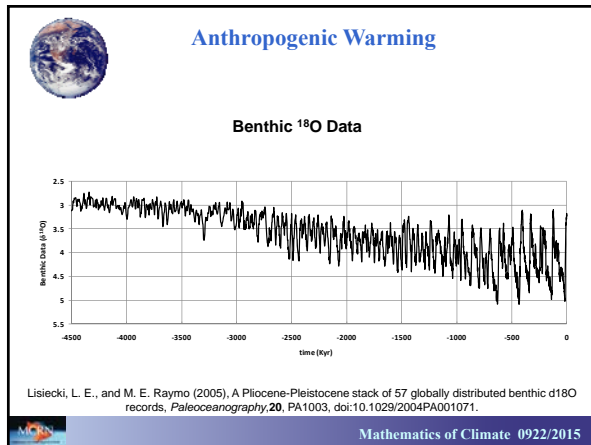
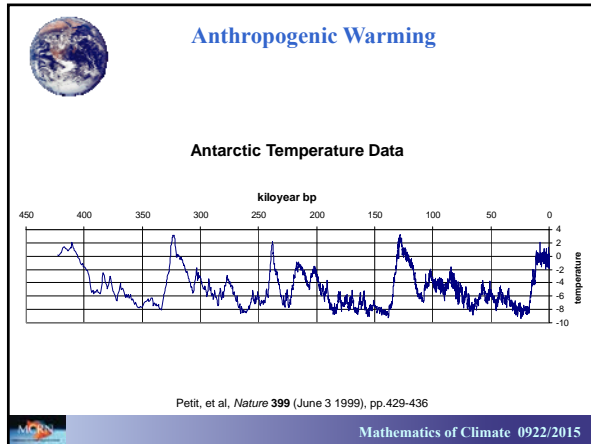



<http://www.mcclatchydc.com/2012/07/10/155668/midwest-drought-may-spark-food.html>

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Anthropogenic Warming

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?

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Heat Balance

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

where T = surface temperature (Kelvin)

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?

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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?



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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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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.





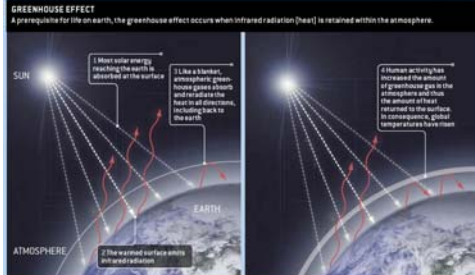


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GREENHOUSE EFFECT
A prerequisite for life on earth, the greenhouse effect occurs when infrared radiation (heat) is retained within the atmosphere.




1 Most solar energy reaching the earth is absorbed at the surface.


2 As a result, atmospheric gases, water vapor, and the heat in the oceans, including back to the earth.

3 Human activity has increased the amount of greenhouse gas in the atmosphere and thus the amount of heat returned to the surface. Increasing global temperatures have risen.

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

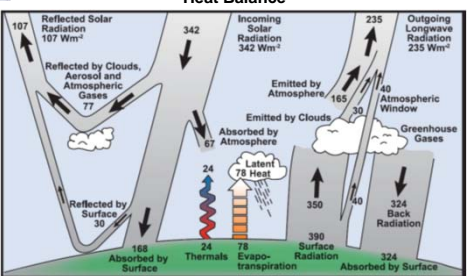


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Heat Balance



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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Anthropogenic Warming

Remember Lake Vostok?



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



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