The Case for Anthropogenic Warming

Richard McGehee
School of Mathematics
University of Minnesota
Mathematics of Climate Seminar
September 11, 2018

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

Anthropogenic Warming

2017 Hurricanes

Harvey and Irma

Anthropogenic Warming

2018 Wildfires

Carr Fire, California


The Great Greenland Thaw: July 2012
Anthropogenic Warming

The Guardian 21 Aug 2018
Arctic’s strongest sea ice breaks up for first time on record

Anthropogenic Warming

Lake Vostok

Core Samples

Antarctic Temperature Data

Petit, et al., Nature 399 (June 3 1999), pp.429-436
Anthropogenic Warming

Ocean Sediment Cores

http://eo.usm.edu/rrussell/climate/paleoclimate/sediment_proxy_records.html

Anthropogenic Warming

Benthic δ18O Data


Anthropogenic Warming


Anthropogenic Warming

Heat Balance

Heating Balance

\[ \sigma T^4 = (1 - \alpha)S \]

where

\( T \) = surface temperature (Kelvin)

\( S \) = solar influx (W/m²)

\( \alpha \) = albedo (reflectivity)

\( \sigma \) = the Stefan-Boltzmann constant

For current values, \( T = 255K \approx -18°C \)

Why isn’t the Earth a Snowball?

Anthropogenic Warming

The Greenhouse Effect

Greenhouse gases (CO₂, H₂O, CH₄) 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

The Greenhouse Effect

Greenhouse gases (CO₂, H₂O, CH₄) 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?


Why isn’t the Earth a Snowball?

The Greenhouse Effect!


Anthropogenic Warming

Heat Balance

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

Anthropogenic Warming

Remember Lake Vostok?

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


Antarctic Temperature Data

http://www.gafsc.nas.gov/via/a000000/a000900/a000996/index.html
Anthropogenic Warming

Antarctic Temperature Data

Petit, et al., Nature 399 (June 3 1999), pp.429-436

Anthropogenic Warming

Atmospheric CO₂ (Vostok data)

Petit, et al., Nature 399 (June 3 1999), pp.429-436

Anthropogenic Warming

Atmospheric CO₂ (Vostok data)

Petit, et al., Nature 399 (June 3 1999), pp.429-436

Anthropogenic Warming

Atmospheric CO₂ & Temperature (Vostok data)

Pam Martin, University of Chicago, 2010

Anthropogenic Warming

Vostok Data

Current conditions are well outside the range recorded in the ice core data.

Anthropogenic Warming

Vostok Data

Extrapolate linear regression to 400 ppm CO₂.

Richard McGehee, University of Minnesota