The Case for Anthropogenic Warming, I

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

Anthropogenic Warming

Wildfiles

2017 Hurricanes

Harvey and Irma

Maria

Ophelia

Anthropogenic Warming

The New York Times

How Has Climate Change Affected Hurricane Dorian?

Hurricane Dorian seen from the International Space Station on Monday.
Credit: NASA/EPA, via Shutterstock


Anthropogenic Warming

Carr Fire, California, 2018
Anthropogenic Warming

The Great Greenland Thaw: July 2012


Anthropogenic Warming

ftp://sidads.colorado.edu/DATASETS/NOAA/G02135/north/monthly/images/09_Sep/N_201209_extn_v3.0.png

Anthropogenic Warming

http://nsidc.org/arcticseaicenews/

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

Anthropogenic Warming

TIME
Record-Breaking Temperatures Around the World Are ‘Almost Entirely’ Due to Climate Change

July 2019 was the hottest July on record globally since temperature records began. Record-Breaking Temperatures Around the World Are ‘Almost Entirely’ Due to Climate Change

Anthropogenic Warming

Some energy comparisons:

- 1 megaton hydrogen bomb: \(4 \times 10^{15}\) Joules
- 1 day of an average hurricane: \(5 \times 10^{12}\) Joules
- Energy absorbed by the oceans since 1990: \(25 \times 10^{22}\) Joules
  - \(= 5,000\) hurricane-days
  - \(= 60,000,000\) H-bombs

So, it has gotten a little hotter recently. What about past climates? Doesn’t the climate always change?
Every hundred thousand years or so the Earth gets a little hotter, but mostly it has been pretty cold. What happened before that?
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?
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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?


Heat Balance
\[ \sigma T^4 - (1 - \alpha) S = \text{solar incoming (visible)} \]

where \( T \) = surface temperature (Kelvin)
\( S \) = solar influx (W/m²)
\( \alpha \) = albedo (reflectivity)
\( \sigma \) = the Stefan-Boltzmann constant

For current values, \( T = 255 \text{K} = -18^\circ \text{C} = 277^\circ \text{F} \)

Why isn’t the Earth a Snowball?

Anthropogenic Warming

Benthic δ¹⁸O Data


Benthic Data (δ¹⁸O)

Anthropogenic Warming

Hansen, et al, Target atmospheric CO₂: Where should humanity aim?

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Who discovered the greenhouse effect?
Anthropogenic Warming

**Why isn’t the Earth a Snowball?**

*The Greenhouse Effect!*


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**Anthropogenic Warming**

**Heat Balance**

Historical Overview of Climate Change Science, IPCC AR4, p.96

http://ipcc-wg1.ucar.edu/wg1/Report/AR4WG1_Fig1.pdf

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**Anthropogenic Warming**

*Okay, the greenhouse gases are important.*

*What do you know about them?*

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**Anthropogenic Warming**

*Remember Lake Vostok?*

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

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**Anthropogenic Warming**

*Antarctic Temperature Data*

Current conditions are well outside the range recorded in the ice core data.
Extrapolate linear regression to 400 ppm CO₂.

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

What determines the Earth’s temperature?  
*There’s more. Stay tuned.*

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