Overview of Climate Science

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Program

- A little history
- Climate science
- Recent trends
- The future
A Little History
The Greenhouse Effect

Jean Baptiste Joseph Fourier (1768-1830)

John Tyndall (1820-1893)
Arrhenius was the first to suggest that fossil fuel combustion would lead to appreciable increases in atmospheric CO$_2$. In 1896, he estimated that doubling CO$_2$ would increase global temperatures by 5-6°C.
• Atmosphere almost transparent to solar radiation
• Atmosphere almost opaque to infrared radiation
• Infrared emission from surface and each layer

_In this model, the surface receives as much radiation from the atmosphere as it does directly from the sun_
In the real world, the surface receives almost **twice** as much **radiation from the atmosphere and clouds** as directly from the sun.
The basic physics of the greenhouse effect were understood and fairly well quantified more than 100 years ago (before computers)
Some Climate History
Paleocene-Eocene Thermal Maximum
CO₂ and Climate

![Graph showing the relationship between CO₂ and climate over time.](image)
Last 450 Thousand Years

Ice Age Temperature Changes

EPICA

Vostok

Ice Volume

ΔTemperature (°C)

Low

High

Thousands of Years Ago

450 400 350 300 250 200 150 100 50 0
Strong Correlation between High Latitude Summer Insolation and Ice Volume

Black: Time rate of change of ice volume
Red: Summer high latitude sunlight

P. Huybers, Science, 2006
Last 2000 Years

“Hockey Stick”

Instrumental Record

Medieval Warm Period

Temperature Anomaly (°C)

Little Ice Age

Year
Arctic air temperature change reconstructed (blue), observed (red)
Low-latitude composite of Thompson (2003) data
Oxygen isotopes in alpine glaciers
Last 130 Years

Global Land–Ocean Temperature Index

- Black line: Annual Mean
- Red line: 5–year Running Mean

Temperature Anomaly (°C)

1880 1900 1920 1940 1960 1980 2000
Distribution of temperature change, 1901-2005
Some 2010 Records
Anomalies in the mean two-meter temperature for May, June and July (deg C), averaged over all land areas north of 20N. Values are from ERA-40 for 1970-1988 and ERA-Interim for 1989-2010 (using pre-release data for June and July 2010). Anomalies are relative to the period 1989-2001 for which both ERA-40 and ERA-Interim data are available.
Temperature Anomalies July 2010
(with respect to a 1971-2000 base period)
National Climatic Data Center/NESDIS/NOAA
Arctic Sea Ice
Arctic Sea Ice Extent
(Area of ocean with at least 15% sea ice)

Extent (millions of square kilometers)

National Snow and Ice Data Center, Boulder CO

18 Sep 2010

2010
2007
1979–2000 Average
±2 Standard Deviations
Sea Level Rise

IPCC 2007:
for 1961–2003:
Models 1.2 mm/year
Data 1.8 mm/year
Hurricanes
2010 Atlantic Hurricane Season
(so far)

- Only 4 other seasons (1933, 1936, 1995, 2005) have had 11 storms by this early
- Julia was the strongest hurricane on record so far east
- Earl was 4th strongest hurricane so far north
- Only second time in history with two simultaneous Cat 4 hurricanes (Igor and Julia)
- Only 2 seasons have had as many Cat 4 storms as we have already had this season
The Future
A genuine out-of-sample prediction

FAR: 1st Assessment Report, 1990
Summary

- Climate varies owing to both natural and anthropogenic factors
- Warming of the last few decades has almost certainly been caused by increasing greenhouse gases
- Regional responses poorly understood but include changes in sea level, precipitation, and storminess
Questions

“All climate change is local”. But how do we convey the dangers of local climate change when, so far, we are not able to predict it?

Uncertainty of climate change projections has been used by climate change deniers as a reason not to act. How do we illustrate the illogic of this reasoning?

How do we get private enterprise to take climate change seriously?
Normal solar cycle variations in solar radiation