An Update on Climate Change

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Ten Indicators of a Warming World

- Air Temperature Near Surface (Troposphere)
- Humidity
- Temperature Over Oceans
- Sea Surface Temperature
- Sea Ice
- Sea Level
- Ocean Heat Content
- Glaciers
- Snow Cover
- Temperature Over Land
Where is global warming going?

- Atmosphere: 2.3%
- Continents: 2.1%
- Glaciers and ice caps: 0.9%
- Arctic sea ice: 0.8%
- Greenland Ice Sheet: 0.2%
- Antarctic Ice Sheet: 0.2%

Data from IPCC 2007
Where is global warming going?

- Ocean: 93.4%
- Atmosphere: 2.3%
- Continents: 2.1%
- Glaciers and ice caps: 0.9%
- Arctic sea ice: 0.8%
- Greenland Ice Sheet: 0.2%
- Antarctic Ice Sheet: 0.2%

Data from IPCC 2007
Decadal changes in average global temperature

- **1980s** warmest decade on record at the time.
- **1990s** even warmer. Every year warmer than 1980s average.
- **2000s** even warmer. Every year warmer than 1990s average.

http://www.ncdc.noaa.gov/bams-state-of-the-climate/
How well do climate models reproduce 20th century climate with and without anthropogenic components?

Except for a failure to capture warmer ocean conditions, in the 1930s the models reproduce observed climate history when all known climate forcings are included.

Were it not for the accumulation of greenhouse gases over the past half century, Earth’s temperature today would be similar to that in 1900.

IPCC 2007
In 2007 the Intergovernmental Panel on Climate Change (IPCC) stated with 90% confidence that\emissions of heat trapping gases from human activities have caused “most of the increase in globally averaged temperature since the mid-20th century”.

Statements of professional societies of oceanographers, geophysicists, and geologists (American Geophysical Union), meteorologists (American Meteorological Society), general scientific organizations (American Association for the Advancement of Science), and the National Academy of Sciences all concur with this position.
Where we’re headed: The IPCC 2007 scenarios for Earth’s temperatures to 2100

The graph shows the projections for Earth's temperatures to 2100, with different scenarios represented by colored lines. The red line indicates scenario A2, the green line A1B, and the blue line B1. The orange line represents year 2000 constant concentrations, while the black line represents the 20th century.

T reached in 2100 on the middle trajectory was last experienced on Earth in the Eocene (25-35 million years ago) when sea level was 20-30 m higher.
A warmer Earth will have less ice, less snow and less frozen ground

• Sea ice is projected to shrink in both the Arctic and Antarctic under all model simulations.

• Some projections show that by mid century, late-summer Arctic sea ice will disappear almost entirely.
Sea Ice Concentration Anomalies
Feb 2013

Total anomaly = -0.7 million sq km
Old v. new ice in Arctic, March 1985 and 2011: These maps show the median age of March sea ice in 1985 (left) and 2011 (right). Overall, the proportion of young ice has increased. By March 2011, ice more than four years old accounts for less than 10 percent of the Arctic ice cover. Image by National Snow and Ice Data Center,
Summer Sea Ice is Being Lost Faster than has been Projected using Climate Models
Annually averaged T increase for CO$_2$ and the short-lived constituents relative to pre-industrial. Global values based on IPCC (2007). Arctic values based on Quinn et al. (2008).
Photomicrograph of sea ice
Diverse Phytoplankton
-the one cell plants of the sea

-About equal to land plants in terms of total biological production

Sir Alister Hardhy
Shells of marine organisms are made of Calcium Carbonate (Ca CO$_3$)
Organisms with CaCO$_3$ skeletal structures will tend to dissolve

'Undersaturation' of surface ocean in N. Pacific & Southern Ocean with respect to aragonite (CaCO$_3$) in 2099

[from Orr et al., 2006 Nature, 437, 681]
The Pteropod *Limacina sp.*
“the Sea Butterfly”
Northern hemisphere continental ice has shrunken since the last glacial maximum & most of what is left now covers Greenland
The Greenland ice cap is experiencing warmer summer conditions, and the major Greenland glaciers are receding.

Number of summer days with temperature above freezing on the surface of the ice cap

UNEP 2013
Contributing Components to Local and Global Sea Level Tide Gauge and Satellite Data for Sea Level 1870 - 2012

Global Mean Sea Level Change

Milne 2008 & NASA
“On the basis of calculations presented here, we suggest that an improved estimate of the range of sea level rise to 2100 including increased ice dynamics lies between 0.8 and 2.0 meters [31 – 78 inches].”
Trends in Sea-Level Change (mm/yr) due to Warming from 1955 to 2003

Milne 2008
Changes in the propagation of an atmospheric wave across temperate latitudes
Under warming Arctic conditions as dashed line

Francis & Varvus 2012
T reached in 2100 on the middle trajectory was last experienced on Earth in the Eocene (25-35 million years ago) when sea level was 20-30 m higher.
GFDL Simulation Projects 50% Reduction by 2050

Five Models Project Sea Ice Extent for Mid-September
Mayor Thomas Menino’s leadership in Boston

A Climate of Progress
City of Boston Climate Action Plan Update 2011

• Reducing community greenhouse gas emissions 25 percent by 2020 and 80 percent by 2050
• Incorporating projected climate change into all formal planning and project review processes
• Engaging all segments of the community in climate action and leadership
• Developing innovative businesses and workforce skills to take advantage of climate action opportunities
CLIMATE SUMMIT

WHAT IF IT'S A BIG HOAX AND WE CREATE A BETTER WORLD FOR NOTHING?

- ENERGY INDEPENDENCE
- PRESERVE RAINFORESTS
- SUSTAINABILITY
- GREEN JOBS
- LIVABLE CITIES
- RENEWABLES
- CLEAN WATER, AIR
- HEALTHY CHILDREN
- ETC. ETC.
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