Section 1: Introduction

GEOG 313/513
Fall 2014
Climate Change: The Current Science

Outline

1. Sources of information
2. Recent and future climate change
3. Indicators and impacts
4. What can we do?
Climate Change: The Current Science

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1. Sources of information
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4. What can we do?
Climate change “denialism” abounds!
Listen to the experts!
Listen to the experts

“I don’t know anything about gall bladders and kidneys, but I do know something about windshields.”
Listen to the experts!

1. Active climate scientists

97% are convinced of human-caused climate change

2. National and international assessments

3. Scientific organizations

4. National academies
Who is listening?

cities, states/provinces  hunters/anglers

US military  religious groups
Climate Change: The Current Science

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Headline Statements from IPCC 2013 report

“Warming of the climate system is unequivocal...the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased.”

“Human influence on the climate system is clear.”

“Continued emissions of greenhouse gases will cause further warming... Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions.”
What’s new in IPCC 2013 report?

- improved analysis of observations of climate system
- climate models have improved
- evidence for human influence has grown
- additional impacts to human and natural systems have been documented
Recent (last 100+ years) climate change

Global Temperature
(meteorological stations)

J. E. Hansen, NASA GISS, data.giss.nasa.gov/gistemp
Animation of map of temperature anomalies during last 100+ years

http://svs.gsfc.nasa.gov/cgi-bin/details.cgi?aid=4030
Positive proof of global warming.
Historical (last 12,000 years) climate change

**Holocene temperature variations**

*End of last glacial period*

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Historical climate change from IPCC 2013 report

- Sea ice trend
- Temperature trends
- Ocean heat content trends

Global Climate Change

IPCC 2013 WGI report
Future climate change from IPCC 2013 report

**IPCC 2013 WGI report**

(a) Global average surface temperature change

(b) Northern Hemisphere September sea ice extent
Future climate change from IPCC 2013 report

(a)

RCP 2.6
Change in average surface temperature (1986-2005 to 2081-2100)

RCP 8.5

IPCC 2013 WGI report
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Causes ("forcings") of climate change
Carbon emissions continue

Atmospheric CO\textsubscript{2} at Mauna Loa Observatory

Scripps Institution of Oceanography
NOAA Earth System Research Laboratory

www.esrl.noaa.gov/gmd/ccgg/trends/
$CO_2$ higher than any time in last 400,000 years
Increases in greenhouse gases

(a) Carbon Dioxide

(b) Nitrous Oxide

(c) Methane

(d) CFC-11 and CFC-12

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## Causes of climate change from IPCC AR5 SPM

<table>
<thead>
<tr>
<th>Emitted compound</th>
<th>Resulting atmospheric drivers</th>
<th>Radiative forcing by emissions and drivers</th>
<th>Level of confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂</td>
<td>CO₂</td>
<td>1.68 [1.33 to 2.03]</td>
<td>VH</td>
</tr>
<tr>
<td>CH₄</td>
<td>CO₂ H₂O O₃ CH₄</td>
<td>0.97 [0.74 to 1.20]</td>
<td>H</td>
</tr>
<tr>
<td>Halocarbons</td>
<td>O₃ CFCs HCFCs</td>
<td>0.18 [0.01 to 0.35]</td>
<td>H</td>
</tr>
<tr>
<td>N₂O</td>
<td>N₂O</td>
<td>0.17 [0.13 to 0.21]</td>
<td>VH</td>
</tr>
<tr>
<td>Anthropogenic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO</td>
<td>CO₂ CH₄ O₃</td>
<td>0.23 [0.16 to 0.30]</td>
<td>M</td>
</tr>
<tr>
<td>NMVOC</td>
<td>CO₂ CH₄ O₃</td>
<td>0.10 [0.05 to 0.15]</td>
<td>M</td>
</tr>
<tr>
<td>NOₓ</td>
<td>Nitrate CH₄ O₃</td>
<td>-0.15 [0.34 to 0.03]</td>
<td>M</td>
</tr>
<tr>
<td>Aerosols and precursors</td>
<td>Mineral dust Sulphate Nitrate Organic carbon Black carbon</td>
<td>-0.27 [0.77 to 0.23]</td>
<td>H</td>
</tr>
<tr>
<td></td>
<td>Cloud adjustments due to aerosols</td>
<td>-0.56 [-1.33 to -0.06]</td>
<td>L</td>
</tr>
<tr>
<td></td>
<td>Albedo change due to land use</td>
<td>-0.15 [-0.25 to -0.05]</td>
<td>M</td>
</tr>
<tr>
<td>Natural</td>
<td>Changes in solar irradiance</td>
<td>0.05 [0.00 to 0.10]</td>
<td>M</td>
</tr>
</tbody>
</table>

### Total anthropogenic RF relative to 1750

- 2011: 2.29 [1.13 to 3.33] (H)
- 1980: 1.25 [0.64 to 1.86] (H)
- 1950: 0.57 [0.29 to 0.85] (M)
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Changes in extreme events

Historical observations

- Percentage Change in Very Heavy Precipitation
  - Percentage Change: 0-10, 10-20, 20-30, 30-40, 40-50, >60
  - Changes: 7%, 21%, 45%, 26%, 3%, 36%

- Observed Changes in Frost-Free Season
  - Increases in Annual Number of Days: +18, +9, +9, +21, +10, +5

Model projections

- Projected Frequency of Extreme Heat (2080-2099 Average)

Simulations for 2080-2099 indicate how currently rare extremes (a 1-in-20-year event) are projected to become more commonplace. A day so hot that it is currently experienced once every 20 years would occur every other year or more frequently by the end of the century under the higher emissions scenario.

USGCRP, Global Climate Change Impacts in the United States, 2009

National Climate Assessment, draft, 2013
Impacts to snow, streamflow

Date of onset of spring runoff pulse. Reddish-brown circles indicate significant trends toward onsets more than 20 days earlier. Lighter circles indicate less advance of the onset. Blue circles indicate later onset. The changes depend on a number of factors in addition to temperature, including altitude and timing of snowfall.

USGCRP, *Global Climate Change Impacts in the United States, 2009*
Benson Glacier, Eagle Cap, Wallowa Mtns, OR

(courtesy USDA)

1920 (H. Richardson)

1992 (D. Jensen)
Estimated effect of climate change on crop yields 1960-2013

*IPCC 2013 WGII report*
Projections of sea level rise

IPCC 2013 WGII report
If West Antarctica sheet melted...

5 Meters (18 Feet) Sea Level Rise

William Haxby, Lamont-Doherty Earth Observatory
Ocean acidification from increased CO₂

ocean pH (acidity)

- 1900-2000: observed increase by 30%
- by 2100: projected doubling

Shells Dissolve in Acidified Ocean Water

National Climate Assessment, draft, 2013
Biological indicators and impacts

3. 7. Tree mortality

8. Rocky Mountain high-elevation areas: Flower phenology changes

11, 14. Earlier first flowering, arrival dates

18. Northward movement of fish

*Box 2.1. Examples of Observed and Projected Biological Responses to Climate Change across the United States*

*National Climate Assessment, draft, 2013*
Bull trout habitat to decline with future warming

[Rieman et al. 2007]
Bark beetle-caused tree mortality throughout North America

Raffa et al., BioScience, 2008
Wildfire: Projections based on future climate change

Littell et al., *Ecological Applications*, 2009; National Academies, *Climate Stabilization Targets*, 2010
Observed evidence is consistent with warming

IPCC 2013 WGI report
Impacts of future climate change
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1. Reduce energy use
2. What else you can do

- become more informed
  - www.homeartblog.com

- talk to friends and family
  - www.port.ac.uk

- vote with your dollars
  - www.core77.com

- consider career choices
  - www.dovetailsolar.com
  - fullcircle.asu.edu

- support policy makers
  - commons.wikimedia.org
  - blogs.villagevoice.com
3. Increase use of renewable energy and avoid extracting more oil, gas, etc.
4. Develop new technology

Nuclear fusion

Solar roads

Artificial trees
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Summary and Conclusions

- Climate change is happening and will continue
  - global AND local
- Serious impacts to environment, including humans
- We can reduce future climate change, but we have to act now