Prediction versus Projection: How weather forecasting and climate models differ.

Aaron B. Wilson, Ph.D.
Understanding Climate Change in Ohio
Thursday 15 May 2014
What are the differences between Weather and Climate?

• **Weather**: The state of the atmosphere, mainly with respect to its effects upon life and human activities. Weather consists of the short-term (minutes to days) variations in the atmosphere.

• **Climate**: The slowly varying aspects of the atmosphere–hydrosphere–land surface system, characterized in terms of suitable averages of the climate system over periods of a month or more, taking into consideration the variability in time of these averaged quantities.

• Let us use this past winter in Ohio to discuss the differences.

*American Meteorological Society Glossary*
<table>
<thead>
<tr>
<th>Rank</th>
<th>Cincinnati</th>
<th></th>
<th>Columbus</th>
<th></th>
<th>Dayton</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>53.9”</td>
<td>1.</td>
<td>67.8”</td>
<td>1.</td>
<td>62.7”</td>
<td>1977-1978</td>
</tr>
<tr>
<td>2.</td>
<td>47.5”</td>
<td>2.</td>
<td>54.6”</td>
<td>2.</td>
<td>54.8”</td>
<td>1950-1951</td>
</tr>
<tr>
<td>3.</td>
<td>47.3”</td>
<td>3.</td>
<td>54.1”</td>
<td>3.</td>
<td>53.6”</td>
<td>2013-2014</td>
</tr>
<tr>
<td>4.</td>
<td>46.3”</td>
<td>4.</td>
<td>50.4”</td>
<td>4.</td>
<td>50.4”</td>
<td>1909-1910</td>
</tr>
<tr>
<td>5.</td>
<td>44.6”</td>
<td>5.</td>
<td>50.6”</td>
<td>5.</td>
<td>44.8”</td>
<td>1963-1964</td>
</tr>
</tbody>
</table>

*Preliminary and subject to change*
Statewide Temperature Ranks
December 2013–February 2014
Period: 1895–2014

Map showing temperature ranks for each state across the United States, with color coding indicating record cold, much below average, below average, near average, above average, much above average, and record warmth.
Land & Ocean Temperature Departure from Average Dec 2013–Feb 2014 (with respect to a 1981–2010 base period)

Data Source: GHCN–M version 3.2.2 & ERSST version 3b

NOAA's National Climatic Data Center
Fri Mar 14 08:13:09 EDT 2014

Please Note: Gray areas represent missing data
Map Projection: Robinson
The year 2013 ties with 2003 as the fourth warmest year globally since records began in 1880. The annual global combined land and ocean surface temperature was 0.62°C (1.12°F) above the 20th century average of 13.9°C (57.0°F). This marks the 37th consecutive year (since 1976) that the yearly global temperature was above average. Currently, the warmest year on record is 2010, which was 0.66°C (1.19°F) above average. Including 2013, 9 of the 10 warmest years in the 134-year period of record have occurred in the 21st century. Only one year during the 20th century—1998—was warmer than 2013.
Historical Context: Ohio

Congressional Temperature Trends

http://temperaturetrends.org/
Historical Context: Global

Global Land–Ocean Temperature Index

- Annual Mean
- 5–year Running Mean

0-2000 m Global Ocean Heat Content

3-Month average through Apr-Jun 2013
Yearly average through 2012
Pentadal average through 2008-2012

NOAA/NESSDIS/NODC Ocean Climate Laboratory
Updated from Levitus et al. 2012

http://data.giss.nasa.gov/
Numerical Weather Prediction

Collect Observations

Assess Present State: Analysis

Predict Change with Model and Interpret Results

24 hr forecast valid 1200 UTC Thu 15 May 2014

Rain

Snow

Wintry mix
Global Models are used for Projections of Future Climate

• Atmosphere-ocean global climate models (AOGCMs)
  – Interactive representation of the atmosphere, ocean, land, and sea ice
  – Forced with time-varying concentrations of atmospheric constituents

• Earth system models (ESMs)
  – AOGCM + interactive biogeochemistry, including the carbon cycle
  – Forced with time-varying emissions of atmospheric constituents
GCMs & Representative Concentration Pathways (RCPs)

http://www.pik-potsdam.de/~mmalte/rcps/
RCP CO₂ Equivalents

Concentration - CO₂-eq. (incl. all forcing agents)

- MESSAGE - RCP 8.5
- AIM - RCP 6.0
- MiniCAM - RCP 4.5
- IMAGE - RCP3-PD (2.6)
Assuming these RCPs are reached, how will the temperature over land respond?

Pushing the Extremes: How Changing Climate Changes Weather
The Takeaway Messages

Weather and Climate are related.
• Climate is highly dependent on temporal scale.
• Changing climate alters associated weather patterns.

Models used to predict weather depend on the current observed state of the atmosphere (analysis) and result in an expected future result that must be interpreted by the forecaster.

Models used to project climate reflect an array of possible scenarios based on assumptions made related to future climate forcing (e.g., CO$_2$). What are the missing assumptions and is the future climate captured by our current understanding?
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**Prediction versus Projection**

<table>
<thead>
<tr>
<th>Type of Information</th>
<th>The Difference</th>
<th>Nature of Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Projections</td>
<td>While both involve analysis of data, the key difference between a forecast and a projection is the nature of the assertion in relation to the assumptions occurring.</td>
<td>A projection simply indicates a future value for the population if the set of underlying assumptions occur.</td>
</tr>
<tr>
<td>Forecasts</td>
<td>In a forecast, the assumptions represent expectations of actual future events.</td>
<td></td>
</tr>
</tbody>
</table>

**Australian Bureau of Statistics**