Recent and Future Trends in North American Climate and Weather

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Outline

• Long-Term Trends in Average Conditions over North America
• Long-Term Trends in Extreme Conditions over North America
• Extrapolation of Long-Term Trends with Climate Models
• Implications of Long-Term Trends for Using Historical Climate Data in Hydrological Design and Modeling
• Opinions are my own and do not necessarily reflect NOAA positions.

Take Away Messages

• There are important long-term trends in the mean temperature and precipitation climates of North America
• No clear links have been established yet between trends in green-house gas concentration and trends in weather extremes, including hurricanes, tornadoes, damaging winds, floods, droughts, cold waves, heat waves, etc.
• Credible extrapolation of trends of other than the grossest features of the climate is not possible with current models
• Models adequate to the task will also be the solution to another major problem: Accurate estimates of current risks of extremes.

Long-Term Trends in Average Conditions over North America

• Most Prominent Trends are Warmer Winters and Springs, in the West, Alaska and most of Canada, and Wetter (Widespread) at All Times of Year
• Temperature Trends Partly Associated with Large-Scale Circulation Changes Linked to the Tropical Western Pacific
• Most Prominent Changes Consistent with Global Warming Scenarios
Long-Term Trends in Extreme Conditions over North America

- Trend in Heavier Precipitation Events, but not Floods
- No Trend in Tornadoes Unexplainable by Trends in Observing & Reporting
- Recent Shift to More Hurricane Activity - Uncertain Whether Long-Term, Multi-Decadal, or Both, but not Unprecedented
- No Trends in Extreme Cold or Warmth (Other than Urban Heat Island Effects or possibly the Southwest)

Hurricane Trends?

The current state of climate science does not support a linkage between climate change and recent increased hurricane activity.
Extrapolation of Long-Term Trends

- Not Reasonable without Physical Basis
- Global Models Cannot Yet Credibly Reproduce the Recent (30-Year) Historical Record on Regional and Local Spatial Scales, so are not Credible for Extrapolation or Future Scenarios
- Extrapolation of Extremes will Require Models with Credible Weathermakers (ENSO, NAO, MJO, etc.)

Climate Model Capabilities

- Existing climate models cannot credibly produce future weather scenarios of other than the gross geographic and seasonal distribution of mean surface temperature.
- This is because they cannot adequately reproduce these features over the recent historical record.

<table>
<thead>
<tr>
<th>Parameters and/or trend(s)</th>
<th>Level of practical interest to policy makers, adaptive planners, and resource managers</th>
<th>Ability of climate models to reproduce over the last 50 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean annual global surface temperature</td>
<td>None</td>
<td>Exceptional</td>
</tr>
<tr>
<td>Regional and seasonal mean surface temperature and precipitation and their interannual variability</td>
<td>Considerable</td>
<td>Fair to poor for surface temperature and poor for precipitation</td>
</tr>
<tr>
<td>Regional and seasonal intraseasonal variability, especially risks of weather extremes and high-impact events</td>
<td>Intense</td>
<td>Poor or unknown</td>
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Climate Model Capabilities

- To adequately reproduce weather scenarios for the recent historical record, existing climate models must be able to reproduce the form, seasonality, and variance of the phenomenon that constitute the dominant controls on weather systems and their variability.

North America Climate/Weather Links

- **El Nino/La Nina controls:**
  - Atlantic/Gulf Tropical Storm/Hurricane activity
  - Winter and spring storm tracks
  - Temperature extremes
North America Climate/Weather

Links

- Subseasonal links to tropical variability:
  - Most active when El Nino absent or La Nina weak (for example Winter 1996-97)
  - Recurrence from 3 to 7 weeks (includes the classic Madden-Julian Oscillation)
  - West coast precipitation, central and eastern U.S. and Canada cold outbreaks, and Atlantic/Gulf Tropical Storm/Hurricane activity

Other

- N. Atlantic Oscillation
- Land/Surface Processes and Feedback: Southwest monsoon, soil moisture, snow, etc.

Climate Model Capabilities

- To adequately reproduce weather scenarios for the recent historical record, existing climate models must be able to reproduce the form, seasonality, and variance of the phenomenon that constitute the dominant controls on weather systems and their variability.

- No existing climate model has been shown to collectively or correctly treat more than half of the critical controls on North American weather.

Estimating Flow PDFs and Flood Risks

- A 30-year record in a stationary climate is inadequate to estimate well first moments for precipitation, while a 50-year record is inadequate to estimate well higher moments and risks of extremes.

- This may be mitigated somewhat for flow statistics. Nevertheless flood risk estimates inherently have large error bars.

- Unfortunately, the climate is non-stationary, implying even larger estimation errors. Paleo/proxy data can not mitigate this problem.

- Thus there is a tradeoff that has to be made between a shorter but more relevant record to estimate risks rather than a longer record from a different climate.
Estimating Flow PDFs and Flood Risks

- The bottom line is that we currently cannot describe today's climate (and associated risks) well.

- The solution lies in the development of credible, global, fine-mesh coupled (land/ocean/atmosphere) models that credibly simulate the form, seasonality, and statistics of all the important controls on weather and weather extremes. Such a system would be used to generate large numbers of synthetic realizations.

- This is likewise the only way credible future scenarios of other than the most gross features of climate will be possible. Downscaling is not a solution.

Take Away Messages

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- Credible extrapolation of trends of other than the grossest features of the climate is not possible with current models.

- Models adequate to the task will also be the solution to another major problem: Accurate estimates of current risks of extremes.