Historical and Projected Future Climatic Changes in the Great Lakes Region

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Outline

• Historical Trends
• Climatic Variability/Extreme Events
• Future Projections
Global Land and Ocean Temperature Anomalies
1880-2019

Regional climate trending warmer
Annual Mean Winter Temperatures vs. Year, Michigan
1895-2019

https://ice-glaces.ec.gc.ca/prod/CVCHACTGL/20190513180000_CVCHACTGL_0010581627.gif

Historical Total Accumulated Ice Coverage (TAC) for the weeks 1105-0514, seasons:1980/81-2018/19

Total accumulé de la couverture des glaces historique (TAC) pour les semaines 1105-0514, saisons:1980/81-2018/19

Regional Great Lakes /
Régionales Grands Lacs

https://ice-glaces.ec.gc.ca/prod/CVCHACTGL/20190513160000_CVCHACTGL_0010581627.gif
Mean seasonal total snowfall (inches)

(Midwestern Regional Climate Center)

Role of the Polar Vortex?
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Date of Tart Cherry Side Green Stage
Traverse City, MI, 1900 - 2018
First, Last Freezes and Frost-Free Season Length
Lansing, MI, 1981-2018

Regional climate trending wetter
Mean fraction of annual precipitation derived from 10 wettest days  
1971-2000

Trend in sum of the top-10 wettest days in a year (%/decade)  
1901-2000

(Pryor et al., 2009)

Record High Lake Water Levels Expected To Continue into the Summer
Climatic trends tend to be associated with certain upper air patterns.

Changes in Absolute Humidity
APR-JUN, 1979-2014

(Feng et al., 2016)
Twentieth Century Regional Climate Change During the Summer in the Central United States Attributed to Agricultural Intensification

Hydrologic Variables vs. Year
Owosso, MI 1900-2009

From: Alter et al., 2017
Geophysical Research Letters
2017GL075604, 12 FEB 2018 DOI: 10.1002/2017GL075604
Growing Season Drought Severity
Michigan, 1895-2017

(Source: NOAA/NCEI, 2018)

Frequency of Days \( \text{PAW}_{150} < 0.50 \) Potential \( \text{PAW}_{150} \)
Ann Arbor, MI, Silt Loam, 1900-2009

The frequency of water stress is declining and occurring earlier in the year

(Source: Pollyea, no date)
Impacts of Climatic Variability

Past history suggests that society may be able to cope/adapt with steady climatic changes, but possibly not with changes in variability (e.g. changes in extremes, storminess)

Climatic changes and trends can occur as changes in:

1) the mean state
2) variability
3) both
Decadal Ratios of Record Highs, Lows

(From Meehl et al, 2009)

Monthly Mean Temperature and Precipitation Departure Extremes
Michigan, 1895-2019

Temperature departures in Red
Precipitation departures in Blue
Extreme Annual Minimum Temperatures
Traverse City, MI 1951-1980 vs 1981-2010

Mean January Temperatures
Traverse City, MI 1951-1980 vs 1981-2010
More Heavy Precipitation

Observed Changes (%) in the Intensity of the 1% Heaviest Precipitation Days (1951-1980 vs. 1981-2010)
### 24-Hour Precipitation Totals (inches) for 2-100 Year Recurrence Intervals

**Lansing, MI**

<table>
<thead>
<tr>
<th>Recurrence Interval</th>
<th>2 Year</th>
<th>10 Year</th>
<th>50 Year</th>
<th>100 Year</th>
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</thead>
<tbody>
<tr>
<td>TP 40 (1938-1957)</td>
<td>2.35</td>
<td>3.70</td>
<td>4.45</td>
<td>4.80</td>
</tr>
<tr>
<td>Huff and Angel (1948-1991)</td>
<td>2.35</td>
<td>3.25</td>
<td>4.45</td>
<td>5.25</td>
</tr>
<tr>
<td>NOAA Atlas 14 Vol. 8 (POR, 2013)</td>
<td>2.43</td>
<td>3.42</td>
<td>4.80</td>
<td>5.50</td>
</tr>
</tbody>
</table>

### How unusual was the rain during the Upper Peninsula Father’s Day Floods?

The graph shows the combined rainstorm intensities and durations expected during a 100, 500, or 1,000-year rainstorm. These rainstorm probabilities are calculated using historical rainfall data.

A 1,000-year rainstorm has a 1 in 1,000 chance of occurring each year.

The circles show rainfall at the Houghton County Airport on June 17th, 2018.

Data and probability curves from a rain gauge at the Houghton County Airport.

New All-Time MI 24Hr Precipitation Record

- Several rounds of training thunderstorms impacted west central Lower Michigan during the morning, afternoon, and early evening hours of July 20, 2019 with rainfall rates of 1”-3” per hour.
- The greatest observed total was 12.95” at Fountain, MI (9 mi E)
- Old Record 9.78”, August 31st, 1914 at Bloomingdale, MI

Projecting the Future:
Global Climate Models (GCMs)
Projected Temperature Changes

Hayhoe et al (2010)

Projected Temperature-Related Changes
2041-2070 vs. 1971-2000

(Pryor and Scavia, 2013)
The warmer the temperature of air, the more water vapor it can potentially hold...

Region projected to become wetter, largely as a result of increasing cold season precipitation

Source: (IPCC, 2007)
Annual

Winter
Summer

Projected Precipitation-Related Changes
2041-2070 vs. 1971-2000

While possibly heavier, precipitation becomes more extreme and erratic

(Pror and Scavia, 2013)
Projected Future Changes in Monthly Streamflow
Great Lakes Basin, 2071-2100 vs. Historical

(Byun et al., 2019)

Ice cover (% loss)
All simulations for RCP8.5 (SUP, MIC, HUR)

2050 time slice 2090 time slice

(Denghan et al., 2018)
Summary

• Overall, mean average temperatures in Michigan rose approximately 1.0ºF during the past century. Warming of about 2.0ºF has occurred between 1980 and the present.
• Milder winter temperatures have led to less ice cover on the Great Lakes and the seasonal spring warm-up is occurring earlier than in the past.
• Annual precipitation rates increased from the 1930’s through the present, due both to more wet days and more extreme events.
• Most recent GCM simulations of the Great Lakes region suggest a warmer and wetter climate in the distant future, with much of the additional precipitation coming during the cold season months.
• Projections of future climate change in Michigan suggest a mix of beneficial and adverse impacts. Peak daily streamflow is projected to increase with shifts towards earlier peak flow timing. Extreme low soil moisture increases by mid-century, but decreases by late century.
• Given the projected rate of climate change, adaptive planning strategies should be dynamic in nature.

Thank You!