Climate Change in Minnesota: A Hydrologic Perspective

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Bassett Creek Watershed Management Commission
June 27, 2019
Golden Valley, MN
Extreme Weather Events for June 27th in Minnesota

Thunderstorm and Flash Flood
6.46” at Zumbrota, MN
(Goodhue County)
June 27, 1998

12 tornadoes in 13 counties
4 deaths, 86 injuries
June 27, 1994

108 degrees F at New London, MN
(Kandiyohi County)
June 27, 1934

20 degrees F at Baudette, MN
(Lake of the Woods County)
June 27, 1970
Rate of Temperature Change in the United States, 1901-2015 (via NOAA) shows geographic disparity in the pace of climate change and the response to it. Temperature change is rapid in northern Minnesota.
Trend in Mean Annual Temperature for MN
<table>
<thead>
<tr>
<th>Measurable Attributes of Precipitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantity</td>
</tr>
<tr>
<td>Type (liquid, frozen)</td>
</tr>
<tr>
<td>Intensity (9-15”)</td>
</tr>
<tr>
<td>Frequency (74-145 days)</td>
</tr>
<tr>
<td>Duration (10 days)</td>
</tr>
<tr>
<td>Seasonality (shifting)</td>
</tr>
<tr>
<td>Landscape relationship</td>
</tr>
<tr>
<td>(interception, absorption, runoff, evaporation)</td>
</tr>
</tbody>
</table>
Change in Annual Precipitation in the United States, 1901-2015 (via NOAA) shows geographic disparity. Minnesota is getting wetter.
### Ranked Listing of Minnesota’s Wettest Years
Back to 1895 (124 years)

Top Ten Wettest January to December Periods on a Statewide Basis. (inches)

<table>
<thead>
<tr>
<th>Rank</th>
<th>Year</th>
<th>Total</th>
<th>Normal</th>
<th>Dep.</th>
<th>%Norm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1977</td>
<td>33.93</td>
<td>27.92</td>
<td>6.01</td>
<td>122</td>
</tr>
<tr>
<td>2</td>
<td>2016</td>
<td>33.54</td>
<td>27.92</td>
<td>5.62</td>
<td>120</td>
</tr>
<tr>
<td>3</td>
<td>1968</td>
<td>33.45</td>
<td>27.92</td>
<td>5.53</td>
<td>120</td>
</tr>
<tr>
<td>4</td>
<td>2010</td>
<td>33.44</td>
<td>27.92</td>
<td>5.52</td>
<td>120</td>
</tr>
<tr>
<td>5</td>
<td>1965</td>
<td>33.24</td>
<td>27.92</td>
<td>5.32</td>
<td>119</td>
</tr>
<tr>
<td>6</td>
<td>1905</td>
<td>32.32</td>
<td>27.92</td>
<td>4.40</td>
<td>116</td>
</tr>
<tr>
<td>7</td>
<td>1991</td>
<td>32.20</td>
<td>27.92</td>
<td>4.28</td>
<td>115</td>
</tr>
<tr>
<td>8</td>
<td>2005</td>
<td>31.60</td>
<td>27.92</td>
<td>3.68</td>
<td>113</td>
</tr>
<tr>
<td>9</td>
<td>1986</td>
<td>31.45</td>
<td>27.92</td>
<td>3.52</td>
<td>113</td>
</tr>
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<td>10</td>
<td>1993</td>
<td>31.44</td>
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</tr>
</tbody>
</table>

* 2018 ranked 15th
Trend in annual precipitation for MN
Seasonal Statewide Precipitation Trends in MN

Winter (D-F)

Spring (M-M)

Summer (J-A)

Fall (S-N)
Average Annual PPT 1891-1920, in

Average Annual PPT 1921-1950, in

Average Annual PPT 1951-1980, in

Average Annual PPT 1981-2010, in

Avg. Annual PPT, in
- < 20
- 21 - 25
- 26 - 28
- 29 - 30
- > 30

Source: MN-SCO
Change in Annual Precipitation "Normals" at Faribault, MN

<table>
<thead>
<tr>
<th>PERIOD</th>
<th>AMOUNT (IN.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1921-1950</td>
<td>24.80&quot;</td>
</tr>
<tr>
<td>1931-1960</td>
<td>27.06&quot;</td>
</tr>
<tr>
<td>1941-1970</td>
<td>29.49&quot;</td>
</tr>
<tr>
<td>1951-1980</td>
<td>30.30&quot;</td>
</tr>
<tr>
<td>1961-1990</td>
<td>31.00&quot;</td>
</tr>
<tr>
<td>1971-2000</td>
<td>31.67&quot;</td>
</tr>
<tr>
<td>1981-2010</td>
<td>32.63&quot;</td>
</tr>
</tbody>
</table>

31 percent increase since 1921-1950 period

Extremes: 10.81" in 1910, 42.20" in 1951
1990s wettest decade of the 20th Century in Minnesota
Radiosonde history of PW at MSP since 1948
(Most record high values have occurred since 1990)
Change in Frequency of Extreme Climate Attributes

Only one occurrence of TRW>10” before 1972, 18 such episodes since (16.27” at Hokah in August 2007)

No measurement of 80°F dew points in history until 1983, scores of measurements since, including 88°F at Moorhead on July 19, 2011

No measurement of 52 inches of annual precipitation in Minnesota history until 1991, ten such measurements since then, including 60.21” at Harmony in 2018
Historic Crests at Fargo, ND

Historic Crests

(1) 40.84 ft on 03/28/2009
(2) 39.72 ft on 04/18/1997
(3) 39.10 ft on 04/07/1897
(4) 38.81 ft on 04/09/2011
(5) 37.34 ft on 04/15/1969
(6) 37.13 ft on 04/05/2006
(7) 36.99 ft on 03/21/2010
(8) 36.69 ft on 04/14/2001
(9) 35.39 ft on 04/09/1989
(10) 34.93 ft on 04/19/1979
Images of the April 22, 1997 Red River Valley Flood
Worst flash flood in Twin Cities history
Delivered 10 inches of rain in 6 hours
July 23-24, 1987 in the Twin Cities
10” in 6 hours, and 17.90” for the month
NOAA Analysis shows more frequent heavy rainfall events
Observations – Minnesota Trends

Minnesota Mega-rain Events

August 6, 1866, Southern Minnesota
July 17-19 1867, Central Minnesota
July 20-22, 1909, Northern Minnesota
September 9-10, 1947 Iron Range
July 21-22, 1972, Grand Daddy Flash Flood
June 28-29, 1975, Northwest Minnesota
July 23-24, 1987, Twin Cities Superstorm
June 9-10, 2002, Northern Minnesota
September 14-15, 2004 Southern Minnesota
August 18-20, 2007, Southern Minnesota
September 22-23, 2010 Southern Minnesota
June 19-20, 2012, Northeast Minnesota
July 11-12, 2016 central and east-central Minnesota
August 10-11, 2016 west-central and southeastern Minnesota

*Defined as 6” or greater rains cover at least 1000 square miles and a peak amount of 8” or greater. Seven events from statehood (1858) to 2001, seven more since 2002.*
Shift in Precipitation Recurrence Intervals

Mega Rains since 2002 show even northern Minnesota is vulnerable.

'1000-yr (approx.) events' in Southern Minnesota in the last decade.

September 14-15, 2004

August 18 through August 20 (8:00 AM CDT), 2007

September 22-23, 2010

A "by-eye" estimate of the total area covered by 10" of rain over the 7 years of 2004-2010 appears to be near 1400 sq. mi. or about 200 sq. mi. per year. Given that the area of the southern 3 layers of counties looks to be approximately 9000 sq. mi., the aerial fraction of the southern three counties covered by 10" per year appears to be approximately 1/100, i.e. at the rate of coverage for the last 7 years an area equal to the whole southern three county area could be covered in about 100 years.
Damage at Whitewater State Park, Aug, 2007
Measures of Climate Change

- Central measures of temperature and precipitation are steeply upward in Minnesota relative to other states.
- Though temperature trends are upward in all seasons, they are rising most rapidly in winter.
- Minimum temperatures are increasing at roughly twice the pace of maximum temperatures.
- Combined with a greater frequency of high dew points, Heat Advisories and Heat Warnings are becoming more common.
- A higher frequency of intense rainfall events is observed.
- A higher frequency of large hail (3/4”) is observed.
- More rainfall events in winter are being reported.
- Changes of atmospheric mixing depth are observed.
- Wide and rapid variation in the hydrologic cycle.
For those who doubt or wish to dismiss the evidence that climate is changing ….the data from our own Minnesota landscape indicate it is happening and already producing consequences. It is clearly poor judgment to ignore this!