



Climate Change and Climate Trends in Our Own Backyard

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**For IATP: Winona Rural Climate Dialogue Citizen Jury
Winona, MN
March 3, 2016**

UNIVERSITY OF MINNESOTA
EXTENSION



**71 degrees F at Milan, MN
(Chippewa County)
Mar 3, 1905
*No snow cover***



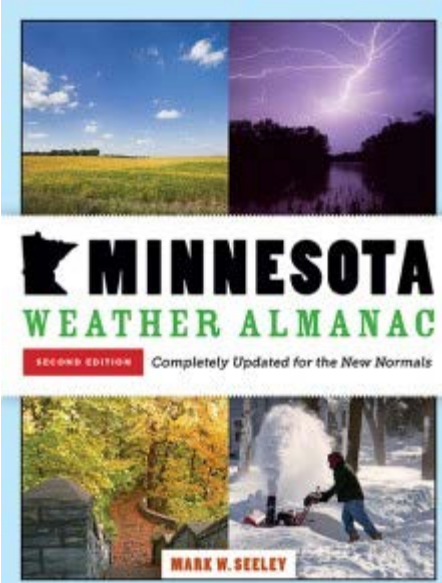
**-44 degrees F at Embarrass, MN
(St Louis County)
Mar 3, 2014
30" snow on the ground**



**Lake Superior 97% ice covered
Mar 3, 1979**



**18.7" of snowfall at Benson, MN
(Swift County)
Mar 3, 1985**



Minnesota weather and climate history

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

CLIMATE CHANGE 2014 Impacts, Adaptation, and Vulnerability

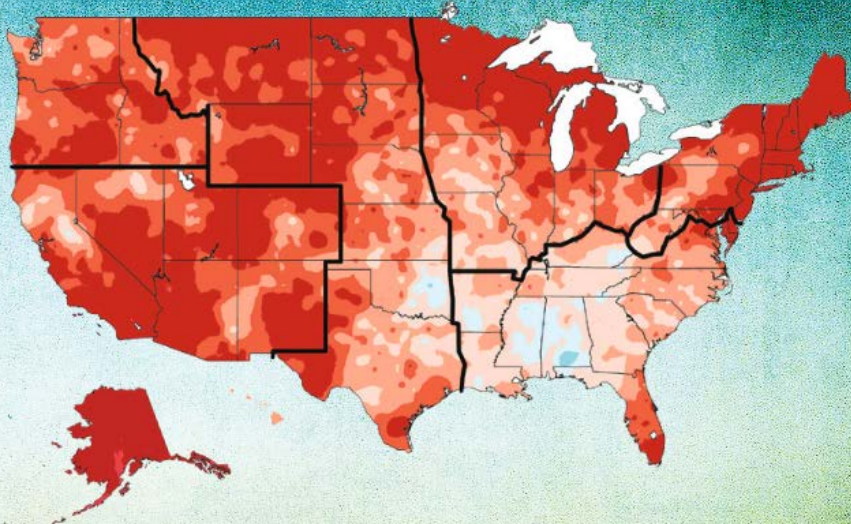
Summary for Policymakers

WG II

WORKING GROUP II CONTRIBUTION TO THE FIFTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE



IPCC 5th Assessment



U.S. National Climate Assessment U.S. Global Change Research Program

Climate Change Impacts in the United States

National Climate Assessment 2014

Information Resources Used

climate.gov
 science & information for a climate-smart nation

News & Features | Maps & Data | Teaching Climate | Supporting Decisions | About | Contact | FAQs | Site Map | What's New

Featured on Climate.gov 1 2 3 4 5

Students Measure Changes in Ice and Snow
 Filed in: Teaching Climate
 This short video features the Alaska Lake Ice and Snow Observatory Network (ALISON project), a citizen science program in which 4th and 5th graders help scientists study the relationship between climate change and lake ice and snow conditions.
[read more](#)

Recent Topics

- Teaching Essential Principle 3: Life on Earth depends on, is shaped by, and affects climate. July 3, 2012. Filed in: Teaching Climate
- National Academies release two reports on climate intervention. February 13, 2015. Filed in: Supporting Decisions
- U.S. Climate Resilience Toolkit. November 17, 2014. Filed in: Supporting Decisions

Global Climate Dashboard

Climate Change | Climate Variability | Climate Projections

Global Average Temperature (°C)
 The temperature near Earth's surface is rising; the bars show each year's average temperature compared to the 20th century average.
[learn more >>](#)

Carbon Dioxide (ppm)
 The amount of carbon dioxide in the atmosphere has risen by 25% since 1958, and by about 40% since the Industrial Revolution.
[learn more >>](#)

Spring Snow Cover (million km²)
 Snow is melting earlier; each bar shows spring snow cover in the Northern Hemisphere compared to the long-term average.
[learn more >>](#)

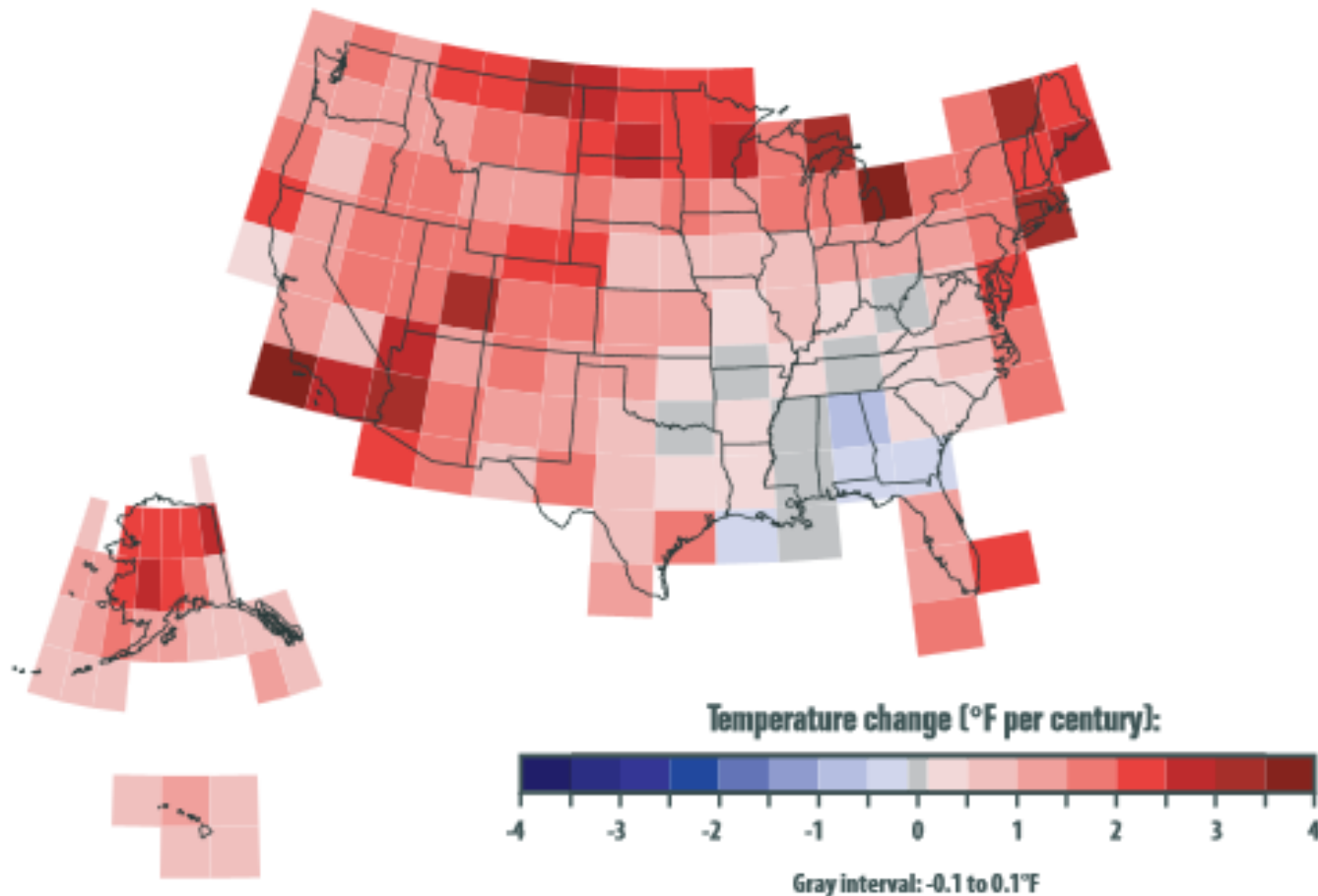
Temperature | Carbon Dioxide | Snow
 Sea Level | Arctic Sea Ice | Ocean Heat
 Sun's Energy | Glaciers | Heat-Trapping Gases

NOAA Climate Monitoring and Global and National Assessment Divisions (climate.gov)

AASC
 (stateclimate.org)

Figure 3. Rate of Temperature Change in the United States, 1901–2008

This figure shows how average air temperatures have changed in different parts of the United States since the early 20th century (since 1901 for the lower 48 states, 1905 for Hawaii, and 1918 for Alaska).

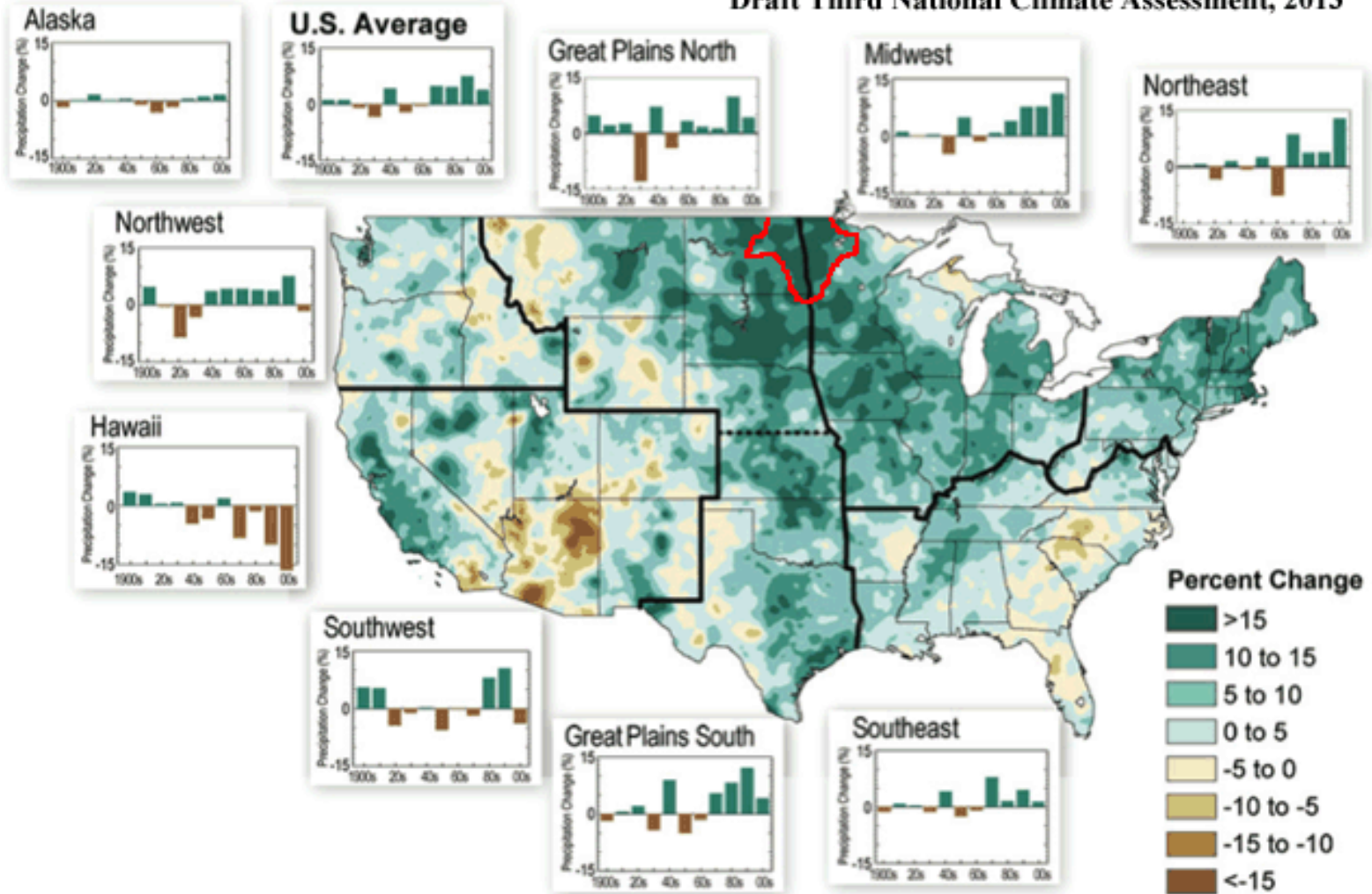


Disparity in the pace of climate change and the response to it

Data source: NOAA, 2009*

Observed U.S. Precipitation Change, 1991-2011 vs. 1901-1960 Average

Draft Third National Climate Assessment, 2013



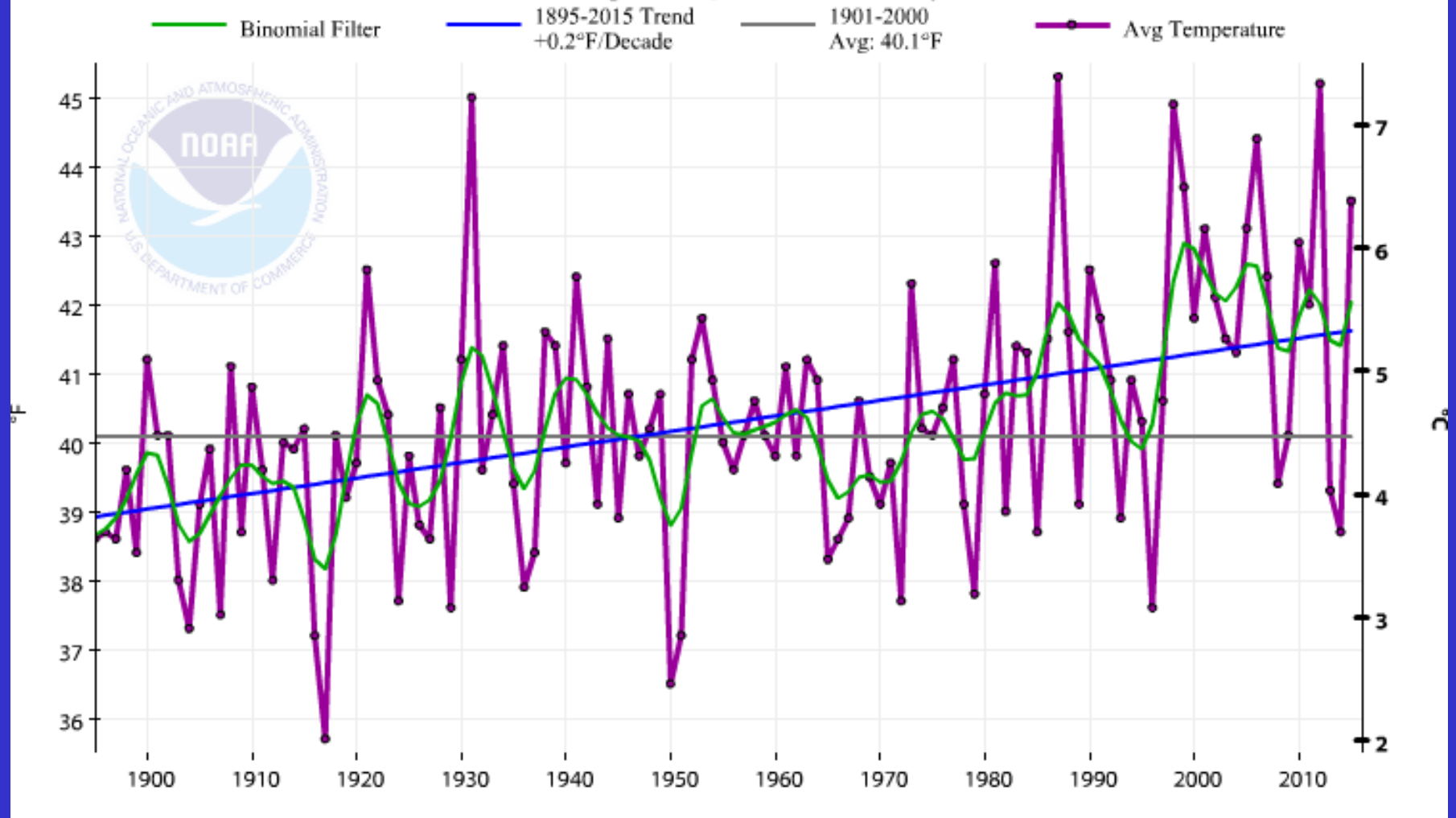
Geographic Disparity in Precipitation Change-IPCC 2013

A satellite-style map of the United States and the Great Lakes region, showing cloud patterns and landmasses. The map is dark with white and grey clouds. The Great Lakes are visible in the upper right quadrant. The text is overlaid on the map.

RECENT SIGNIFICANT CLIMATE TRENDS IN MINNESOTA AND THE WESTERN GREAT LAKES

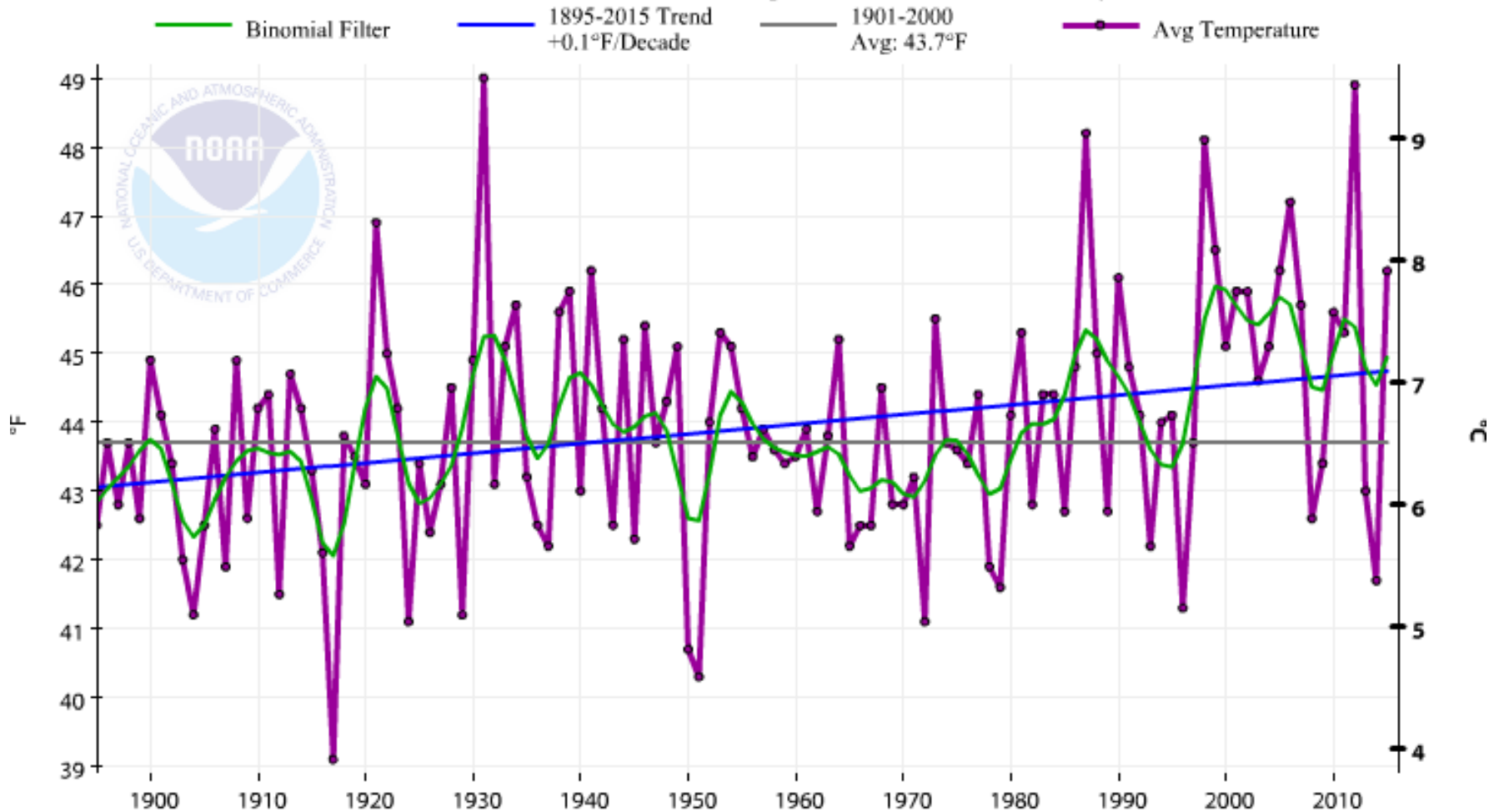
- TEMPERATURE: WARM WINTERS AND HIGHER MINIMUM TEMPERATURES
- DEWPOINTS: GREATER FREQUENCY OF TROPICAL-LIKE ATMOSPHERIC WATER VAPOR
- MOISTURE: AMPLIFIED PRECIPITATION SIGNAL, THUNDERSTORM CONTRIBUTION

Minnesota, Average Temperature, January-December

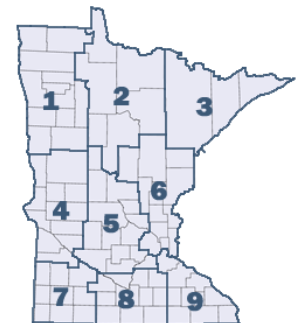


Temp trend is upward (about 2°F per century) and more frequently near historical warmth

Minnesota, Climate Division 9, Average Temperature, January-December



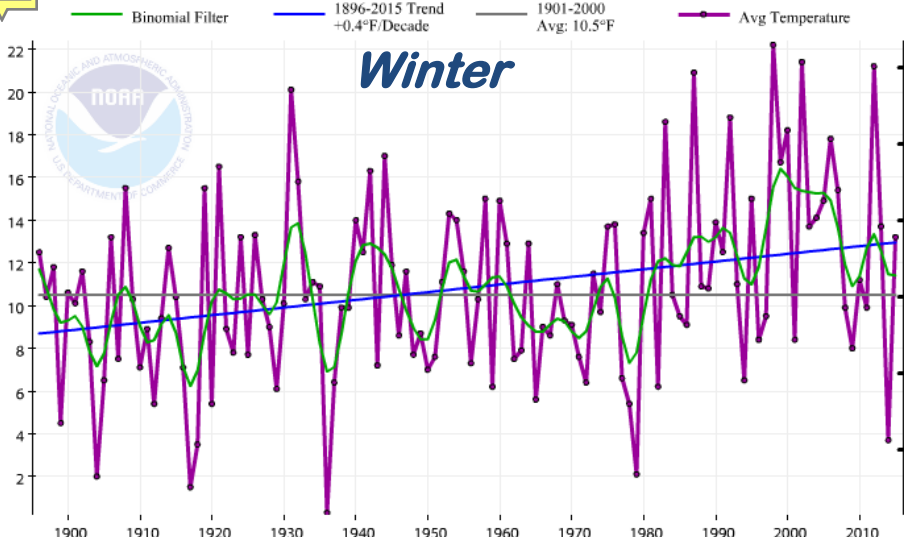
**Trend in annual temperature for southeastern MN
Upward by about 1°F per century**





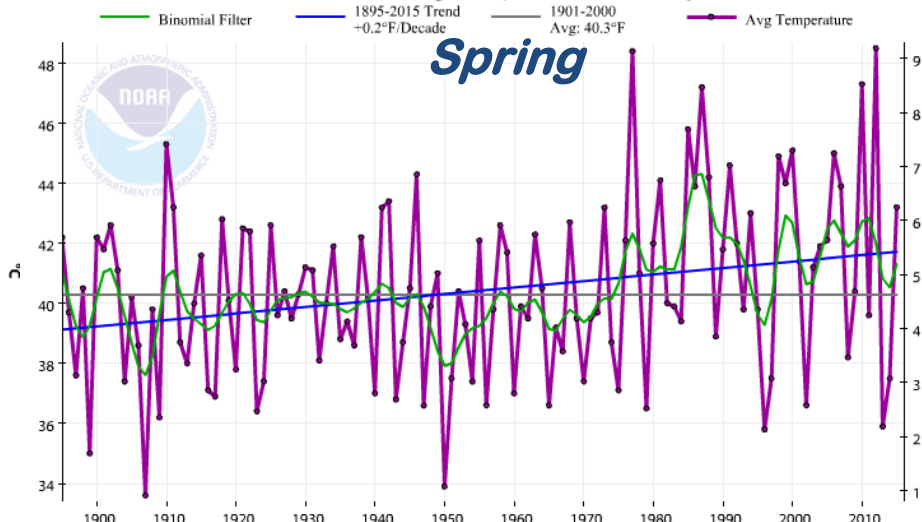
Minnesota, Average Temperature, December-February

Winter



Minnesota, Average Temperature, March-May

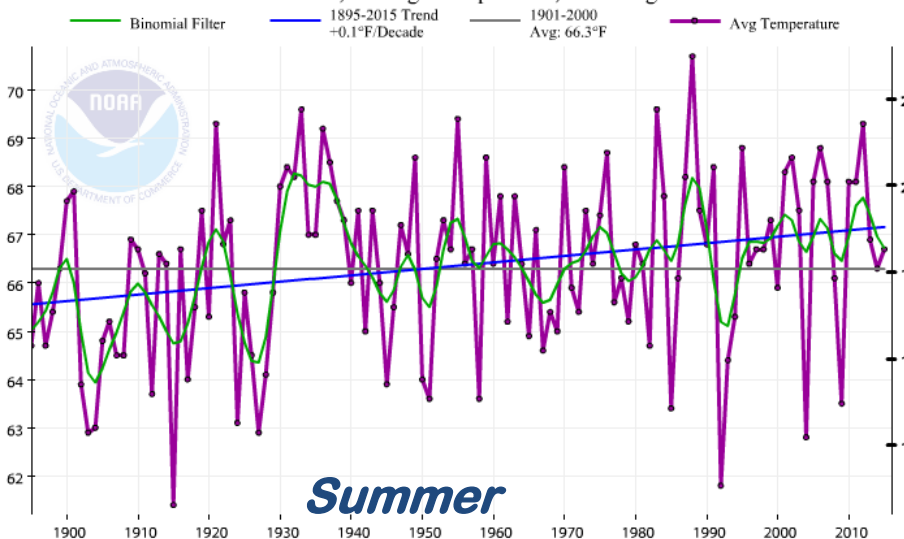
Spring



Seasonal Statewide Temperature Trends in MN

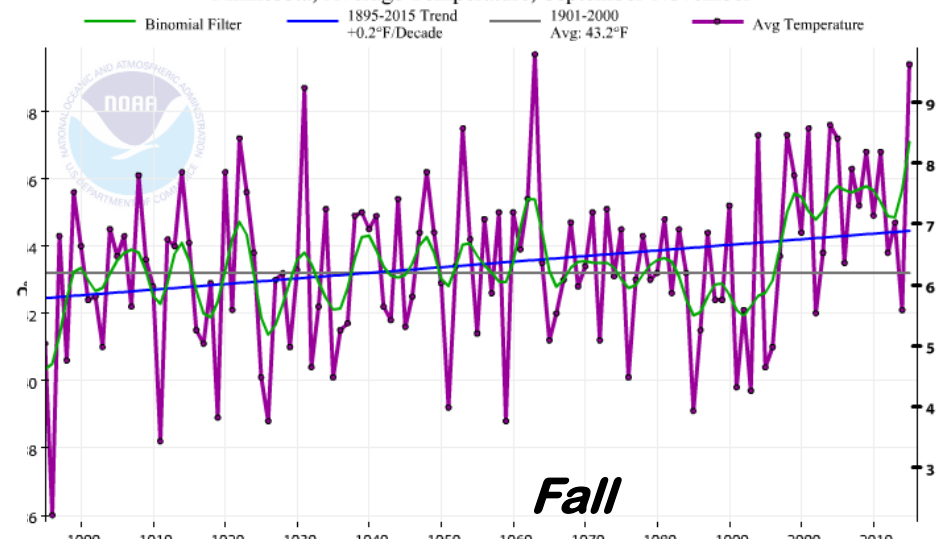
Minnesota, Average Temperature, June-August

Summer



Minnesota, Average Temperature, September-November

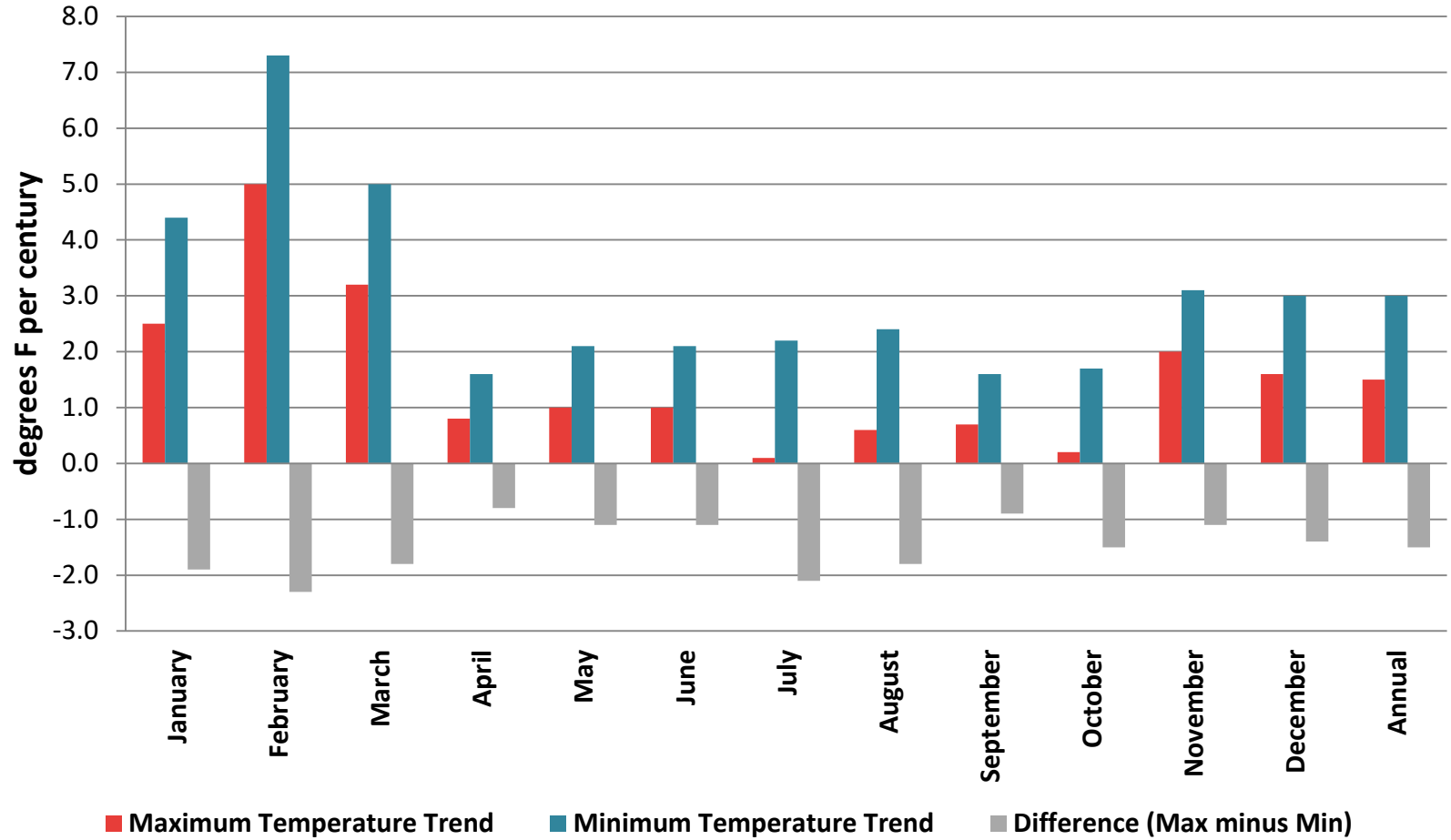
Fall



Trends in mean monthly temperatures at Winona, MN 1971-2000 normals vs 1981-2010 normals (F)

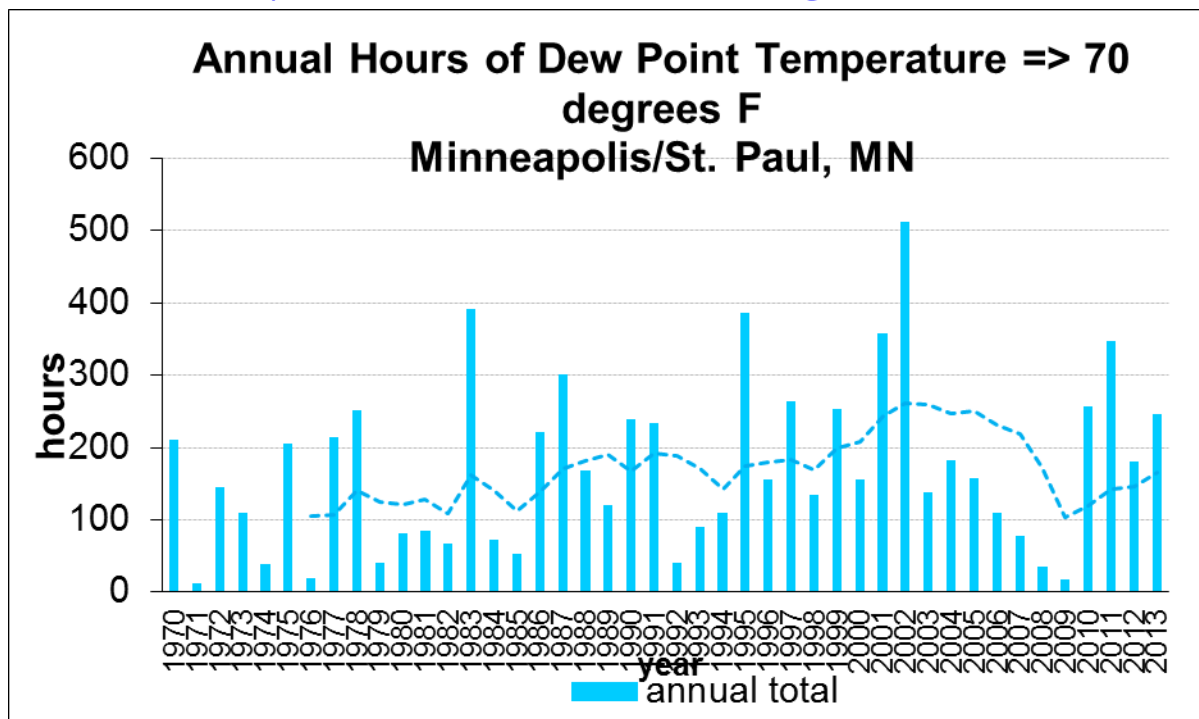
<u>Month</u>	<u>Min Change</u>	<u>Max Change</u>	<u>Mean Change</u>
January	+4.8	+2.2	+3.5
February	+3.3	+0.8	+2.0
March	+2.1	+0.7	+1.9
April	+2.5	+1.5	+2.0
May	+1.7	NC	+0.8
June	+1.8	+0.2	+1.0
July	+1.8	+0.1	+0.9
August	+2.2	+0.3	+1.2
September	+2.9	+0.6	+1.7
October	+2.2	-0.1	-1.0
November	+2.3	+0.4	+1.3
December	+3.4	+1.4	+2.4

Minnesota State-Averaged Temperature Trends 1895-2013



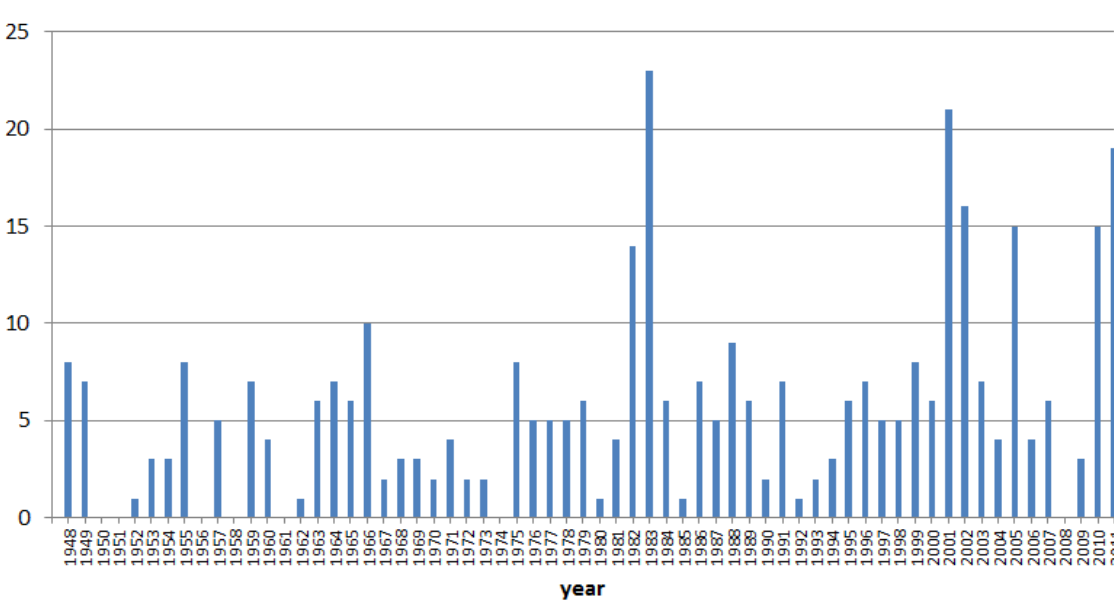
Trend in episodes of dewpoints of 70 F or higher

Latitude 45 degrees

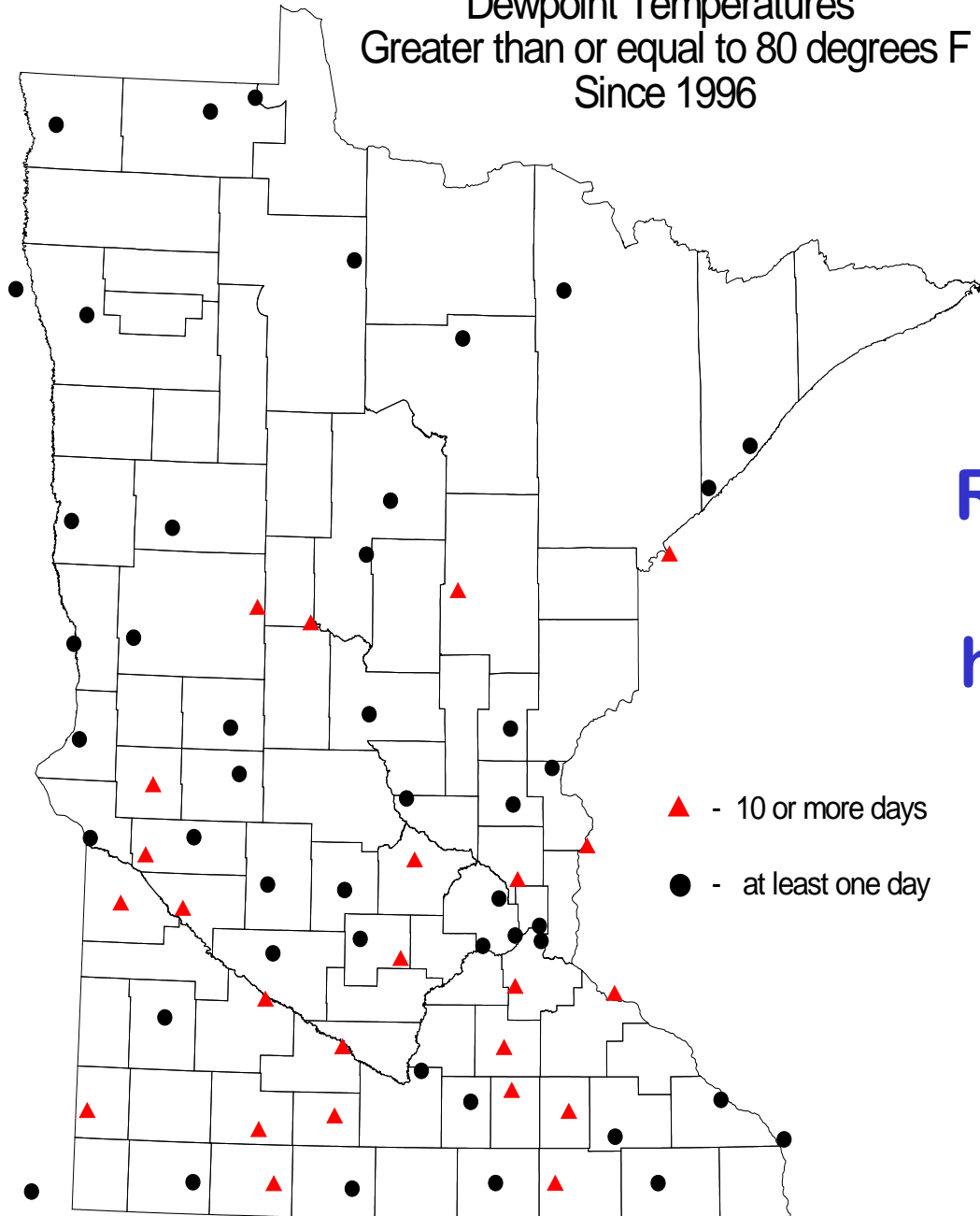


Hours with dewpoints of 70 degrees F or higher at Voyageurs National Park

Latitude 48.5 degrees



Dewpoint Temperatures
Greater than or equal to 80 degrees F
Since 1996



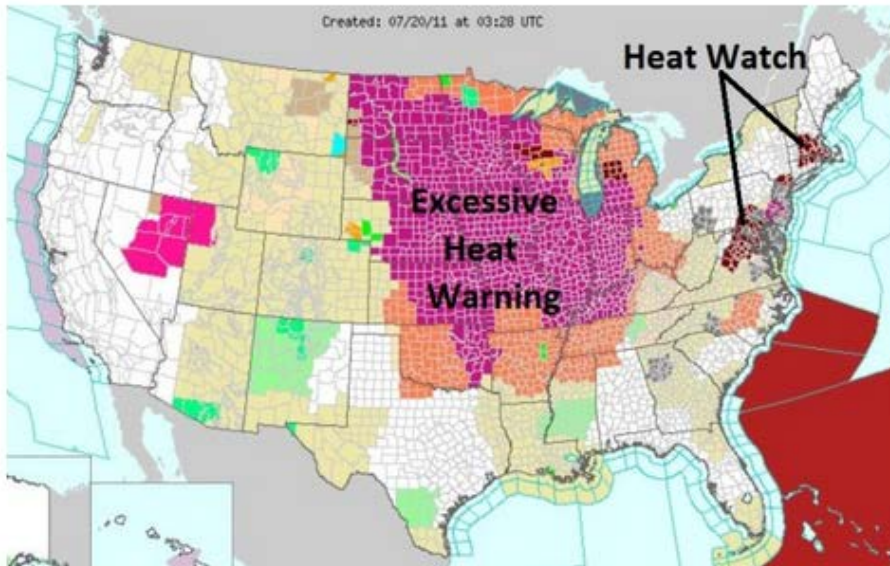
**DP 80 F or higher.
Readings have been
statewide with
highest frequencies
in central and
southern counties**

Frequencies of tropical-like dew points (70 F or higher) and associated Heat Index values for the Twin Cities since 1945

Year	Hours with DP of 70 F or greater	Range of Heat Index Values (F)
1947	256	99 - 112
1949	303	98 - 112
1955	345	98 - 113
1957	243	98 - 112
1959	317	99 - 113
1960	259	98 - 112
1978	252	99 - 114
1983	392	102 - 110
1987	302	98 - 104
1995	387	98 - 116
1997	264	98 - 113
1999	254	98 - 116
2001	357	98 - 110
2002	512	98 - 109
2010	256	98 - 111
2011	347	98 - 118 (*134)
2013	248	99 - 105
2014	213	99 - 111



The Great Heatwave of '11. Heat indices will top 100 again today from the Great Plains eastward to the Great Lakes, Ohio Valley and southeastern USA, gripping the eastern 2/3rds of America.



July 19-20, 2011 Heat Wave

Heat Index:

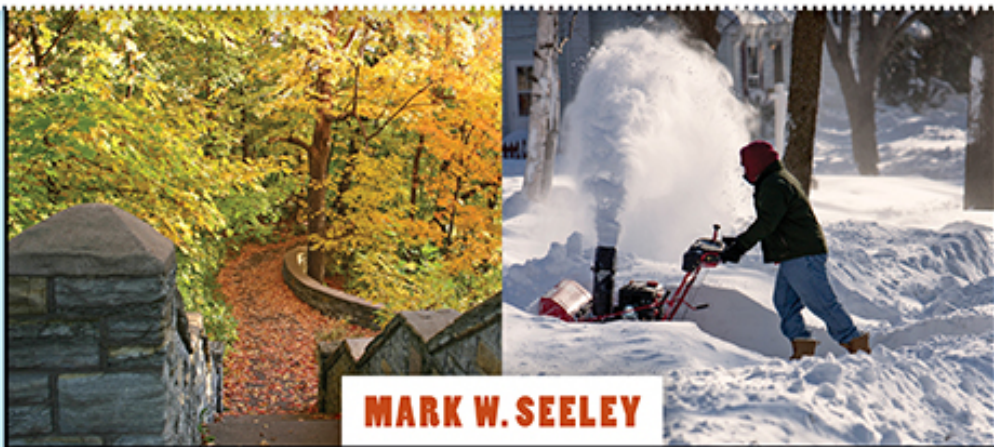
- 112°F Faribault**
- 114°F Mankato**
- 114°F New Ulm**
- 114°F Waseca**
- 117°F Owatonna**
- 118°F Red Wing**
- 110°F Albert Lea**
- 114°F St James**
- 114°F Fairmount**
- 121°F Austin**
- 134°F Moorhead**



MINNESOTA WEATHER ALMANAC

SECOND EDITION

Completely Updated for the New Normals



MARK W. SEELEY

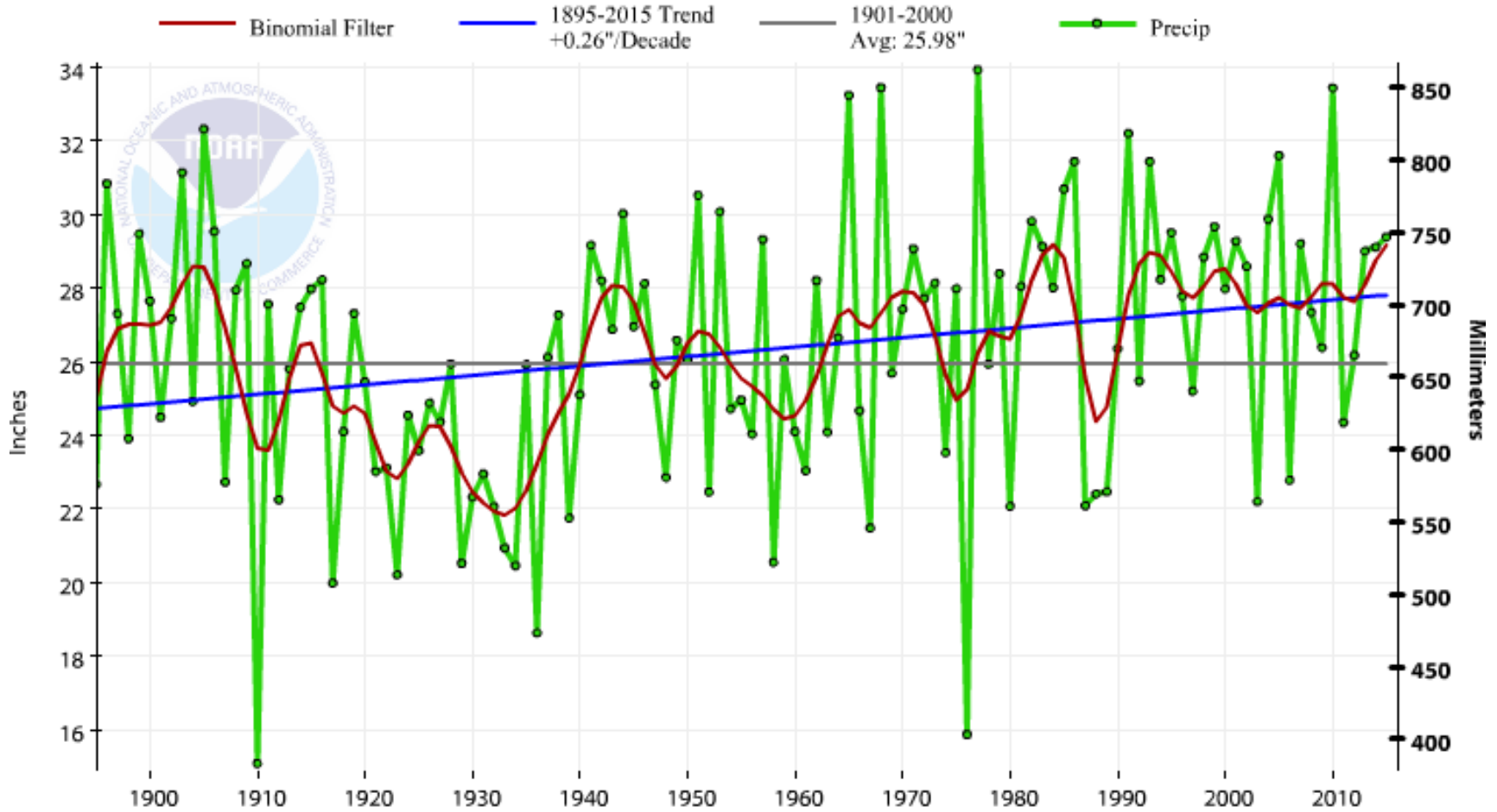
Historical Minnesota Heat Waves:

Red denotes dewpoint driven

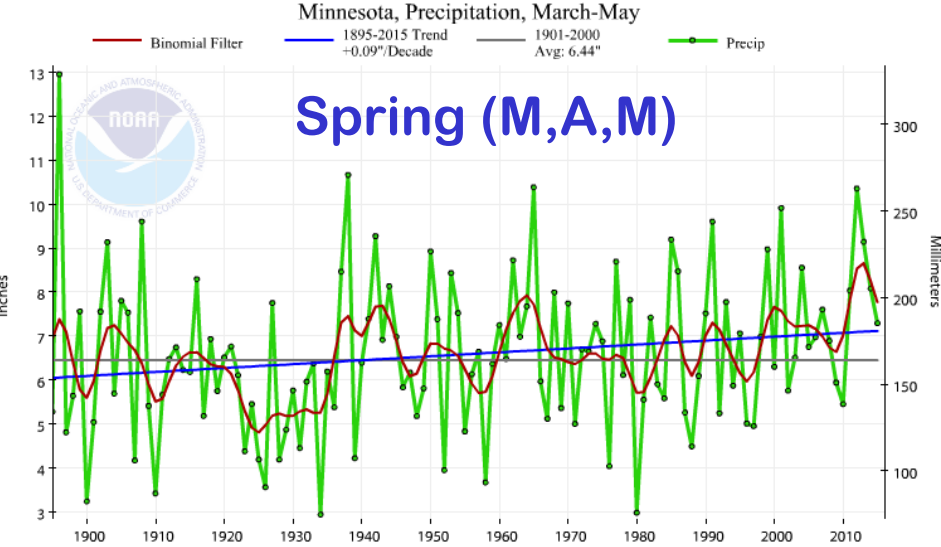
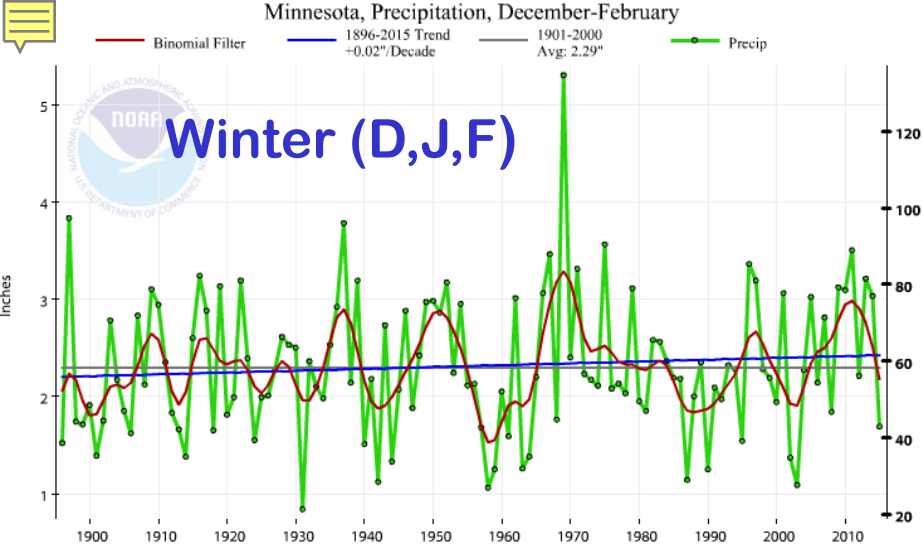
1883, 1894, 1901,
1910, 1917, 1921,
1931, 1933, 1934,
1936, 1937, 1947,
1948, 1949, 1955,
1957, 1959, 1964,
1976, 1977, 1983,
1988, 1995, 1999,
2001, 2005, 2006,
2007, 2010, 2011,
2012, 2013, 2014

(pattern is episodic but
increasing in frequency)

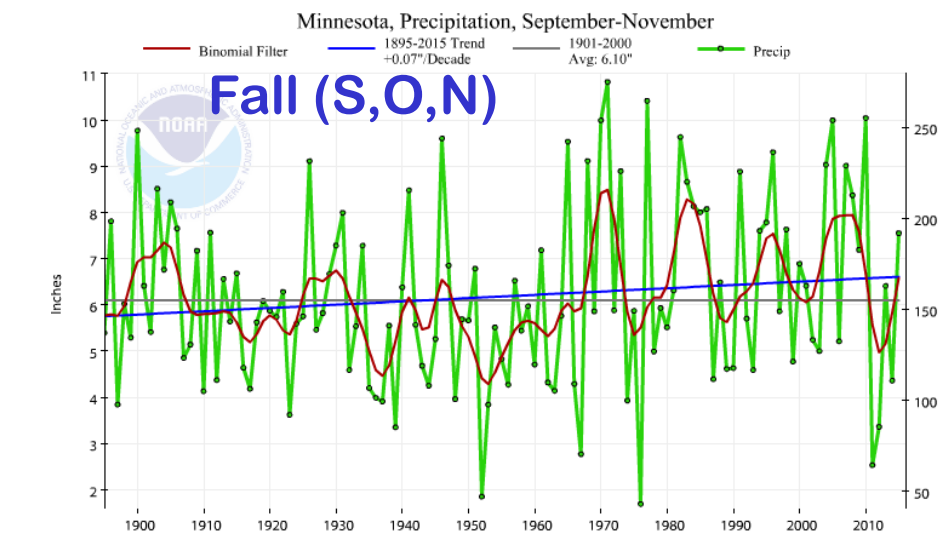
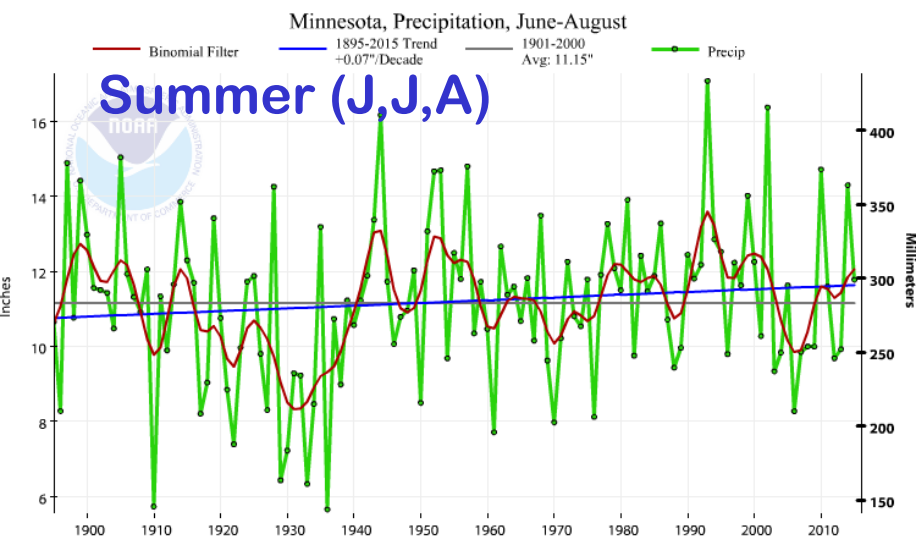
Minnesota, Precipitation, January-December



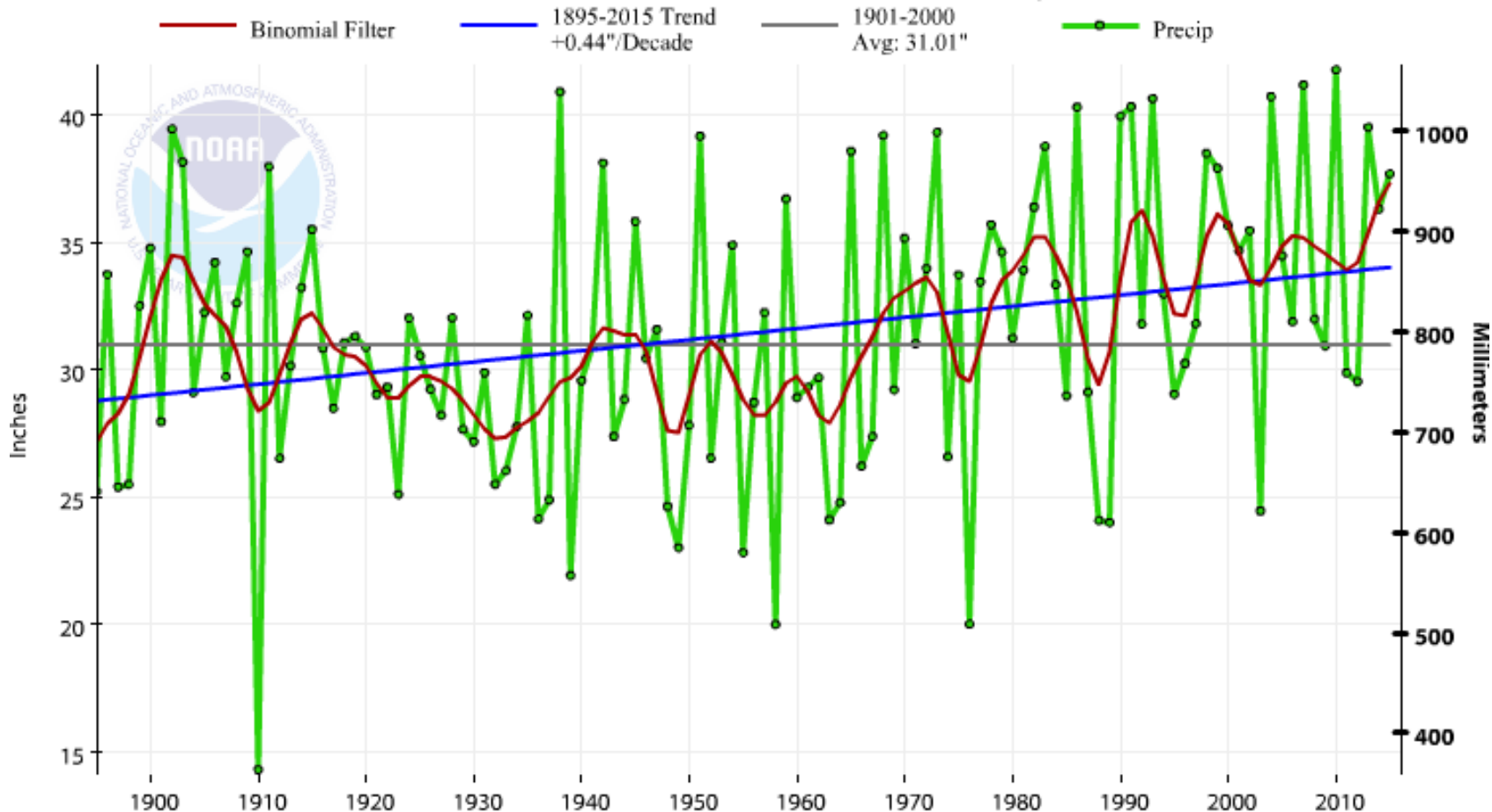
***Trend in annual precipitation for MN
Upward by 2.60" per century***



Seasonal Trends in MN Precipitation



Minnesota, Climate Division 9, Precipitation, January-December



**Annual precipitation trend in SE-Minnesota
Upward by 4.40 inches per century**

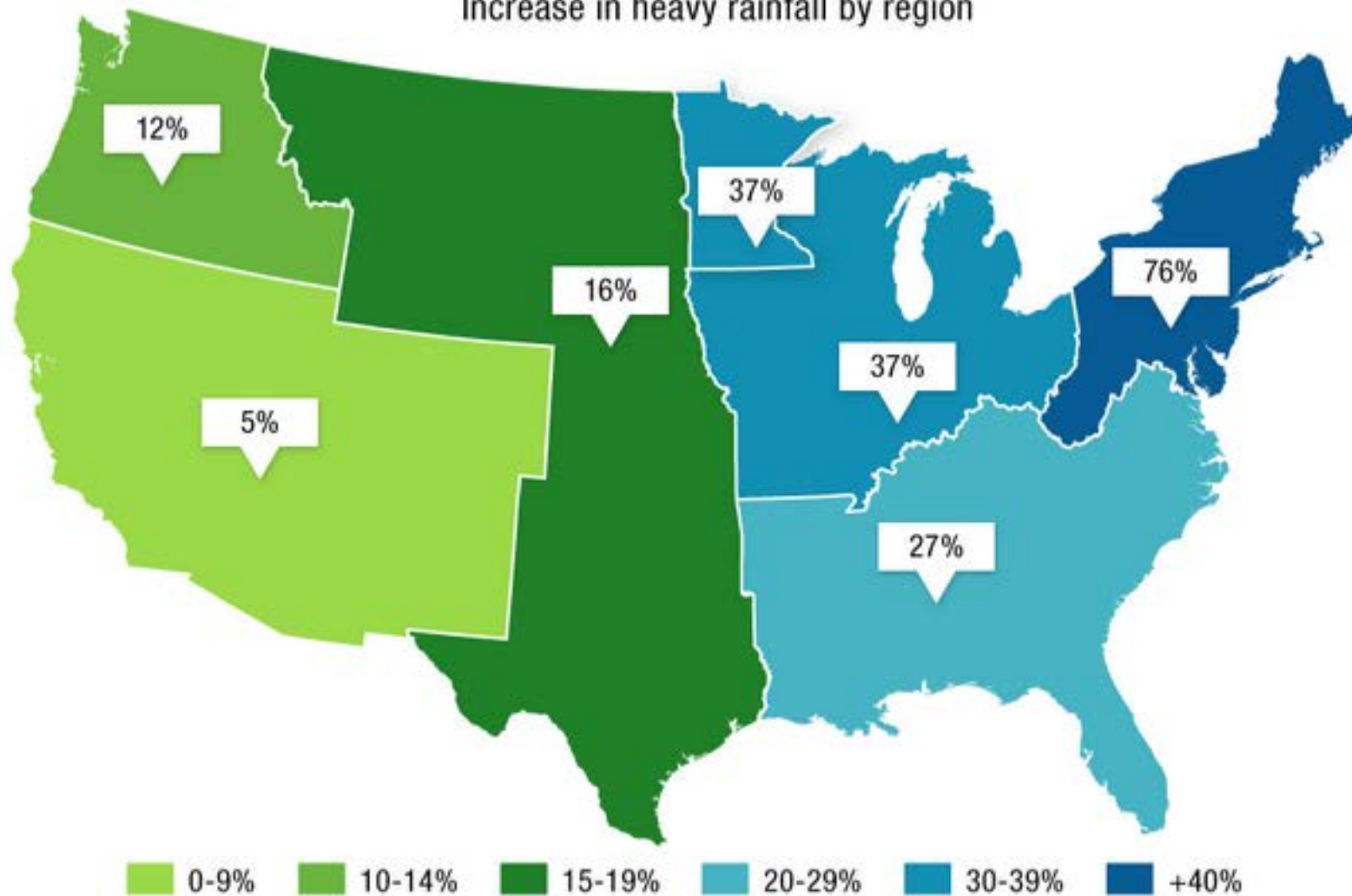


Change in Annual Precipitation Normals at Winona, MN

<u>PERIOD</u>	<u>AMOUNT (IN.)</u>
1921-1950	30.34"
1931-1960	30.57"
1941-1970	31.29"
1951-1980	32.81"
1961-1990	34.19"
1971-2000	34.61"
1978-2007	34.64"

14 percent increase since 1921-1950
period

Increase in heavy rainfall by region



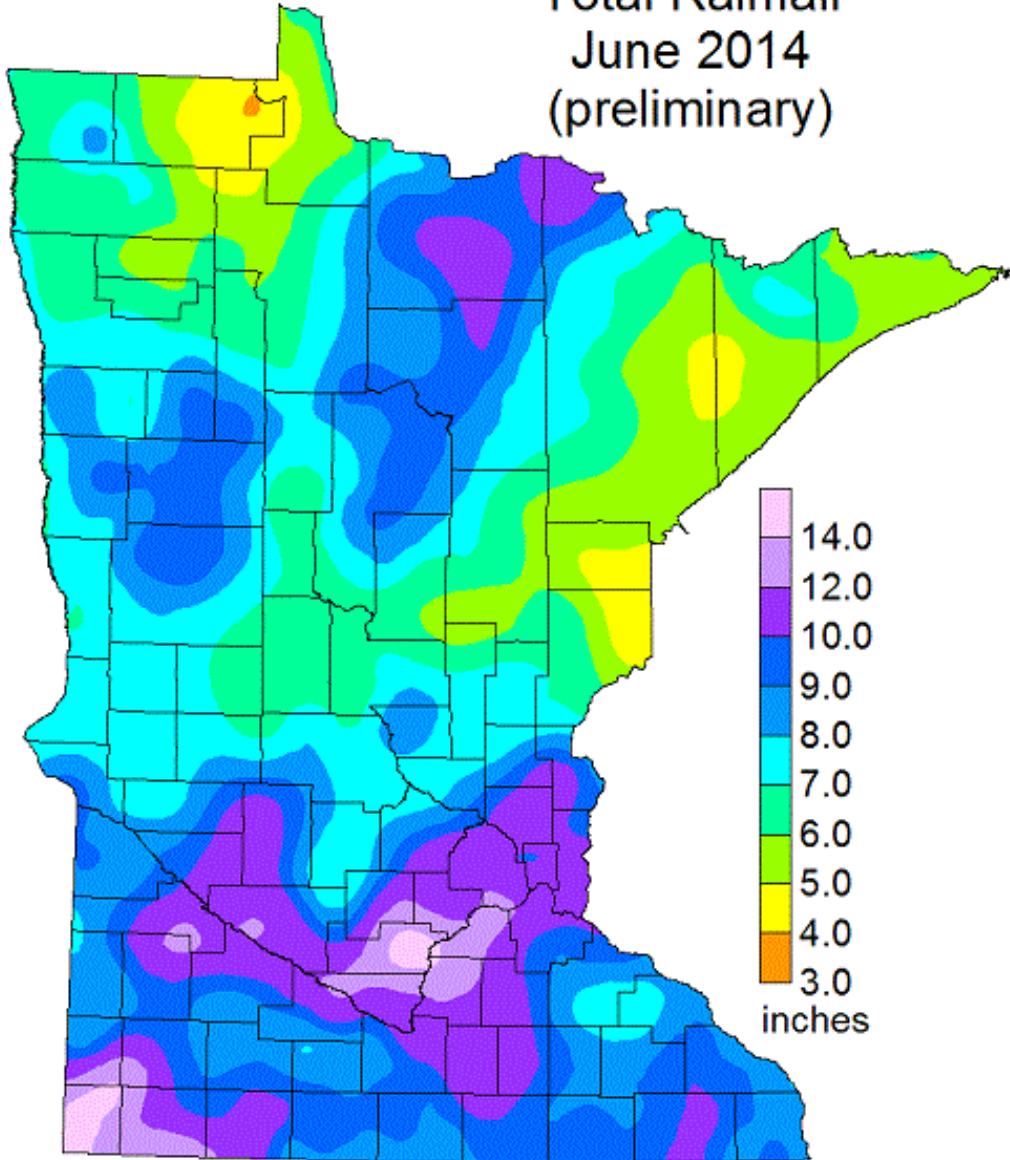
Source: National Climate Assessment, National Climatic Data Center

Historical recurrence interval of 2 inch rains in southern and eastern MN was calculated to be once per year. This is no longer the case.

Observed 2 inch rainfalls for the period 1991 – 2015 and maximum single day value for various communities:

Location	No. 2 in. rains	Maximum Value (date)
Albert Lea	49	7.50 (6/15/1978)
Waseca	54	5.63 (9/23/2010)
Winnebago	47	8.64 (9/25/2005)
Owatonna	46	6.47 (8/19/2007)
Amboy	42	9.48 (9/23/2010)
Windom	40	8.84 (9/23/2010)
Fairmont	41	6.20 (9/15/2004)
Blue Earth	47	5.50 (6/15/1978)
Bricelyn	42	9.22 (9/14/2004)
Winona	40	5.10 (8/19/2007)

Total Rainfall
June 2014
(preliminary)

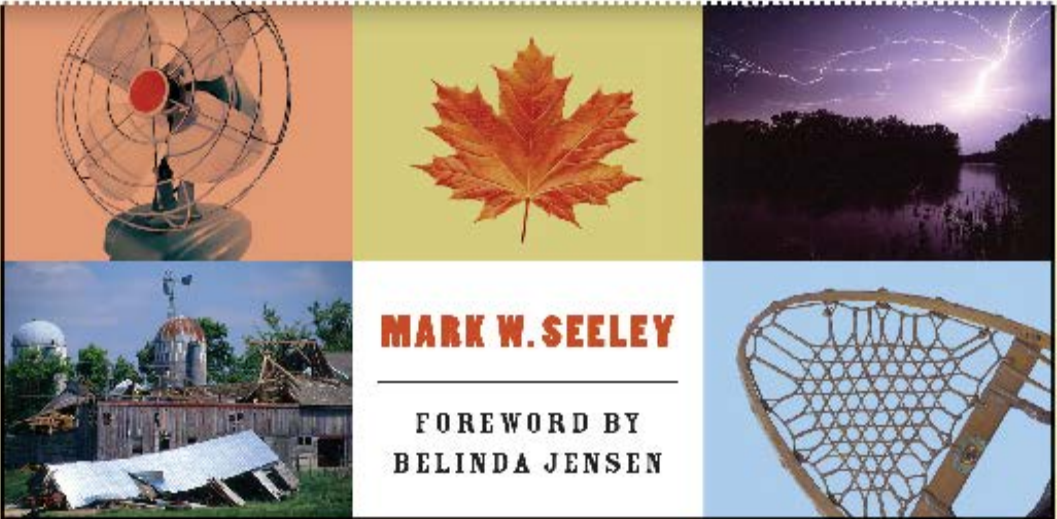


June 2014
Wettest month in history
on a statewide basis

Hawley 10.95"
International Falls 10.24"
Kabetogama 11.93"
Granite Falls 10.99"
Belle Plaine 15.16"
Glencoe 14.61"
MSP 11.36"
Luverne 13.84"
Redwood Falls 14.24"
Waseca 12.93"
Rushford 12.76"

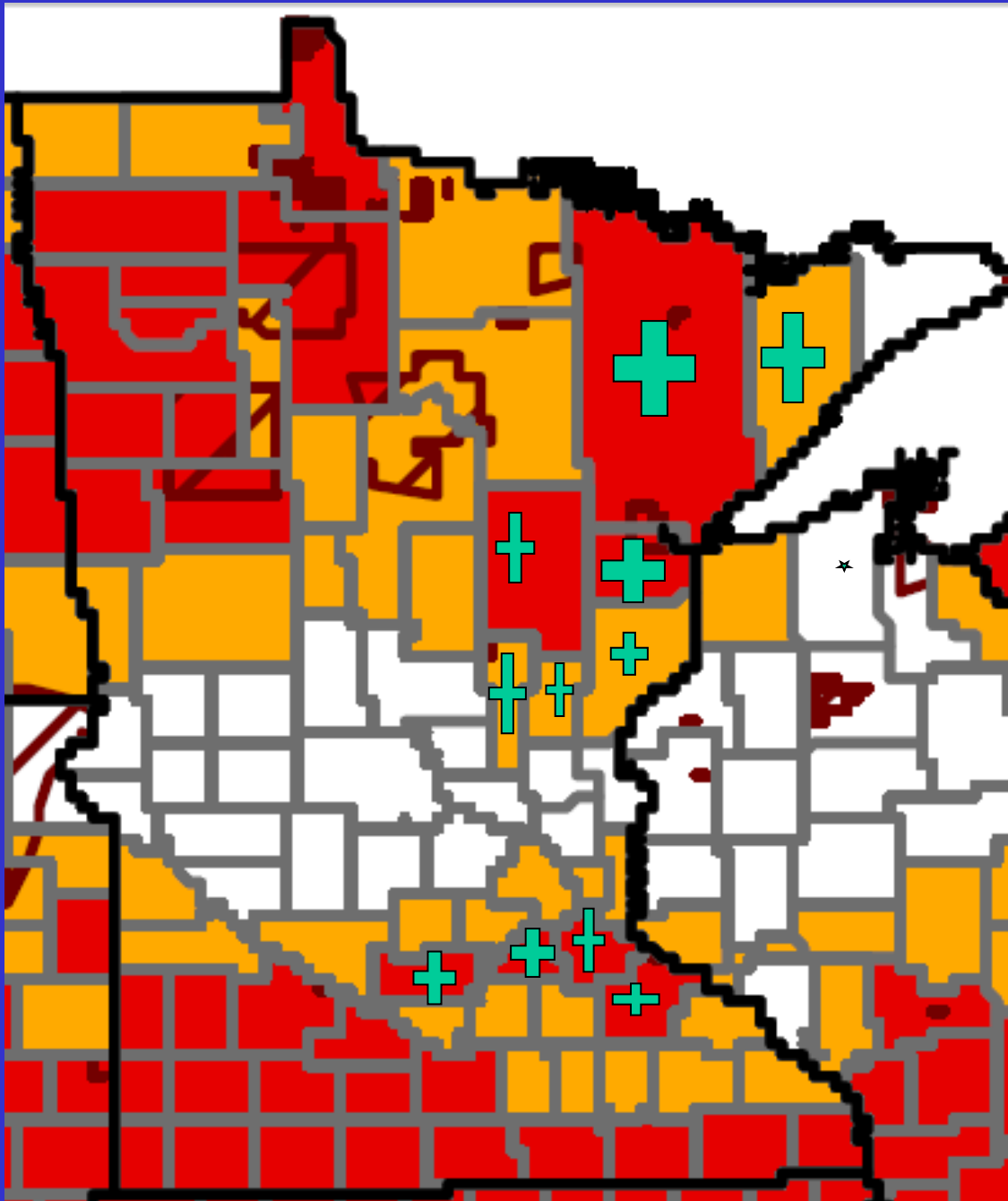


MINNESOTA WEATHER ALMANAC



Historic Droughts (Associated fires)

- 1829, 1852, 1856
- 1863-1864, 1871-1872
- 1894, 1896, 1900,
- 1910, 1918, 1921-1923
- 1926, 1929-1934,
- 1936-1939, 1948,
- 1954-1956, 1961,
- 1976, 1980, 1984,
- 1987, 1988, 1997, 2005-
- 2006, 2007 2008
- 2009, 2010, 2011,
- 2012, 2013

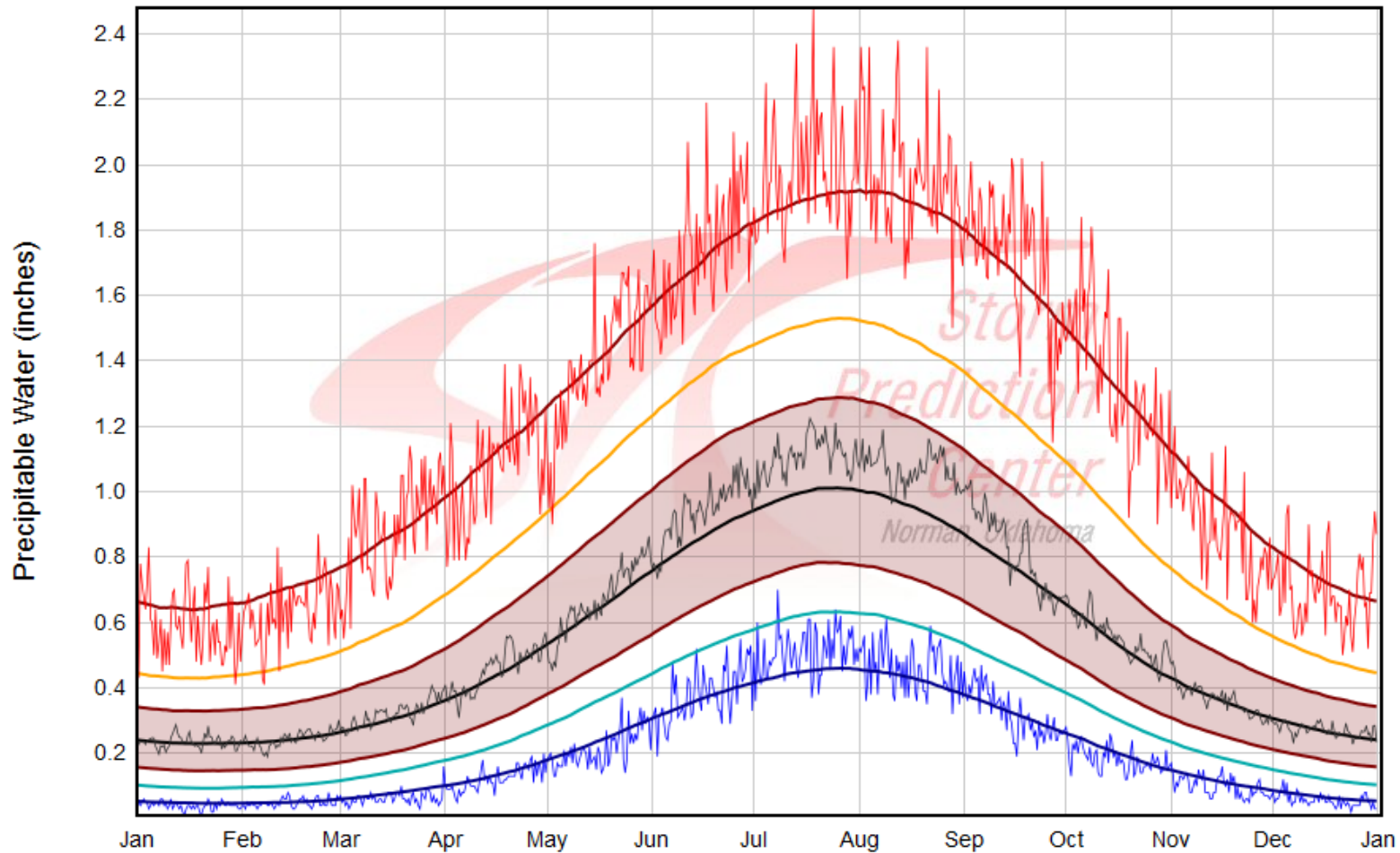


MN Counties
designated for
federal disaster
assistance in
2012

All are
associated with
drought except
those with

+ Which designates
for flood or severe
storm

ALL Soundings for MPX



01 Jan 00 UTC

Daily Min (Thin Line): 0.06
Min Moving Average: 0.08
10% Moving Average: 0.15
25% Moving Average: 0.22

Median Moving Average: 0.32
Daily Mean (Thin Line): 0.33

75% Moving Average: 0.46
90% Moving Average: 0.64
Max Moving Average: 1.05
Daily Max (Thin Line): 0.90

Radiosonde history of PW at MSP since 1948
(Most record high values have occurred since 1990)



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

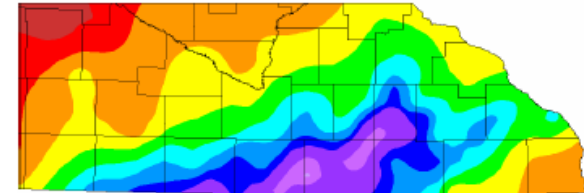
June 19-20, 2012, Northeast Minnesota

**Defined as 6" or greater rains cover at least 1000 square miles and a peak amount of 8" or greater*

Shift in Precipitation Recurrence Intervals

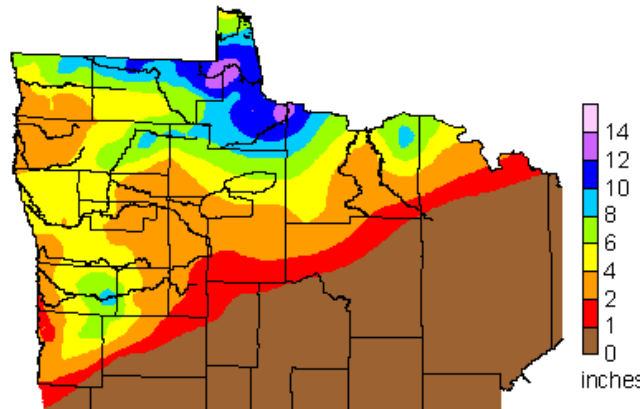
Mega Rains since 2002

'1000-yr (approx.) events' in Southern Minnesota in the last decade.
September 14-15, 2004



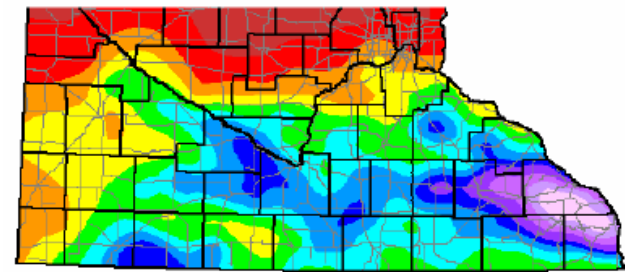
0 1 2 3 4 5 6 7 8 10 12 14 inches

Rainfall Totals - June 9 and 10, 2002



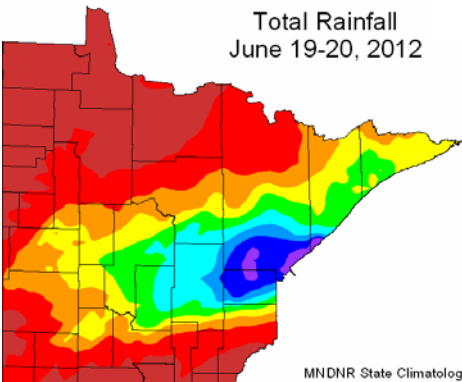
14
12
10
8
6
4
2
1
0
inches

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

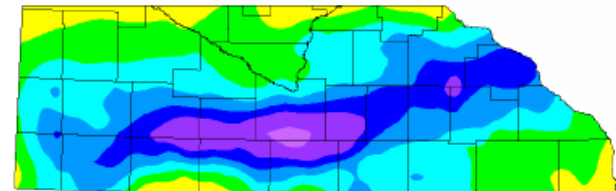


0 1 2 3 4 5 6 7 8 10 12 14 inches
September 22-23, 2010

Total Rainfall
June 19-20, 2012



MNDNR State Climatology Office



3 4 5 6 7 8 10 inches

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 20000 sq. mi. the areal 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.

0 1 2 3 4 5 6 7 8 10 inches

Consequences Observed and Associated with Climate Change in Minnesota and the western Great Lakes

- Adjustments to storm sewer systems, irrigation, drainage, runoff, sediment, and shoreline management
- Adjustments in public health (Heat Waves, allergy season)
- Modified fisheries management
- Mitigation of flooding potential
- Longer growing season, shift in Plant Hardiness Zones
- Change in biological organisms (pathogens, pests, microbes)
- Change in animal migration, hibernation, and foraging
- Change in frequency and magnitude of insured losses
- Change in drought and fire weather frequencies
- Increased use of air conditioning
- Amplified variability of watershed volume flows



Rabbits in the sky



A Poodle in the sky



Our state climate database indicates that many attributes of our environment are changing.....some changes are evident in the measurement of averages, variability, and extremes.....and further these changes are having observable consequences. It is clearly poor judgment to ignore this!

Snail in the sky



Pig in the sky

