Proceedings of the 2nd Annual Nitrogen: Minnesota's' Grand Challenge & Compelling Opportunity Conference

CONFERENCE SUPPORTERS

Minnesota Department of Agriculture

USDA

Mosaic

Minnesota Soybean Research & Promotion Council

Agrium

University of Minnesota Extension

MVTL

N-Serve Nitrogen Stabilizer

Instinct II Nitrogen Stabilizer

Dow

Dow AgroSciences

Agvise Laboratories

SMBSC

MAWRC Minnesota Agricultural Water Resource Center

Minnesota Corn Growers Association

MCPR Minnesota Crop Production Retailers

Koch Agronomic Services, LLC

West Central

MNICCA

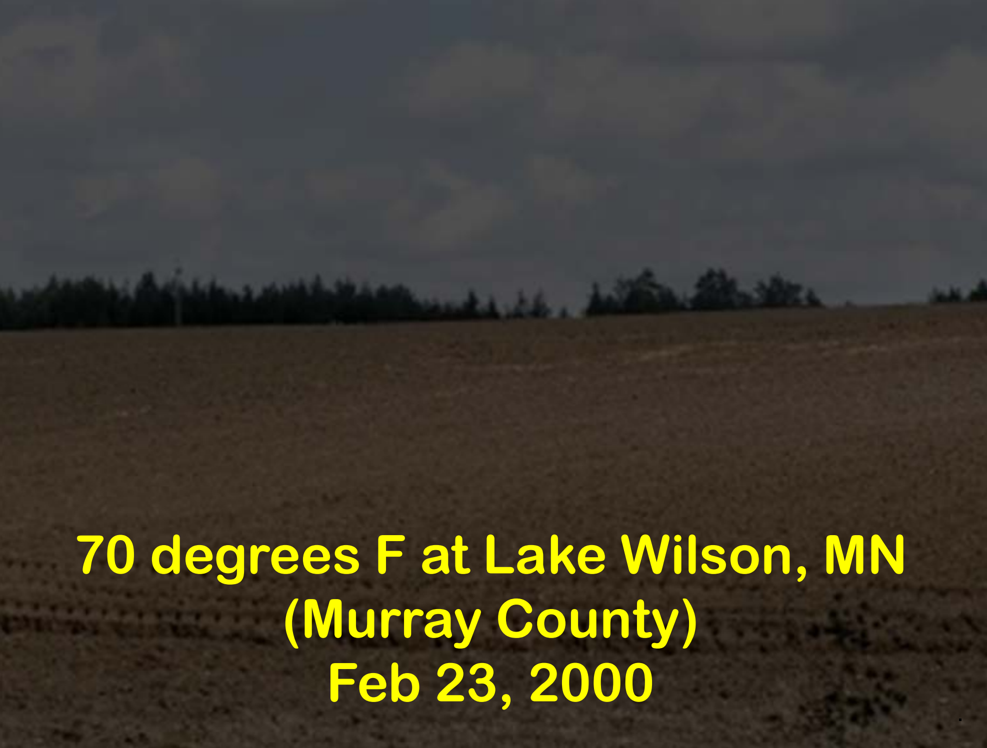
CCA | CPAg

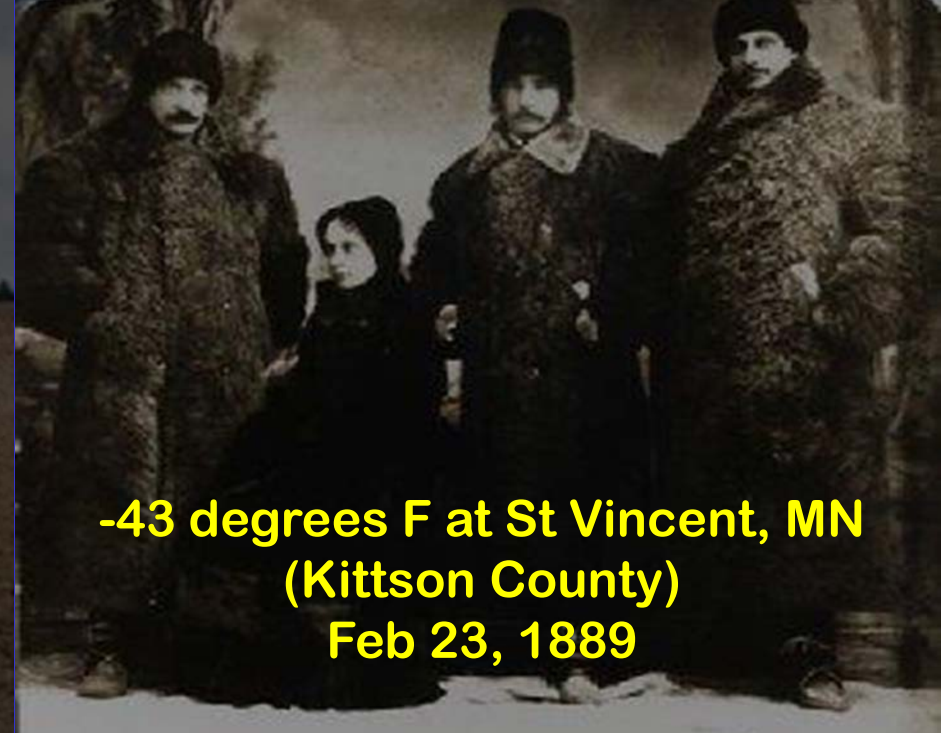
Climate Trends and Their Implicaitons

Dr. Mark Seeley
Department of Soil, Water, and Climate
University of Minnesota
St Paul, MN 55108

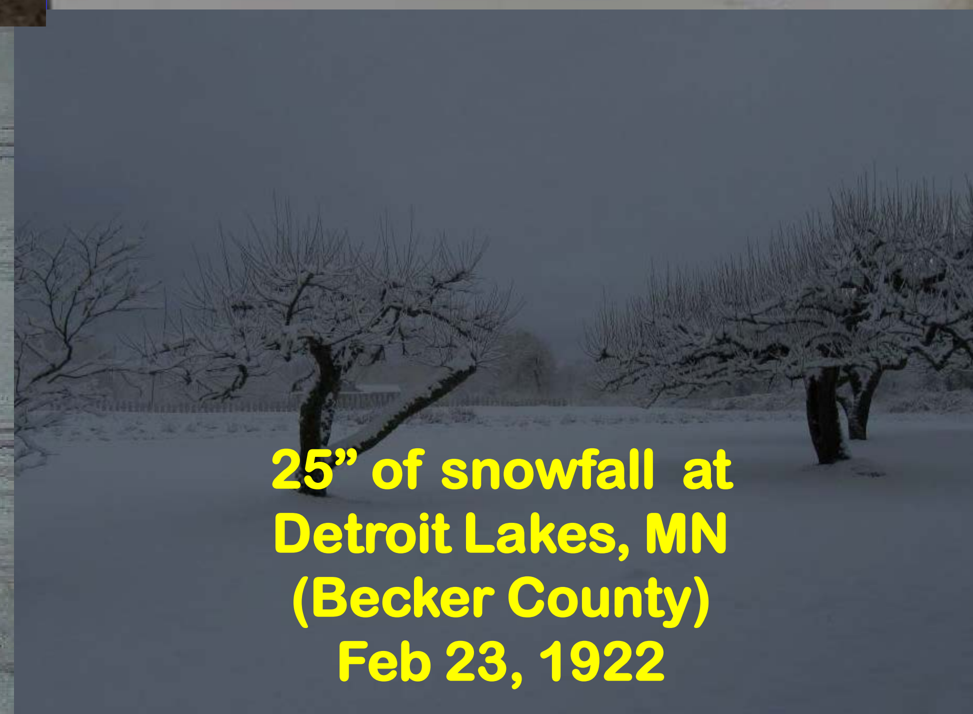
Nitrogen-Minnesota's Grand Challenge & Compelling Opportunities Conference
February 23, 2016
Rochester, MN

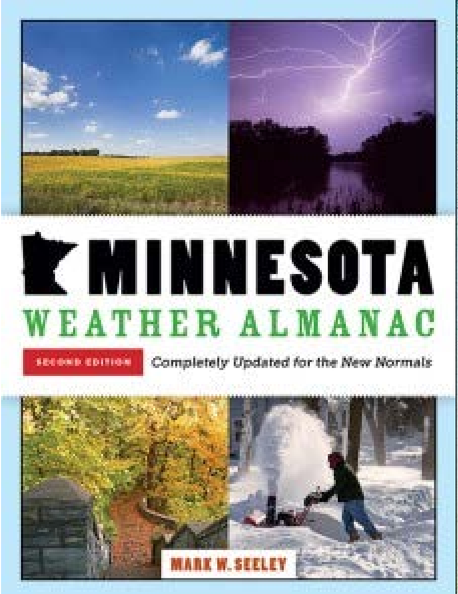
University of Minnesota
EXTENSION


70 degrees F at Lake Wilson, MN
(Murray County)
Feb 23, 2000

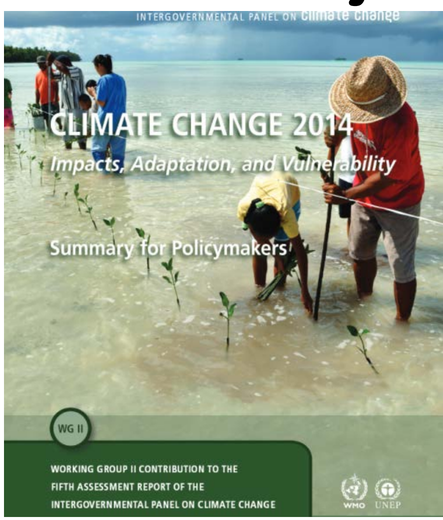

-43 degrees F at St Vincent, MN
(Kittson County)
Feb 23, 1889


Lake Superior almost
completely frozen over
Feb 23, 1979

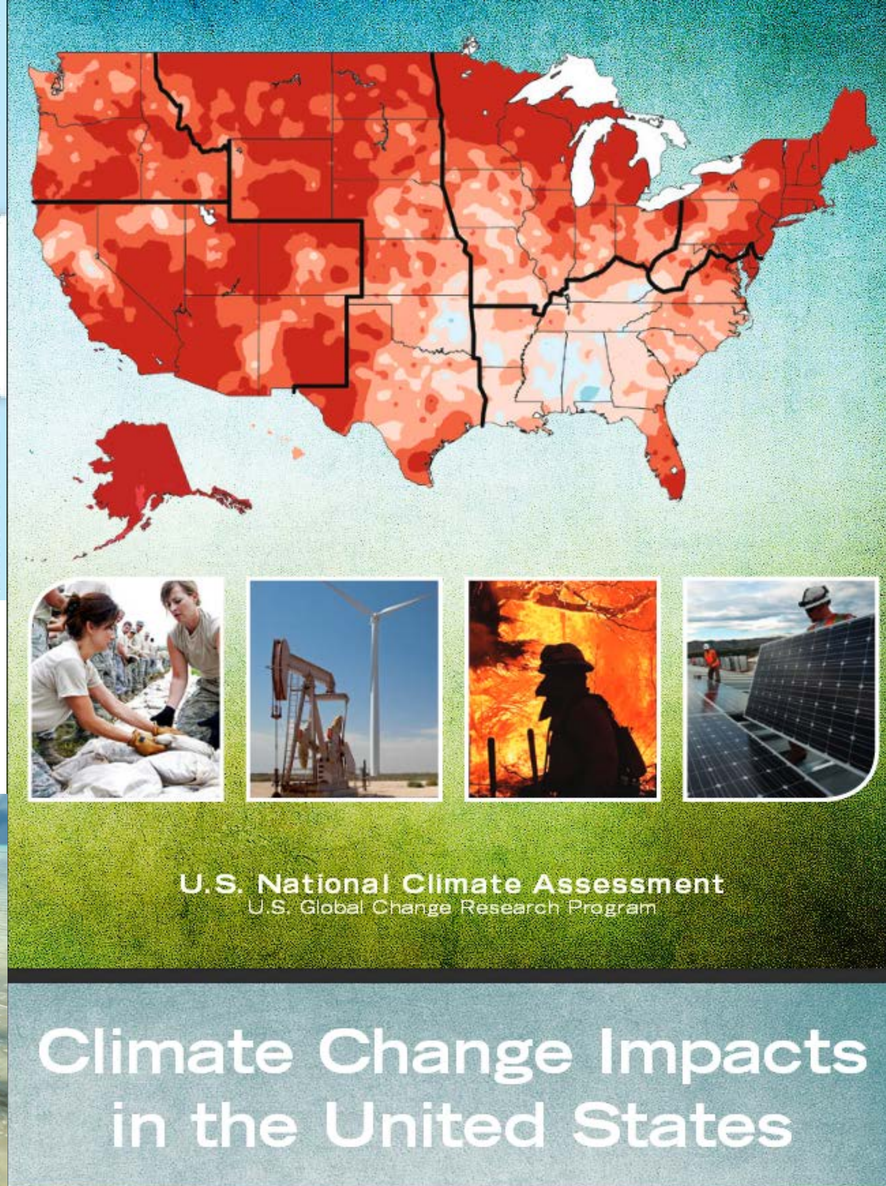

25" of snowfall at
Detroit Lakes, MN
(Becker County)
Feb 23, 1922



Minnesota weather and climate history



IPCC 5th Assessment



National Climate Assessment 2014

NOAA Climate Monitoring and Global and National Assessment Divisions
At climate.gov

AASC

Information Resources Used

Segments

Changes in Temperature and Precipitation

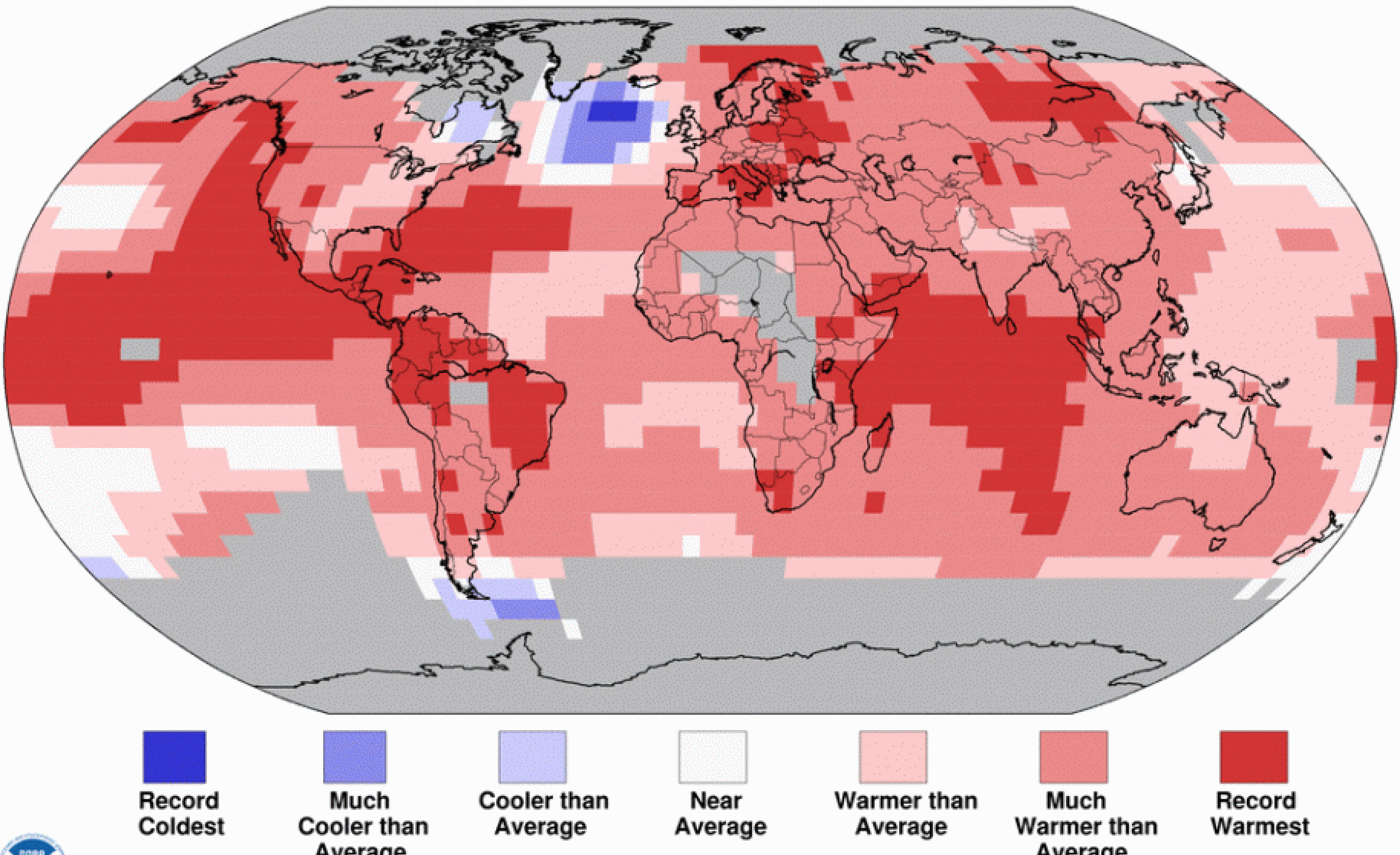
Some Associated Impacts

Comments on 2016 Outlooks

Land & Ocean Temperature Percentiles Jan–Dec 2015

NOAA's National Centers for Environmental Information

Data Source: GHCN–M version 3.3.0 & ERSST version 4.0.0



Wed Jan 13 12:15:02 EST 2016

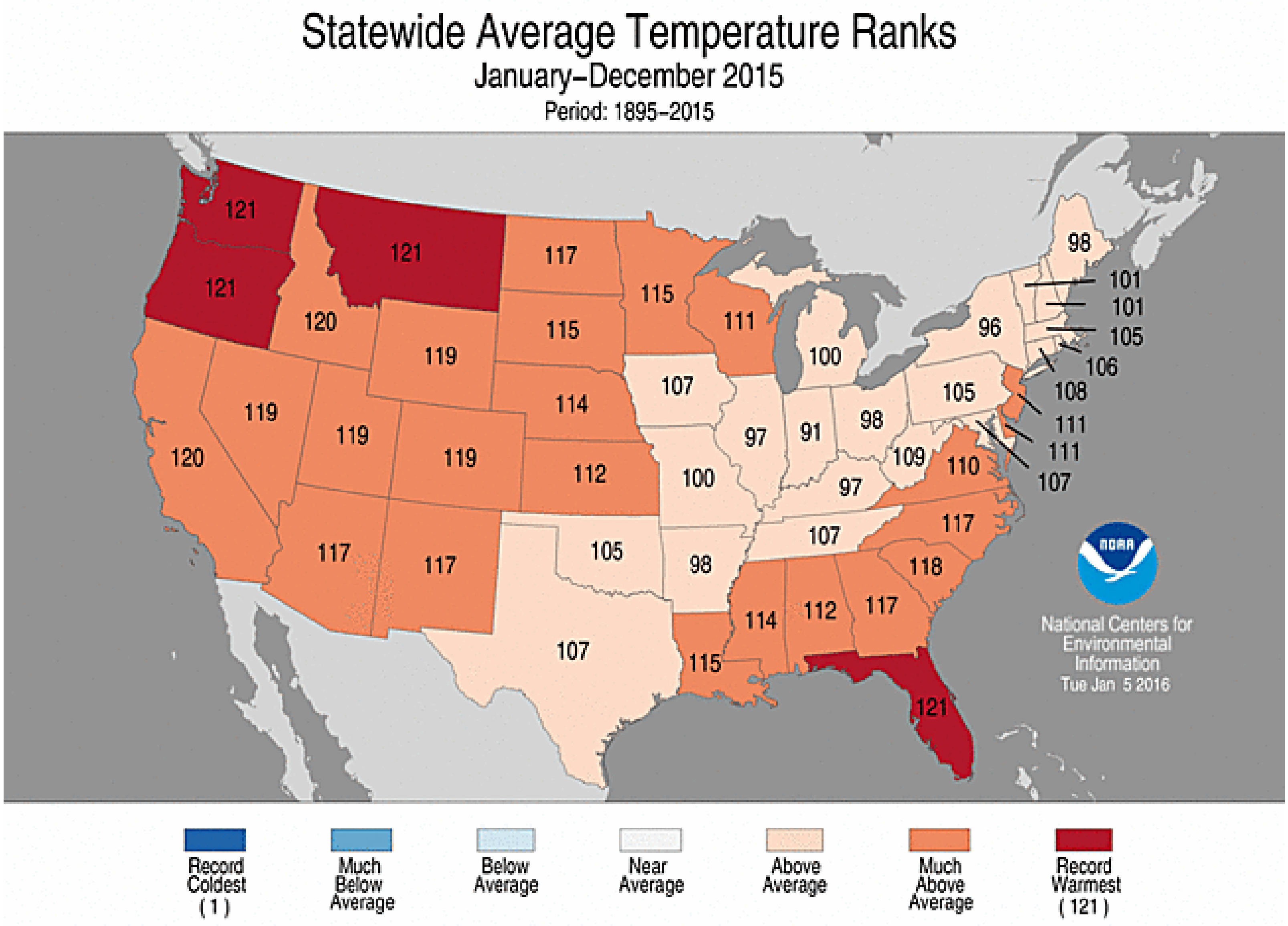
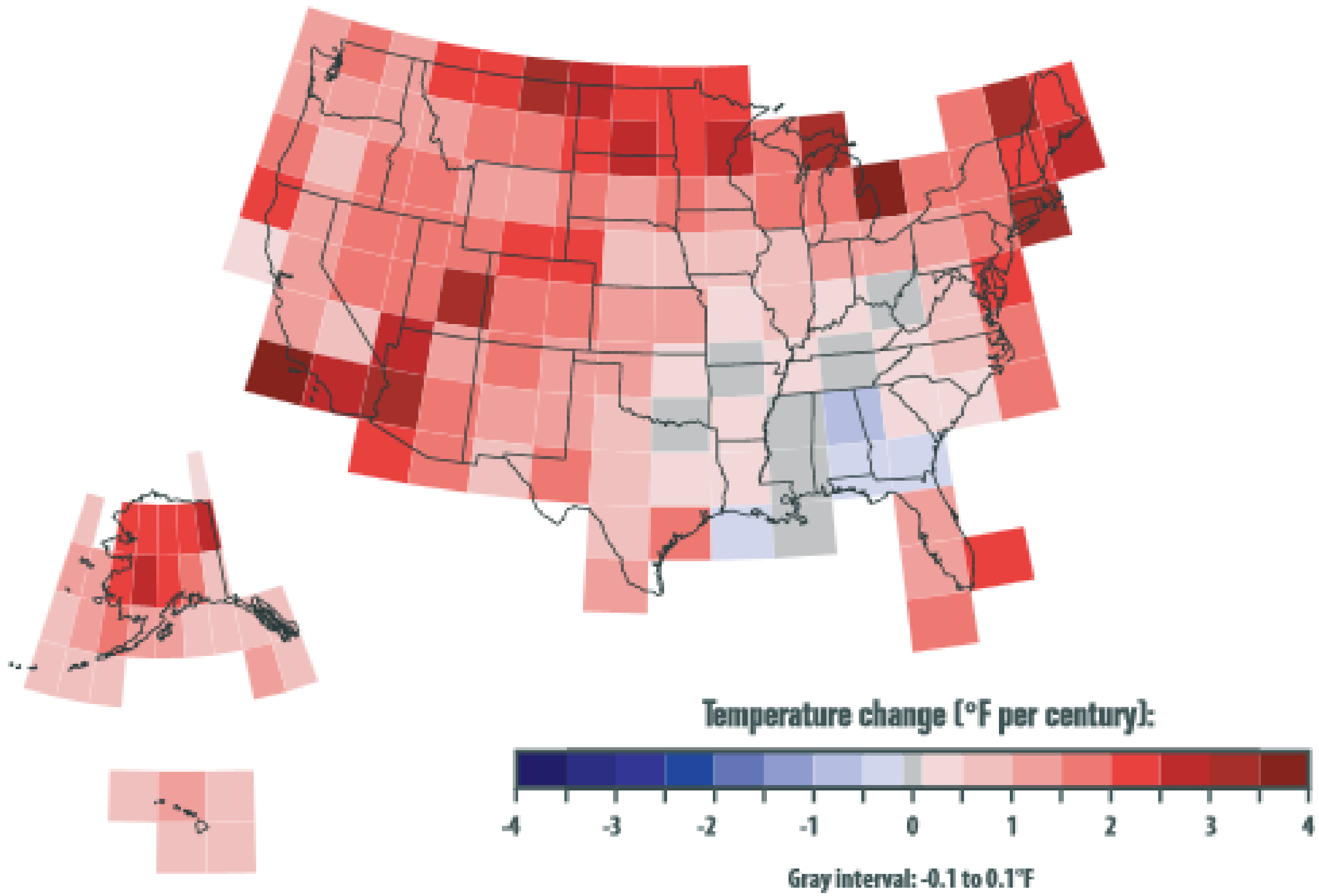

Statewide Average Temperature Ranks
January–December 2015
Period: 1895–2015
121
121
121
117
115
115
111
120
119
100
96
98
101
101
105
106
108
111
111
107
107
105
119
119
119
114
97
91
98
109
110
120
112
100
97
117
107
117
117
105
98
118
114
112
117
107
115
121
National Centers for Environmental Information
Tue Jan 5 2016
Record Coldest (1)
Much Below Average
Below Average
Near Average
Above Average
Much Above Average
Record Warmest (121)

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

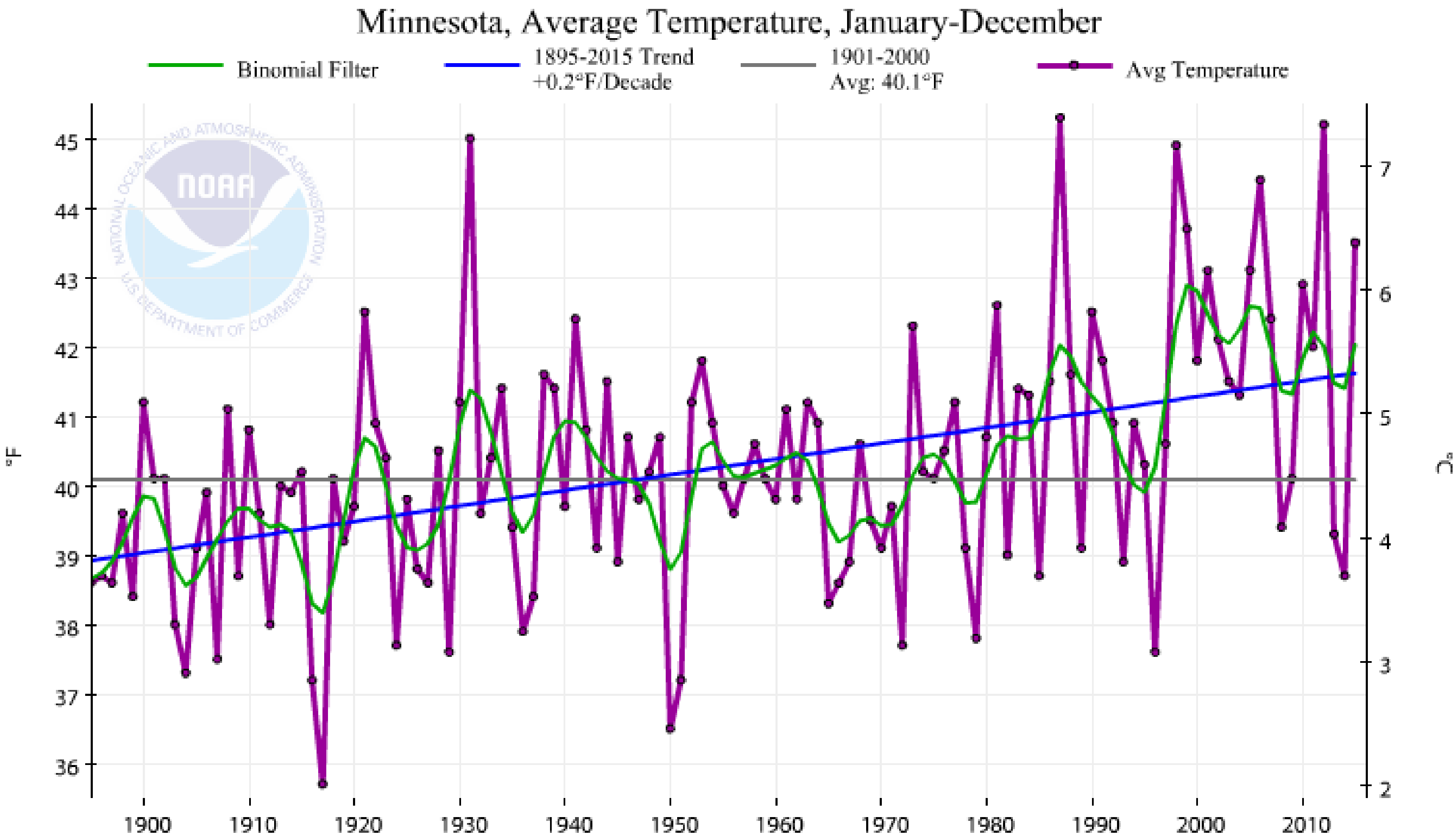
This figure shows how average air temperatures have changed in different parts of the United States since the early 20th century (since 1901 for the lower 48 states, 1905 for Hawaii, and 1918 for Alaska).



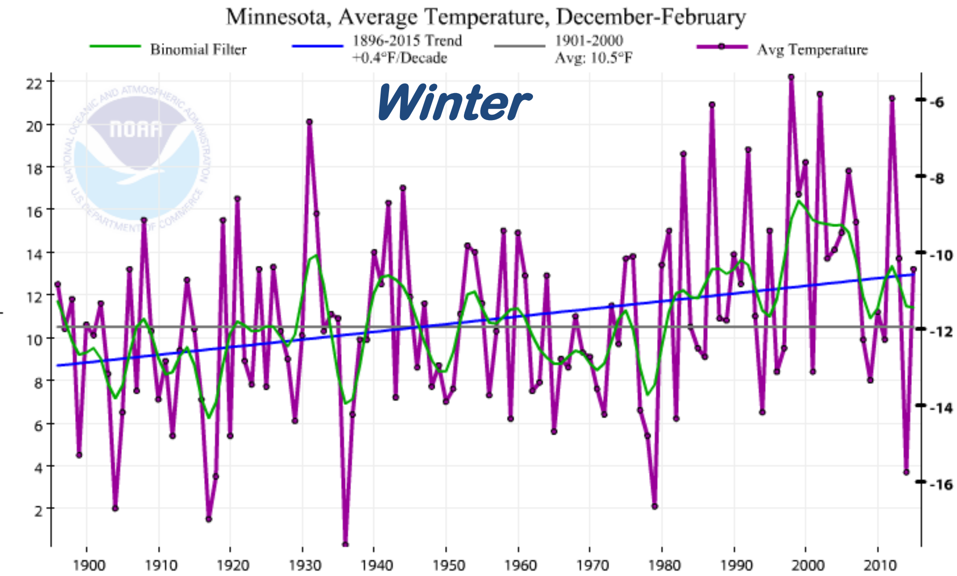
Data source: NOAA, 2009*

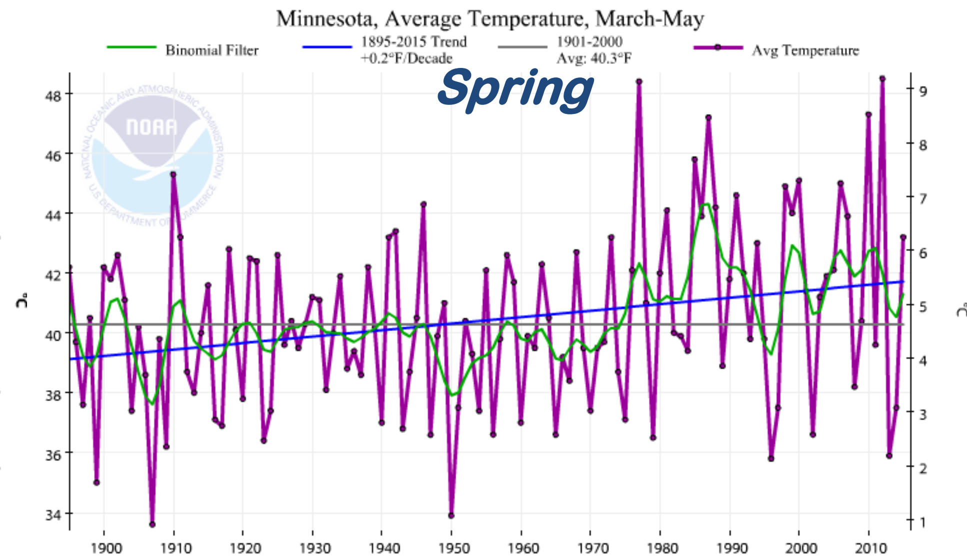
Disparity in the pace of climate change and the response to it

Minnesota Mean Annual Temperature Trends

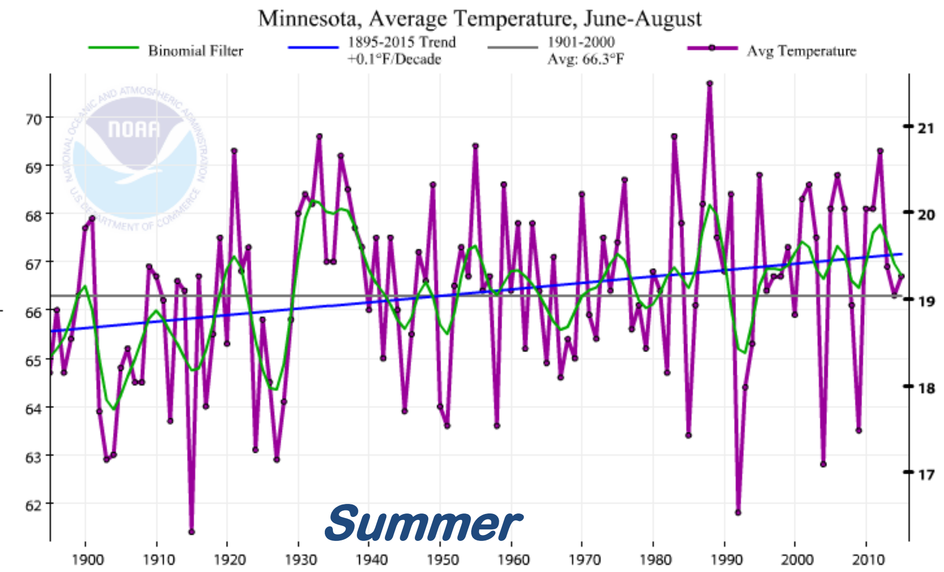


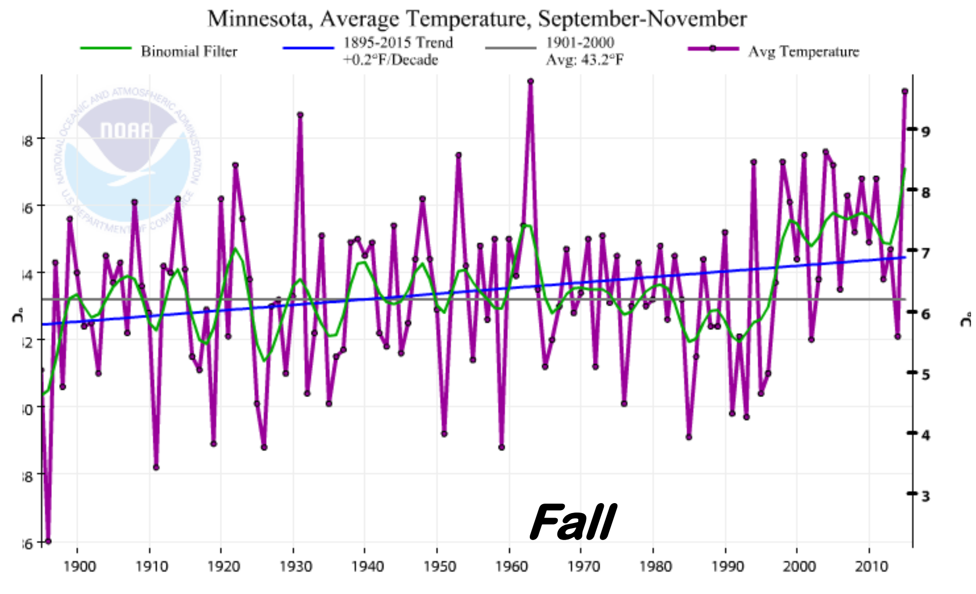
Temp trend is upward and more frequently above the 90th percentile, pace is 2°F per century.





Seasonal Statewide Temperature Trends in MN



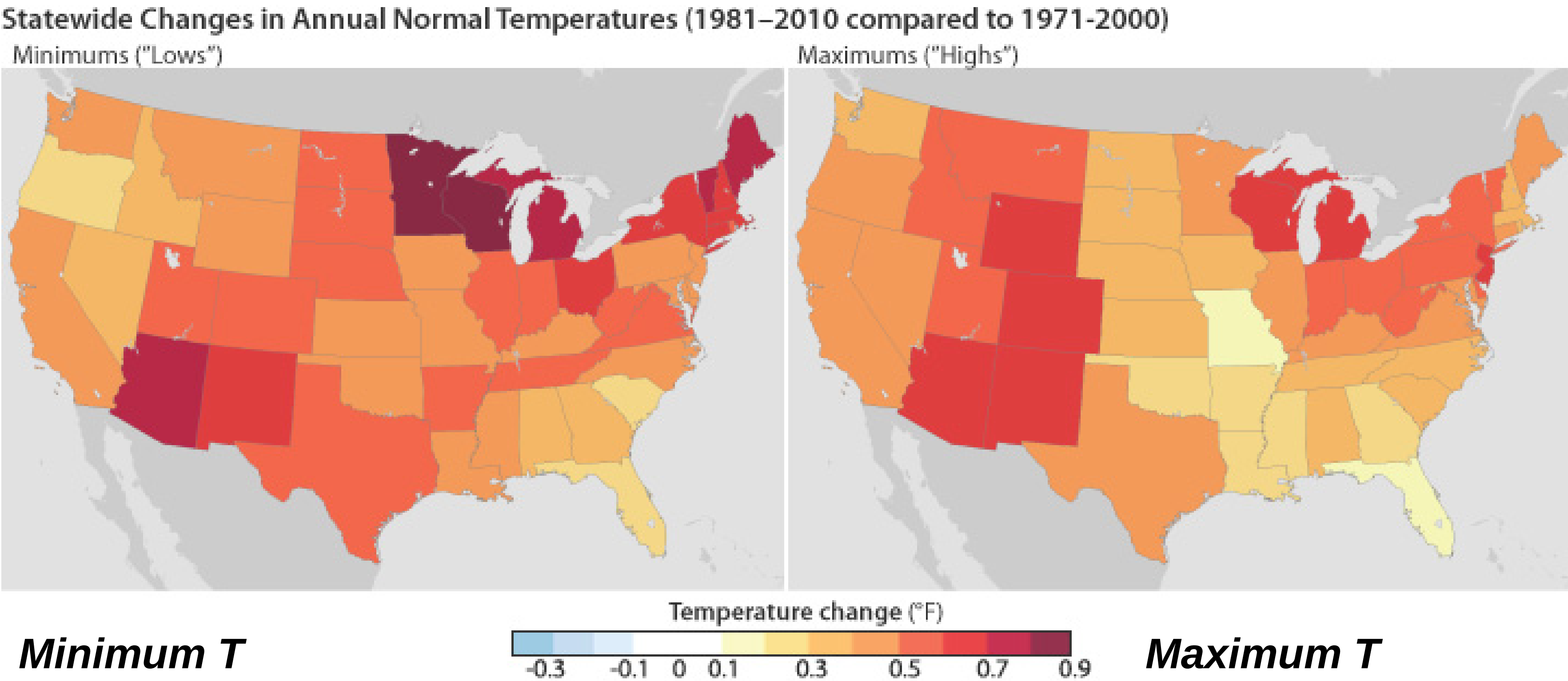


Trends in mean monthly temperatures at Winona, MN 1971-2000 normals vs 1981-2010 normals (F)

Month	Min Change	Max Change	Mean Change
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

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

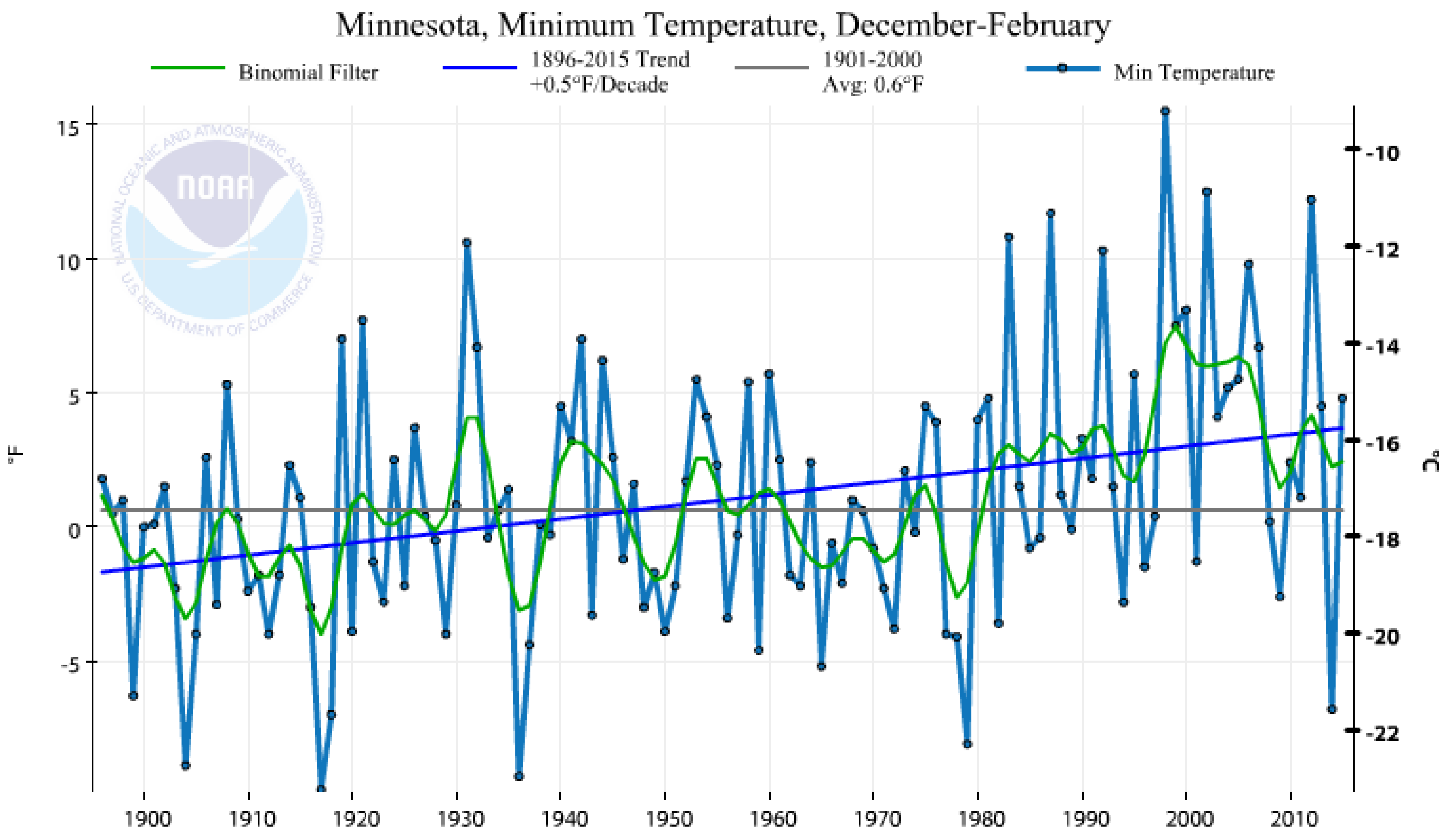
Month	Min Change	Max Change	Mean Change
January	+3.0	+2.1	+2.5
February	+0.1	+0.2	+0.1
March	-0.1	-0.1	-0.2
April	+1.3	+0.2	+0.7
May	+0.9	-0.8	+0.1
June	+1.6	-0.4	+0.5
July	+1.1	+0.2	+0.7
August	+1.6	+0.4	+1.0
September	+1.3	+0.6	+1.0
October	+1.7	-0.3	+0.7
November	+2.1	+1.7	+1.9
December	+2.2	+1.4	+1.8



Minimum T ***Maximum T***

There are regional differences in the rate of change in maximum versus minimum temperature

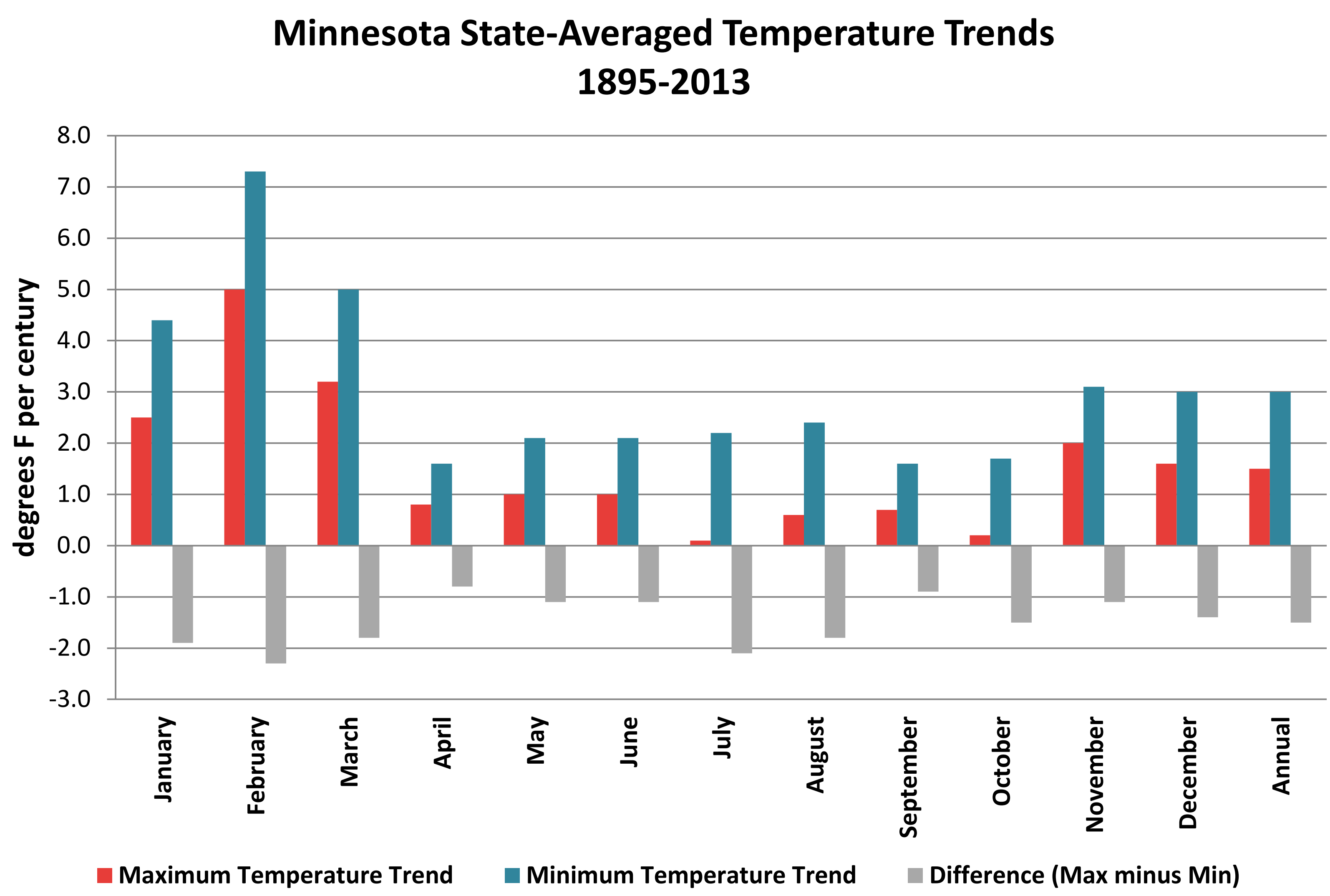
Statewide



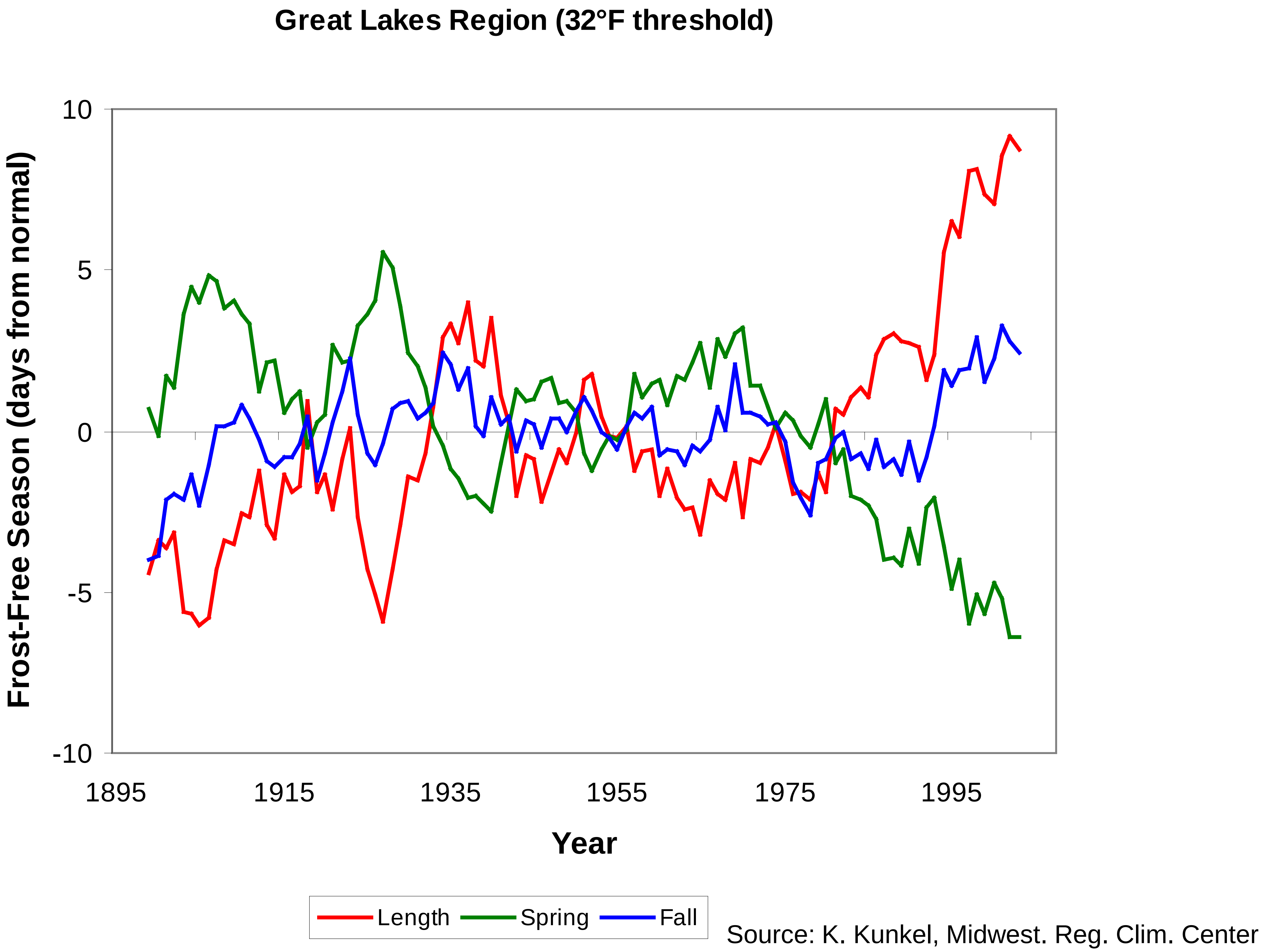
Change in average winter minimum temperature is 5°F per century

Trends in average winter minimum temperatures Rochester, MN

Period of Record	Ave Min Temp in Deg. F
1951 - 1980	Jan 1.9
1961 - 1990	Jan 2.7
1971 - 2000	Jan 3.7
1981 - 2010	Jan 7.7
1951 - 1980	Feb 7.6
1961 - 1990	Feb 8.1
1971 - 2000	Feb 10.6
1981 - 2010	Feb 12.4
1951 - 1980	Mar 19.2
1961 - 1990	Mar 21.3
1971 – 2000	Mar 22.6
1981 - 2010	Mar 24.3



Minnesota State-Averaged Temperature Trends
1895-2013
degrees F per century
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
January
February
March
April
May
June
July
August
September
October
November
December
Annual
Maximum Temperature Trend
Minimum Temperature Trend
Difference (Max minus Min)


Great Lakes Region (32°F threshold)
Frost-Free Season (days from normal)
10
5
0
-5
-10
1895
1915
1935
1955
1975
1995
Year
Length
Spring
Fall
Source: K. Kunkel, Midwest. Reg. Clim. Center

Consequences of Warmer Temperatures

Change in depth and duration of soil freezing

More rapid breakdown of crop residues

Earlier planting opportunities based on soil temperature

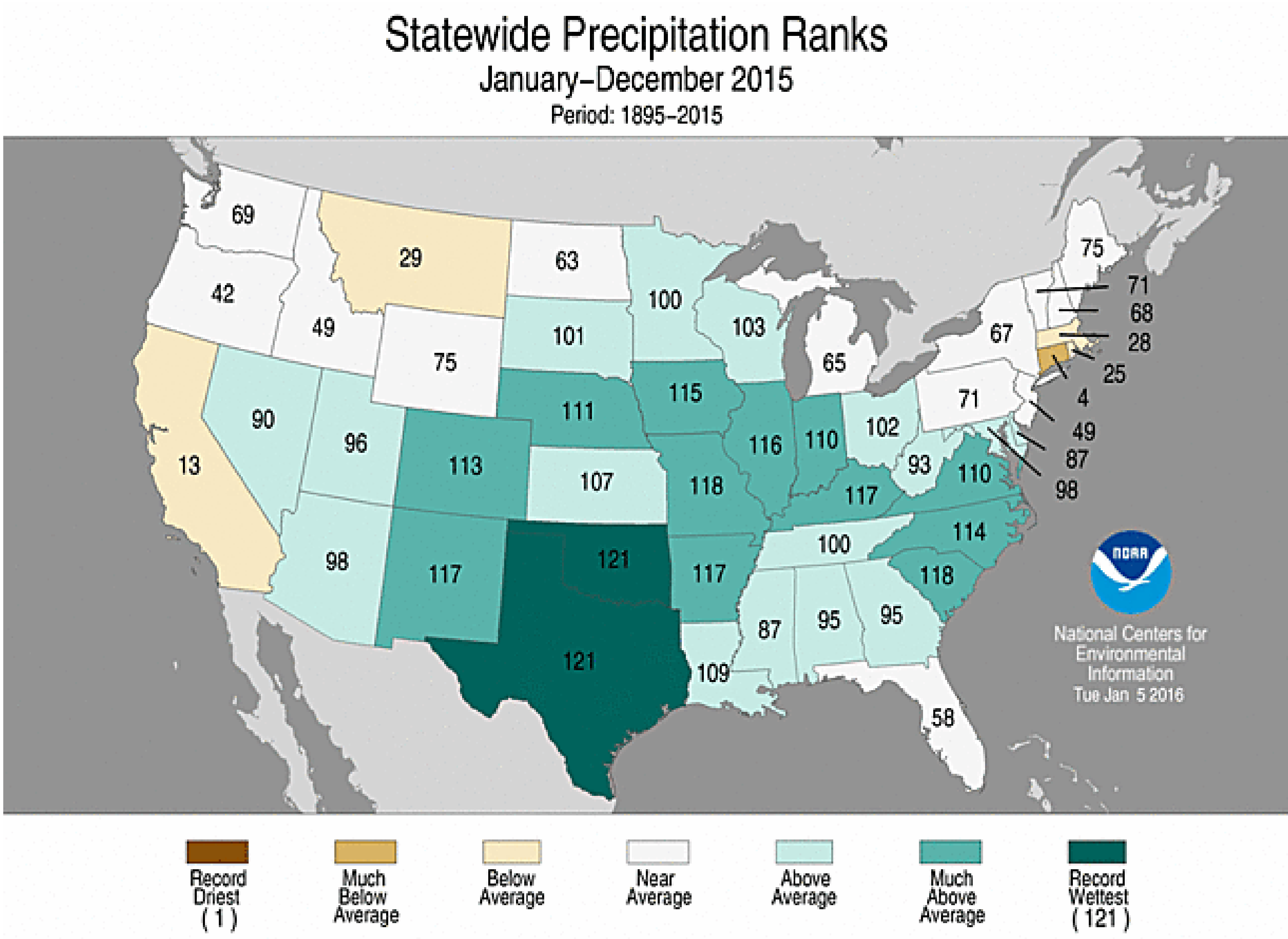
Later fall nitrogen applications due to warm soils

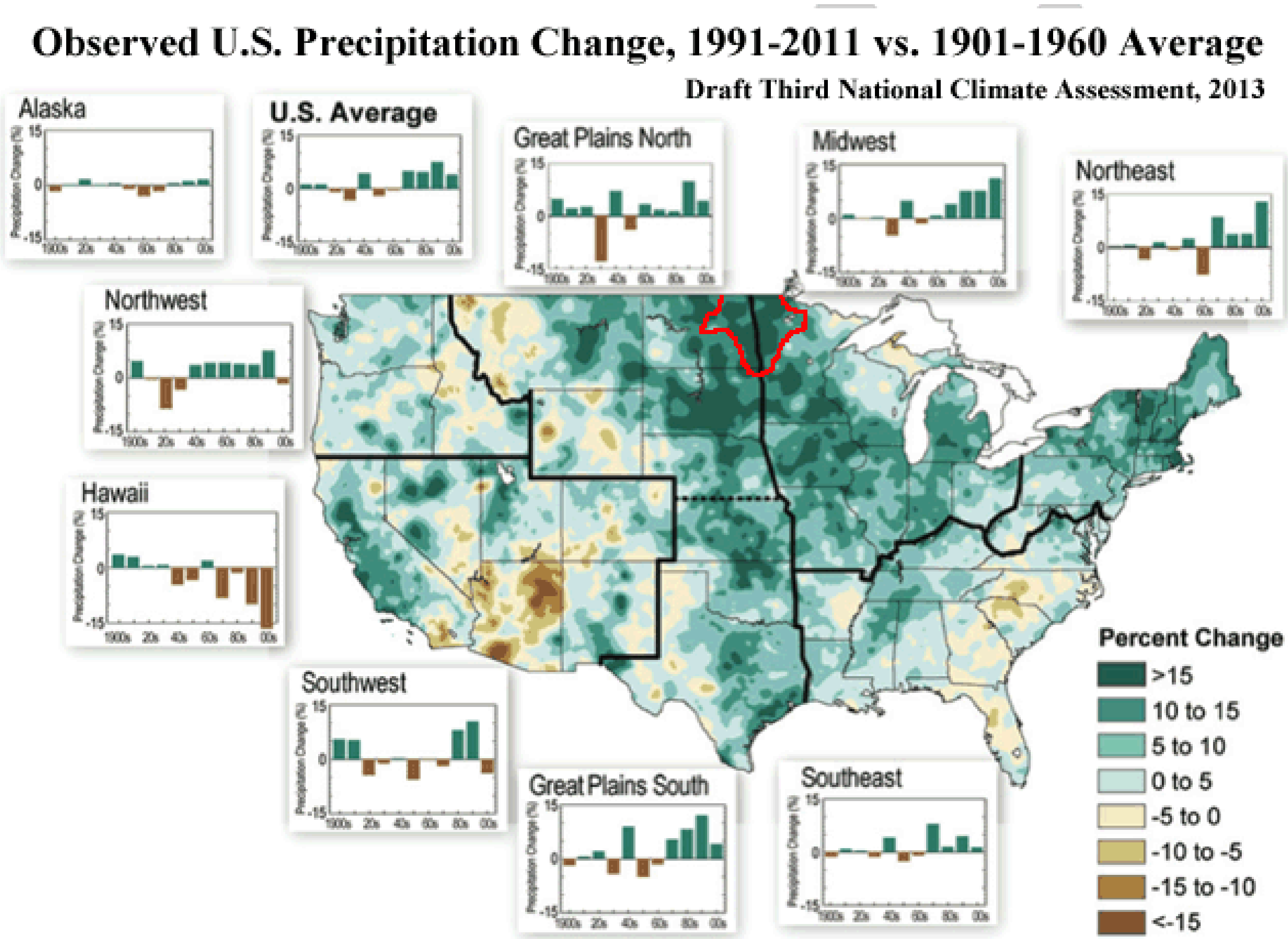
Change in survival rates of insect pests, parasites, plant pathogens, and soil microbes

Increased number of freeze/thaw cycles/ more intermittent snow cover during winter

Longer growing seasons

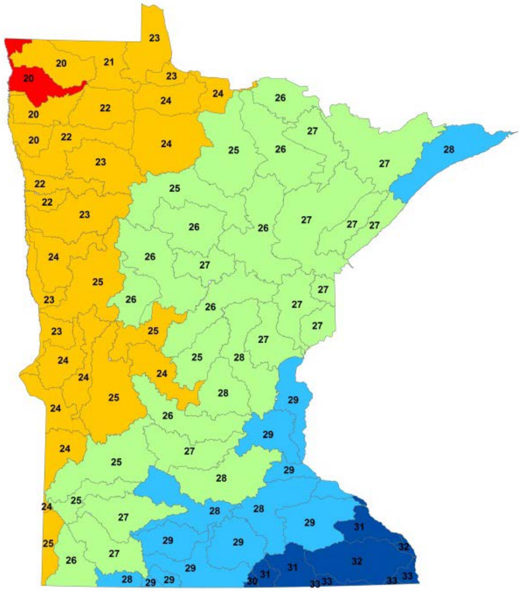
More Growing Degree Days, especially spring and autumn


Statewide Precipitation Ranks
January–December 2015
Period: 1895–2015
69
29
63
75
42
100
71
49
101
103
68
67
28
75
65
25
90
111
115
71
4
96
102
49
116
110
13
113
107
93
110
87
118
117
98
114
100
98
117
121
117
118
95
87
95
121
109
58
National Centers for Environmental Information
Tue Jan 5 2016
Record Driest (1)
Much Below Average
Below Average
Near Average
Above Average
Much Above Average
Record Wettest (121)

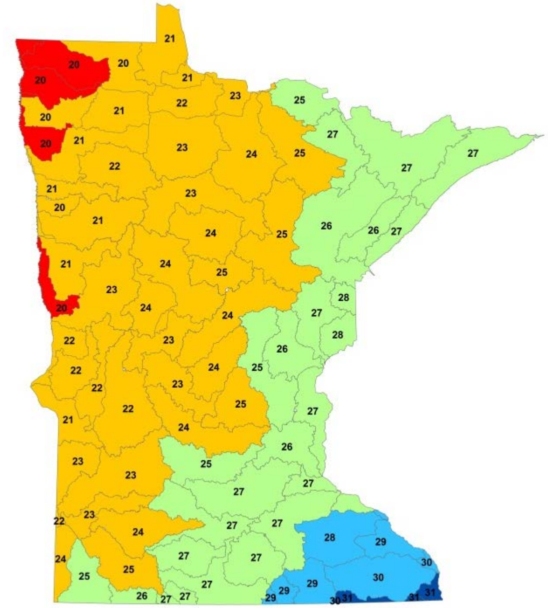


Geographic Disparity in Precipitation Change-IPCC 2013

Average Annual PPT 1891-1920, in



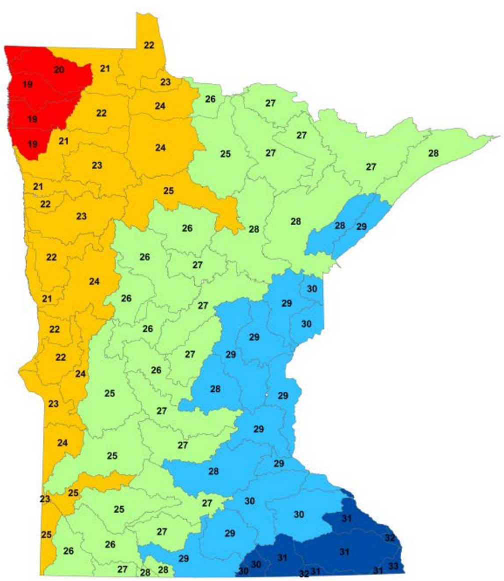
Average Annual PPT 1921-1950, in



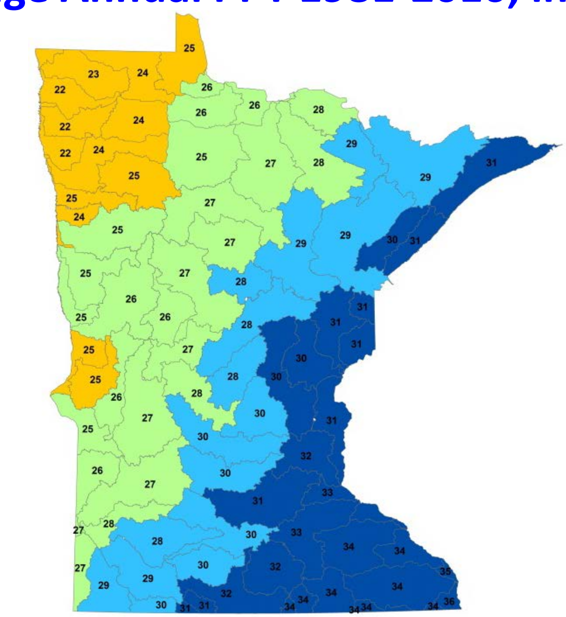
Avg. Annual PPT, in

- < 20
- 21 - 25
- 26 - 28
- 29 - 30
- > 30

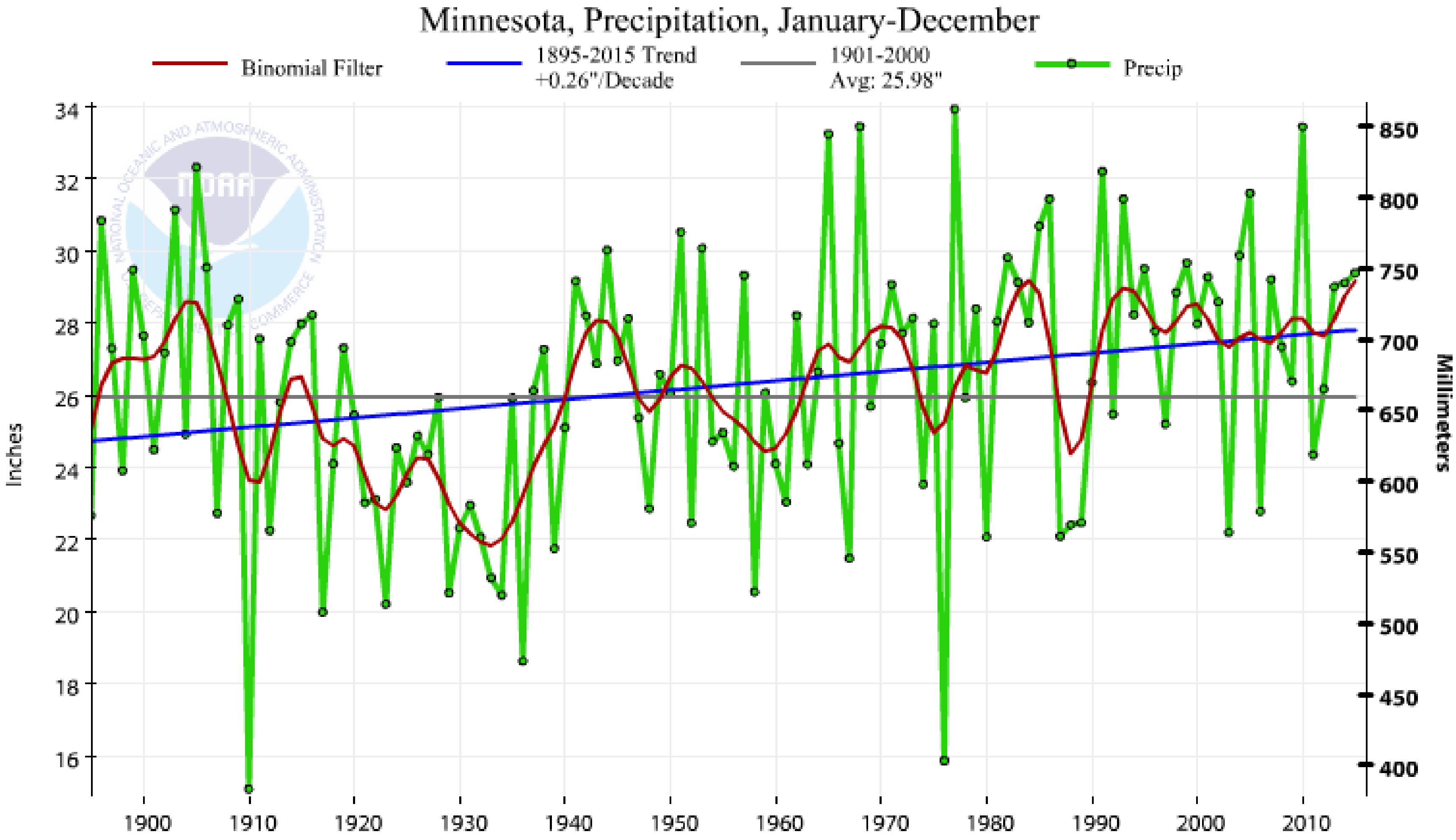
Average Annual PPT 1951-1980, in



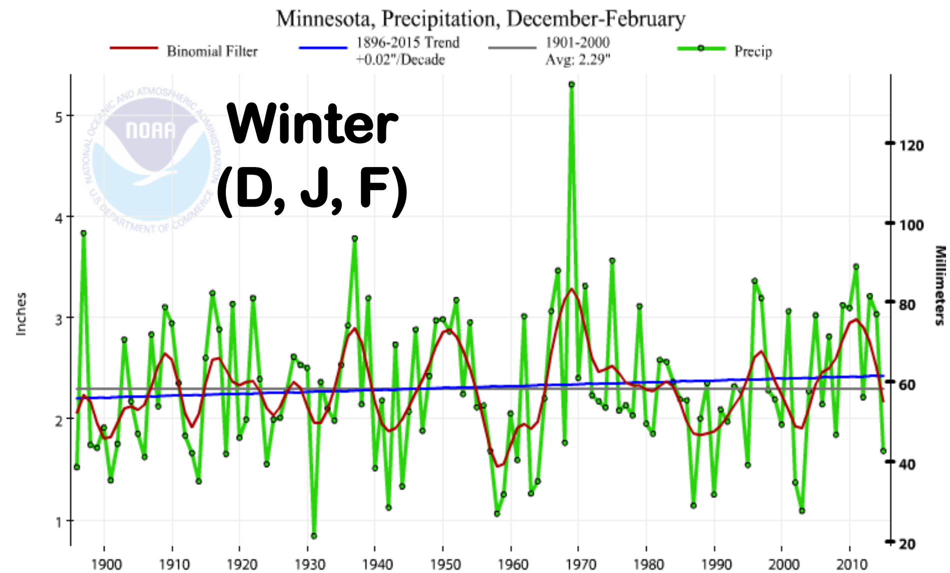
Average Annual PPT 1981-2010, in

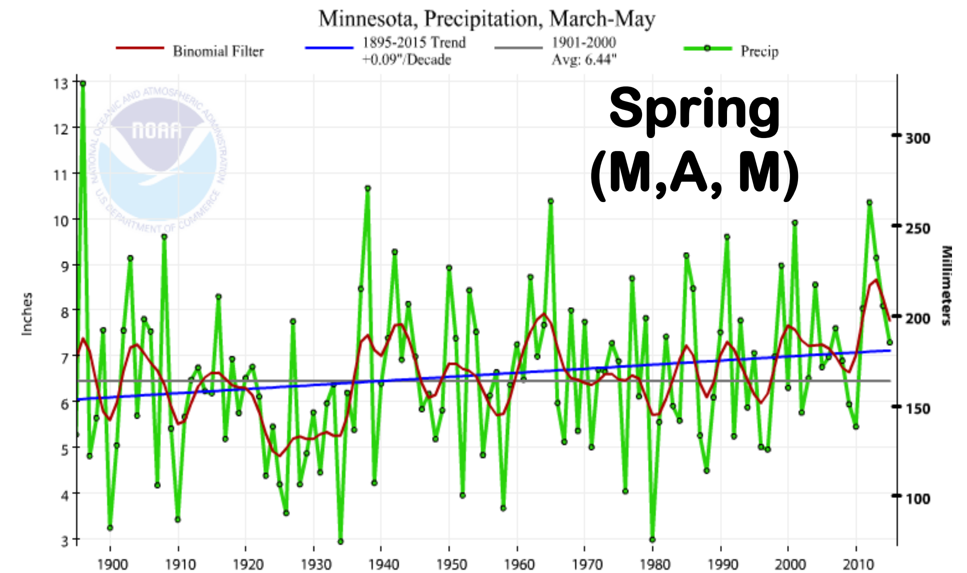


Source: MN-SCO

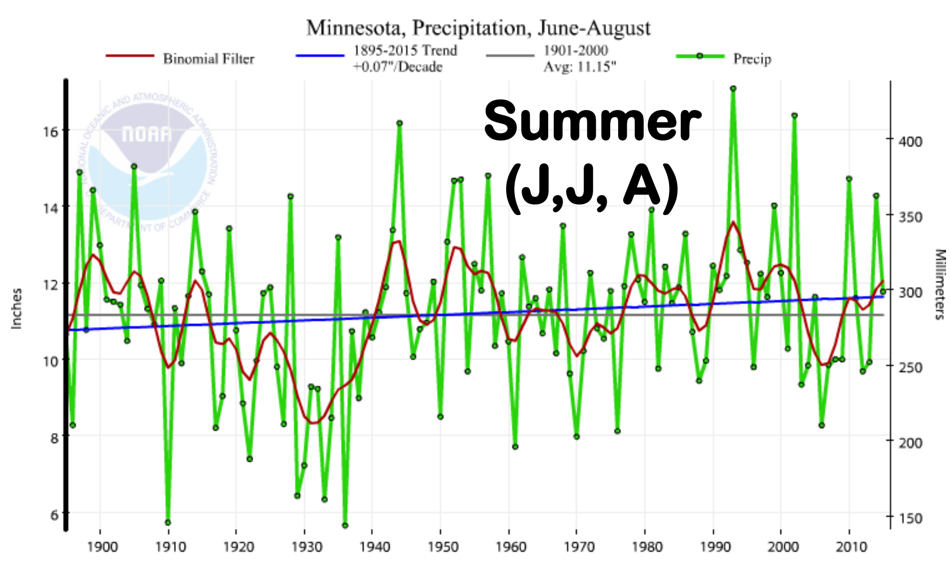


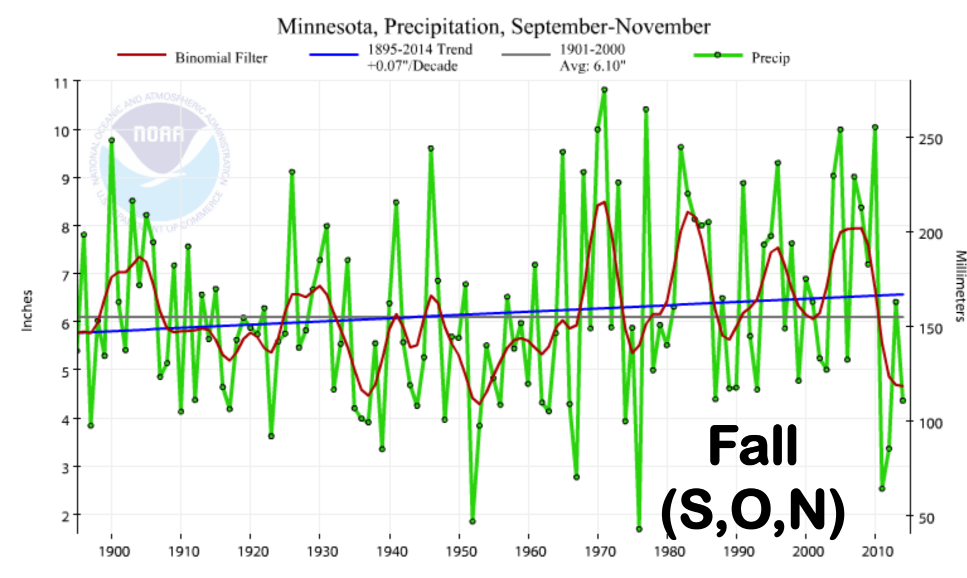
Trend in annual precipitation for MN





Statewide Seasonal Trends in Minnesota Precipitation





Change in Annual Precipitation "Normals" at Faribault, MN

PERIOD	AMOUNT (IN.)
1921-1950	24.80″
1931-1960	27.06″
1941-1970	29.49″
1951-1980	30.30″
1961-1990	31.00″
1971-2000	31.67″
1981-2010	32.63″

31 percent increase since 1921-1950 period

Extremes: 10.81″ in 1910, 42.20″ in 1951

Change in Annual Precipitation Normals at Winona, MN

PERIOD	AMOUNT (IN.)
1921-1950	30.34”
1931-1960	30.57”
1941-1970	31.29”
1951-1980	32.81”
1961-1990	34.19”
1971-2000	34.61”
1981-2010	35.12”

16 percent increase since 1921-1950 period

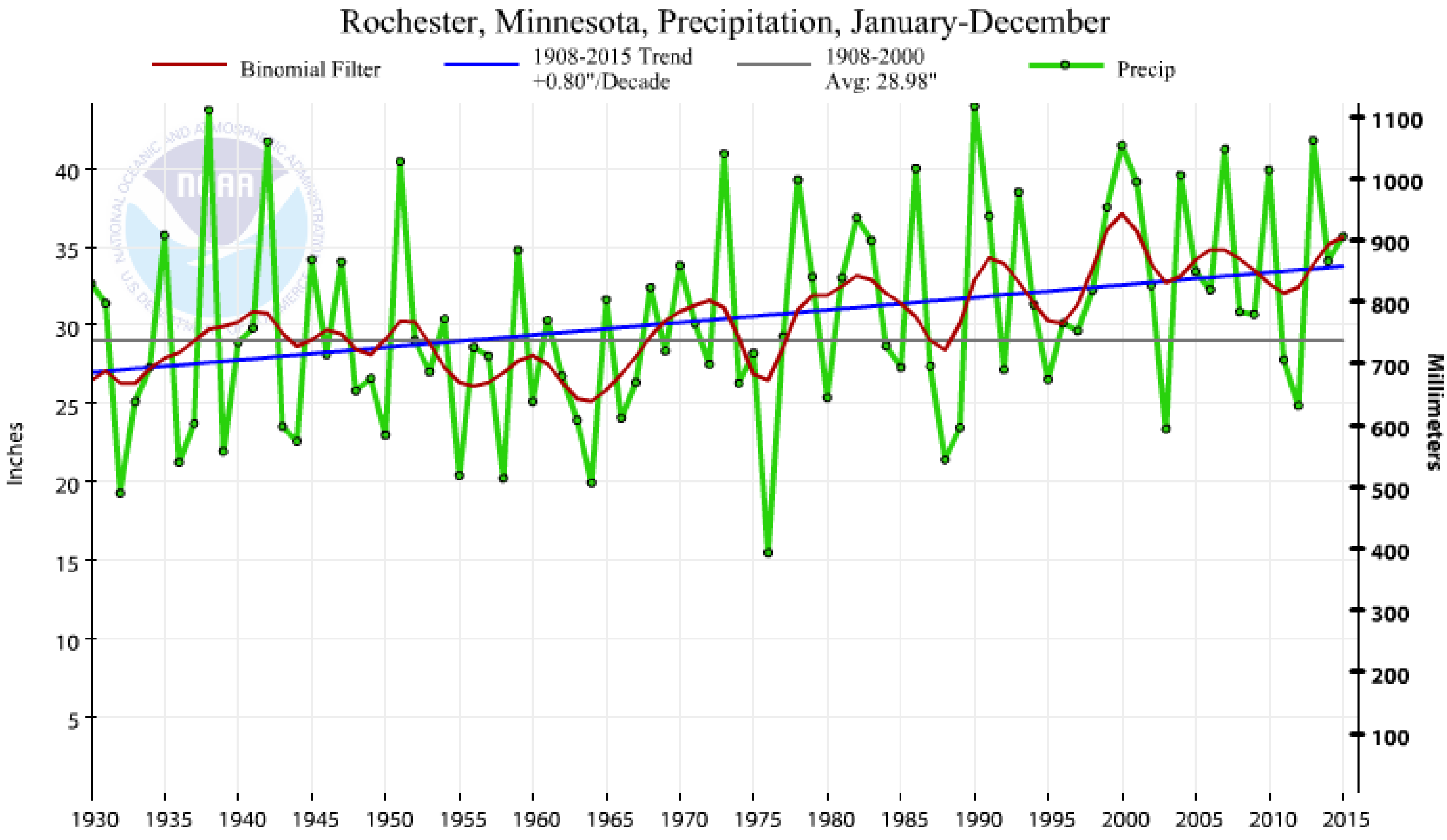
Extremes:

Trends in average annual precipitation for Rochester, MN

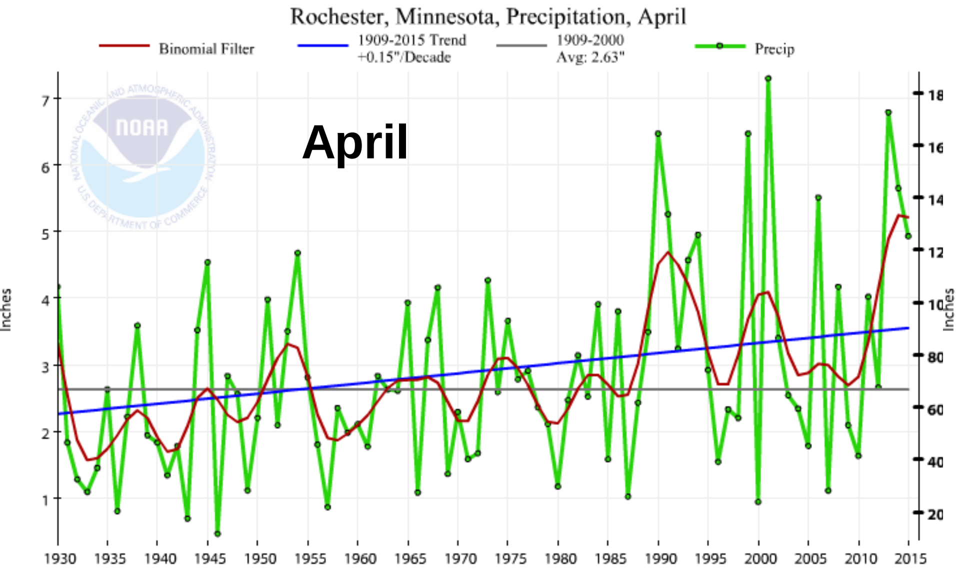
Period of Record	Ave Min Temp in Deg. F
1931 - 1960	28.48”
1941 - 1970	28.52”
1951 - 1980	28.55”
1961 - 1990	29.67”
1971 - 2000	31.44”
1981 - 2010	33.02”
1991 – 2015*	33.52”

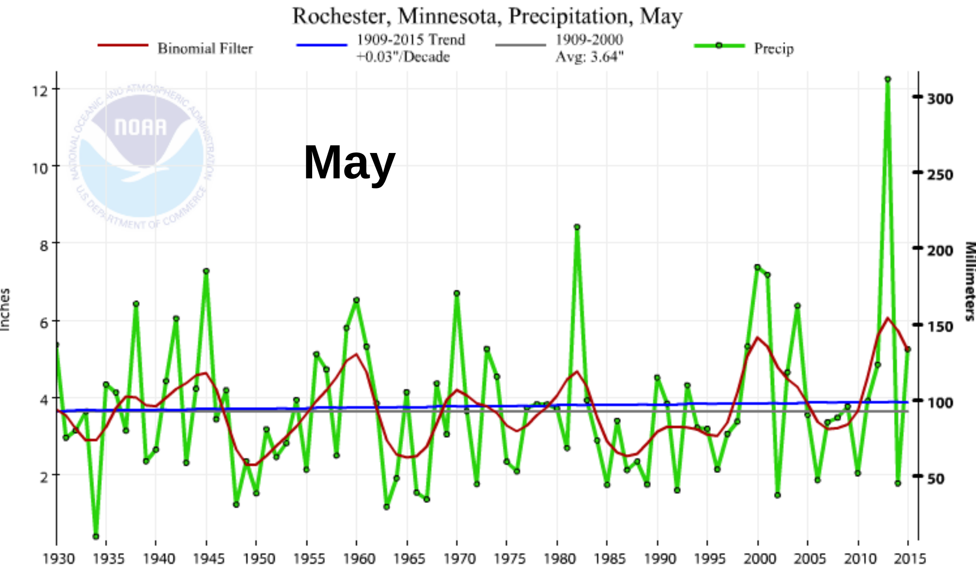
16 percent increase since 1931-1960

Extremes: 11.86” in 1910, 43.94” in 1990

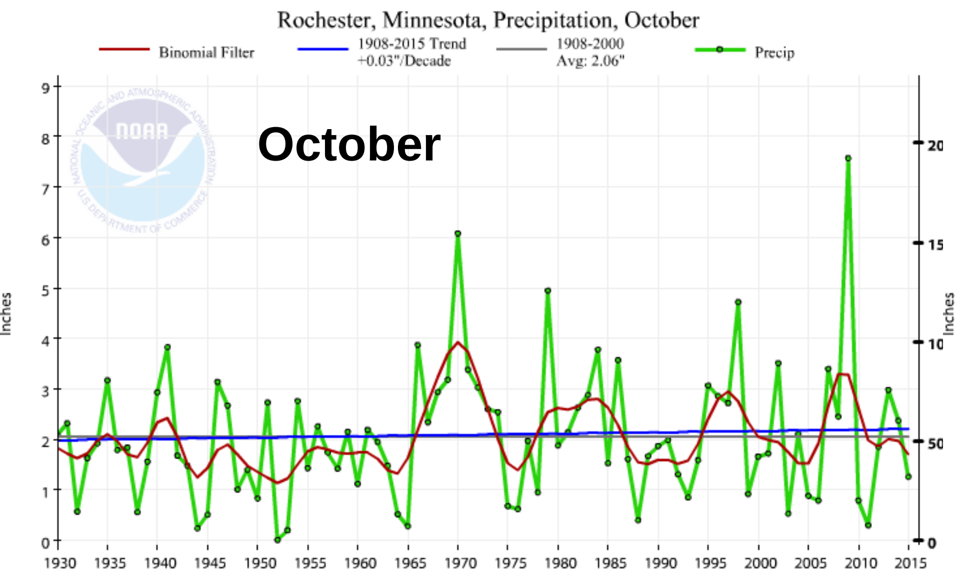


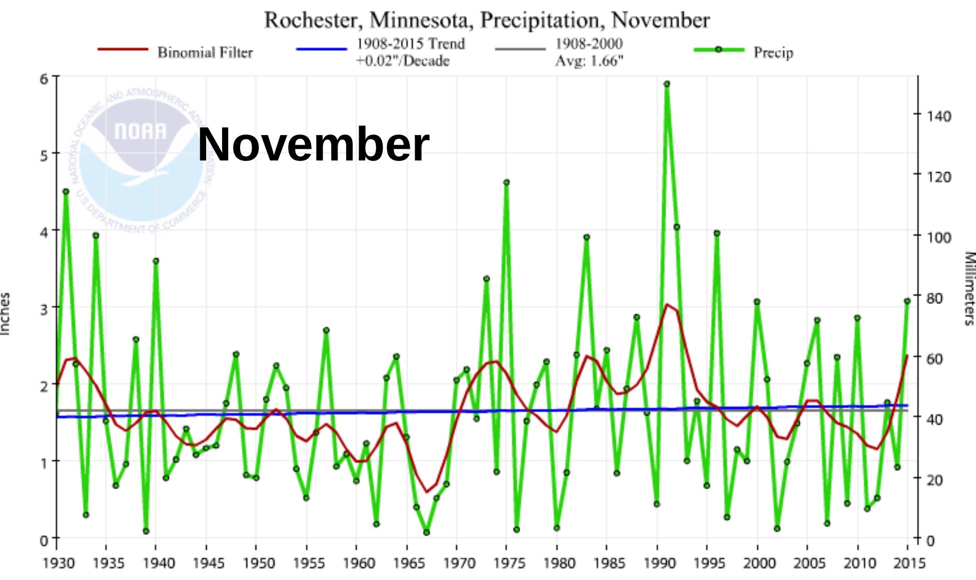
Long term annual precipitation trend at Rochester is about an 8 inch increase per century, on of the highest in the state.

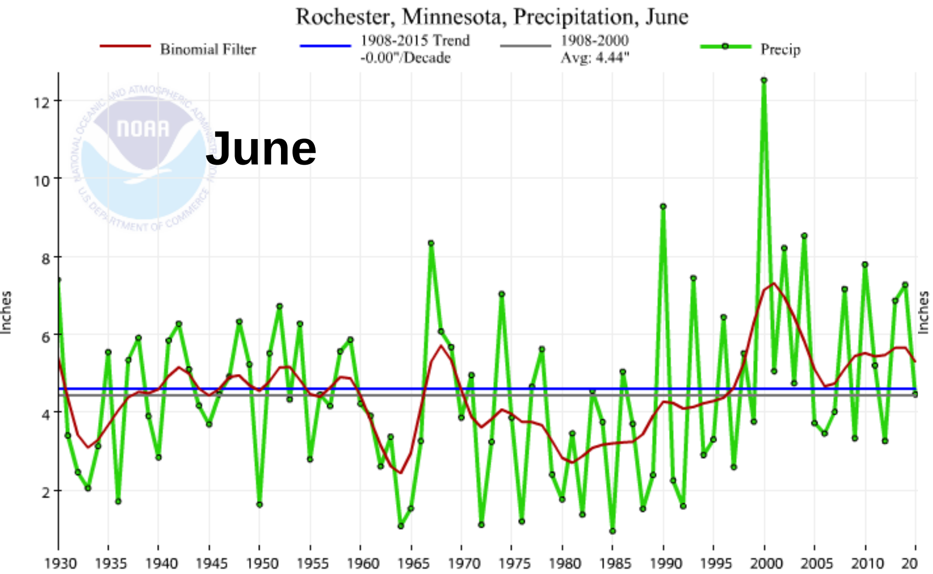


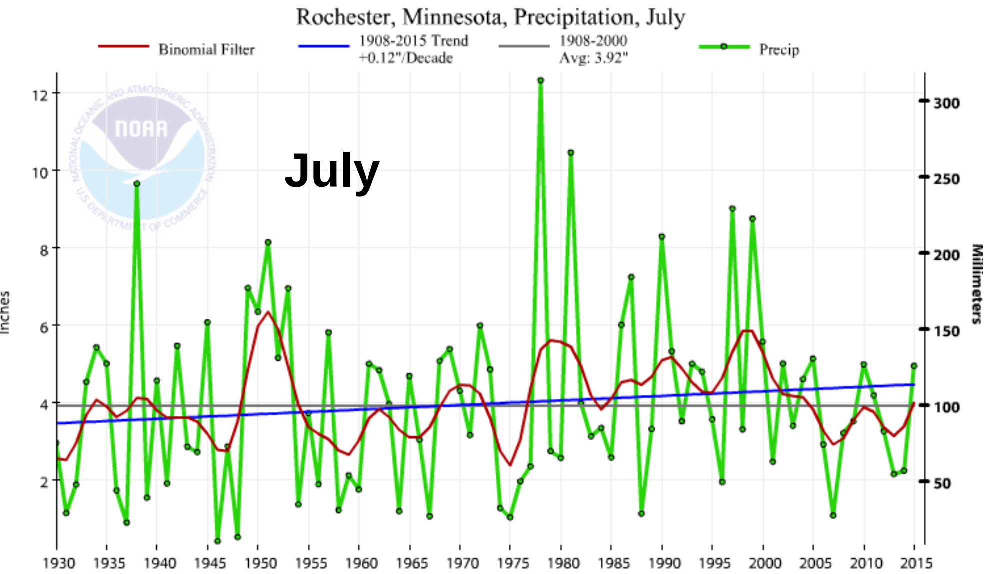


Precipitation trends for field working months at Rochester, MN

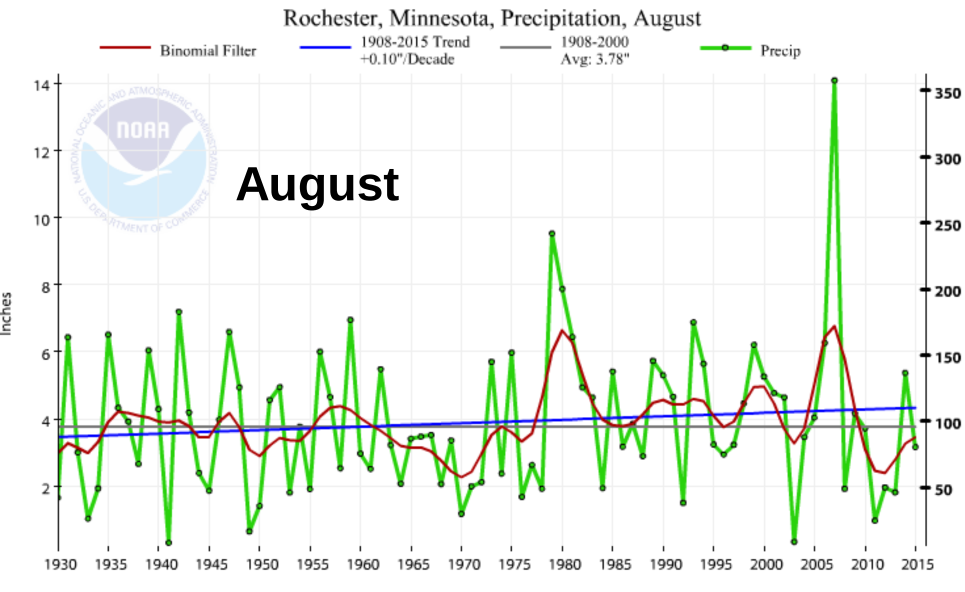


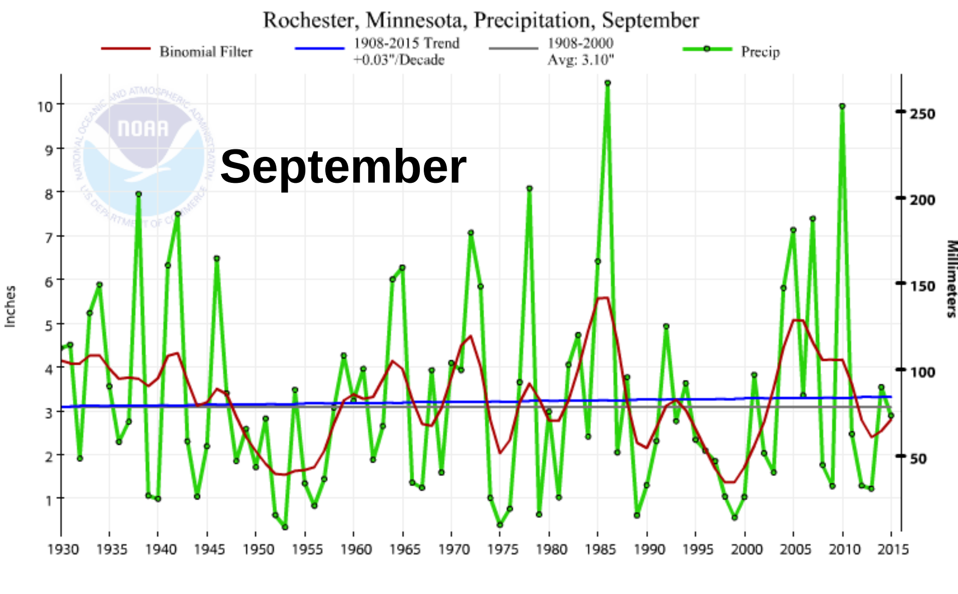


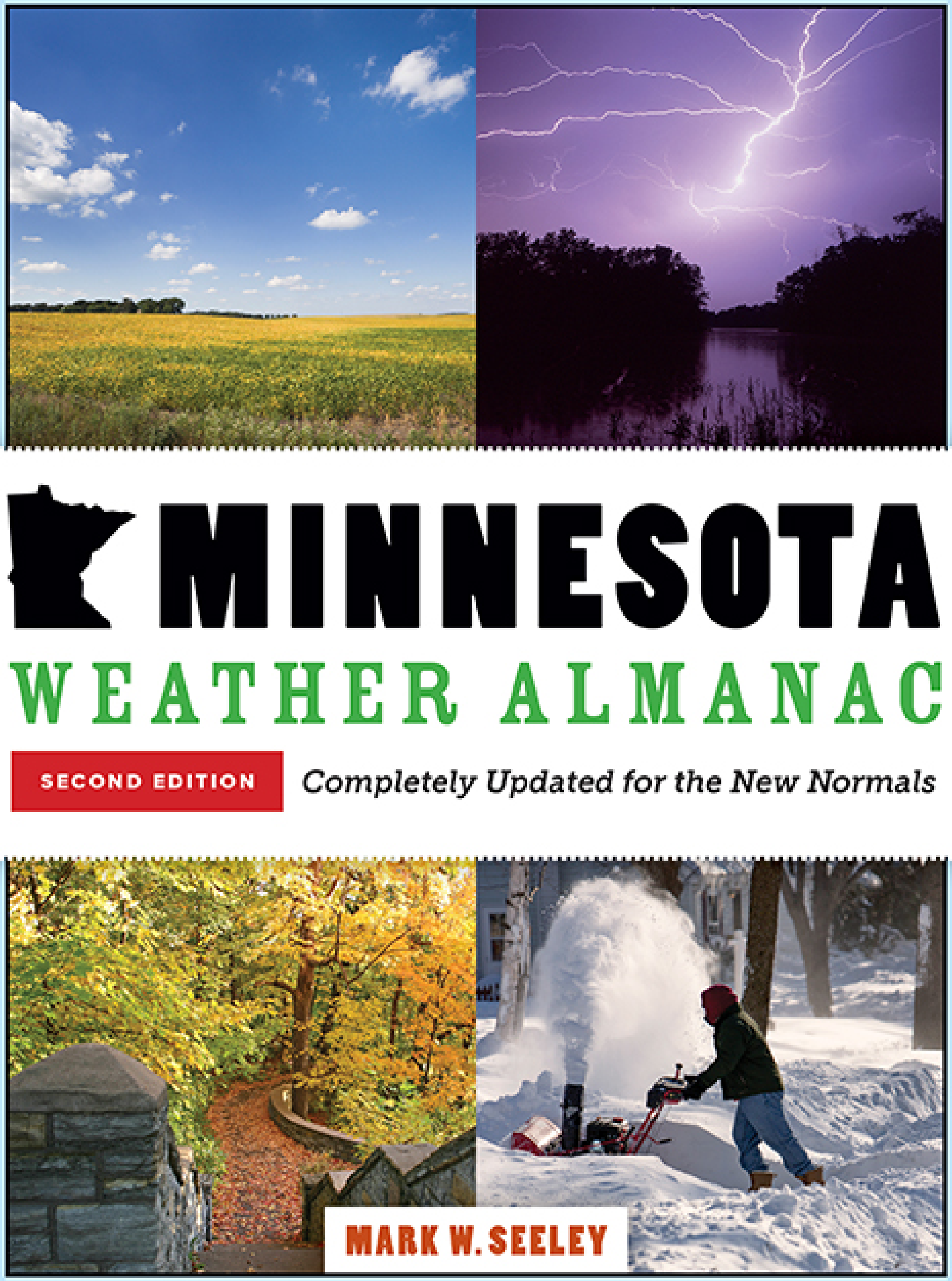




Precipitation trends during the growing season months at Rochester, MN







Measurable Attributes of Precipitation

Quantity

Type (liquid,frozen)

Intensity (9-15")

Frequency (74-145 days)

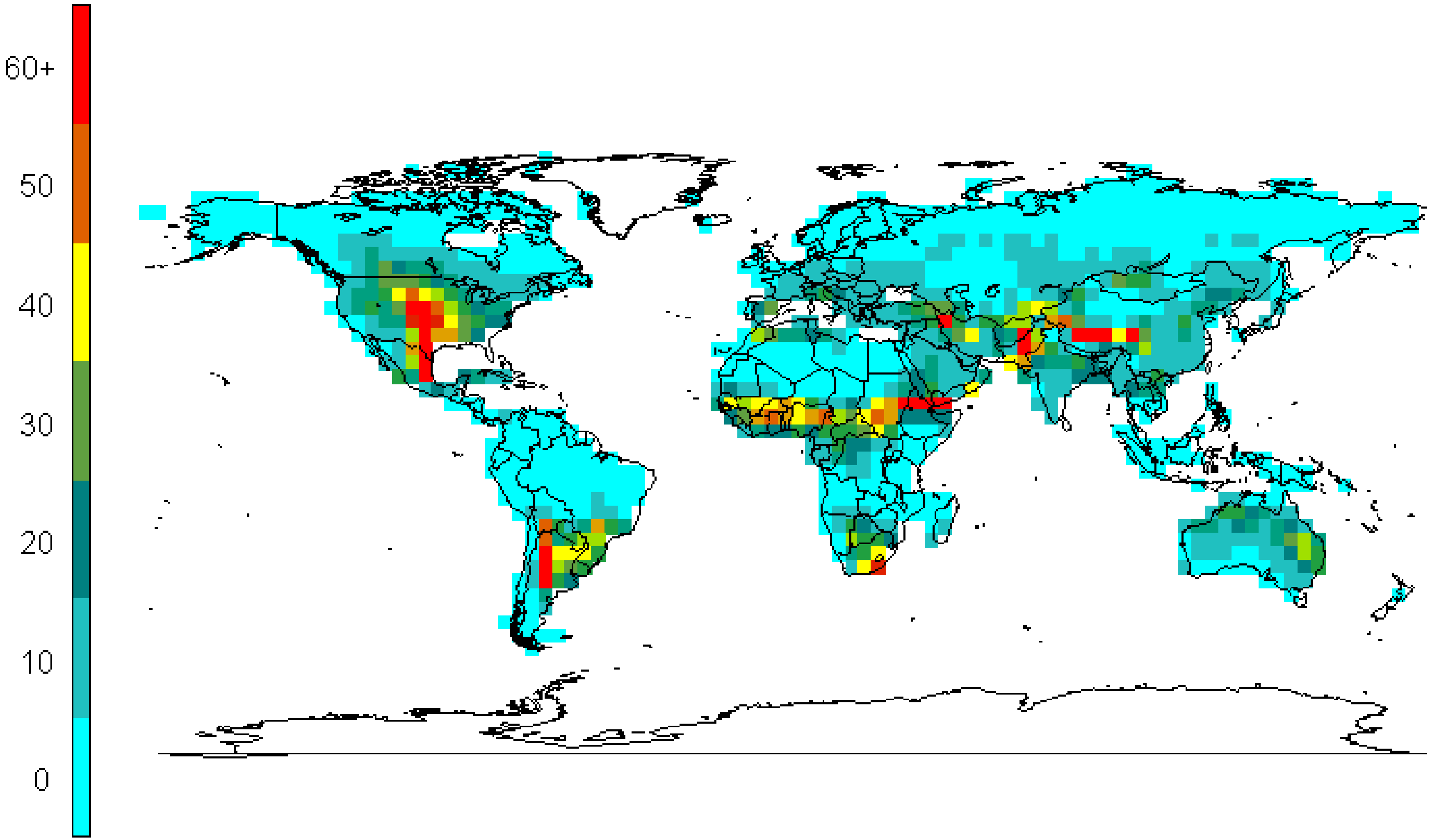
Duration (10 days)

Seasonality (shifting)

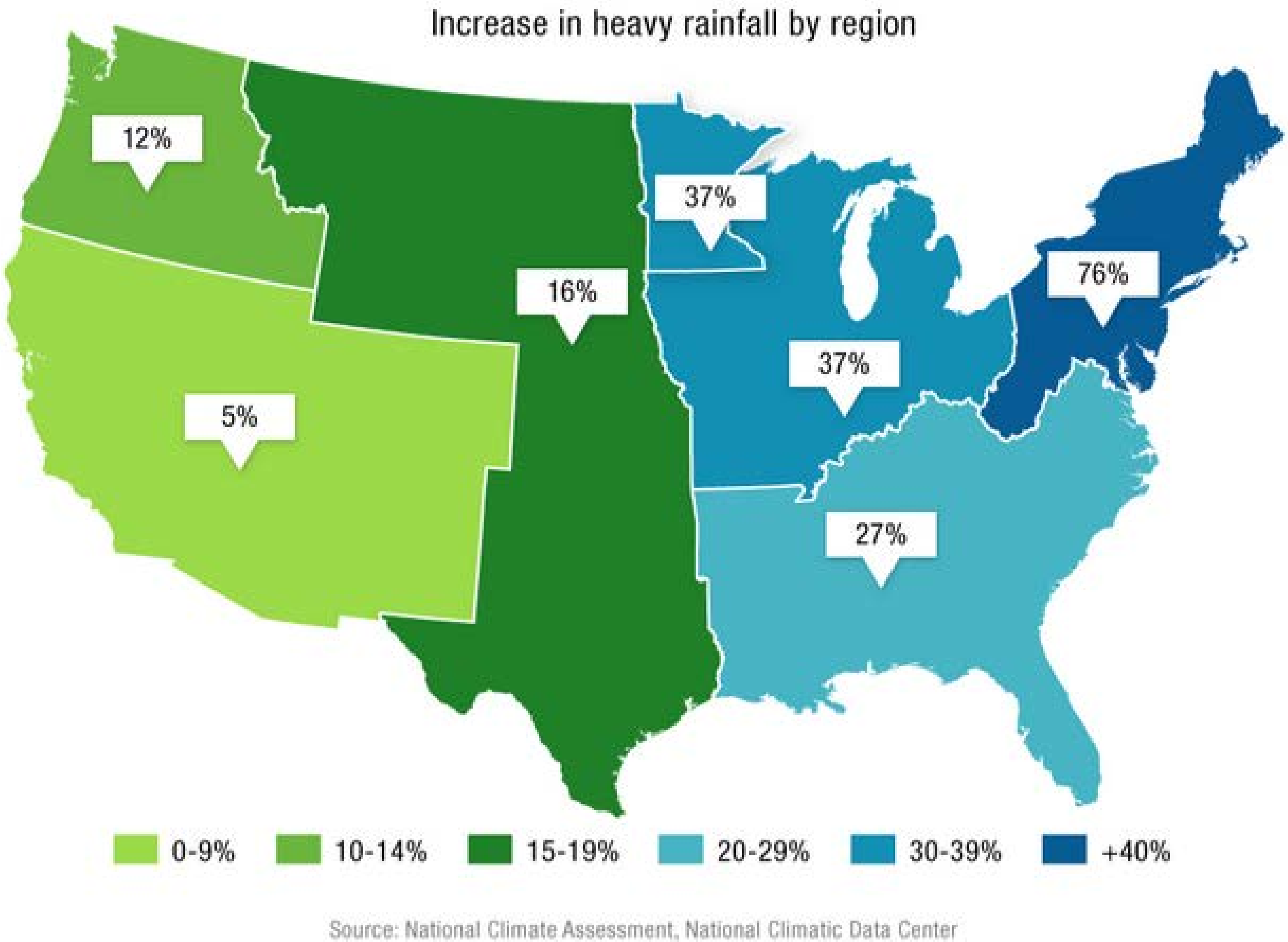
Landscape relationship

(interception, absorption, runoff, evaporation)

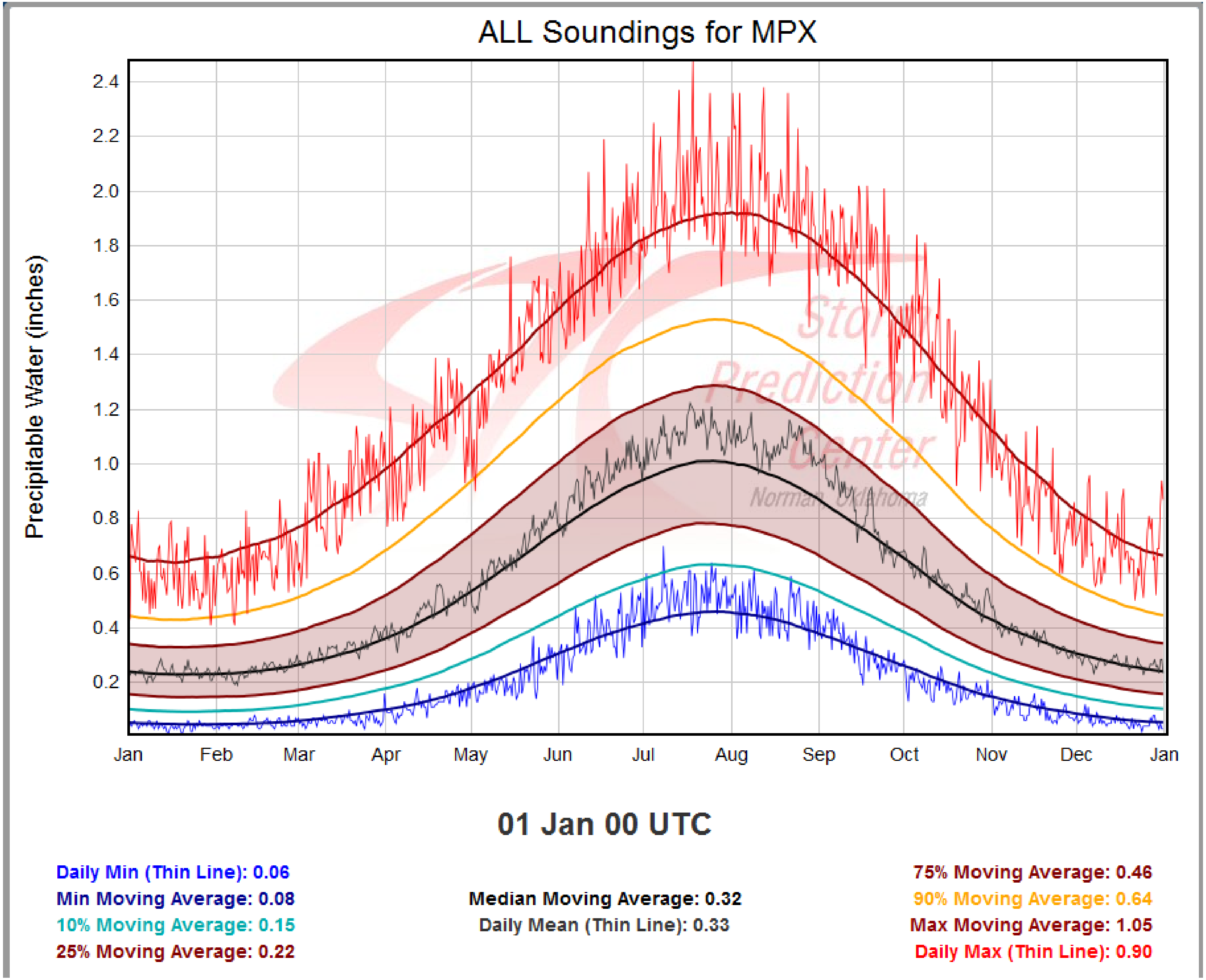
Days per Year with Favorable Severe Parameters



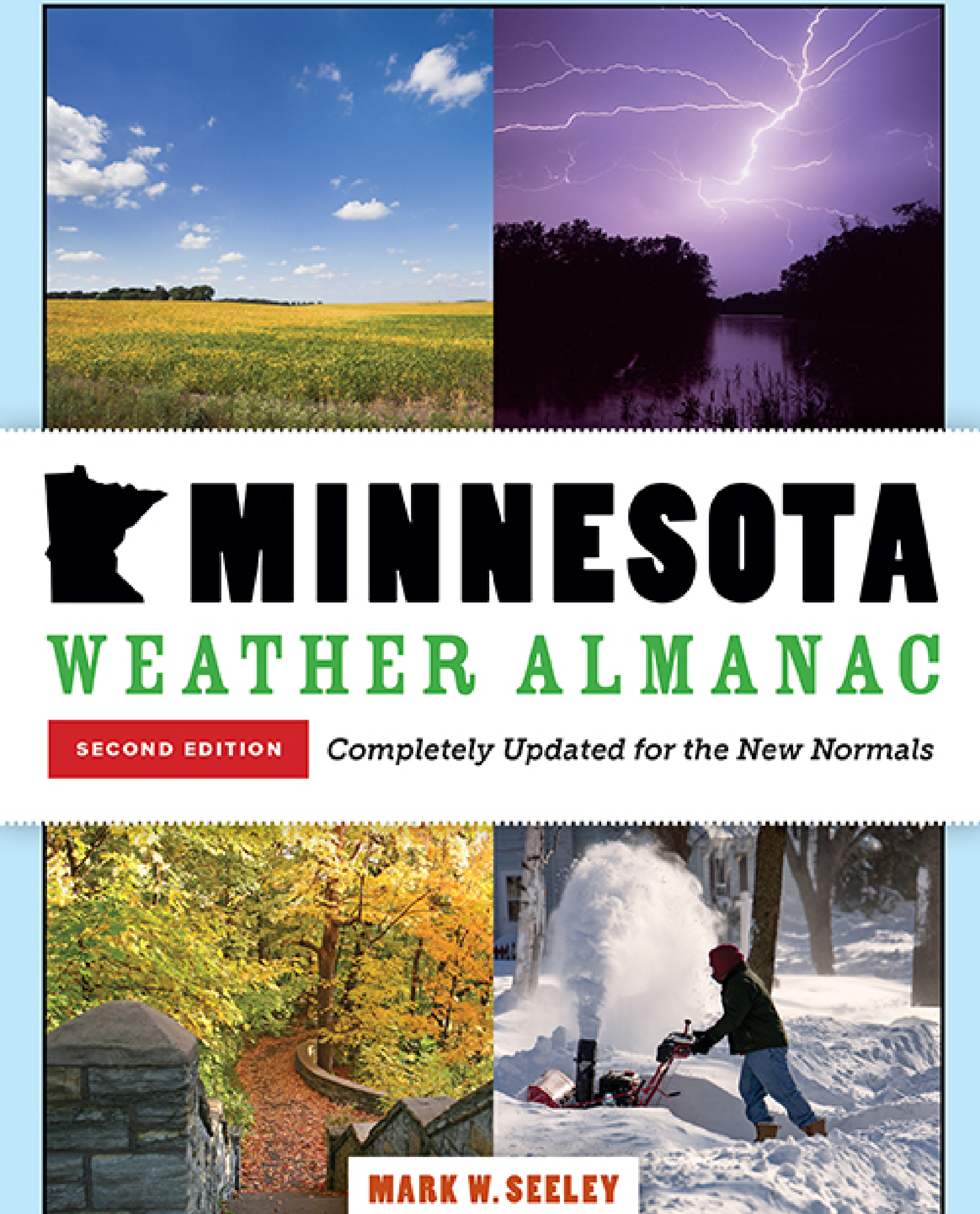
from Brooks et al, NOAA-SSL, 2012



Increase in heavy rainfall by region
12%
16%
37%
37%
76%
5%
27%
0-9%
10-14%
15-19%
20-29%
30-39%
+40%
Source: National Climate Assessment, National Climatic Data Center



Radiosonde history of PW at MSP since 1948



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,
2005-2007 2008
2009, 2010, 2011,
2012, 2013

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)**

Observations – Minnesota Trends

Minnesota Mega-rain Events

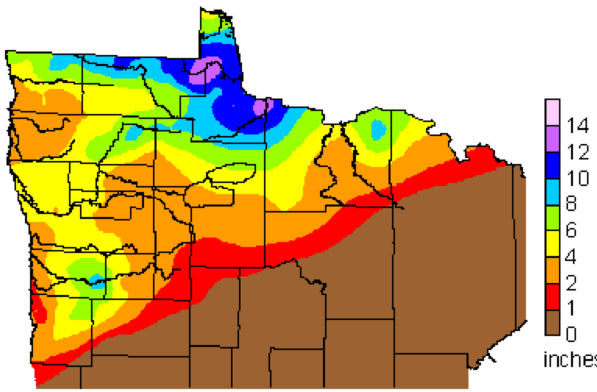
August 6, 1866, Southern Minnesota
July 17-19 1867, Central Minnesota
July 20-22, 1909, Northern Minnesota
September 9-10, 1947 Iron Range
July 21-22, 1972, Grand Daddy Flash Flood
June 28-29, 1975, Northwest Minnesota
July 23-24, 1987, Twin Cities Superstorm
June 9-10, 2002, Northern Minnesota
September 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

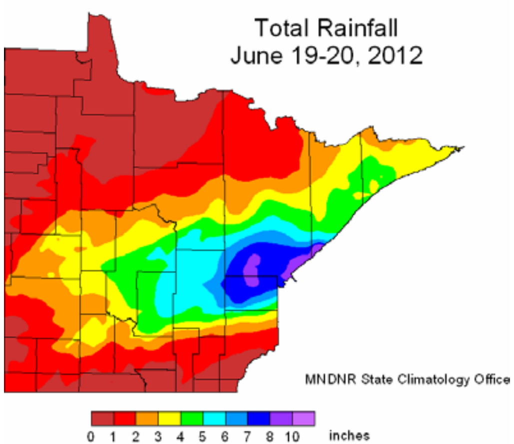
Shift in Precipitation Recurrence Intervals

Mega Rains since 2002

Rainfall Totals - June 9 and 10, 2002

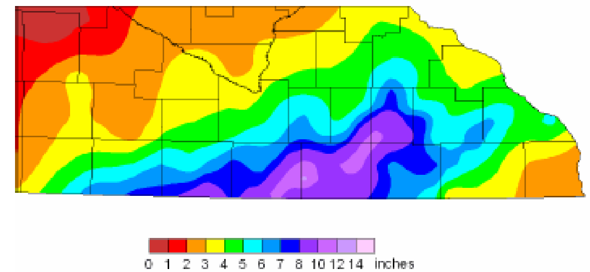


State Climatology Office - DNR Waters

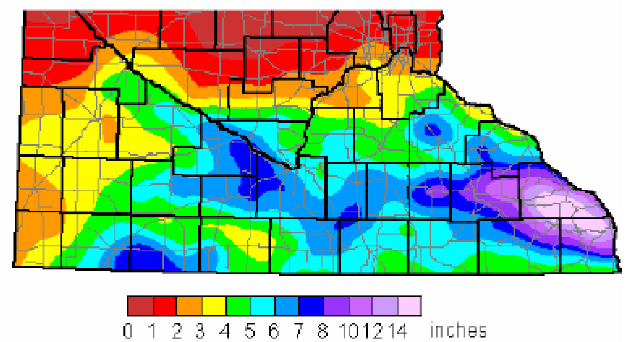


'1000-yr (approx.) events' in Southern Minnesota in the last decade.

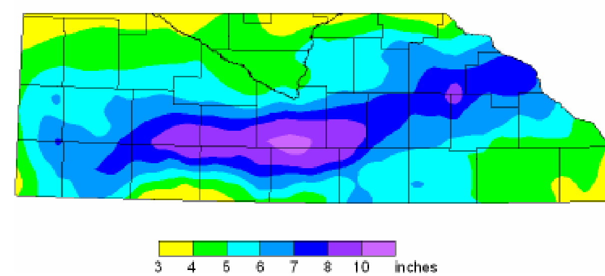
September 14-15, 2004



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 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.

Consequences of Changes in Precipitation Quantity and Character

Altered irrigation, tile drainage, runoff, sediment, and shoreline management

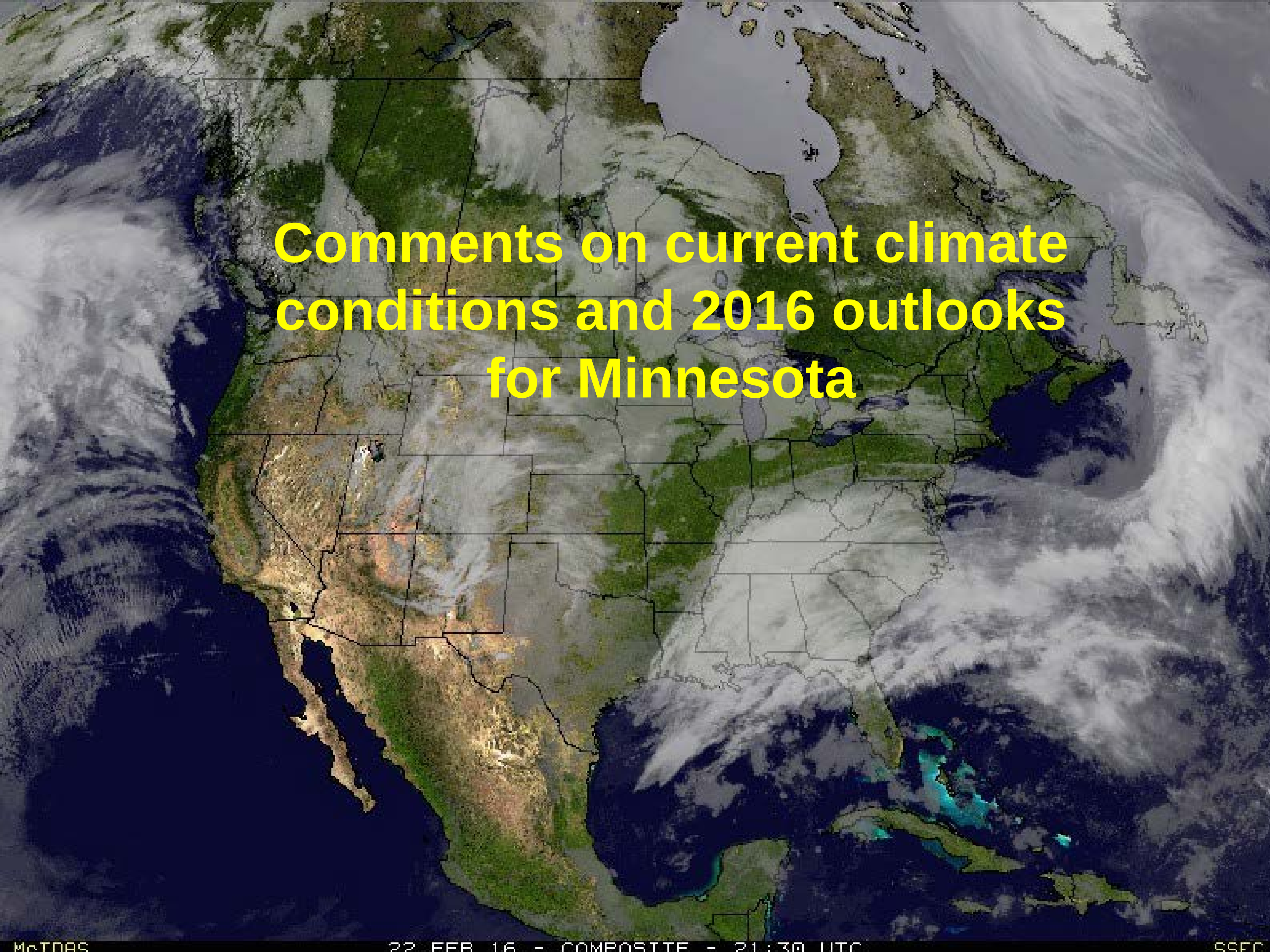
Change in storm sewer runoff and culvert designs

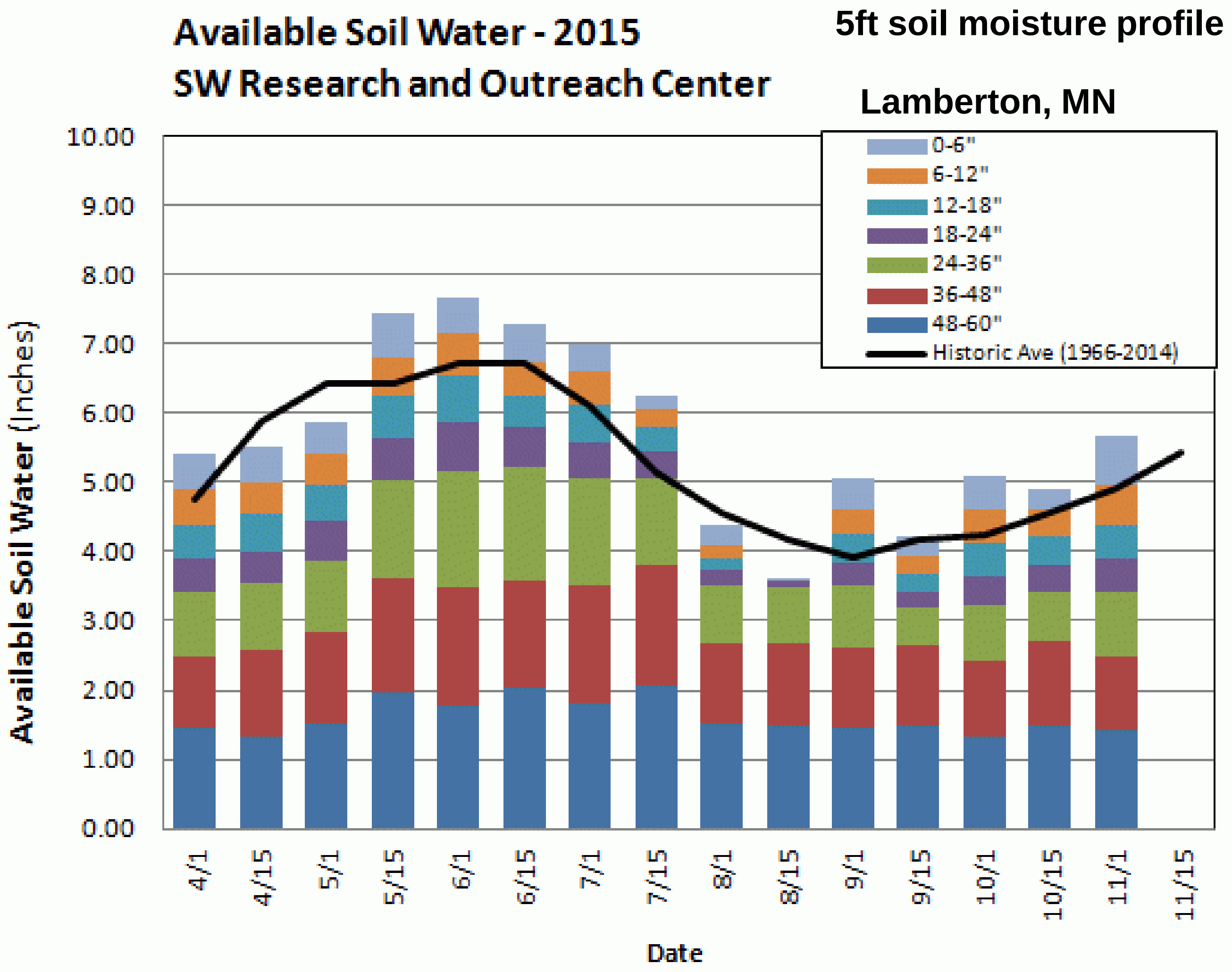
Mitigation of soil erosion via buffers, contours, and cover crops

Mitigation of flooding potential

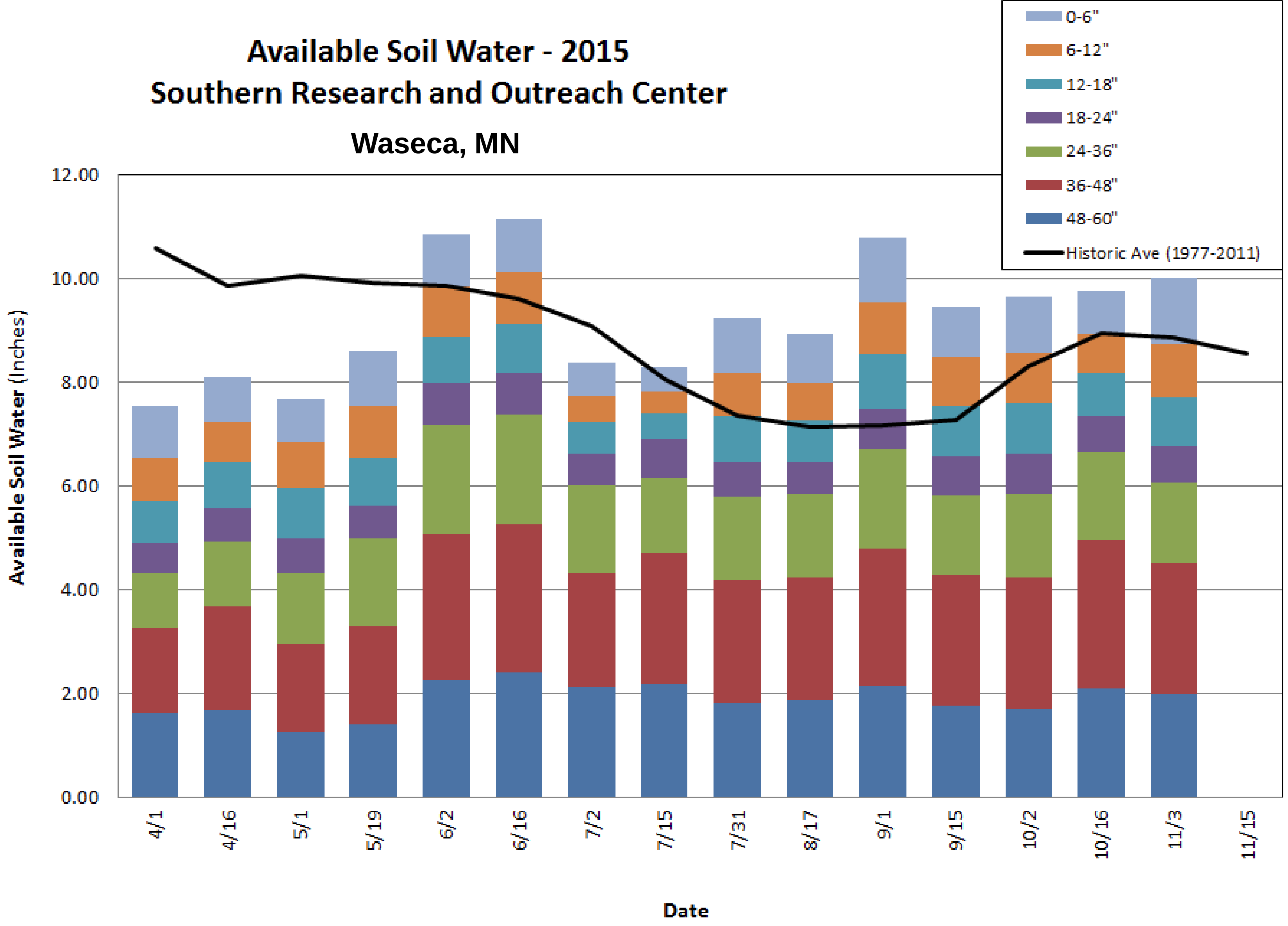
Impact on insurance risk and claims

Comments on current climate conditions and 2016 outlooks for Minnesota

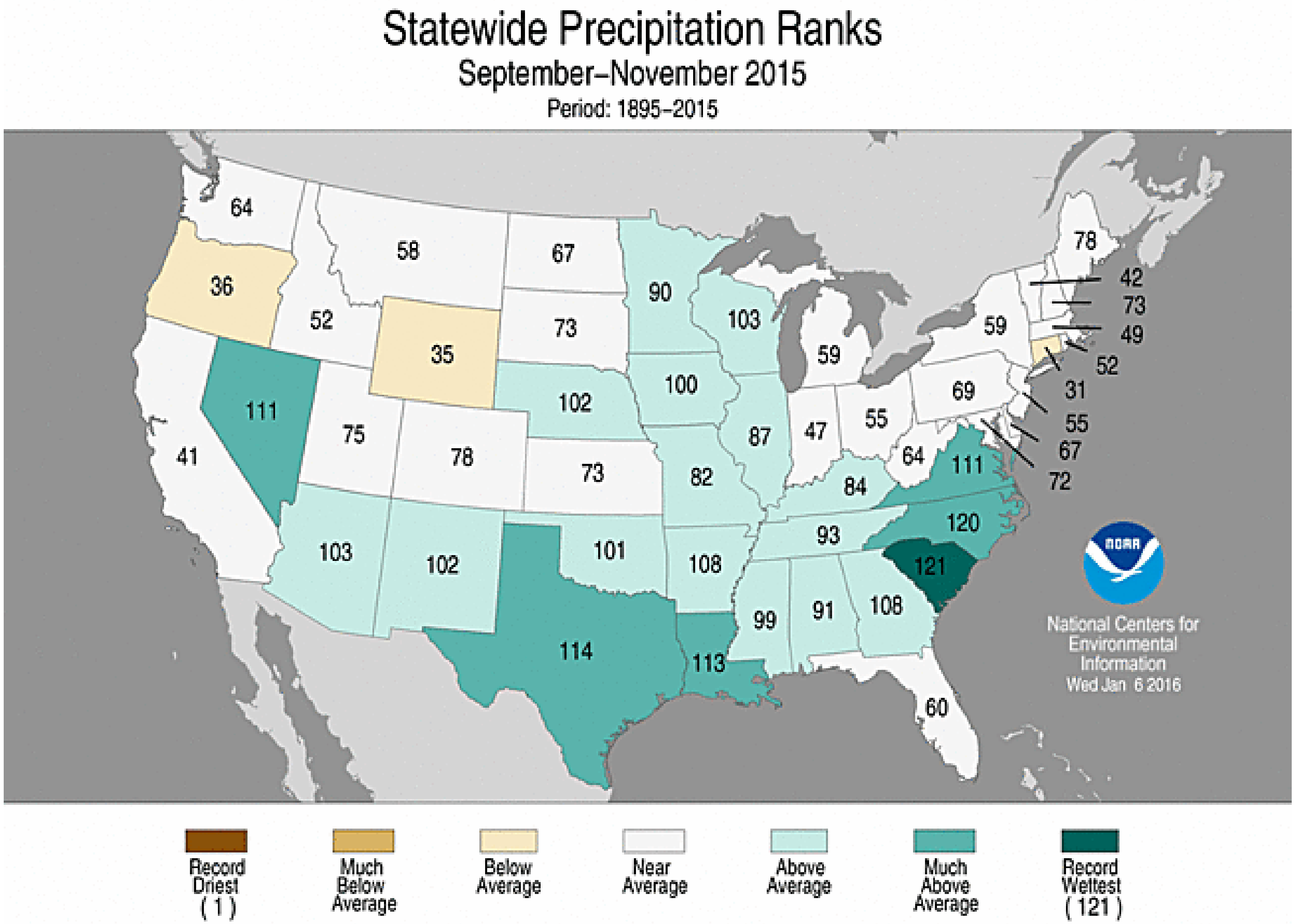




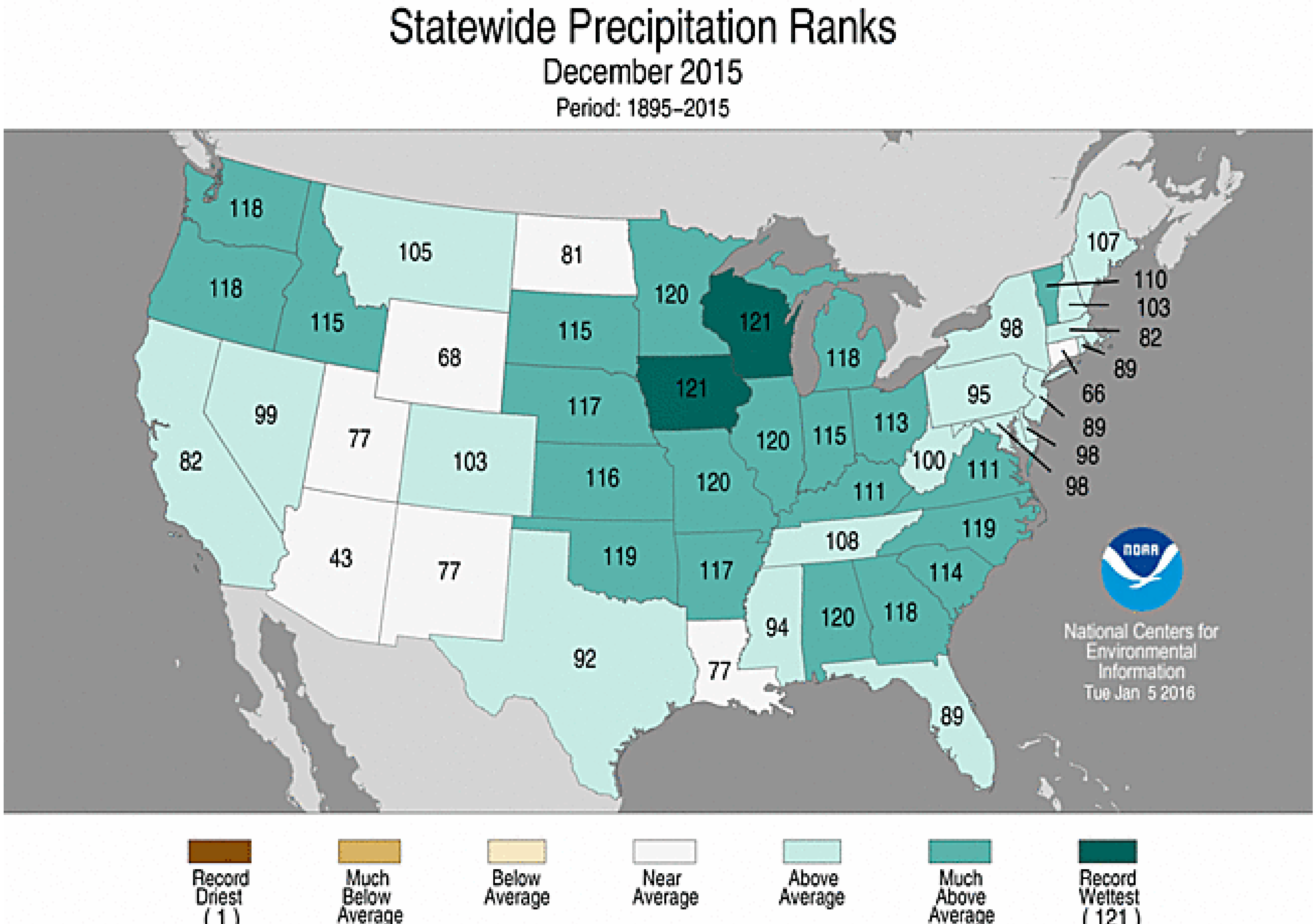
Current Frost Depths:
6” at Pipestone
8” at Lamberton
12” at Waseca
Average historical values for mid-February range from 25” to 35”



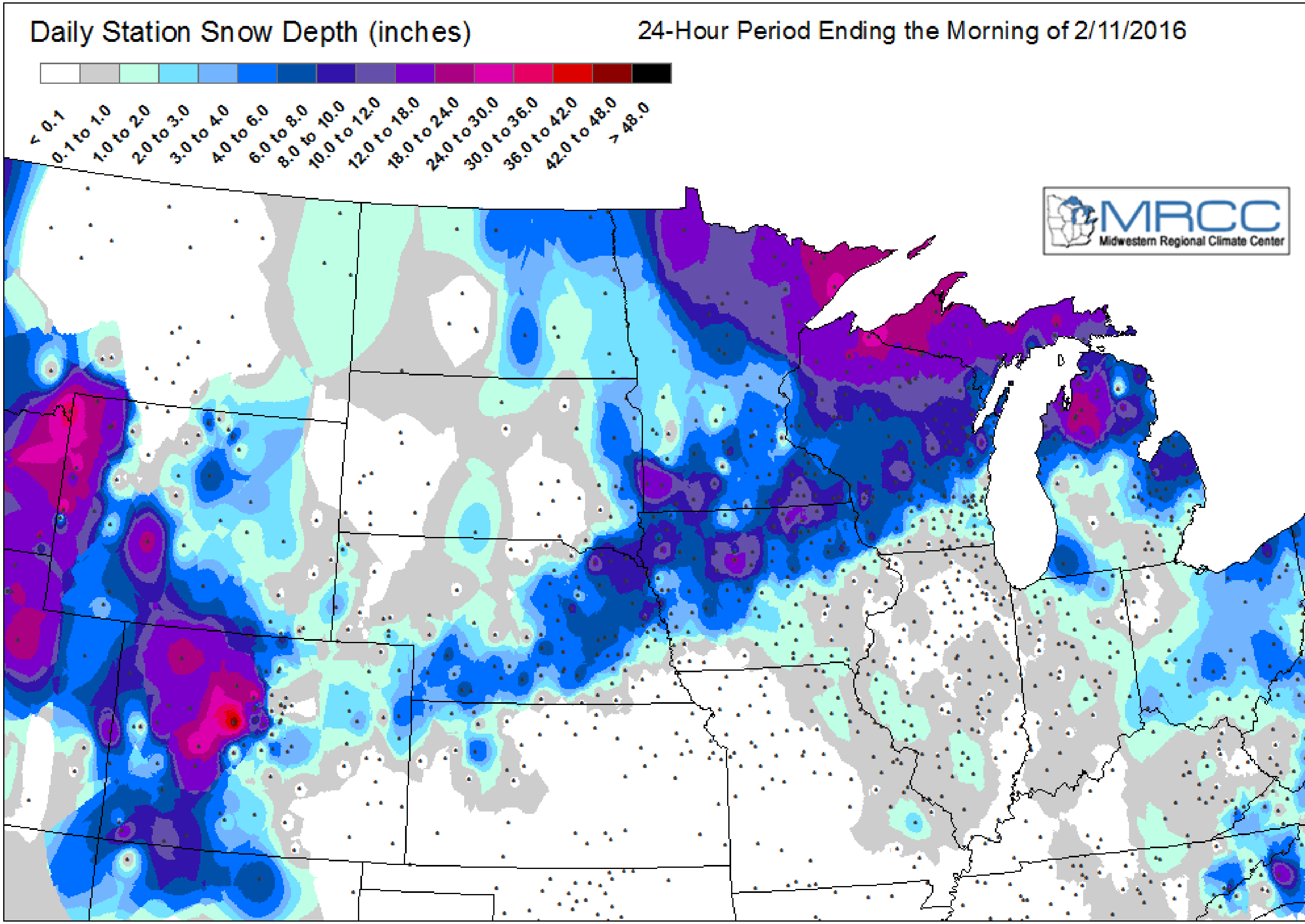
5 ft soil moisture profile measurements



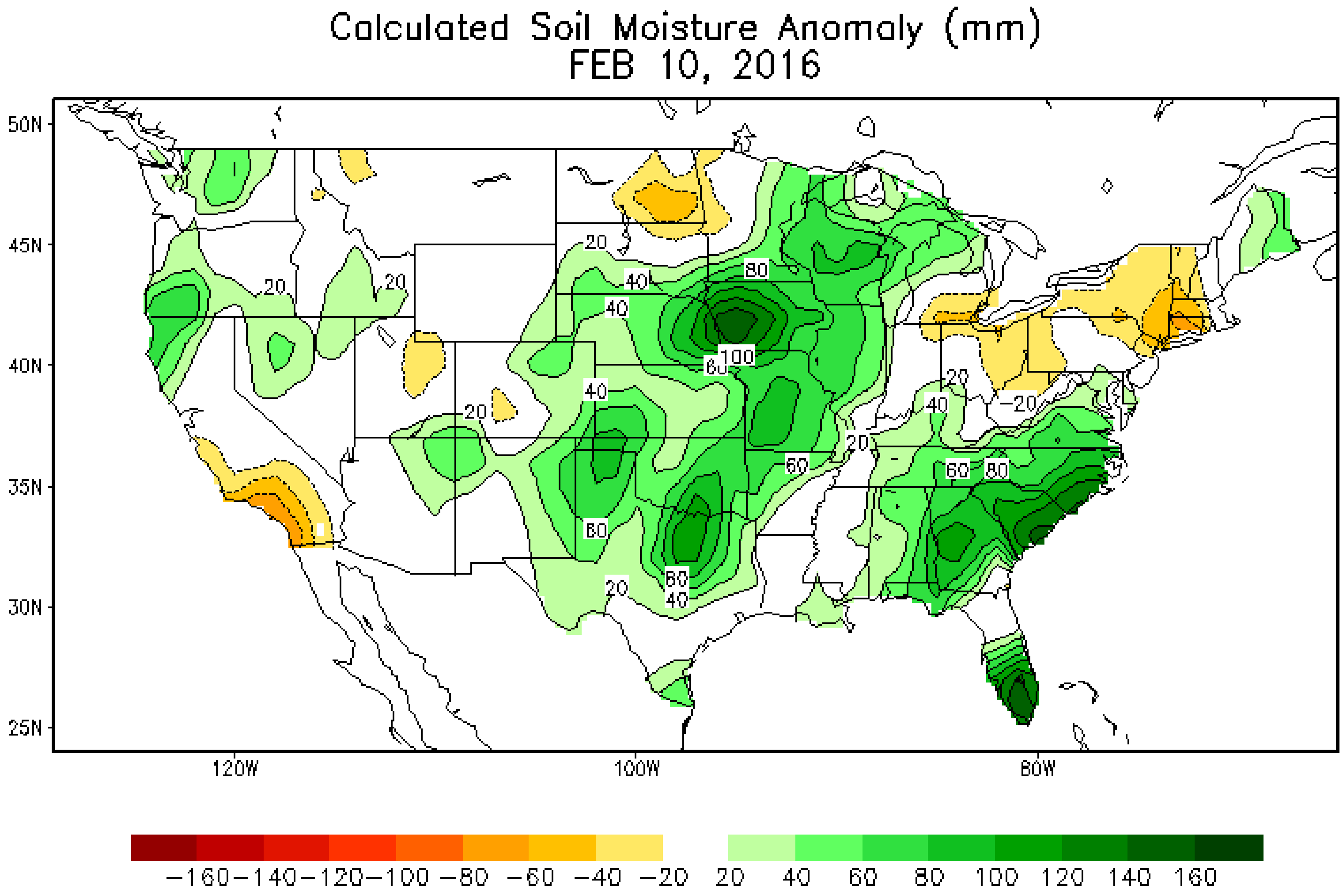
Wetter than normal autumn in Minnesota with 2-3 extra inches of precipitation across many counties



Second wettest December of all-time in Minnesota, trailing only 1968. Many areas received more rain than snow and some reported over 3 inches.



Regional snow depth map, Feb 11, 2016

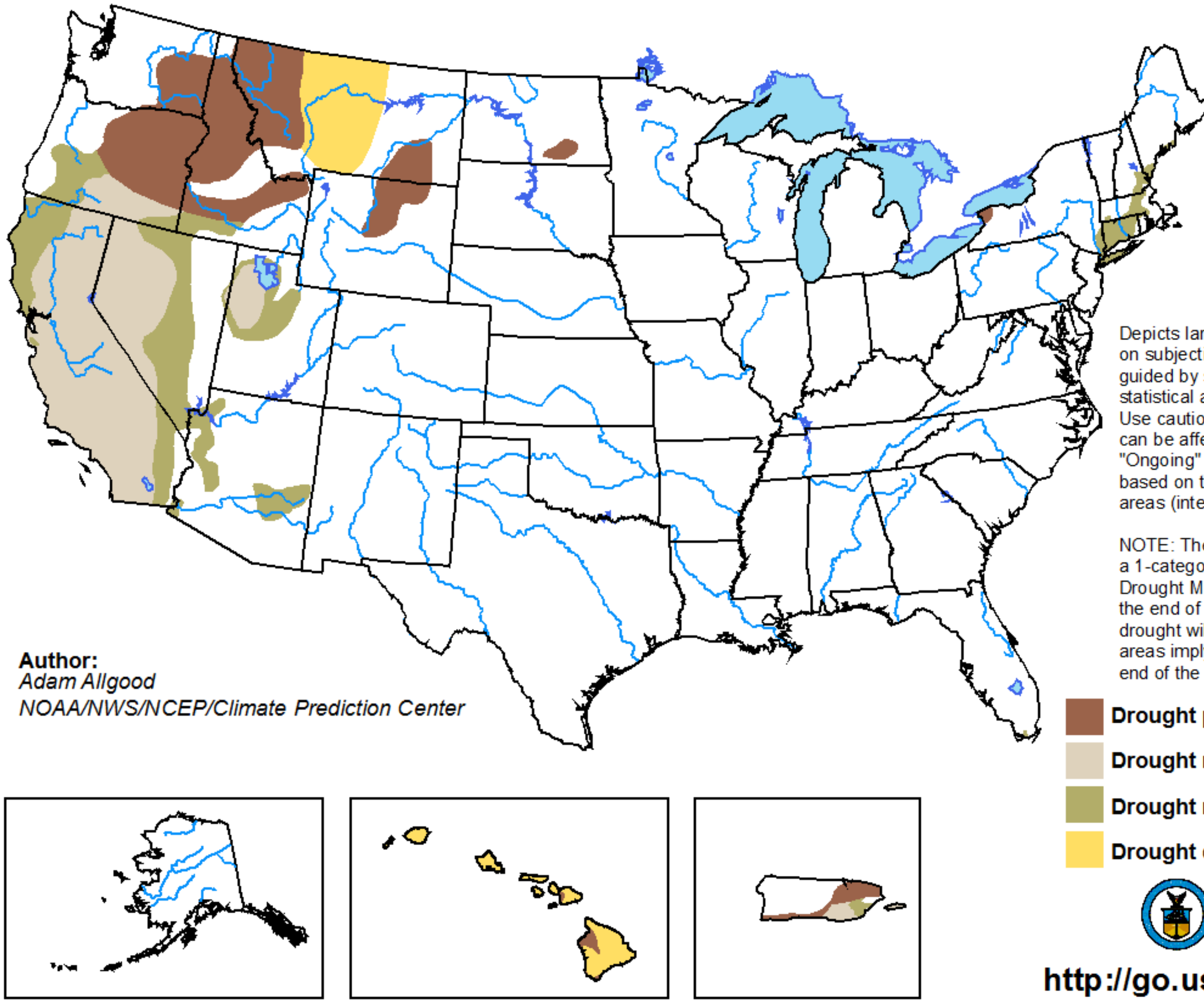


Stored soil moisture anomaly for Feb 10, 2016 indicates a surplus of 2-4 inches across southern MN

U.S. Seasonal Drought Outlook

Drought Tendency During the Valid Period

Valid for January 21 - April 30, 2016
Released January 21, 2016

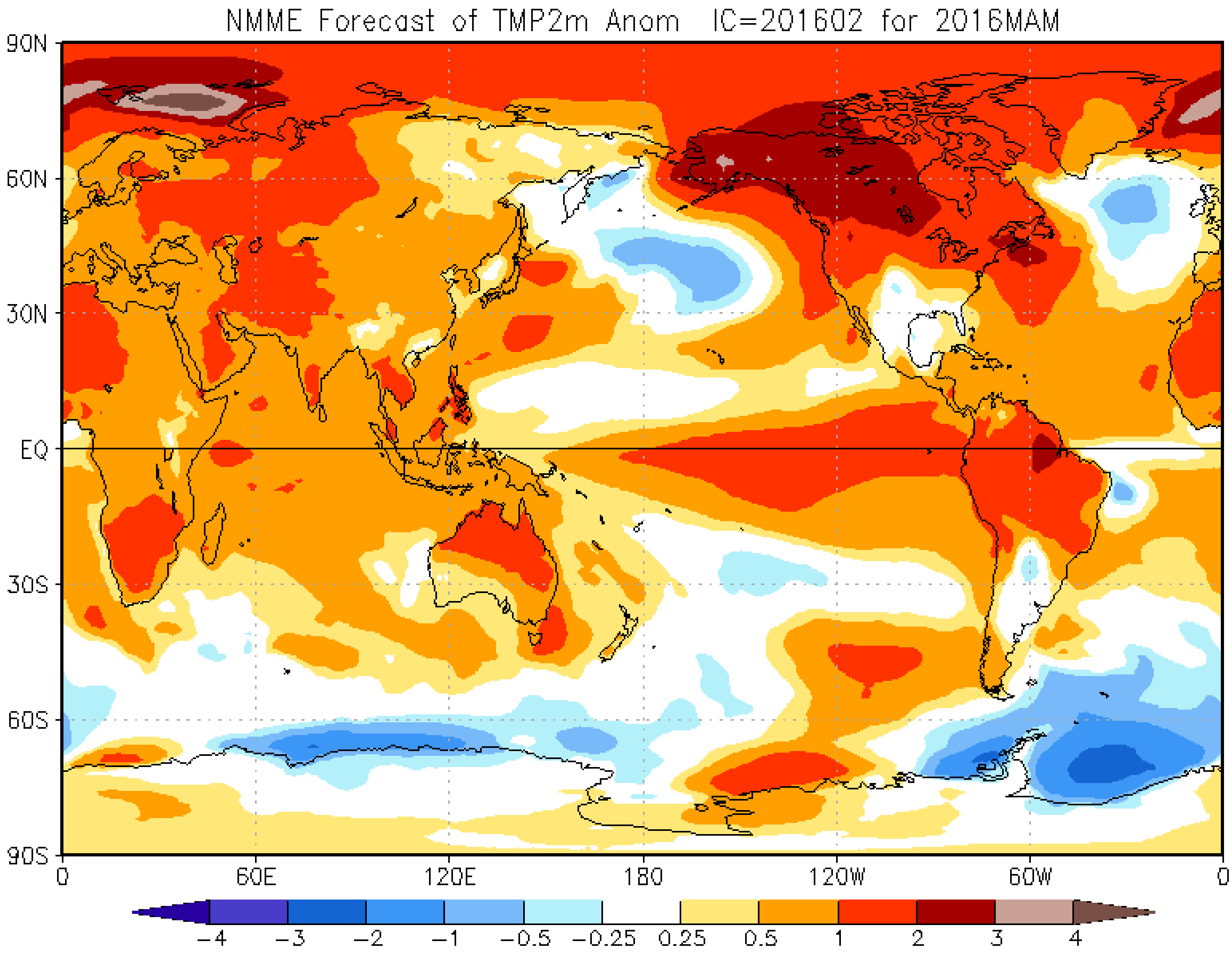


Depicts large-scale trends based on subjectively derived probabilities guided by short- and long-range statistical and dynamical forecasts. Use caution for applications that can be affected by short lived events. "Ongoing" drought areas are based on the U.S. Drought Monitor areas (intensities of D1 to D4).

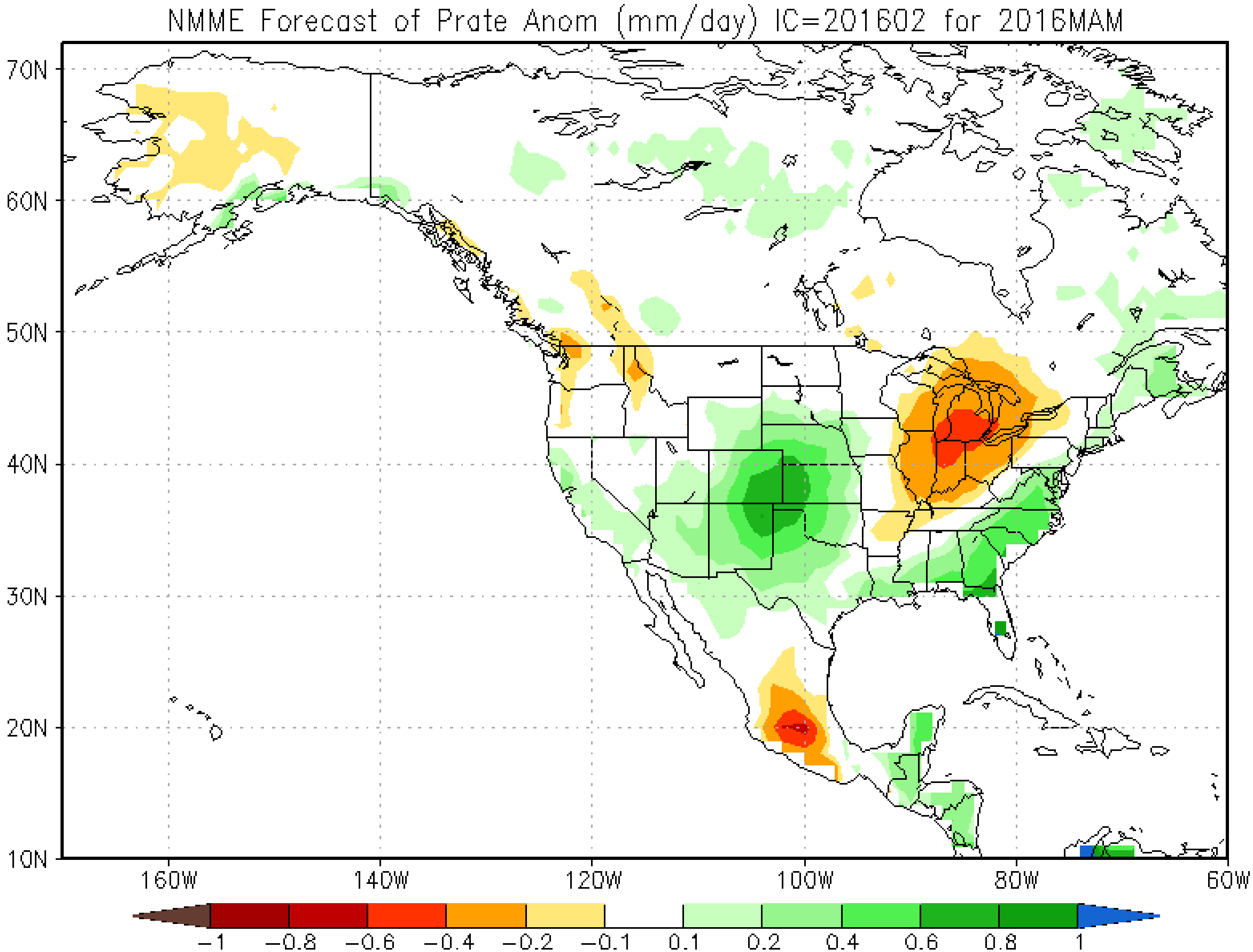
NOTE: The tan areas imply at least a 1-category improvement in the Drought Monitor intensity levels by the end of the period, although drought will remain. The green areas imply drought removal by the end of the period (D0 or none).

Author:
Adam Allgood
NOAA/NWS/NCEP/Climate Prediction Center

http://go.usa.gov/3eZ73



Ensemble forecast for March-May, 2016 Temperature Anomaly



Ensemble forecast for precipitation anomaly March-May 2016

SUMMARY

Trends toward warmer temperature and more precipitation continue in recent years.

Probability for early spring is high (early loss of soil frost).

Probability for warmer than normal growing in 2016 season is high.

Outlook for moisture is uncertain, but stored soil moisture provides a better than normal buffer for 2016.