Changing Weather and Climate Patterns: Effects on Fertilizer Management

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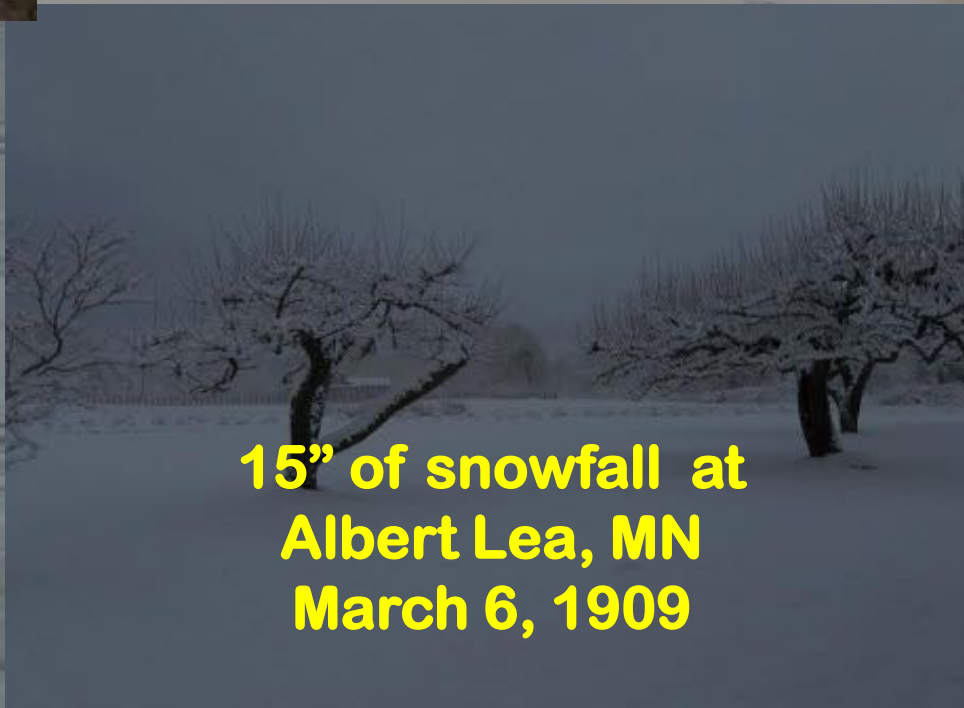
MDA-Crop Nutrient Management Conference
February 9, 2015
Mankato, MN

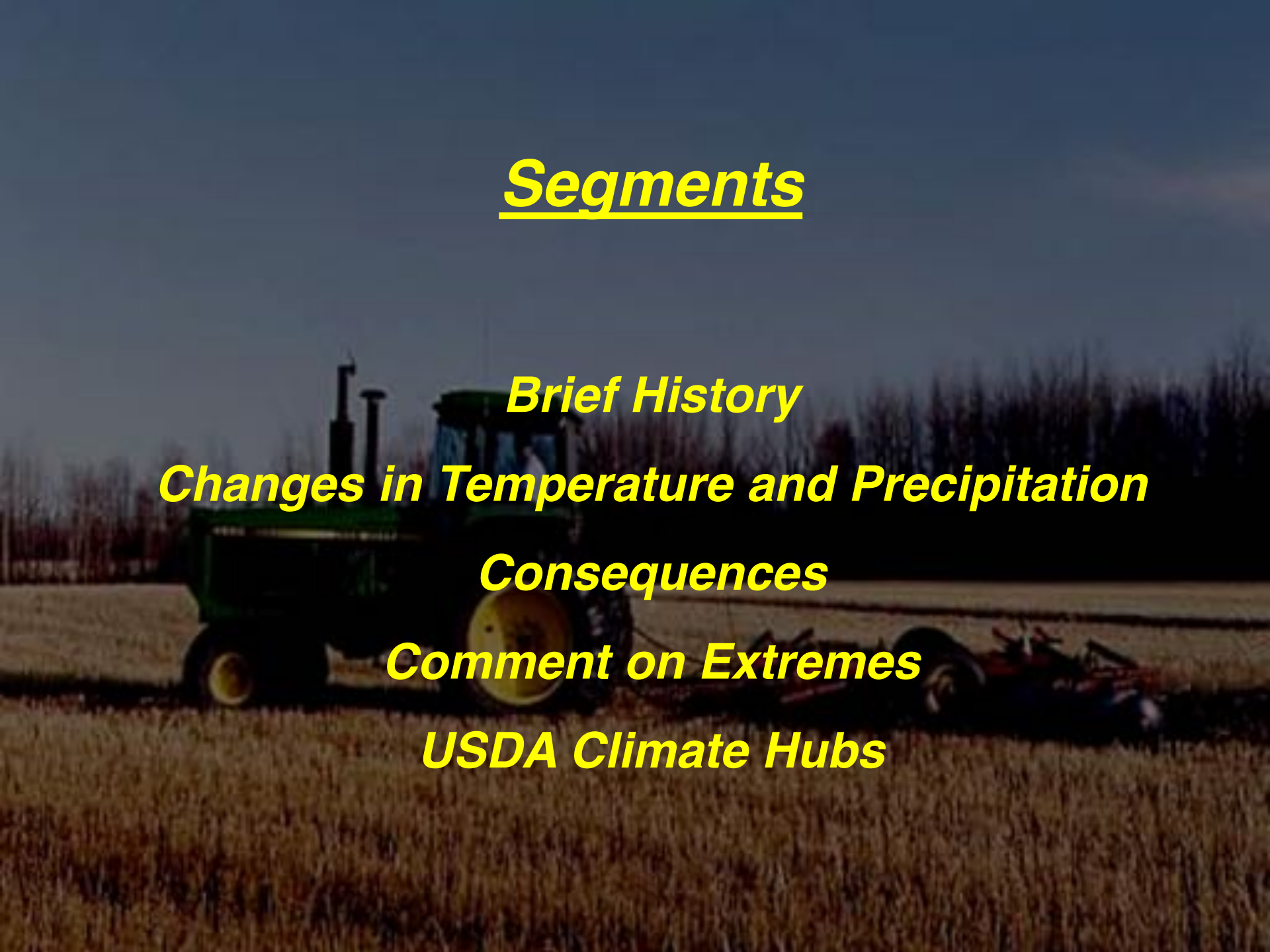
UNIVERSITY OF MINNESOTA
EXTENSION


63 degrees F at Canby, MN
February 9, 1991


-59 degrees F at Leech Lake, MN
February 9, 1899


Lake Superior almost
completely frozen over
February 9, 1979


15” of snowfall at
Albert Lea, MN
March 6, 1909



Segments

Brief History

Changes in Temperature and Precipitation

Consequences

Comment on Extremes

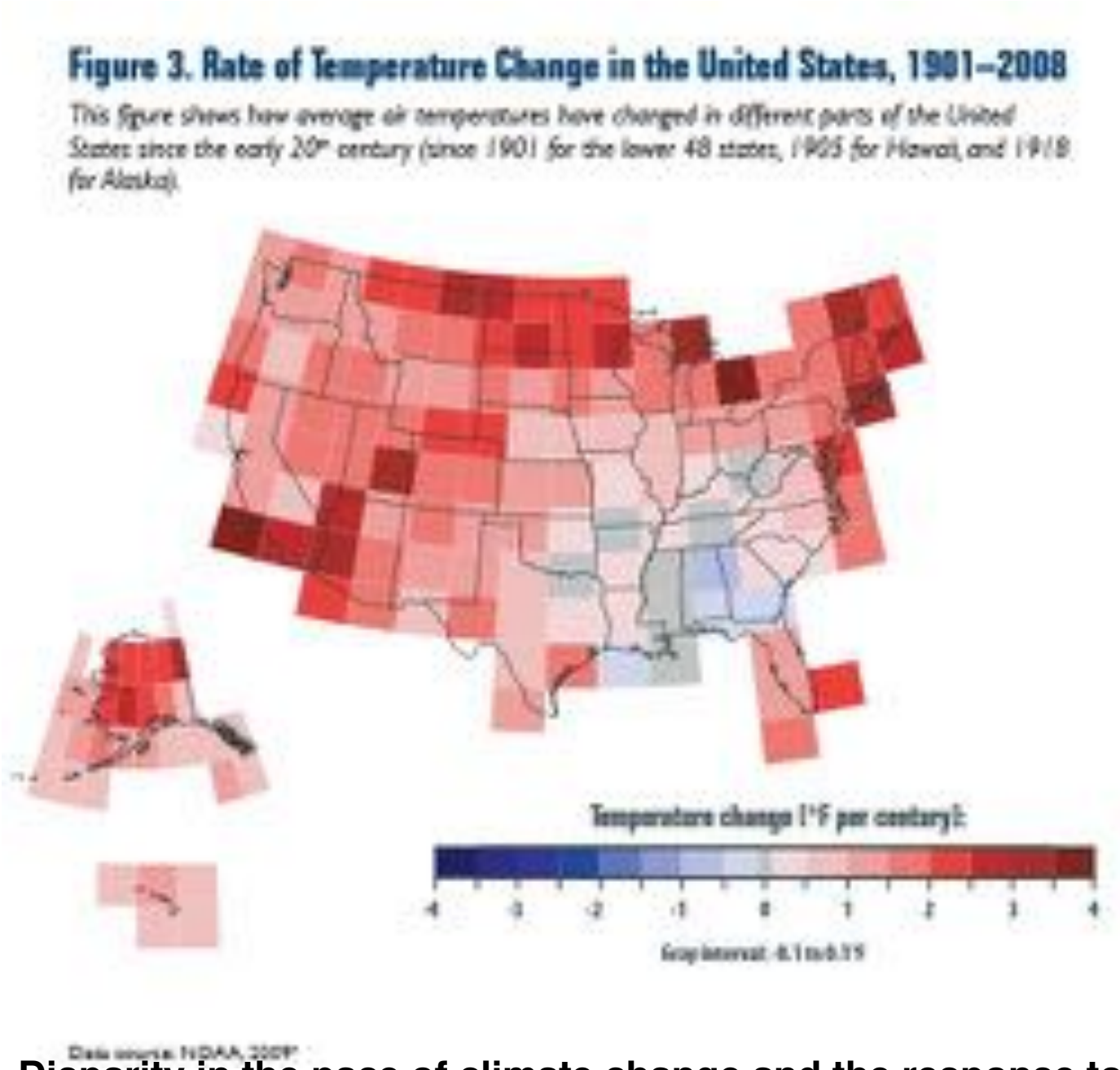
USDA Climate Hubs

Chronology of Minnesota Weather and Climate-Related Disasters: A sample listing since 1976

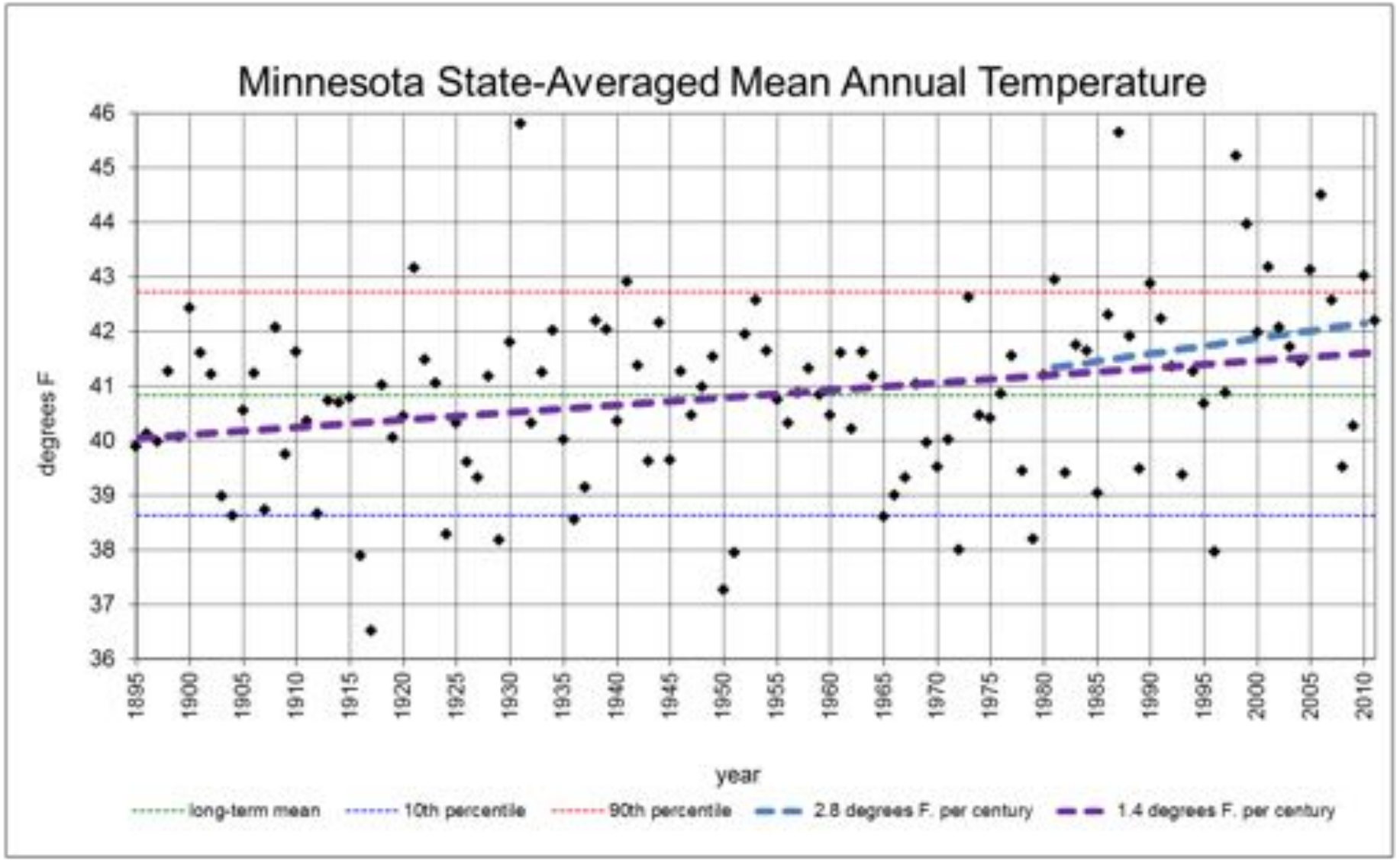
1976 Drought-Creation of Extension Climatologist Faculty Position
1978 flash floods in Rochester area (Zumbro R. July and Sept)
1979 flooding, late planting, delayed harvest
1980 drought in western MN counties
Threat of snow loads in winters of 1981-82, 1983-84. 2000-2001, 2010-2011
1983, 1995, 1999, 2001, 2005, 2011 Heat Waves (Health and Livestock Stress)
1984 drought in western Minnesota
1987 , 1989, 2013 severe winterkill of forage crops
1988 drought statewide*
1989 Red River spring flooding
1991 floods in southern Minnesota
1992 Chandler tornado
1993 floods on Minnesota and Mississippi Rivers
1995 derecho Itasca State Park and heat wave
1997 statewide spring floods*
1998 March tornado outbreak in southern MN*
1999 derecho in BWCA and heat wave
**Denotes over $1 billion in losses*

Chronology of Minnesota Weather and Climate-Related Disasters: A sample listing (continued)

2000 Granite Falls Tornado
2001 spring floods on Minnesota and Mississippi Rivers
2002 flash floods in northern Minnesota
2004 flash floods in southern Minnesota
2007 Flash floods in SE Minnesota (simultaneous with drought)
2005-2012 Drought response every summer
2009 Red River spring snow melt flooding (66 days Moorhead)
2010 Tornado Outbreak (48 on June 17th, 113 total), Red River Flooding
2011 Red River Flooding/Hennepin/Anoka Tornadoes
2012 Flash floods Cannon River and Duluth (simultaneous with drought)
2013Winterkill, April Ice Storm, Prevented Planting from a wet spring
2014 Wet Spring, Prevented Planting, June Flooding

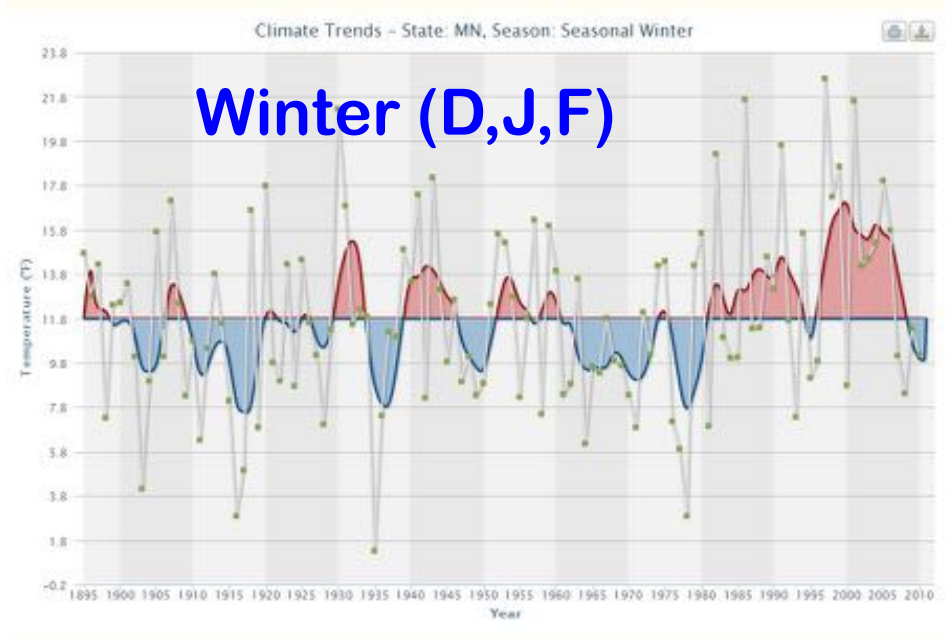


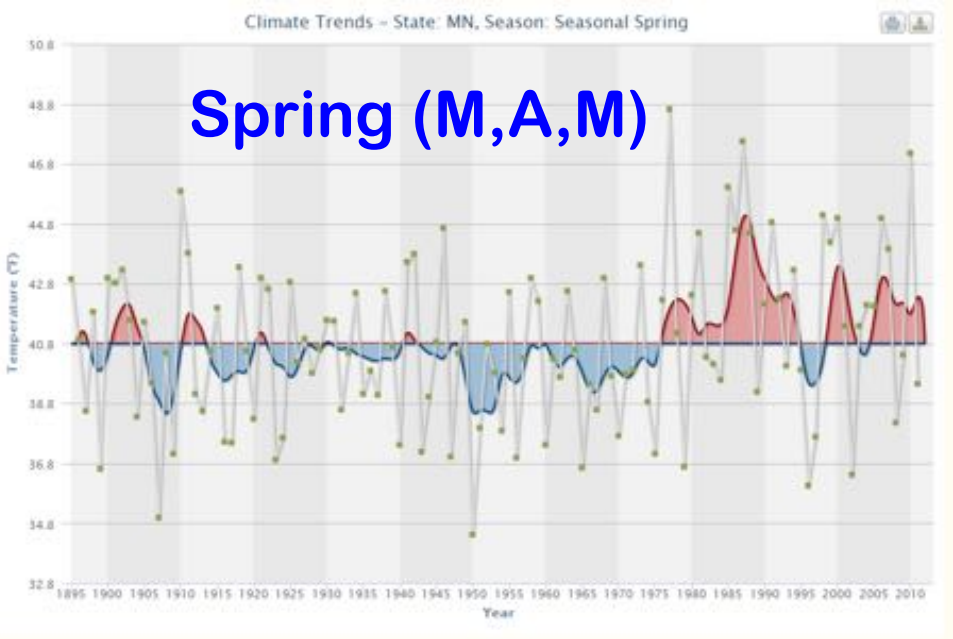
Disparity in the pace of climate change and the response to it

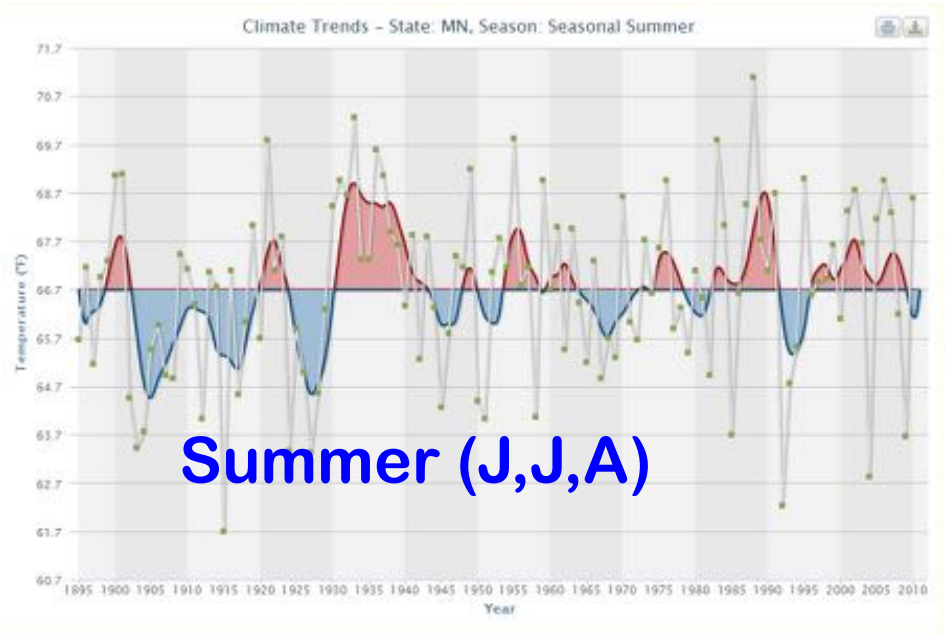


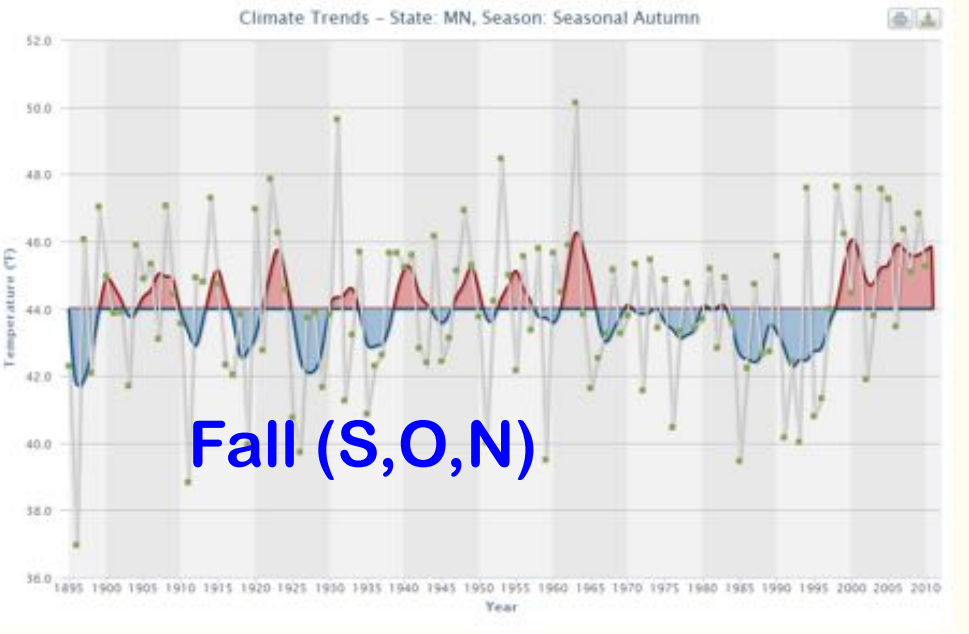
Temp trend is upward and more frequently above the 90th percentile

Seasonal Temperature Trends in MN









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

Trends in average winter minimum temperatures Milan, MN

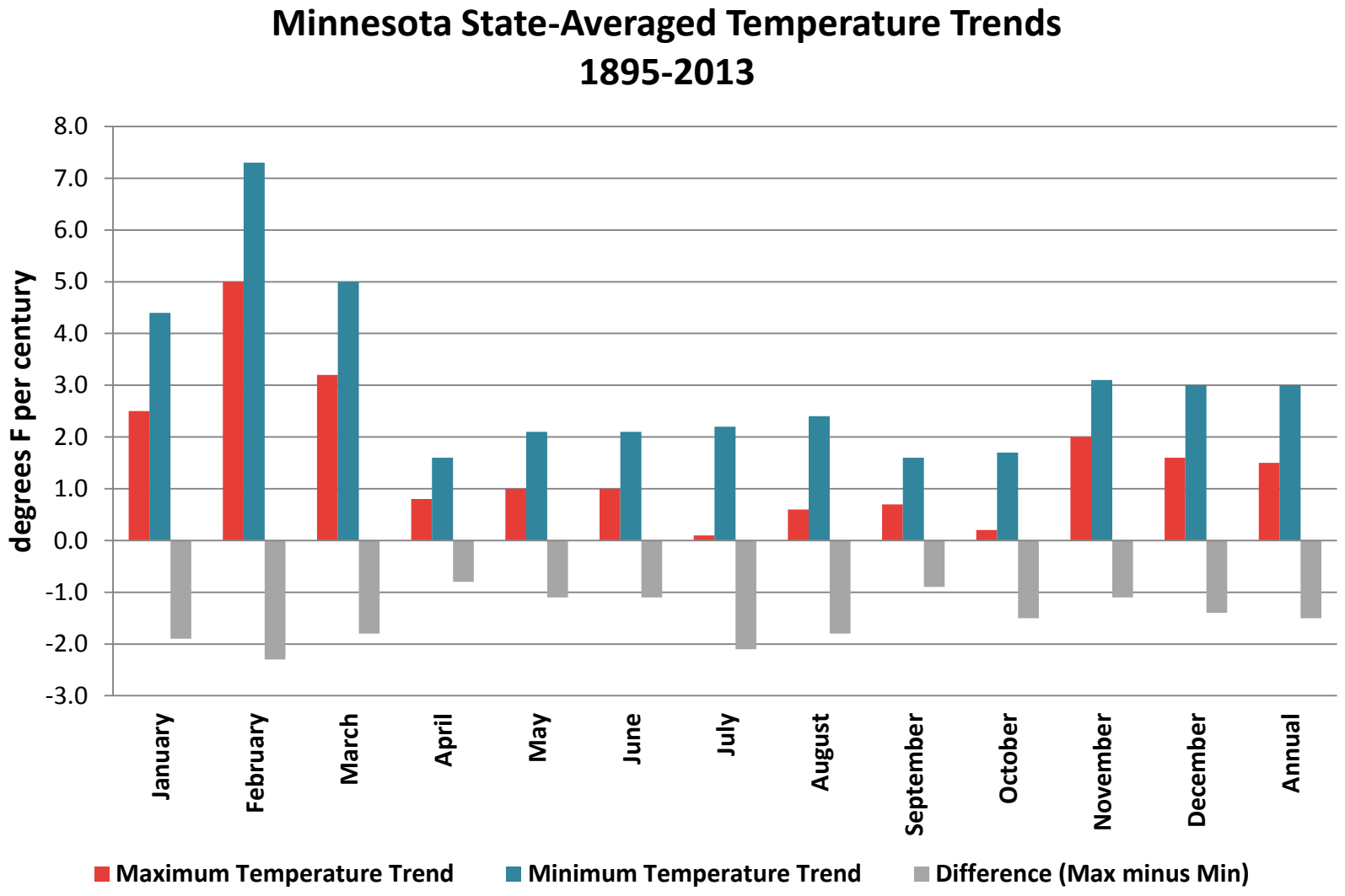
Period of Record	Ave Min Temp in Deg. F
1951 - 1980	Jan -4.3
1961 - 1990	Jan -0.9
1971 - 2000	Jan 0.3
1981 - 2010	Jan 3.7
1951 - 1980	Feb 2.3
1961 - 1990	Feb 5.3
1971 - 2000	Feb 8.2
1981 - 2010	Feb 9.3
1951 - 1980	Mar 15.1
1961 - 1990	Mar 19.2
1971 – 2000	Mar 21.0
1981 - 2010	Mar 22.0

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

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

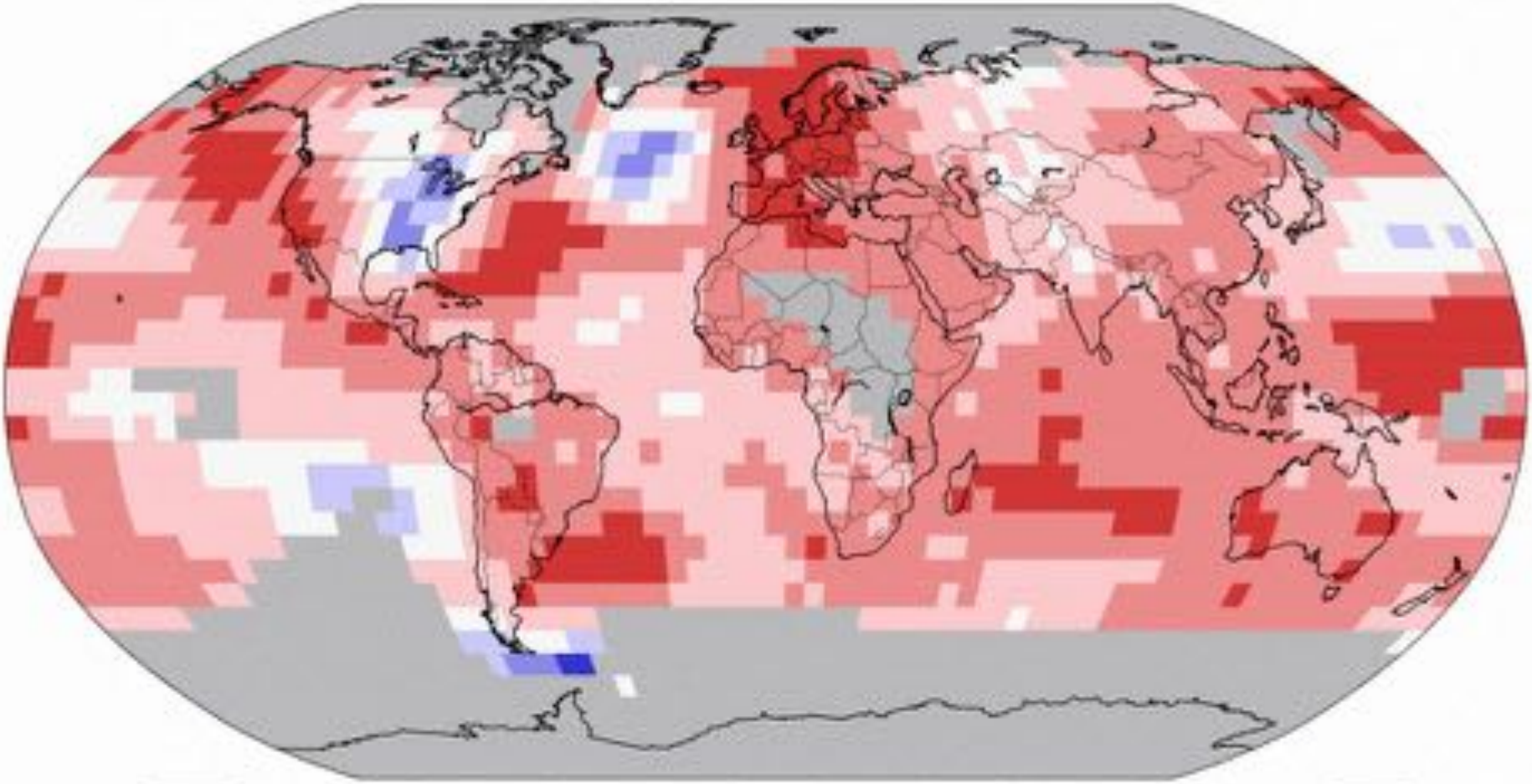
Month	Min Change	Max Change	Mean Change
January	+3.4	+1.5	+2.9
February	+0.8	+0.9	+0.8
March	+0.9	+1.2	+1.0
April	+0.7	+1.5	+1.1
May	+0.1	-0.1	NC
June	+0.5	+0.2	+0.3
July	+0.7	+0.5	+0.6
August	+0.4	+0.7	+0.5
September	+0.9	+1.0	+0.9
October	+0.5	+0.5	+0.5
November	+1.3	+2.3	+1.7
December	+2.1	+1.7	+1.8


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)

Land & Ocean Temperature Percentiles Jan–Dec 2014

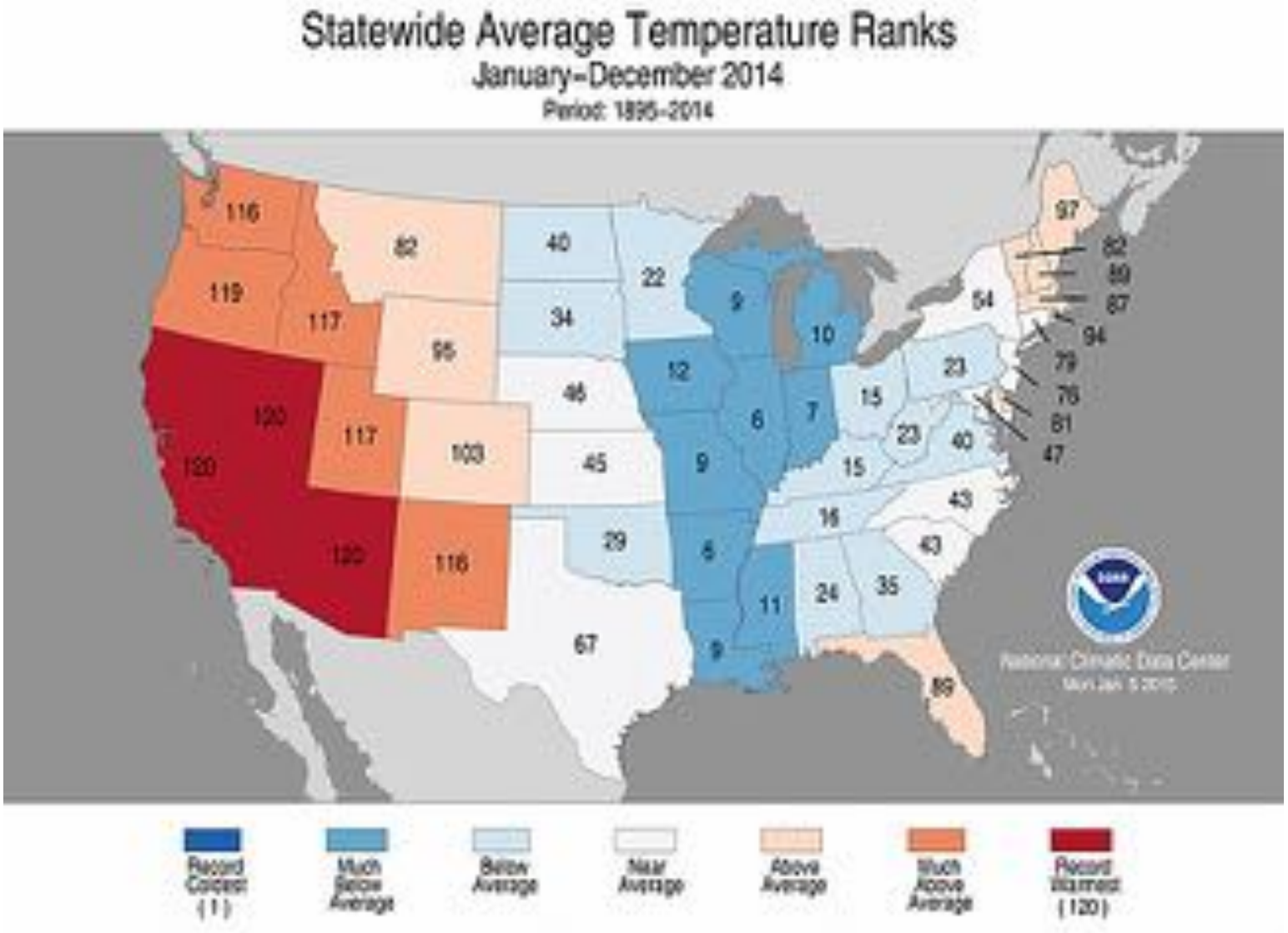
NOAA's National Climatic Data Center

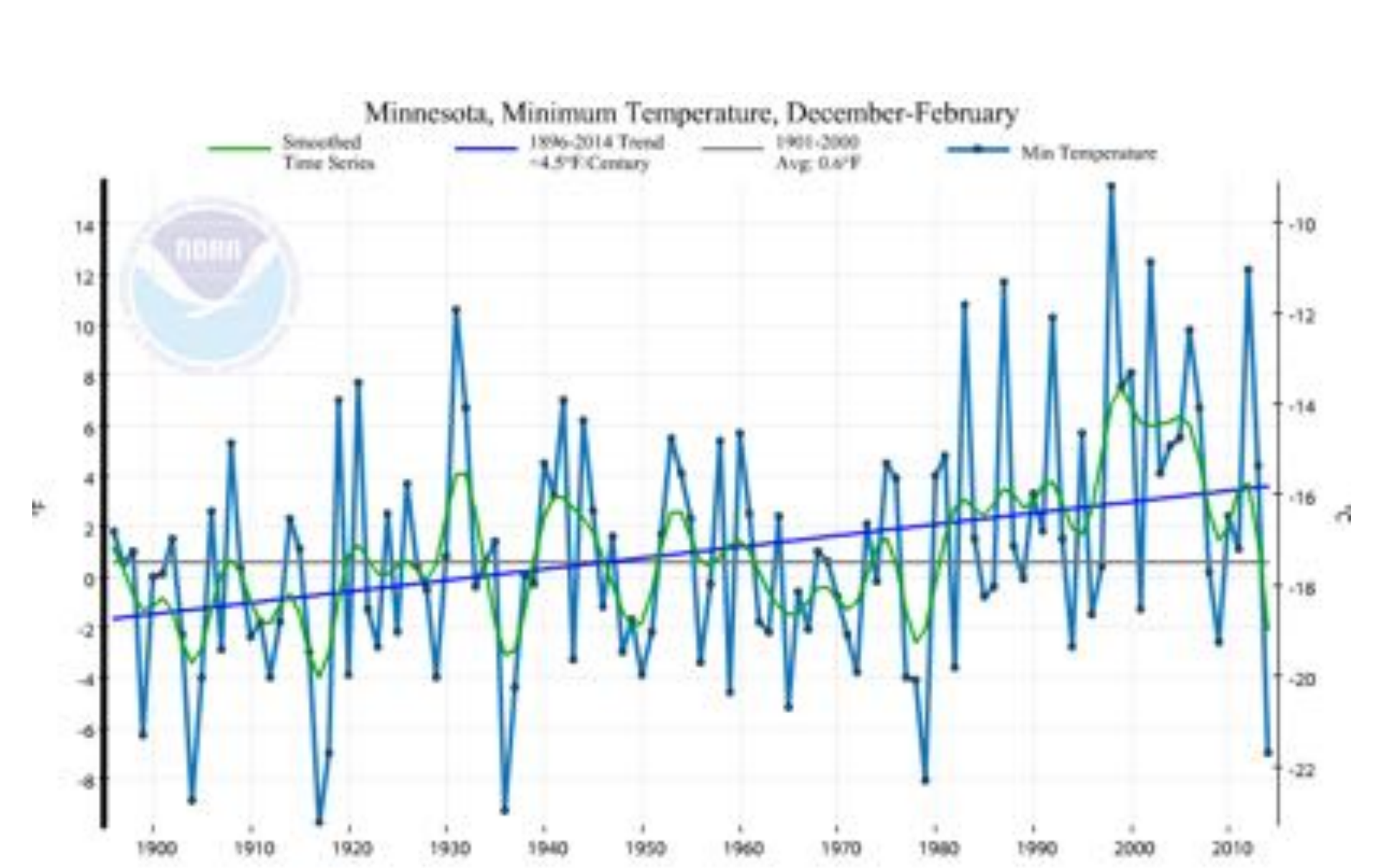
Data Source: GHCN–M version 3.2.2 & ERSST version 3b

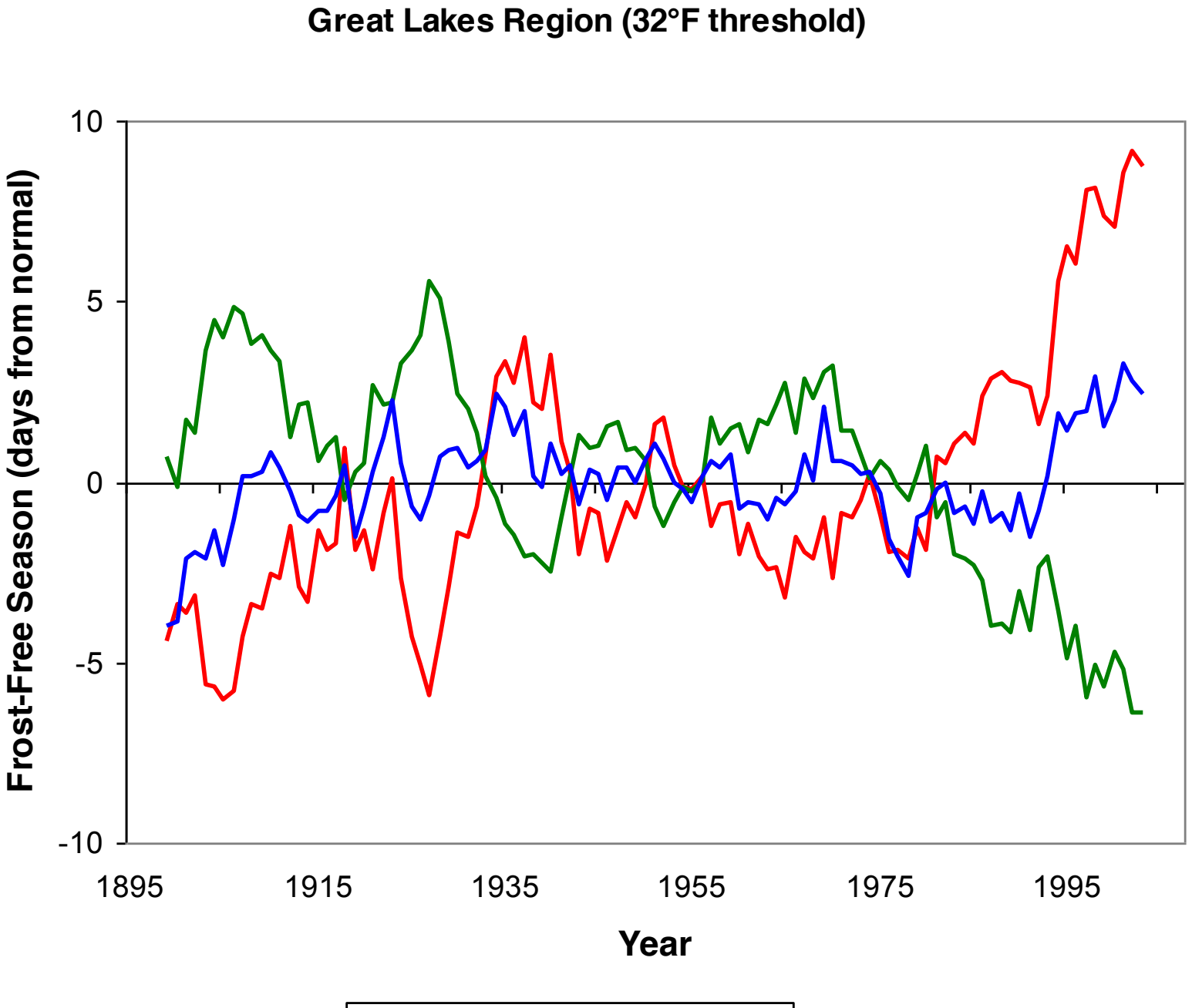


Record Coldest | Much Cooler than Average | Cooler than Average | Near Average | Warmer than Average | Much Warmer than Average | Record Warmest

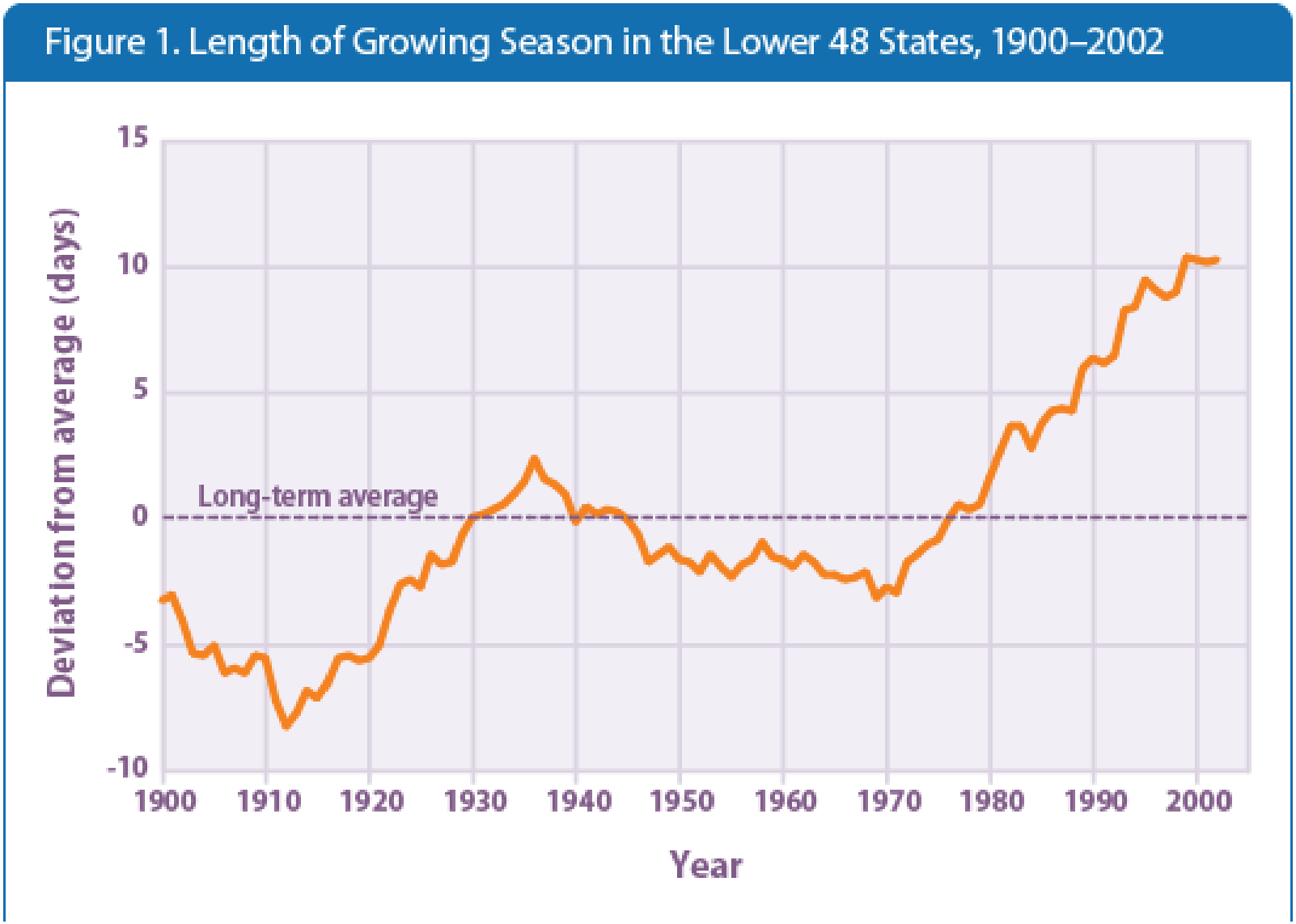
Mon Jan 12 19:34:46 EST 2015


Statewide Average Temperature Ranks
January–December 2014
Period: 1895–2014
116
82
40
22
97
119
117
34
9
10
54
95
12
23
46
6
7
15
120
117
103
23
40
120
45
9
15
43
16
29
43
116
6
24
35
11
67
9
89
National Climatic Data Center
Record Coldest (1)
Much Below Average
Below Average
Near Average
Above Average
Much Above Average
Record Warmest (120)


Minnesota, Minimum Temperature, December-February
Smoothed Time Series
1896-2014 Trend +4.5°F/Century
1901-2000 Avg: 0.6°F
Min Temperature
14
12
10
8
6
4
2
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-22
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010

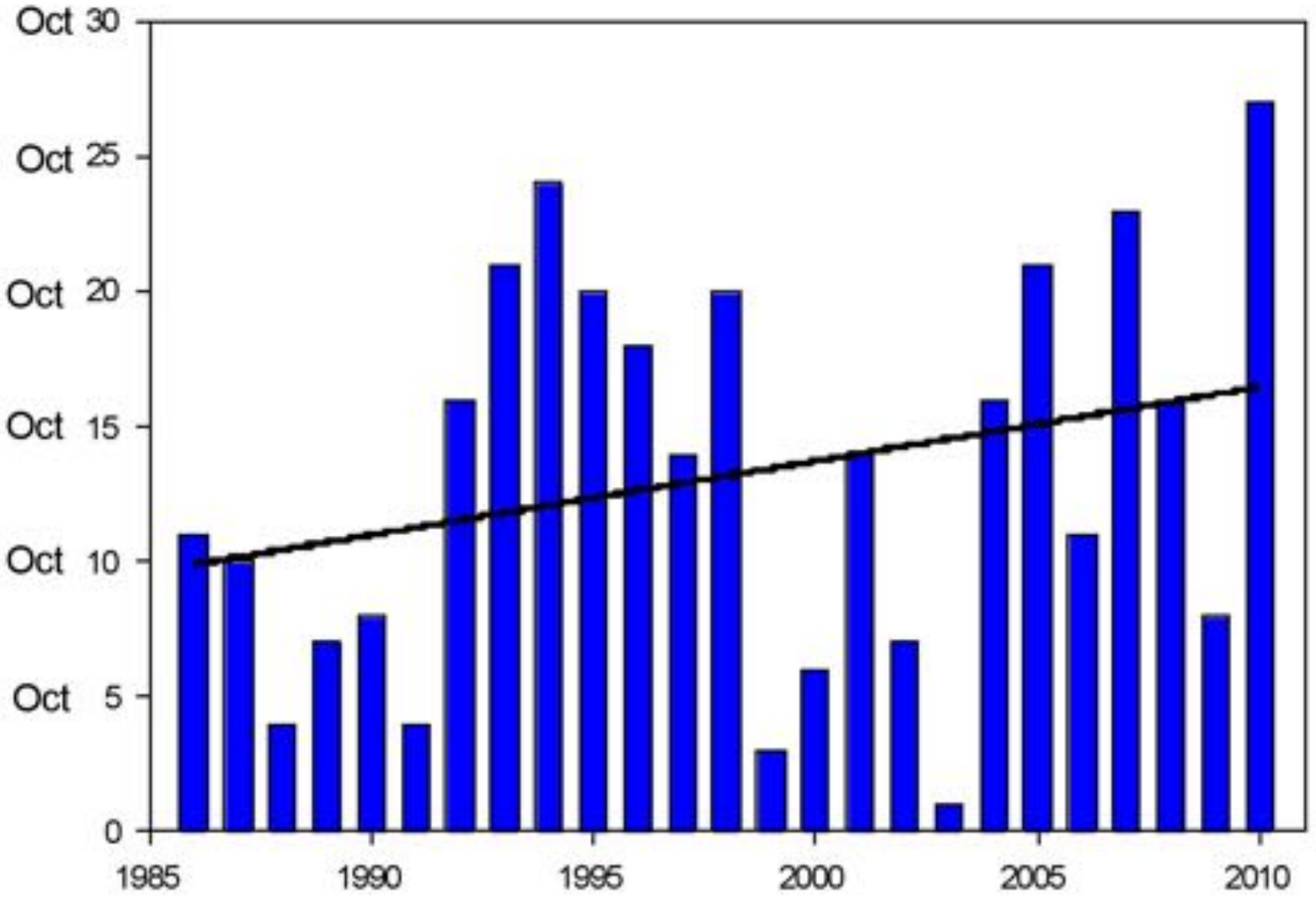


Source: K. Kunkel, Midwest. Reg. Clim. Center



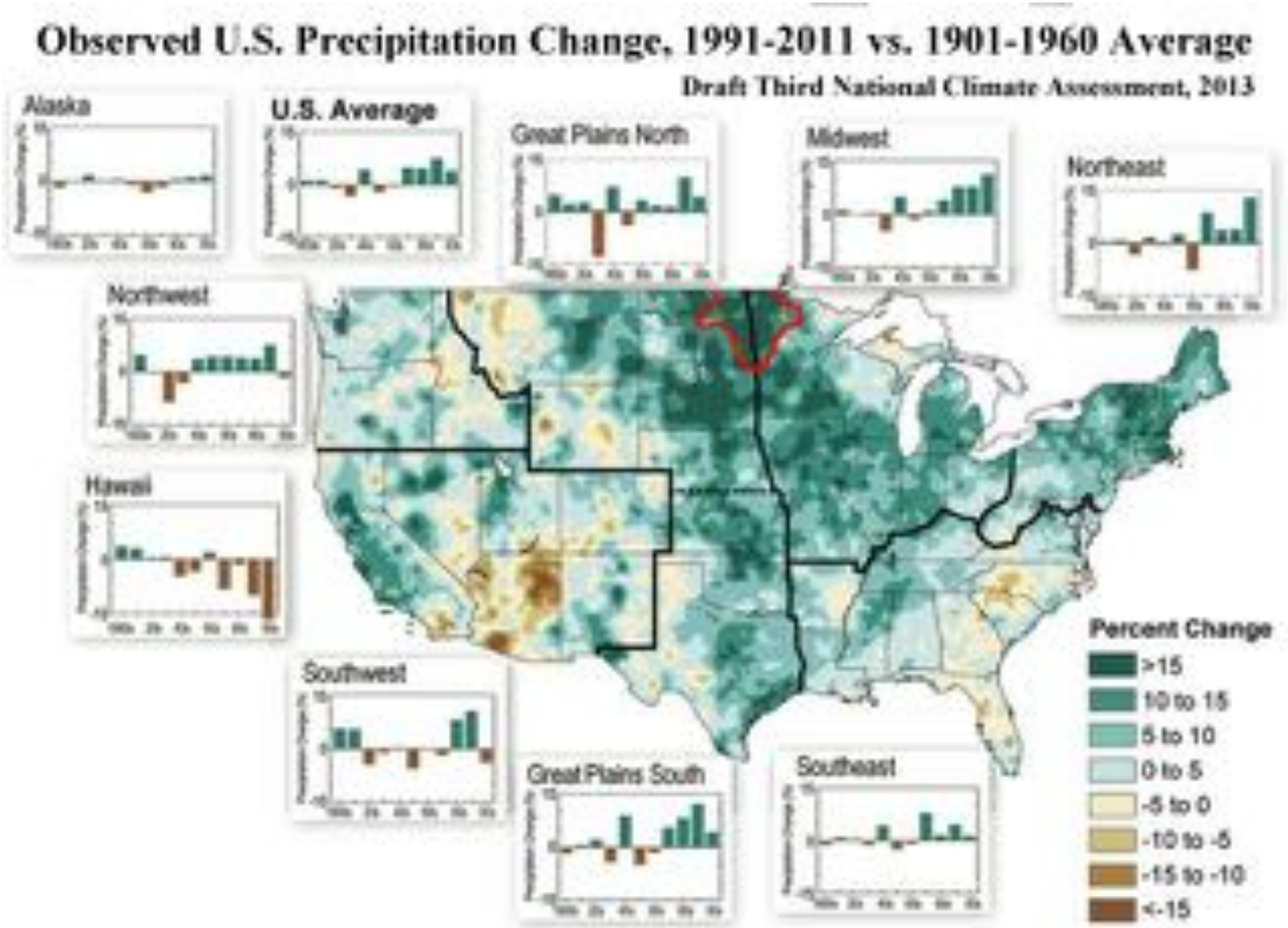
Average change in the length of the growing season for the 48 contiguous states in the USA (EPA)

Autumn date when 4” soil temperature falls below 50°F
From Northern Iowa



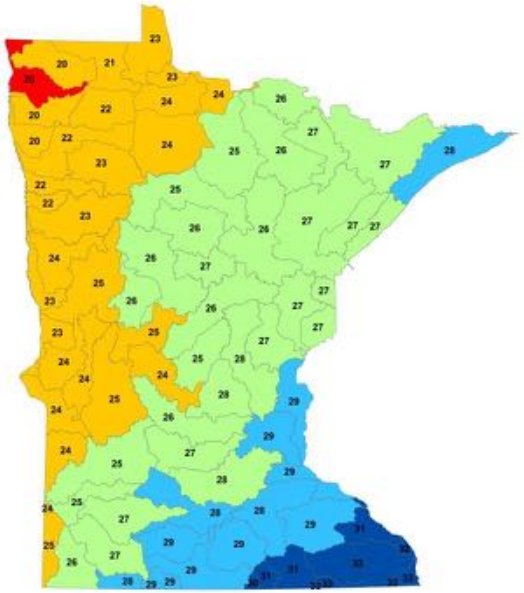
Consequences of Warm Winters and Higher Minimum Temperatures

- Change in depth and duration of soil and lake freezing
- More rapid breakdown of crop residues
- Later fall nitrogen applications (soil temp too high)
- Change in survival rates of insect pests, parasites, plant pathogens, and soil microbes
- Reduced energy use for heating (HDD)
- Increased number of freeze/thaw cycles (damaged roads)
- Change in Plant Hardiness Zones
- Longer growing seasons
- Change in exposure times to mold and allergens

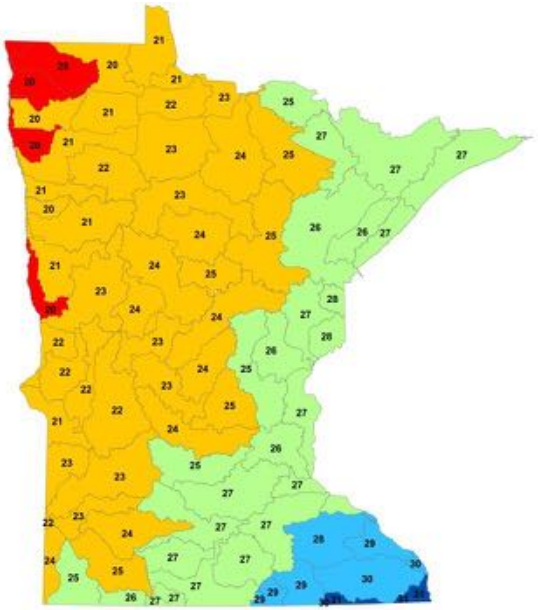


Geographic Disparity in Precipitation Change-IPCC 2013

Average Annual PPT 1891-1920, in



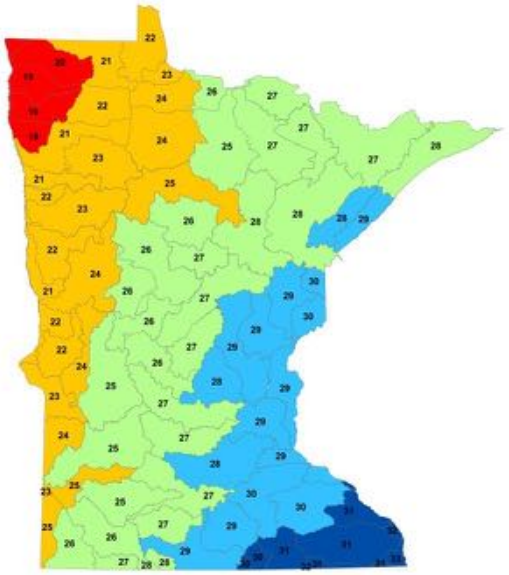
Average Annual PPT 1921-1950, in



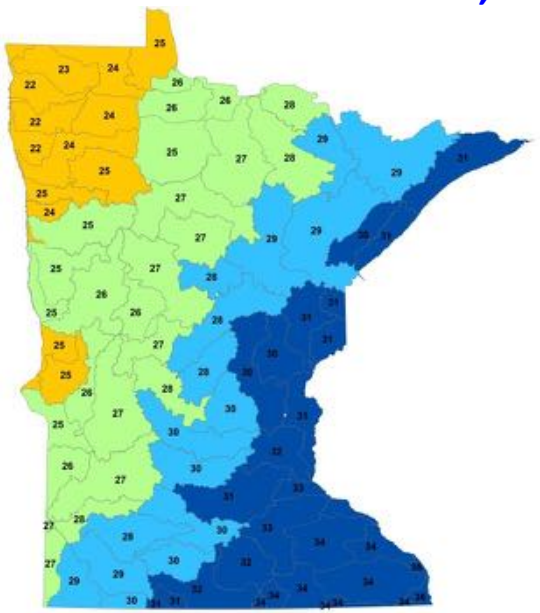
Avg. Annual PPT, in

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

Average Annual PPT 1951-1980, in

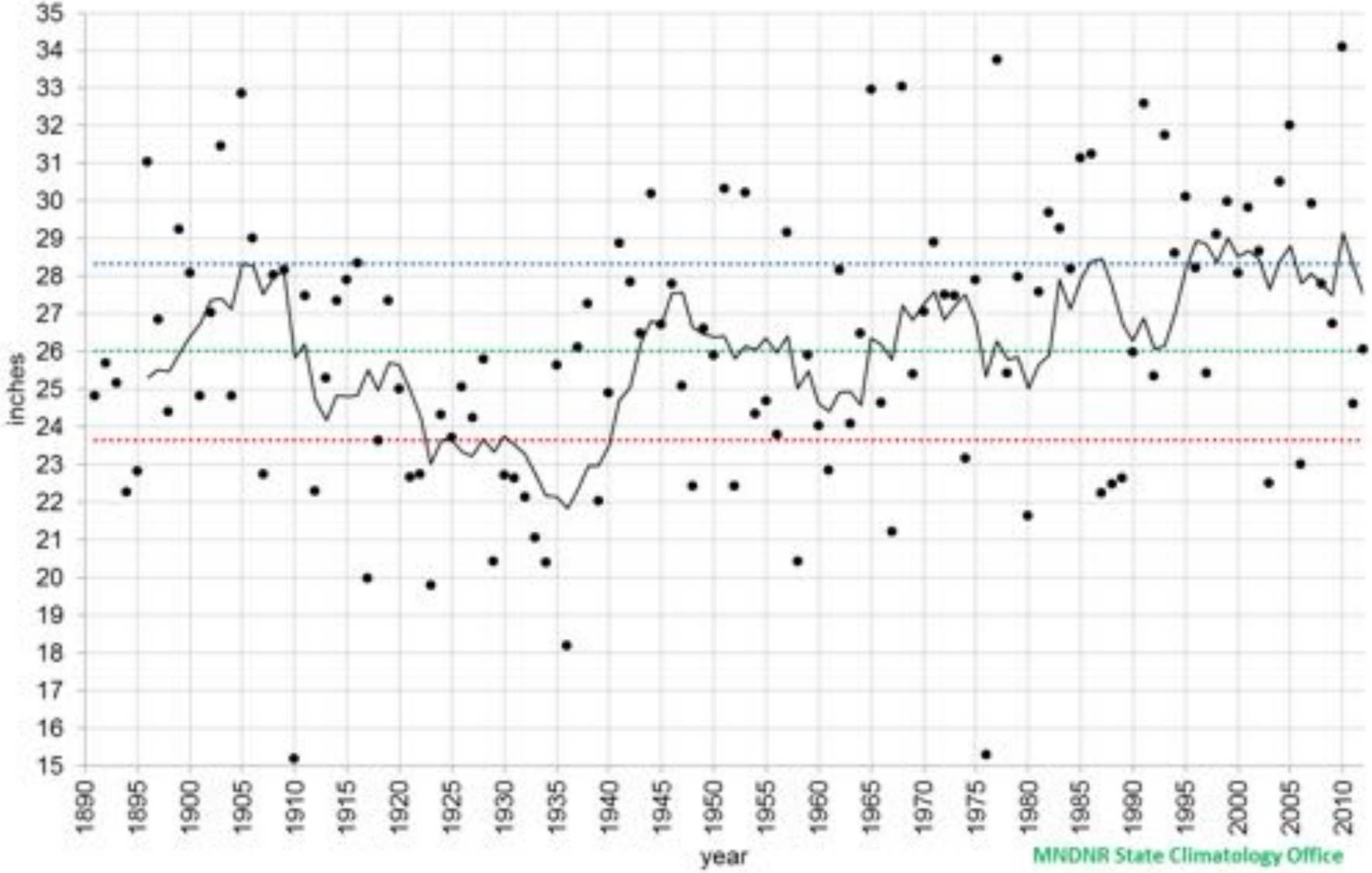


Average Annual PPT 1981-2010, in

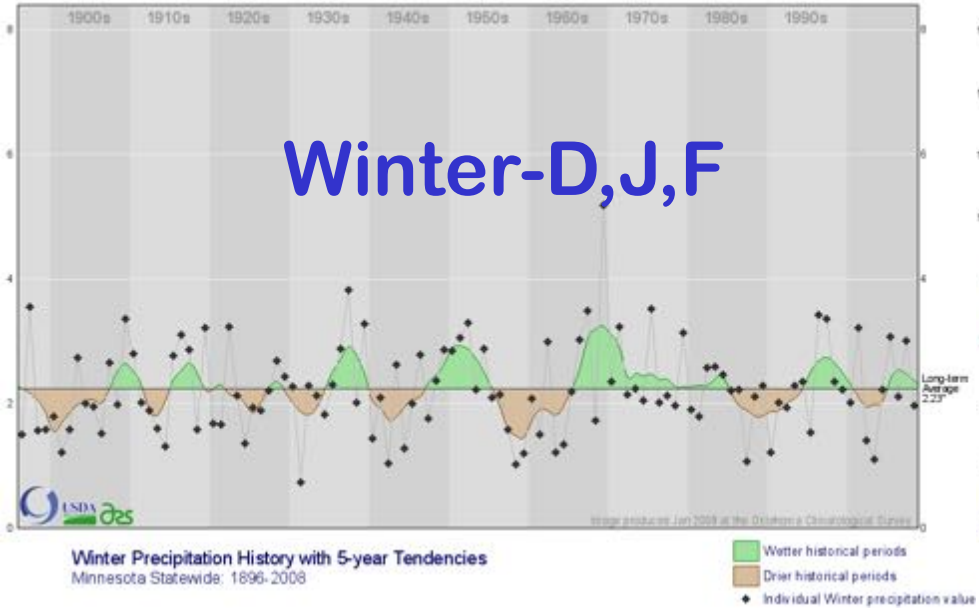


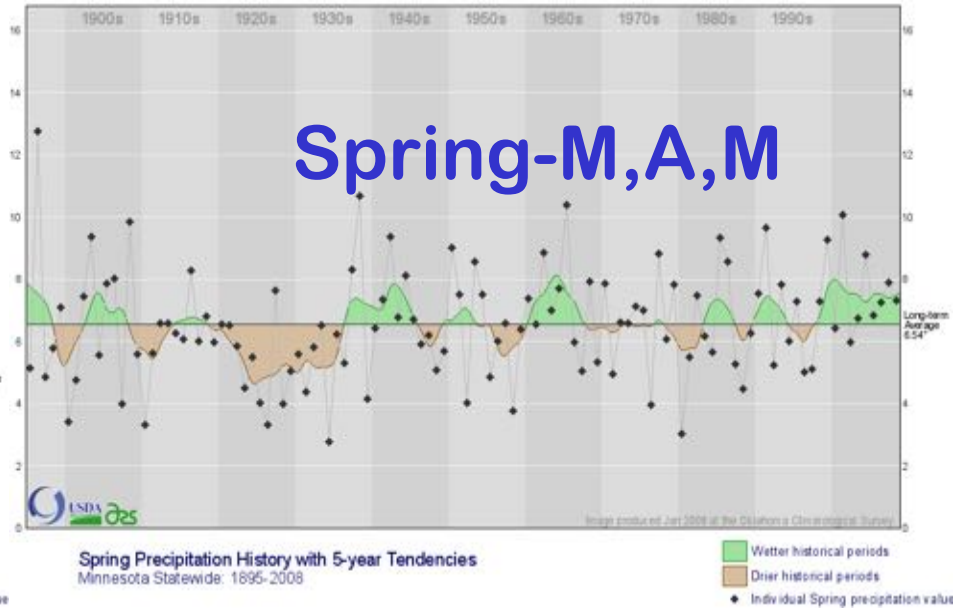
Source: MN-SCO

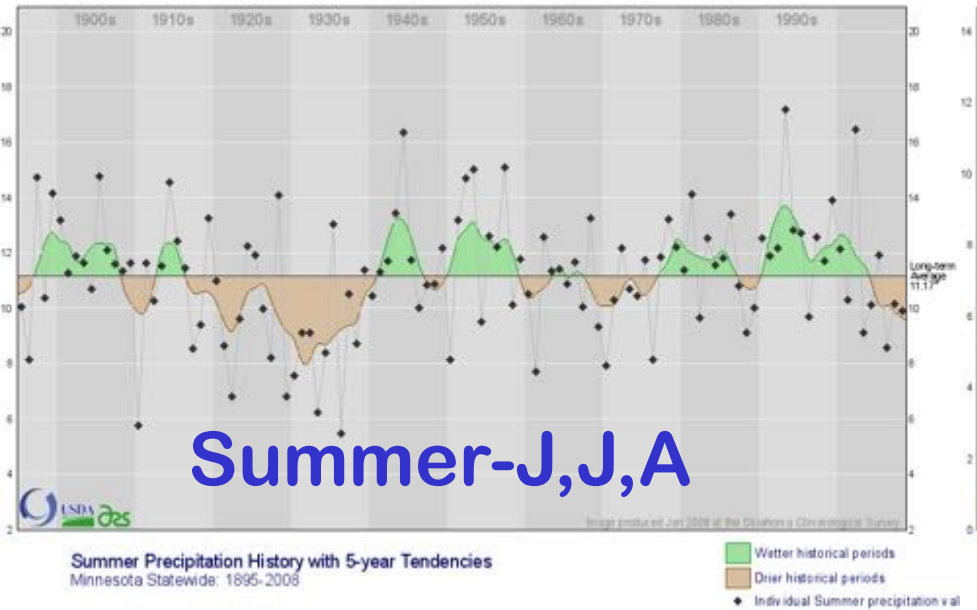
Minnesota State-Averaged Annual Precipitation

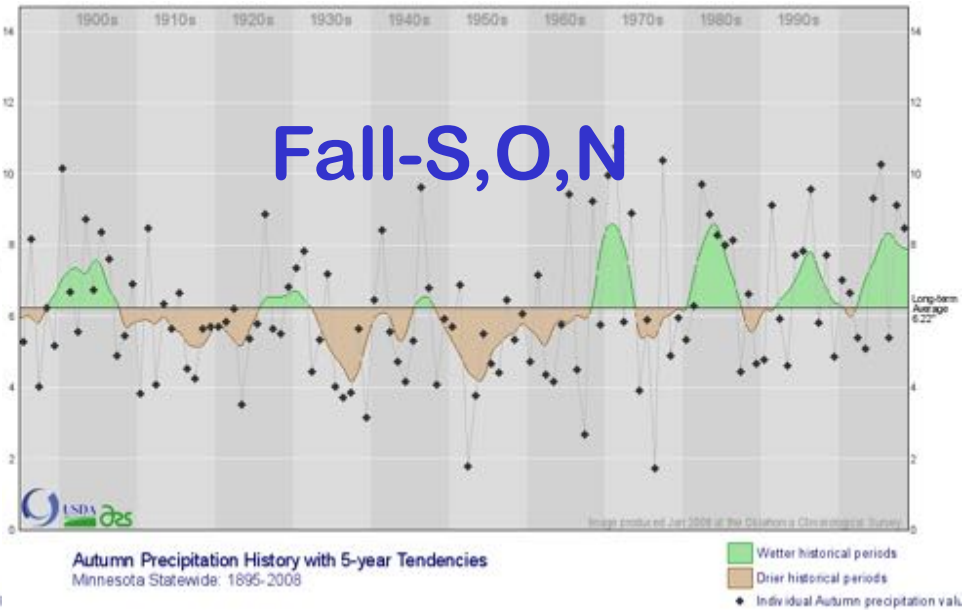


Seasonality in MN Precipitation Trends









Change in Annual Precipitation Normals at Milan, MN

PERIOD	AMOUNT (IN.)
1921-1950	21.53”
1931-1960	23.57”
1941-1970	25.53”
1951-1980	25.13”
1961-1990	24.12”
1971-2000	24.71”
1981-2010	26.14”

21 percent increase since 1921-1950

Extremes 7.91” in 1976, 39.58” in 1995

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

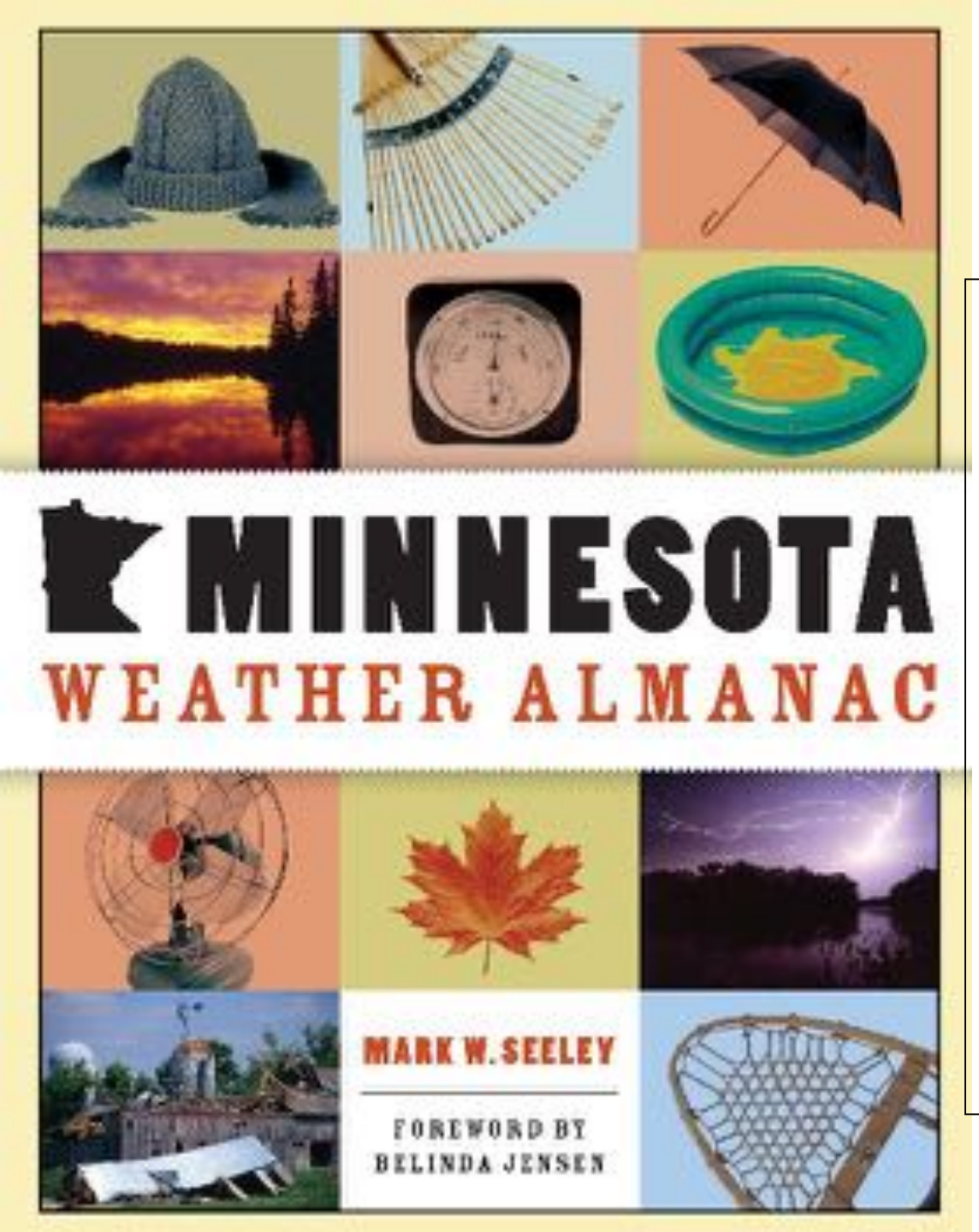
Extremes: 10.81″ in 1910, 42.20″ in 1951

Change in Annual Precipitation "Normals" at Waseca, MN

PERIOD	AMOUNT (IN.)
1921-1950	27.55″
1931-1960	27.82″
1941-1970	29.94″
1951-1980	30.62″
1961-1990	32.45″
1971-2000	34.69″
1981-2010	35.72″

30 percent increase since 1921-1950 period

Extremes 17.43″ 1976; 50.46″ 1991



Measurable Attributes of Precipitation

Quantity

Type (liquid,frozen)

Intensity *(9-15")*

Frequency *(74-145 days)*

Duration *(10 days)*

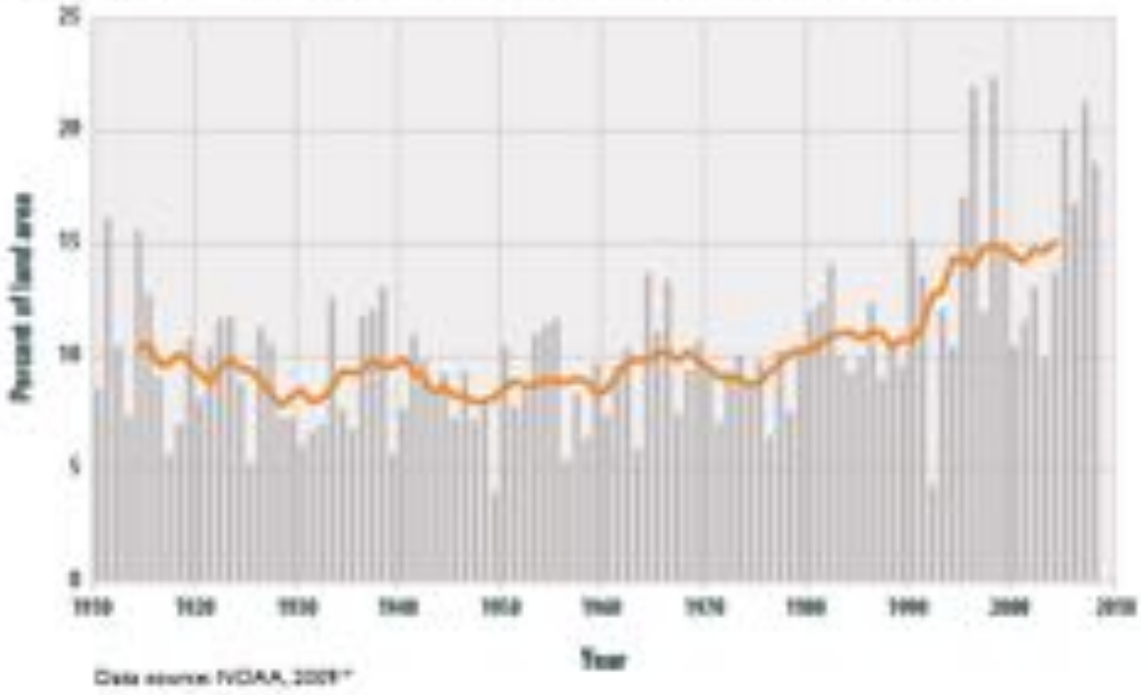
Seasonality *(shifting)*

Landscape relationship

(interception, absorption, runoff, evaporation)

Figure 1. Extreme One-Day Precipitation Events in the Lower 48 States, 1910–2008

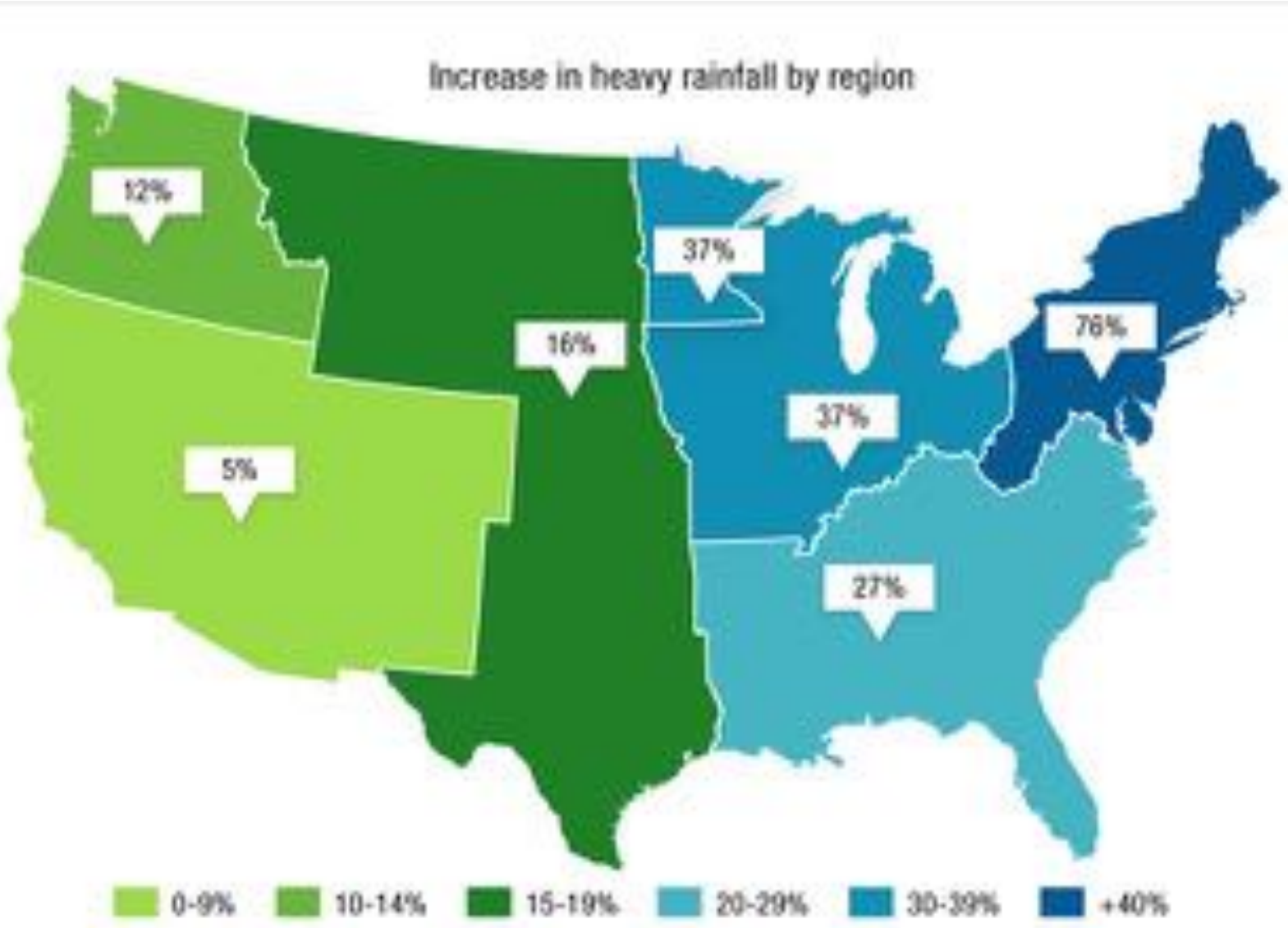
This figure shows the percentage of the land area of the lower 48 states where a much greater than normal portion of total annual precipitation has come from extreme single-day precipitation events. The bars represent individual years, while the line is a smoothed nine-year moving average.

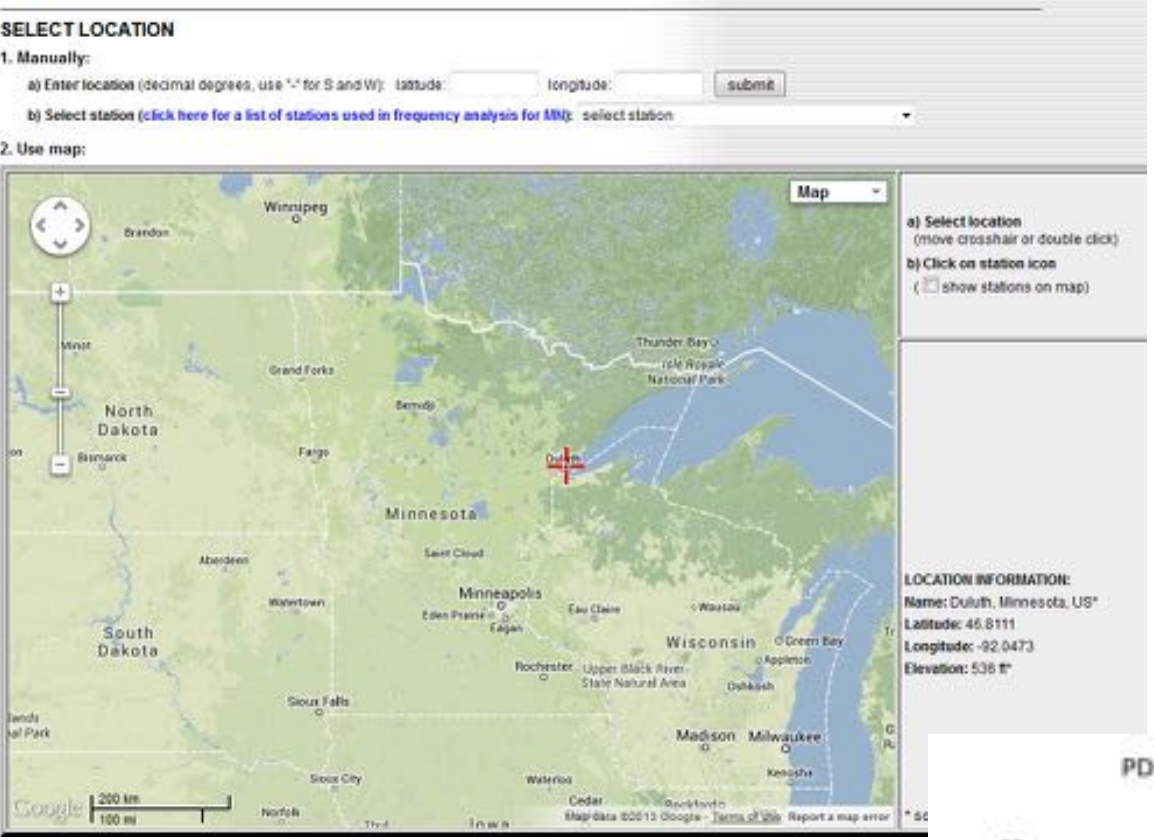


Data source: NCDC, 2009[1]

Figure 2. Abnormally High Annual Precipitation in the Lower 48 States, 1895–2008

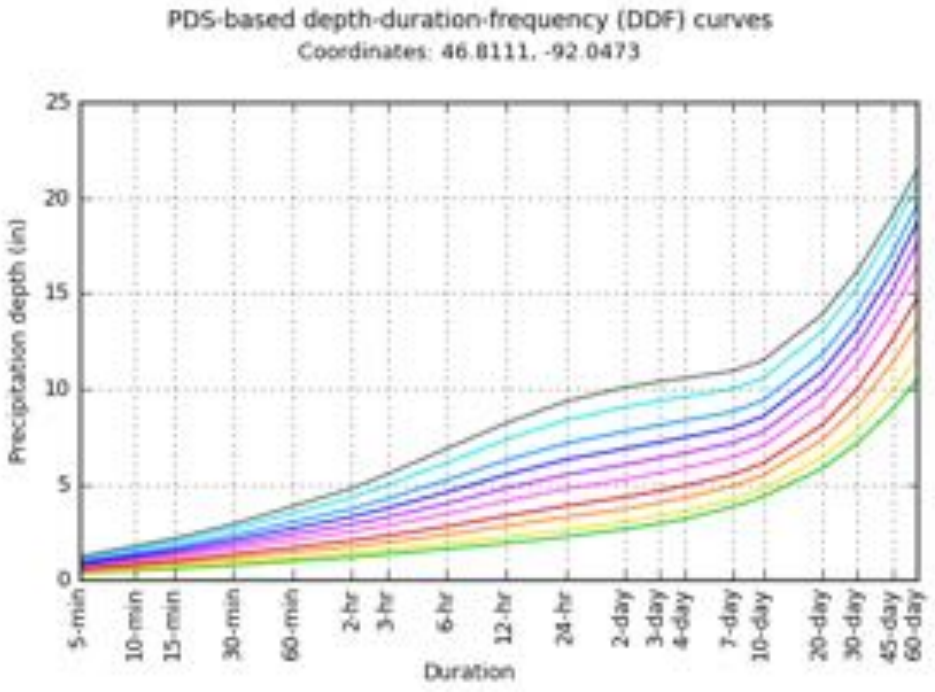
This figure shows the percentage of the land area of the lower 48 states that experienced much greater than normal precipitation in any given year, which means it scored 2.0 or above on the annual Standardized Precipitation Index (SPI). The thicker orange line shows a nine-year moving average that smooths out some of the year-to-year fluctuations, while the straight black line is the trend line that fits the data best.


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



Access to NOAA-Atlas 14 On the Web is cursor-based graphical and tabular access to the most current data base from NCDC

WEB SITE:
http://www.dnr.state.mn.us/climate/noaa_atlas_14.html



POINT PRECIPITATION FREQUENCY (PF) ESTIMATES

WITH 90% CONFIDENCE INTERVALS AND SUPPLEMENTARY INFORMATION
NOAA Atlas 14, Volume 8, Version 2

PF tabular | PF graphical | Supplementary information | Print Page

PDS-based precipitation frequency estimates with 90% confidence intervals (in inches)[1]

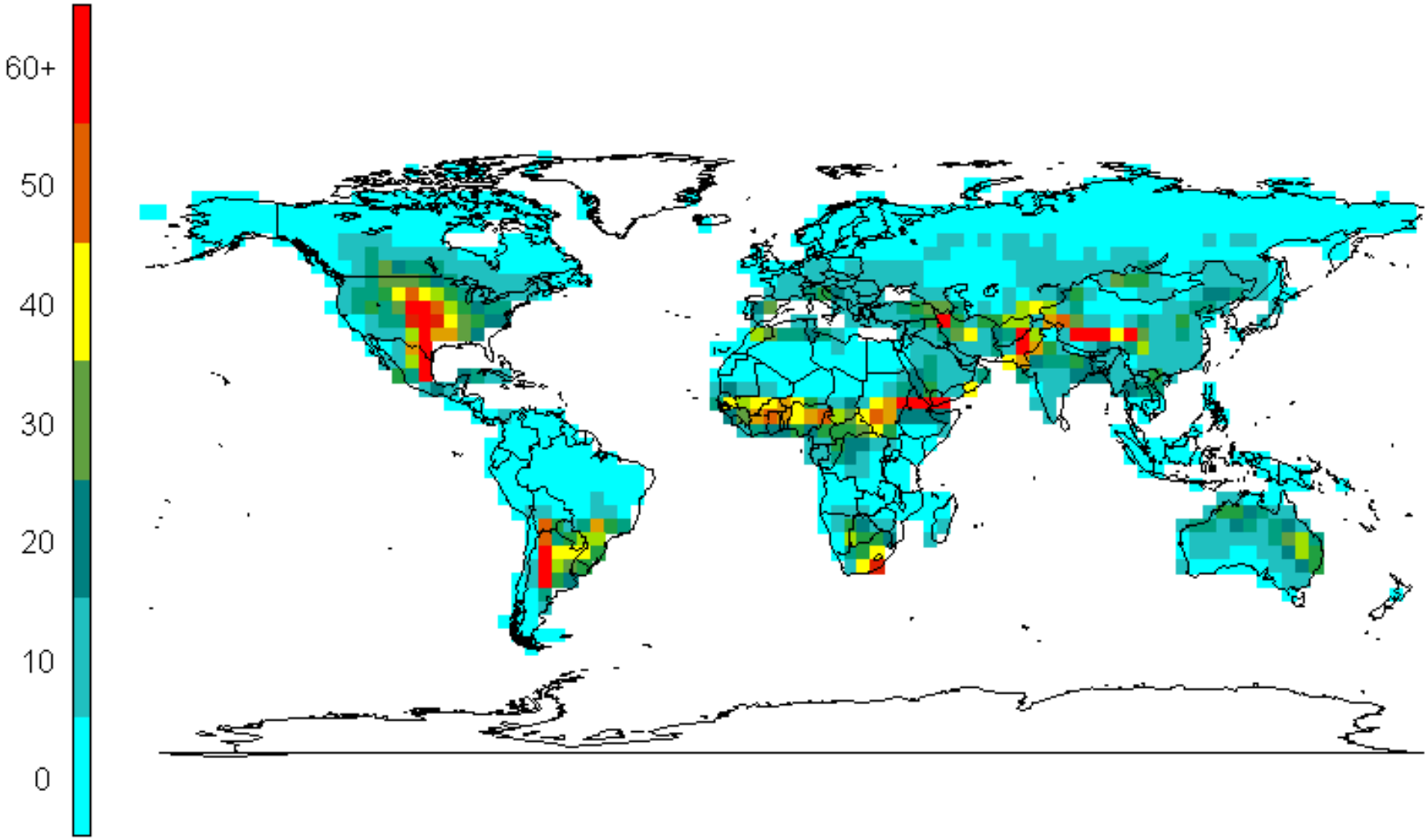
Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.377 (0.298-0.487)	0.449 (0.355-0.580)	0.570 (0.449-0.736)	0.674 (0.527-0.874)	0.820 (0.620-1.09)	0.935 (0.691-1.25)	1.05 (0.751-1.44)	1.18 (0.803-1.63)	1.34 (0.881-1.90)	1.47 (0.939-2.10)
10-min	0.552 (0.437-0.712)	0.658 (0.520-0.850)	0.835 (0.658-1.08)	0.986 (0.772-1.28)	1.20 (0.908-1.60)	1.37 (1.01-1.84)	1.54 (1.10-2.10)	1.72 (1.18-2.39)	1.97 (1.29-2.78)	2.16 (1.38-3.08)
15-min	0.673 (0.532-0.869)	0.802 (0.634-1.04)	1.02 (0.802-1.32)	1.20 (0.942-1.56)	1.46 (1.11-1.95)	1.67 (1.23-2.24)	1.88 (1.34-2.57)	2.10 (1.43-2.92)	2.40 (1.57-3.40)	2.63 (1.68-3.75)
30-min	0.910 (0.720-1.17)	1.09 (0.860-1.41)	1.39 (1.09-1.80)	1.64 (1.29-2.13)	2.00 (1.52-2.67)	2.29 (1.69-3.07)	2.58 (1.84-3.52)	2.88 (1.97-4.00)	3.29 (2.16-4.66)	3.61 (2.30-5.16)
60-min	1.18 (0.930-1.52)	1.40 (1.10-1.80)	1.77 (1.40-2.30)	2.11 (1.65-2.74)	2.60 (1.97-3.48)	2.99 (2.22-4.04)	3.41 (2.44-4.67)	3.85 (2.64-5.37)	4.47 (2.94-6.34)	4.96 (3.16-7.08)
2-hr	1.44 (1.15-1.83)	1.70 (1.36-2.17)	2.16 (1.72-2.76)	2.58 (2.04-3.30)	3.19 (2.46-4.23)	3.70 (2.78-4.94)	4.24 (3.07-5.75)	4.82 (3.34-6.67)	5.64 (3.75-7.94)	6.30 (4.06-8.91)
3-hr	1.62 (1.30-2.04)	1.90 (1.53-2.40)	2.41 (1.93-3.04)	2.87 (2.29-3.65)	3.58 (2.79-4.73)	4.18 (3.16-5.55)	4.83 (3.52-6.52)	5.53 (3.86-7.60)	6.52 (4.37-9.14)	7.33 (4.75-10.3)
6-hr	1.90 (1.55-2.37)	2.23 (1.82-2.77)	2.83 (2.30-3.53)	3.38 (2.73-4.24)	4.25 (3.35-5.55)	4.98 (3.82-6.54)	5.78 (4.26-7.73)	6.65 (4.70-9.07)	7.91 (5.35-11.0)	8.93 (5.85-12.4)
12-hr	2.17 (1.79-2.66)	2.55 (2.10-3.13)	3.24 (2.67-3.96)	3.88 (3.17-4.76)	4.86 (3.88-6.26)	5.69 (4.41-7.37)	6.59 (4.92-8.78)	7.57 (5.40-10.2)	8.97 (6.13-12.3)	10.1 (6.69-13.9)
24-hr	2.47 (2.07-2.98)	2.87 (2.40-3.47)	3.60 (3.00-4.36)	4.28 (3.55-5.21)	5.33 (4.30-6.77)	6.22 (4.88-7.96)	7.18 (5.42-9.37)	8.24 (5.95-11.0)	9.75 (6.74-13.3)	11.0 (7.34-15.0)
2-day	2.86 (2.43-3.41)	3.24 (2.74-3.85)	3.94 (3.33-4.70)	4.61 (3.87-5.53)	5.67 (4.66-7.13)	6.59 (5.25-8.34)	7.61 (5.82-9.82)	8.73 (6.38-11.5)	10.4 (7.25-14.0)	11.7 (7.90-15.8)
3-day	3.14 (2.68-3.70)	3.52 (3.00-4.15)	4.23 (3.60-5.00)	4.91 (4.16-5.83)	5.98 (4.94-7.45)	6.92 (5.54-8.67)	7.94 (6.12-10.2)	9.06 (6.67-11.9)	10.7 (7.53-14.3)	12.0 (8.19-16.2)
4-day	3.35 (2.88-3.93)	3.75 (3.22-4.40)	4.49 (3.85-5.28)	5.19 (4.42-6.13)	6.28 (5.21-7.75)	7.21 (5.80-8.97)	8.23 (6.37-10.5)	9.35 (6.90-12.2)	11.0 (7.75-14.6)	12.3 (8.39-16.4)
7-day	3.88 (3.38-4.49)	4.35 (3.78-5.04)	5.18 (4.48-6.01)	5.92 (5.09-6.90)	7.05 (5.88-8.54)	7.99 (6.47-9.78)	8.99 (7.01-11.3)	10.1 (7.49-12.9)	11.6 (8.25-15.3)	12.8 (8.83-17.0)
10-day	4.39 (3.85-5.04)	4.91 (4.30-5.64)	5.81 (5.06-6.69)	6.61 (5.72-7.64)	7.76 (6.50-9.30)	8.71 (7.09-10.6)	9.70 (7.59-12.0)	10.7 (8.03-13.7)	12.2 (8.73-15.9)	13.4 (9.26-17.7)
20-day	6.03 (5.35-6.81)	6.69 (5.93-7.56)	7.79 (6.87-8.82)	8.70 (7.63-9.91)	9.98 (8.42-11.7)	11.0 (9.02-13.0)	12.0 (9.46-14.6)	13.0 (9.79-16.2)	14.3 (10.3-18.4)	15.4 (10.8-20.1)
30-day	7.44 (6.65-8.32)	8.24 (7.37-9.23)	9.54 (8.49-10.7)	10.6 (9.37-12.0)	12.0 (10.2-13.9)	13.1 (10.8-15.4)	14.1 (11.2-17.0)	15.2 (11.5-18.8)	16.5 (12.0-21.0)	17.5 (12.3-22.7)
45-day	9.22 (8.32-10.2)	10.3 (9.23-11.4)	11.9 (10.6-13.2)	13.1 (11.7-14.7)	14.8 (12.6-16.9)	16.0 (13.3-18.6)	17.2 (13.8-20.5)	18.3 (13.9-22.4)	19.7 (14.3-24.8)	20.6 (14.6-26.6)
60-day	10.7 (9.74-11.8)	12.0 (10.9-13.2)	13.9 (12.6-15.4)	15.4 (13.8-17.1)	17.3 (14.9-19.6)	18.7 (15.6-21.6)	20.0 (16.1-23.6)	21.2 (16.2-25.8)	22.6 (16.5-28.3)	23.6 (16.8-30.3)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

NOAA Atlas 14

Data for Mankato, MN

Days per Year with Favorable Severe Parameters



from Brooks et al, NOAA-SSL, 2012

2010 Minnesota Tornadoes

48 on June 17, 2010

OPERATIONAL EF SCALE	
EF Number	3 Second Gust (mph)
0	65-85
1	86-110
2	111-135
3	136-165
4	166-200
5	Over 200

Tornado Enhanced Fujita Intensity Rating

- = EF4 (4)
- = EF3 (4)
- = EF2 (8)
- = EF1 (31)
- = EF0 (66)

Total = 113

First ever EF-5 Tornado in Canada, (Elie, Manitoba) June 22, 2007

First 4 inch thunderstorm rainfall Churchill, Manitoba, Aug 24, 2010

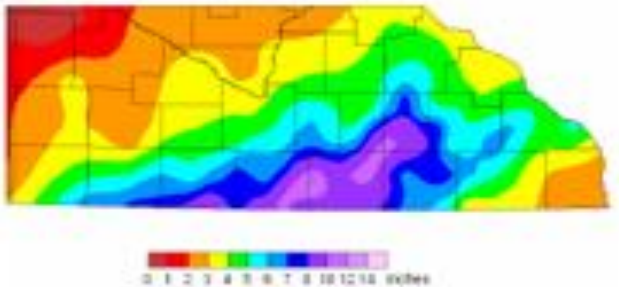
Located at nearly 59 degrees N. latitude, Churchill, Manitoba reported their first ever 4.12 inch thunderstorm rainfall on August 24, 2010! Previous record was 2.45 inches.

Shift in Precipitation Recurrence Intervals

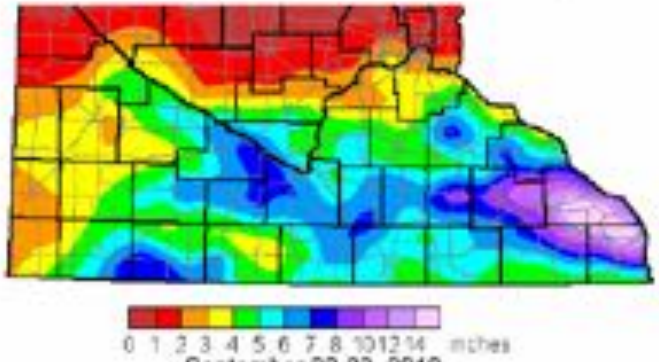
Three one thousand year events since 2004

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

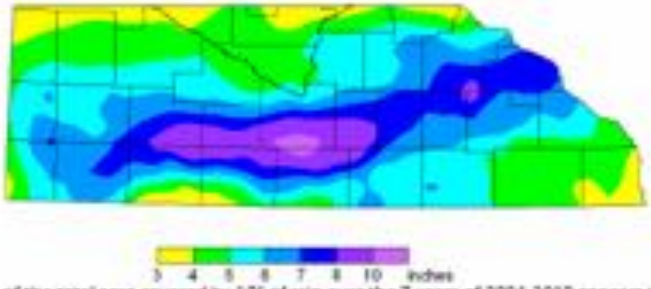
September 14-15, 2004



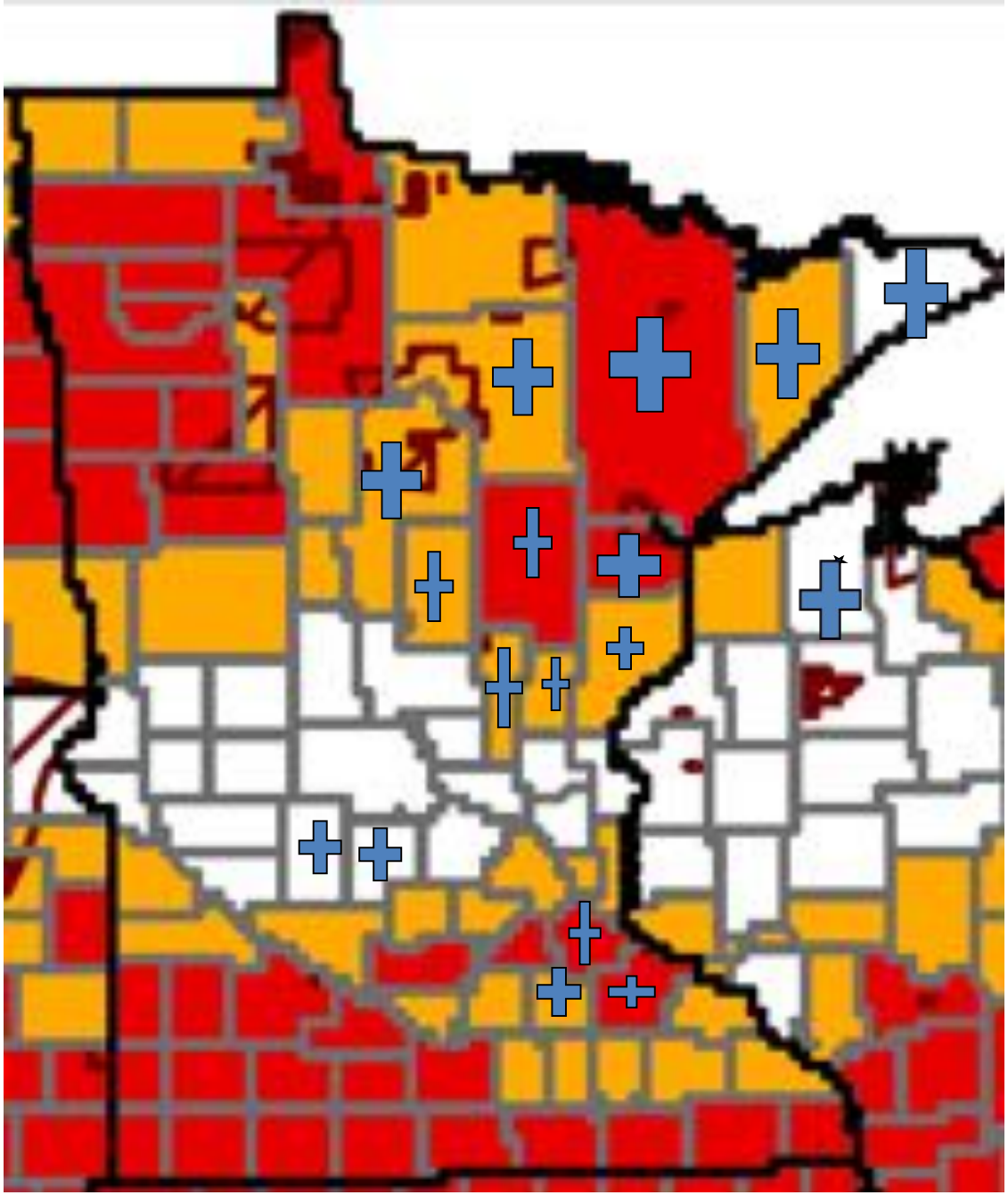
August 18 through August 20 (8:00 AM CDT), 2007



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.



MN Counties designated for federal disaster assistance in 2012

All are associated with drought except those with ✚

which designates for flood or severe storm


Nov, 2012
Discharge (cfs)
Rainfall (in)
850
800
750
700
650
600
550
500
450
0.25
0.20
0.15
0.10
0.05
0.00
10/29/12
11/05/12
11/12/12
11/19/12
11/26/12
Jun, 2012
Discharge (cfs)
Rainfall (in)
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
1.00
0.80
0.60
0.40
0.20
0.00
06/06
06/09
06/12
06/15
06/18
06/21
06/24
06/27
06/30
St Louis River at Scanlon, MN
90 fold difference in 5 months
-largest extreme variation in
volume flow in 105 years

Consequences of Changes in Precipitation Quantity and Character

- Altered irrigation, tile drainage, runoff, sediment, and shoreline management
- Change in storm sewer runoff design
- Mitigation of soil erosion
- Mitigation of flooding potential
- Impact on insurance risk and claims

USDA Regional Climate Hubs will provide:

- **Technical Support**
- **Assessments and Forecasts**
- **Outreach and Education**

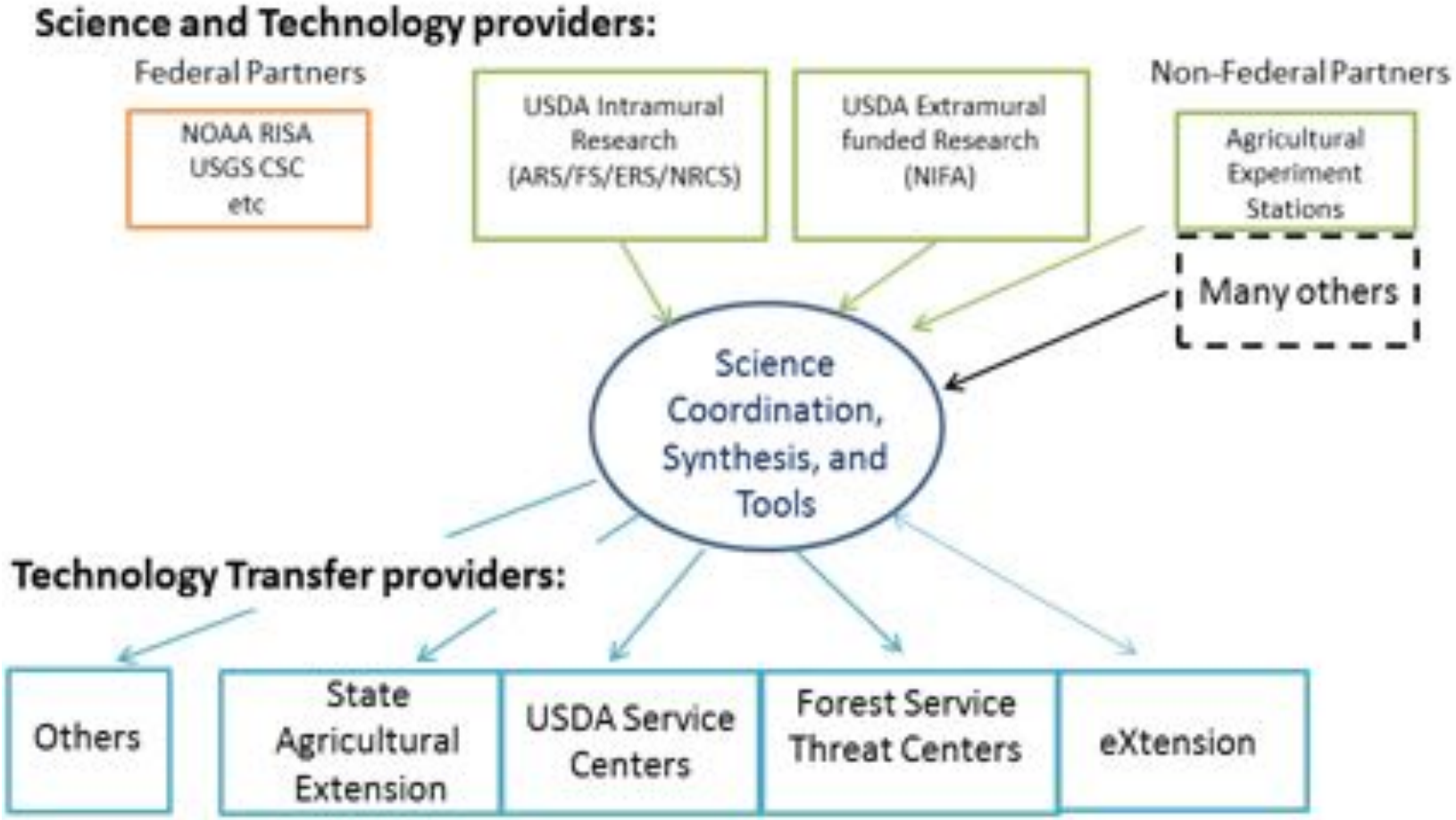
USDA

USDA 150 YEARS

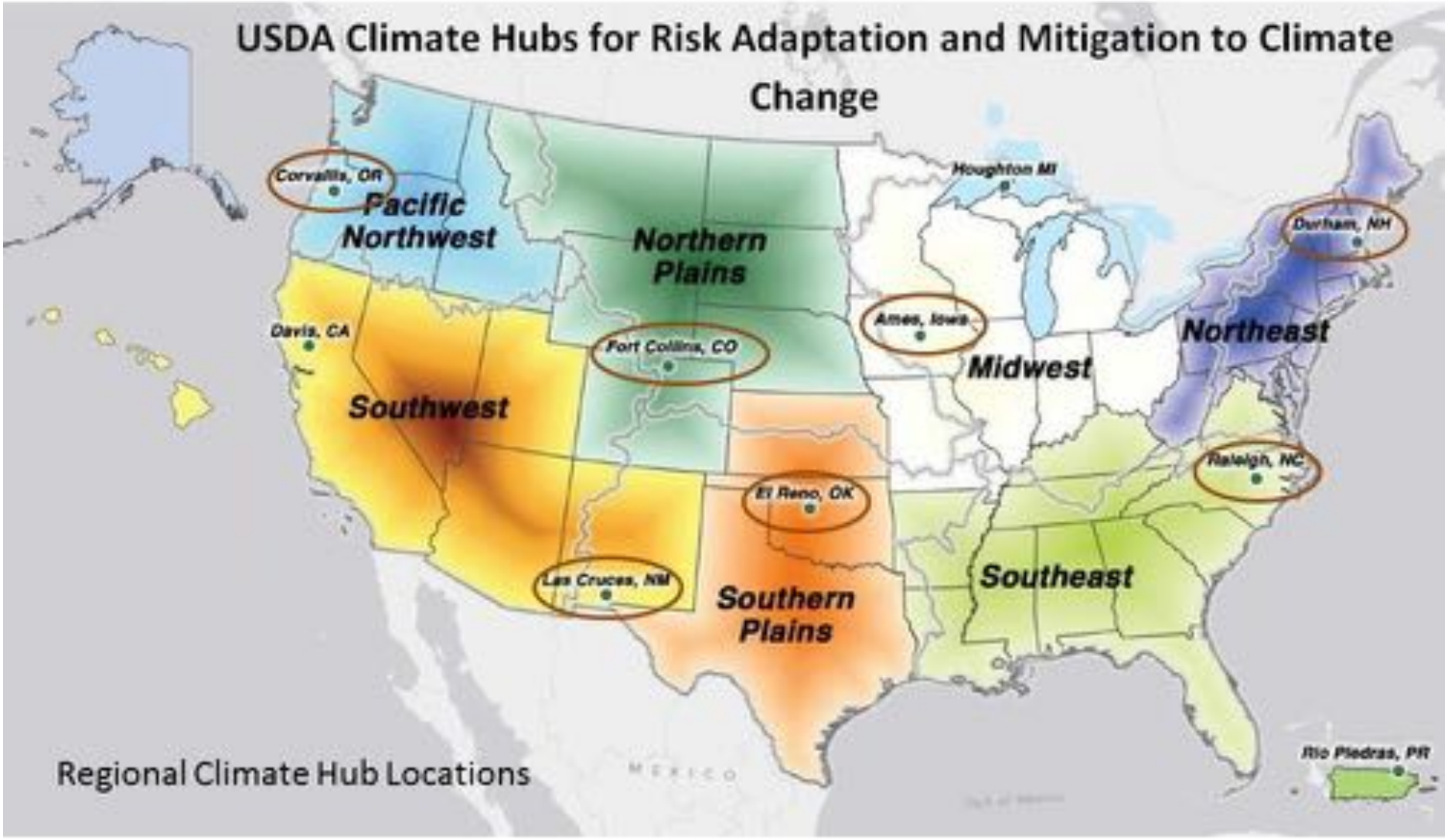
Vision: Agricultural production and natural resources maintained and strengthened under increasing climate variability and environmental change

Mission: To develop and deliver science-based, region-specific information and technologies to agricultural and natural resource managers that enable climate-smart decision-making and provide assistance to enable land managers to implement those decisions.

Conceptual Framework for a USDA Regional Hub



Revised USDA Climate Hub Regions



- Establish work plans