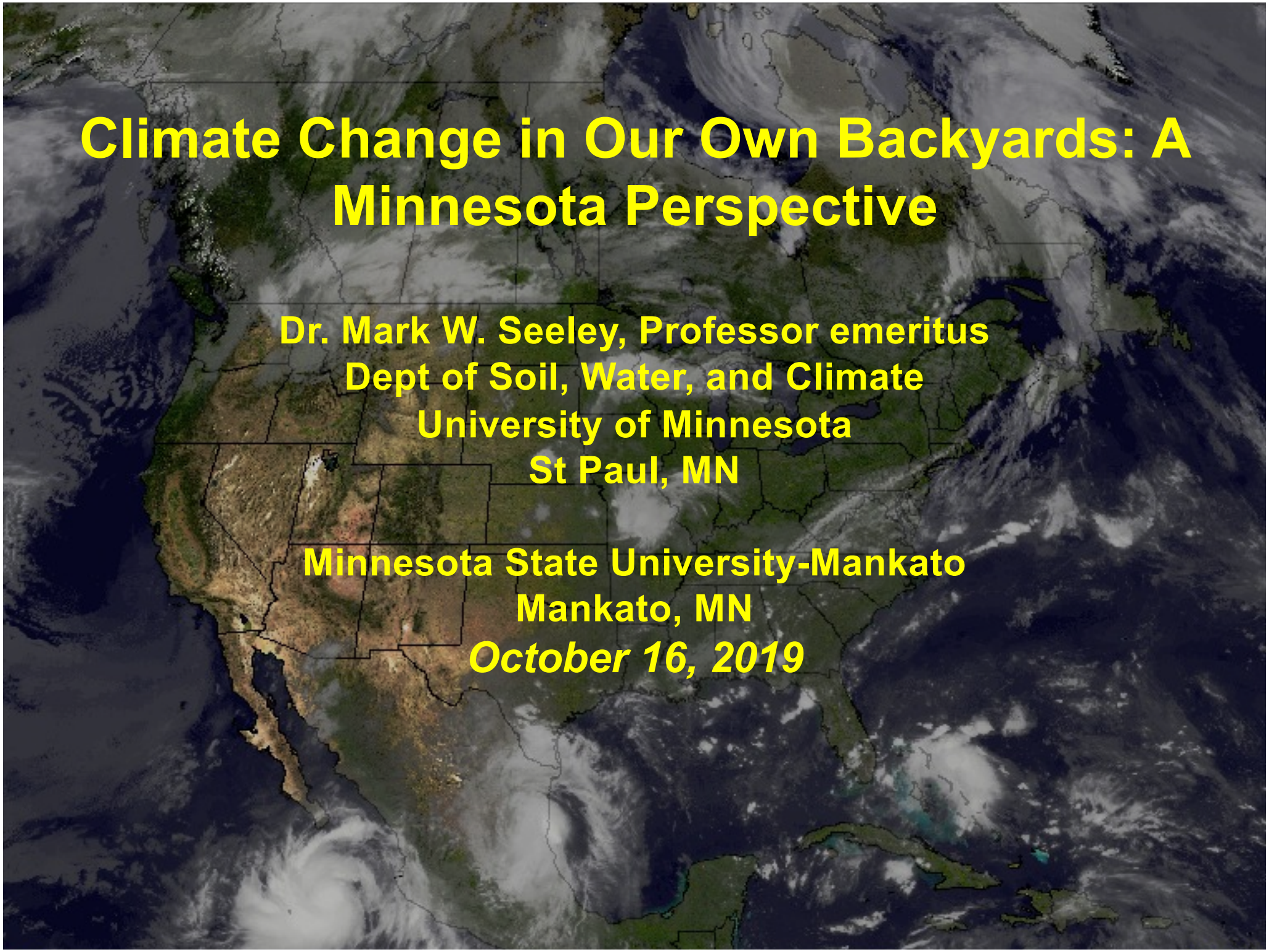
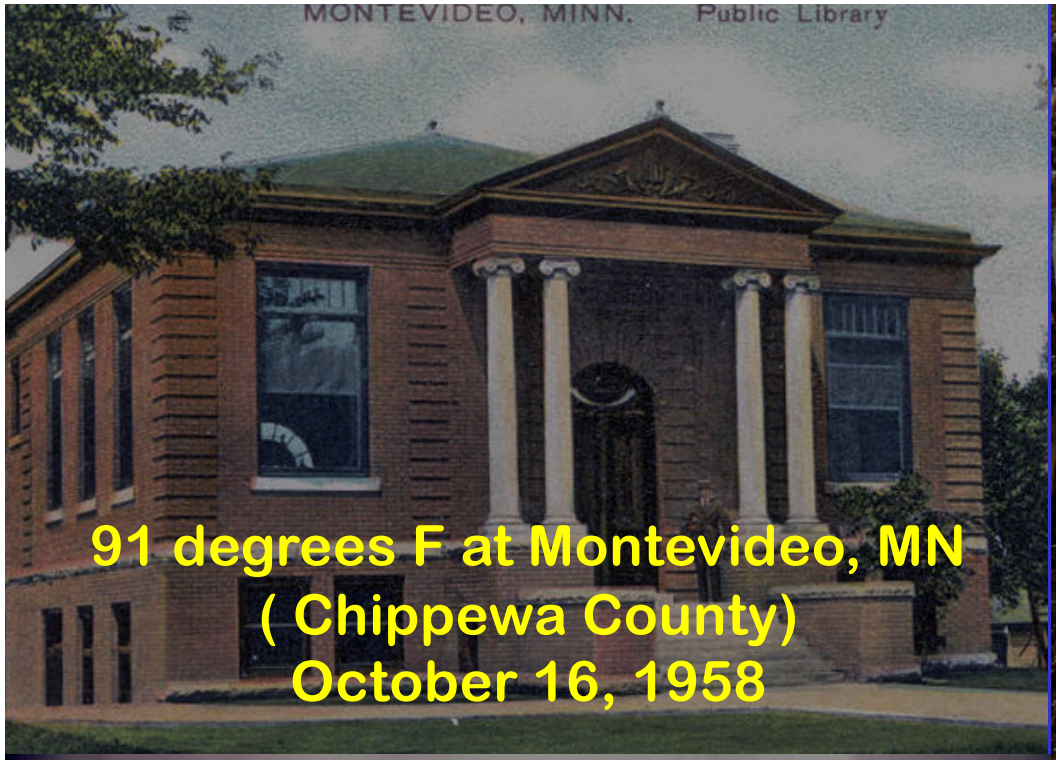


Climate Change in Our Own Backyards: A Minnesota Perspective

Dr. Mark W. Seeley, Professor emeritus
Dept of Soil, Water, and Climate
University of Minnesota
St Paul, MN

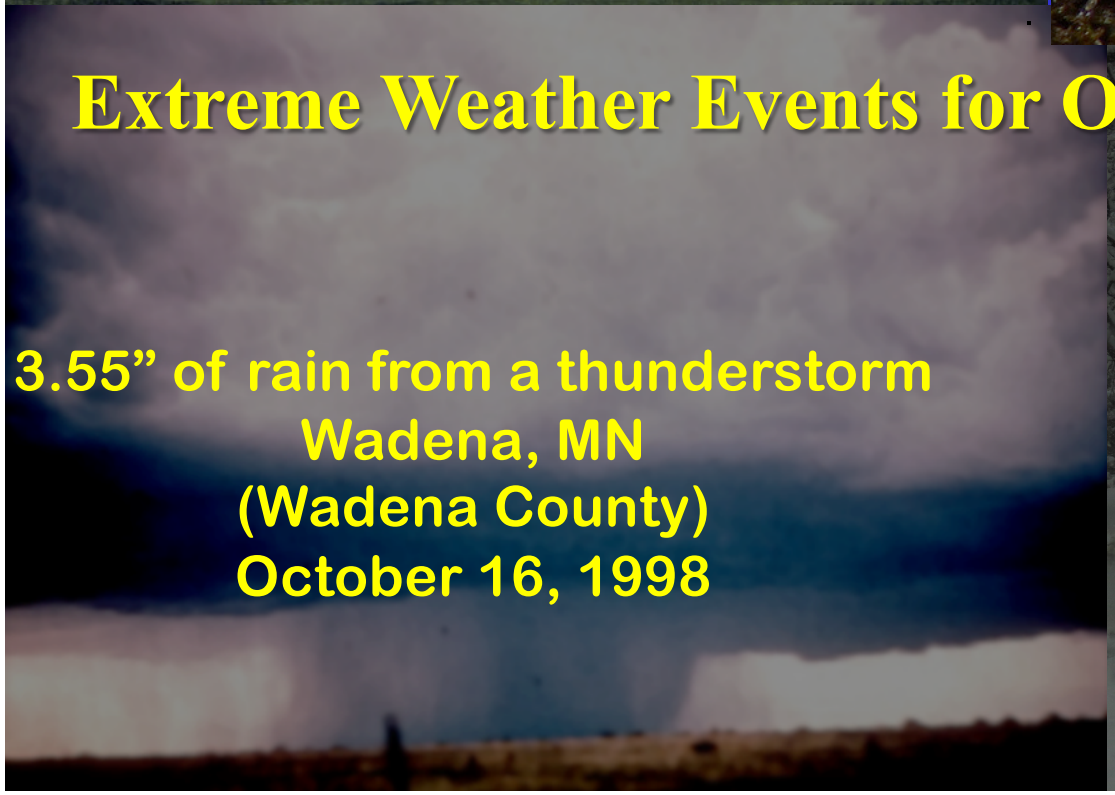
Minnesota State University-Mankato
Mankato, MN
October 16, 2019

Extreme Weather Events for October 16th in Minnesota



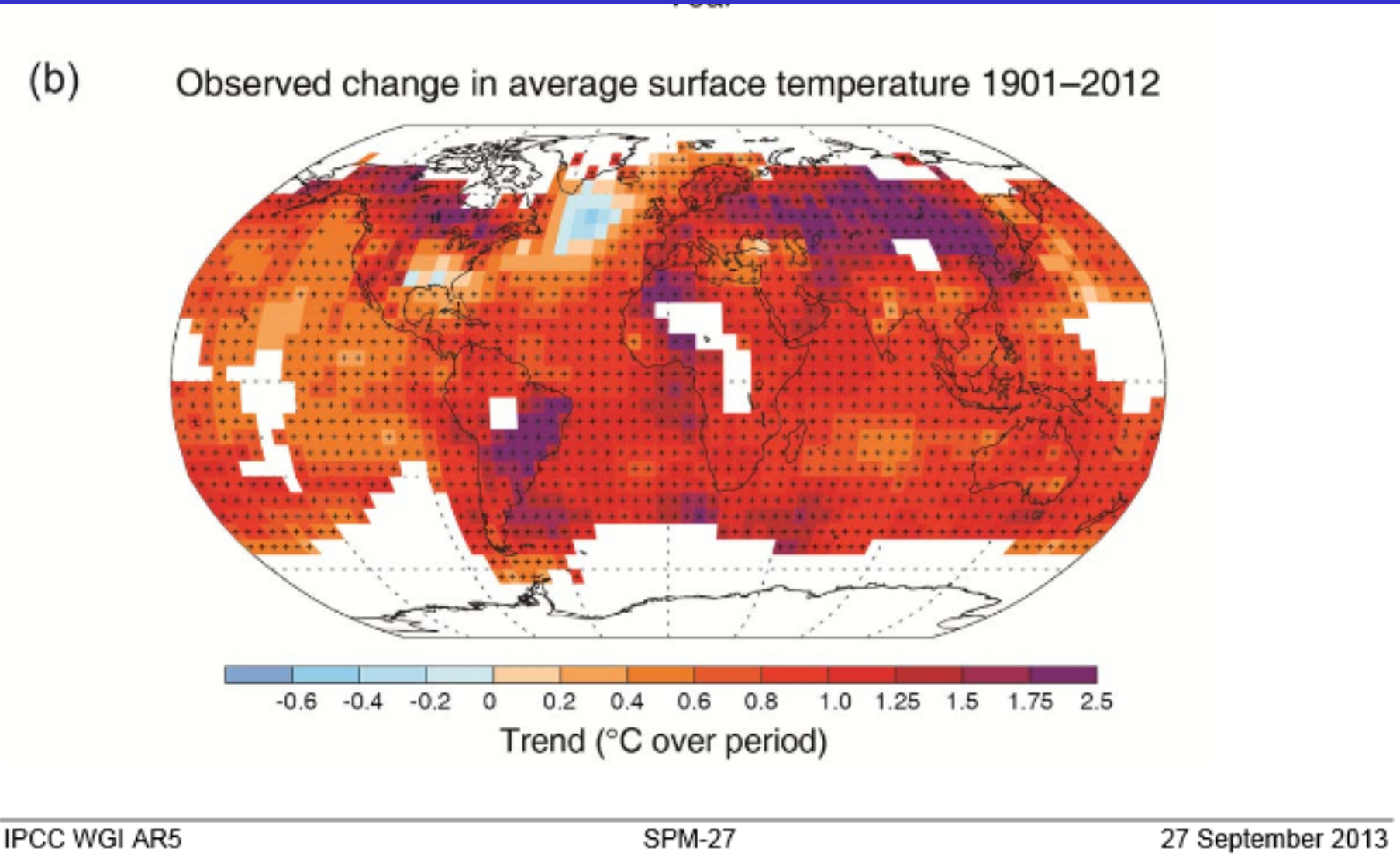
91 degrees F at Montevideo, MN
(Chippewa County)
October 16, 1958

4 degrees F at Bemidji, MN
(Beltrami County)
October 16, 1952



3.55” of rain from a thunderstorm
Wadena, MN
(Wadena County)
October 16, 1998

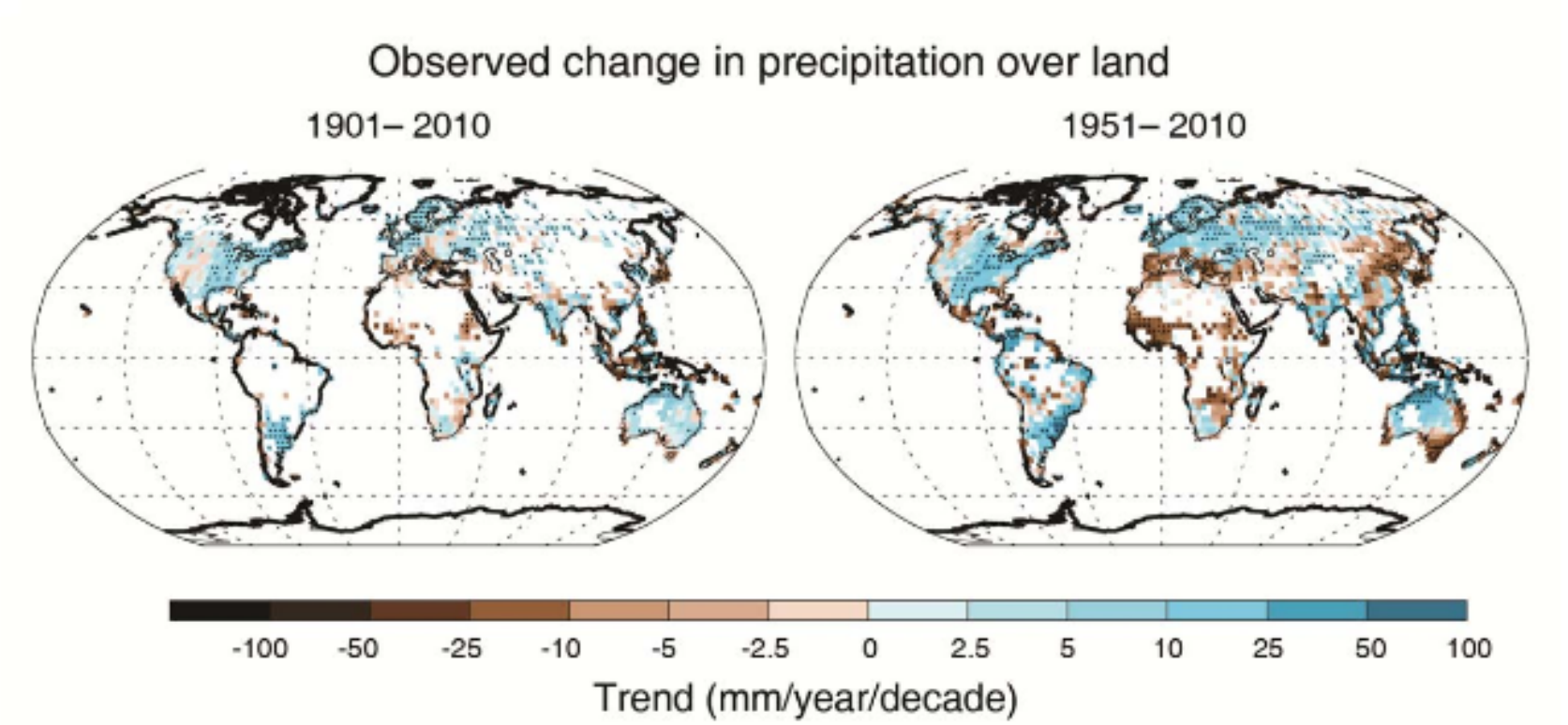
10.0” of snowfall at
Bird Island, MN
(Renville County)
October 16, 1937



Geographic Disparity in Temperature Change

From IPCC –AR5 Report

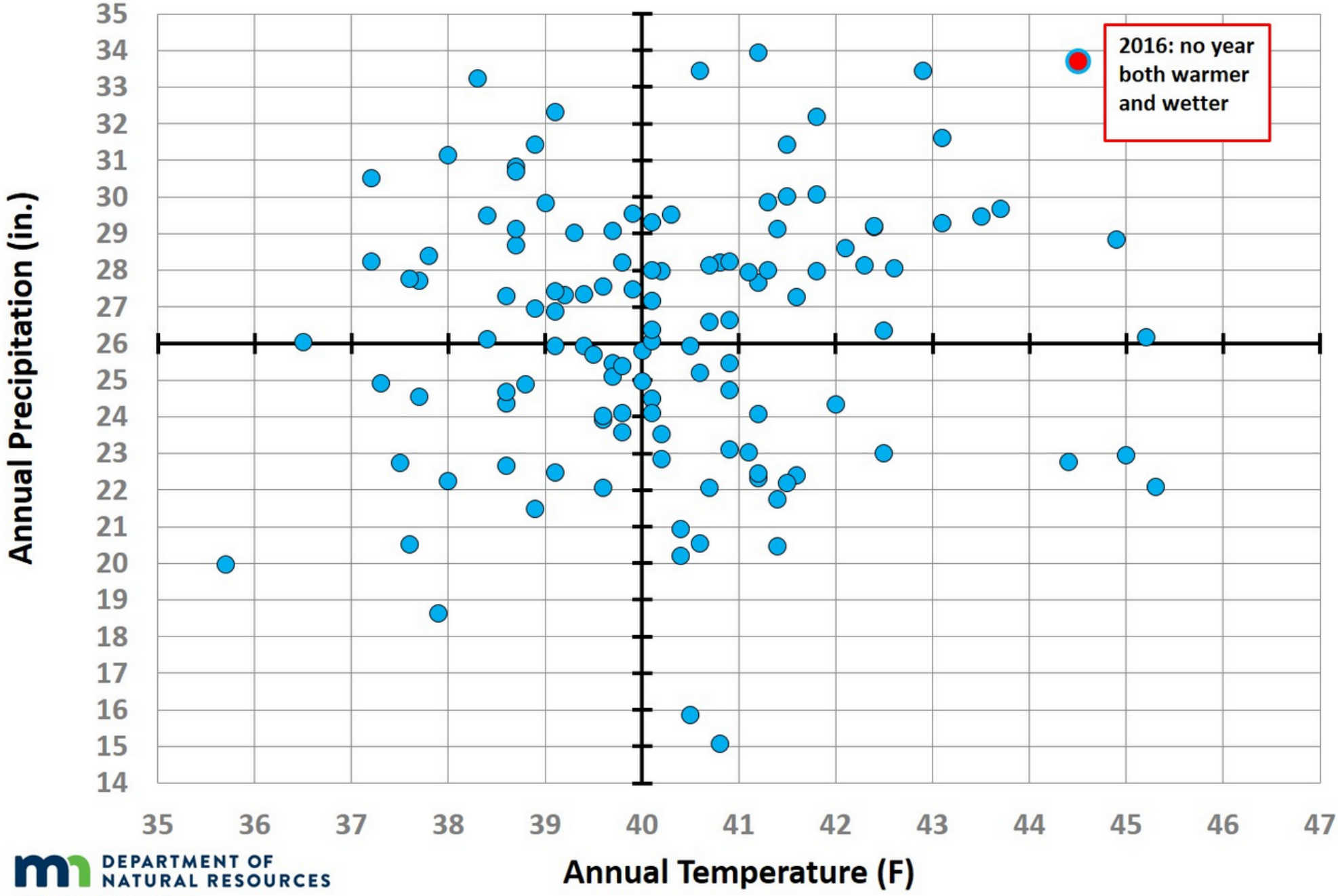
Figure SPM.2 [FIGURE SUBJECT TO FINAL COPYEDIT]



Net Change in Precipitation Over Land

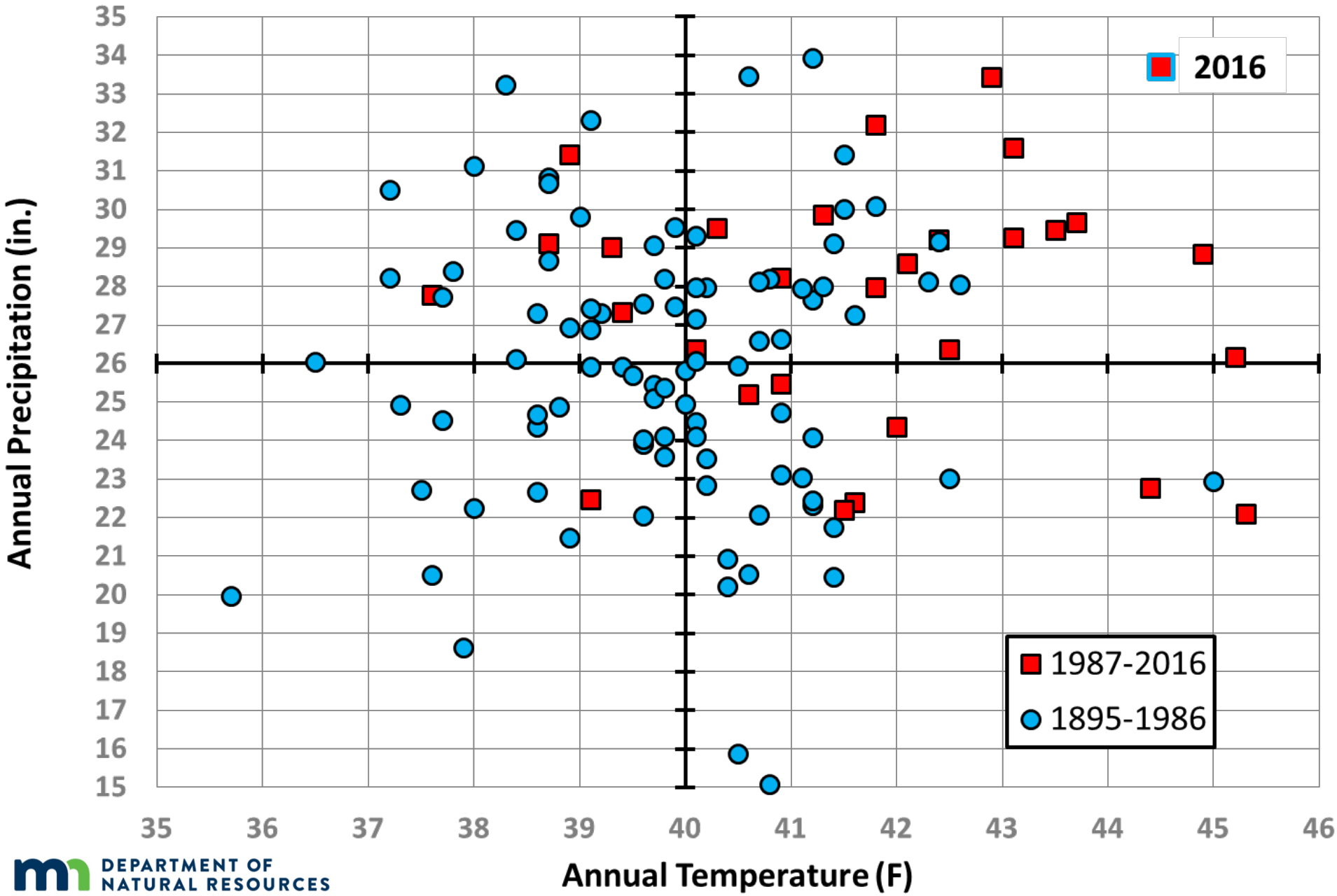
From IPCC-AR5 Report

Minnesota Average Temperature and Precipitation

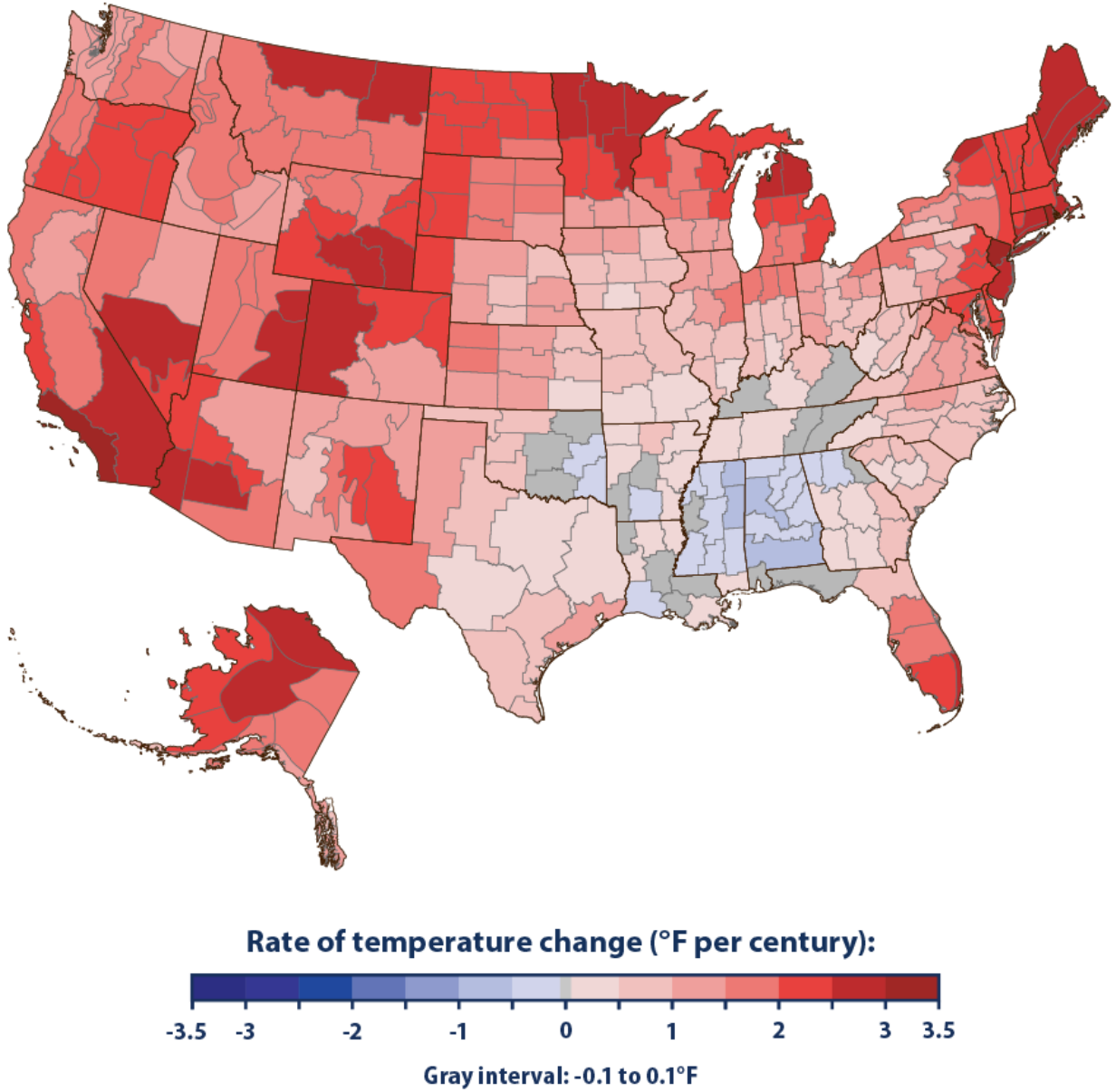


DEPARTMENT OF NATURAL RESOURCES
State Climatology Office

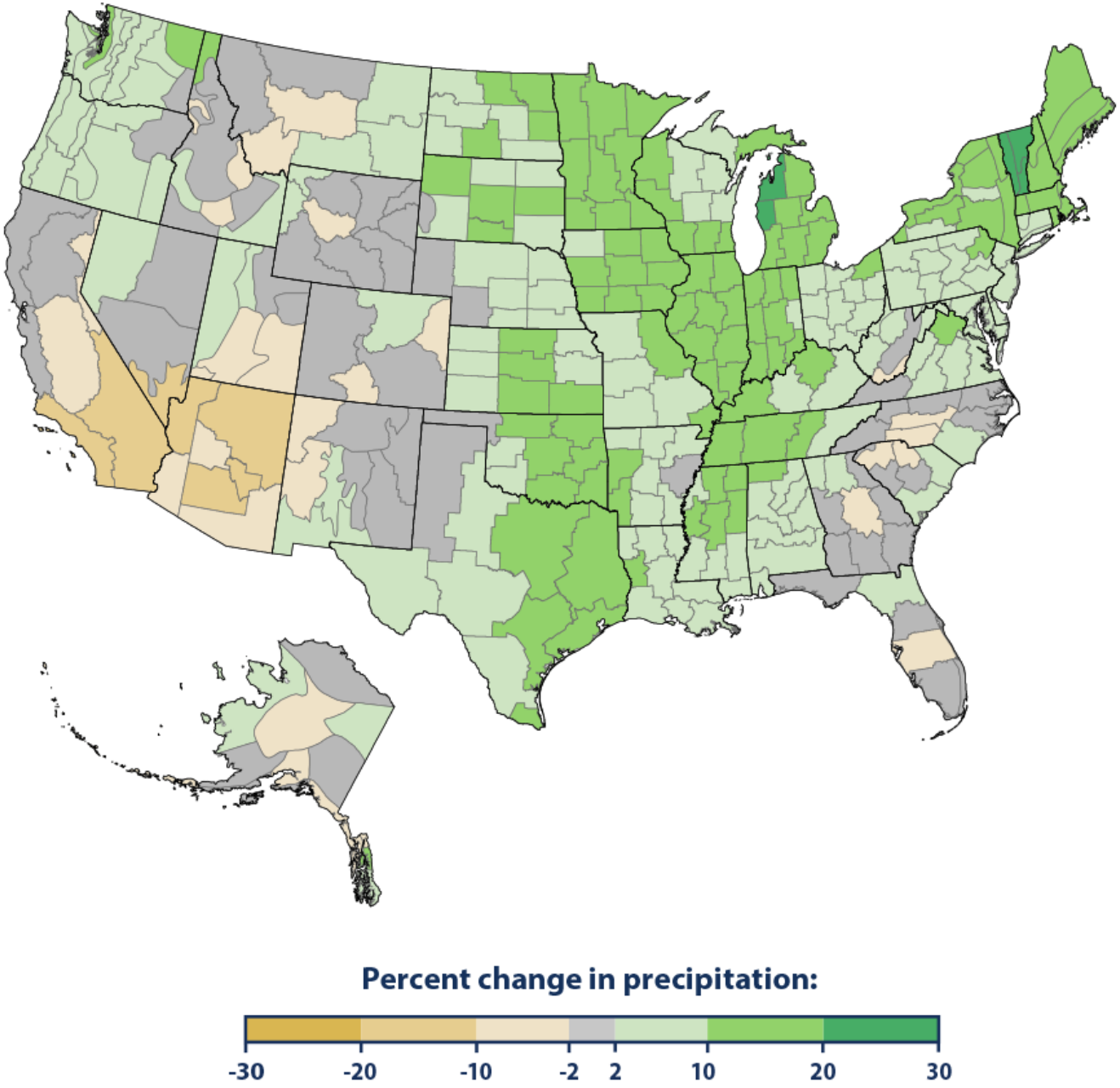
Minnesota Average Temperature and Precipitation



DEPARTMENT OF NATURAL RESOURCES
State Climatology Office

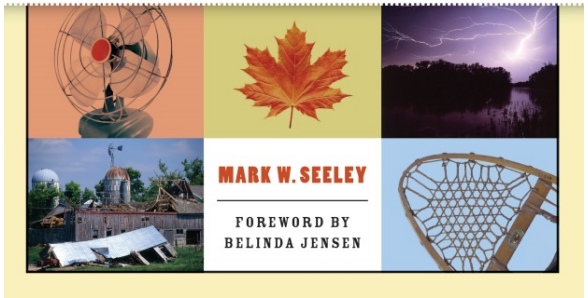


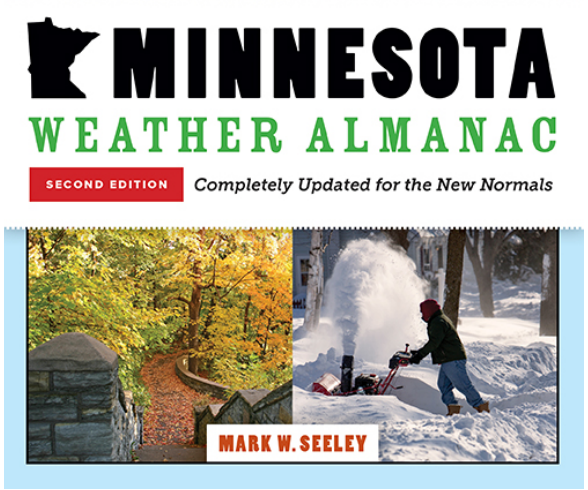
Rate of Temperature Change in the United States, 1901-2015 (via NOAA) shows geographic disparity in the pace of climate change and the response to it. Temperature change is rapid in northern Minnesota



Change in Annual Precipitation in the United States, 1901-2015 (via NOAA) shows geographic disparity. Minnesota is getting wetter.

Published by MHS Press in 2006





Published by MHS Press in 2015

Over 17,000 new daily climate records set in Minnesota's observation network since the 1st edition.

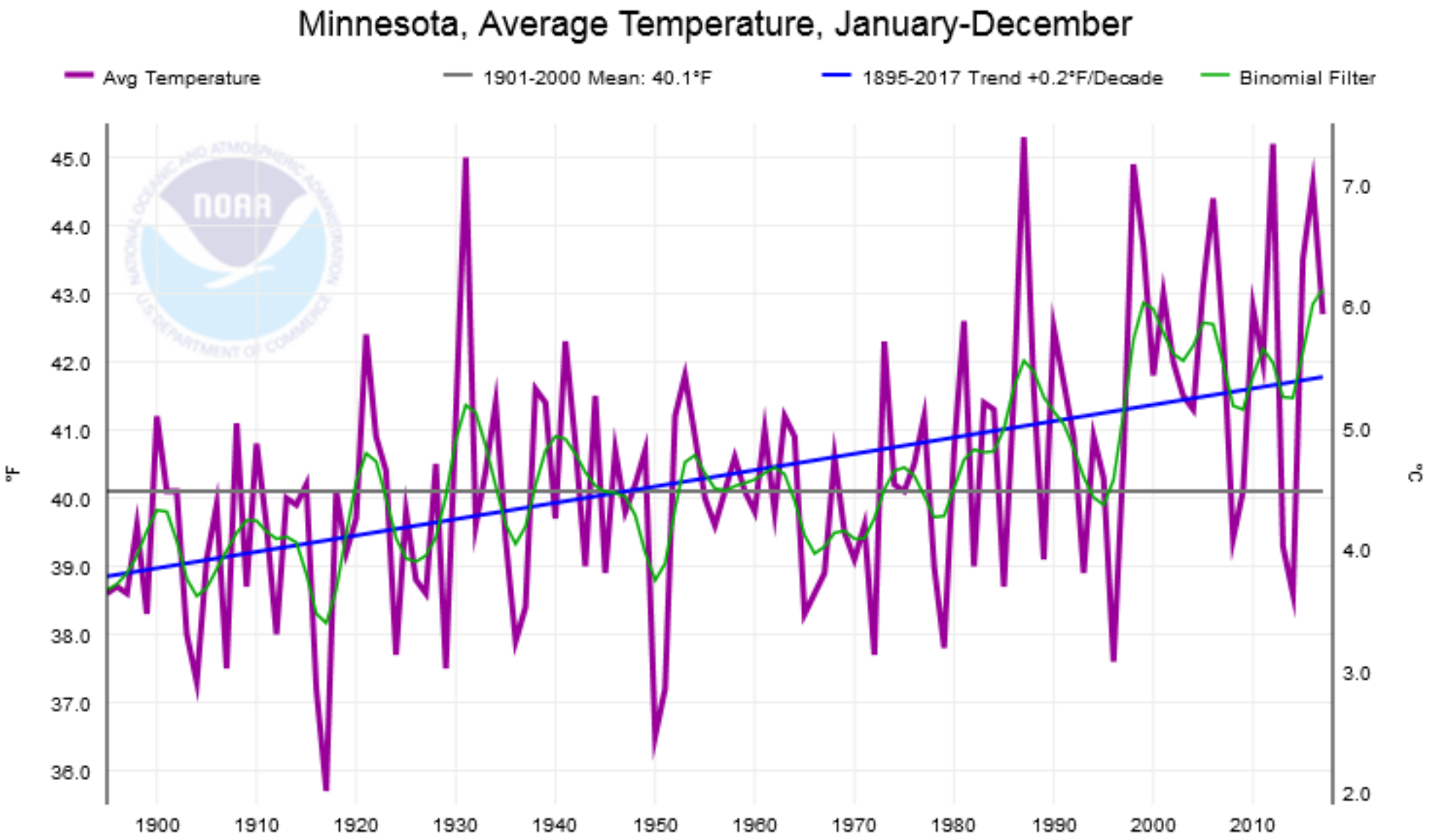
165 daily statewide climate records were set or tied skewed to warmth and heavy rainfalls

Ranked Listing of Minnesota's Warmest Years Back to 1895 (124 years)
Top Ten Warmest January to December Periods on a Statewide Basis (°F).

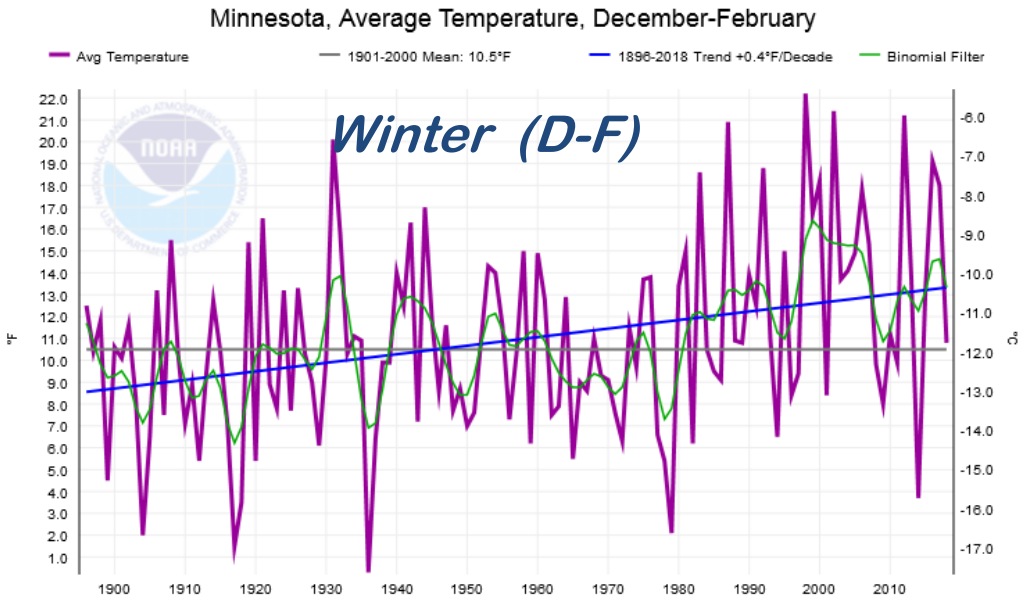
Rank	Year	Avg.	Normal	Dep.
1	1987	45.3	41.5	3.8
2	2012	45.2	41.5	3.7
3	1931	45.0	41.5	3.6
4	1998	44.9	41.5	3.4
5	2016	44.6	41.5	3.1
6	2006	44.4	41.5	2.9
7	1999	43.7	41.5	2.2
8	2015	43.5	41.5	2.0
9	2005	43.1	41.5	1.6
9	2001	43.1	41.5	1.6
10	2010	42.8	41.5	1.4

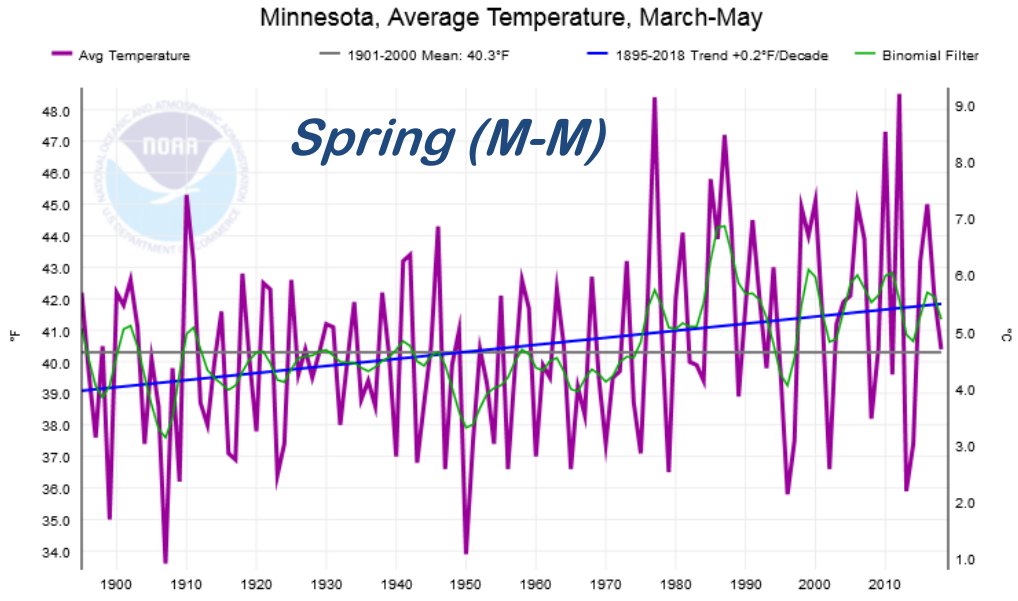
Ranked Listing of Minnesota's Wettest Years Back to 1895 (124 years)
Top Ten Wettest January to December Periods on a Statewide Basis. (inches)

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

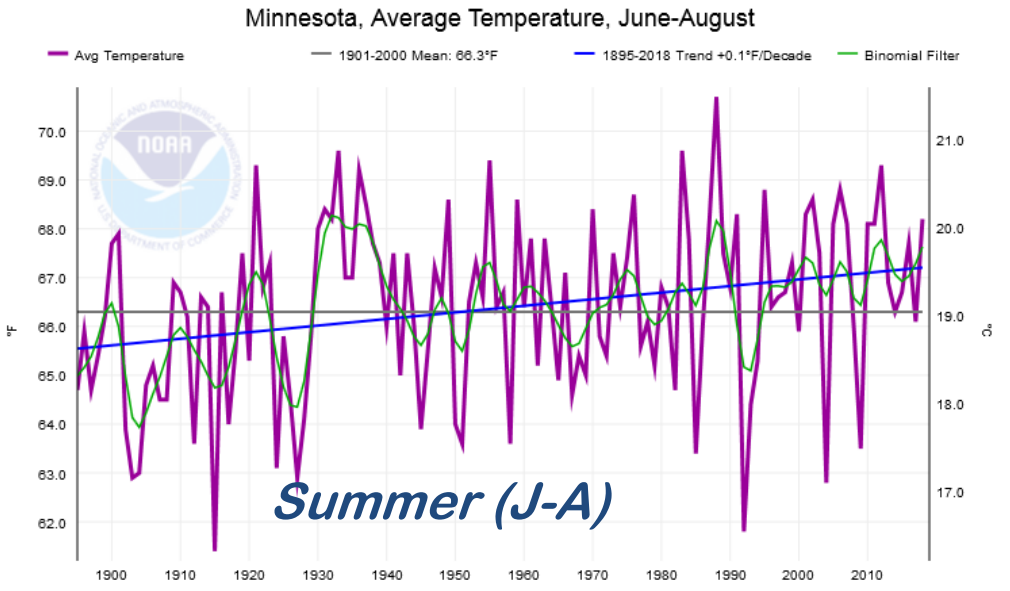


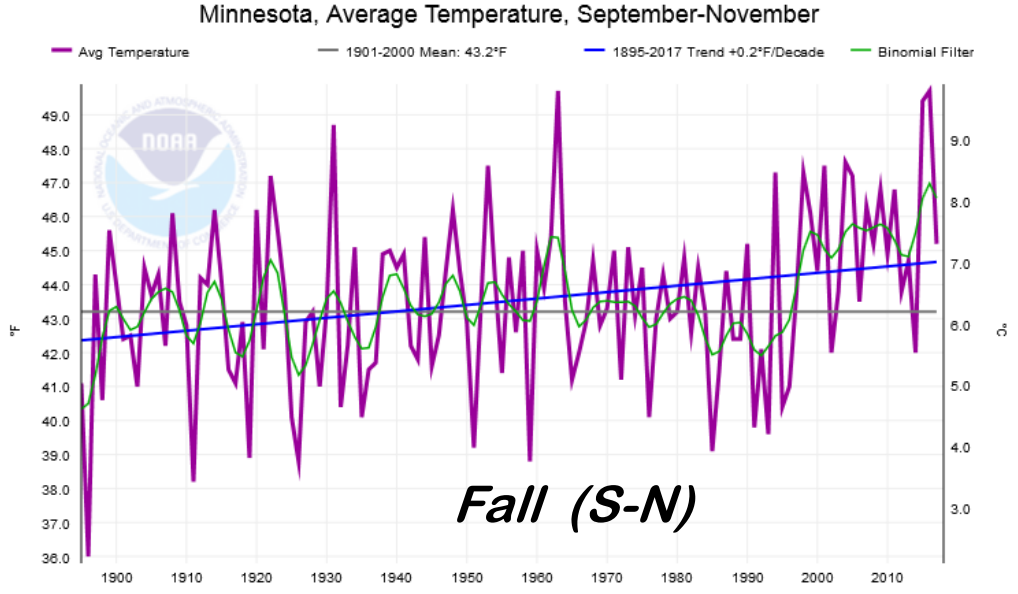
Trend in Mean Annual Temperature for MN





Seasonal Statewide Temperature Trends in MN





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

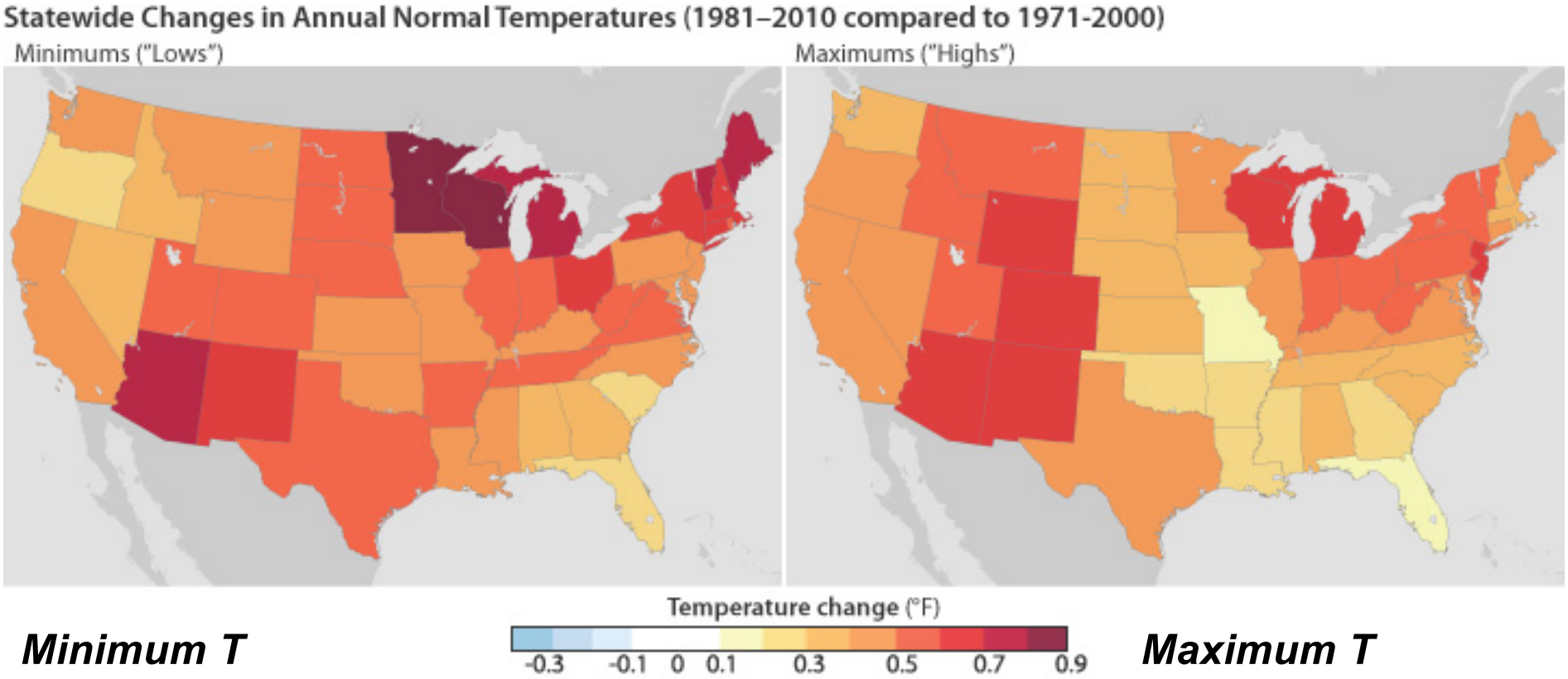
Month	Min Change	Max Change	Mean Change
January	+3.0	+2.1	+2.5
February	+0.1	+0.2	+0.1
March	-0.1	-0.1	-0.2
April	+1.3	+0.2	+0.7
May	+0.9	-0.8	+0.1
June	+1.6	-0.4	+0.5
July	+1.1	+0.2	+0.7
August	+1.6	+0.4	+1.0
September	+1.3	+0.6	+1.0
October	+1.7	-0.3	+0.7
November	+2.1	+1.7	+1.9
December	+2.2	+1.4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

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

Month	Min Change	Max Change	Mean Change
January	+2.5	+1.9	+2.2
February	+0.5	+0.7	+0.6
March	+0.7	+1.1	+0.9
April	+0.9	+1.7	+1.2
May	+0.7	-0.1	+0.3
June	+1.2	+0.3	+0.7
July	+1.1	+0.5	+0.7
August	+1.1	+0.7	+0.9
September	+1.3	+0.8	+1.1
October	+0.6	+0.4	+0.5
November	+1.1	+1.5	+1.3
December	+1.2	+0.9	+1.0

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

Month	Min Change	Max Change	Mean Change
January	+2.3	+1.5	+1.9
February	+0.7	+0.2	+0.4
March	+0.5	+0.2	+0.3
April	+0.6	+0.6	+0.6
May	+1.0	-1.2	-0.2
June	+0.9	-1.0	-0.1
July	+0.8	-0.6	+0.1
August	+1.0	-0.6	+0.1
September	+1.5	-0.1	+0.6
October	+0.8	-0.5	+0.1
November	+1.7	+1.4	+1.5
December	+2.0	+0.8	+1.3



Minimum T ***Maximum T***

There are regional differences in the rate of change in maximum versus minimum temperature. Minnesota's minimum temperature are warming more rapidly than the maximum temperatures. (from NOAA-NCEI)

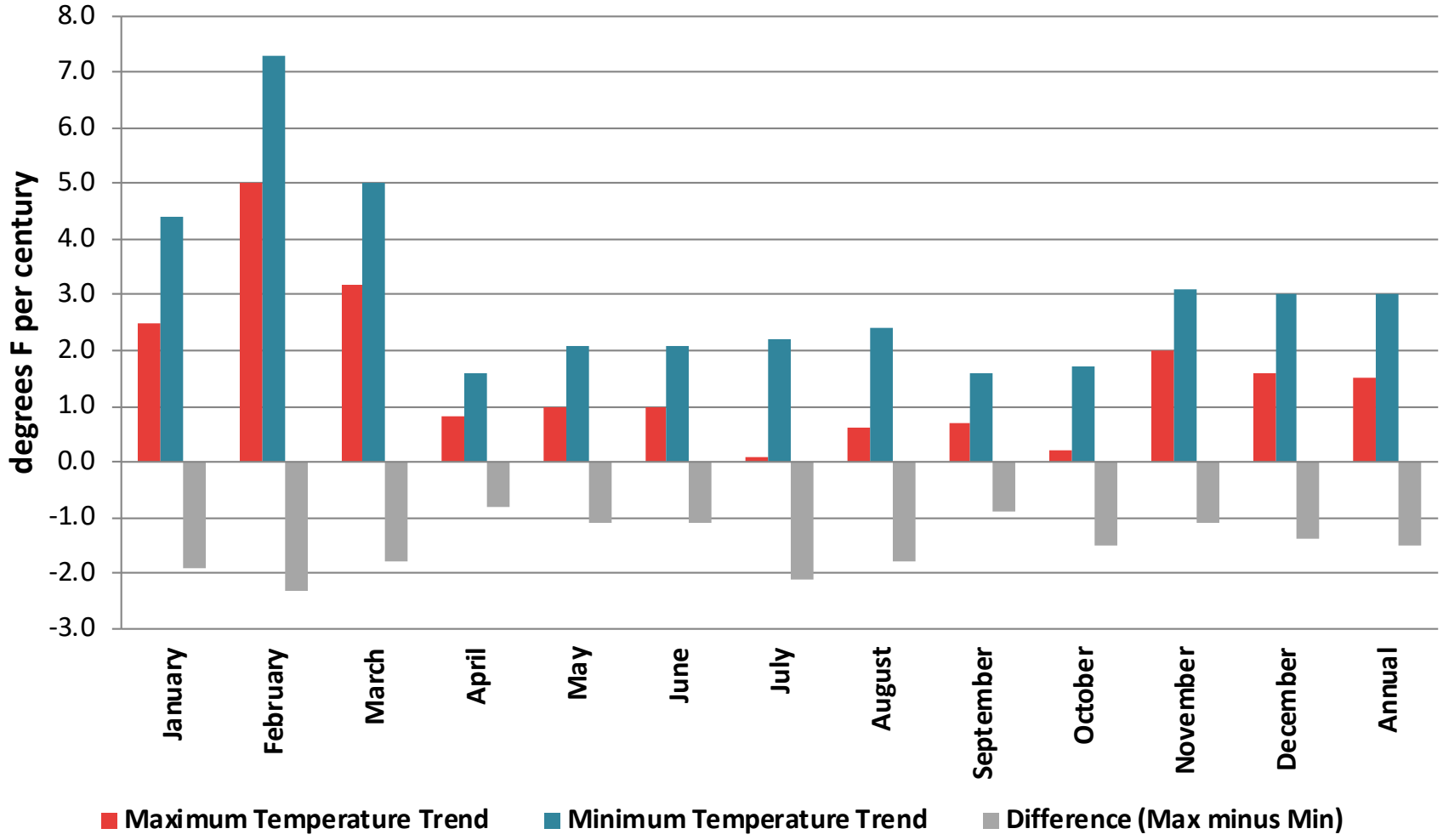
Trends in average winter minimum temperatures Milan, MN

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 average winter minimum temperatures Windom, MN

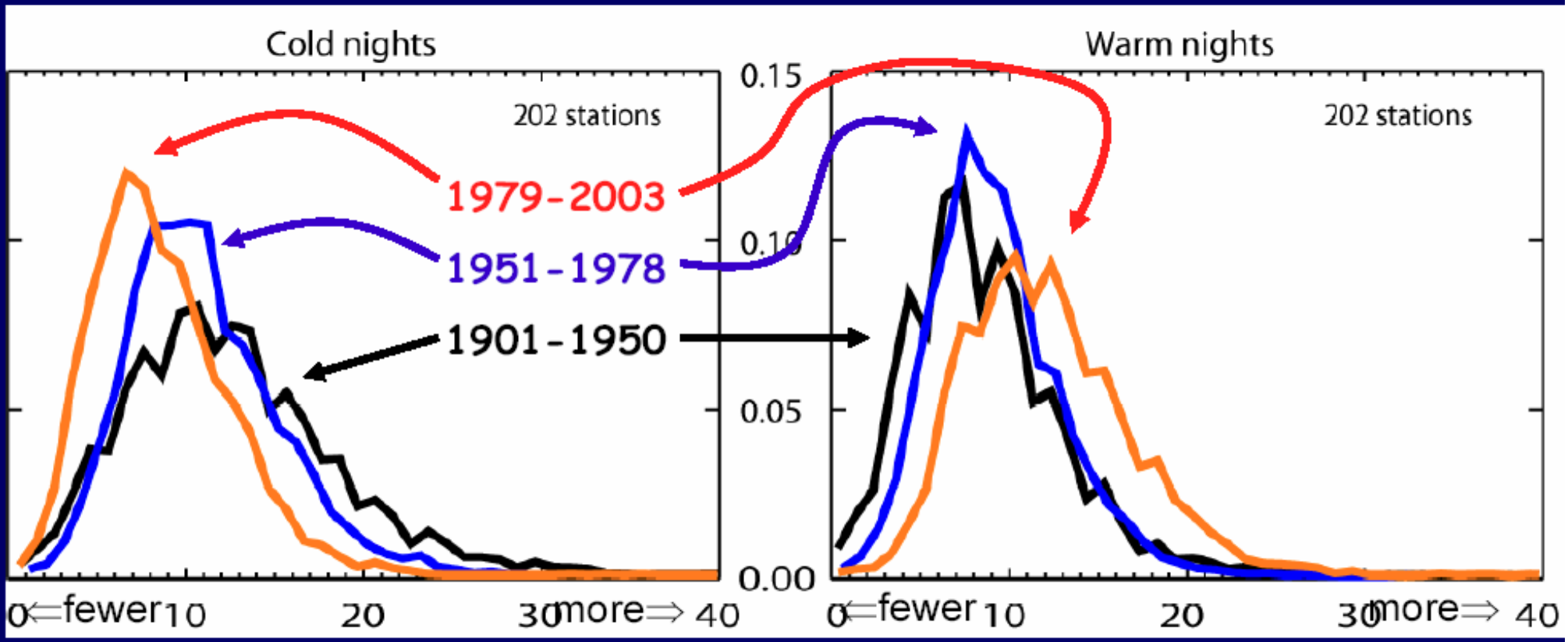
Period of Record	Ave Min Temp in Deg. F
1951 - 1980	Jan -0.3
1961 - 1990	Jan 3.3
1971 - 2000	Jan 4.0
1981 - 2010	Jan 6.3
1951 - 1980	Feb 6.1
1961 - 1990	Feb 9.0
1971 - 2000	Feb 10.6
1981 - 2010	Feb 11.1
1951 - 1980	Mar 17.7
1961 - 1990	Mar 21.7
1971 – 2000	Mar 22.1
1981 - 2010	Mar 22.3

Minnesota State-Averaged Temperature Trends by Month
1895-2013



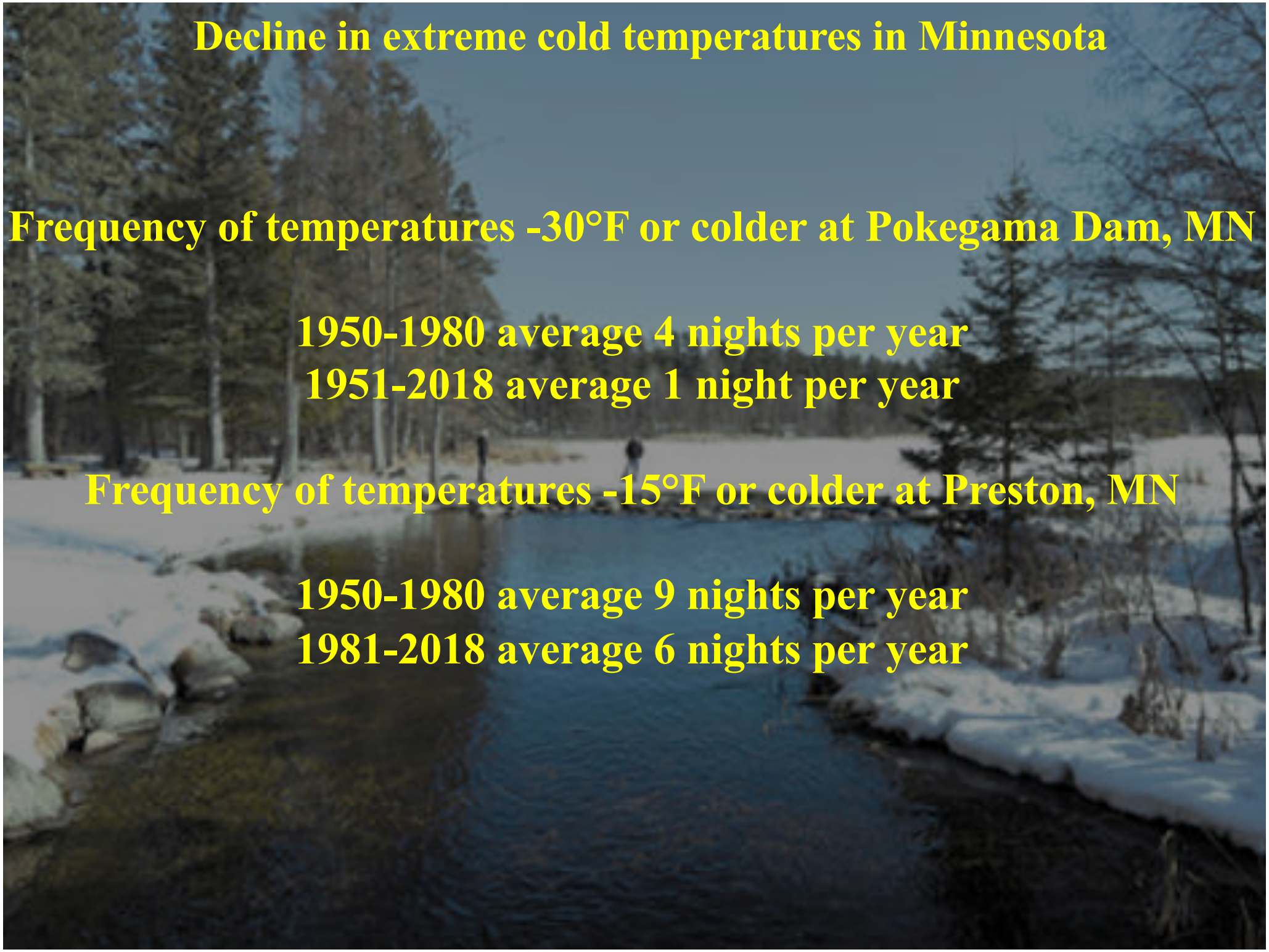
From MN-DNR-State Climatology Office

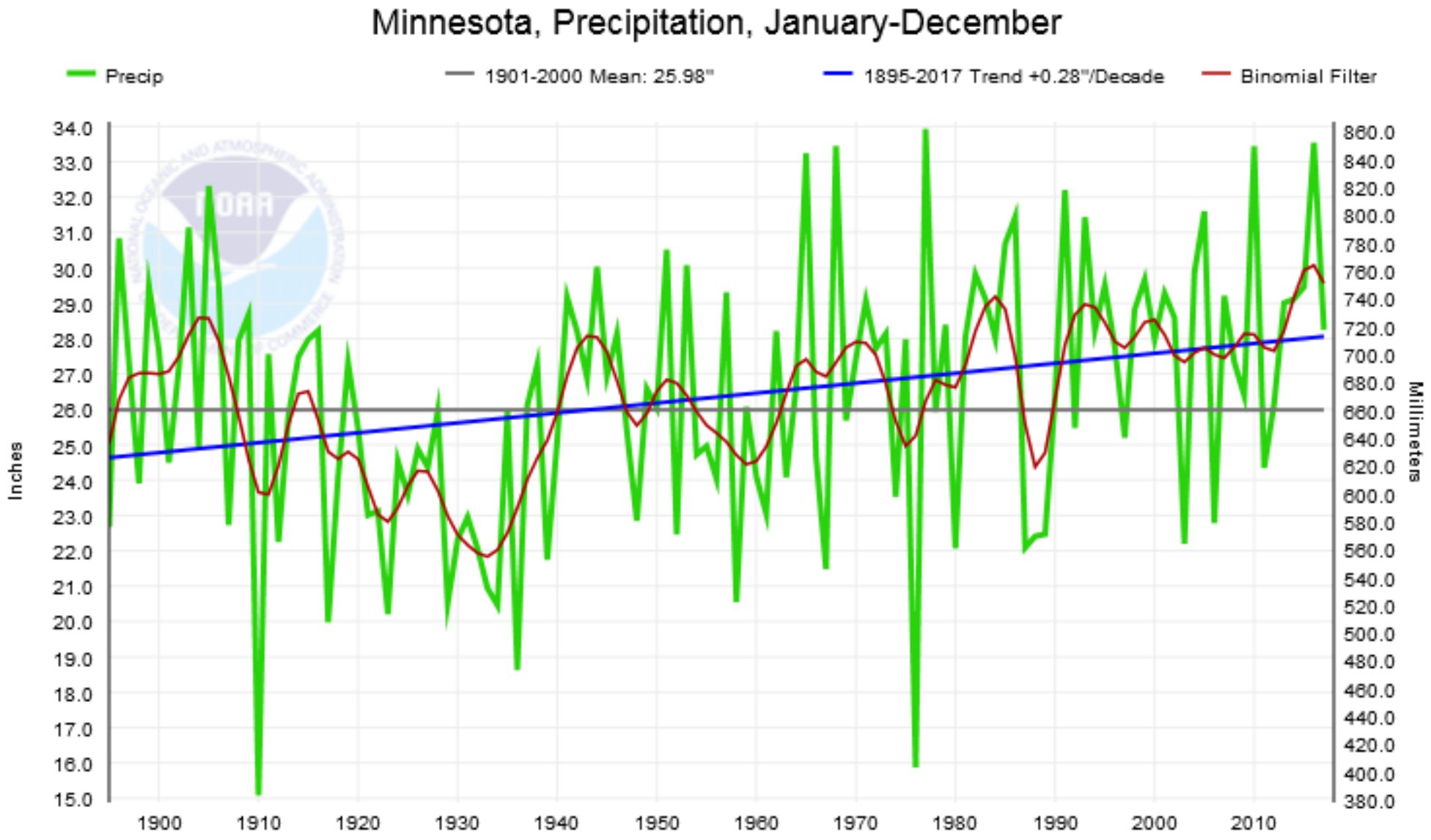
Warm nights are increasing; cold nights decreasing



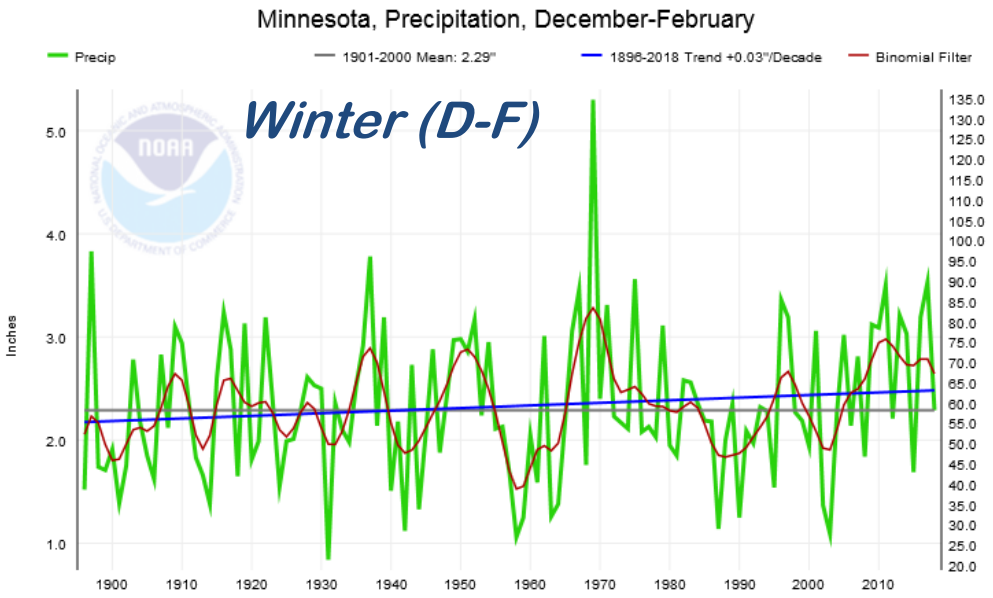
Frequency of occurrence of cold or warm temperatures for 202 global stations for 3 time periods:
1901 to 1950 (black), 1951 to 1978 (blue) and 1979 to 2003 (red).

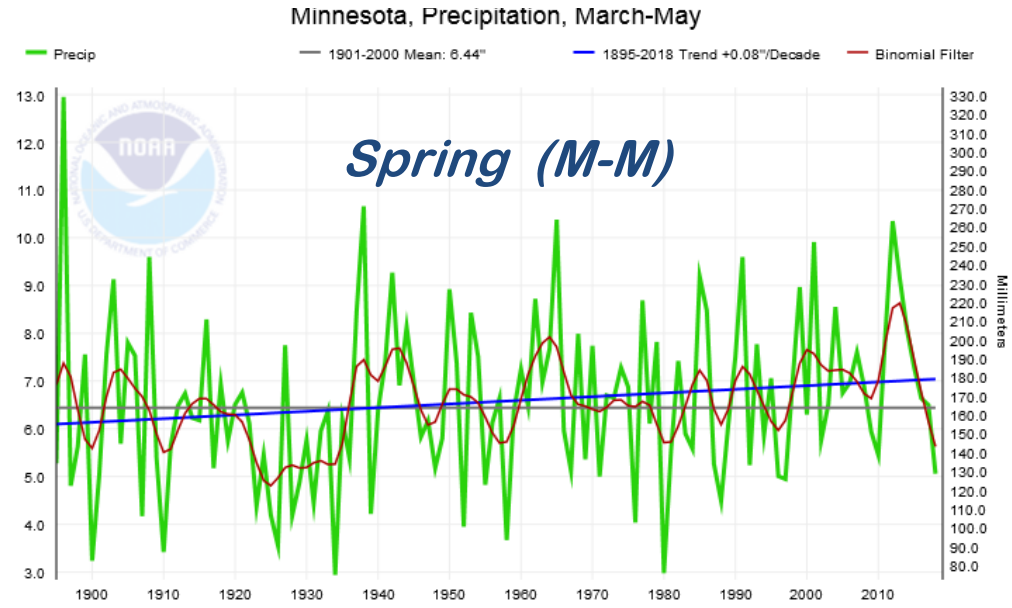
Warming is weighted towards minimum temperature change


Decline in extreme cold temperatures in Minnesota
Frequency of temperatures -30°F or colder at Pokegama Dam, MN
1950-1980 average 4 nights per year
1951-2018 average 1 night per year
Frequency of temperatures -15°F or colder at Preston, MN
1950-1980 average 9 nights per year
1981-2018 average 6 nights per year

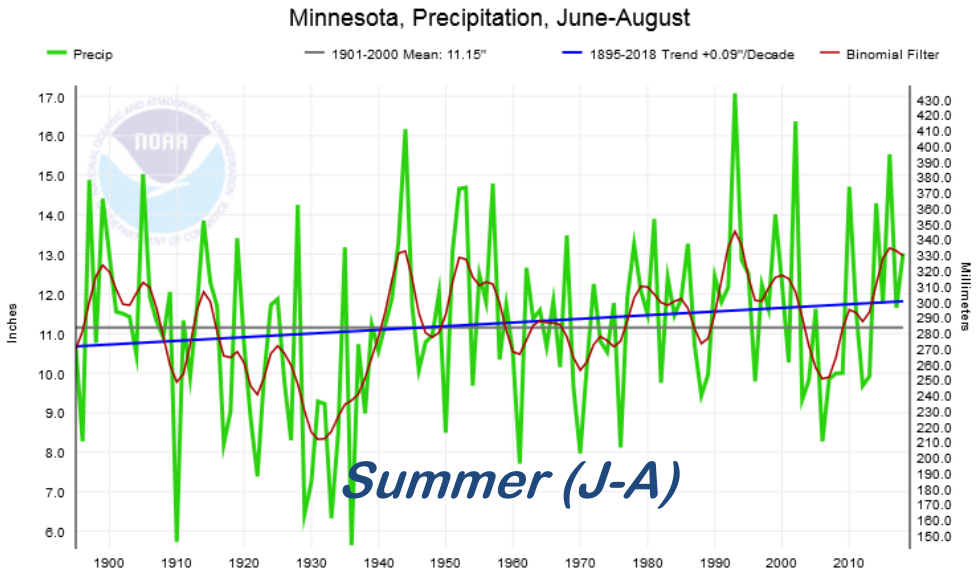


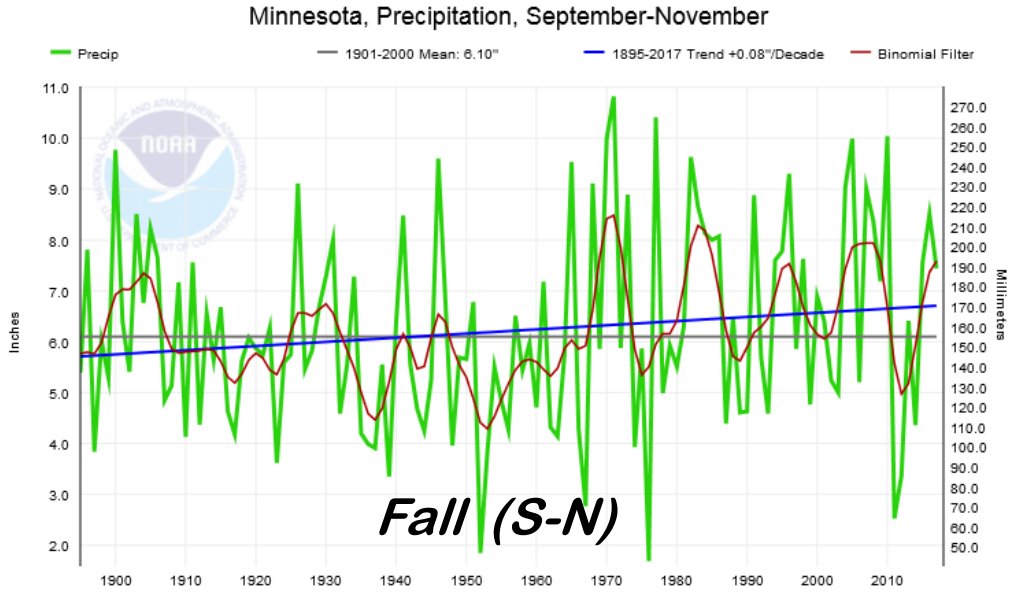
Trend in annual precipitation for MN



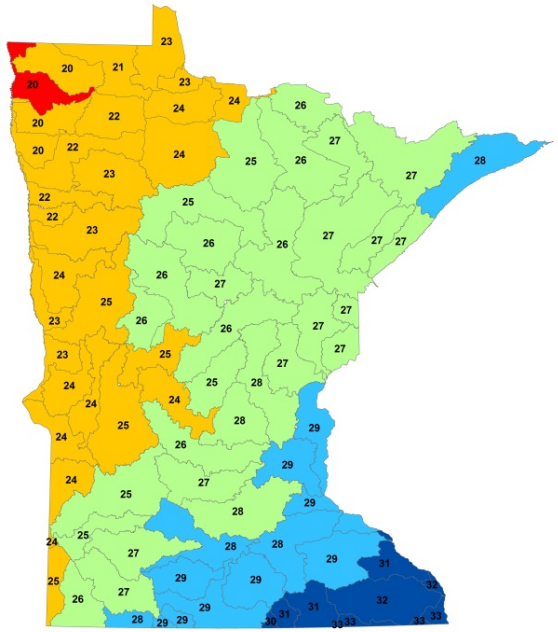


Seasonal Statewide Precipitation Trends in MN

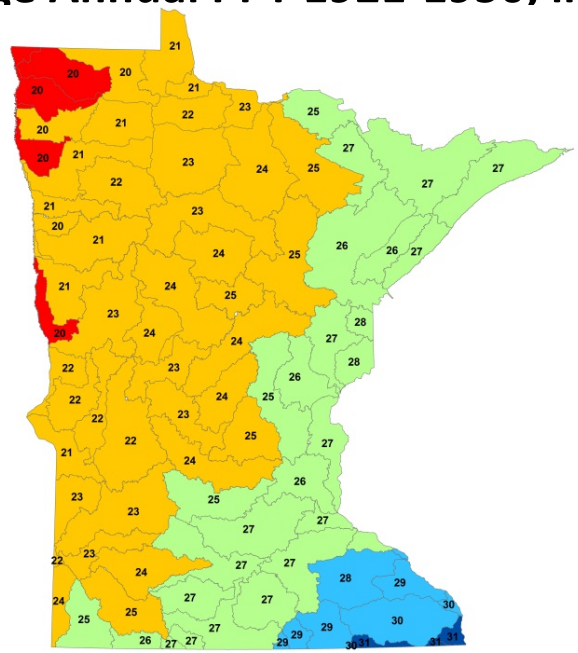




Average Annual PPT 1891-1920,



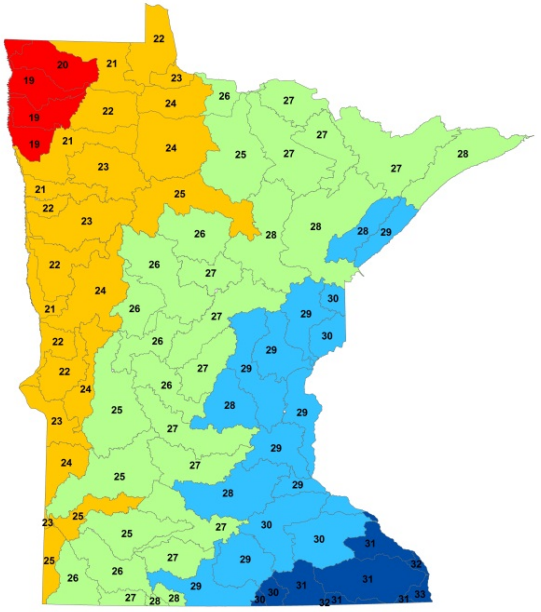
Average Annual PPT 1921-1950, in



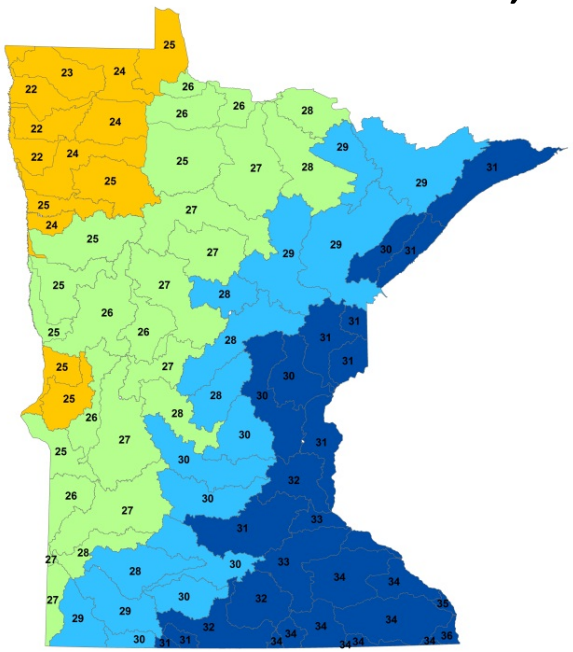
Avg. Annual PPT, in

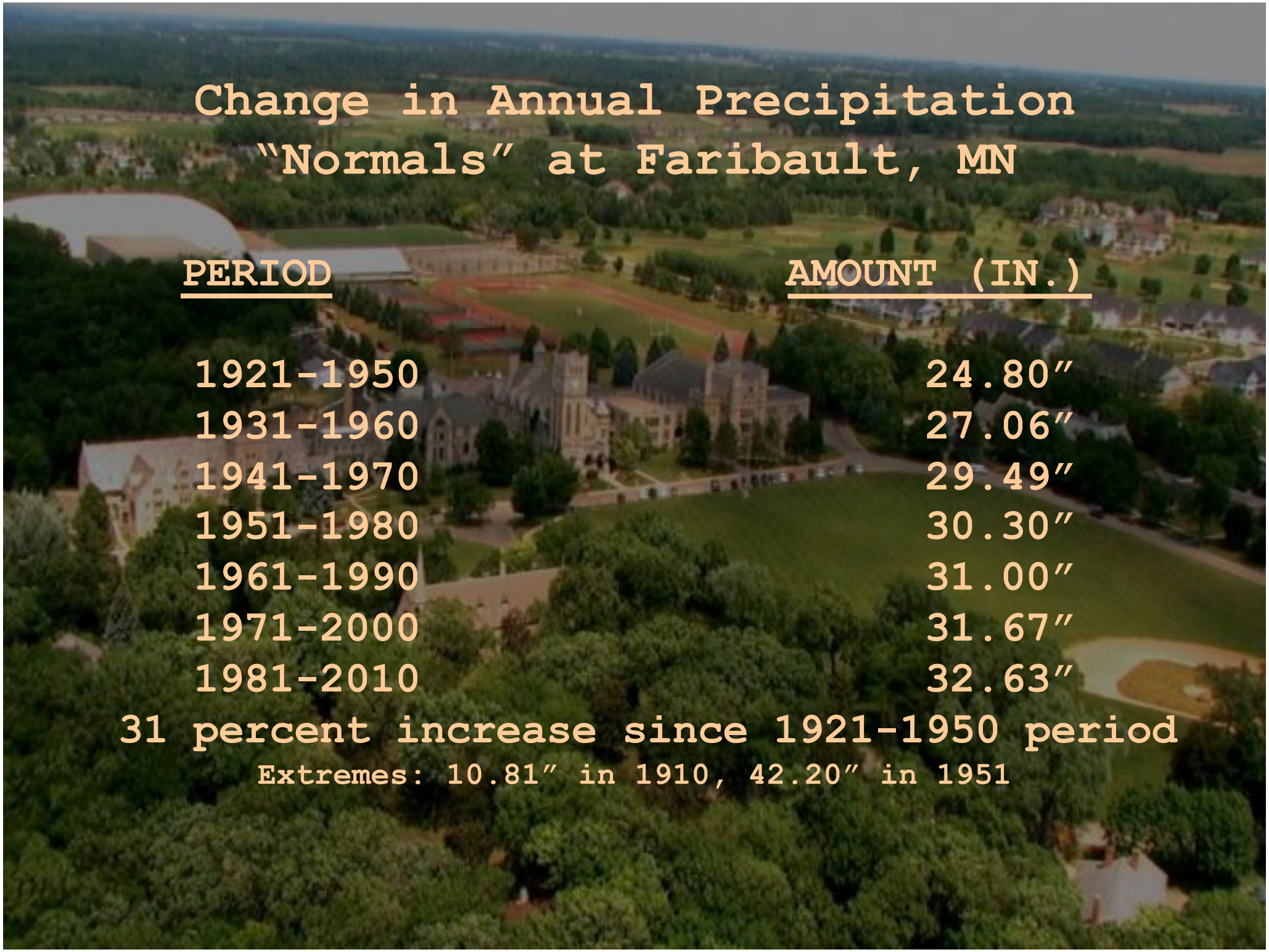
- < 20
- 21 - 25
- 26 - 28
- 29 - 30
- > 30

Average Annual PPT 1951-1980, in



Average Annual PPT 1981-2010, in



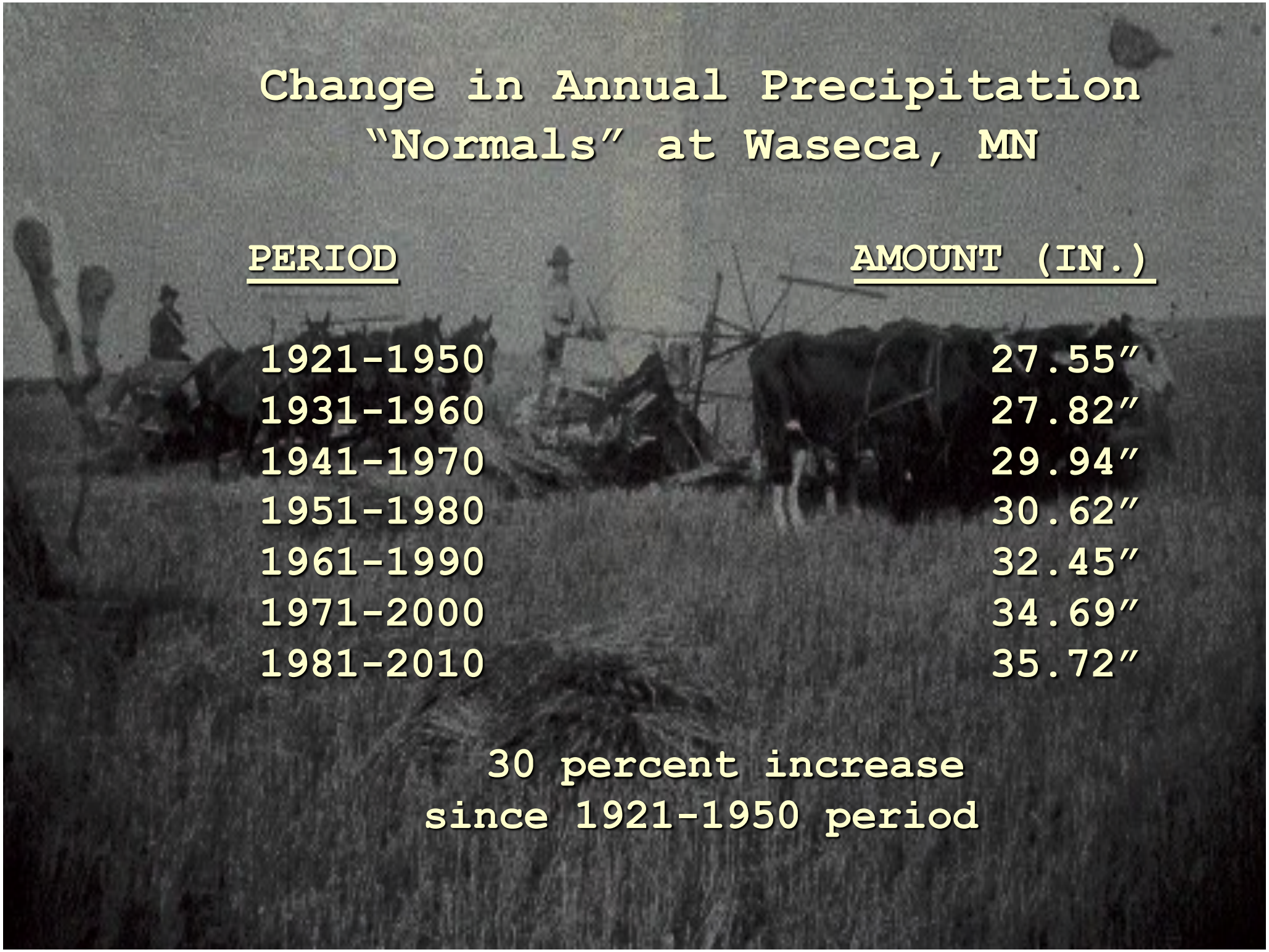


Change in Annual Precipitation
"Normals" at Faribault, MN

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

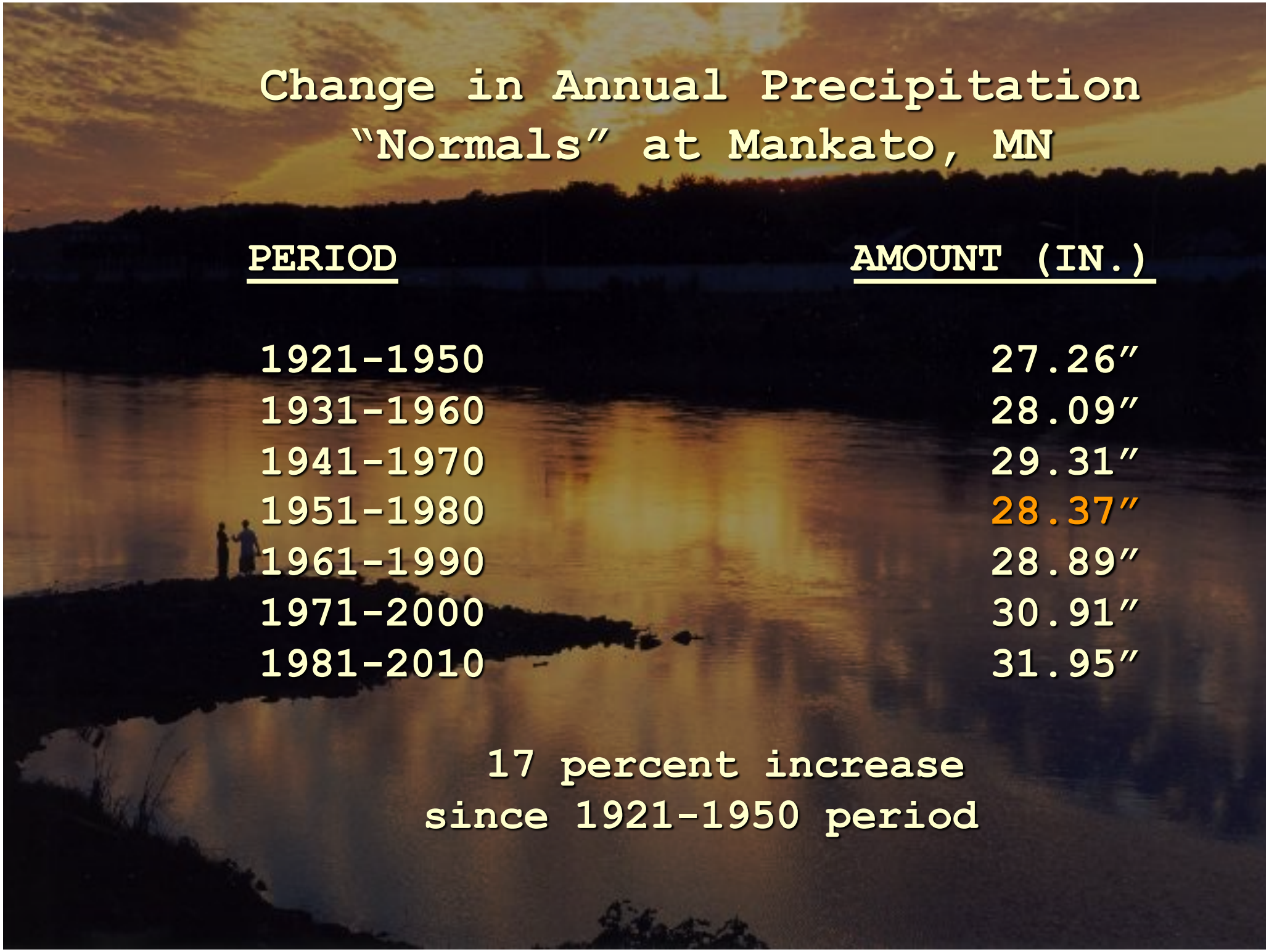
Extremes: 10.81" in 1910, 42.20" in 1951



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

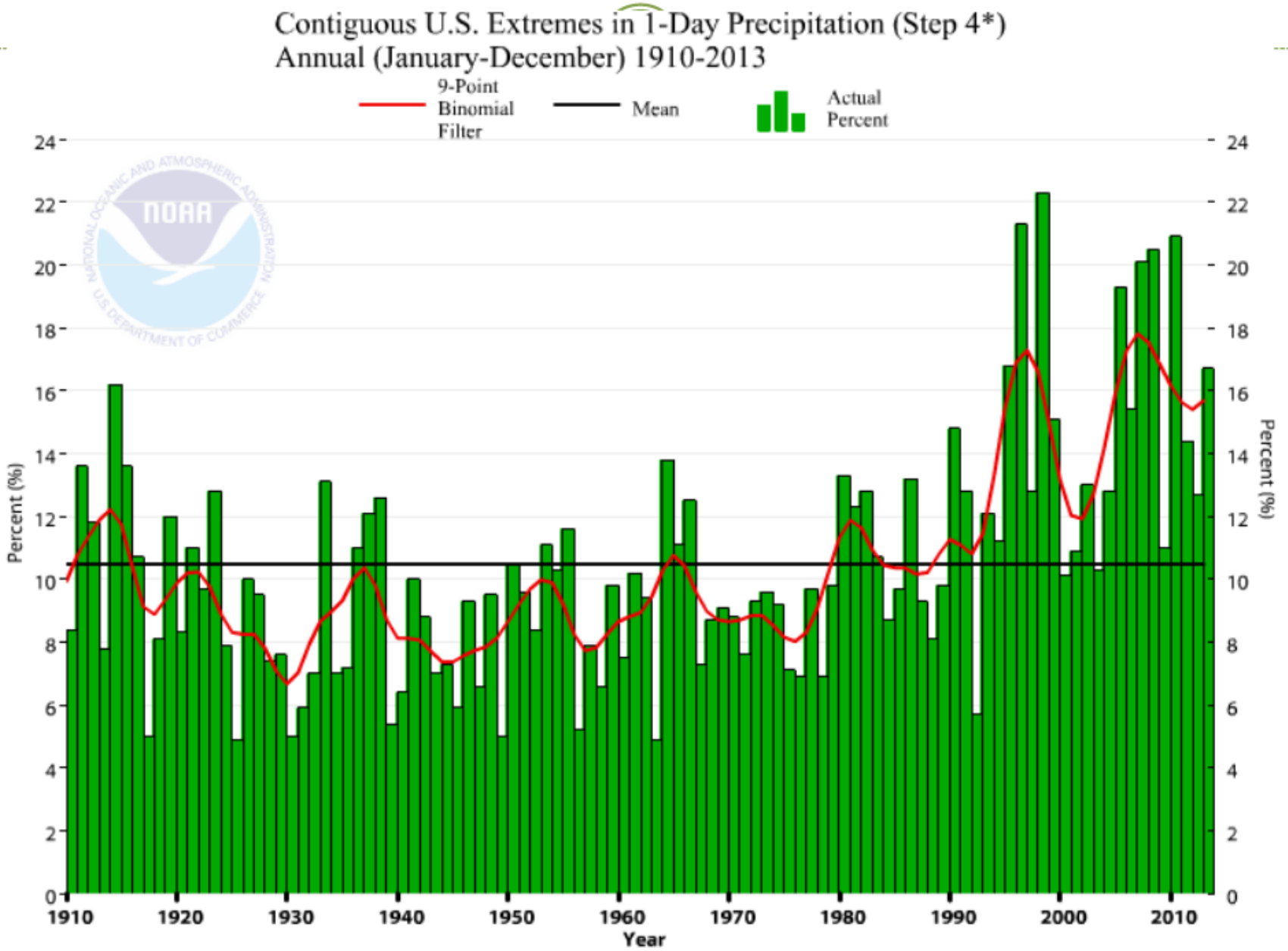


Change in Annual Precipitation "Normals" at Mankato, MN

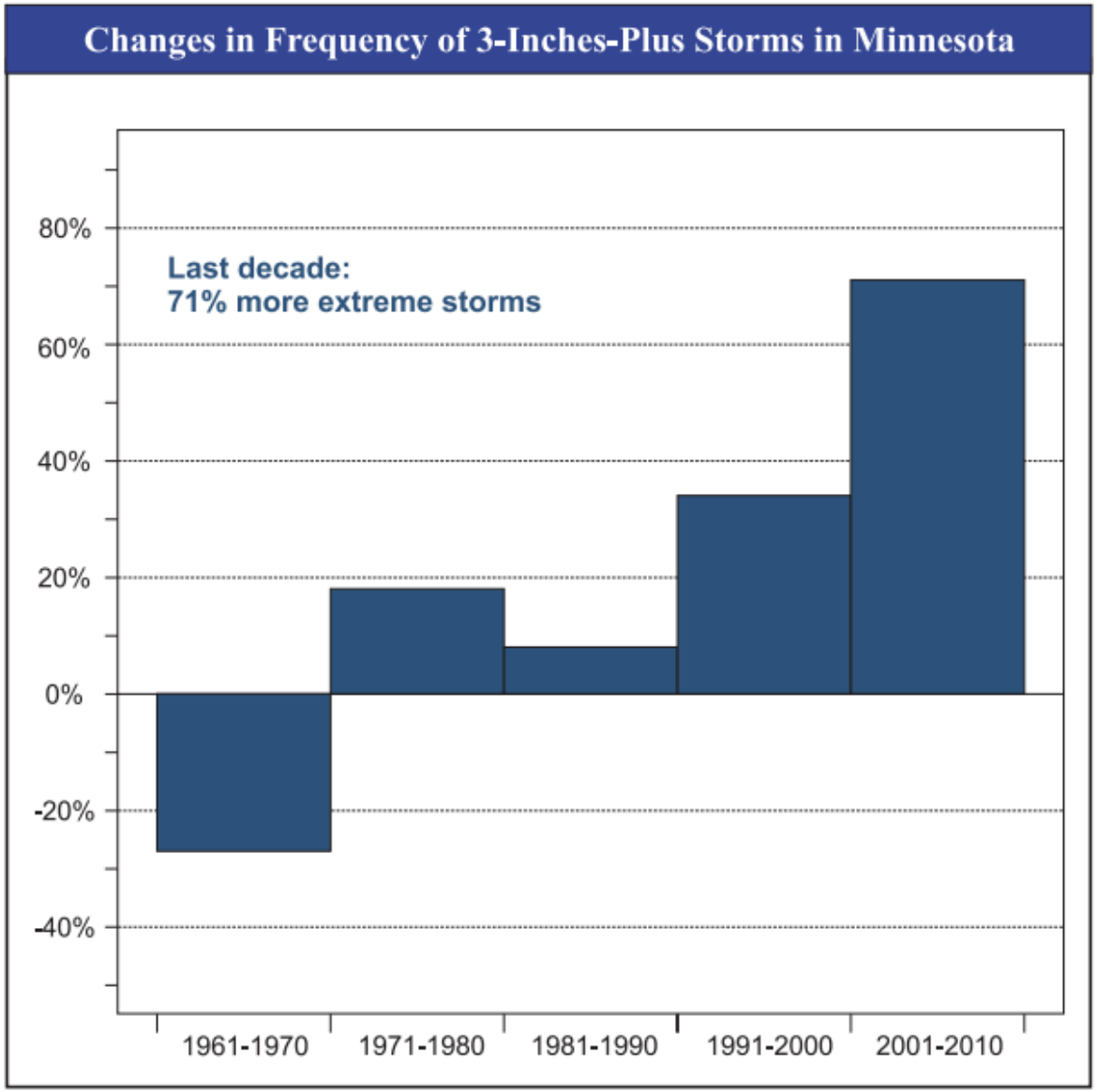
PERIOD	AMOUNT (IN.)
1921-1950	27.26″
1931-1960	28.09″
1941-1970	29.31″
1951-1980	28.37″
1961-1990	28.89″
1971-2000	30.91″
1981-2010	31.95″

17 percent increase
since 1921-1950 period

National Heavy Precipitation Changes (www.ncdc.noaa.gov/extremes/cei)

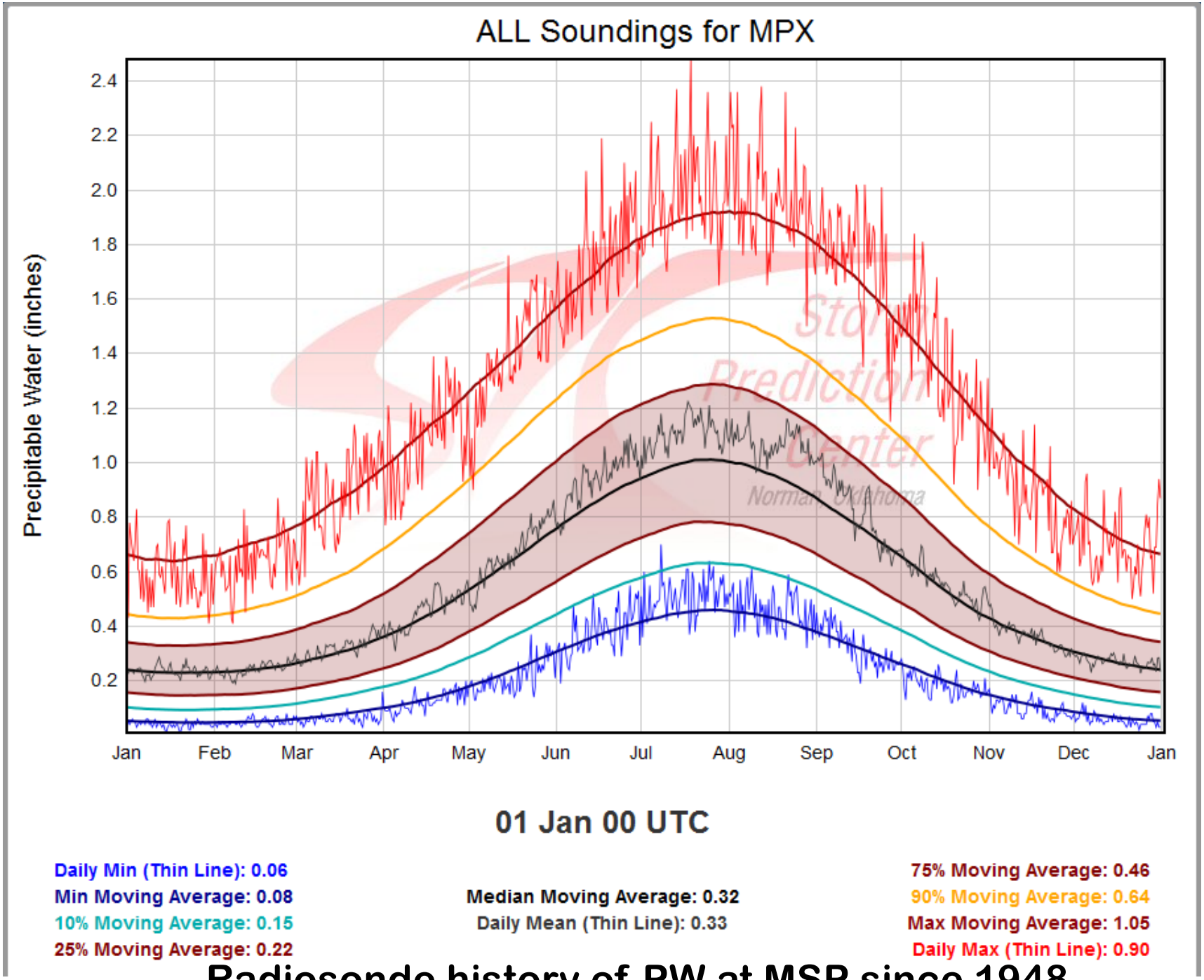


Trends in MN Flash Flooding Events



Top 10 Flash Flooding Years from 1961-2011
(1) 2002
(2) 2010
(3) 1978
(4) 2004
(5) 2005
(6) 1991
(7) 2000
(8) 1995
(9) 1973
(10) 1981

Rocky Mountain Climate Organization and Natural Resources Defense Council



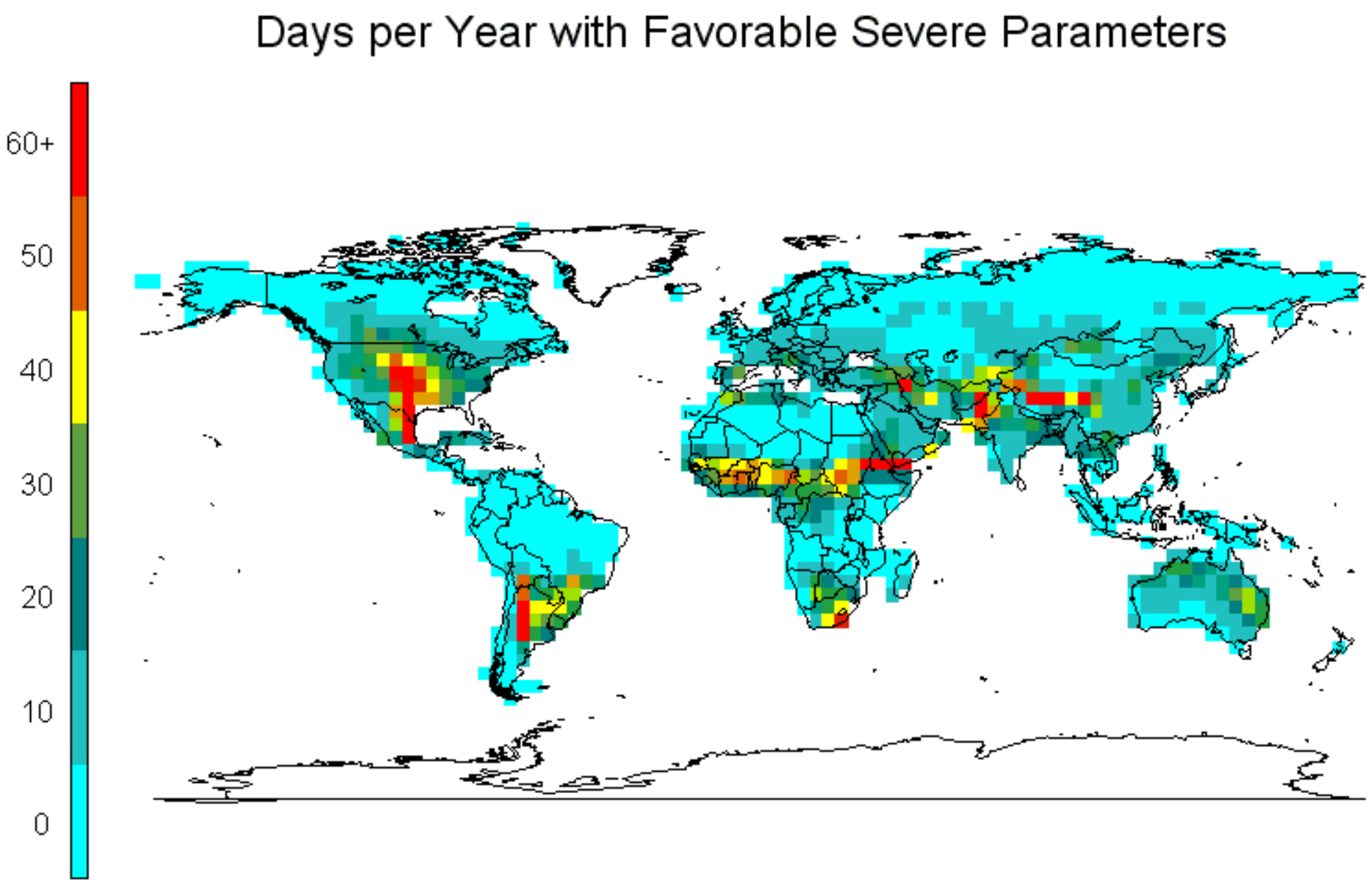
Radiosonde history of PW at MSP since 1948

(Most record high values have occurred since 1990)

Historical recurrence interval of 2 inch rains in MN/IA is once per year.

Observed 2 inch rainfalls for the period 1991 – 2017 (most recent 27 years) and maximum single day value for selected communities:

Location	No. 2 in. rains	Maximum Value (date)
Algona, IA	44	7.17 (8/31/1962)
Albert Lea	55	7.50 (6/15/78)
Sioux City, IA	41	5.50 (7/17/1972)
Decorah, IA	46	8.06 (8/24/2016)
Estherville, IA	46	6.45 (9/15/2004)
Clarion, IA	61	5.74 (9/20/1983)
Carroll, IA	49	6.87 (7/10/1993)
Waseca	60	7.64 (9/22/2016)
Winnebago	50	8.64 (9/25/2005)



from Brooks et al, NOAA-SSL, 2012

Annual Baseball+ Sized Hail in Minnesota

25
20
15
10
5
0
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010

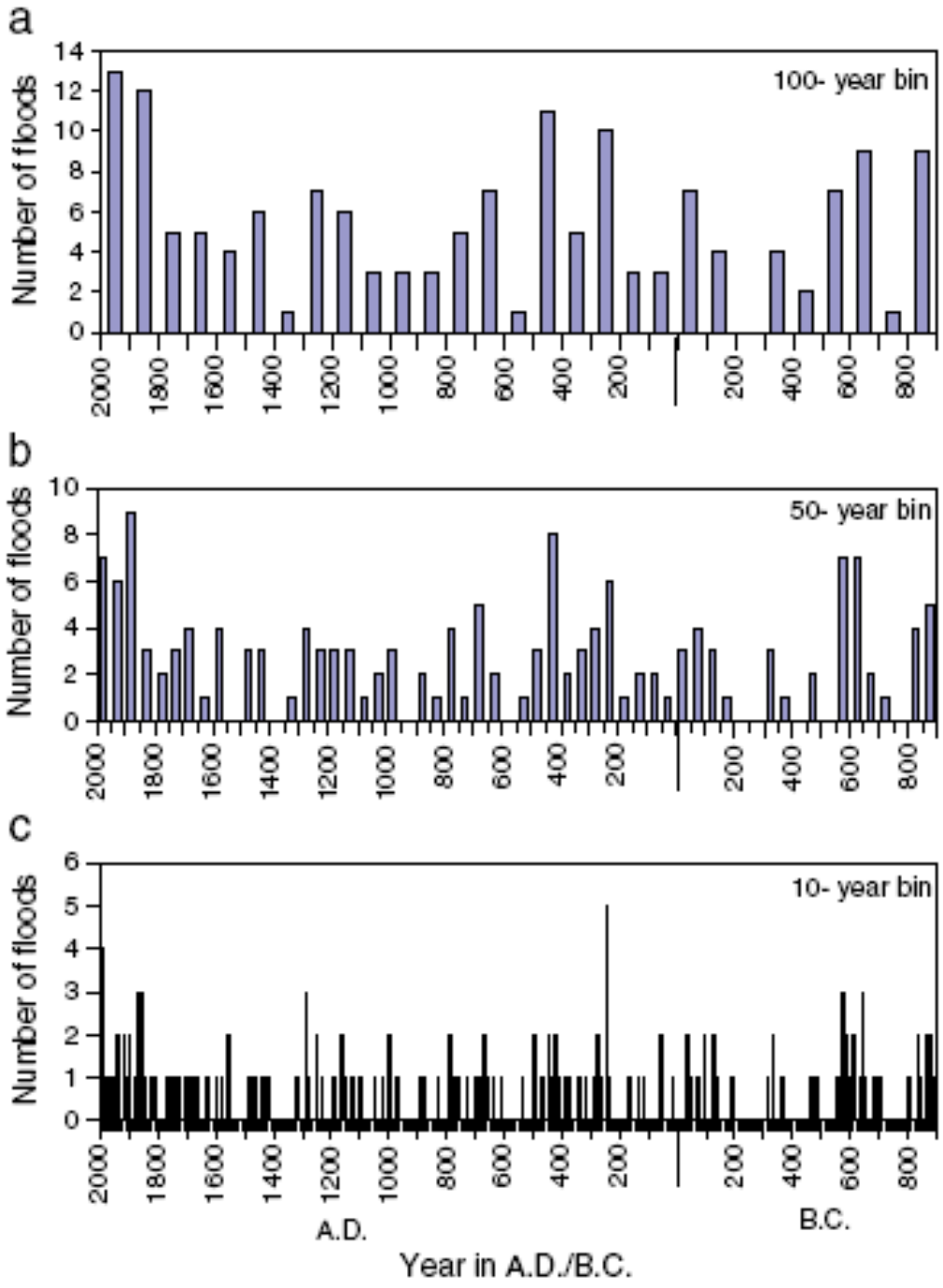
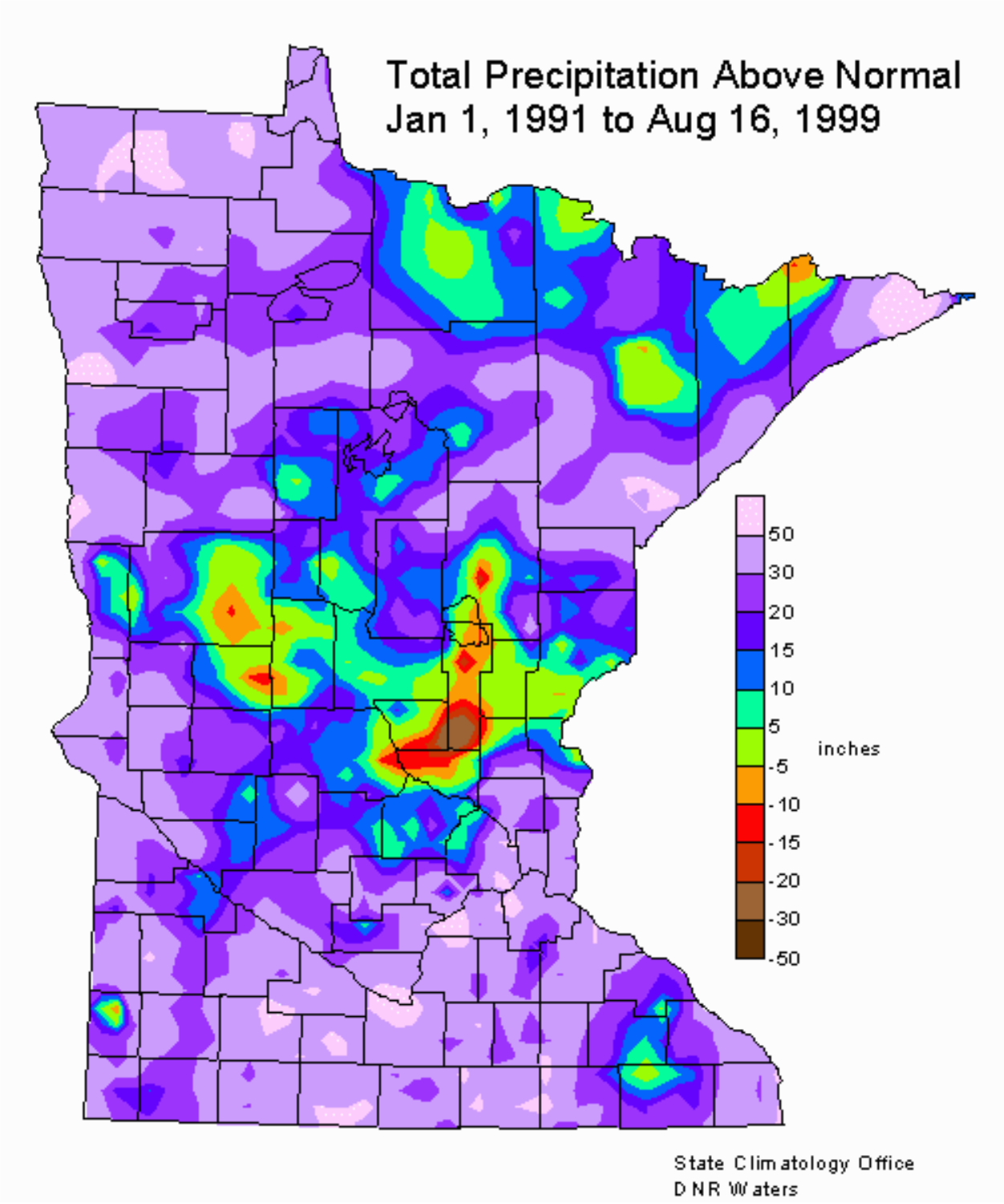


Fig. 9. Plots showing number of floods per 100 yr (a), per 50 yr (b), and per decade (c).

3000 years of flood frequency in SE MN (Spring Valley) reconstructed

From: S. Dasgupta et al, Earth and Planetary Science Letters, 300: pp 46-54, 2010

1990s wettest decade of the 20th Century in Minnesota



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

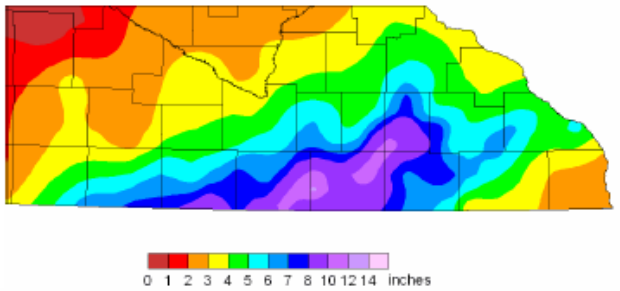
Defined as 6" or greater rains cover at least 1000 square miles and a peak amount of 8" or greater. Seven events from statehood (1858) to 2001, seven more since 2002.

Shift in Precipitation Recurrence Intervals

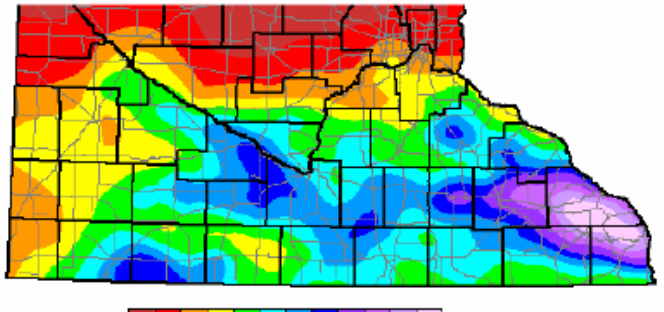
Mega Rains since 2002 show even northern Minnesota is vulnerable .

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

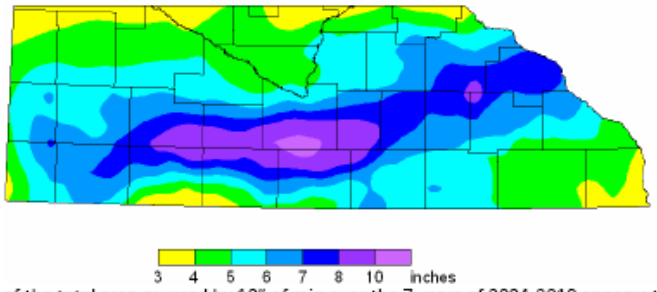
September 14-15, 2004



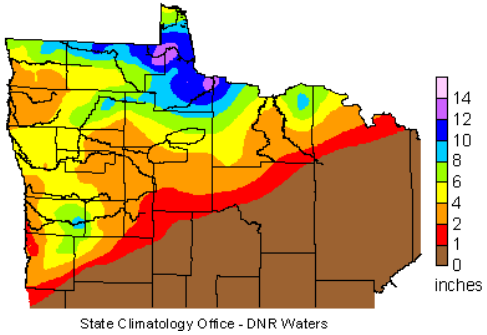
August 18 through August 20 (8:00 AM CDT), 2007



September 22-23, 2010

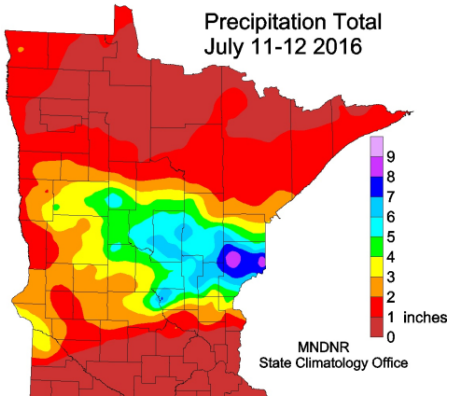


Rainfall Totals - June 9 and 10, 2002

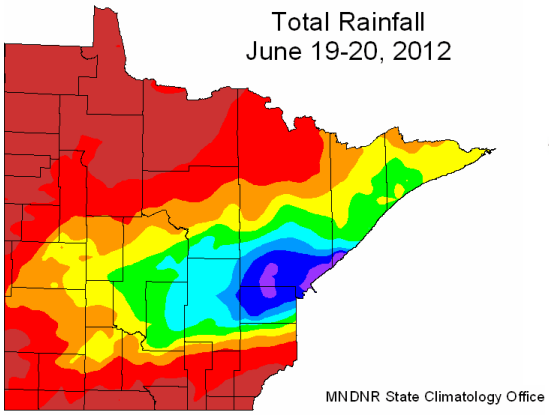


State Climatology Office - DNR Waters

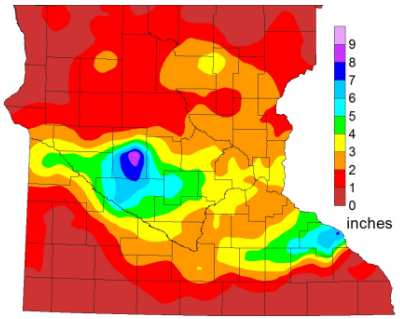
Precipitation Total
July 11-12 2016



Total Rainfall
June 19-20, 2012



Precipitation Total
August 10-11 2016



DNR State Climatology Office, Aug 11, 2016

'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. ıi. or about 200 sq. mi per year. Given that the area of the southern 3 layers of counties looks to be approximately 0000 sq. mi. the areal fraction of the southern three counties covered by 10" per year appears to be approximately /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.

Attributes of this storm:

Observers in 28 counties reported 4” or more

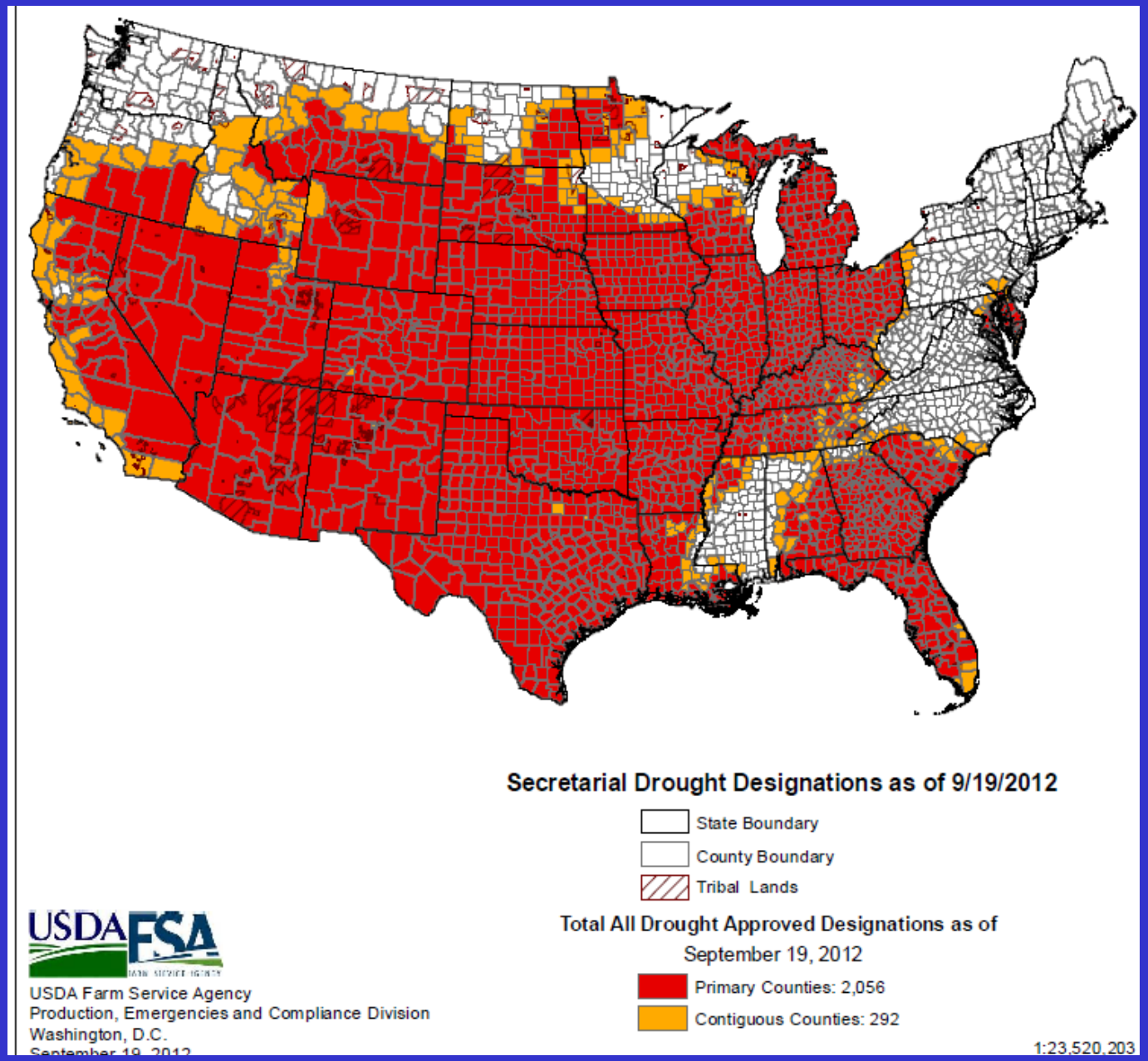
Observers in 3 counties (Winona, Fillmore, Houston) reported 14” or more

Dewpoints 60-65 degrees F

Diffuse, weak jet stream

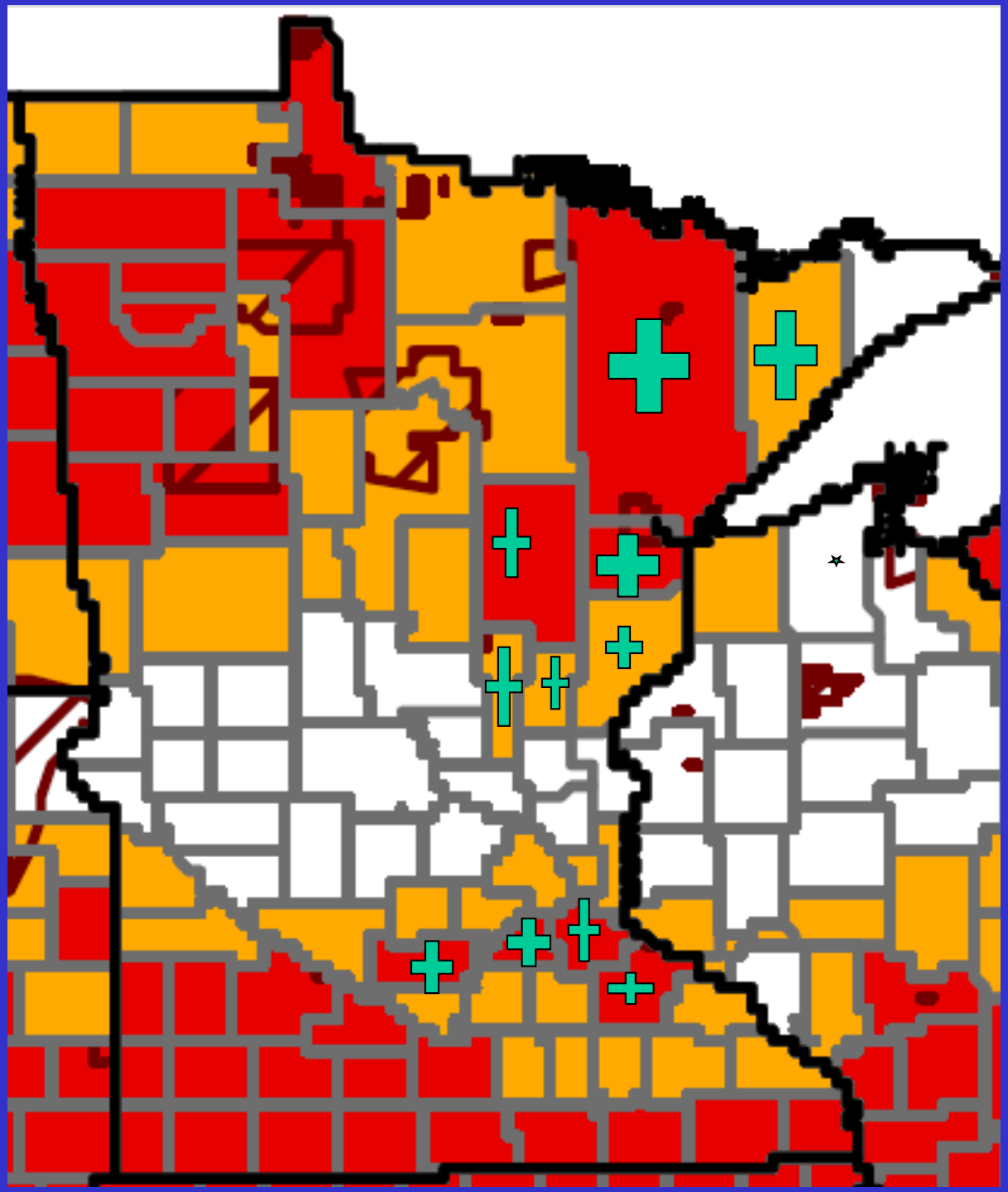
Rushford, MN - August 19, 2007
Image courtesy of Fillmore Co. Emergency Management

Damage at Whitewater State Park, Aug, 2007



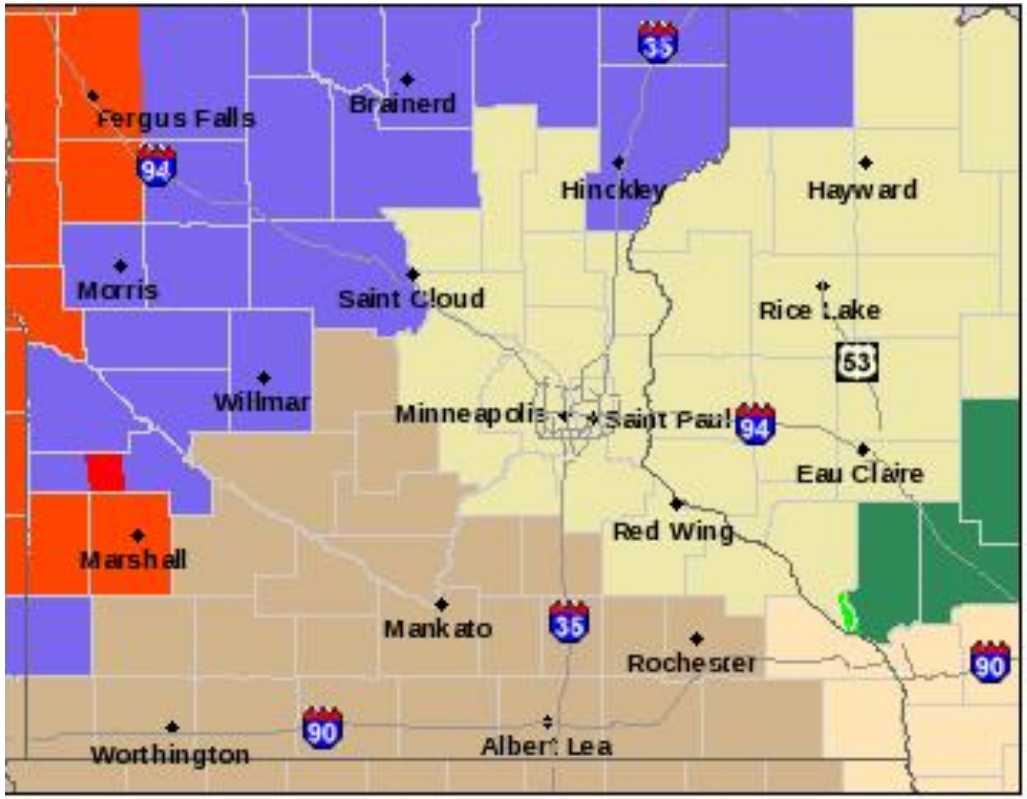
2012 Drought specific disaster declarations by county-most ever

Record number of counties, and record subscription to Federal Crop Insurance



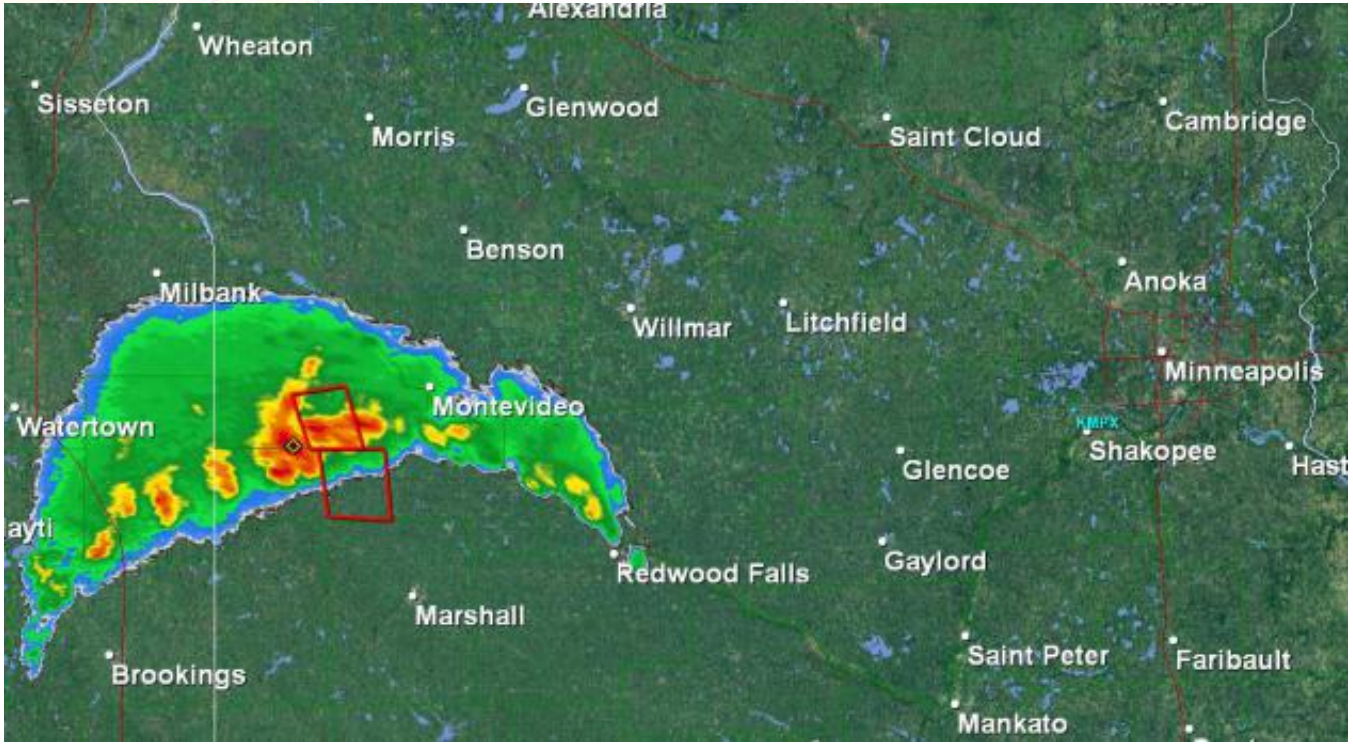
MN Counties designated for polar-opposite federal disaster assistance in 2012

All yellow and red counties are associated with drought except those with ✚ which designates for flood or severe storm



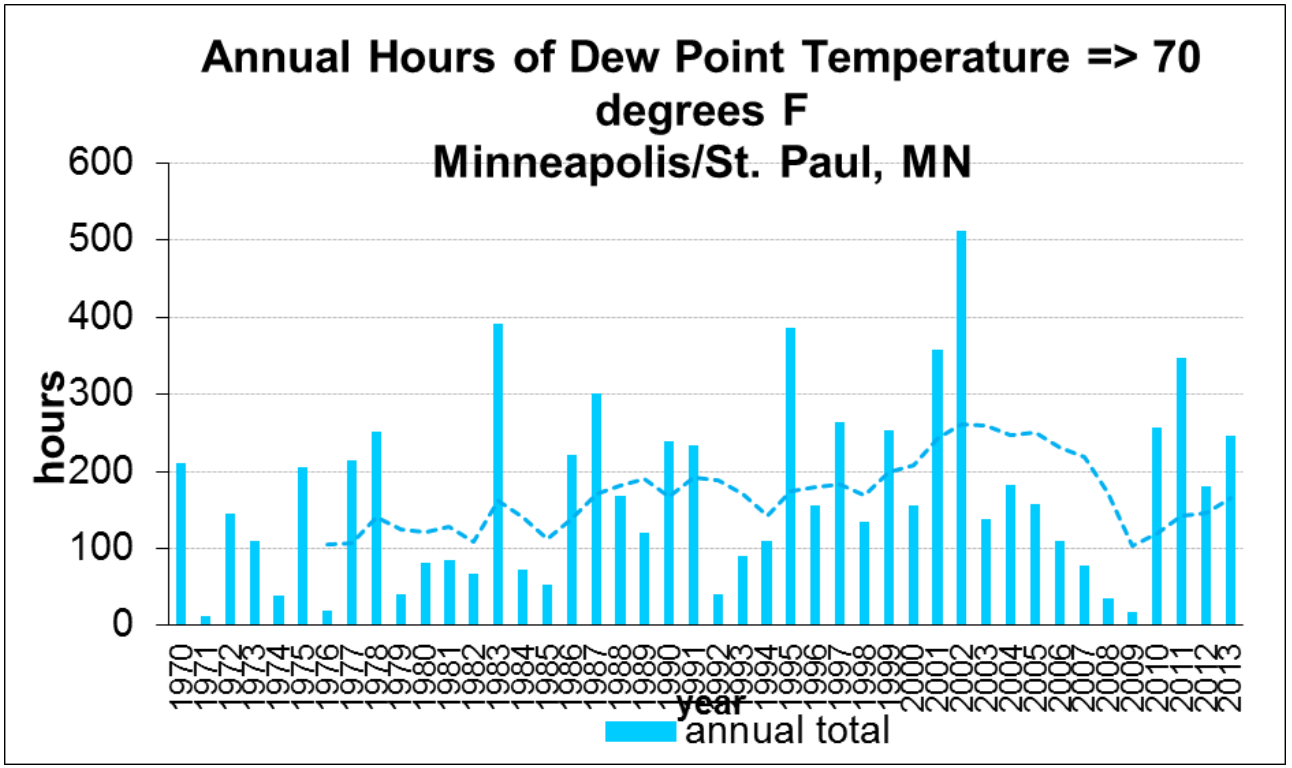
A Weather Singularity

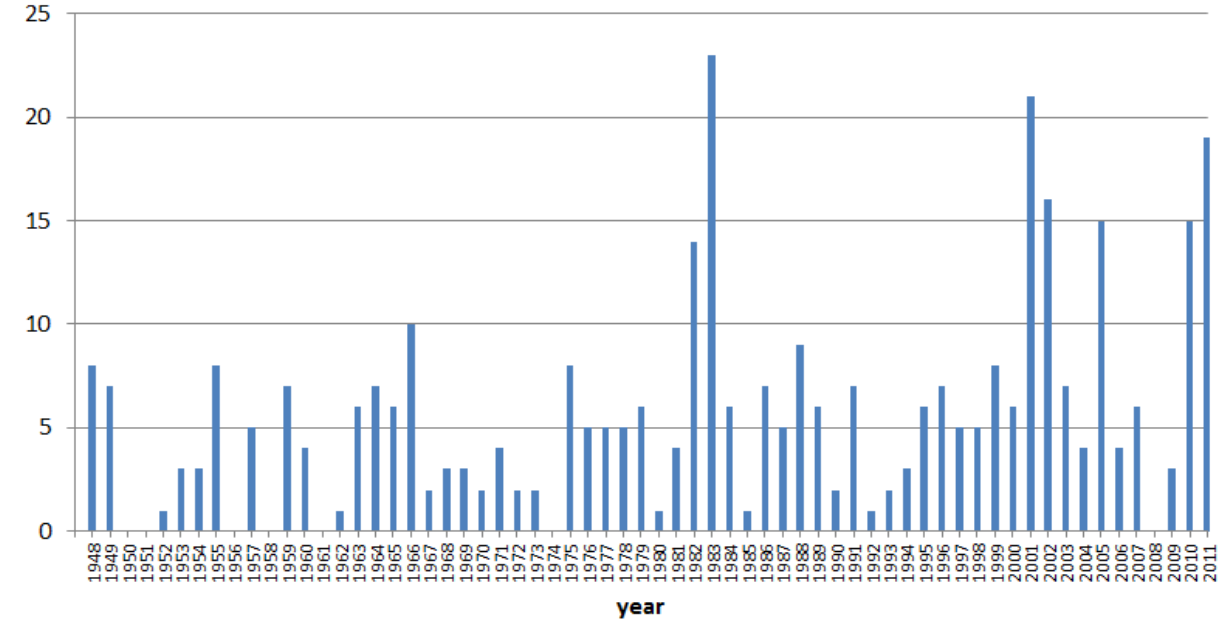
Tornado Warning and Tornado Warning in Lac Qui Parle County on March 31, 2014



Trend in episodes of dewpoints of 70 F or higher

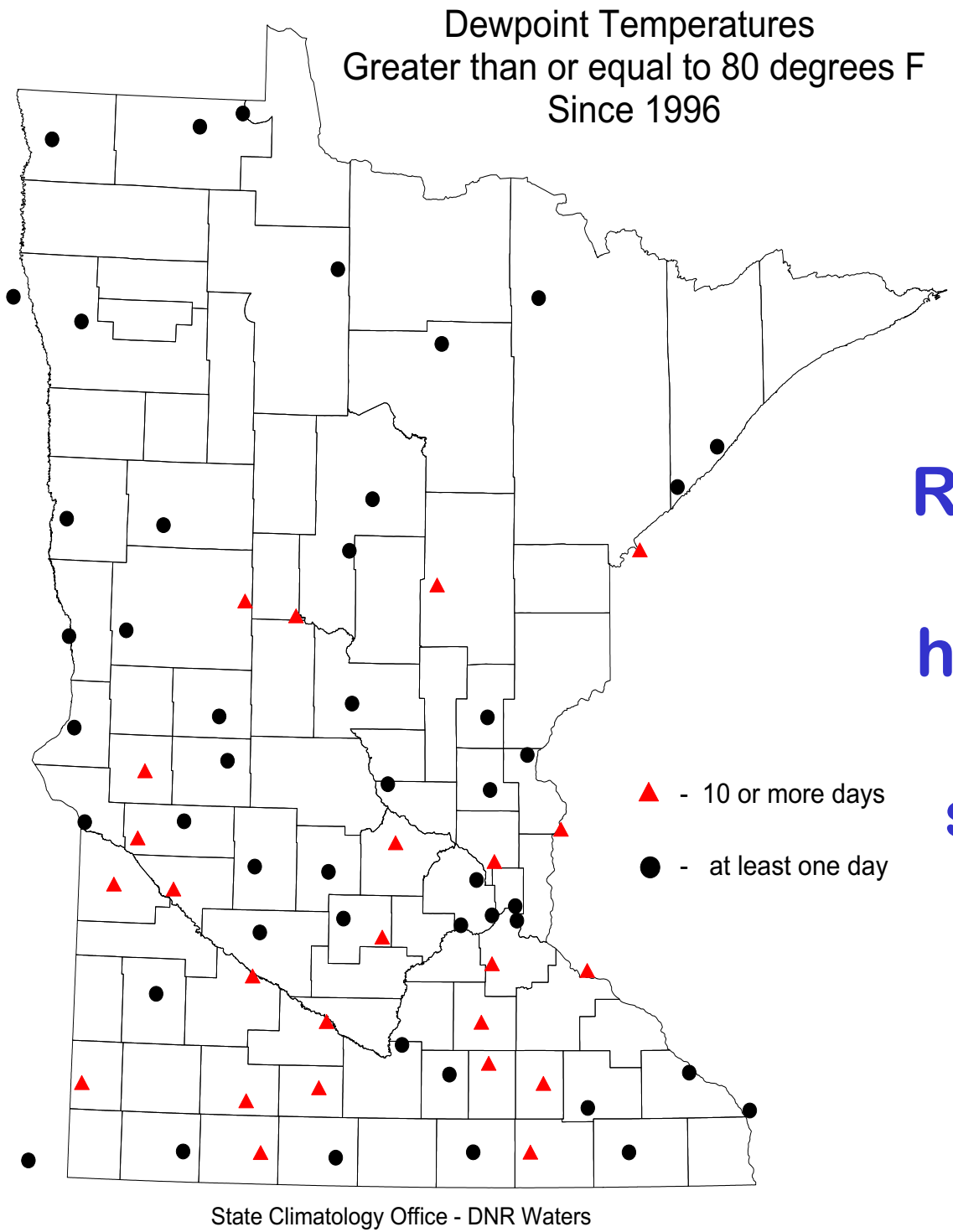
Latitude 45 degrees





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

Latitude 48.5 degrees

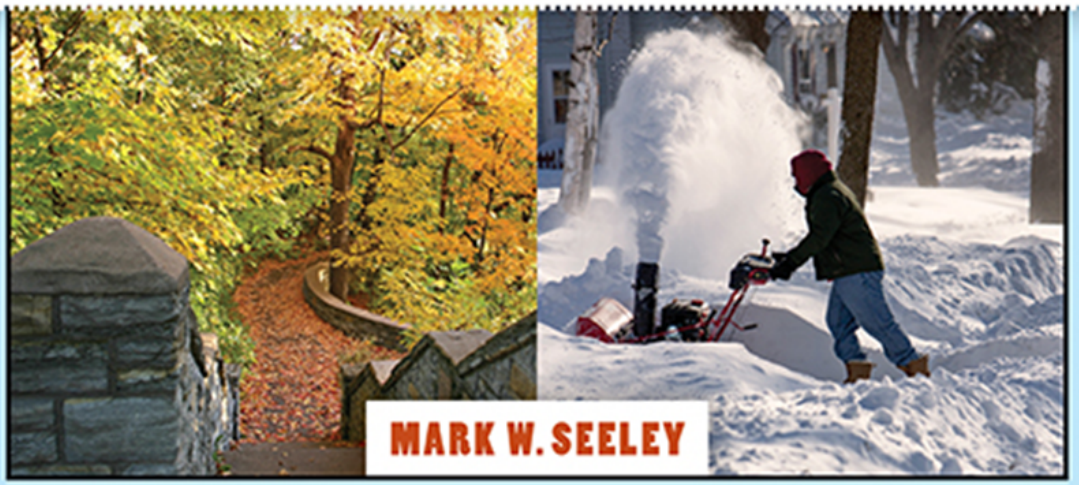


DP 80 F or higher. Readings have been statewide with highest frequencies in central and southern counties

MINNESOTA
WEATHER ALMANAC

SECOND EDITION

Completely Updated for the New Normals



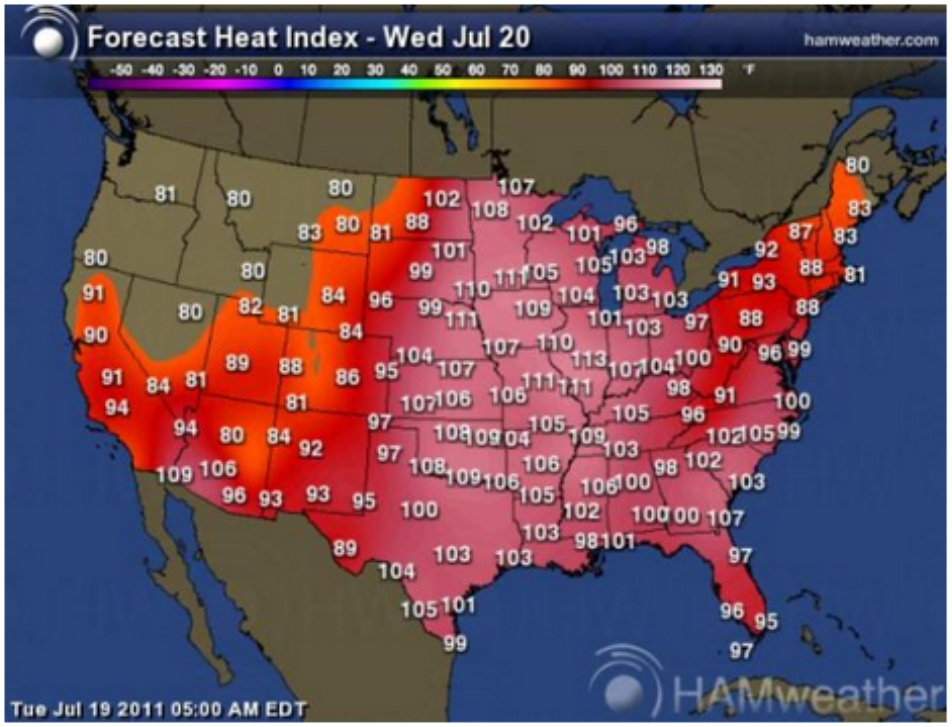
MARK W. SEELEY

Historical Minnesota Heat Waves:

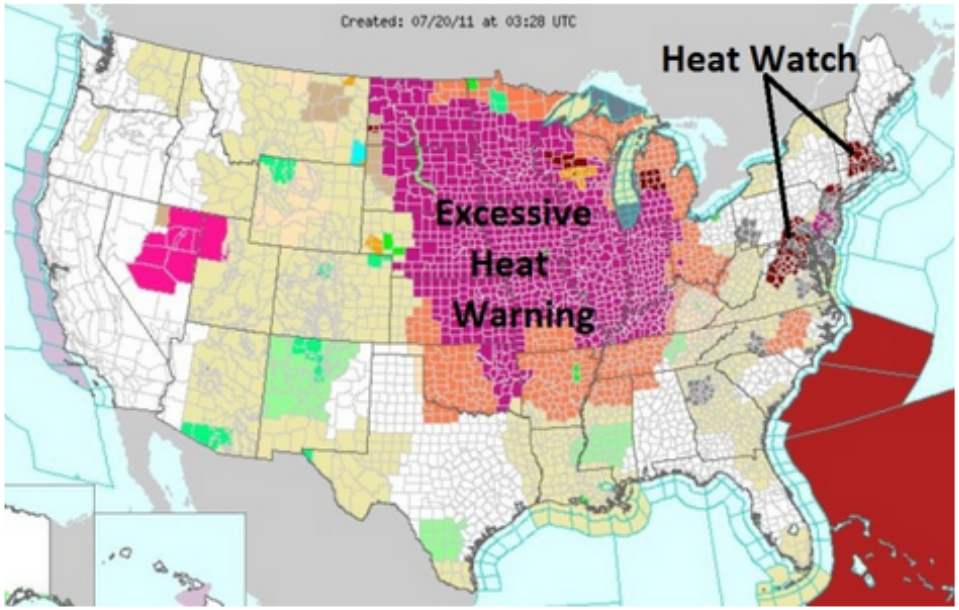
Red denotes dewpoint driven

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, 2018

(pattern is episodic but increasing in frequency)



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.



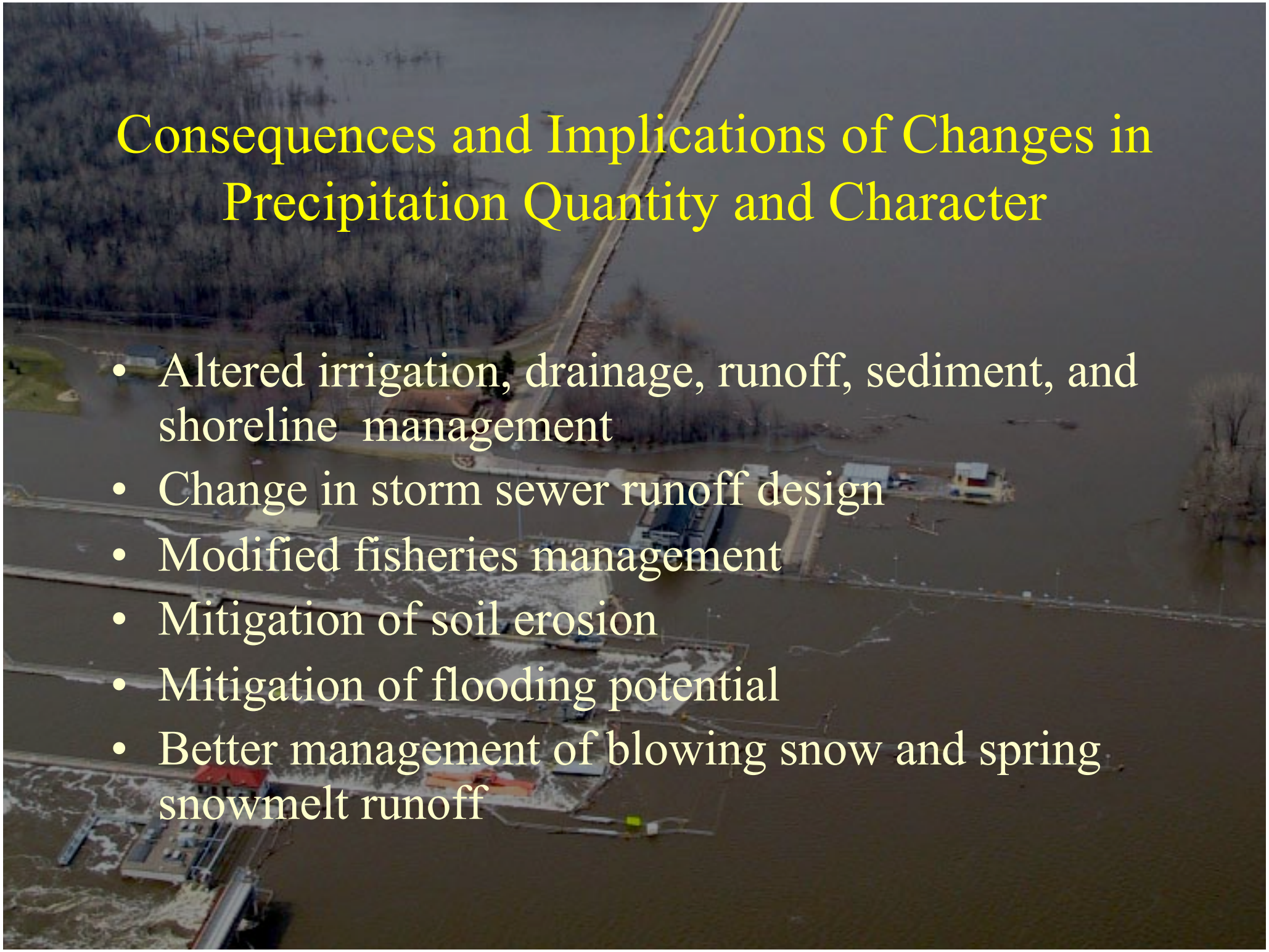
July 19-20, 2011
Heat Wave

Heat Index:

112°F Faribault
114°F Mankato
114°F New Ulm
114°F Waseca
117°F Owatonna
118°F Red Wing
119°F Twin Cities
110°F Albert Lea
114°F St James
114°F Fairmount
121°F Austin
134°F Moorhead

Consequences of Warmer Temperatures

- Change in depth and duration of soil and lake freezing
- Later fall nitrogen applications by farmers(soil temp too high)
- Fewer winter adverse weather disruptions to outdoor projects
- Change in over winter survival rates of insect pests and plant diseases, and soil microbes
- Reduced energy use for heating (fewer HDD)
- Change in Plant Hardiness Zones
- Longer frost-free growing seasons
- Increased number of freeze/thaw cycles (damaged roads)
- Change in animal migration, hibernation, and foraging
- Longer exposure times to mold and allergens
- More frequent Heat Advisories from the NWS



Consequences and Implications of Changes in Precipitation Quantity and Character

- Altered irrigation, drainage, runoff, sediment, and shoreline management
- Change in storm sewer runoff design
- Modified fisheries management
- Mitigation of soil erosion
- Mitigation of flooding potential
- Better management of blowing snow and spring snowmelt runoff

Consequences of Increased Frequency in Tropical-like Dew Points

- Seasonal dynamics of pathogen, parasite, insect, and microorganism populations
- Increased workload in heat related health care (exposure differentials, MS, COPD, Obesity)
- Increased stress on livestock (change in feed ration, water, weight gain, mild production and reproduction)
- Increased demand for environmental controls

Climate Adaptation Conference

Past, Present, Future, Together

November 14, 2018

University of Minnesota

Continuing Education and Conference Center

1890 Buford Avenue

St. Paul, MN 55108

Registration

Early bird registration through October 28: $100

Late registration October 29 - November 13: $125

Student registration (must be enrolled in a college or university): $50

Parking is included in registration fee in lot S104

Draft agenda updated 9/7/18

MINNESOTA CLIMATE ADAPTATION AWARDS

Award Nominations are now closed .pdf

National Adaptation Forum

Action today for a better tomorrow

May 9-11, 2017 — Saint Paul, Minnesota #NAF2017

National Adaptation Forum Vitals

Meet the Forum

The National Adaptation Forum is the gathering of the adaptation minded. Since the Forum is created by and for the members of the adaptation community, the meeting focuses on issues of the day - *established and emerging*.

The videos below highlight the 2017 Forum plenaries - we hope you enjoy learning more about what took place in Saint Paul!

Watch Videos

What's New

The 2017 Plenary Recordings are now available!

Click **HERE** to see all recordings.

You can also read the **full PDF program** or search the **online Forum Program** for speakers, topics, and themes.

Webinars

Missed the last webinar?
You can catch the replay online.

June 27, 2017
"One Stick at a Time" In pursuit of climate adaptations for a more sustainable future
View webinar

Get the Next Webinar on your calendar:
December 05, 2017
A Rapid Vulnerability Assessment Tool
More details

Our Sponsors

Participants in “Faith-based perspectives and action plans on climate change adaptation” at the National Adaptation Forum: Dr. Mark Seeley, Dr. Teddie Potter, Paul Douglas, Rev. Mitch Hescox, Dr. Odeh Muhawesh, and Rabbi Fred Schlinder Dobb.

Leaders from all Three Abrahamic Faith Traditions Agree

We are gifted by God and called by God to study and care for God's handiwork. Our faith energizes and guides us to be part of this world and to be engaged in our community for its betterment. Both faith and science are gifts from God, given to us for learning, imagining, inventing, caring, and understanding the world. We promote the use of both as we take action to care for our planet and each other. Therefore:

We stand up for all children, grandchildren, and future generations.
Their health is already threatened by climate related impacts and their future is diminished by our lack of action. We must do more to safeguard God's good earth, our precious biosphere, for those who come after us. All of our traditions teach us to sustain this holy trust from generation to generation

We stand up for the poor.
Every one of our traditions emphasizes compassion for the least among us. The poor and marginalized are a shared concern as they are most harmed by pollution, most dependent on the seas for food, live closest to the land, are most vulnerable to heat extremes, and yet they use and emit the least carbon.

We stand up for creation itself.
All three faiths agree that the Earth is God's and it is a religious obligation to care for God's creation. All creation reflects God's glory and all species deserve a place on Earth beside us. We therefore demonstrate our love for God when we protect creation.

We call for action.

We call upon all people of faith to address the greatest moral challenge of our time by taking action to reduce our ecological footprint in our homes, our workplaces, and our spiritual communities. We invite you to join us in becoming committed guardians of the future and more responsible members of the creation community.

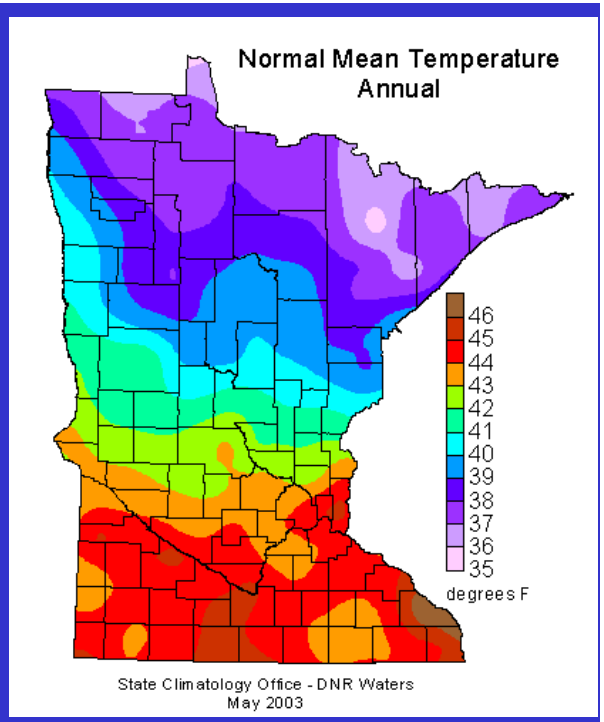
Derived from panelists who participated in the 2017 National Adaptation Forum, May 9-11, in St Paul Minnesota: co-chaired by Paul Douglas, President of Aeris Weather, and Dr. Mark Seeley, Climatologist, University of Minnesota.

-Dr. Teddie Potter, University of Minnesota School of Nursing, and Director of Inclusivity and Diversity for the School
-Rabbi Fred Scherlinder Dobb, Adat Shalom Reconstructionist Congregation of Bethesda, MD and Chairperson of the Coalition on the Environment and Jewish Life.
-Reverend Mitch Hescox, President of the Evangelical Environmental Network, New Freedom, PA and co-author (with Paul Douglas) of Caring for Creation: The Evangelical's Guide to Climate Change and a Healthy Environment.
-Dr. Odeh Muhawesh, Adjunct Professor at the University of St Thomas, specialist in Islamic Theology, Jurisprudence, and Modern History of the Middle East. On the Board of the Muslim-Christian Dialogue Center at the University of St Thomas.

Some Adaptation and Mitigation Behaviors and Examples

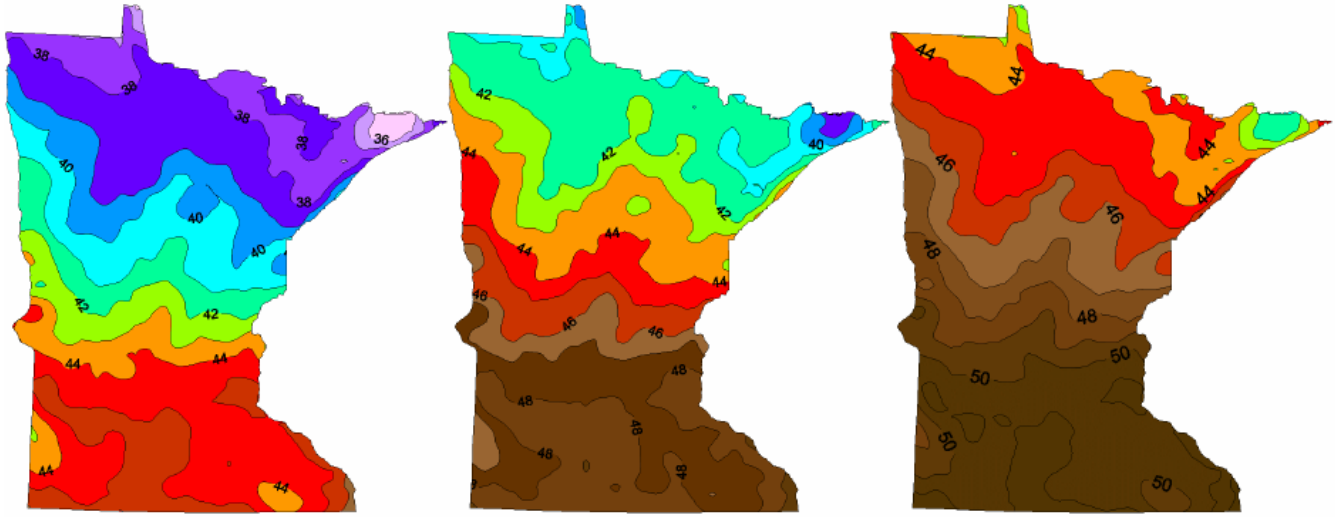
Modifications to storm water management
Mitigation for blue-green algae
Use of renewable energy sources (wind, solar)
Water conservation practices
Tree planting (shade and interception of heavy rain)
Waste Reduction, Recycling, Composting
Emphasis on locally produced foods
Ride share, biking, mass transit
Electric and hybrid vehicles
Organic and manure fertilizer applications
Energy use conservation practices
Role modeling respectful stewardship behaviors
Advocating government policies to incentivize the above

1971-200 Annual Mean Annual Temperature Map



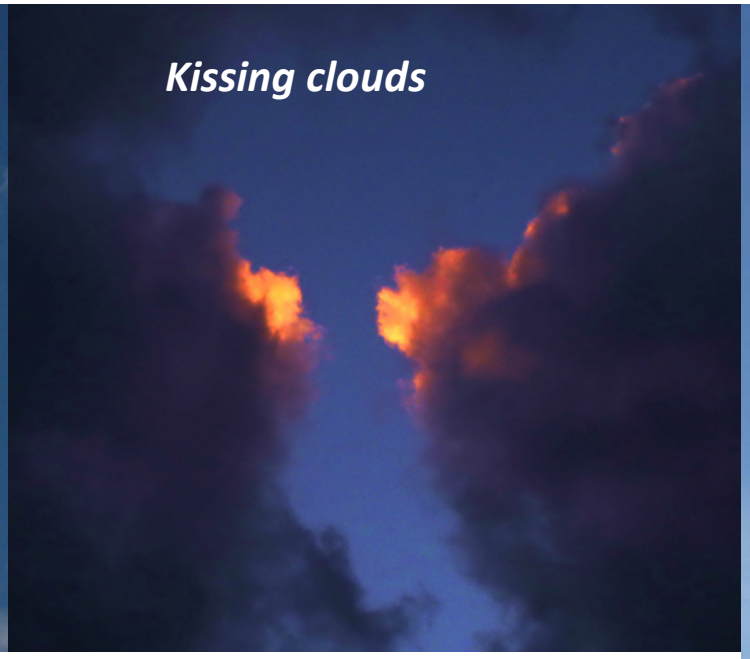
Decadal average annual temperature from 16 GCM models runs showing 250 mile northern migration of the 44 degrees F isotherm
Source: CMIP-Lawrence-Livermore and MN State Climatology Office

The following maps are A1B decadal average from 16 GCM models (39 runs).
The color scheme is the same one used in our most recent (1971-2000) annual 'normal' map at http://www.climate.umn.edu/doc/historical/temp_norm_adj.htm



1981-1990 **2031-2040** **2061-2070**

The A1 scenarios are of a more integrated world: characterized by:
rapid economic growth;
A global population that reaches 9 billion in 2050 and then gradually declines;
The quick spread of new and efficient technologies;
income and way of life converge between regions; extensive social and cultural interactions.
A1B - A balanced emphasis on all energy sources.



Images courtesy of the Cloud Appreciation Society