DEPARTMENT OF NATURAL RESOURCES

Minnesota's Changing Climatology

What it Does and Does Not Mean

Kenny Blumenfeld, DNR State Climatology Office

***MNDOT State Aid Construction group*, Feb. 28, 2017**

Today

1. Confusion and misconceptions about climate change in Minnesota
2. What we have and have not observed (in MN)
3. What the science tells us we should and should not expect (in MN)

Sources of climate change confusion among users

1. Inconsistent info and sources
2. Inconsistent depth
3. Uneven awareness/understanding
4. Inability to keep up
5. Non-expert interpreters

→ **Often trying to form policies and make big decisions!**

Common misconceptions

1. Global climate change = regional or local
   - Global impacts assumed to be happening here
   - Important because decisions made and resources managed **here**
2. Observations = Projections
   - Frequently conflated even though very different

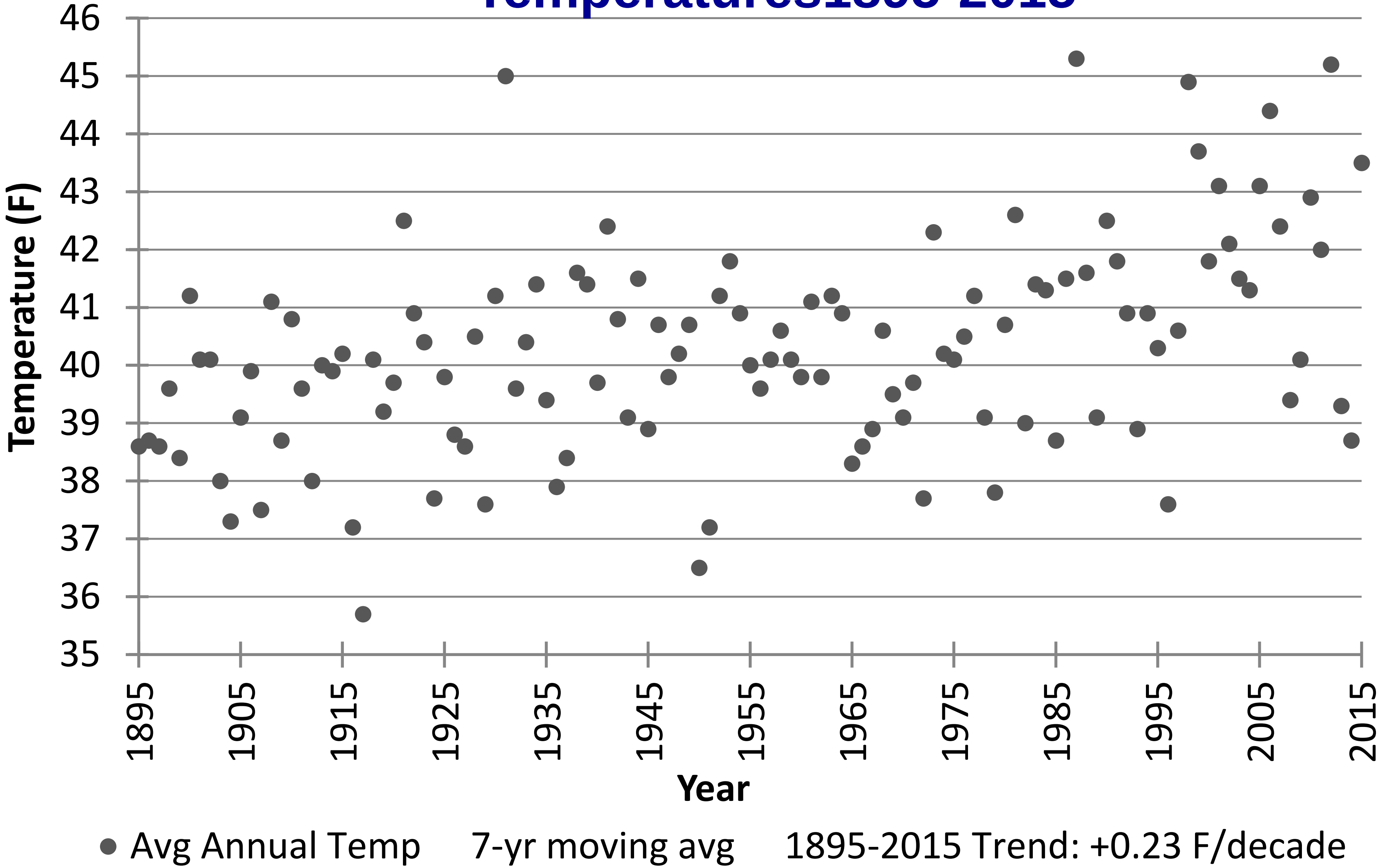
DEPARTMENT OF NATURAL RESOURCES

Common misconceptions

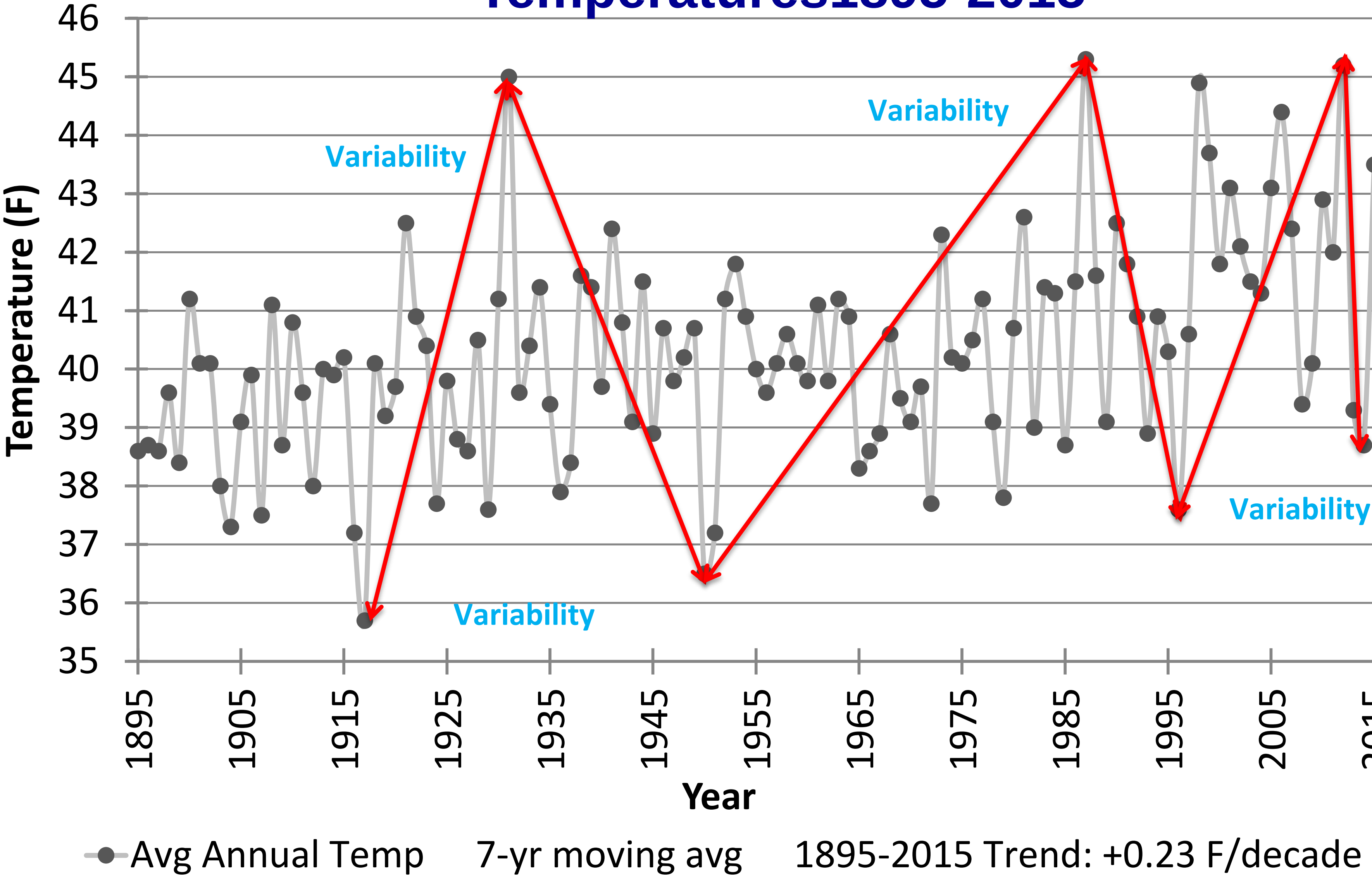
3. Variability vs Trends
   - Leading source of confusion: e.g., Many examples of high variability assumed to be indicative of trends
     - Even earnest climatologists guilty!
   - Variability thought to prove or disprove trends; trends thought to negate variability

4. “I got it!”
   - Many people up to date, as of 2006

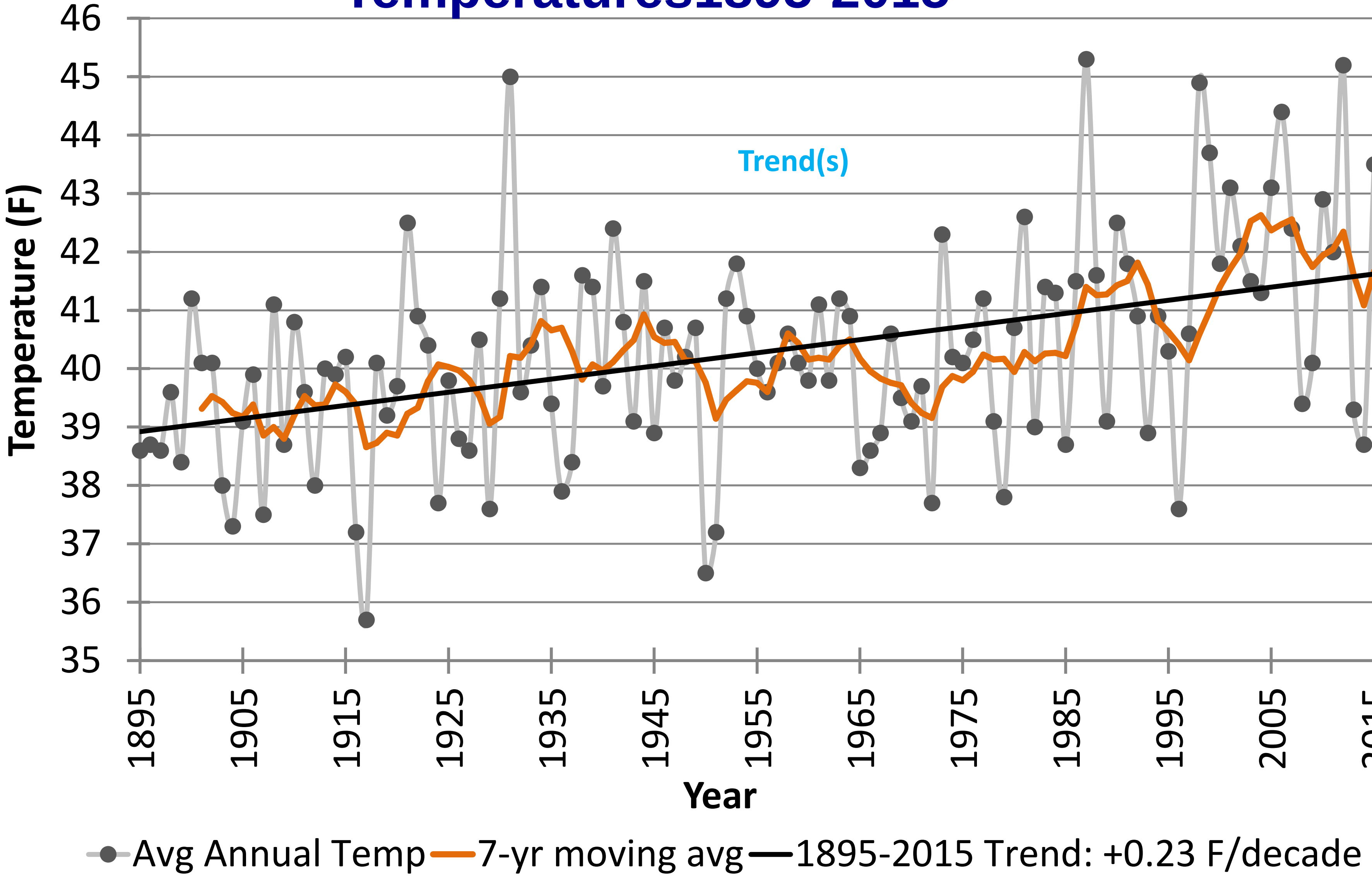
Example: Minnesota Average Annual Temperatures1895-2015



Example: Minnesota Average Annual Temperatures1895-2015



Minnesota Average Annual Temperatures1895-2015



The Challenge

- Limited funds and resources allocated for CC
- Limited on-staff expertise
- Pressure (or desire) from customers, bosses, consultants, experience…to do *something*

The need

- Establish a baseline of consistent scientific climate change information specific to state of MN
- Assist with decision-making and planning
  →Journals, assessments, tools & datasets; custom analyses

Main Points

1. Warming ***well underway*** in Minnesota
   - **Trend observed, projected**
2. Cold temperatures rising fastest
   - **Trend observed, projected**
3. Annual precipitation increasing
   - **Trend observed, projected**

Main Points

4. Extreme rainfall events increasing
   - **Trend observed, projected + high natural variability**
5. No trend for heat waves (yet)
   - **No trend observed. Trend projected**
6. No trend for drought (yet)
   - **No trend observed. Possible trend projected**
7. No trend for tornadoes (or severe weather)
   - **No trend observed. Possible trend projected**

Confidence that climate change has *already* impacted common Minnesota weather/climate hazards

Confidence	Hazard	Recent & Current Observations
Highest	**Extreme cold**	Rapid decline in severity, frequency
	Extreme rainfall	Becoming larger and more frequent
High	**Heavy snowfall**	Large events more frequent
Moderately Low	**Severe thunderstorms & tornadoes**	Historical comparisons difficult; Few major tornadoes in MN since late 2010
Lowest	**Heat waves**	No recent increases or worsening
	Drought	

Confidence that climate change will impact common Minnesota weather/climate hazards beyond 2025

Confidence	Hazard	Expectations beyond 2025
Highest	**Extreme cold**	Continued rapid decline
	Extreme rainfall	Unprecedented events expected
High	**Heat waves**	Increases in severity, coverage, and duration expected
Moderately High	**Drought**	Increases in severity, coverage, and duration possible
Moderately Low	**Heavy snowfall**	Large events less frequent as winter warms
Moderately Low	**Severe thunderstorms & tornadoes**	More "super events" possible, even if frequency decreases

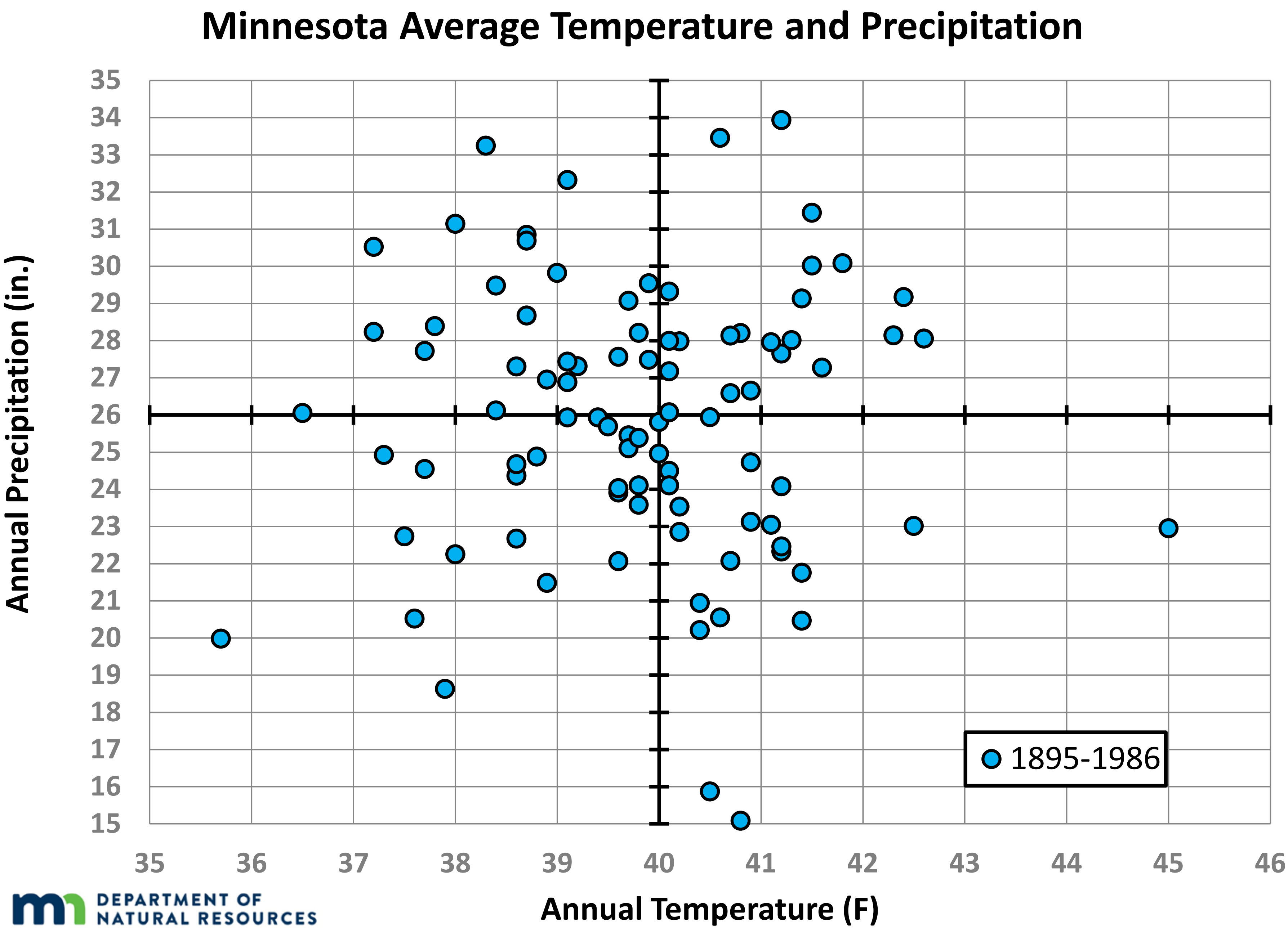
Assorted impacts

Climate/Impacts	Effect	Confidence of increased impacts (relative to normal) in next 10 years
Flooding	• Sewer backup, contamination • Water infrastructure damage • Property damage • Damage to roads, highways	High
More Freeze/Thaw Cycles	• Reduced pavement life cycles, potholes • Presumably many others	Highest
Higher winter and minimum temps	• Longer growing season • Longer construction season • Agricultural “false starts” (killing frost after early onset growing season) • Cold-limited invasives • Loss of winter recreation (major) • Altered spring flow timing/distribution	Highest

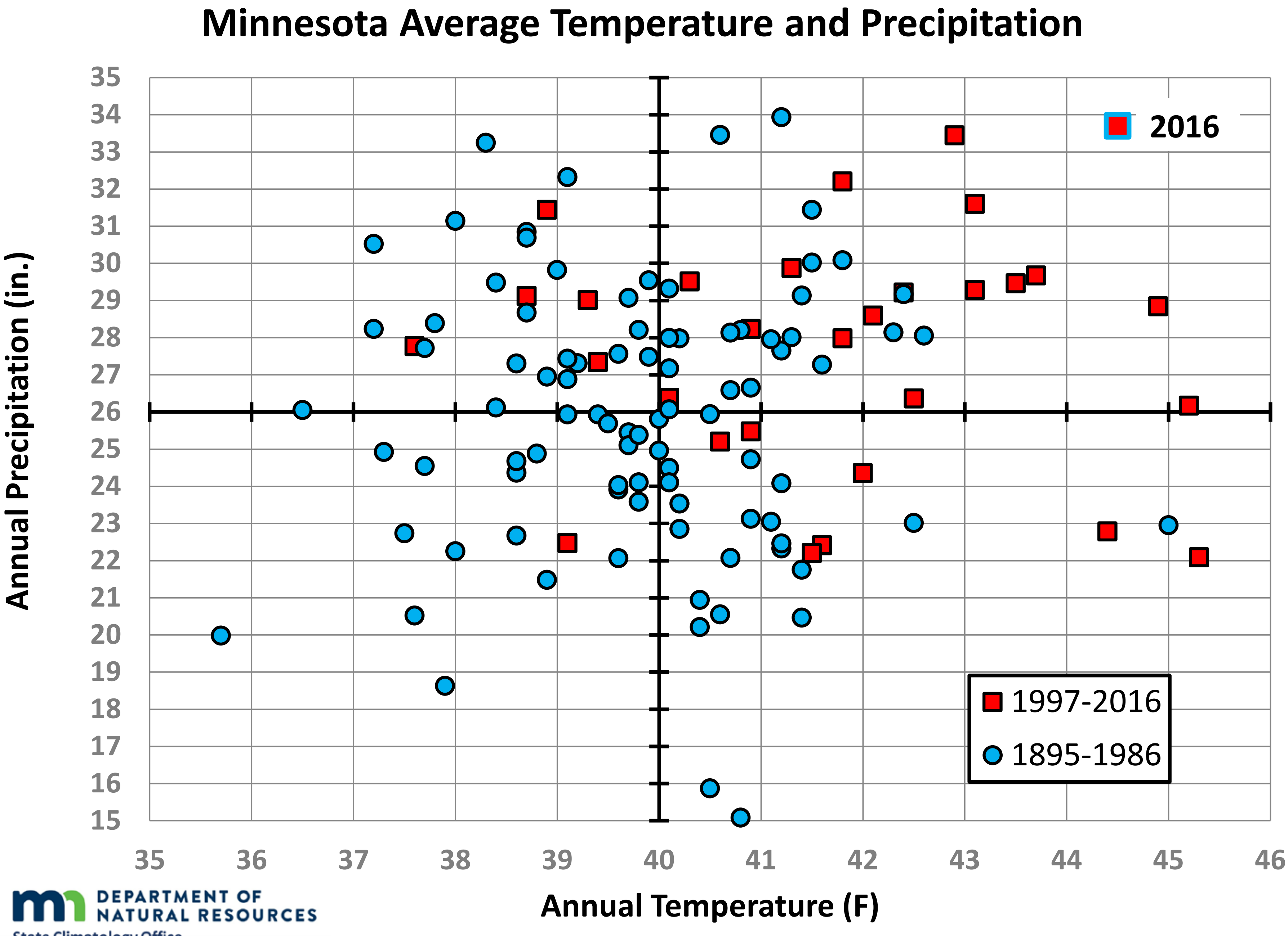
DEPARTMENT OF NATURAL RESOURCES

Assorted impacts

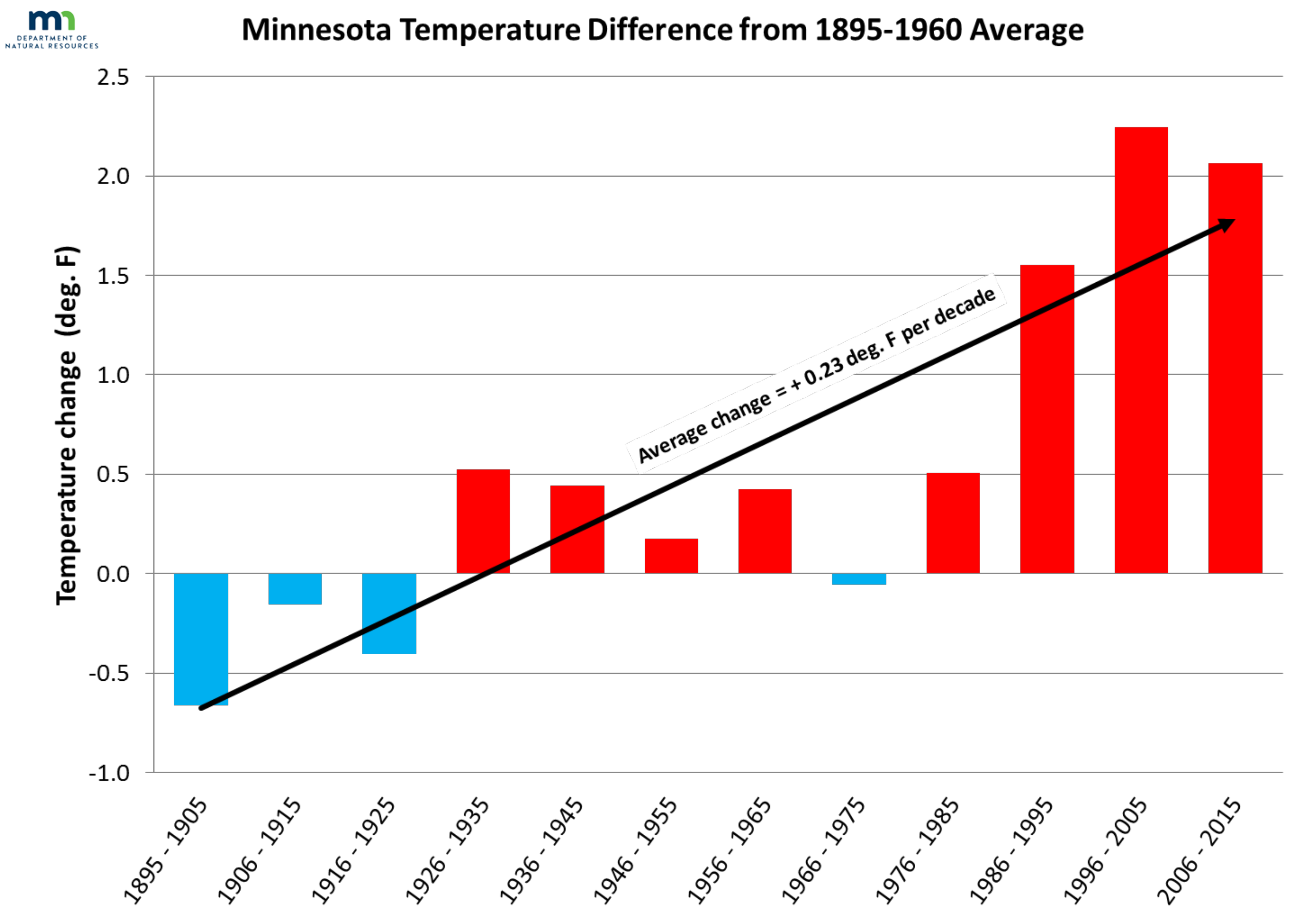
Climate/Impacts	Effect	Confidence of increased impacts (relative to normal) in next 10 years
Extreme heat	• Pavement buckling • Increased cooling requirements • Electrical/grid malfunctions • Heat illness/death • Tropical pathogens • Crime?	Low (socioeconomic factors at play)
Drought	• Stressed vegetation>>more erosion • Groundwater depletion all sectors	Unknown or Low
Wildfires	• Forest/vegetation turnover • Structural/property damage • Evacuation	Unknown
Vegetation & wildlife	• Shifts in species ranges • More invasives (land, air, water) • Altered migrations	In progress



DEPARTMENT OF NATURAL RESOURCES
State Climatology Office



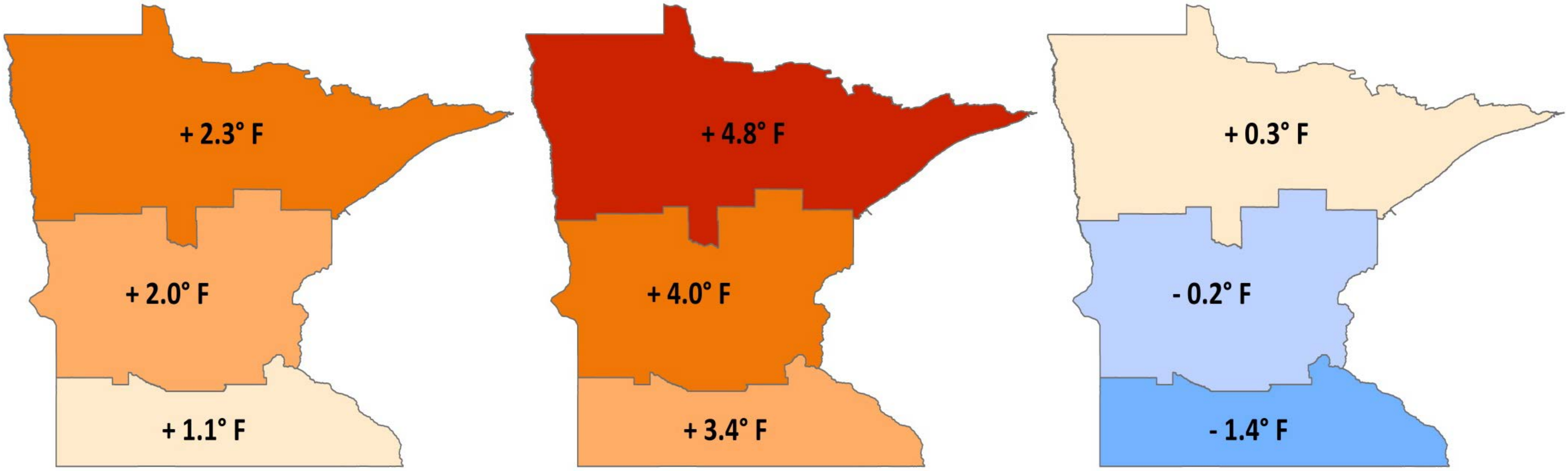
Minnesota Average Temperature and Precipitation
2016
1997-2016
1895-1986
Annual Precipitation (in.)
Annual Temperature (F)
35
34
33
32
31
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
35
36
37
38
39
40
41
42
43
44
45
46
DEPARTMENT OF NATURAL RESOURCES
State Climatology Office



DEPARTMENT OF NATURAL RESOURCES
Minnesota Temperature Difference from 1895-1960 Average
Temperature change (deg. F)
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
Average change = + 0.23 deg. F per decade
1895 - 1905
1906 - 1915
1916 - 1925
1926 - 1935
1936 - 1945
1946 - 1955
1956 - 1965
1966 - 1975
1976 - 1985
1986 - 1995
1996 - 2005
2006 - 2015

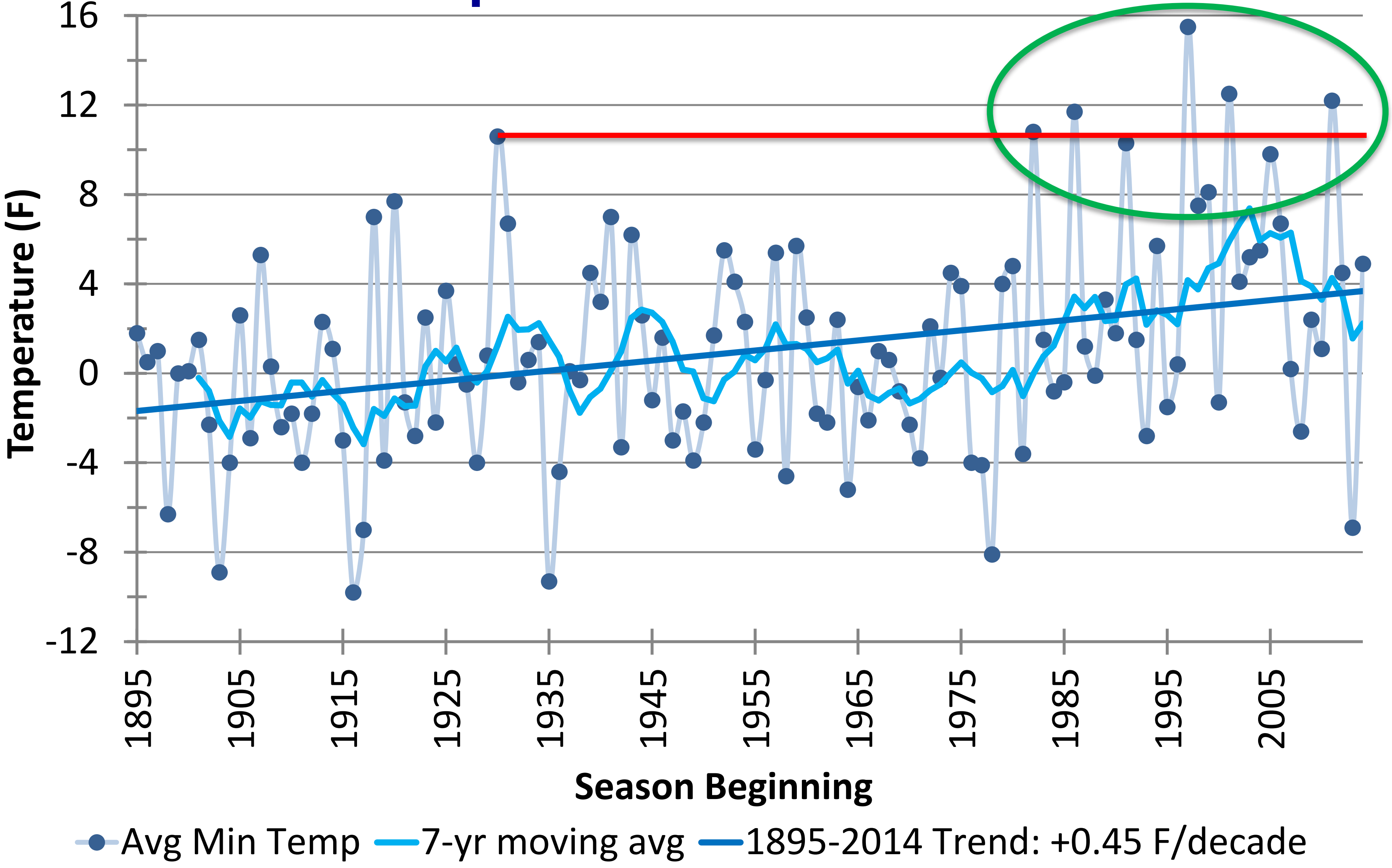
Changes not consistent across *seasons* or times of day

Total temperature change, 1895-2015



Annual Average | Winter Lows | Summer Highs

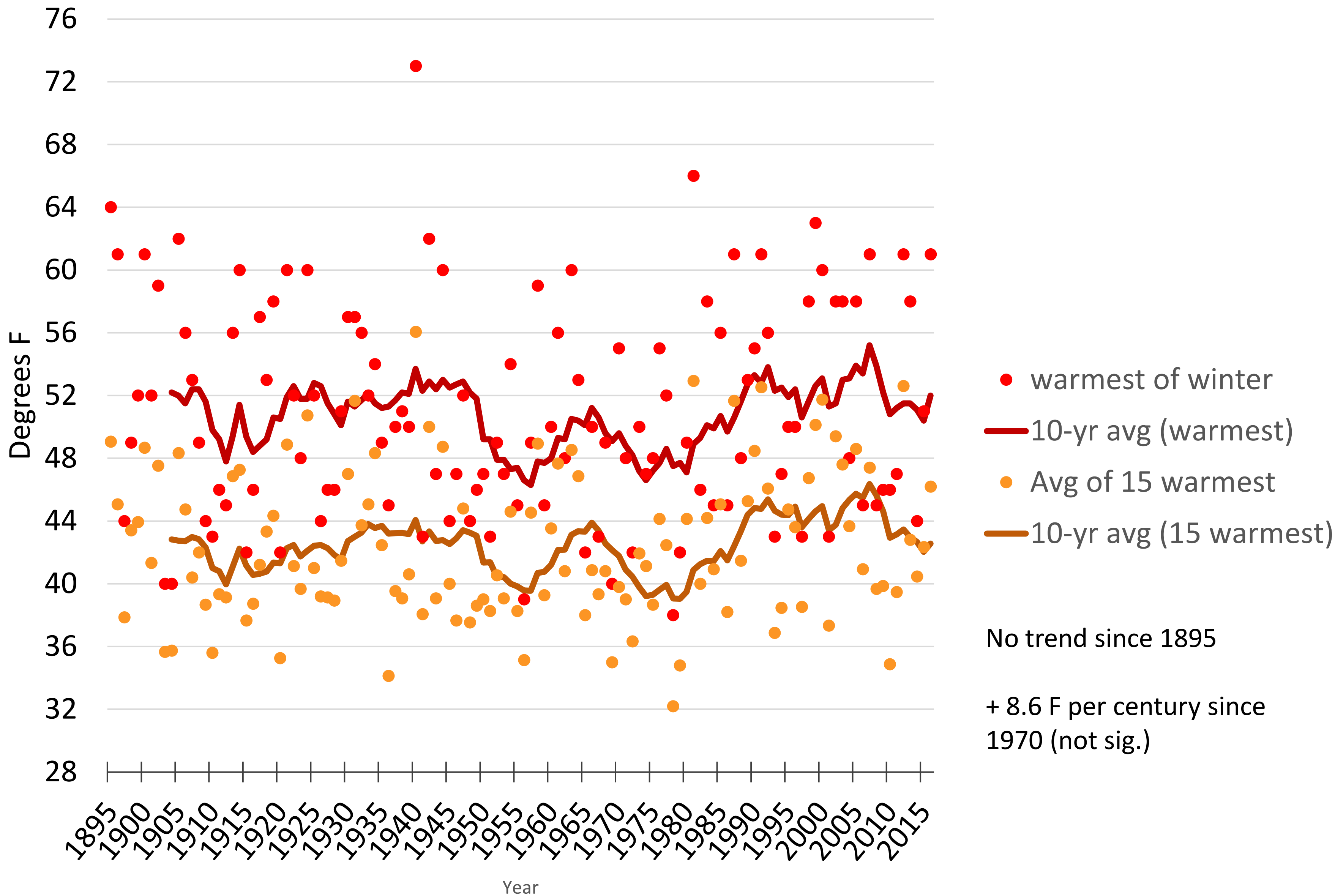
Minnesota Average Winter Minimum Temperatures 1895-2014



Winter warming 10x faster than summer

Season	Temperature Metric	Avg. change per decade since 1895	Avg. change per decade since 1970
Winter (Dec - Feb)	Seasonal Avg.	+ 0.36°F	+ 1.00°F
Summer (Jun - Aug)	Seasonal Avg.	+ 0.14°F	+ 0.10°F

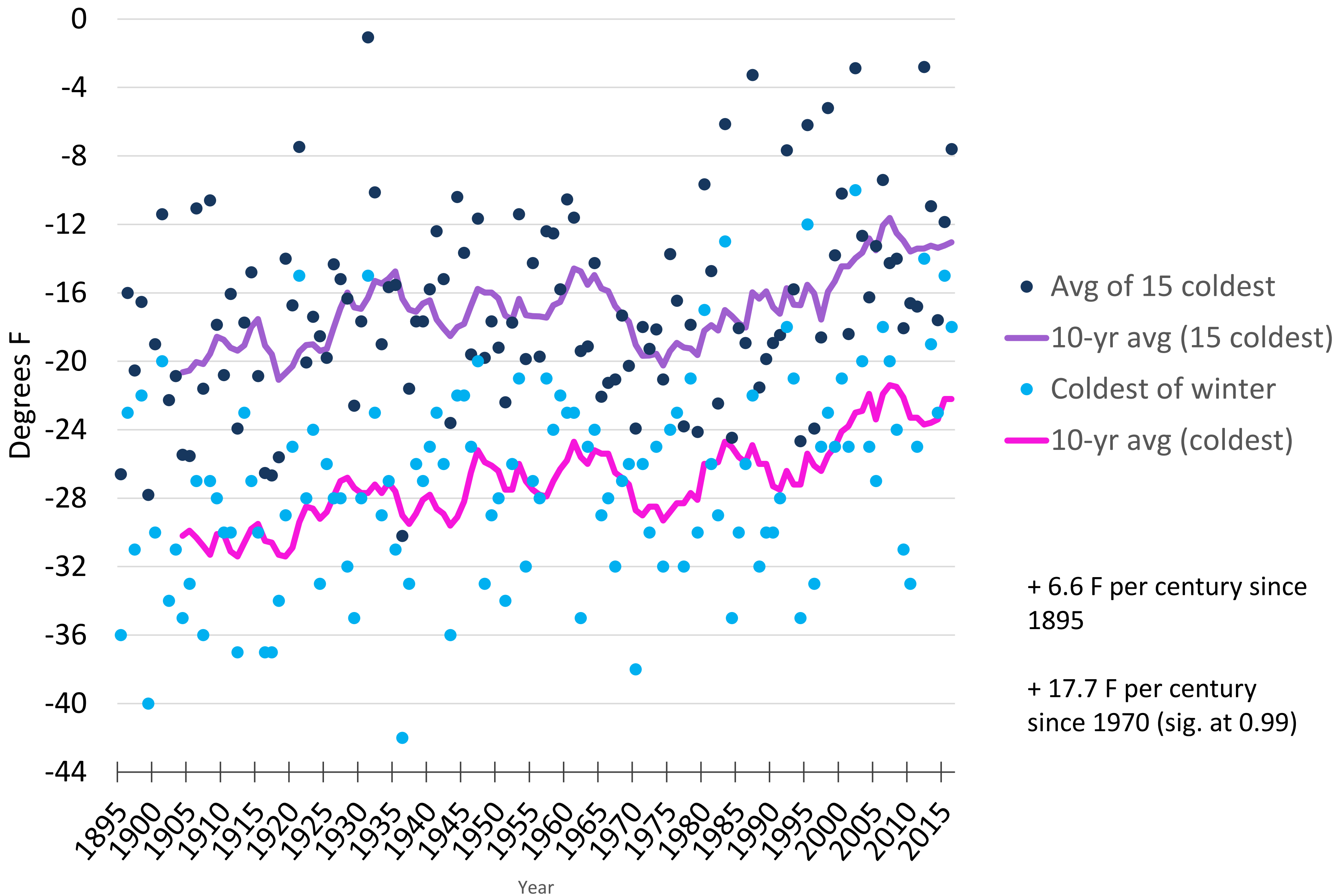
Warmest Days of Winter, Milan (MN), 1895-2016



No trend since 1895

+ 8.6 F per century since 1970 (not sig.)

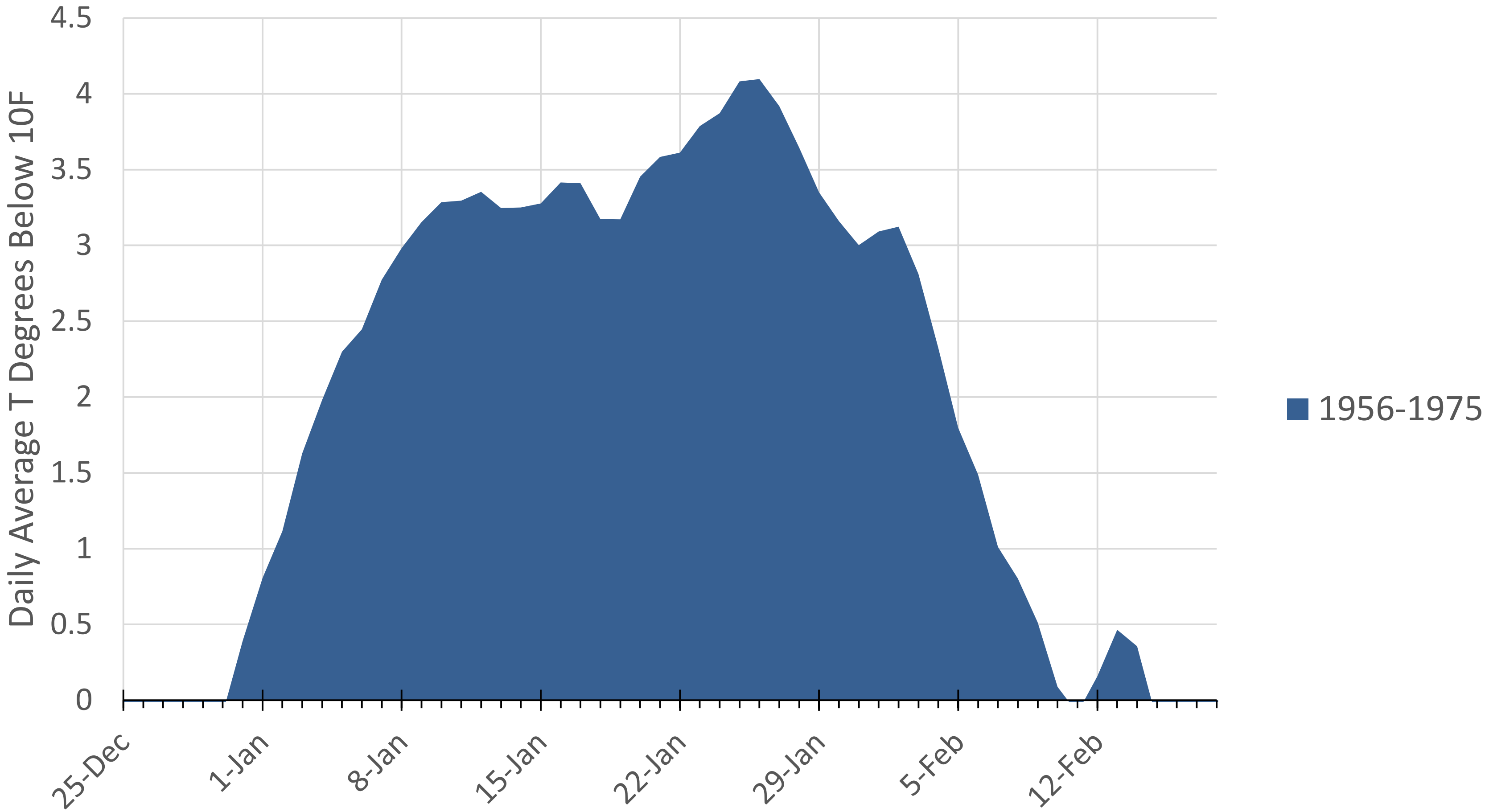
Coldest Days of Winter, Milan (MN), 1895-2016



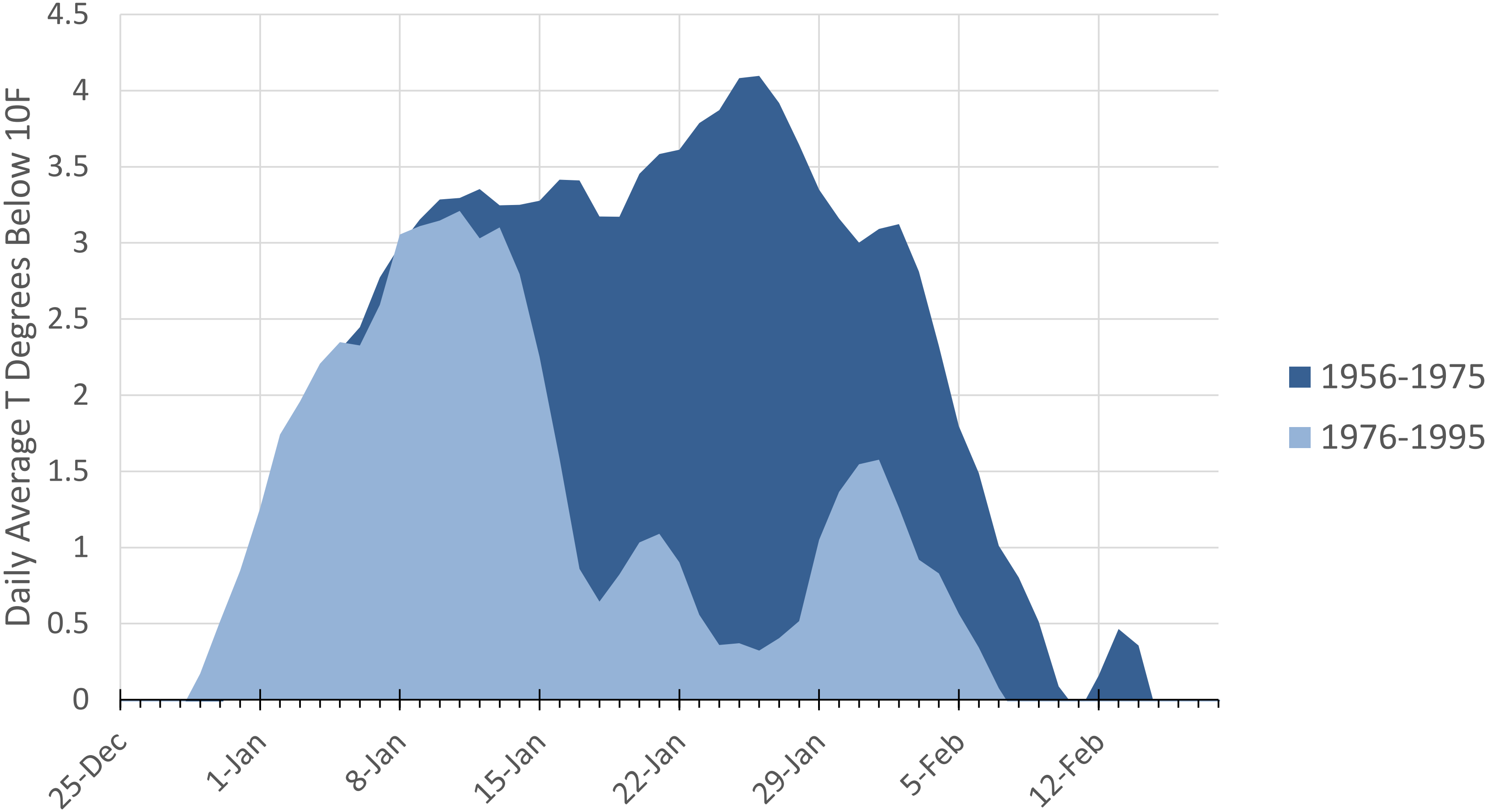
+ 6.6 F per century since 1895

+ 17.7 F per century since 1970 (sig. at 0.99)

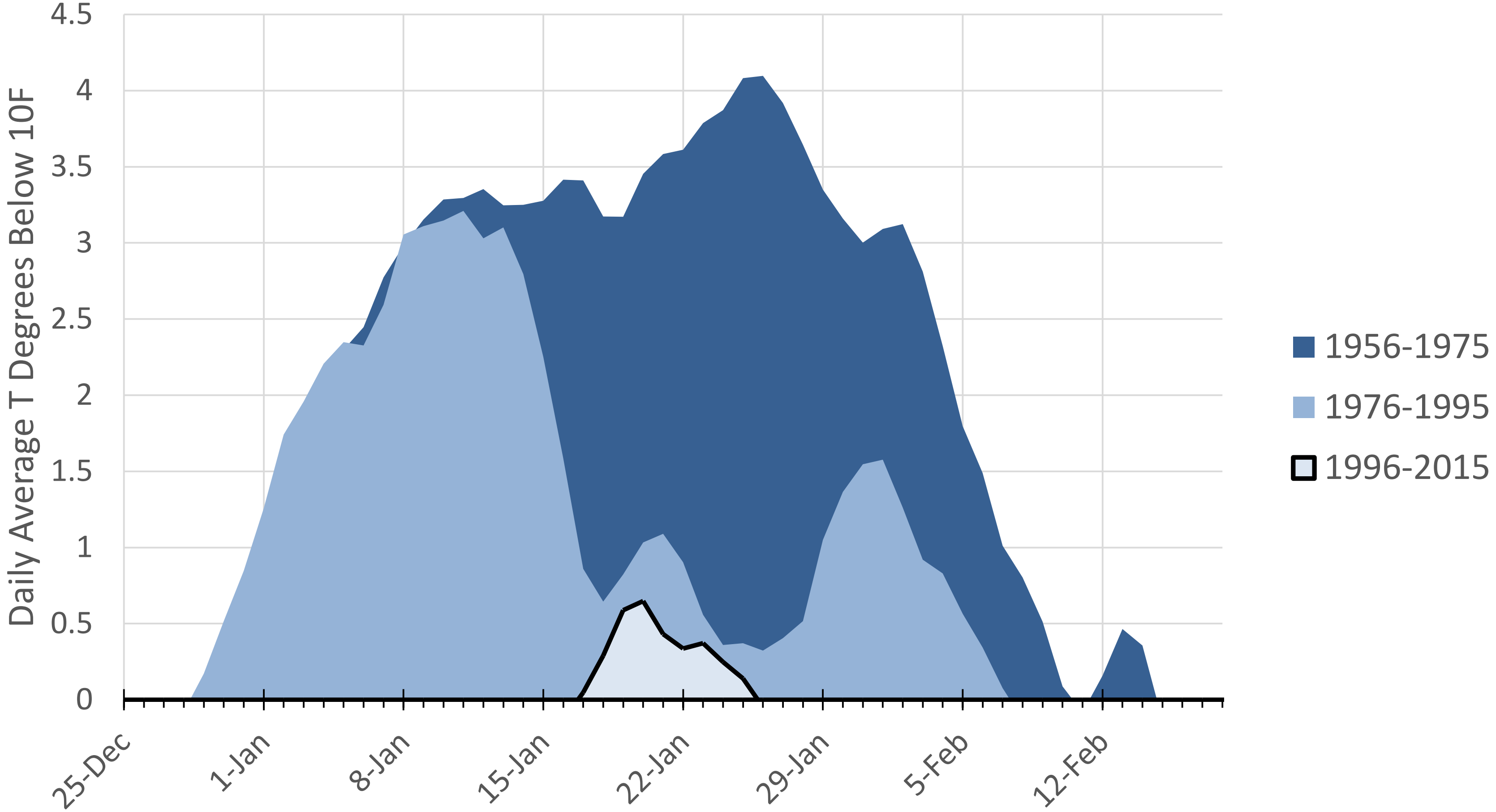
Length and Magnitude of 10 F Temperature Season, Duluth MN



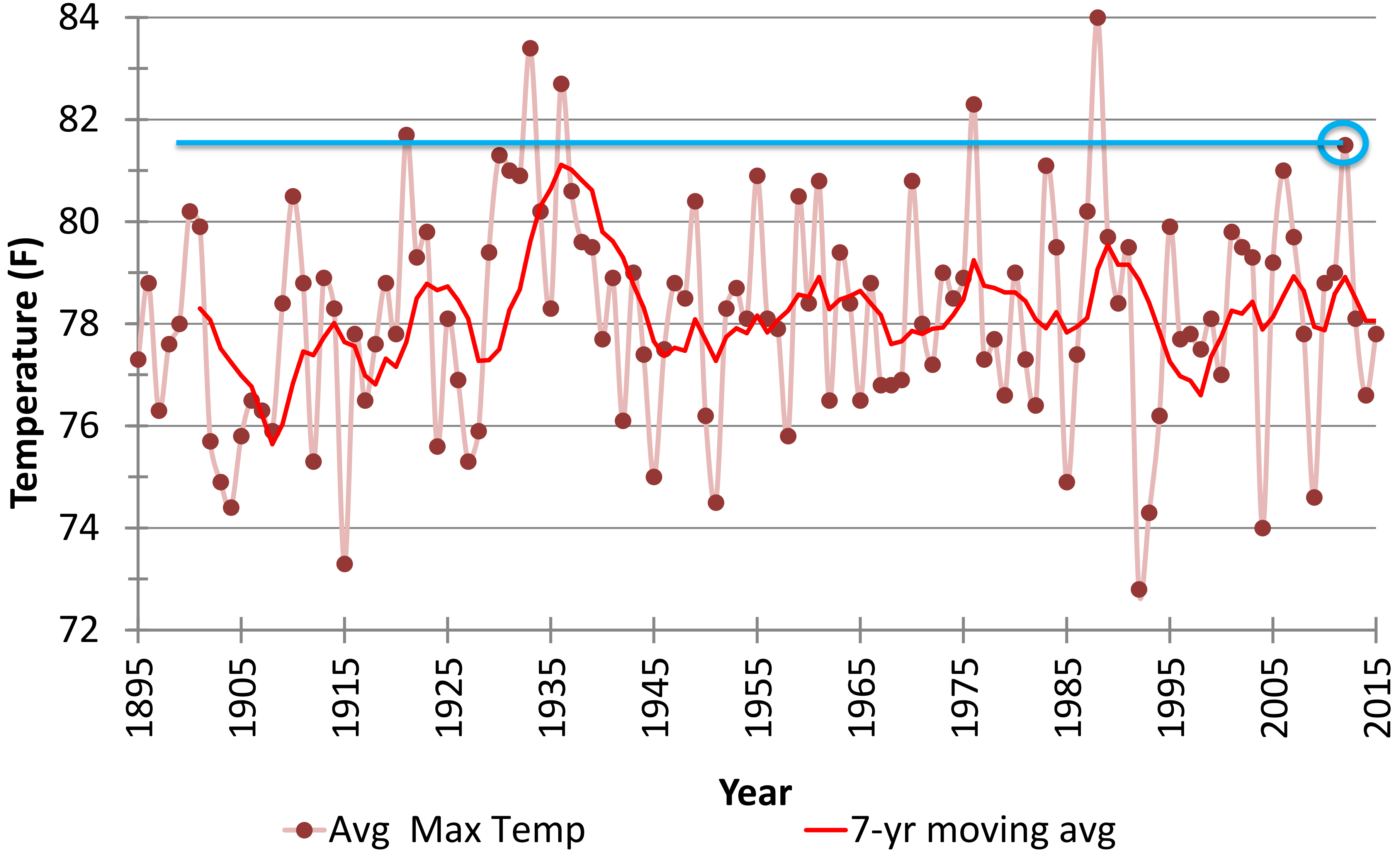
Length and Magnitude of 10 F Temperature Season, Duluth MN



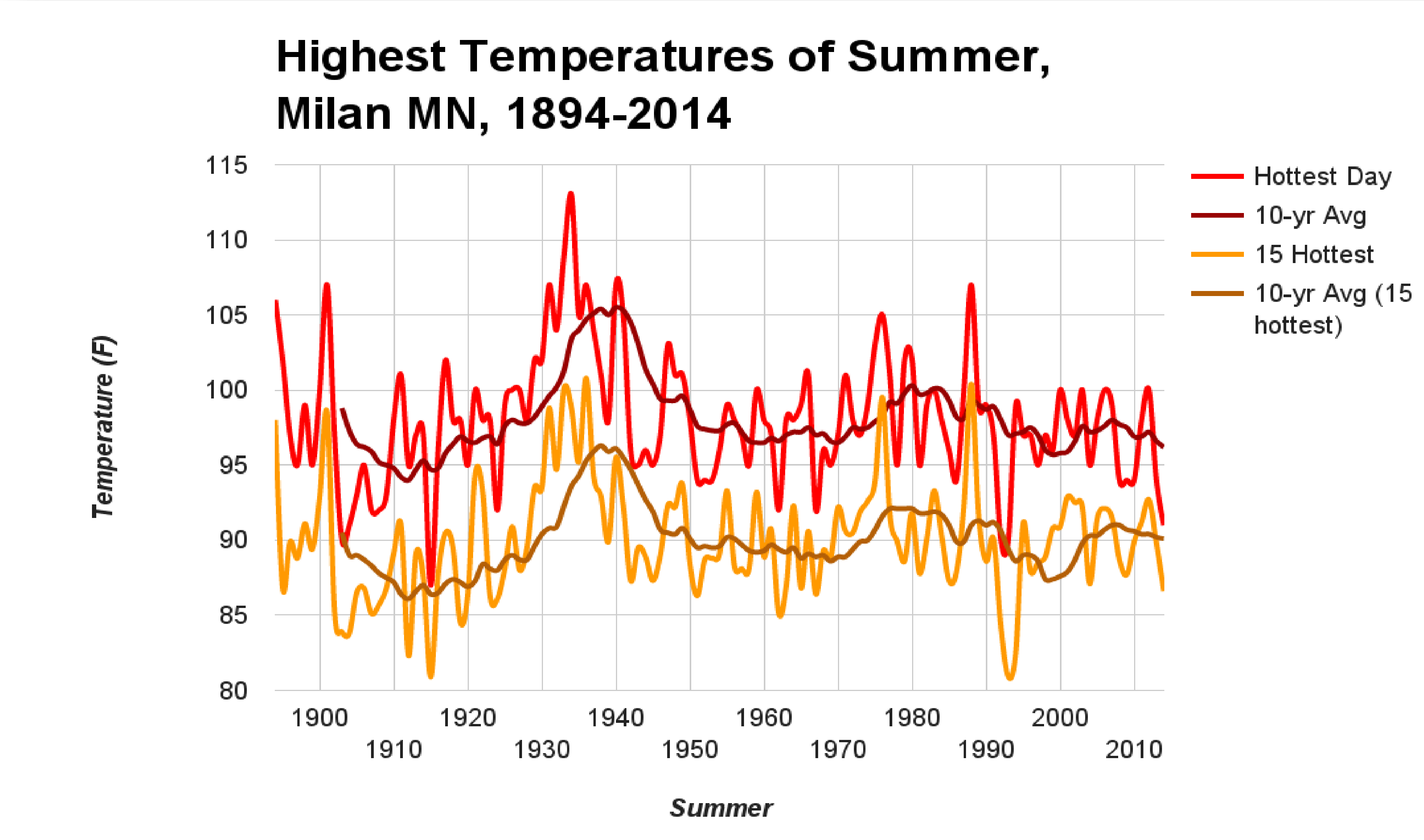
Length and Magnitude of 10 F Temperature Season, Duluth MN



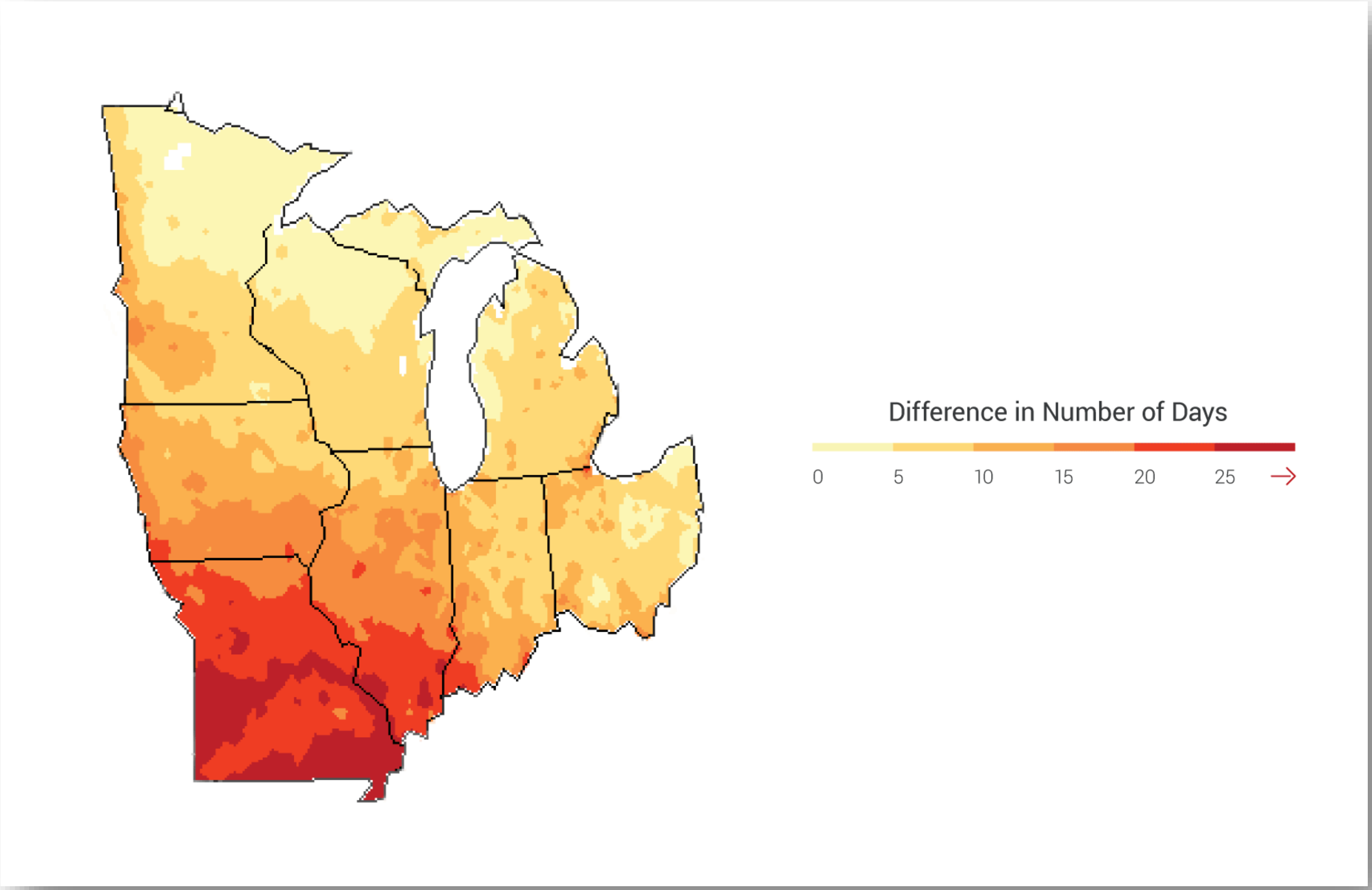
Minnesota Average Summer Maximum Temperatures1895-2015



Extreme heat not increasing--yet

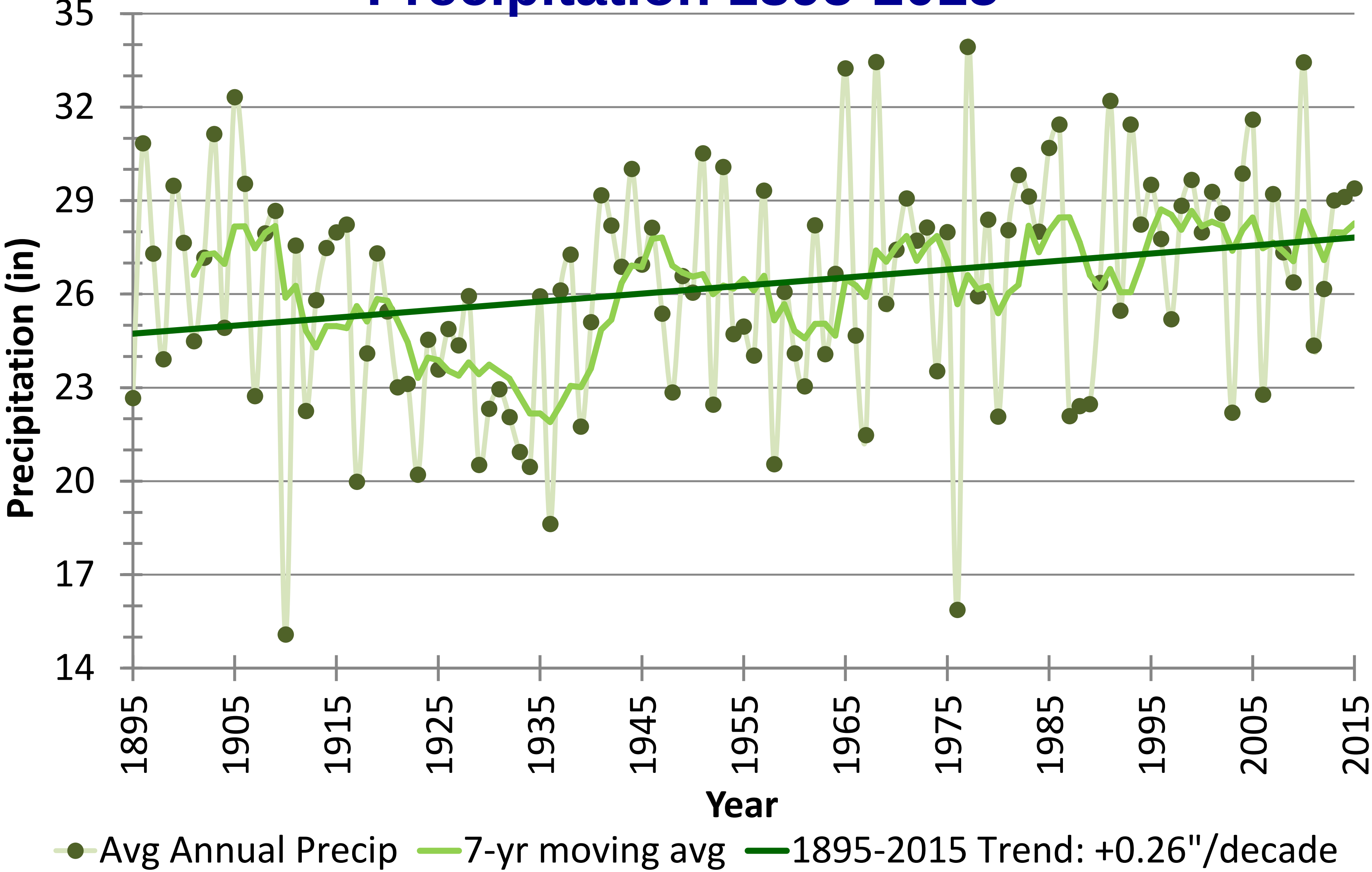


However, additional days above 95 F projected by mid-century



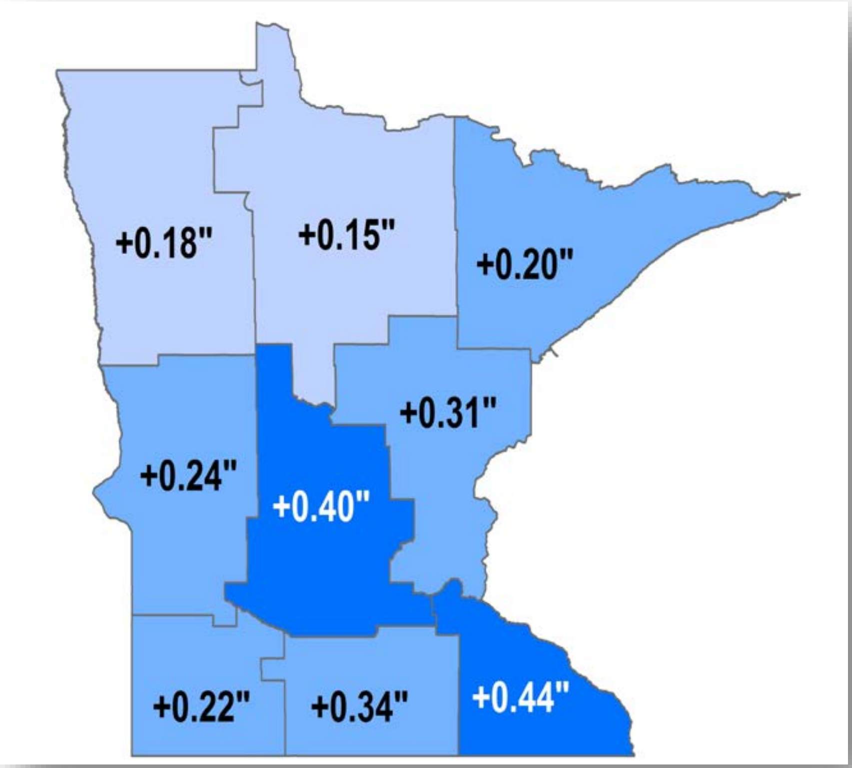
Source: 2014 National Climate Assessment, Midwest Chapter

Minnesota Average Annual Precipitation 1895-2015

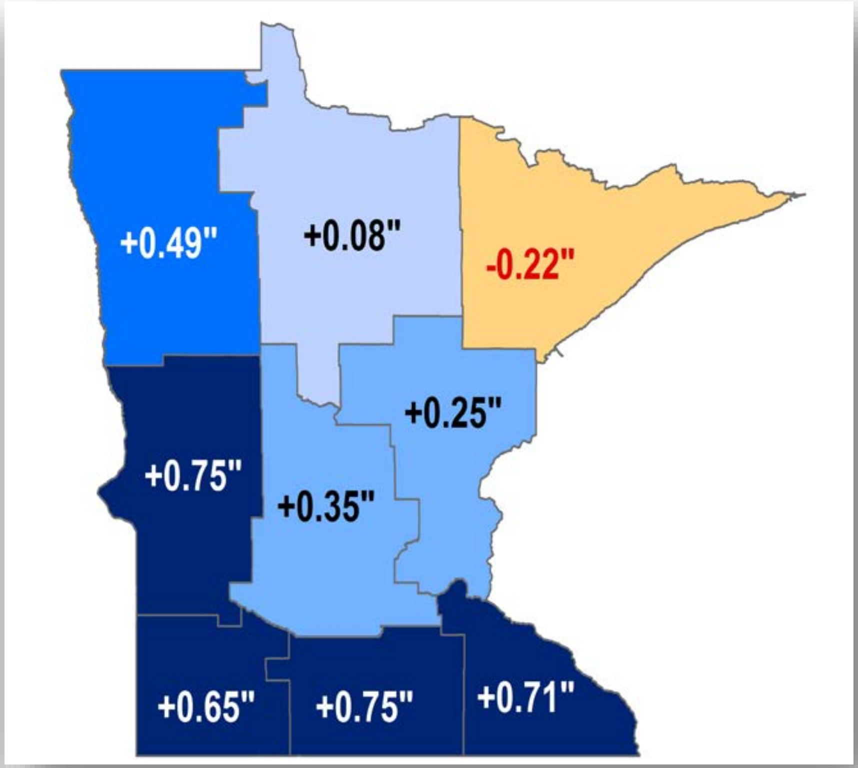


Average change in annual precipitation (per decade)

1895-2015



1970-2015

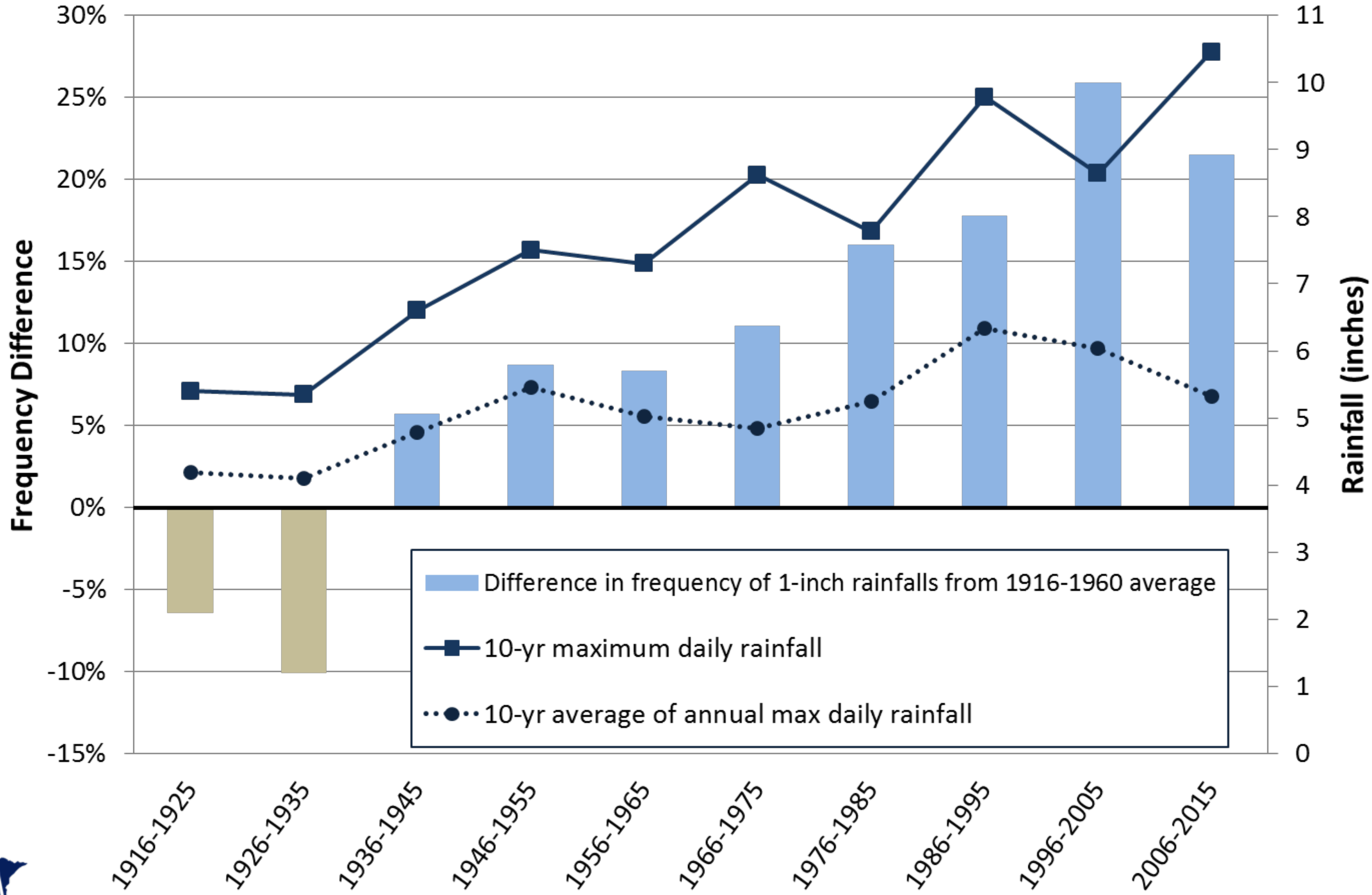


Number and magnitude of heavy and extreme rainfall events increasing

40 long-term recording stations:

- Increases in the frequency of 1, 2, and 3-inch rainfalls recorded annually
- Increases in the size of the largest rainfalls

Changes in Heavy Precipitation Frequency and Intensity from 40 Long-Term Minnesota Stations, 1916-2015



MNDNR State Climatology Office

Before

Source MPR

After

Source MPR

Before

Source MPR

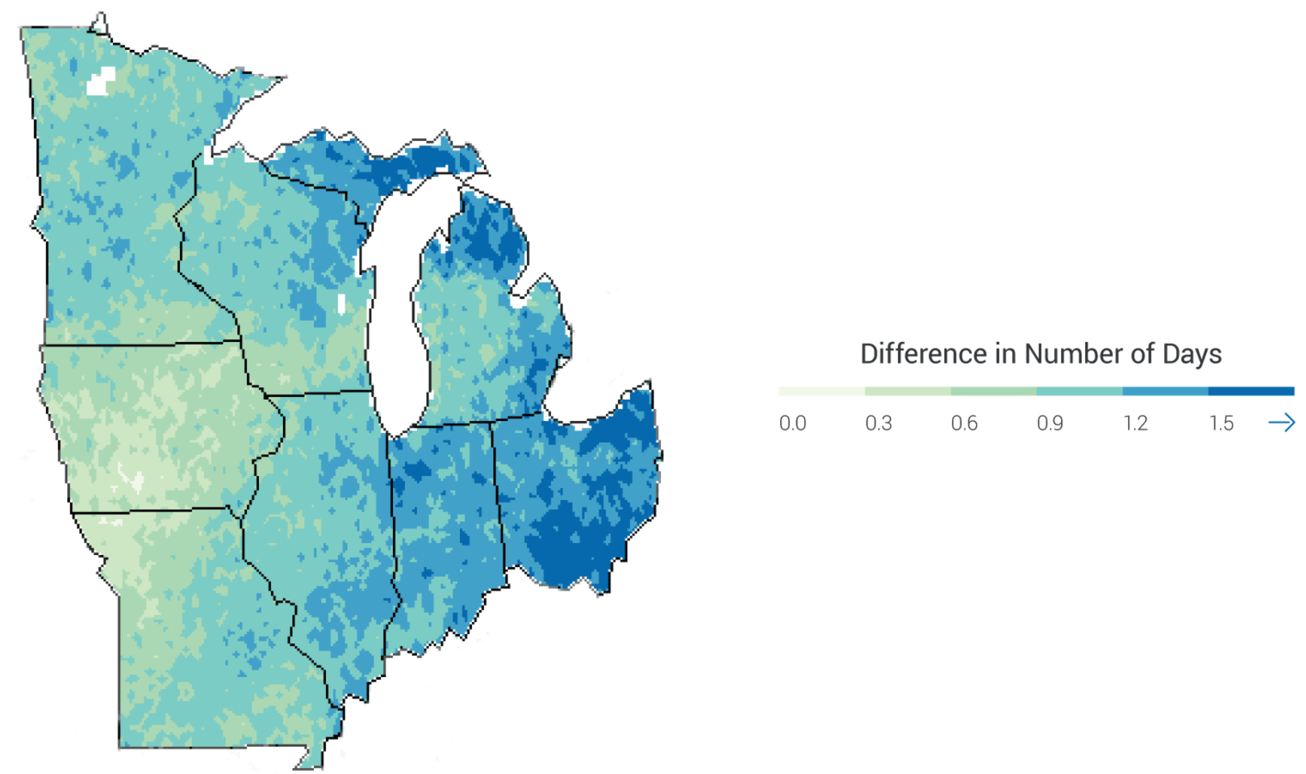
After

Source MPR

Extreme rainfall: "Mega" rain events (6" + over 1000 sq mi) are increasing

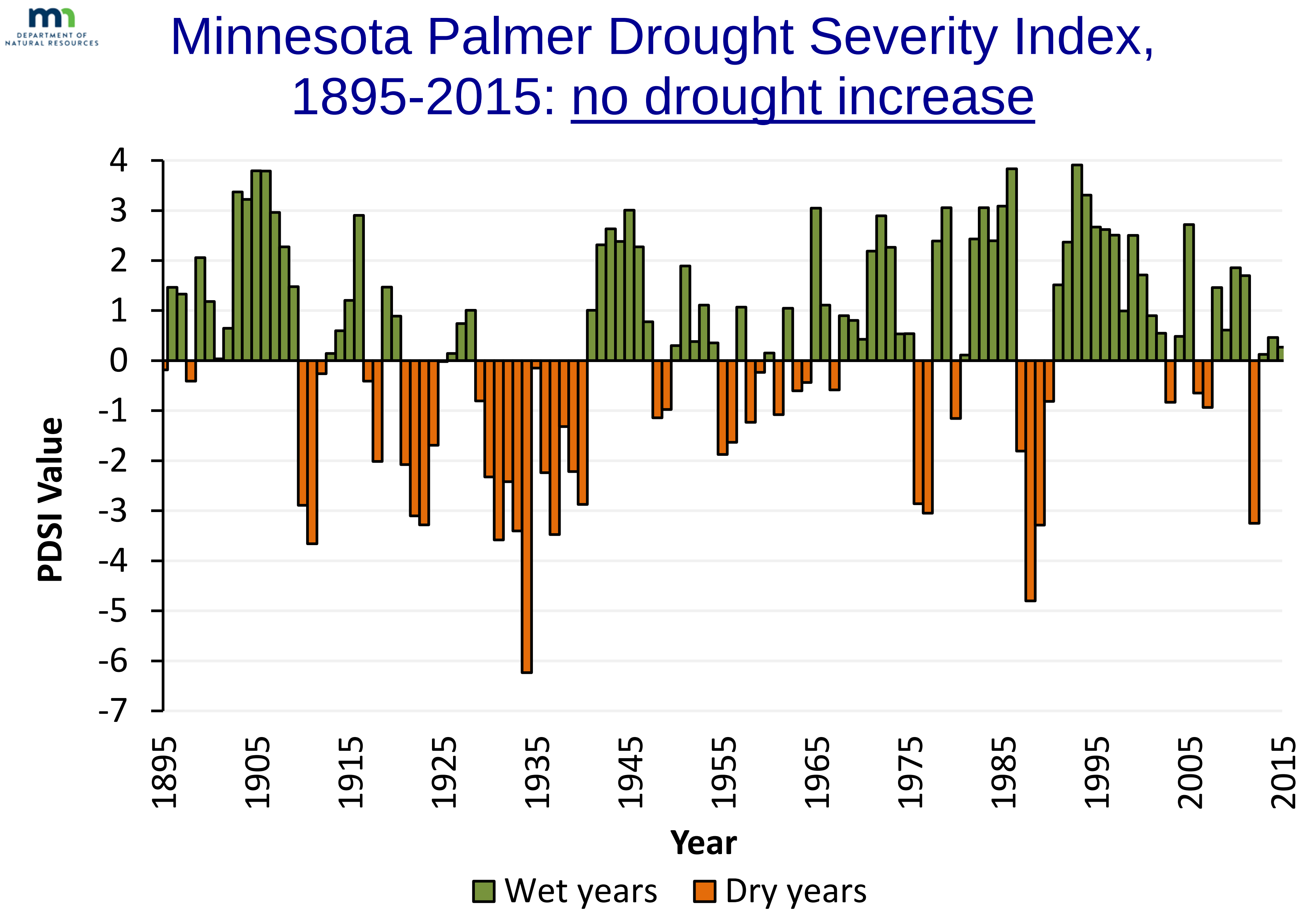
- June 28-29, 1975, Northwest MN
- June 30-July 2, 1978, Southeast MN
- July 23-24, 1987, Twin Cities Superstorm
- June 9-10, 2002, Northern MN
- September 14-15, 2004 Southern MN
- August 18-20, 2007, Southern MN
- September 22-23, 2010 Southern MN
- June 19-20, 2012, Northeast MN
- July 11-12, 2016, East-central MN
- August 10-11, 2016, Central and Southeast MN

Continued increase in "upper 2 percentile" rainfall events projected by mid-century



Source: 2014 National Climate Assessment, Midwest Chapter

Minnesota Palmer Drought Severity Index, 1895-2015: no drought increase



However, “hydrothermal deficit” and stress noted in northeast MN forests.

Box 1 Forest droughts have increased in recent decades.

What changes in drought are in progress now?

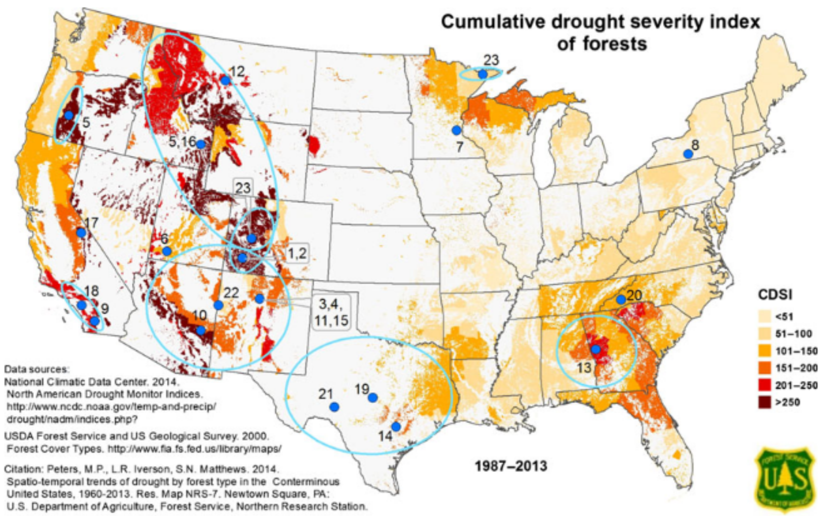
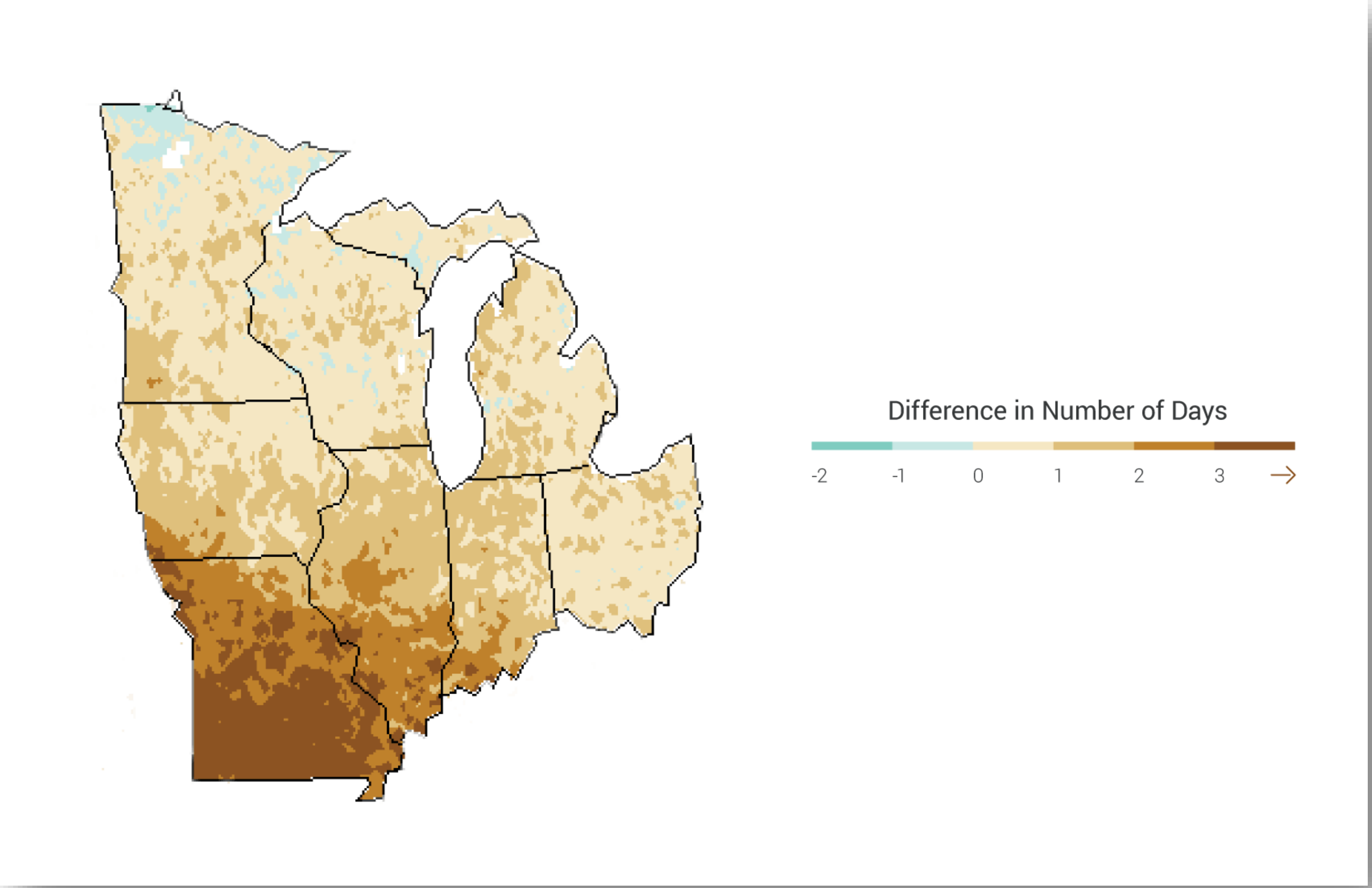


Fig. B1.1. Cumulative drought severity index (CDSI) for forested lands from 1987 to 2013, (modified from Peters *et al.*, 2014), with selected locations of drought- and heat-induced tree mortality indicated by blue circles (modified from Allen *et al.*, 2010 and Figure 4–7 in IPCC, 2014). Numbers correspond to supporting references. (modified from Peters *et al.*, 2014) (1) Anderegg *et al.* (2012) (2) Anderegg *et al.*, (2013b) (3) Breshears *et al.*, (2005) (4) Breshears *et al.*, (2009) (5) Creeden *et al.* (2014) (6) DeRose and Long (2012) (7) Faber-Langendoen and Tester (1993) (8) Fahey (1998) (9) Fellows & Goulden, (2012) (10) Ganey & Vojta, (2011) (11) Garrity *et al.* (2013) (12) Kaiser *et al.* (2012) (13) Klos *et al.*, (2009) (14) Kukowski *et al.* (2012) (15) Macalady and Bugmann (2014) (16) Meddens *et al.* (2012) (17) Millar *et al.*, (2012) (18) Minnich, (2007) (19) Moore *et al.* (2013) (20) Olano and Palmer (2003) (21) Twidwell *et al.* (2013) (22) Williams *et al.*, (2013) (23) Worrall *et al.*, (2013).

Clark, James S., et al. "The impacts of increasing drought on forest dynamics, structure, and biodiversity in the United States." *Global change biology* (2016).

And, additional consecutive dry days projected by mid-century



Source: 2014 National Climate Assessment, [Midwest Chapter]

In Summary

1. Warming ***well underway*** in Minnesota
2. Cold days, winter, warming fastest
3. Annual precipitation increasing
4. Extreme rainfall events increasing
5. No trend for heat waves (yet)
6. No trend for drought (yet)

Resources

Climate Science

MN DNR State Climatology Office

The State Climatology Office manages, analyzes, and disseminates climate information in service to the citizens of Minnesota. They have a comprehensive website, are available to assist with all climatological inquiries, and should be considered an essential resource for any project that involves past data climate data. They can help users identify, select, and interpret results from climate model projections.

http://www.dnr.state.mn.us/climate/index.html

http://www.dnr.state.mn.us/climate/climate_change_info/index.html

651-296-4214

Climate Change in the Midwest

This report addresses the potential impacts of climate change on natural systems, human health, and several important economic sectors within the Midwest

Winkler, Julie A., Jeffrey A. Andresen, Jerry L. Hatfield, David Bidwell, and Daniel Brown. (Eds.). 2014. *Climate Change in the Midwest: A Synthesis Report for the National Climate Assessment*. Washington, DC: Island Press. 269 pp. See the online version at: http://nca2014.globalchange.gov/report/regions/midwest

Global Climate Change

NASA Global Climate Change: This award-winning site presents great visuals, up-to-date data, and resources for all types of audiences.

http://climate.nasa.gov/

Resources

Impacts and Assessments

Ecosystem Impacts

A synthesis of our scientific understanding of the way climate change is affecting biodiversity, ecosystems, ecosystem services, and what strategies might be employed to decrease current and future risks.

Staudinger, Michelle D., Nancy B. Grimm, Amanda Staudt, Shawn L. Carter, F. Stuart Chapin III, Peter Kareiva, Mary Ruckelshaus, and Bruce A. Stein. 2012. *Impacts of Climate Change on Biodiversity, Ecosystems, and Ecosystem Services: Technical Input to the 2013 National Climate Assessment*. Cooperative Report to the 2013 National Climate Assessment. 296 pp.

Forests

This assessment evaluates the vulnerability of forest ecosystems in the Laurentian Mixed Forest Province of Minnesota under a range of future climates. Using past a present climate, vegetation impact models were run, which provided a range of potential vegetative responses to climate.

Handler et al. 2014. *Minnesota forest ecosystem vulnerability assessment and synthesis: a report from the Northwoods Climate Change Response Framework project*. Gen. Tech. Rep. NRS-133. Department of Agriculture, Forest Service, Northern Research Station. Newtown Square, PA; U.S. 228 p.

Source: 2014 National Climate Assessment, Midwest Chapter

Resources

Impacts and Assessments

Forests

This document provides a collection of resources designed to help forest managers incorporate climate change considerations into management and devise adaptation tactics. Topics covered include: a description of the overarching Climate Change Response Framework, a "menu" of adaptation strategies and approaches, a workbook process, and examples of real-world situations.

Swanston, Chris, and Maria Janowiak.(Eds.) 2012. Forest adaptation resources: climate change tools and approaches for land managers. Gen. Tech. Rep. NRS-87. Department of Agriculture, Forest Service, Northern Research Station. Newtown Square, PA: U.S. 121 p.

Grasslands

The purpose of this document is to provide key scientific findings about climate changes in and impacts to protected areas and includes a section specifically about grasslands along with others.

Loehman, Rachel. 2009. Understanding the science of climate change: talking points - impacts to prairie potholes and grasslands. Natural Resource Report NPS/NRPC/NRR—2009/138. National Park Service, Fort Collins, CO: U.S. 38 p.

Source: 2014 National Climate Assessment, Midwest Chapter

Resources

Impacts and Assessments

Inland Fisheries

This background paper gives guidance to natural resource professionals, legislators, and other decision makers concerning the impacts of climate change on inland waters.

Inland Water Technical Team. 2012. Inland Water Ecosystems. National Fish, Wildlife and Plants Climate Adaptation Strategy. 38 p.

Water Resources

The chapter on water from the third IPCC report with 11 key messages on how changes in rainfall will affect different water resources.

Georgakakos, A., P. Fleming, M. Dettinger, C. Peters-Lidard, T. Richmond, K. Reckhow, K. White, and D. Yates, 2014: *Ch. 3: Water Resources. Climate Change Impacts in the United States: The Third National Climate Assessment*, J.M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 69-112.

Wetlands

A comparison of wetland conditions between two 30-year periods (1946–1975; 1976–2005) using a hindcast simulation approach to determine if recent climate warming in the region has already resulted in changes in wetland condition.

Werner, Brett A., W. Carter Johnson, and Glenn R. Guntenspergen. 2013. *Evidence for 20th century climate warming and wetland drying in the North American prairie pothole region.* Ecology and Evolution, 3(10), 3471-3482.

Source: 2014 National Climate Assessment, Midwest Chapter

Resources

Adaptation and Management

Climate Adaptation Knowledge Exchange (CAKE): Shared knowledge base for managing natural and built systems in the face of climate change.

http://www.cakex.org/

This paper describes how adaptation is an ongoing process, not a fixed endpoint.

Stein, Bruce A., Amanda Staudt, Molly S. Cross, Natalie S. Dubois, Carolyn Enquist, Roger Griffis, Lara J. Hansen, Jessica J. Hellmann, Joshua J. Lawler, Erik J. Nelson, and Amber Pairis. 2013. Preparing for and managing change: climate adaptation for biodiversity and ecosystems. Frontiers in Ecology and the Environment 11: 502–510.

Source: 2014 National Climate Assessment, Midwest Chapter

DEPARTMENT OF NATURAL RESOURCES

Resources

Adaptation and Management

A review of the relevant literature related to climate change and upland management effects on prairie pothole wetland water levels and hydroperiods.

Renton, David A., David M. Mushet, and Edward S. DeKeyser. 2015. *Climate change and prairie pothole wetlands—Mitigating water-level and hydroperiod effects through upland management*: U.S. Geological Survey Scientific Investigations Report 2015–5004, 21 p.

This document provides a collection of resources designed to help forest managers incorporate climate change considerations into management and devise adaptation tactics. Topics covered include: a description of the overarching Climate Change Response Framework, a "menu" of adaptation strategies and approaches, a workbook process, and examples of real-world situations.

Swanston, Chris, and Maria Janowiak.(Eds.) 2012*. Forest adaptation resources: climate change tools and approaches for land managers*. Gen. Tech. Rep. NRS-87. Department of Agriculture, Forest Service, Northern Research Station. Newtown Square, PA: U.S. 121 p.

Source: 2014 National Climate Assessment, Midwest Chapter

Thank you!

Contact:

- Kenneth.Blumenfeld@state.mn.us
- 651-296-4214

DEPARTMENT OF NATURAL RESOURCES