DEPARTMENT OF NATURAL RESOURCES

The Changing Winters of Northeastern Minnesota: Phantoms, Throwbacks, and Large Variations

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DNR State Climatology Office

Northeast Minnesota's pronounced ***OBSERVED*** trends

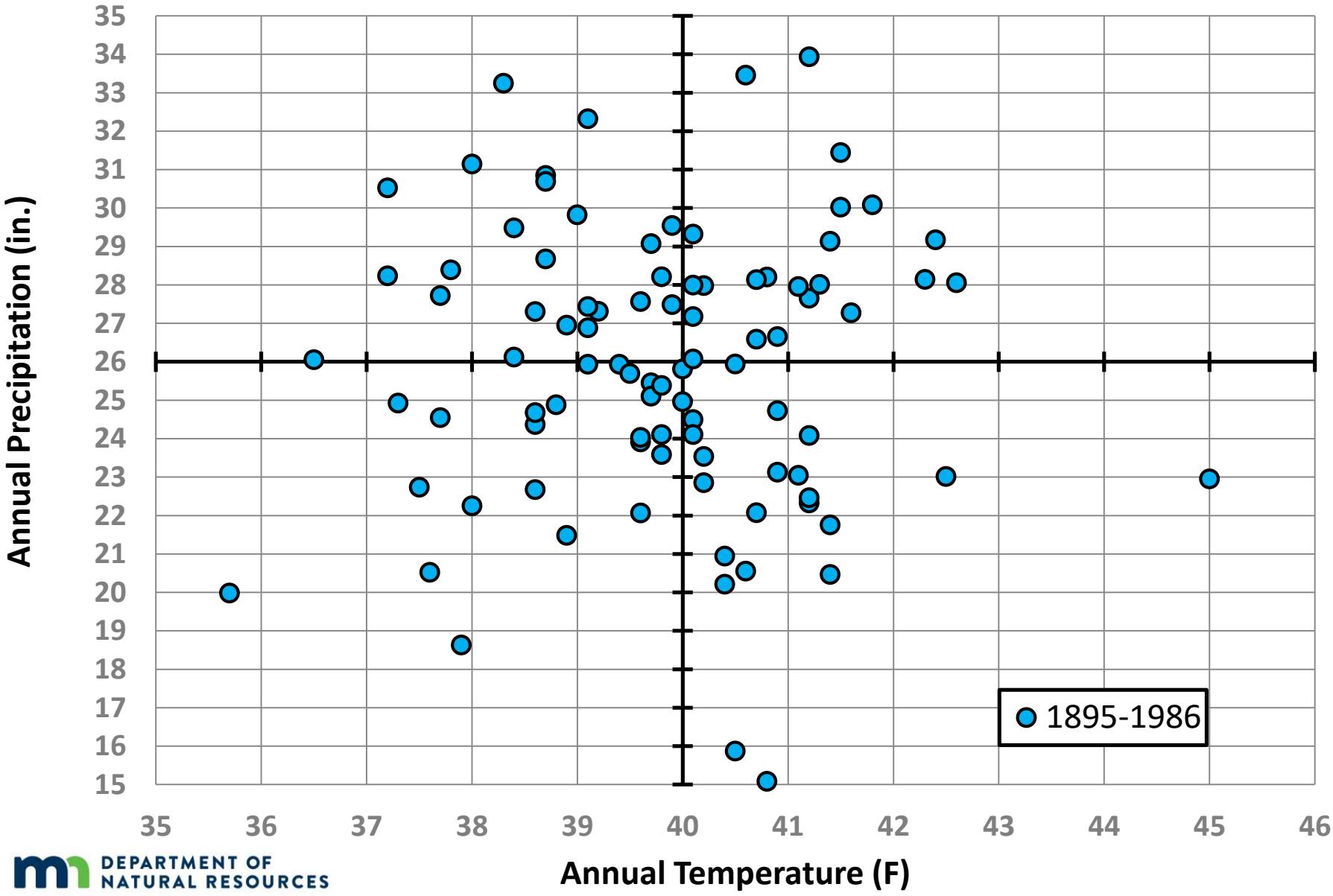
1. Annually: wetter and warmer
   - **Major shift observed, projected to continue**
2. Winter: shorter, less cold, more snowfall, less snow*cover*
   - **Rapid loss in cold extremes, projected to continue**
3. Summer: fewer cool nights, more frequent and heavier downpours
   - **More and larger "big" events, projected to continue**

How Northeast MN Differs from Rest of State

- Faster warming (annually)
- More warming during summer, including summer days
- Precip increasing during winter, but steady rest of year
- Winter still “insulated” but large changes underway

MN Getting Warmer and Wetter

Minnesota Average Temperature and Precipitation



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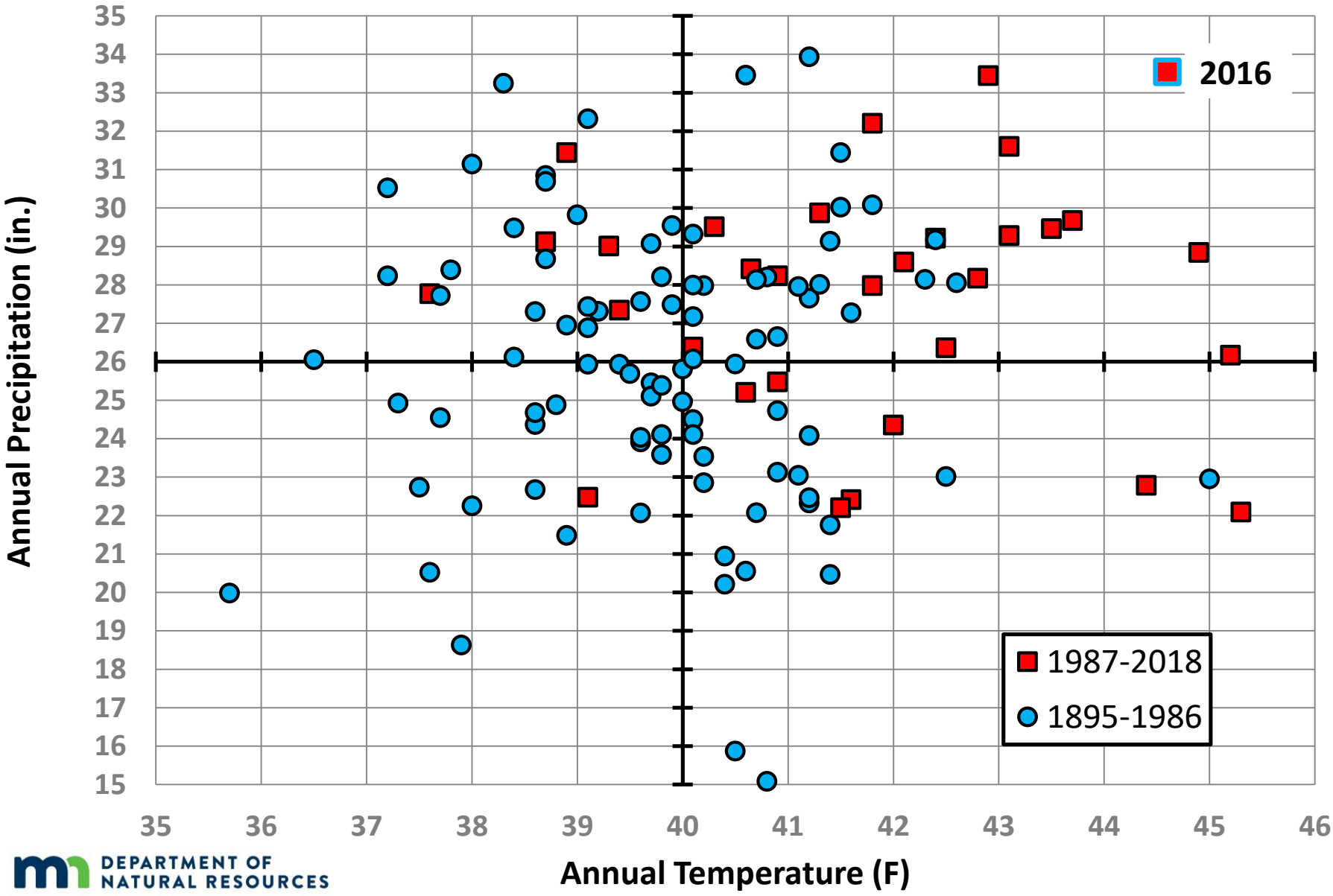
Minnesota Average Temperature and Precipitation



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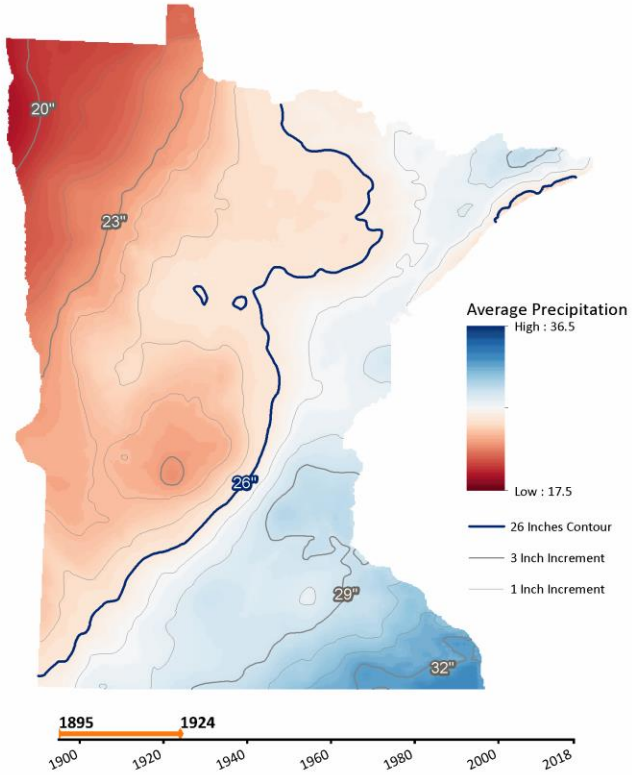
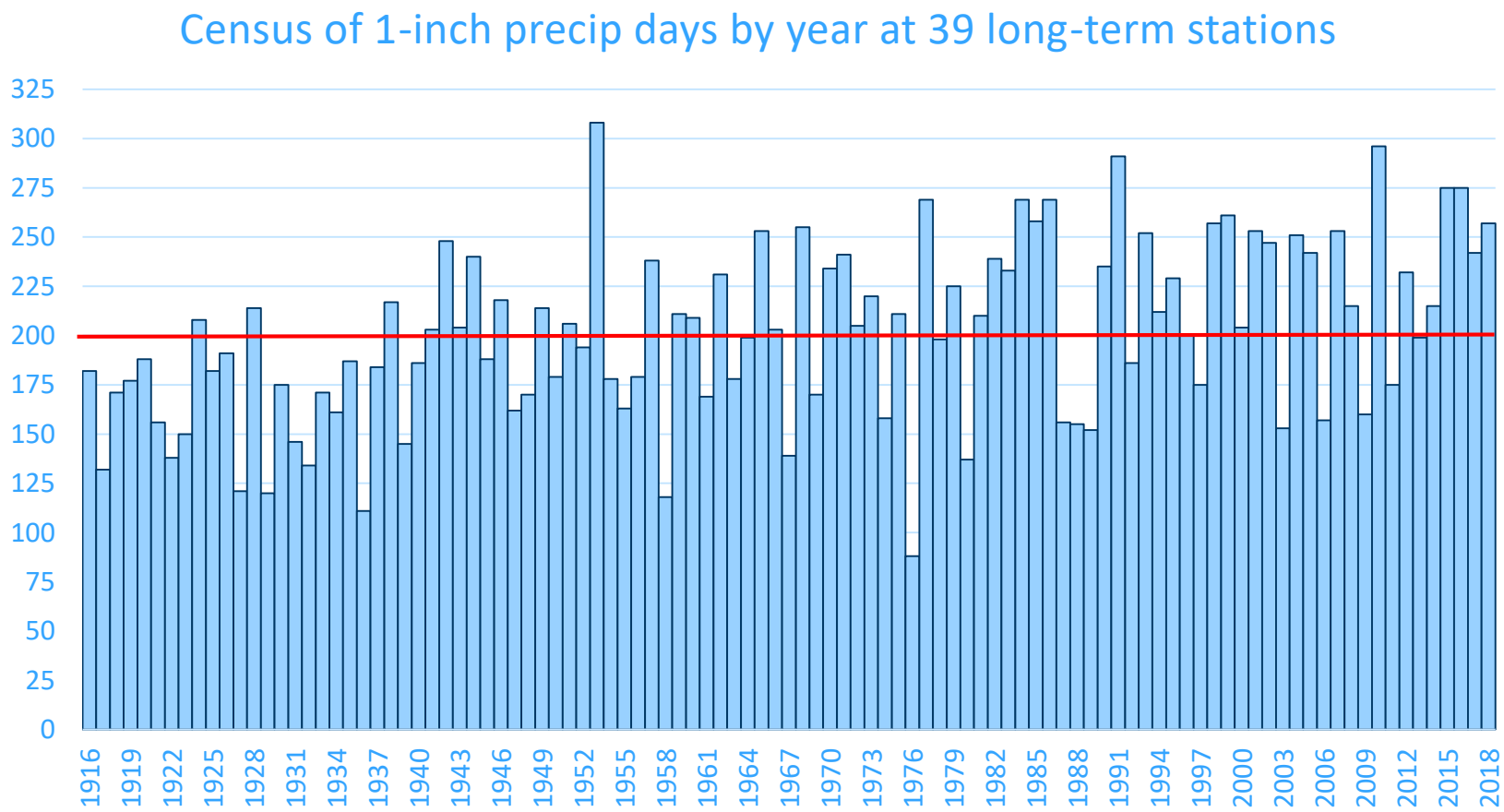
30-Year Average Annual Precipitation

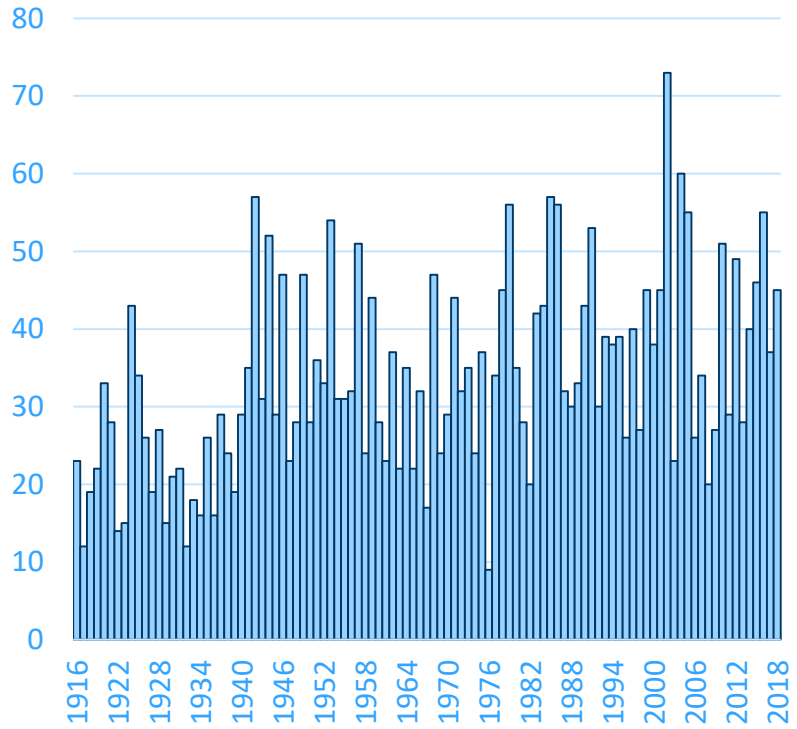


More 1” precip events

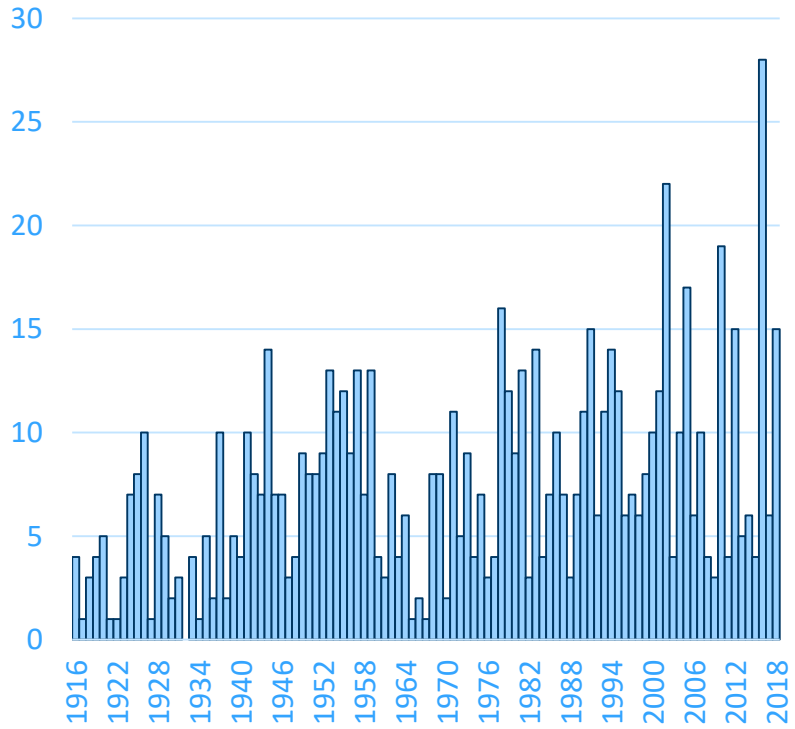


2” and 3” precip events increasing too

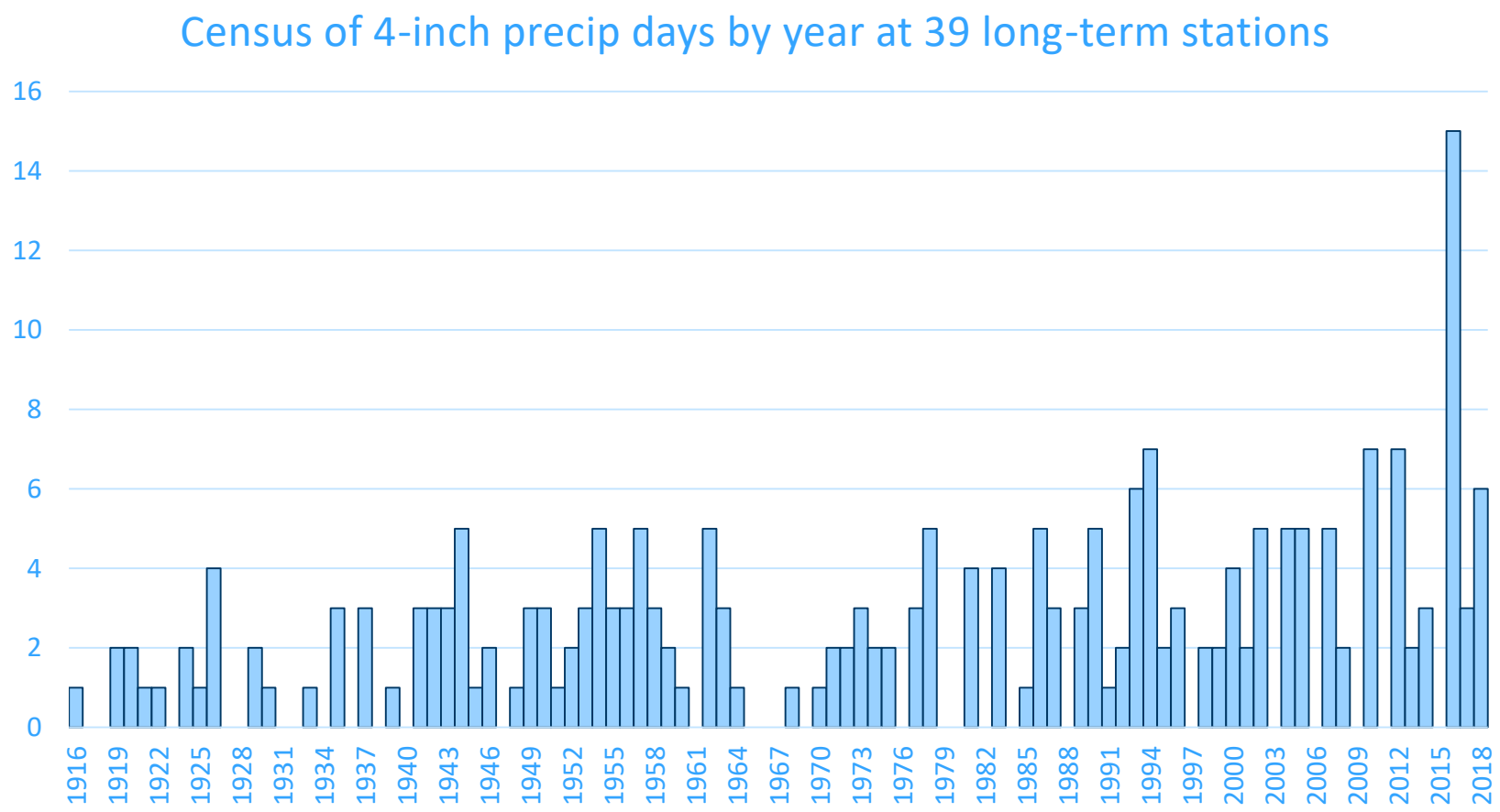
Census of 2-inch precip days by year at 39 long-term stations



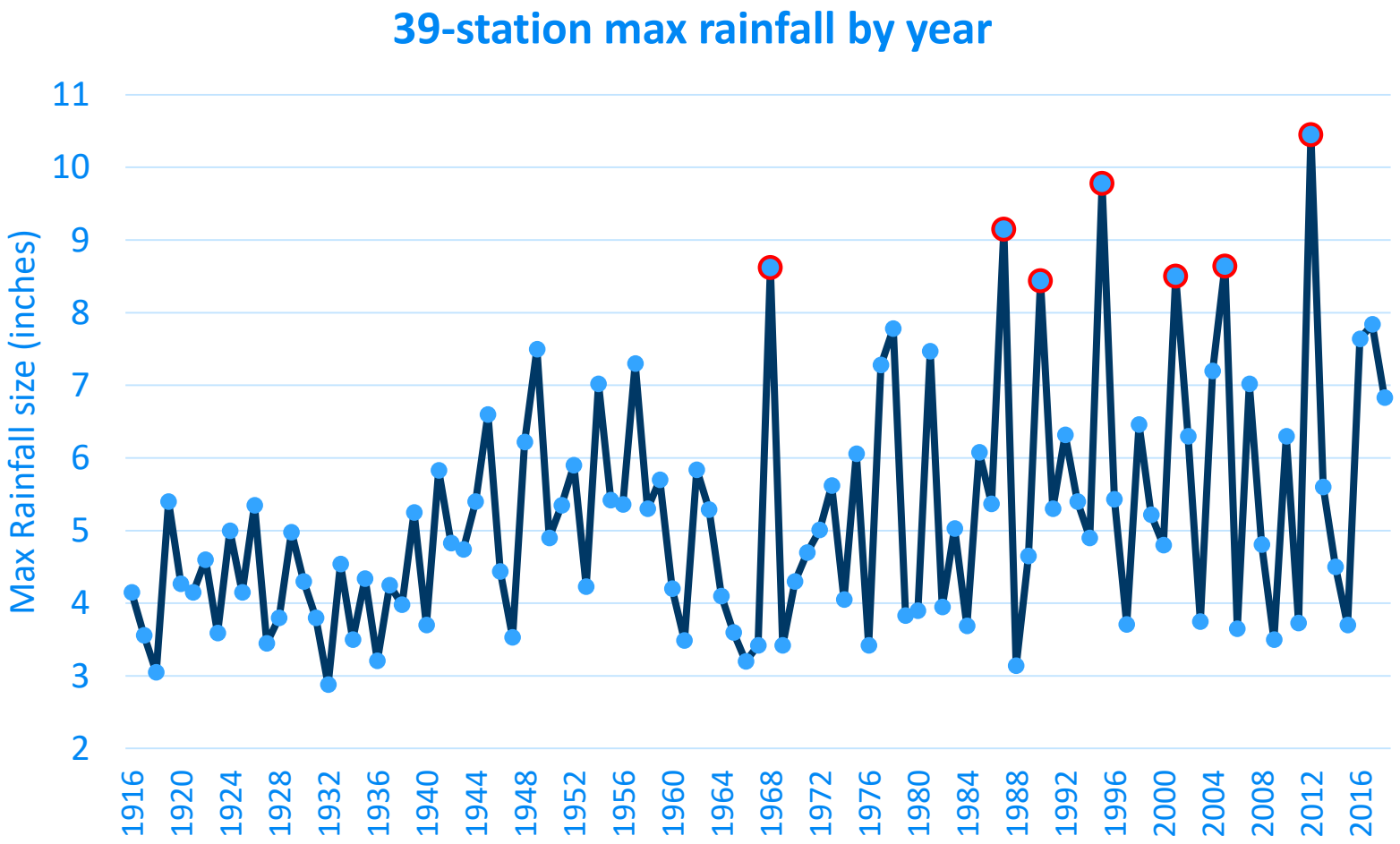
Census of 3-inch precip days by year at 39 long-term stations



Even 4-inchers increasing



Heaviest rain in state often larger, more variable



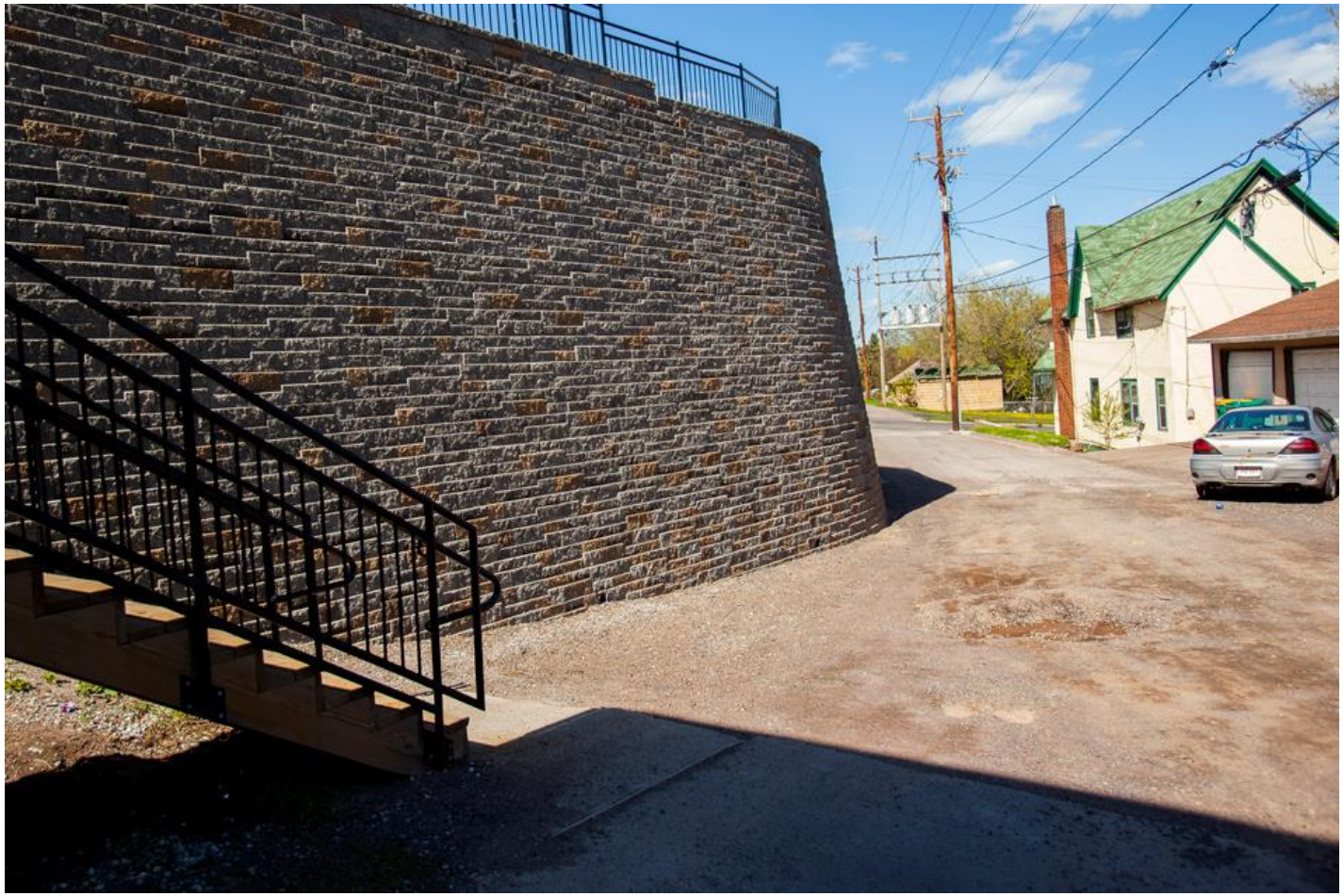
Before

Source MPR

After

Source MPR

Before

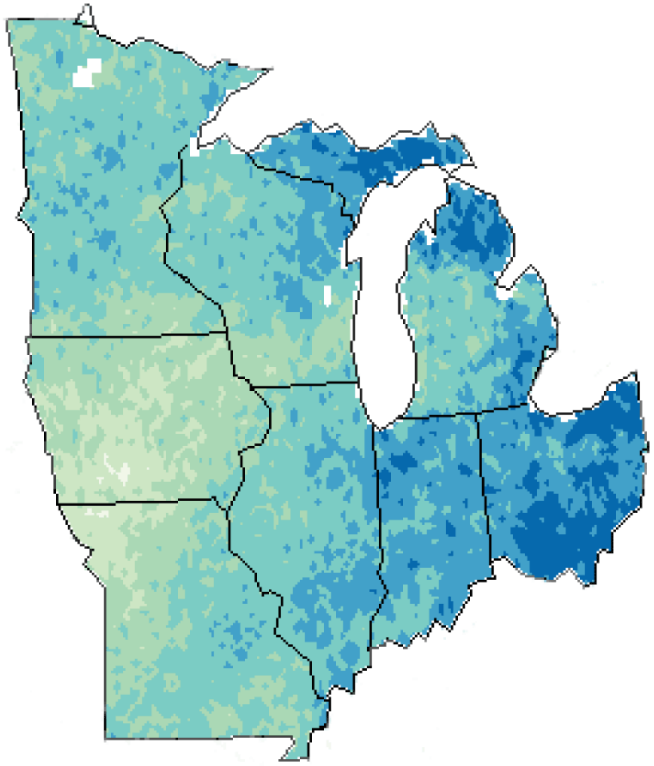


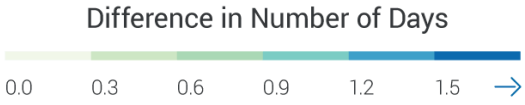
Source MPR

After

Source MPR

Projections: Continued increase in “upper 2 percentile” rainfall



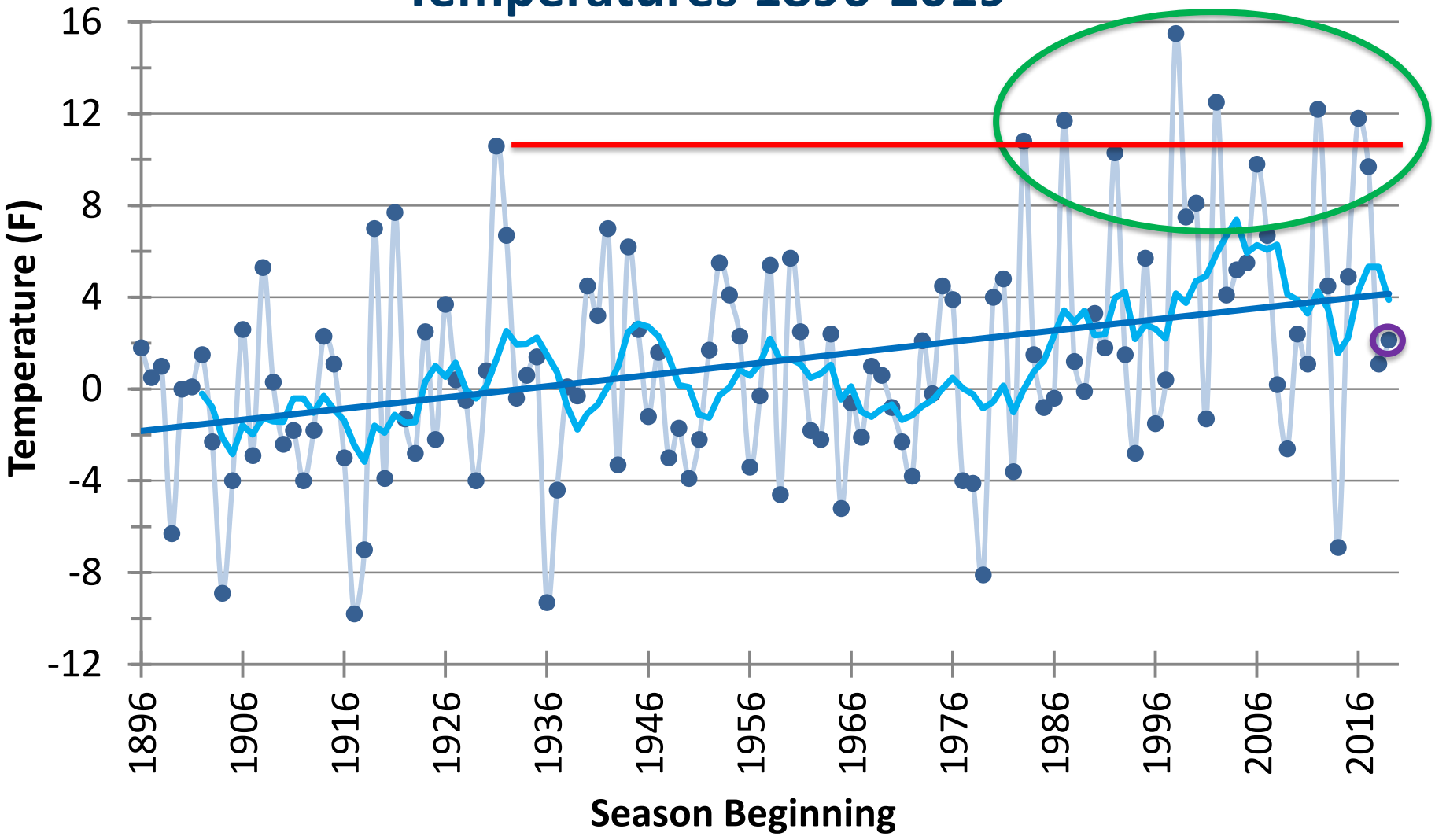


Source: 2014 National Climate Assessment, Midwest Chapter

Northeast MN winter warming 3-4x faster than summer

Season	Temperature Metric	Avg. change per decade since 1895	Avg. change per decade since 1970
Winter (Dec - Feb)	Seasonal Avg.	**+ 0.43°F**	**+ 0.88°F**
Summer (Jun - Aug)	Seasonal Avg.	**+ 0.15°F**	**+ 0.23°F**

Minnesota Average Winter Minimum Temperatures 1896-2019



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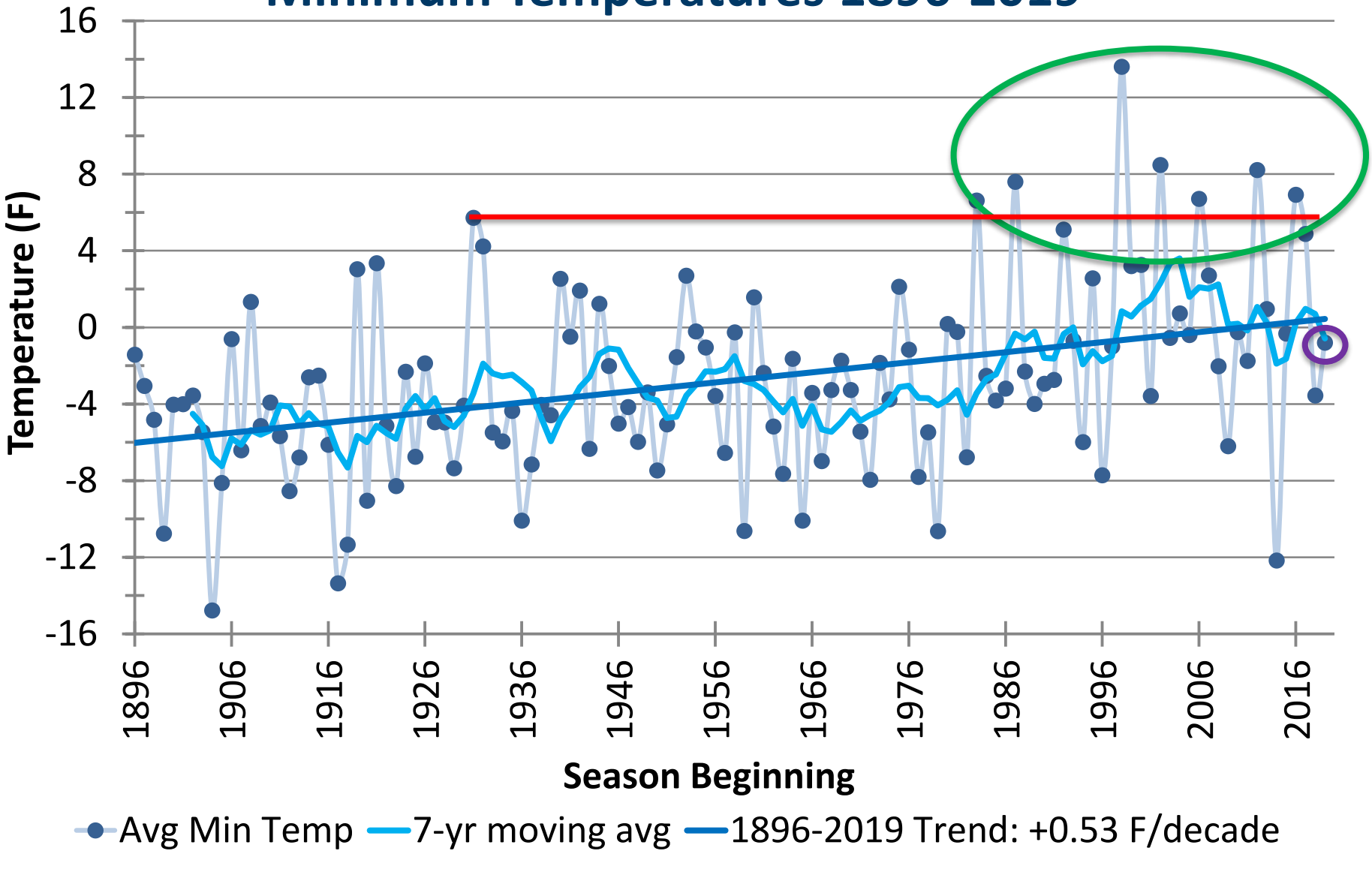
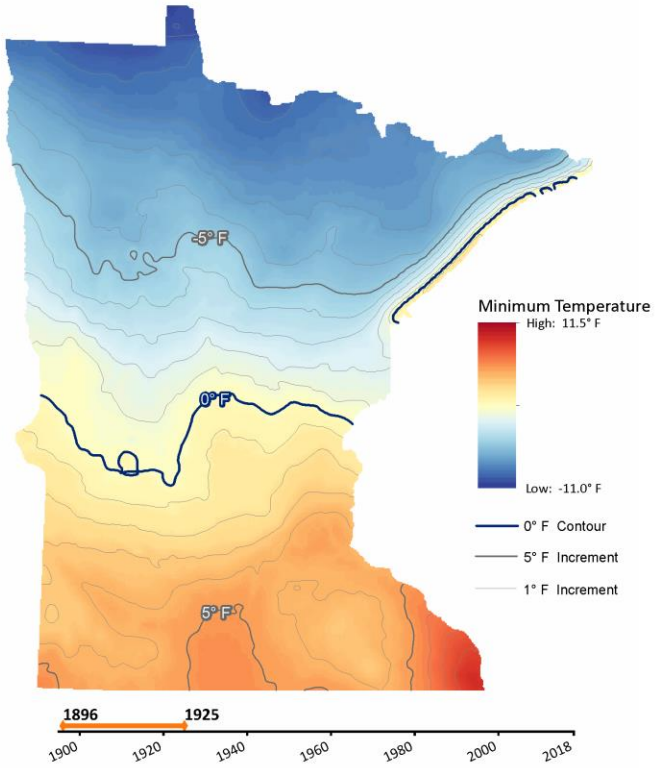
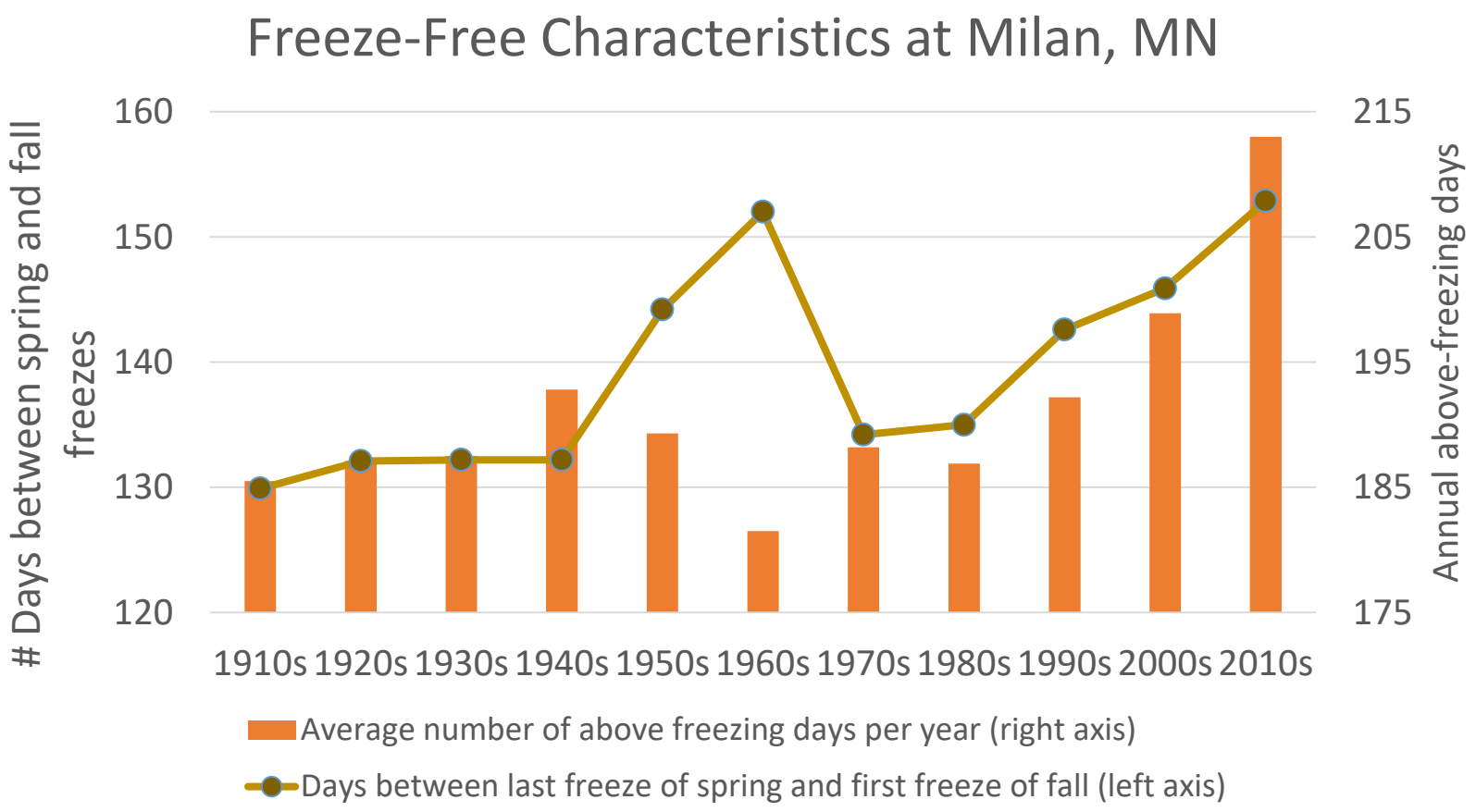
Northeast Minnesota Average Winter Minimum Temperatures 1896-2019



30-Year Average Minimum Winter Temperature



Days entirely above freezing increasing dramatically



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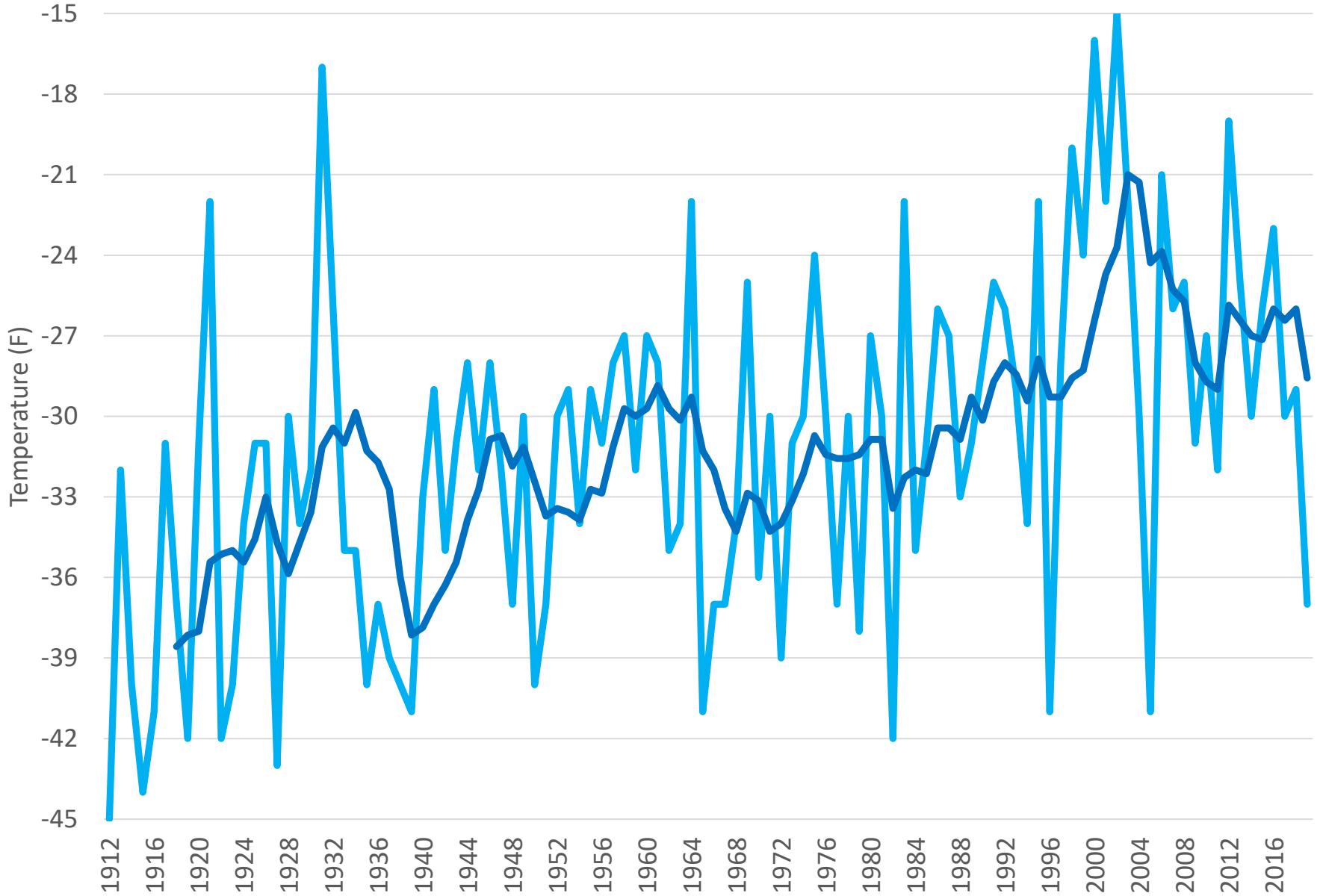
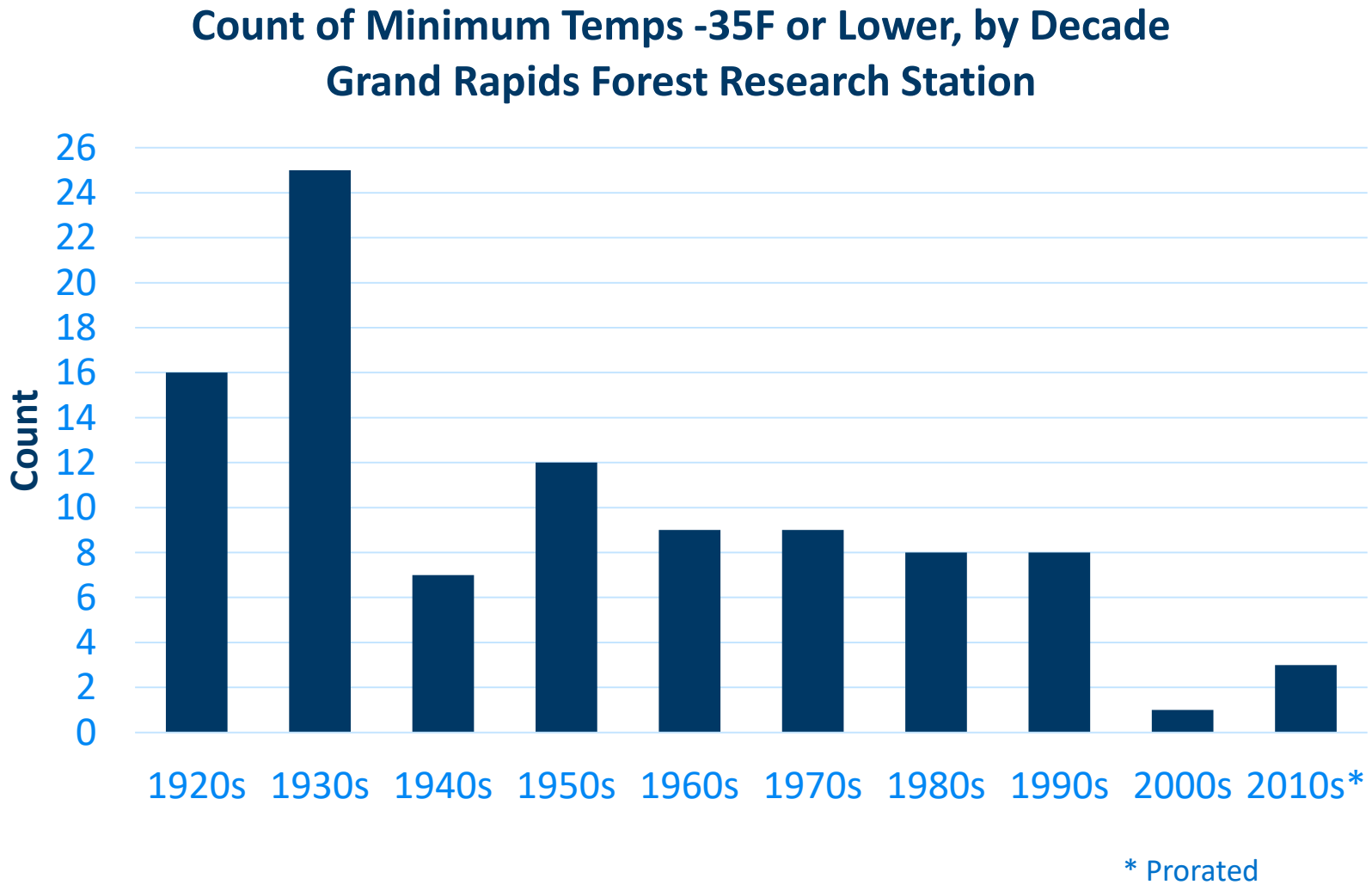
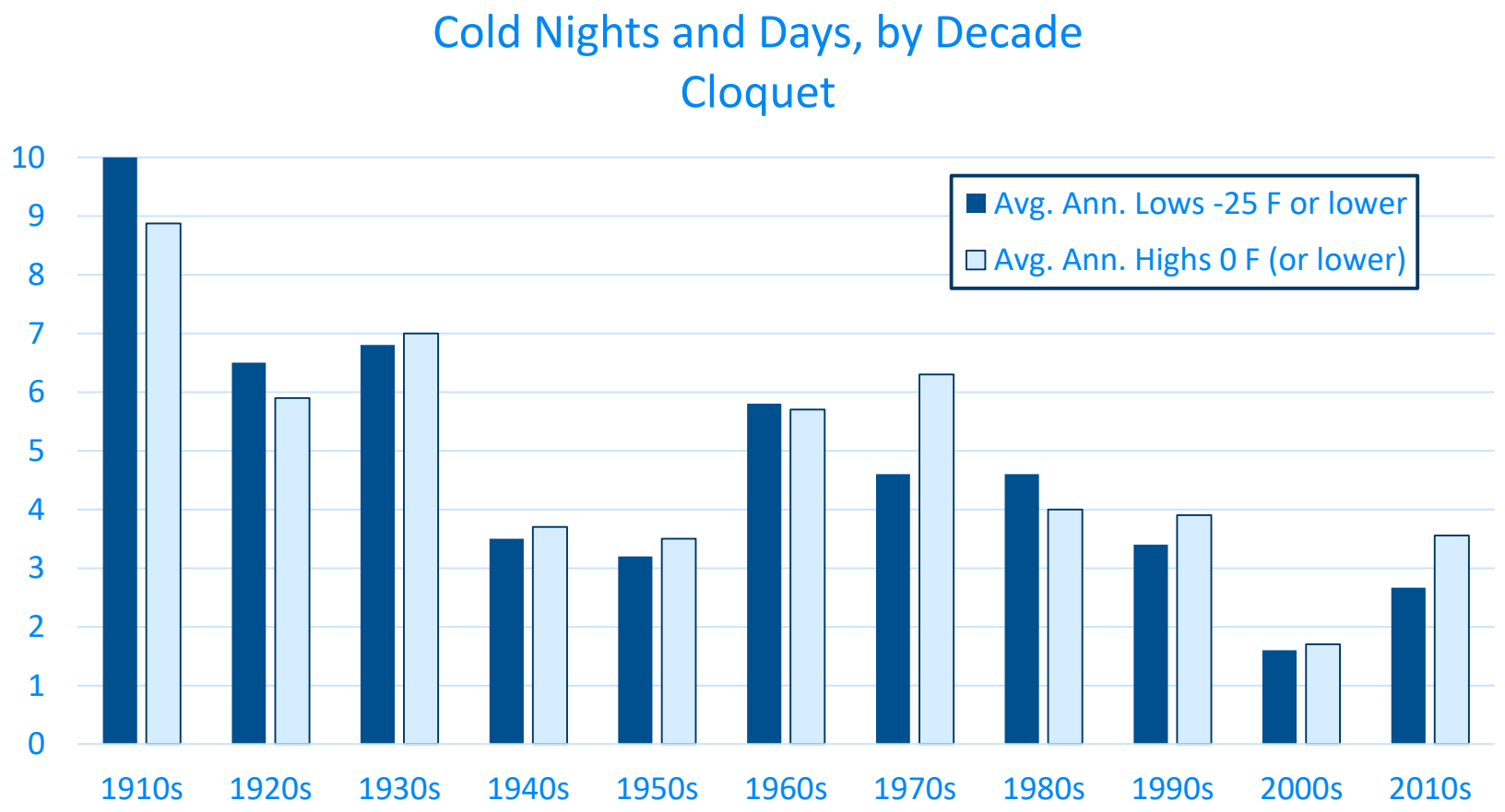
Lowest Low of Winter, Cloquet



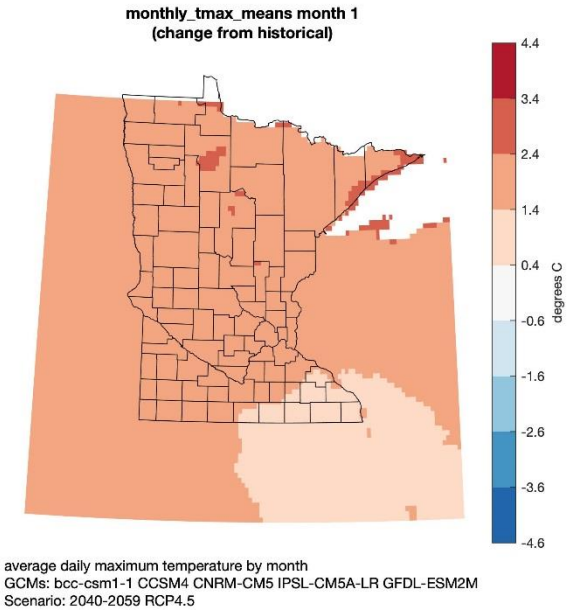
Loss of Cold Extremes Across MN



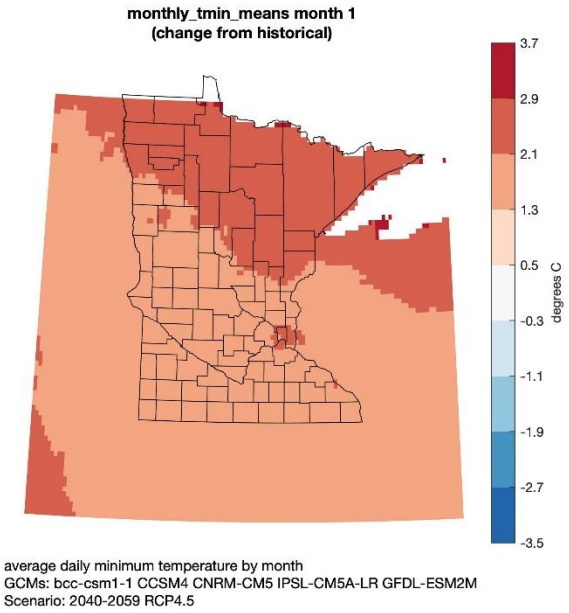
Fewer -25 F Lows and 0 F Highs in Cloquet



Mid-century modelling, RCP 4.5: January temps increase an additional 4-5 degrees F

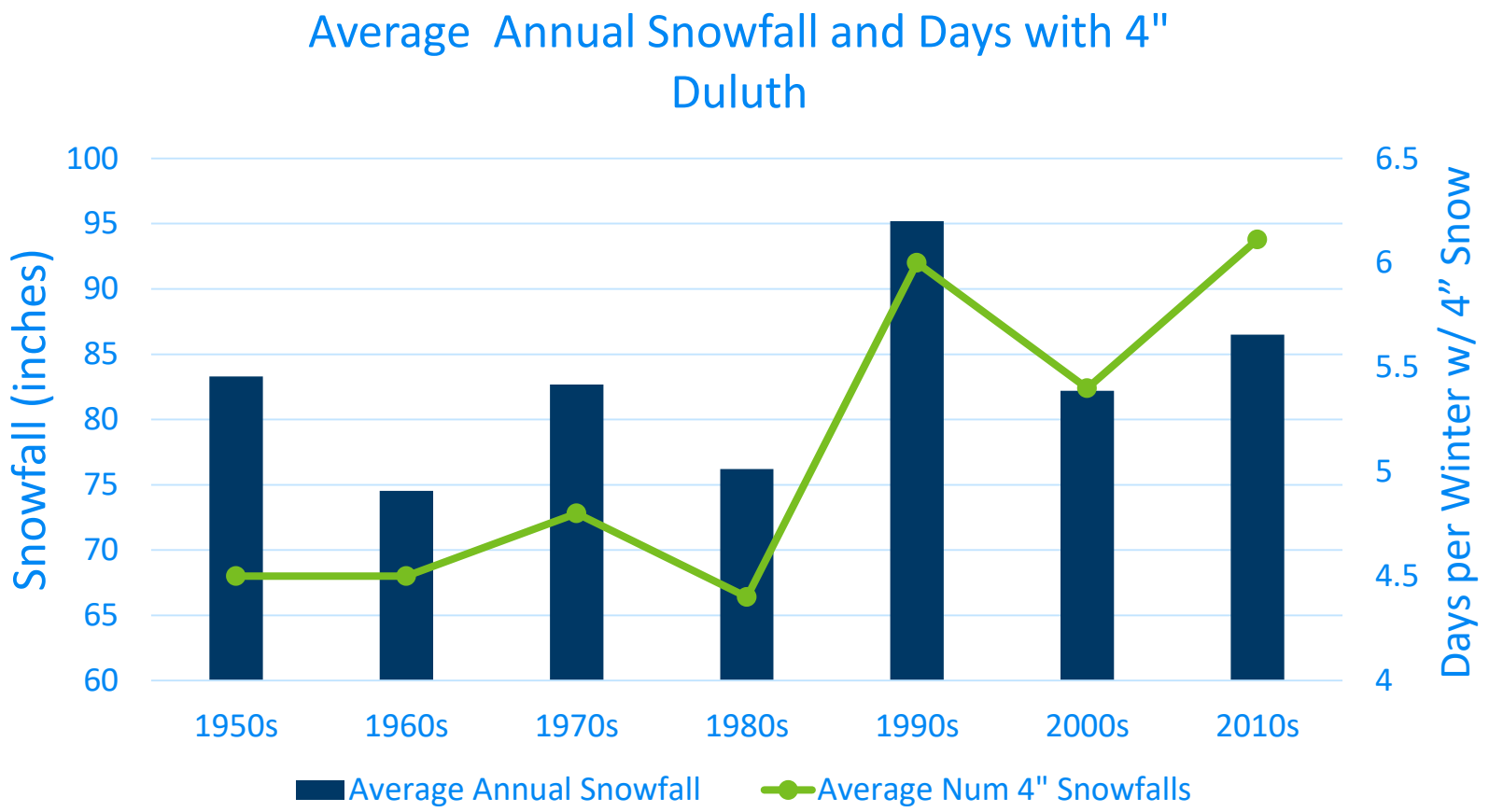


average daily maximum temperature by month
GCMs: bcc-csm1-1 CCSM4 CNRM-CM5 IPSL-CM5A-LR GFDL-ESM2M
Scenario: 2040-2059 RCP4.5

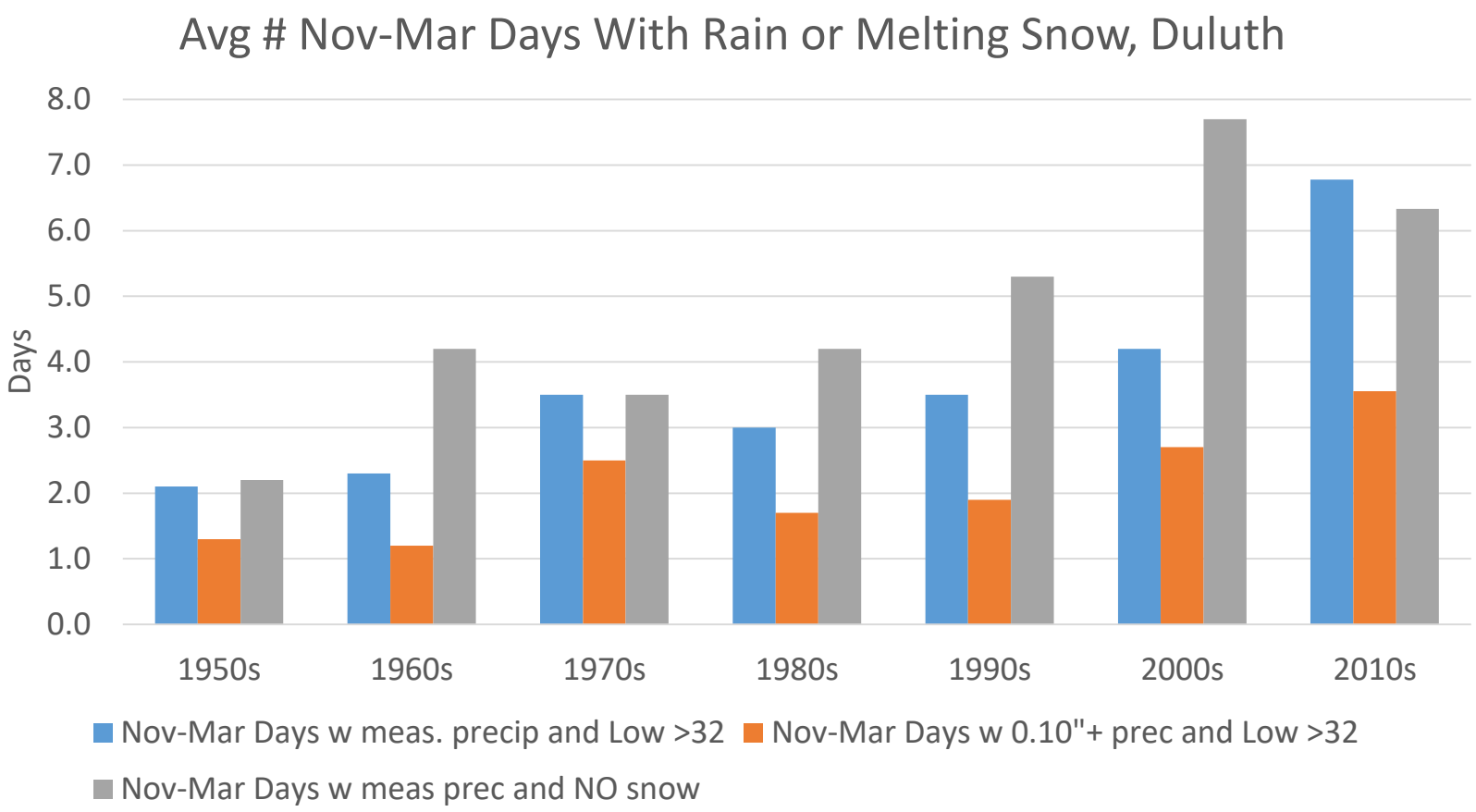


average daily minimum temperature by month
GCMs: bcc-csm1-1 CCSM4 CNRM-CM5 IPSL-CM5A-LR GFDL-ESM2M
Scenario: 2040-2059 RCP4.5

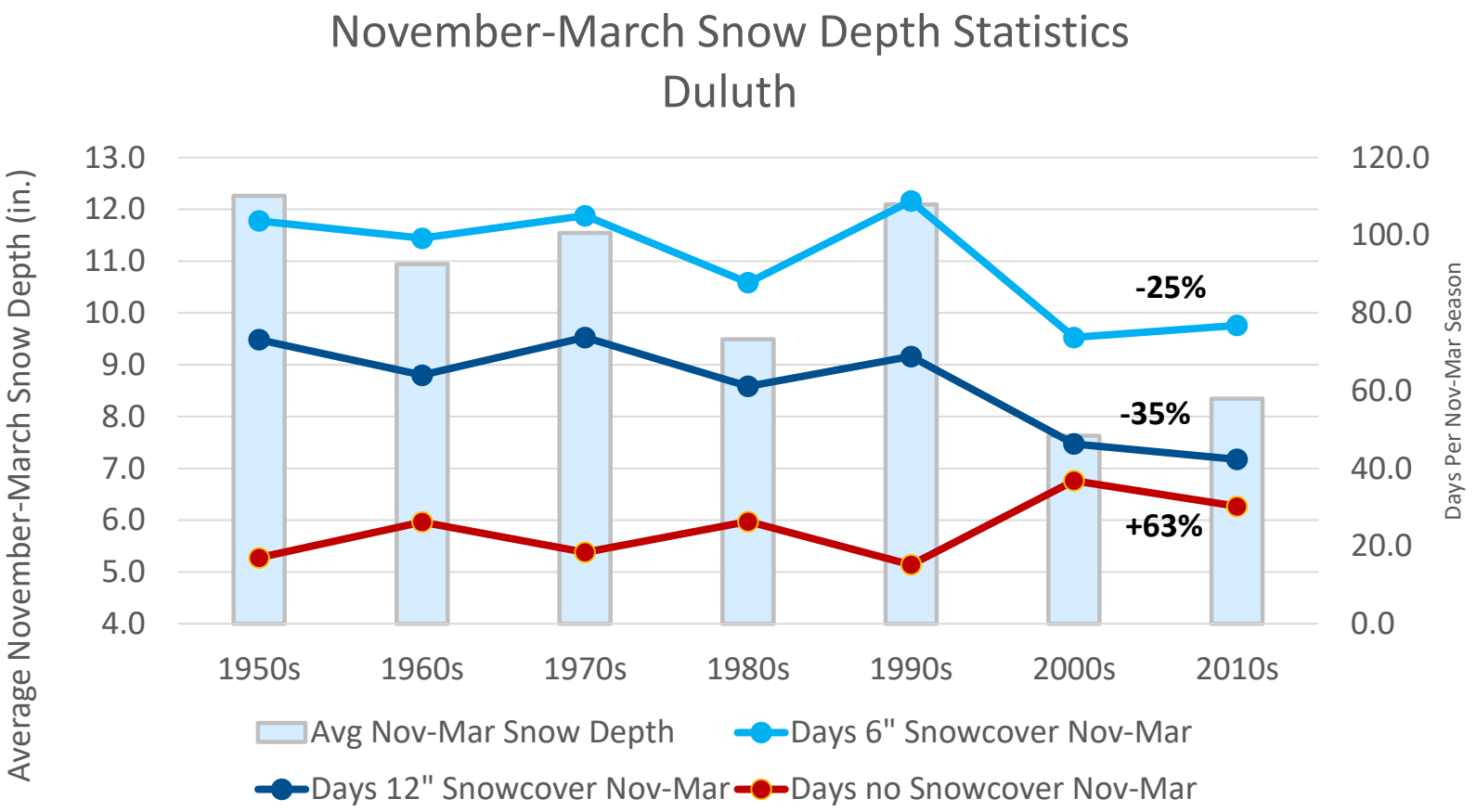
Annual snowfall steady or increasing
Days with ≥ 4 inches increasing



Liquid Precip Increasing During Winter

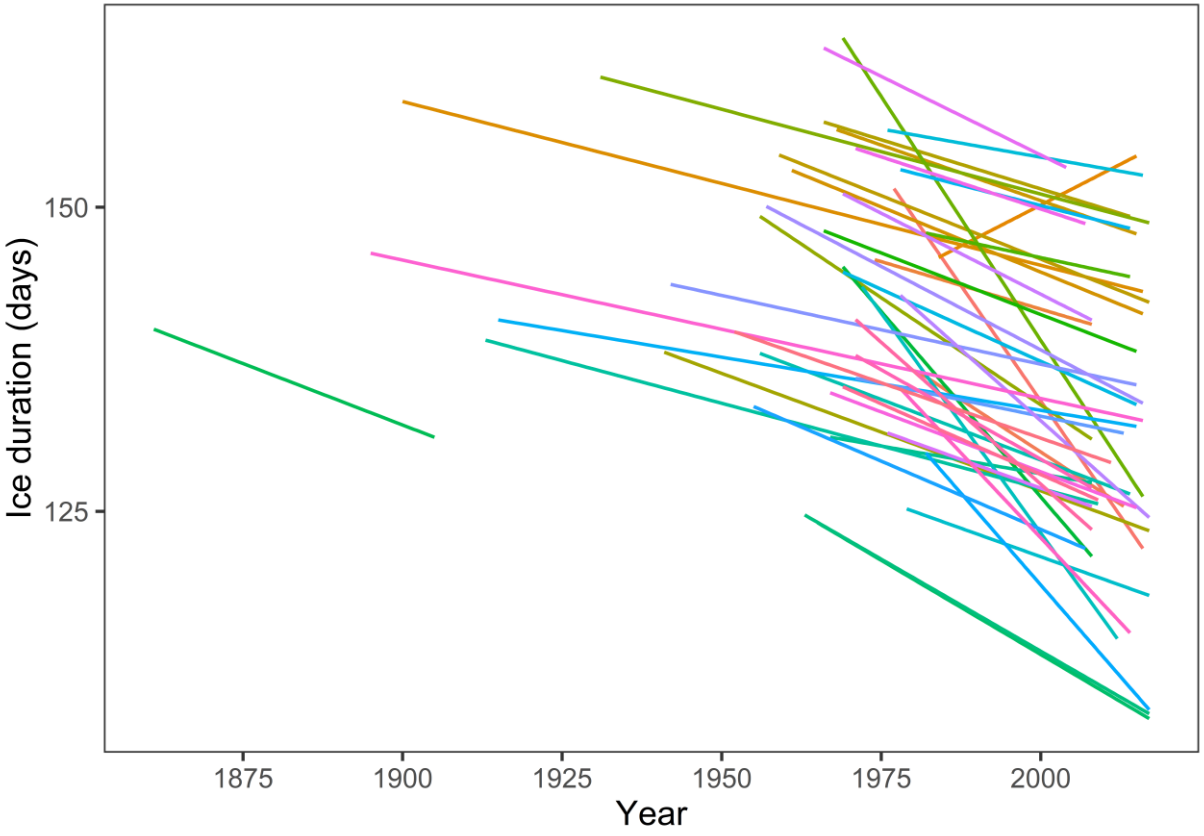


Snow Depth Declining



Lake ice season decreasing

- Long-term state-avg decline is 1.8 days per decade
- Decline from 1987-2017 is ***-4.2*** days per
- (Source DNR internal analyses)



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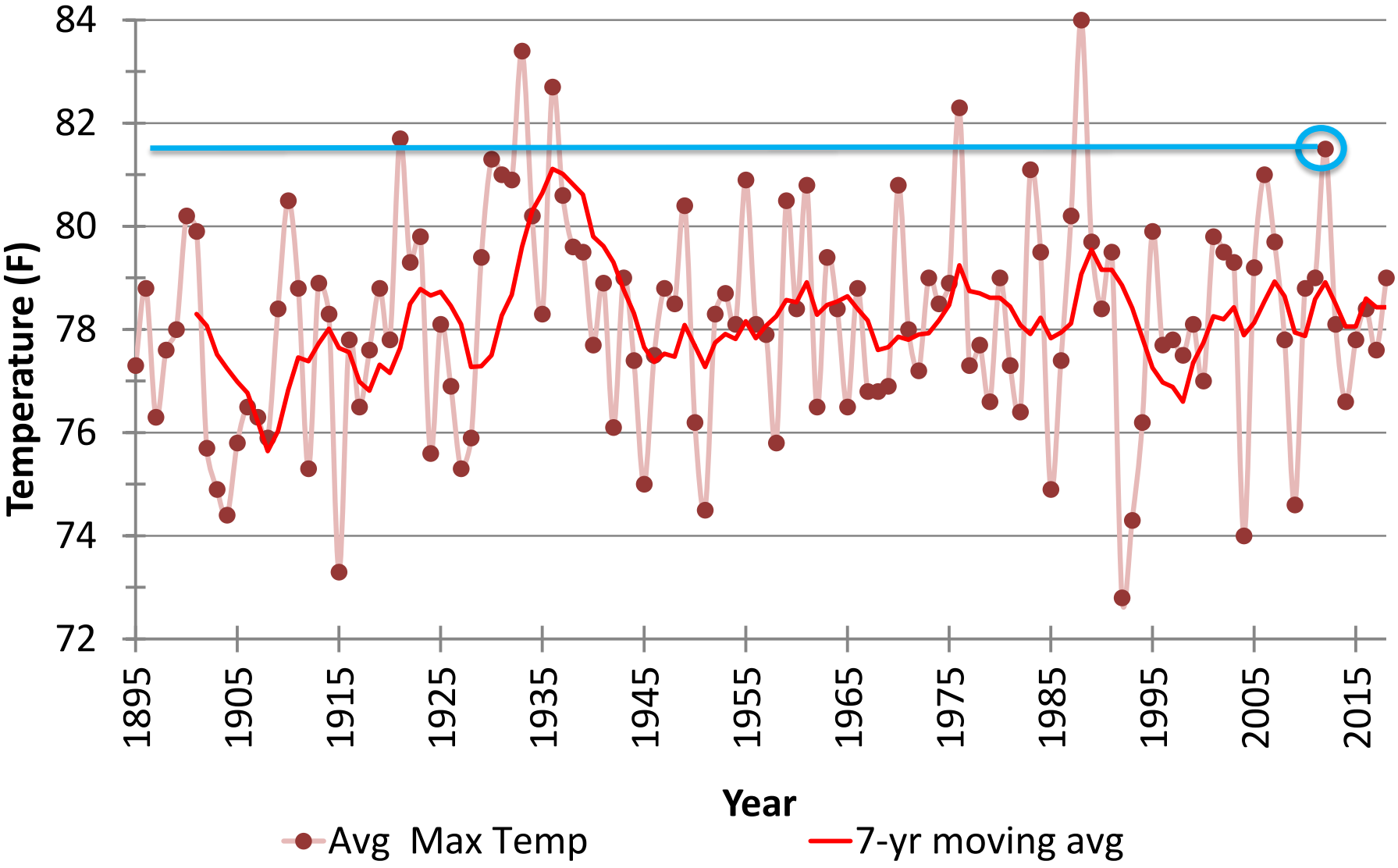
Minnesota Average Summer Maximum Temperatures 1895–2018



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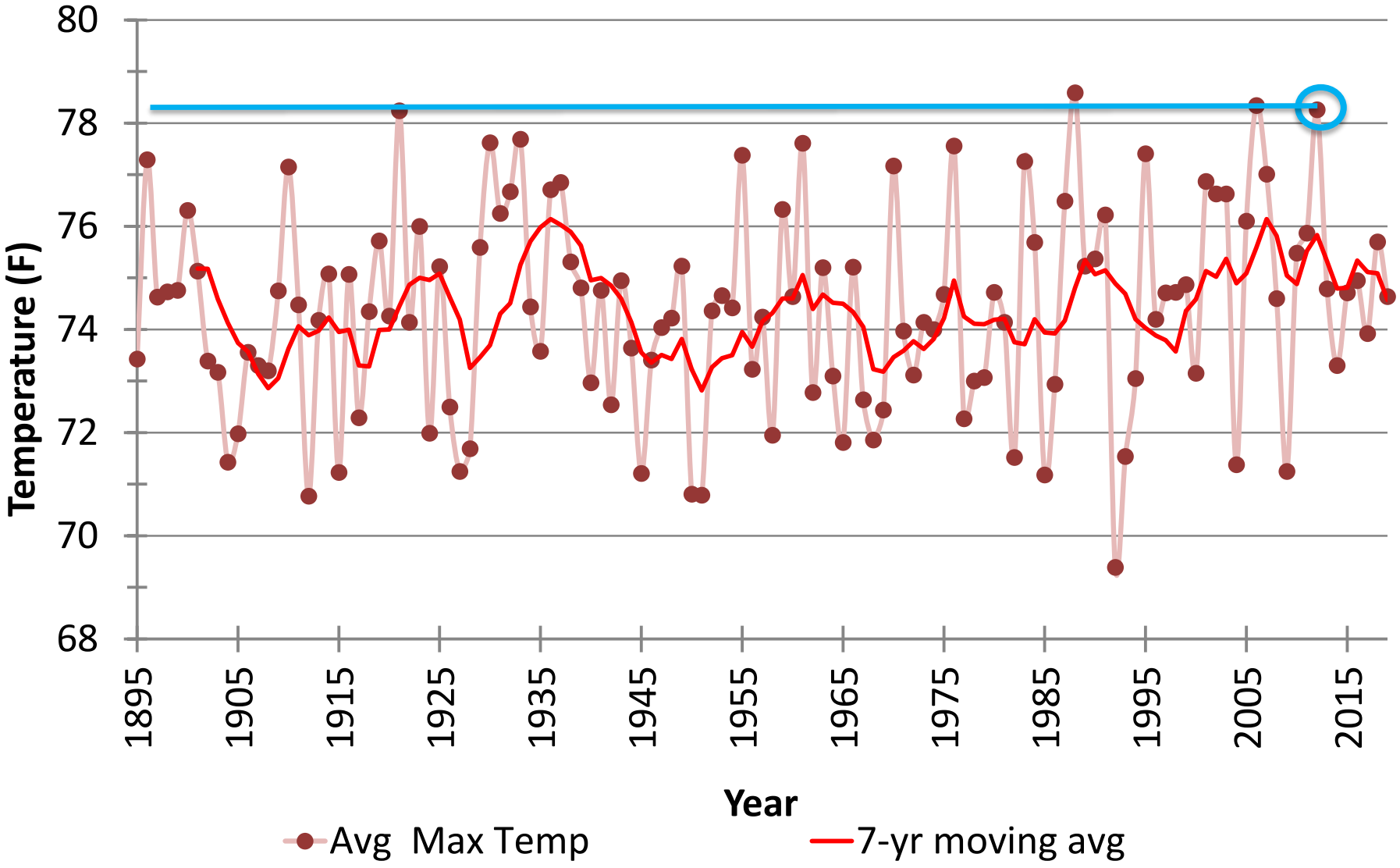
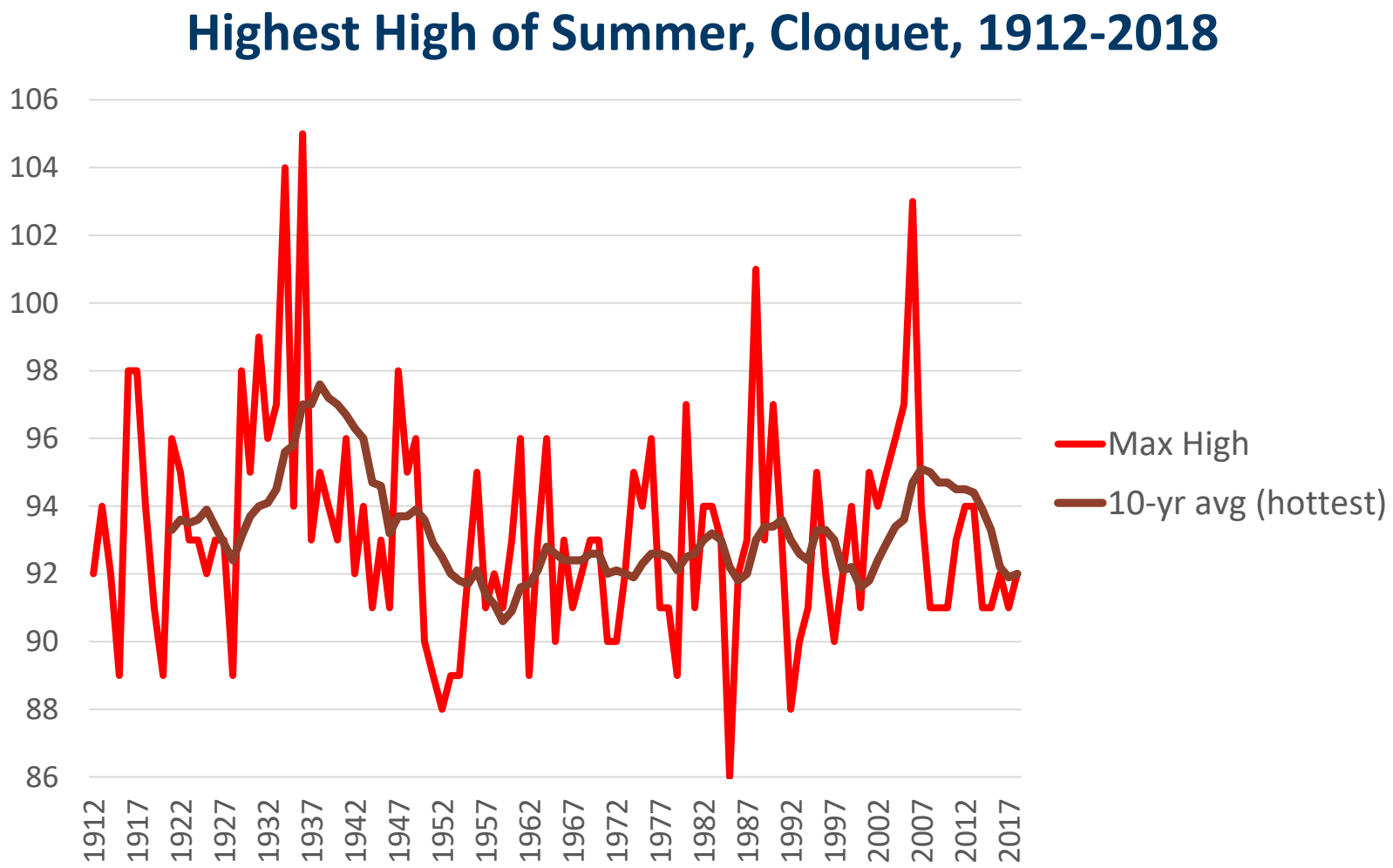
Northeast Minnesota Average Summer Maximum Temperatures 1895–2019



Extreme heat not increasing--yet



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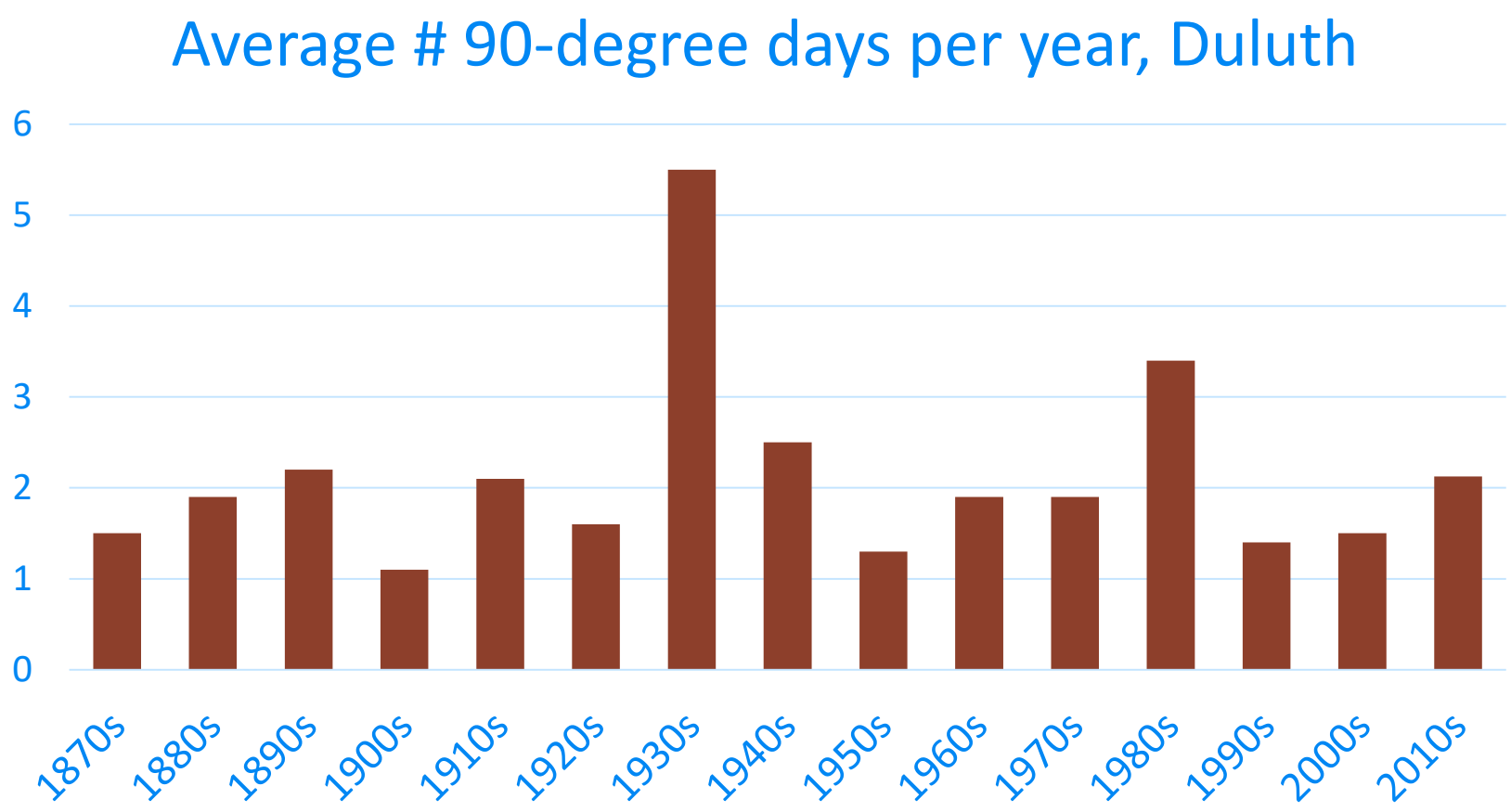
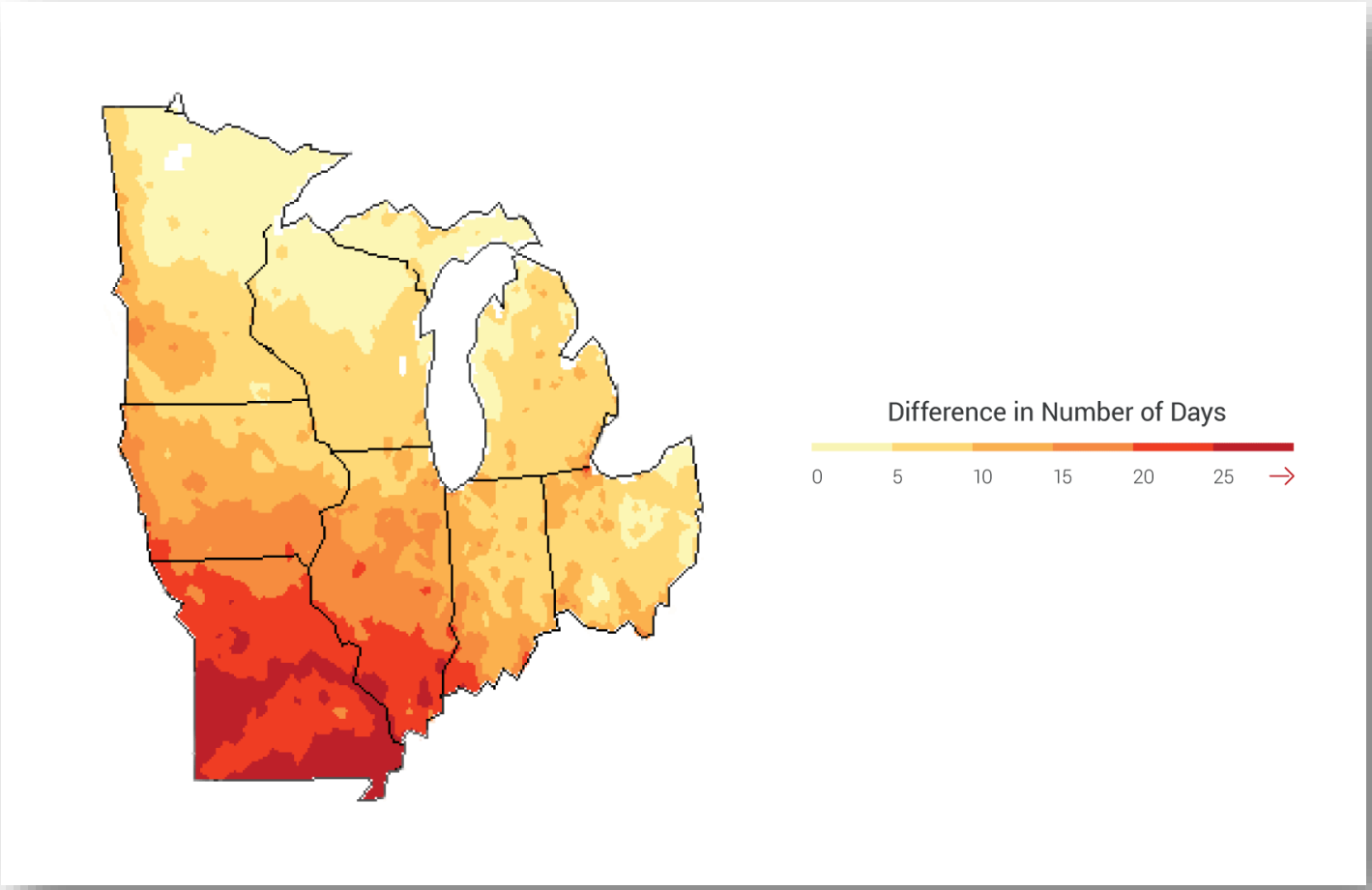


However, additional days above 95 F projected by mid-century



Source: 2014 National Climate Assessment, Midwest Chapter

“Hydrothermal deficit” and stress noted in northern MN forests

Box 1 Forest droughts have increased in recent decades.

What changes in drought are in progress now?

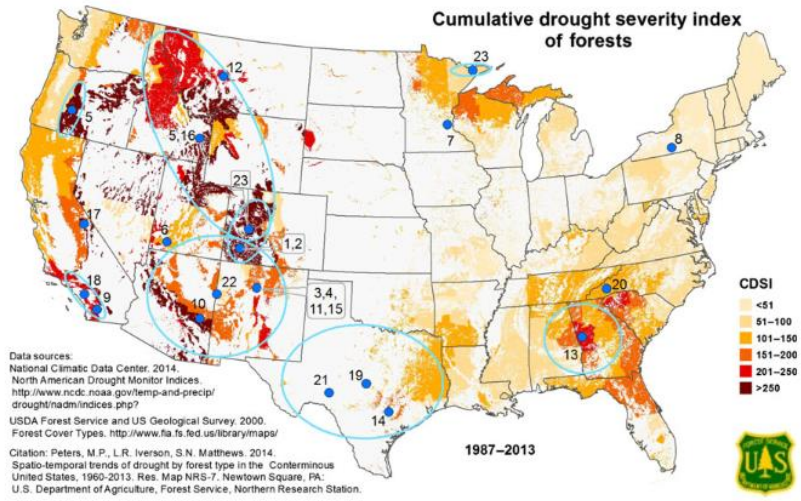
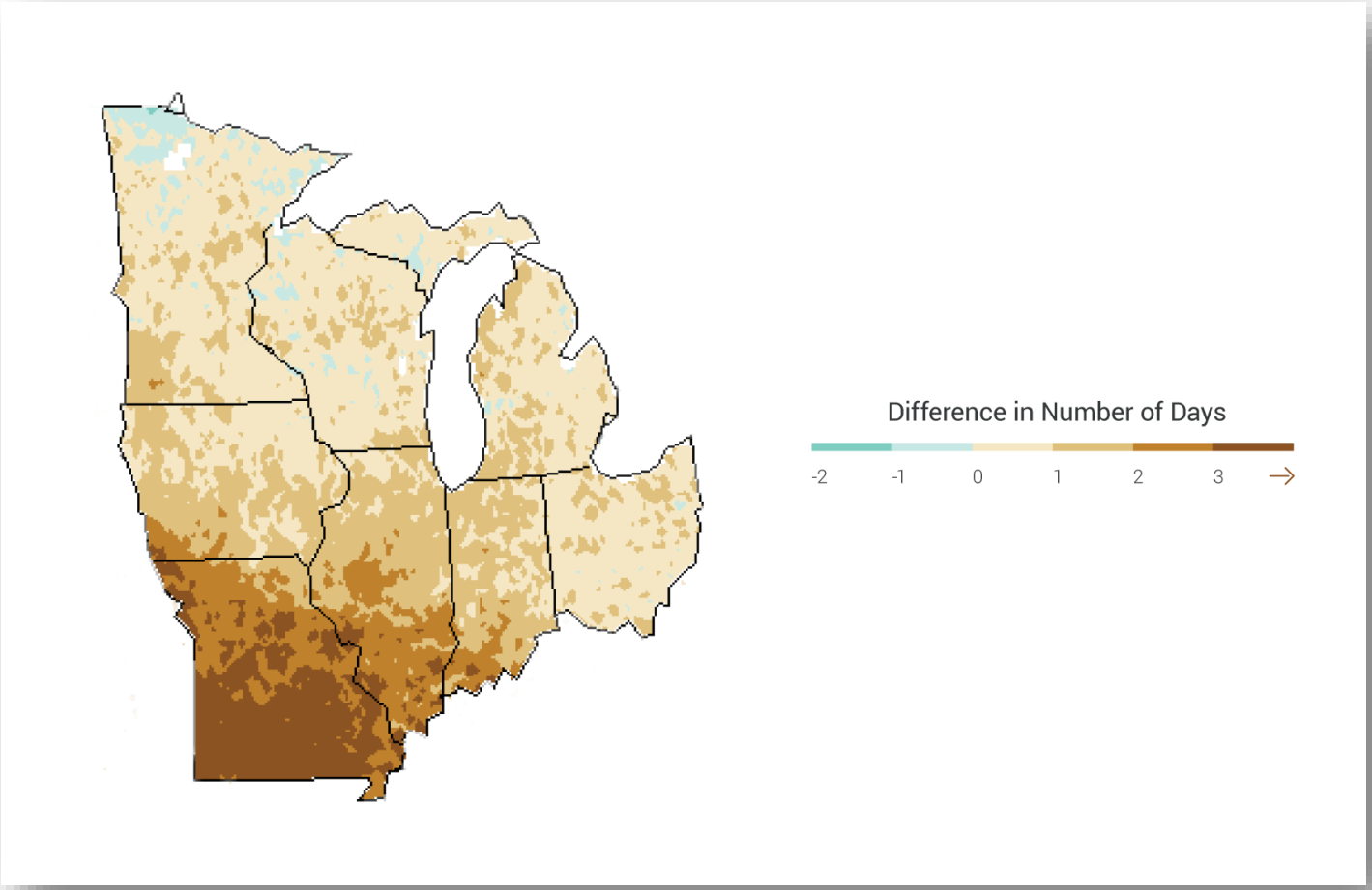


Fig. B1.1. Cumulative drought severity index (CDSI) for forested lands from 1987 to 2013, (modified from Peters *et al.*, 2014), with selected locations of drought- and heat-induced tree mortality indicated by blue circles (modified from Allen *et al.*, 2010 and Figure 4–7 in IPCC, 2014). Numbers correspond 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).

Additional consecutive dry days projected by mid-century, though no “smoking gun”



Source: 2014 National Climate Assessment, Midwest Chapter

In Summary

1. Northeast MN has gotten warmer, with profound changes during winter
2. Snowfall has remained steady, with increases in heavy snow
3. However, snow depth is declining
4. Summer warming is lesser, but still greater/faster than rest of MN
5. Further warming projected, with continued increases in precipitation extremes

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Thank You!

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