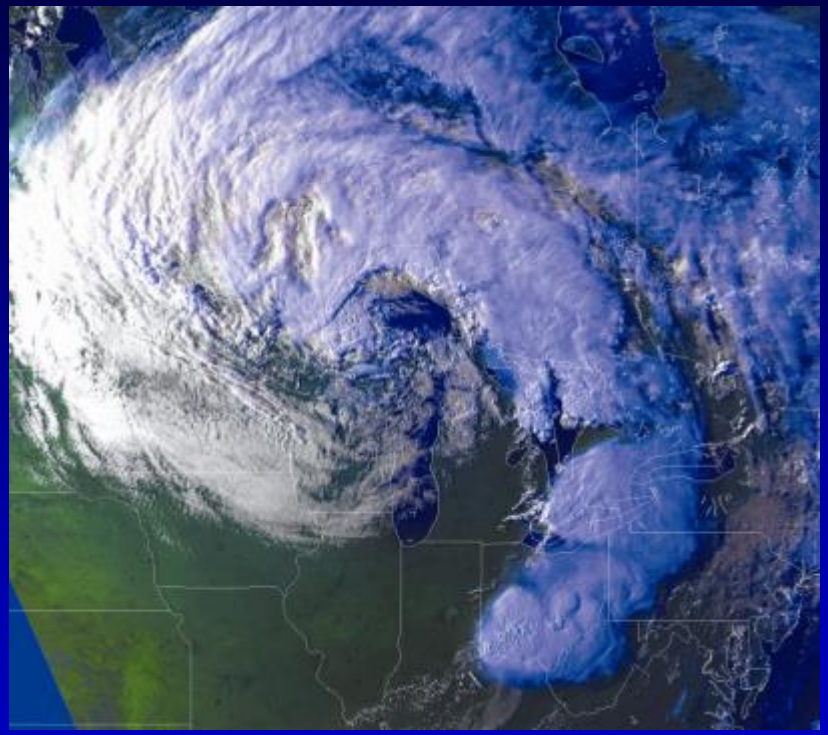
Historical and Projected Future Climate Changes in the Great Lakes Region



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GLISA
GREAT LAKES INTEGRATED SCIENCES + ASSESSMENTS

MICHIGAN STATE UNIVERSITY
AgBioResearch

MICHIGAN STATE
UNIVERSITY
EXTENSION

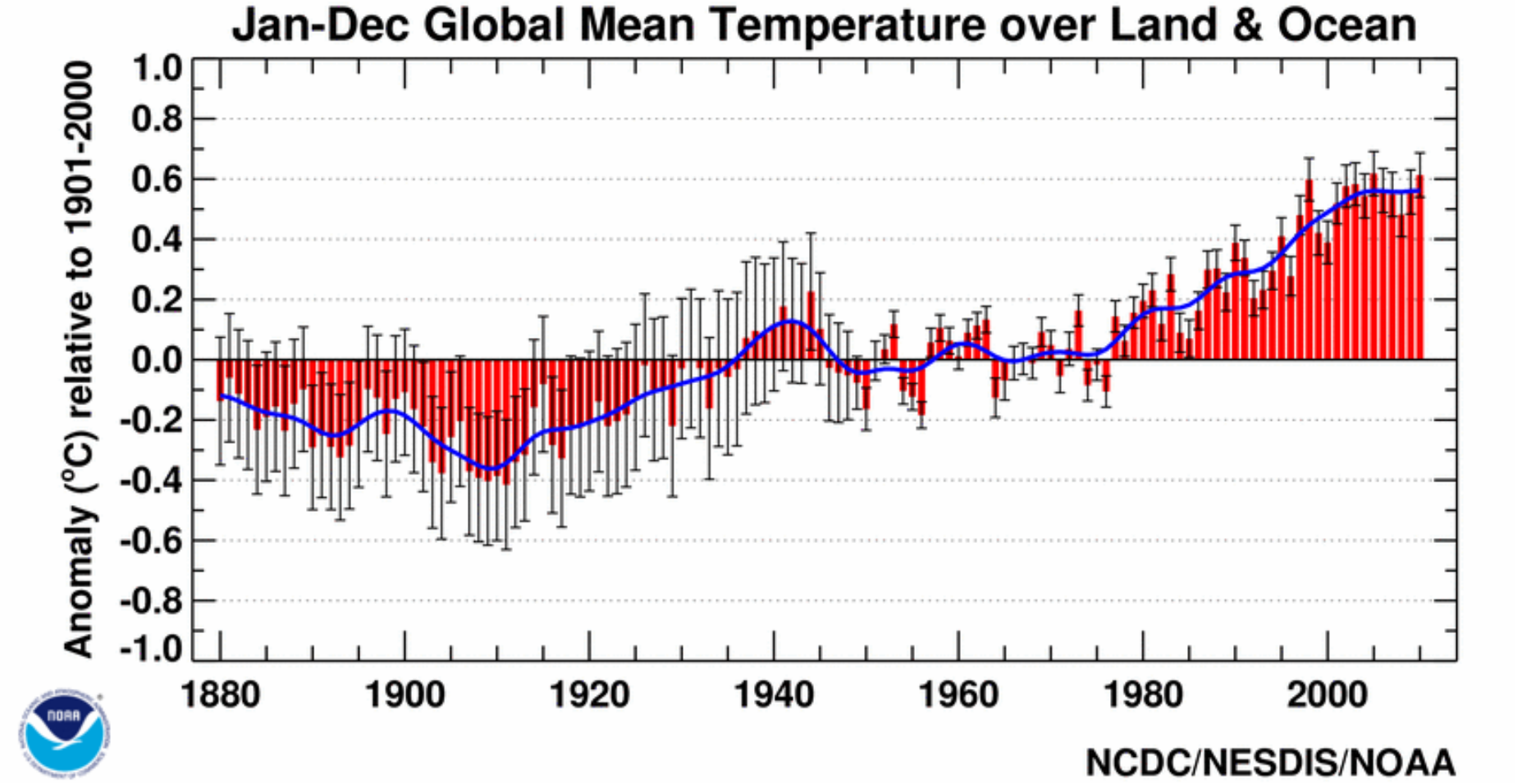
Outline

- Historical Trends
- Future Projections
- Climatic Variability/Extreme Events

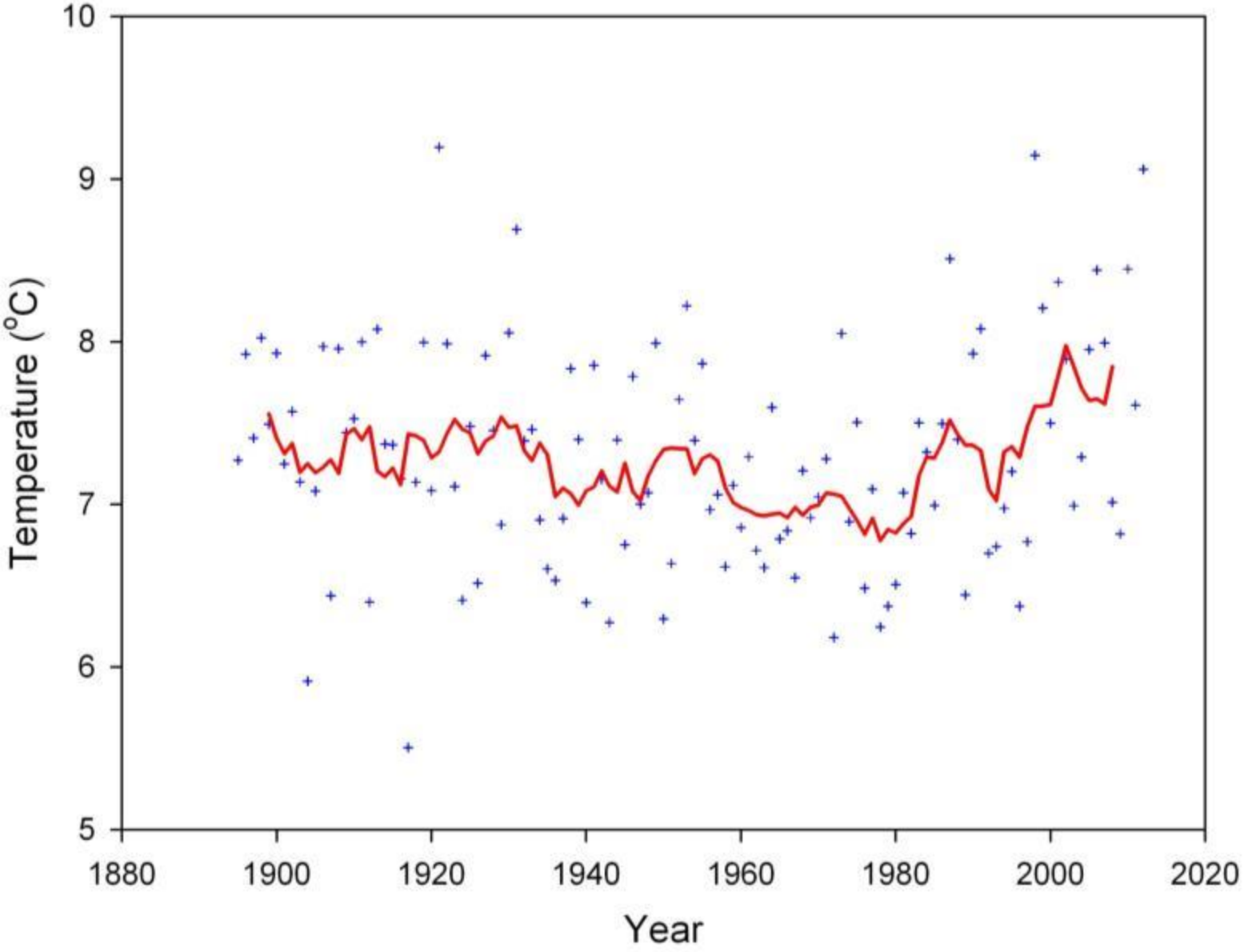
Historical Trends

Some Notable Pre-Instrumental Trends in the Great Lakes Region

- Tropical humid conditions during the Carboniferous and Devonian eras.
- Frigid, glacial/periglacial conditions as recently as 12,000 years ago during the end of the Pleistocene era.
- During early portions of the Holocene era, climate in the region warmed rapidly, resulting in a relatively mild and dry climate which lasted until about 5,000 YBP. Great Lakes levels fell until the lakes became terminal or confined about 7,900 YBP and vegetation in the region gradually transitioned from boreal to xeric species.
- Beginning about 5,000 YBP, climate cooled and precipitation totals increased, favoring the establishment of more mesic vegetation.
- During the late Holocene, the region experienced a period of relatively mild temperatures from approximately 800A.D. to 1300 A.D. followed by a period of relatively cool temperatures from about 1400A.D. until the late 19th Century.

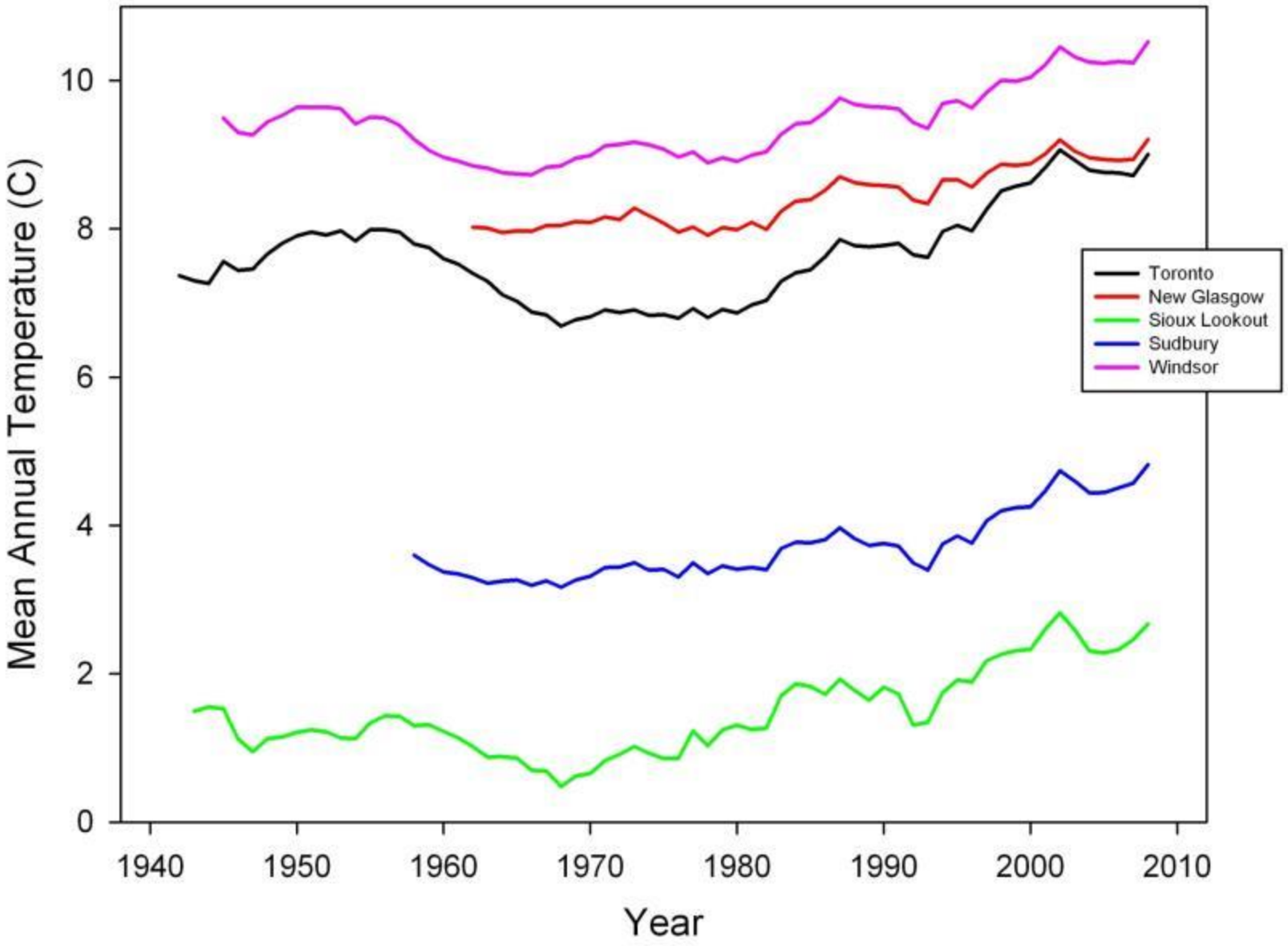

Jan-Dec Global Mean Temperature over Land & Ocean
Anomaly (°C) relative to 1901-2000
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
1880
1900
1920
1940
1960
1980
2000
NCDC/NESDIS/NOAA

Mean Temperatures vs. Year, Michigan 1895-2012



Mean Annual Temperatures

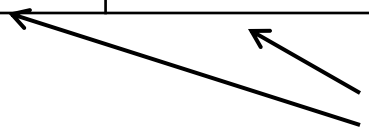
Ontario Locations



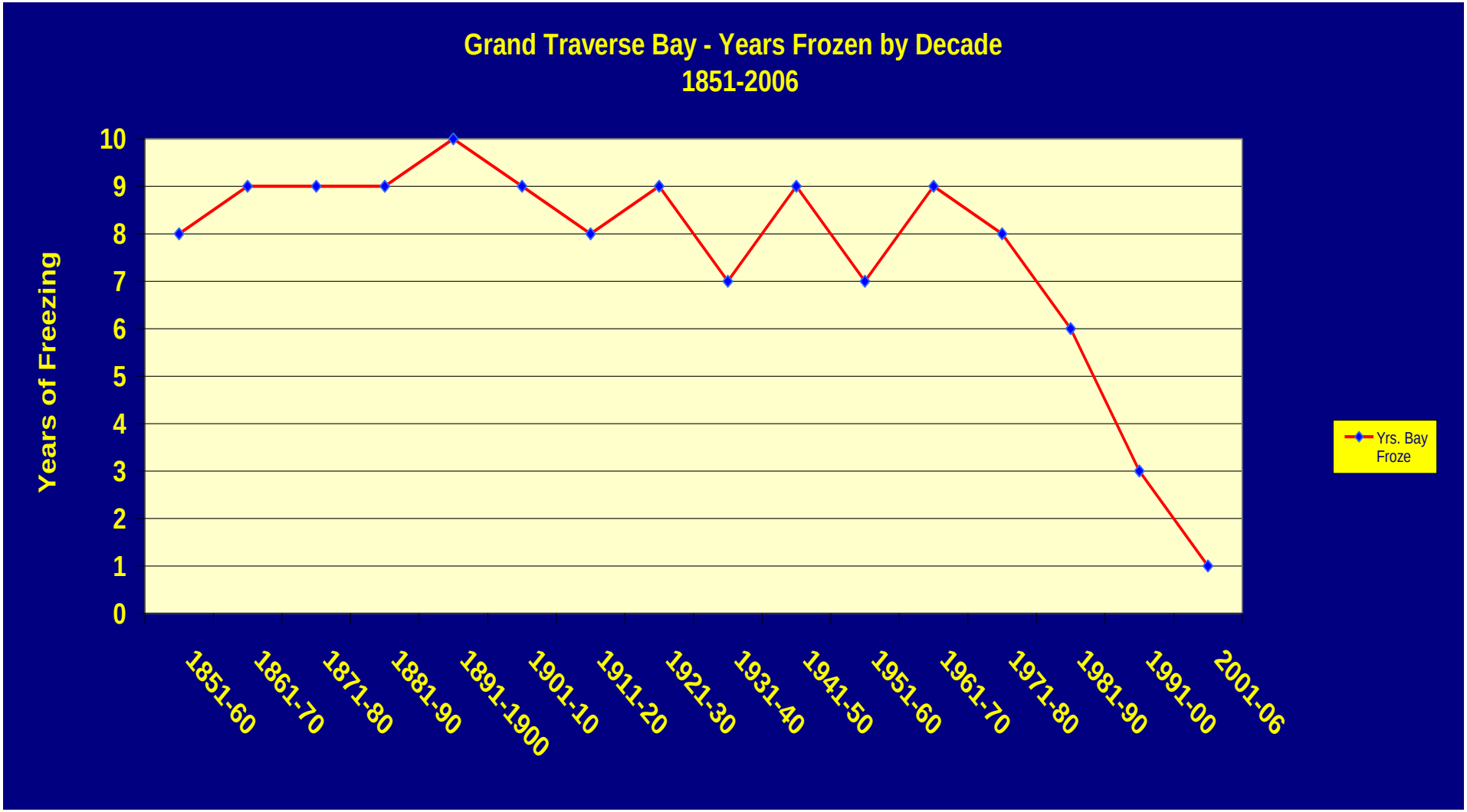
Seasonal Changes in Mean Temperature

1895-2010 (ºF/year)

State	Season				
	Annual	Winter	Spring	Summer	Fall
IA	0.009**	0.014	0.014**	0.004	0.001
IL	0.004	0.005	0.011*	-0.001	-0.001
IN	0.003	0.006	0.010*	-0.005	-0.001
MI	0.001	0.008	0.007	-0.006	-0.008
MN	0.014***	0.022*	0.015**	0.008*	0.006
MO	0.005	0.008	0.010*	0.002	-0.004
OH	0.008***	0.011	0.014***	0.002	0.003
WI	0.009***	0.019*	0.013*	0.002	0.002
Reg. Avg.	0.007	0.012	0.012	0.001	0.000

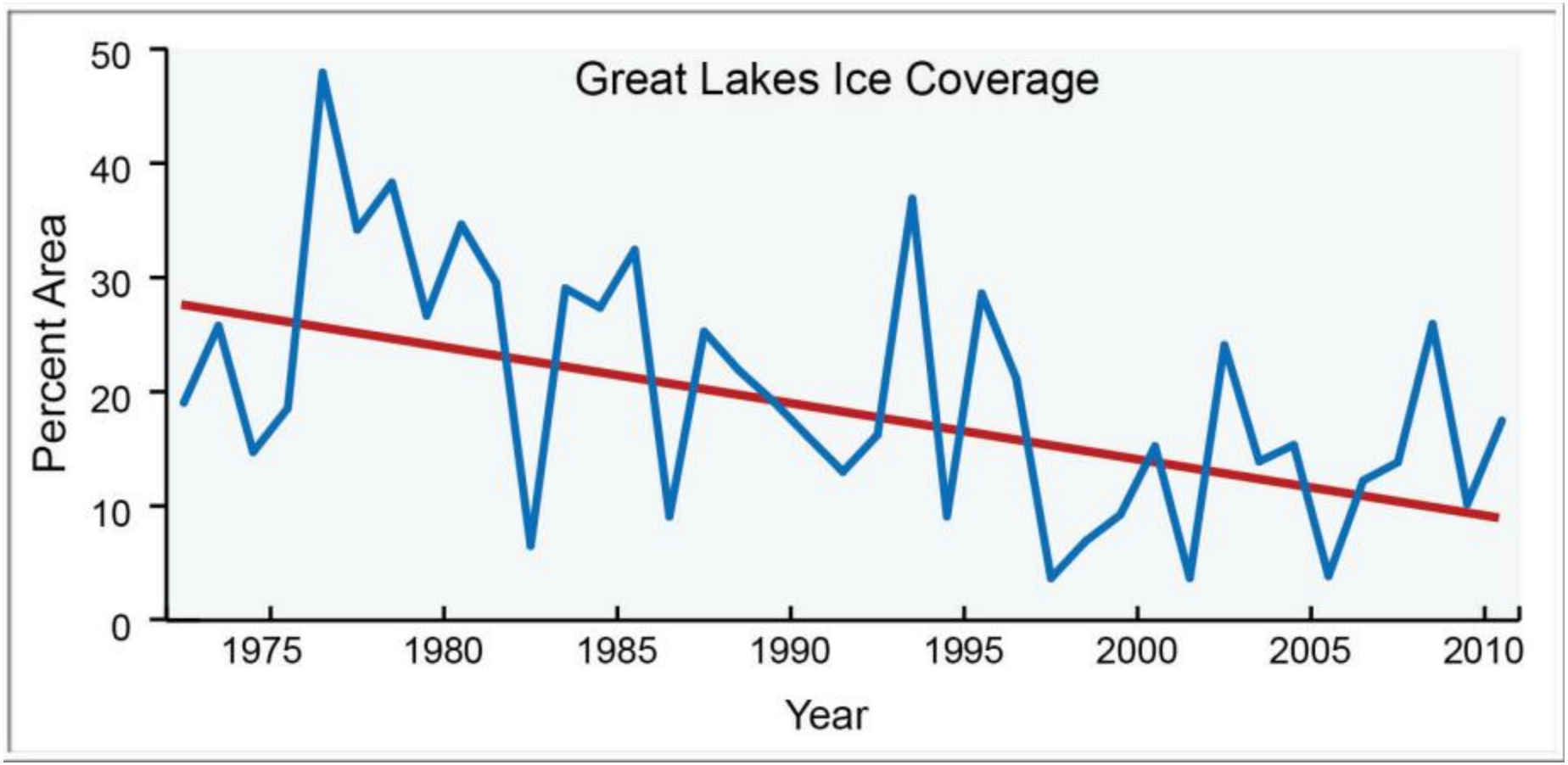


Relatively greater changes in winter, spring

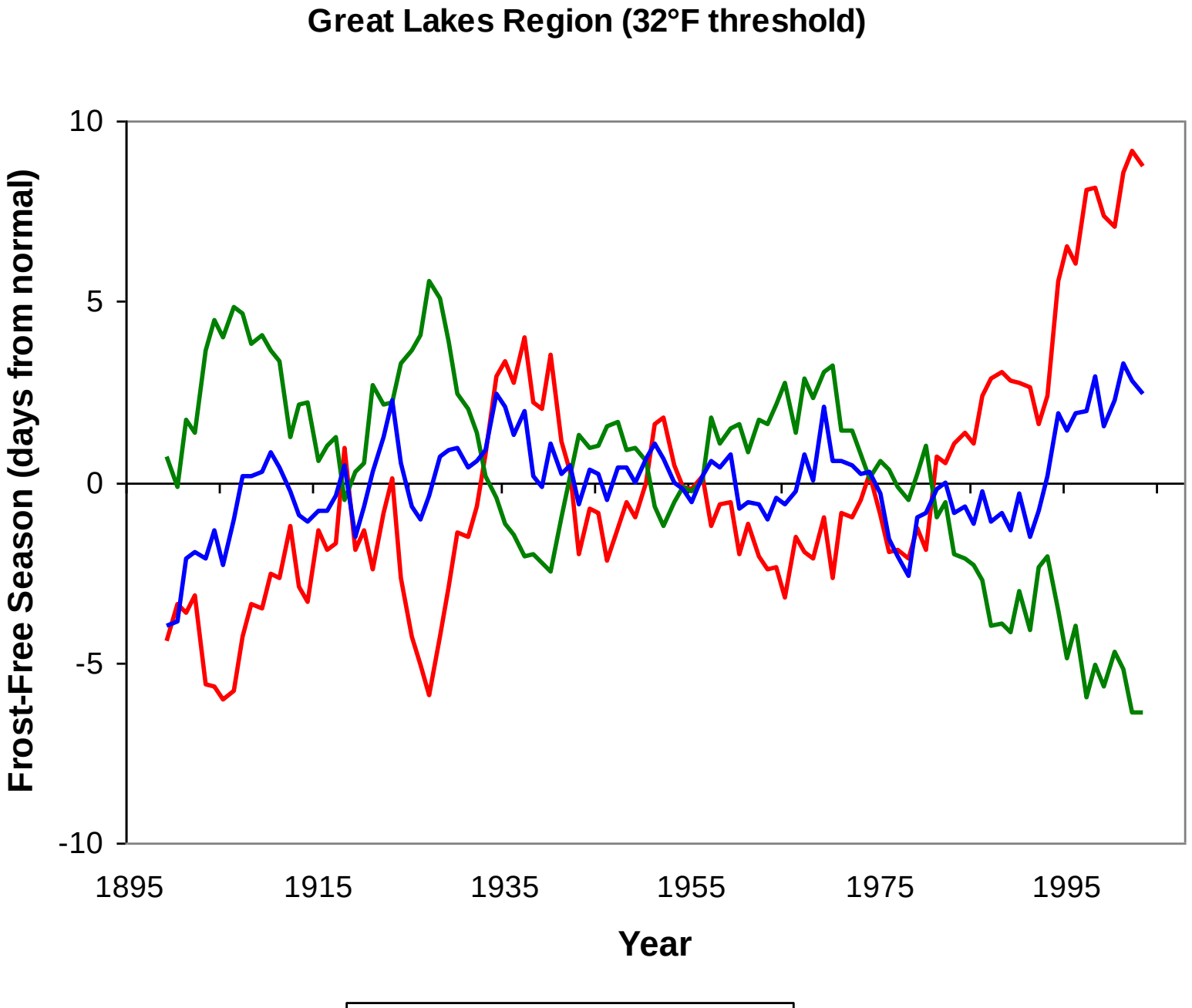

Grand Traverse Bay - Years Frozen by Decade
1851-2006
Years of Freezing
10
9
8
7
6
5
4
3
2
1
0
1851-60
1861-70
1871-80
1881-90
1891-1900
1901-10
1911-20
1921-30
1931-40
1941-50
1951-60
1961-70
1971-80
1981-90
1991-00
2001-06
Yrs. Bay Froze

Changes in Great Lakes Ice Coverage

1972-2011



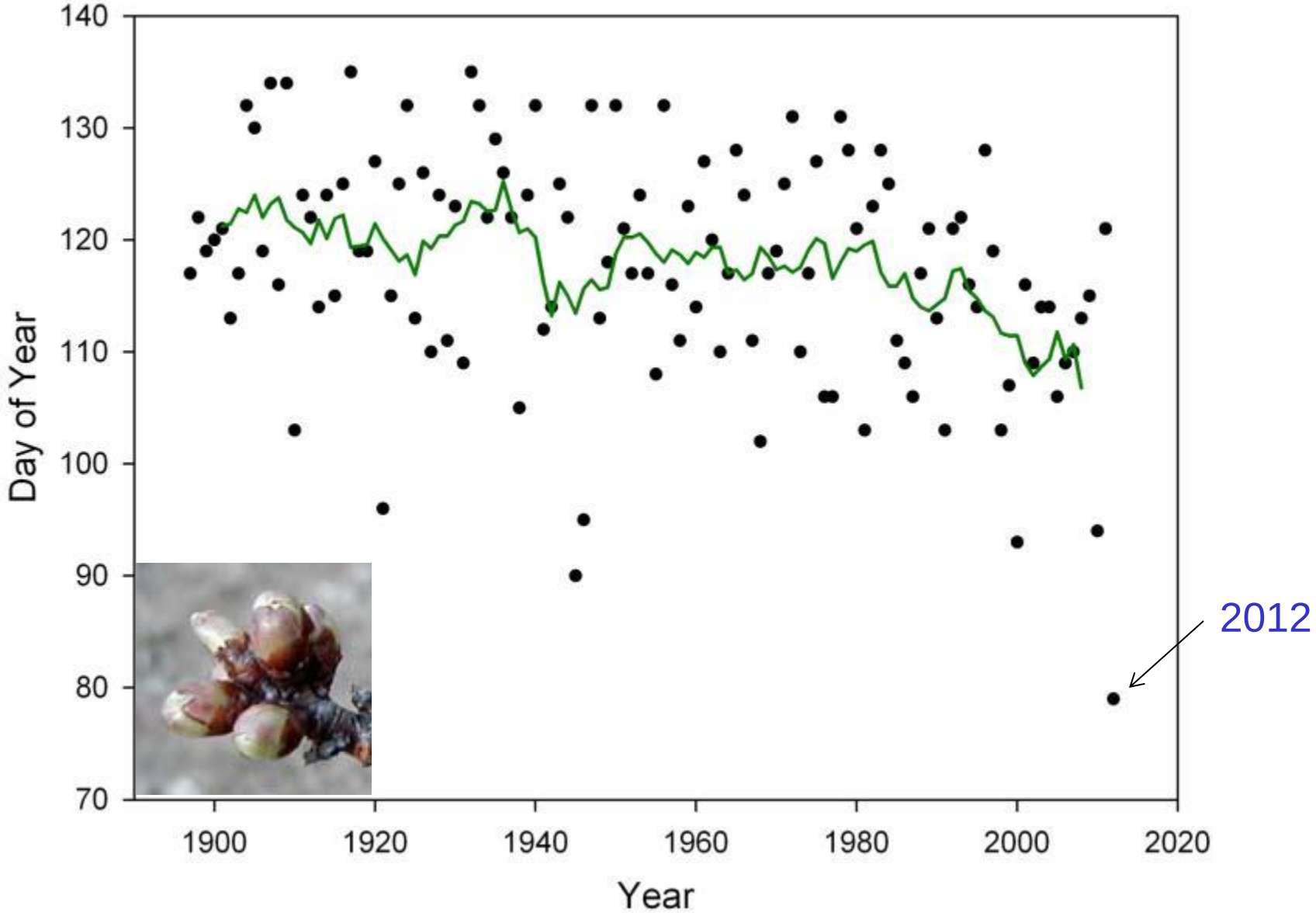
(Wang et al., 2012)



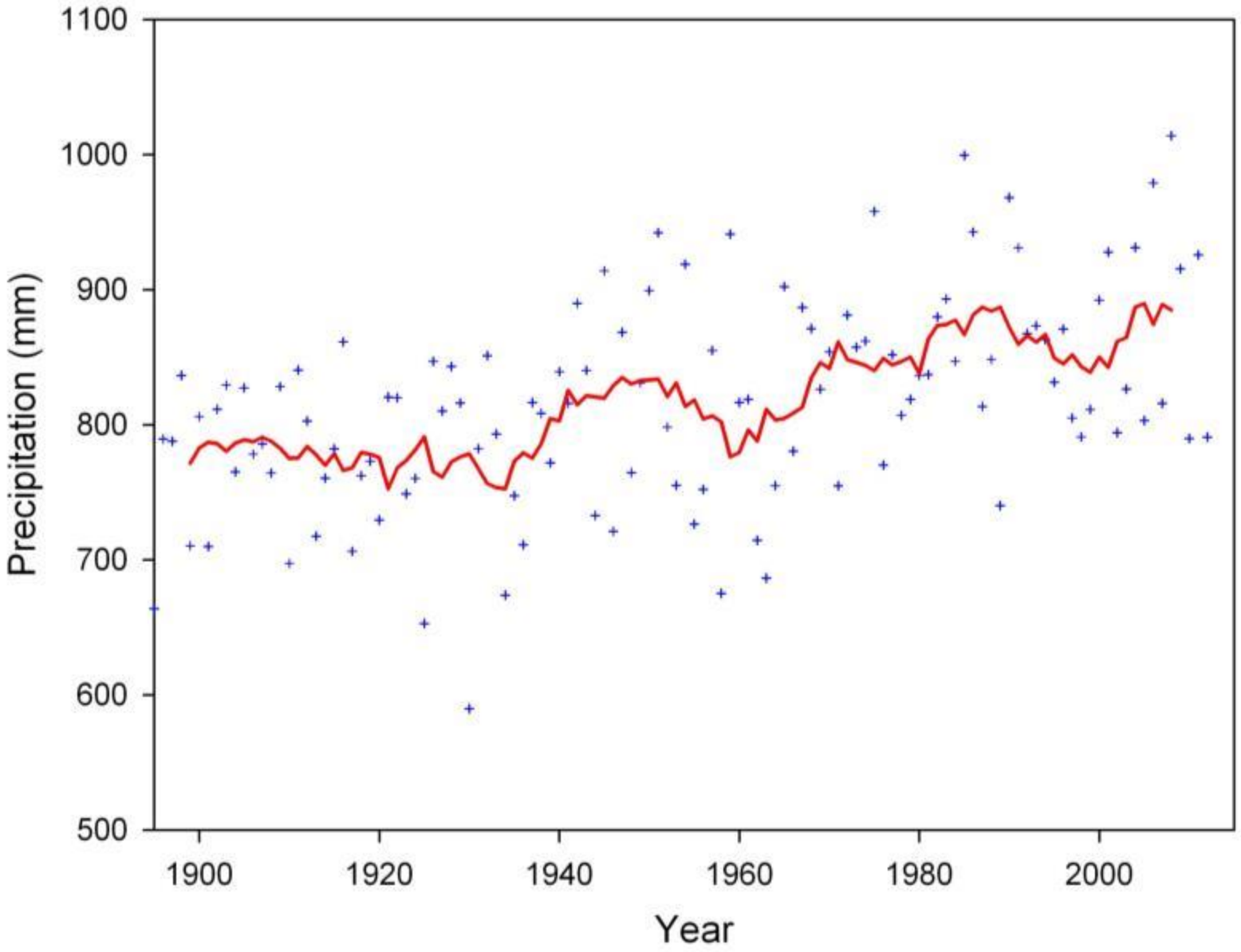
Source: K. Kunkel, Midwest. Reg. Clim. Center

Date of Side Green vs. Year

1901-2012, Traverse City, MI

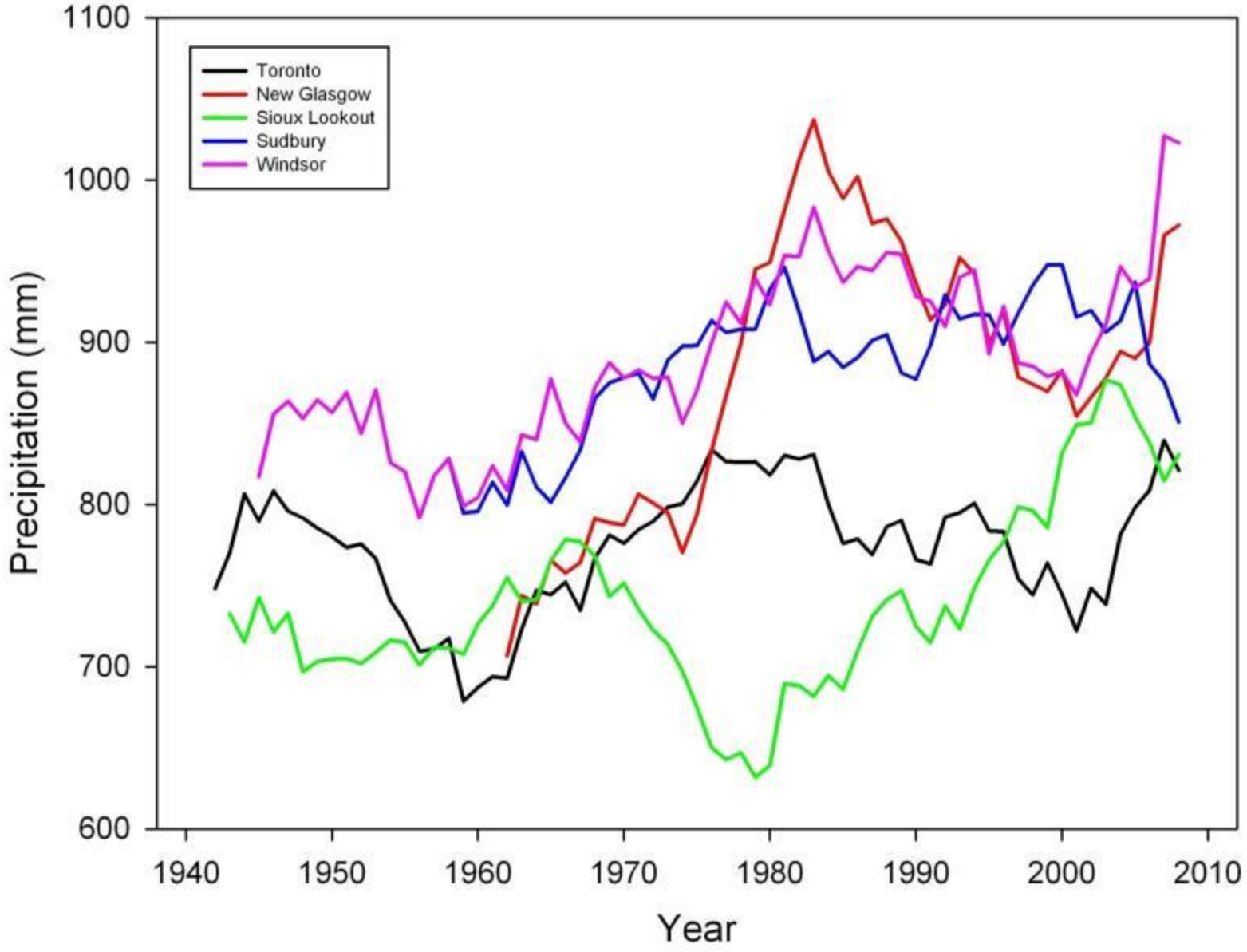


Annual Precipitation vs. Year, Michigan 1895-2012



Mean Annual Precipitation

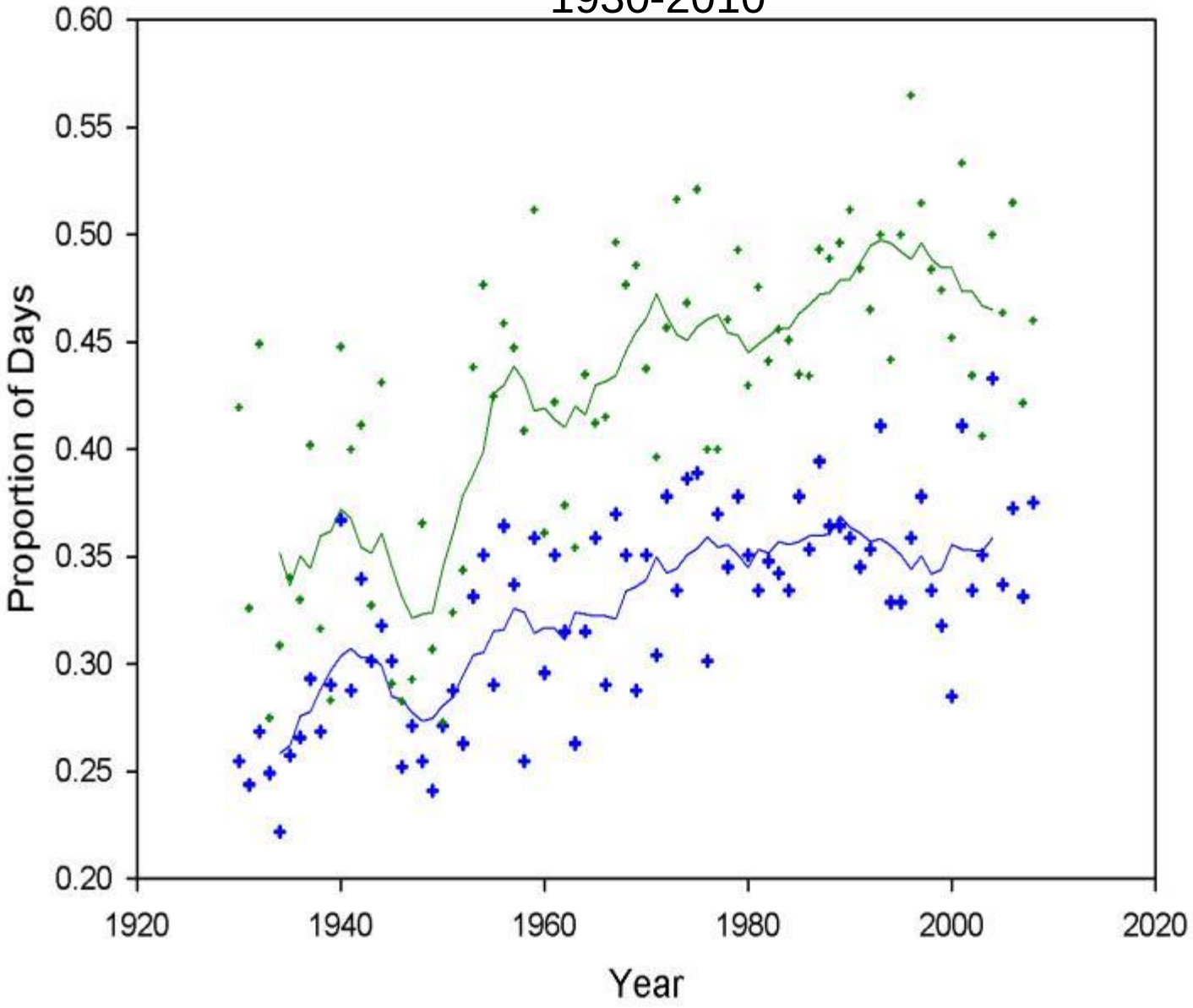
Ontario Locations

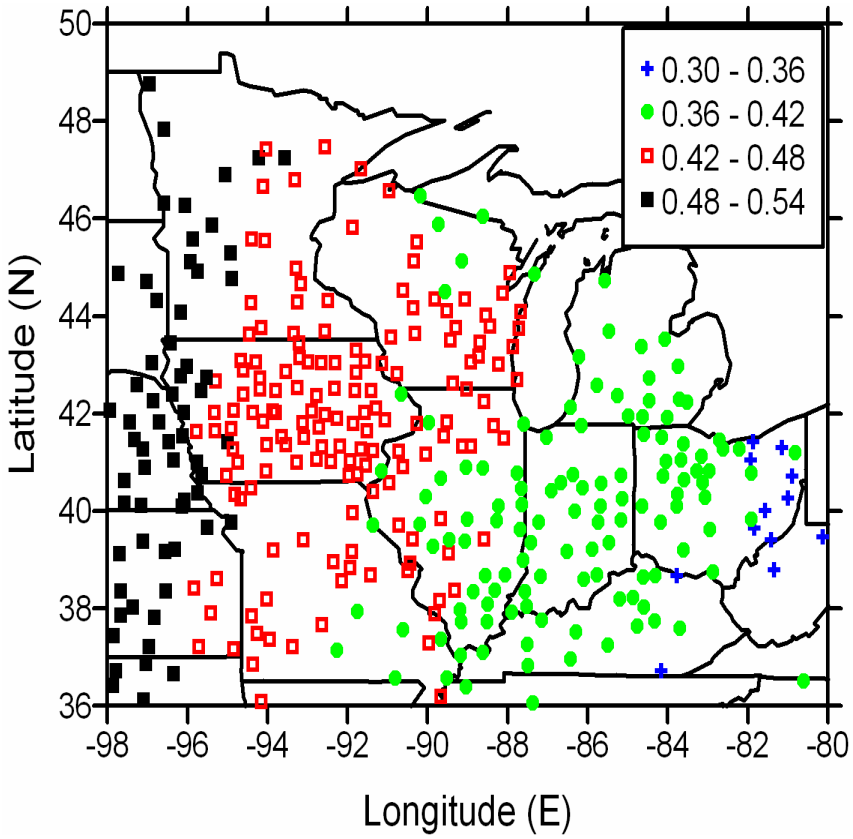


Frequency of Wet Days and Wet/Wet Days

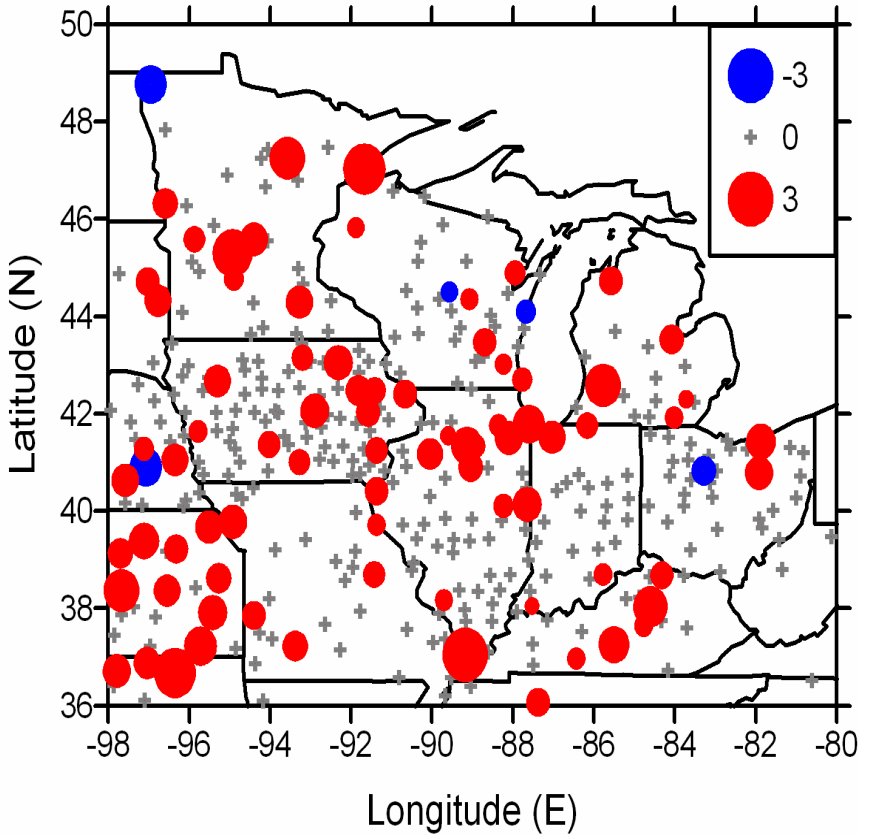
Caro, MI

1930-2010



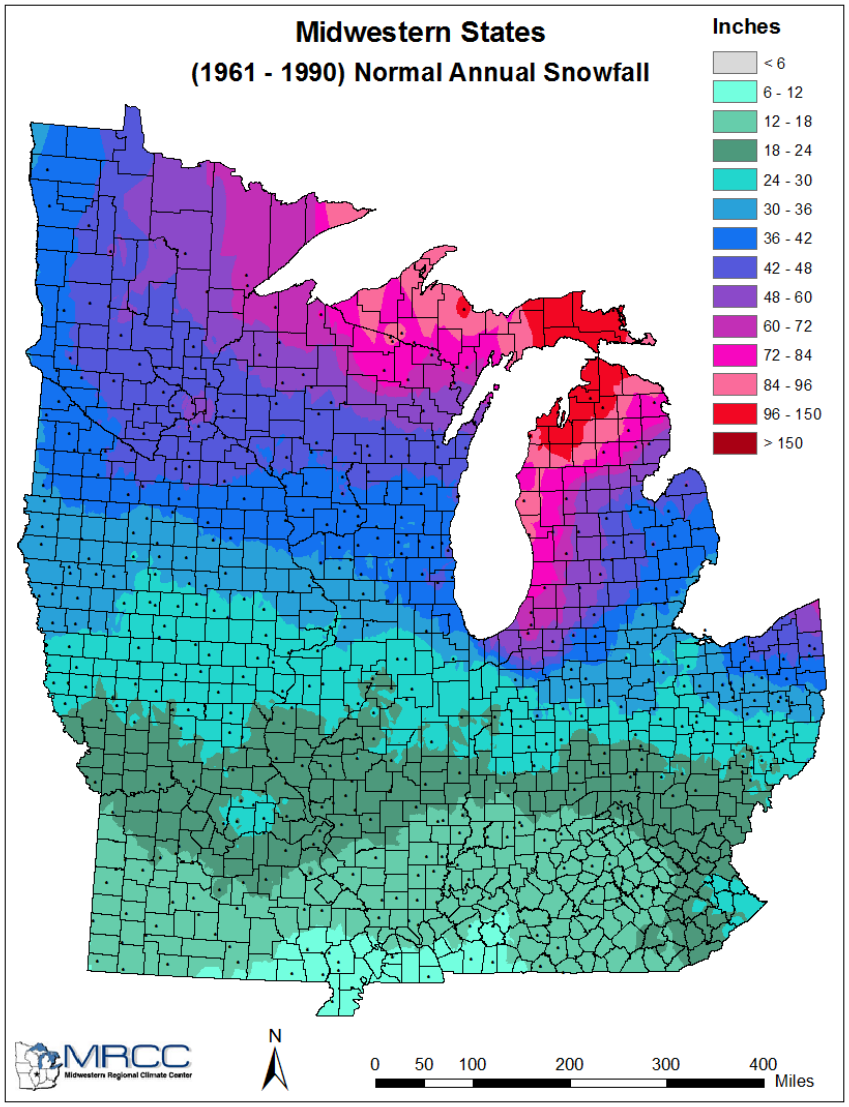


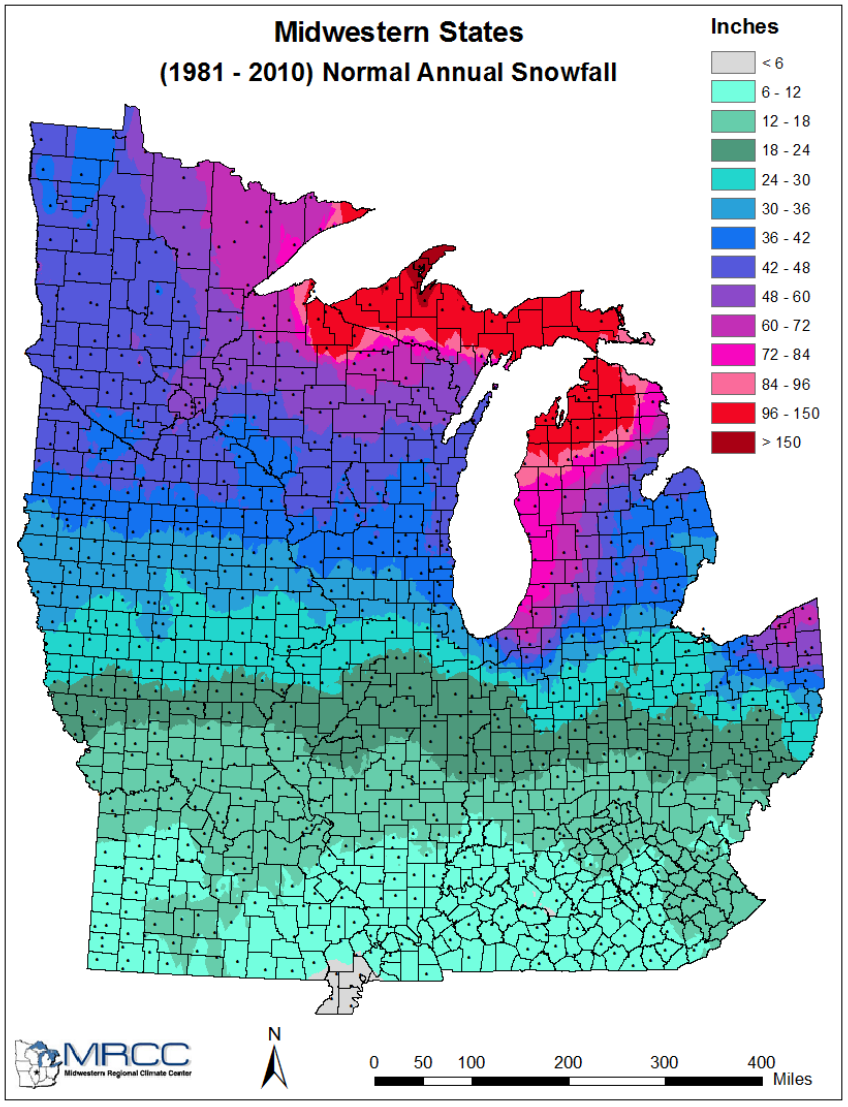
Mean fraction of annual precipitation derived from10 wettest days
1971-2000



Trend in sum of the top-10 wettest days in a year (%/decade)
1901-2000

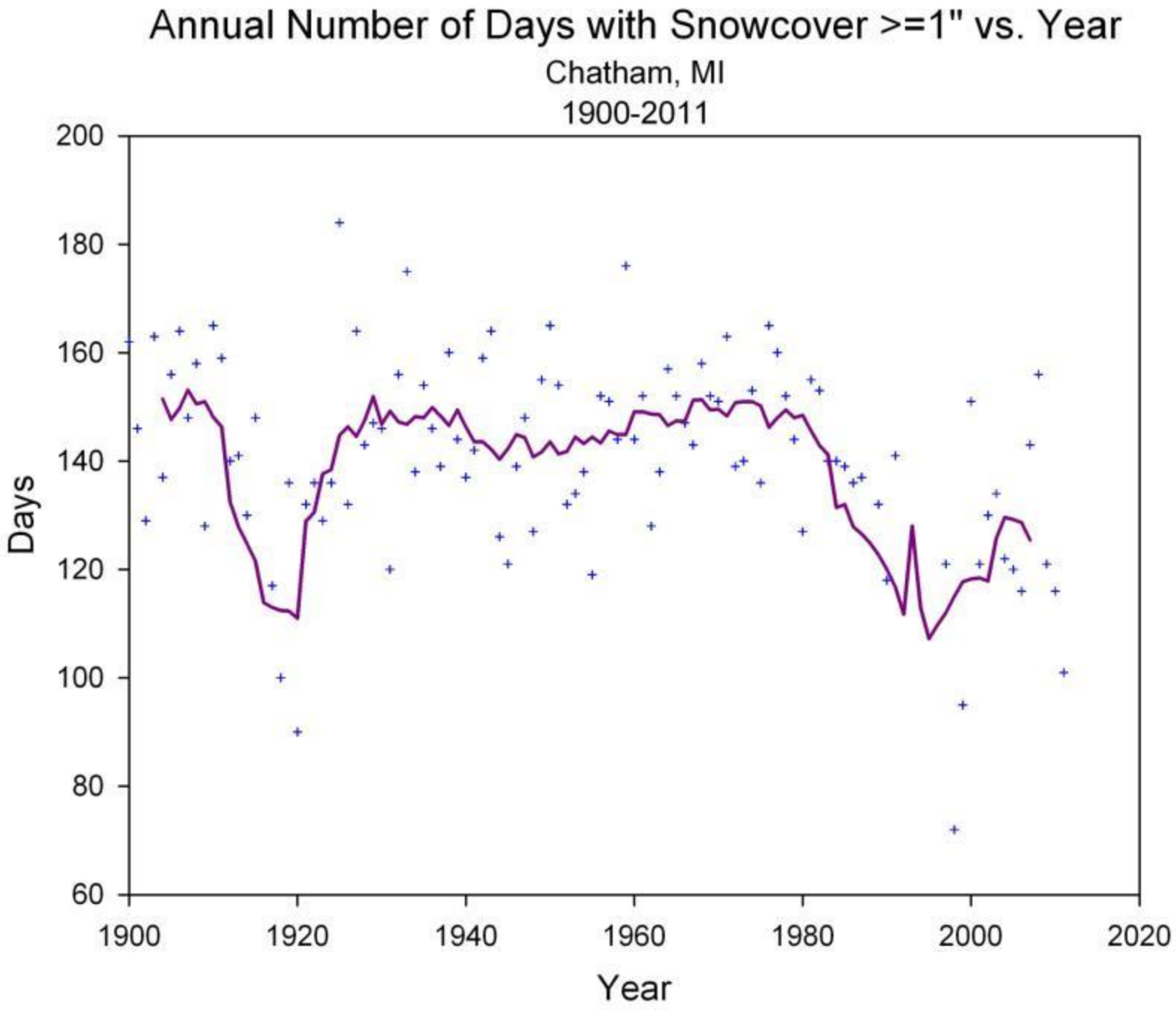
(Pryor et al., 2009)



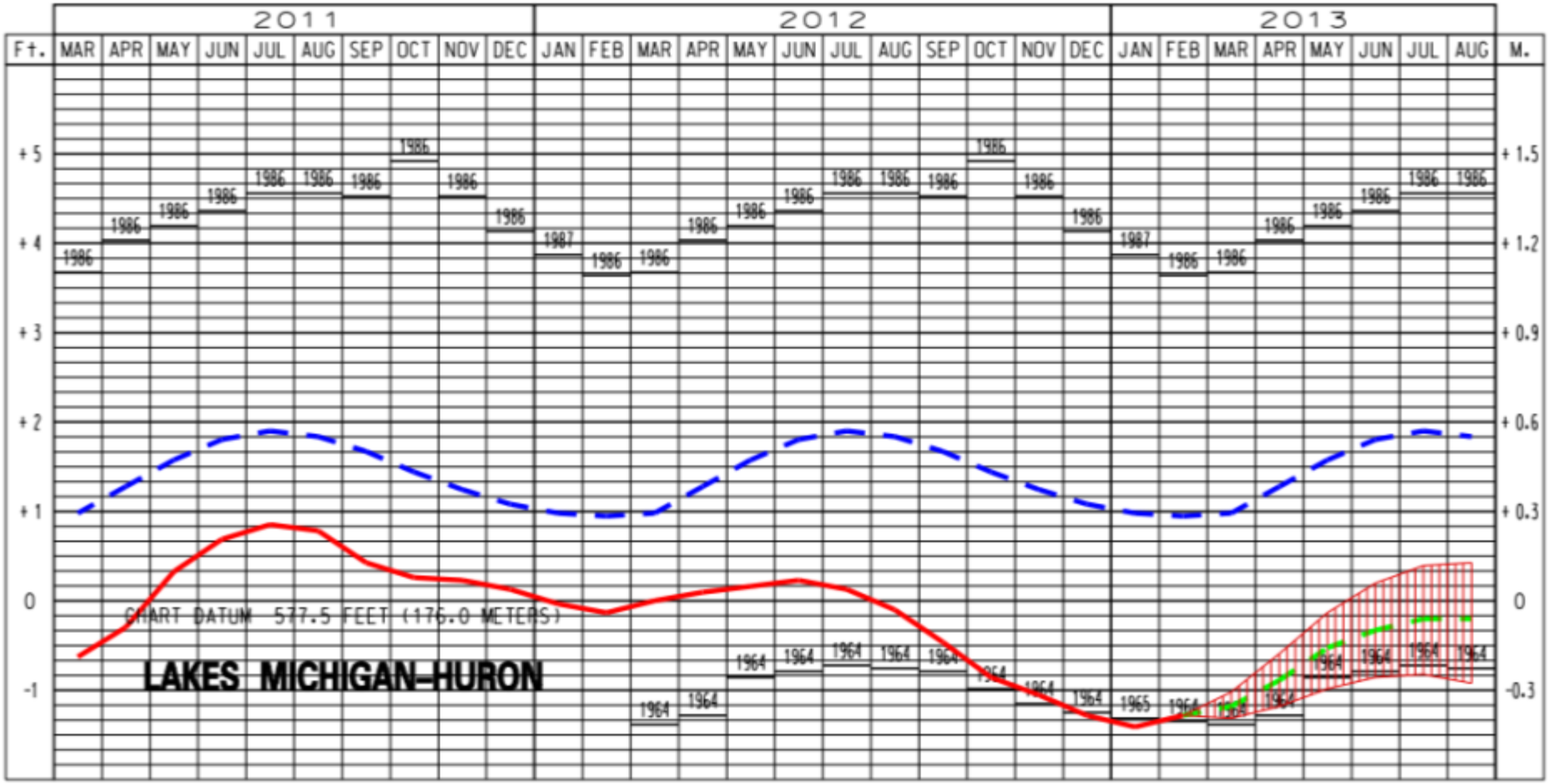


Mean seasonal total snowfall (inches)

(Midwestern Regional Climate Center)


Annual Number of Days with Snowcover >=1" vs. Year
Chatham, MI
1900-2011
Days
200
180
160
140
120
100
80
60
1900
1920
1940
1960
1980
2000
2020
Year

LAKES MICHIGAN–HURON WATER LEVELS – MARCH 2013



LEGEND

LAKE LEVELS

RECORDED

PROJECTED

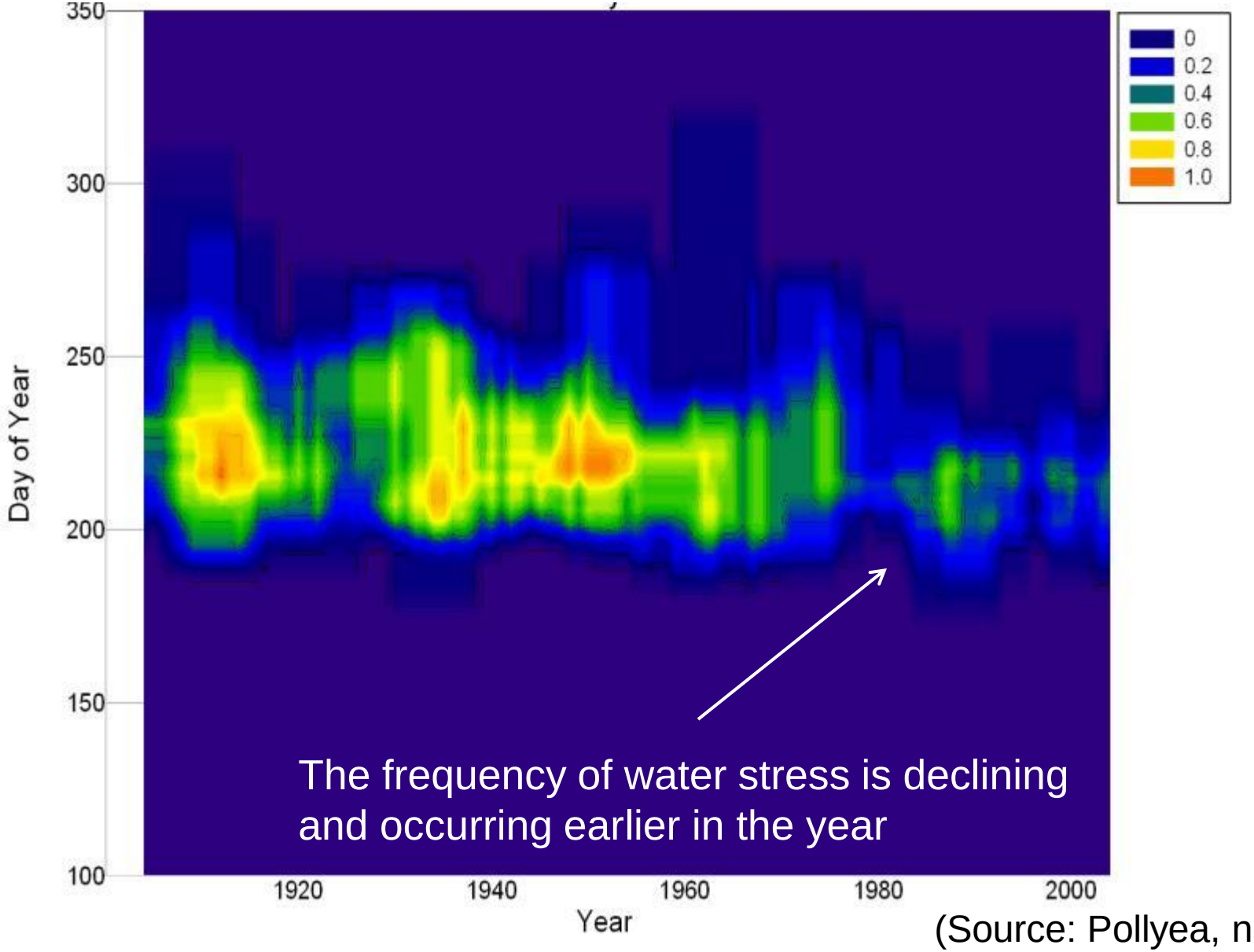
AVERAGE **

	MAXIMUM **	MINIMUM **
1918-2011	1985	1936
1997-2011	1985	1934
1981-2011	1973	1926
2002-2011	1973	1934

** Average, Maximum and Minimum for period 1918-2011

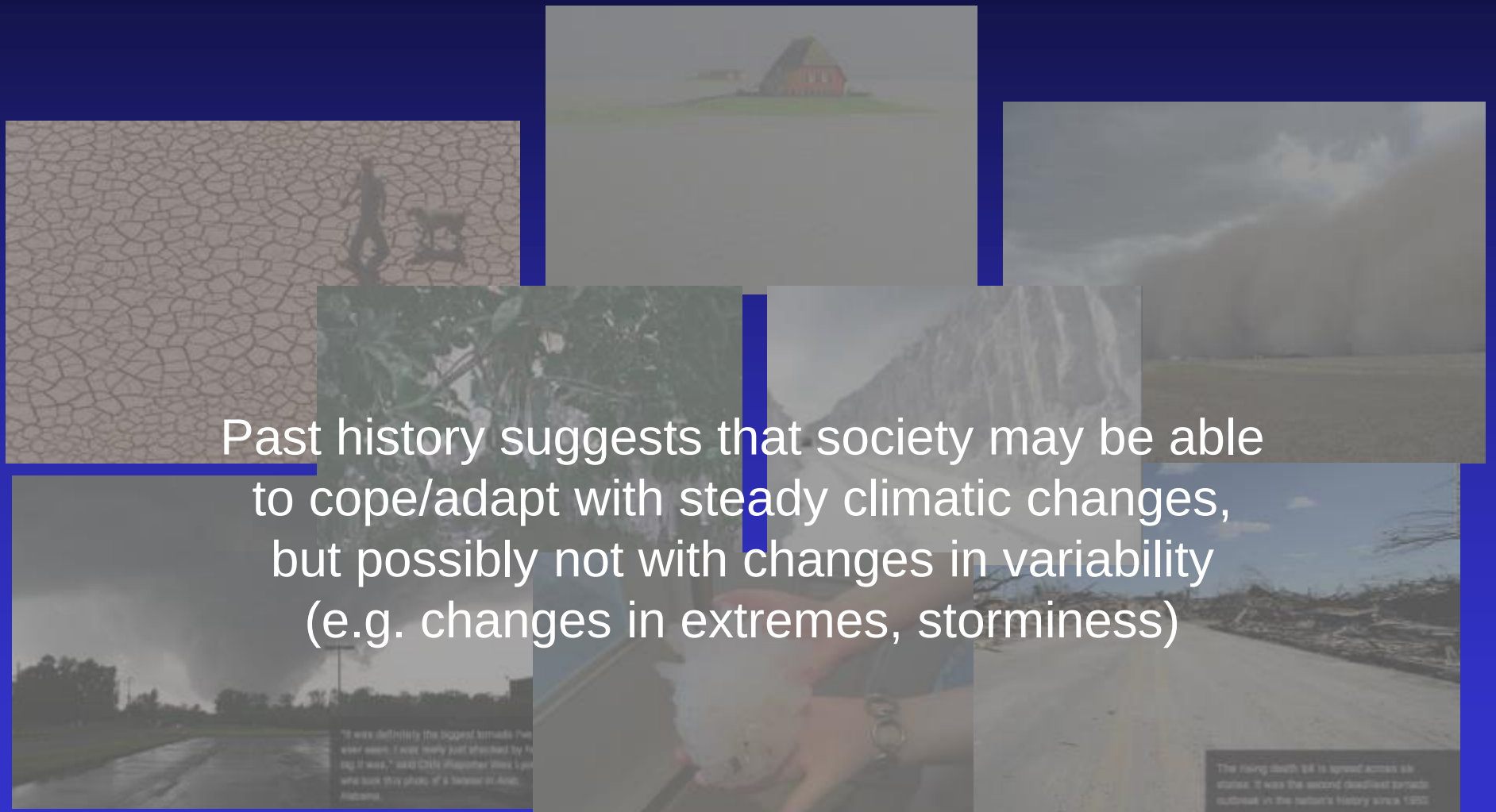
Frequency of Days PAW_{150} < 0.50 Potential PAW_{150}

Ann Arbor, MI, Silt Loam, 1900-2009

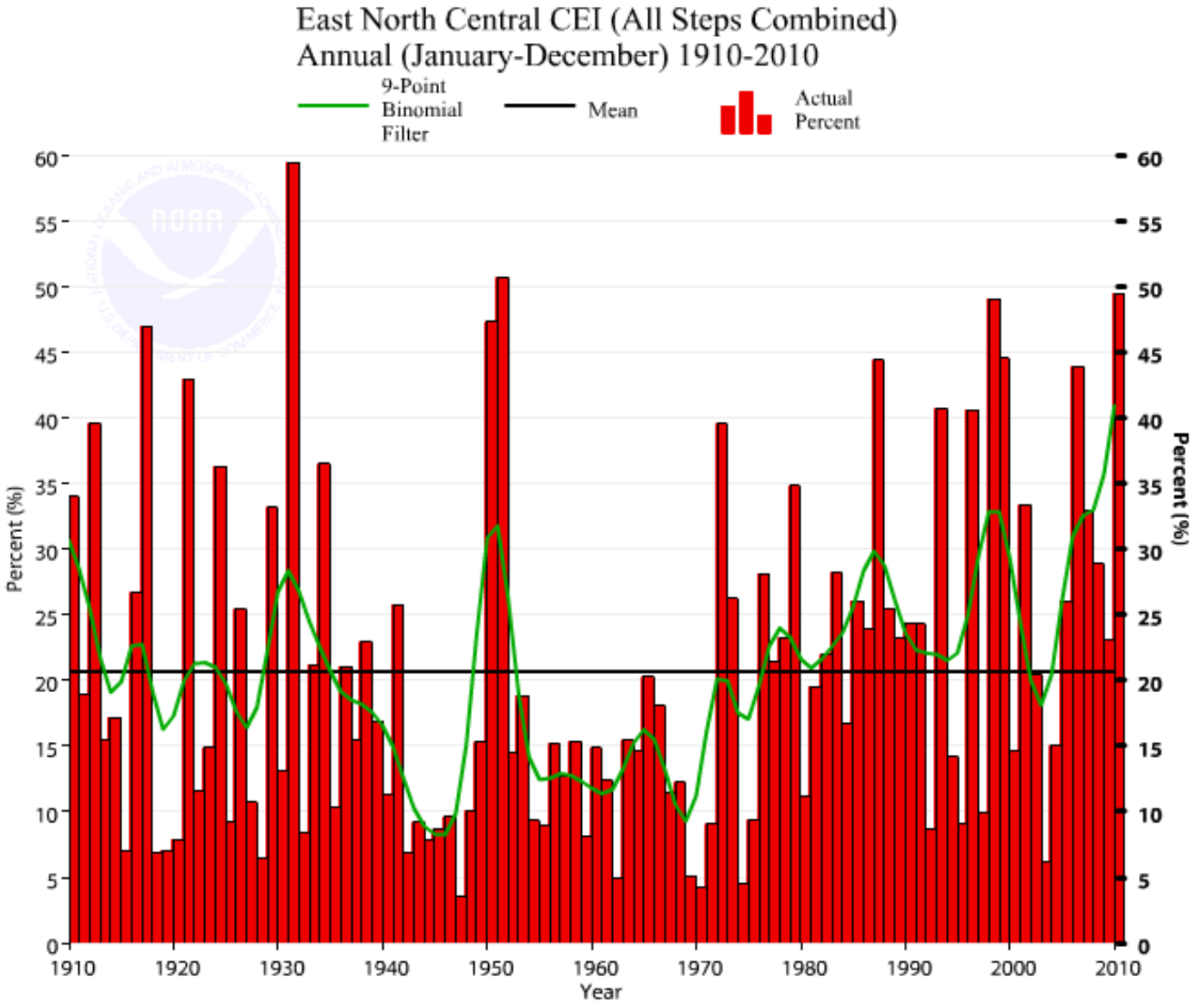


(Source: Pollyea, no date)

Impacts of Climatic Variability



Past history suggests that society may be able
to cope/adapt with steady climatic changes,
but possibly not with changes in variability
(e.g. changes in extremes, storminess)



(Source: NCDC, 2011)

Worldwide Weather Disasters, 1980-2010

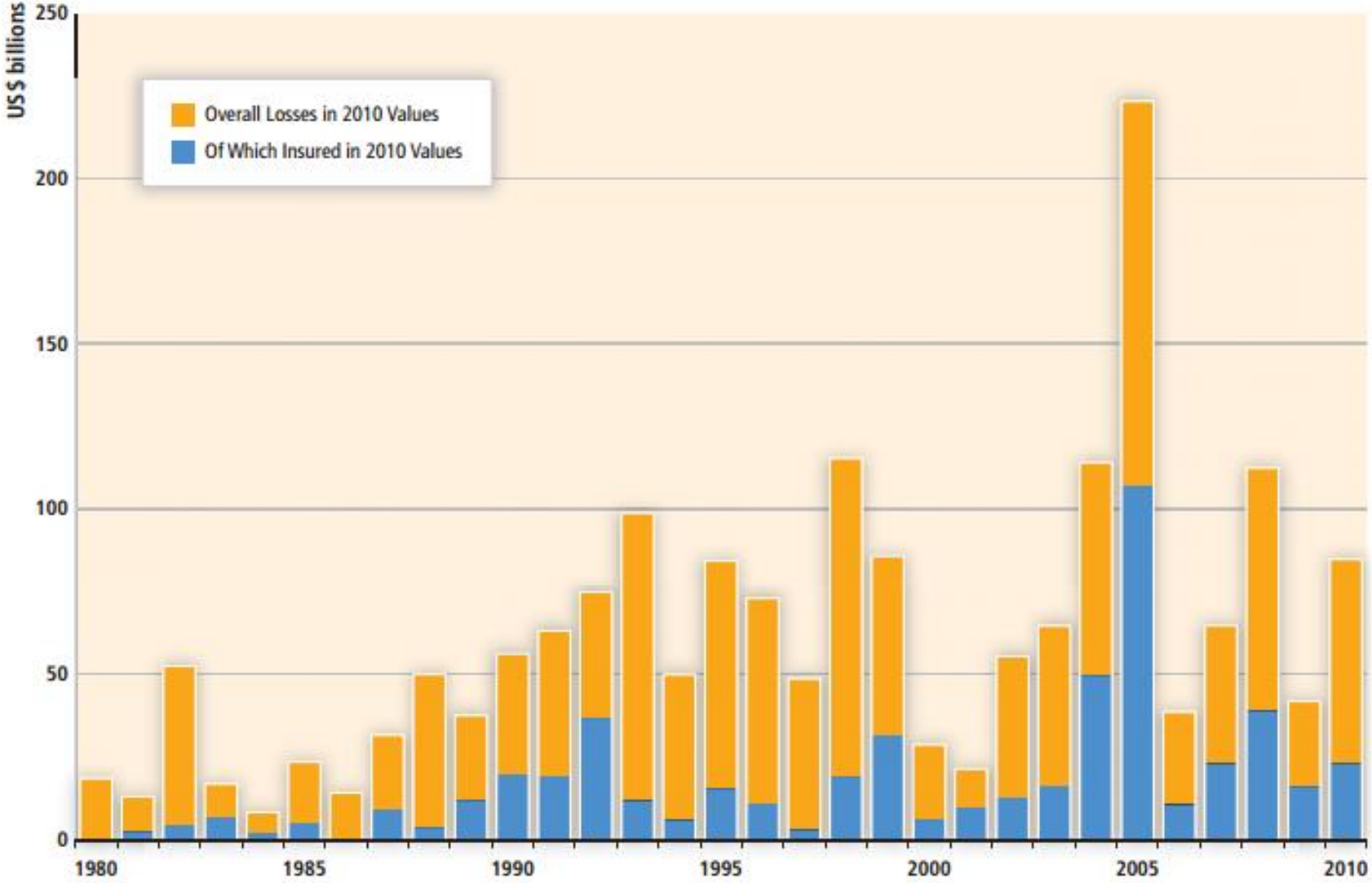
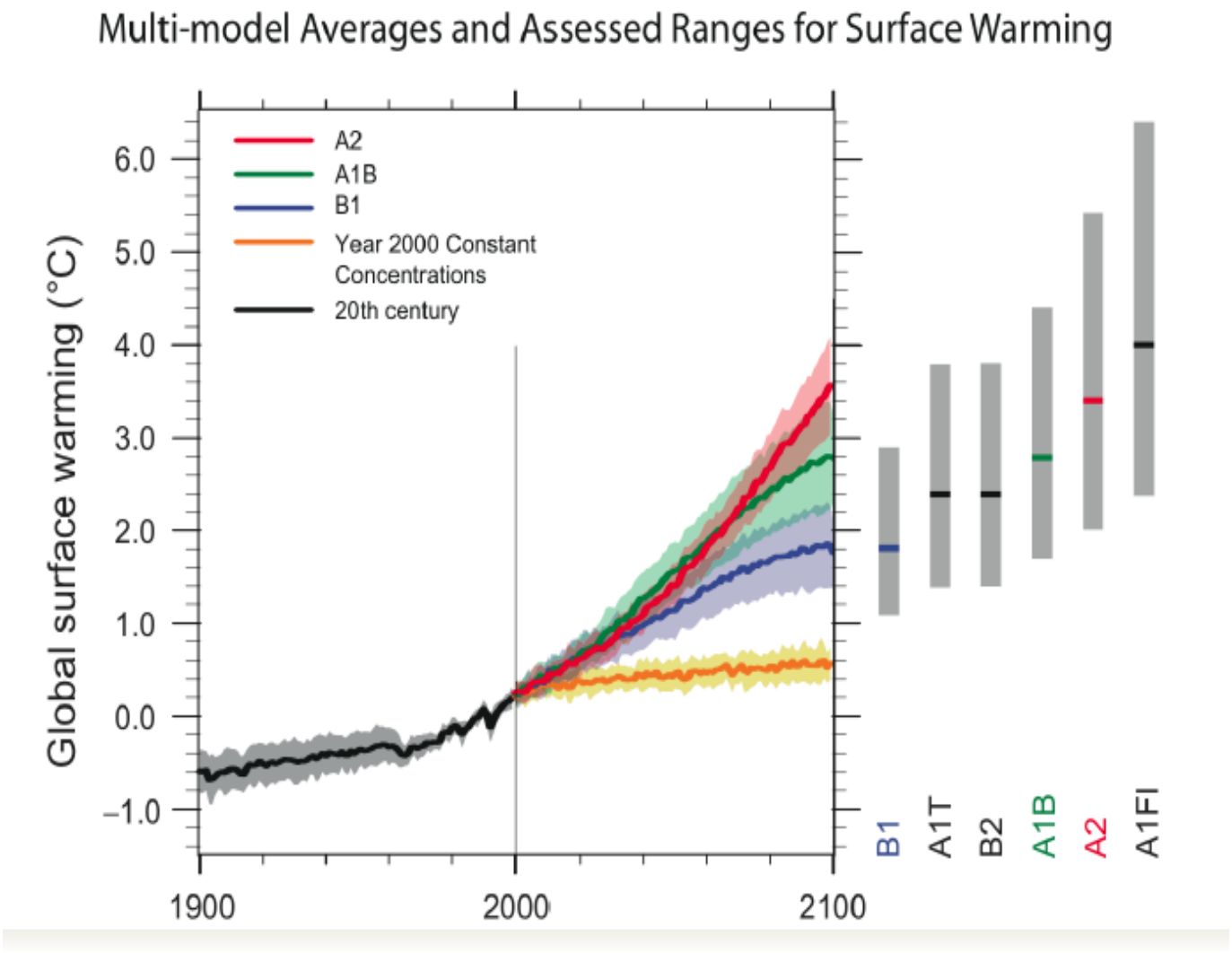
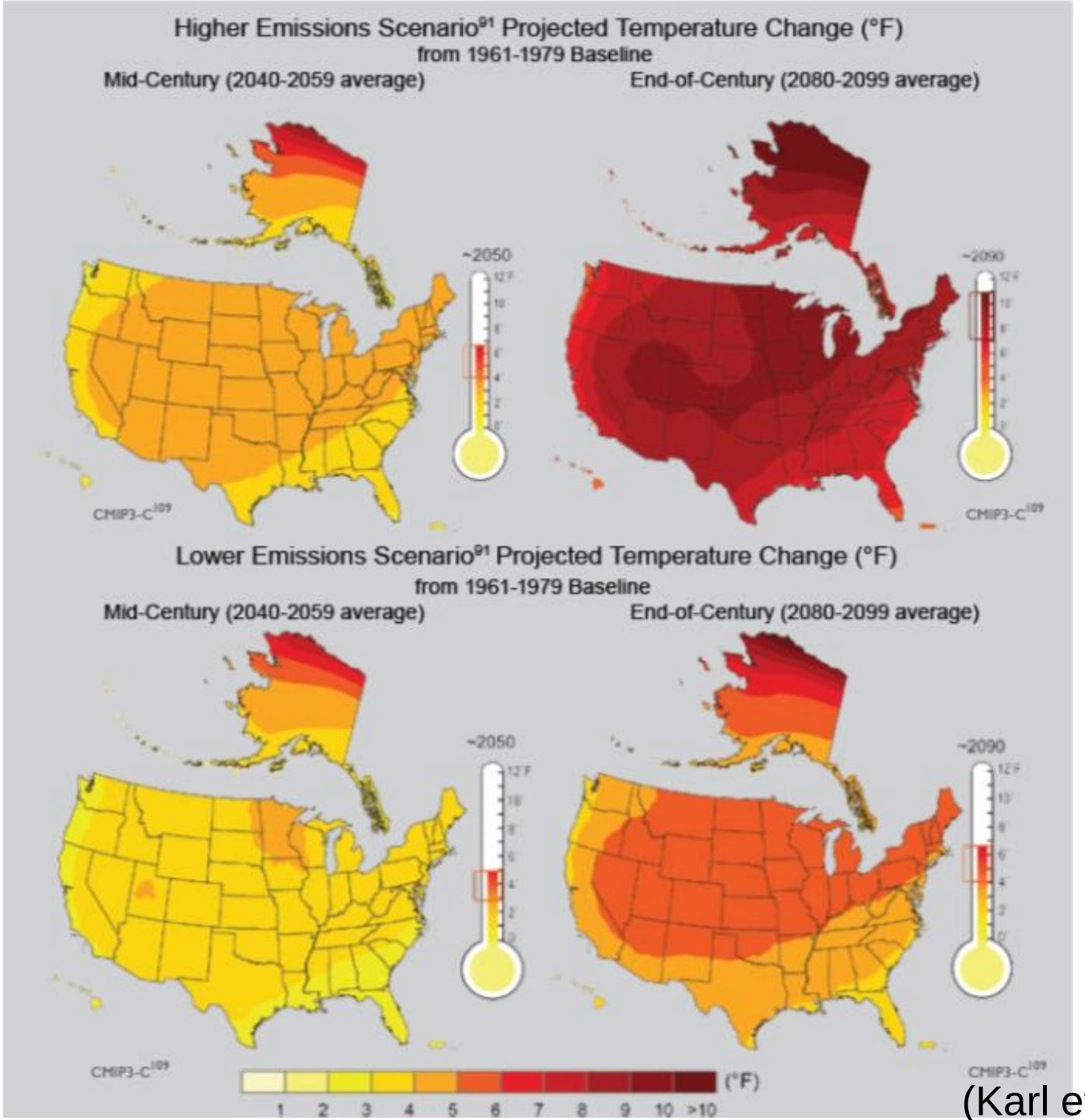


Figure 4-8 | The overall losses and insured losses from weather- and climate-related disasters worldwide (in 2010 US$). These data for weather- and climate-related 'great' and 'devastating' natural catastrophes are plotted without inclusion of losses from geophysical events. A catastrophe in this data set is considered 'great' if the number of fatalities exceeds 2,000, the number of homeless exceeds 200,000, the country's GDP is severely hit, and/or the country is dependent on international aid. A catastrophe is considered 'devastating' if the number of fatalities exceeds 500 and/or the overall loss exceeds US$ 650 million (in 2010 values). Data from Munich Re, 2011.

Future Projections

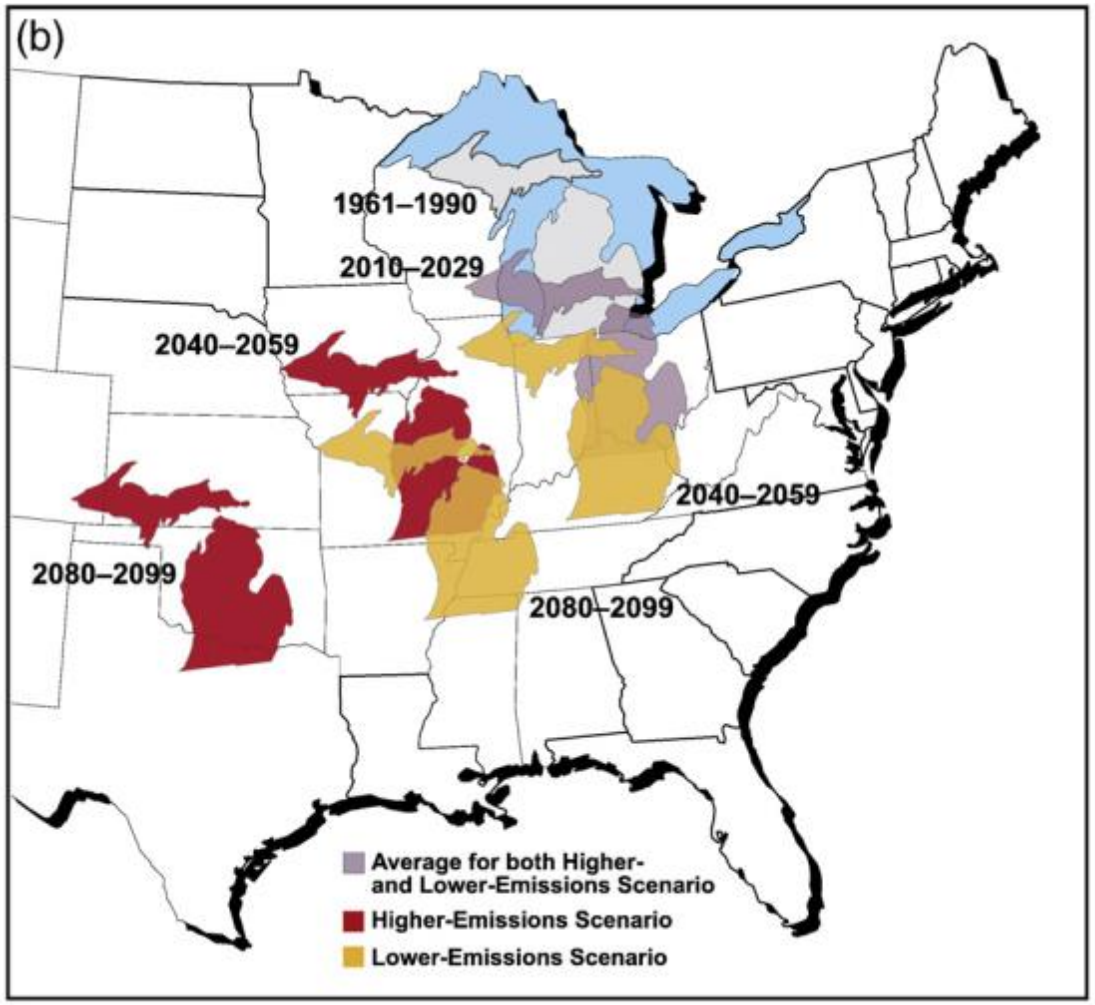


Source: (IPCC, 2007)



(Karl et al., 2009)

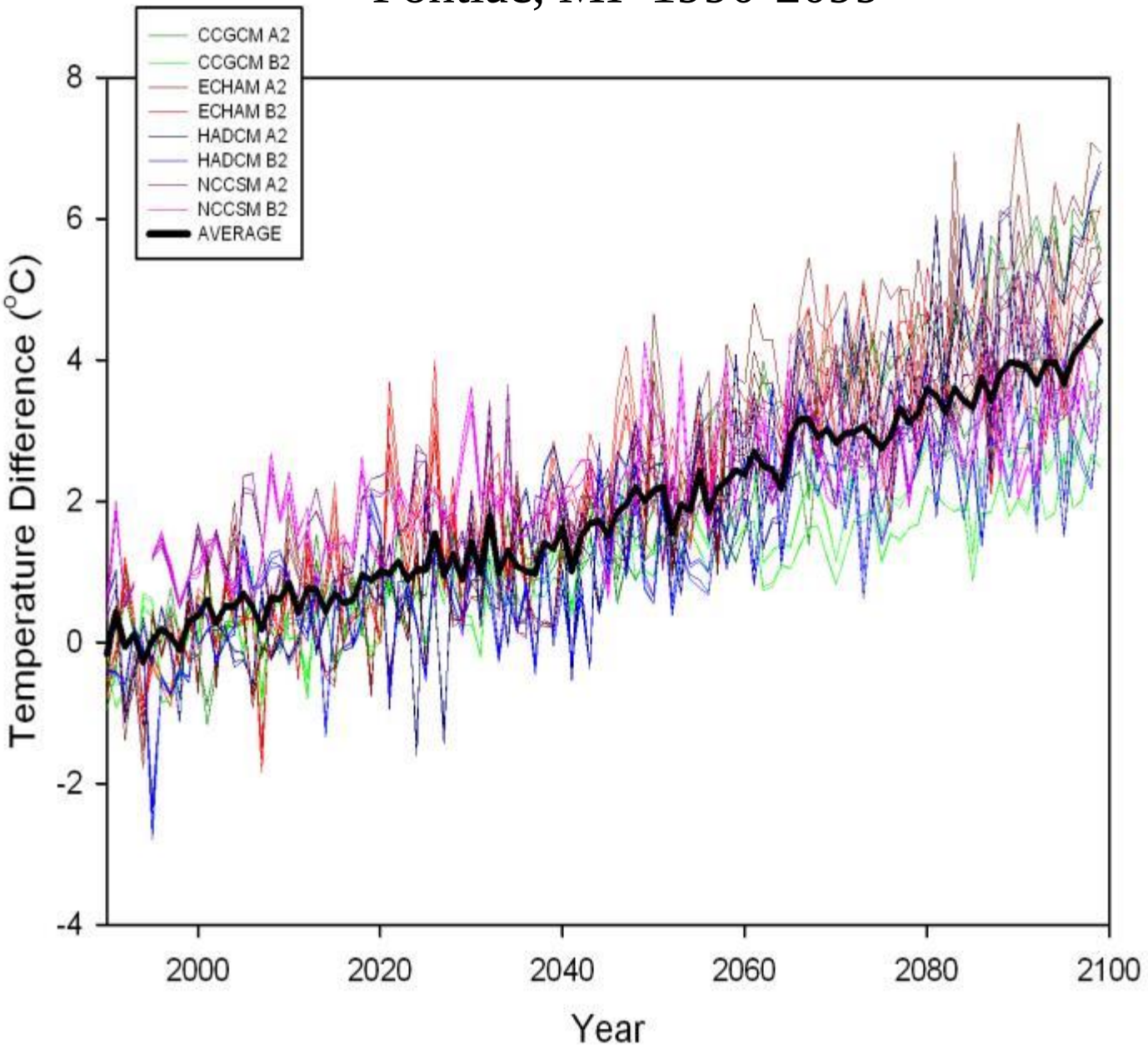
Projected Temperature Changes



Hayhoe et al (2010)

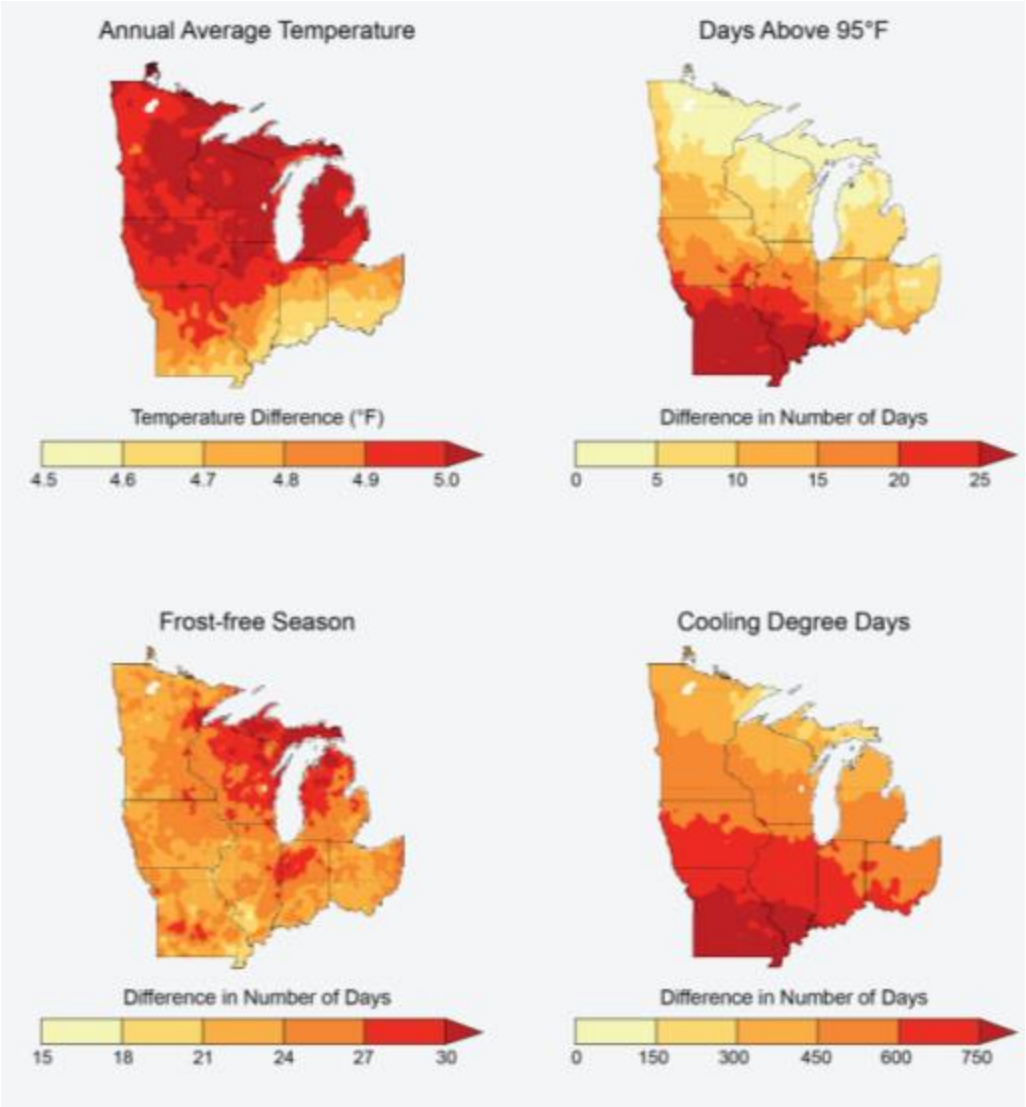
Model-Projected Mean Temperature Differences

Pontiac, MI 1990-2099

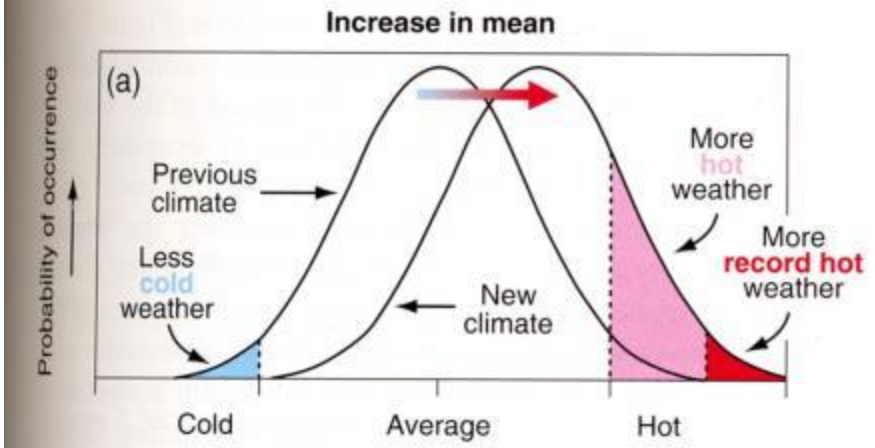


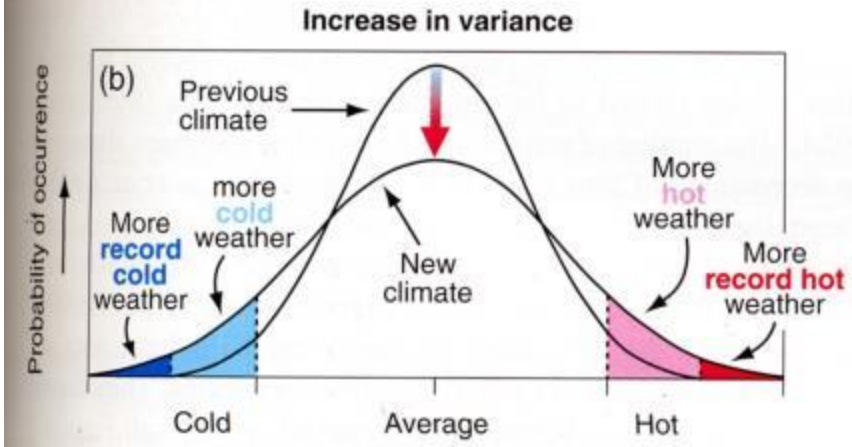
Projected Temperature-Related Changes

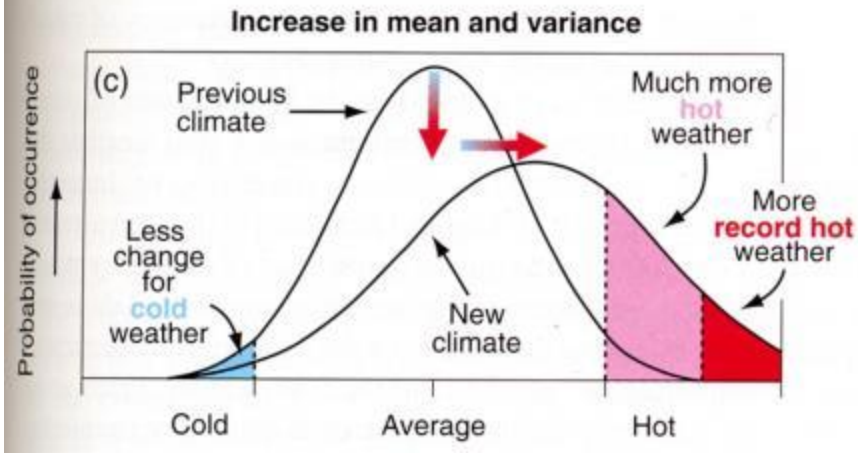
2041-2070 vs. 1971-2000



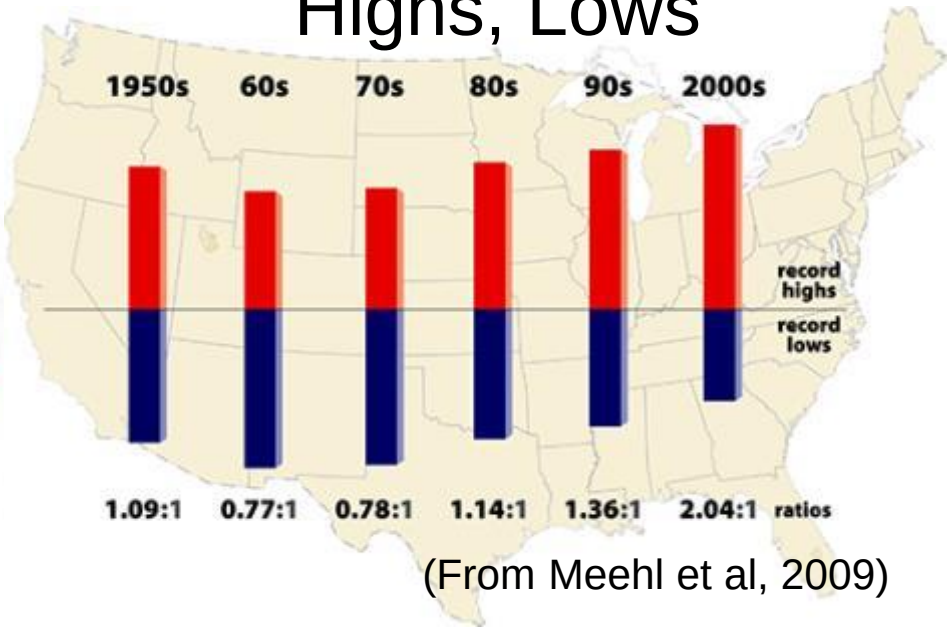
(Pryor and Scavia, 2013)



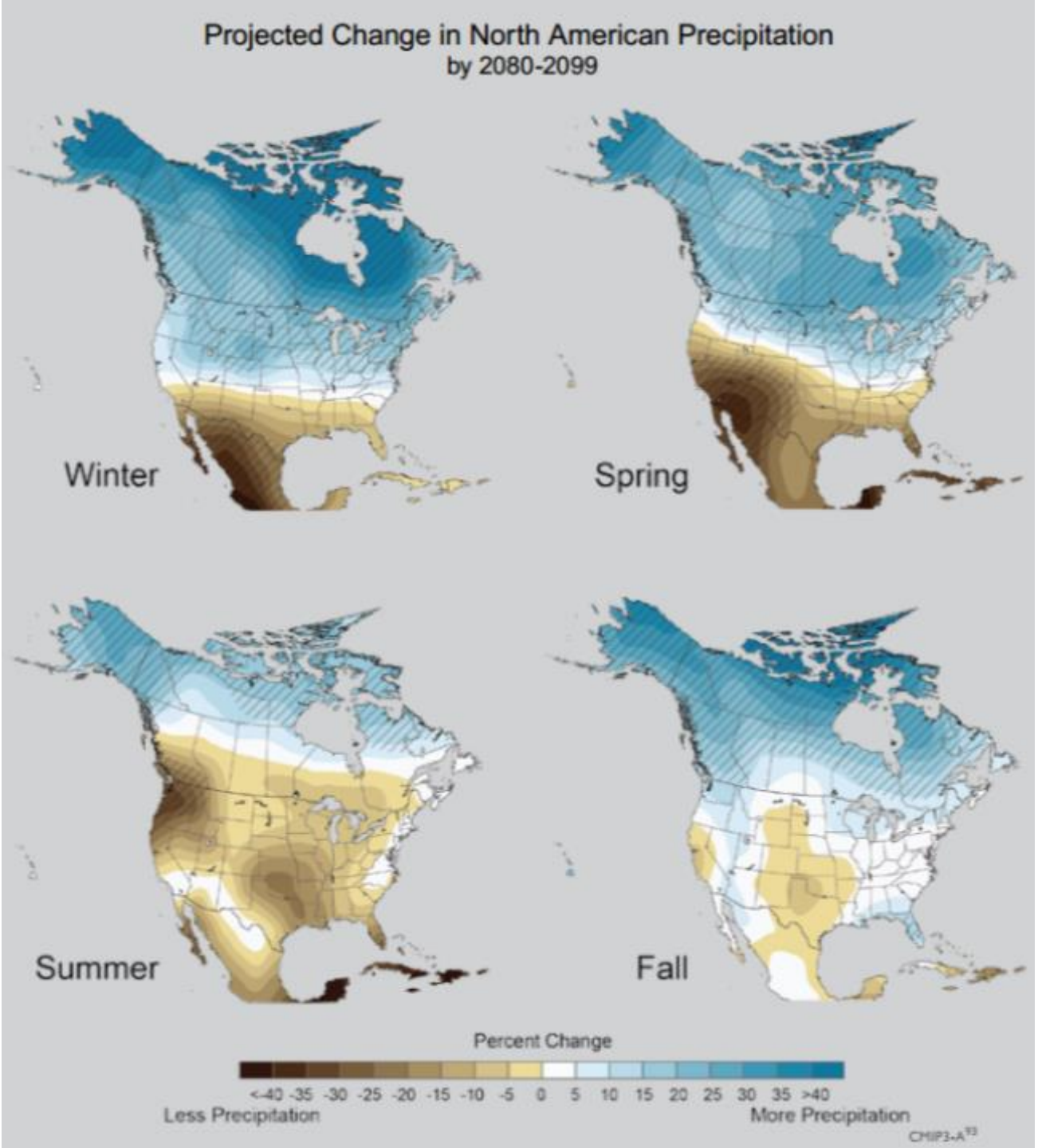




Decadal Ratios of Record Highs, Lows

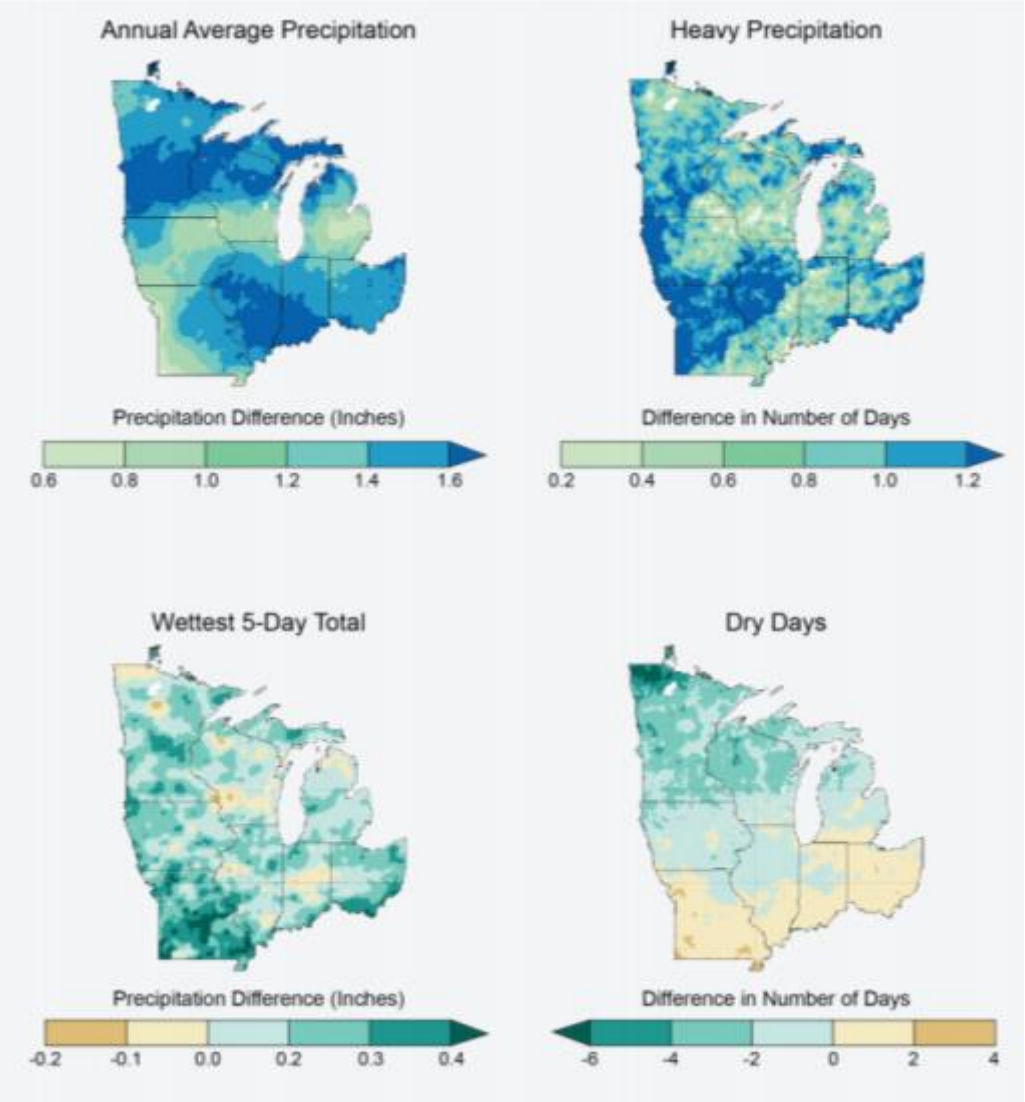


(From Meehl et al, 2009)


Projected Change in North American Precipitation
by 2080-2099
Winter
Spring
Summer
Fall
Percent Change
<-40 -35 -30 -25 -20 -15 -10 -5 0 5 10 15 20 25 30 35 >40
Less Precipitation
More Precipitation
CMIP3-A

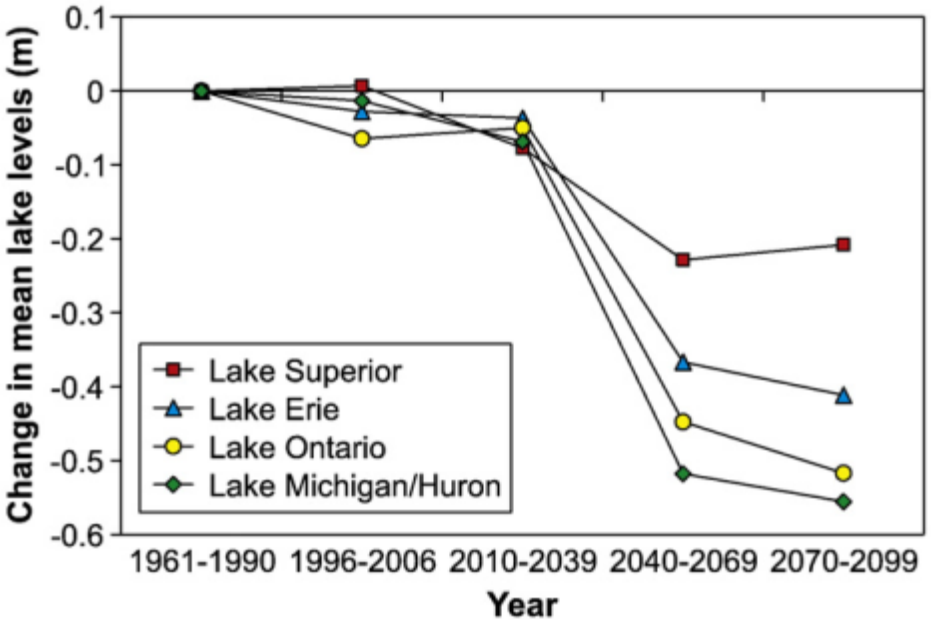
Projected Preciptation-Related Changes

2041-2070 vs. 1971-2000



(Pryor and Scavia, 2013)

Projected Great Lakes Levels



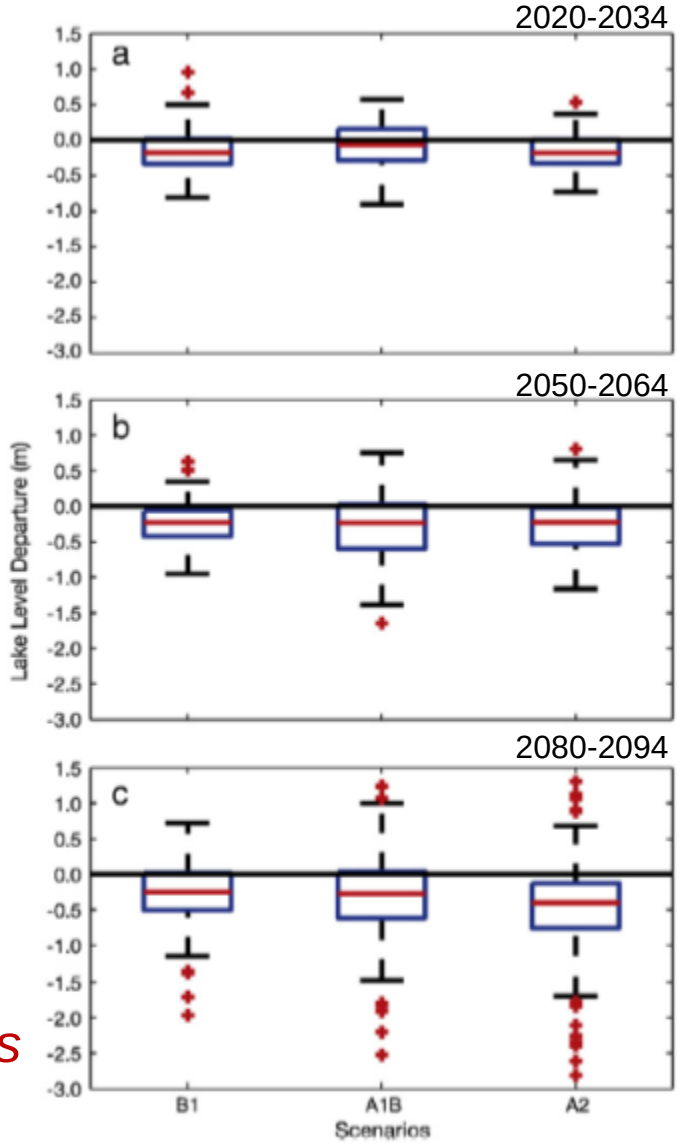


Fig. 7. Lake Michigan-Huron level departure (m) distributions based on the GCM/GLERL simulations for the three emission scenarios for (a) 2020–2034, (b) 2050–2064, and (c) 2080–2094.

*** *Recent results by Lofgren et al (2011) suggest less reduction in future lake levels*

(Hayhoe et al., 2010)
(Angel and Kunkel, 2010)

Weather Anomaly or Climate Change?

- It is very difficult to distinguish anthropogenic signal from natural variability
- Ultimately, the physical processes and mechanisms responsible for weather and climate are the same
- Changes in the frequency of some extremes are consistent with long term trends
- Recent extremes are also generally consistent with future climate projections
- The recent weather extremes and climate change are likely not mutually exclusive: "…Although global warming is likely playing a role in this event, it probably did not play a major one. Meteorology, not climate change, is the main ingredient in the March 2012 U.S. extreme warmth". Of climate change, he said, ". . . its contribution to the magnitude of current conditions is quite small (but not zero) indeed." *Marty Hoerling (NOAA ESRL)*

Projected Future Weather Extremes-Related Impacts (IPCC, 2012)

- ***Virtual Certainty:*** increases in the frequency and magnitude of warm daily temp. extremes and decreases in cold extremes.
- ***Very Likely:*** Increase in the length, frequency, and/or intensity of warm spells or heat waves. Mean sea level rise will contribute to upward trends in extreme coastal high water levels.
- ***Likely:*** Increase in the frequency of heavy precipitation and the proportion of total rainfall from heavy events, and in avg. tropical cyclone maximum wind speed.
- ***Medium Confidence:*** Intensification of droughts, and decreases in the global frequency of tropical cyclones and the number of extratropical cyclones.

Summary

- Extreme weather conditions during 2012 were consistent with some historical trends (e.g. warmer spring temperatures) while differing from others (summer drought).
- Overall, the Great Lakes region has become warmer and wetter during the past few decades, with warming of about 2.0ºF has occurred between 1980 and the present.
- Much of the recent warming has occurred during the cold season, leading to less ice cover on the Great Lakes and an earlier spring warm-up.
- Annual precipitation rates increased from the 1930's through the present, due to both more wet days and more heavy precipitation events.
- Most recent GCM simulations of the Great Lakes region suggest a warmer and wetter climate in the distant future, with much of the additional precipitation coming during the cold season months.


Questions?