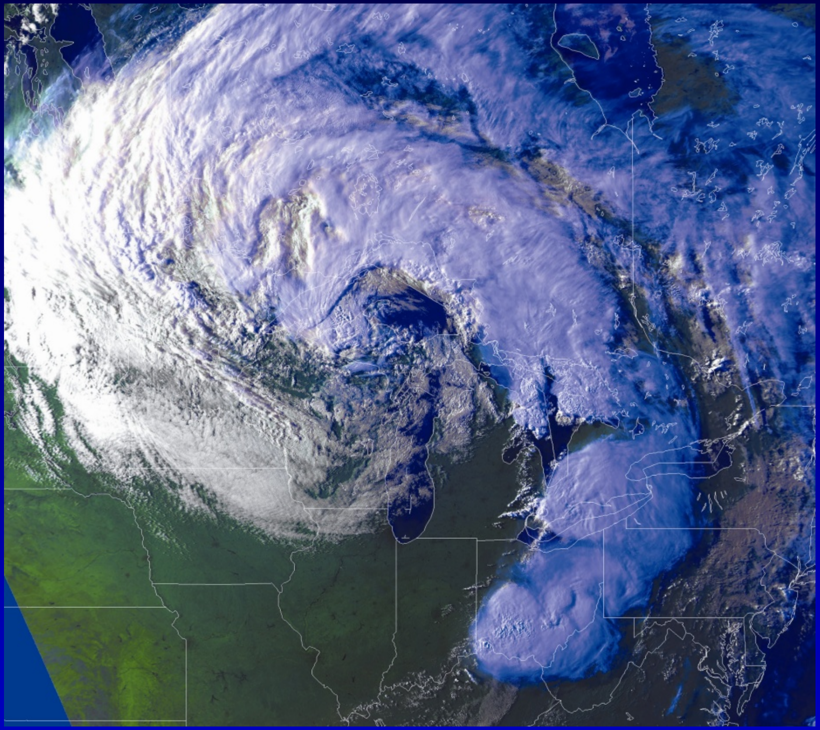
Historical and Projected Future Climatic Trends in the Great Lakes Region



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GLISA
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UNIVERSITY
EXTENSION

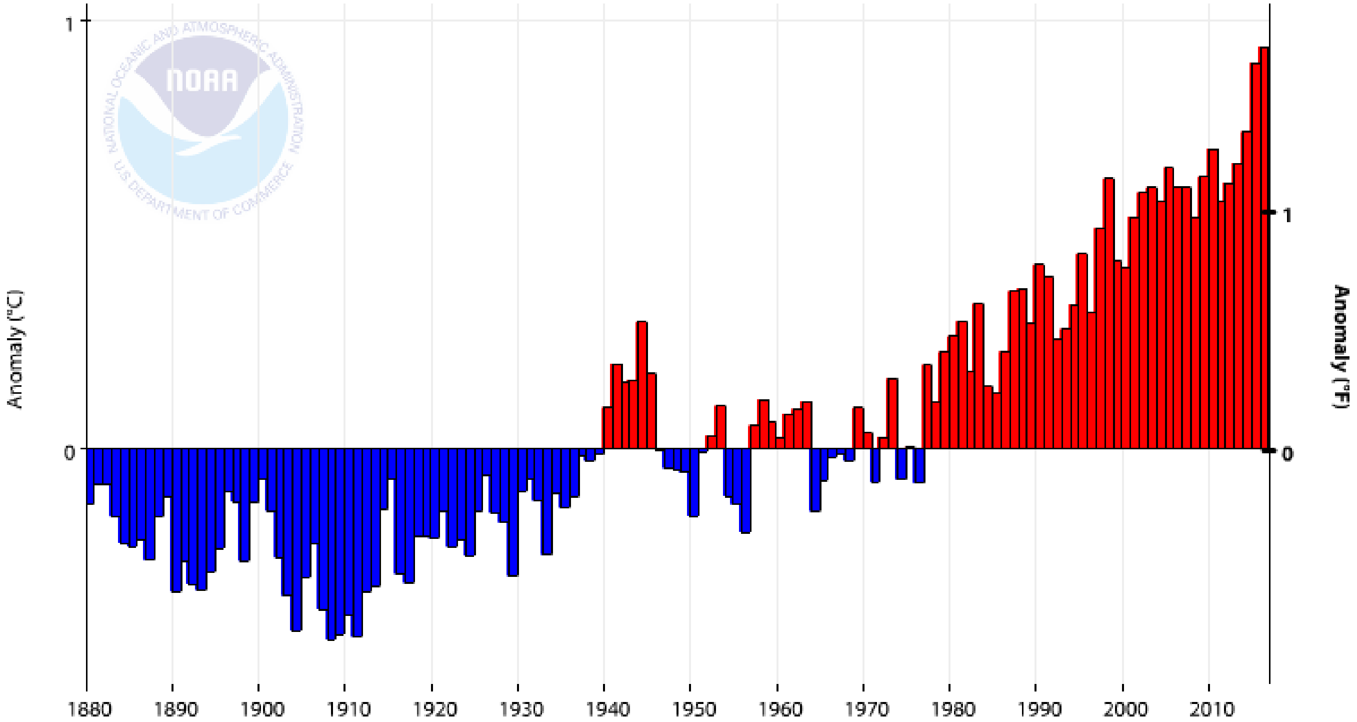
Outline

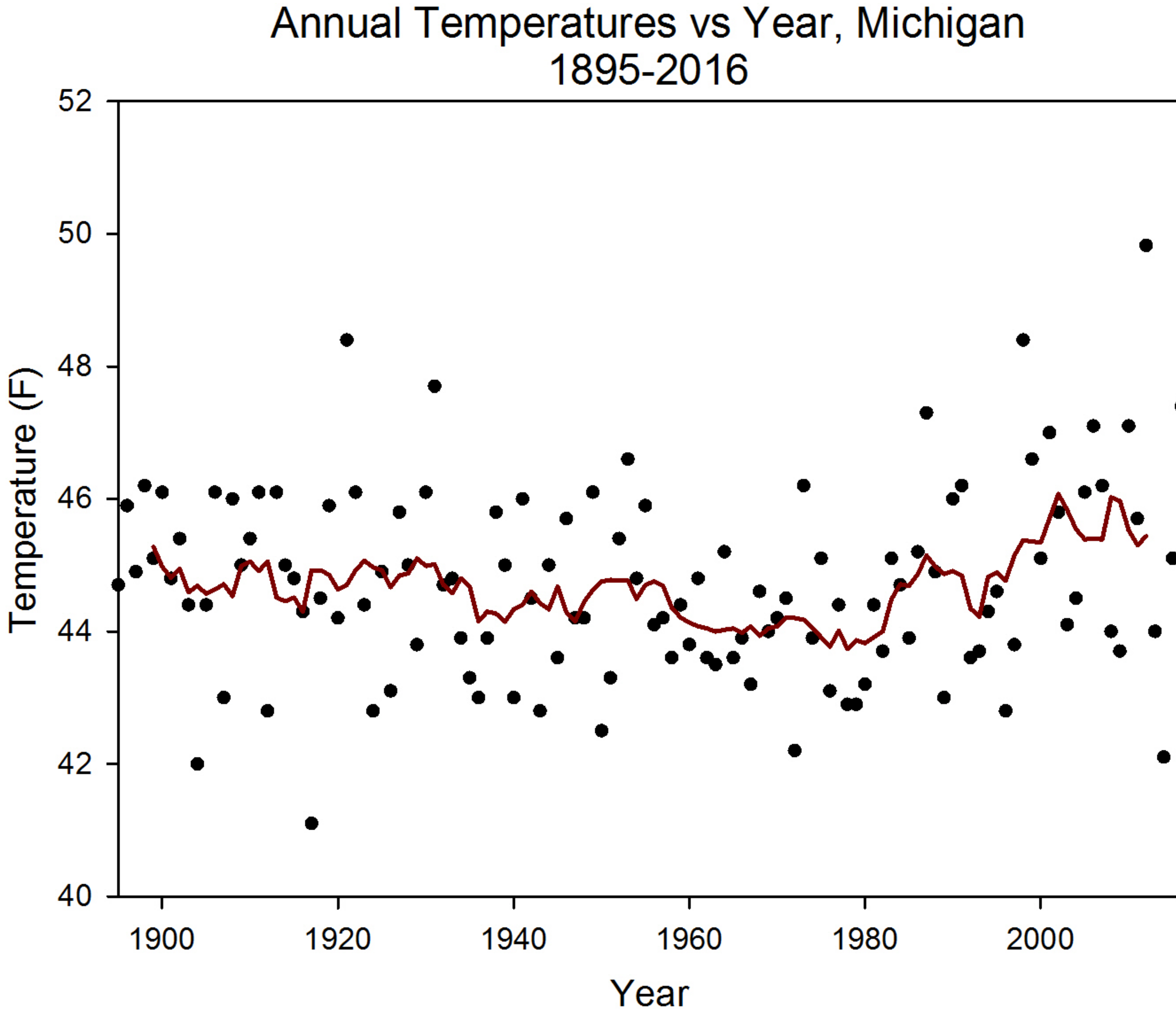
- Historical Trends
- Climatic Variability/Extreme Events
- Future Projections

Historical Trends

Global Land and Ocean Temperature Anomalies

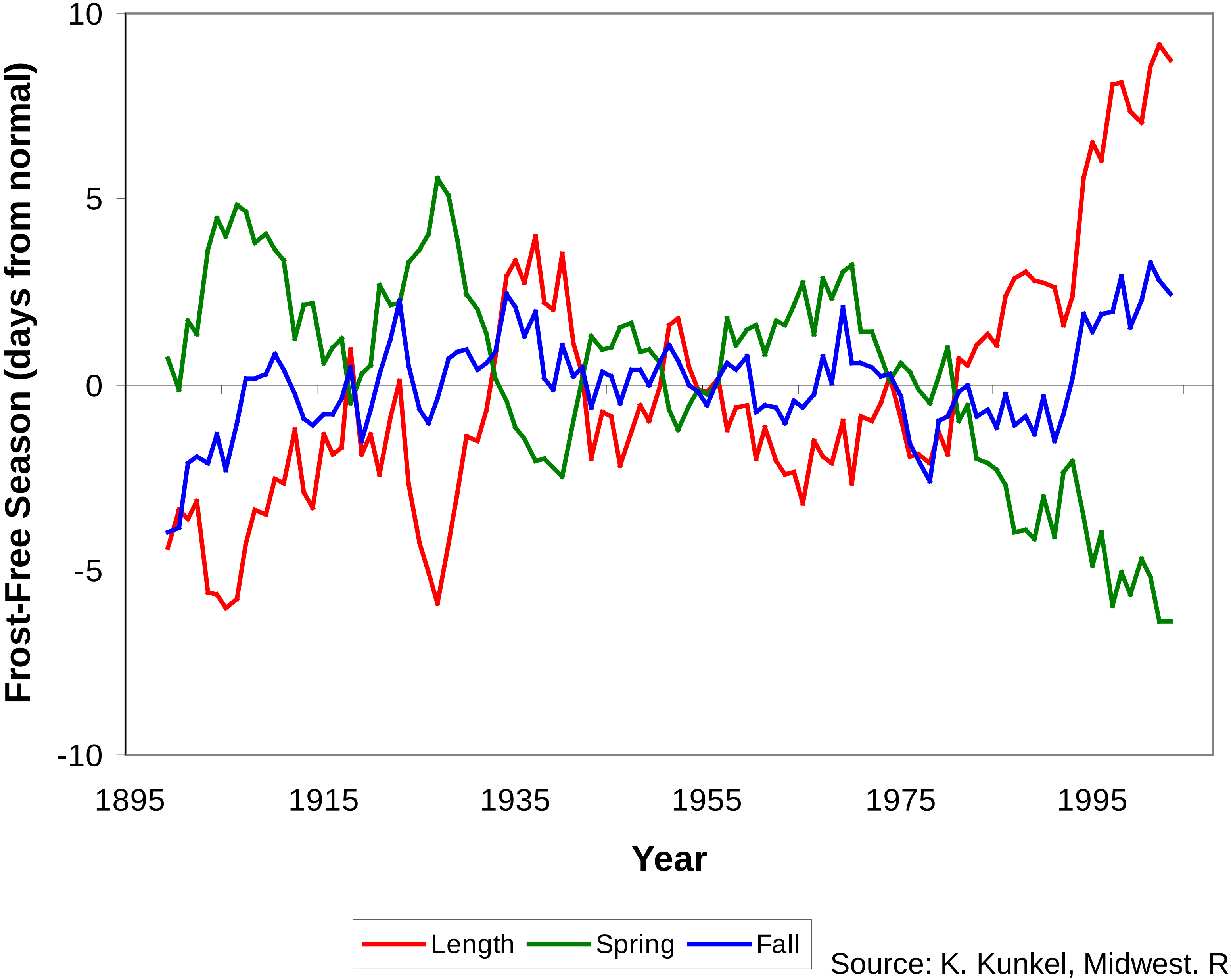
1880-2016



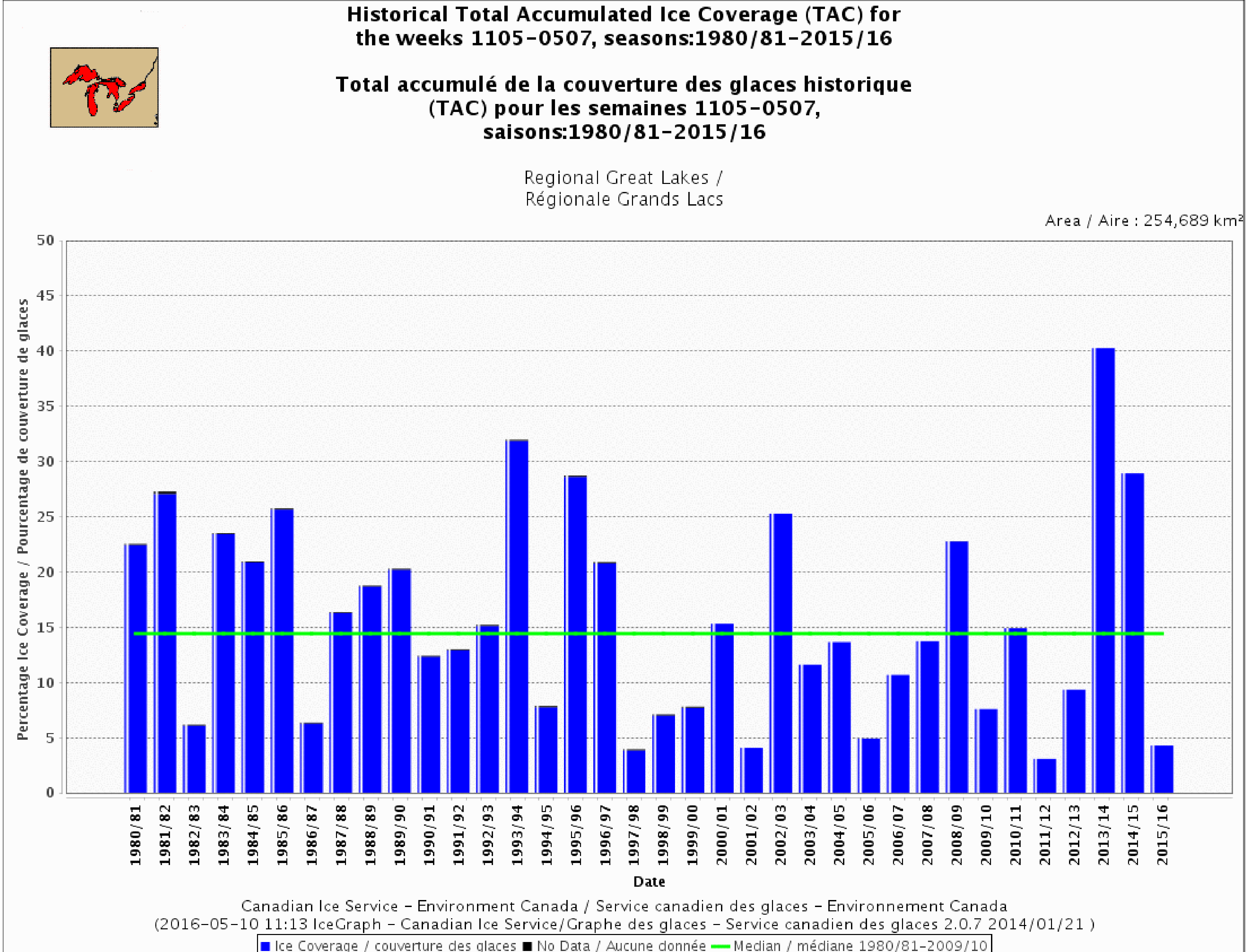

Annual Temperatures vs Year, Michigan
1895-2016
Temperature (F)
52
50
48
46
44
42
40
1900
1920
1940
1960
1980
2000
Year

Changes in the Length of the Frost Free Season

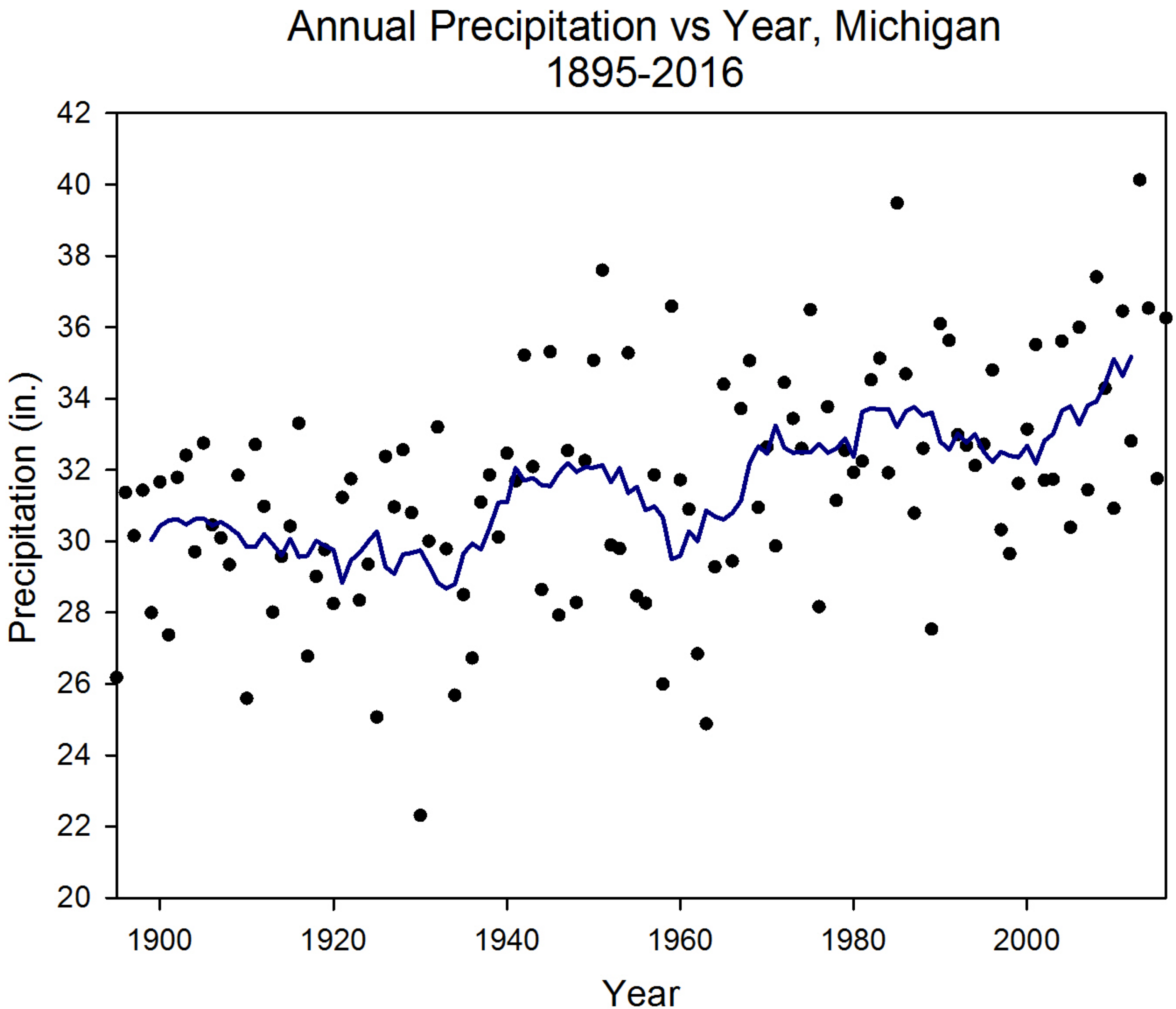
Great Lakes Region

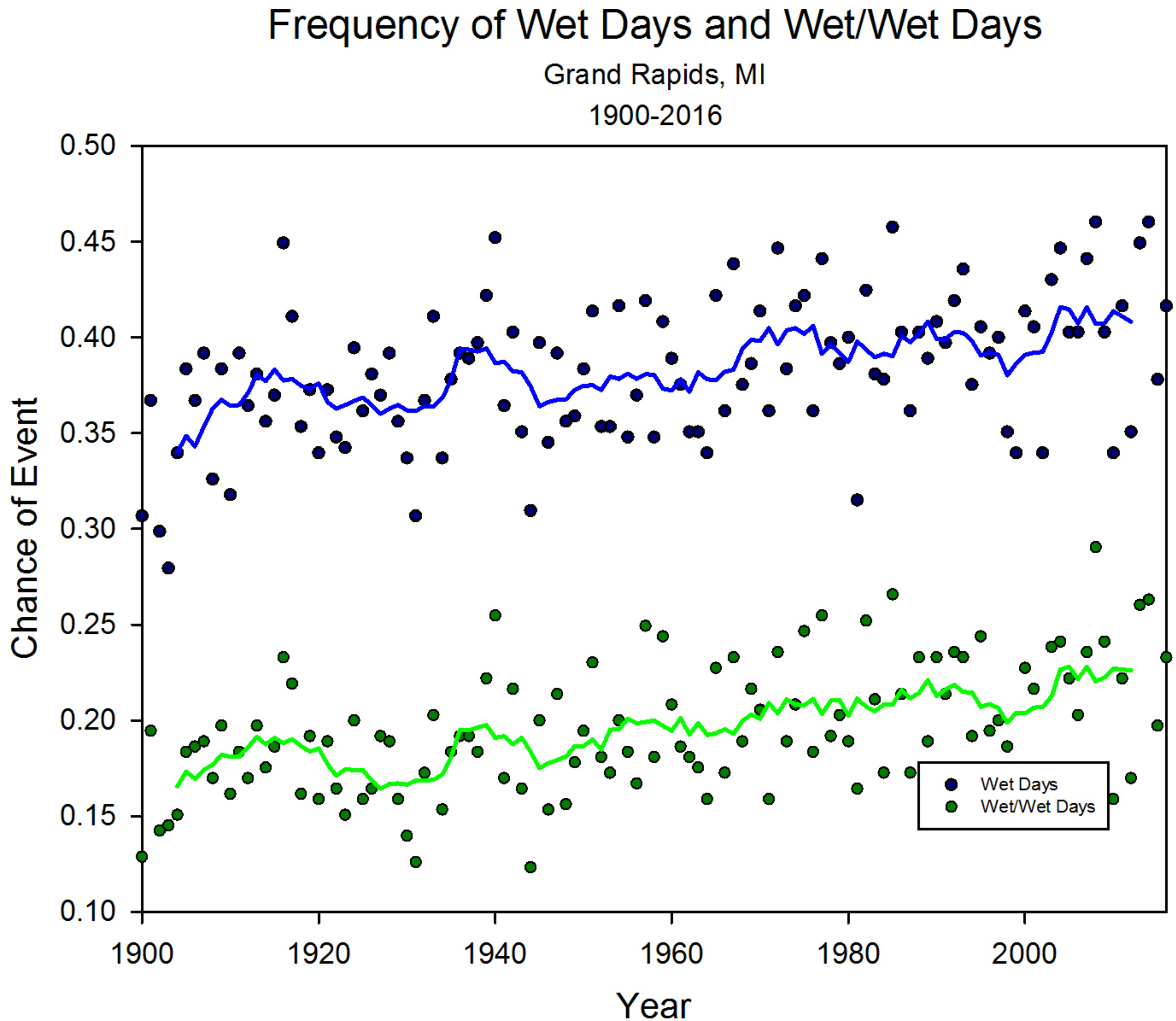


Source: K. Kunkel, Midwest. Reg. Clim. Center

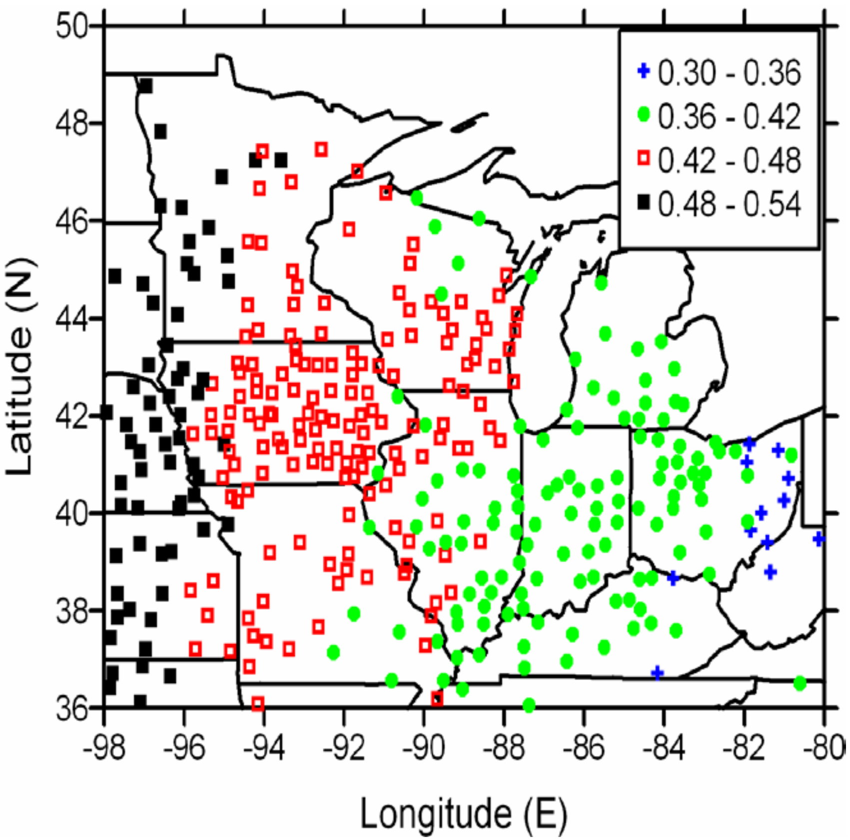


Historical Total Accumulated Ice Coverage (TAC) for
the weeks 1105-0507, seasons:1980/81-2015/16
Total accumulé de la couverture des glaces historique
(TAC) pour les semaines 1105-0507,
saisons:1980/81-2015/16
Regional Great Lakes /
Régionale Grands Lacs
Area / Aire : 254,689 km²
Percentage Ice Coverage / Pourcentage de couverture de glaces
50
45
40
35
30
25
20
15
10
5
0
1980/81
1981/82
1982/83
1983/84
1984/85
1985/86
1986/87
1987/88
1988/89
1989/90
1990/91
1991/92
1992/93
1993/94
1994/95
1995/96
1996/97
1997/98
1998/99
1999/00
2000/01
2001/02
2002/03
2003/04
2004/05
2005/06
2006/07
2007/08
2008/09
2009/10
2010/11
2011/12
2012/13
2013/14
2014/15
2015/16
Date
Canadian Ice Service - Environment Canada / Service canadien des glaces - Environnement Canada
(2016-05-10 11:13 IceGraph - Canadian Ice Service/Graphe des glaces - Service canadien des glaces 2.0.7 2014/01/21)
Ice Coverage / couverture des glaces
No Data / Aucune donnée
Median / médiane 1980/81-2009/10

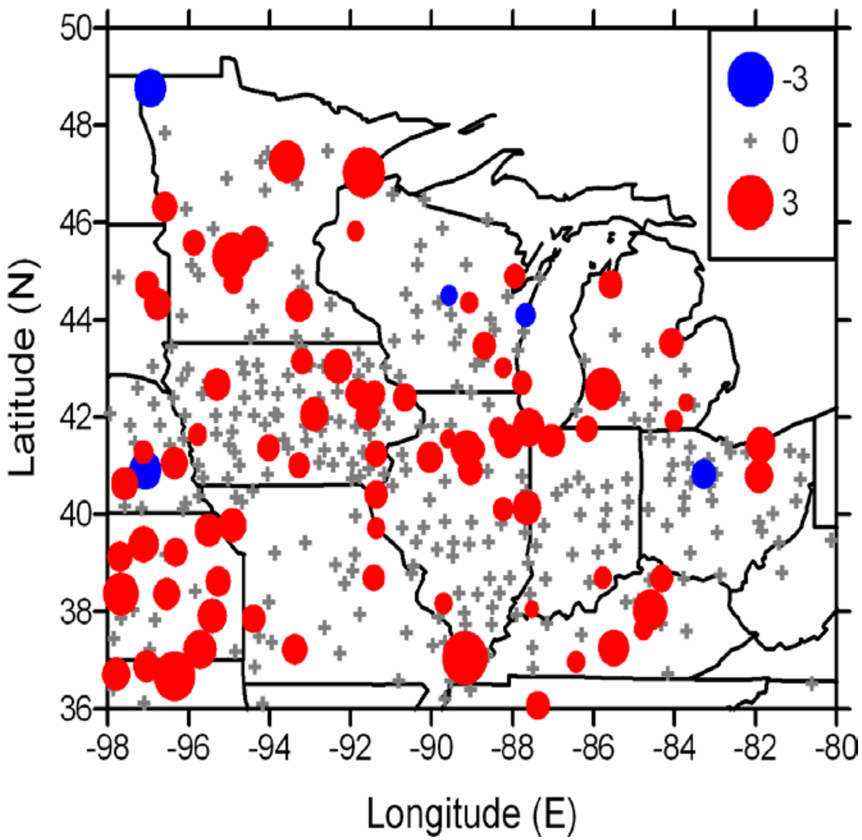

Annual Precipitation vs Year, Michigan
1895-2016
Precipitation (in.)
42
40
38
36
34
32
30
28
26
24
22
20
1900
1920
1940
1960
1980
2000
Year



(Source: MI State Climatologist's Office)

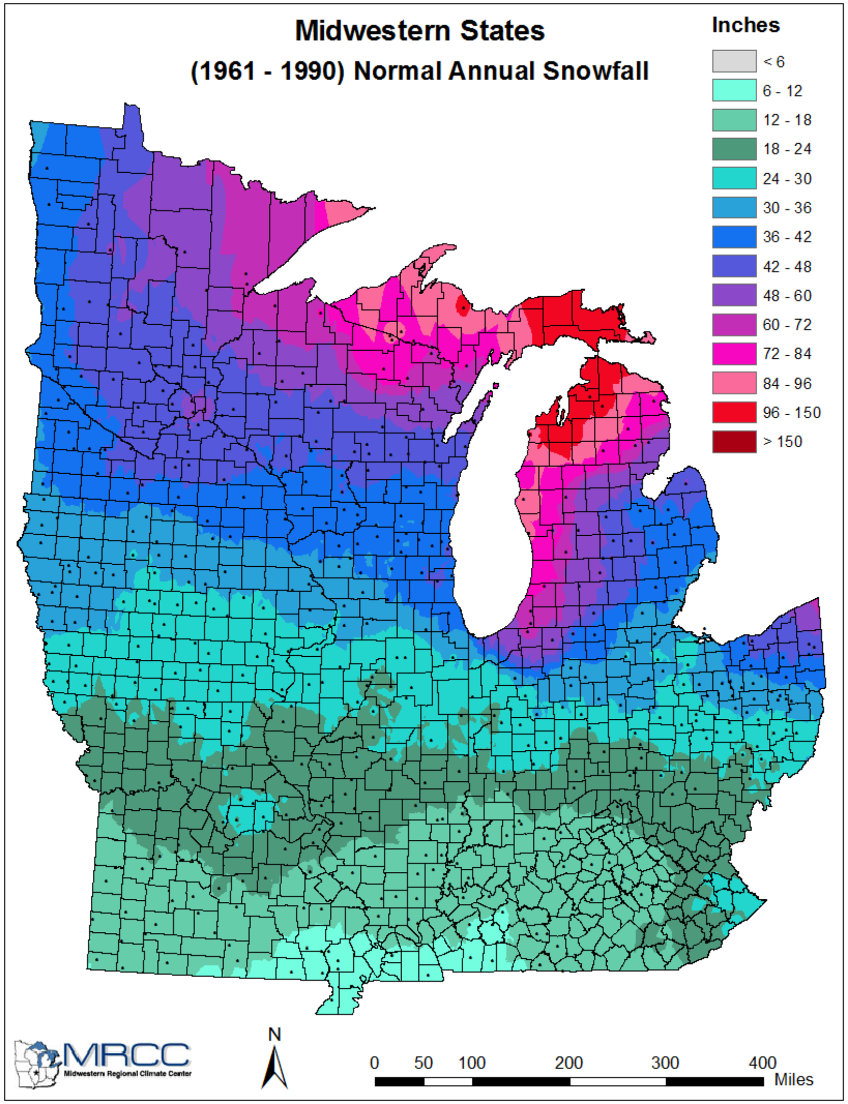


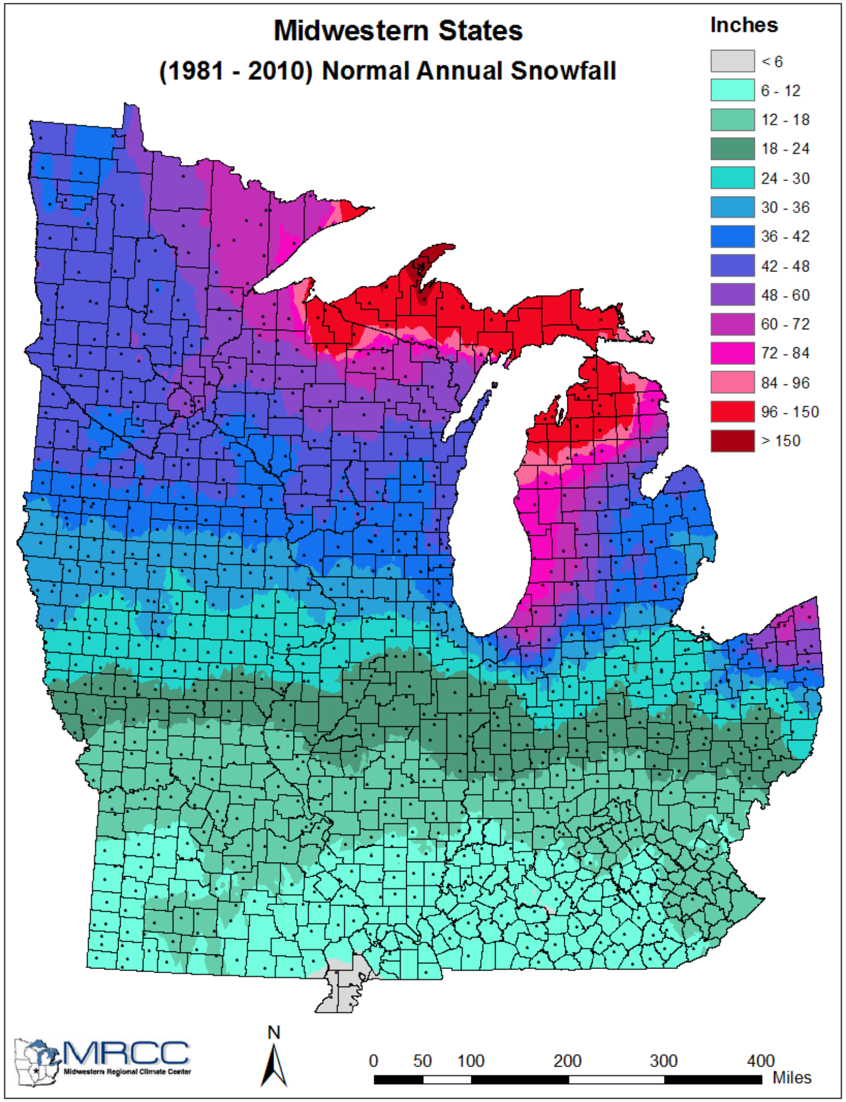
Mean fraction of annual precipitation derived from10 wettest days
1971-2000



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

(Pryor et al., 2009)

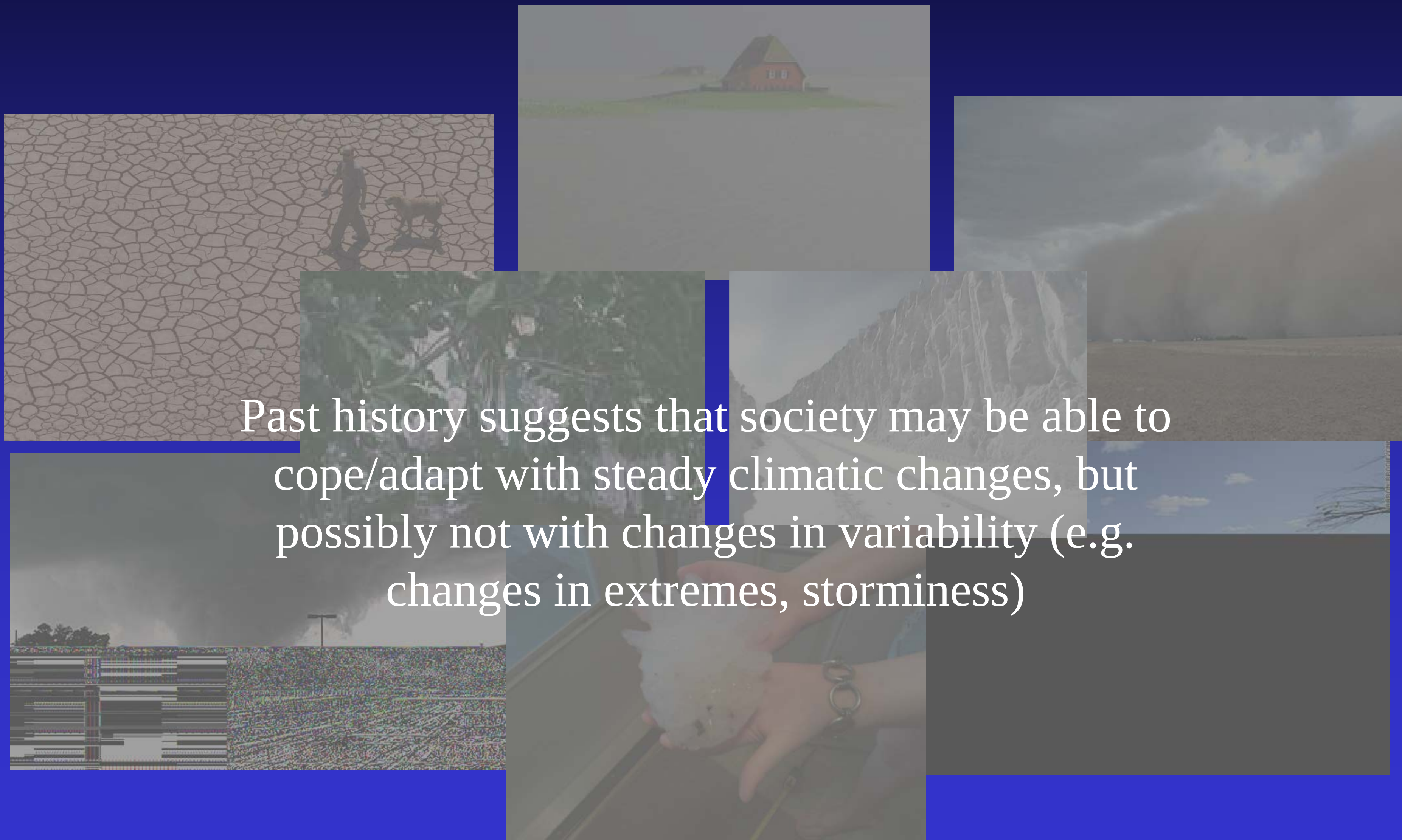




Mean seasonal total snowfall (inches)

(Midwestern Regional Climate Center)

Impacts of Climatic Variability



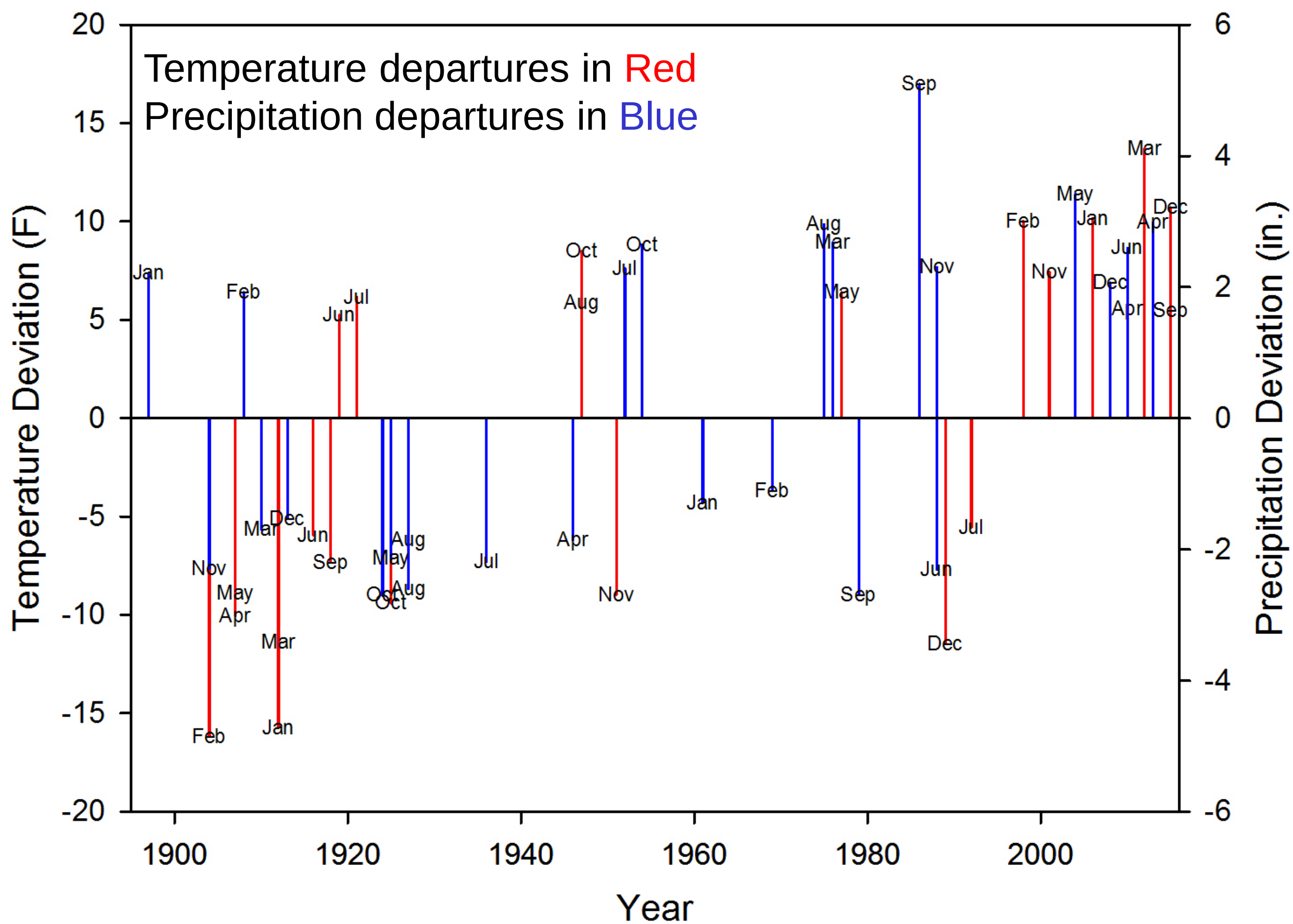
Past history suggests that society may be able to cope/adapt with steady climatic changes, but possibly not with changes in variability (e.g. changes in extremes, storminess)

Some Recent Extreme Weather Events in Michigan

- Heat wave, March 2012
- Major drought, summer 2012
- Wettest year on record in MI 2013
- Coldest winter in more than 100 years, 2013/2014
- Top ten coldest winter 2014/2015
- Record warm December 2015

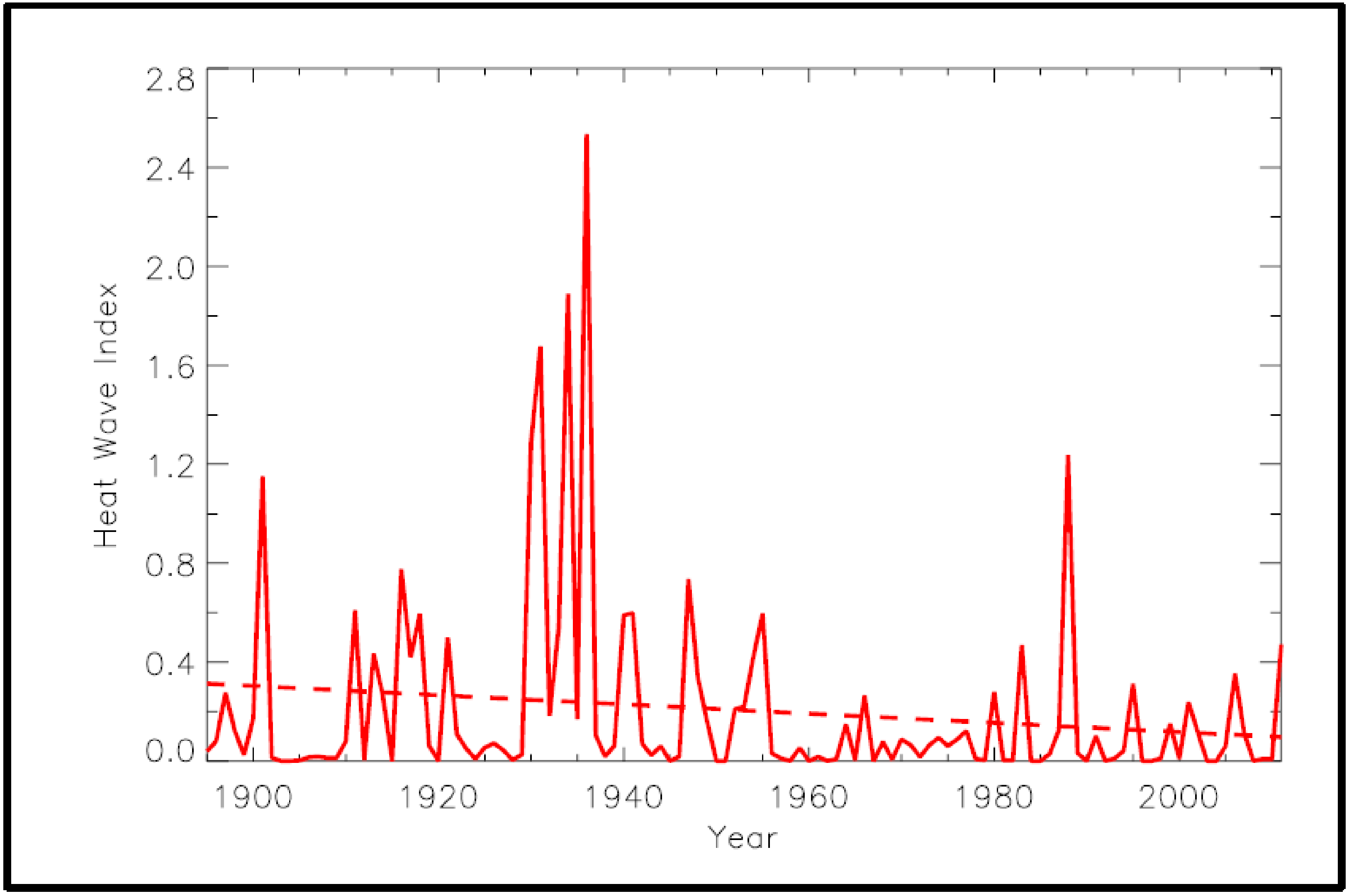
Monthly Mean Temperature and Precipitation Departure Extremes

Michigan, 1895-2016



Heat Wave Frequency

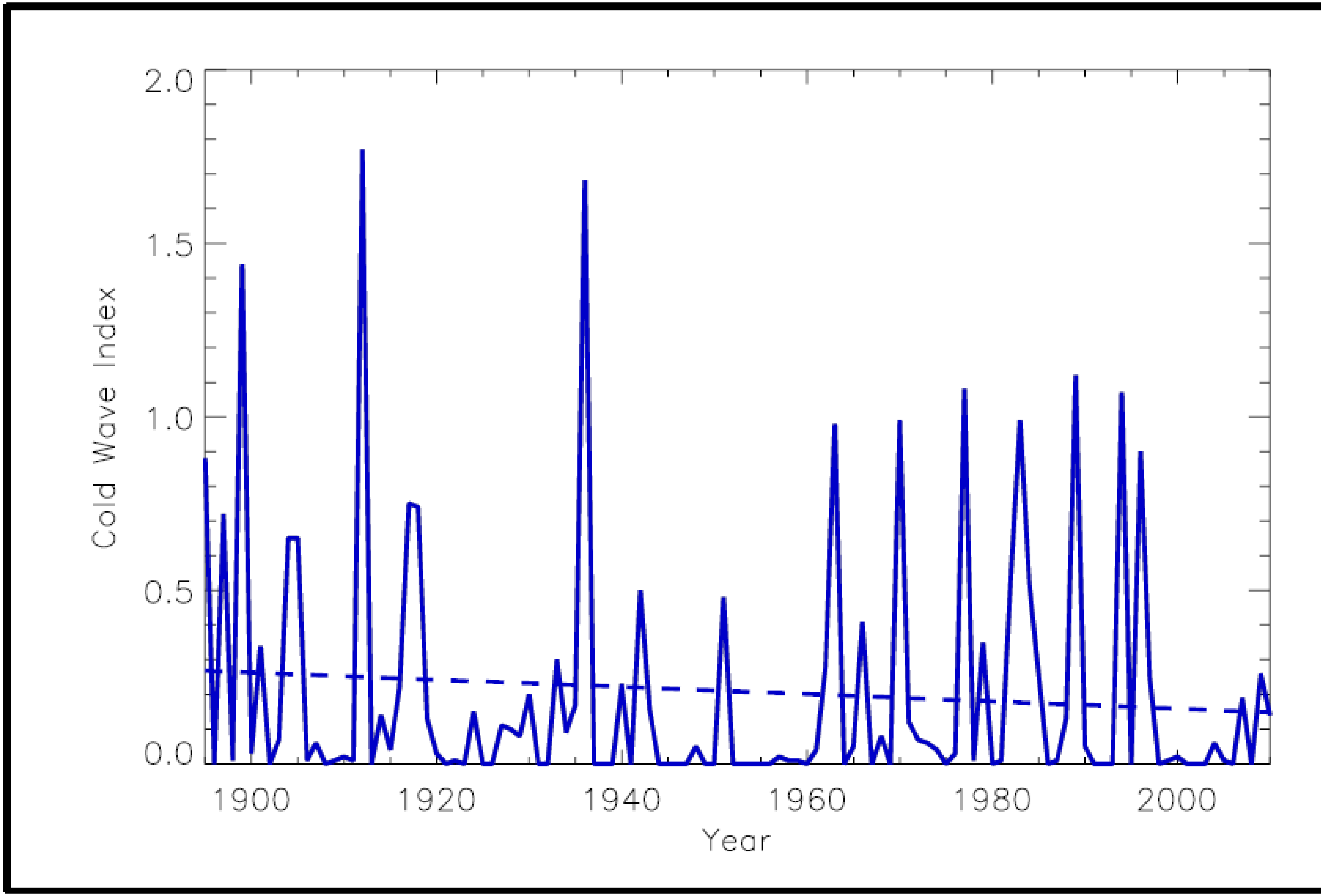
Midwest Region, 1895-2012



(Kunkel et al., 2013)

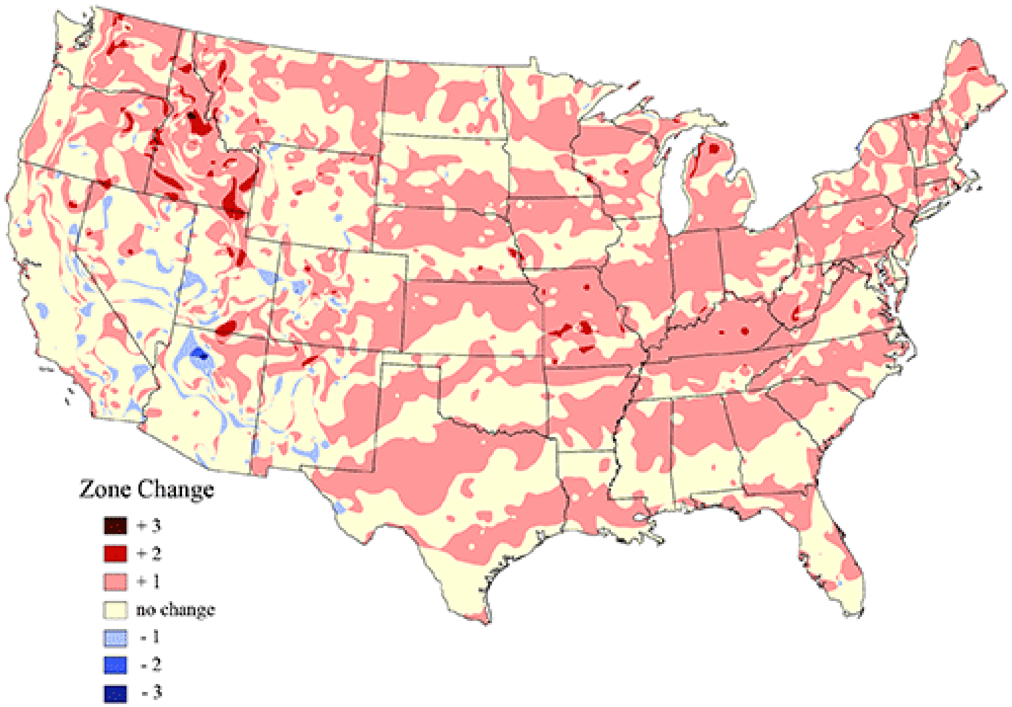
Cold Wave Frequency

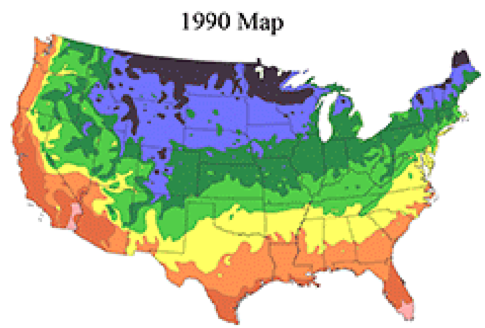
Midwest Region, 1895-2012



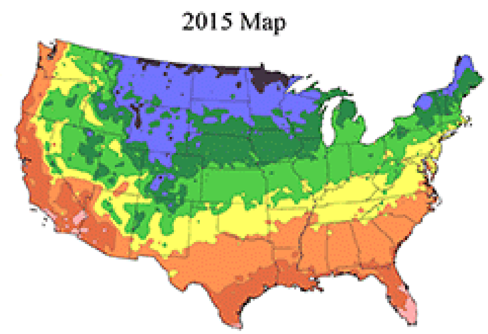
(Kunkel et al., 2013)

Differences Between 1990 USDA Hardiness Zones and 2015 Arborday.org Hardiness Zones





After USDA Plant Hardiness Zone Map, USDA Miscellaneous Publication No. 1475, Issued January 1990.



Arbor Day Foundation Plant Hardiness Zone Map published in 2015.

Zone

2 3 4 5 6 7 8 9 10

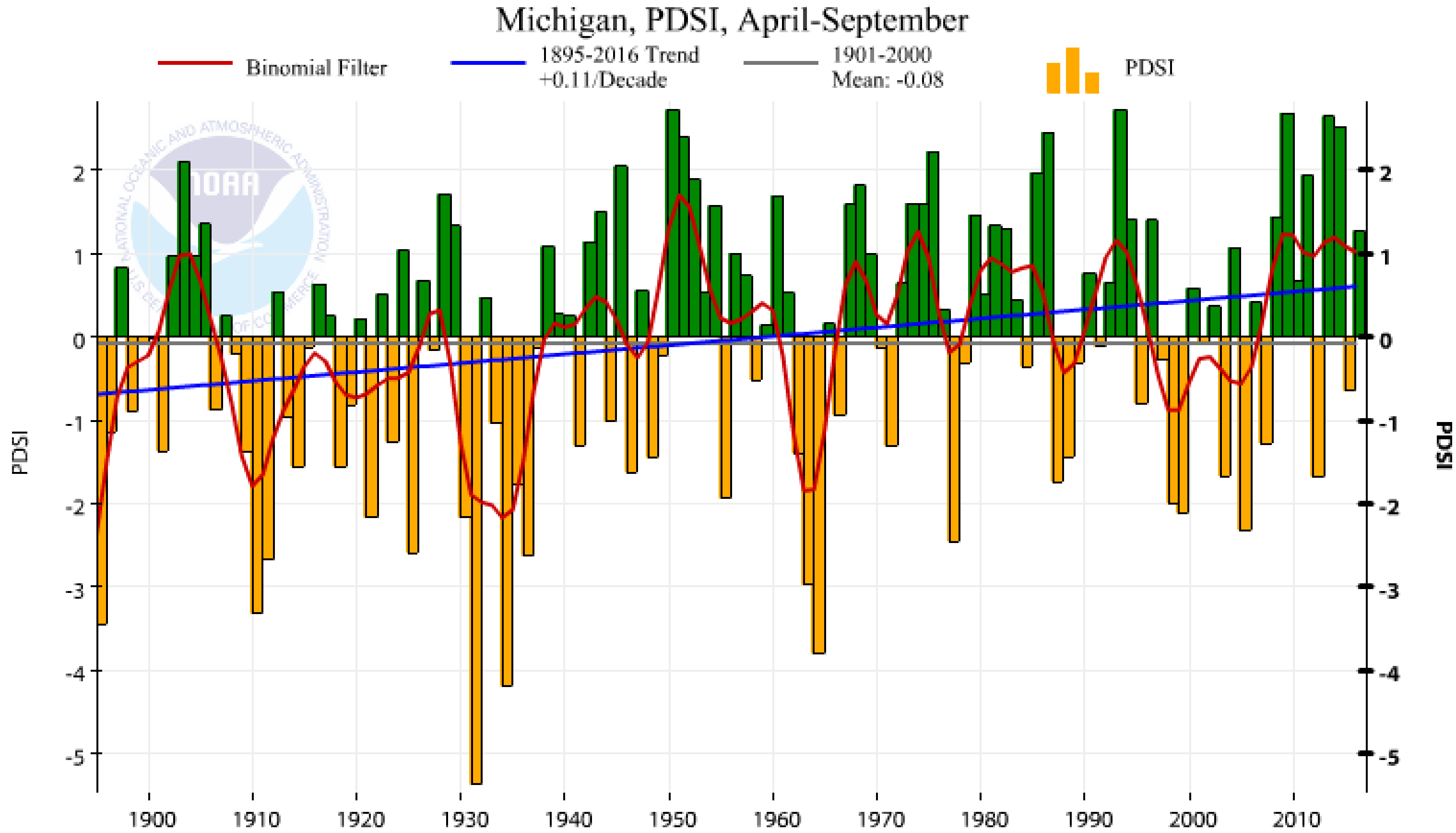
24-Hour Precipitation Totals (inches) for 2-100 Year Recurrence Intervals

Lansing, MI

	Recurrence Interval			
	2 Year	10 Year	50 Year	100 Year
TP 40 (1938-1957)	2.35	3.70	4.45	4.80
Huff and Angel (1948-1991)	2.35	3.25	4.45	5.25
NOAA Atlas 14 Vol. 8 (POR, 2013)	2.43	3.42	4.80	5.50

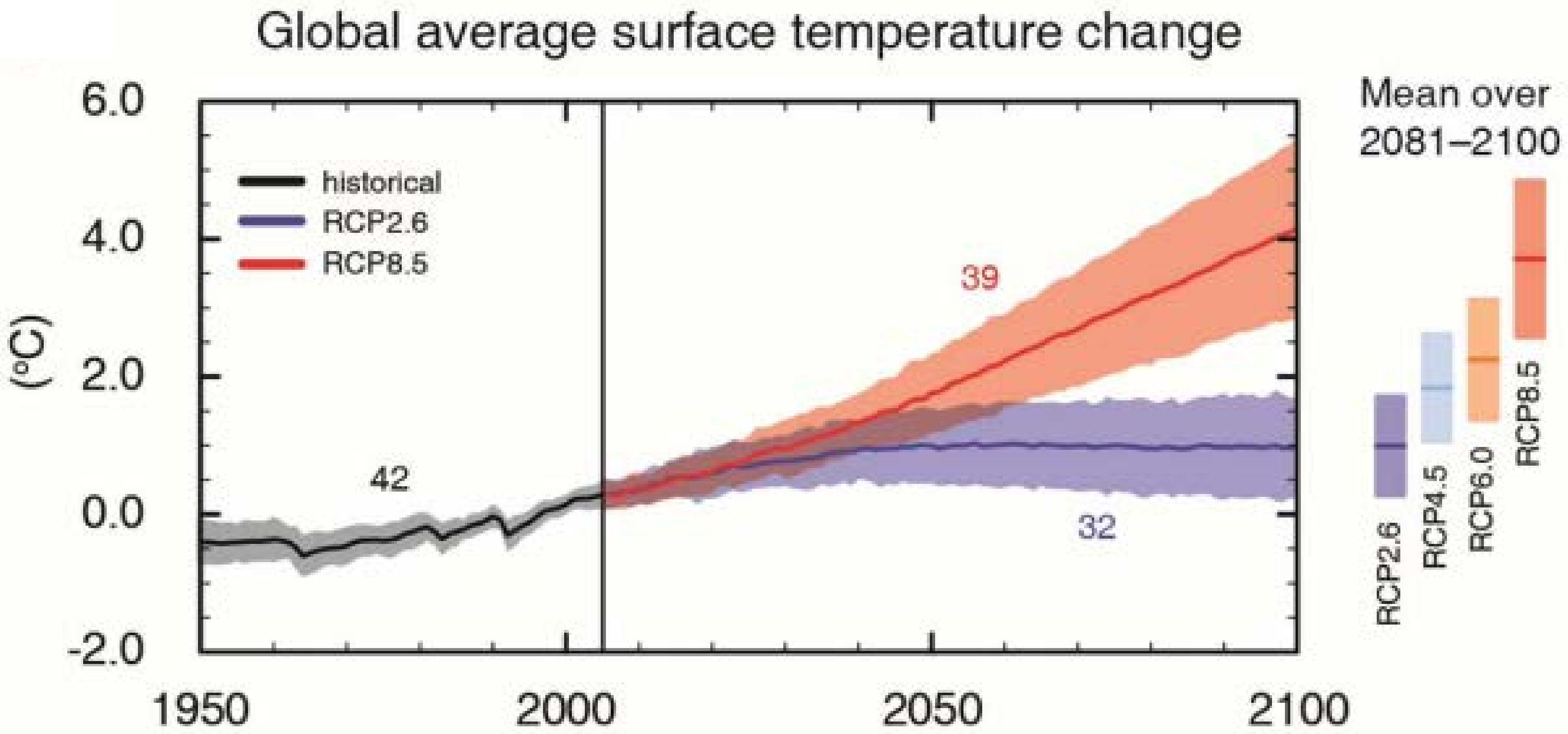
Growing Season Drought Severity

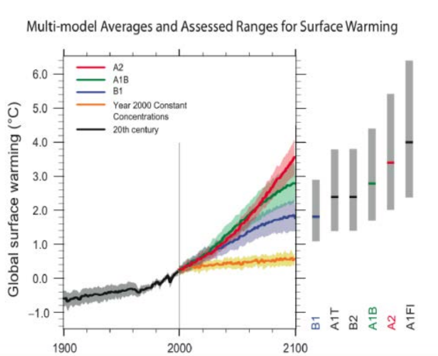
Michigan, 1895-2016



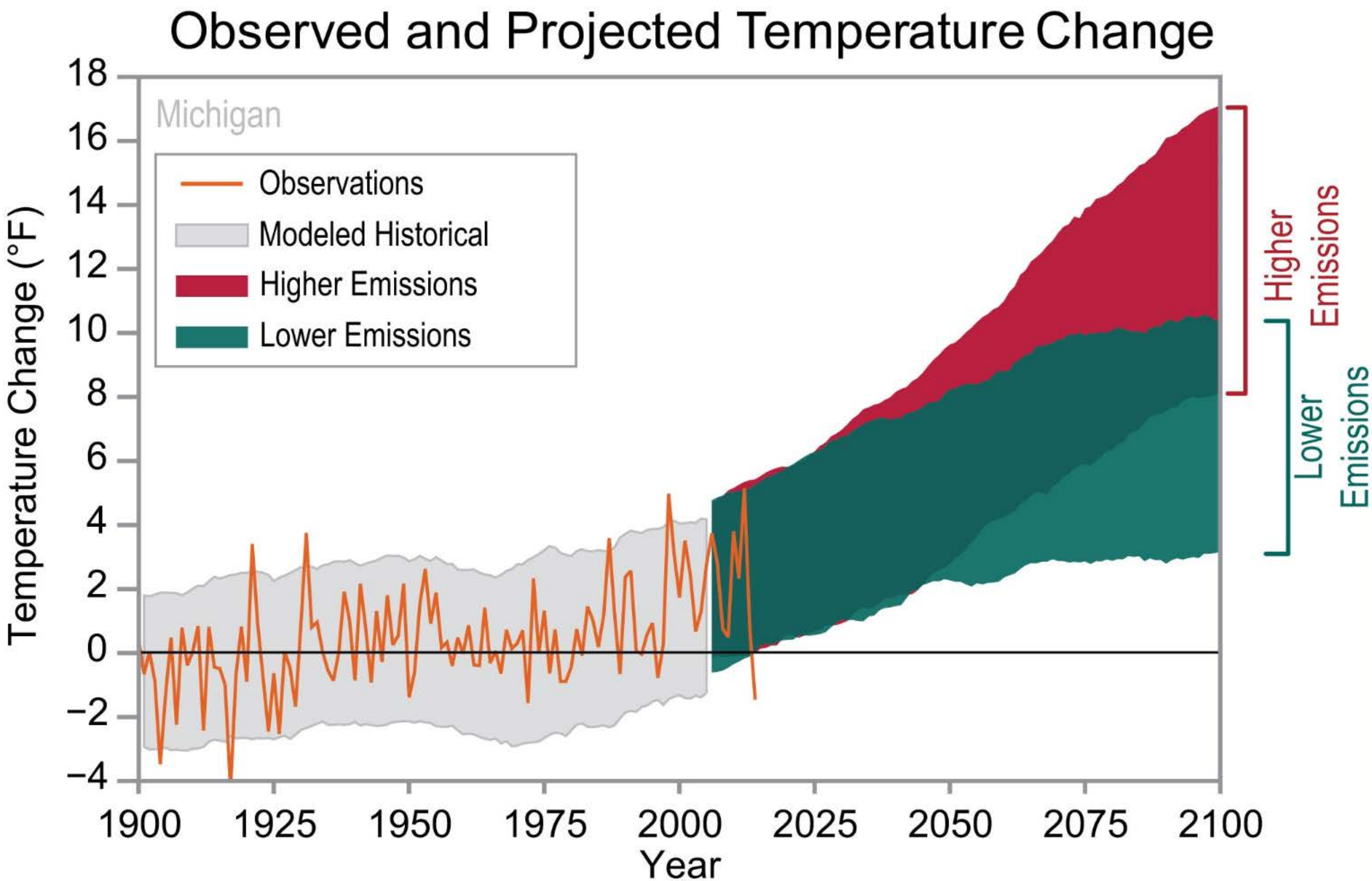
(Source: NOAA/NCEI, 2017)

Future Projections


Global average surface temperature change
6.0
4.0
2.0
0.0
-2.0
(°C)
historical
RCP2.6
RCP8.5
42
39
32
1950
2000
2050
2100
Mean over
2081–2100
RCP2.6
RCP4.5
RCP6.0
RCP8.5


Multi-model Averages and Assessed Ranges for Surface Warming
A2
A1B
B1
Year 2000 Constant
Concentrations
20th century
Global surface warming (°C)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
−1.0
1900
2000
2100
B1
A1T
B2
A1B
A2
A1FI

(IPCC, 2013)

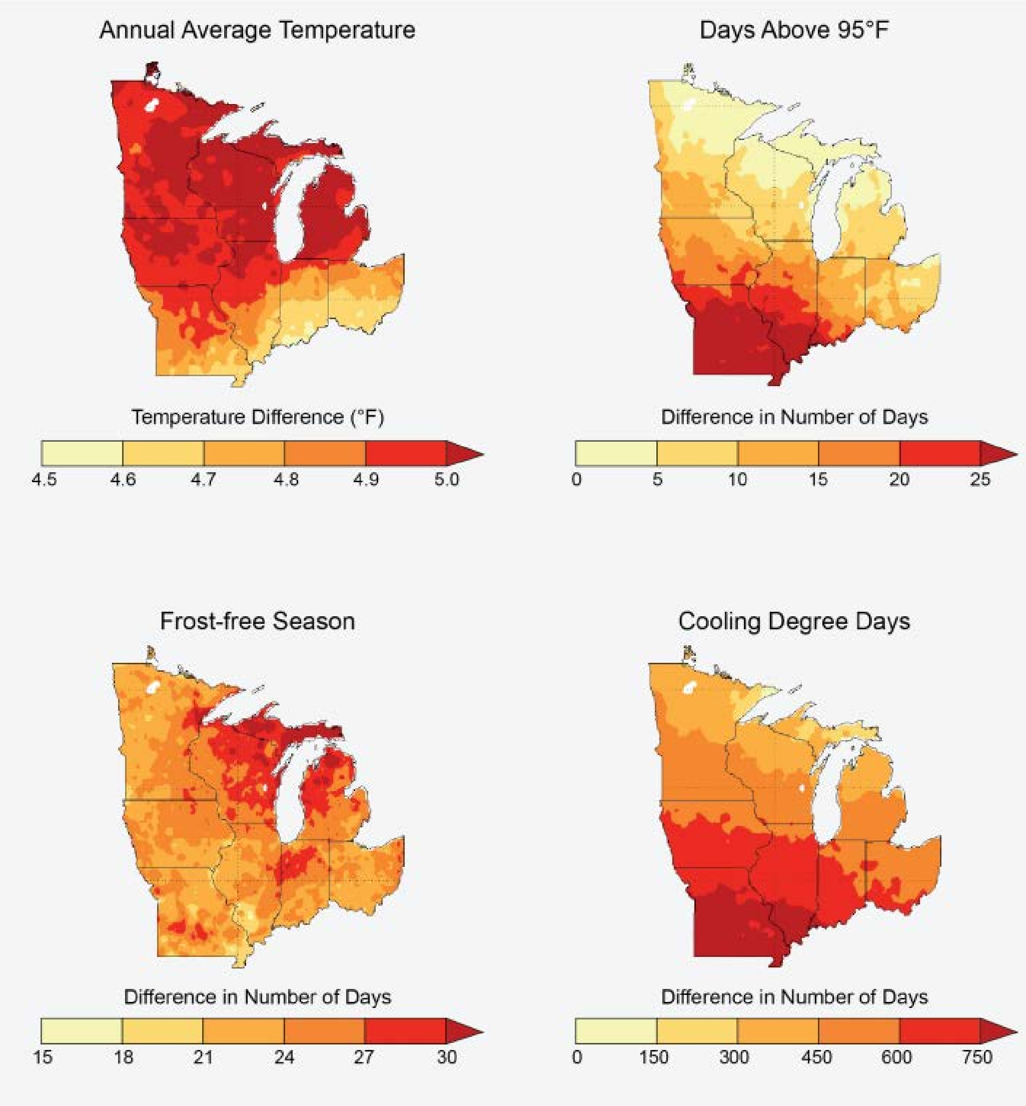


Observed and Projected Temperature Change
Michigan
Observations
Modeled Historical
Higher Emissions
Lower Emissions
Temperature Change (°F)
18
16
14
12
10
8
6
4
2
0
−2
−4
1900
1925
1950
1975
2000
2025
2050
2075
2100
Year
Higher Emissions
Lower Emissions

(NCICS, 2017)

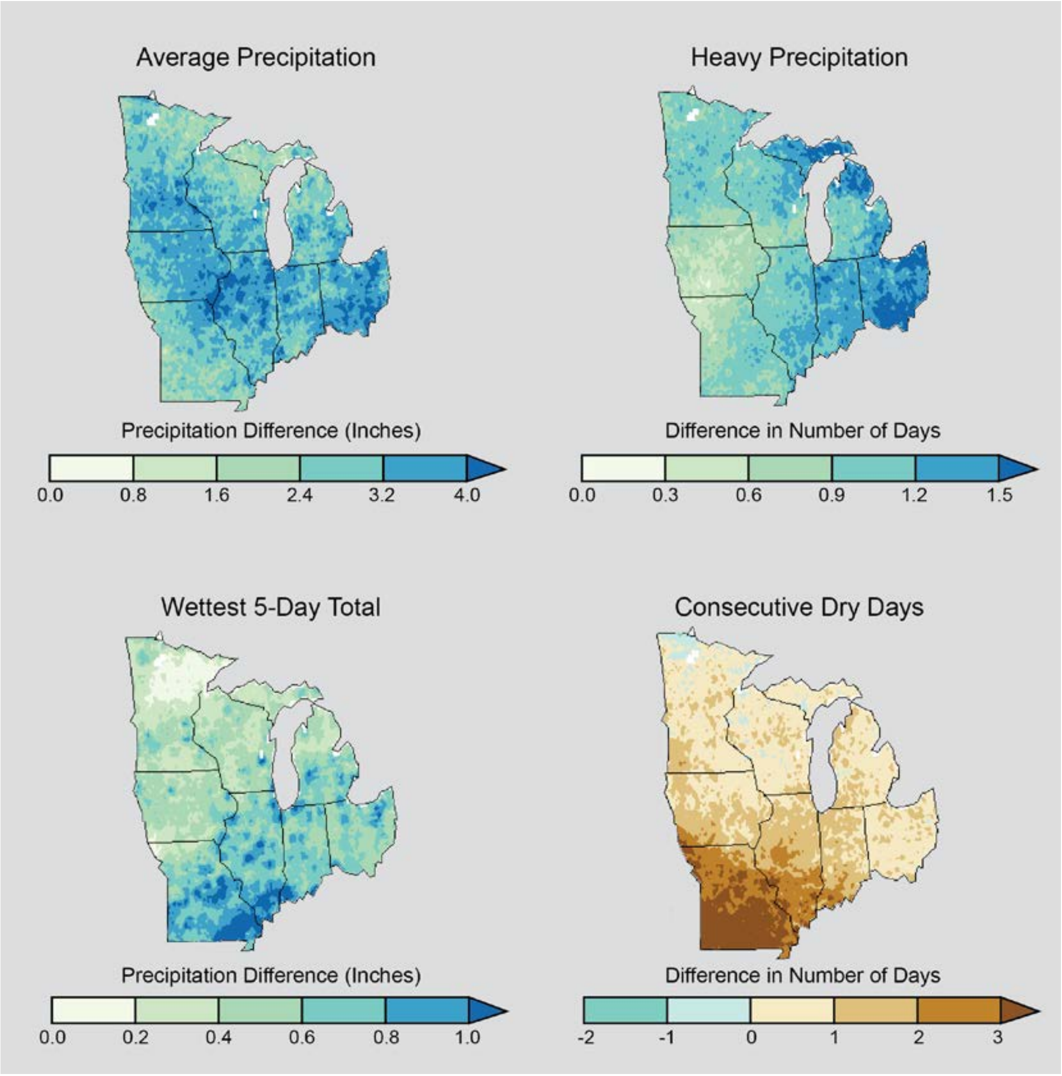
Projected Temperature-Related Changes

2041-2070 vs. 1971-2000



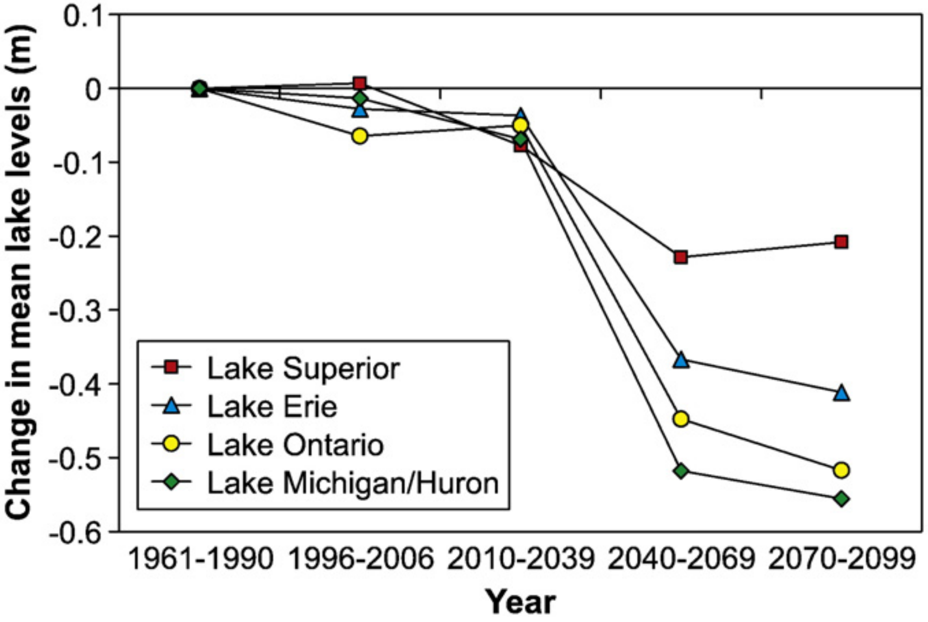
(Pryor and Scavia, 2013)

Projected Precipitation-Related Changes
2041-2070 vs. 1971-2000



(Pryor and Scavia, 2013)

Projected Great Lakes Levels



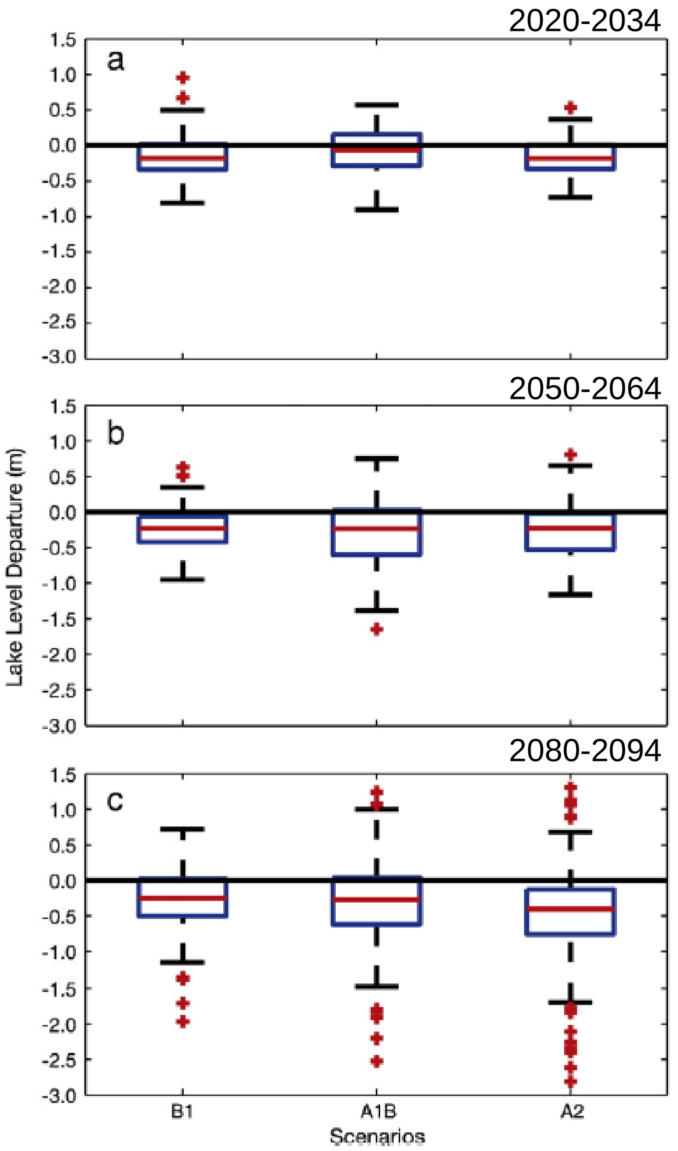


Fig. 7. Lake Michigan-Huron level departure (m) distributions based on the GCM/GLERL simulations for the three emission scenarios for (a) 2020–2034, (b) 2050–2064, and (c) 2080–2094.

**** More recent results by Lofgren et al (2011) and Gronewold et al (2013) suggest smaller changes in future lake levels*

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

Potential Water Quality Related Impacts

- In general, warmer climates should result in higher water temperatures.
- Increasing frequency of extremes (including both floods and droughts) may exacerbate many forms of water pollution ranging from sediment load, nutrients, and dissolved organic carbon to pathogens, pesticides, and salt. They may also modify water quality by direct effects of dilution or concentration of dissolved substances and enhance decomposition and flushing of organic matter into streams.
- Microorganism activity (and associated removal of pollutants) is projected to change in response to increased temperature and increased or decreased streamflow.
- Land use change, deforestation, urban sprawl, and the increase of impermeable surfaces may also contribute to water quality degradation.

(IPCC, 2013)

Summary

- Overall, mean average temperatures in Michigan rose approximately 1.0ºF during the past century. Warming of about 2.0ºF has occurred between 1980 and the present.
- Milder winter temperatures have led to less ice cover on the Great Lakes and the seasonal spring warm-up is occurring earlier than in the past.
- Annual precipitation rates increased from the 1930's through the present, due both to more wet days and more extreme 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.
- Projections of future climate change in Michigan suggest a mix of beneficial and adverse impacts.
- A changing climate leads to many potential challenges for dependent human and natural systems, especially with respect to climate variability.
- Given the projected rate of climate change, adaptive planning strategies should be dynamic in nature


Thank You!
Photo Credit: Dan Brown