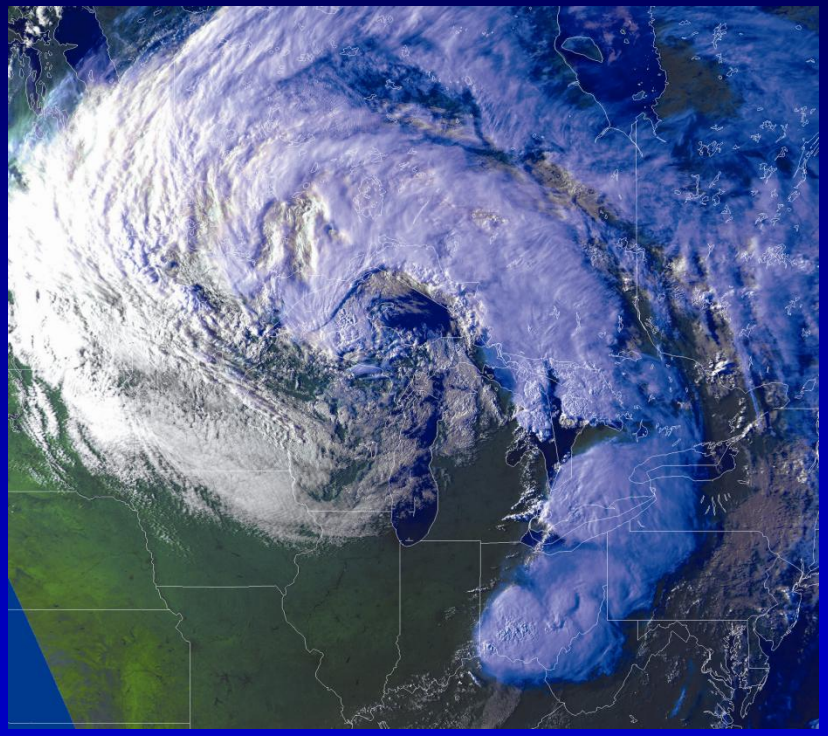
Historical Trends and Projected Future Climate Changes in the Great Lakes Region



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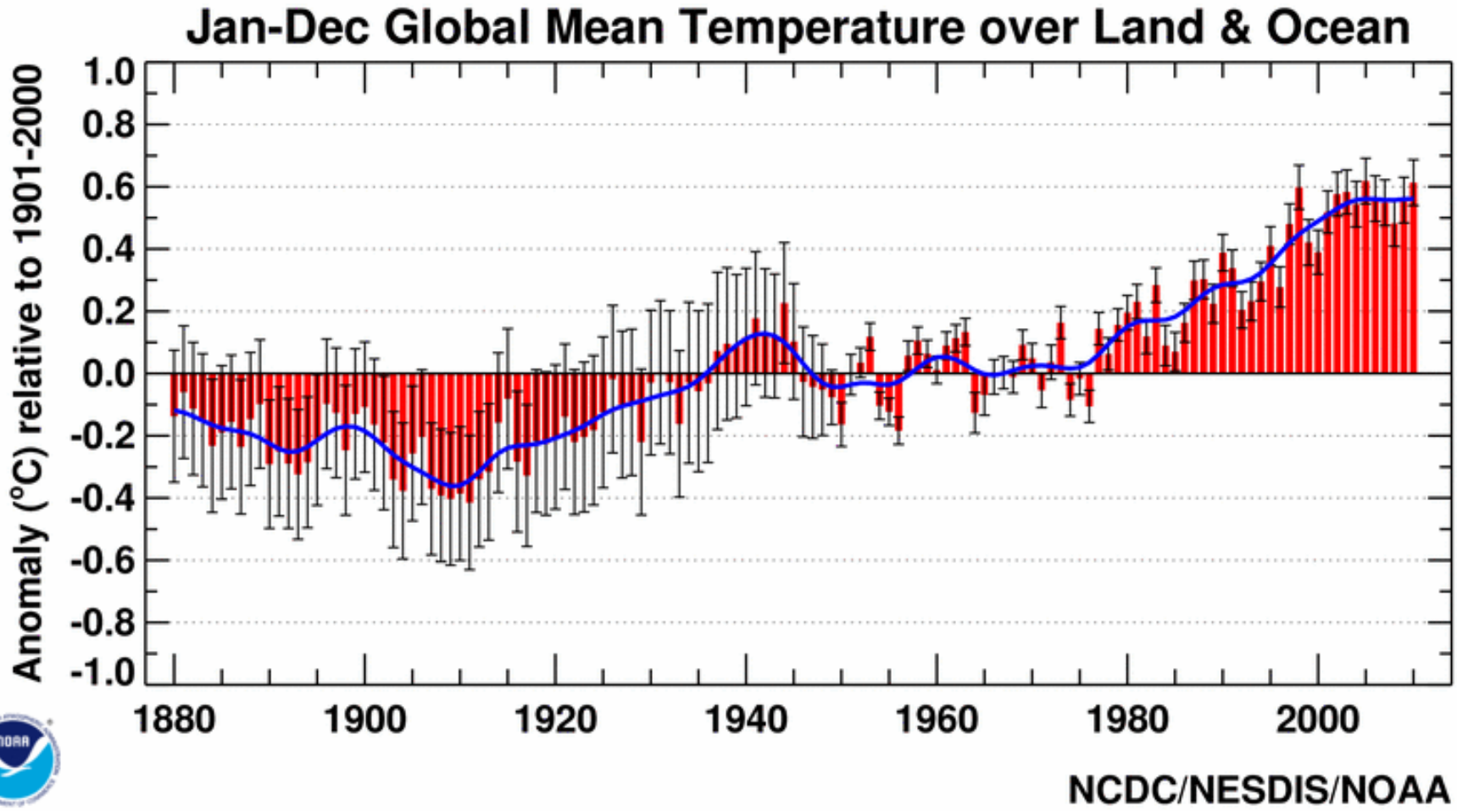
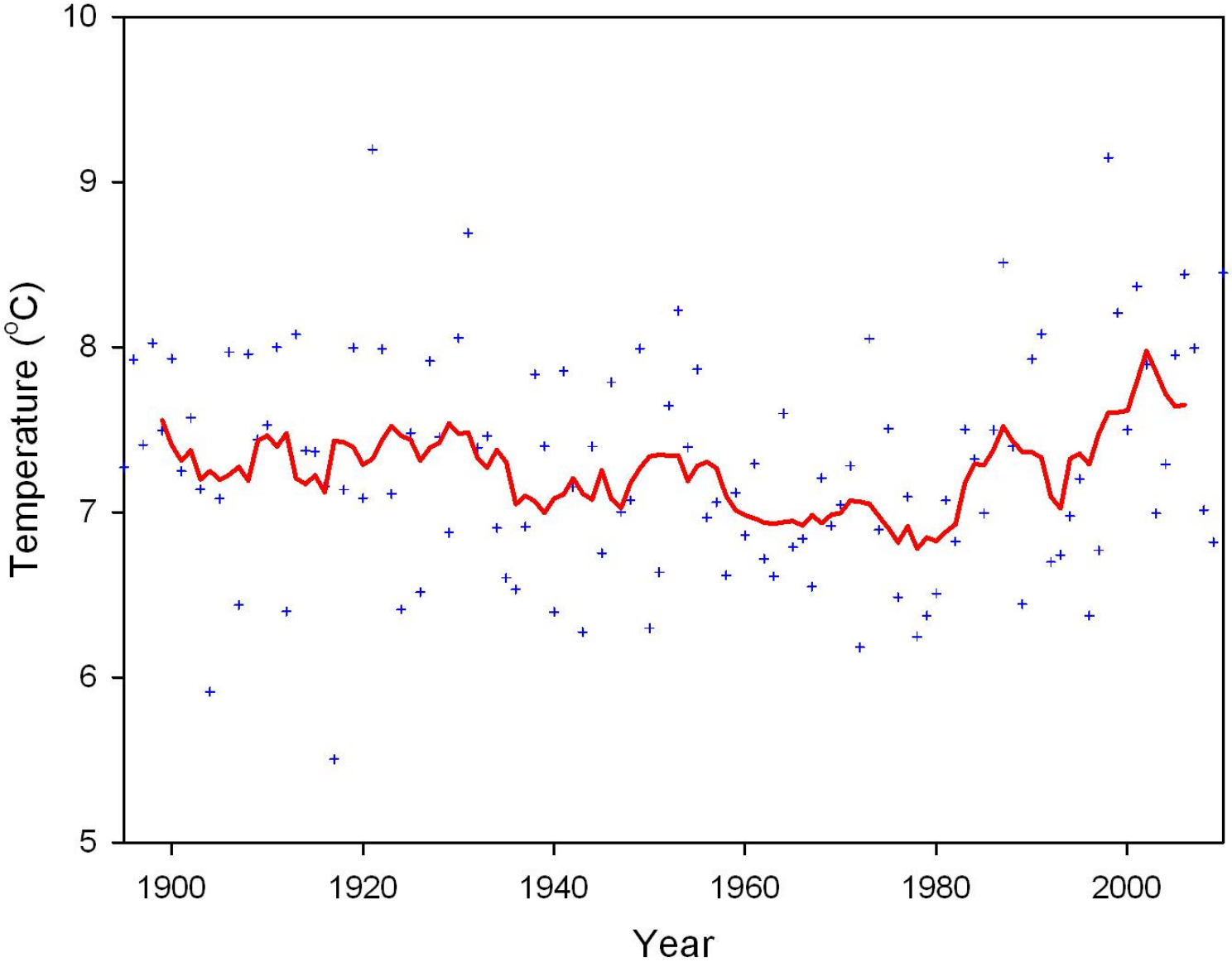
GREAT LAKES INTEGRATED SCIENCES + ASSESSMENTS

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

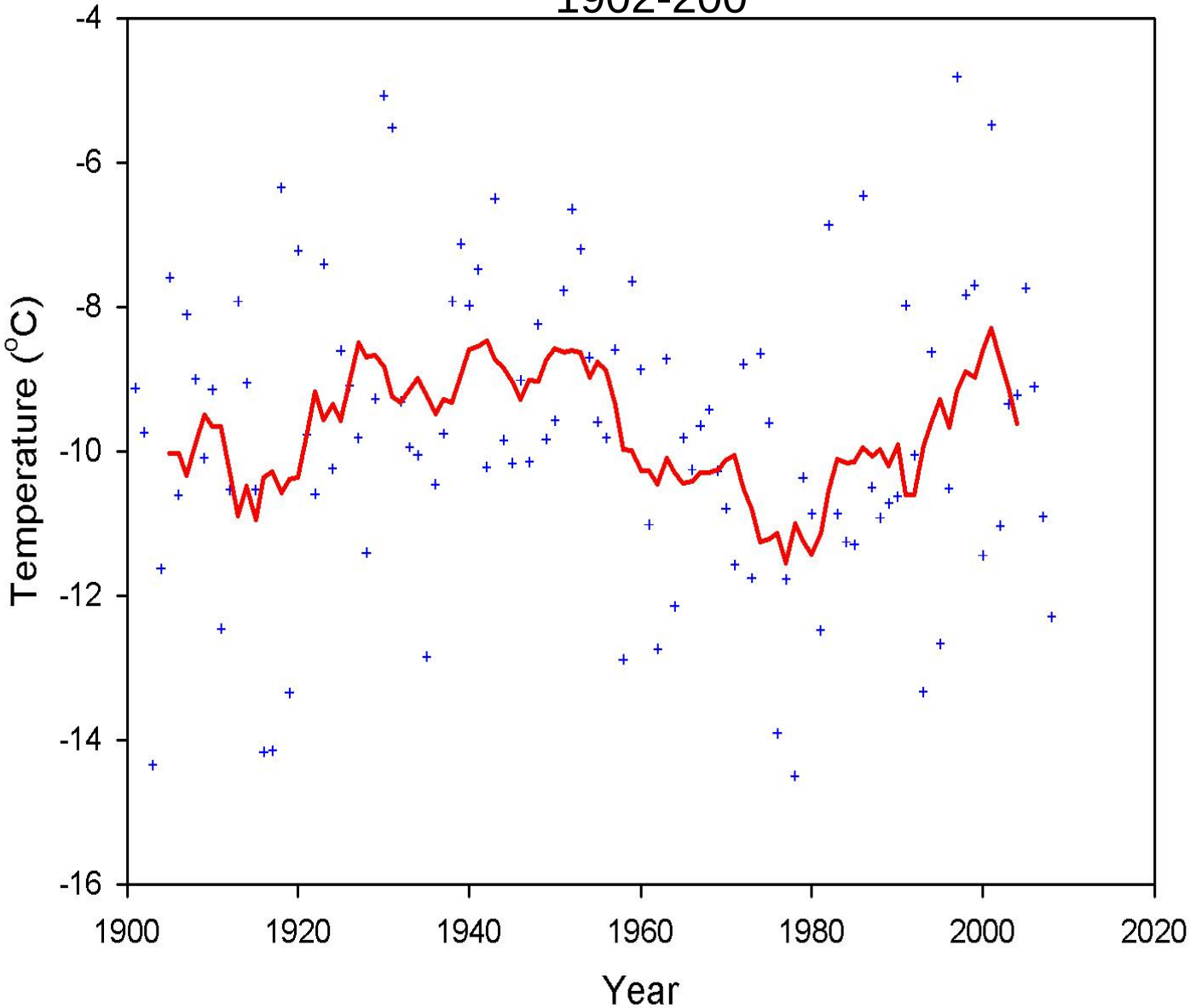
Mean Temperatures vs. Year, Michigan 1895-2010



Mean Winter Temperatures vs. Year

Ironwood, MI

1902-200



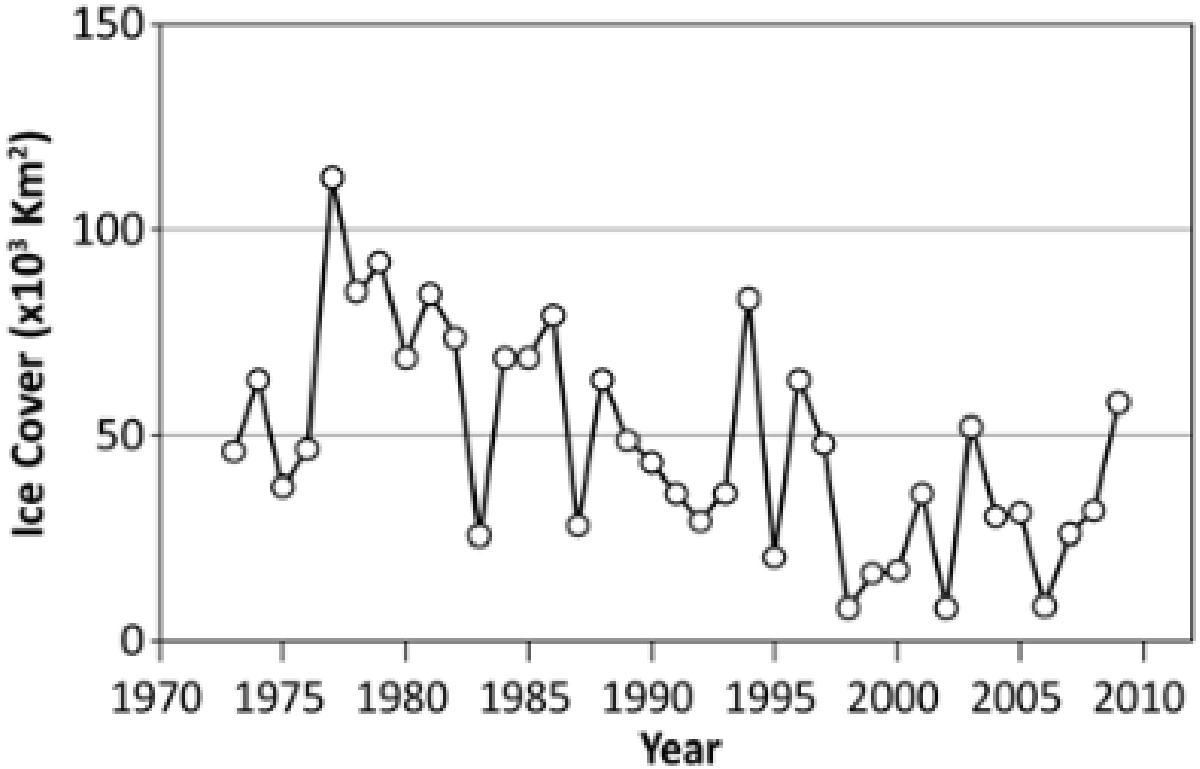
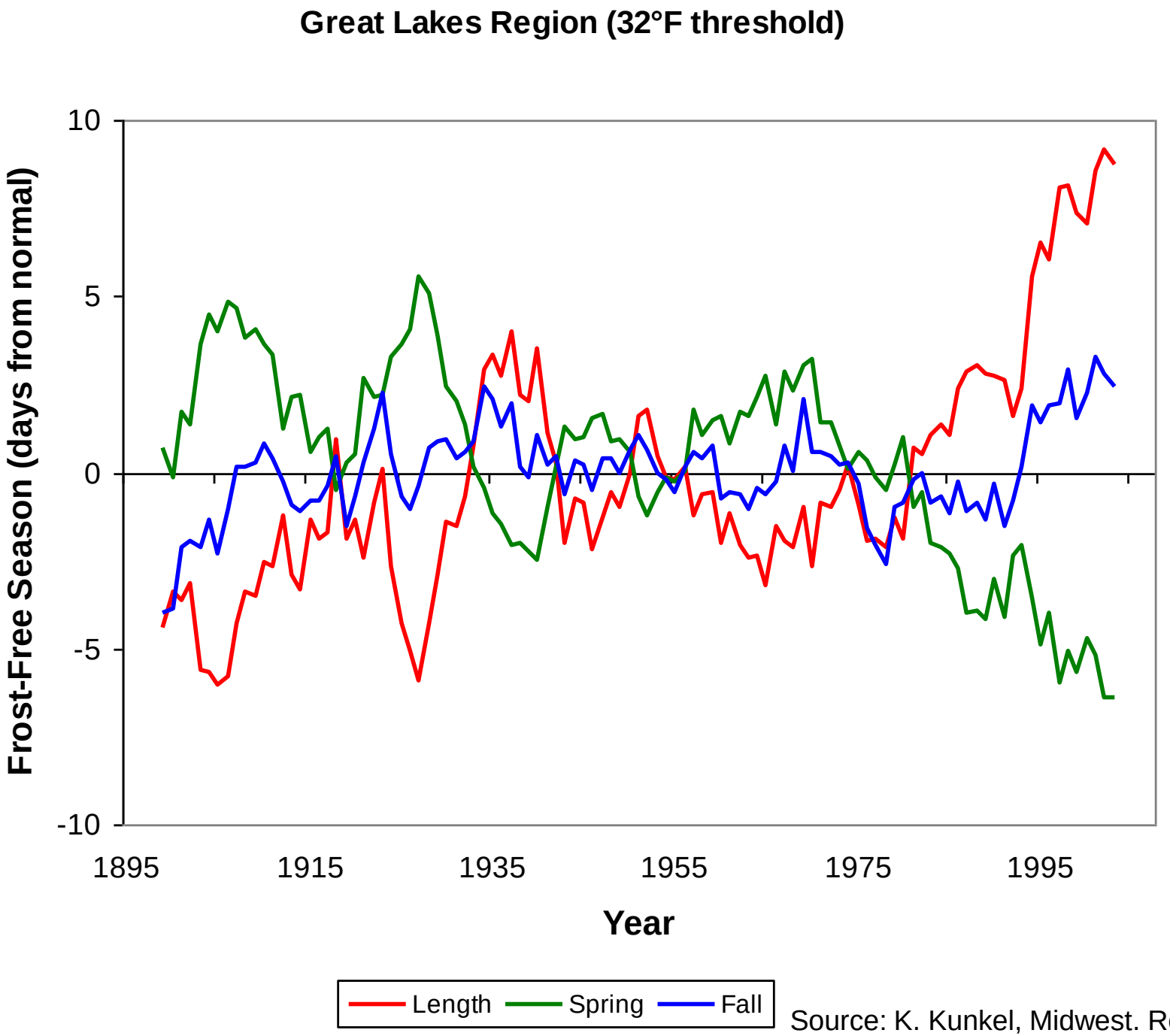
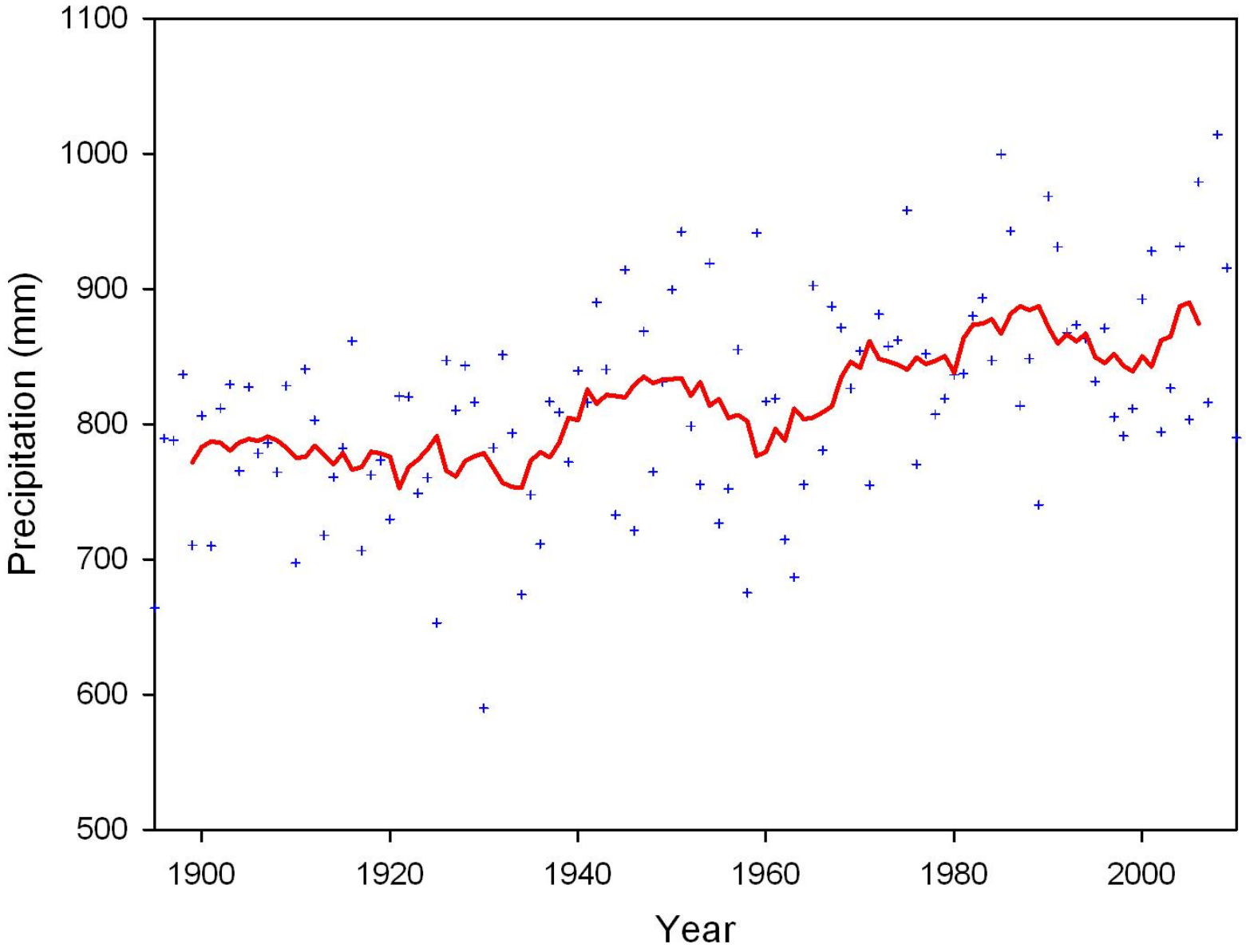


Figure 10. Time series of annual averaged ice area for the Great Lakes. From Wang et al. (2010).



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

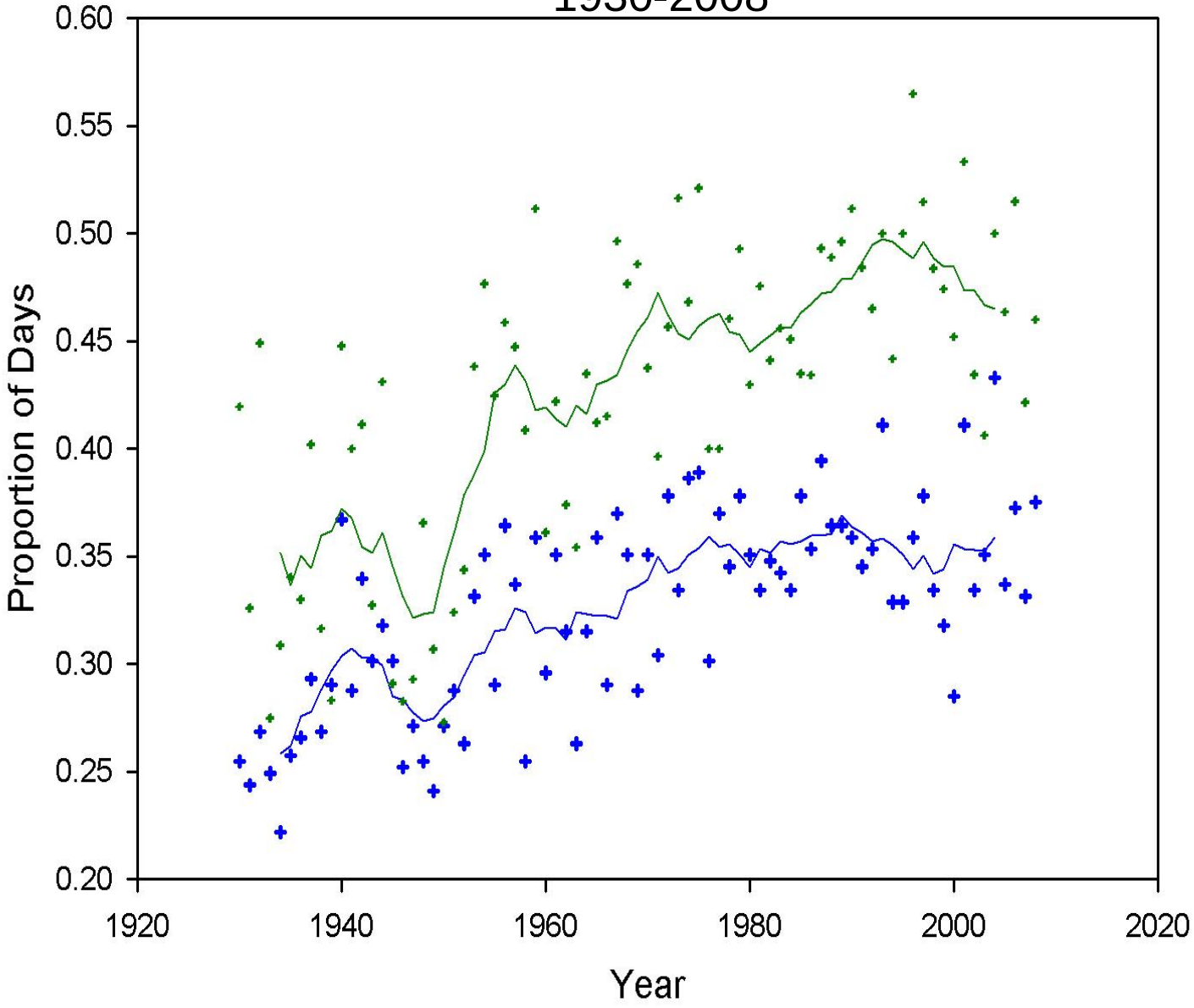
Annual Precipitation vs. Year, Michigan
1895-2010



Frequency of Wet Days and Wet/Wet Days

Caro, MI

1930-2008



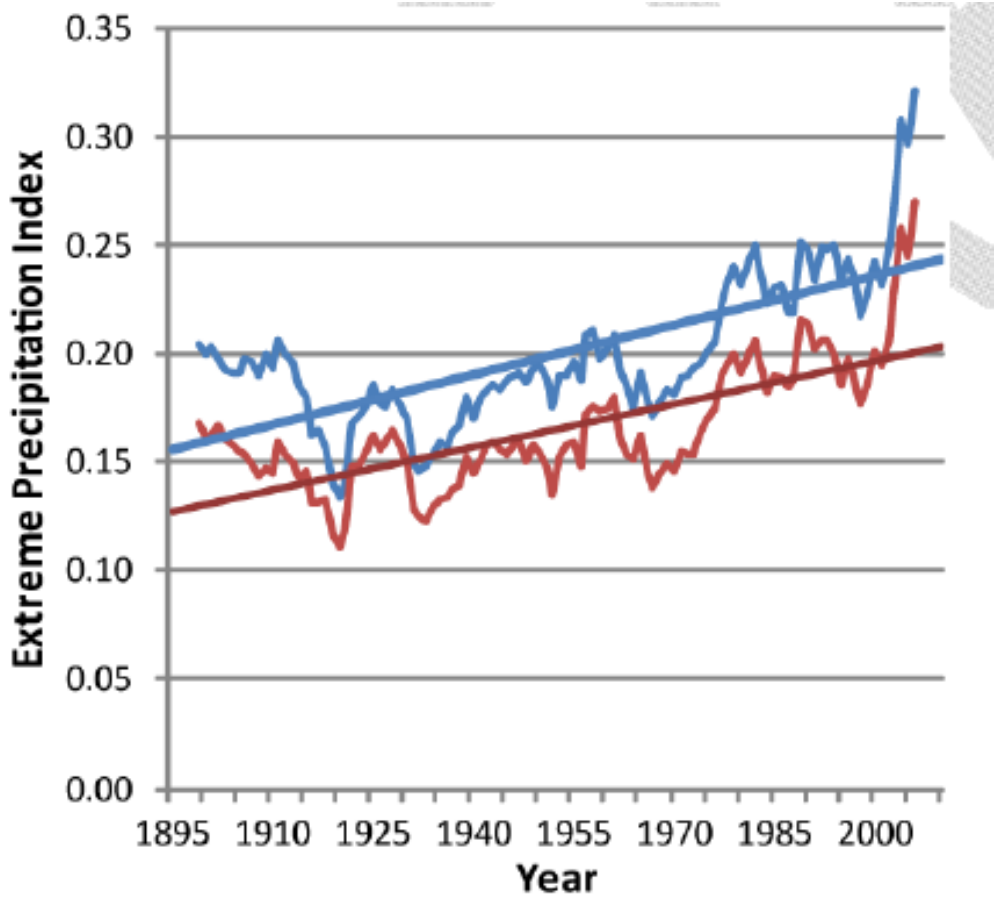
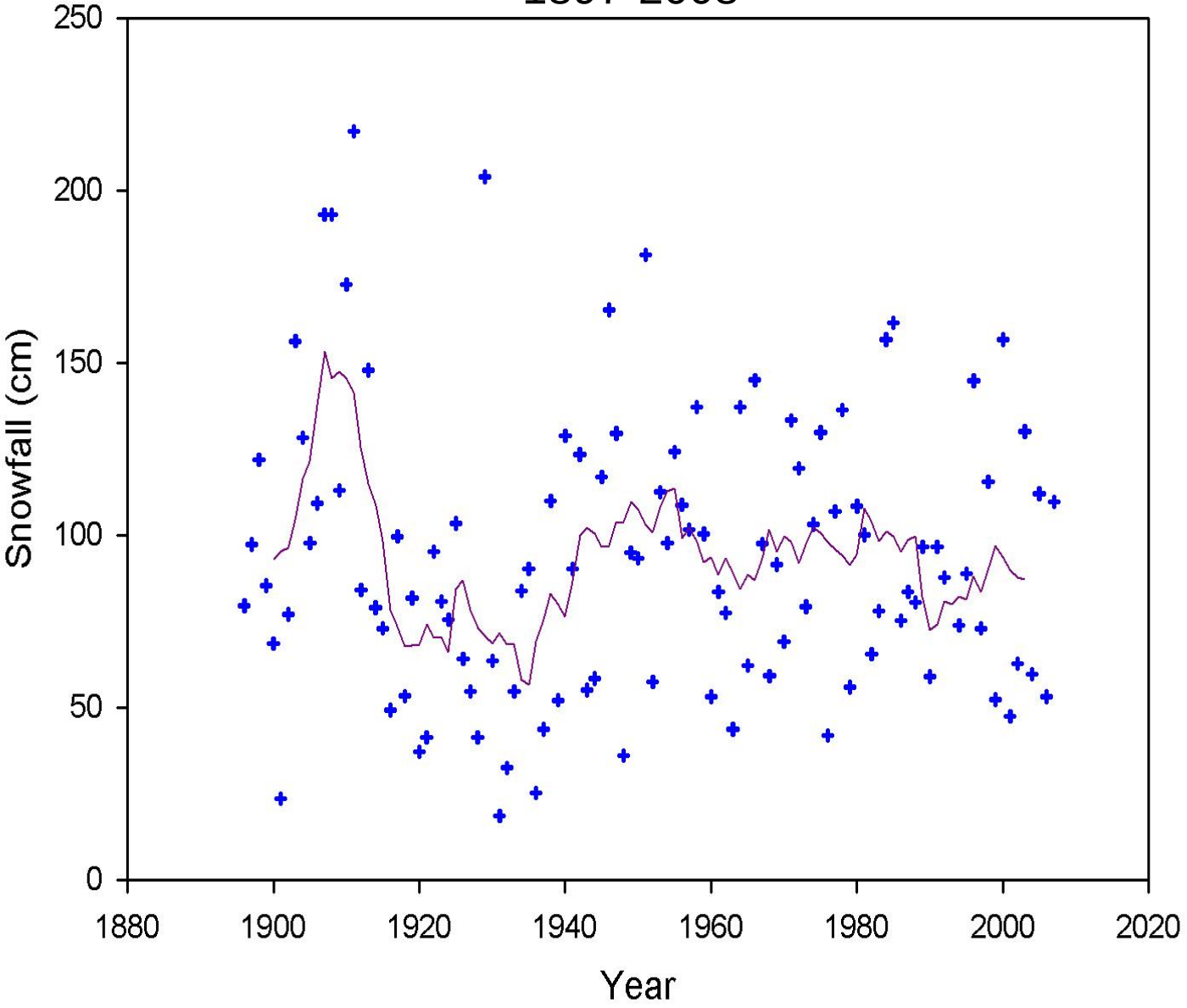


Figure 4. Time series of extreme precipitation index for the occurrence of 1-day, 1 in 5 year extreme precipitation events. The annual time series and linear trend (straight line) are shown in blue. A time series for the months of May through September is shown in red. Analysis is average for the states of IL, IN, IA, MI, MN, MO, OH, and WI. Based on data from the National Climatic Data Center for the cooperative observer network and updated from Kunkel et al. (2003).

Total Seasonal Snowfall vs. Year

Bay City, MI

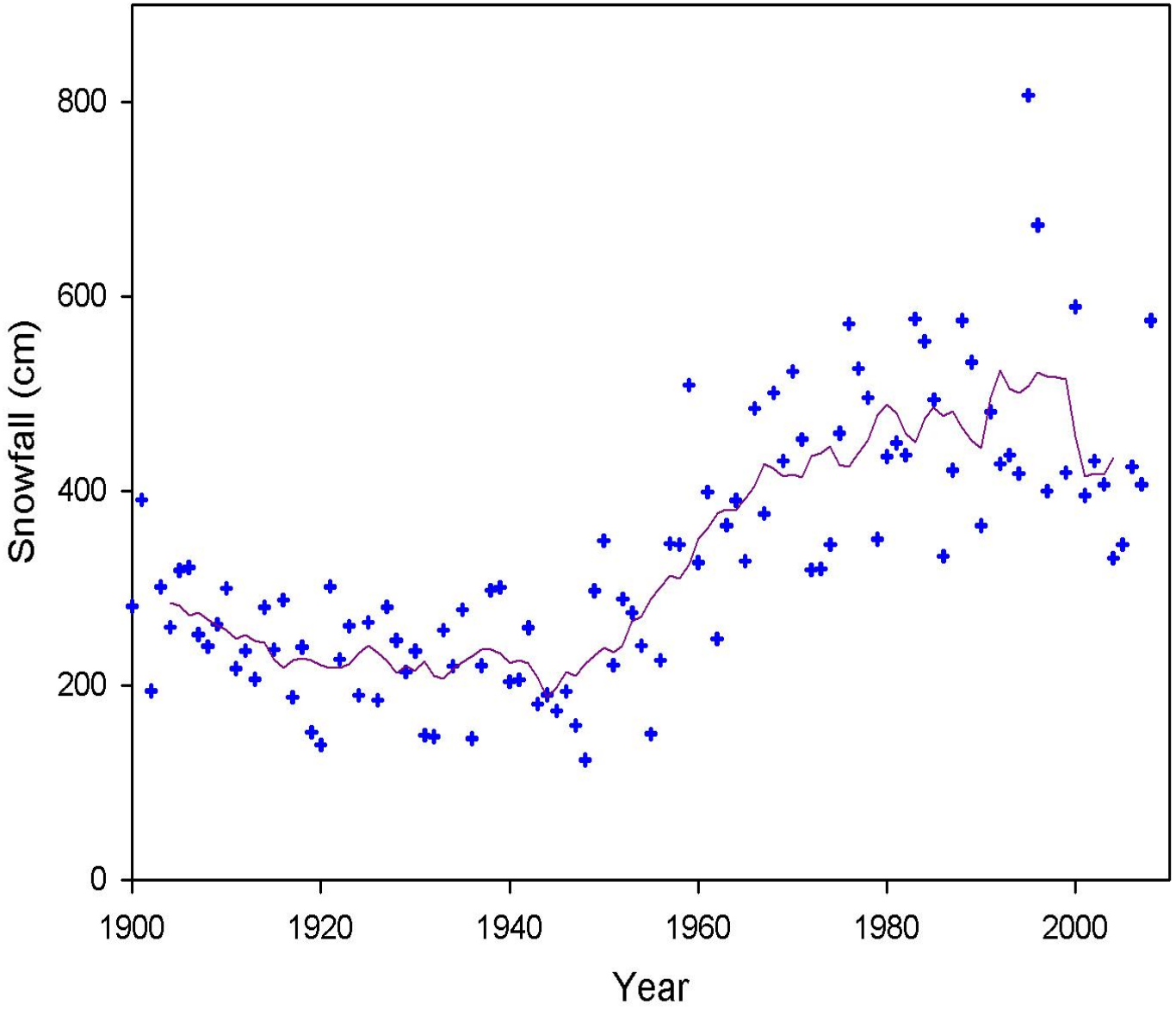
1897-2008



Total Seasonal Snowfall vs. Year

Chatham, MI

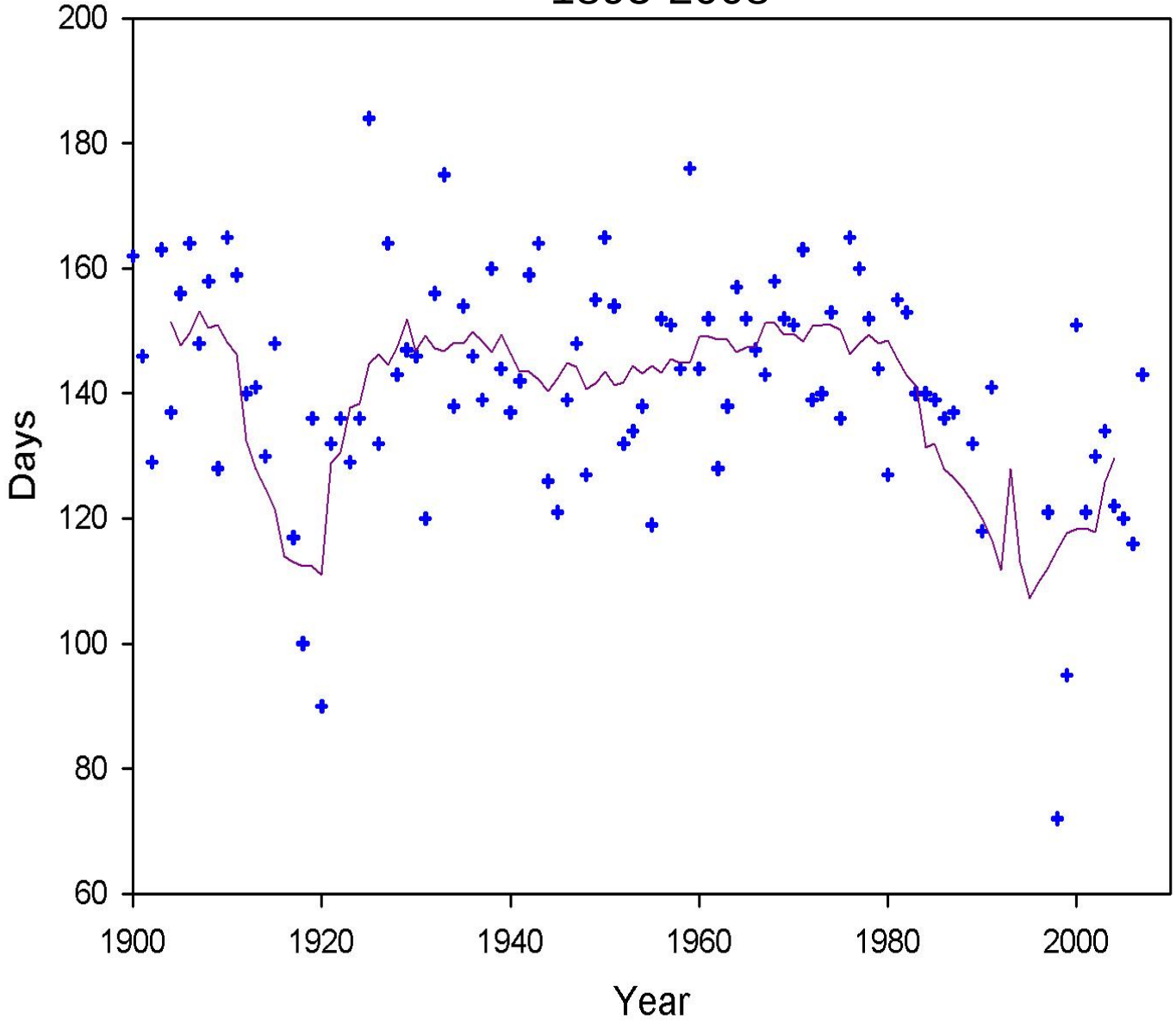
1901-2008



Annual Number of Days with Snowcover >= 1” vs. Year,

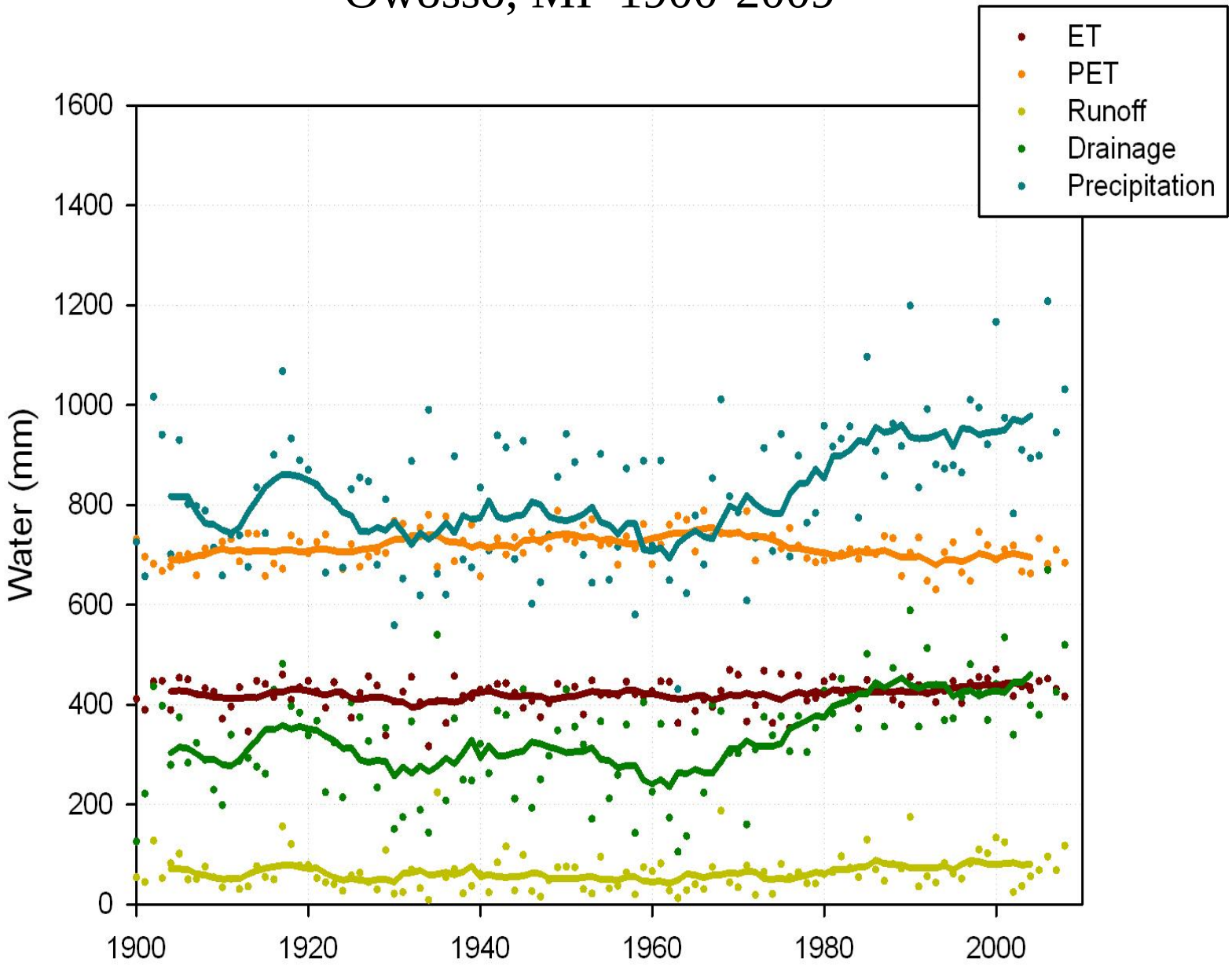
Chatham, MI

1895-2008



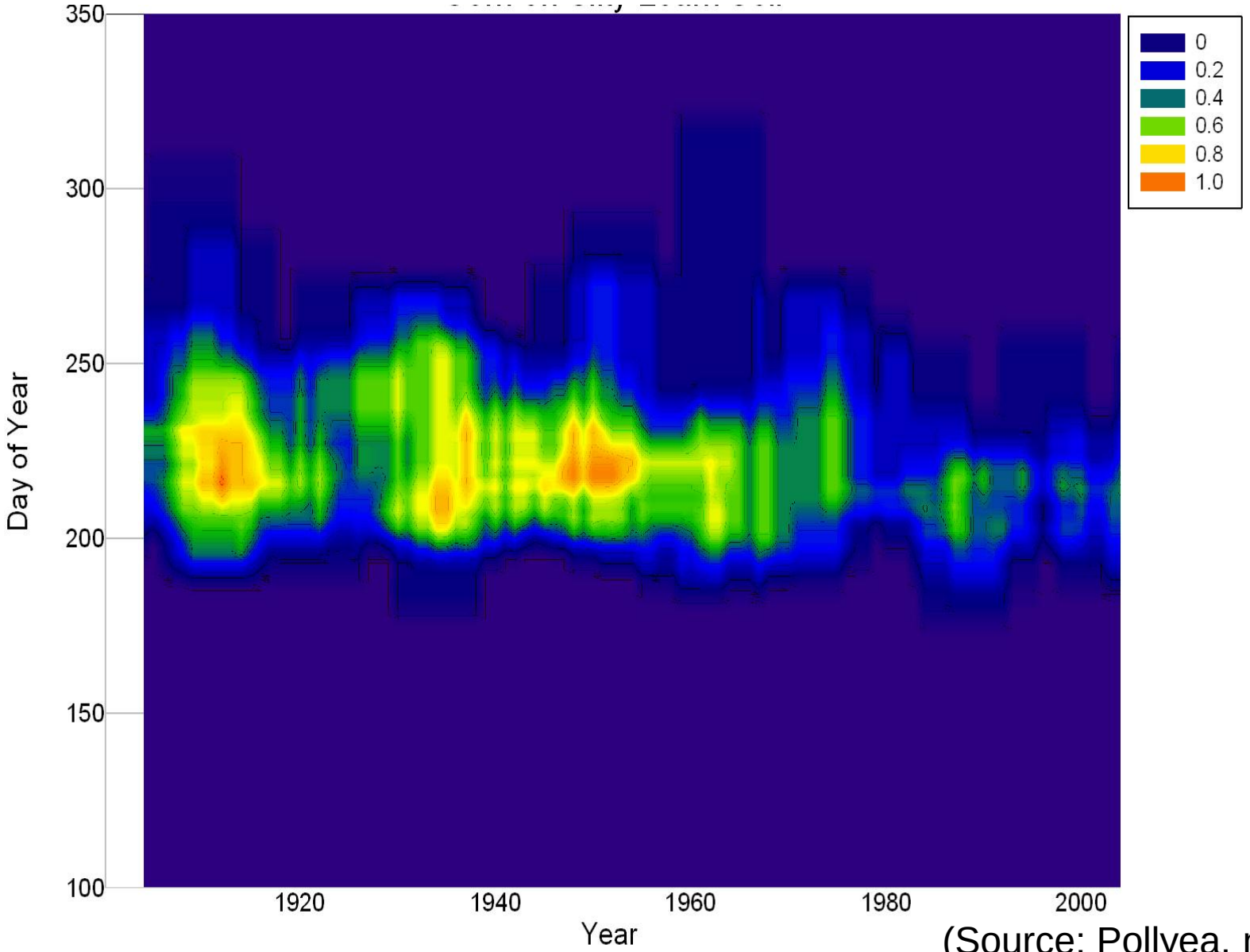
Hydrologic Variables vs. Year

Owosso, MI 1900-2009



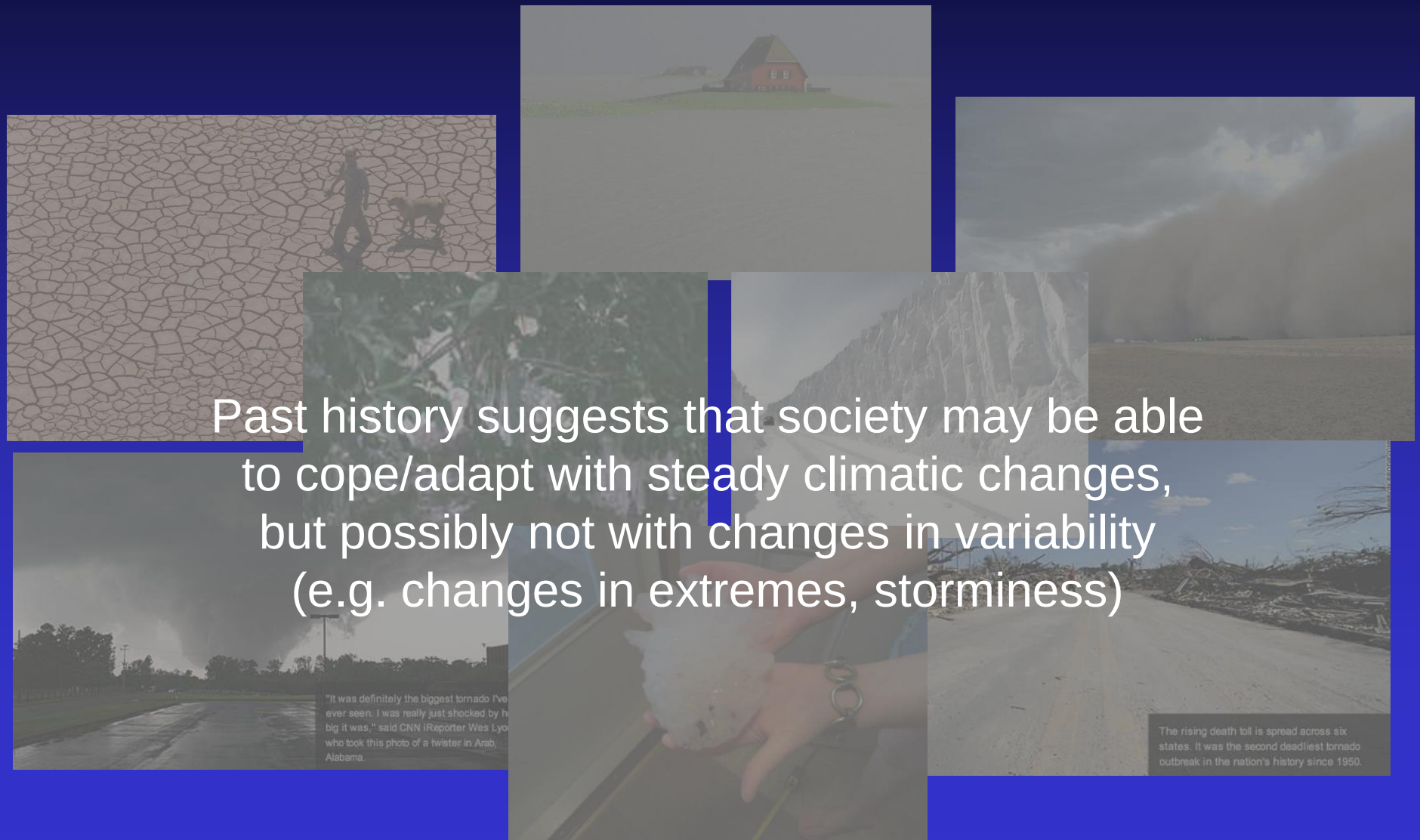
Frequency of Days $PAW_{150} < 0.50$ Potential PAW_{150}

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)

Economic Impacts of Climate Variability

- Total U.S. economic output varies by up to $485 billion/year owing to weather variability.
- From 1980 to 2010 there were 99 weather disasters in the U.S. in which damages exceeded $1 billion. Total cost of those disasters was $725 billion.
- In 2011, the costs of all weather-disaster damages so far has climbed past $35 billion.
- As of August 30th this year, the U.S. has experienced 10 weather disasters costing over $1 billion each, which breaks the previous record for the number of such U.S. weather disasters in an entire year.

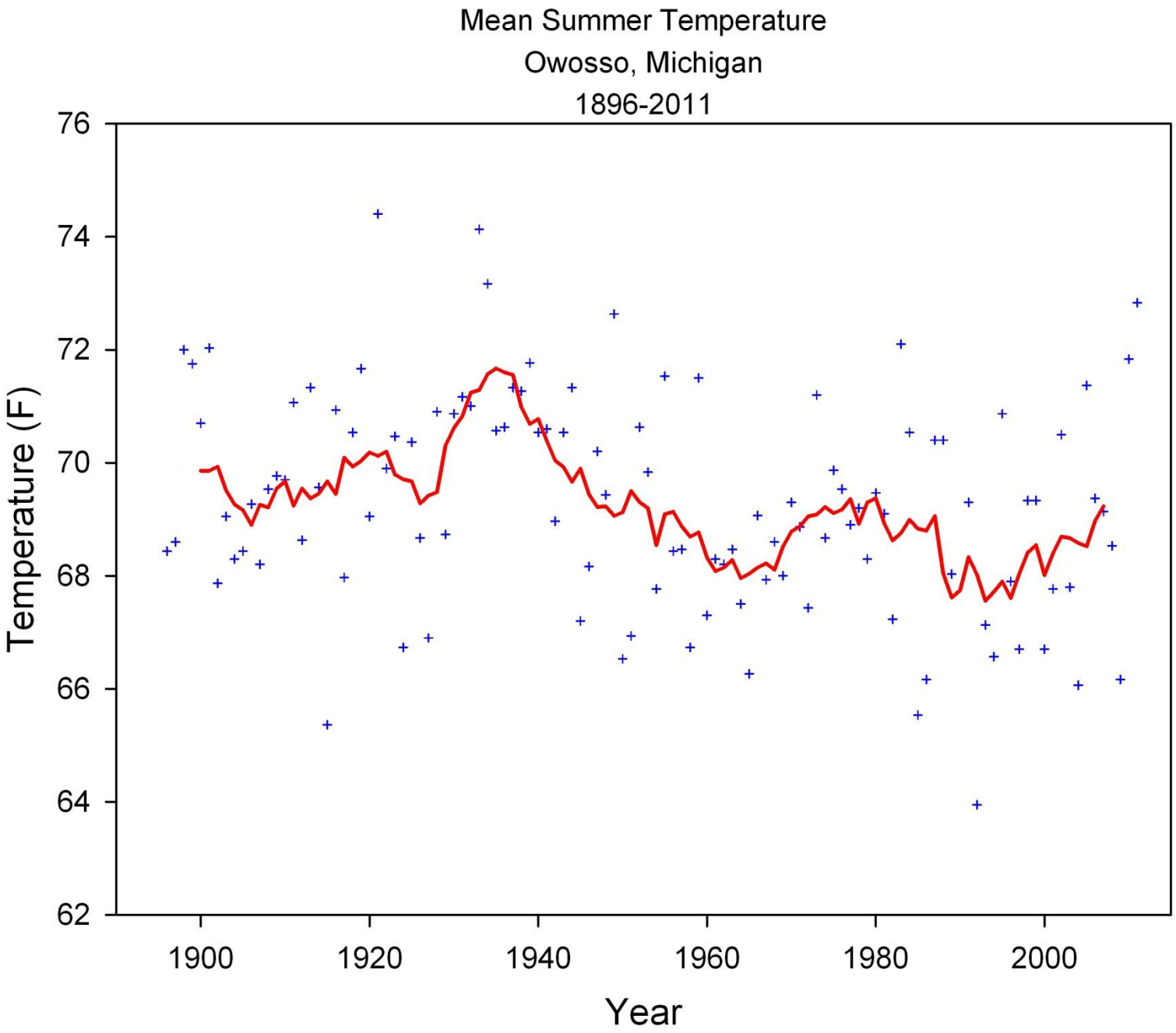
(*Source: NOAA, 2011*)

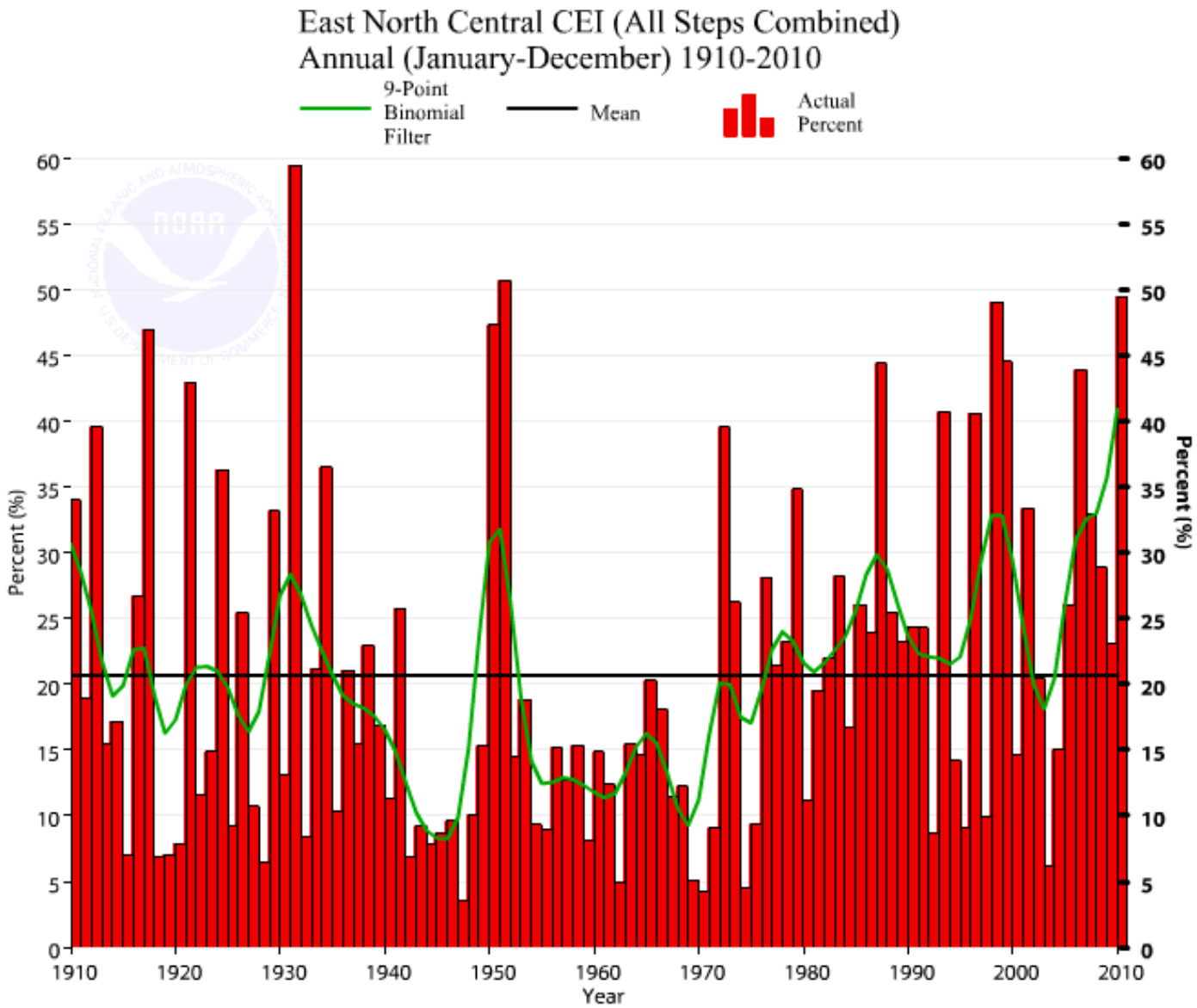
July 2011 Heatwave Summary: USA

- At least 200 million people in the United States impacted
- At least 60 related fatalities in 10 states (as of 31 AUG)
- Heat linked with extreme drought conditions across much of southern Great Plains
- 2,712 high-temperature records were either tied or broken
- At least one weather station in all 50 states set or tied a daily high temperature record at some point during July
- Two weather stations tied for the hottest temperature ever recorded during July (120 F at Blythe, CA and Gila Bend, AZ)
- More than 70 days with max. temperature greater than 100 F, sections of TX and OK
- Highest heat index globally on July 19, Morehead, MN (134 F)

July 2011 Heatwave Summary: MI

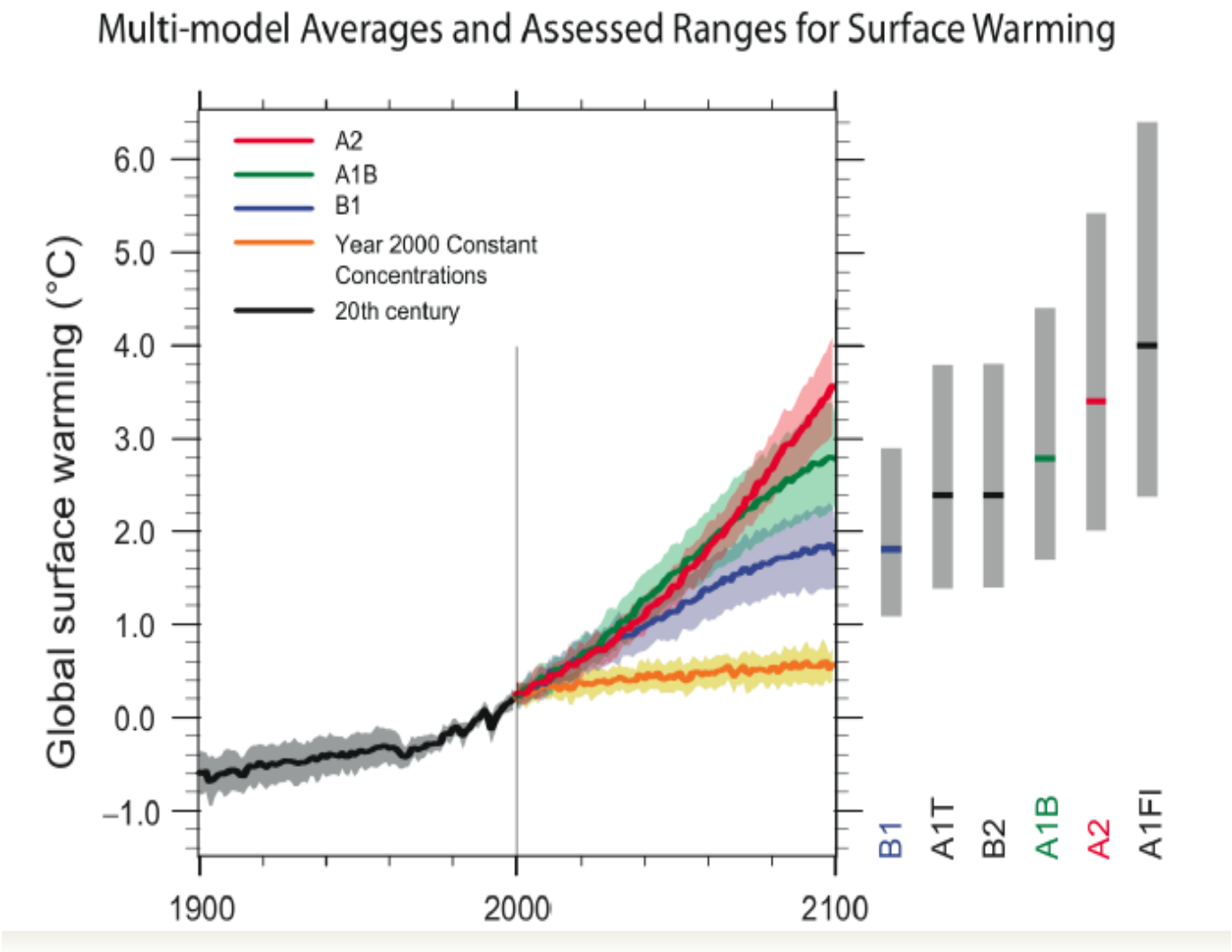
- Mean temperatures averaged 3.7 F above normal
- Warmest July since 1955 and the 6th warmest statewide since 1895 (most of the warmest Julys on record occurred during the 1930's and 1920's)
- High temperatures during the month reached or exceeded 90 F on as many as 15 days in some southern areas of the state
- Total precipitation for the month varied greatly from north to south, with less than 0.50" (less than 25% of normal) across some areas of western Upper and northwestern Lower Michigan to more than 10.00" (more than 300% of normal) across portions of the south.


Mean Summer Temperature
Owosso, Michigan
1896-2011
Temperature (F)
76
74
72
70
68
66
64
62
1900
1920
1940
1960
1980
2000
Year



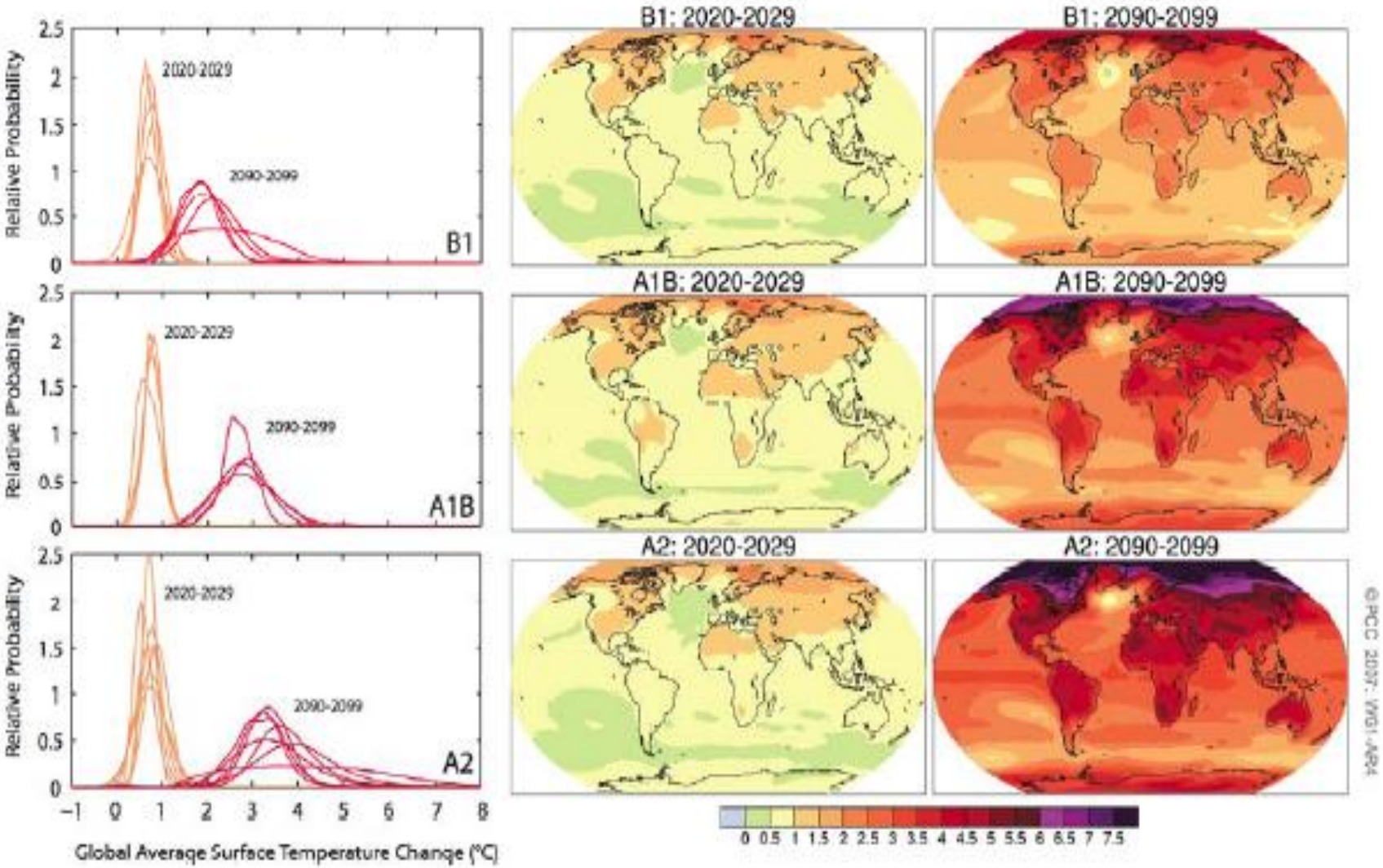
(Source: NCDC, 2011)

Projecting the Future:
Global Climate Models (GCMs)



Source: (IPCC, 2007)

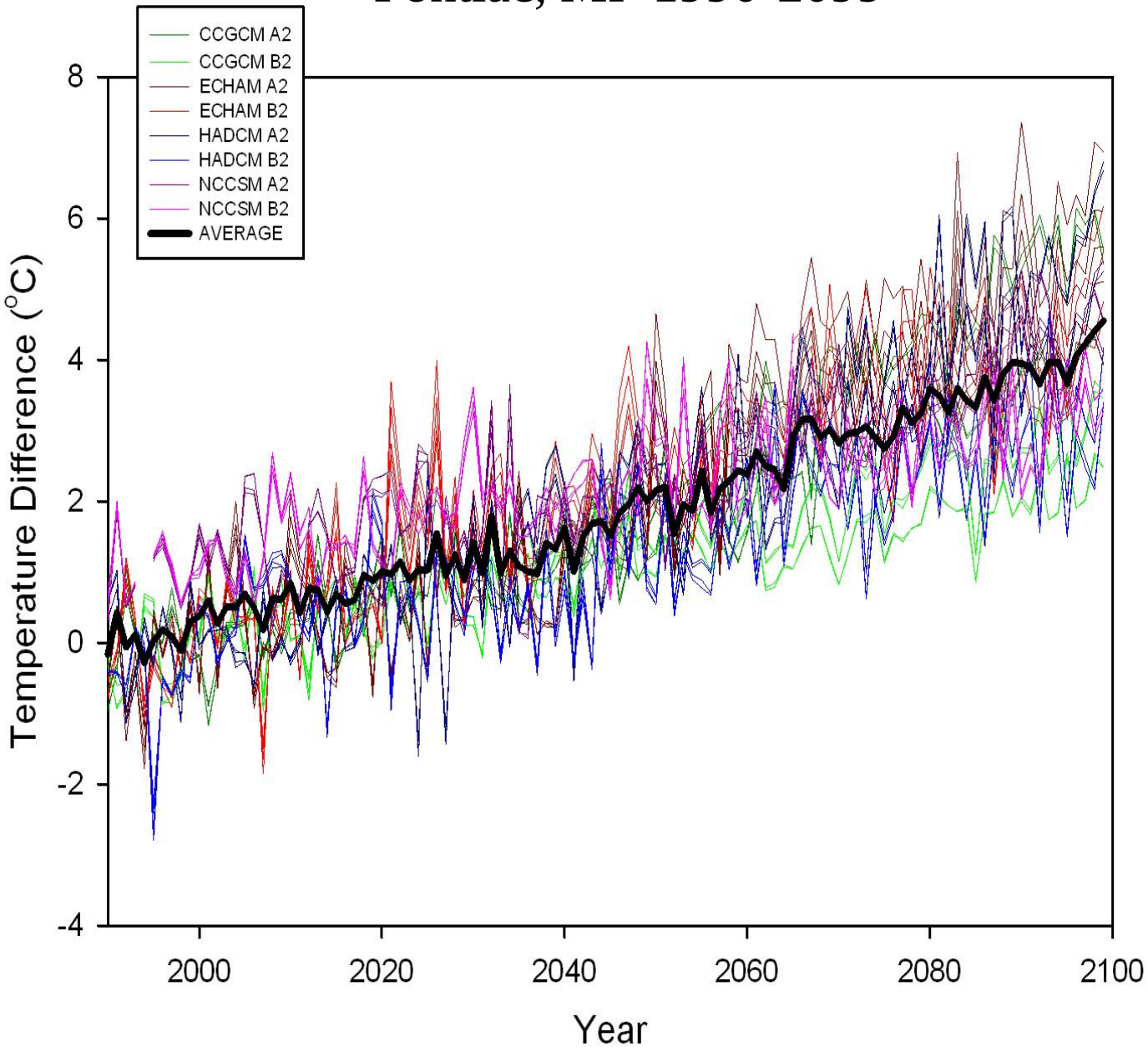
AOGCM Projections of Surface Temperatures



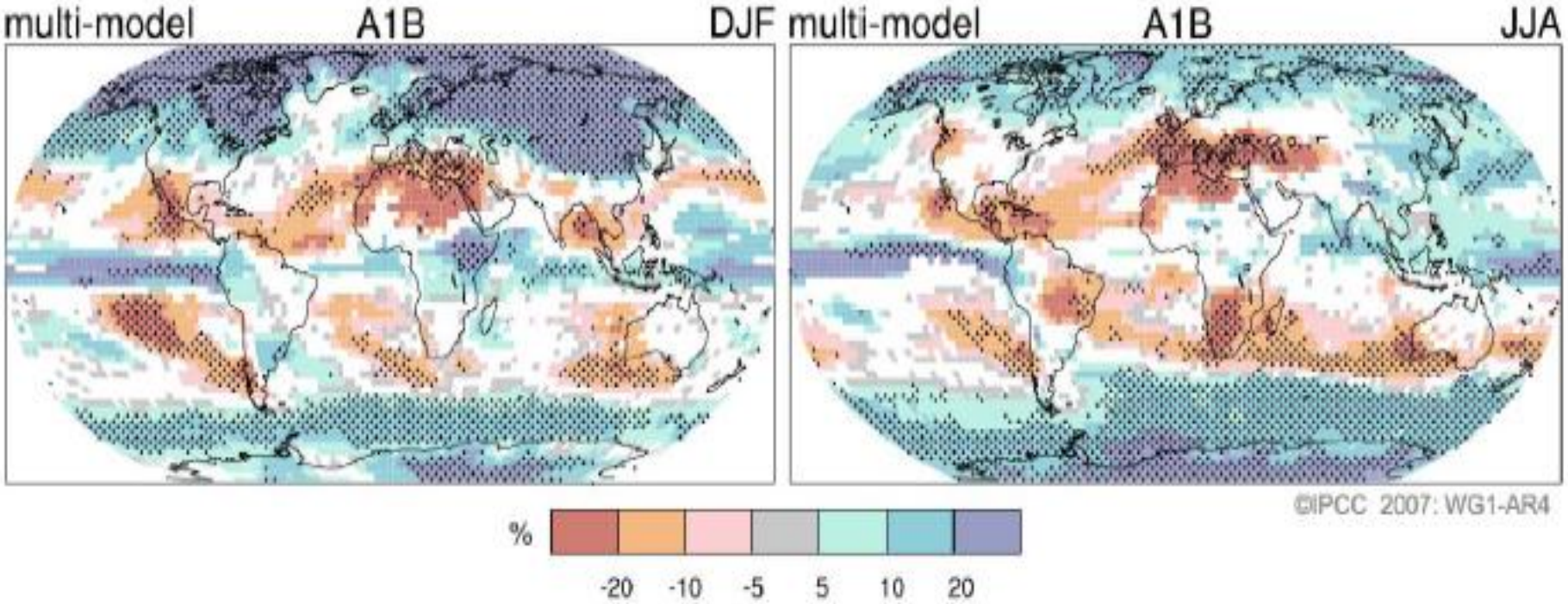
Source: (IPCC, 2007)

Model-Projected Mean Temperature Differences

Pontiac, MI 1990-2099



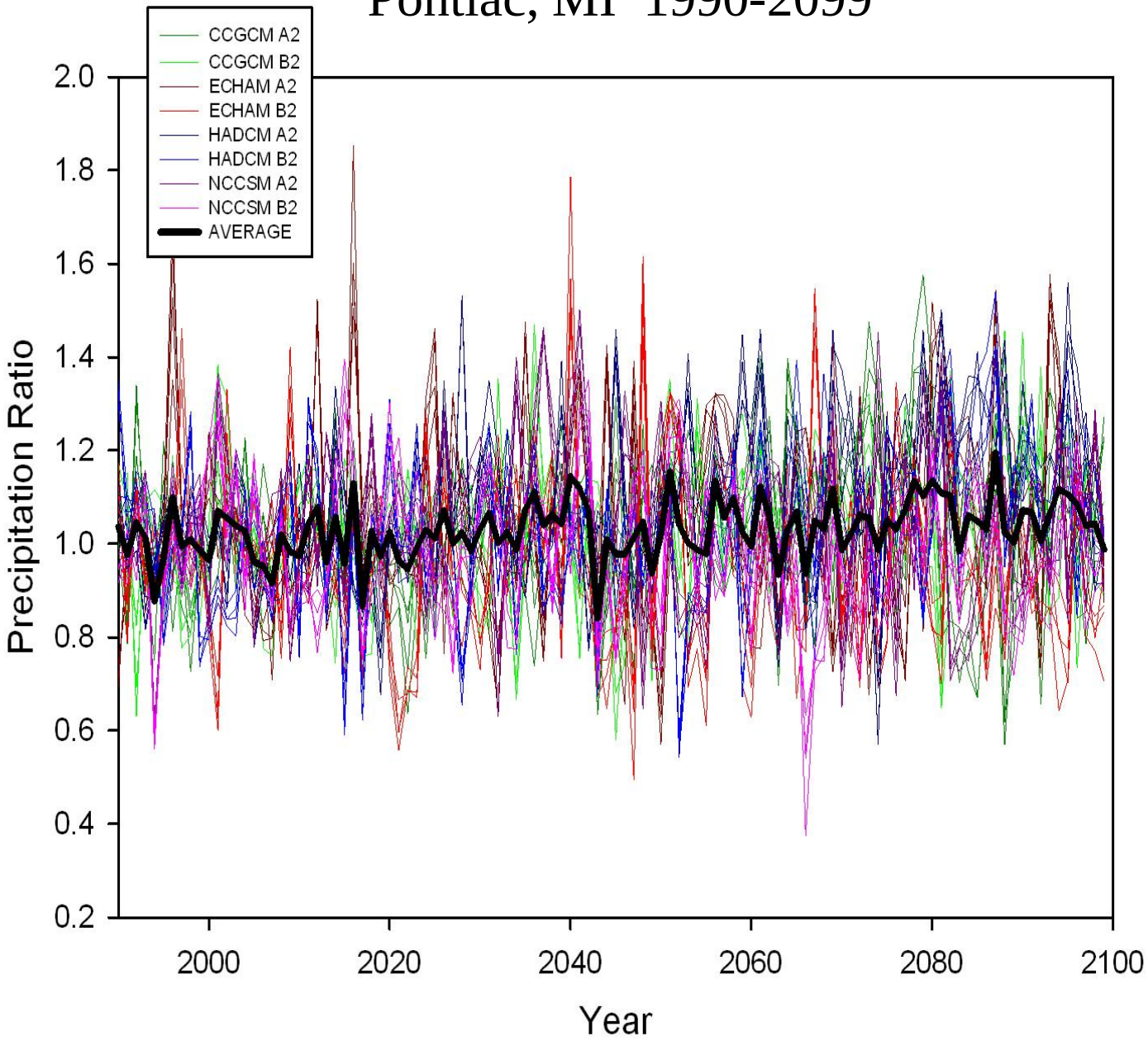
Projected Patterns of Precipitation Changes



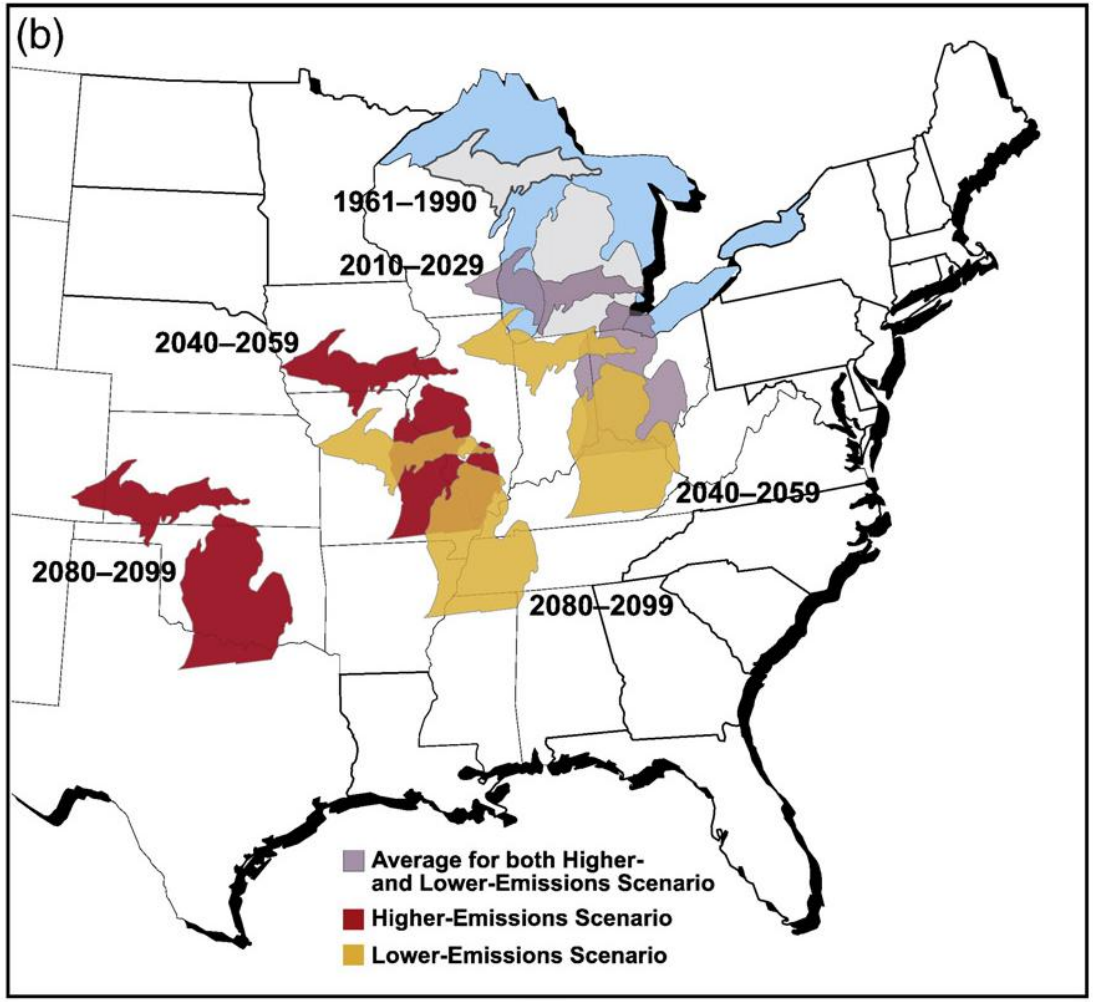
Source: (IPCC, 2007)

Model-Projected Precipitation Ratios

Pontiac, MI 1990-2099



Projected Temperature Changes



Hayhoe et al (2010)

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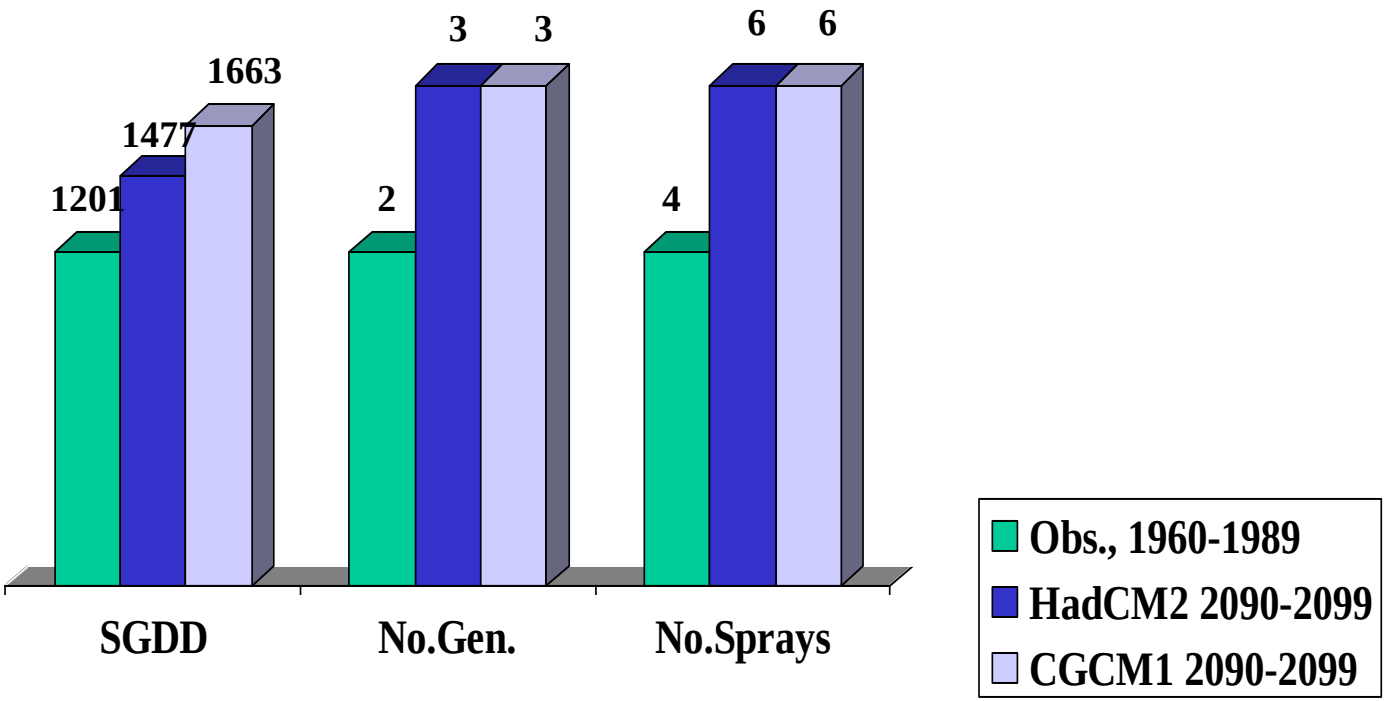
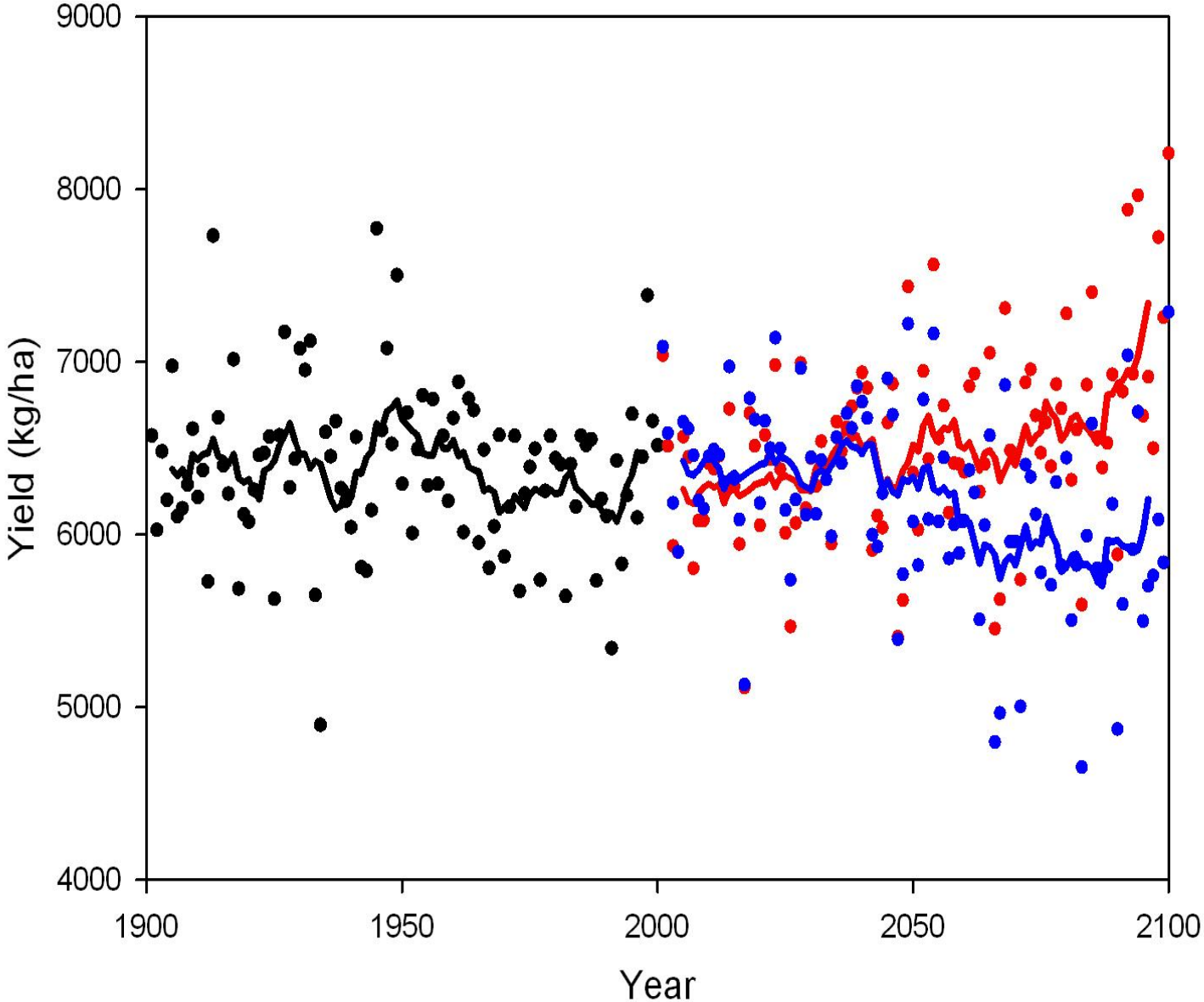
Simulated Pest Management Parameters, Apple Codling Moth

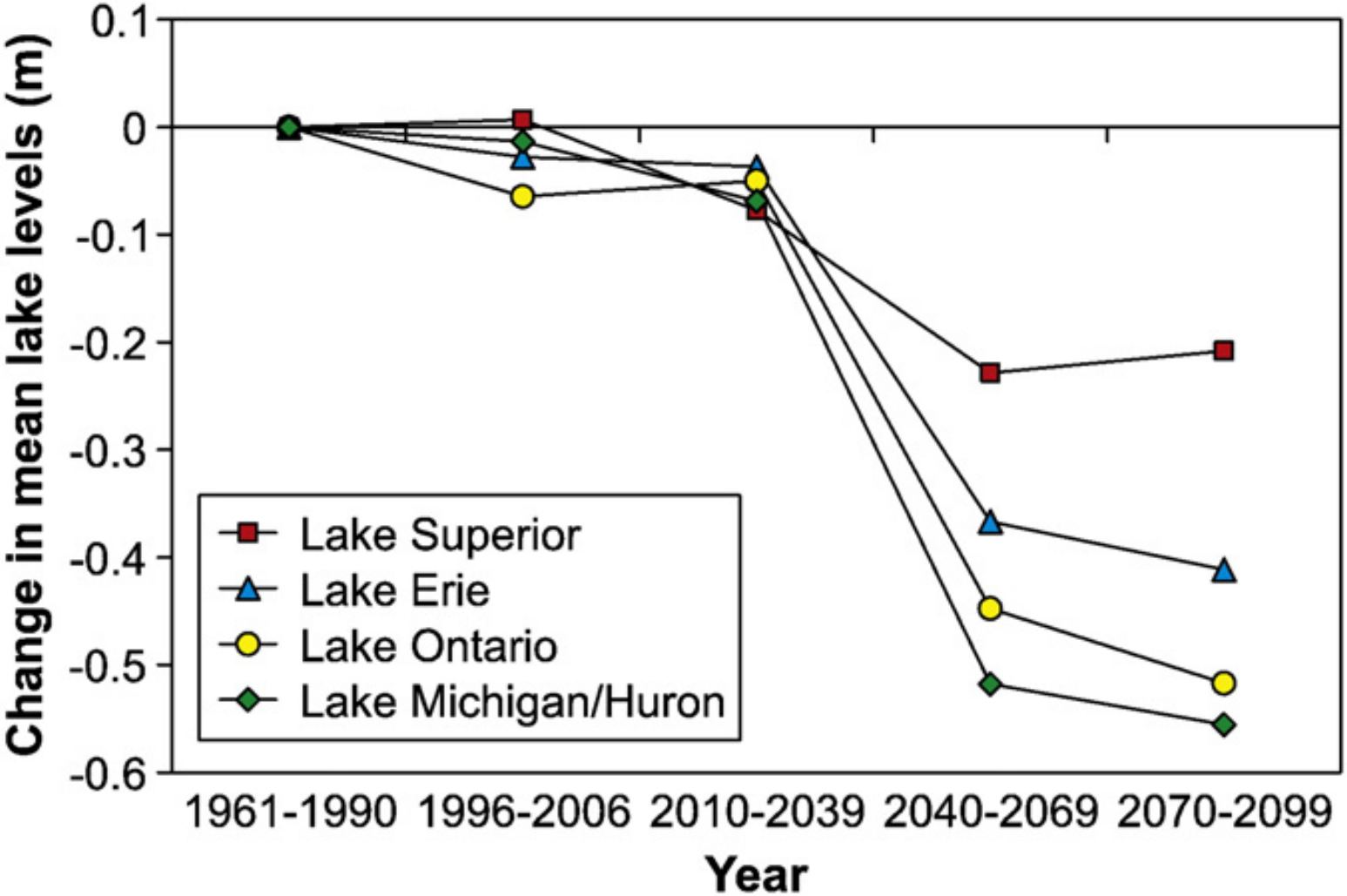
East Jordan, MI



Historical and Projected Wheat Yields by Year With and Without CO_2 Enrichment

Pontiac, MI





Hayhoe et al (2010)

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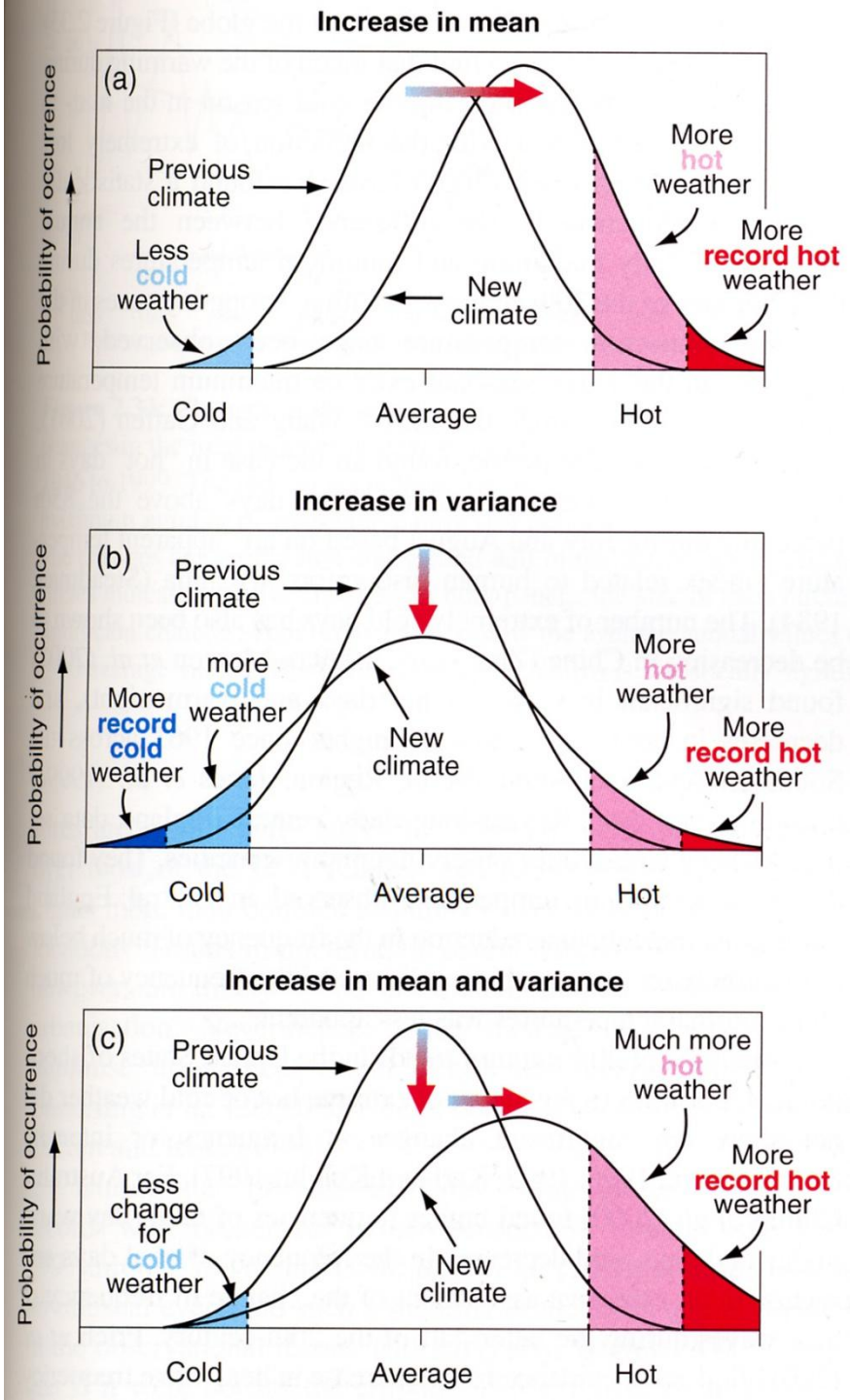
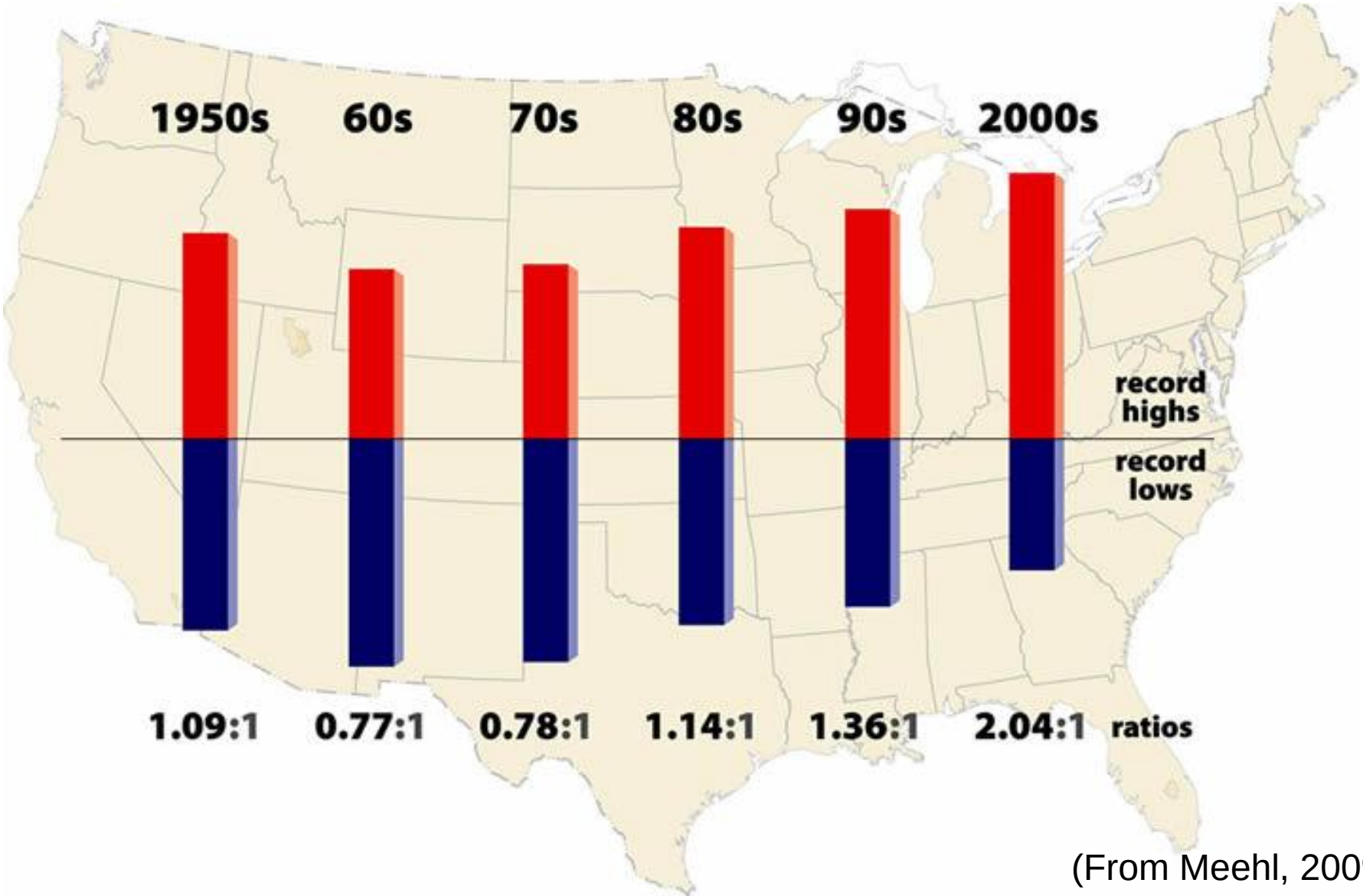


Technological adaptations should be possible given slow, steady changes in climate.

However, if changes in the mean are accompanied by increases in variability, adaptation will be much more difficult.

Changing Frequency of Record High/Low Temperatures



(From Meehl, 2009)

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, much of it concentrated during the winter season and at night.
- 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 1990's but have leveled off recently.
- 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.


Questions?