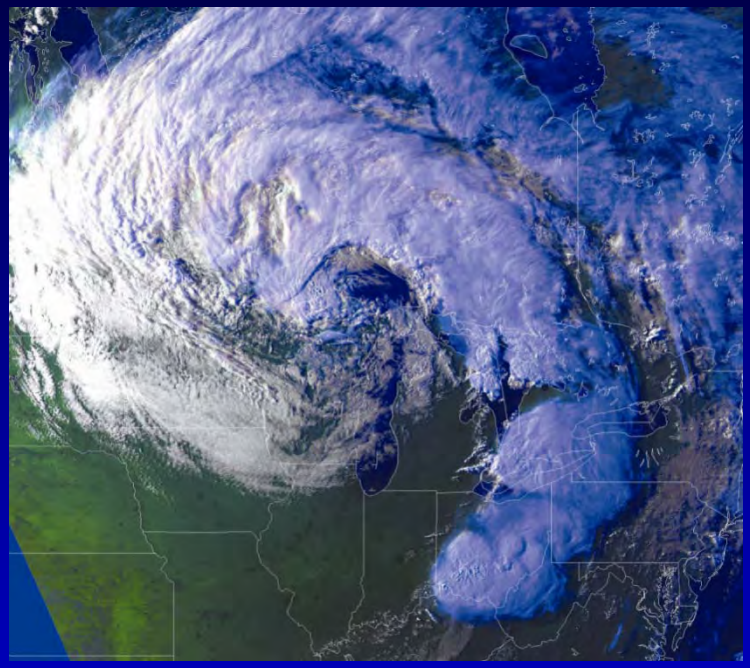
Historical and Projected Future Climate Changes in the Great Lakes Region



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GLISA
A NOAA RISA TEAM

CLIMATE CENTER
UNIVERSITY OF MICHIGAN

MICHIGAN STATE UNIVERSITY
AgBioResearch

MICHIGAN STATE
UNIVERSITY
EXTENSION

Great Lakes Integrated Sciences & Assessments (GLISA)

- Connects climate science/research with climate services and practitioners

Scale Matters:
Global, Regional, Local

Global trends are more certain than regional trends.

Natural variability plays a larger role at the regional scale.

Local changes in land use can alter the severity of climate change impacts.

Outline

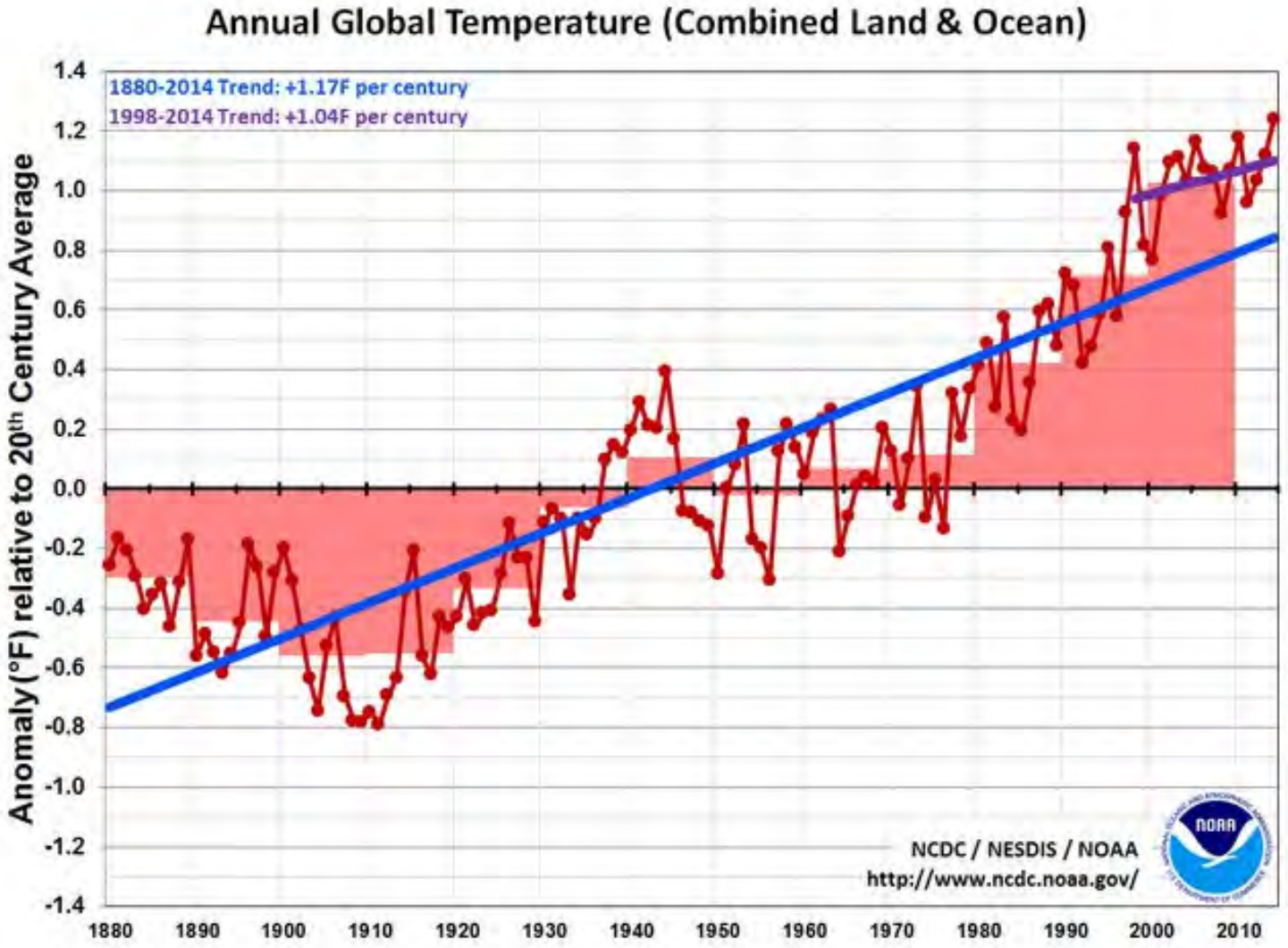
- Historical Trends
- Climatic Variability/Extreme Events
- Future Projections

Historical Trends

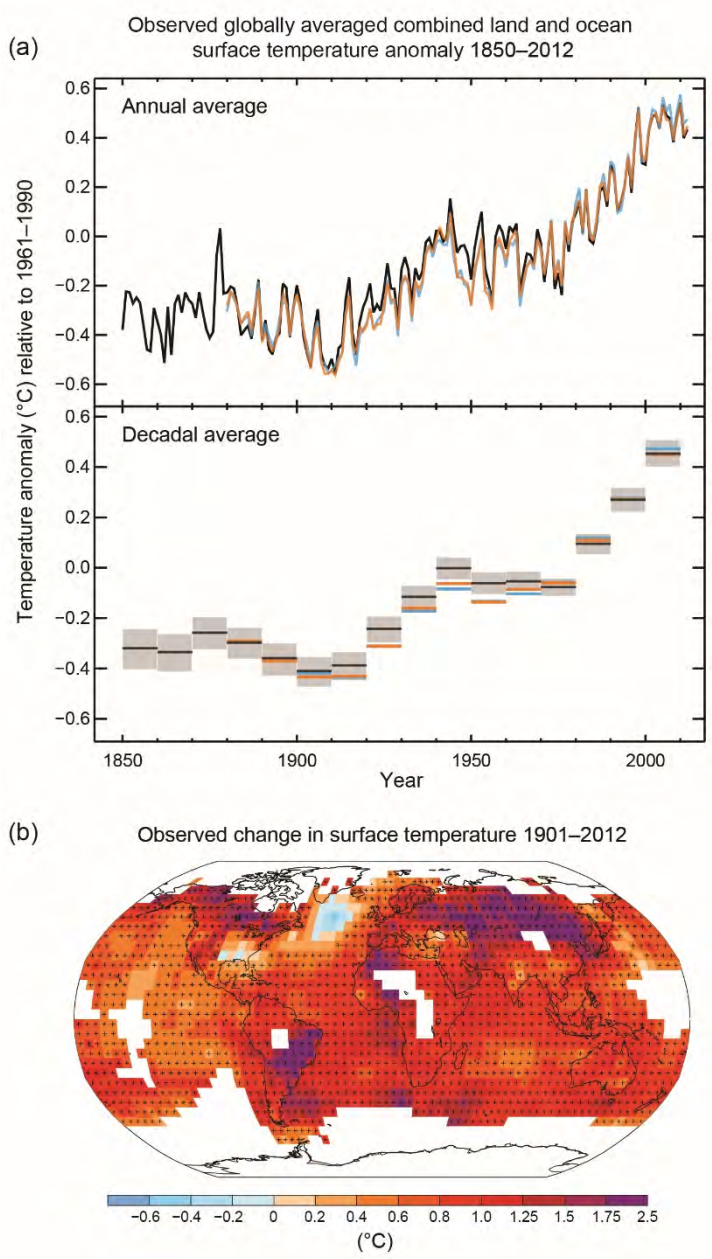
Some Notable Pre-Instrumental Trends in the Great Lakes Region

- 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.

Global Temperature Trends



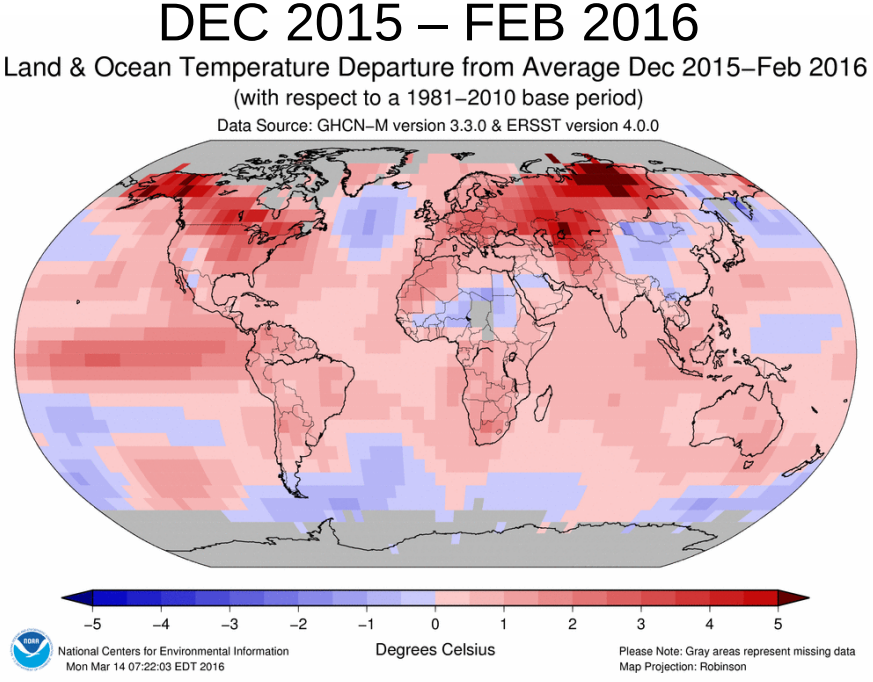
Global Temperature Trends, 1850-2012



(IPCC, 2013)

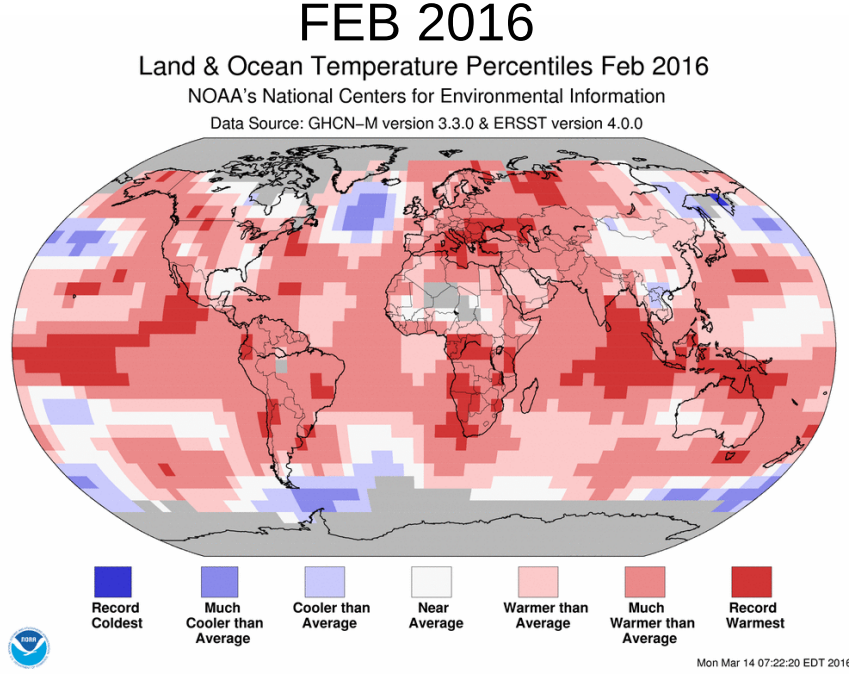
Global Highlights

DEC 2015 – FEB 2016



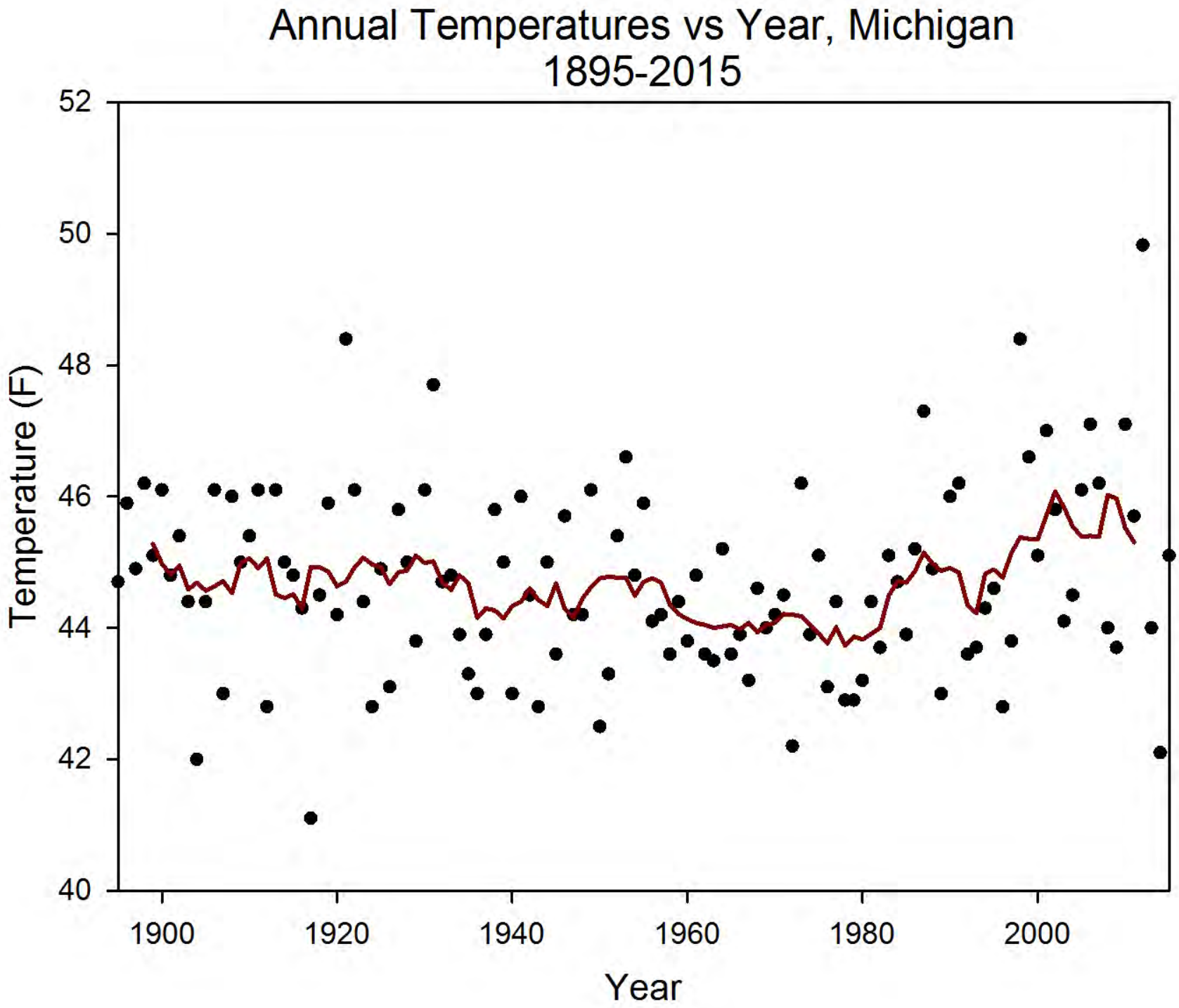
Warmest DEC-FEB on record at 1.1°C above normal, which is largest 3-month departure on record.

FEB 2016



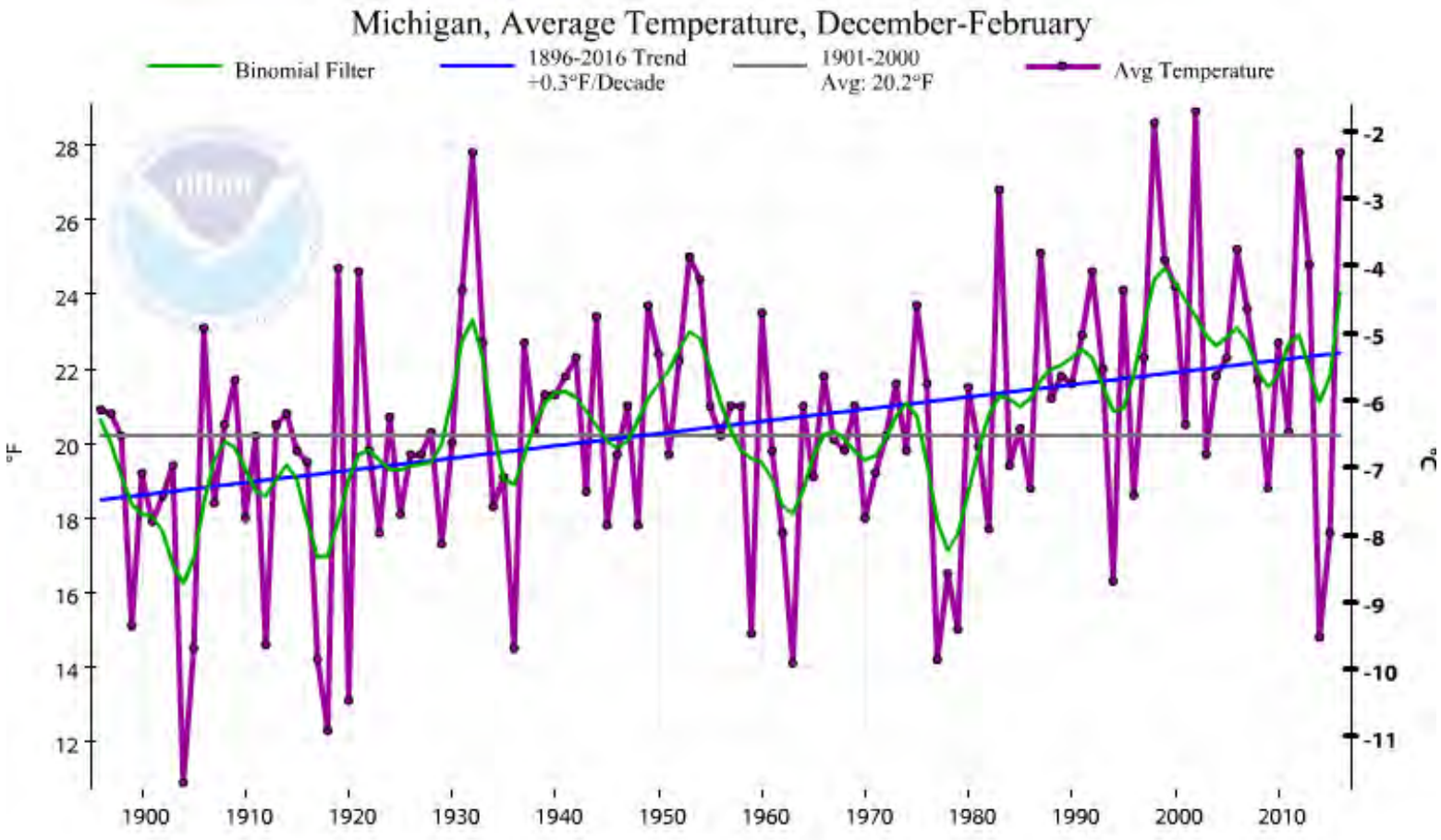
Warmest FEB on record at 1.2°C above normal, which is largest monthly departure on record.

10th consecutive month a monthly record has been broken

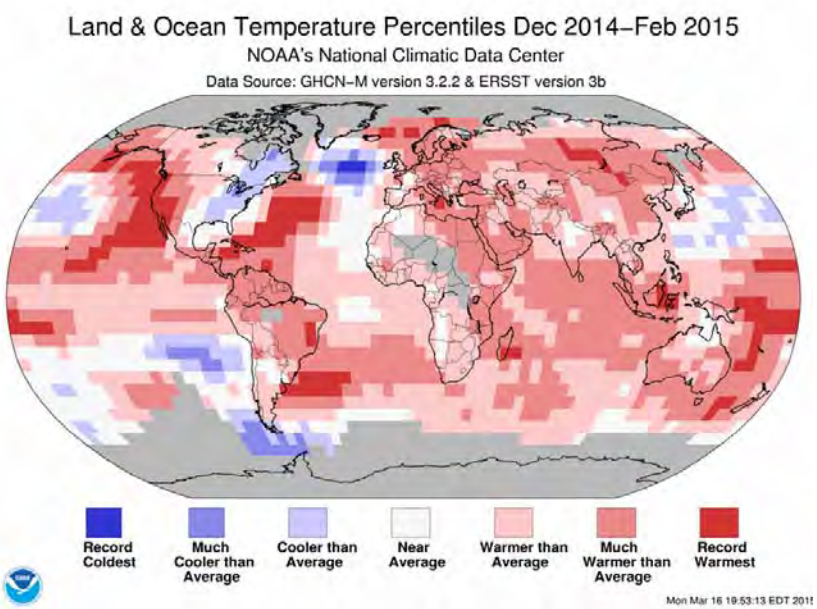

Annual Temperatures vs Year, Michigan
1895-2015
Temperature (F)
52
50
48
46
44
42
40
1900
1920
1940
1960
1980
2000
Year

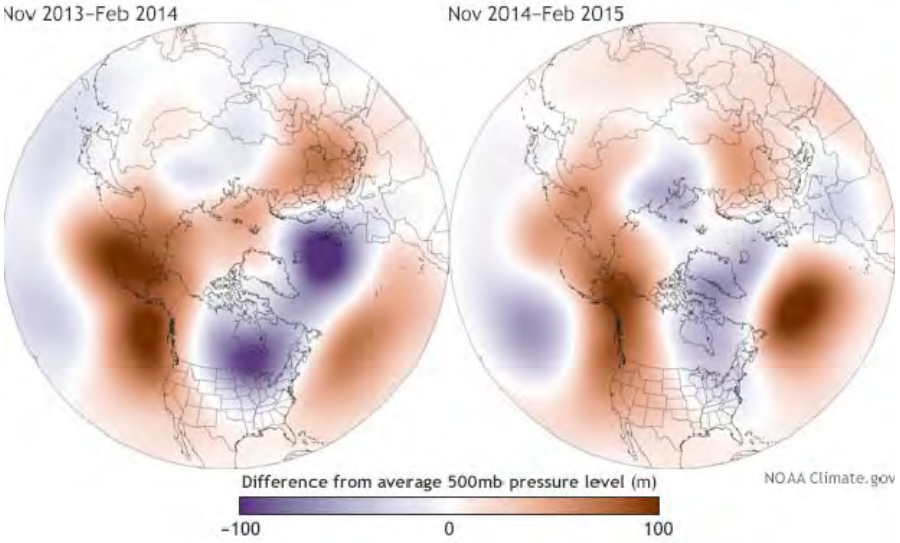
Mean Winter Temperatures

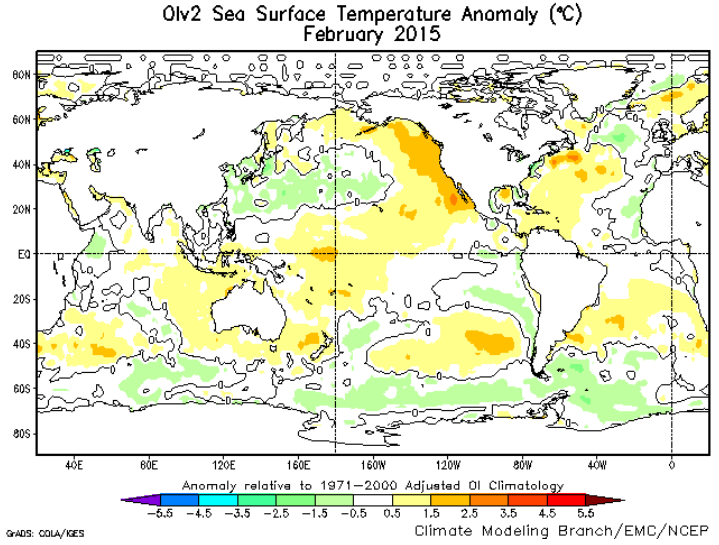
Michigan, 1895-2015

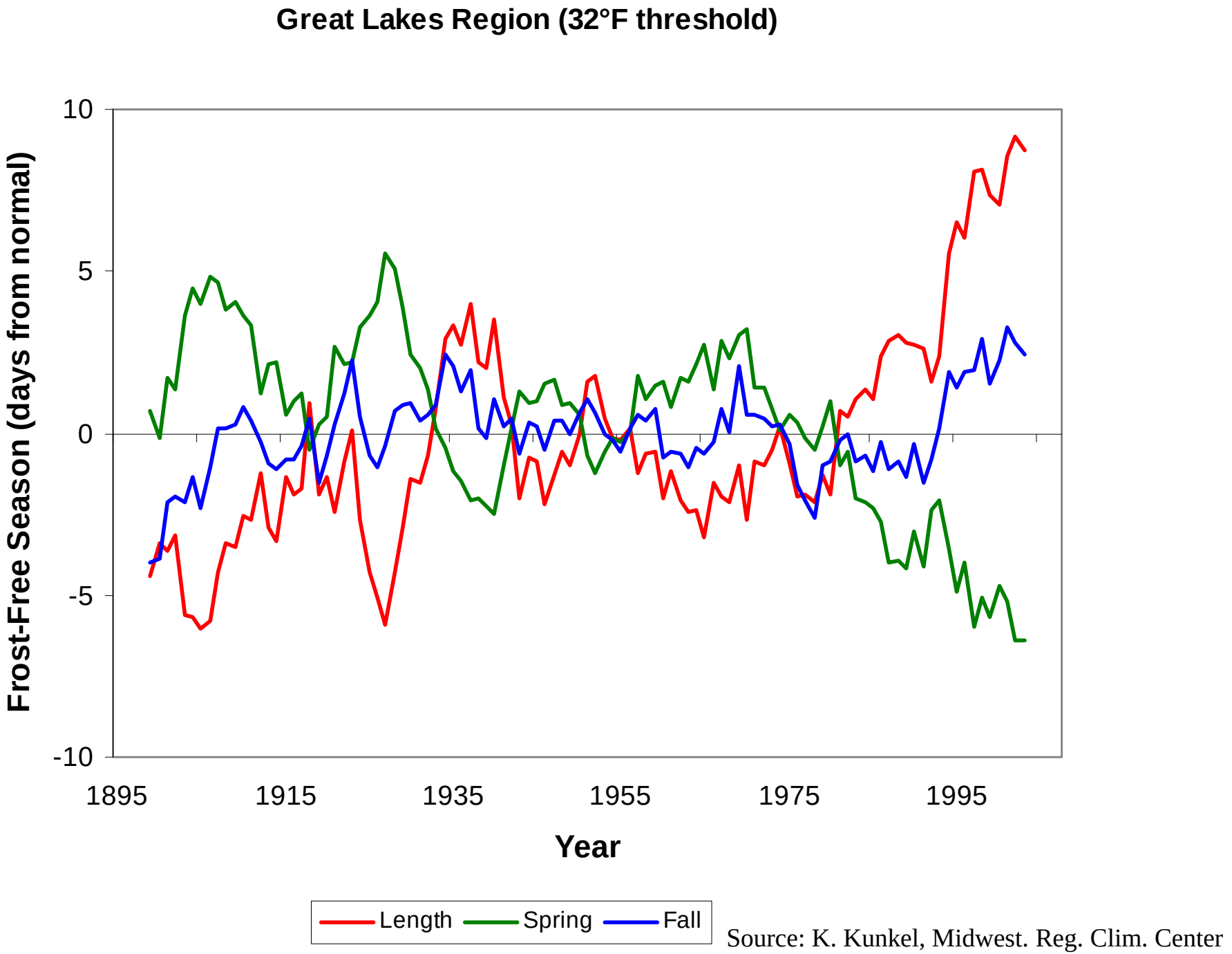


Forcing of Recent Winter Patterns?

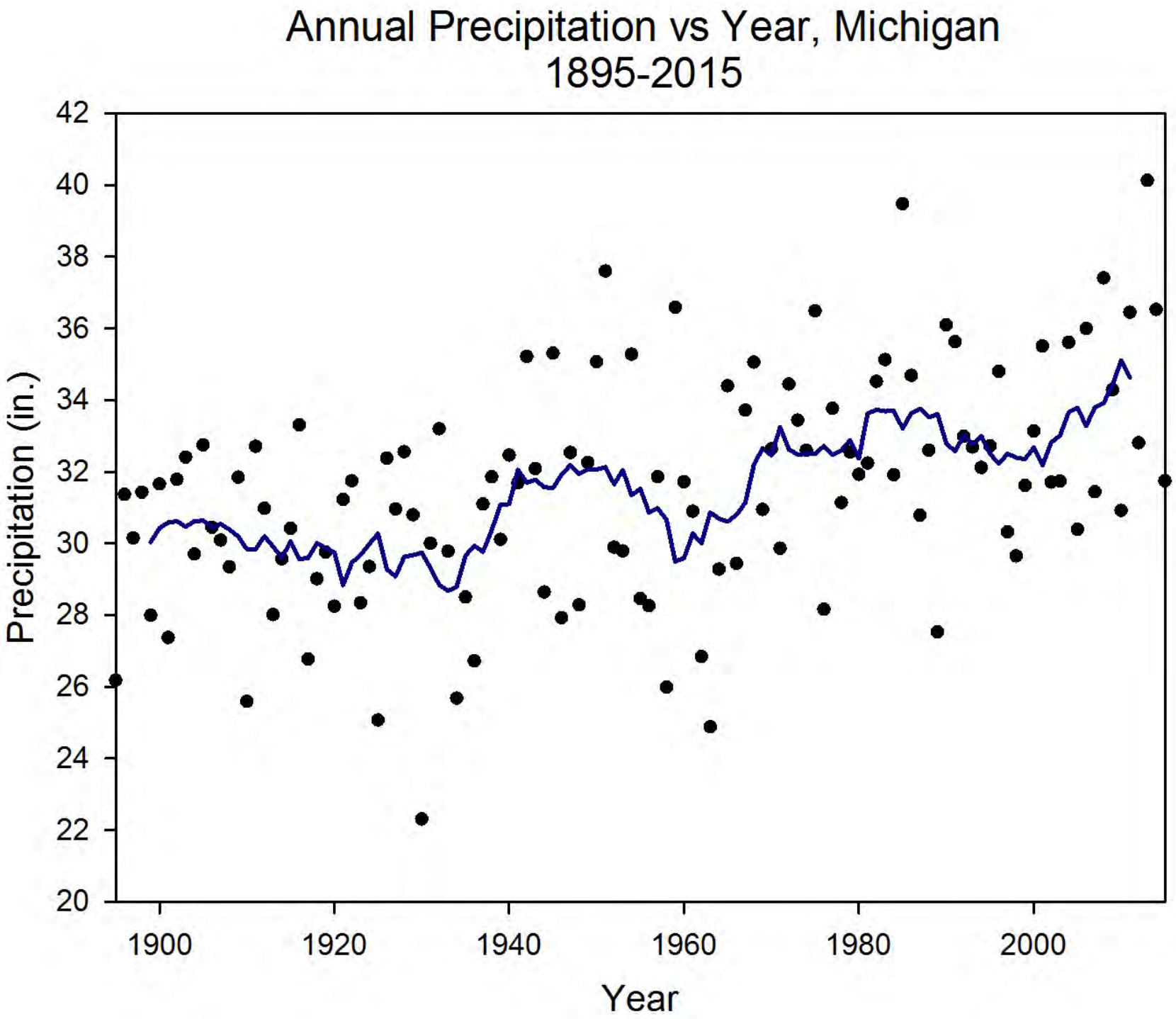








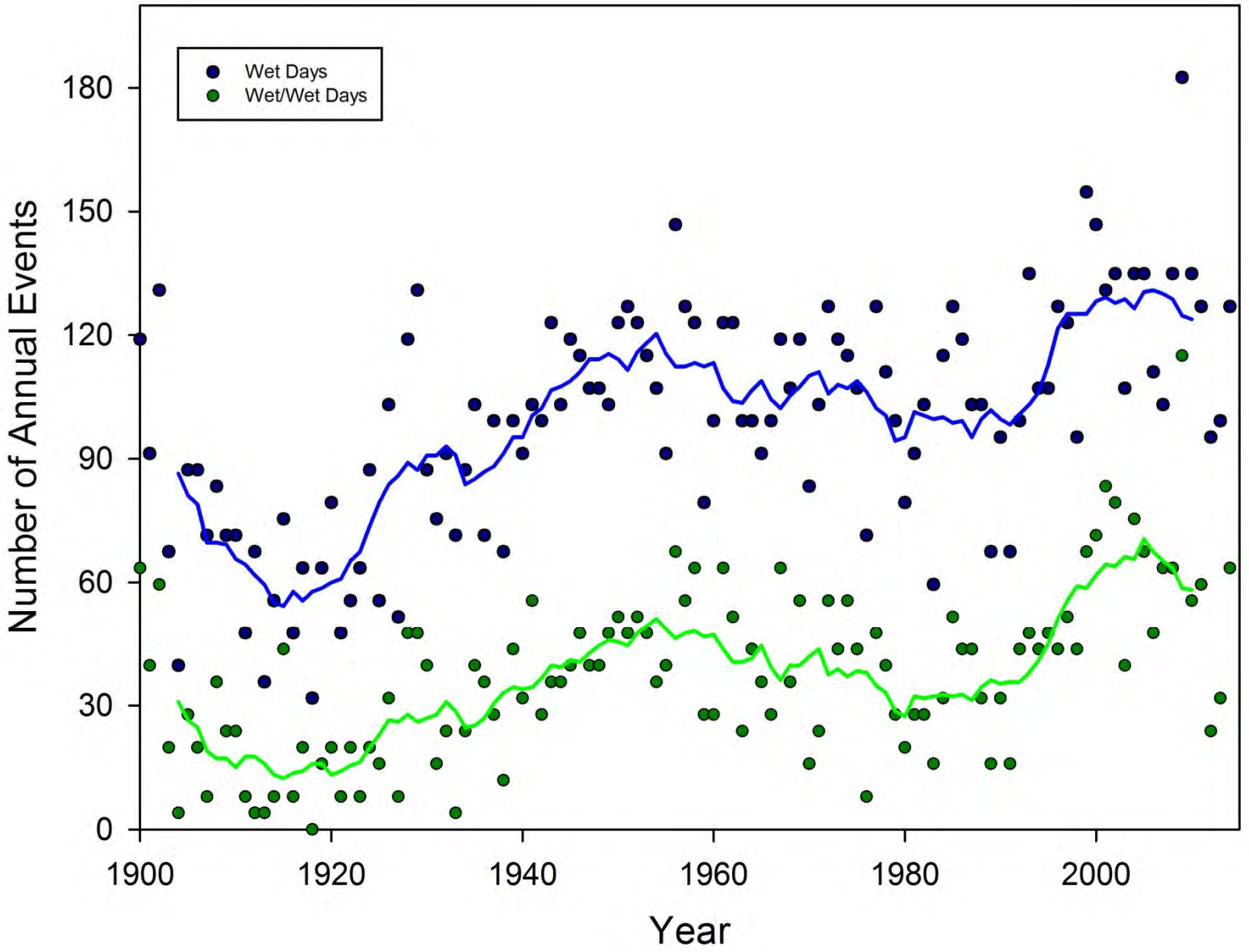
Source: K. Kunkel, Midwest. Reg. Clim. Center

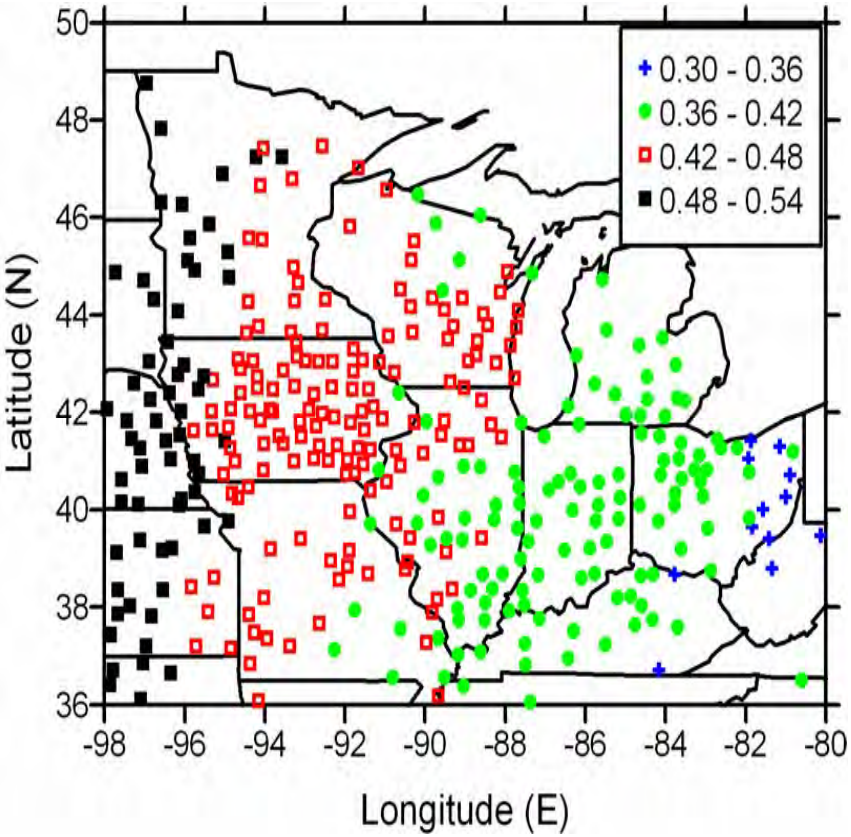

Annual Precipitation vs Year, Michigan
1895-2015
Precipitation (in.)
42
40
38
36
34
32
30
28
26
24
22
20
1900
1920
1940
1960
1980
2000
Year

Frequency of Wet Days and Wet/Wet Days

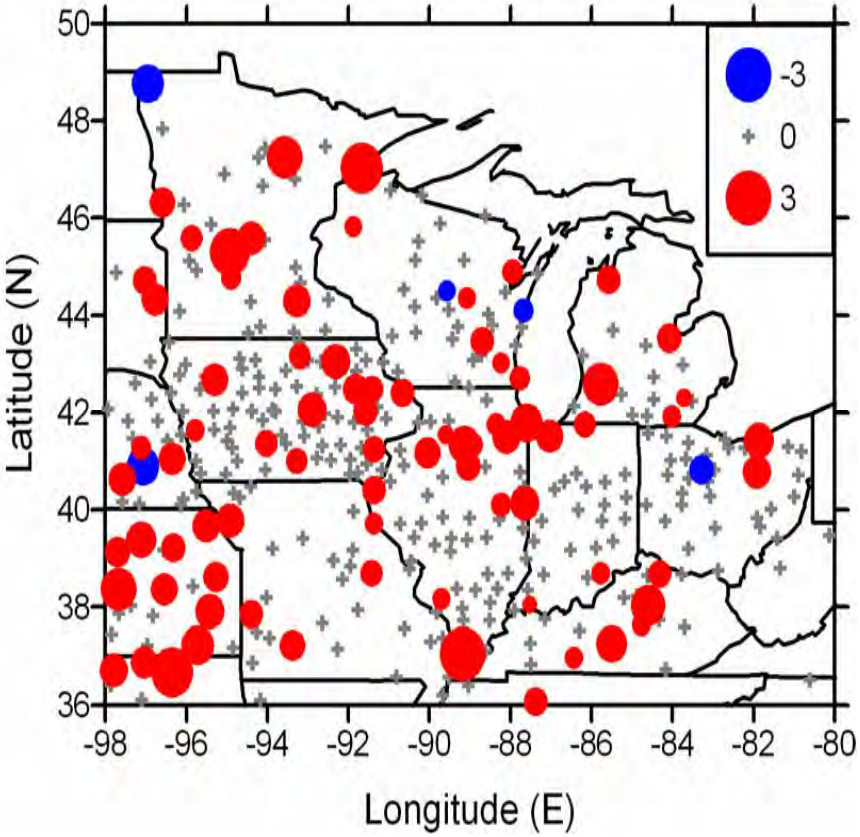
Traverse City, MI

1900-2014





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)

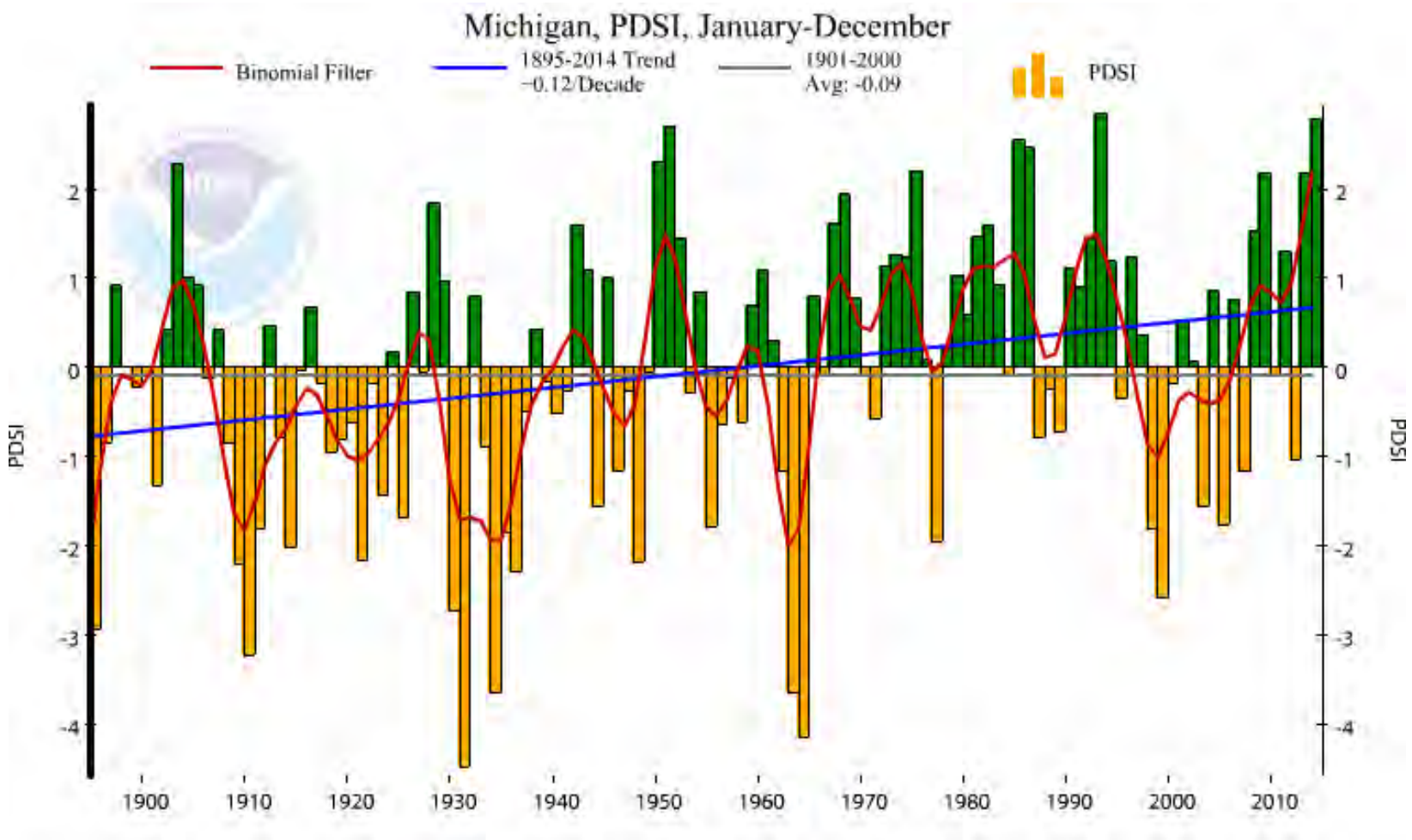
24-Hour Precipitation Totals (inches) for 2-10 Year Recurrence Intervals

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

Drought Severity vs. Year

Michigan, 1895-2014

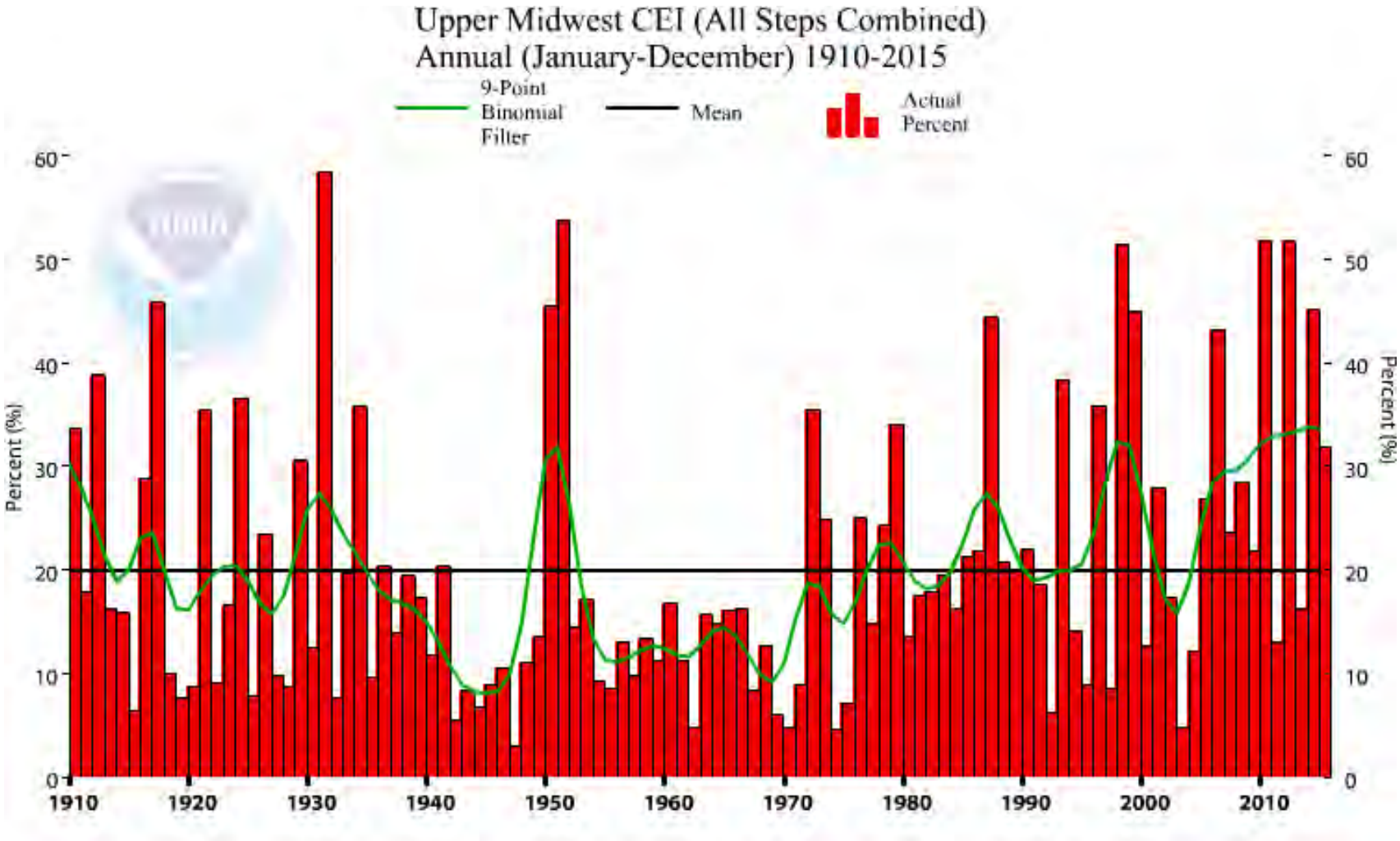


Impacts of Climatic Variability

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
- Top five warmest winter 2015/2016



(Source: NCEI, 2016)

Worldwide Weather Disasters, 1980-2010

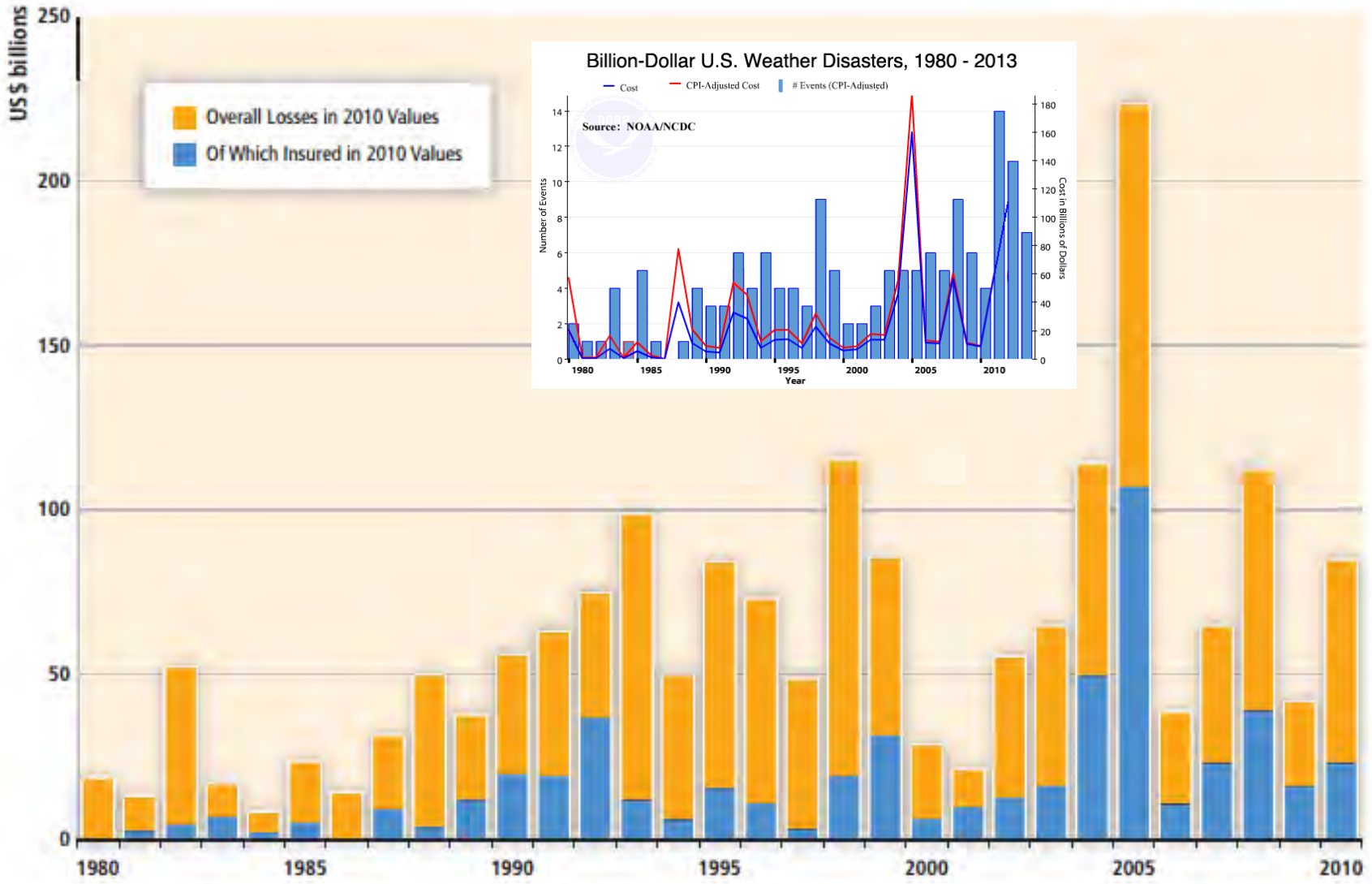
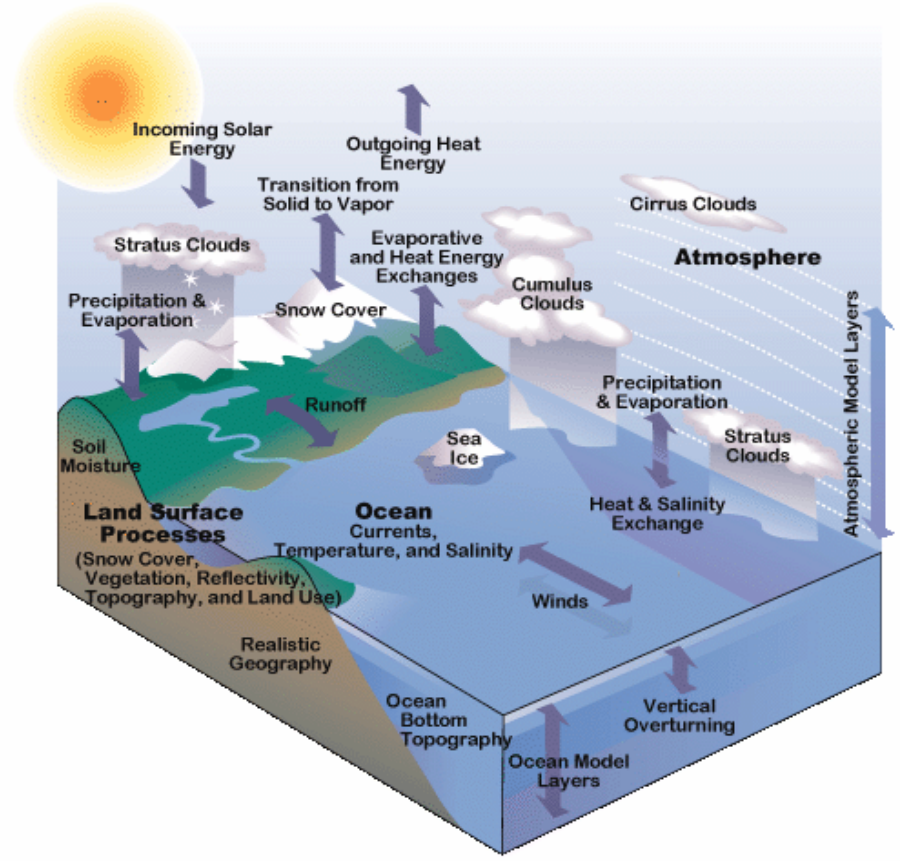


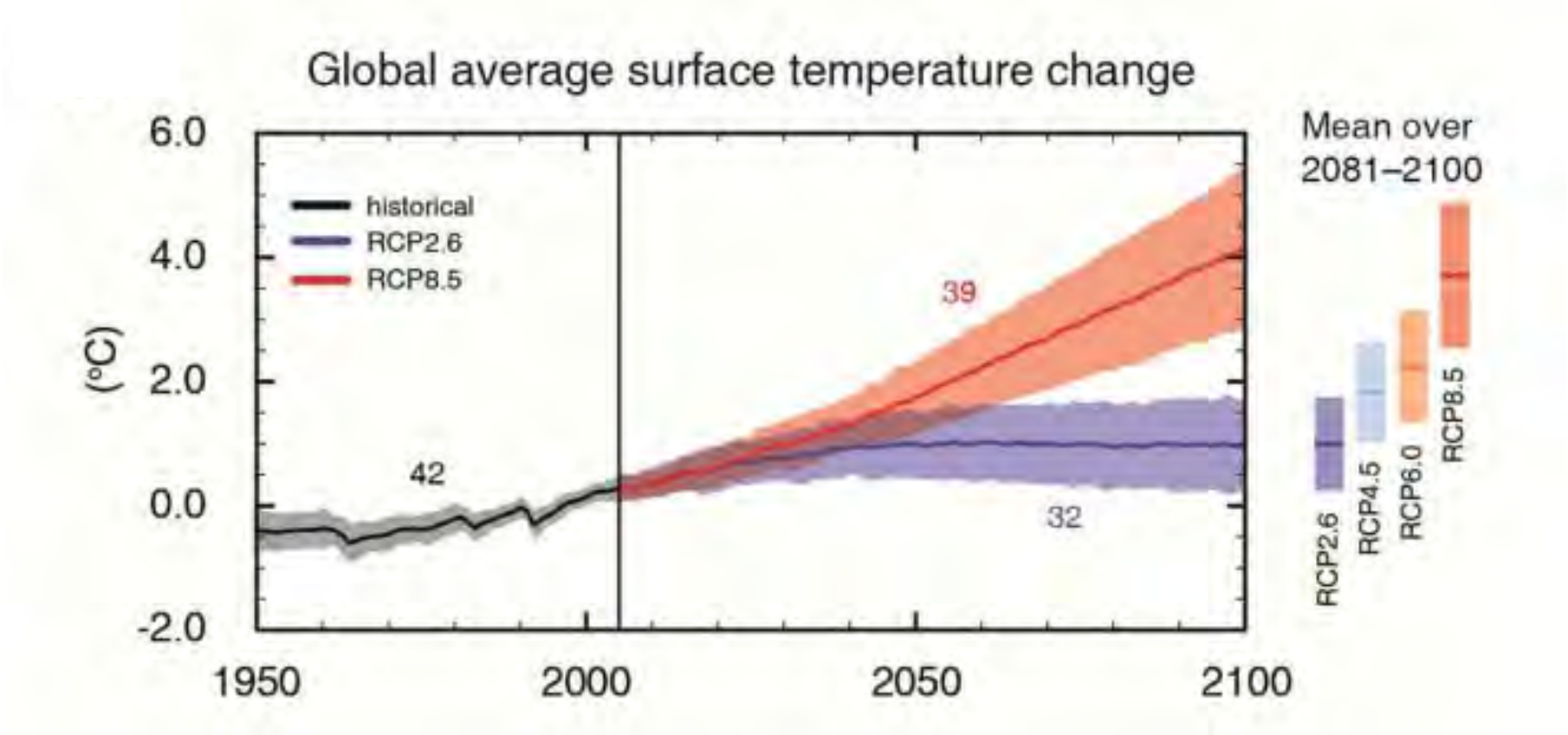
Figure 4-8 | The overall losses and insured losses from weather- and climate-related disasters worldwide (in 2010 US$). These data for weather- and climate-related 'great' and 'devastating' natural catastrophes are plotted without inclusion of losses from geophysical events. A catastrophe in this data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

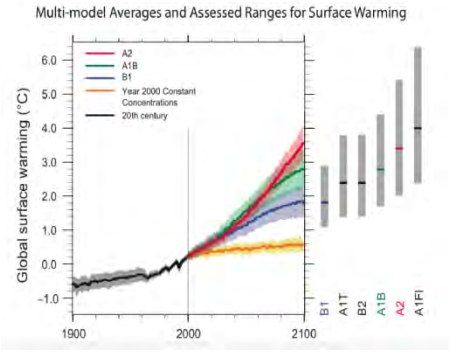
Future Projections

Climate Projections

- Climate models use equations to represent the Earth's climate system
- Provide a projection of future climate under multiple scenarios
- Temperature projections have higher certainty than precipitation
- Spatial resolution of projections depends on model type
- Representation of clouds is one of the largest sources of uncertainty in climate models



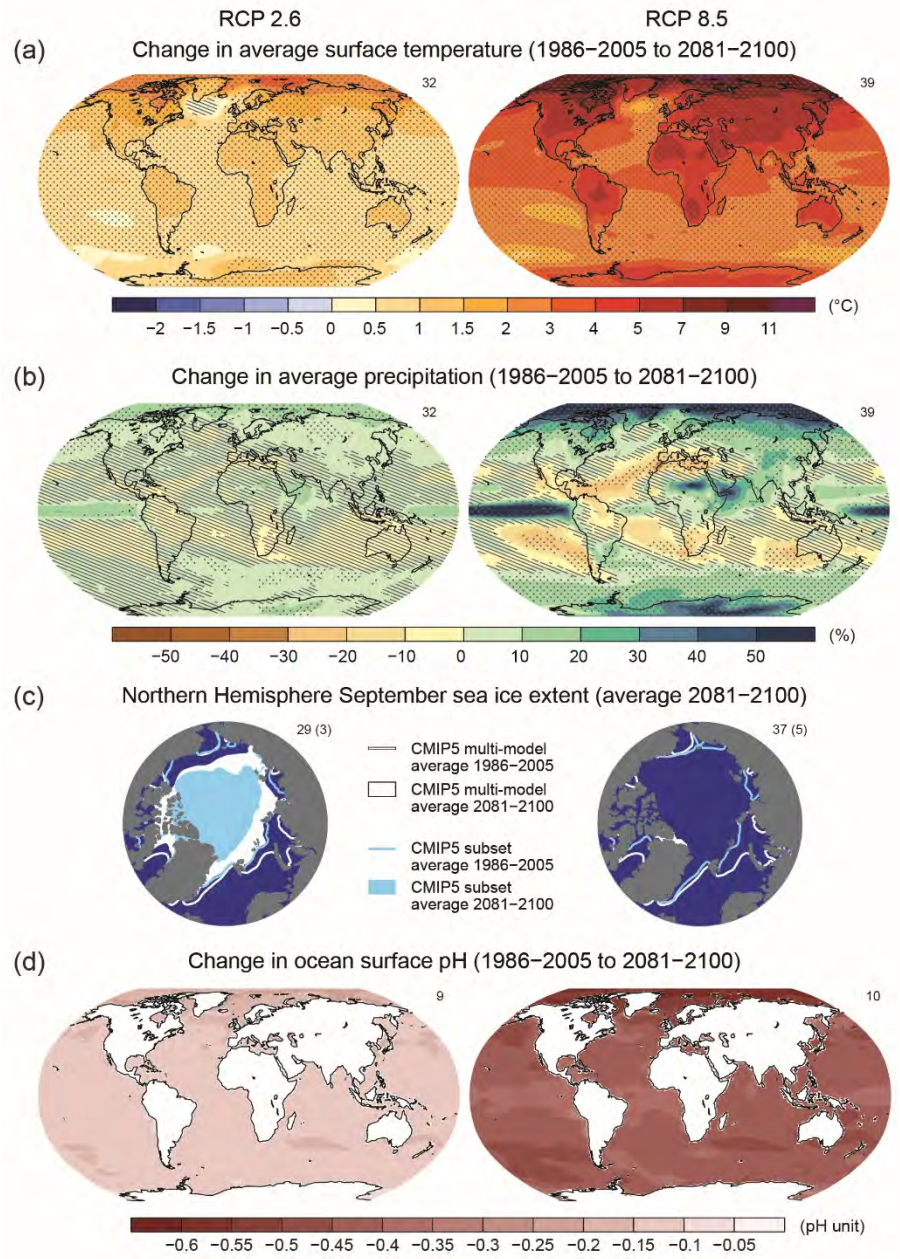

Global average surface temperature change
6.0
4.0
2.0
0.0
-2.0
(°C)
1950
2000
2050
2100
historical
RCP2.6
RCP8.5
42
39
32
Mean over
2081–2100
RCP2.6
RCP4.5
RCP6.0
RCP8.5


Multi-model Averages and Assessed Ranges for Surface Warming
Global surface warming (°C)
A2
A1B
B1
Year 2000 Constant Concentrations
20th century
B1
A1T
B2
A1B
A2
A1FI

(IPCC, 2013)

Projected Future Temperature Changes

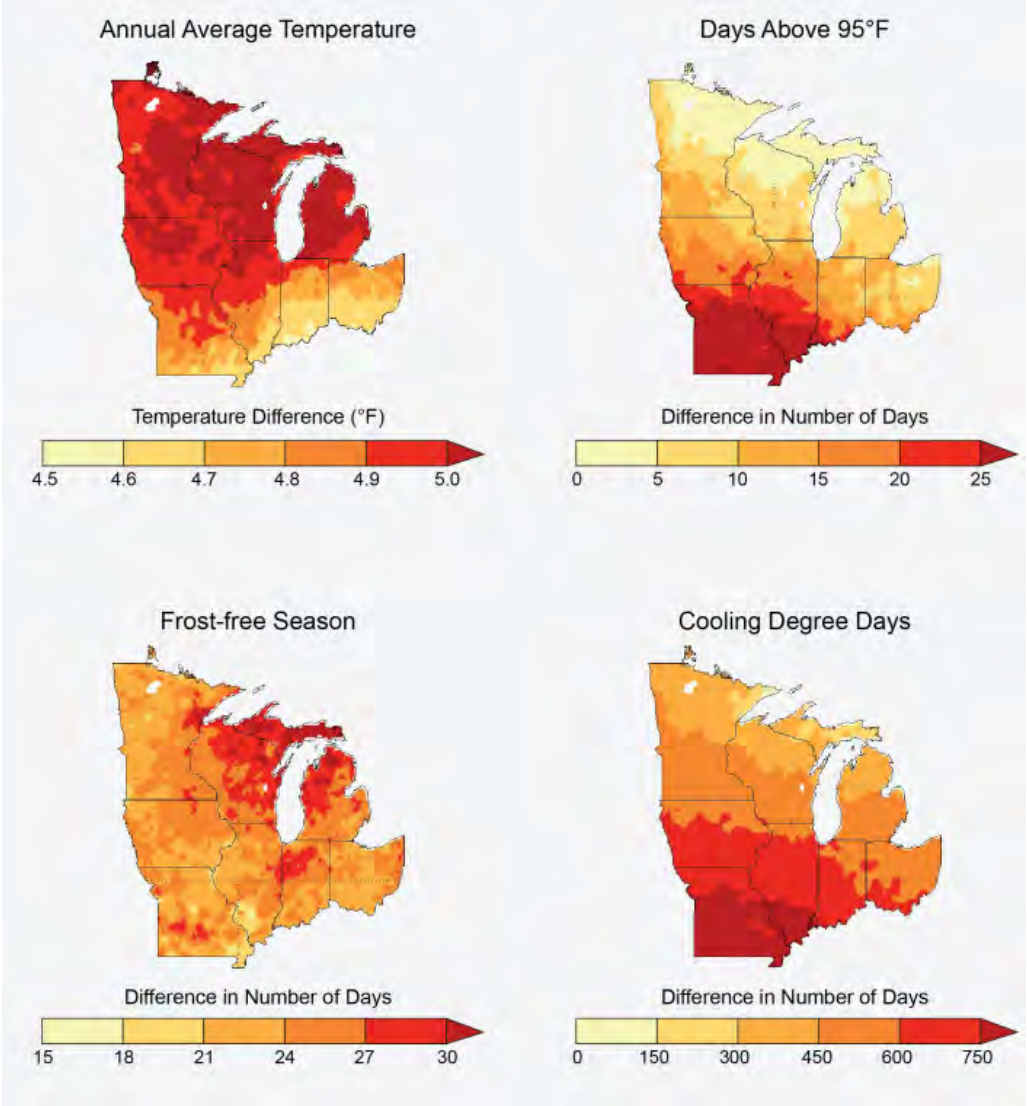
2081-2100 vs. 1986-2005



(IPCC, 2013)

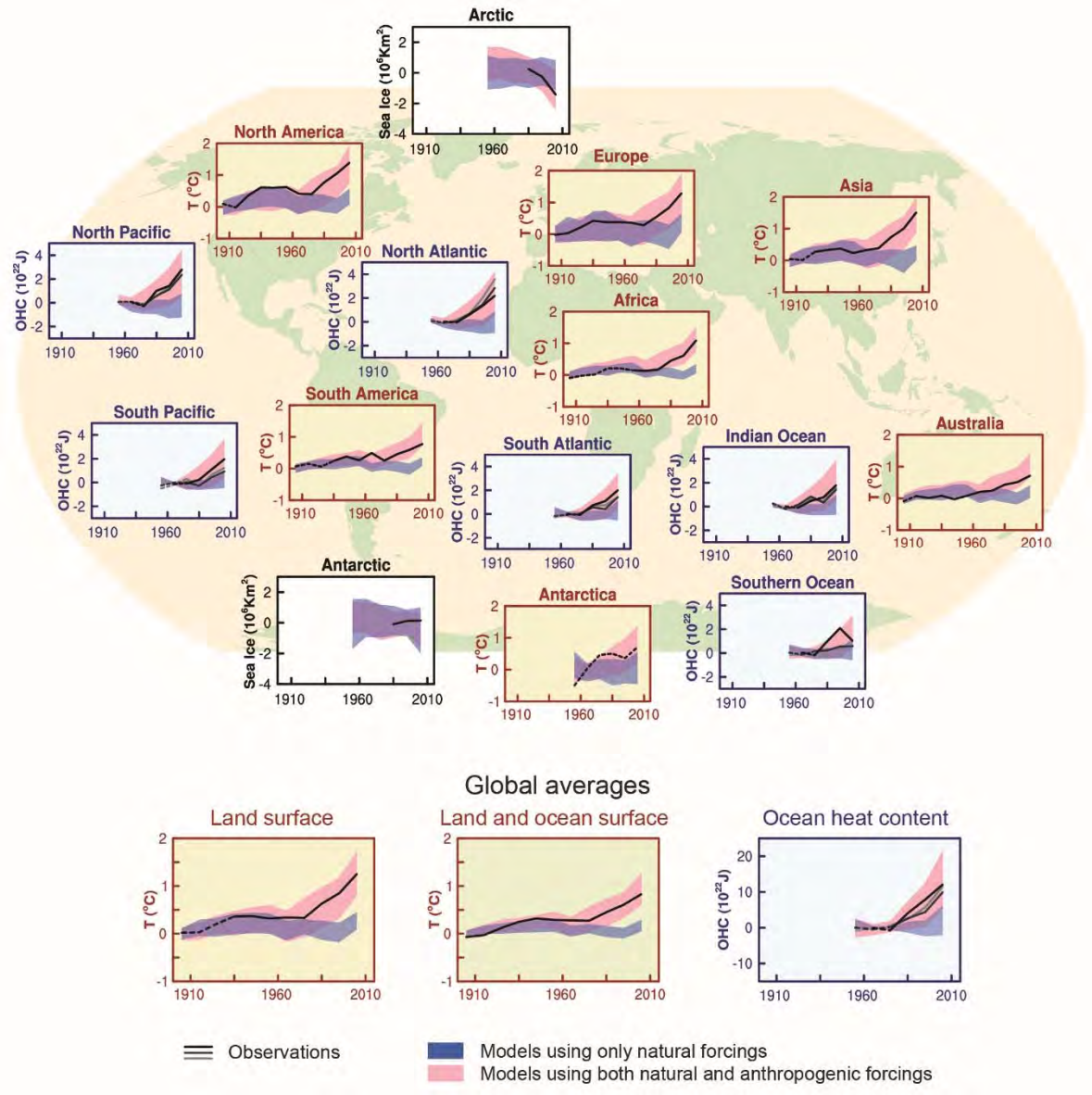
Projected Temperature-Related Changes

2041-2070 vs. 1971-2000



(Pryor and Scavia, 2013)

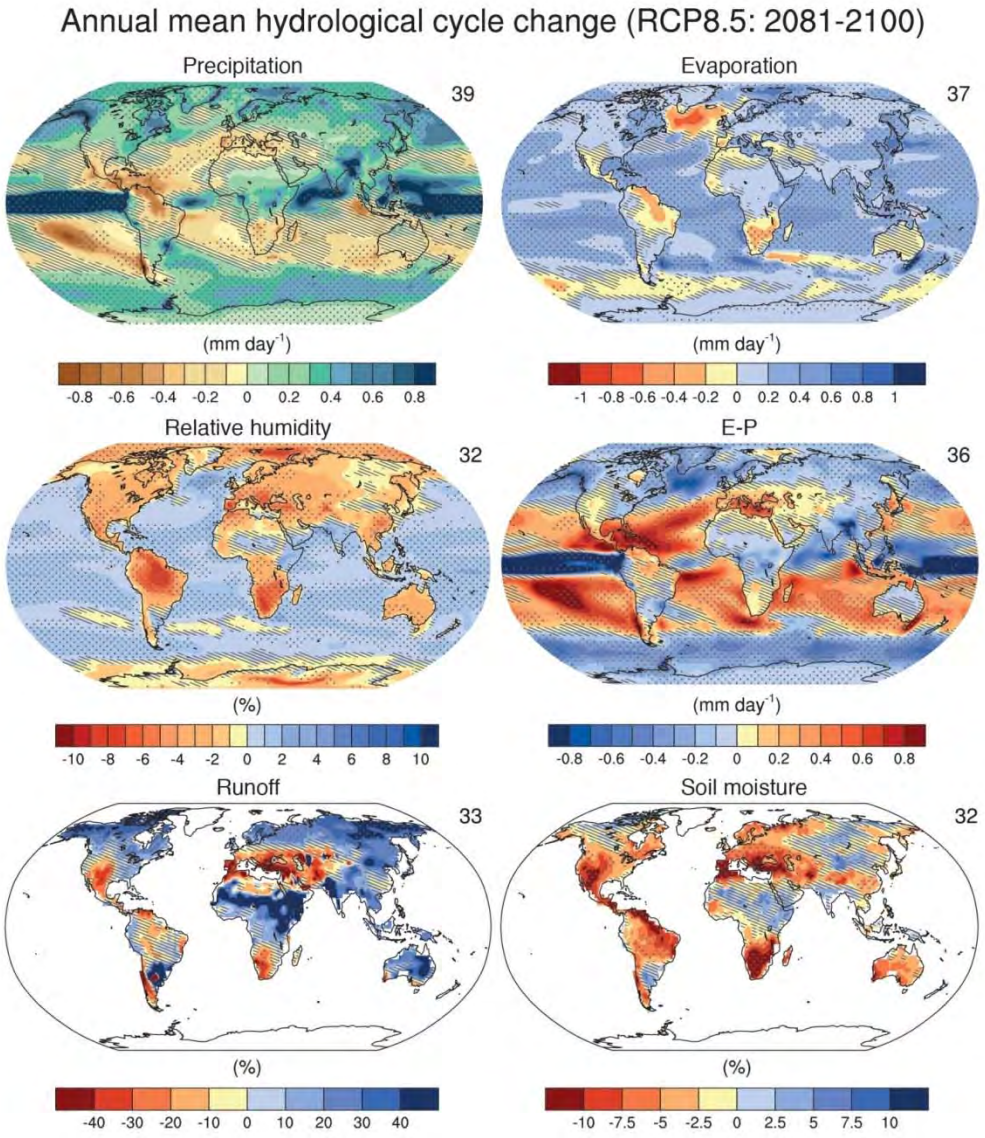
Anthropogenic Signal or Atmospheric Noise?



(IPCC, 2013)

Projected Future Precipitation Changes

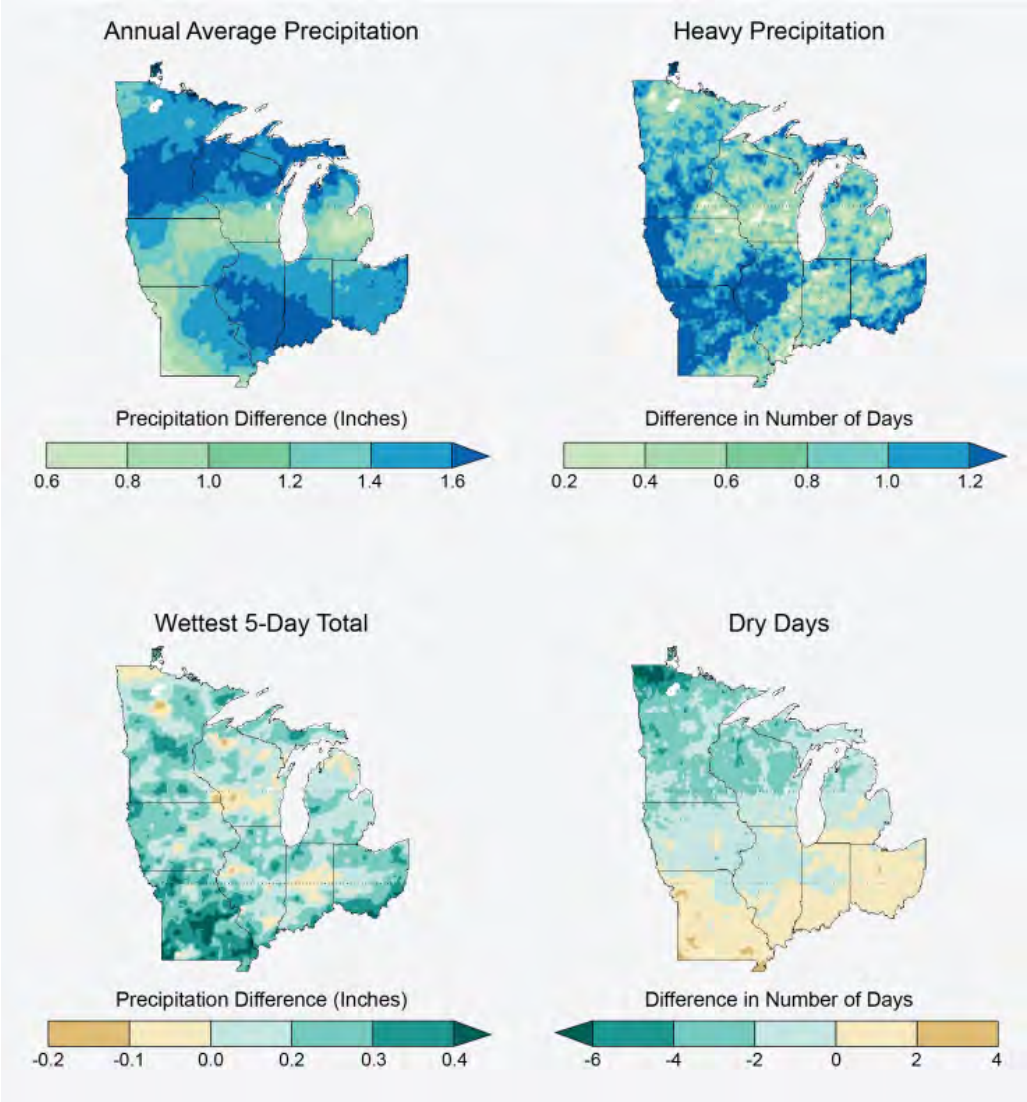
2081-2100 vs. 1986-2005



(IPCC, 2013)

Projected Preciptation-Related Changes

2041-2070 vs. 1971-2000



(Pryor and Scavia, 2013)

Risk of Major Droughts in the Future

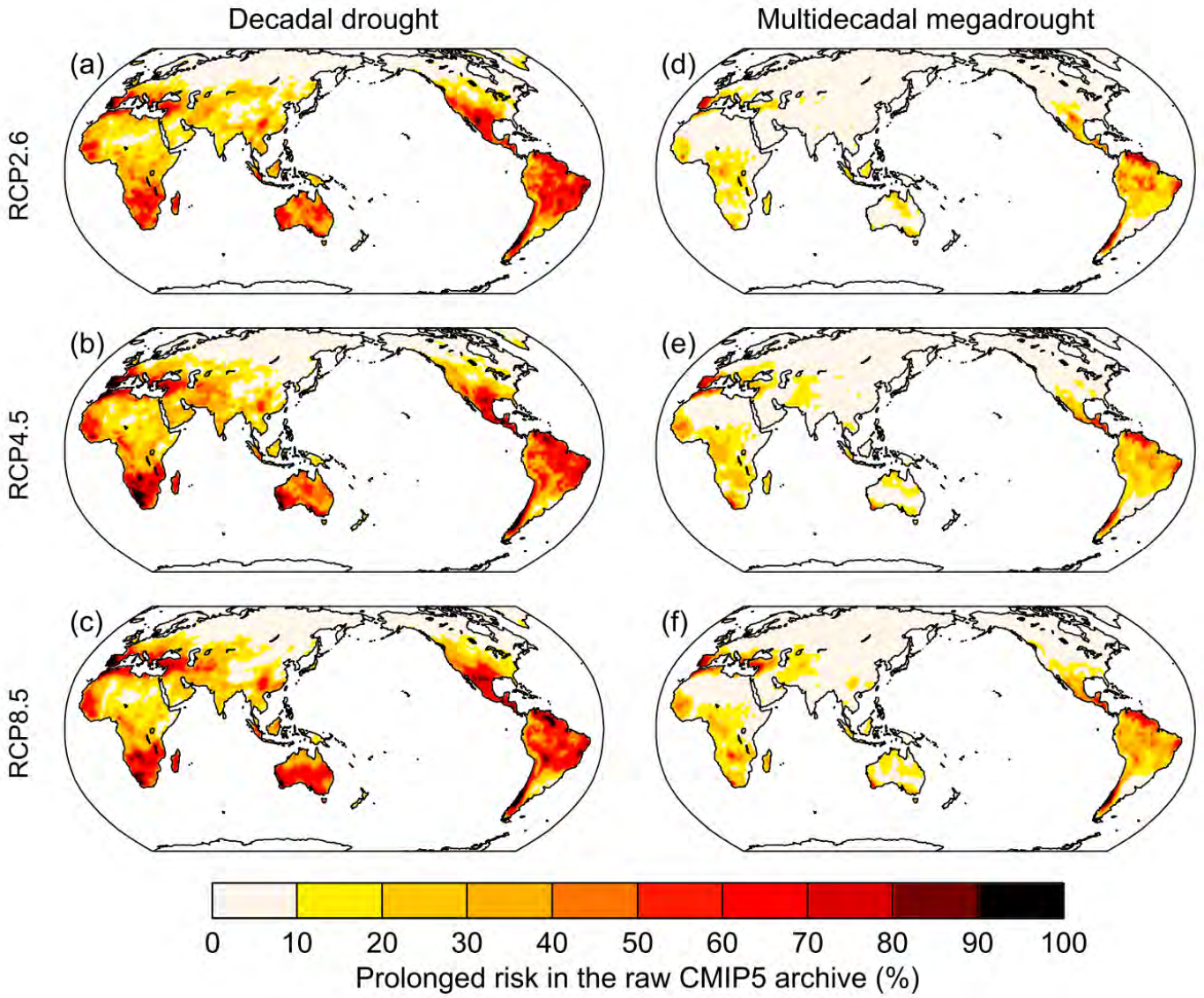


FIG. 16. Global estimates of (left) decadal and (right) multidecadal megadrought in the raw CMIP5 archive. As in Fig. 9, risk is calculated as the percent of the total number of models (27) that simulate a decadal or multidecadal megadrought. Forcing scenarios are indicated to the left of each map.

(From Ault et al., 2014)

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 expected rate of climate change, adaptive planning strategies should be dynamic in nature


Thank You!
Questions?
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