WATER SUPPLY PLANNING AND MANAGEMENT:

CLIMATE VARIABILITY AND CHANGE

Derek Winstanley

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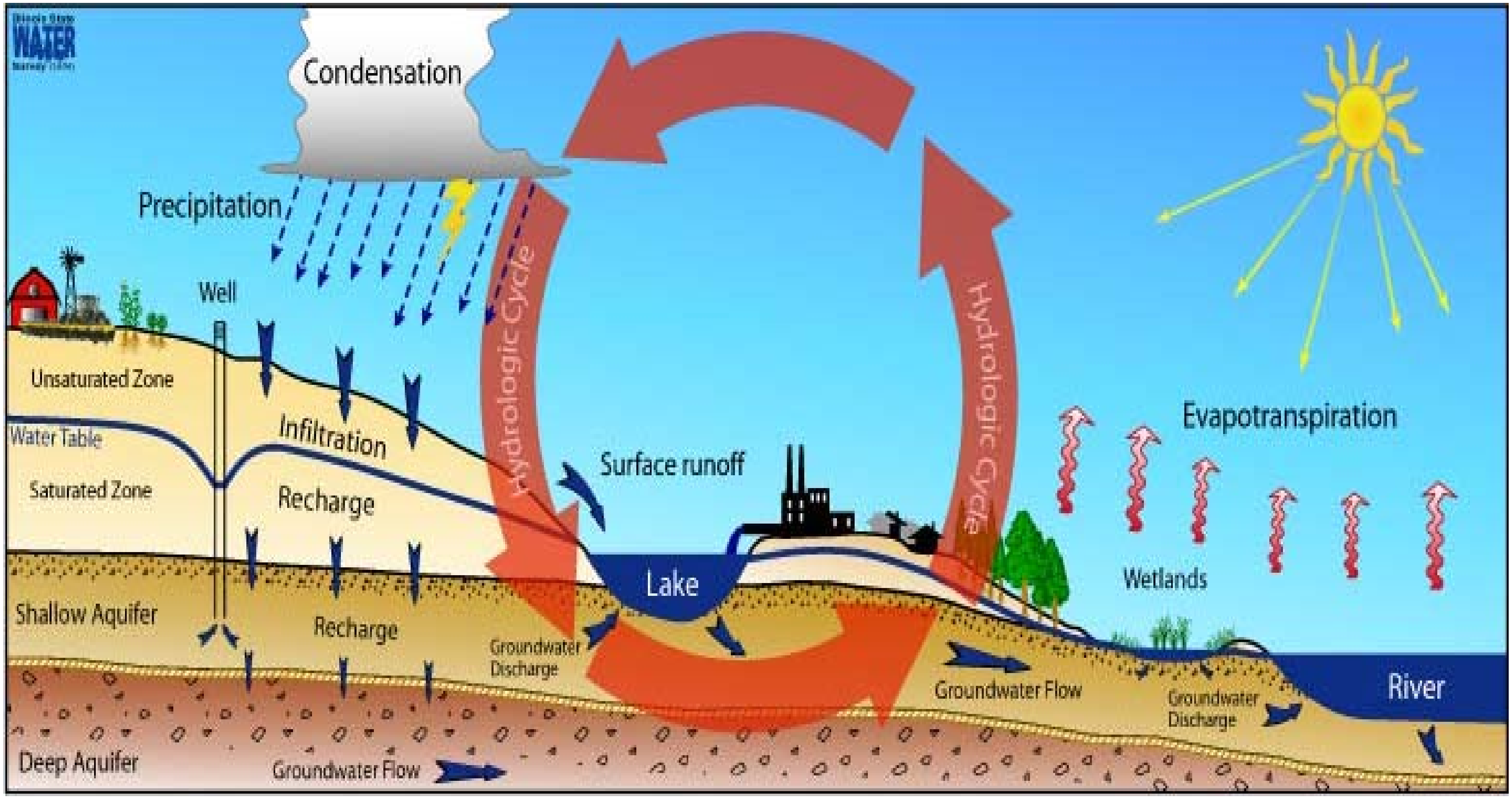
IDNR/OWR **ISWS**

CONTENTS

ACKNOWLEDGMENTS

- Ken Kunkel, ISWS
- Jim Angel, ISWS
- Xin-zhong Liang, ISWS
- Mike Palecki, ISWS
- Vern Knapp, ISWS
- USGS streamflow data
- NOAA climate data

THE WATER CYCLE: CLIMATE, SURFACE WATER, and GROUNDWATER ARE LINKED



1. CLIMATE CONDITIONS ARE A MAJOR FACTOR IN WATER SUPPLY
2. LONG-RANGE WATER SUPPLY PLANNING REQUIRES CONSIDERATION OF CLIMATIC CONDITIONS TO 2050 AND PERHAPS BEYOND
3. FUTURE CLIMATIC CONDITIONS ARE HIGHLY UNCERTAIN
4. THE CHALLENGE IS HOW TO DEAL WITH UNCERTAINTIES AND ASSOCIATED RISKS

DEFINITION of CLIMATE

- The statistical aggregate of weather conditions over a period of time: temperature; precipitation; wind; cloudiness; storms; etc.
- Climate “normals” are set over 30 year periods: means; extremes; frequencies of occurrence etc.
- Current “normal” period is 1971-2000.
- This will change to 1981-2010 in 2011.

DEFINITIONS:

CLIMATE VARIABILITY
and
CLIMATE CHANGE

DEFINITION of CLIMATE VARIABILITY

- Variations (ups and downs) in climatic conditions on time scales of months, years, decades, centuries, and milenia. Includes droughts and floods.

DEFINITION of CLIMATE CHANGE

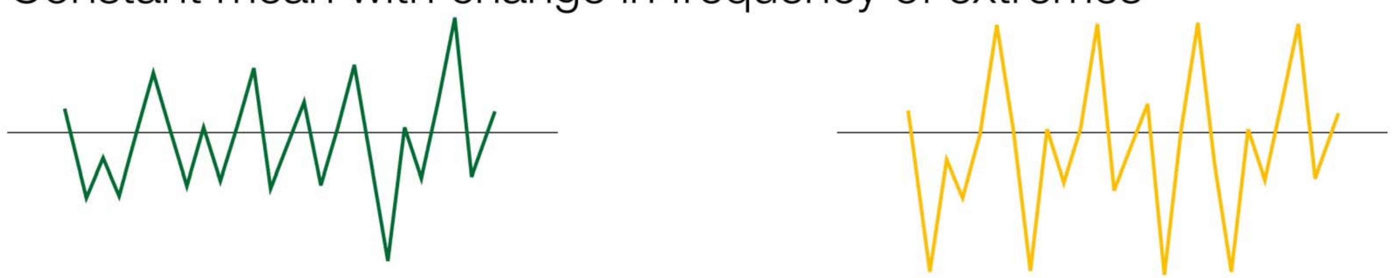
- A statistically significant change in climate characteristics over a period of time.
  - From one 30-year period to another
  - From one century to another
  - From one millenium to another
- You can’t have climate change over less than a 30-year period.
- Climate change can be a change in the mean, a change in extremes, or change in frequencies.

EXAMPLES OF CLIMATE CHANGE

- Change in the annual mean

- Constant mean with change in extremes

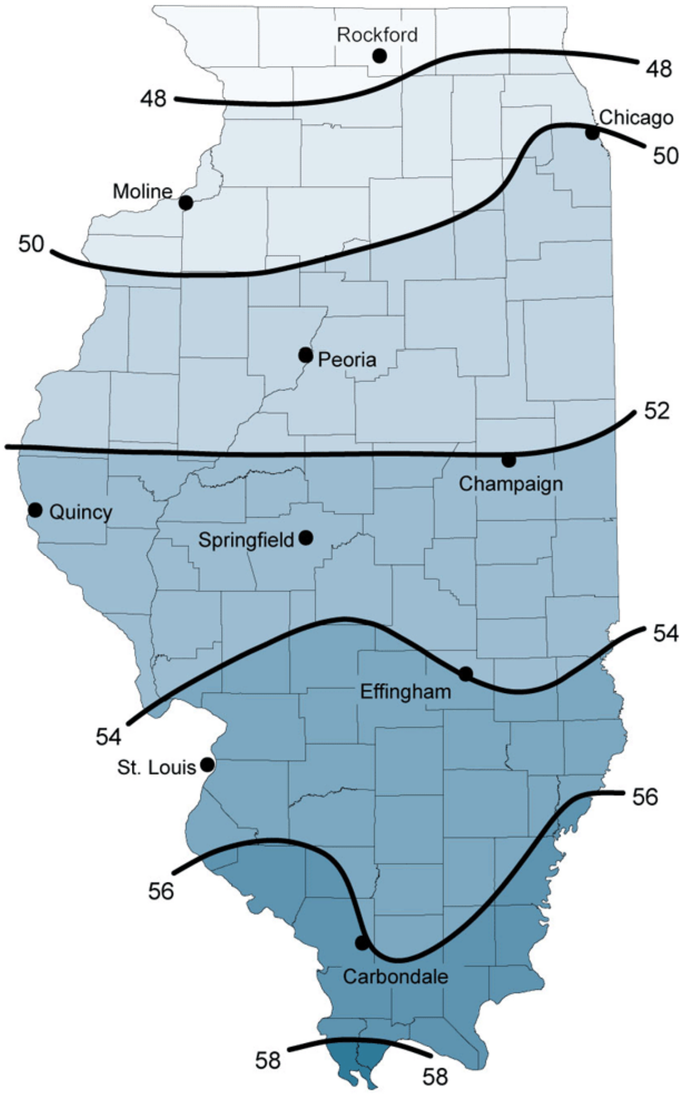
- Constant mean with change in frequency of extremes



EFFECTS OF CLIMATE VARIABILITY AND CHANGE ON WATER SUPPLY

- **Droughts and lower precipitation reduce water availability**
- **Higher temperatures increase the loss of water and increase water demand**
- **Droughts and high temperatures combined have the largest impacts on water supply and demand**

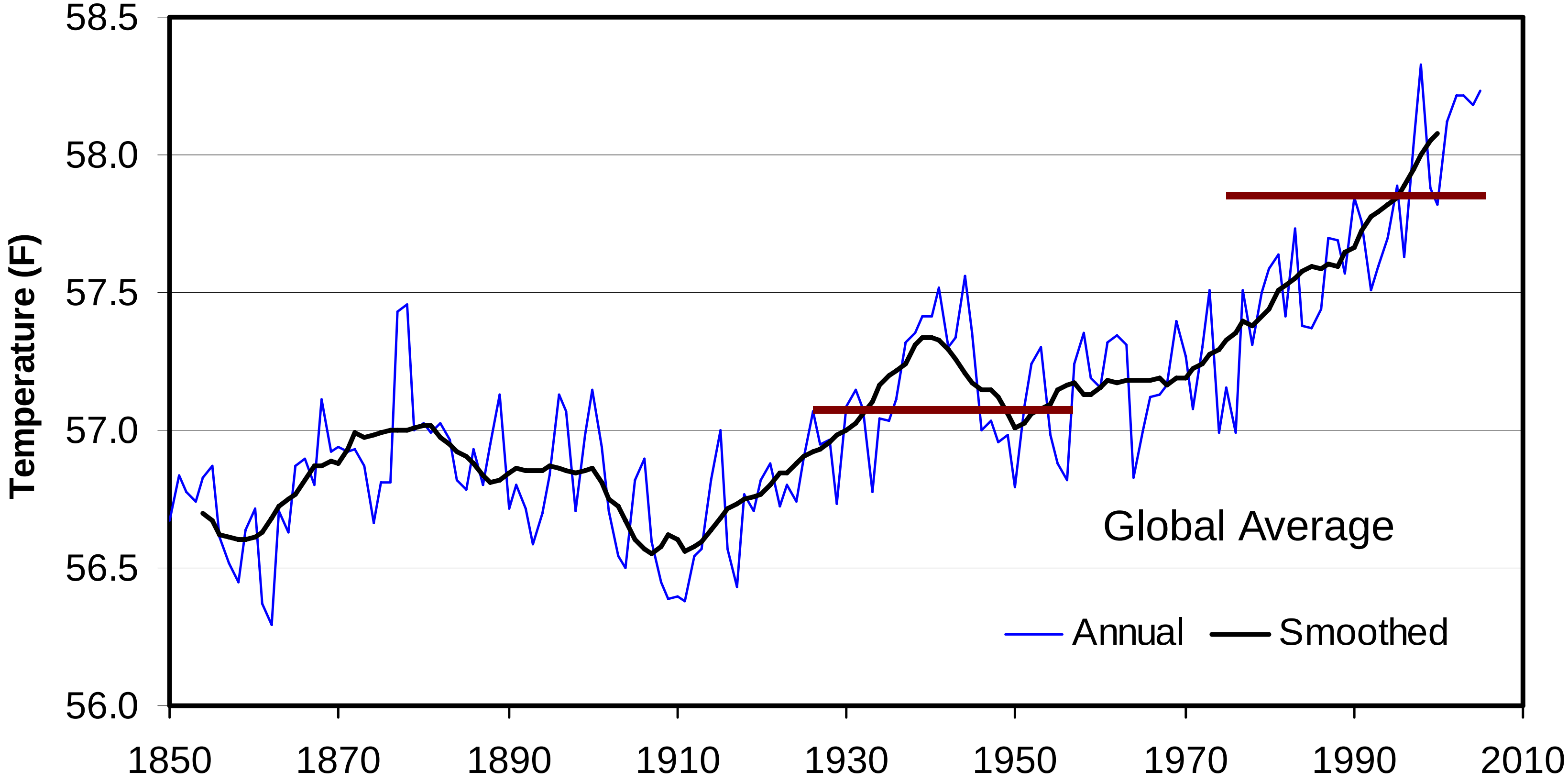
MEAN ANNUAL TEMPERATURE 1971-2000



Average annual temperature (°F) in Illinois, 1971-2000

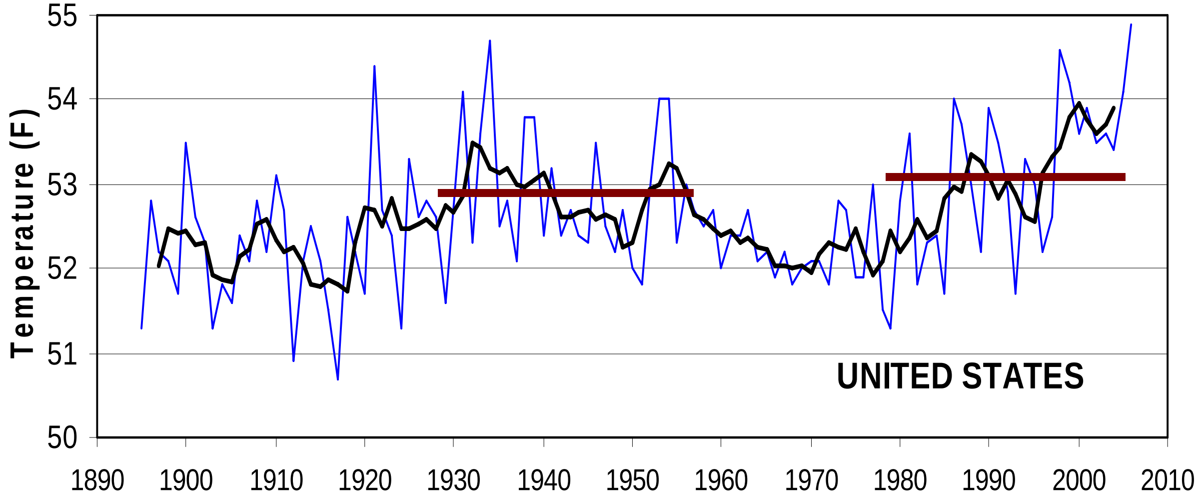
Global Warming

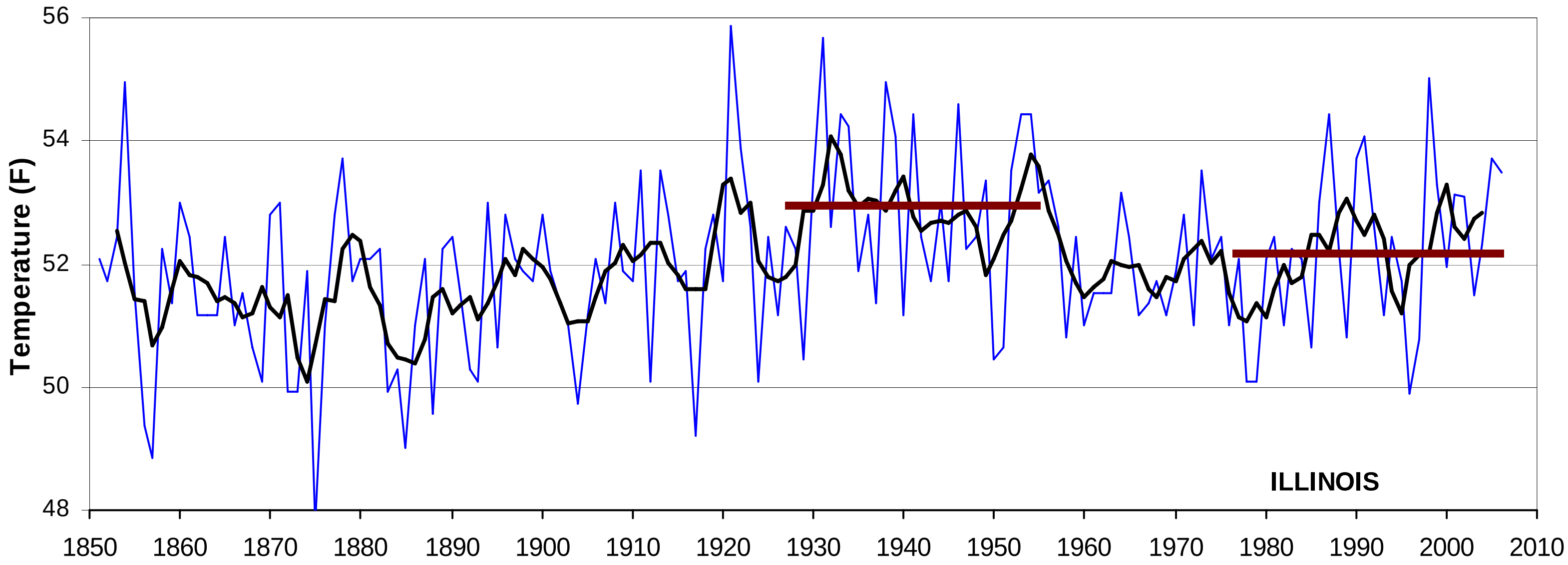
Source: Hadley Centre, UK



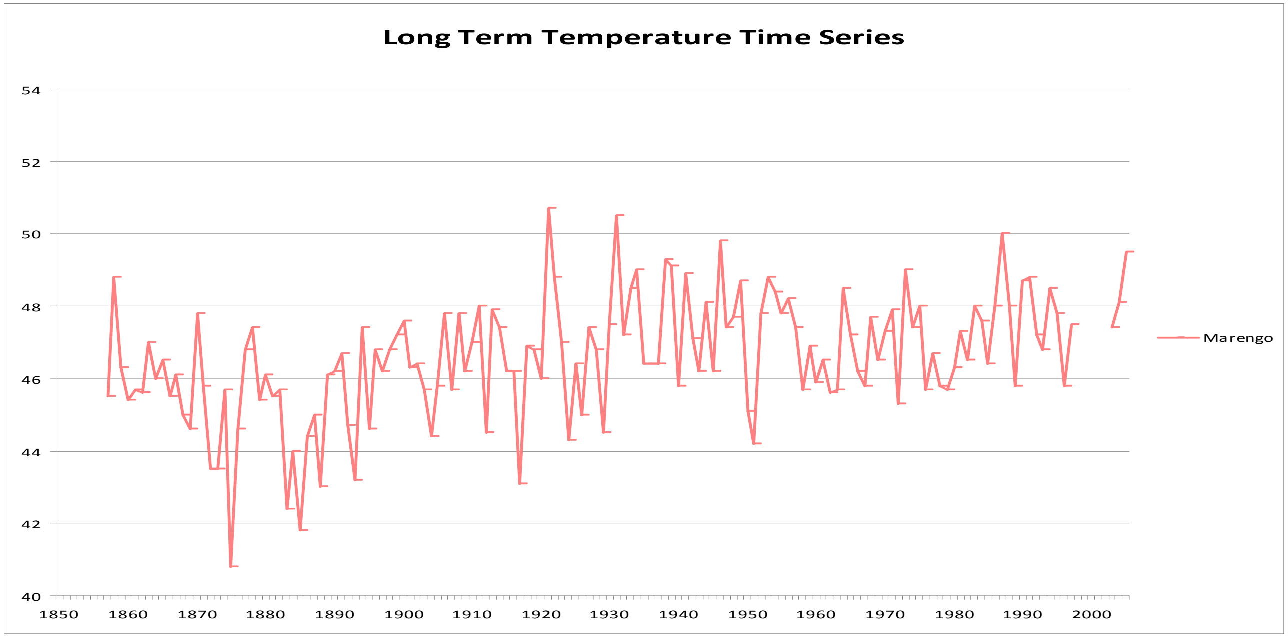
Temperature _ Annual _ Smoothed

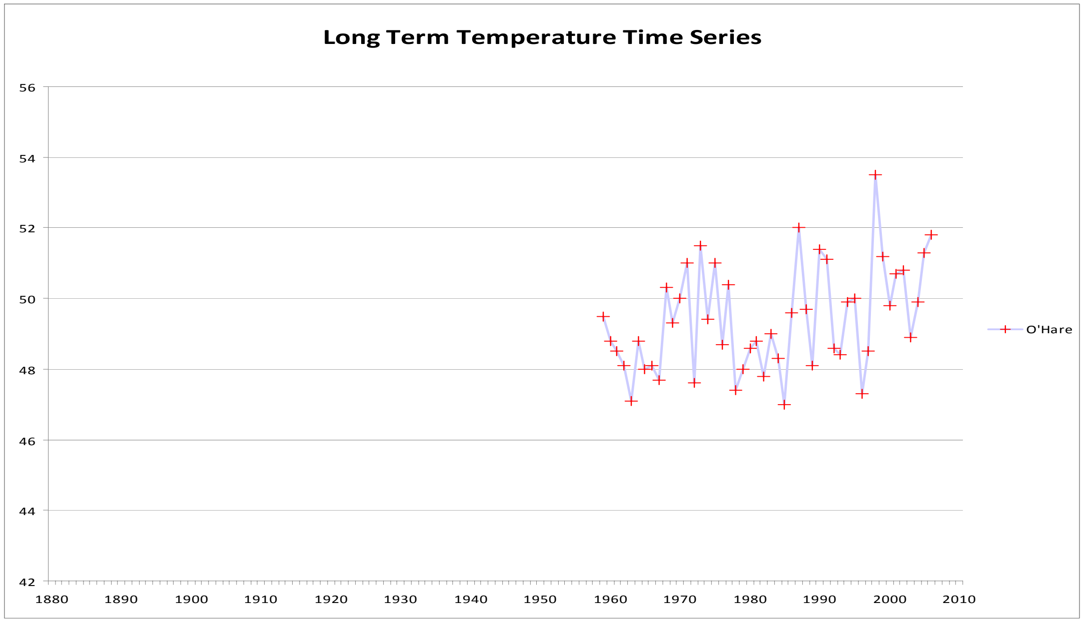
Source: Jim Angel, Illinois State Water Survey





Annual Temperature: Marengo and O'Hare





ANNUAL TEMPERATURE TRENDS

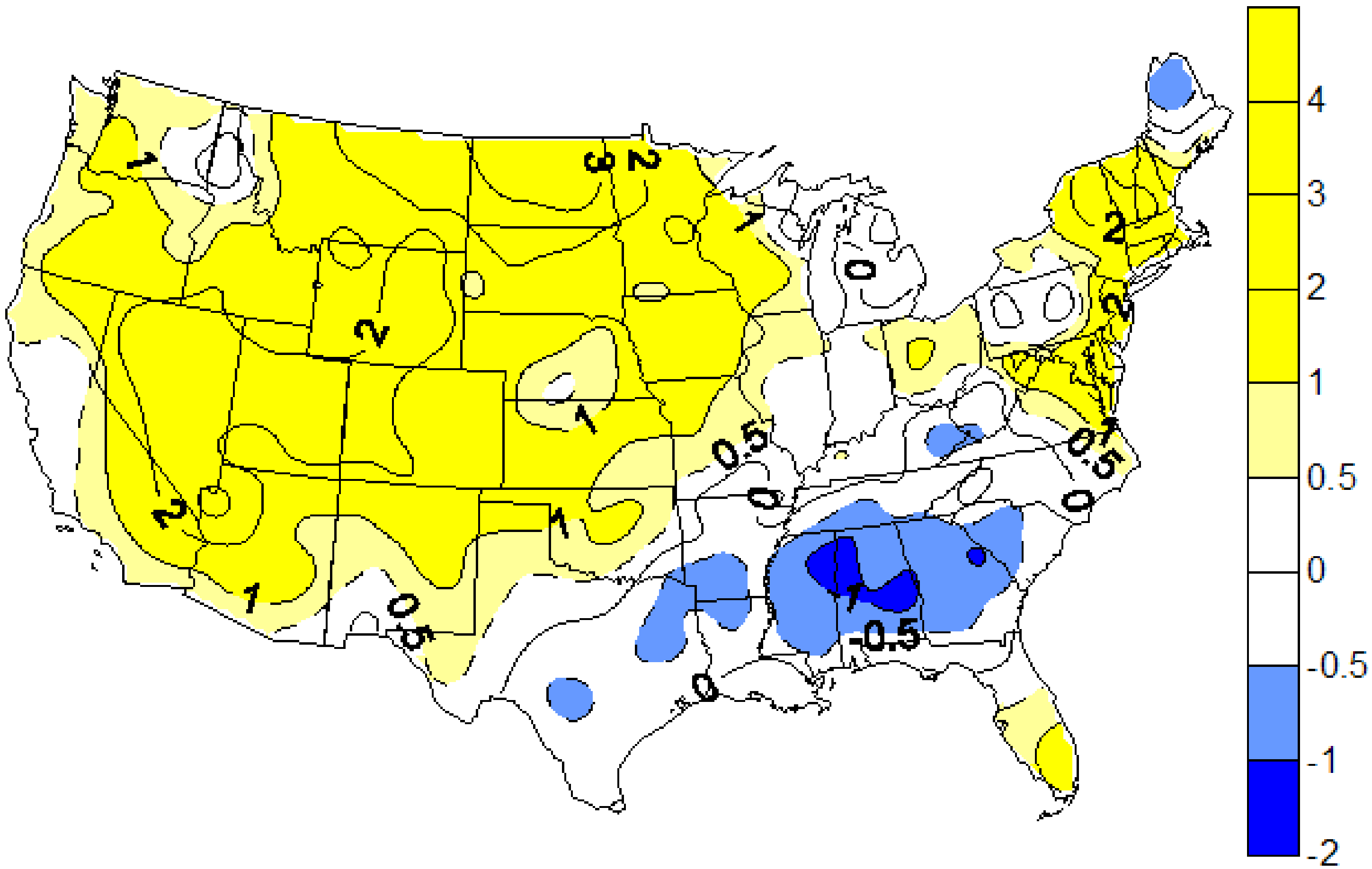
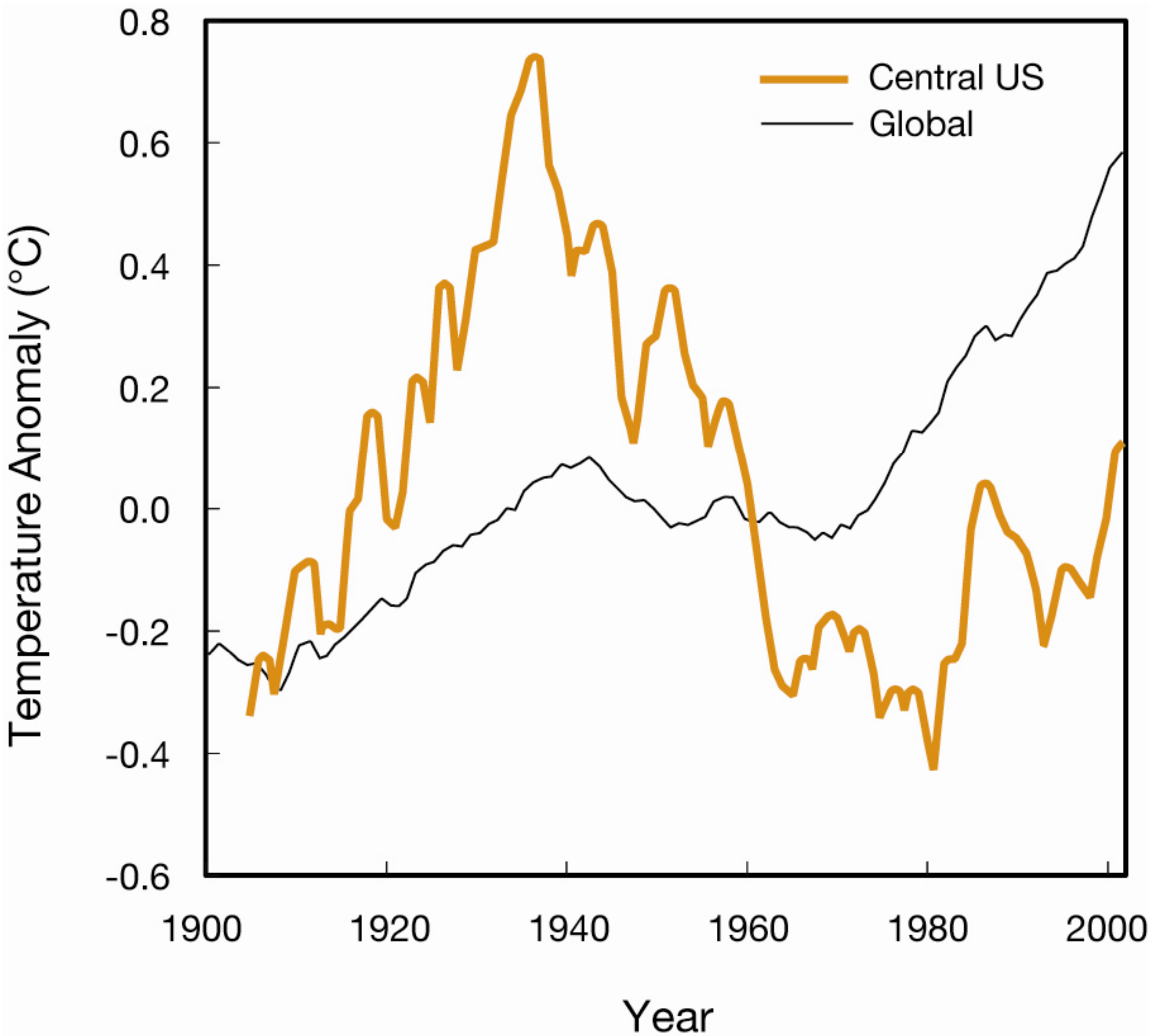
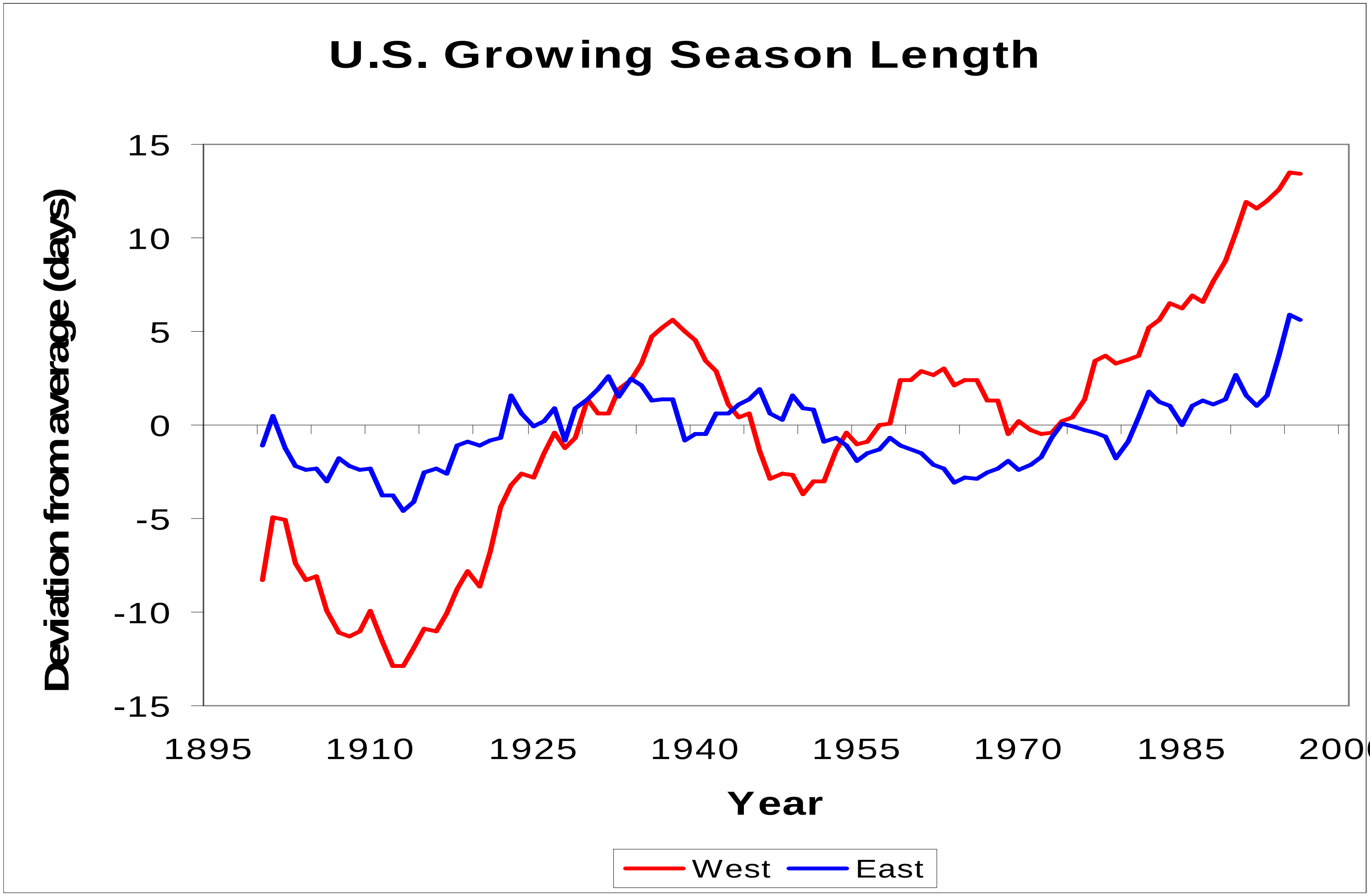


Figure 1. ANNUAL temperature trends in the U.S. expressed as the total change over the period 1895-2006 in degrees F and derived from climate division data. Copyright 2007. Illinois State Water Survey.

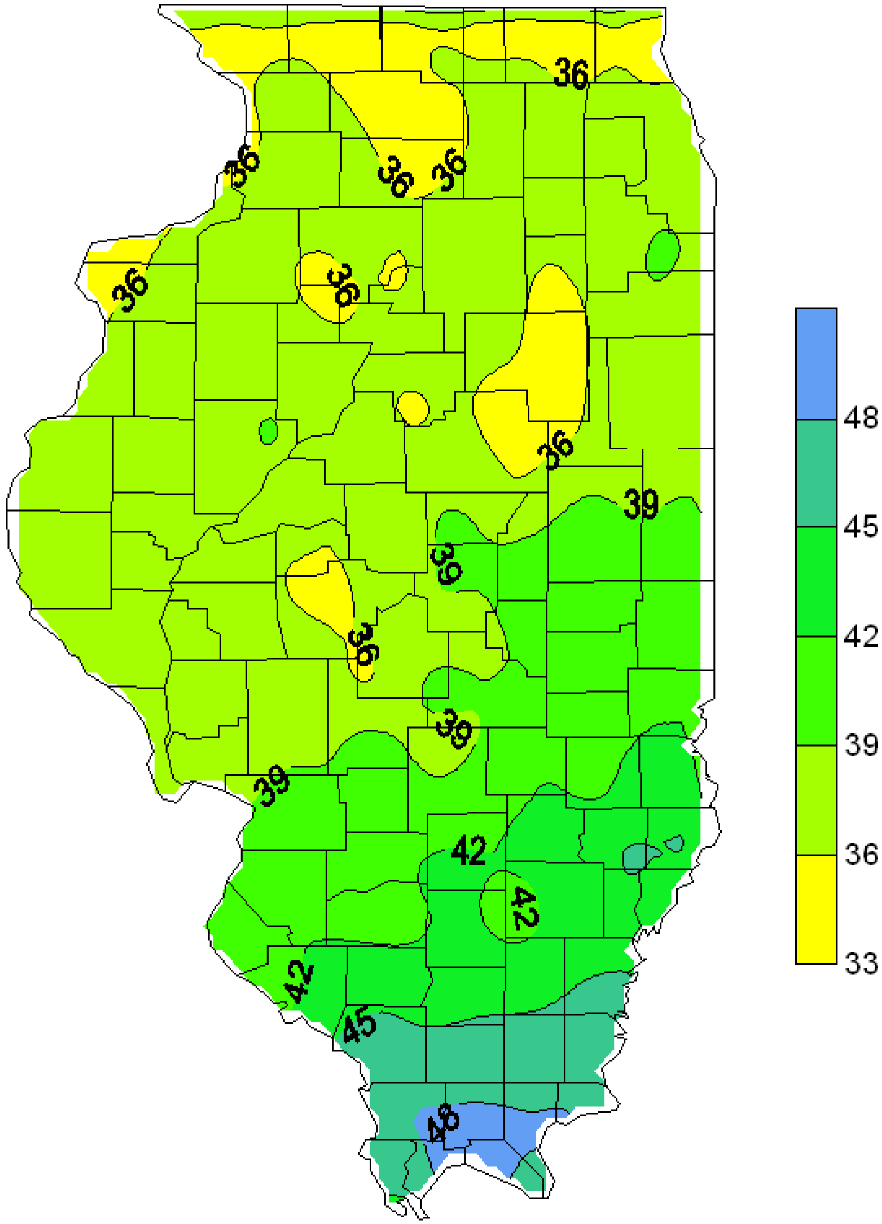
TEMPERATURE CHANGES IN ILLINOIS AND CENTRAL USA ARE NOT THE SAME AS GLOBAL AVERAGE TEMPERATURE TRENDS



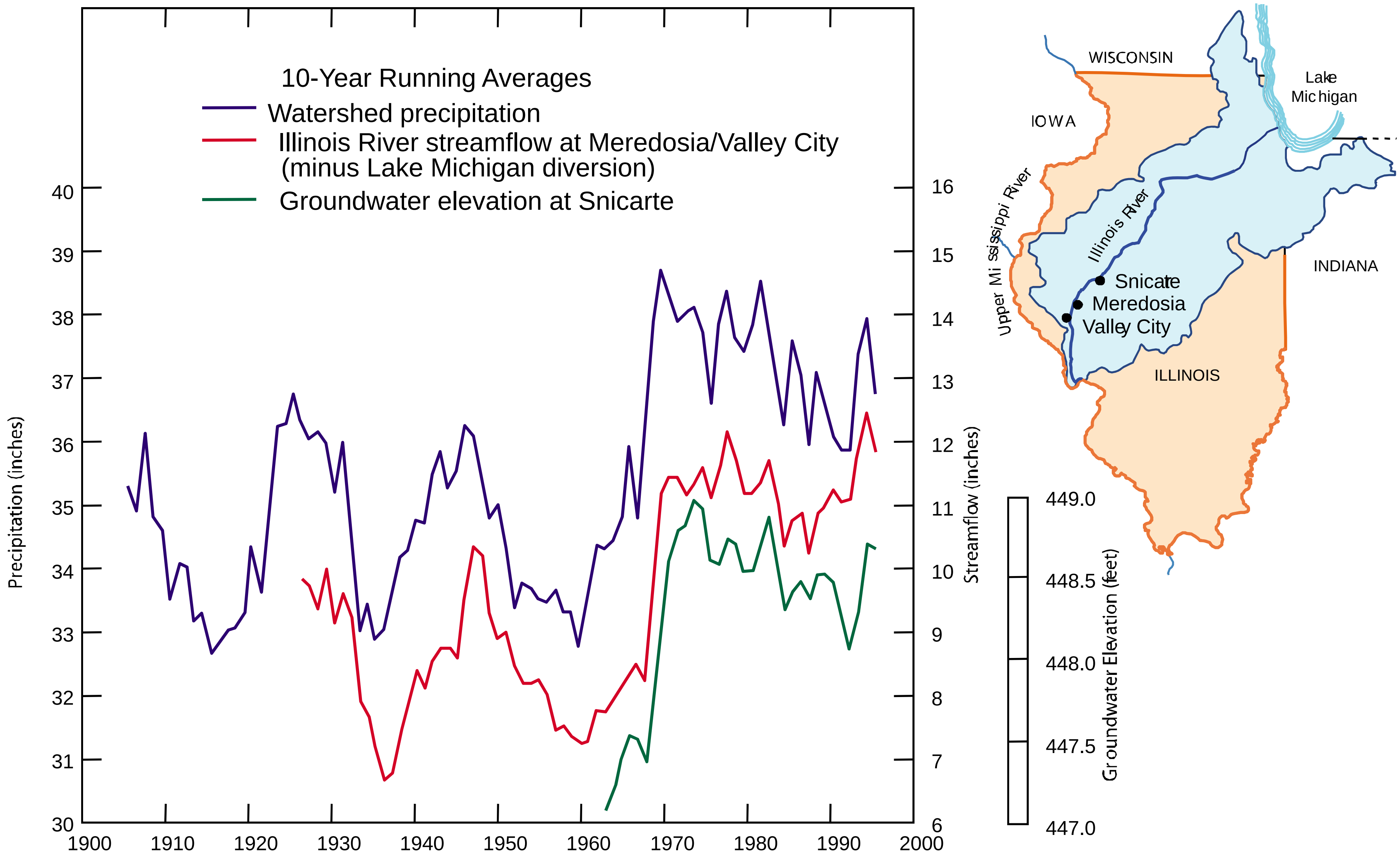
20+ DAYS INCREASE IN GROWING SEASON IN WEST.
NOT MUCH CHANGE IN EAST (K. Kunkel)



1971-2000 Normal Annual Precipitation (in)

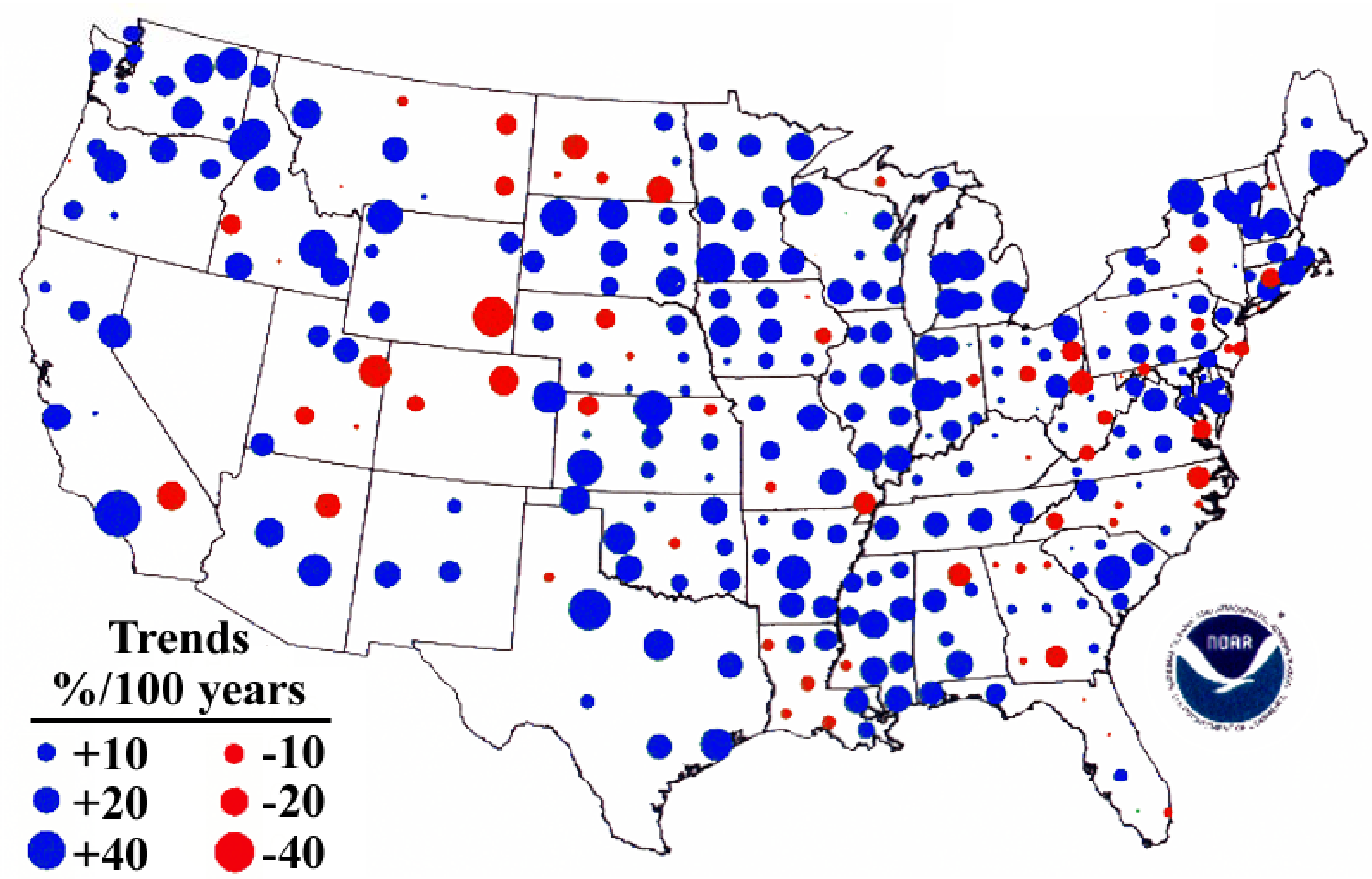


Illinois State Water Survey, Office of the State Climatologist



10-year running averages of Illinois River watershed precipitation, streamflow (minus Lake Michigan diversion), and groundwater elevation.

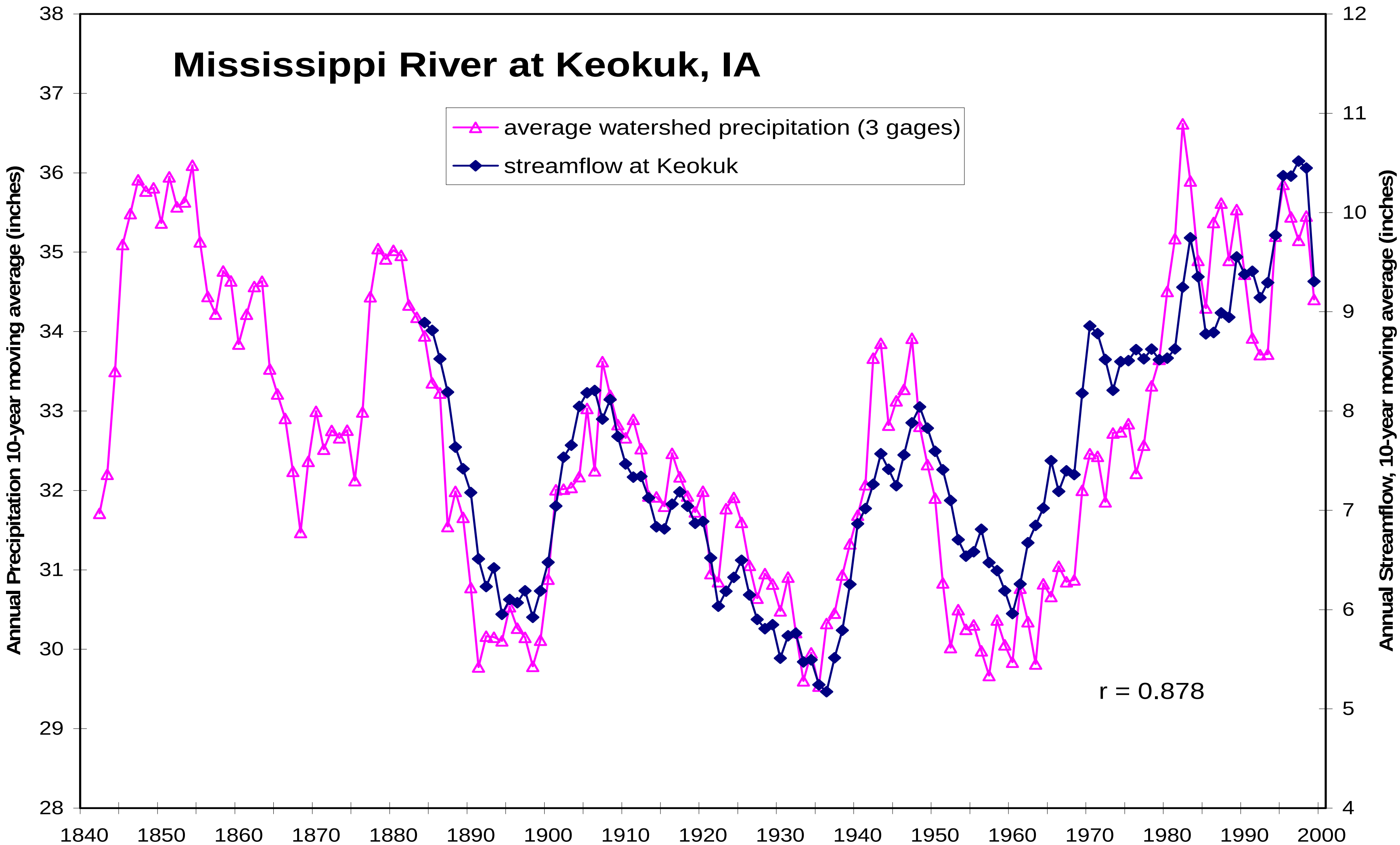
USA 20th CENTURY PRECIPITATION TRENDS



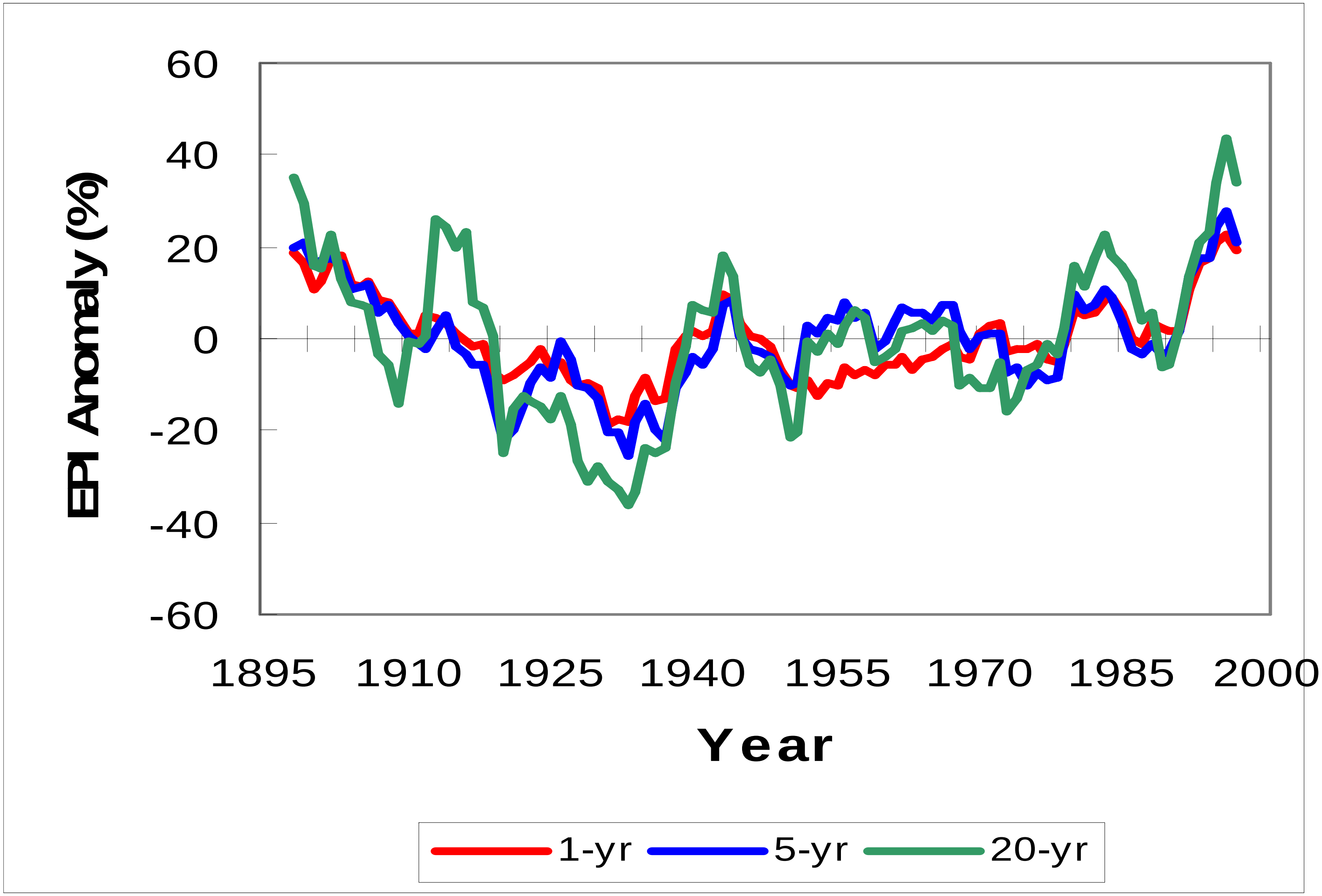
Climate – Streamflow Relationship Illinois

- A 10 percent change in precipitation typically results in a 20-30 percent change in streamflow

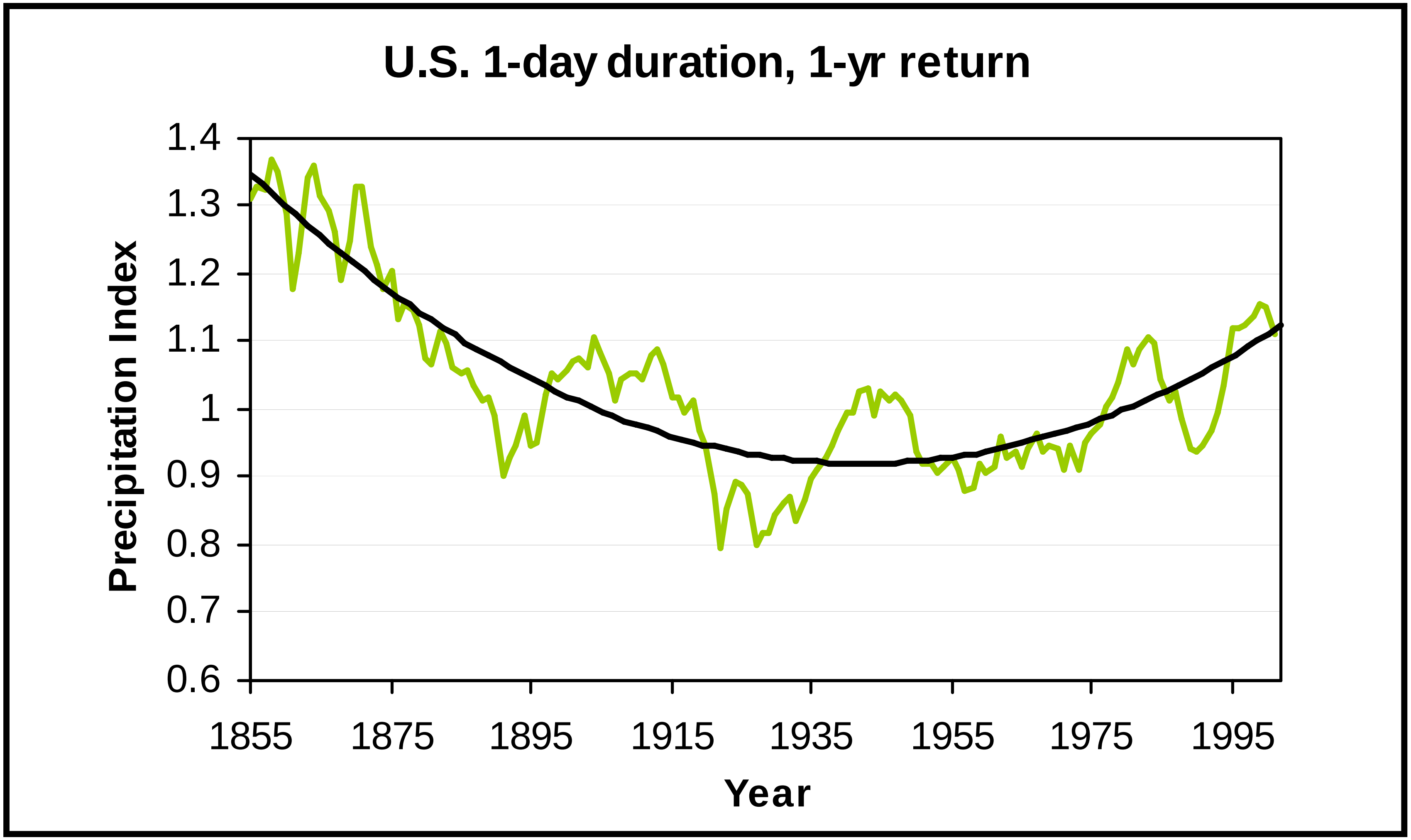
Vern Knapp in Winstanley et al. (2006), ISWS IEM 2006-02



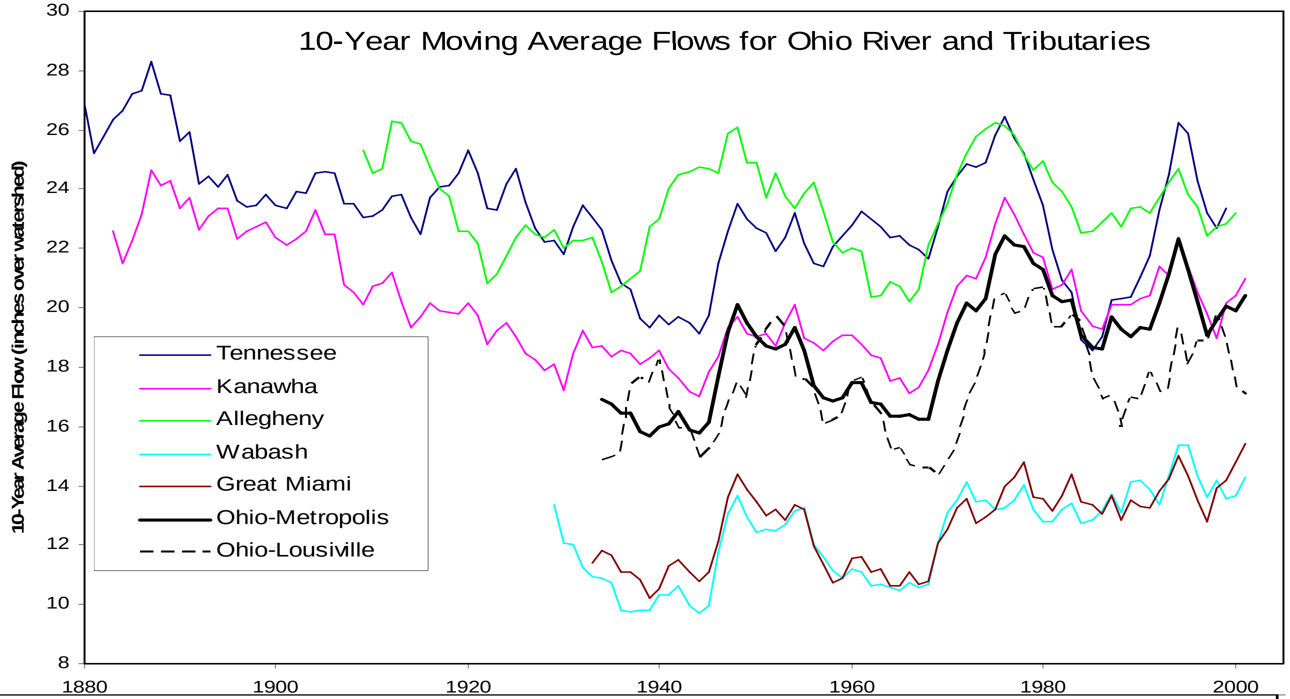
Trends in Heavy Precipitation Events Across USA (K. Kunkel)

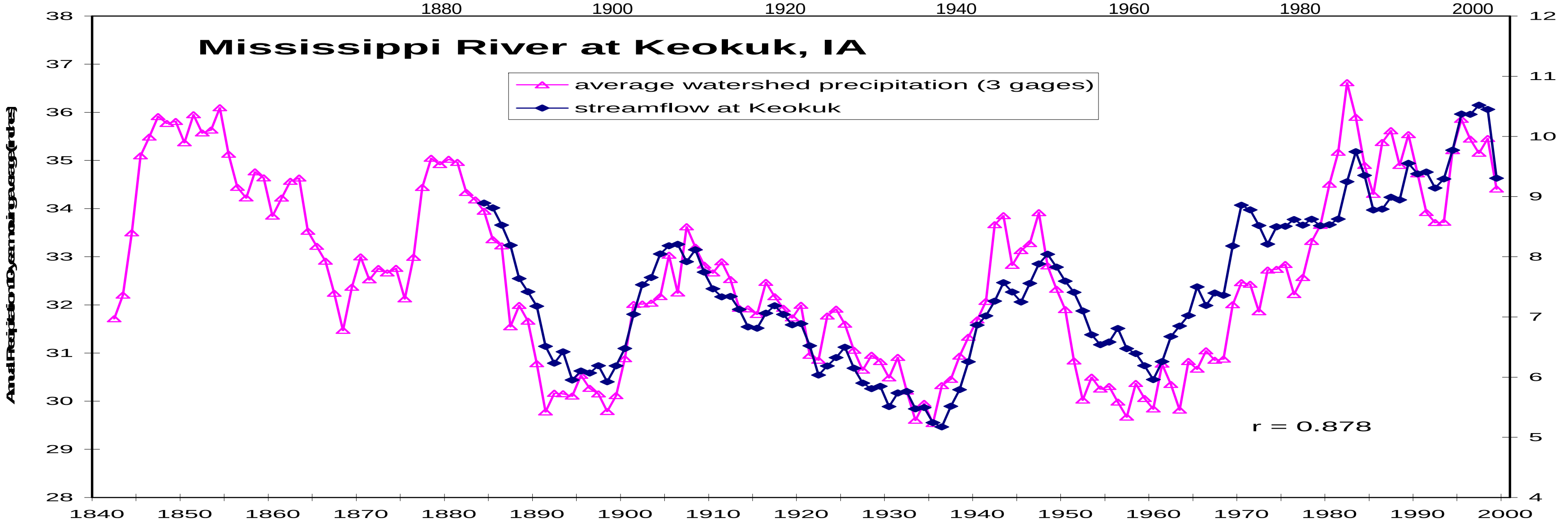


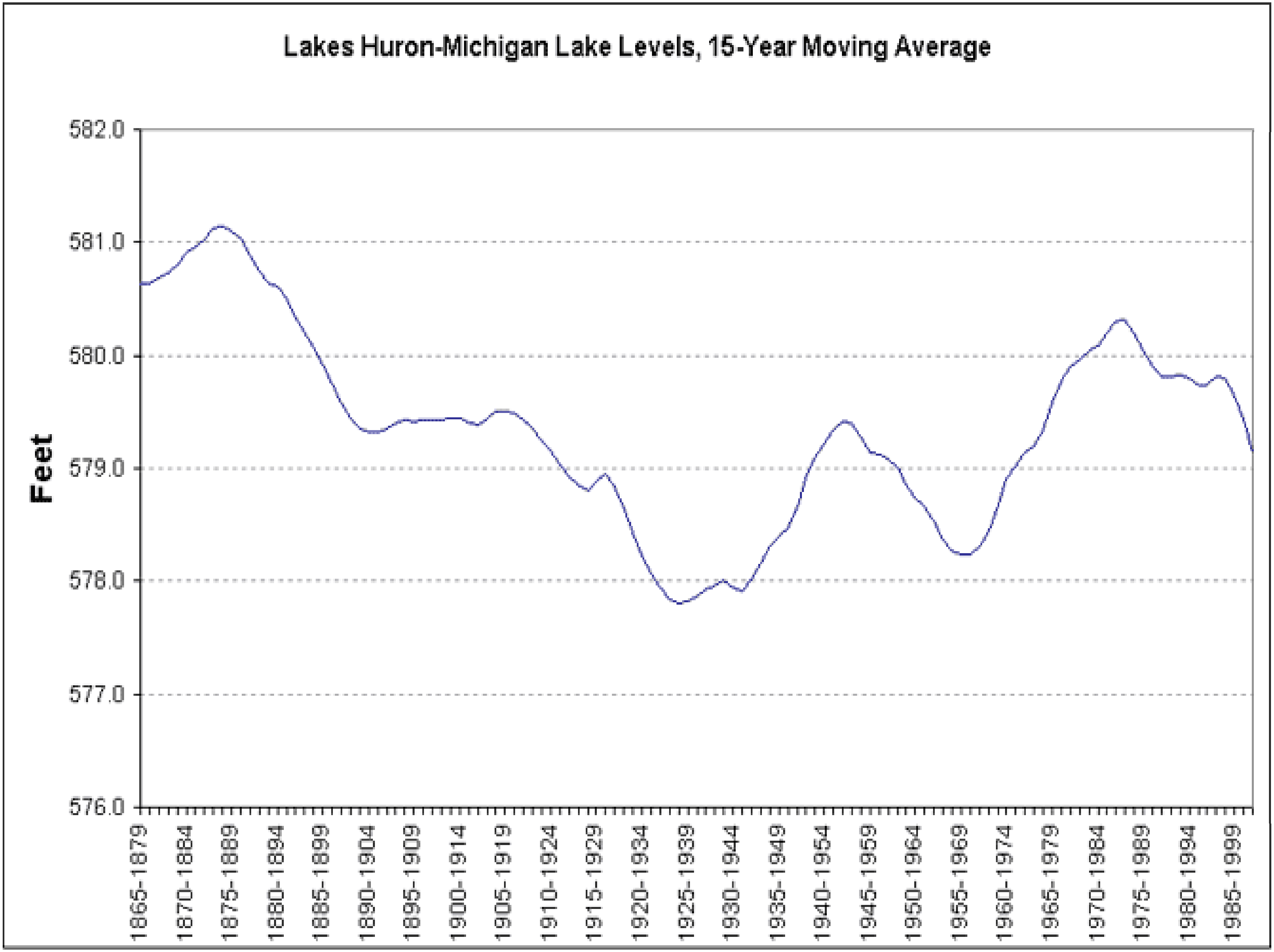
Trends in Precipitation Events Across USA (M. Palecki)



Vern Knapp, ISWS

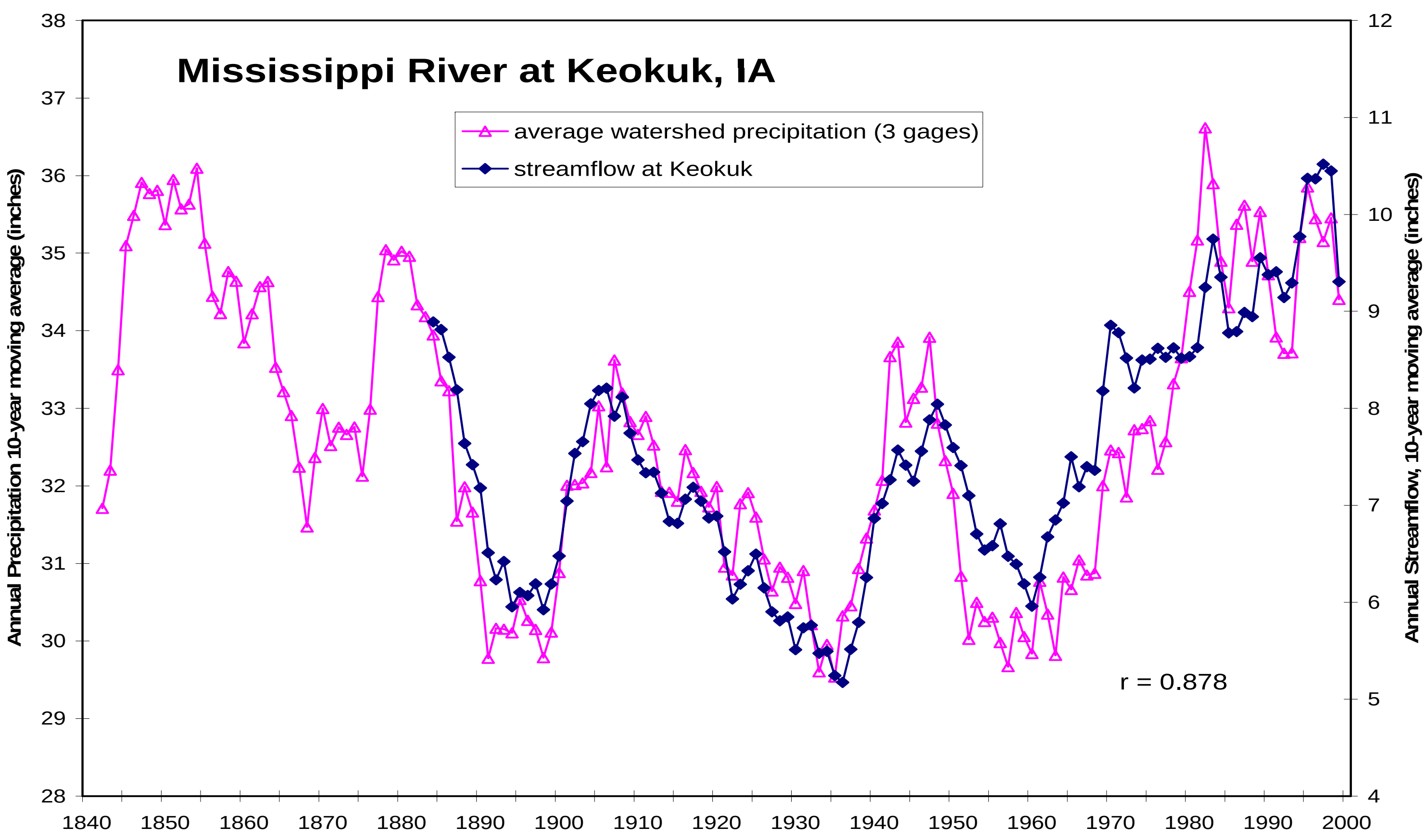





Lakes Huron-Michigan Lake Levels, 15-Year Moving Average
Feet
582.0
581.0
580.0
579.0
578.0
577.0
576.0
1865-1879
1870-1884
1875-1889
1880-1894
1885-1899
1890-1904
1895-1909
1900-1914
1905-1919
1910-1924
1915-1929
1920-1934
1925-1939
1930-1944
1935-1949
1940-1954
1945-1959
1950-1964
1955-1969
1960-1974
1965-1979
1970-1984
1975-1989
1980-1994
1985-1999

QUESTION: IF THE INCREASE IN PRECIPITATION SINCE 1900 IS DUE TO THE INCREASING GREENHOUSE EFFECT, WHAT CAUSED EQUALLY HIGH PRECIPITATION IN THE 19th CENTURY AND A DECREASE IN PRECIPITATION THROUGH THE FIRST HALF OF THE 20th CENTURY?

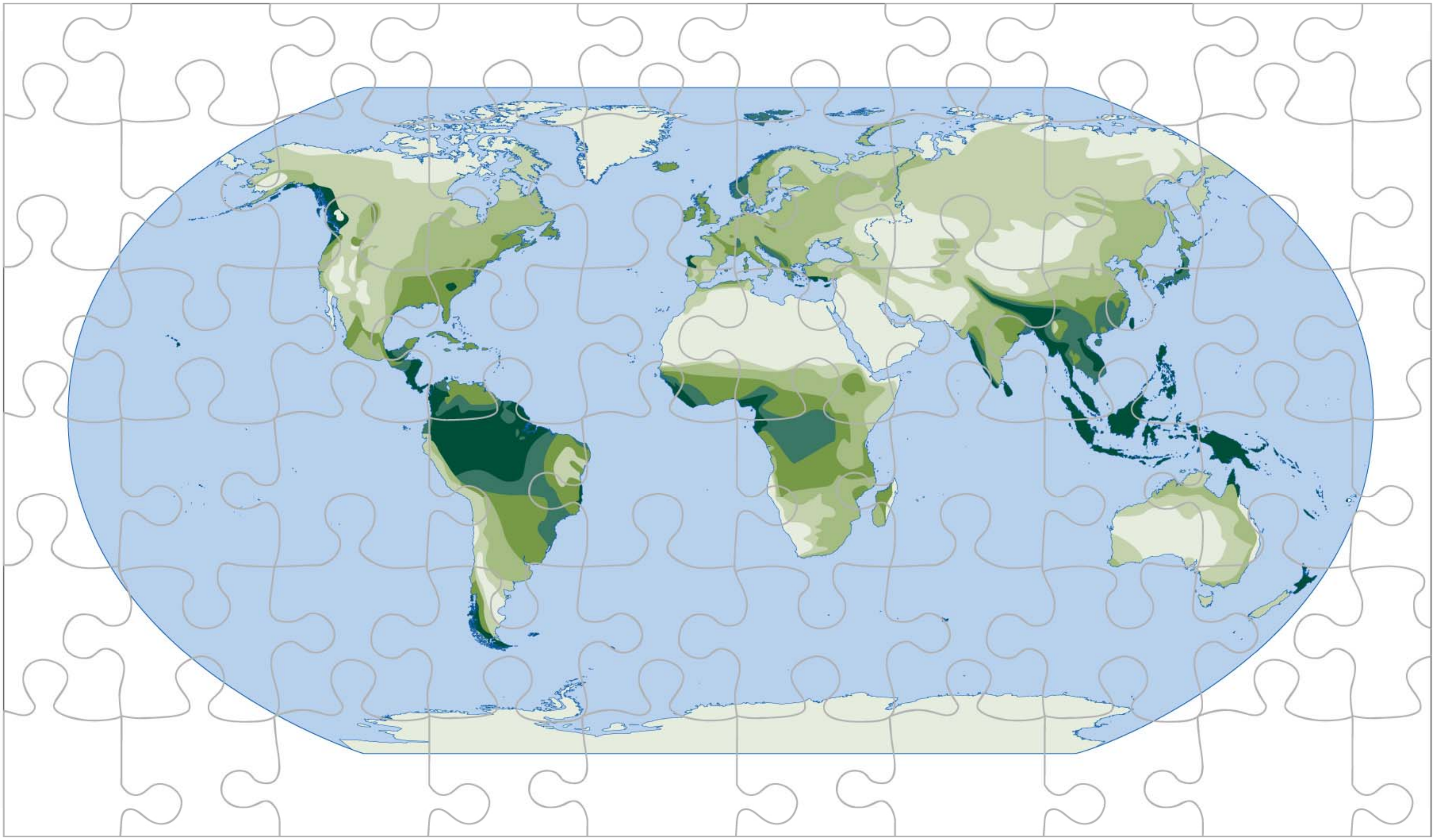
ANSWER: UNEXPLAINED NATURAL VARIABILITY.



FUTURE CLIMATE

- Future climate will be influenced by natural processes and human influences.

- There are 2 guides to possible future climatic conditions:-
  - The past record (what has occurred can occur again)
  - Climate modeling



WEAKNESS of GCMs in SIMULATING PRECIPITATION (Wigley, 2004)

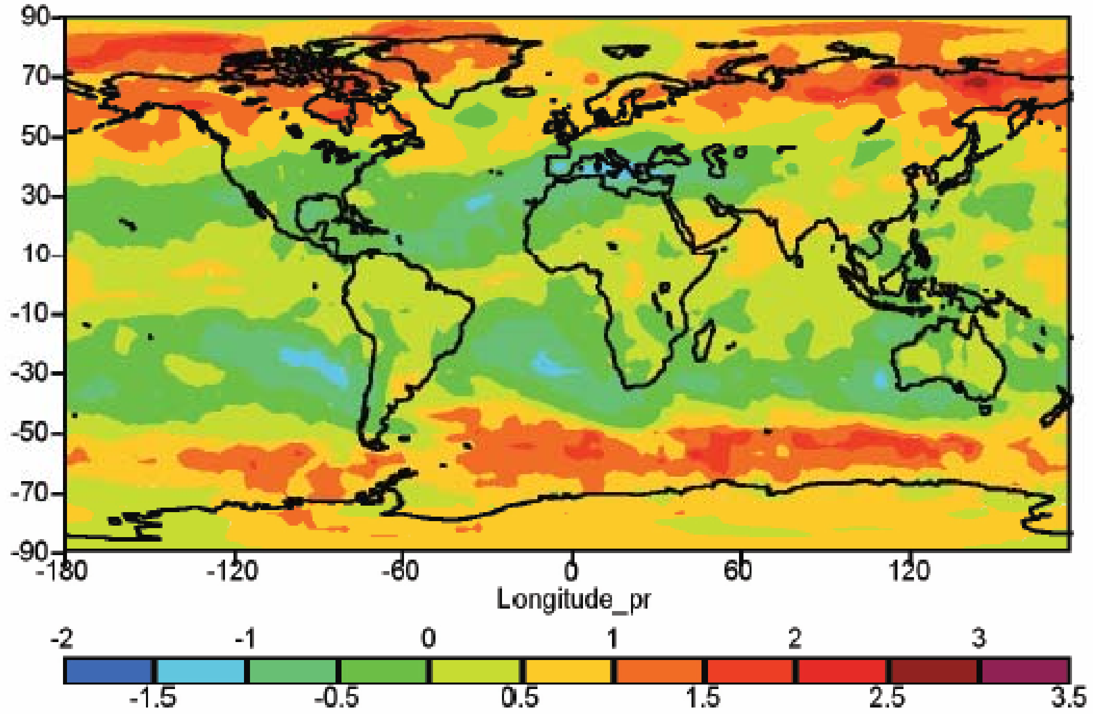
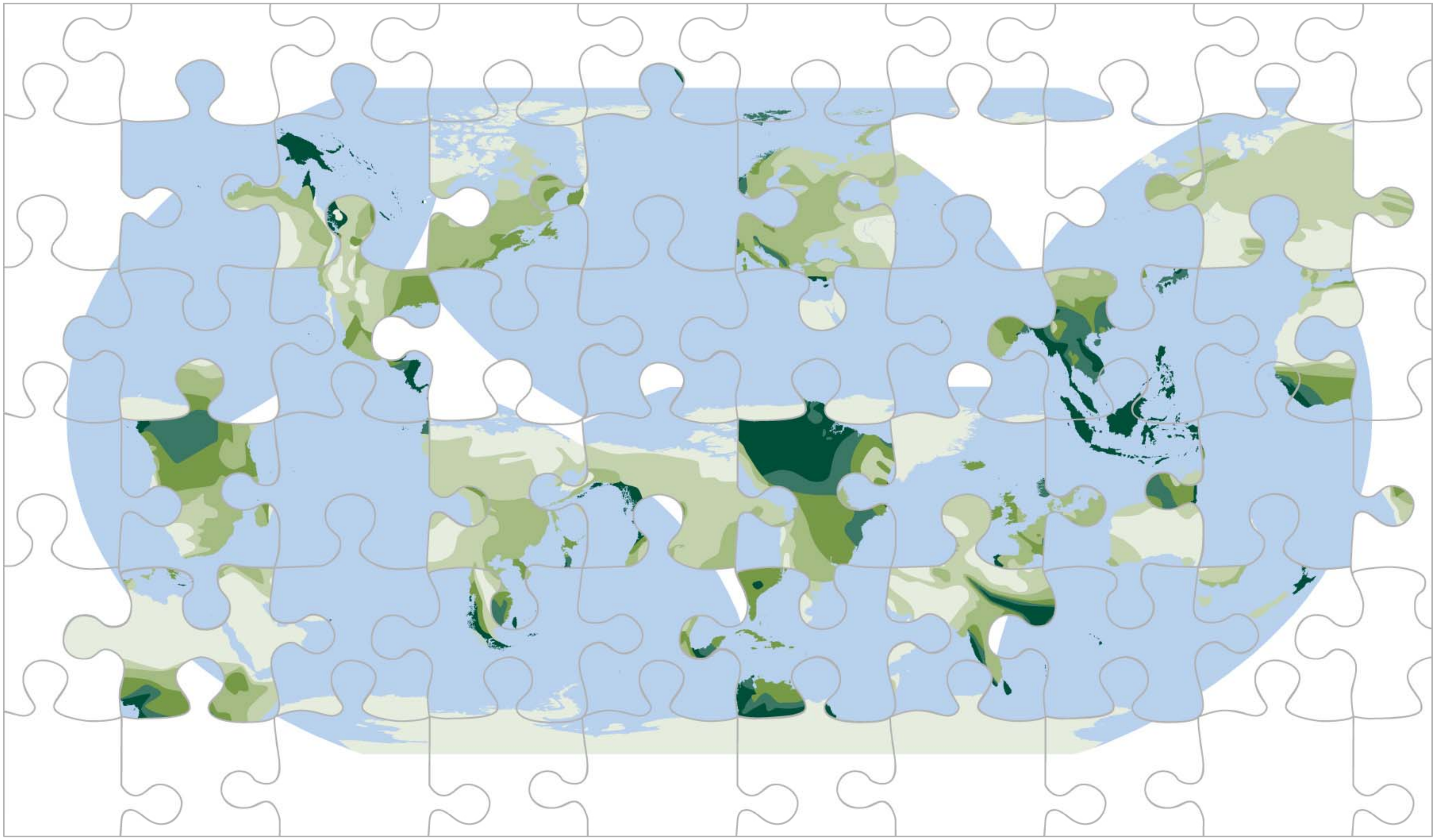
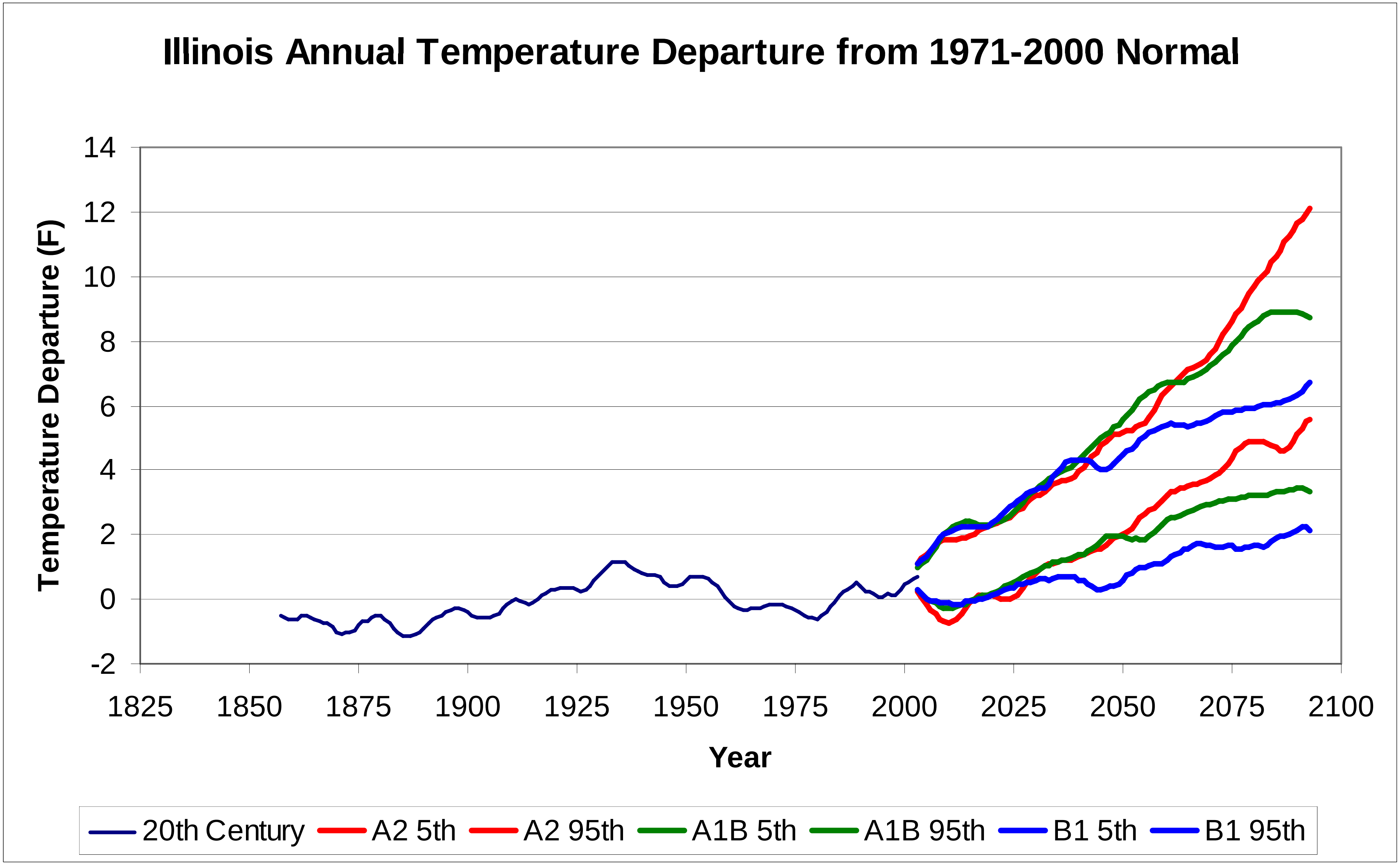
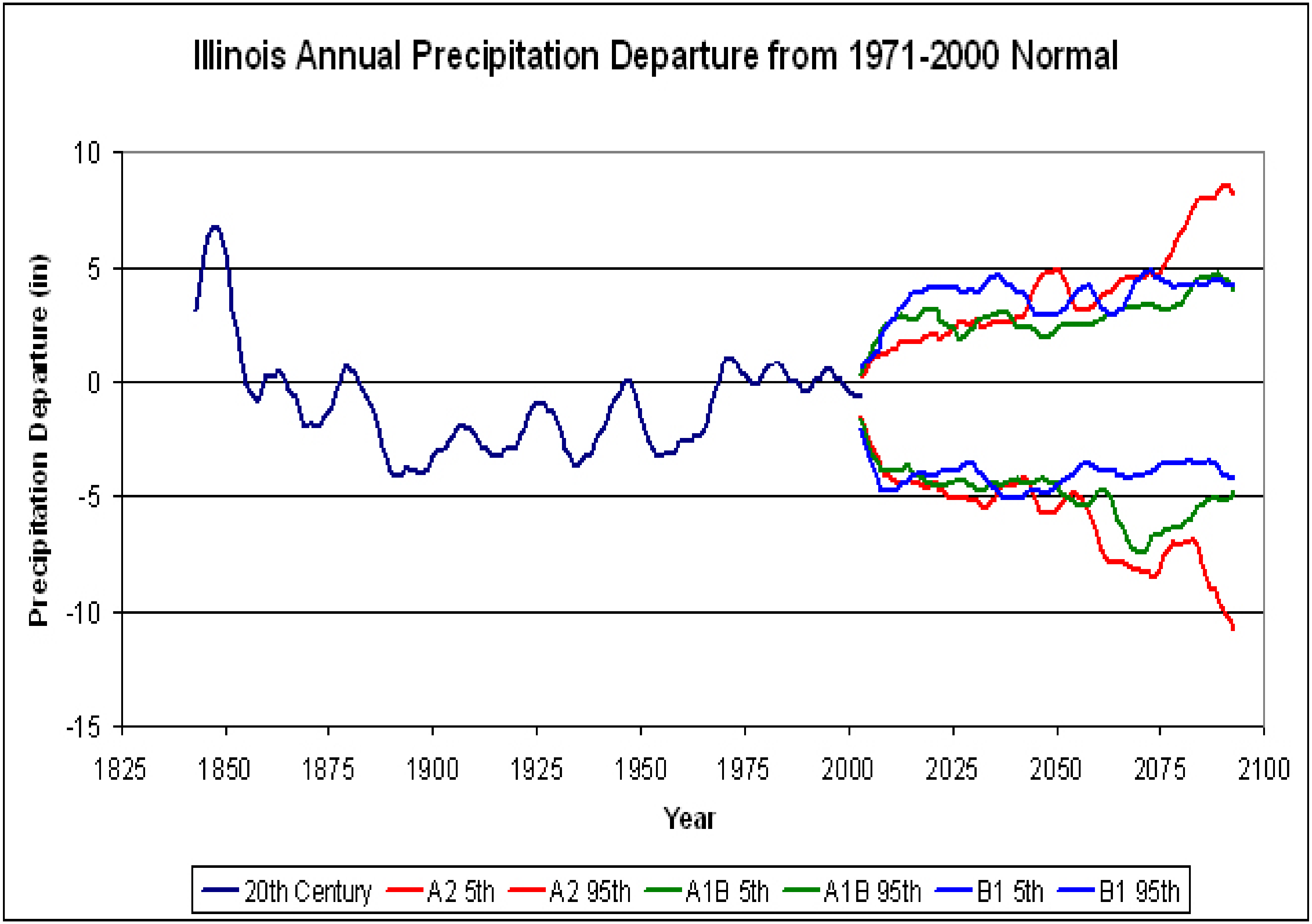


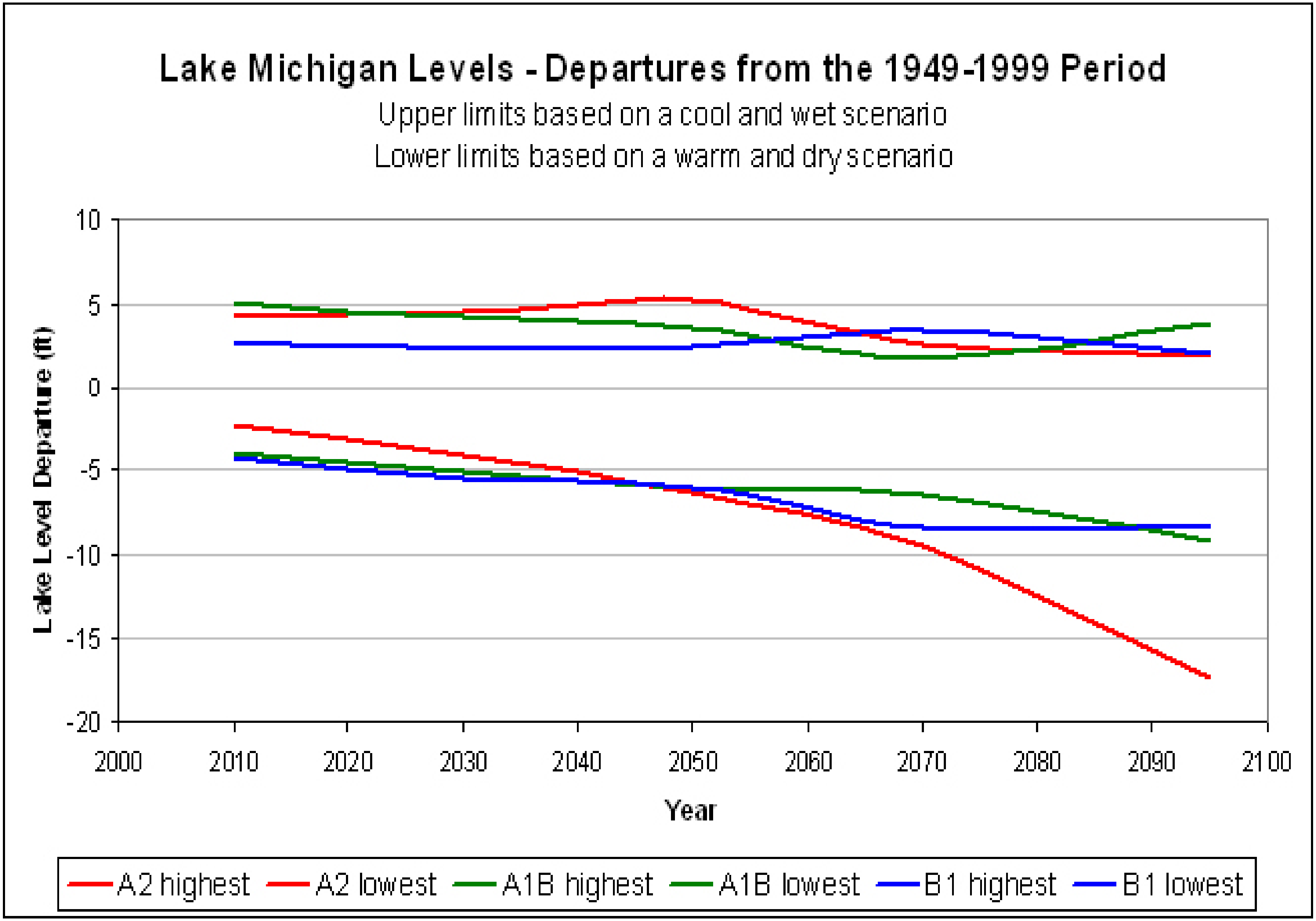
Figure 21. Inter-model signal-to-noise ratios for annual-mean precipitation (mean precipitation change per 1°C global-mean warming, averaged over 17 AOGCMs, divided by the inter-model standard deviation). This is a measure of both the sign and strength of the expected precipitation change and the level of agreement between models. Values between −1 and +1 indicate considerable uncertainty in the expected change.




Illinois Annual Temperature Departure from 1971-2000 Normal
Temperature Departure (F)
14
12
10
8
6
4
2
0
-2
1825
1850
1875
1900
1925
1950
1975
2000
2025
2050
2075
2100
Year
20th Century
A2 5th
A2 95th
A1B 5th
A1B 95th
B1 5th
B1 95th



Illinois Annual Precipitation Departure from 1971-2000 Normal
Precipitation Departure (in)
10
5
0
-5
-10
-15
1825
1850
1875
1900
1925
1950
1975
2000
2025
2050
2075
2100
Year
20th Century
A2 5th
A2 95th
A1B 5th
A1B 95th
B1 5th
B1 95th



Lake Michigan Levels - Departures from the 1949-1999 Period
Upper limits based on a cool and wet scenario
Lower limits based on a warm and dry scenario
10
5
0
-5
-10
-15
-20
Lake Level Departure (ft)
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090
2100
Year
A2 highest
A2 lowest
A1B highest
A1B lowest
B1 highest
B1 lowest

1 in 200 YEAR DROUGHT

The Water Cycle and Water Budgets in Illinois:
A Framework for Drought and Water-Supply Planning

Derek Winstanley, James R. Angel, Stanley A. Changnon, H. Vernon Knapp,
Kenneth E. Kunkel, Michael A. Palecki, Robert W. Scott, and H. Allen Wehrmann

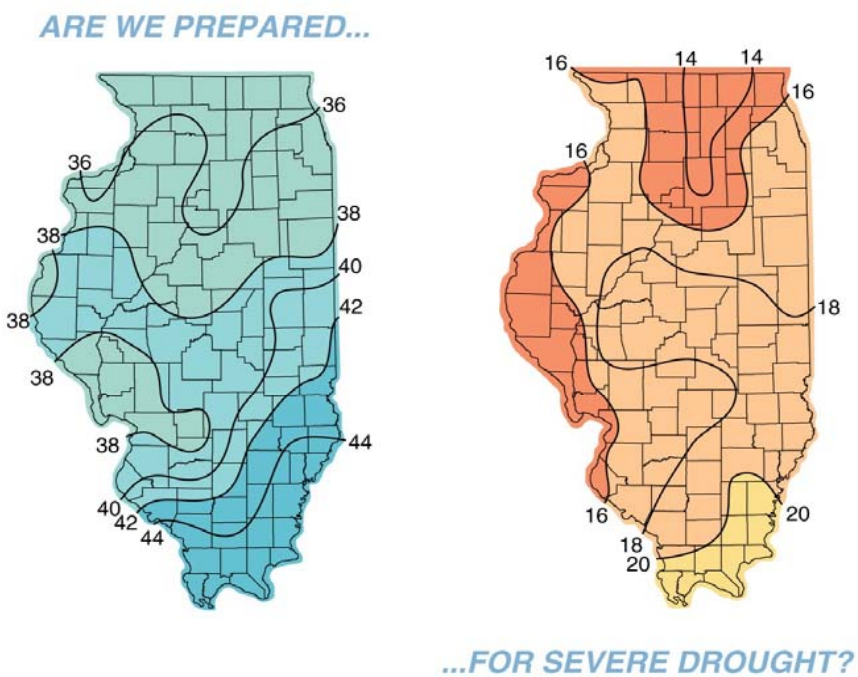


Table 2. Expected Average Precipitation for All Sites, Expressed as Percent of Normal (1971-2000), for Selected Drought Durations and Return Periods

Drought Duration	*25-year return period*	*50-year return period*	*100-year return period*	*200-year return period*
12 months	59.1	52.5	47.8	44.0
18 months	66.8	60.1	55.2	51.3
24 months	71.9	64.8	59.7	55.5
36 months	77.8	71.1	66.2	62.2
48 months	81.8	75.0	70.1	66.1
60 months	85.3	78.3	73.2	69.0

CLIMATE, WATER DEMAND AND WATER AVAILABILITY: UNCERTAINTY AND RISK

WATER DEMAND TO 2050

- Three scenarios will assume 1971-2000 climatic conditions
- Separate analyses will be conducted to evaluate the sensitivity of water demand to climate change (+6^{o}F and + and – 5 ins precipitation) and severe droughts

WATER AVAILABILITY TO 2050

- Reference scenarios will assume 1971-2000 climatic conditions
- Separate analyses will be conducted to evaluate the sensitivity of water availability to climate change (+6^{o}F and + and – 5 ins precipitation) and severe droughts

Derek Winstanley

Illinois State Water Survey

dwinstan@uiuc.edu
217-244 5459
www.sws.uiuc.edu/wsp/watersupply.asp

THANK YOU!