Trends in Illinois River Streamflow and Flooding

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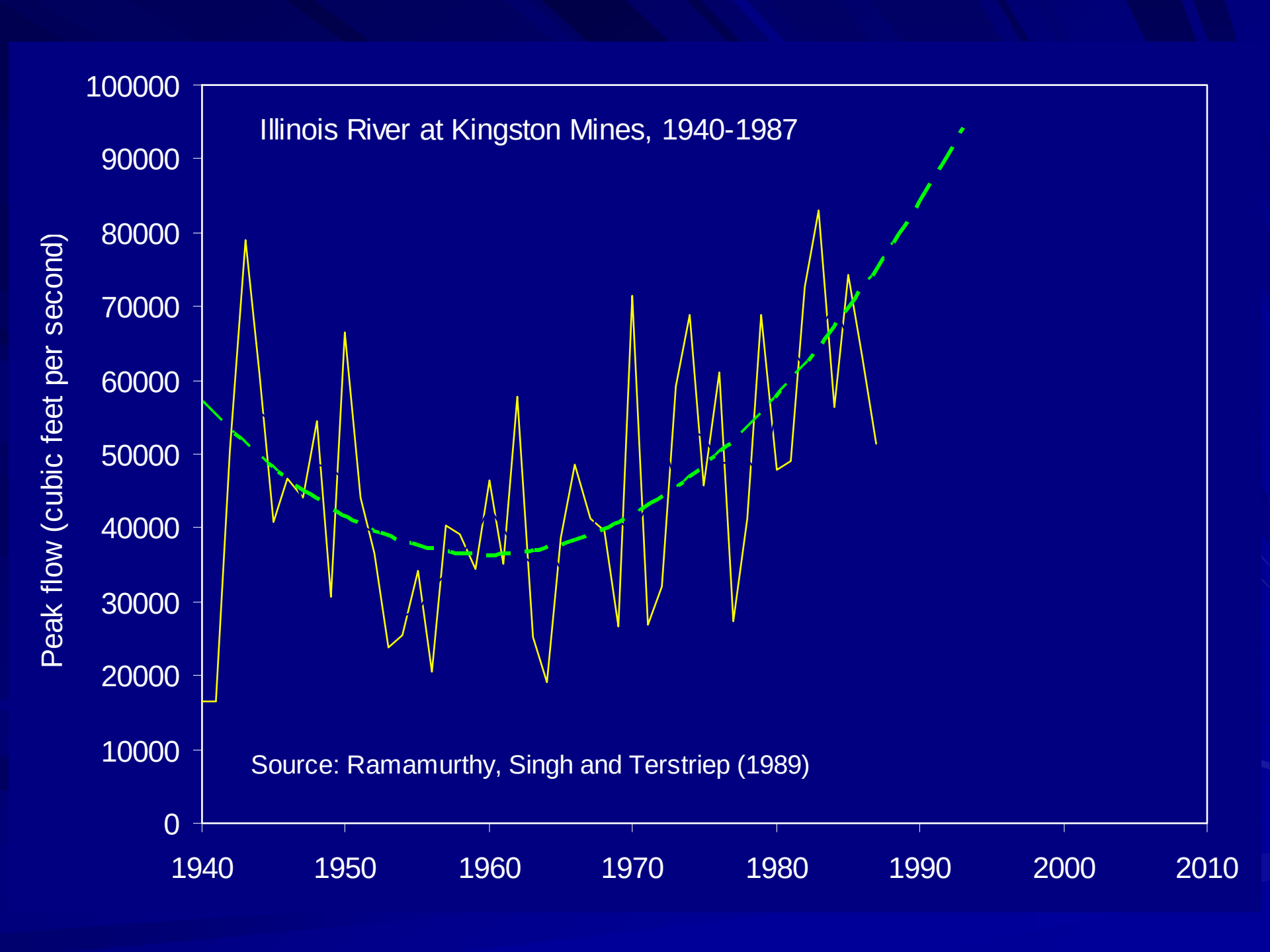
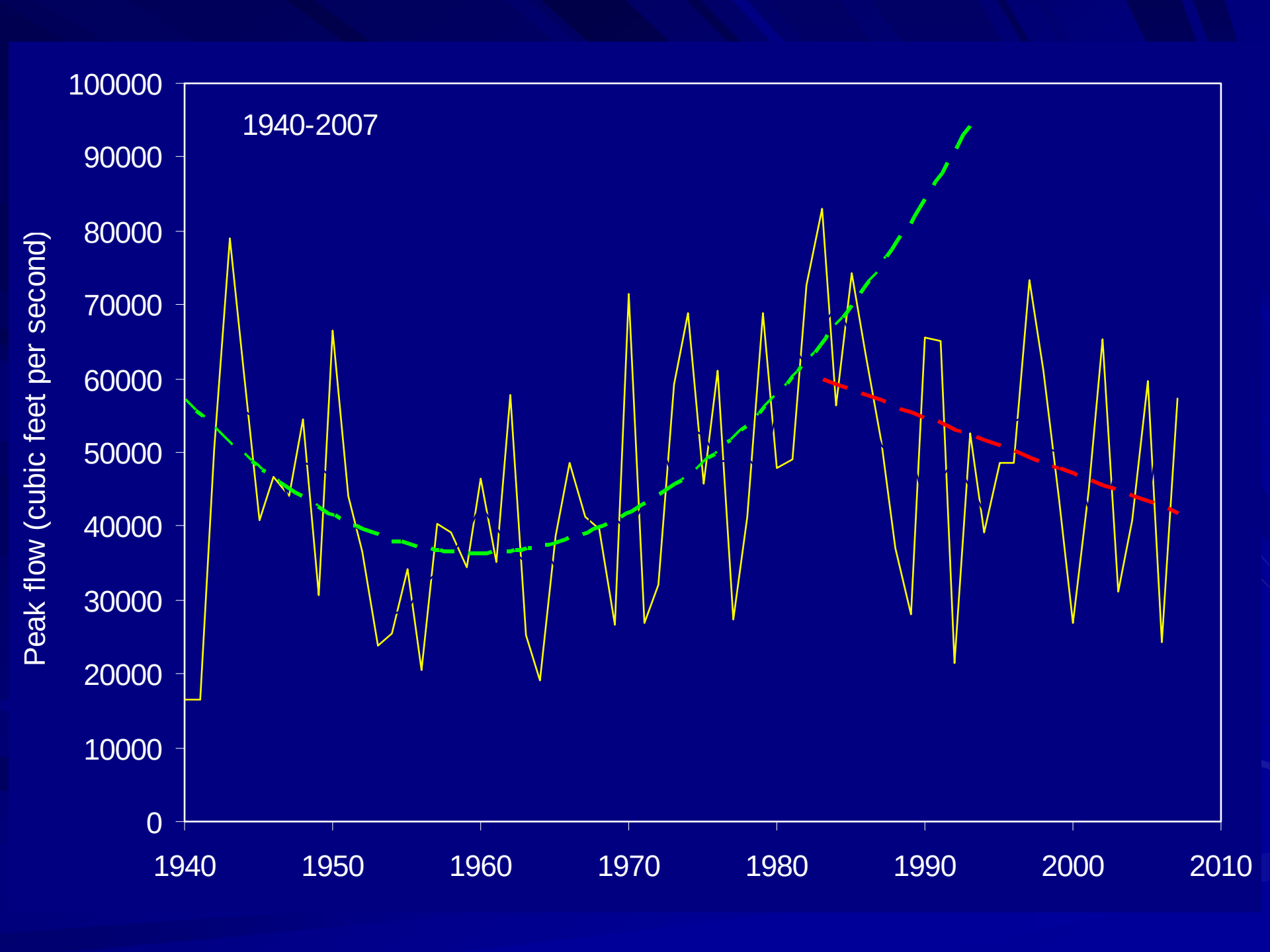
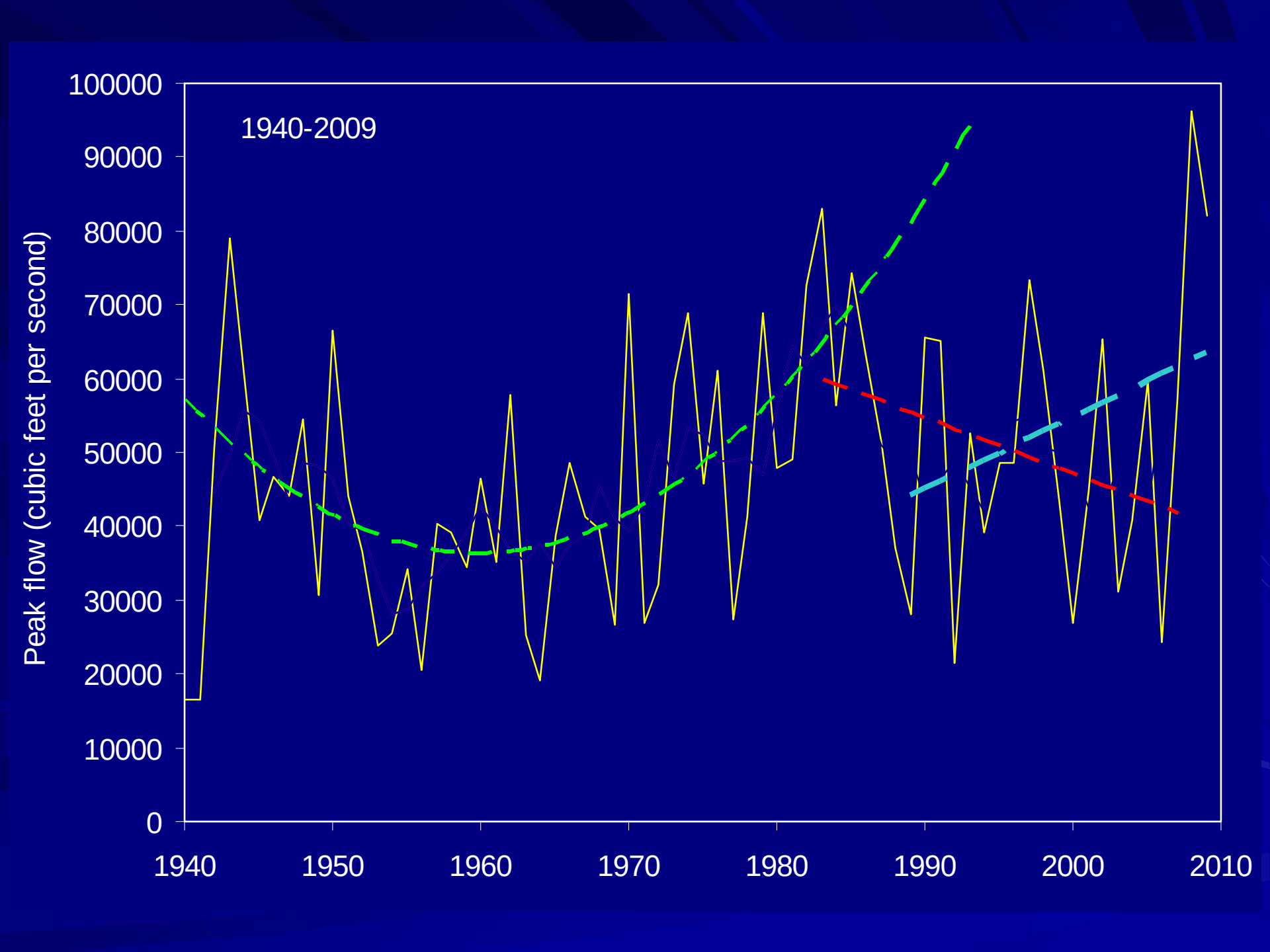
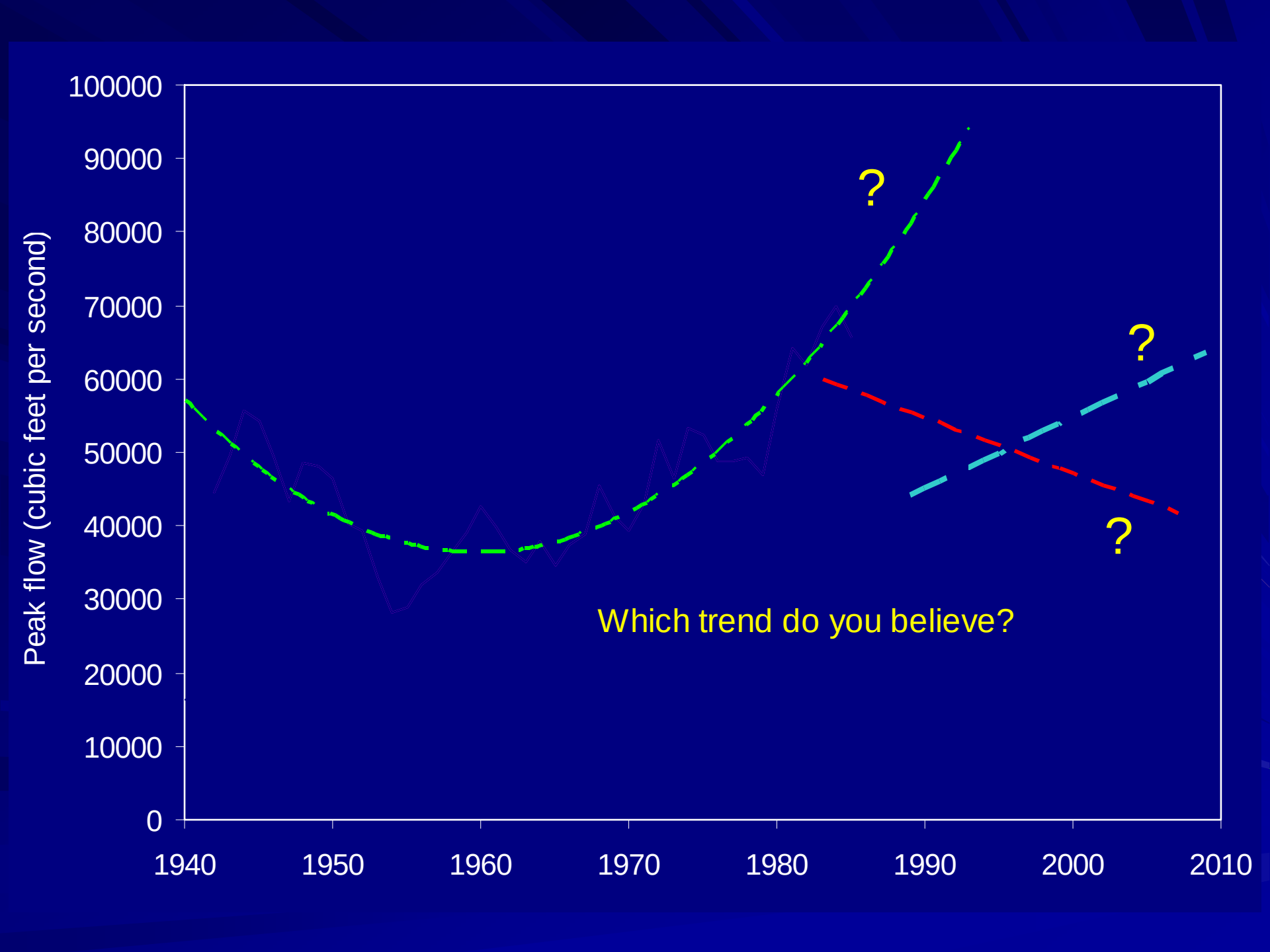
Selected recommendations from the Illinois River Integrated Management Plan

- Determine the contribution of changing precipitation patterns to streamflow trends
- Conduct analysis to examine why the frequency of major floods is increasing
- Establish goals for water yields


Illinois River at Kingston Mines, 1940-1987
Peak flow (cubic feet per second)
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
1940
1950
1960
1970
1980
1990
2000
2010
Source: Ramamurthy, Singh and Terstriep (1989)


1940-2007
Peak flow (cubic feet per second)
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
1940
1950
1960
1970
1980
1990
2000
2010


1940-2009
Peak flow (cubic feet per second)
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
1940
1950
1960
1970
1980
1990
2000
2010

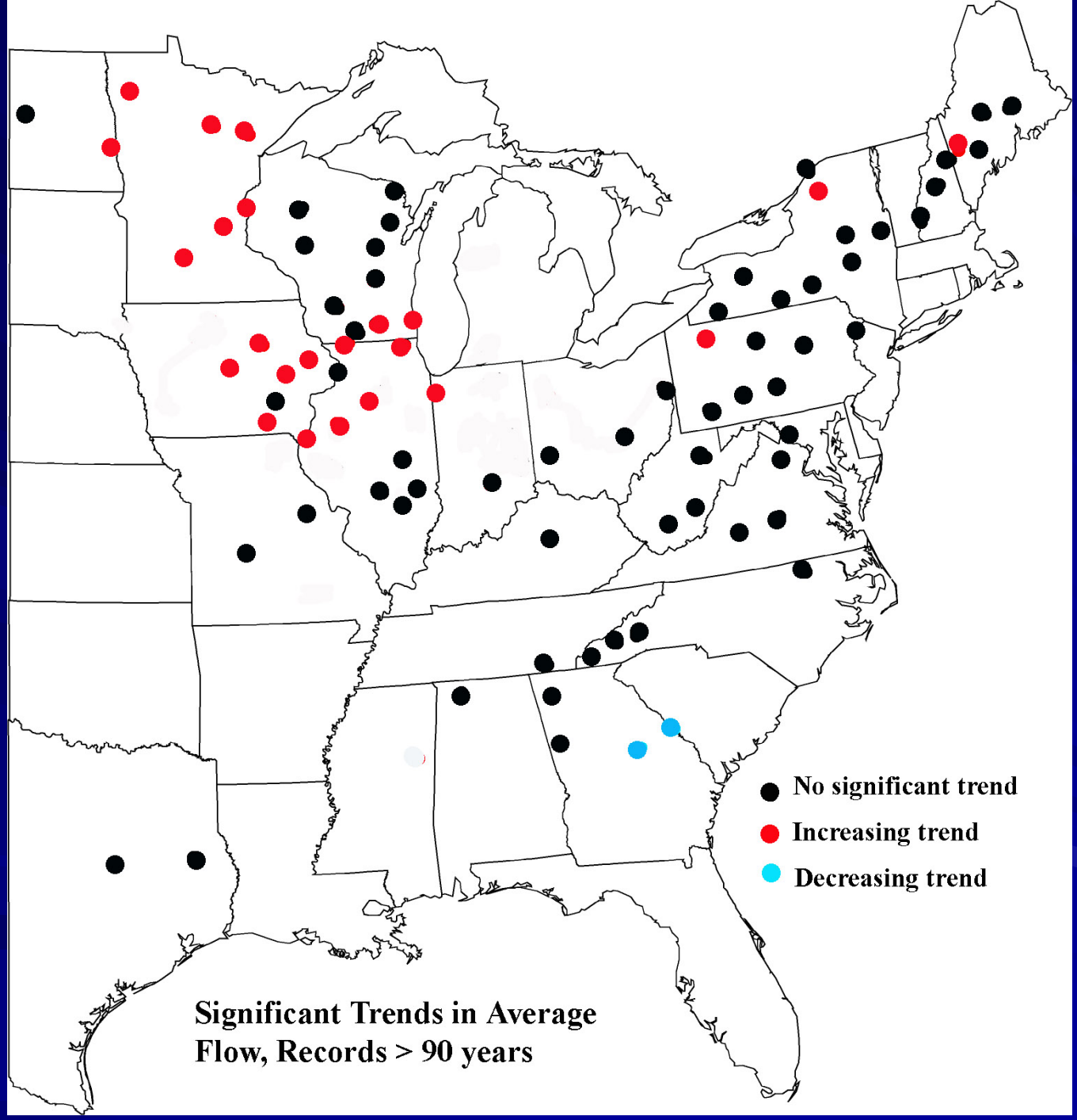

Peak flow (cubic feet per second)
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
1940
1950
1960
1970
1980
1990
2000
2010
?
?
?
Which trend do you believe?

Evaluation of Streamflow Trends

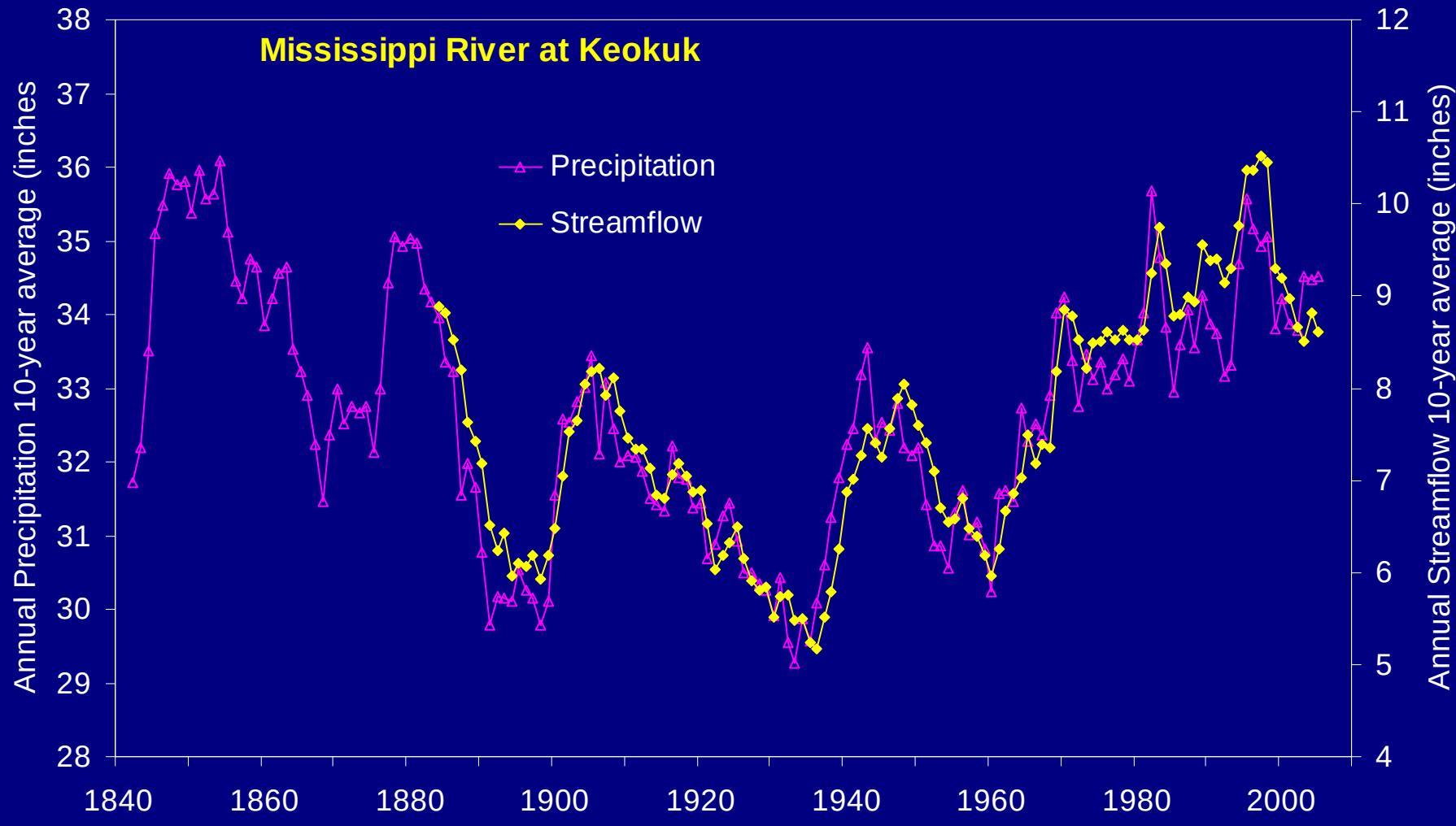
- Highly dependent on period of years analyzed
- Hydrologic and climatic records experience considerable inter-decadal variability
- Most observed trends are not based on factors that are highly predictable into the future
- The best perspective on streamflow trends is provided by looking at the broader picture
  - longest historical flow records
  - what's happening within the greater region

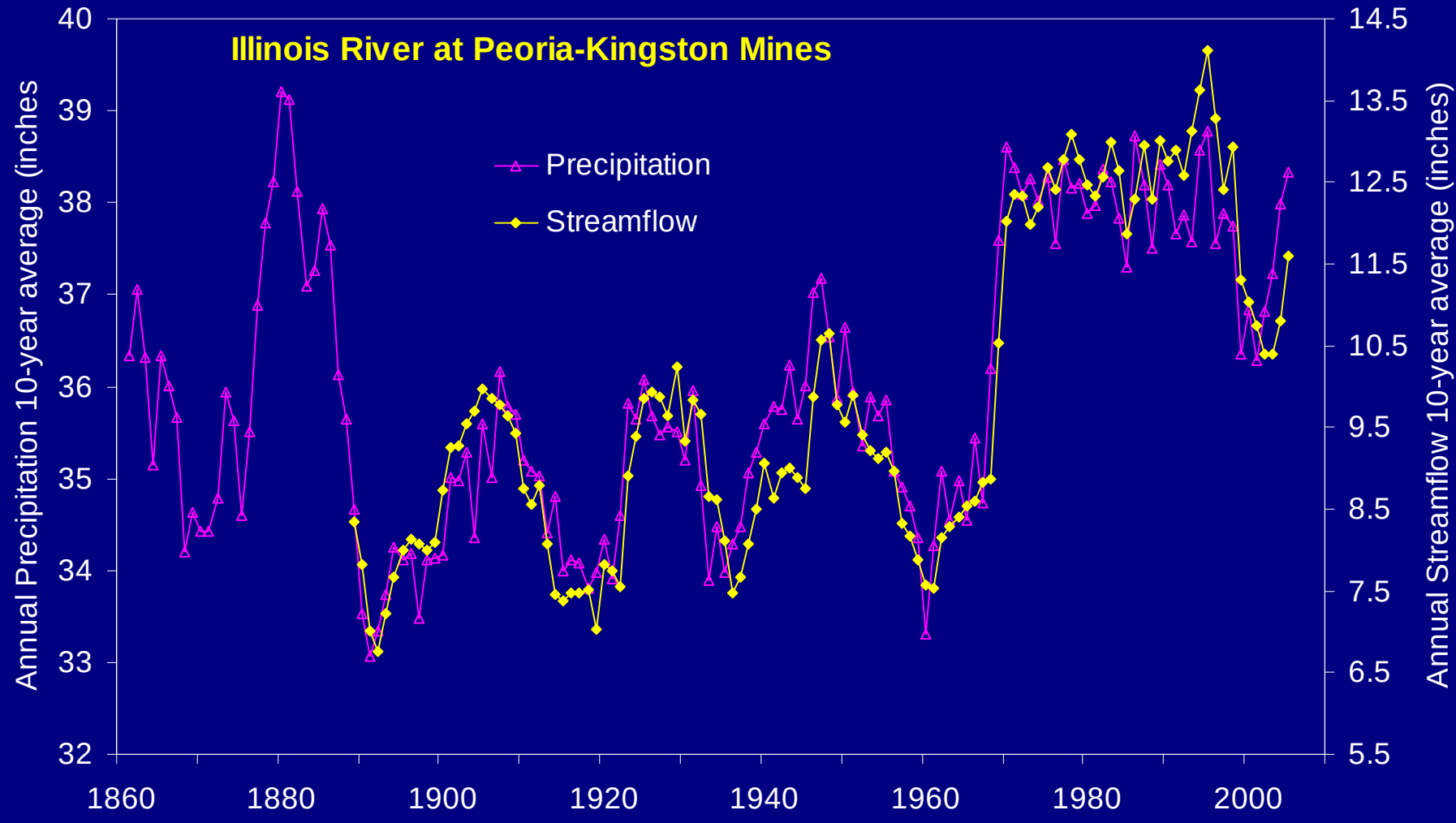
HCDN Streamflow Trend Studies

- McCabe and Wolock (USGS, 2002)
  - For much of Eastern US, the 1971-1999 average and minimum streamflows were significantly greater than the previous 30 years (1941-1970). This did not have the character of a linear increasing trend, but of an abrupt step increase, coincident with a increases in precipitation. There were comparatively few trends in annual maximum flows.
- Knapp (2005)
  - Looked at only the longest available records (>90 years) in the Eastern US. From these longer records, the only region with consistent increasing trends is the upper Midwest.

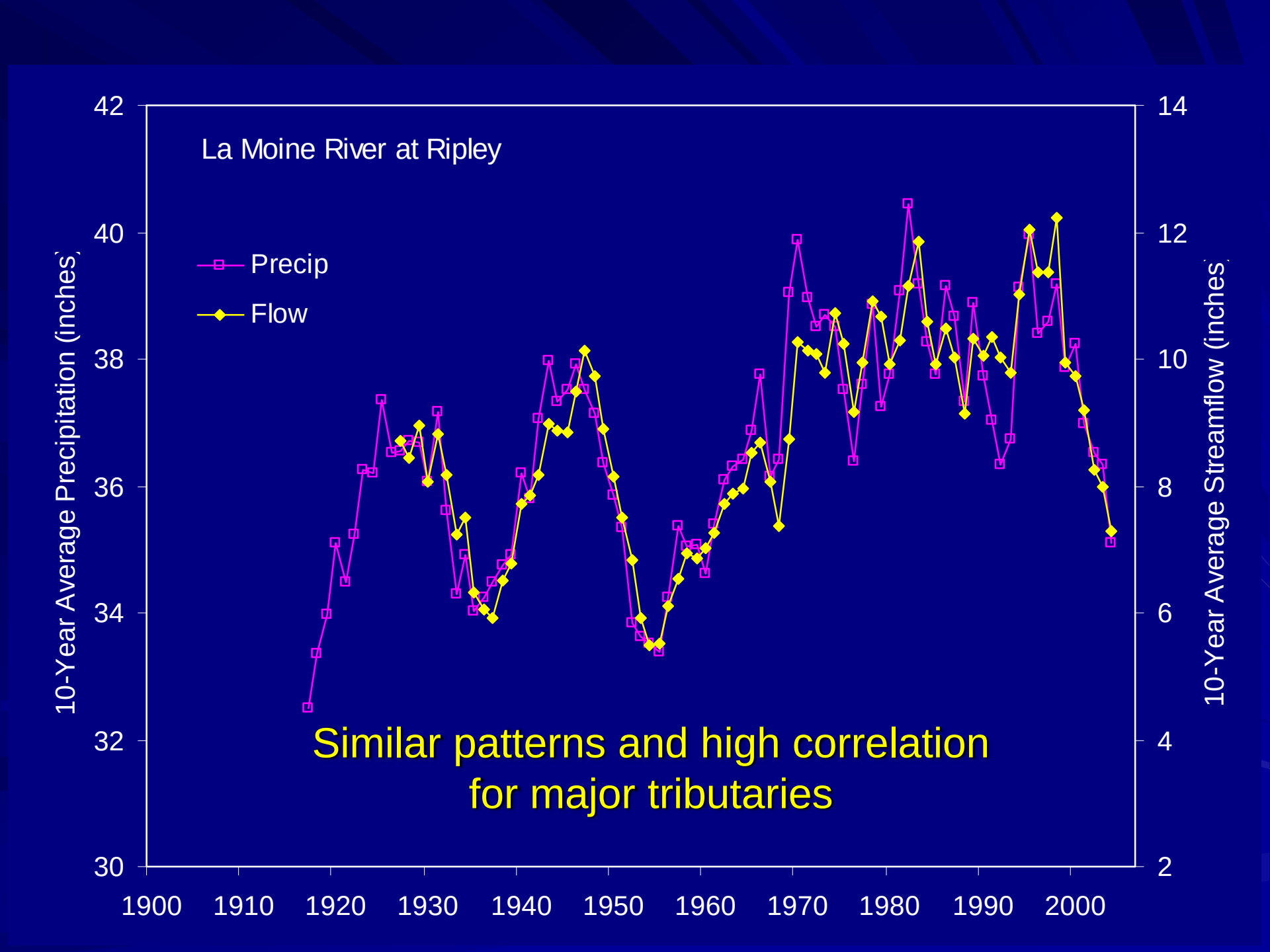

No significant trend
Increasing trend
Decreasing trend
Significant Trends in Average Flow, Records > 90 years

The longest records are on the Mississippi River; total flow is highly correlated to precipitation





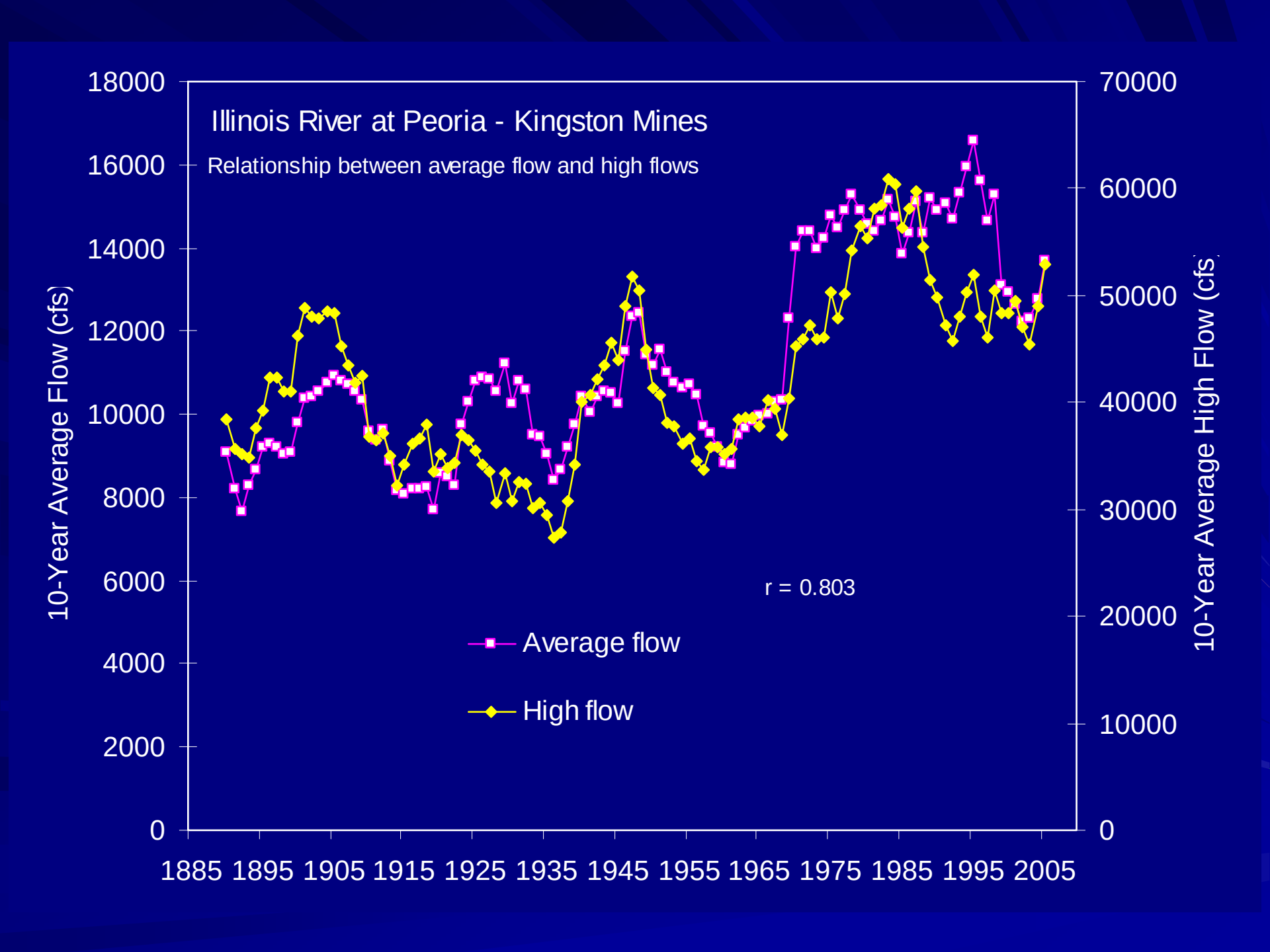
*Flow record includes: USGS gage at Kingston Mines 1940-2009; USGS gage at Peoria 1903-1906 & 1910-1939; Weather Bureau daily river stages, 1884-1910, with flows estimated from 1903 USGS rating curve.
Influence of Lake Michigan diversion has been removed from flow records.

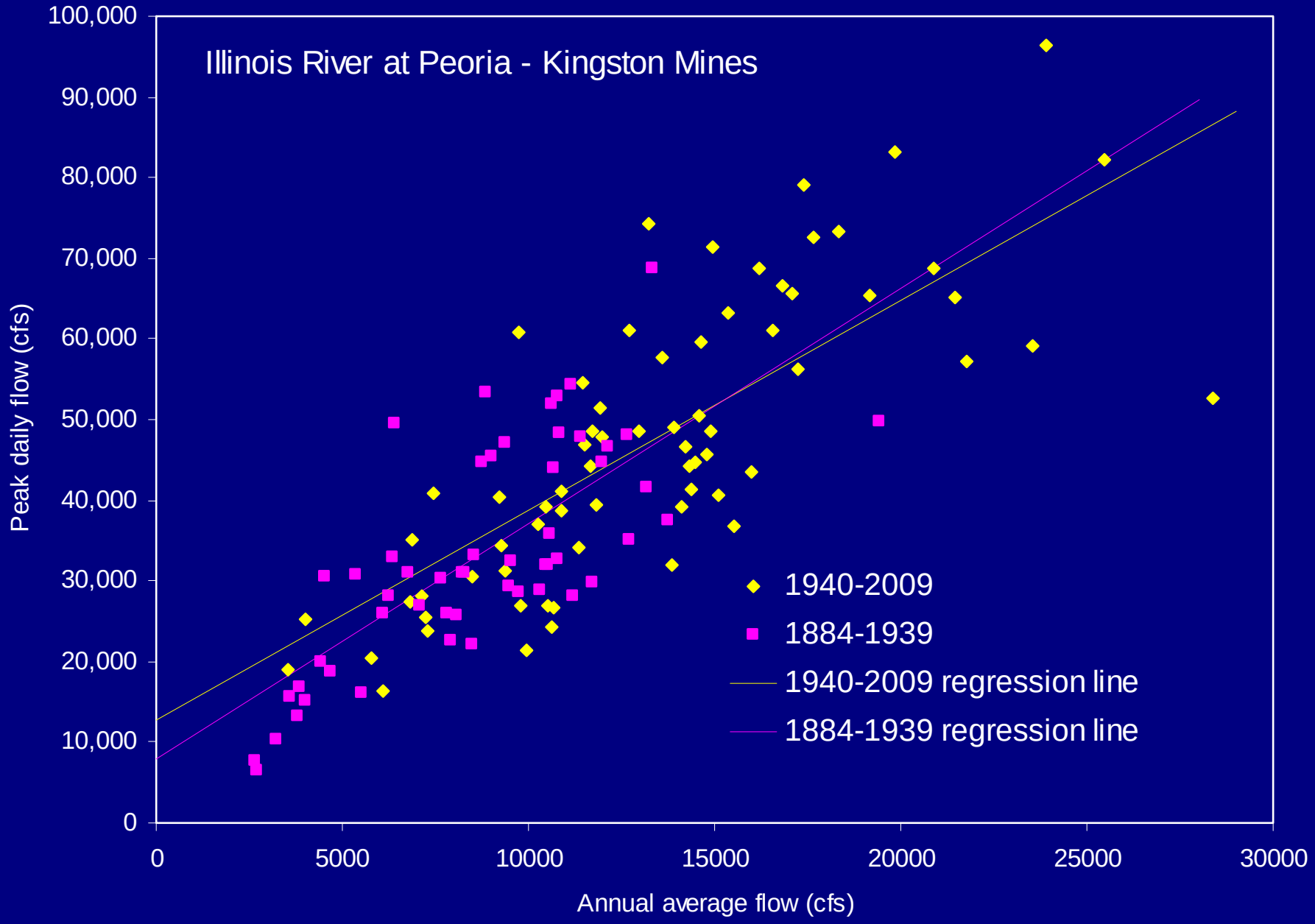

La Moine River at Ripley
Precip
Flow
10-Year Average Precipitation (inches)
10-Year Average Streamflow (inches)
42
40
38
36
34
32
30
14
12
10
8
6
4
2
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
Similar patterns and high correlation
for major tributaries

The changing precipitation pattern is the dominant factor in determining water yield

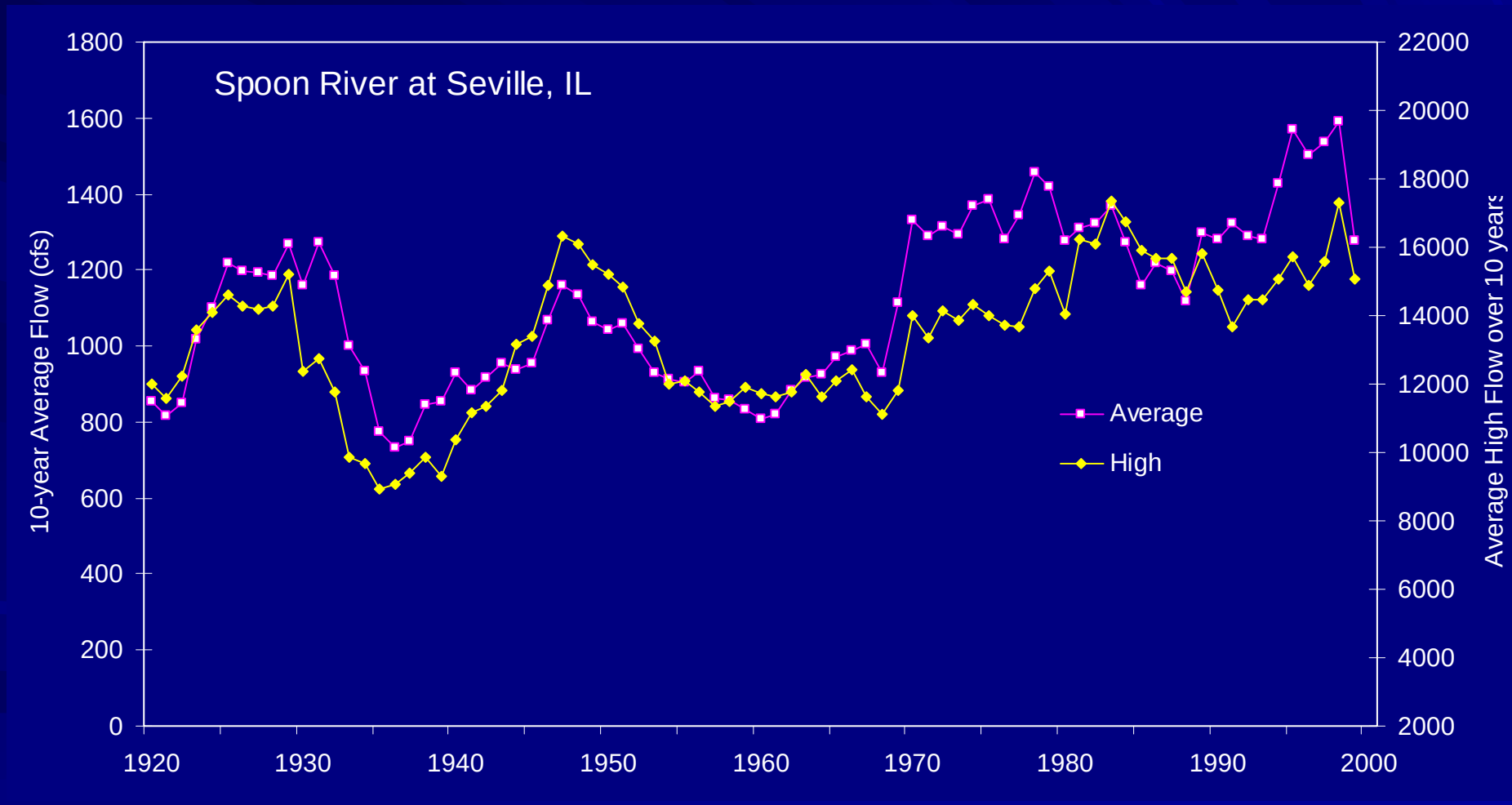
- Despite all of the hydrologic changes (including artificial drainage and land use change) over the past 130 years, the relationship to precipitation in these and other long-term records has been remarkably consistent.
- Mass land use changes can change yields (somewhat)
  - Urbanization
  - Vegetative cover with high transpiration rates

How does this relate to flooding trends?

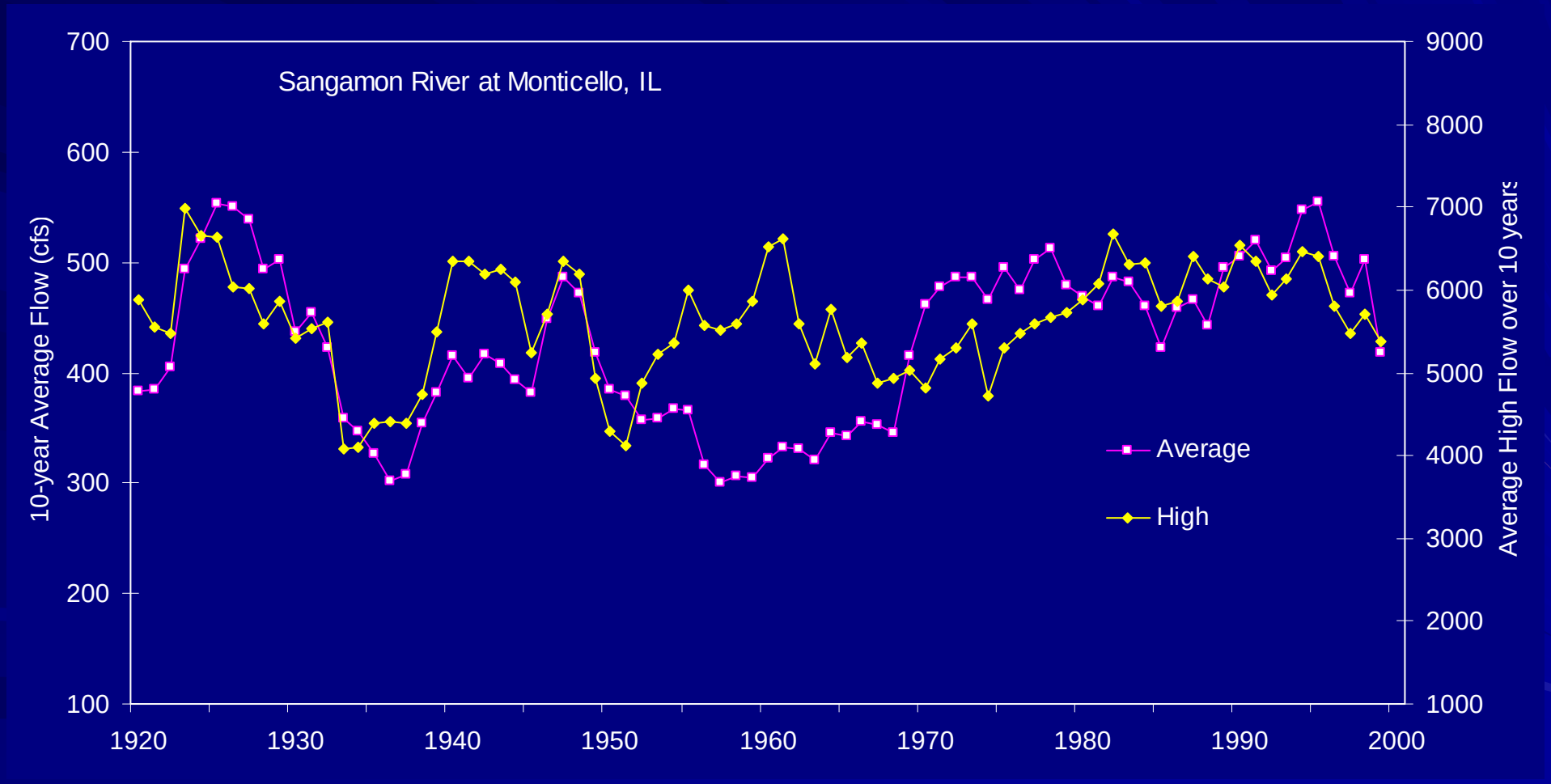

Illinois River at Peoria - Kingston Mines
Relationship between average flow and high flows
10-Year Average Flow (cfs)
10-Year Average High Flow (cfs)
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
70000
60000
50000
40000
30000
20000
10000
0
1885 1895 1905 1915 1925 1935 1945 1955 1965 1975 1985 1995 2005
r = 0.803
Average flow
High flow


Illinois River at Peoria - Kingston Mines
Peak daily flow (cfs)
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
0
5000
10000
15000
20000
25000
30000
Annual average flow (cfs)
1940-2009
1884-1939
1940-2009 regression line
1884-1939 regression line

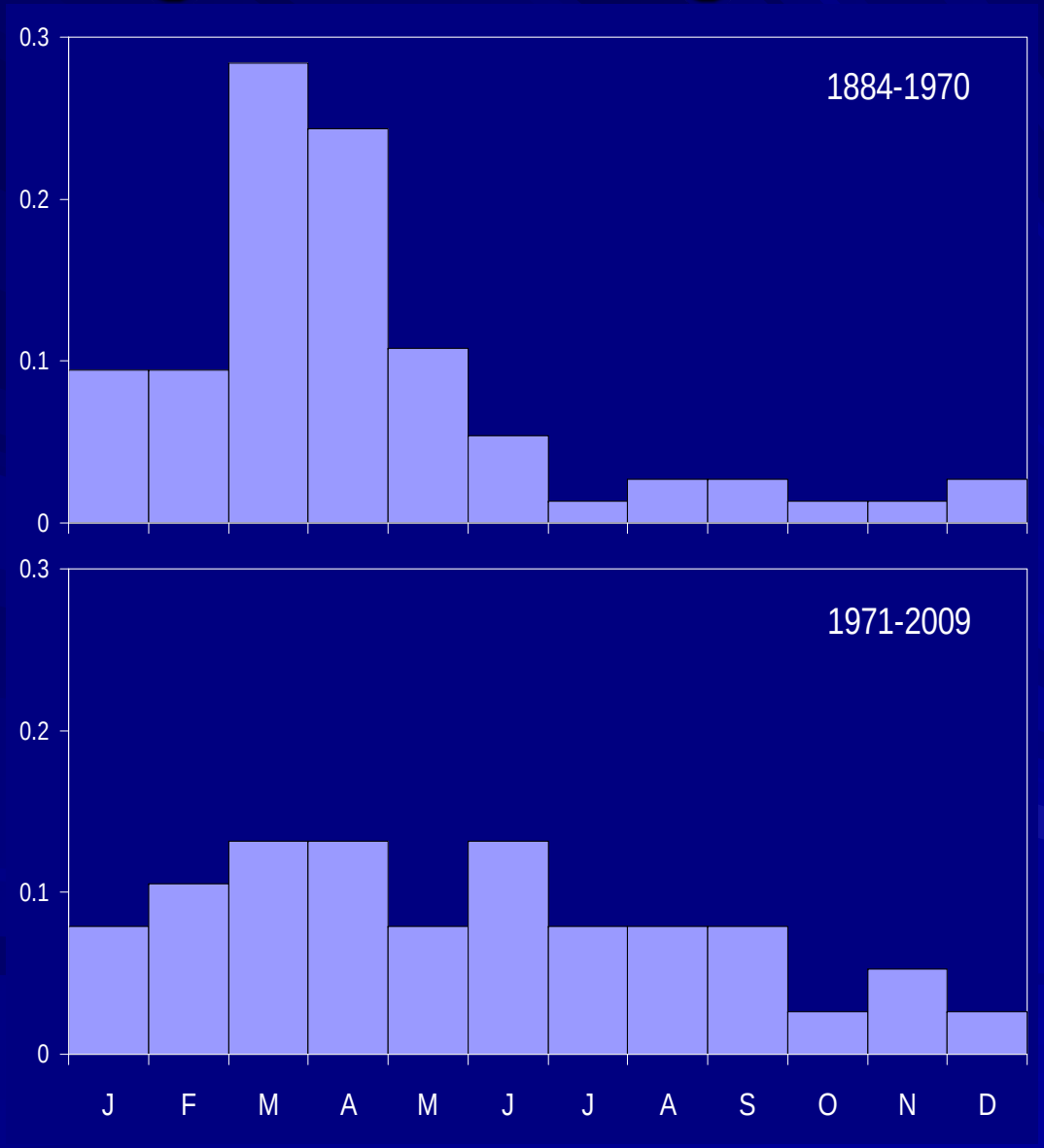
Major tributaries: Either increasing trends in both average and high flows …



…or no trends in average and high flows



Change in Flooding Season



Factors affecting shifts in flooding season 1970-2008

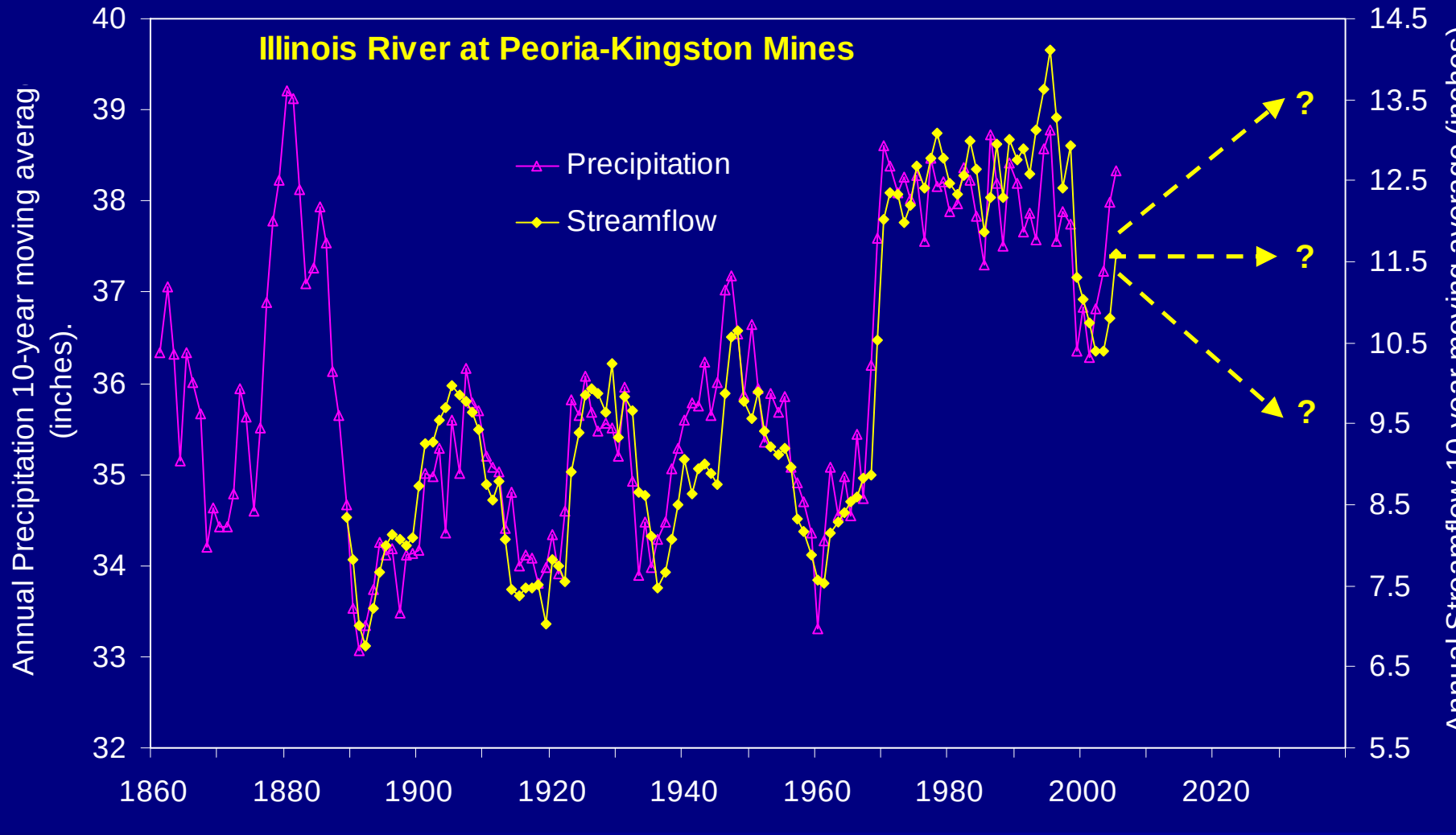
- Warmer winters and decreased snowfall have reduced the magnitudes of floods in early spring
- Increase in heavy precipitation events, particularly in the latter half of the year
- General increase in soil moisture in summer and fall (caused by greater precipitation throughout the year)

Trends in Illinois River flooding are most directly related to trends in average flows and precipitation

Caveats

- This same relationship of increasing trends in both high flows and average flow is not present in all regions of the Midwest
- These results also do not directly apply to small- and medium-sized watersheds, where storage and other local factors can commonly affect trends in flooding
- Local efforts to detain floodwaters clearly have an affect on flood peaks in smaller streams
- Issue of scale – There are many examples in hydrology where processes observed on smaller streams are not translatable to larger streams

What does the future hold for us? How will the climate change?



Climate Change
Impacts on Water Resources

Recent climate change reports have projected the following for the Great Lakes and Midwest:

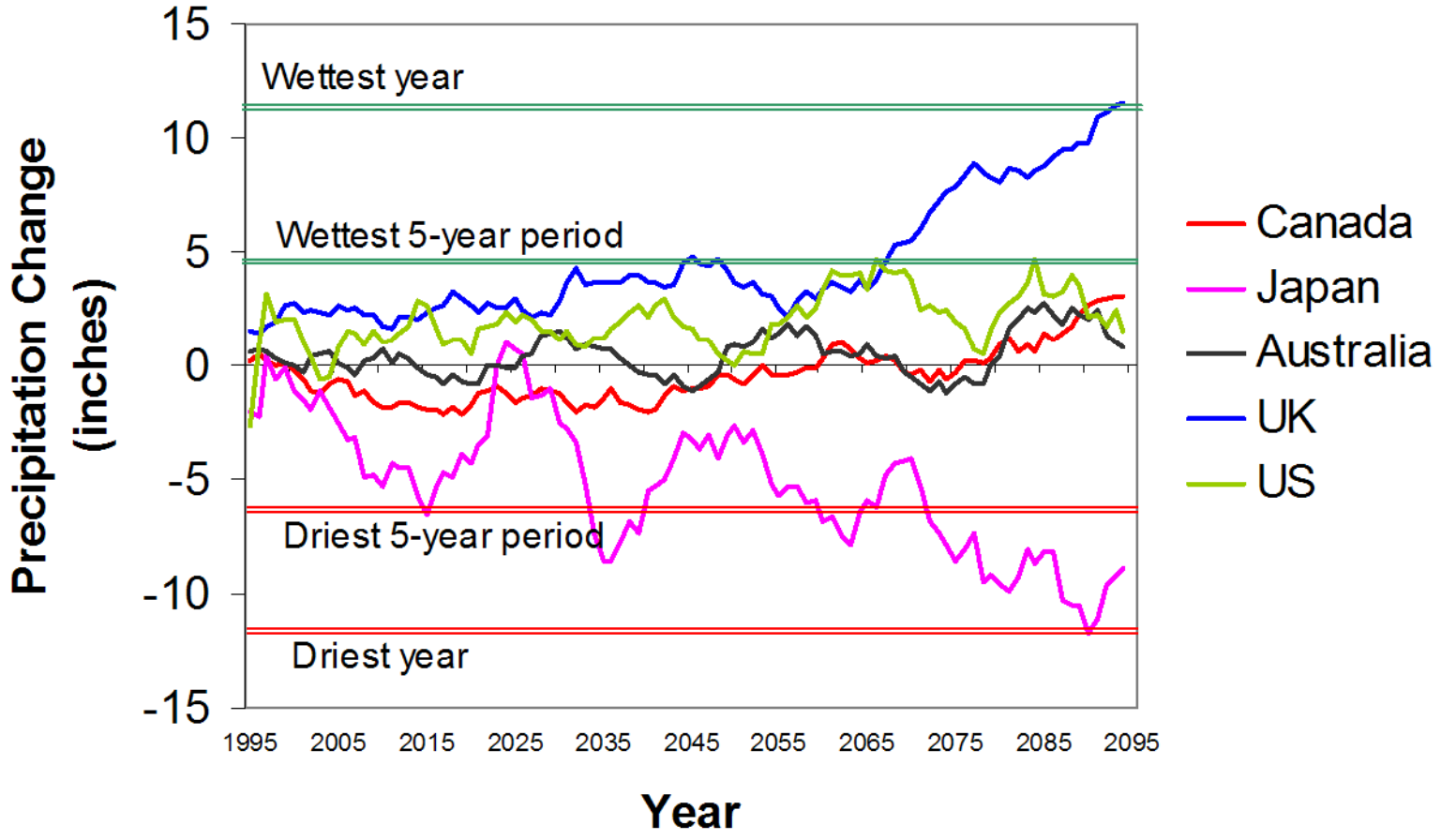
- We could see wetter Springs and drier Summers
- Heavier precipitation events may increase in magnitude and frequency as part of climate change, causing more flooding
- There could be extended summer periods of precipitation deficit and low flows
- Thus, the hydrologic cycle could intensify, resulting in more extreme floods and droughts

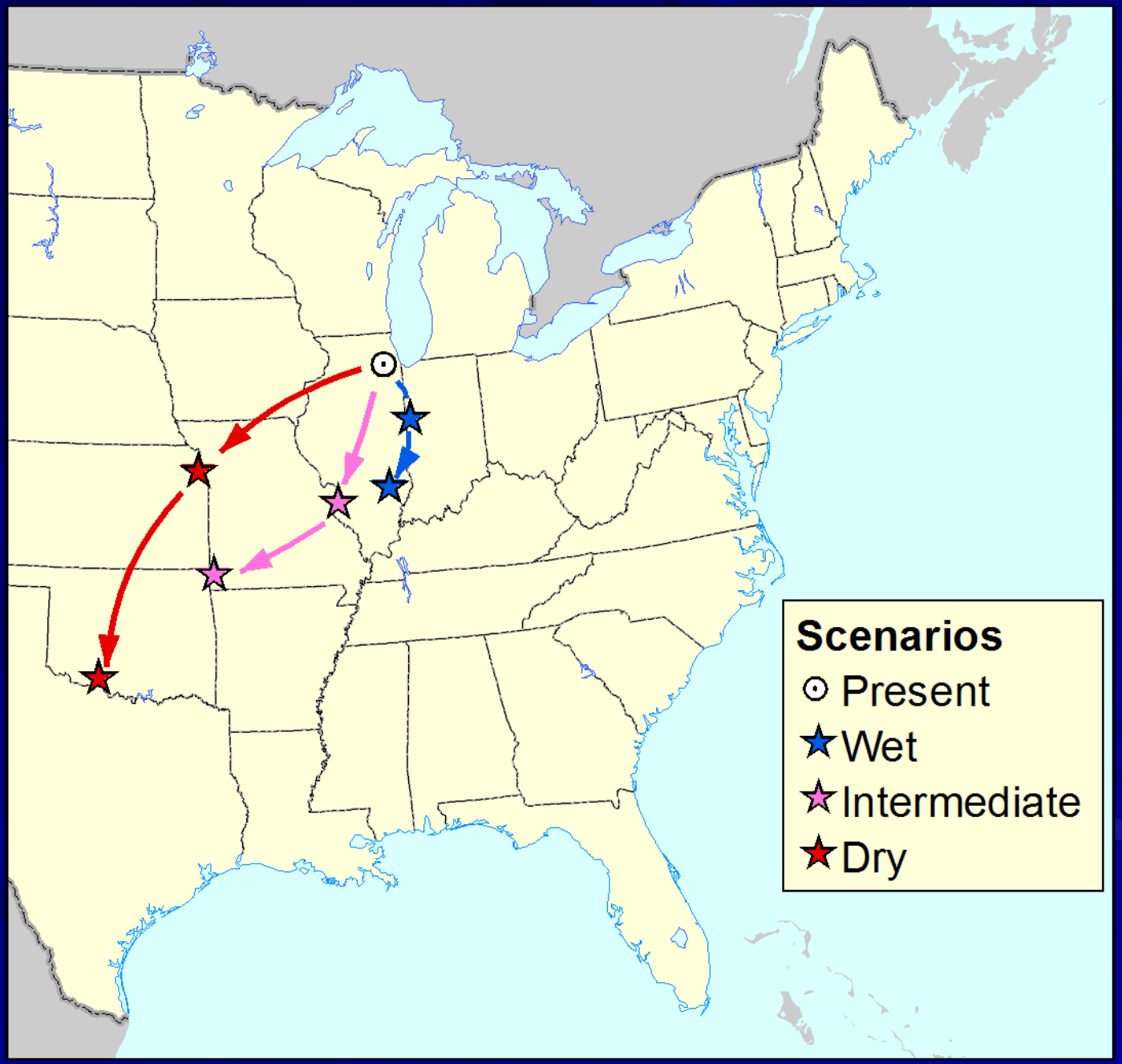
These reports base their conclusions on selected climate scenarios

However,

- There are 23 Global Climate Models considered to be equally credible
- Over 150 different scenarios from these models
- The models are consistent with respect to temperature increase, although the projected amount may differ
- Precipitation is more difficult to model and there is little agreement between models in precipitation trends, much less in determining seasonal trends
- “It’s hard to place much confidence in any one characterization of future precipitation when the various models are all across the board.”

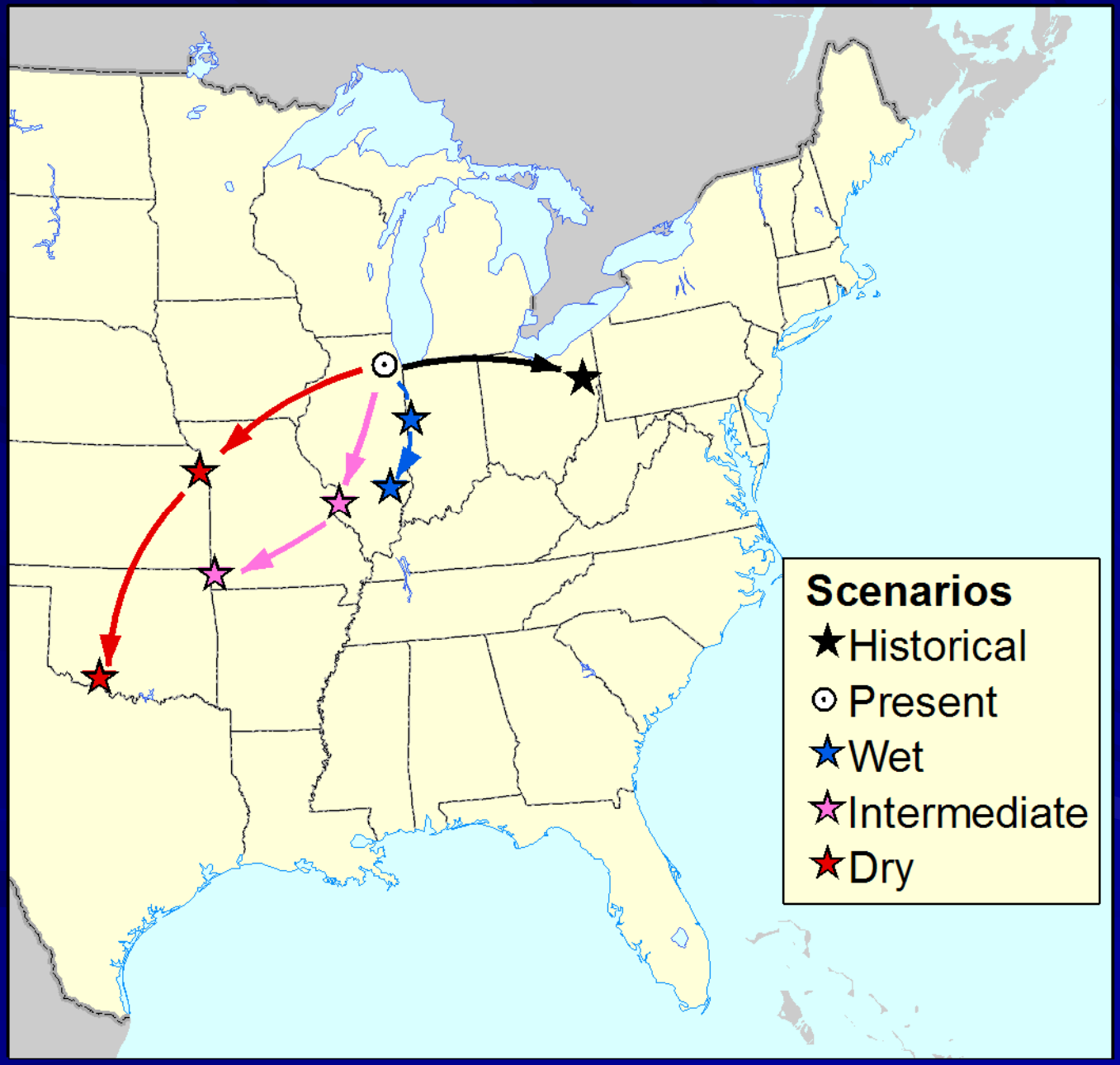
Global Climate Model Projections
Annual Precipitation - Illinois




Scenarios
Present
Wet
Intermediate
Dry

Inconsistency between the current Midwest climate and global model predictions

- Much of Midwest (and eastern USA) shows no 20th Century warming. Precipitation has increased by 7-10% for much of the Upper Midwest. Some GCM models suggest precipitation increases of this magnitude, but only following 50-100 years of climate change.
- This means either that observed patterns in precip and streamflow over the past 30 years are associated almost entirely with climate variability, or that the GCM models are not developed enough to correctly predict climate trends (or perhaps both are true) in the Midwest.
- The precipitation/streamflow increase of the past 30 years does appear to be within the range of conditions that have been experienced in the previous 150 years (although at the upper end of the range).


Scenarios
Historical
Present
Wet
Intermediate
Dry

Conclusion

- In the Illinois River basin, precipitation changes appear to be the driving force behind increases in streamflow and flooding
- We have only a limited influence on water yields
- We don’t have a reliable projection of future climate conditions and how streamflow and flooding will change.
- Projected precipitation changes differ considerably depending on climate model. Common perceptions concerning their potential impacts may not hold true for the Midwest and other regions.