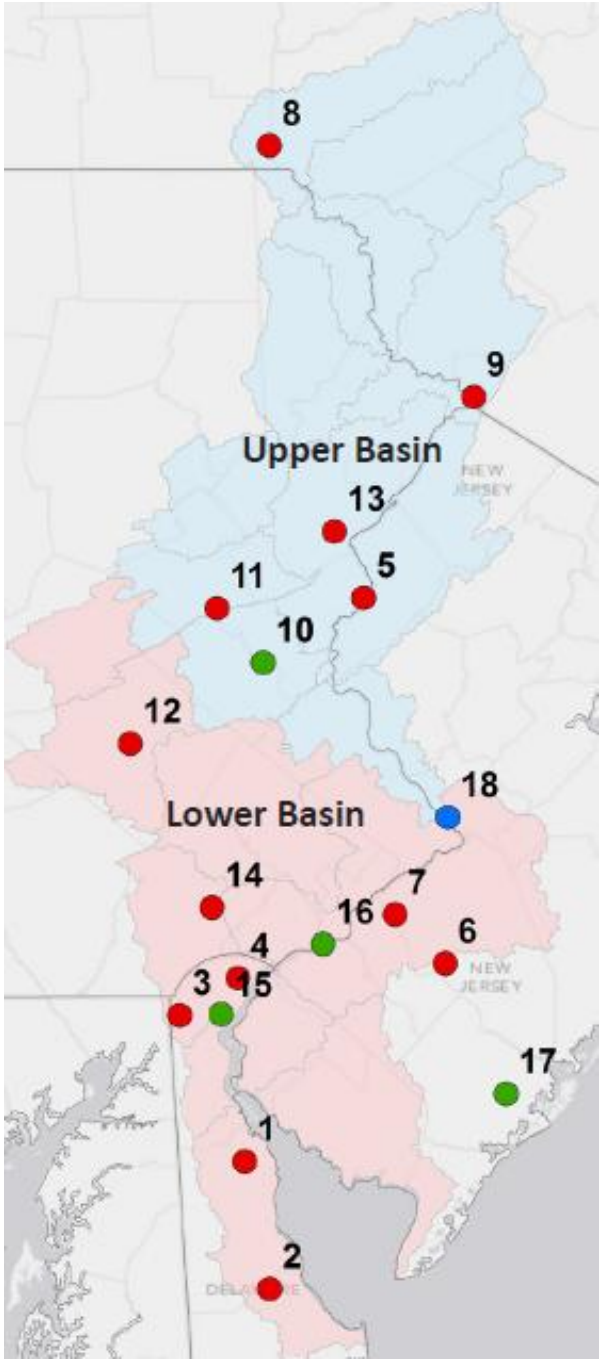
Historical Climate Change and Variability in the Delaware River Basin

Chapter 7 of Technical Report for Estuary and Basin

Raymond Najjar
Andrew Ross
Danielle Kreeger
Susan Kilham

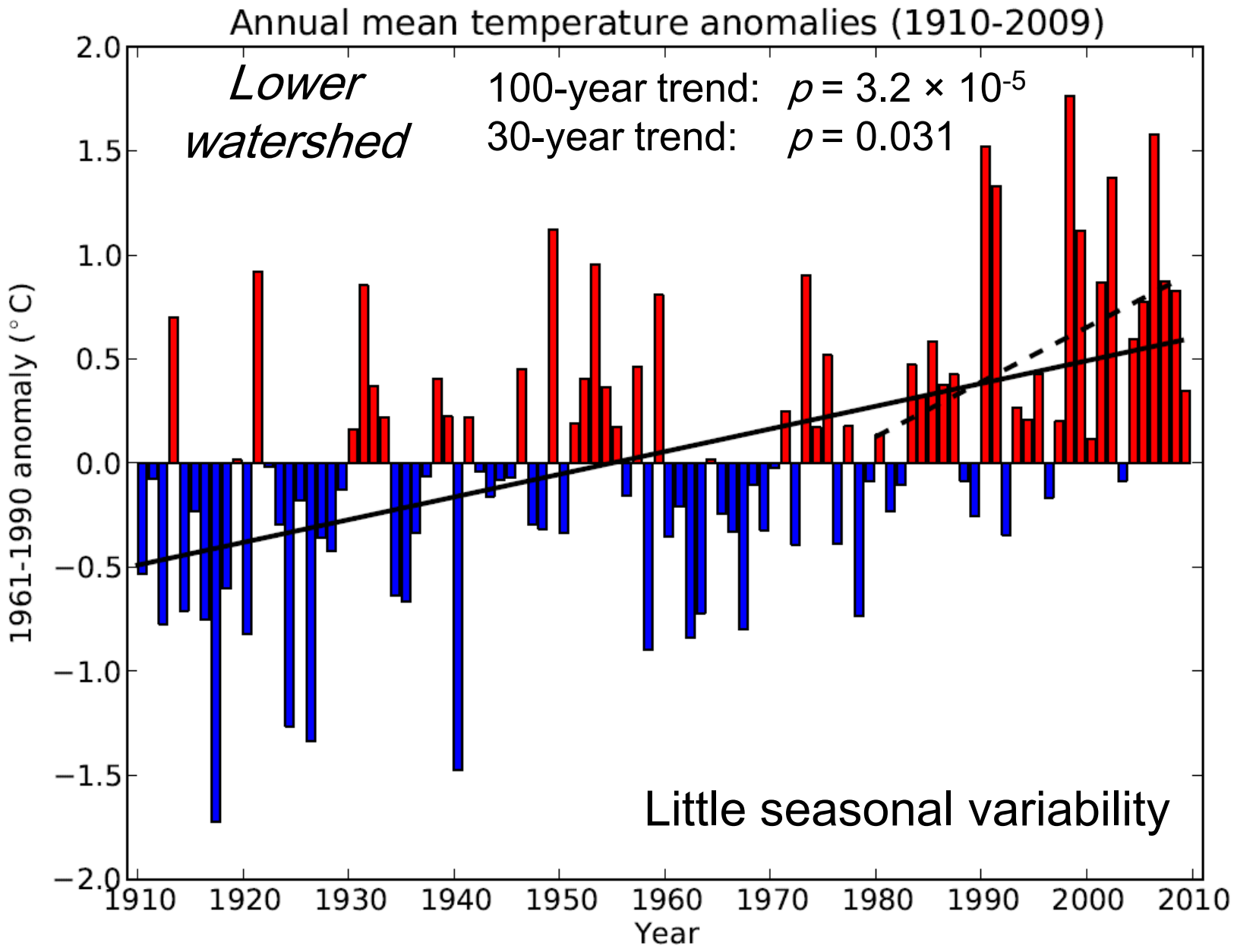
2013 Delaware Estuary Summit



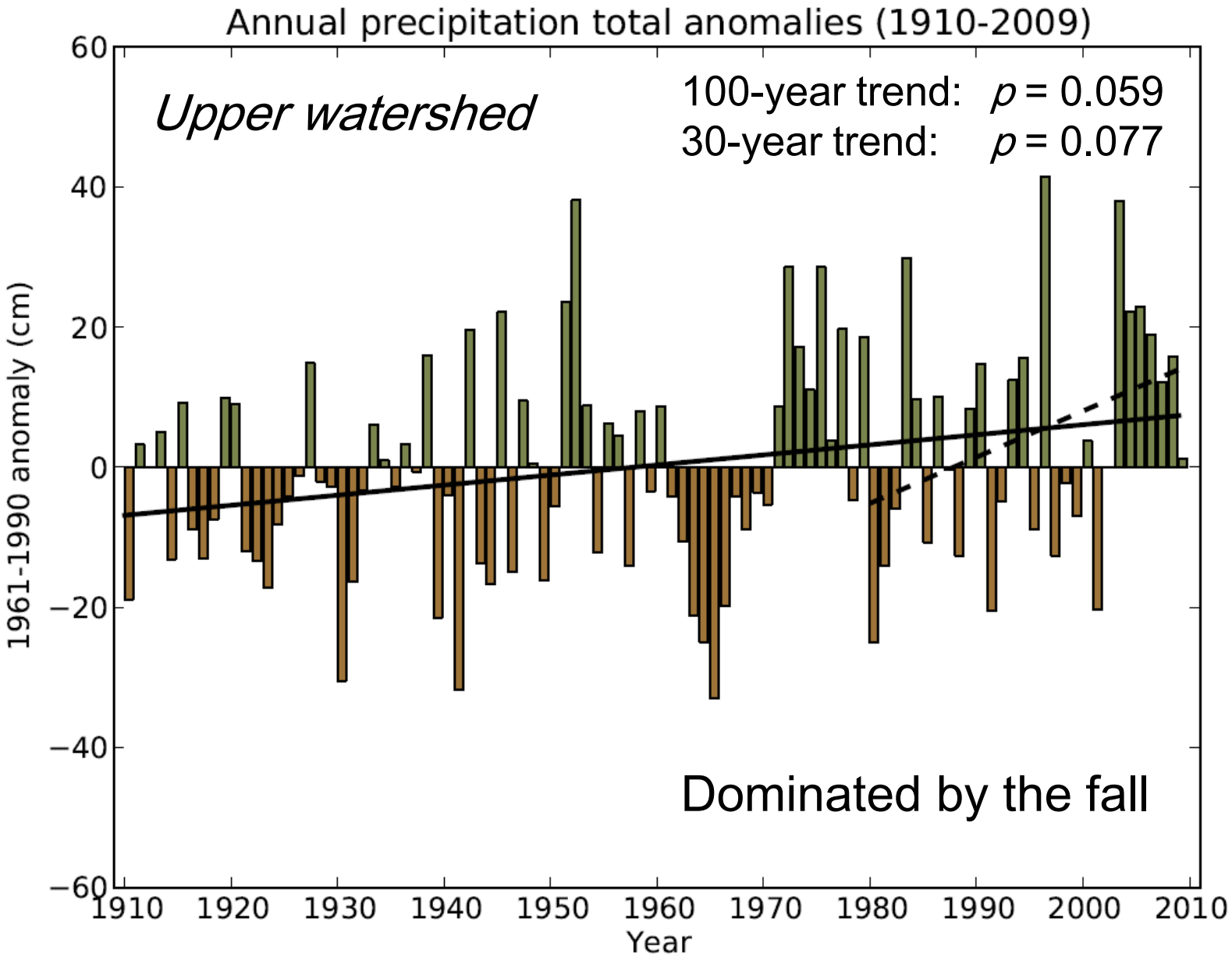
Goal: Comprehensively document changing climate of the Delaware River Basin

- Temperature
- Precipitation
- Snow cover
- Wind speed
- Streamflow
- Ice jams
- Low-pressure systems

HCN monthly temperature data (adjusted)



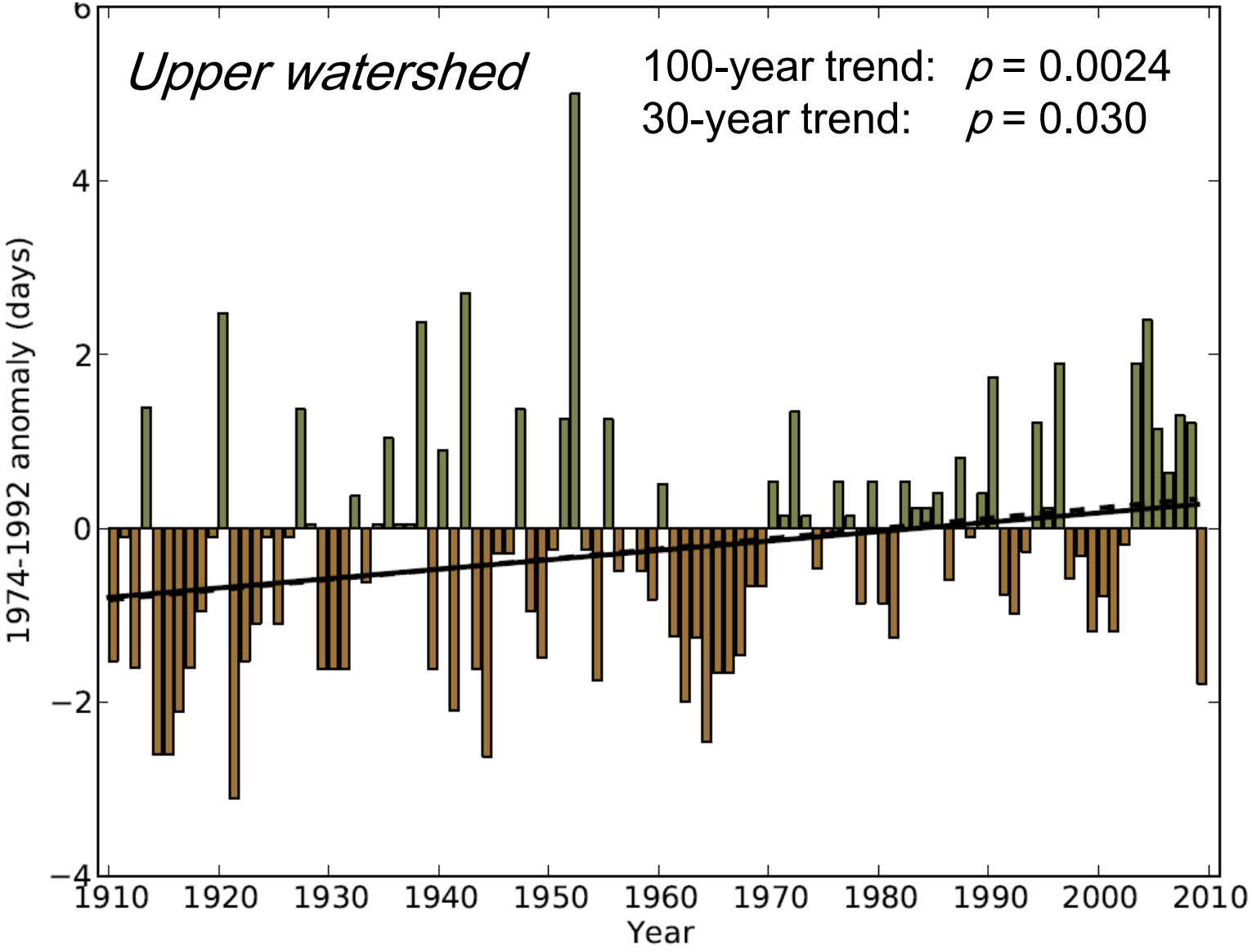
HCN monthly precipitation data



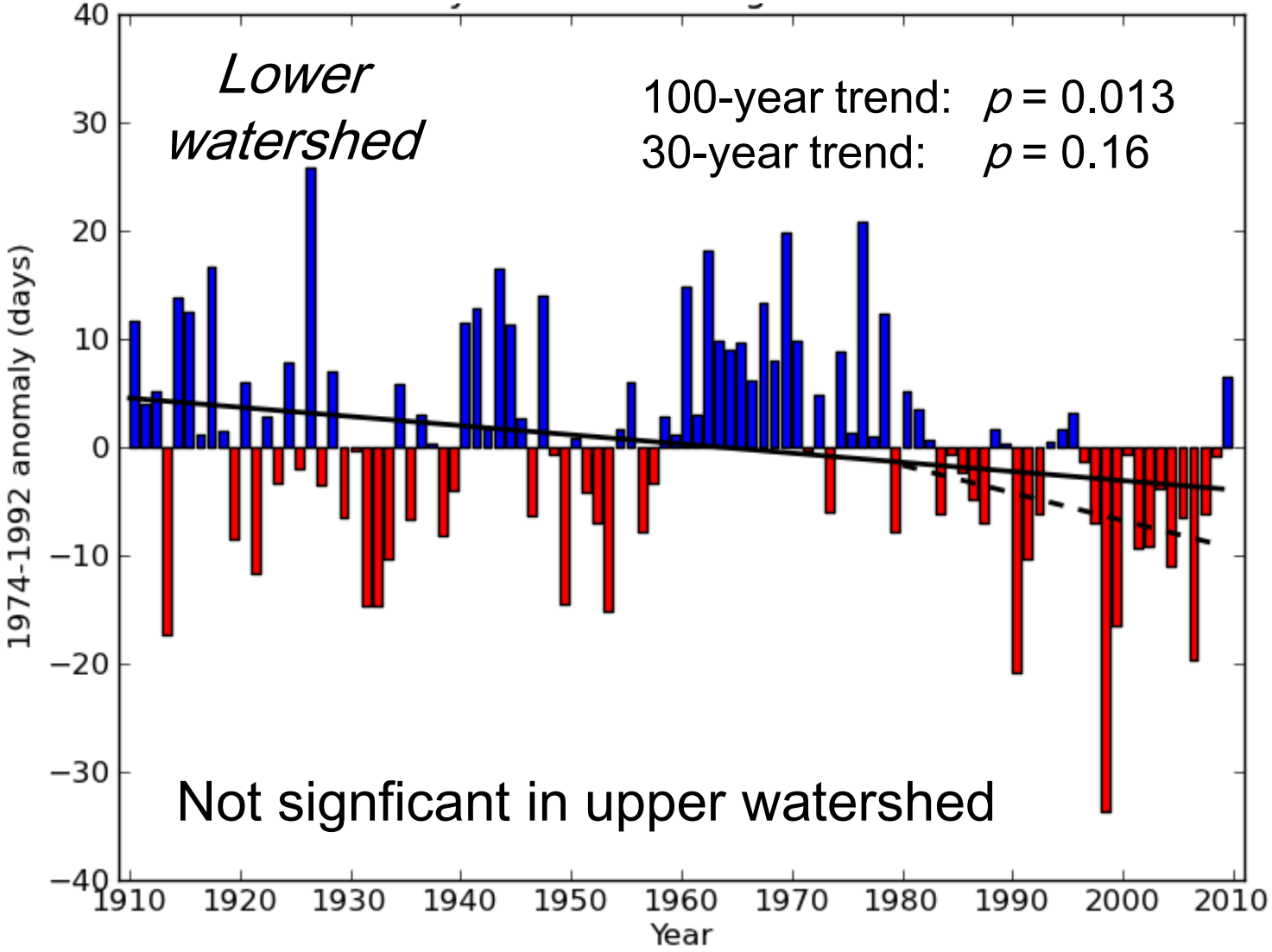
Trends in Temperature and Precipitation Extremes

1. Days per year above 90° F **NS**
2. Days per year below 32° F 
3. Annual maximum # consecutive dry days **NS**
4. Days per year of heavy (>4.5 cm) precip. 
5. Annual maximum 5-day precip. total 

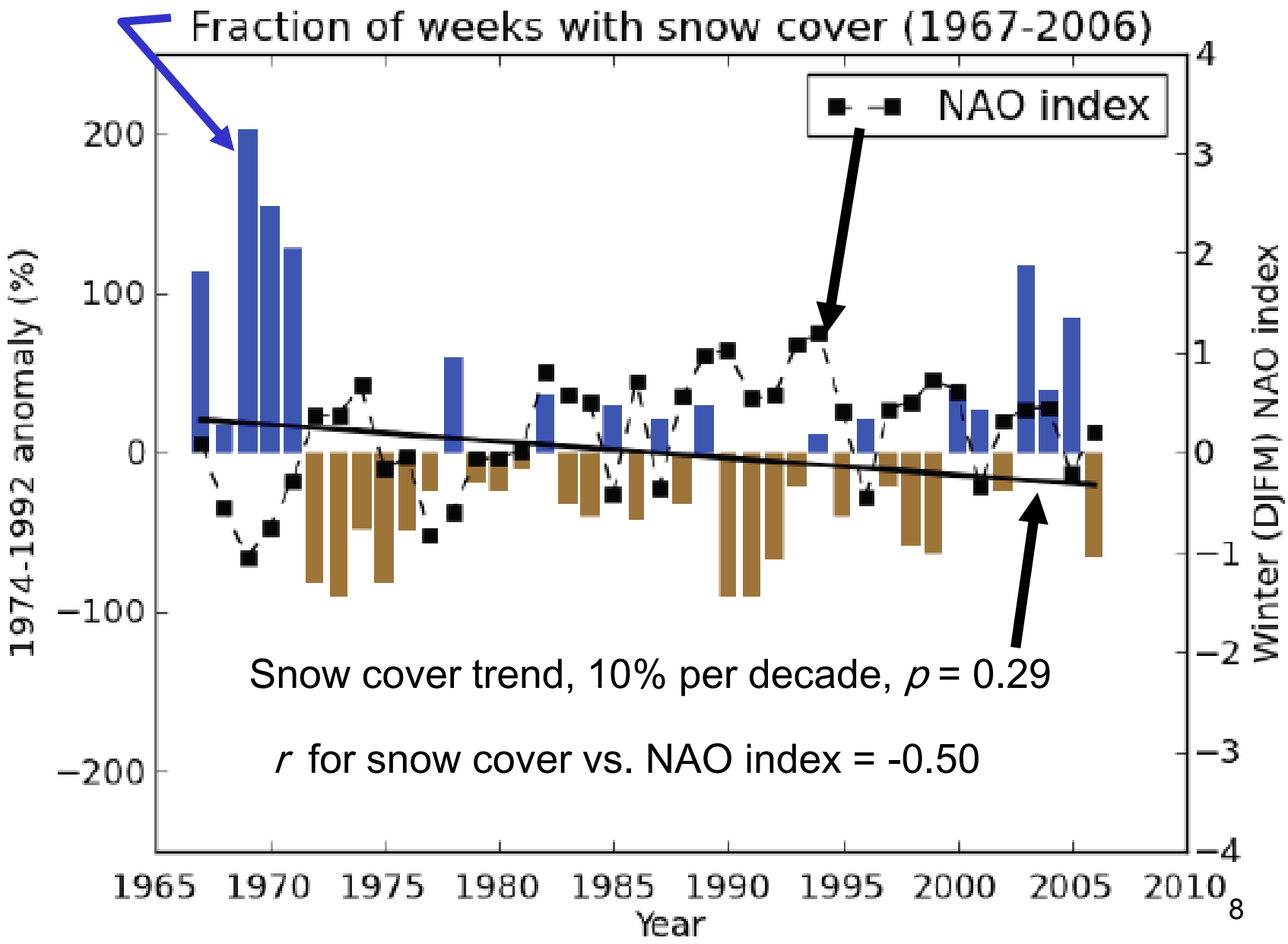
Days with > 4.5 cm precip, anomalies (HCN daily data)



Days below freezing, anomalies (HCN daily data, unadjusted)

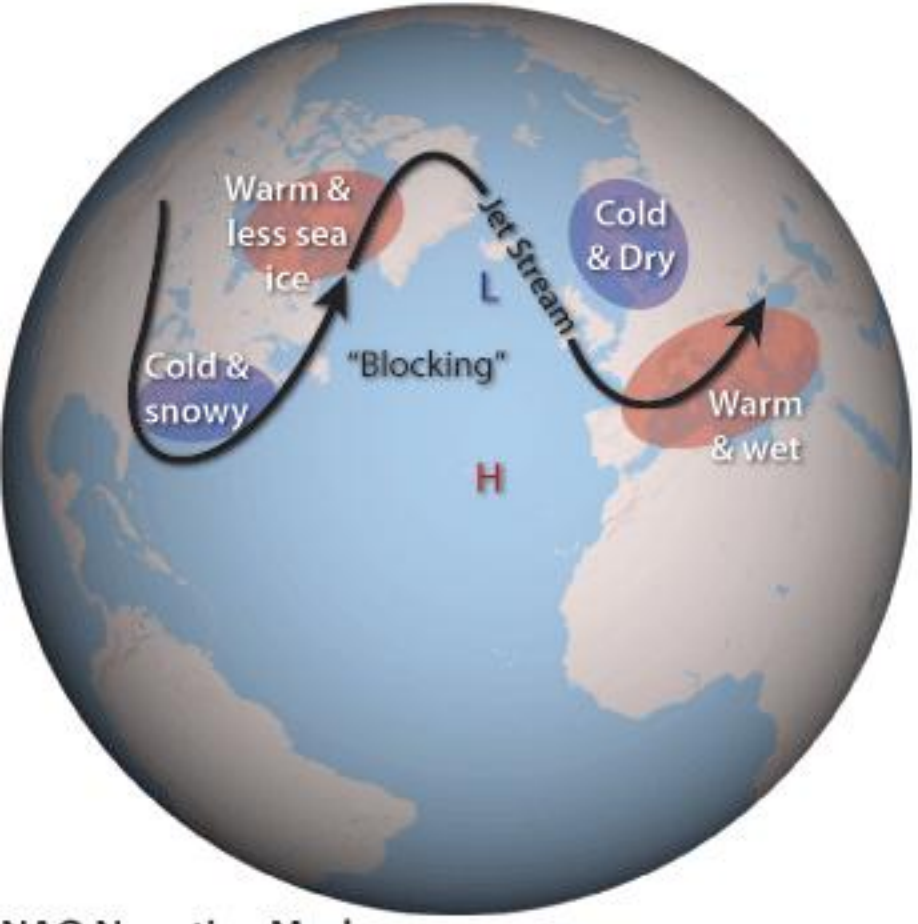


Snow Cover (Rutgers & NSIDC)

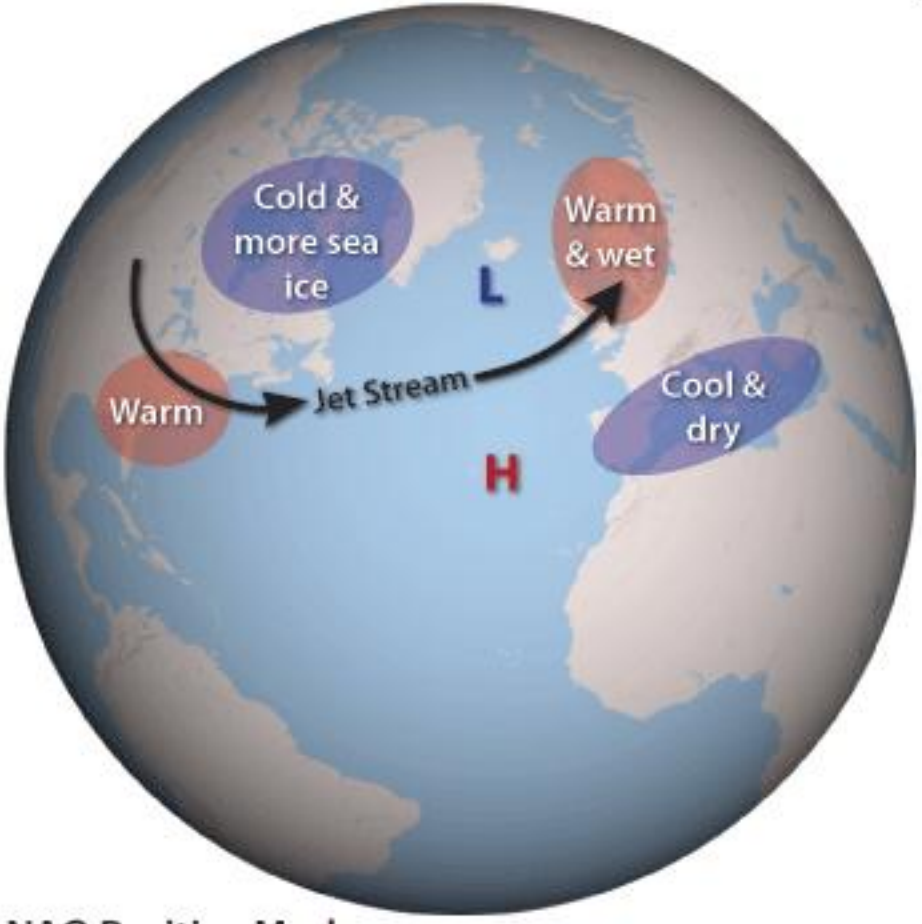


- NAO

+ NAO



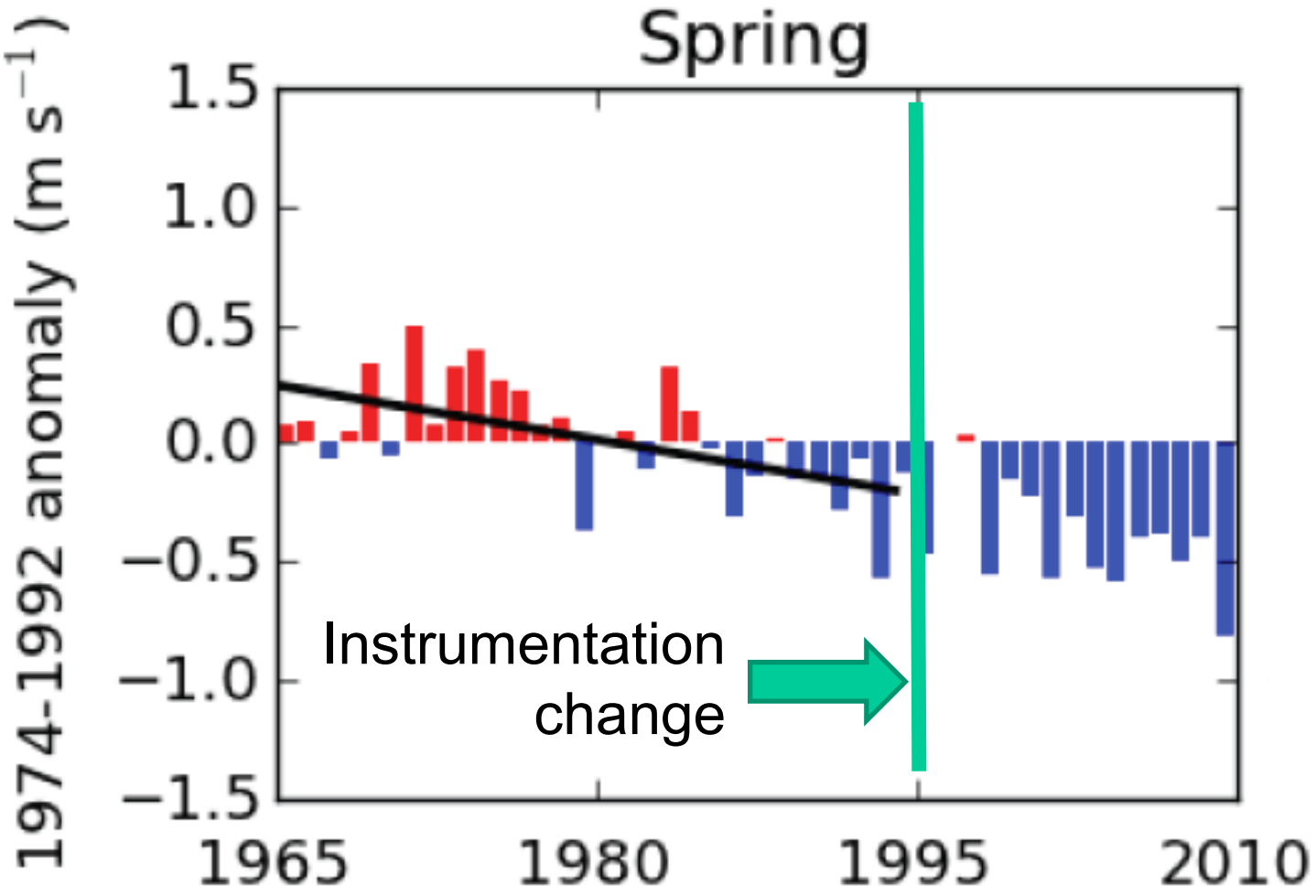
NAO Negative Mode



NAO Positive Mode

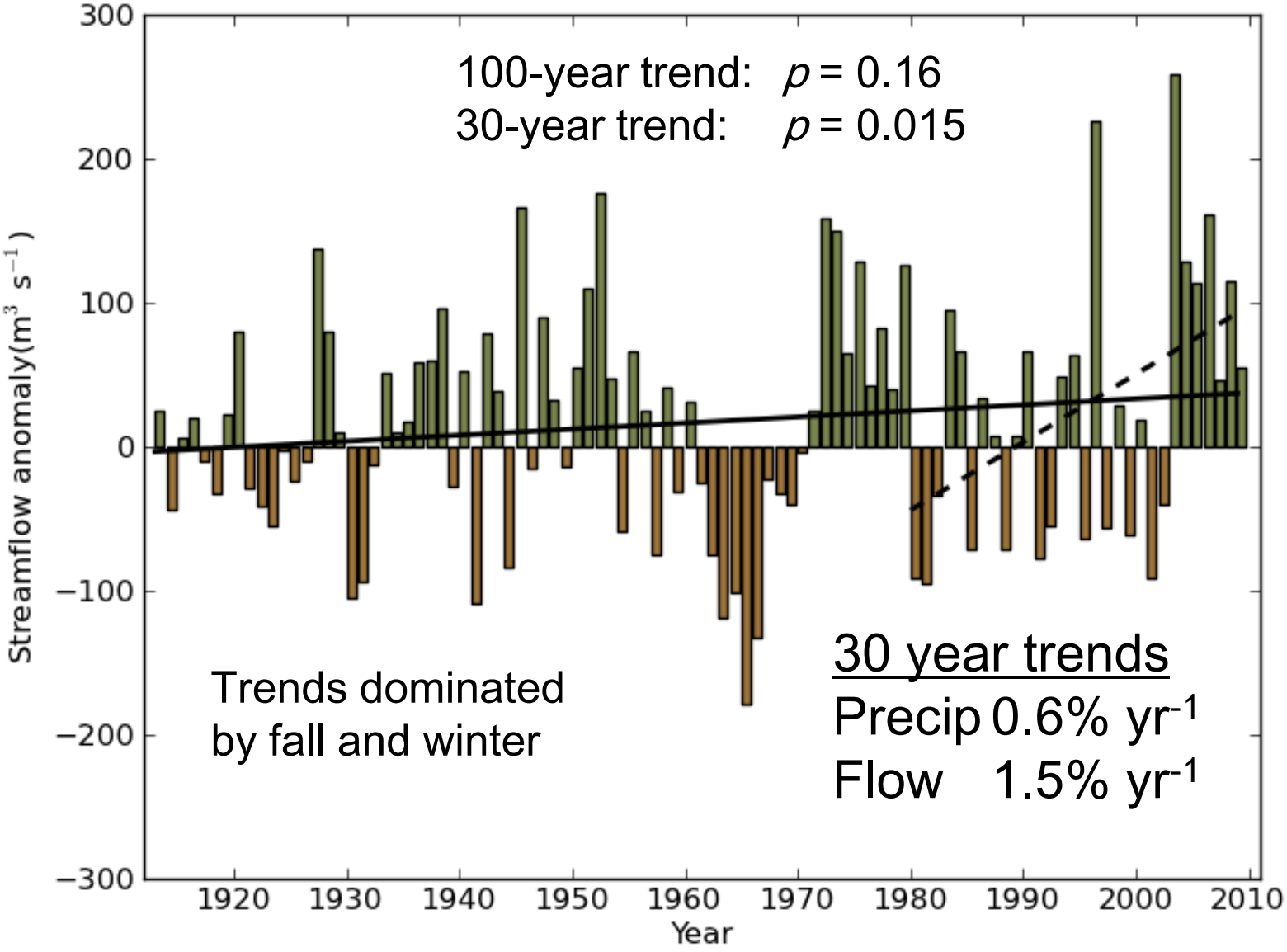
Source: NOAA ClimateWatch Magazine

Wind speed (NCDC)

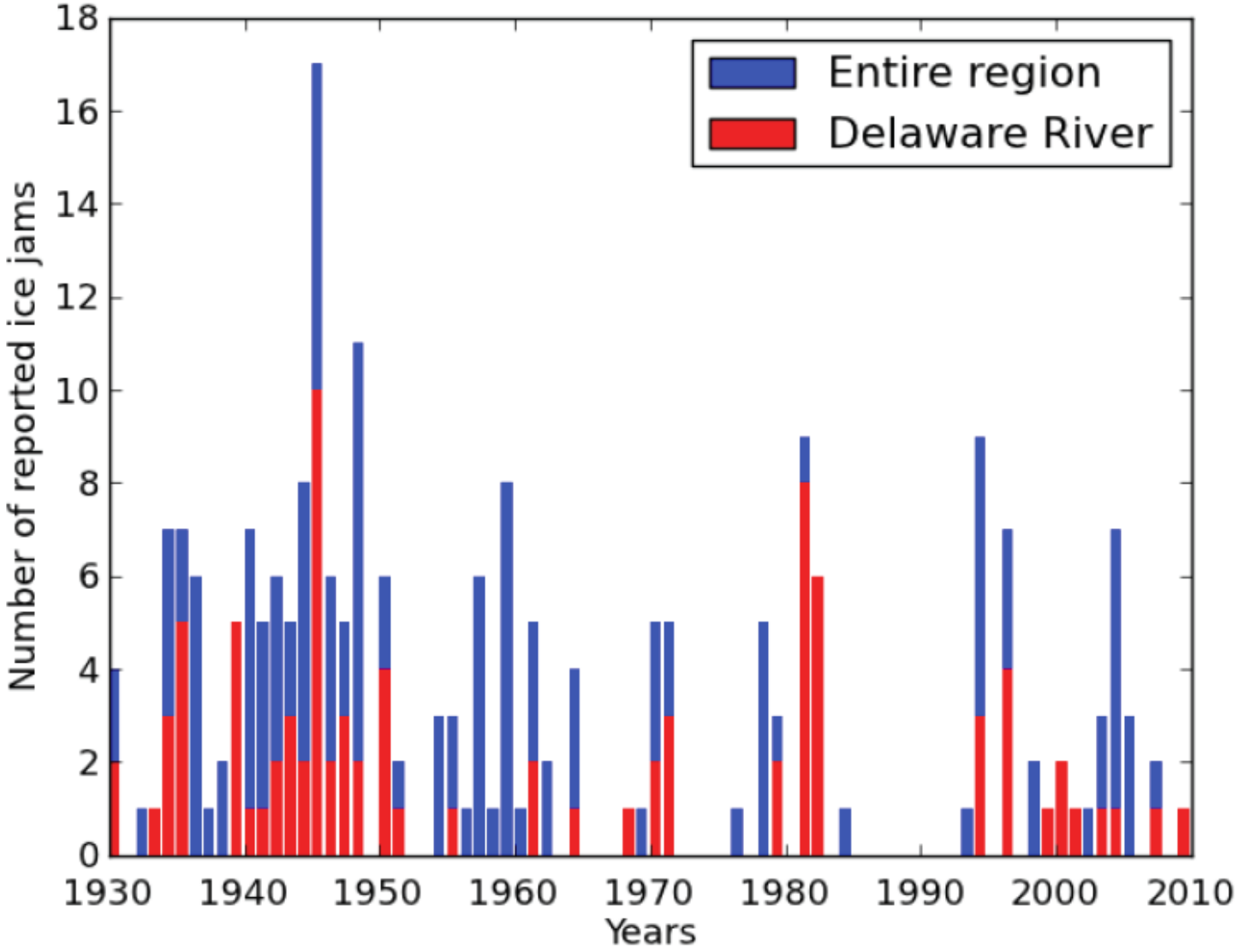


Declining winds found in all seasons.
Declines seen throughout Northern Hemisphere

Streamflow at Trenton (USGS)

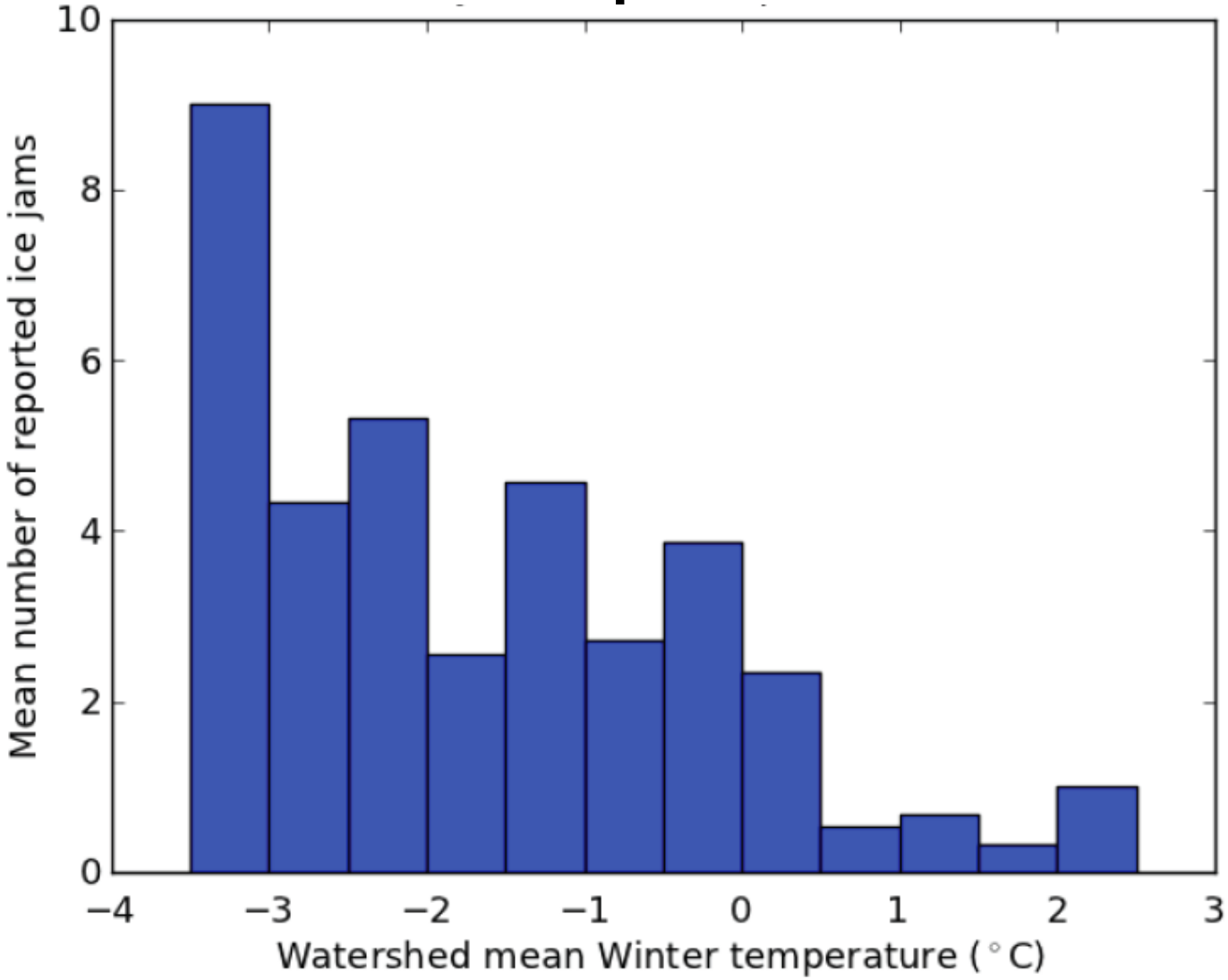


Reported Ice Jams in DRB

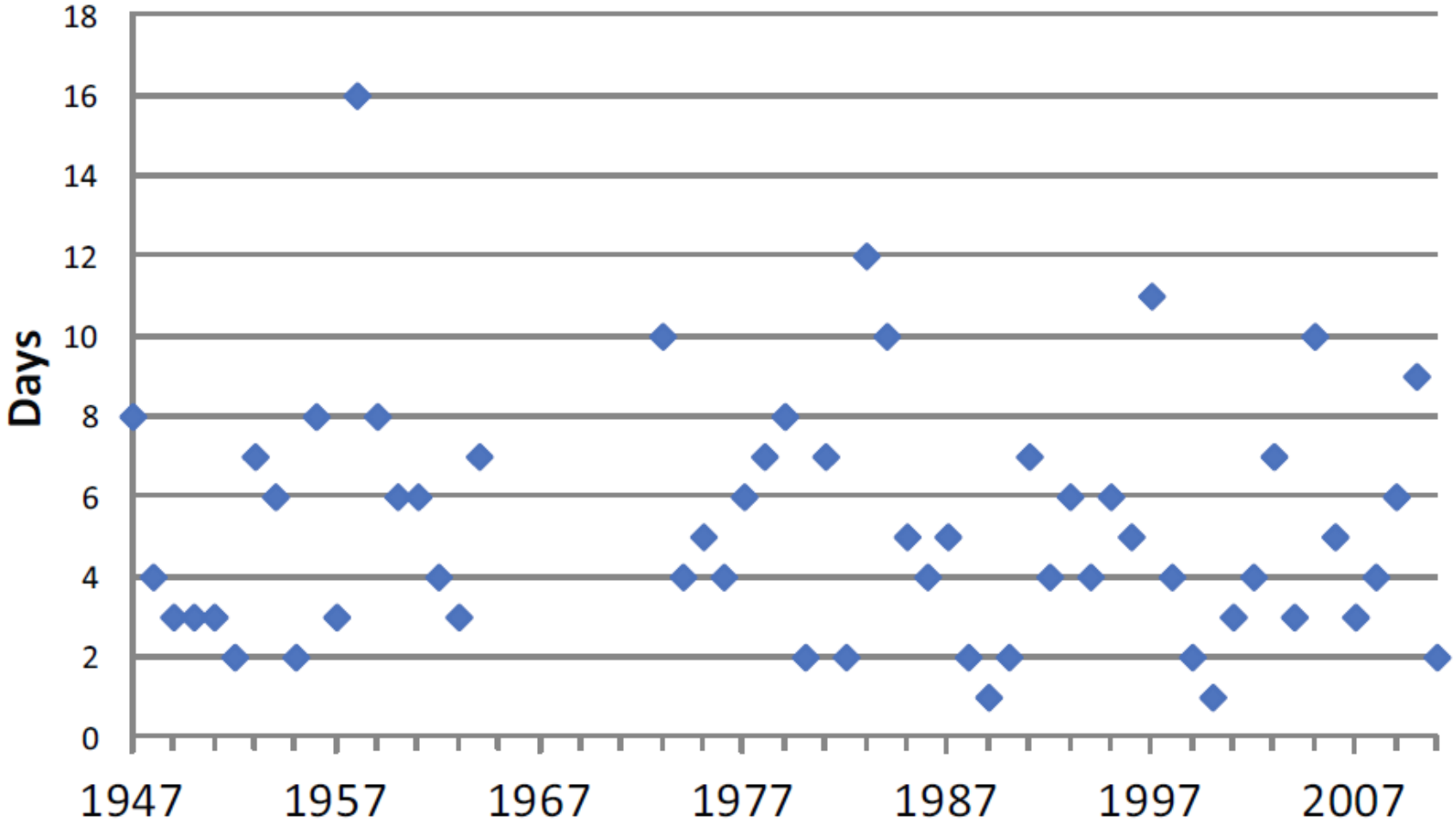


Source: Ice Jam Database of the U.S. Army Cold Regions Research and Engineering Laboratory

Relationship between ice jams and temperature



Number of days per year with mean pressure below 1000 mb at Atlantic City



Summary: Temperature and precipitation trends

Temperature trends:

- High (>95%) confidence in long-term warming (significant in all seasons & both basins)
- Recent warming trends are greater but less significant

Precipitation trends:

- Modest (>90%) confidence in long- & short-term annual increases
- High confidence in long-term fall increases

Summary: Extreme climate events

- Heavy precipitation showing significant increases
- Drought metric: no significant trends
- Extreme temperatures: no significant trends, except lower watershed freezing days

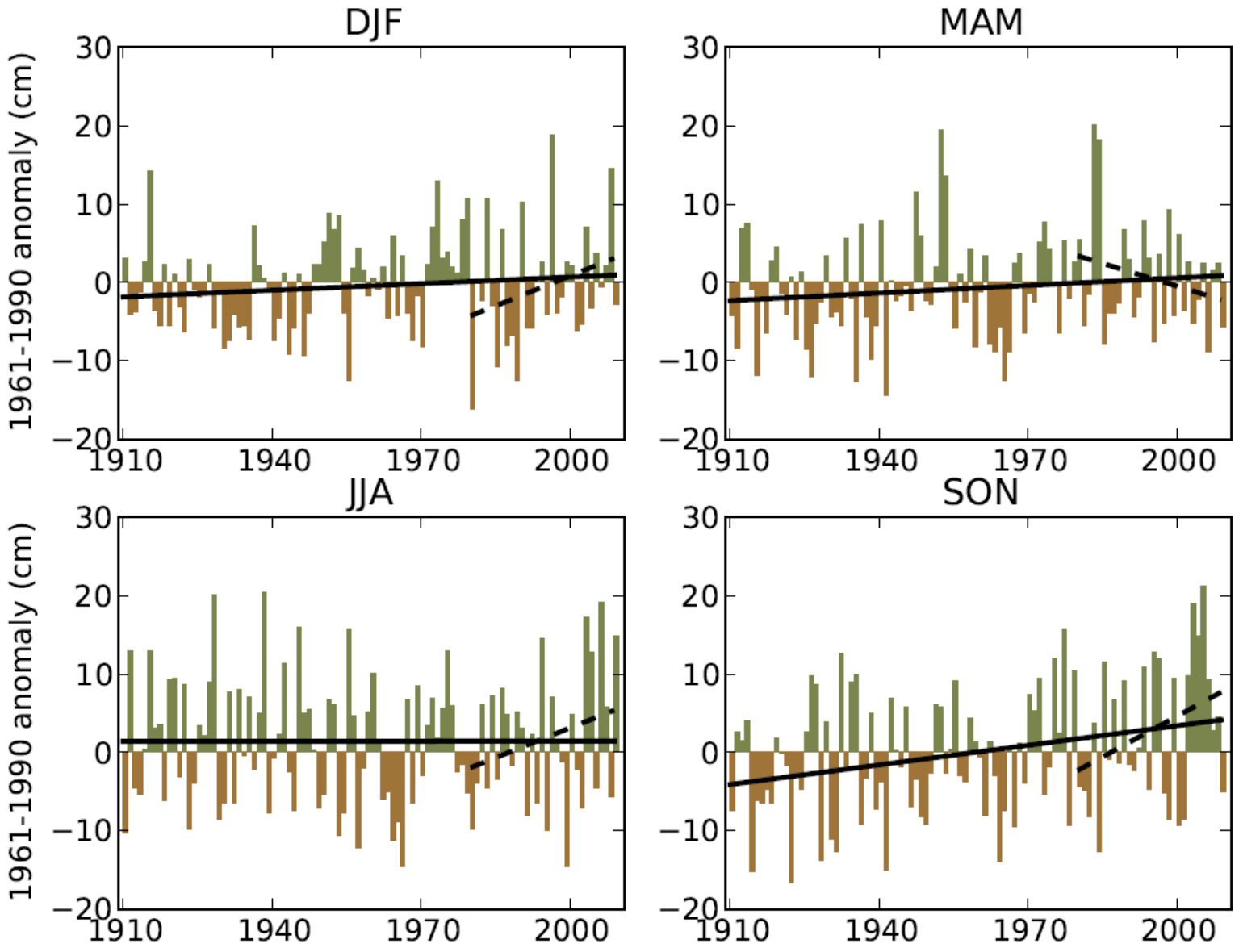
Summary: Other indicators

- Snow cover declining, not significantly; inverse correlation with NAO
- Wind speed declining significantly
- Streamflow increasing significantly, particularly in winter and fall
- Ice jam reports declining
- No trend in low pressure systems

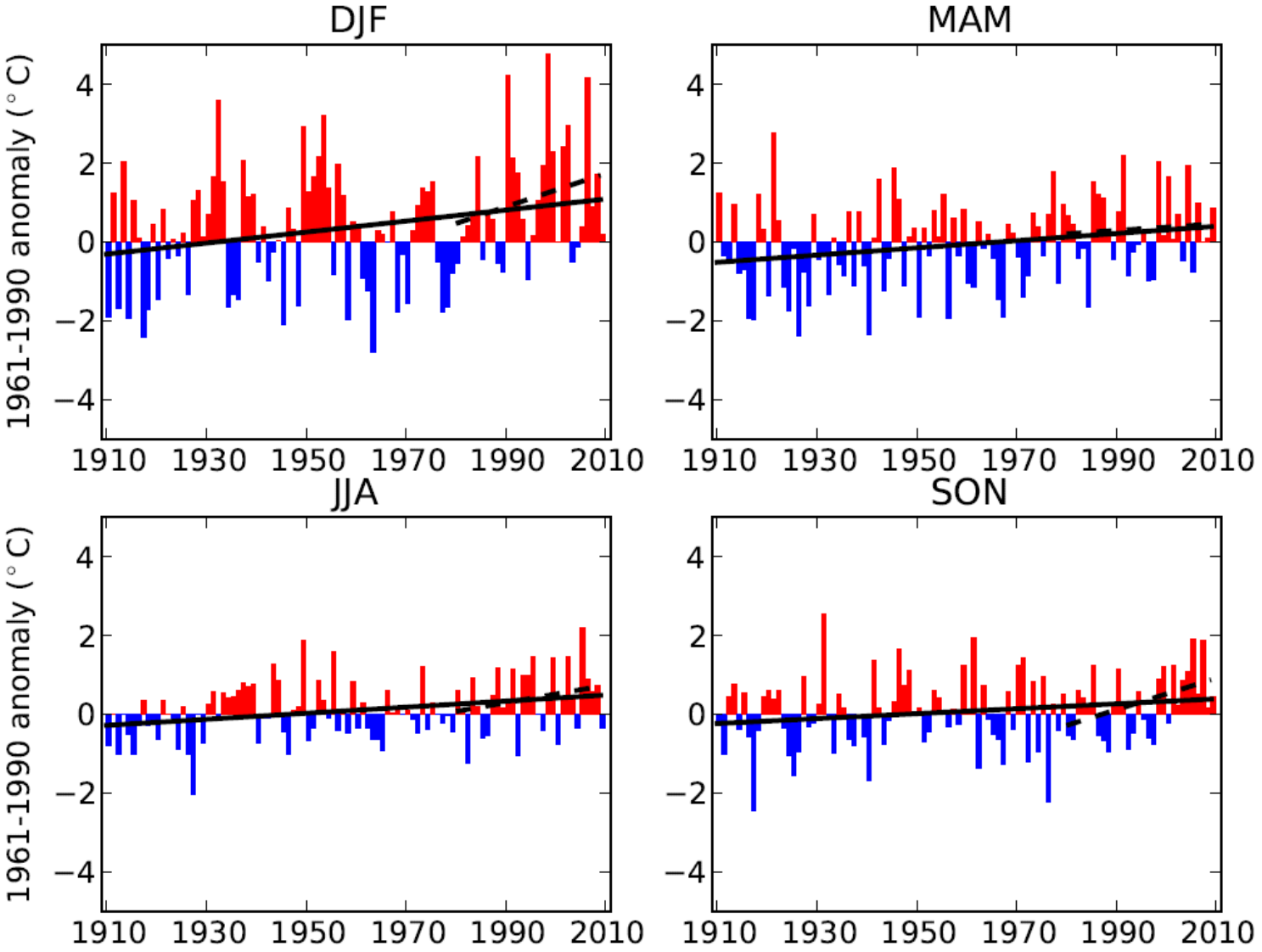
Thank you

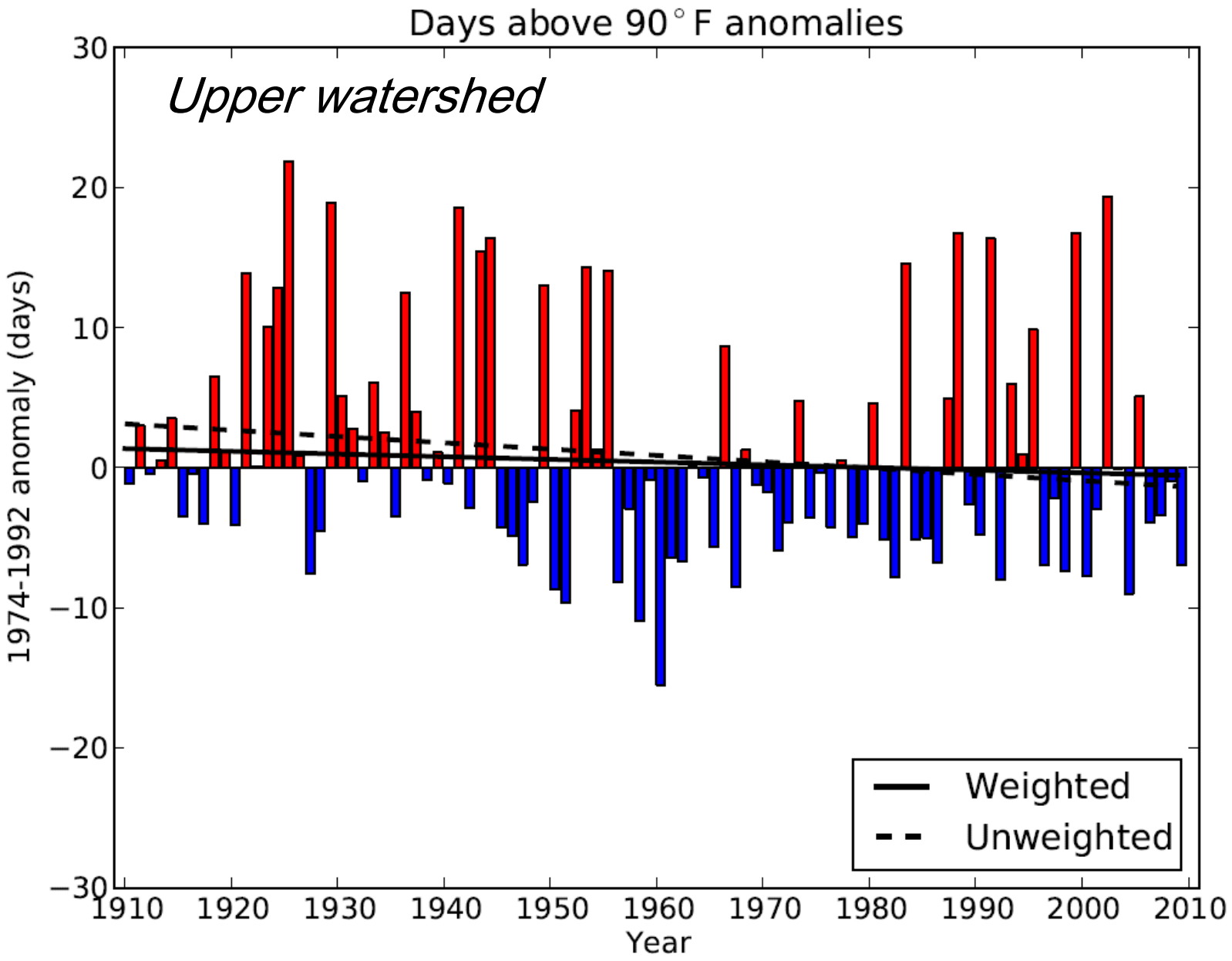
Extra figures

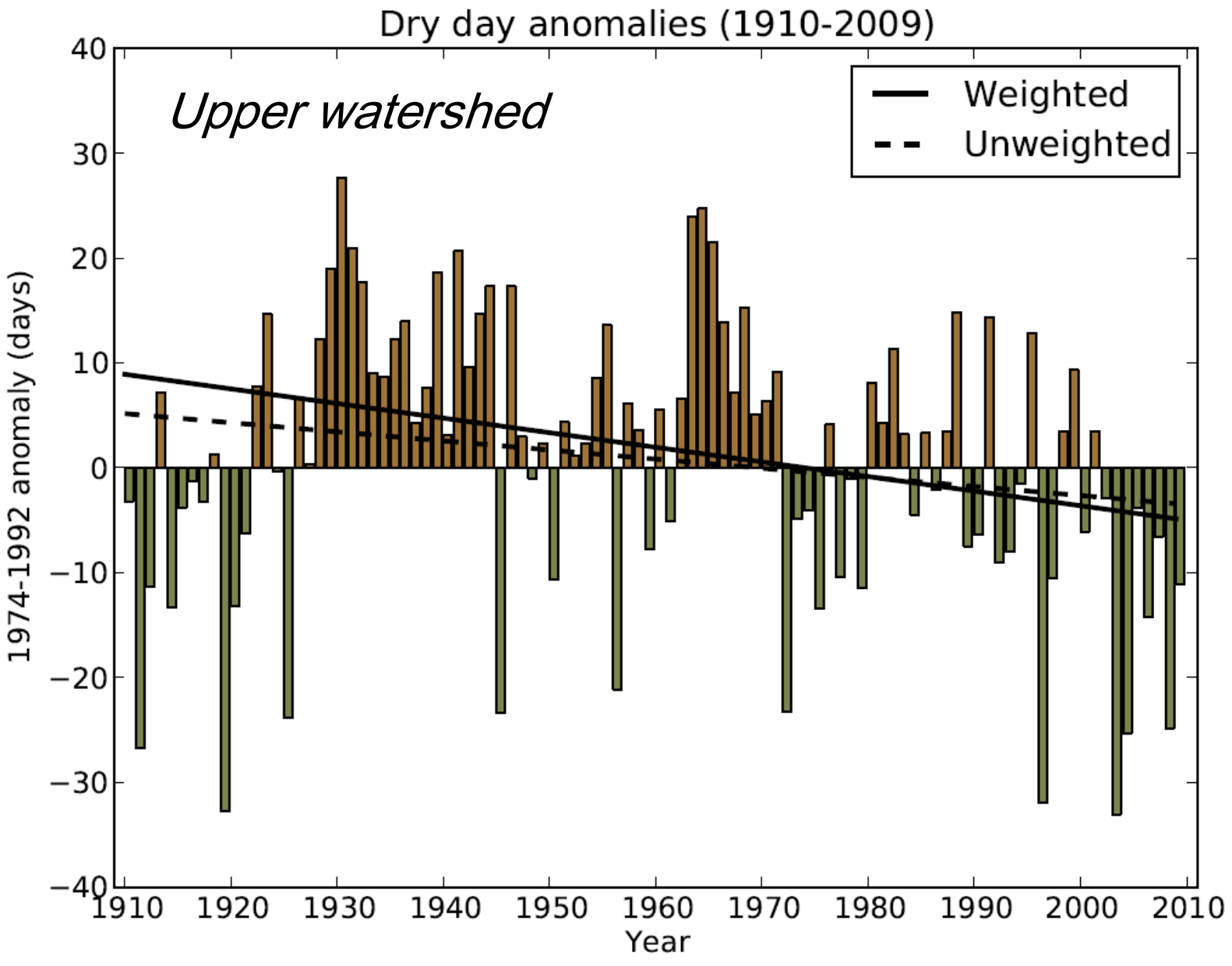
Upper watershed

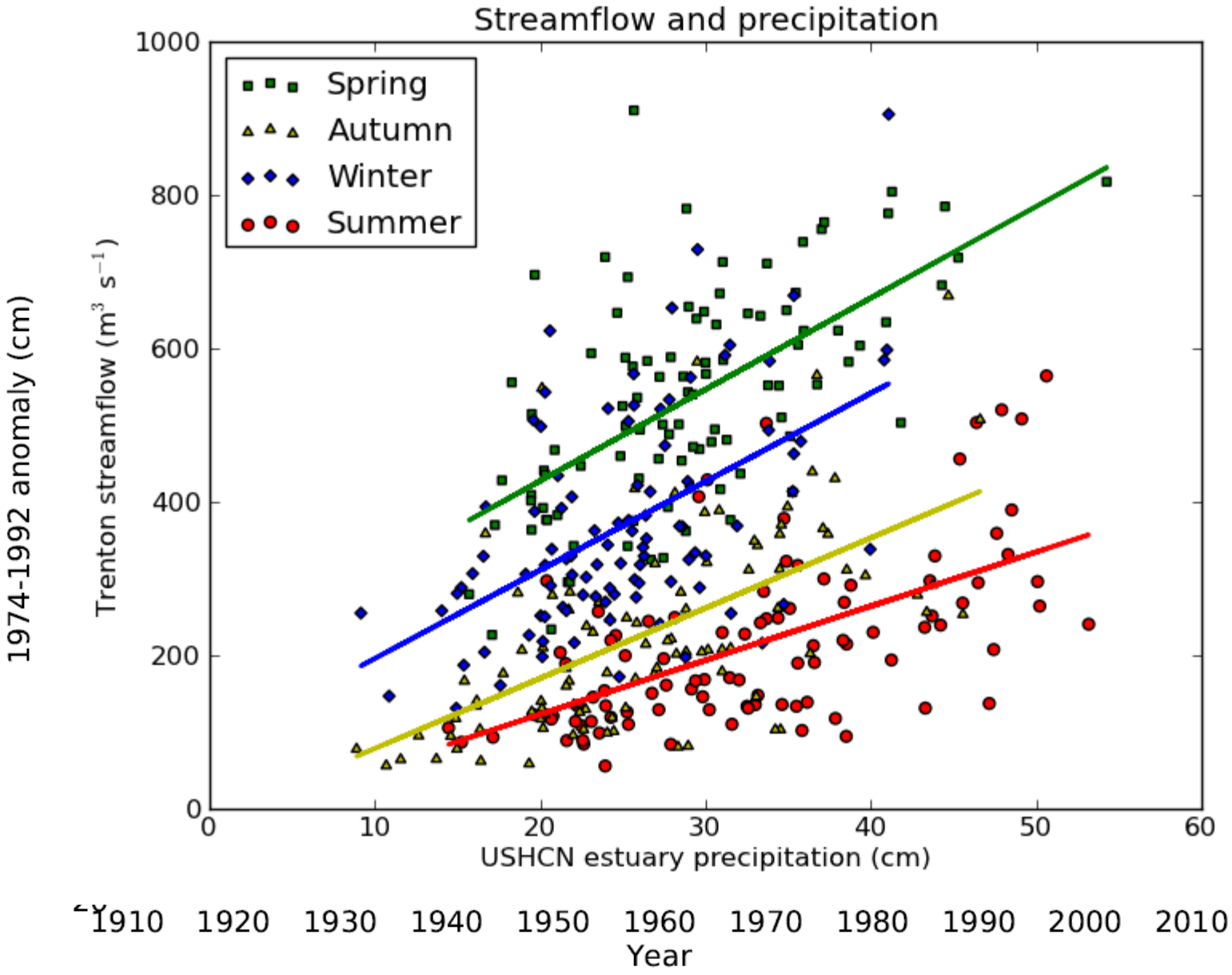


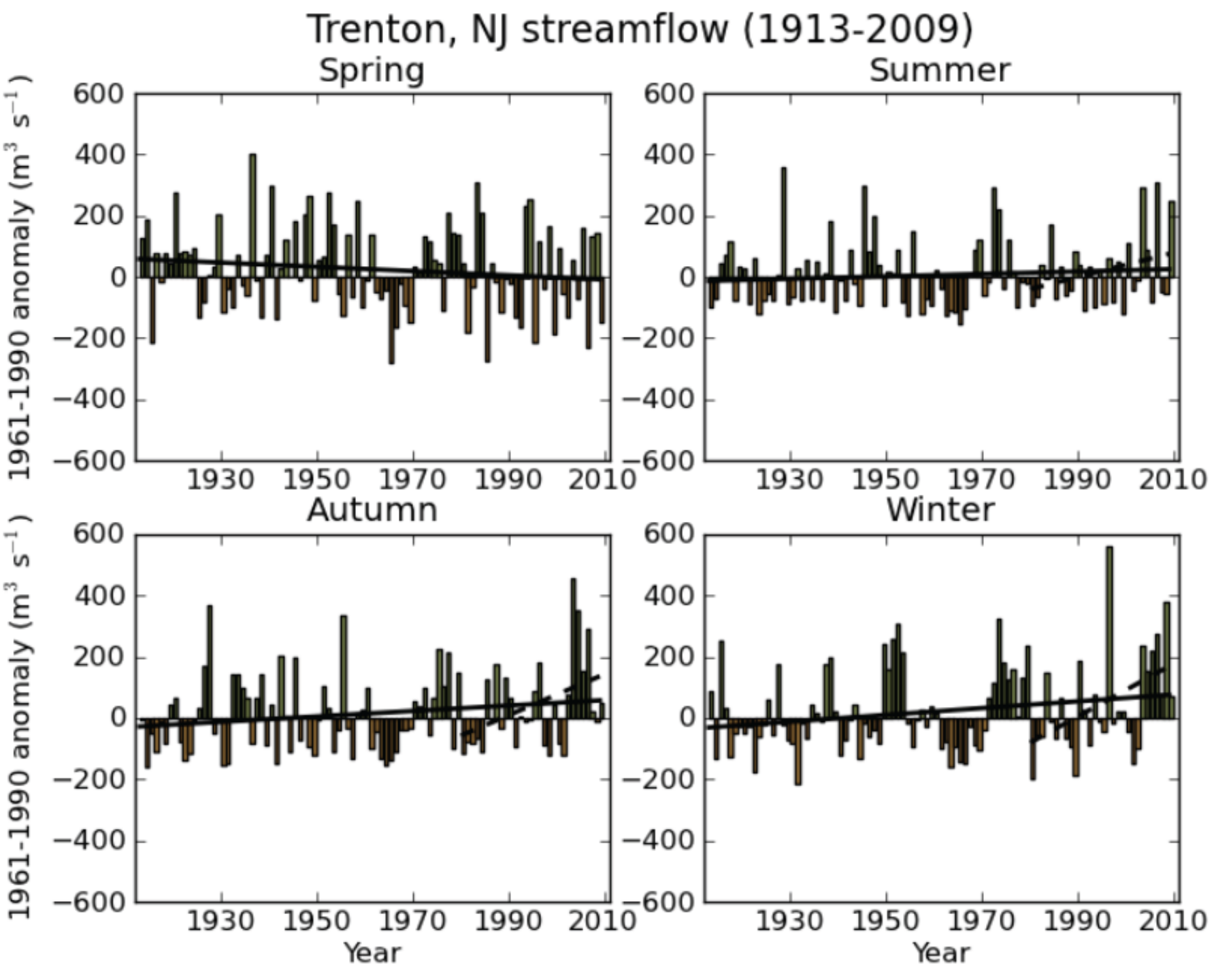
Upper watershed



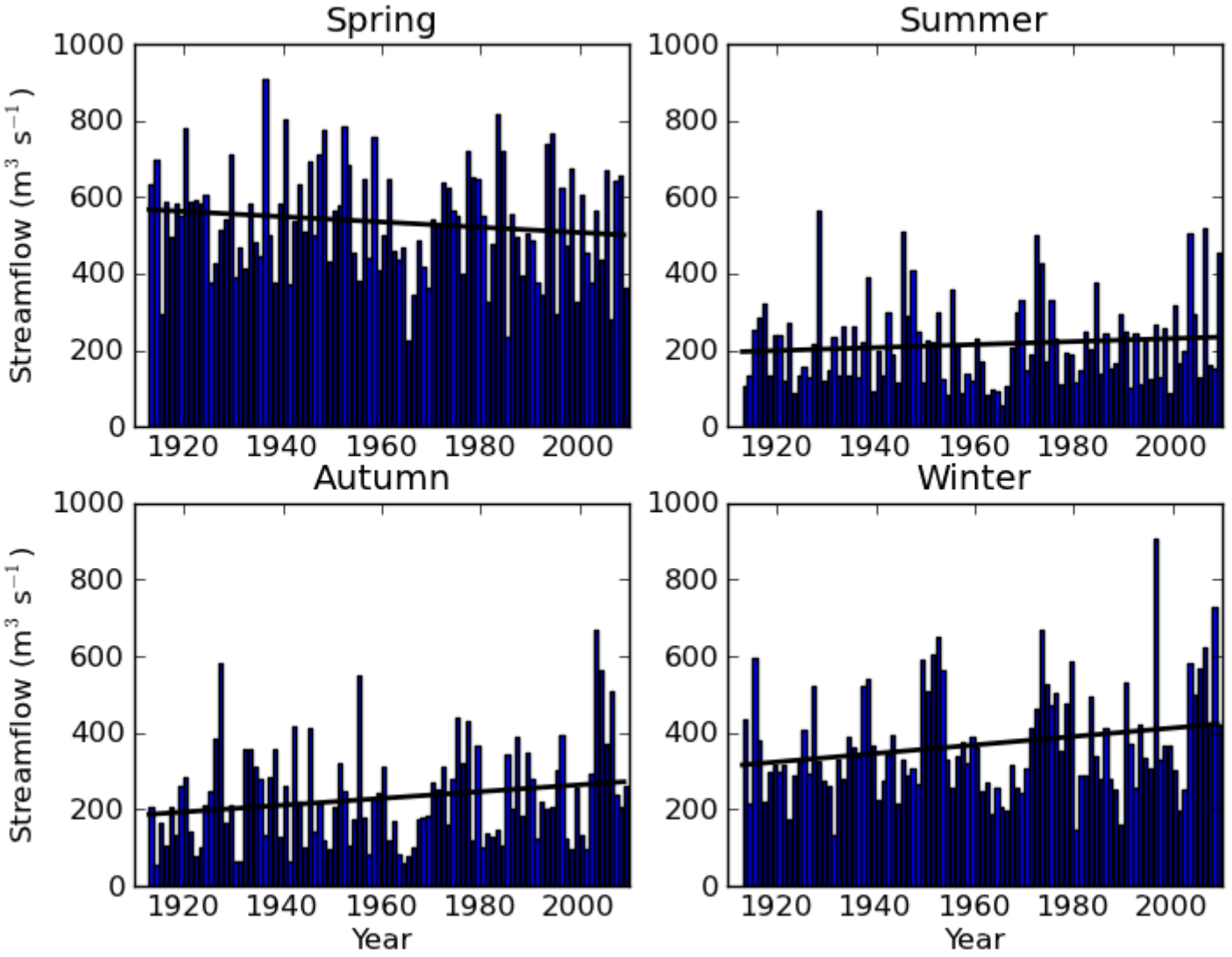

Days above 90°F anomalies
Upper watershed
1974-1992 anomaly (days)
30
20
10
0
−10
−20
−30
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Year
Weighted
Unweighted


Dry day anomalies (1910-2009)
Upper watershed
Weighted
Unweighted
1974-1992 anomaly (days)
Year
40
30
20
10
0
−10
−20
−30
−40
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010

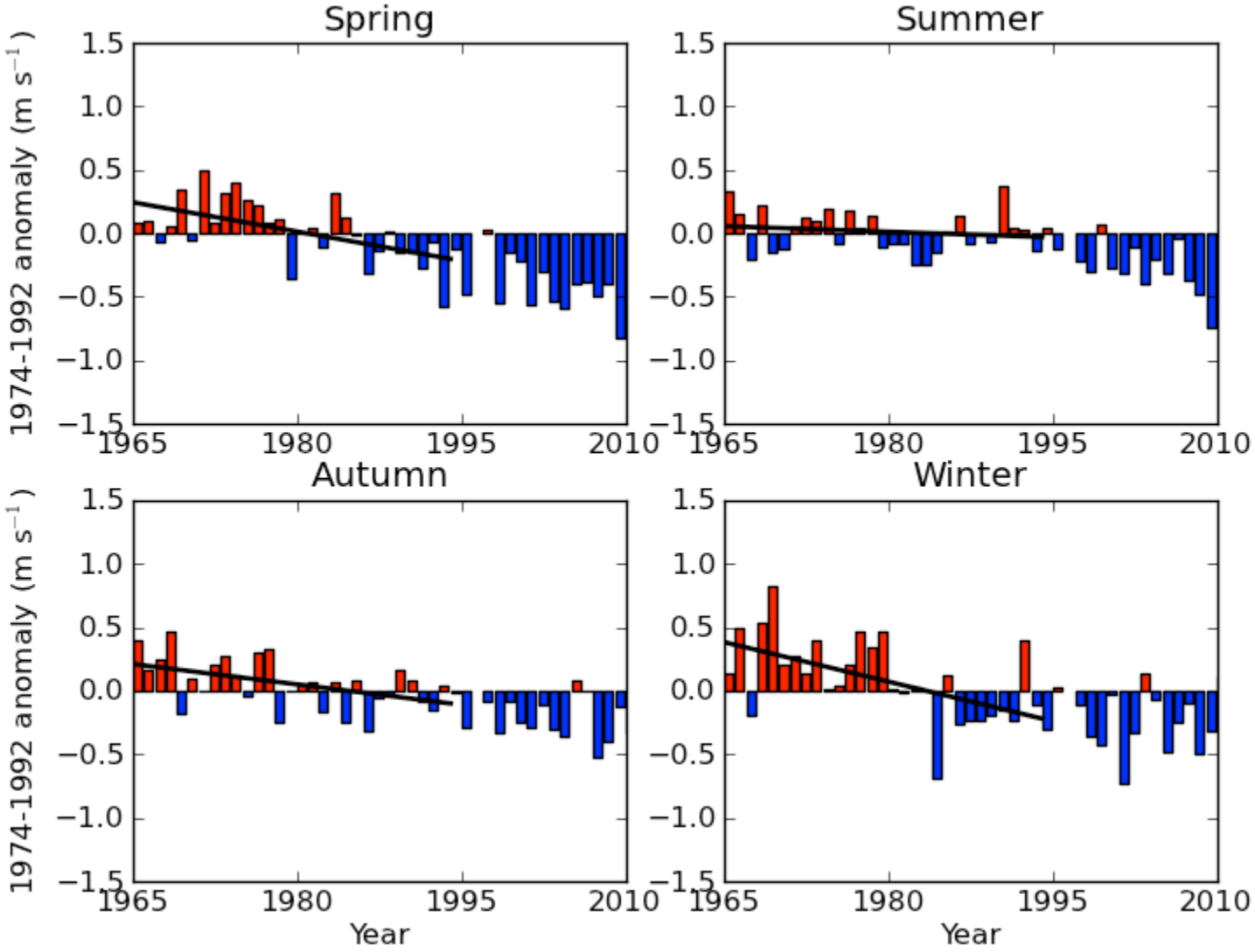

Streamflow and precipitation
Spring
Autumn
Winter
Summer
1000
800
600
400
200
0
0
10
20
30
40
50
60
Trenton streamflow (m^3 s^{-1})
1974-1992 anomaly (cm)
USHCN estuary precipitation (cm)
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Year


Trenton, NJ streamflow (1913-2009)
Spring
Summer
Autumn
Winter
1961-1990 anomaly (m^3 s^{-1})
600
400
200
0
−200
−400
−600
1930
1950
1970
1990
2010
Year

Trenton streamflow



Wind speed trends



Data averaged among four stations: Wilmington, DE; Allentown, PA; Philadelphia, PA (1955-1994); and Atlantic City, NJ