Hydro-climatic Drought in the Delaware River Basin

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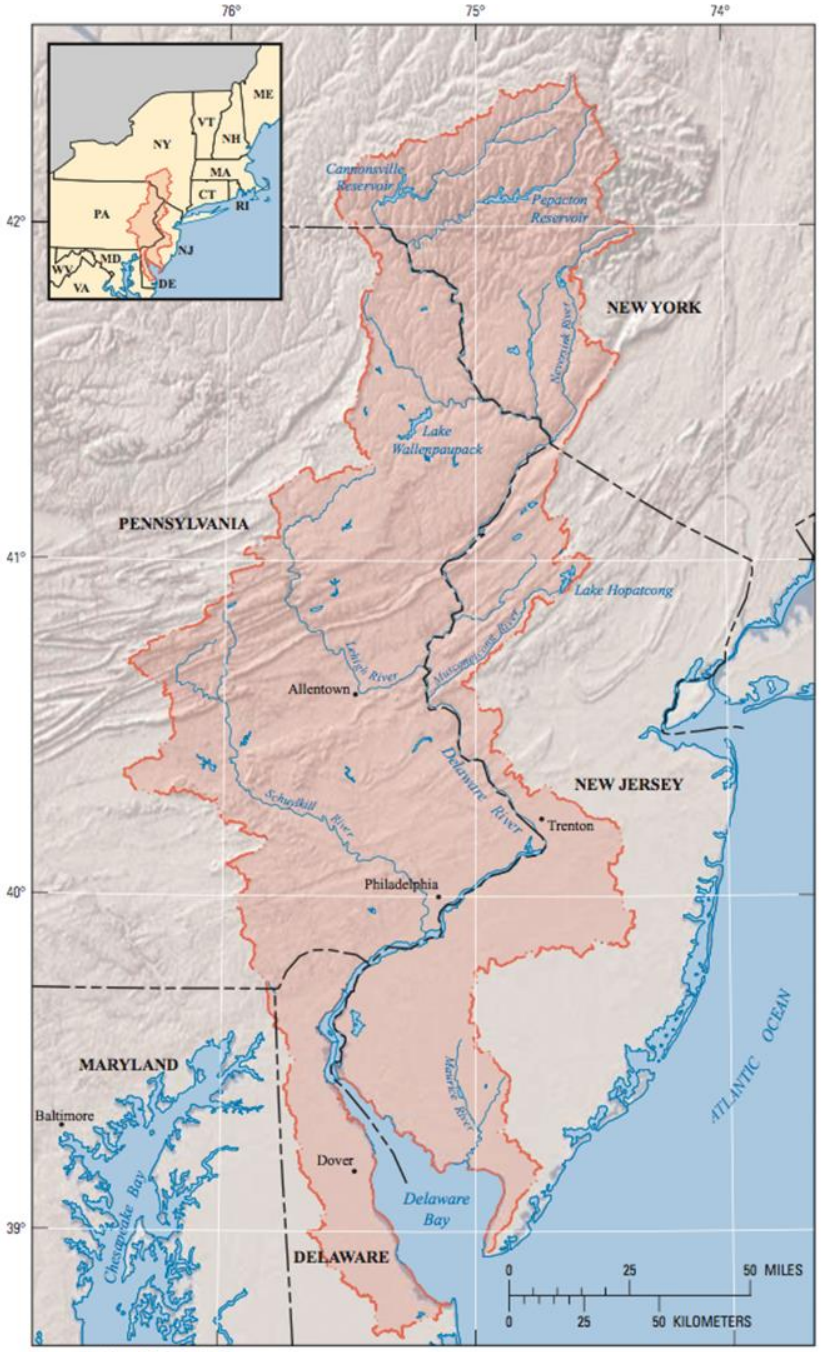
The Delaware River Basin (DRB)

- Basin area ~ 35,000 km^2

- Provides water to about 15 million people within and outside of the basin (including two of the largest U.S. cites: New York City and Philadelphia)

- Also is important for aquatic ecosystems



Base modified from U.S. Geological Survey 1:100,000-scale digital data

This research is part of the USGS Integrated Water Availability Assessments Program

Objectives:

(1) identify multi-year drought events in the Delaware River Basin (DRB) during the instrumental period (e.g. 1901 through 2015)

(2) determine the climatic causes of DRB drought events

(3) place the drought events identified for the instrumental period in the context of climate variability and drought occurrence since the year 490 CE

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Data

- Monthly temperature and precipitation data for 1895 through 2015, 4km resolution (PRISM data set)

    - 2067 PRISM grid cells for the Delaware River Basin

- Monthly measured runoff for 13 USGS 8-digit hydrologic units, 1950-2013 (used to verify a water balance model)

- Reconstructed Palmer Drought Severity Index values (490-2005), 0.5 degree grid resolution [15 grid cells in the DRB]

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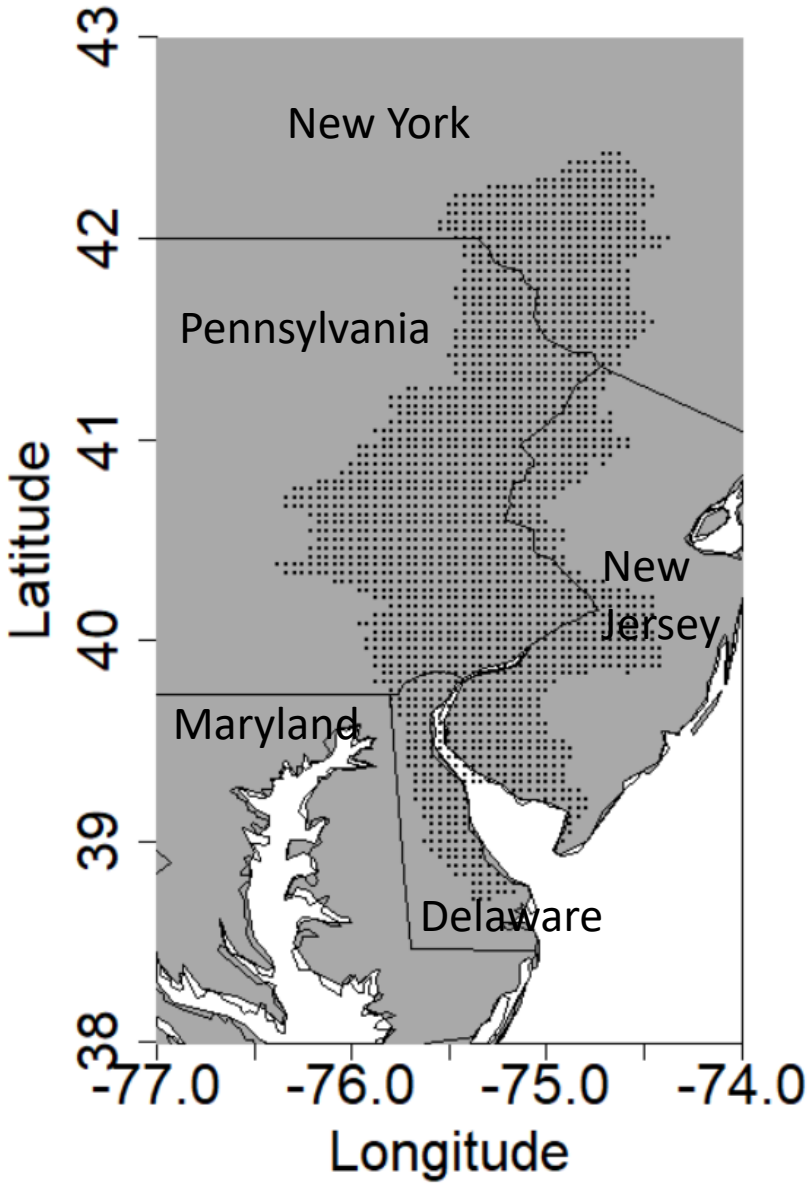
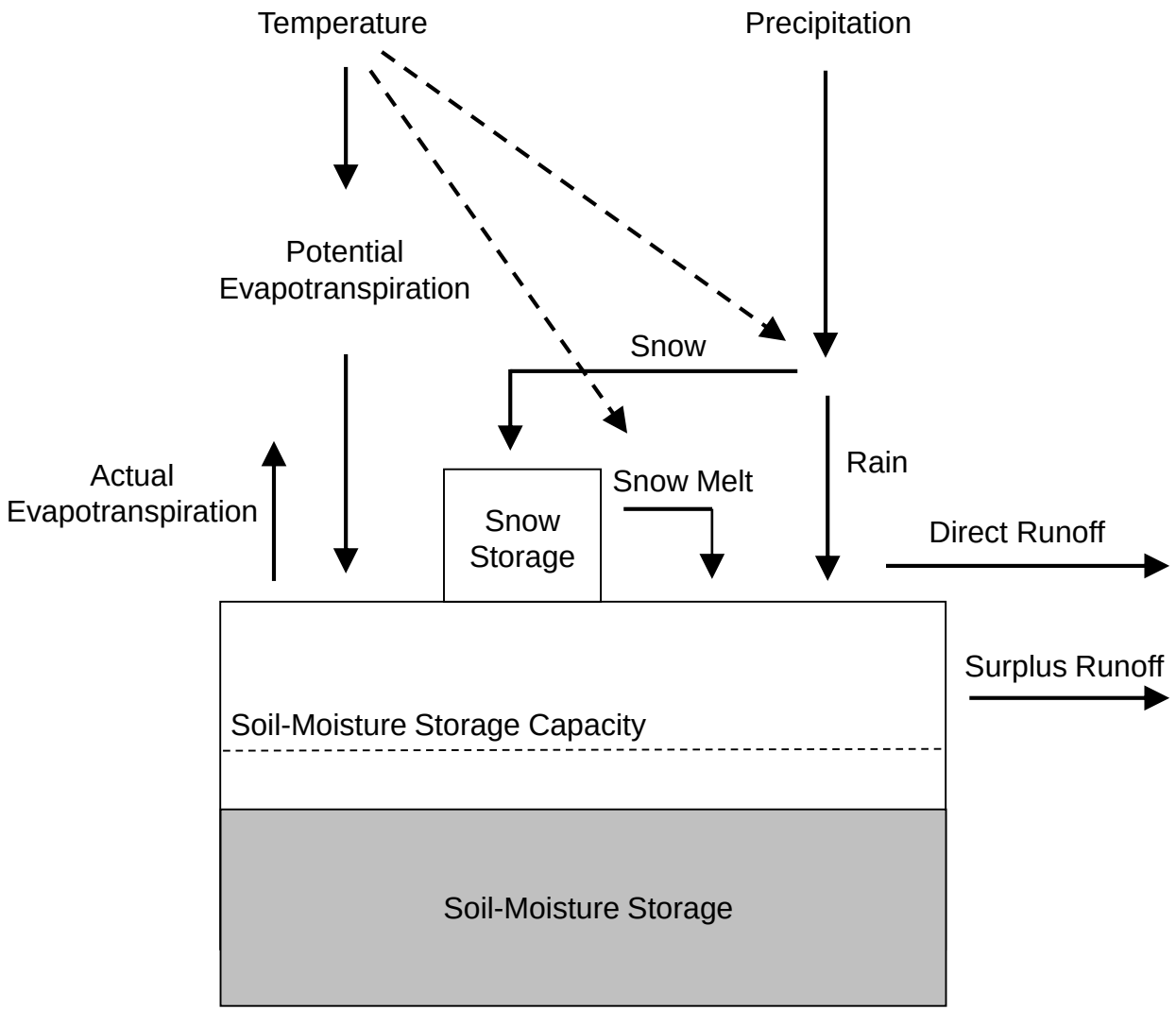
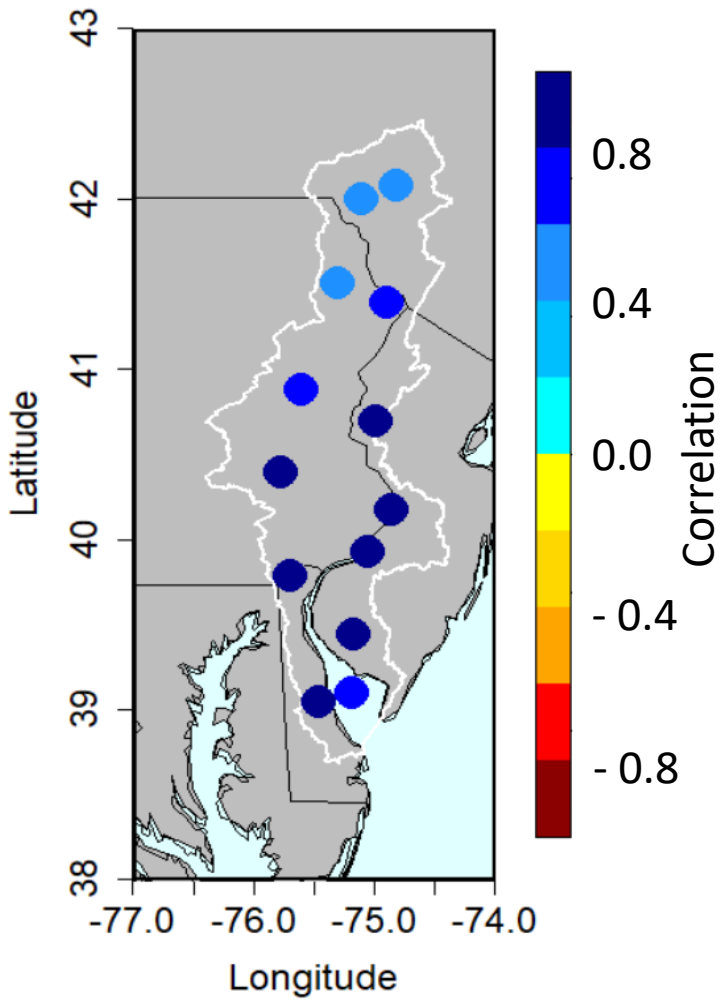
PRISM grid cells in the DRB (2067 grid cells), data for 1895 through 2015

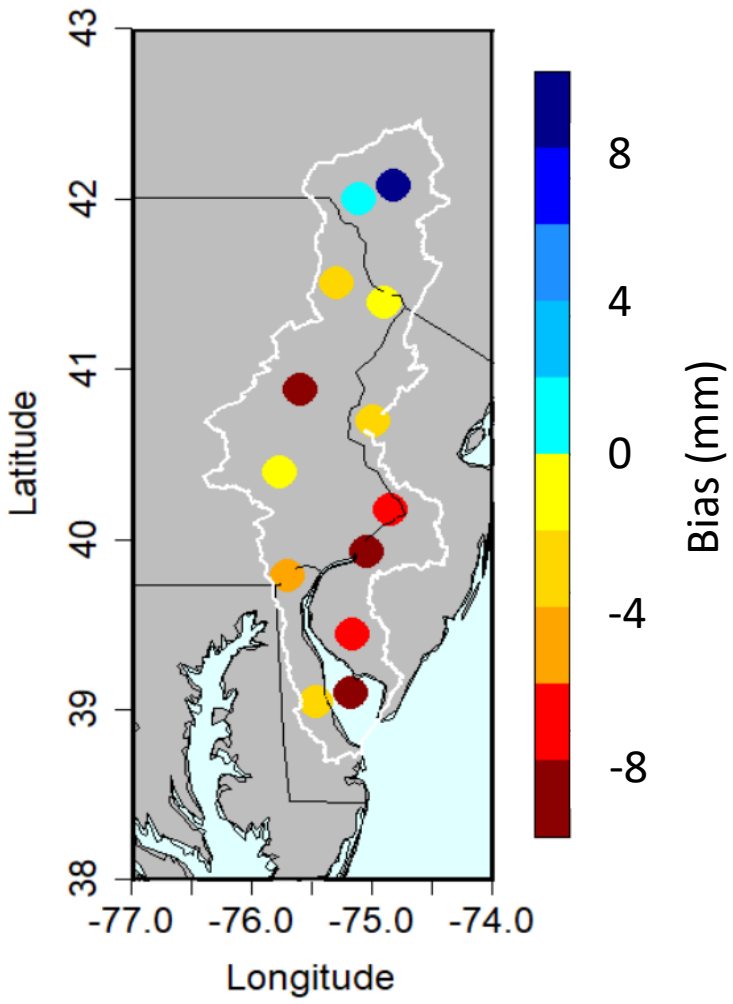


Monthly Water Balance Model



Correlation and bias (estimated – measured) for comparisons of monthly measured and water balance estimated runoff for 13 hydrologic units in the DRB, 10/1950-9/2013

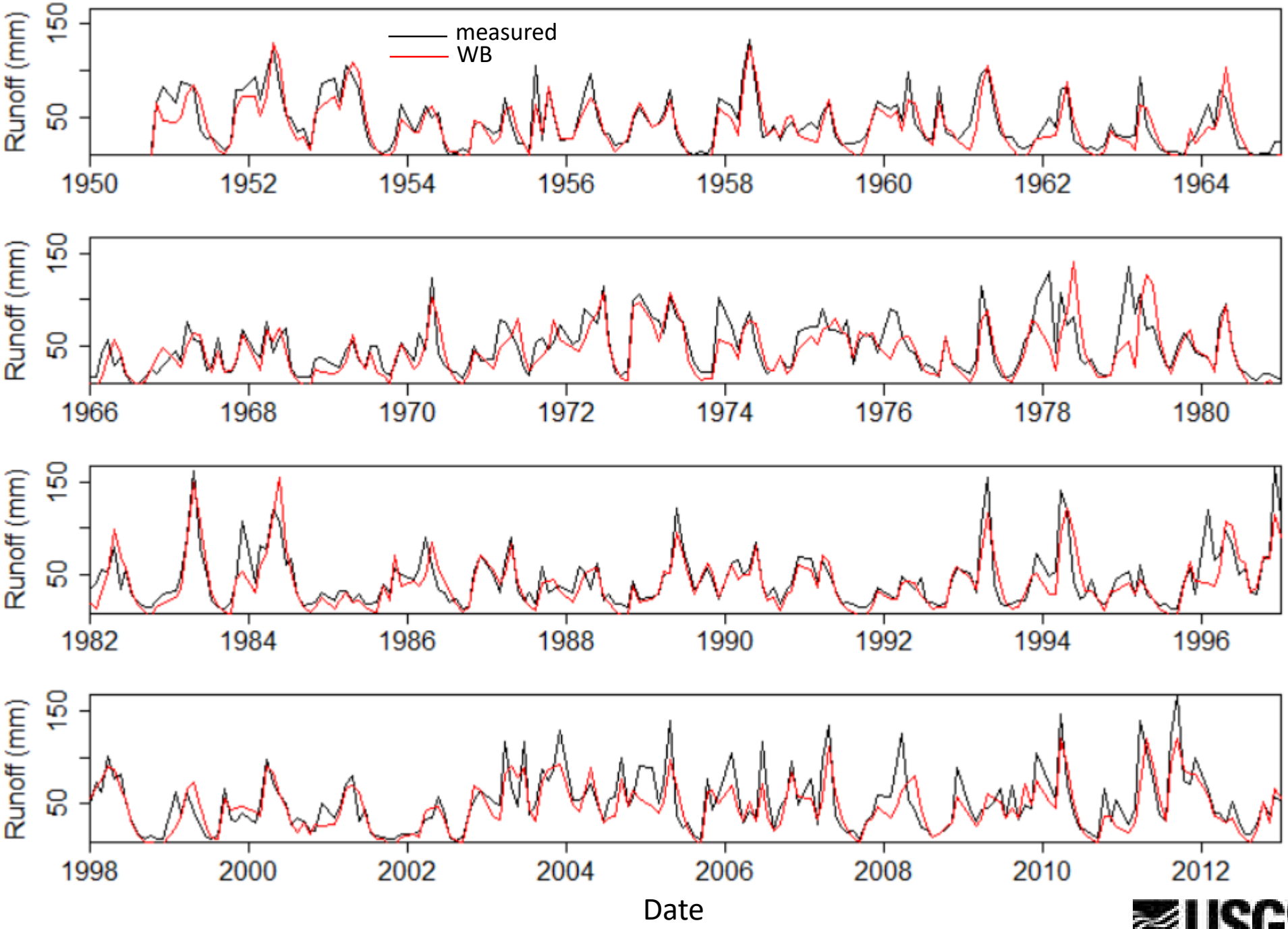




Comparison of monthly mean DRB runoff

r = 0.84

bias = -4 mm



Defining Drought

A drought event is defined according to the following “rules” –

1. Below median water-year runoff is needed to initiate a drought period.

2. There can be one intervening year with above median runoff.

3. There must be at least two consecutive years with below median runoff within a drought period.

4. Two or more years of above median runoff are needed to end a drought.

5. The total length of a drought period must be at least 4 years in length.

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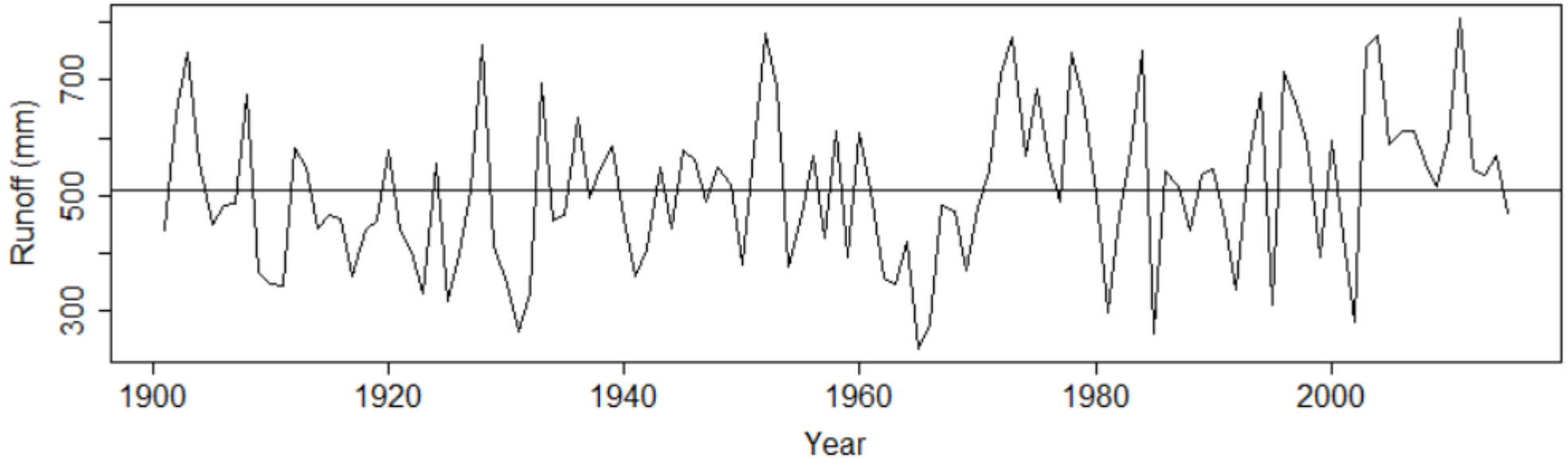
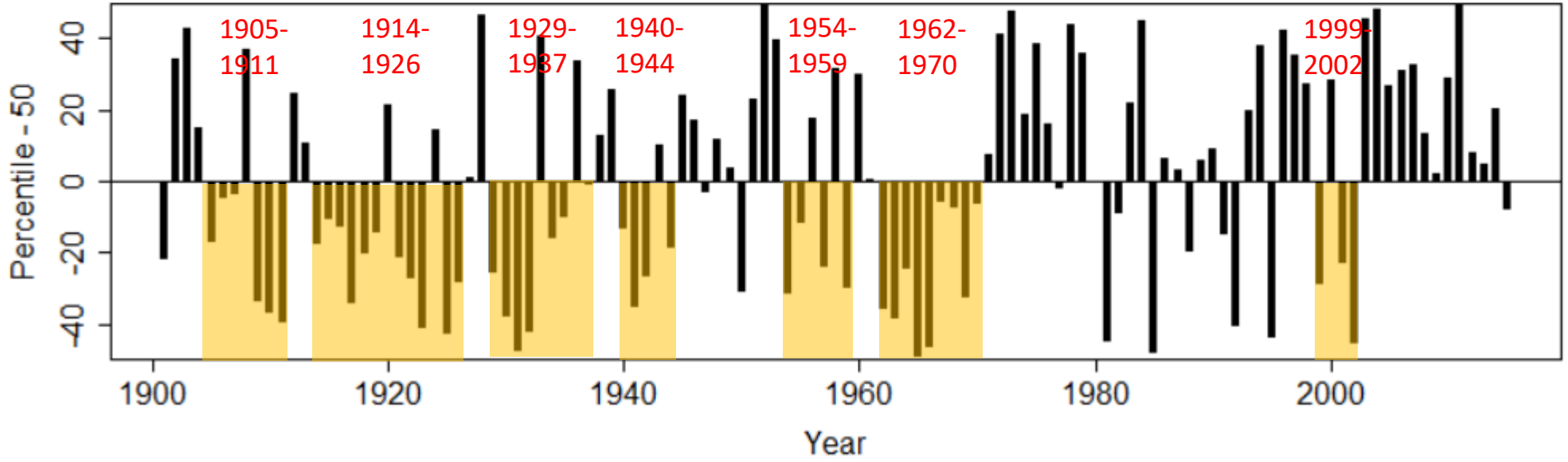
7 Delaware River Basin Droughts

a. mean DRB water-year runoff



The mean water-year runoff for the DRB explains ~80% of the variability in DRB water-year runoff for all 2067 PRISM grid cells

b. percentiles of mean DRB water-year runoff and drought periods (drought events are highlighted in yellow)



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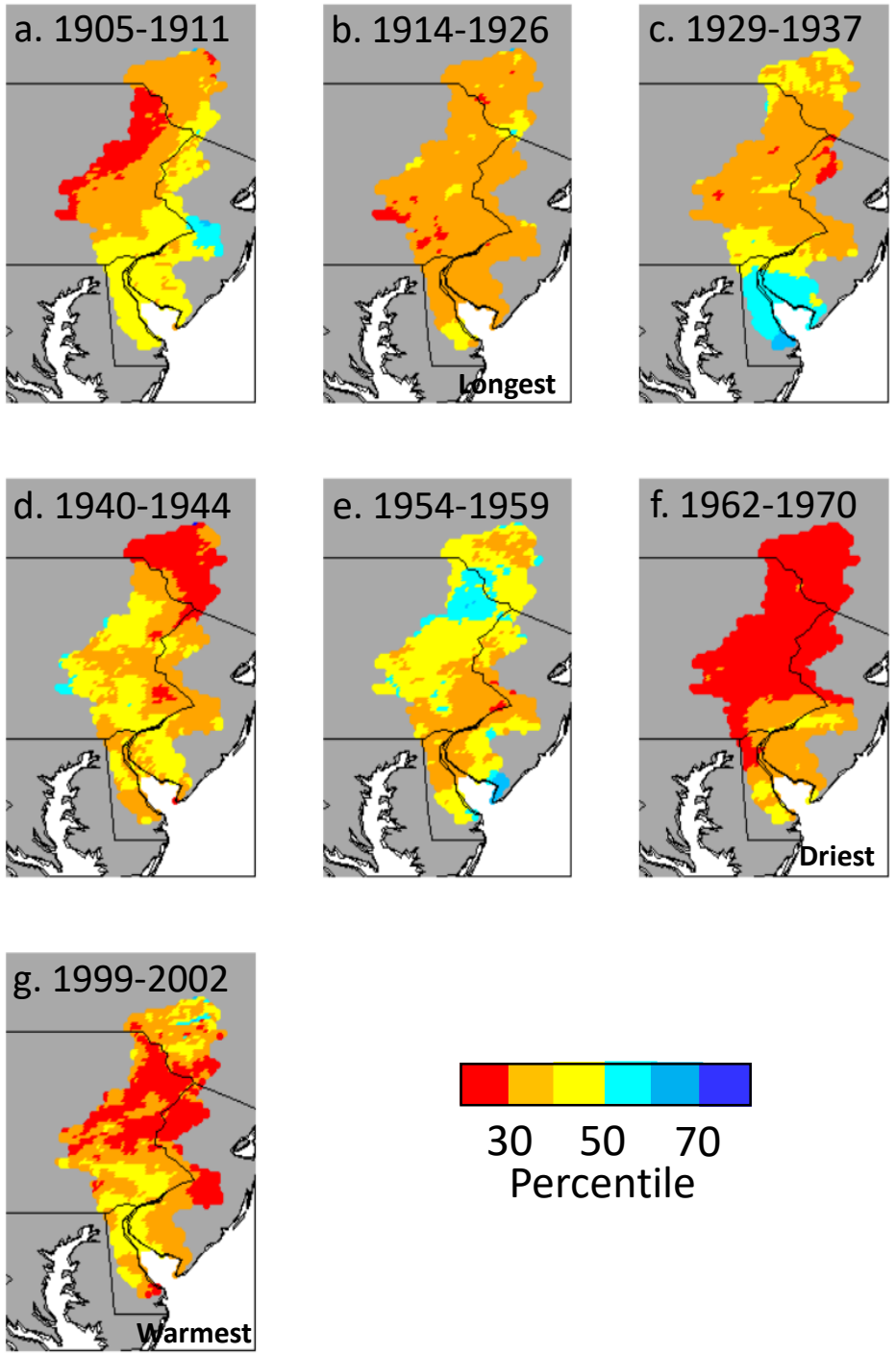
Mean percentile of water-year runoff for 7 DRB droughts

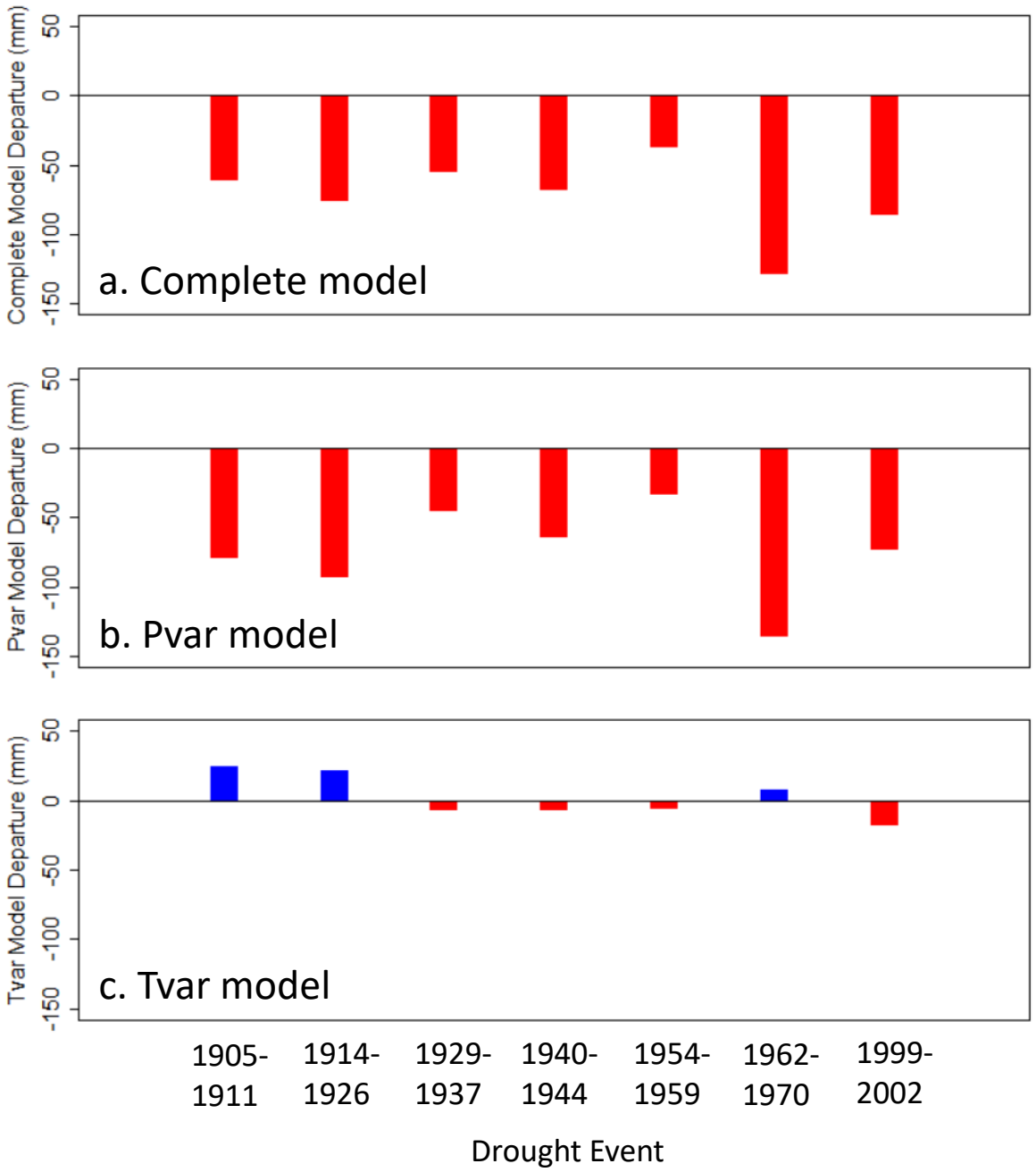
- 87% to 100% of grid cells with runoff percentiles < 50%
- Longest drought – 1914-1926
- Driest drought – 1962-1970 (mean runoff percentile ~ 22, DRB drought of record)
- Shortest drought – 1999-2002 (and warmest drought)
- 6 of the 7 droughts occurred before 1970



Temperature and precipitation effects on DRB drought events

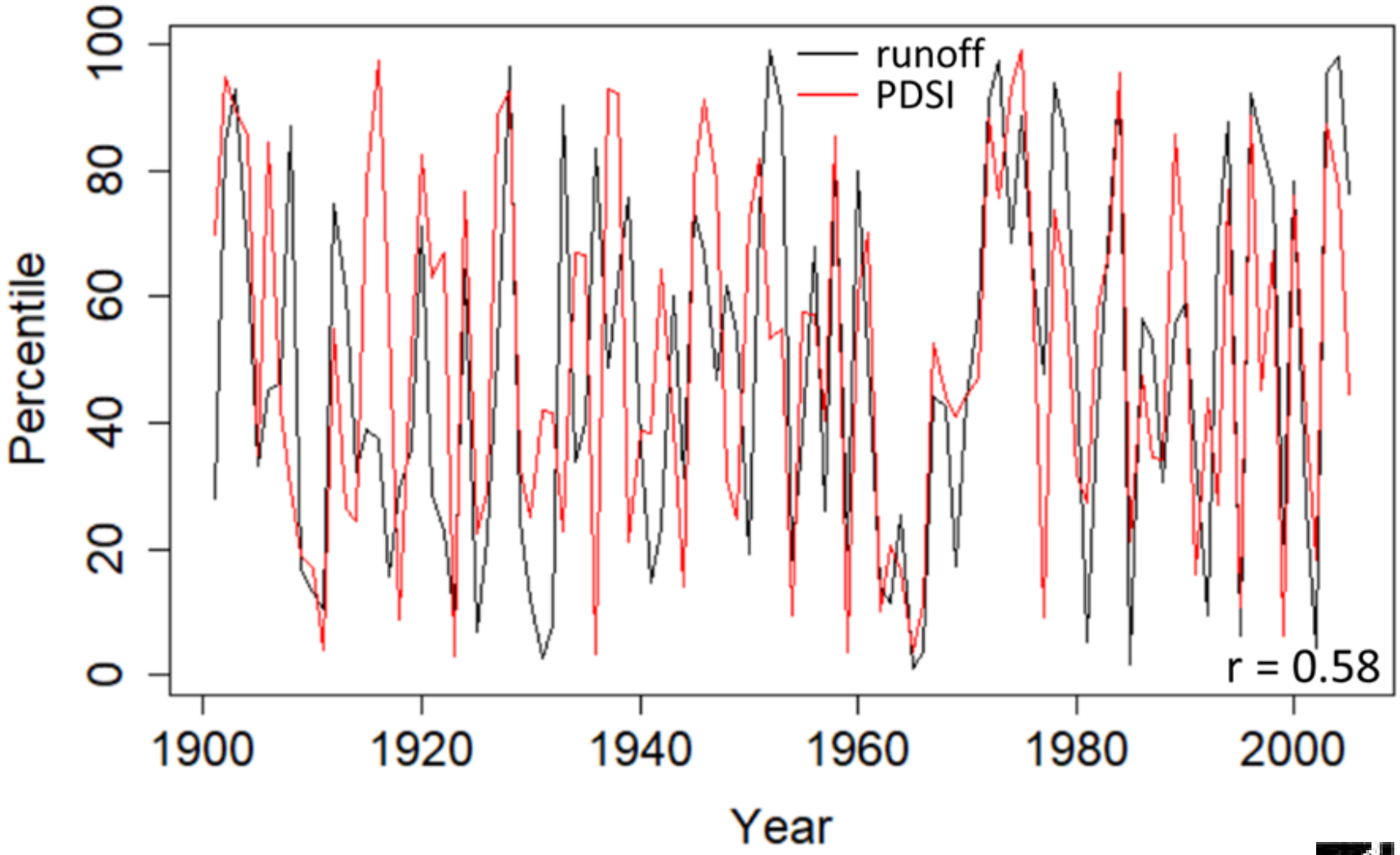
Droughts in the DRB have largely been driven by precipitation deficits

Mean water-year DRB runoff departures



Using PDSI as a proxy for runoff

Percentiles of water-year runoff and summer (JJA) Palmer Drought Severity Index (PDSI) values for the Delaware River Basin for 1901 through 2005.



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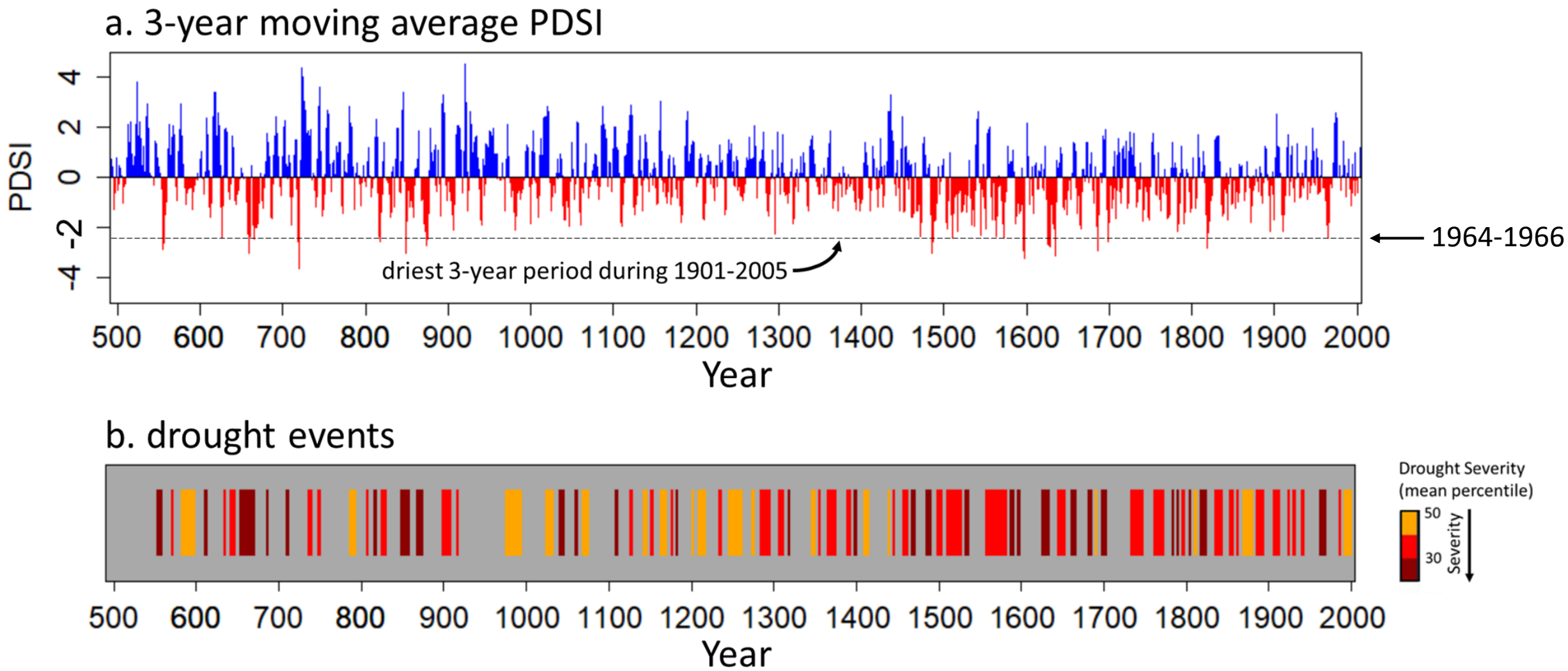
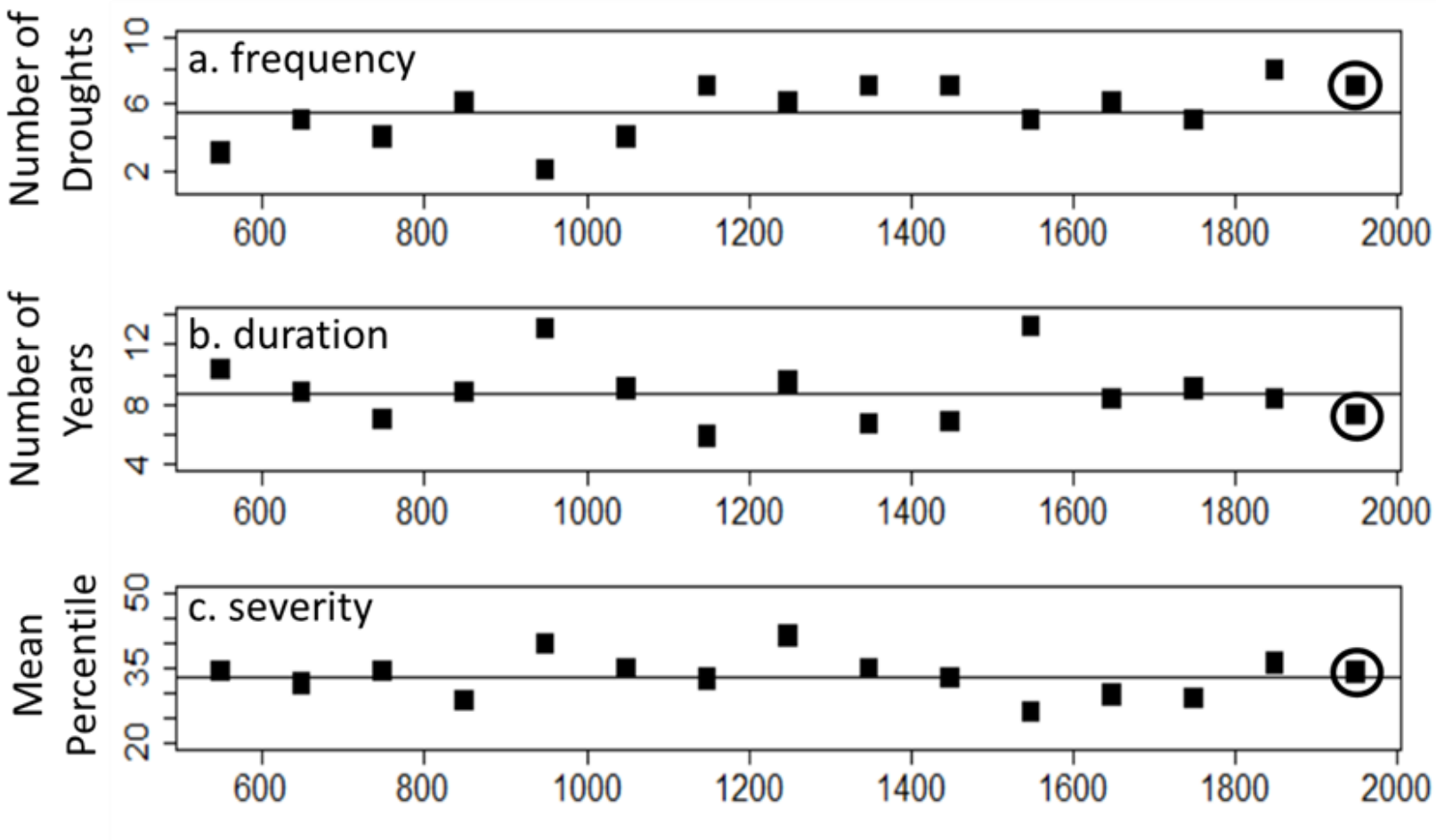
Pre-historic droughts in the DRB



- 75 DRB drought events during 490-1900
- Drought durations ranged from 4 to 27 years
- Drought severity ranged from 17 (driest) to 50 (wettest)

Statistics of Delaware River Basin drought events by century

(Values are plotted for the mid-point of each century and the statistics for the most recent century are circled for reference.)



Summary

- Seven drought events were identified for 1901 through 2015 in the Delaware River Basin.

- Droughts were more prevalent before about 1970. After about 1970 precipitation and runoff increased and drought occurrence and duration decreased.

- Droughts in the Delaware River Basin have largely been driven by precipitation deficits.

- PDSI can serve as a proxy for water-year Delaware River Basin runoff.

- Analysis of pre-historic droughts indicated that there have been some past drought events that were longer and more severe than those during the 20th century. A reoccurrence of longer and more severe droughts could result in substantial water supply shortages in the Delaware River Basin.

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