# Understanding Trends in Load

Isabella Bertani, Gopal Bhatt, Gary Shenk, and the Factors Team

Modeling Workgroup Quarterly Review 1/6/2021

RECAP FROM OCT QUARTERLY

# Broader scope of analysis

- **How do we use monitoring data to validate/improve CAST predictions?**
  - Assess discrepancies between WRTDS- and CAST-predicted trends in loads to understand where and why CAST underperforms and how to improve it

RECAP FROM OCT QUARTERLY

# Broader scope of analysis

- **How do we use monitoring data to validate/improve CAST predictions?**
  - Assess discrepancies between WRTDS- and CAST-predicted trends in loads to understand where and why CAST underperforms and how to improve it

- Before we can compare CAST and WRTDS loads, the influence of non-management factors that are not accounted for in CAST <u>by design</u> should be removed from WRTDS trends
  - E.g., long-term non-stationarity in flow, memory effects of large storms/droughts, wet-dry cycles, lags in groundwater nutrient transport and BMP effectiveness…

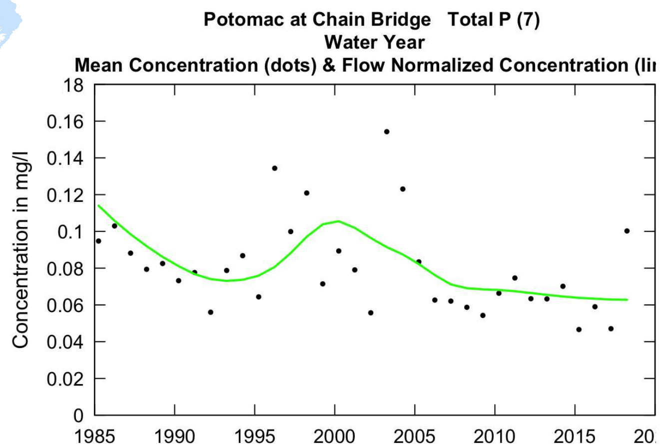
**RECAP FROM OCT QUARTERLY**

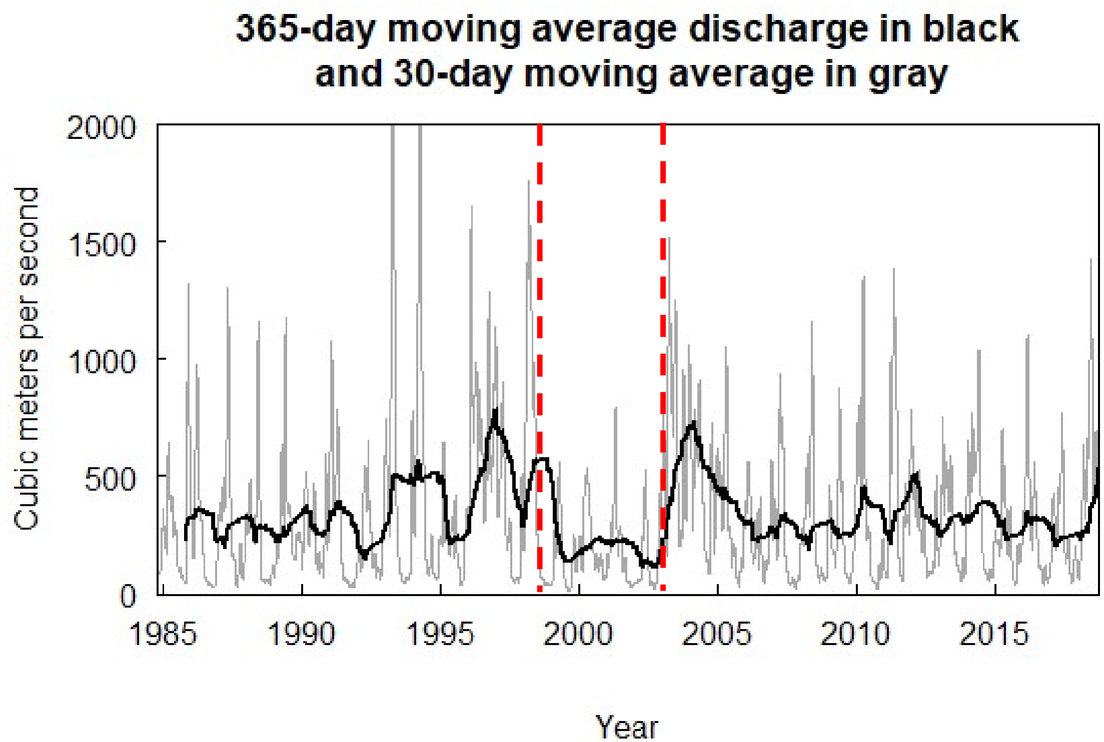
# Understanding "humps" in TP loads

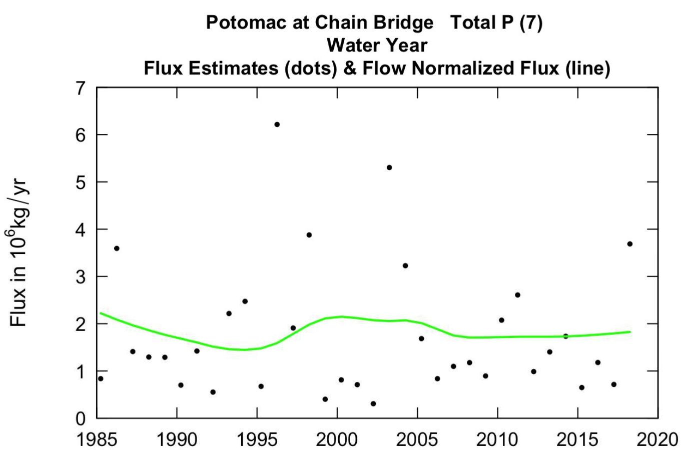
- WRTDS flow-normalized (FN) TP loads exhibit 'humps' around late 90s – early 00s at several stations
- Understanding which processes may be causing these "humps" may help us reconcile differences between WRTDS- and CAST-estimated loads
- "Humps" seem to roughly coincide with prolonged dry conditions (~99-02) across the watershed
- Is this prolonged drought associated with changes in the C-Q relationship that may have resulted in the "humps"?

# Potomac River at Chain Bridge

**RECAP FROM OCT QUARTERLY**




**Hirsch, unpublished**

# Potomac River at Chain Bridge

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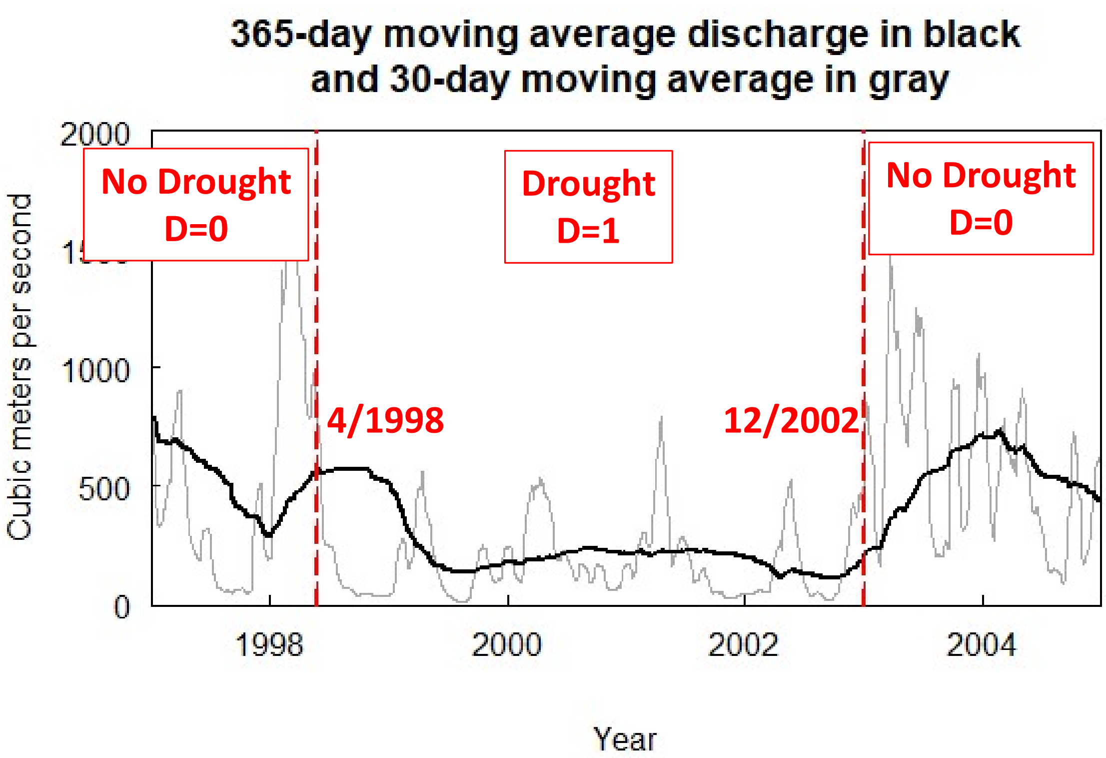



**Log[TP] ~ LogQ + LogQ$^2$ + SinDY + CosDY + D**

**D: Binary Drought/No Drought variable**

Positive relationship between **[TP]** and **D**

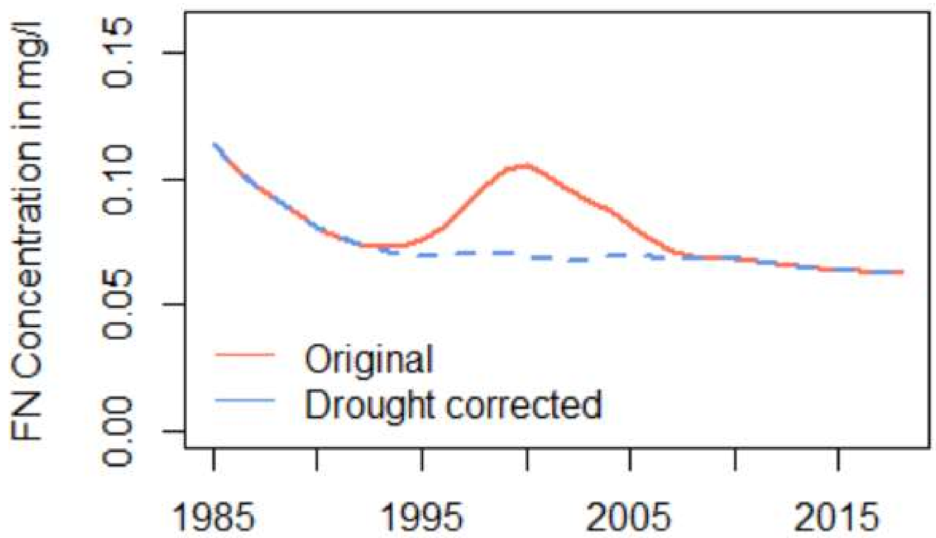
**[TP] higher** than expected **during the "Drought"** compared to "No Drought" period

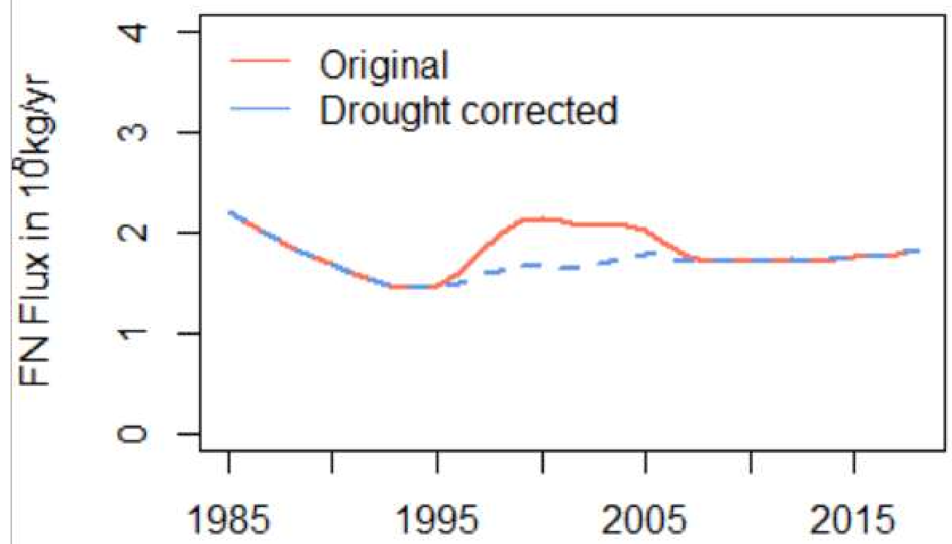
**Hirsch, unpublished**

RECAP FROM OCT QUARTERLY

# Potomac River at Chain Bridge

After removing the “excess” [TP] associated with the drought, the “hump” disappears



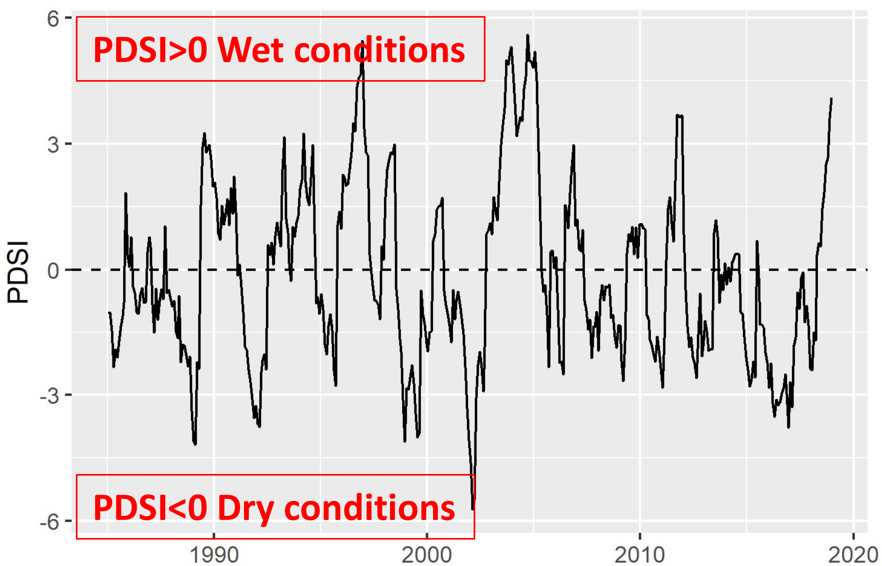



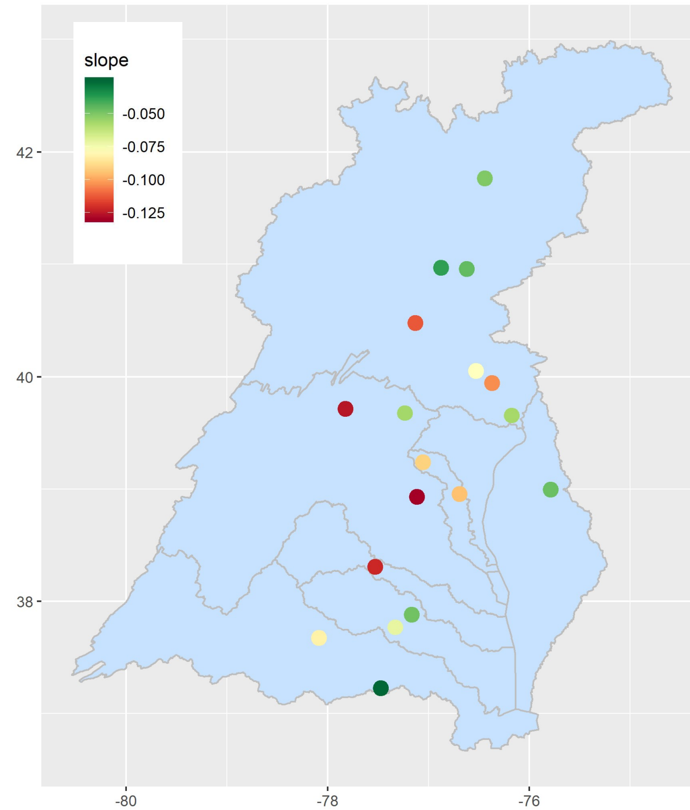

**Hirsch, unpublished**

# Relationship between [TP] and Palmer Drought Severity Index (PDSI)

**RECAP FROM OCT QUARTERLY**

Monthly **PDSI** in CB Watershed (1985-2018)




All stations showed negative relationship (slope) between [TP] and PDSI

[TP] tends to be higher than expected during dry spells

https://rda.ucar.edu/datasets/ds299.0/

# Outline of Analysis Updates

1. Assess spatial variability in drought timing and intensity across watershed by estimating station-specific PDSI

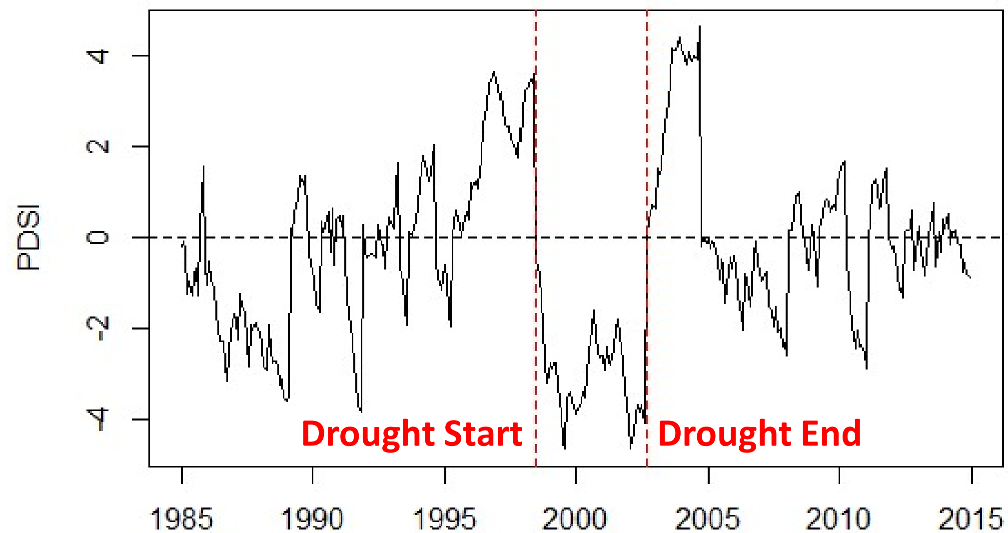
2. Compare drought timing at each station with time window used to define D binary variable that leads to best [TP] regression model performance (mismatch between drought time window and best-performing time window may suggest that factors other than drought may be at play?)

3. Compare different approaches to generate "drought-corrected" FN TP loads at all stations

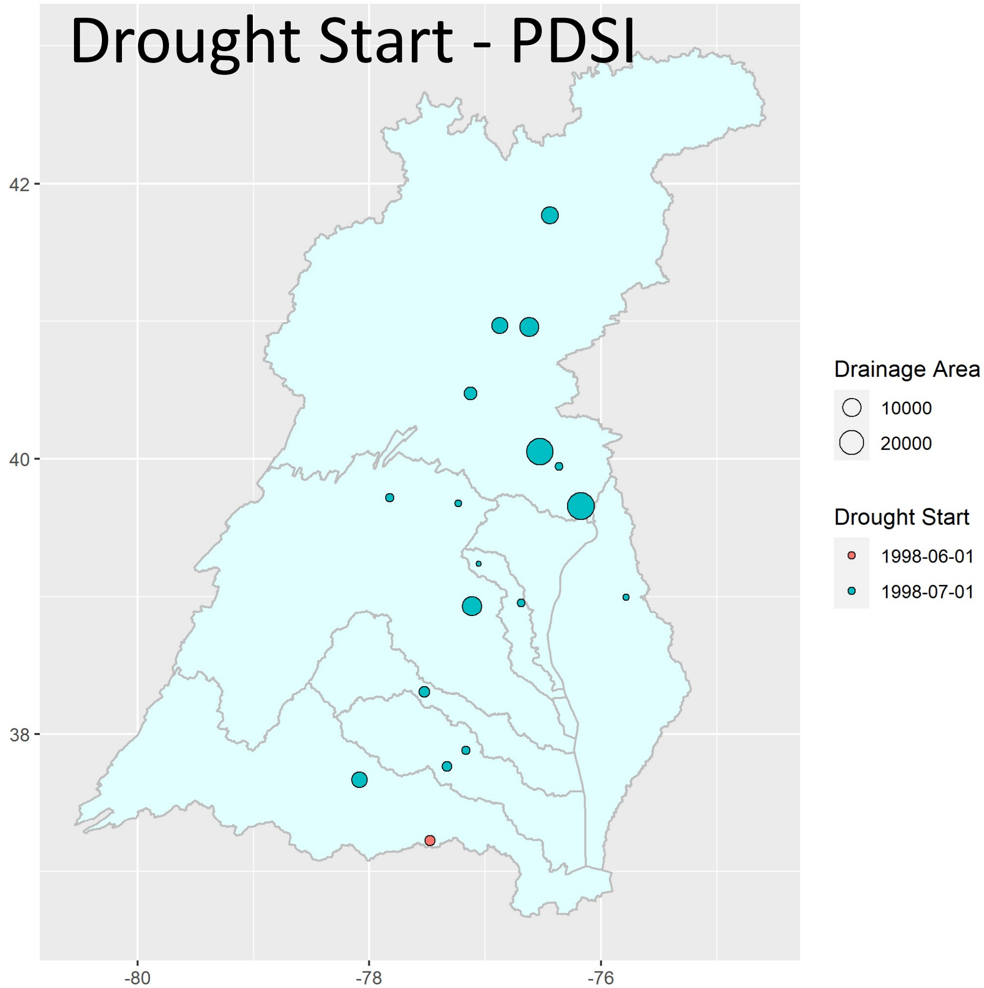
# 1. Assess spatial variability in drought timing and intensity

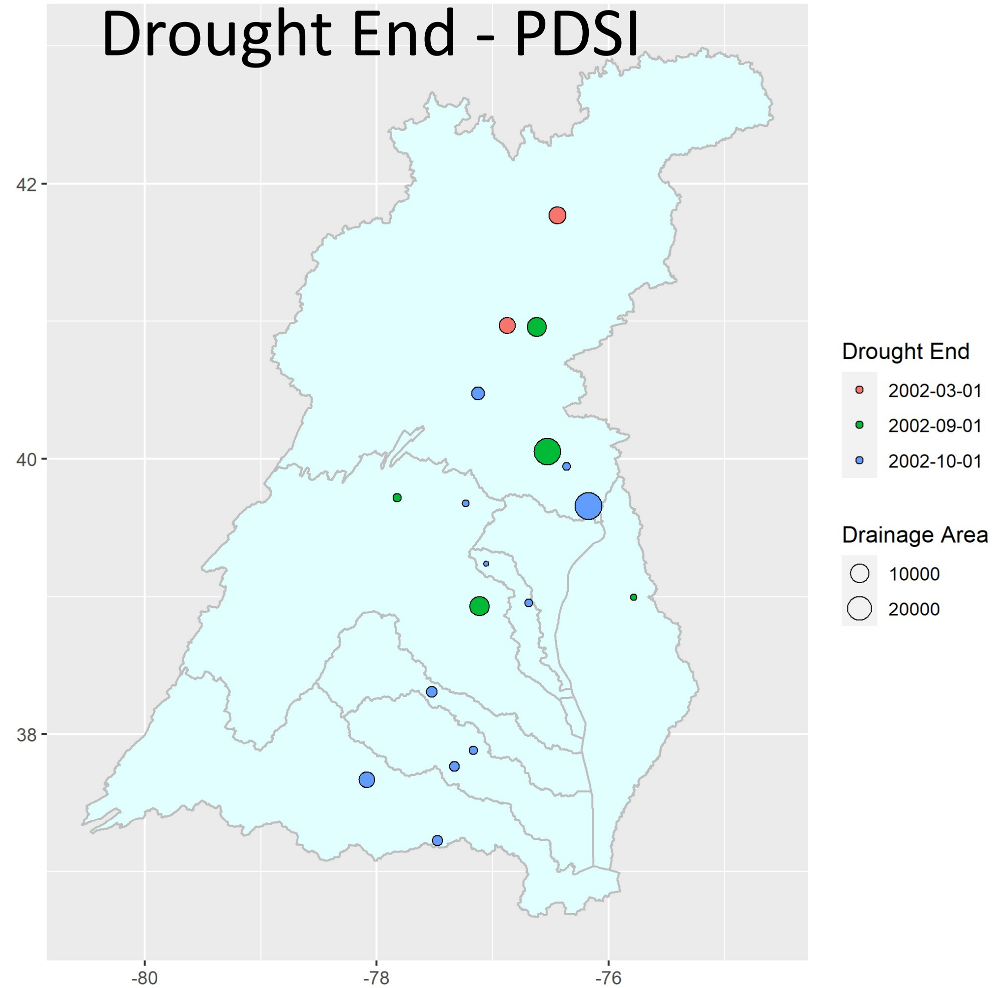
- Used monthly NLDAS precipitation and potential evapotranspiration (area-weighted average across land segments upstream of each USGS station)
- Calculate **station-specific** monthly **PDSI** and **SPEI** indices (1985-2014)
- Estimated approximate drought start and end at each station
- Estimated drought intensity as difference between mean PDSI during drought and mean PDSI 2 years before and after drought

**POTOMAC RIVER AT CHAIN BRIDGE, DC**




https://climatedataguide.ucar.edu/climate-data/palmer-drought-severity-index-pdsi
https://spei.csic.es/



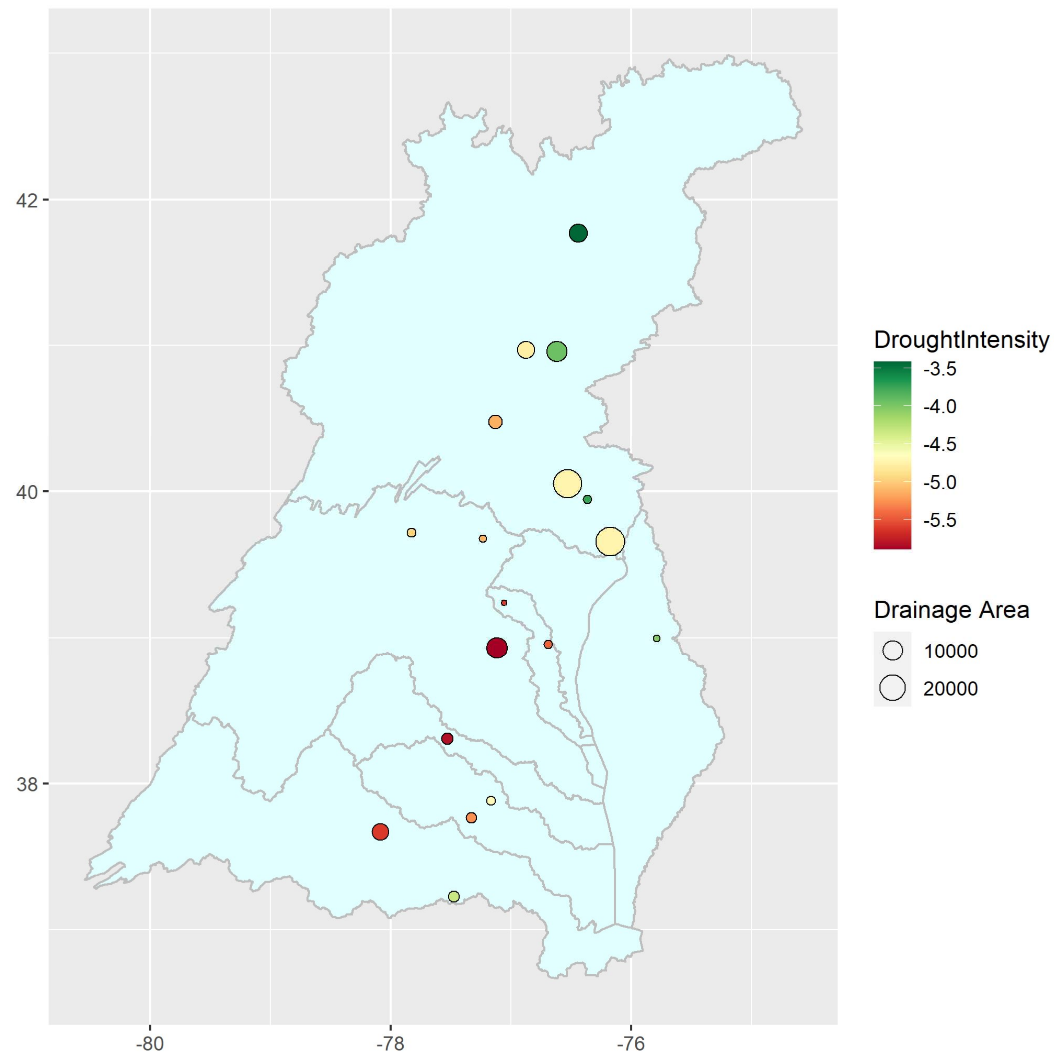




Most stations show similar “drought” time window (~ [6/98 – 10/02])

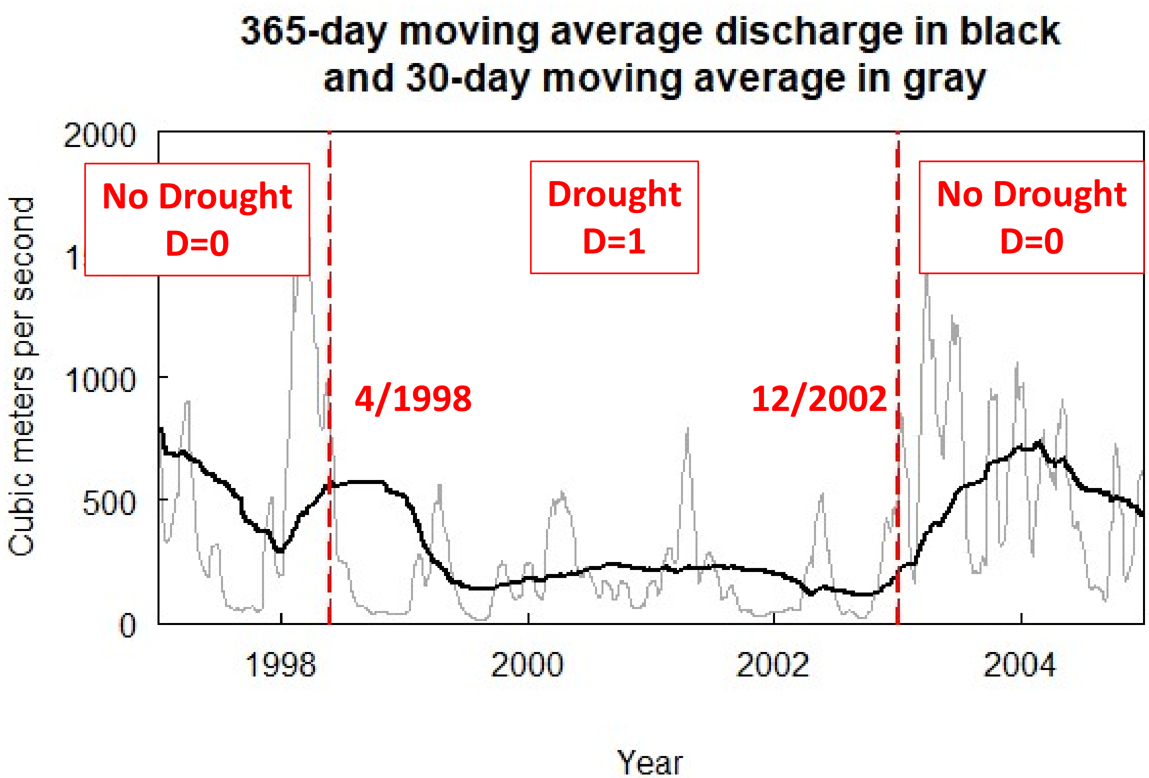
# Drought Intensity

Warmer colors indicate "more intense" drought

North-south gradient in drought intensity



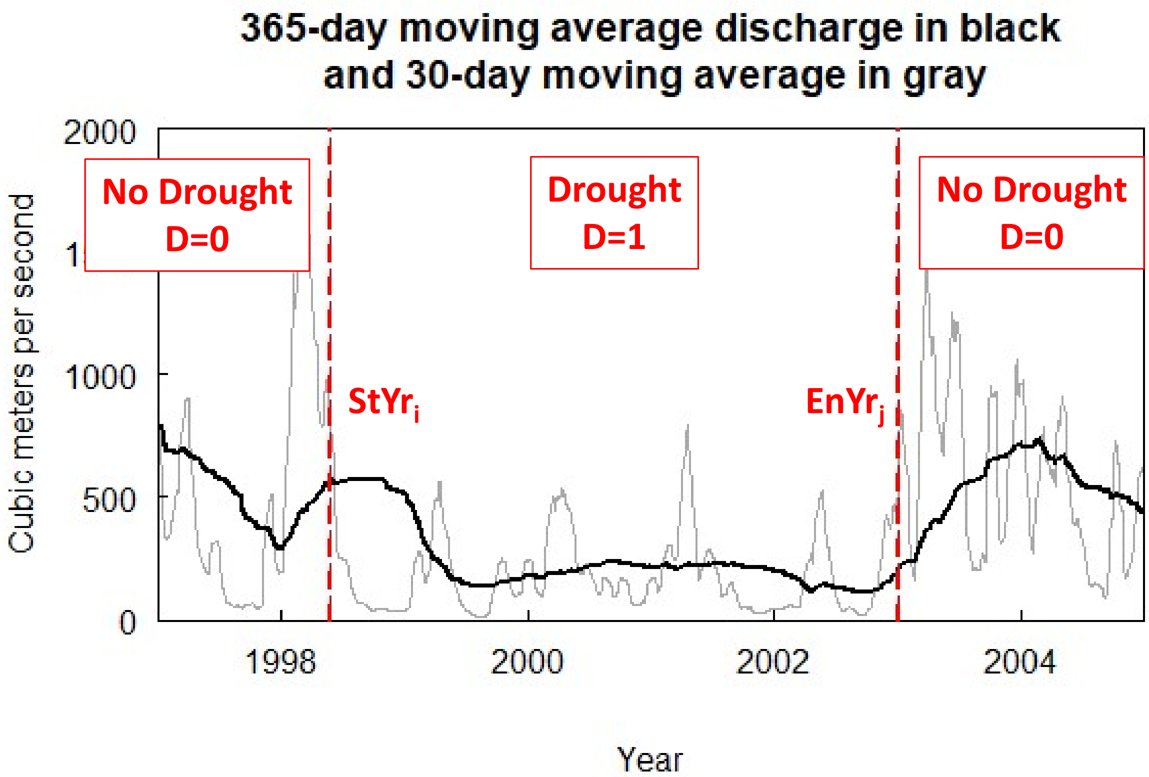
# 2. Compare drought timing with best performing time window




- Most stations show similar “drought” time window (~ [6/98 – 10/02])
- Evaluate whether time windows different from [6/98-10/02] better explain increases in [TP]

**Hirsch, unpublished**

# 2. Compare drought timing with best performing time window

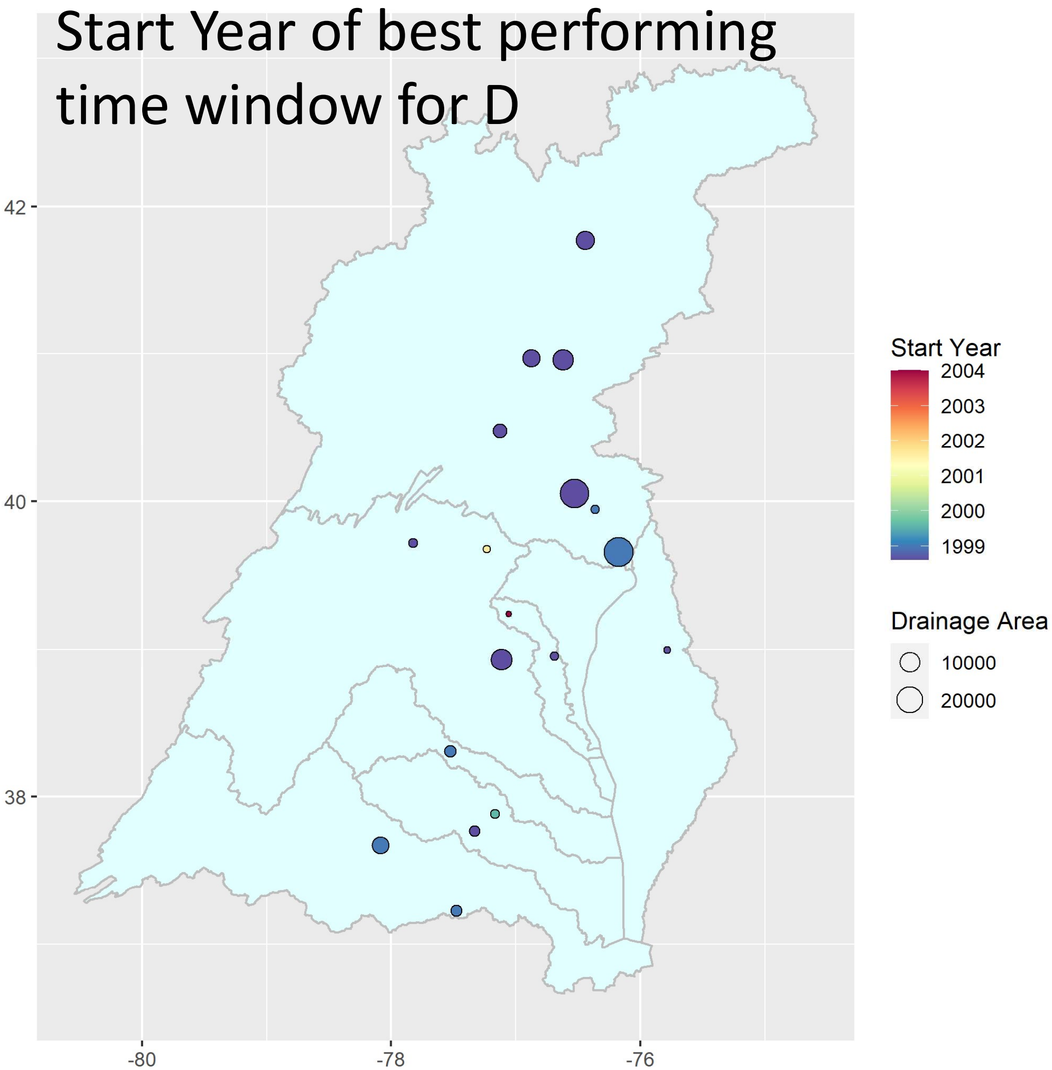


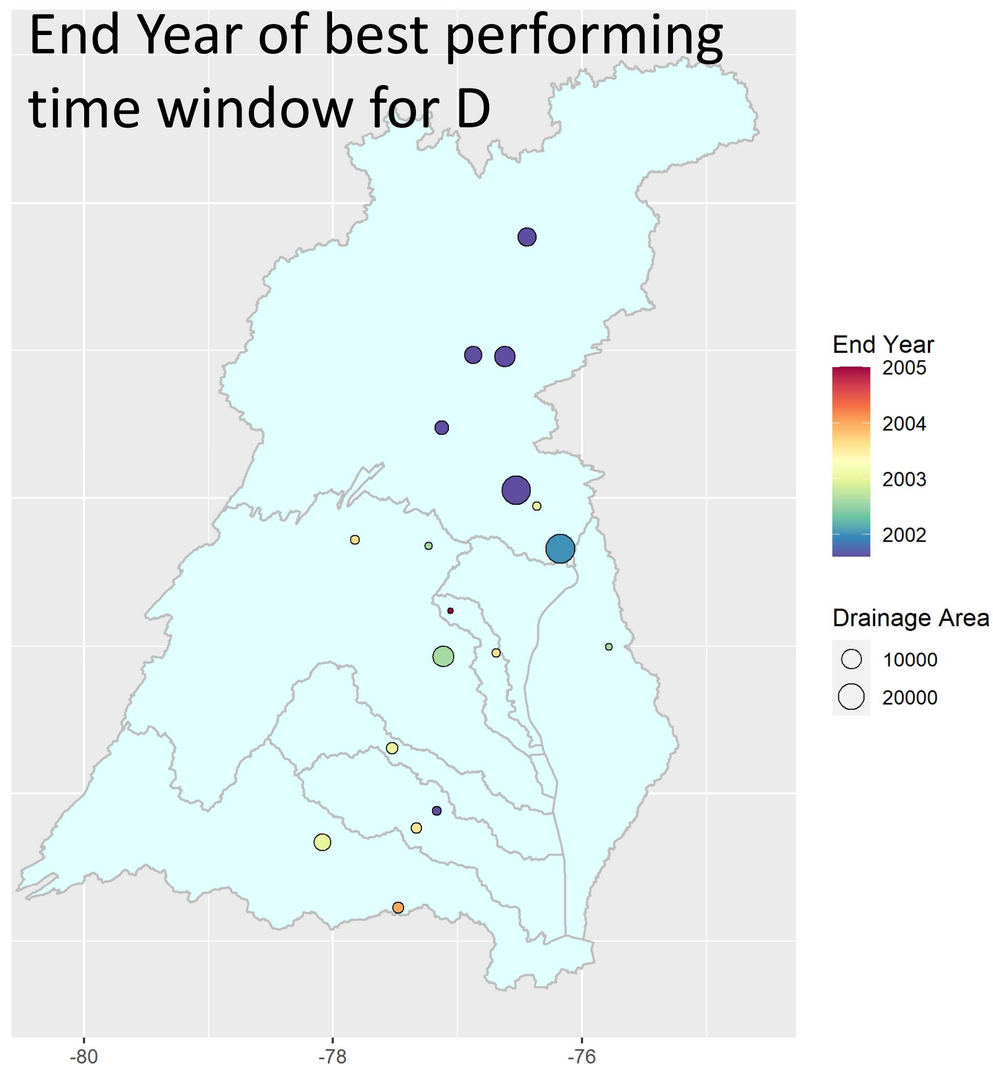

Fit regression model shifting the "drought" time window

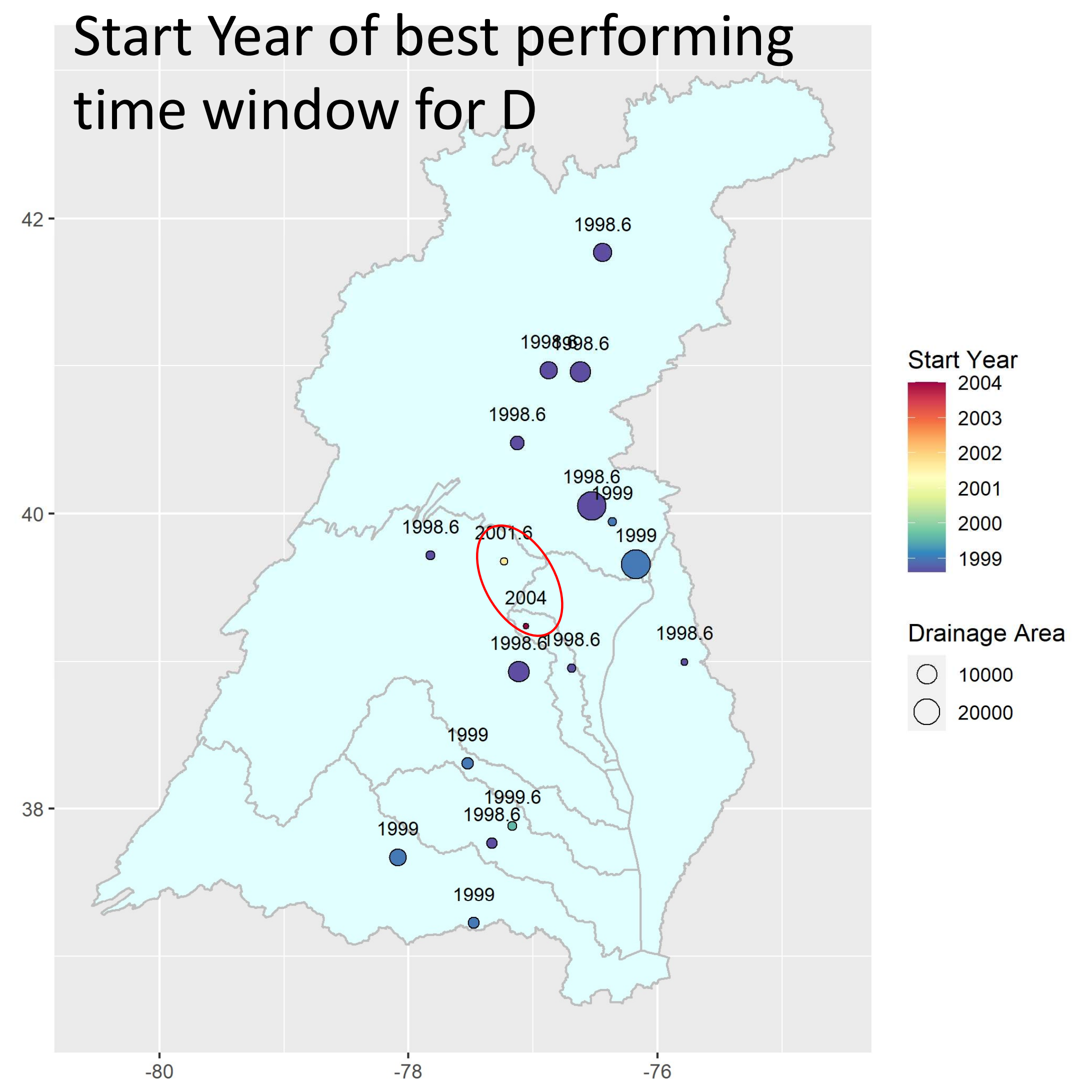
**Log[TP] ~ LogQ + LogQ$^2$ + SinDY + CosDY + D**

**D = 1 for StYr$_i$, EnYr$_j$**

where i varies from 1985 to 2011
j varies from (i+1) to (i+5)


Start Year of best performing time window for D
Start Year
2004
2003
2002
2001
2000
1999
Drainage Area
10000
20000
42
40
38
-80
-78
-76


End Year of best performing time window for D
End Year
2005
2004
2003
2002
Drainage Area
10000
20000
-80
-78
-76


Start Year of best performing time window for D
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Drainage Area
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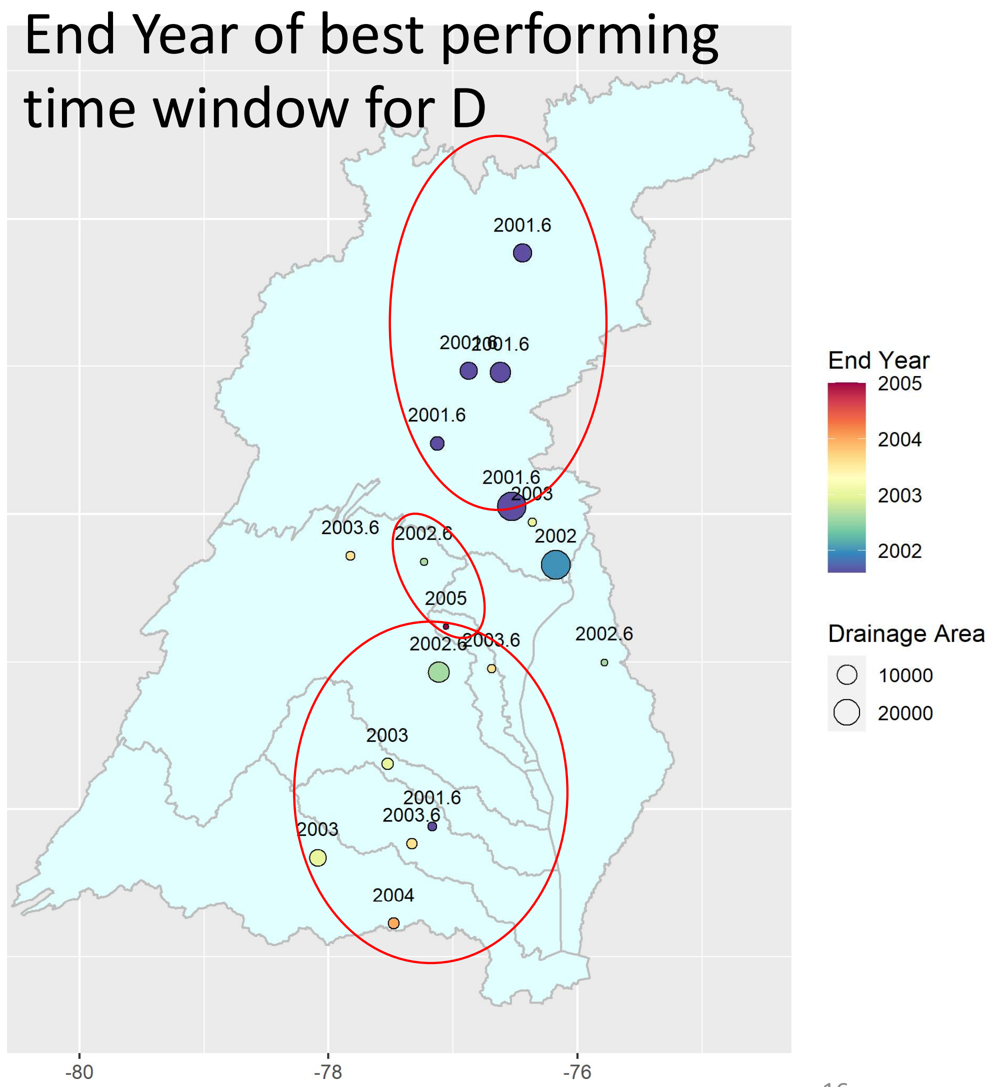
End Year of best performing time window for D
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Drainage Area
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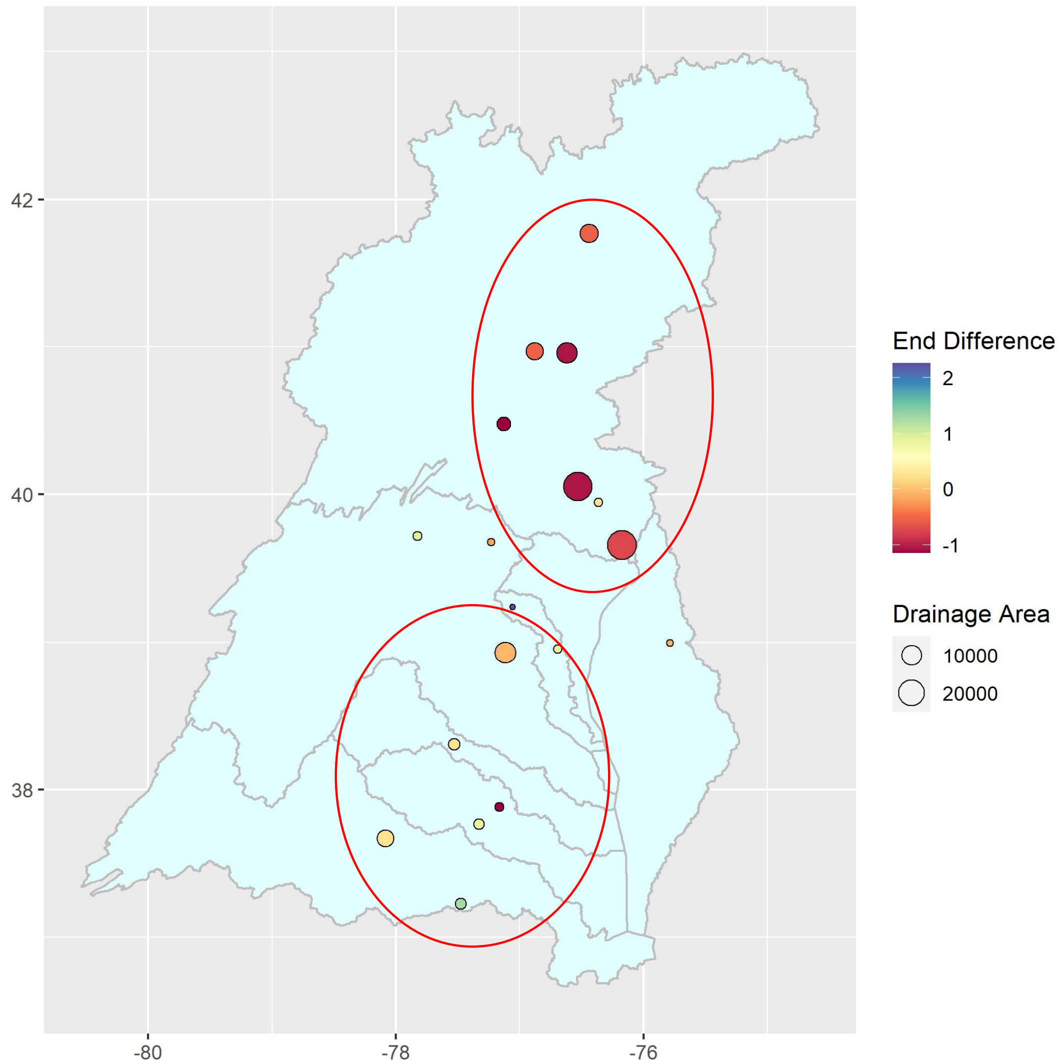



# Difference between End Year of best-performing time window and End Year of Drought

- At northern stations (where drought was less intense) the time window that best explains the increase in [TP] is ~ one year shorter than the drought time window

- At southern stations, the time window that best explains the increase in [TP] ends somewhat later than the drought time window

# Summary

- Similar timing of drought across the watershed, but north-south gradient in intensity
- Results of simple regression suggest that higher [TP] concentrations start to occur at ~ the same time across most stations (mid 98 – early 99)
- The period with higher [TP] seems to end earlier at northern stations, where drought was less intense
- A closer look at spatial patterns in [TP] behavior needed to better understand/confirm these findings

## 3. Remove "drought effect" using different approaches

Adjusted TP concentrations in time window that gave best regression model performance as previously defined.

Adjustment based on:

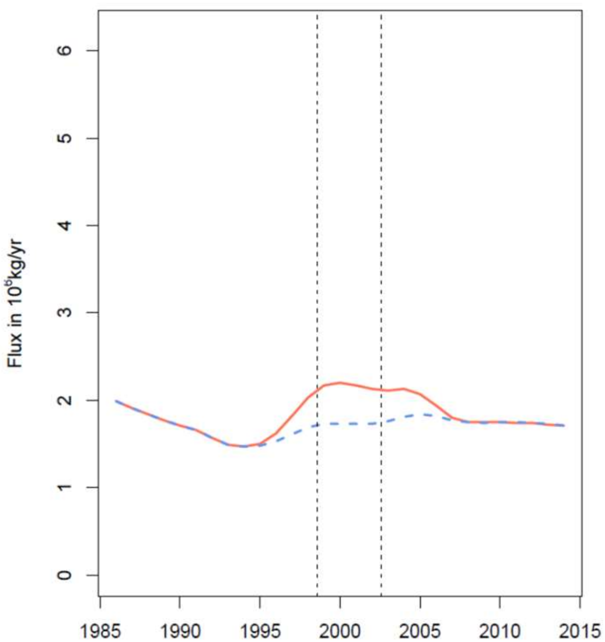
- Drought coefficient from regression model with **D binary variable**
- Regression coefficient of **PDSI** included as predictor in WRTDS regression
- Regression coefficient of **SPEI** included as predictor in WRTDS regression

Example

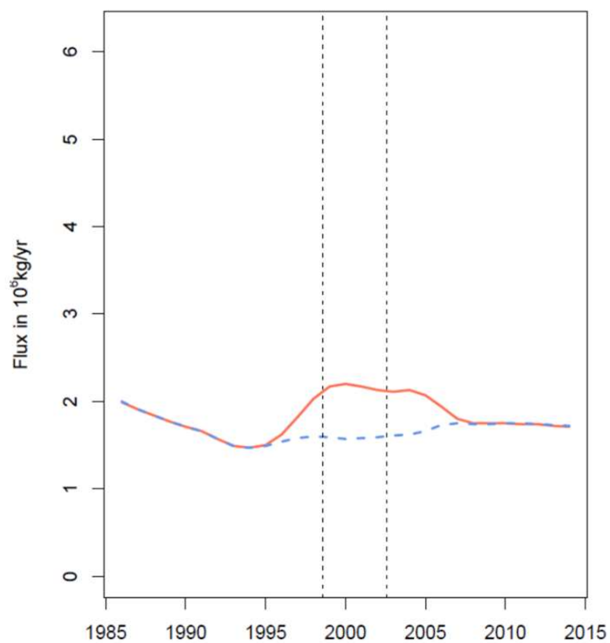
# POTOMAC RIVER AT CHAIN BRIDGE

[TP] concentrations in the time window 6/98 – 6/02 were adjusted according to one of three approaches

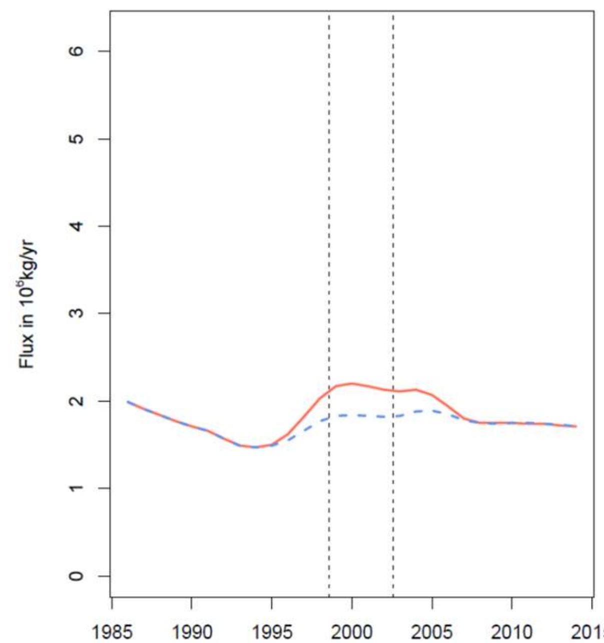
**D binary variable**



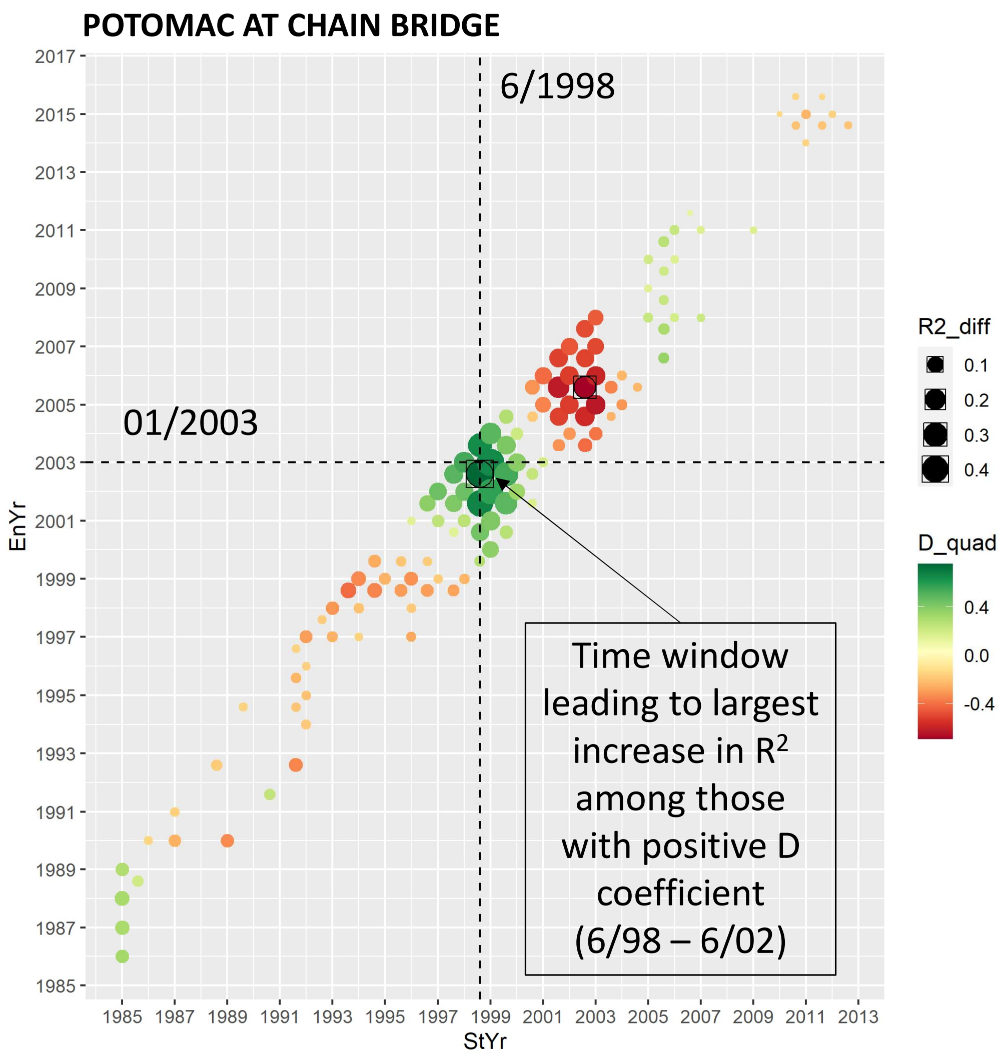

**SPEI**




**PDSI**



# 2. Compare drought timing with best performing time window

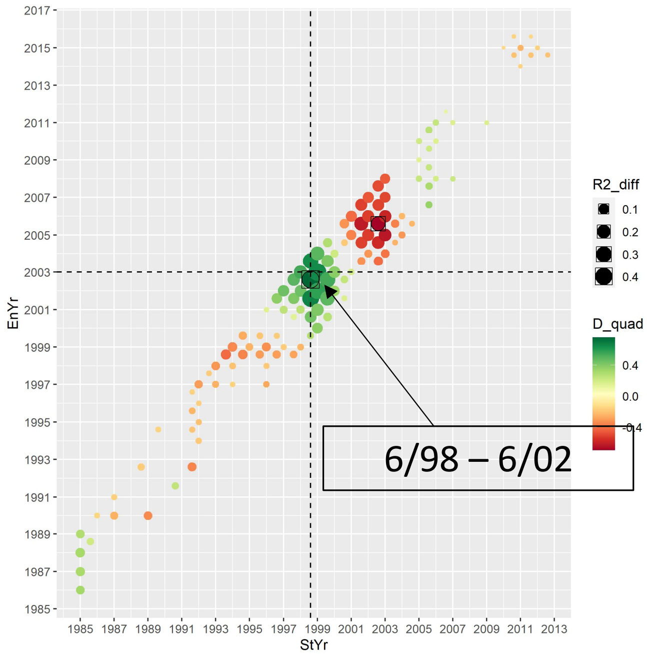



- Each circle represents a different regression model where **D** was set to 1 for years in **StYr** (x axis) **– EnYr** (y axis)
- Color is proportional to the coefficient estimated for **D**. A positive coefficient means that [TP] tends to be higher during the time window represented by **D [StYr-EnYr]**
- Size is proportional to the percent increase in $R^2$ obtained when including **D** in the model compared to a model without **D**
- When a circle is missing, the coefficient for **D** was not distinguishable from zero

# Example

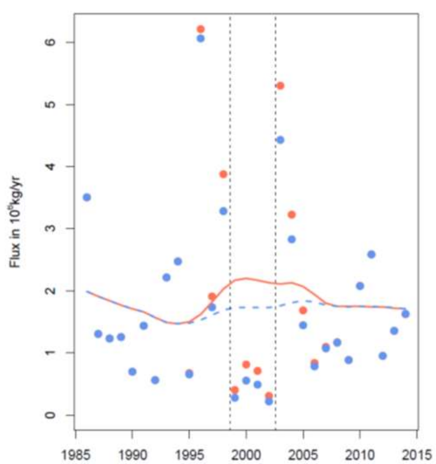
# 1646580

**POTOMAC RIVER AT CHAIN BRIDGE, AT WASHINGTON, DC**

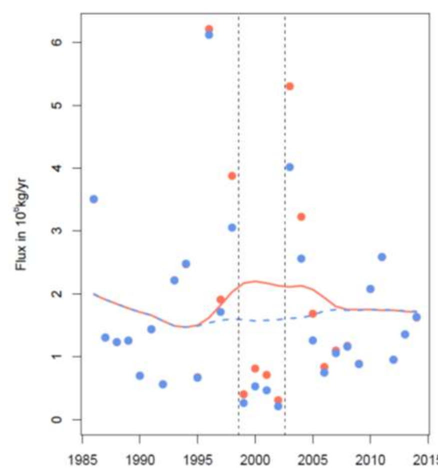



[TP] concentrations in the time window 6/98 – 6/02 were adjusted according to one of three approaches

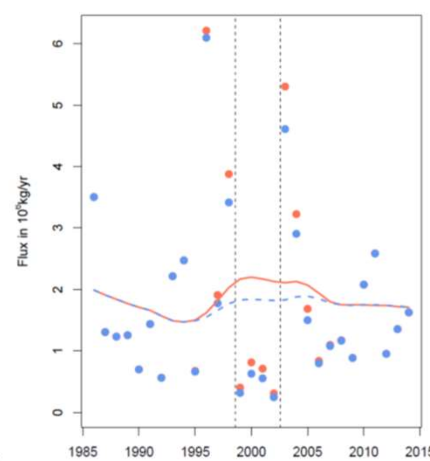
**HIRSCH**




**SPEI**



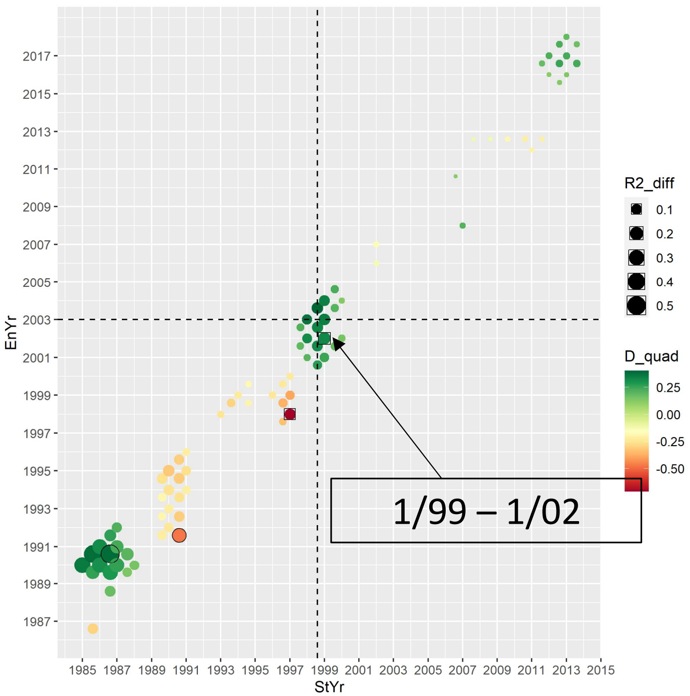

**PDSI**



# Example

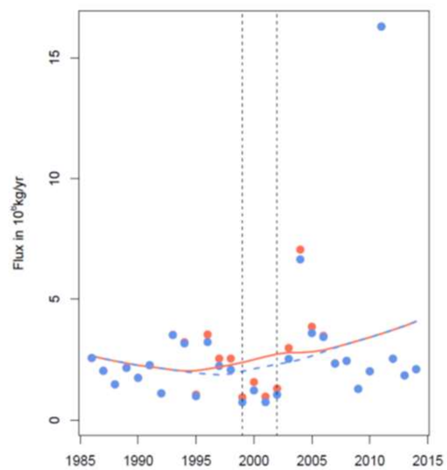
## 1578310

### SUSQUEHANNA RIVER AT CONOWINGO, MD

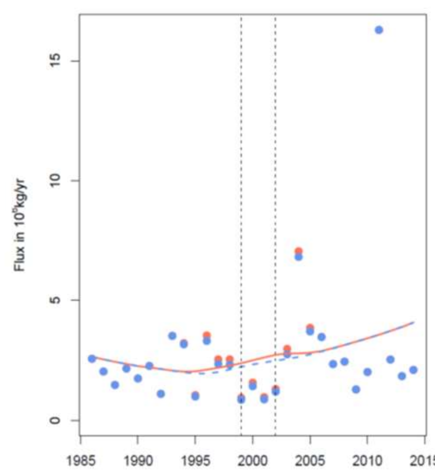



[TP] concentrations in the time window 1/99 – 1/02 were adjusted according to one of three approaches

**HIRSCH**



**SPEI**



**PDSI**