







Leveraging continuous dissolved oxygen data to reduce water quality model uncertainty

Joseph Fogarty, PhD Thomas Amidon, BCES
Sarah Beganskas, PhD Jacob Bransky

November 9, 2026
AWRA National Conference
Philadelphia, PA

Delaware River Basin Commission
DELAWARE • NEW JERSEY
PENNSYLVANIA • NEW YORK
UNITED STATES OF AMERICA

What are change factors, and why are they used?

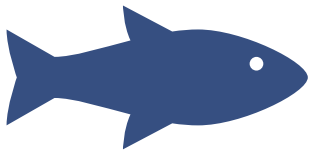
How can we apply change factors to water quality modeling?

How well does it work?



How will we use this methodology?

What are change factors, and why are they used?



How can we apply change factors to water quality modeling?



How well does it work?



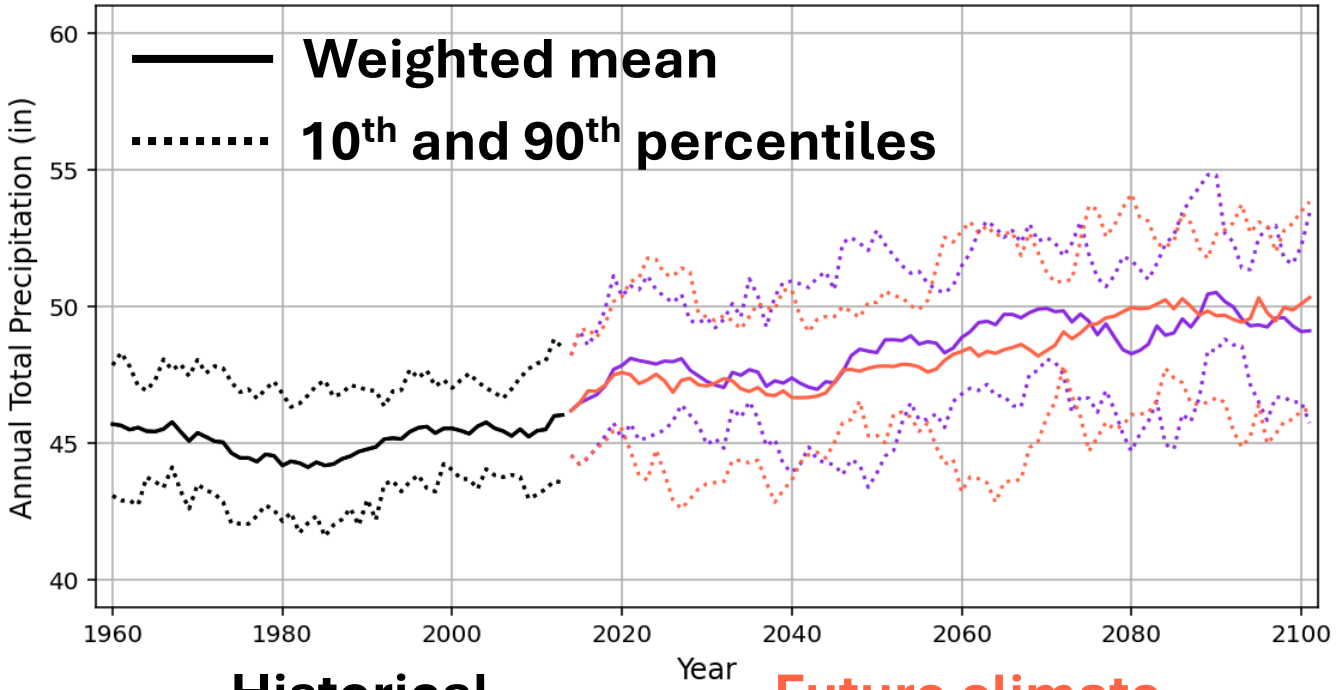
How will we use this methodology?

What can we learn from how climate models assess future conditions?

Delaware River Basin Commission
DELAWARE • NEW JERSEY
PENNSYLVANIA • NEW YORK
UNITED STATES OF AMERICA

STANDARD APPROACH

- Use **model projections under a future scenario** (raw model output)
- These projections are subject to **significant uncertainty**:
  - Climate models **do not perfectly recreate** past conditions
  - Applying a model to **unobserved conditions** (e.g., climate change)



Historical period (1950–2012)

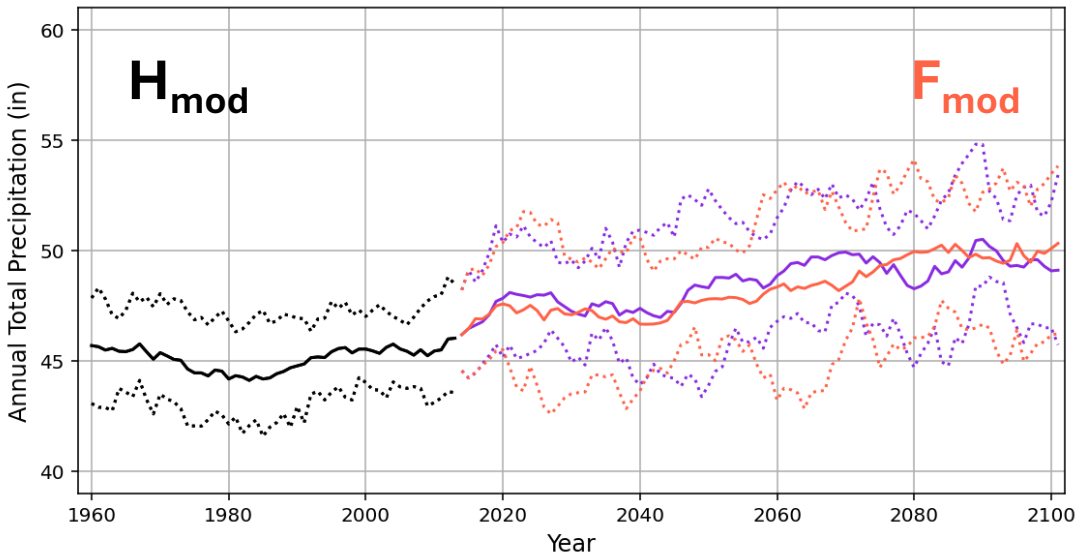
Future climate change scenarios (2015–2100)

What can we learn from how climate models assess future conditions?

Delaware River Basin Commission
DELAWARE • NEW JERSEY
PENNSYLVANIA • NEW YORK
UNITED STATES OF AMERICA

CHANGE FACTOR (CF) APPROACH

- Use **model output to characterize relative change** between future and historical conditions
- Apply that relative change to **observed historical data**
- Reduces uncertainty:
  - **Preserves features of observed data** that are difficult to capture in models
  - **Leverages model capabilities** to characterize unobserved conditions



$$CF = \frac{F_{mod}}{H_{mod}}$$

$$Future\ Value = CF * H_{obs}$$



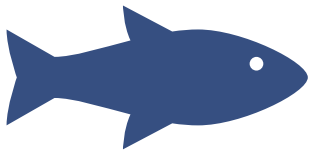
Delaware River Basin Commission
DELAWARE • NEW JERSEY
PENNSYLVANIA • NEW YORK
UNITED STATES OF AMERICA

MODELING OBJECTIVE:

Relate changes in **loading conditions** to **dissolved oxygen levels** throughout the Delaware River Estuary

- Like climate models, the water quality model **does not perfectly recreate observed conditions**
  - Uncertainty when modeling complex dynamics
- Like future climate scenarios, potential loading scenarios are **unobserved**
  - No data under these conditions
- **Could applying change factors improve estimations of DO under different loading scenarios?**

Change factors **reduce model uncertainty** to represent **unobserved conditions**



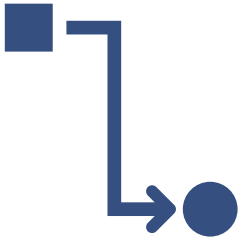
How can we apply change factors to water quality modeling?



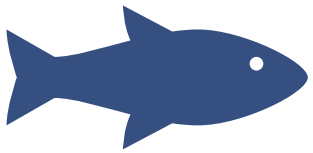
How well does it work?



How will we use this methodology?



Change factors **reduce model uncertainty** to represent **unobserved conditions**



How can we apply change factors to water quality modeling?

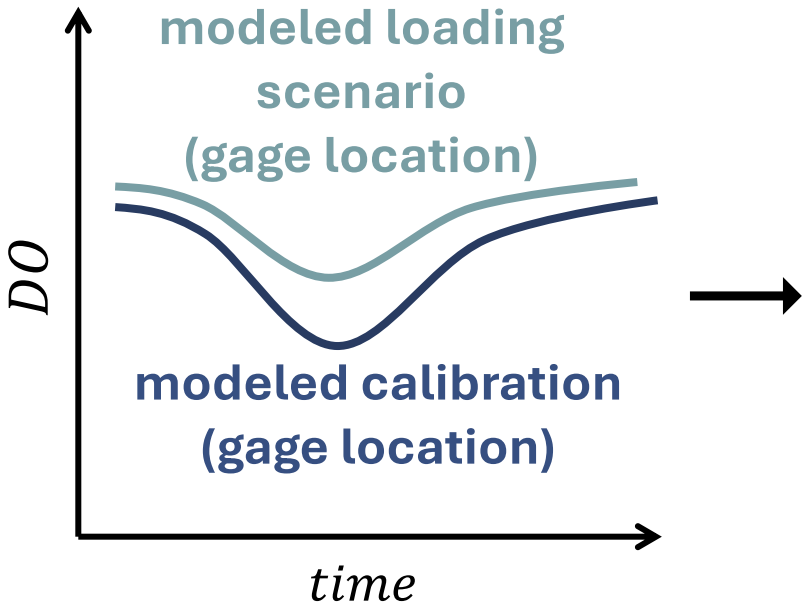


How well does it work?

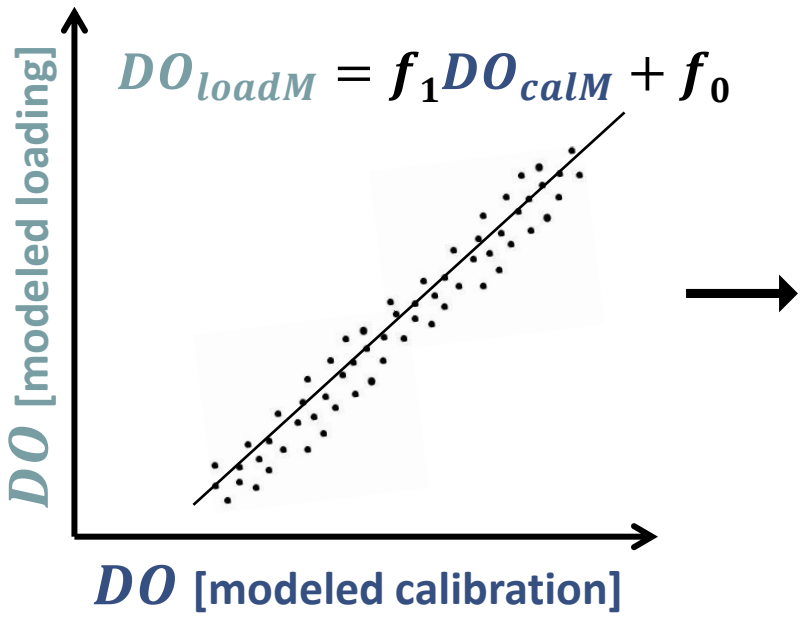


How will we use this methodology?

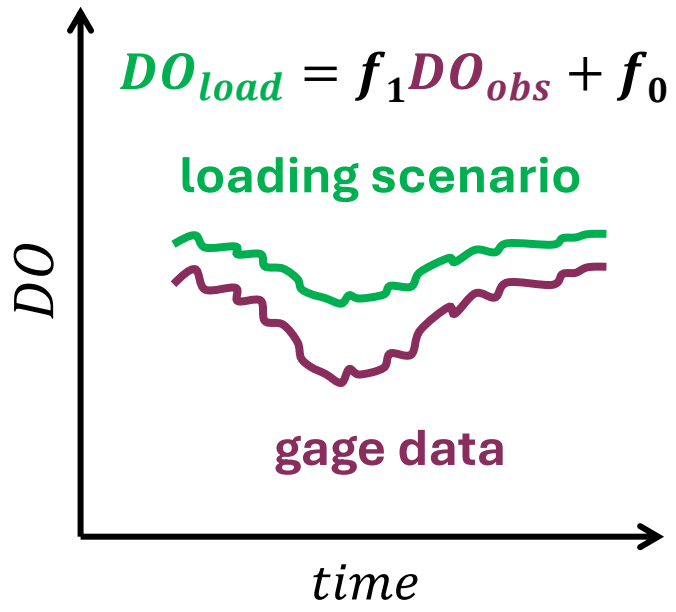
STEP 1. Loading Change Factor (LCF): Determine **loading scenario DO** at gage locations.



Use **3 years** for which water quality model was developed (2012, 2018, 2019)

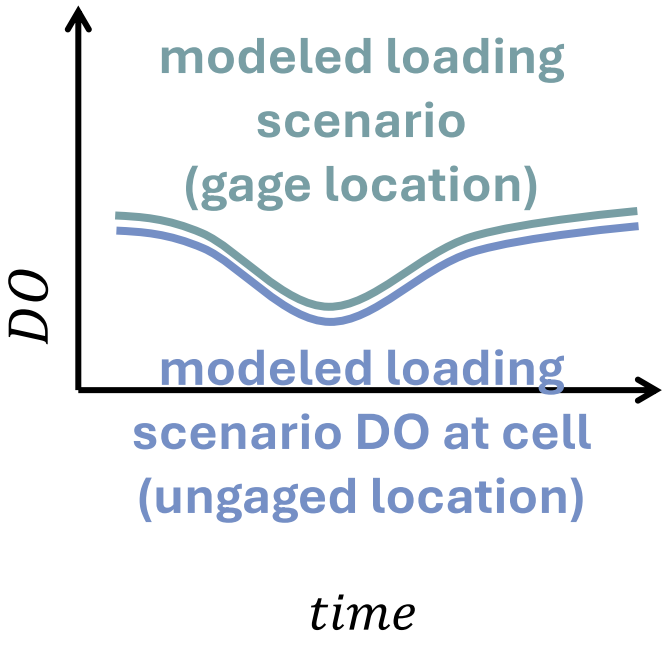


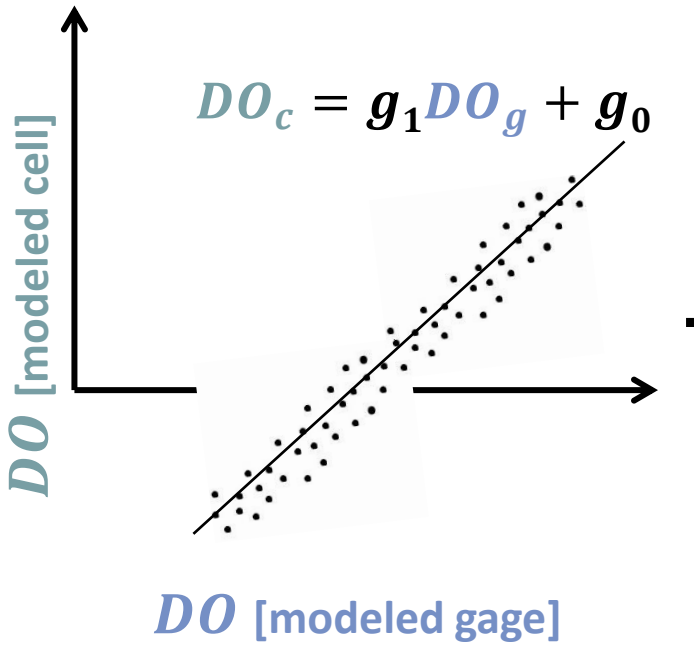
Use **linear regression** to relate baseline and loading scenarios



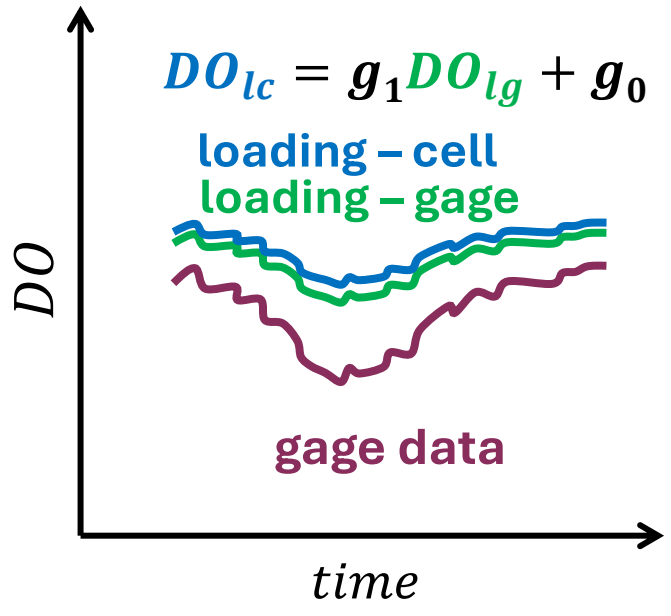
Apply relationship to **15 years** of continuous gage data (2011–2025)

STEP 2. Spatially Weighted Interpolation (SWI): Extend loading scenario DO to **ungaged locations**.





Use **linear regression** to relate DO at cell and gage locations



Estimate **loading scenario DO at ~1,700 ungaged locations**

Change factors **reduce model uncertainty** to represent **unobserved conditions**

DRBC's approach expands WQ model results to **unobserved years, locations, and scenarios**

How well does it work?



How will we use this methodology?

Change factors **reduce model uncertainty** to represent **unobserved conditions**

DRBC's approach expands WQ model results to **unobserved years, locations, and scenarios**

How well does it work?

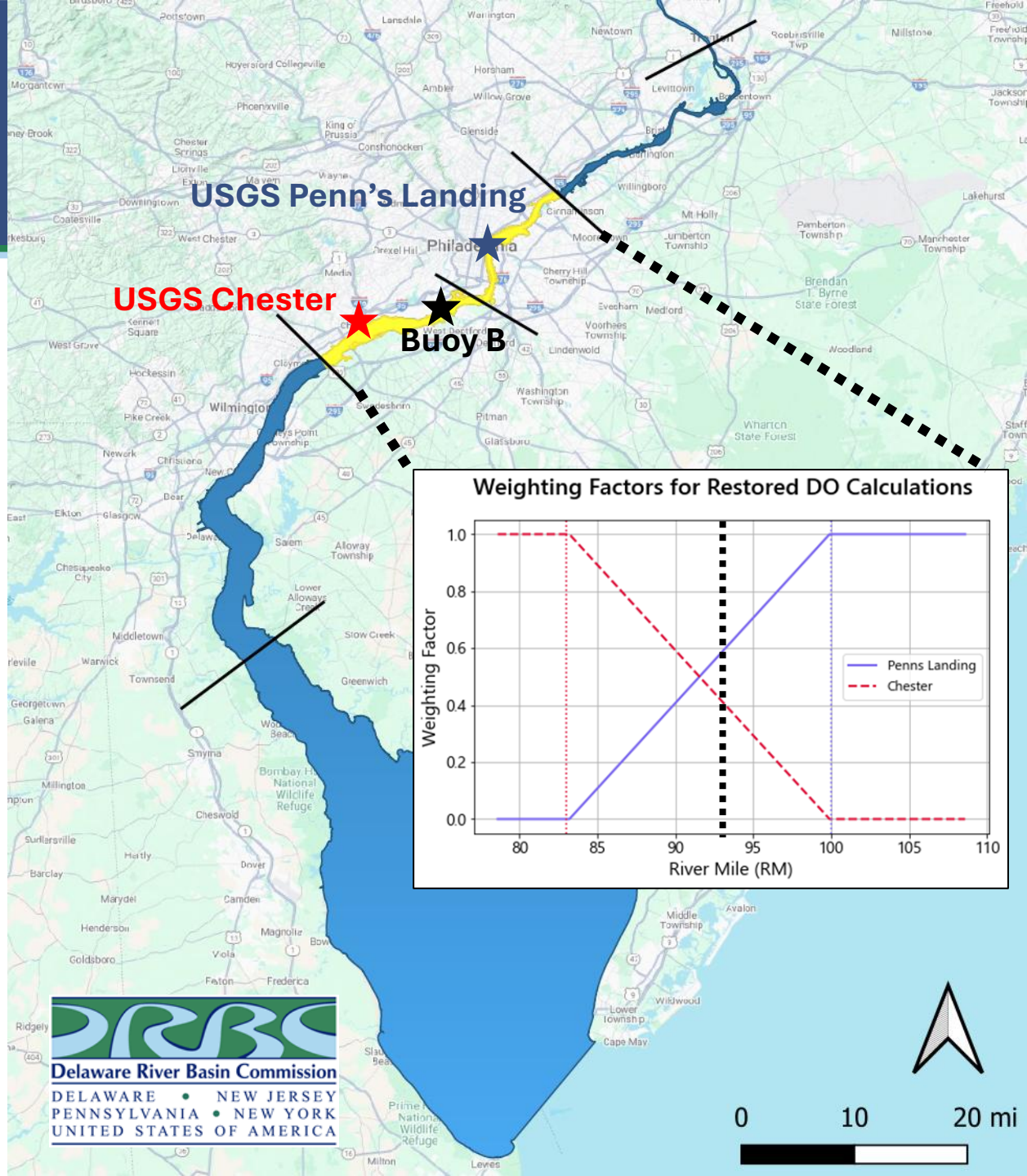


How will we use this methodology?

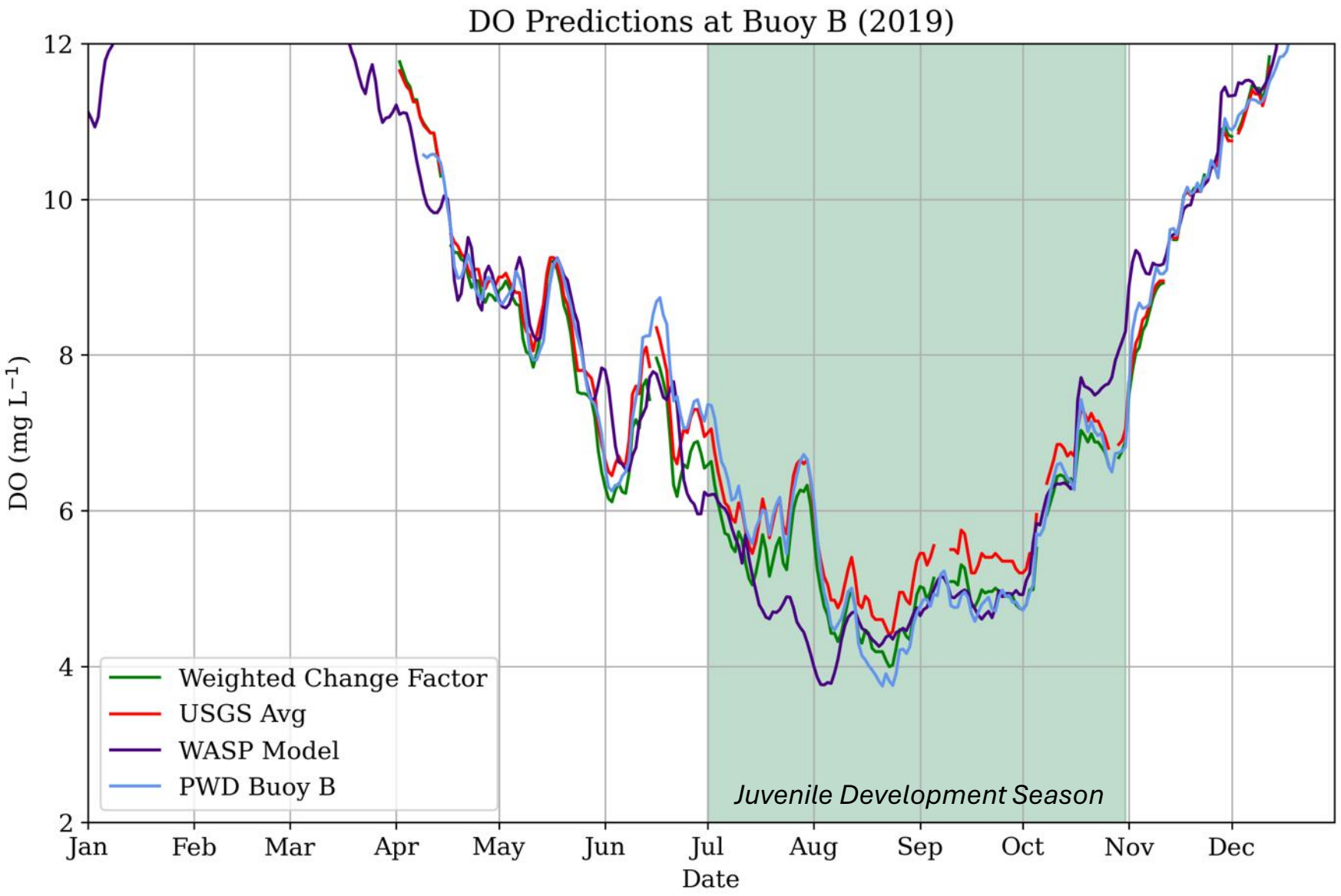
We have independent data to test this methodology

- Two Predictions:
  - $DO_{BB,Ch}$: DO @ Buoy B (USGS Chester)
  - $DO_{BB,PL}$: DO @ Buoy B (USGS Penn's Landing)

$$DO_{BB} = w_{Ch} DO_{BB,Ch} + w_{PL} DO_{BB,PL},$$
$$w_{Ch} + w_{PL} = 1$$



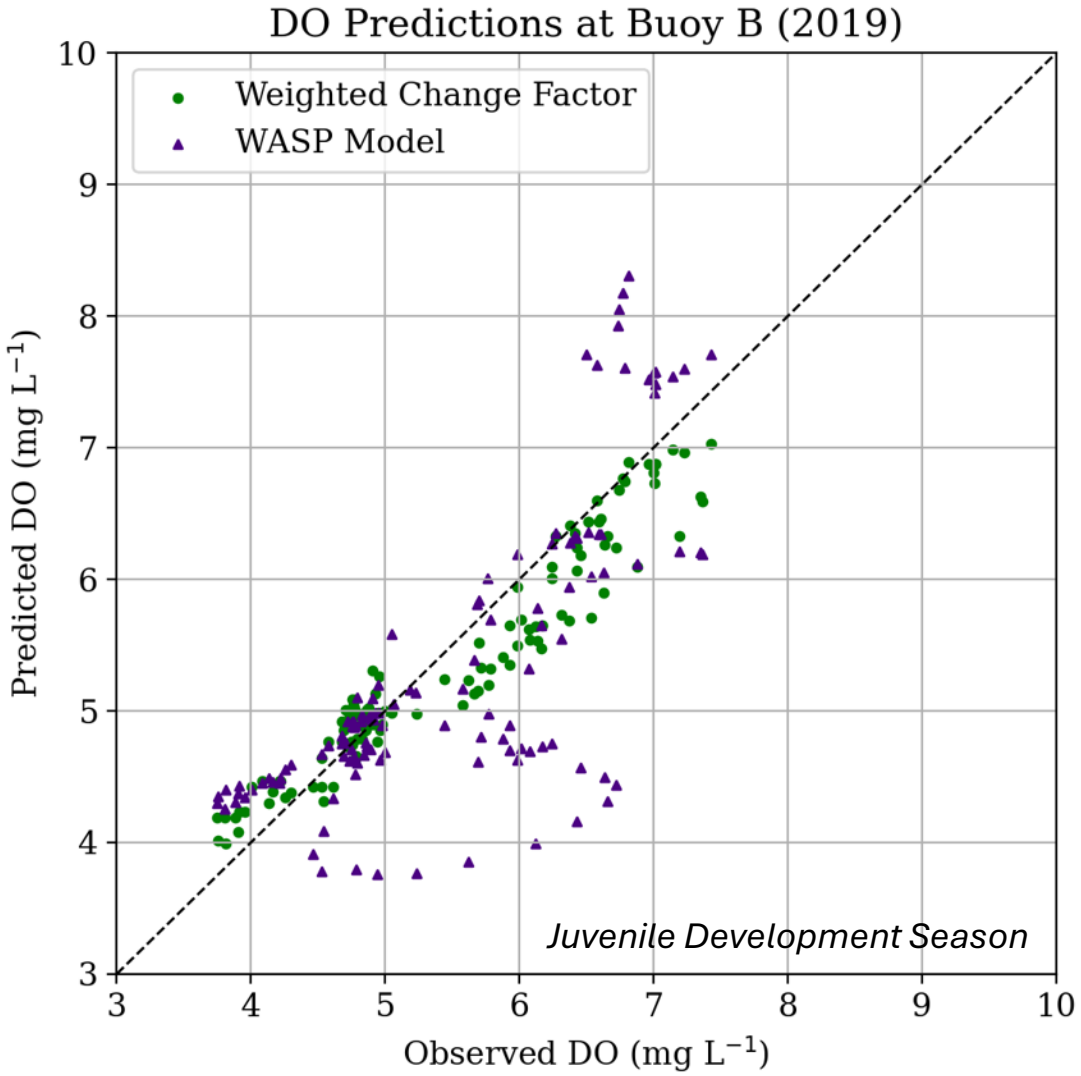
We have independent data to test this methodology



Entire Year		
Method	R^2	$RMSE$
WASP Model	0.91	0.66
USGS Avg	0.97	0.36
Change Factor	0.97	0.36

Juvenile Development Season (Jul 1 – Oct 31)		
Method	R^2	$RMSE$
WASP Model	0.37	0.79
USGS Avg	0.81	0.44
Change Factor	0.89	0.34

We have independent data to test this methodology

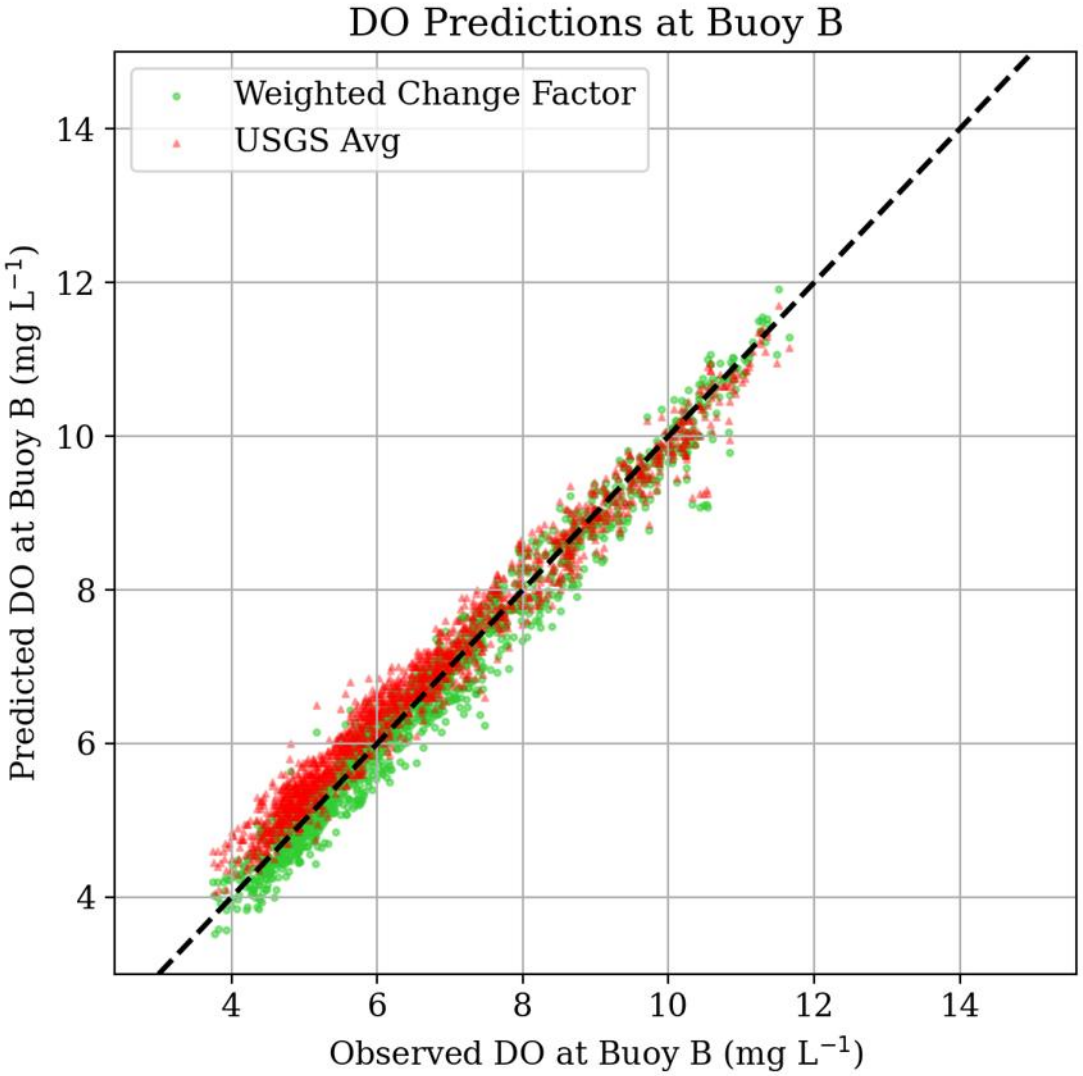


Entire Year		
Method	R^2	$RMSE$
WASP Model	0.91	0.66
USGS Avg	0.97	0.36
Change Factor	0.97	0.36

Juvenile Development Season (Jul 1 – Oct 31)		
Method	R^2	$RMSE$
WASP Model	0.37	0.79
USGS Avg	0.81	0.44
Change Factor	0.89	0.34

Evaluating Change Factor

during the period of record (2015 – 2023)

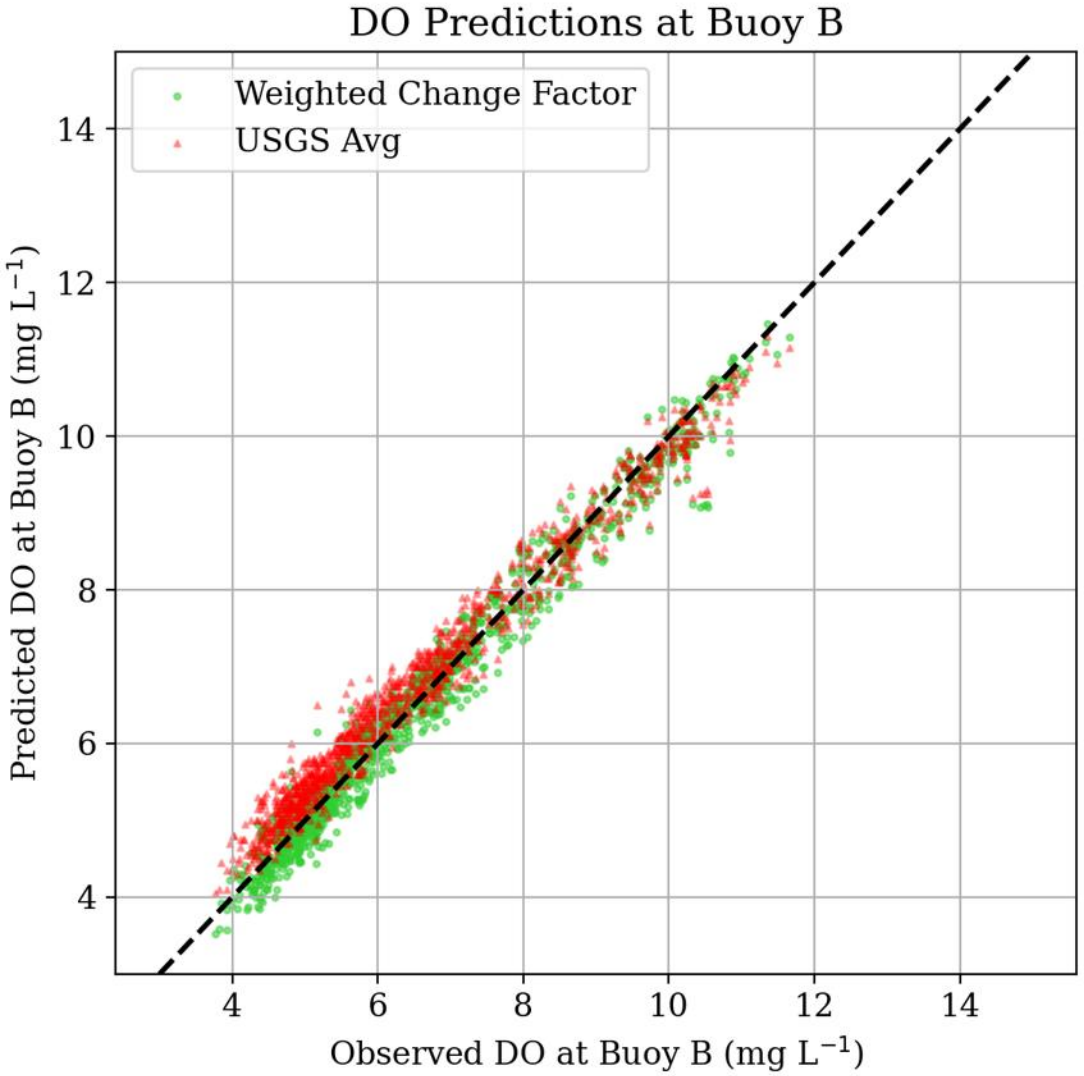


*What about **including** years outside the model calibration?*

Method	R^2	$RMSE$ (mg L^{-1})	Bias (mg L^{-1})
WASP (not shown)	0.85	0.67	0.19
Change Factor	0.98	0.28	0.05
USGS Avg	0.96	0.38	−0.21

Evaluating Change Factor

during the period of record (2015 – 2023, excl. 2018 – 2019)



*What about **ONLY** years outside the model calibration?*

Method	R^2	$RMSE$ (mg L^{-1})	Bias (mg L^{-1})
WASP (not shown)	N/A	N/A	N/A
Change Factor	0.98	0.28	0.05
USGS Avg	0.95	0.39	−0.22

Change factors **reduce model uncertainty** to represent **unobserved conditions**

DRBC's approach expands WQ model results to **unobserved years, locations, and scenarios**

The WQ change factor approach **improves DO predictions** in the DRE



How will we use this methodology?

Change factors **reduce model uncertainty** to represent **unobserved conditions**

DRBC's approach expands WQ model results to **unobserved years, locations, and scenarios**

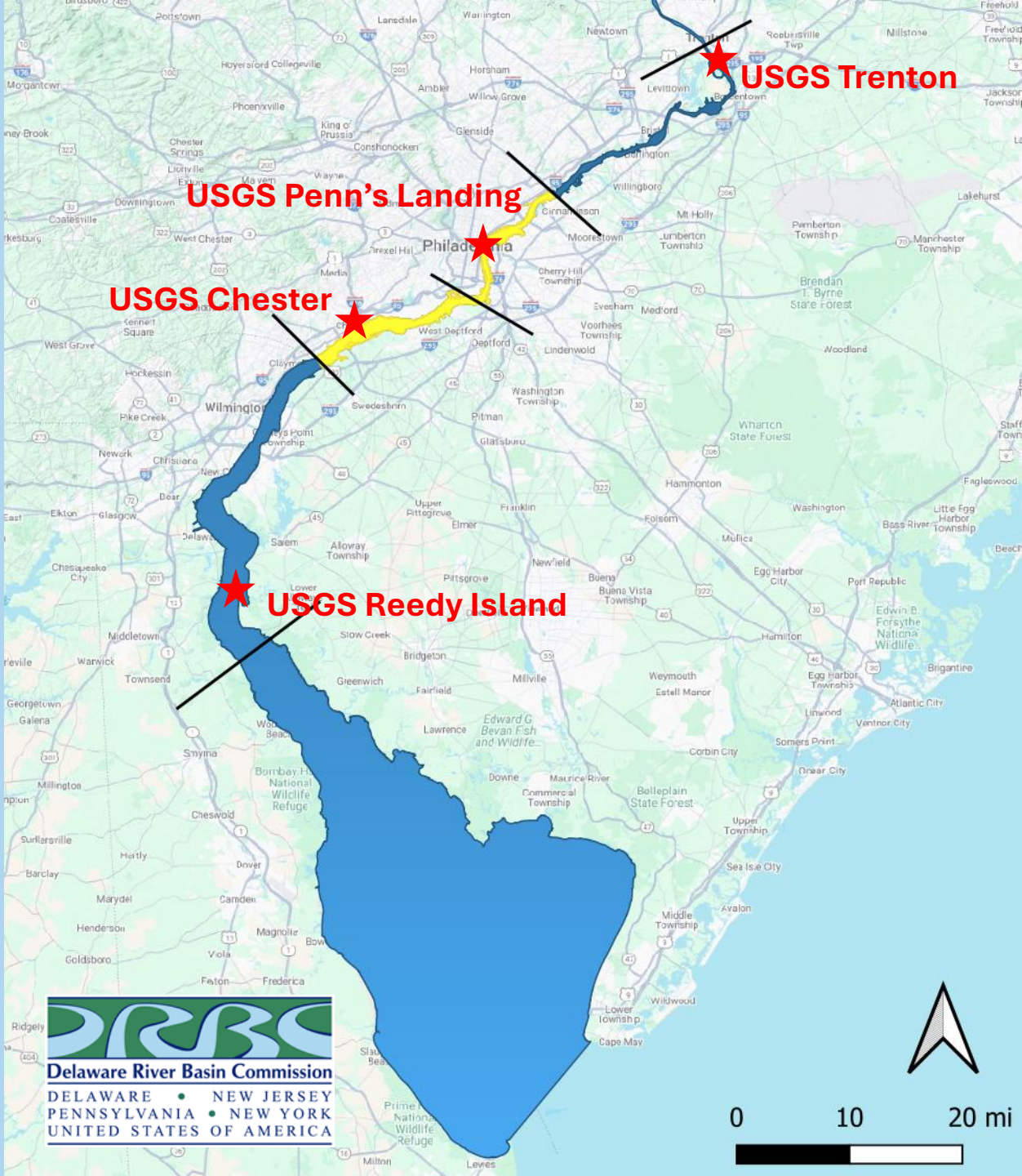
The WQ change factor approach **improves DO predictions** in the DRE



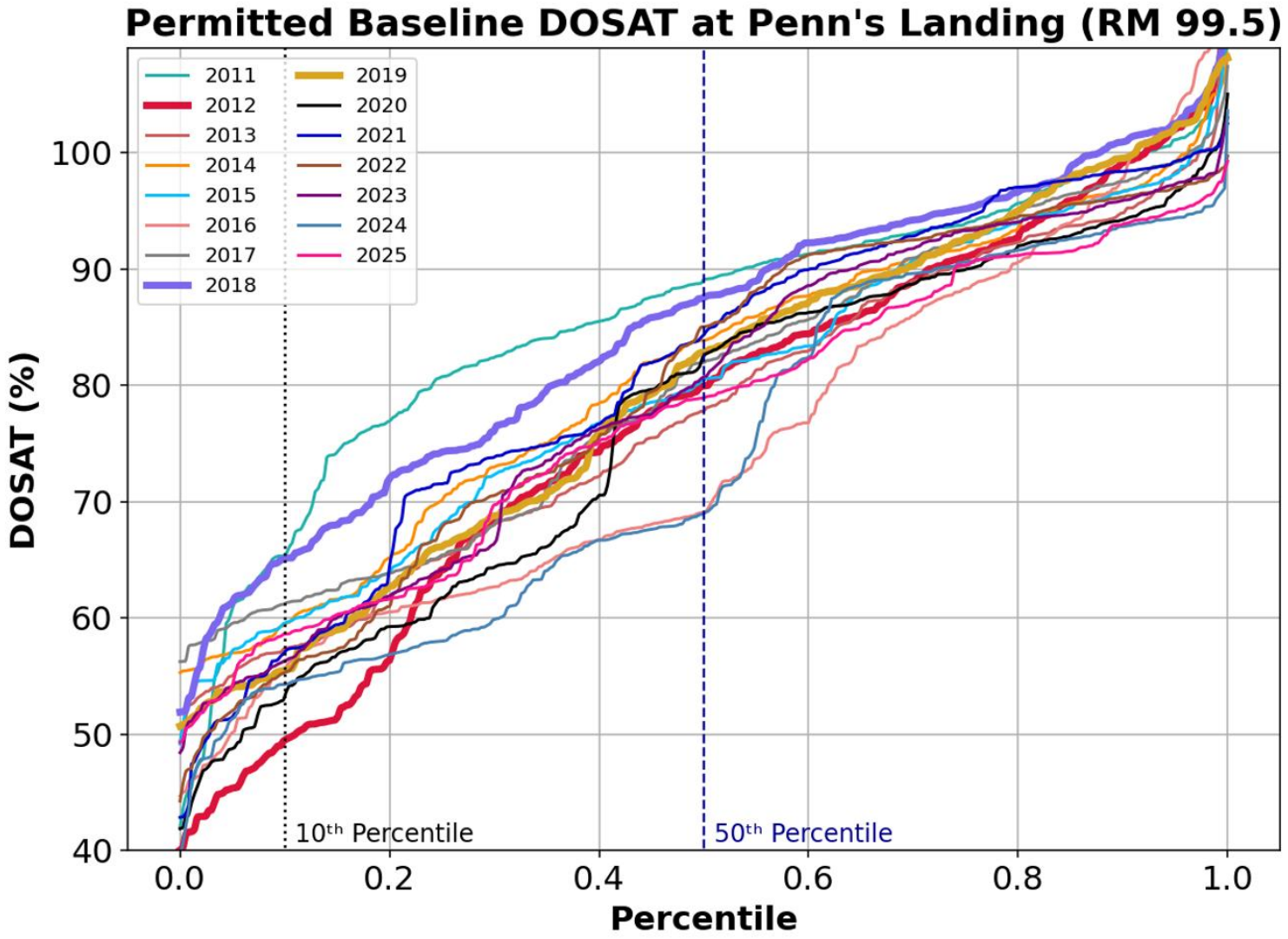
How will we use this methodology?

How will we use this methodology?

- Use of a state-of-the-art **dissolved oxygen model**
- Capture the entire Estuary **using four USGS gages**
- Projection of loading scenarios on **15 years of data**



This method reveals the effect of loading scenarios under **multiple hydrologic conditions**



Change factors **reduce model uncertainty** to represent **unobserved conditions**

DRBC's approach expands WQ model results to **unobserved years, locations, and scenarios**

The WQ change factor approach **improves DO predictions** in the DRE



This approach allows us to evaluate a **wide range of hydrologic conditions**



Delaware River Basin Commission
DELAWARE • NEW JERSEY
PENNSYLVANIA • NEW YORK
UNITED STATES OF AMERICA

MODELING OBJECTIVE:

Relate changes in **loading conditions** to **dissolved oxygen levels** throughout the Delaware River Estuary

Are you interested in the development of the model where we use this method?

Are you interested in learning more about the physics, chemistry, and biology of the Delaware River Estuary?

Then come to our session tomorrow!

Session 44: How a Dynamic, 3D, Fully Coupled Water Column and Sediment Model Unpacked the Dissolved Oxygen Drivers in the Delaware River Estuary

Tuesday November 10
3:30 – 5:00 PM
Columbus B









- Change factors **reduce model uncertainty** to represent **unobserved conditions**.
- DRBC's approach expands WQ model results to **unobserved years, locations, and scenarios**.
- The WQ change factor approach **improves DO predictions** in the DRE.

Joseph Fogarty, PhD joseph.fogarty@drbc.gov
Sarah Beganskas, PhD sarah.beganskas@drbc.gov

Thank you! What questions do you have?

Delaware River Basin Commission
DELAWARE • NEW JERSEY
PENNSYLVANIA • NEW YORK
UNITED STATES OF AMERICA