

A space-time interpolation tool for Chesapeake Bay dissolved oxygen (4D Tool): Development and vertical array use

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Hypoxia Collaborative
April 28, 2026

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Goal: Bay Oxygen Research Group & 4-D tool

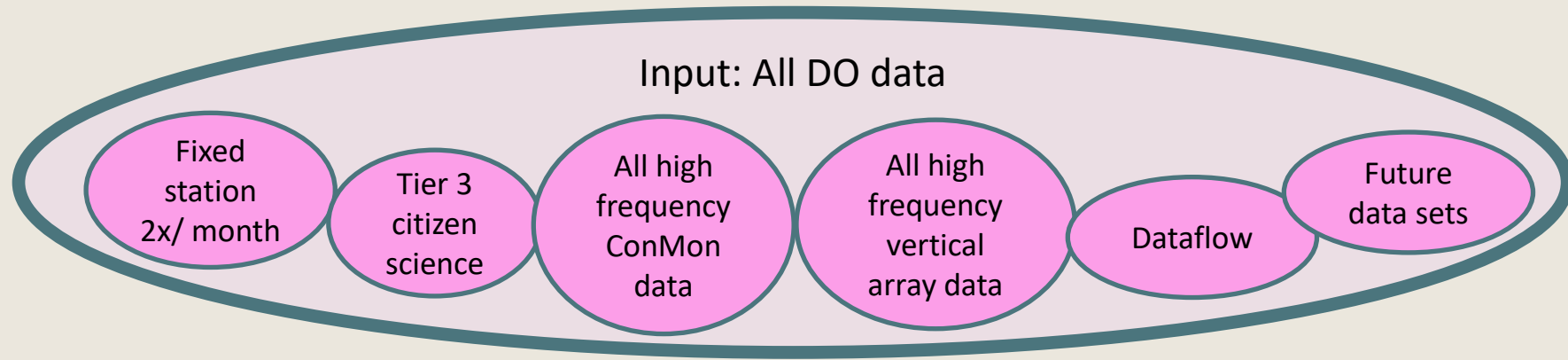
To develop a spatial-and-temporal interpolation tool for water quality monitoring data collected in the tidal waters of the Chesapeake Bay, thus enabling the evaluation of both long- and short-duration water quality criteria.

Specifically, the tool should be able to:

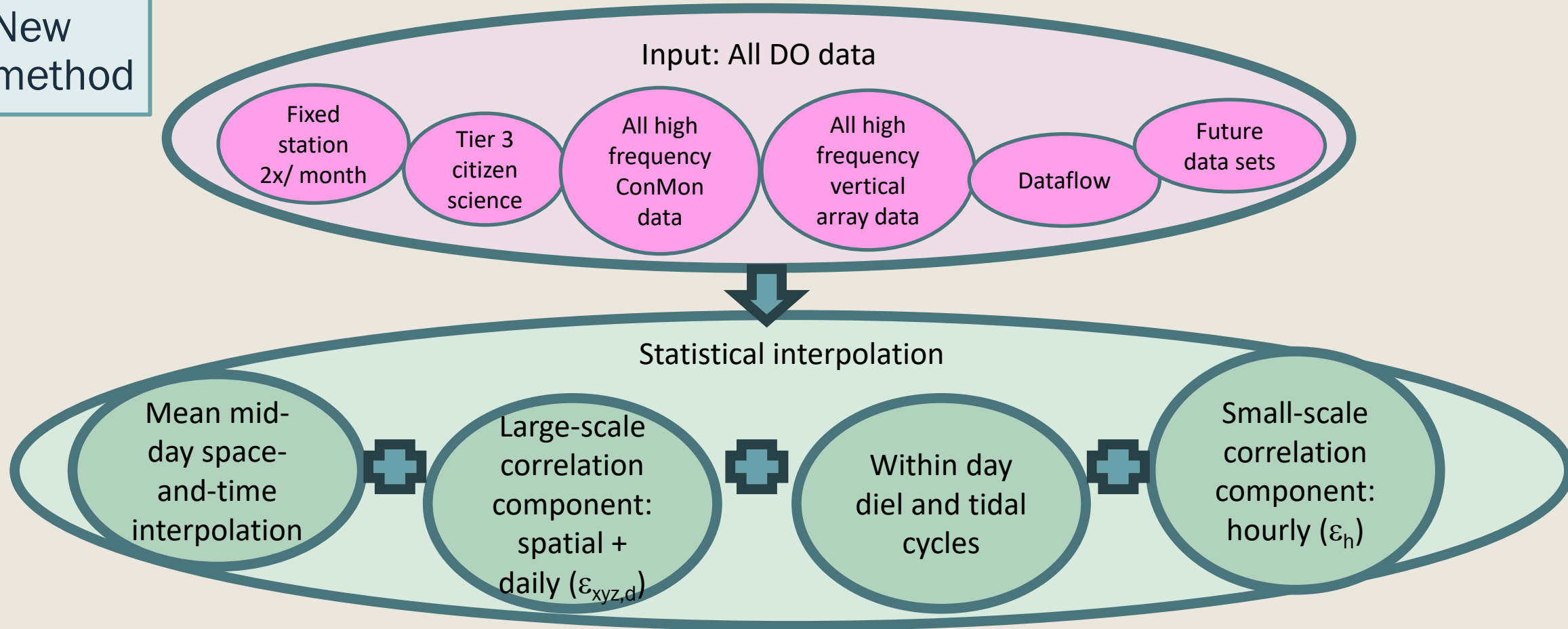
- *Interpolate observed dissolved oxygen in space and time (“4D”),**
- *Provide statistical estimates of uncertainty,*
- *Reproduce daily and hourly variability of the data, and*
- *Allow for post-processing of the interpolation output into designated uses (DU).*

*Note: Focus on development so far has been on dissolved oxygen, but ultimately chlorophyll *a* and clarity may be evaluated as well.

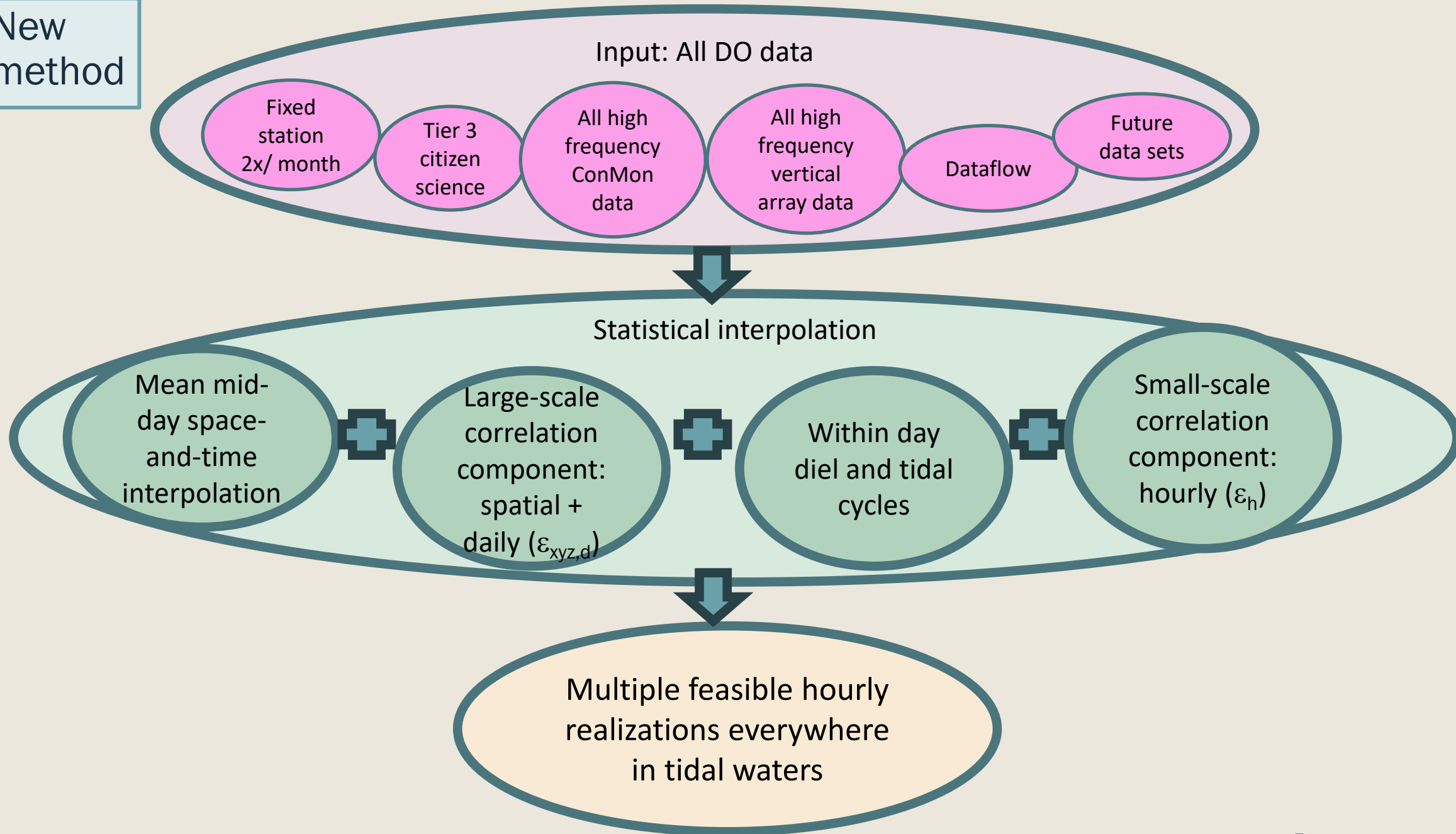
New method



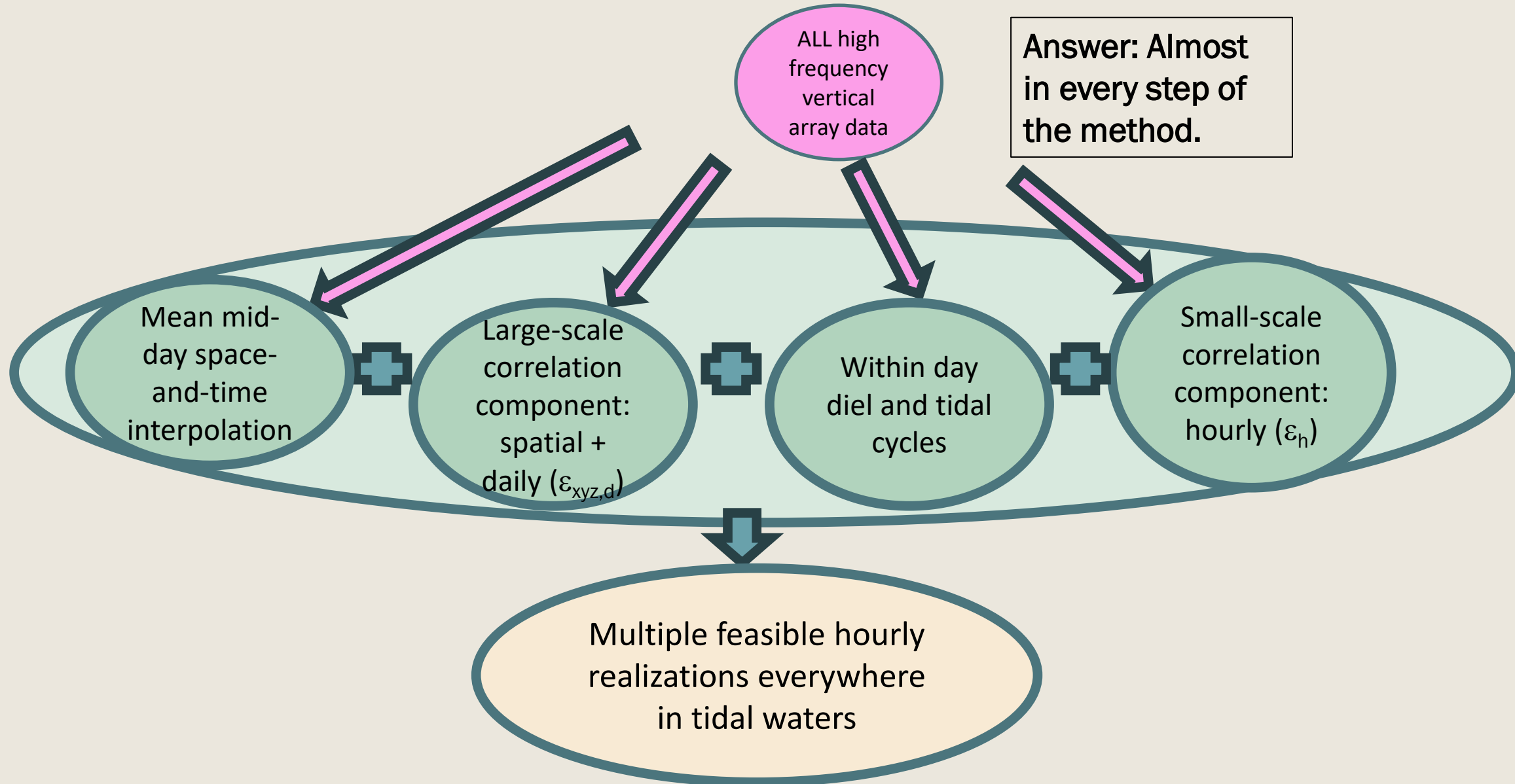
New method



New method



Question: Where is/will the vertical array data be used?

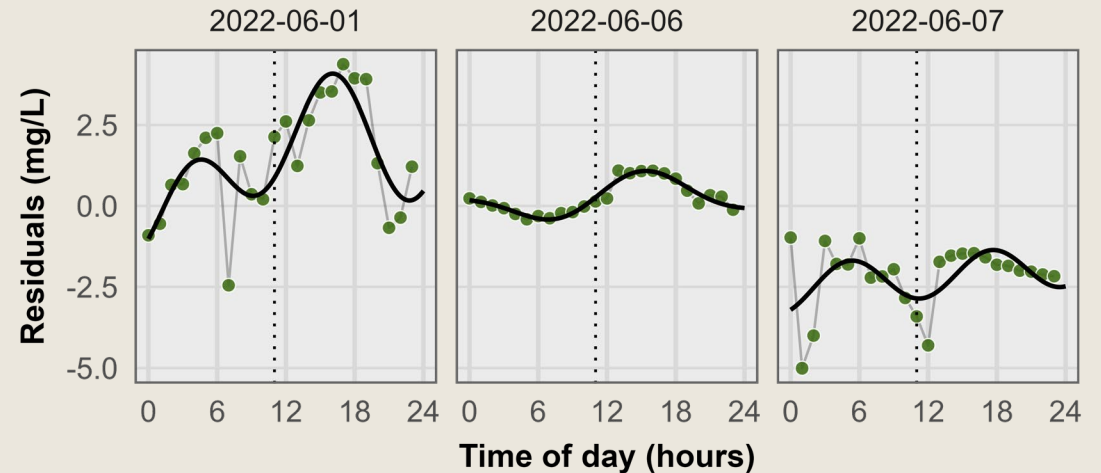


Vertical array data is some of the only data we have that can inform high frequency variability below the surface.

Daily Cycle

- Sub-sample time series data to hourly time series.
- Fit 1st order Fourier series at 24 h and 12.42 h with linear trend.
- Extract parameters from each data set and evaluate variability with season and location.

$$y(t) = \beta_0 + \beta_1 t + \beta_2 \sin\left(\frac{2\pi t}{24}\right) + \beta_3 \cos\left(\frac{2\pi t}{24}\right) + \beta_4 \sin\left(\frac{2\pi t}{12.42}\right) + \beta_5 \cos\left(\frac{2\pi t}{12.42}\right) + \varepsilon(t)$$

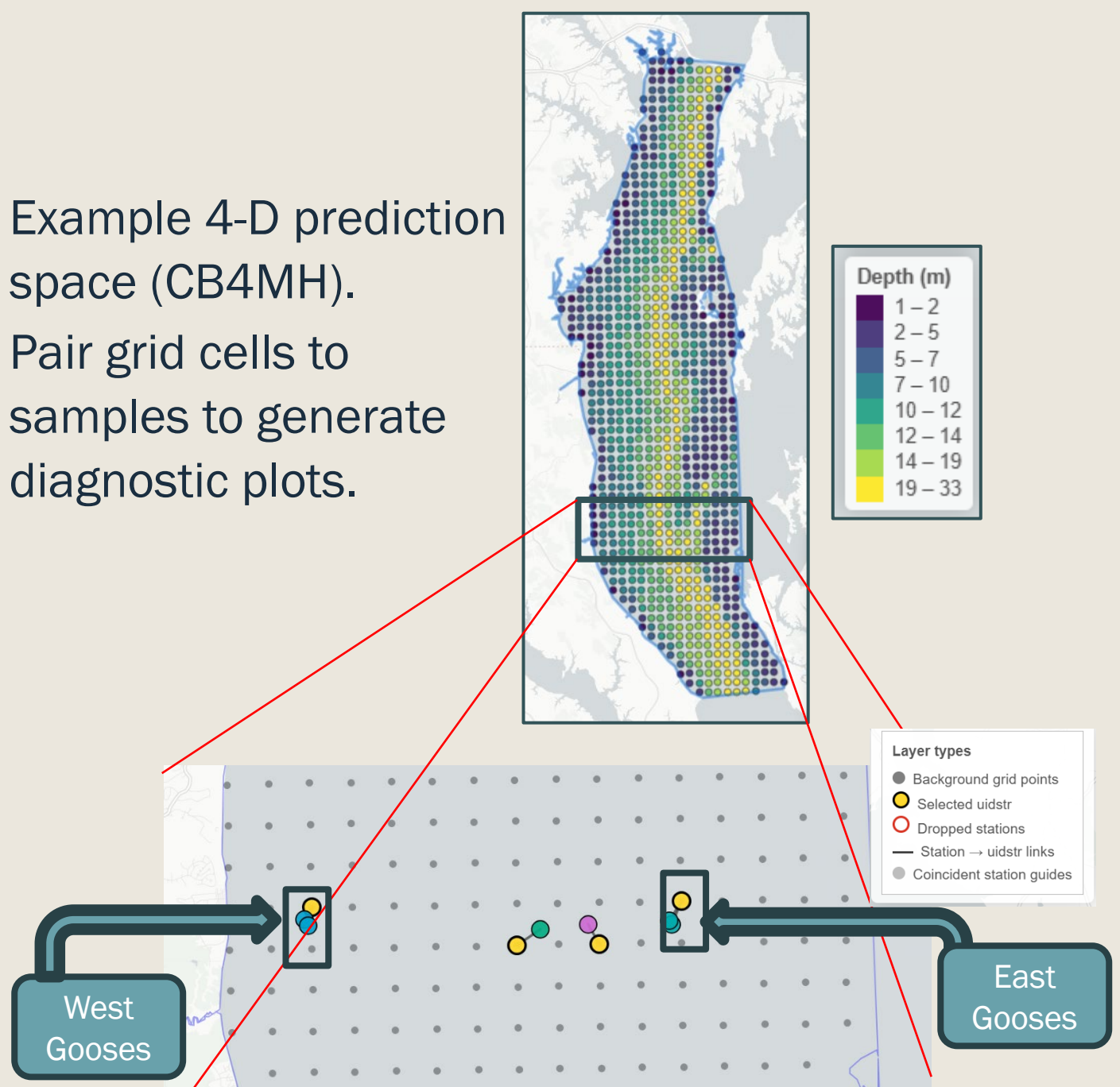


Slide from Jon Harcum, Tetra Tech

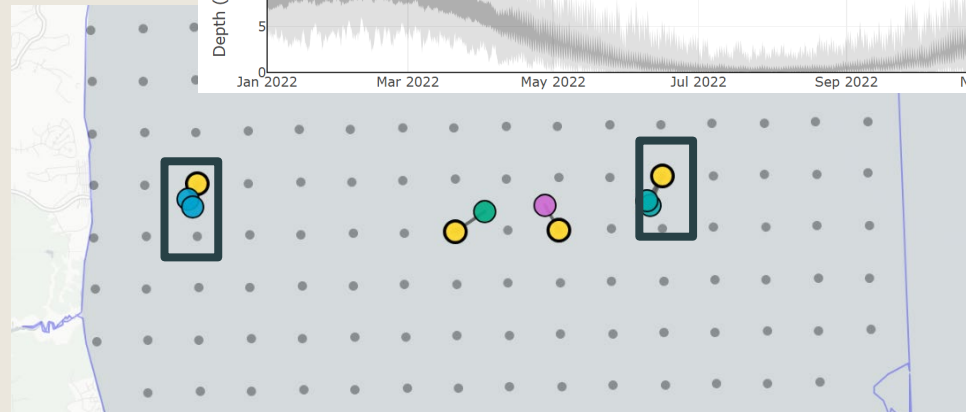
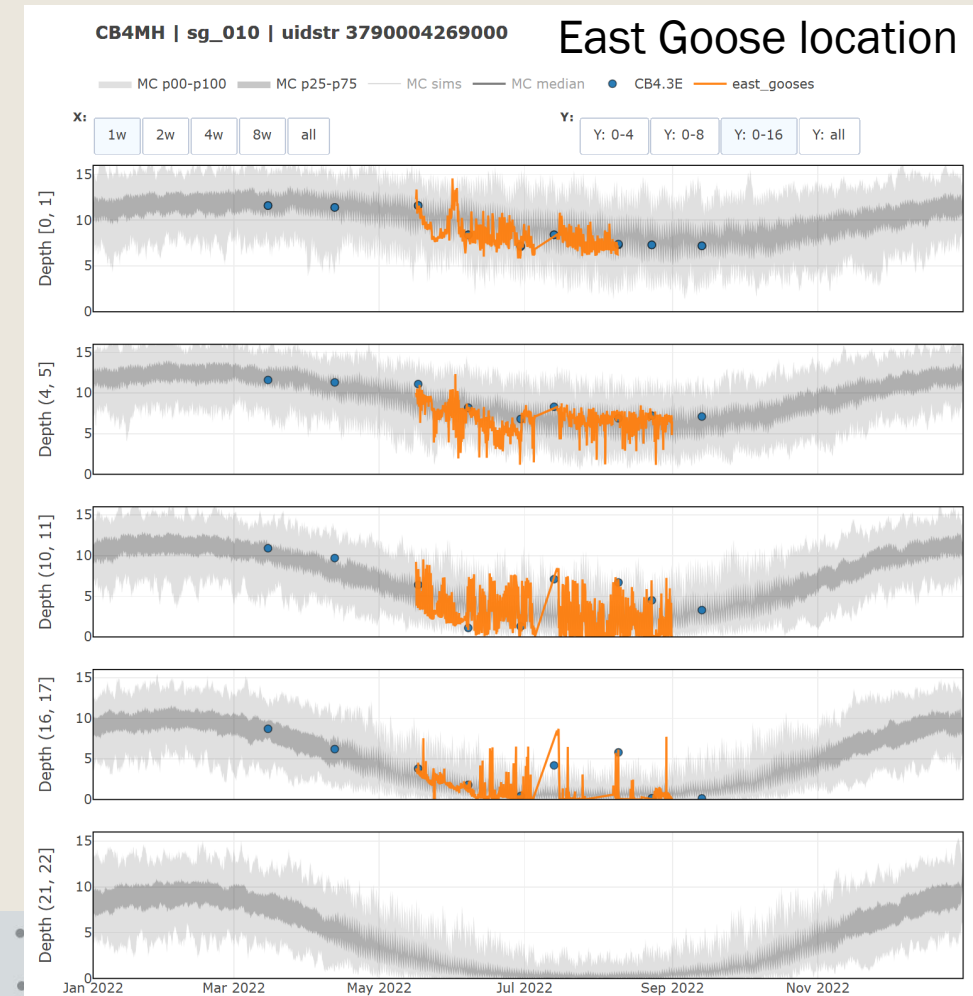
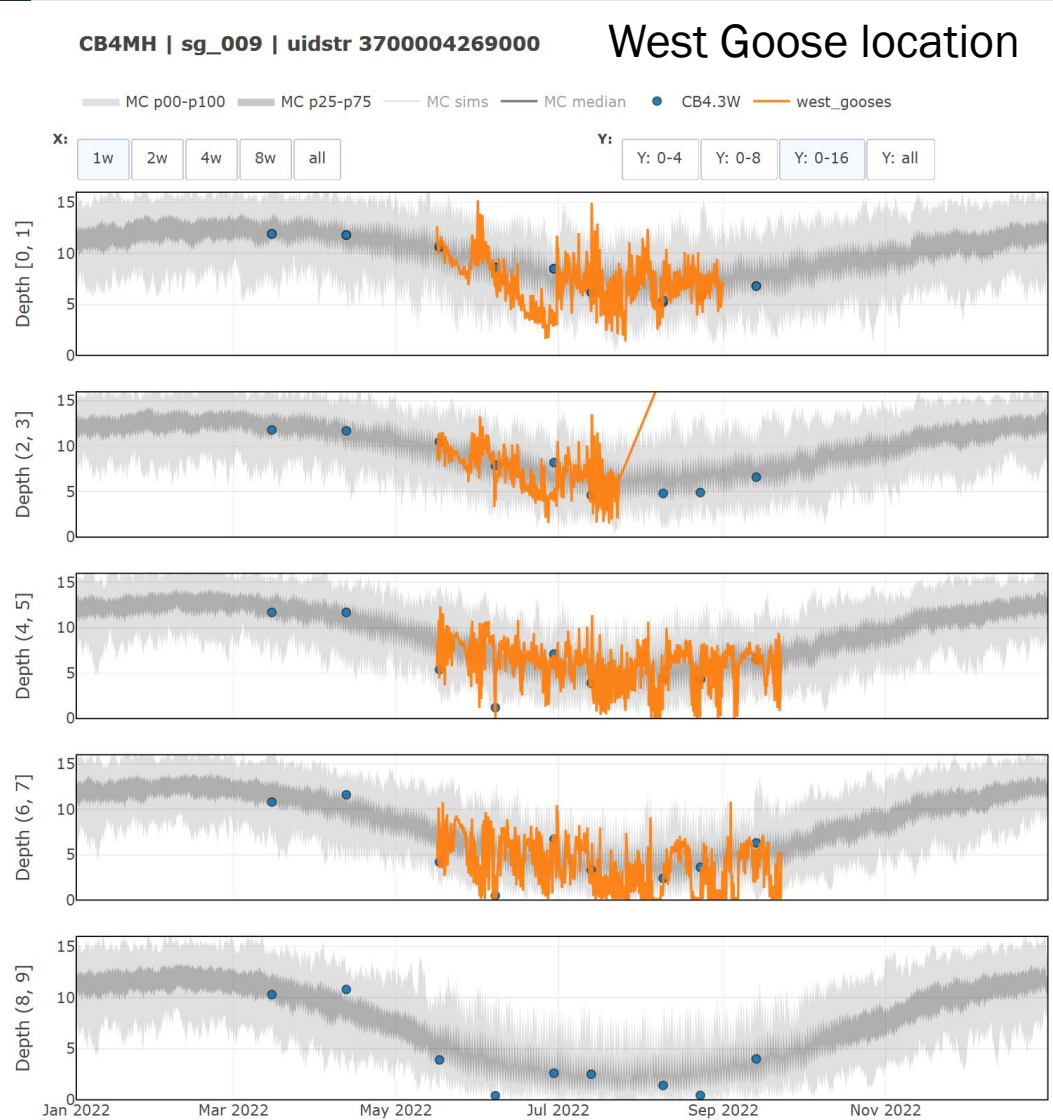
For clarity, plots show observed units (mg/L); analyses were performed with beta-logit-transformed DO, so results may differ slightly though patterns are unchanged.

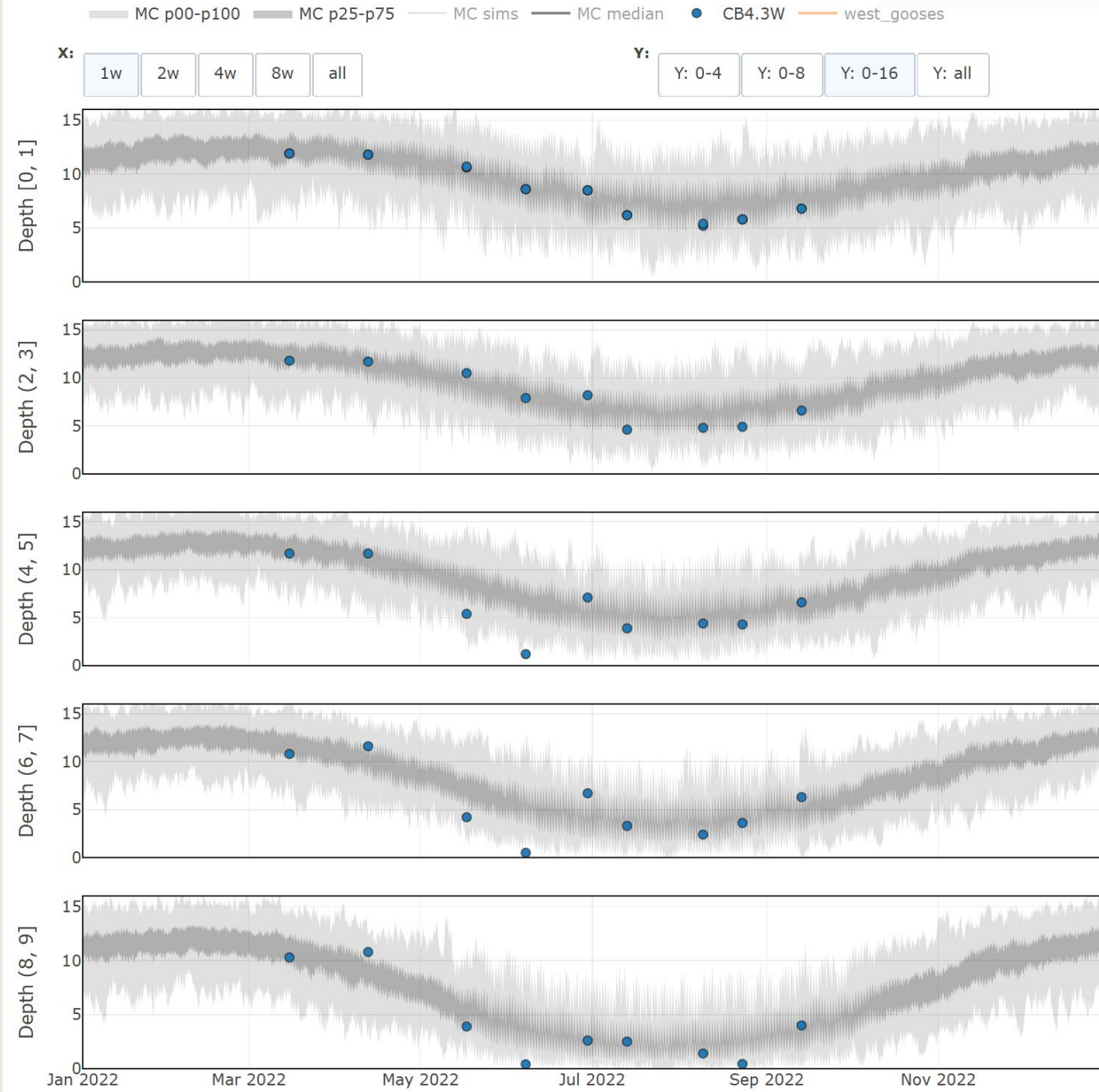
*Also very
useful for
comparing to
hourly 4D
results.*

- Example 4-D prediction space (CB4MH).
- Pair grid cells to samples to generate diagnostic plots.



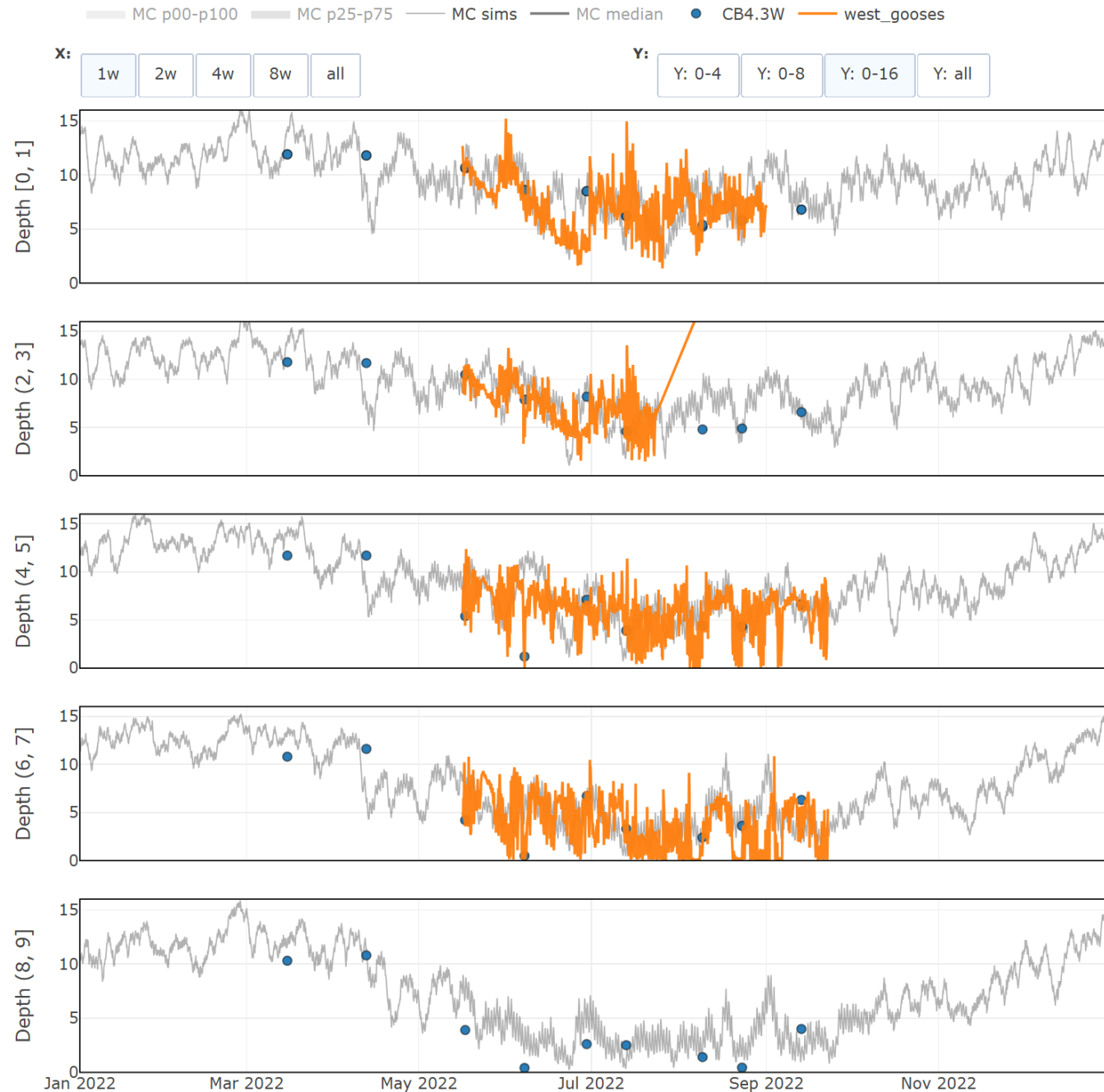
Draft output compared to vertical array data



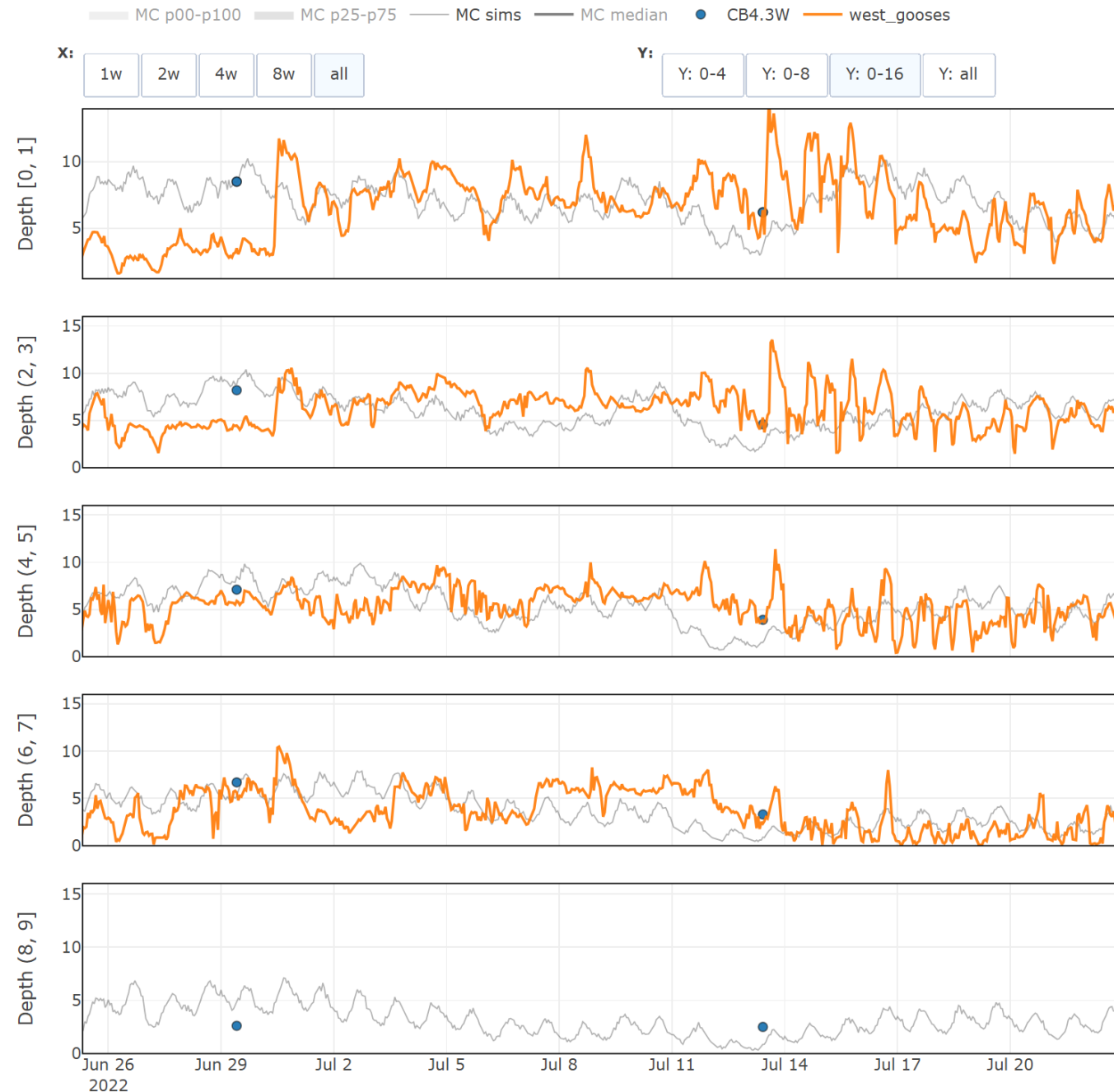


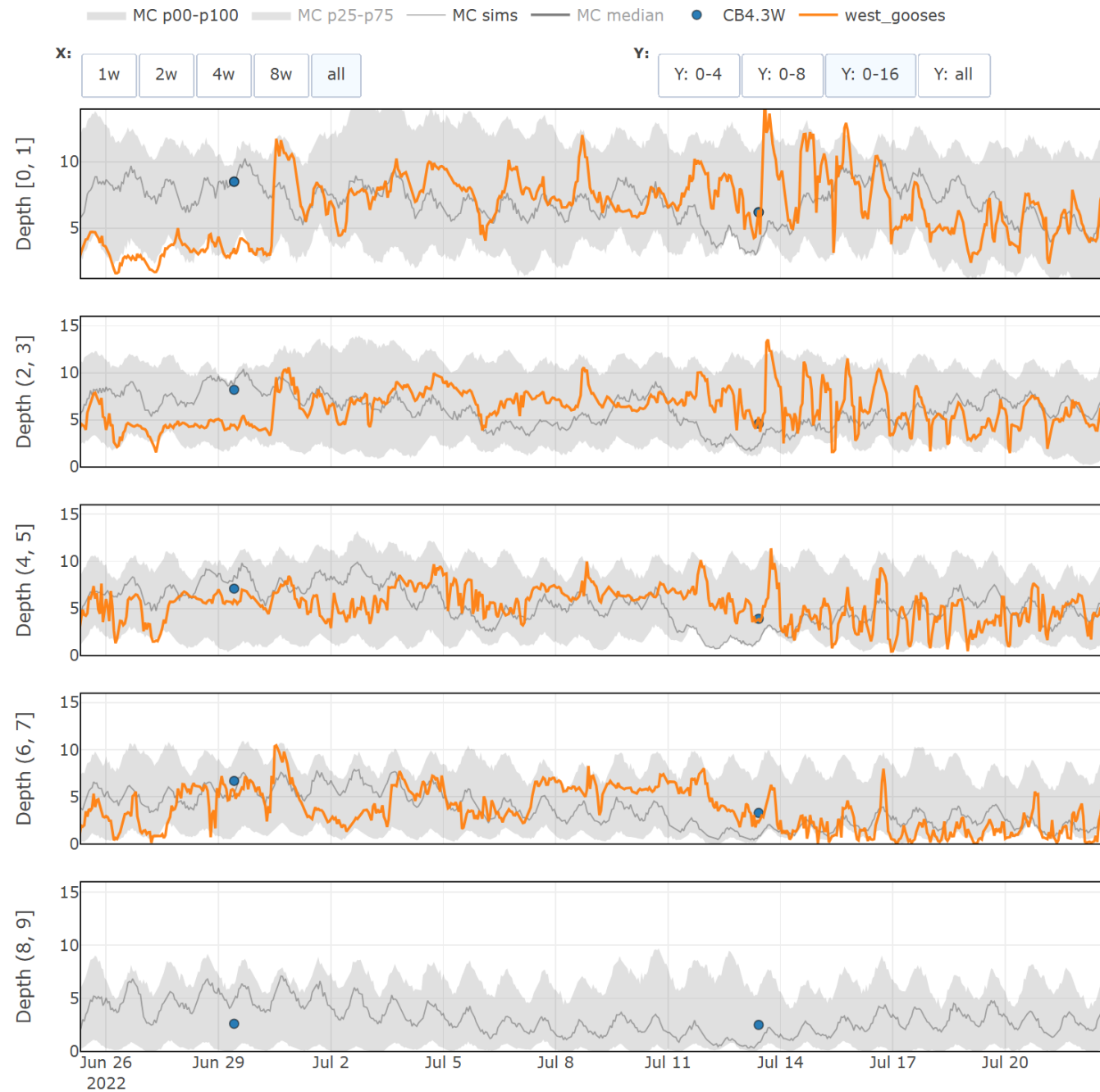
Without high frequency vertical array data, there is much less information to compare with 4D results.

CB4MH | sg_009 | uidstr 3700004269000 DRAFT at West Goose location



Gray line is just one simulation. Comparison shows how it captures the nature of the data.

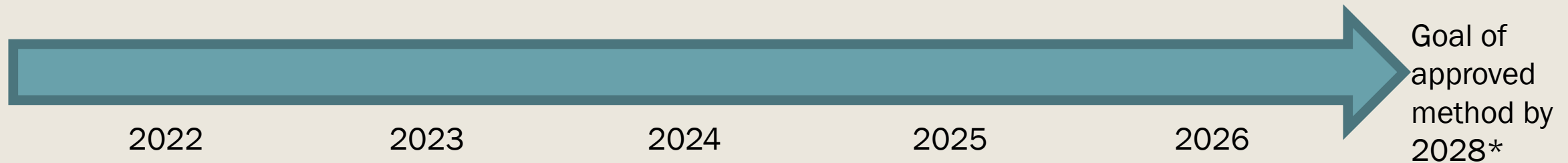




Although one simulation won't match data exactly, range of simulations will cover the values and should capture the relevant statistical properties of the data.

Summary

- Work continues in next few months finishing development tasks.
- Remainder of the year, focus on:
 - *Case studies and testing,*
 - *Linking to criteria assessment methods, and*
 - *Documentation.*



*with 2030 goal of reporting on all criteria

extras

Purpose: Build a tool for more complete criteria assessment

DO criteria that currently can be evaluated with existing approaches and data

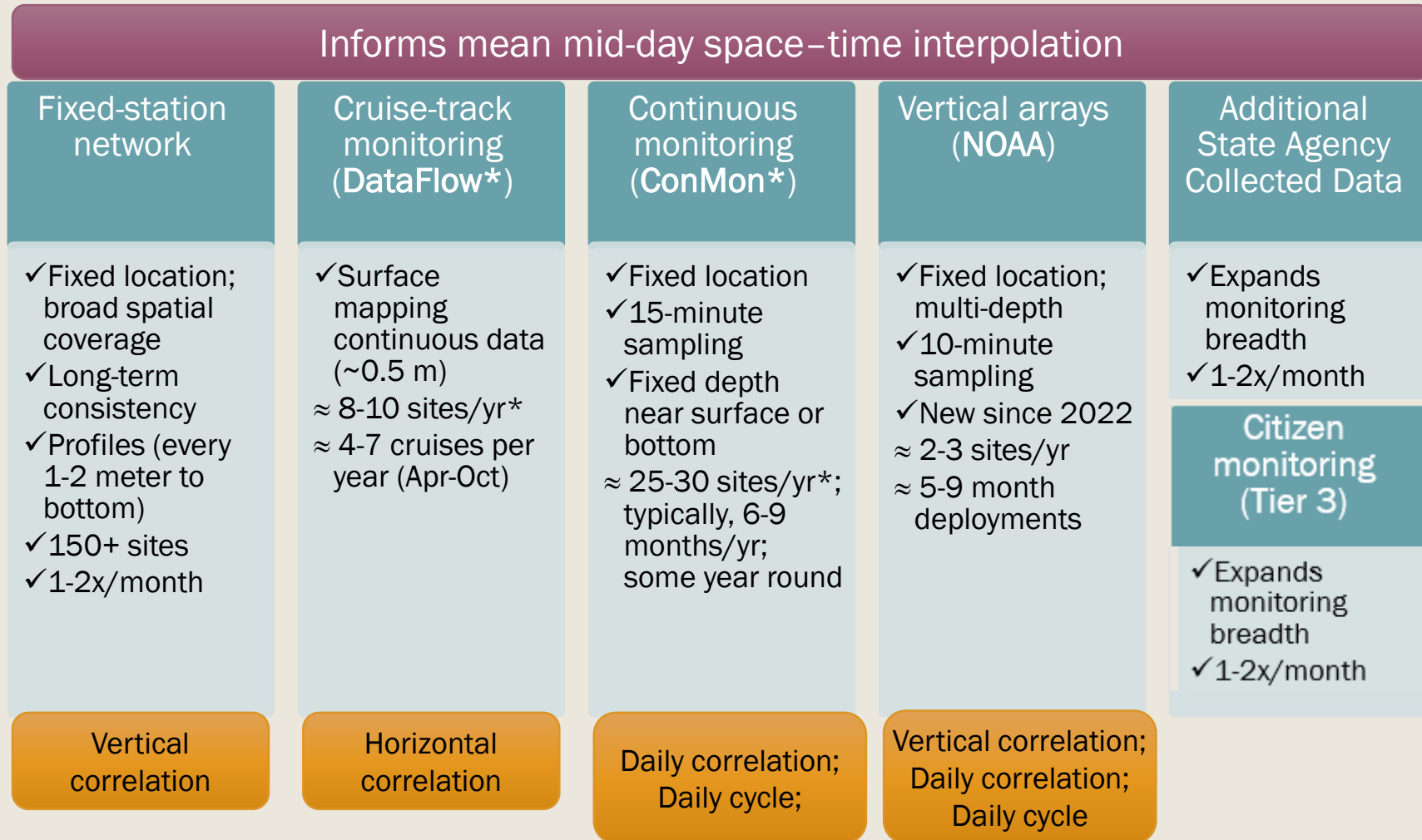
Table 1. Chesapeake Bay dissolved oxygen criteria.

Designated Use	Criteria Concentration/Duration	Protection Provided	Temporal Application
Migratory fish spawning and nursery use *	7-day mean ≥ 6 mg liter ⁻¹ (tidal habitats with 0-0.5 ppt salinity)	Survival/growth of larval/juvenile tidal-fresh resident fish; protective of threatened/endangered species.	February 1 - May 31
	Instantaneous minimum ≥ 5 mg liter ⁻¹	Survival and growth of larval/juvenile migratory fish; protective of threatened/endangered species.	
	Open-water fish and shellfish designated use criteria apply		June 1 - January 31
Shallow-water bay grass use	Open-water fish and shellfish designated use criteria apply		Year-round
Open-water fish and shellfish use	30-day mean ≥ 5.5 mg liter ⁻¹ (tidal habitats with 0-0.5 ppt salinity)	Growth of tidal-fresh juvenile and adult fish; protective of threatened/endangered species.	Year-round
	30-day mean ≥ 5 mg liter ⁻¹ (tidal habitats with >0.5 ppt salinity)	Growth of larval, juvenile and adult fish and shellfish; protective of threatened/endangered species.	
	7-day mean ≥ 4 mg liter ⁻¹	Survival of open-water fish larvae.	
	Instantaneous minimum > 3.2 mg liter ⁻¹	Survival of threatened/endangered sturgeon species. ¹	
Deep-water seasonal fish and shellfish use	30-day mean ≥ 3 mg liter ⁻¹	Survival and recruitment of bay anchovy eggs and larvae.	June 1 - September 30
	1-day mean ≥ 2.3 mg liter ⁻¹	Survival of open-water juvenile and adult fish.	
	Instantaneous minimum ≥ 1.7 mg liter ⁻¹	Survival of bay anchovy eggs and larvae.	
	Open-water fish and shellfish designated-use criteria apply		October 1 - May 31
Deep-channel seasonal refuge use	Instantaneous minimum ≥ 1 mg liter ⁻¹	Survival of bottom-dwelling worms and clams.	June 1 - September 30
	Open-water fish and shellfish designated use criteria apply		October 1 - May 31

*Note a 30-day mean 6 mg/L MSN value is evaluated for purpose of the WQ indicator.

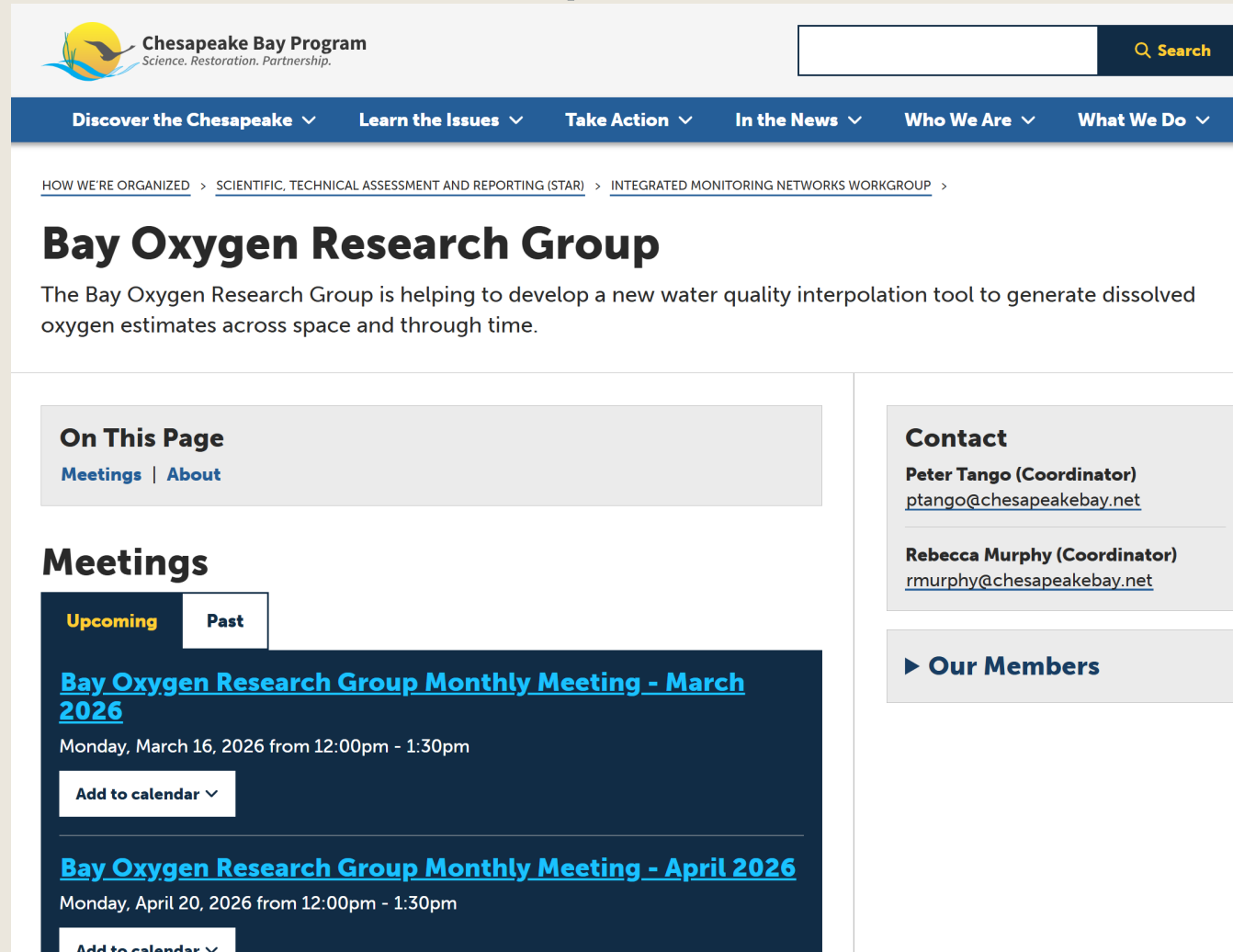
¹ At temperatures considered stressful to shortnose sturgeon (>29°C), dissolved oxygen concentrations above an instantaneous minimum of 4.3 mg liter⁻¹ will protect survival of this listed sturgeon species.

Data Landscape



*Sites commonly rotated about every 3 years to broaden coverage

Chesapeake Bay Program (CBP) Bay Oxygen Research Group



The screenshot shows the Chesapeake Bay Program website. The header includes the logo and navigation links: Discover the Chesapeake, Learn the Issues, Take Action, In the News, Who We Are, and What We Do. A search bar is also present. The main content area is titled "Bay Oxygen Research Group" and describes the group's mission to develop a water quality interpolation tool. A sidebar on the left contains "On This Page" links for Meetings and About, and a "Meetings" section with tabs for Upcoming and Past. The Upcoming meetings list two events: "Bay Oxygen Research Group Monthly Meeting - March 2026" and "Bay Oxygen Research Group Monthly Meeting - April 2026", both on Mondays at 12:00pm to 1:30pm, with "Add to calendar" buttons. The right sidebar contains a "Contact" section with information for Peter Tango and Rebecca Murphy, and a link to "Our Members".

Chesapeake Bay Program
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Discover the Chesapeake ▾ Learn the Issues ▾ Take Action ▾ In the News ▾ Who We Are ▾ What We Do ▾

HOW WE'RE ORGANIZED > SCIENTIFIC, TECHNICAL ASSESSMENT AND REPORTING (STAR) > INTEGRATED MONITORING NETWORKS WORKGROUP >

Bay Oxygen Research Group

The Bay Oxygen Research Group is helping to develop a new water quality interpolation tool to generate dissolved oxygen estimates across space and through time.

On This Page
[Meetings](#) | [About](#)

Meetings

Upcoming **Past**

[Bay Oxygen Research Group Monthly Meeting - March 2026](#)
Monday, March 16, 2026 from 12:00pm - 1:30pm
[Add to calendar ▾](#)

[Bay Oxygen Research Group Monthly Meeting - April 2026](#)
Monday, April 20, 2026 from 12:00pm - 1:30pm
[Add to calendar ▾](#)

Contact
Peter Tango (Coordinator)
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Rebecca Murphy (Coordinator)
rmurphy@chesapeakebay.net

► Our Members

- Group of CBP partners providing guidance, ideas, and review.
- Meets monthly during this development phase.
- Attendees include future users; state teams involved in criteria assessment; EPA, NOAA and USGS federal partners; and academic collaborators.
- Feel free to join if you're interested.

<https://www.chesapeakebay.net/who/group/bay-oxygen-research-group>