4-Dimensional interpolation tool for dissolved oxygen in Chesapeake Bay

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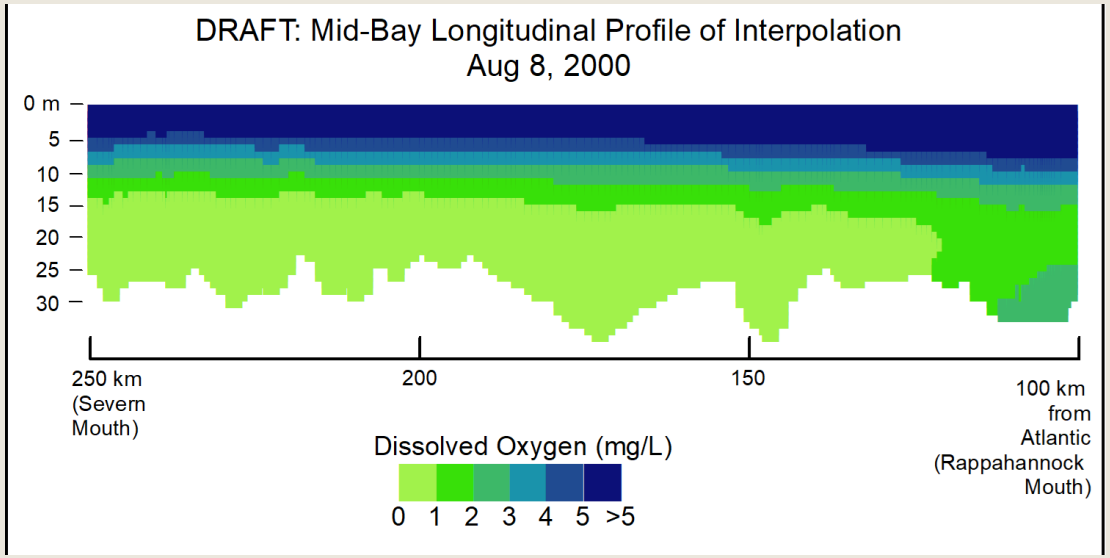

STAR Meeting
August 28, 2025

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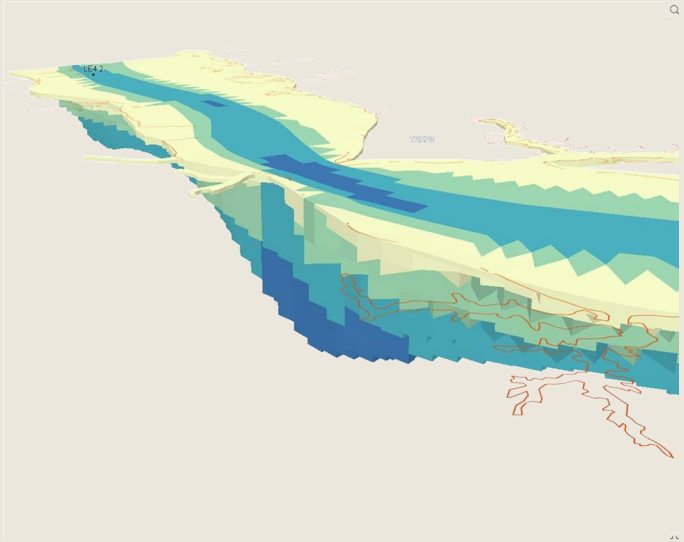
What makes the tool 4-D?

Space

Time

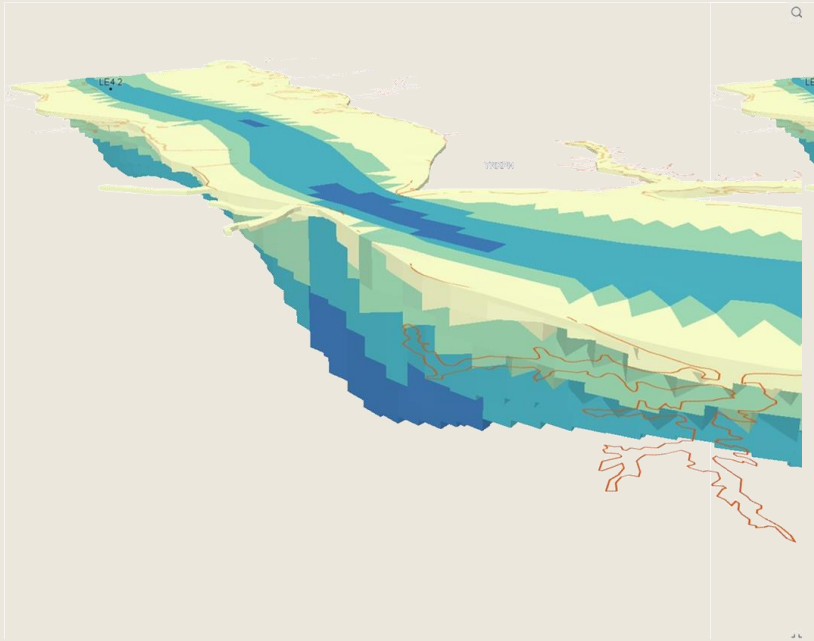
Spatial & Temporal

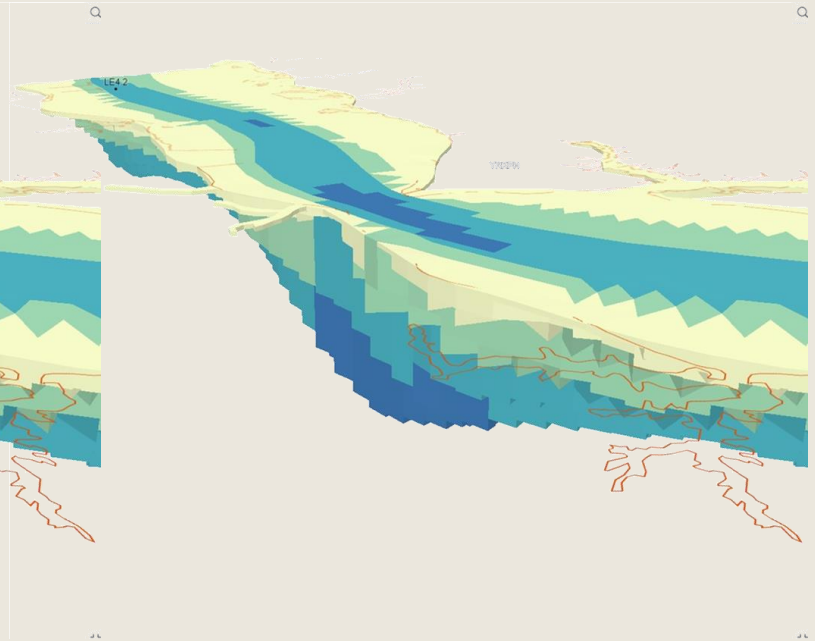
3-D + 1-D = 4-D

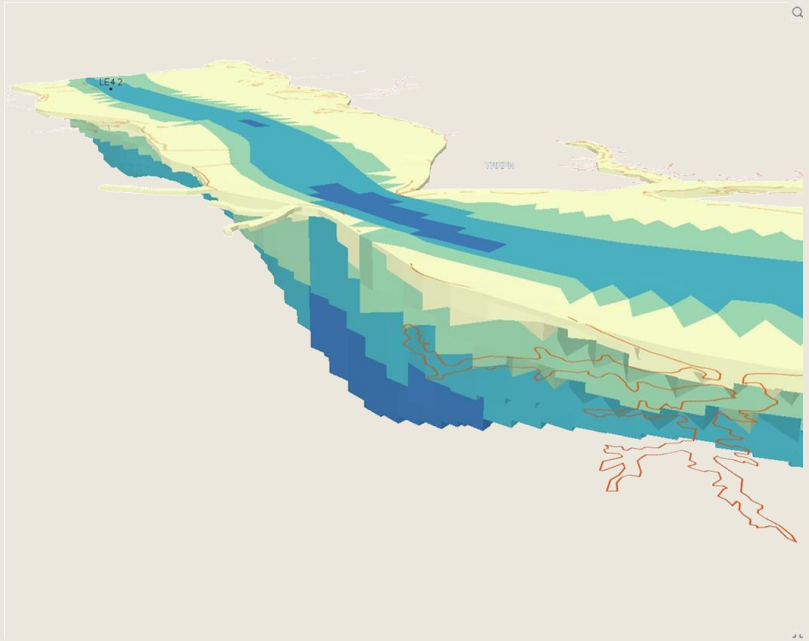


Create a 3D representation of DO through time (4D)

3/1/2024 Midnight 3/1/2024 1am … 8/01/2025 11pm



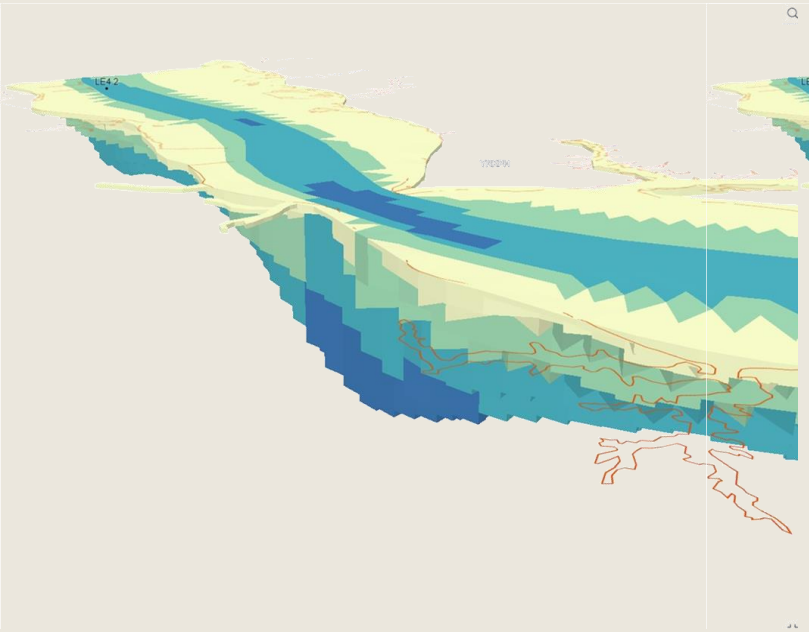




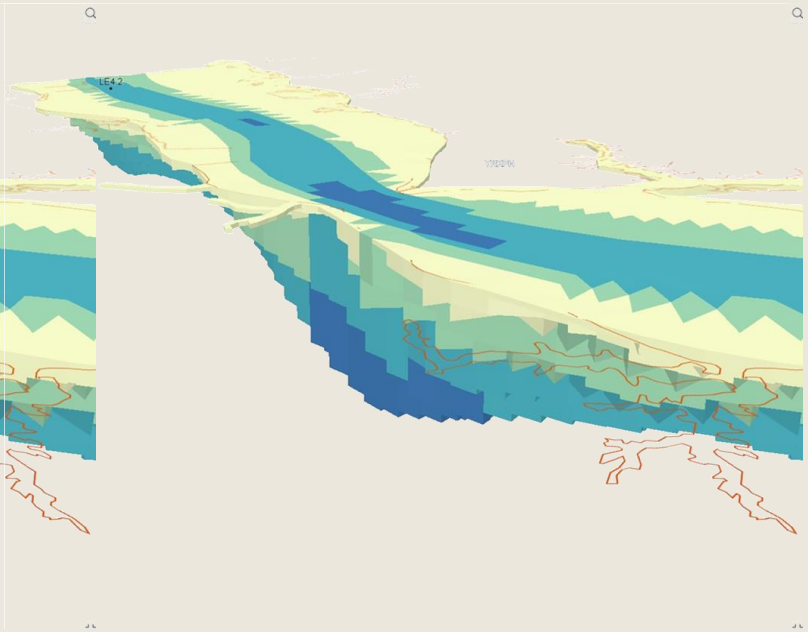
What is interpolation?

Interpolation makes a prediction inside your data to fill gaps

3/1/2024 Midnight



3/1/2024 1am



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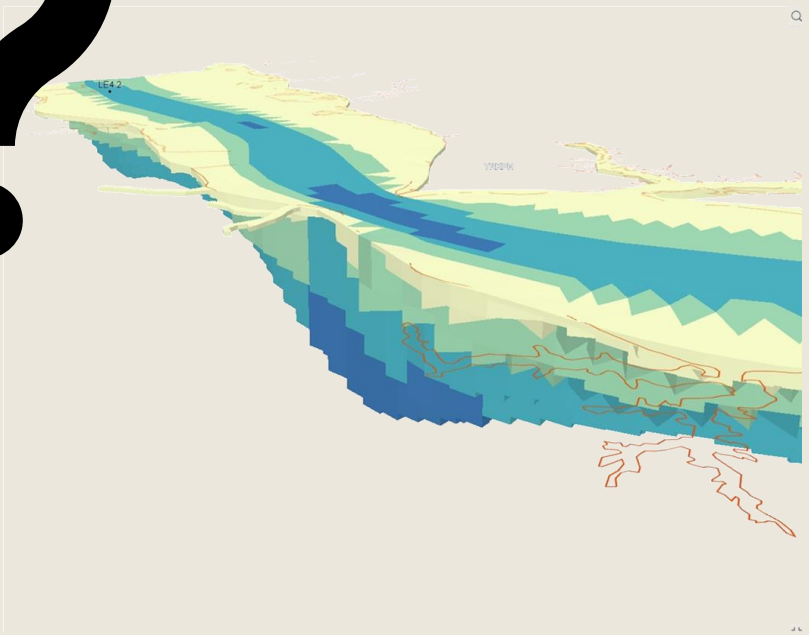
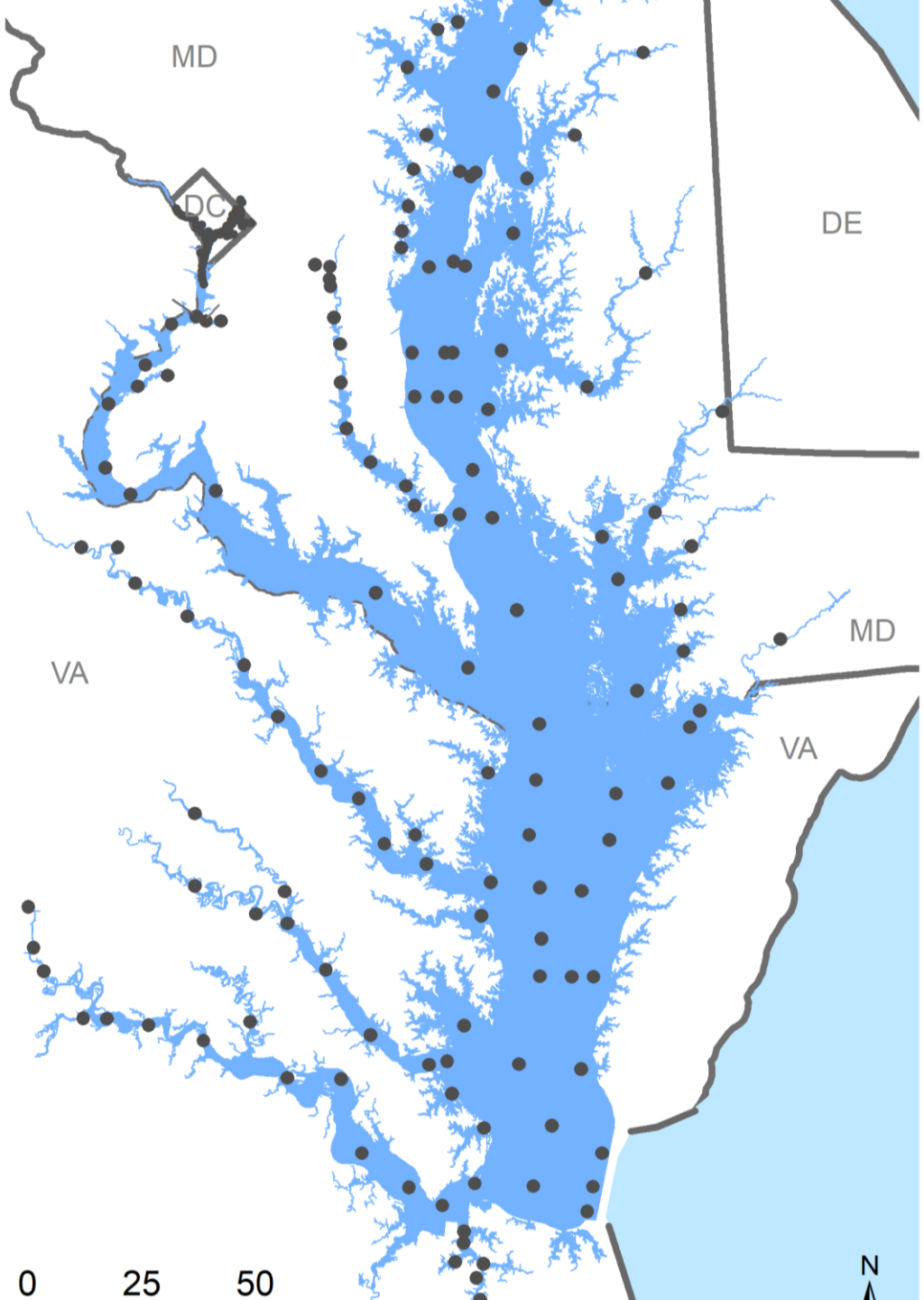
8/01/2025 11pm



Why does the partnership need a 4-D tool?



There cannot be monitoring everywhere:

- Funding constraints
- Timing/travel logistics

Monitoring

Water Quality Criteria

Purpose: Build a tool for more complete criteria assessment

Dissolved oxygen (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

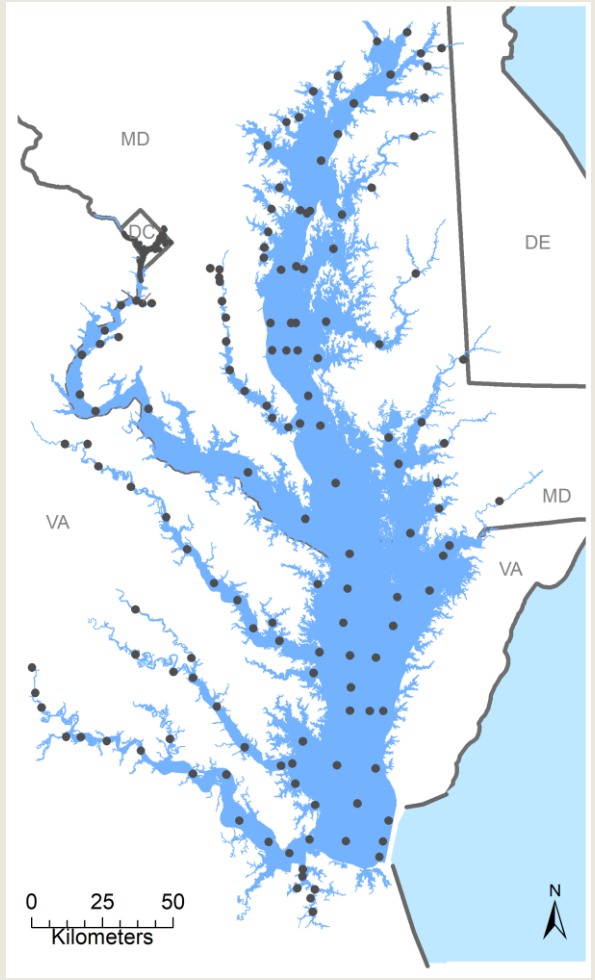
[1] At temperatures considered stressful to shortnose sturgeon (>29°C), dissolved oxygen concentrations above an instantaneous minimum of 4.3 mg liter^{-1} will protect survival of this listed sturgeon species.

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

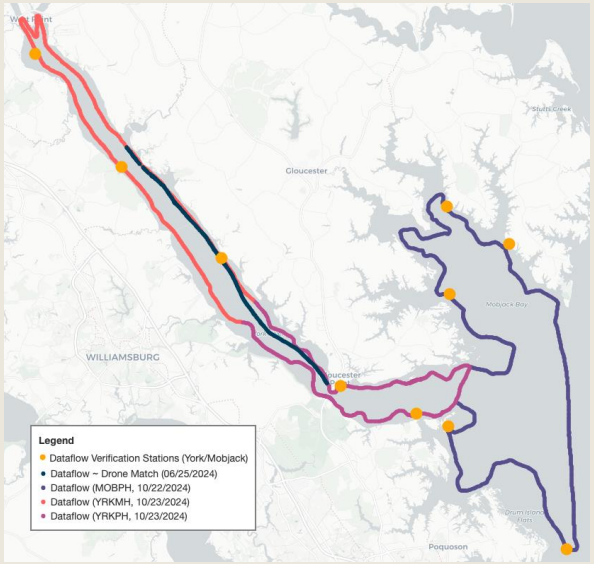
From EPA 2003 Ambient Water Quality Criteria

Dissolved Oxygen data sets

Bi-weekly long-term sampling (DOEE, MDDNR, VADEQ, CBP)

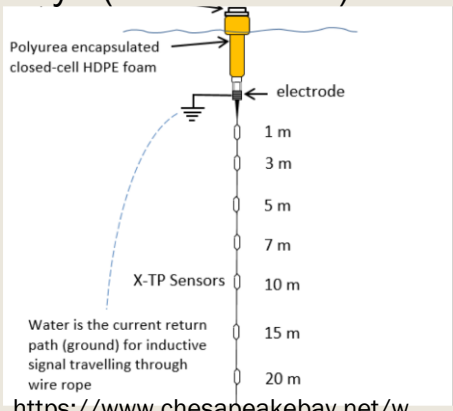


Dataflow (MDDNR and VECOS)



From http://vecos.vims.edu/

New continuous vertical arrays (NOAA & CBP)



https://www.chesapeakebay.net/who/group/hypoxia-collaborative-team

Shallow water continuous monitoring (MDDNR and VECOS)

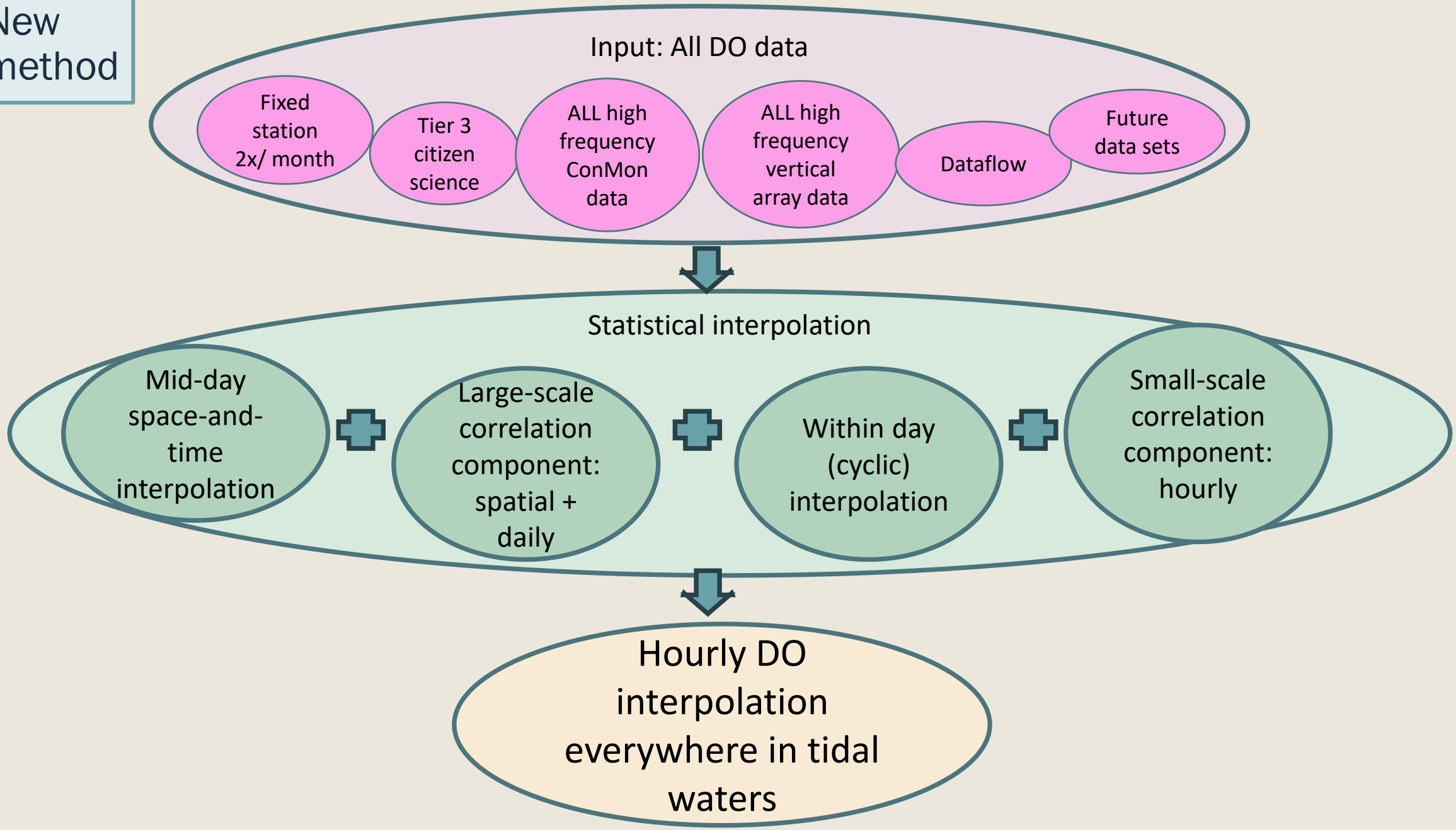
From http://vecos.vims.edu/

From https://eyesonthebay.dnr.maryland.gov/

And more: Citizen science, riverkeepers, and research data sets

IT'S TIME TO BREAK DOWN THE TOOL!

New method


Input: All DO data
Fixed station 2x/ month
Tier 3 citizen science
ALL high frequency ConMon data
ALL high frequency vertical array data
Dataflow
Future data sets
Statistical interpolation
Mid-day space-and-time interpolation
Large-scale correlation component: spatial + daily
Within day (cyclic) interpolation
Small-scale correlation component: hourly
Hourly DO interpolation everywhere in tidal waters

Daily DO estimates

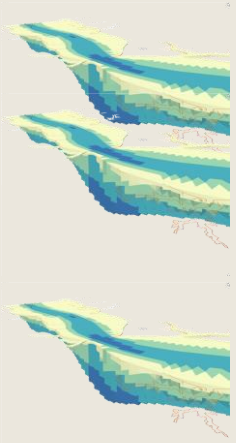
Mid-day space-and-time interpolation

3/1/2024

3/2/2024

...

8/1/2025



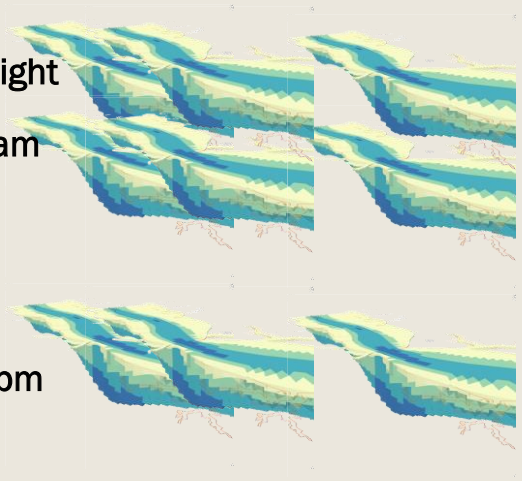
Hourly estimates

Within day (cyclic) interpolation

3/1/2024 Midnight

3/1/2024 1am

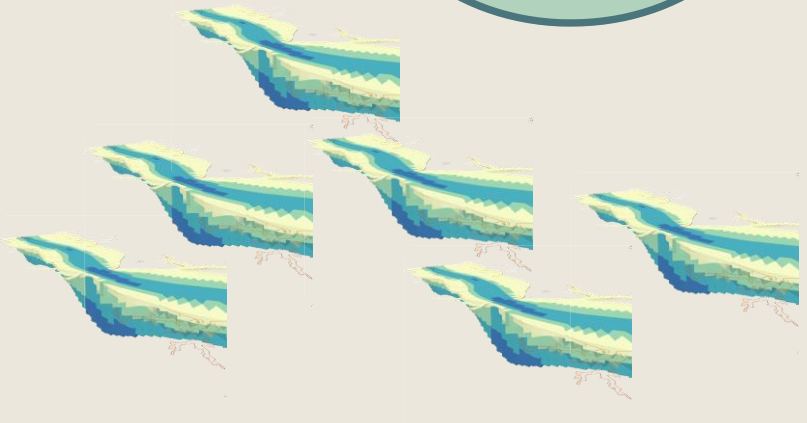
8/1/2025 11pm

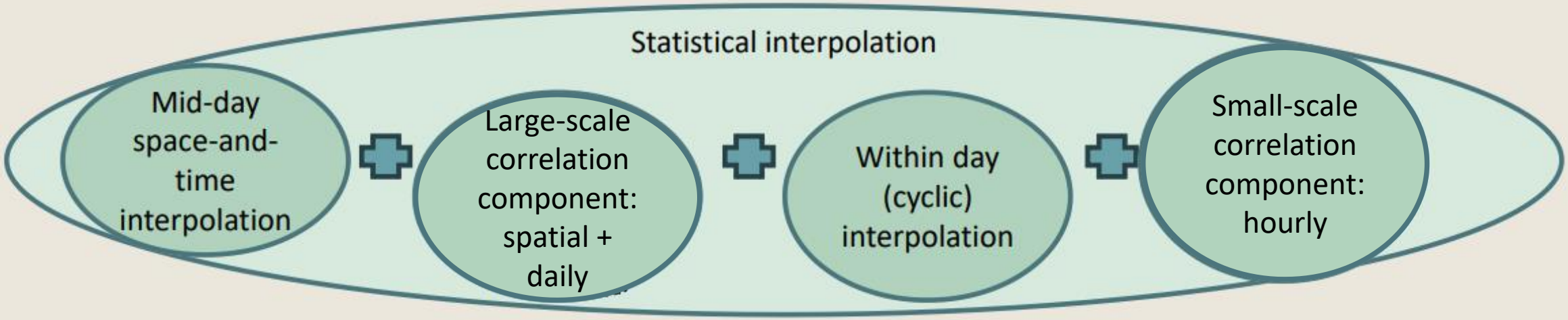


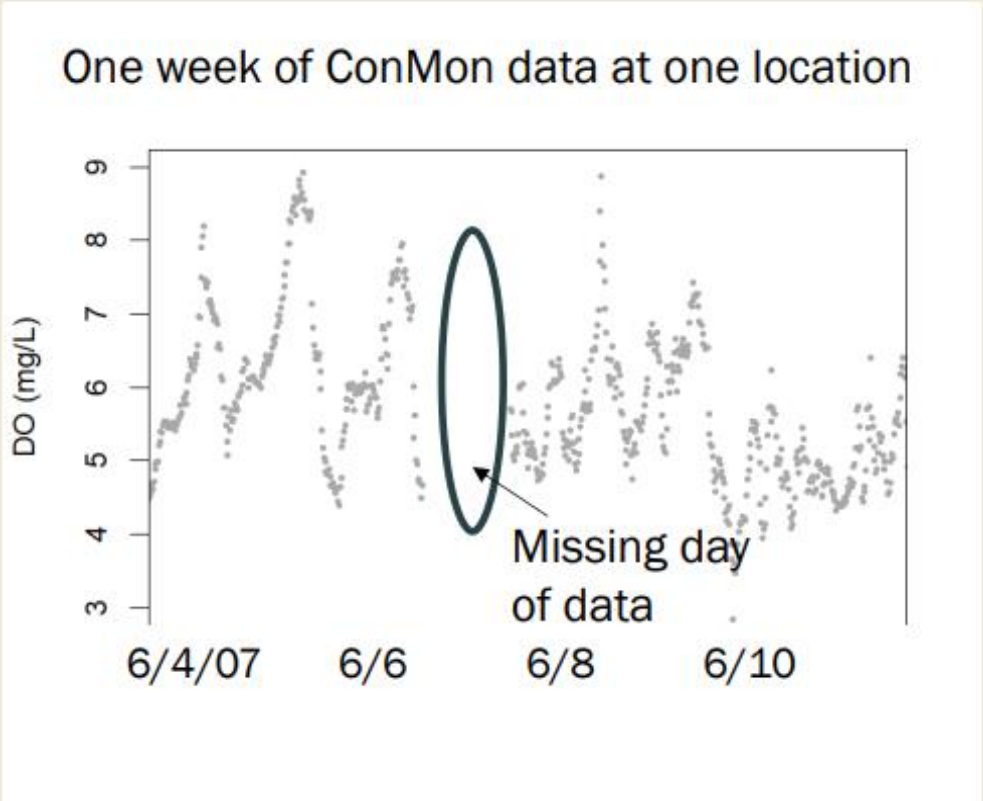
Estimates to show variations

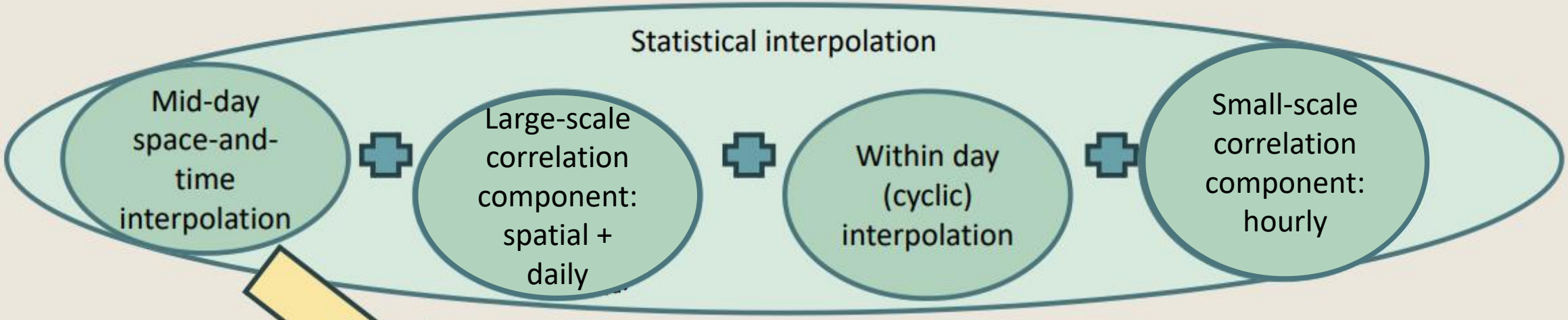
Large-scale correlation component: spatial + daily

Small-scale correlation component: hourly

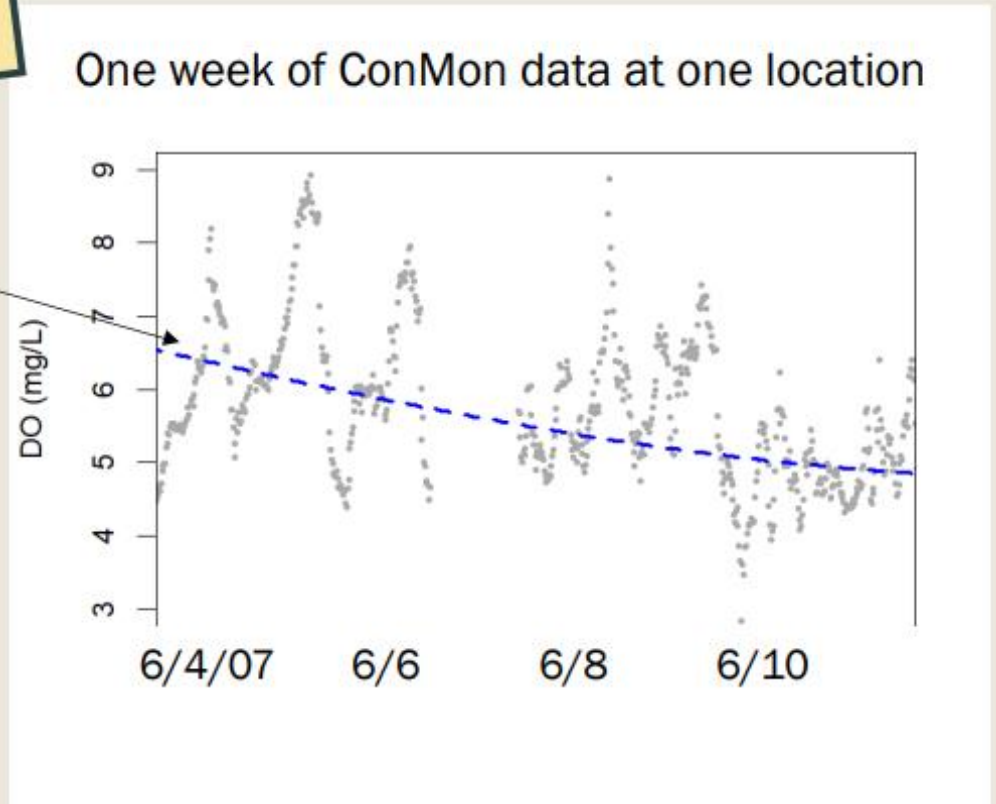


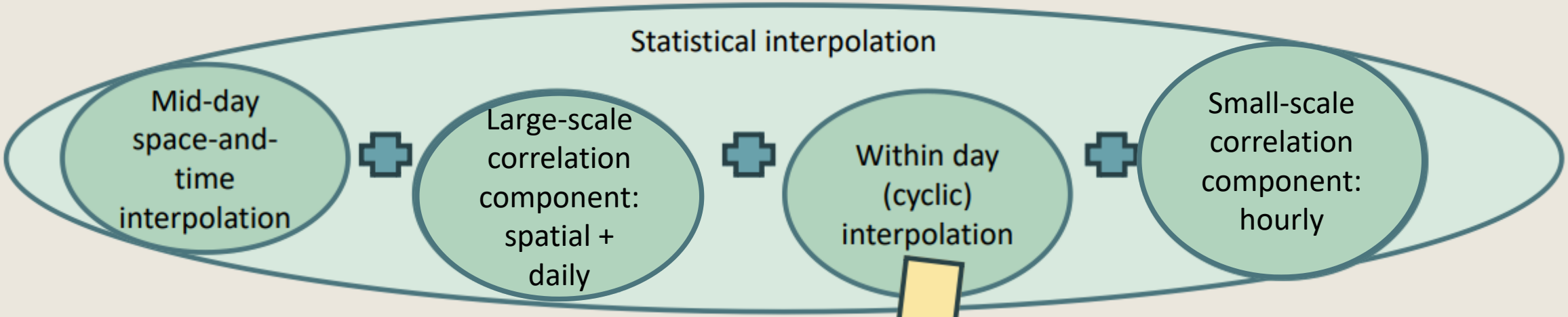

Statistical interpolation
Mid-day space-and-time interpolation
Large-scale correlation component: spatial + daily
Within day (cyclic) interpolation
Small-scale correlation component: hourly


One week of ConMon data at one location
DO (mg/L)
3
4
5
6
7
8
9
6/4/07
6/6
6/8
6/10
Missing day of data

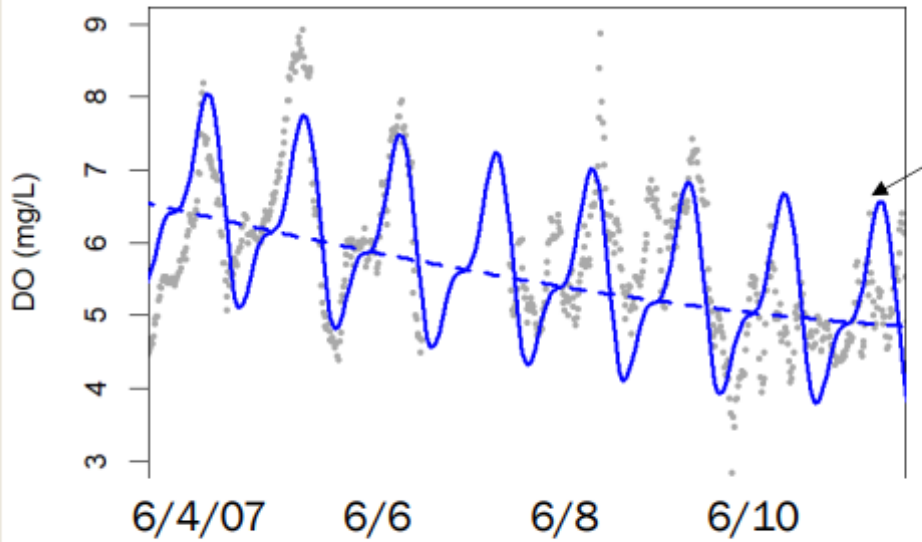


Mid-day interpolation:
Represents the gradual decrease observed in the data over this week.

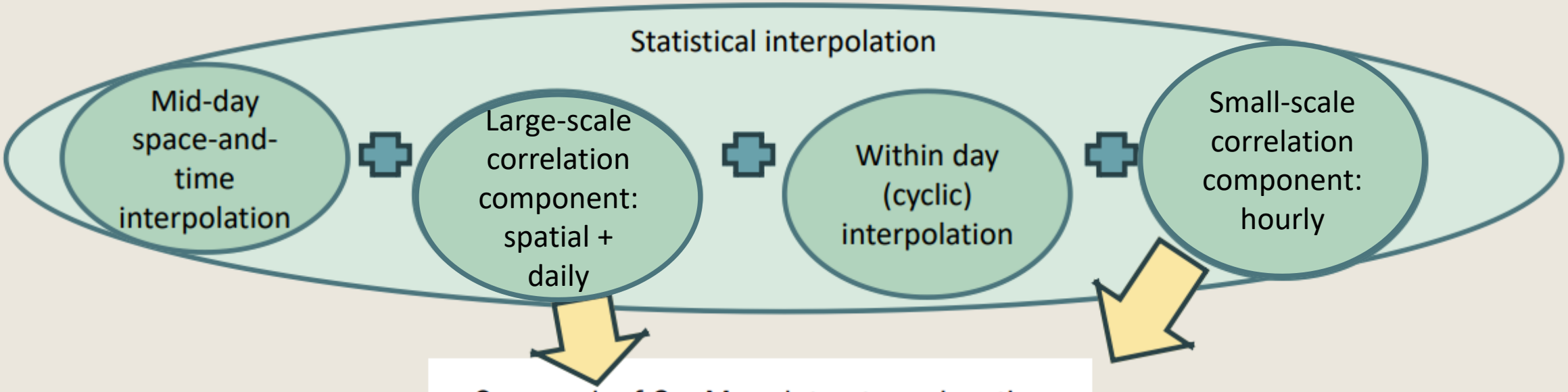




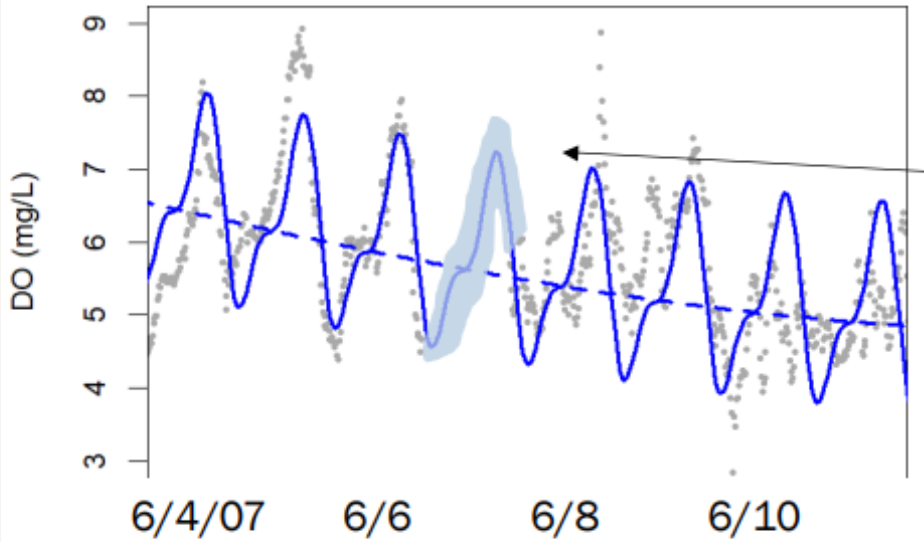
One week of ConMon data at one location



Within day (cyclic) interpolation:
Added to the daily interpolation and represents the diel and tidal cycles *(in practice, cycles will vary daily and by location)*

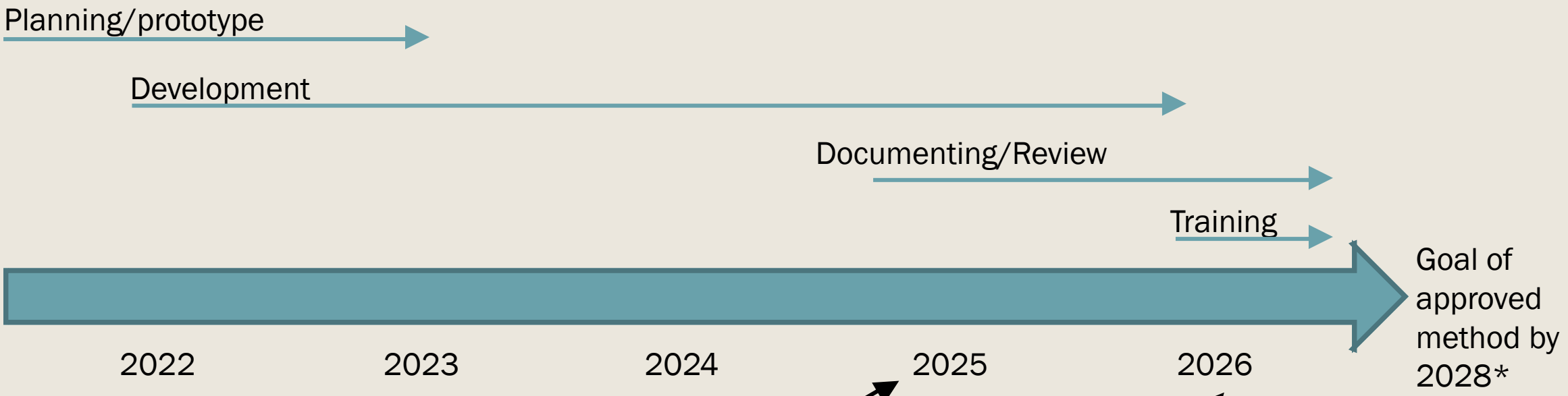


One week of ConMon data at one location



Multiple realizations:
Correlation components provide multiple realizations.

4-D interpolator development timeline



By the end of 2025:

- Working 4-D tool,
- Collaboration ongoing with CAP on criteria assessment methods.

In 2026-2027:

- Documenting,
- Additional functionality as needed for linking to criteria assessment,
- Preparing for training & review.

*with 2030 goal of reporting on all criteria