

Methods: Biological models

Six DO models:

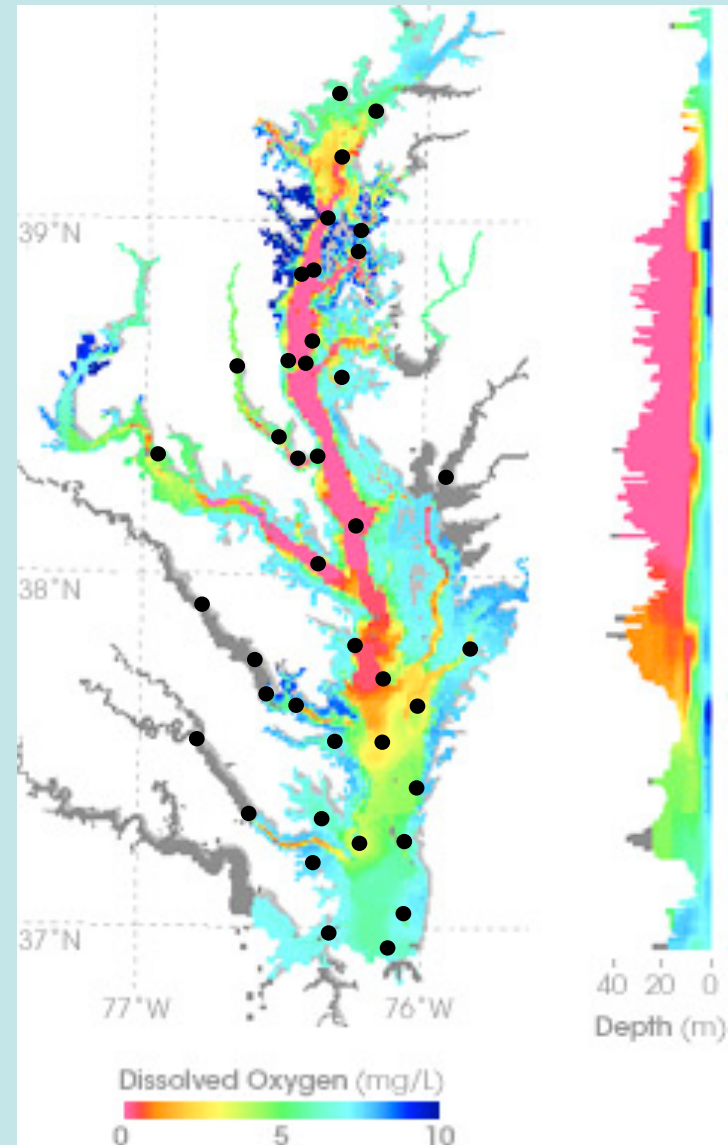
- ICM: Complex biology
- ChesROMS-bgc: Multi-compartmental model
- EFDC-1eqn: Simple one equation respiration
(includes SOD)
- CBOFS-1term: Constant net respiration
- ChesROMS-1term: Constant net respiration
- ChesROMS-1DD: Depth dependent net respiration

Methods: 40 CBP station data

late July
2004

Dissolved Oxygen [mg/L]
interpolated from
CBP station data

- = ~40 CBP stations used in this model-data comparison



Outline

1. Methods

- Hydrodynamic models
- Biological (DO) models
- Data

2. Relative model skill

- Animations
- Target diagrams
- Hypoxic volume (HV) time series

3. Model analyses

- Uncertainties in interpolated HV estimates
- Modifications of sampling strategies
- Study of mechanistic processes affecting hypoxia

4. Summary and Conclusions

Relative model skill: animation

Constant Respiration

ICM

Bottom DO [mg/L]

Animation deleted to make the ppt smaller!

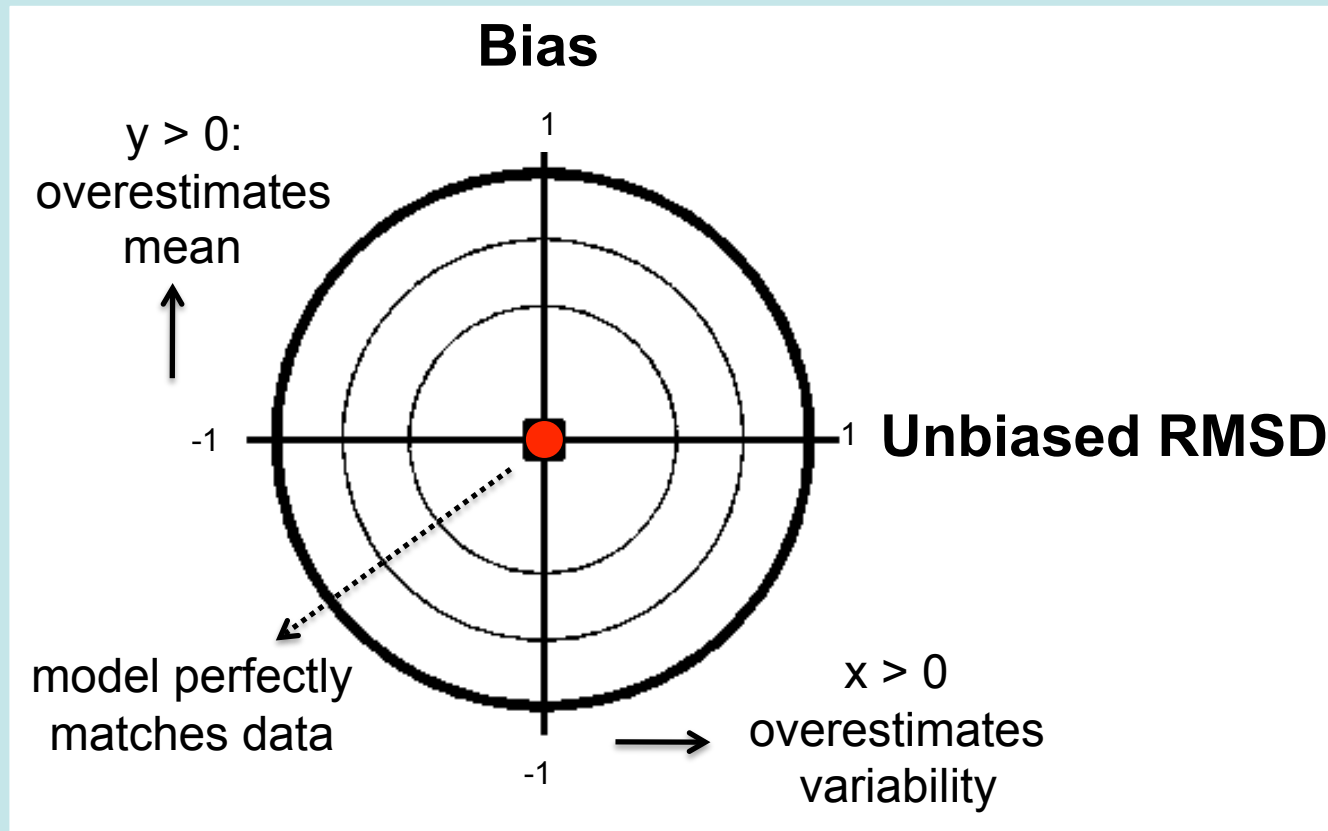
Relative model skill: Target diagrams

$$\text{Total RMSD}^2 = \text{Bias}^2 + \text{unbiased RMSD}^2$$

distance
from origin

mean

variability



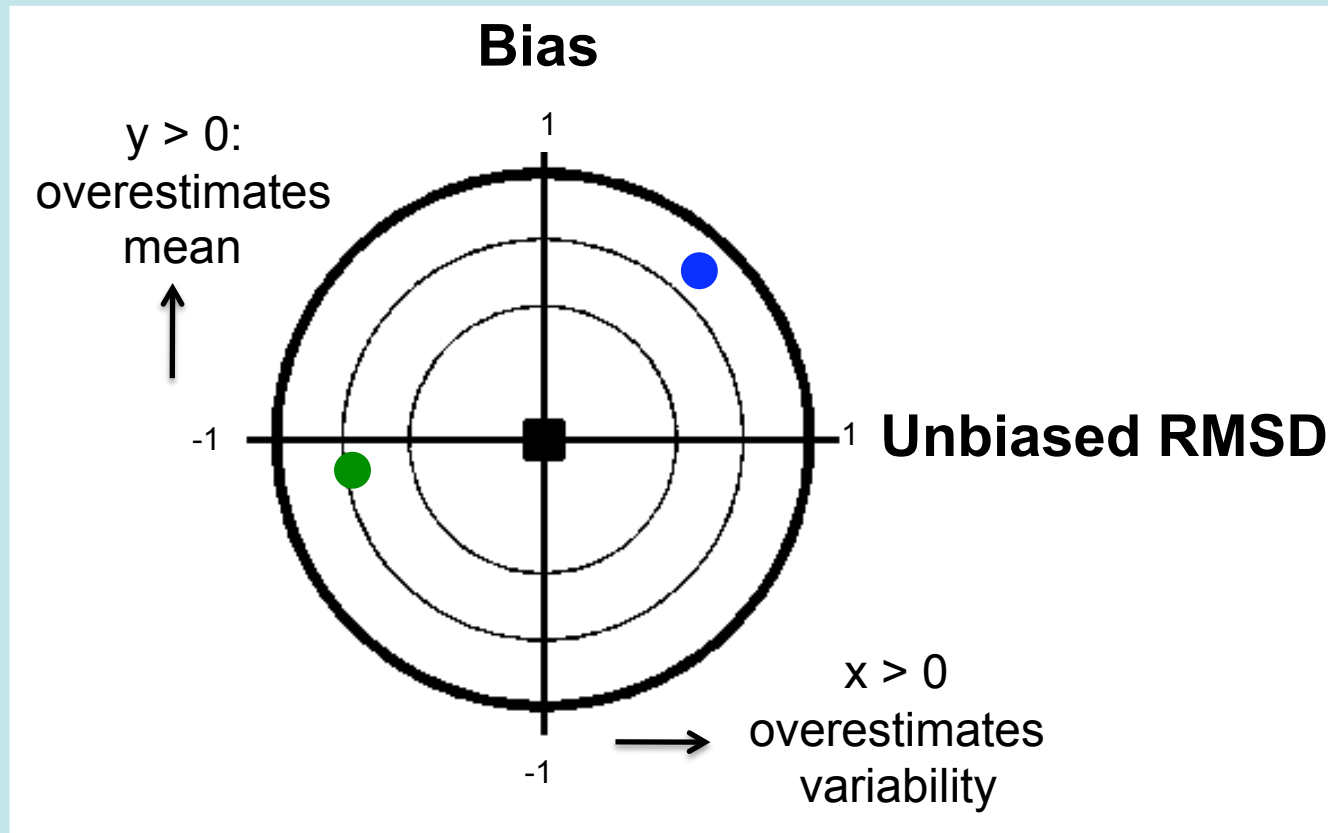
Relative model skill: Target diagrams

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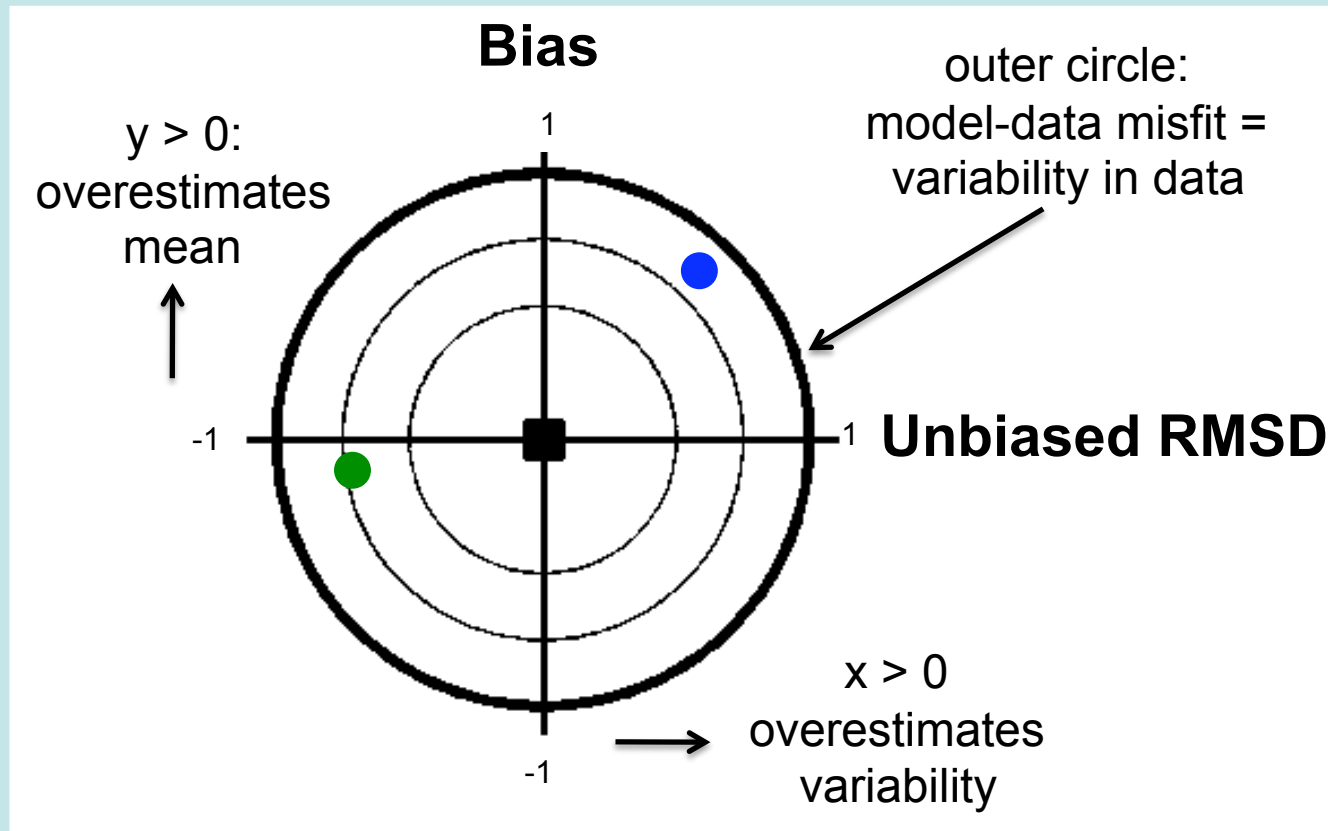
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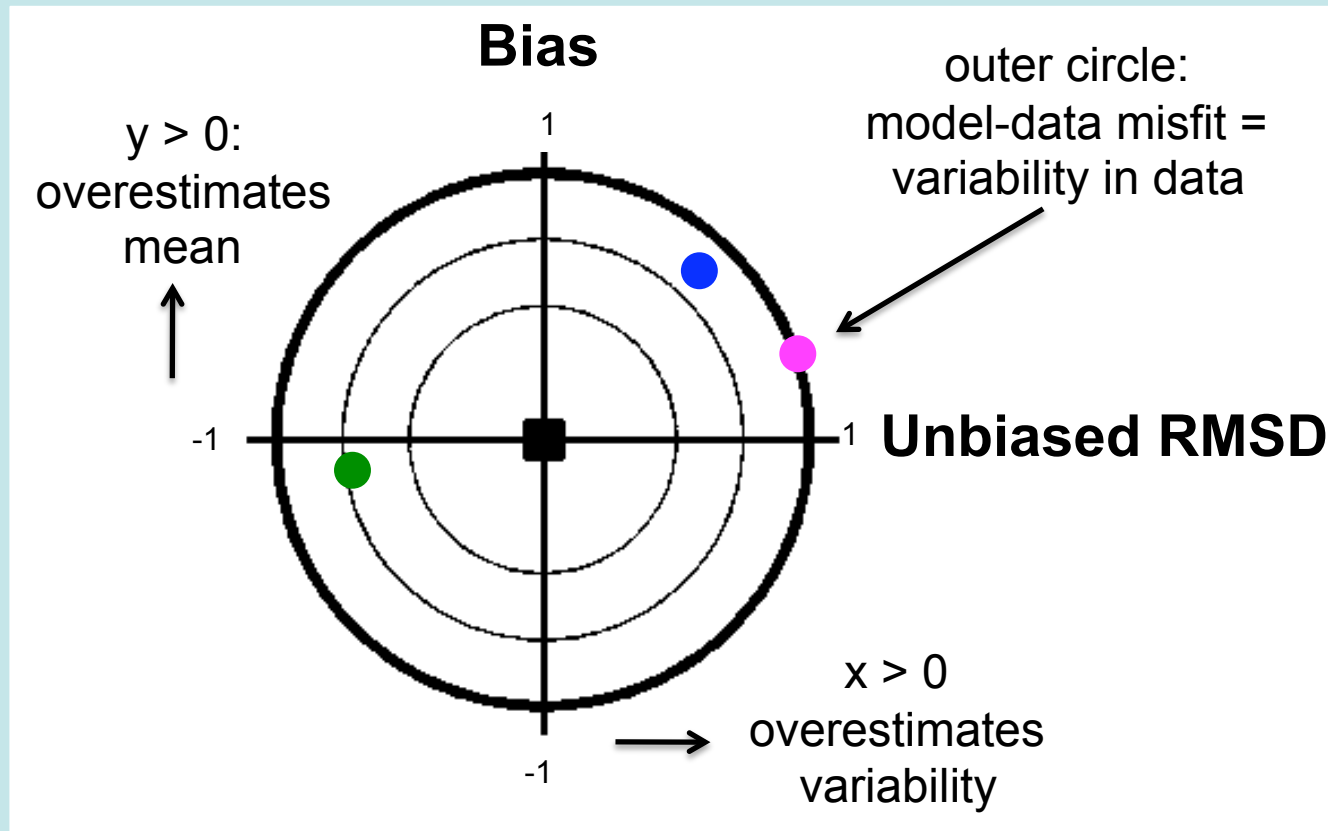
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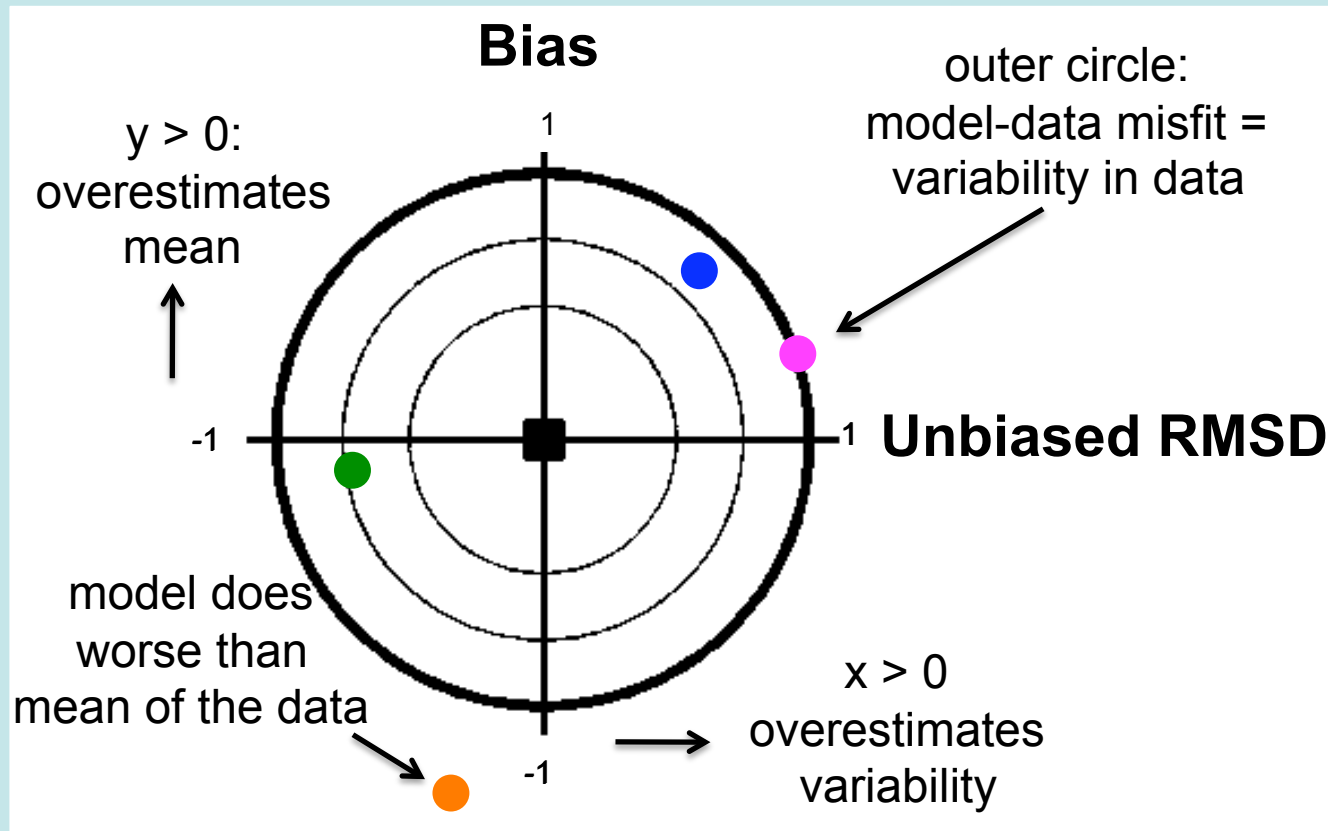
Relative model skill: Target diagrams

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mean

variability



Methods: Biological models

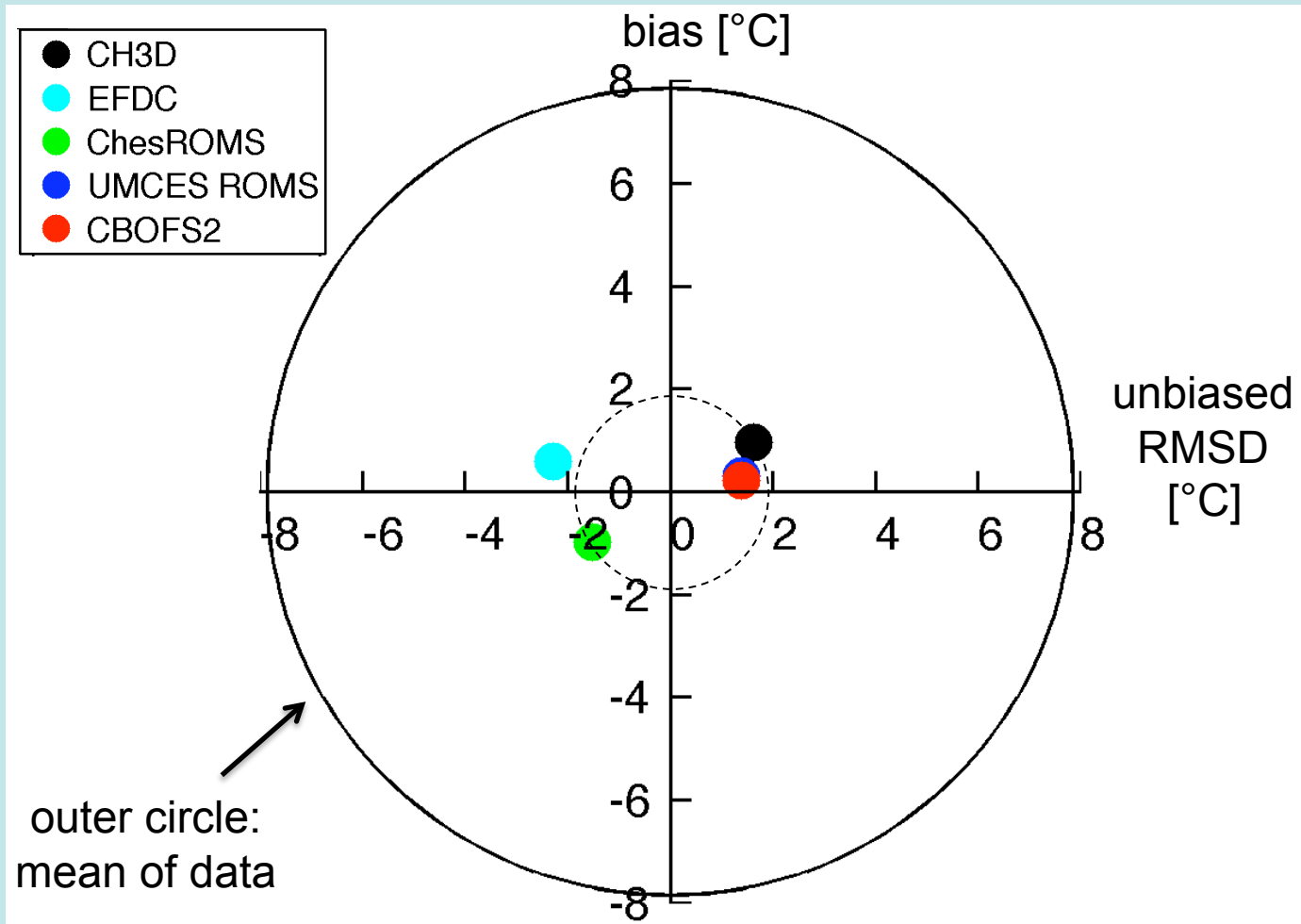
Five hydrodynamic models:

- bottom temperature
- bottom salinity
- maximum stratification (dS/dz)
- depth of maximum stratification

Six DO models:

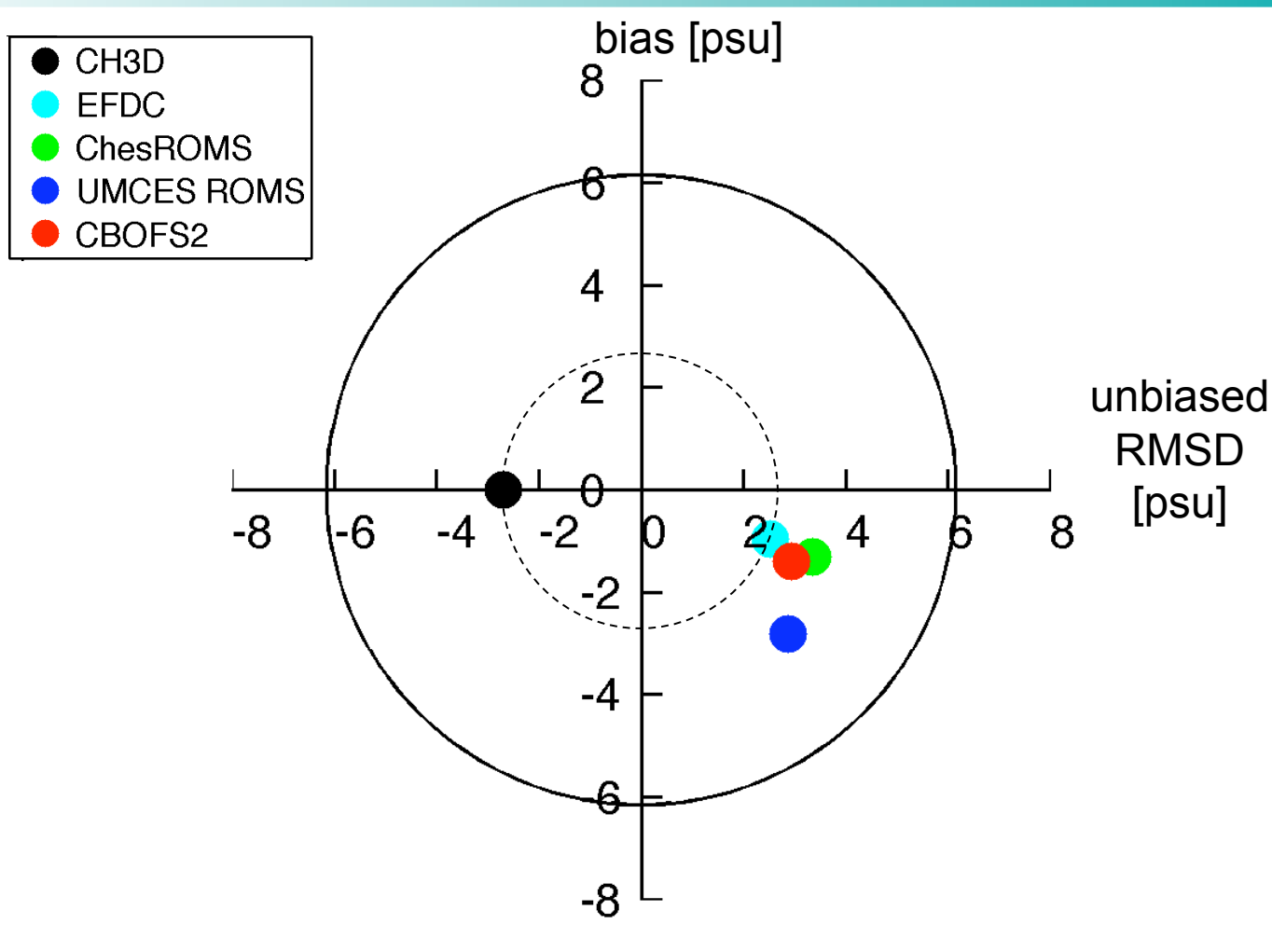
- bottom DO
 - Spatial variability
 - Temporal variability
- hypoxic volume

Results: Bottom Temperature (2004)



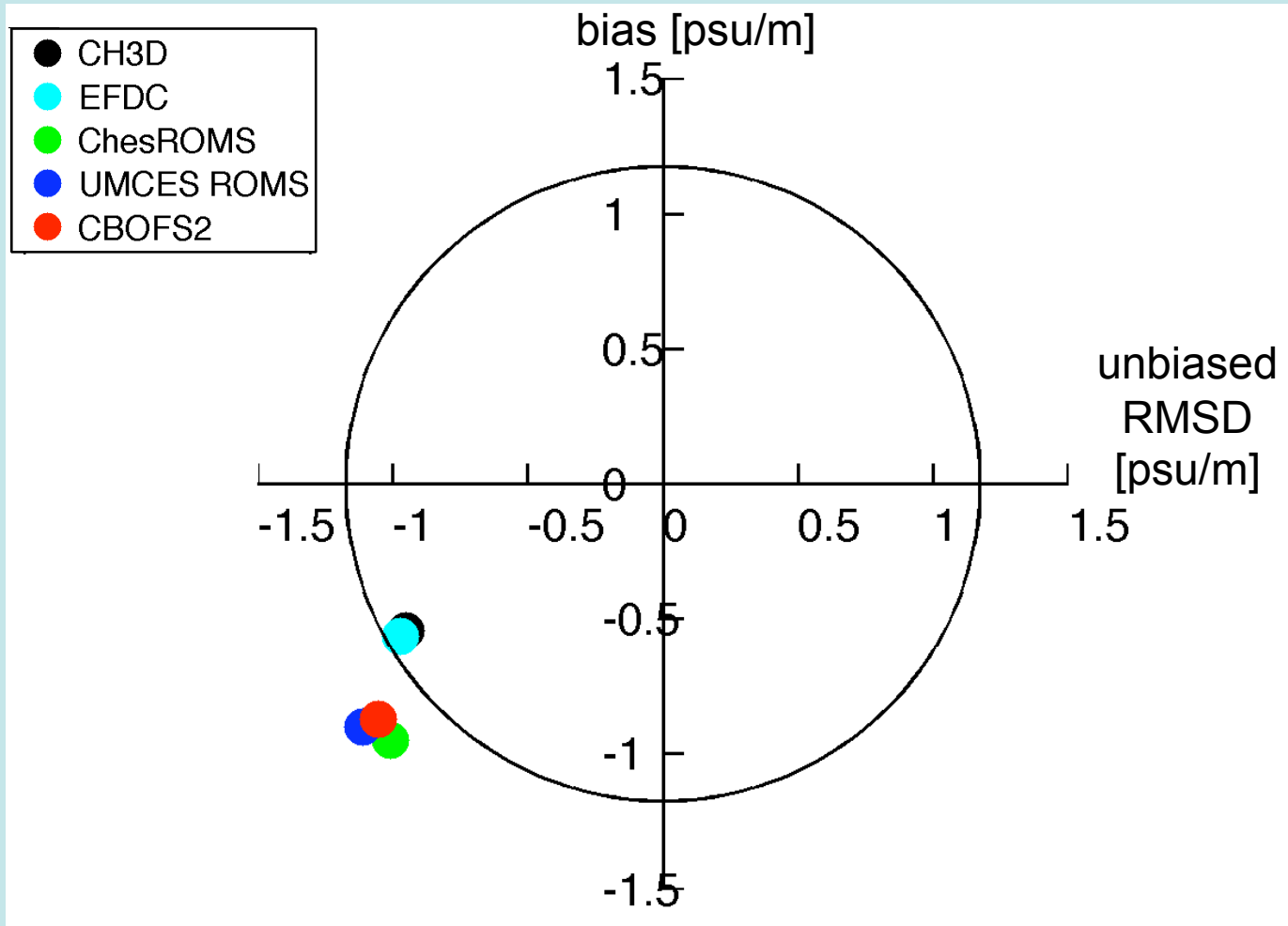
Models all successfully reproduce seasonal/spatial variability of bottom temperature (ROMS models do best)

Results: Bottom Salinity (2004)



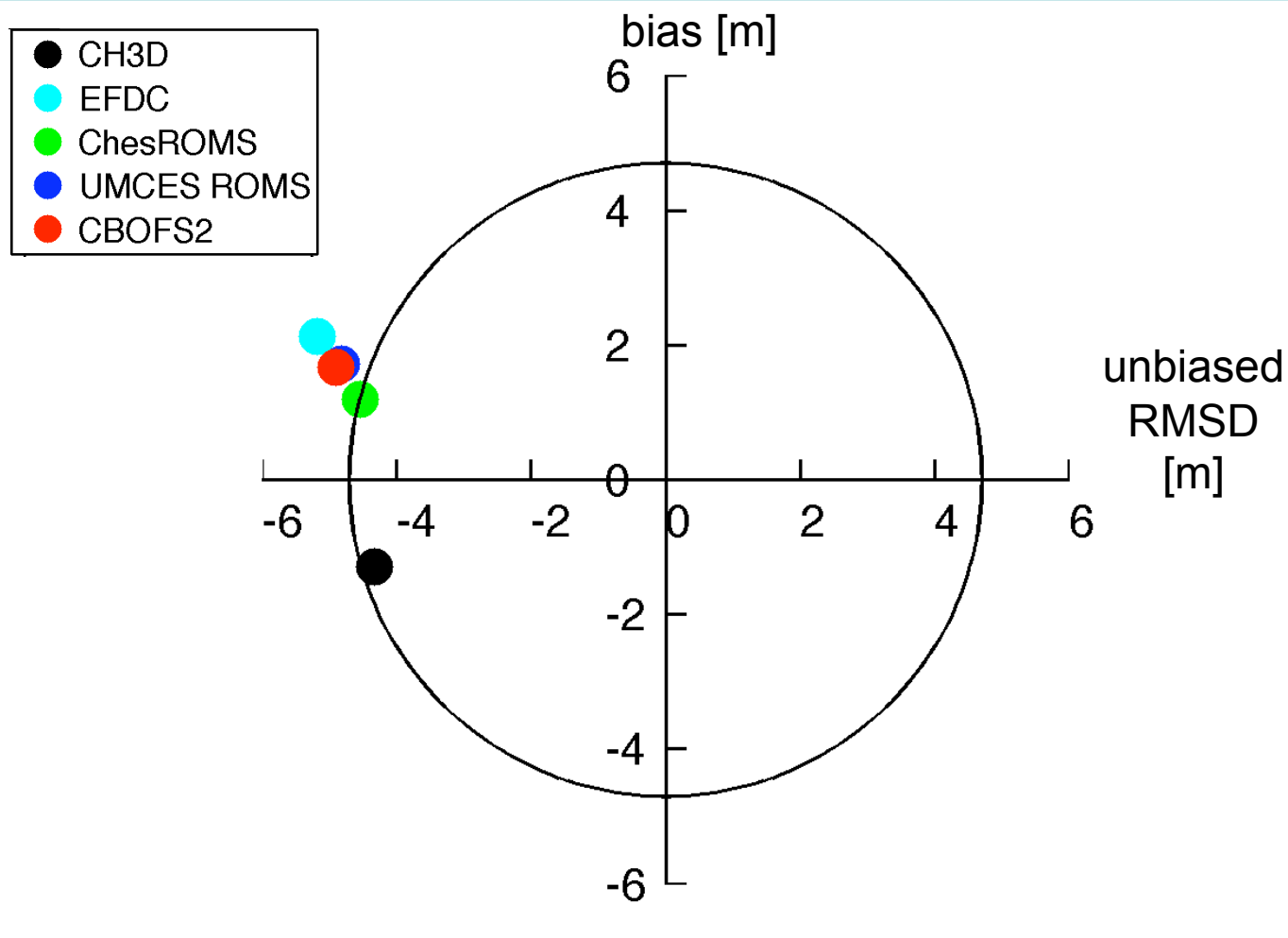
CH3D, EFDC reproduce bottom salinity best

Results: Stratification (max dS/dz)



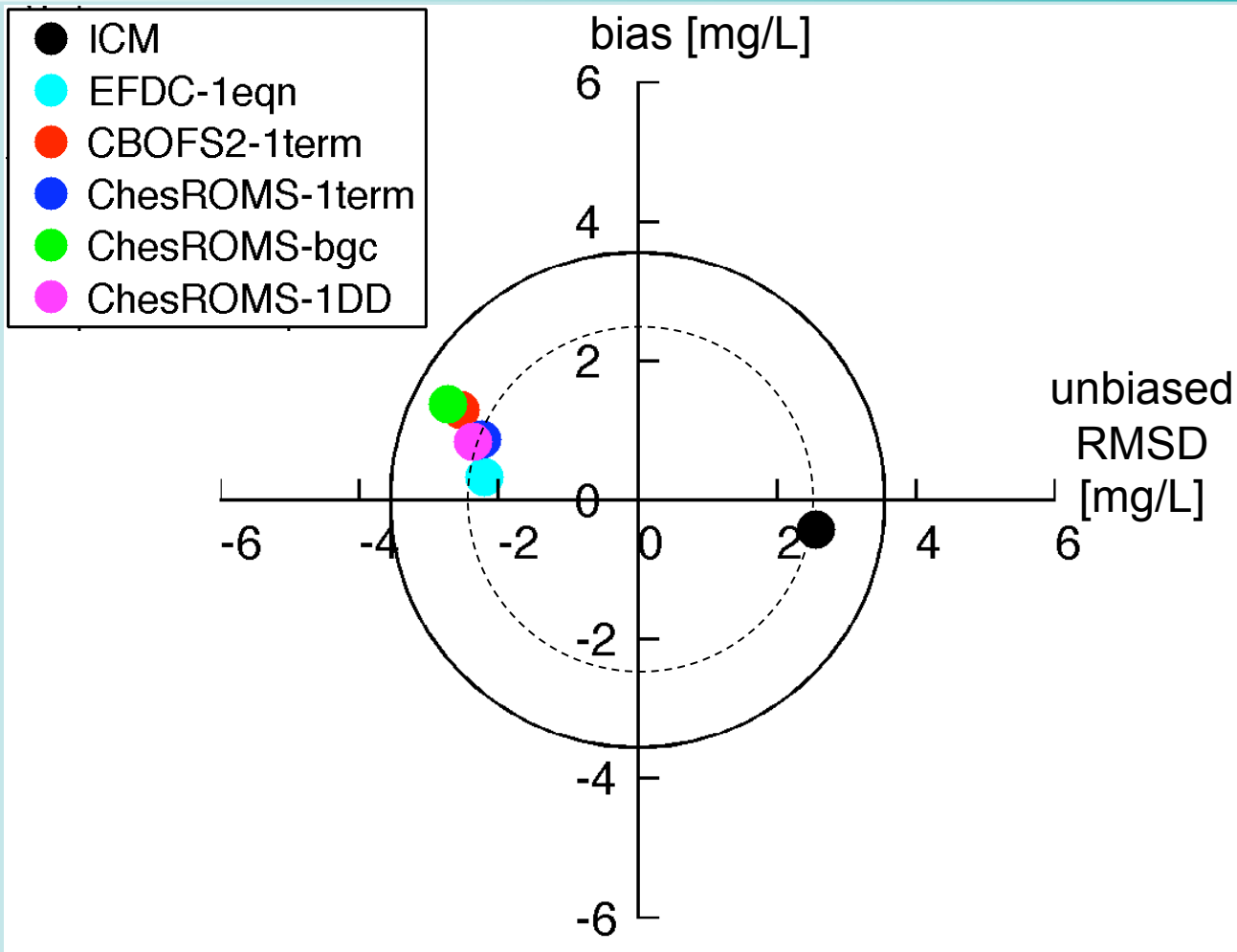
Stratification is a challenge; CH3D, EFDC reproduce seasonal/spatial variability best

Results: Depth of Max. Stratification



Stratification is a challenge; CH3D, ChesROMS reproduce the depth of stratification the best

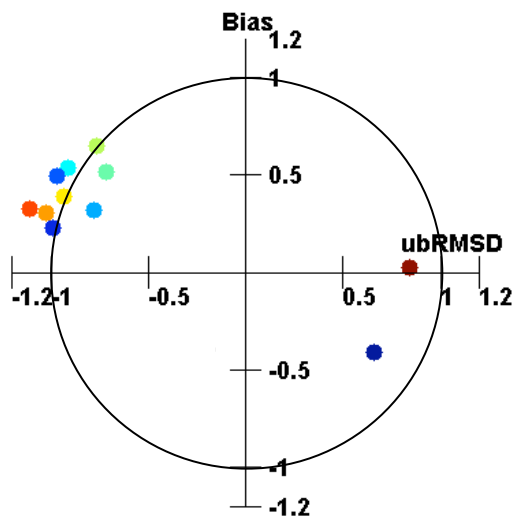
Results: Bottom Dissolved Oxygen



Simple models reproduce seasonal + temporal variability in bottom DO about as well as ICM

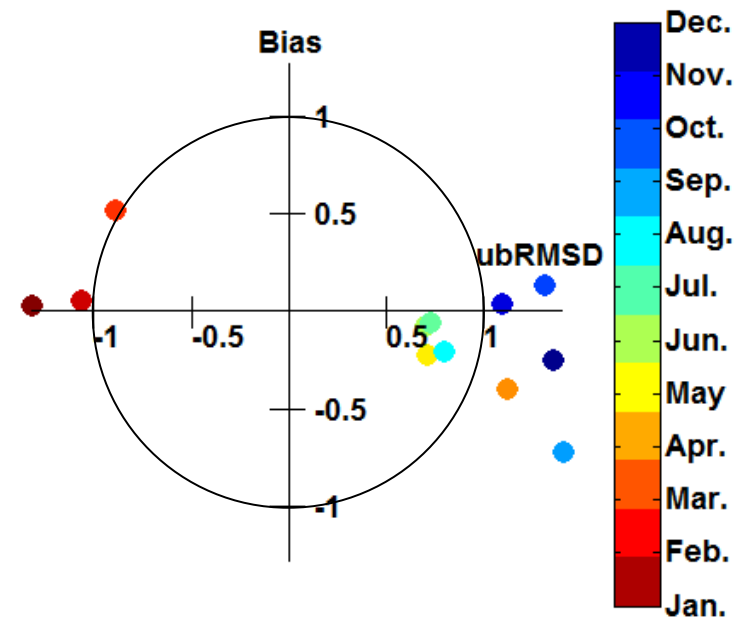
Results: Bottom DO – spatial variability

1-term DO model



Total RMSD = 1.0 ± 0.1

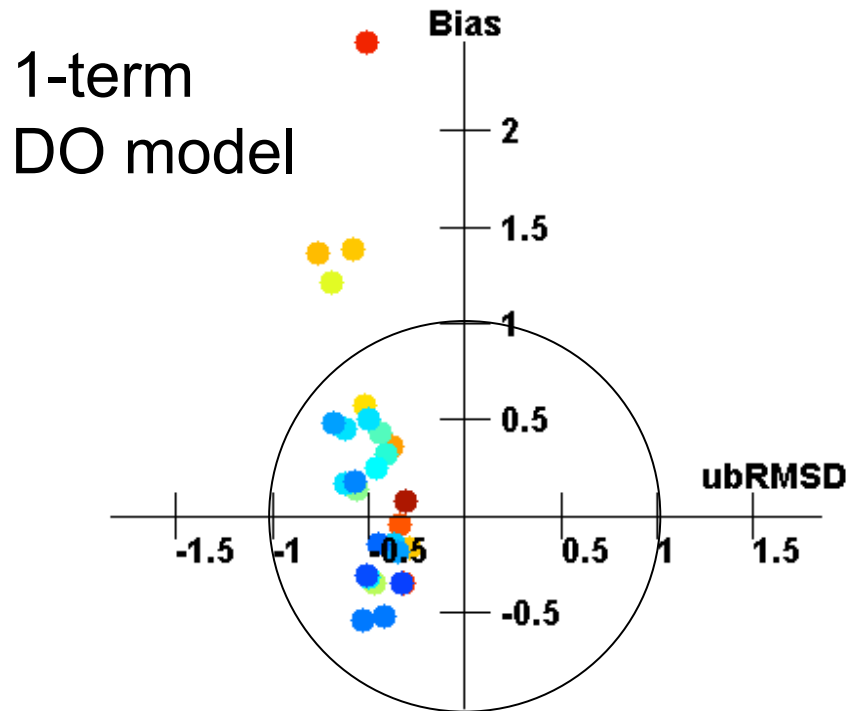
ICM
(CBP model)



Total RMSD = 1.1 ± 0.1

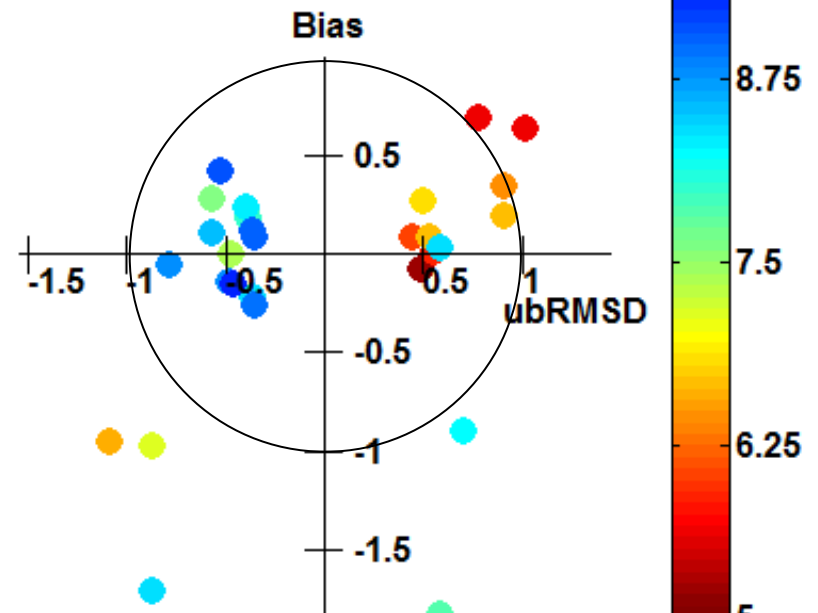
Overall model-data fit to CBP station
bottom DO data is similar

Results: Bottom DO – temporal variability



Total RMSD = 0.9 ± 0.1

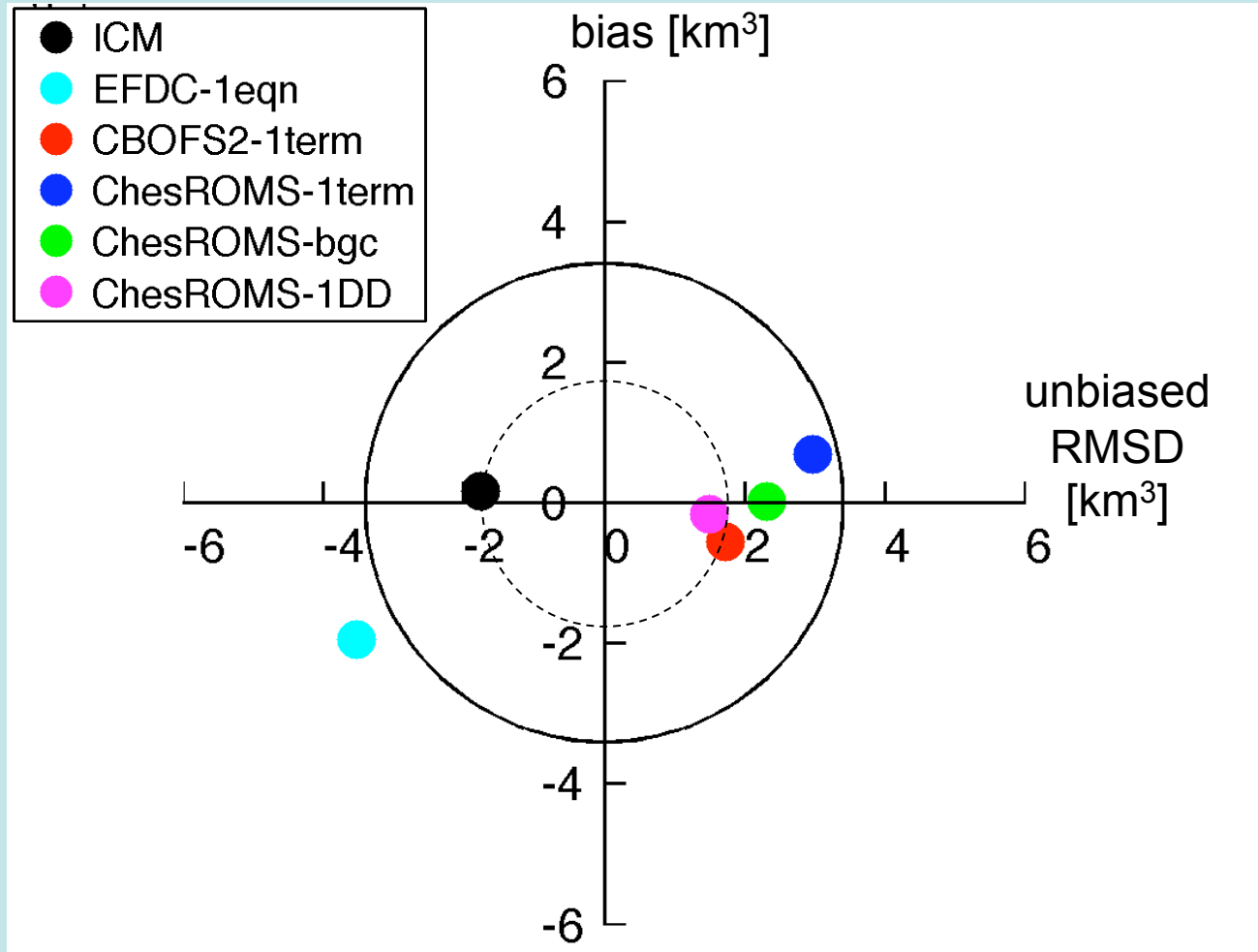
ICM
(complex CBP model)



Total RMSD = 0.9 ± 0.1

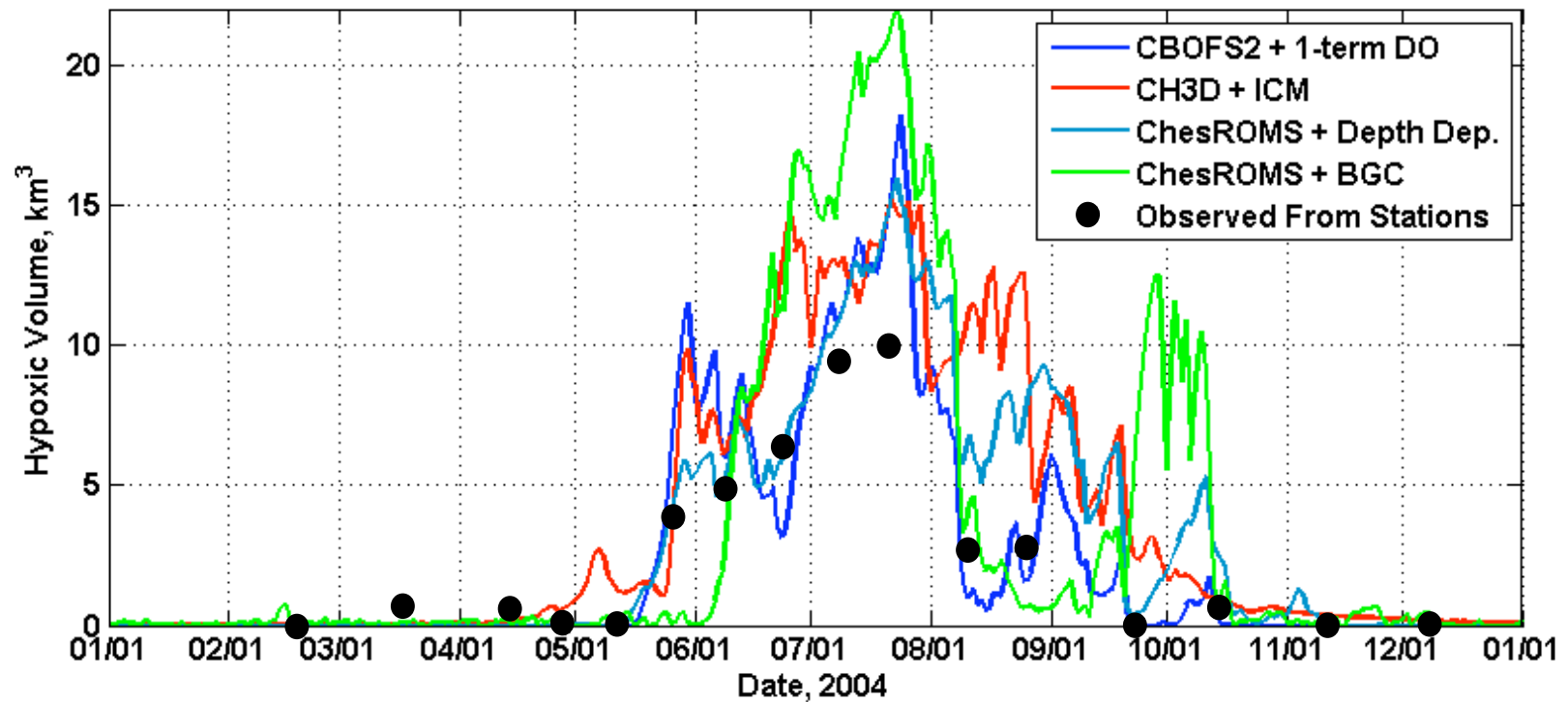
1-term DO model underestimates high DO and overestimates low DO: high not high enough, low not low enough

Results: Hypoxic Volume



Several simple DO models reproduce seasonal variability of hypoxic volume about as well as ICM

Results: Hypoxic Volume Time Series



Several simple DO models reproduce seasonal variability of hypoxic volume about as well as ICM

Courtesy of A. Bever

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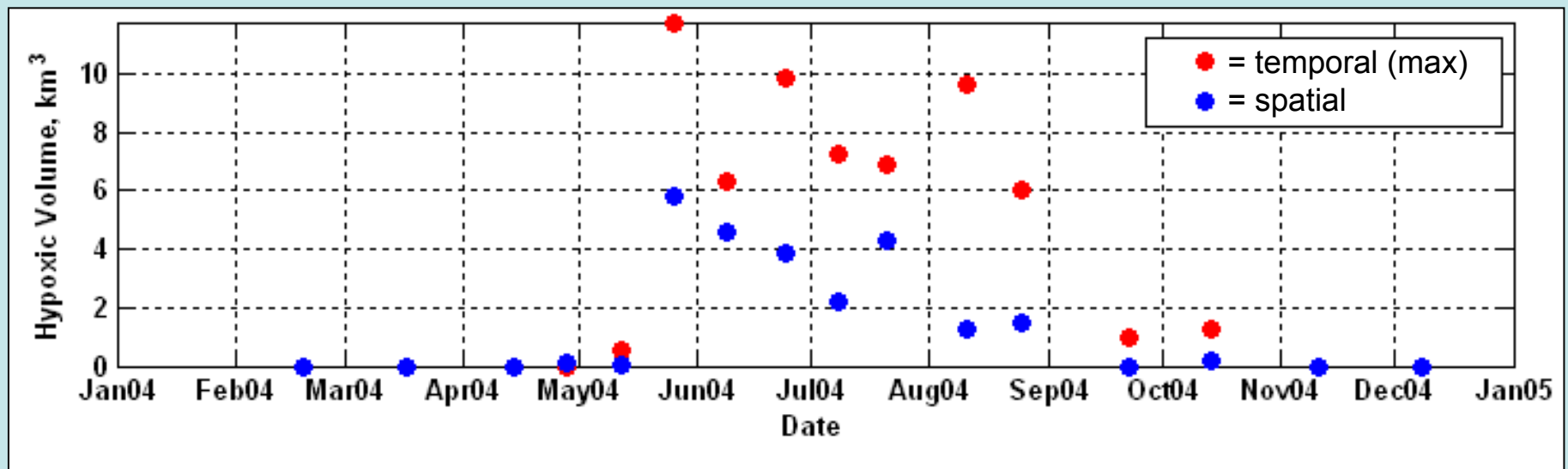
3. Model analyses

- Uncertainties in interpolated HV estimates
- Modifications of sampling strategies
- Study of mechanistic processes affecting hypoxia

4. Summary and Conclusions

Analyses: Uncertainty in hypoxic volume 'data'

Uncertainties Computed from ChesROMS+1-term model



Mean modeled summer HV = $\sim 8 \text{ km}^3$

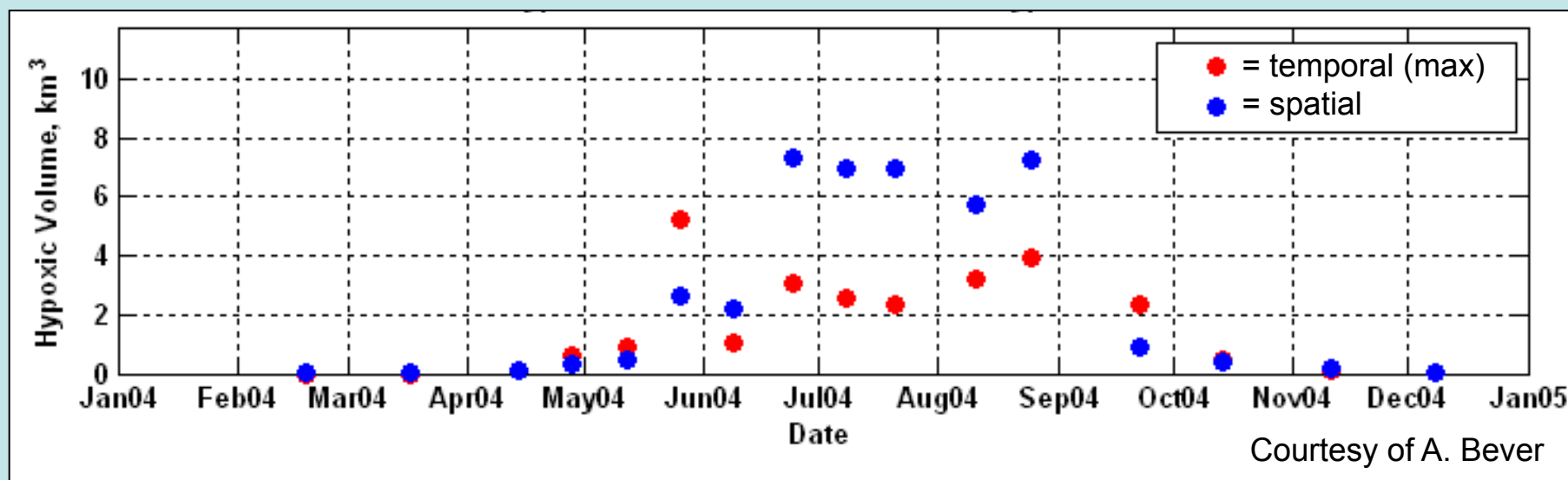
Summer uncertainties:

Spatial interpolations/extrapolations: $\sim 4 \text{ km}^3$

Temporal issues: up to 6 to 10 km^3 Courtesy of A. Bever

Analyses: Uncertainty in hypoxic volume 'data'

Uncertainties Computed from CH3D+ICM model



Mean modeled summer HV = $\sim 11 \text{ km}^3$

Summer uncertainties:

Spatial interpolations/extrapolations: $\sim 6 \text{ km}^3$

Temporal issues: up to $\sim 3 \text{ km}^3$

Courtesy of A. Bever

Analyses: Uncertainty in hypoxic volume 'data'

Spatial uncertainties in HV interpolations: ~ **5 km³**

Temporal uncertainties in HV interpolations: up to ~ **6 km³**

Summer 2004 HV from interpolations: ~ **7.5 km³**

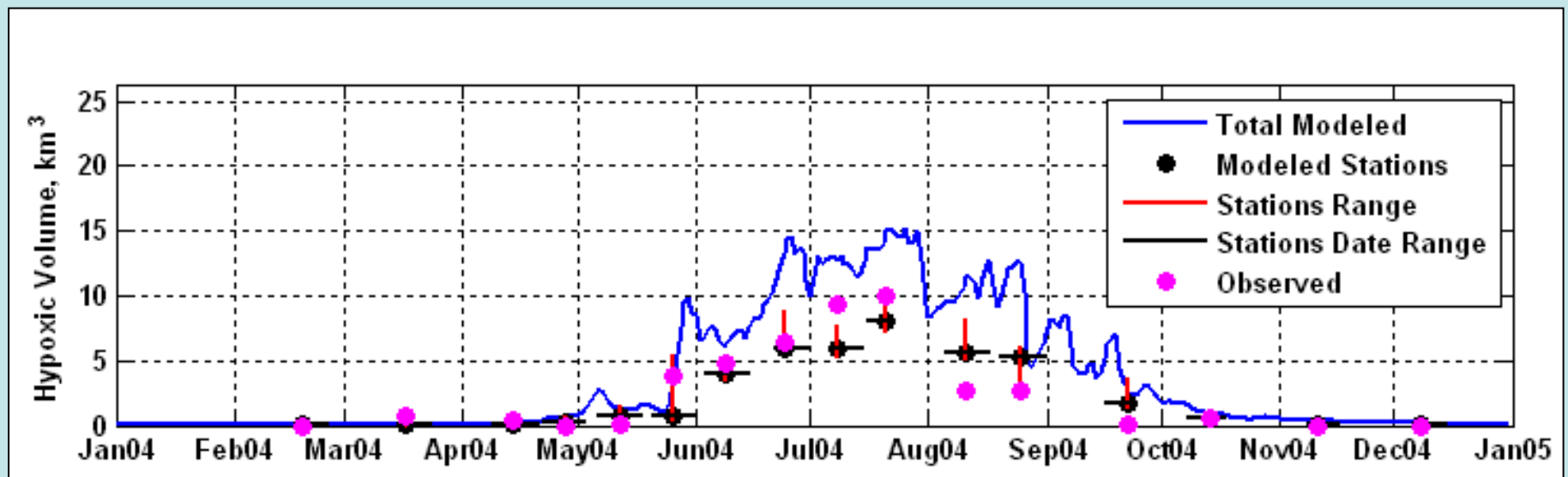
Summer 2004 HV from ChesROMS: ~ **8 km³**

Summer 2004 HV from ICM: ~ **11 km³**

It's not clear which of the three summer 2004 HV estimates is closest to the true value

Analyses: Uncertainty in hypoxic volume 'data'

HV from CH3D+ICM model

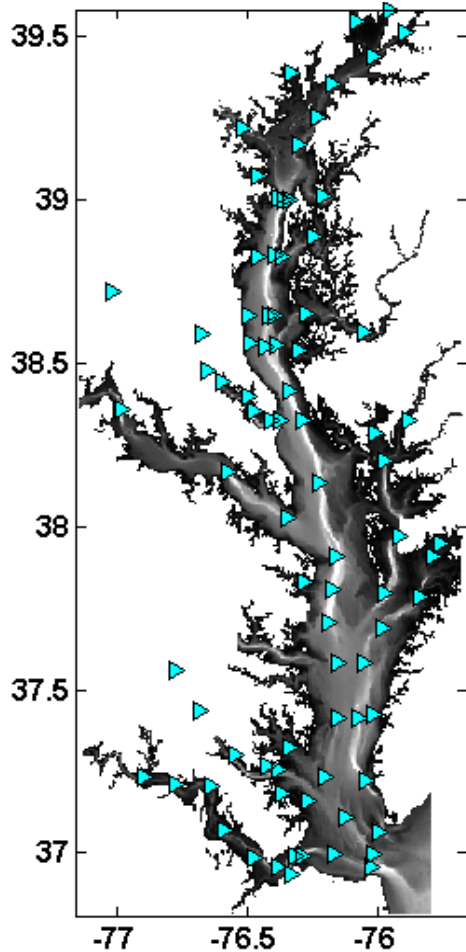


In July 2004, ICM underestimates observed hypoxia at CBP stations, but difference between interpolated model results and integration of complete model results is $\sim 5 \text{ km}^3$

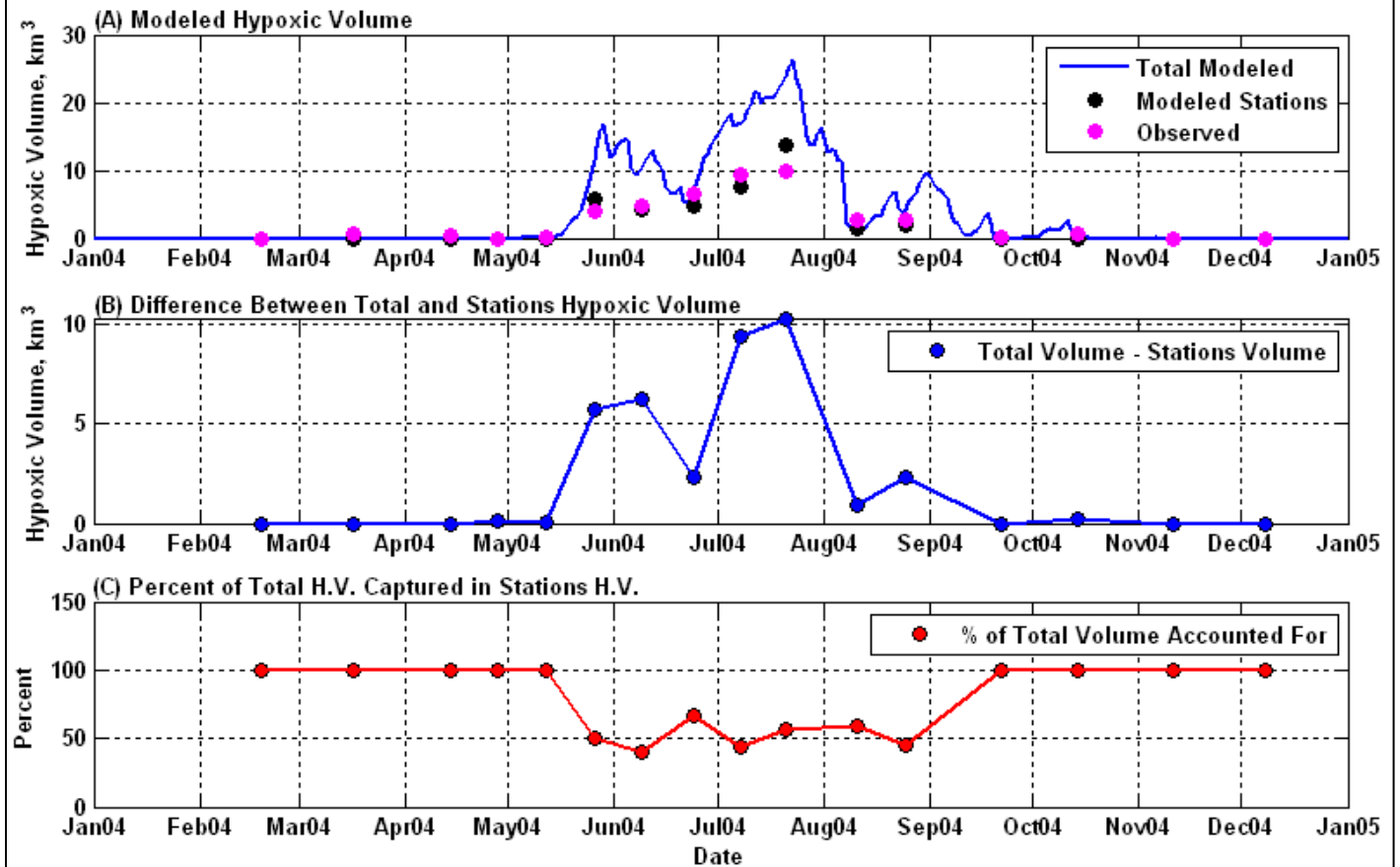
Courtesy of A. Bever

Analyses: Which CBP stations should be included?

Selected Station Locations

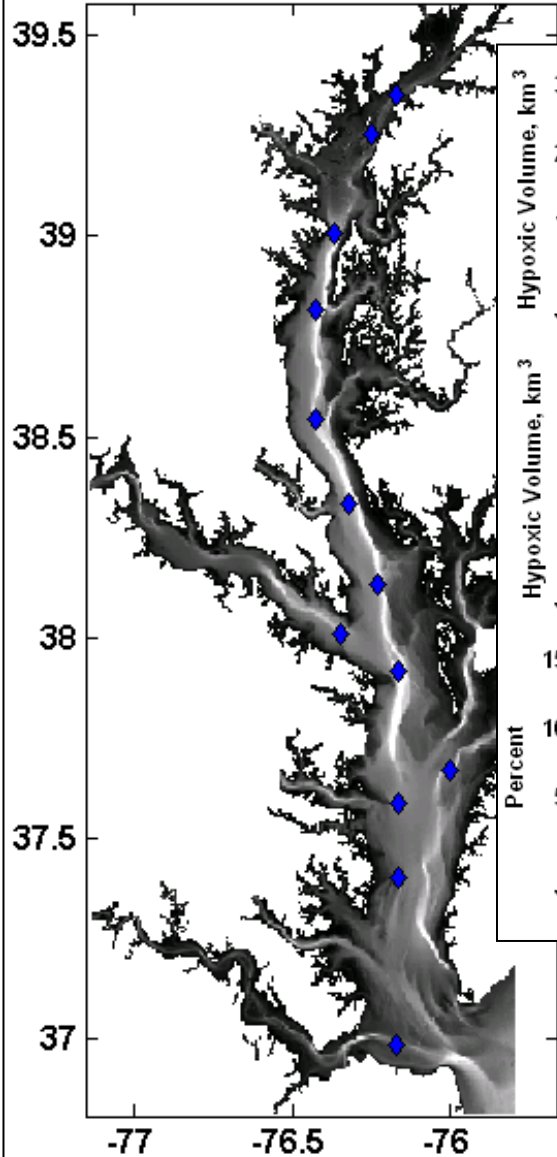


1-Eq. DO Model – All stations

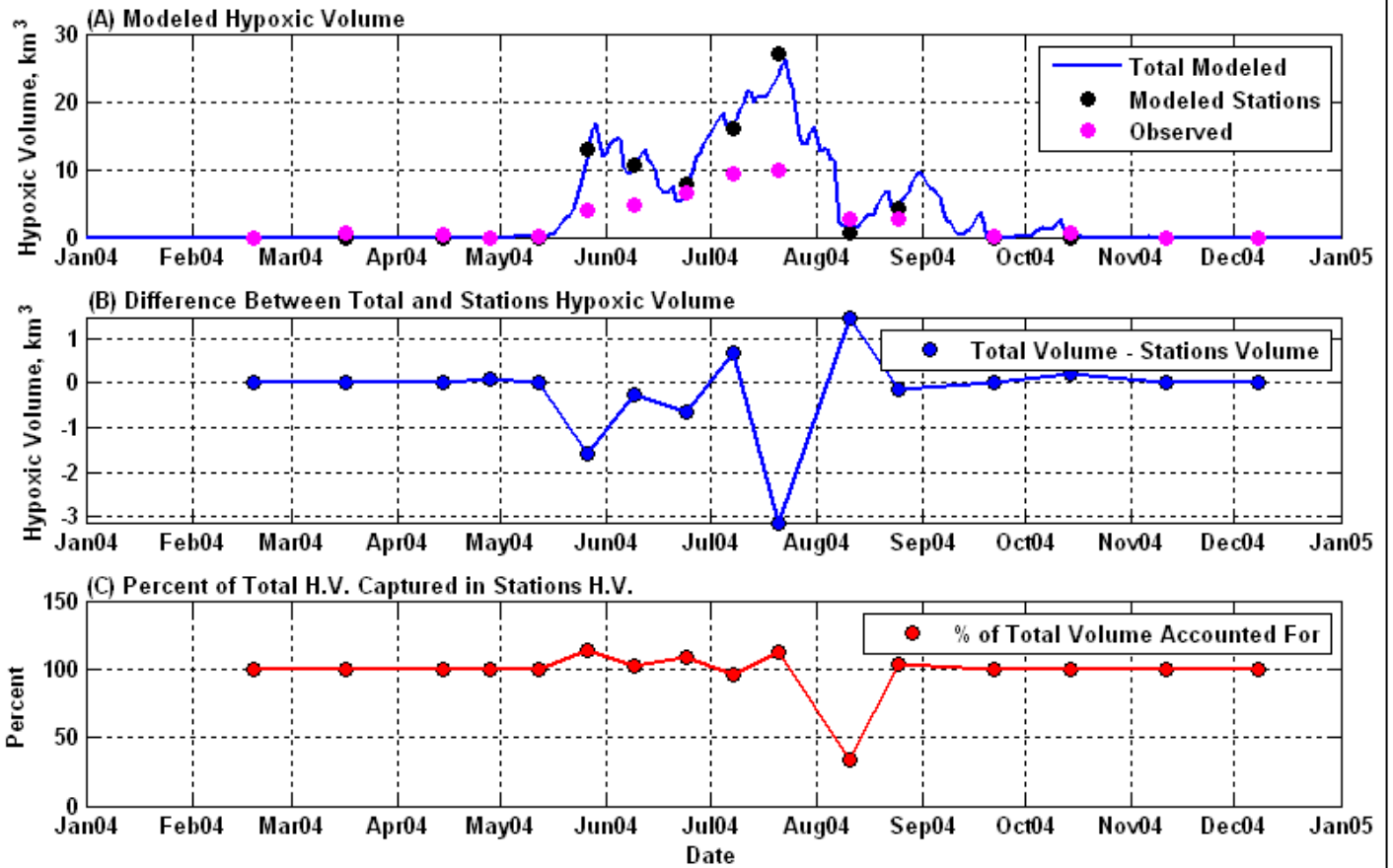


Courtesy of A. Bever

Selected Station Locations



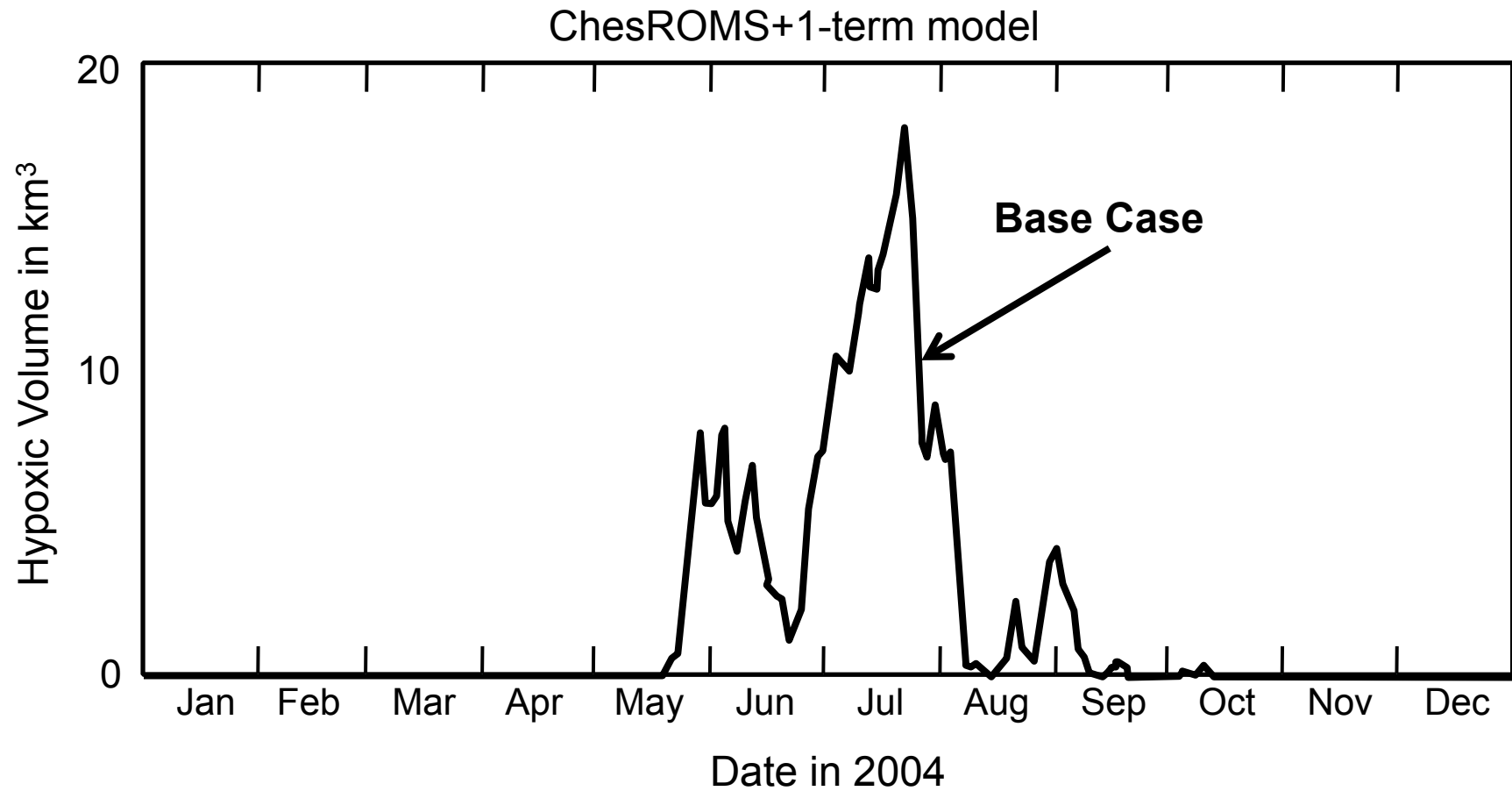
1-Eq. DO Model – 13 stations



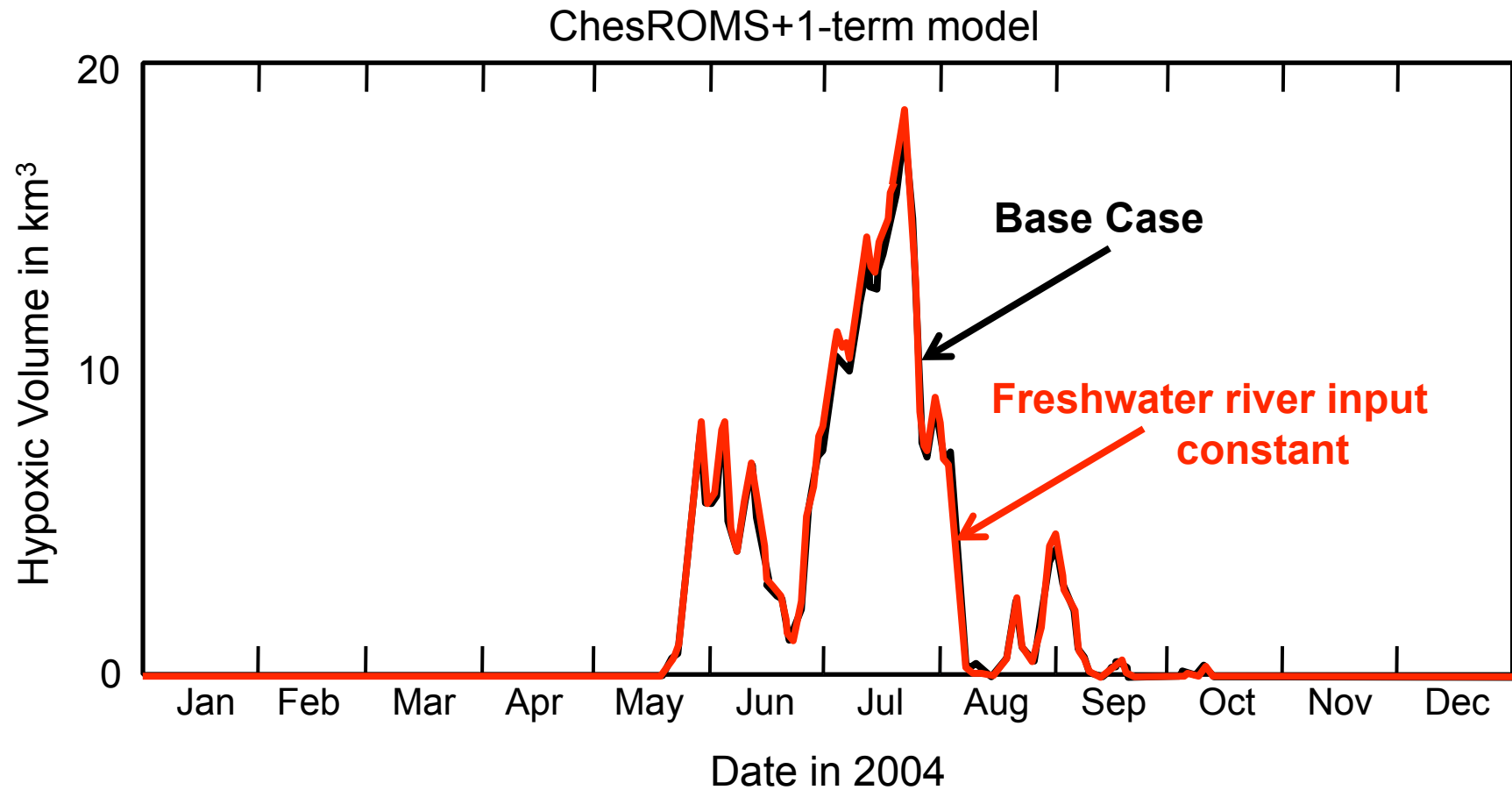
Synthetic data indicate that including 13 stations in HV interpolator provides better estimate of 'true' volume than including ~90 stations

Courtesy of A. Bever

Effect of physical forcing on hypoxia

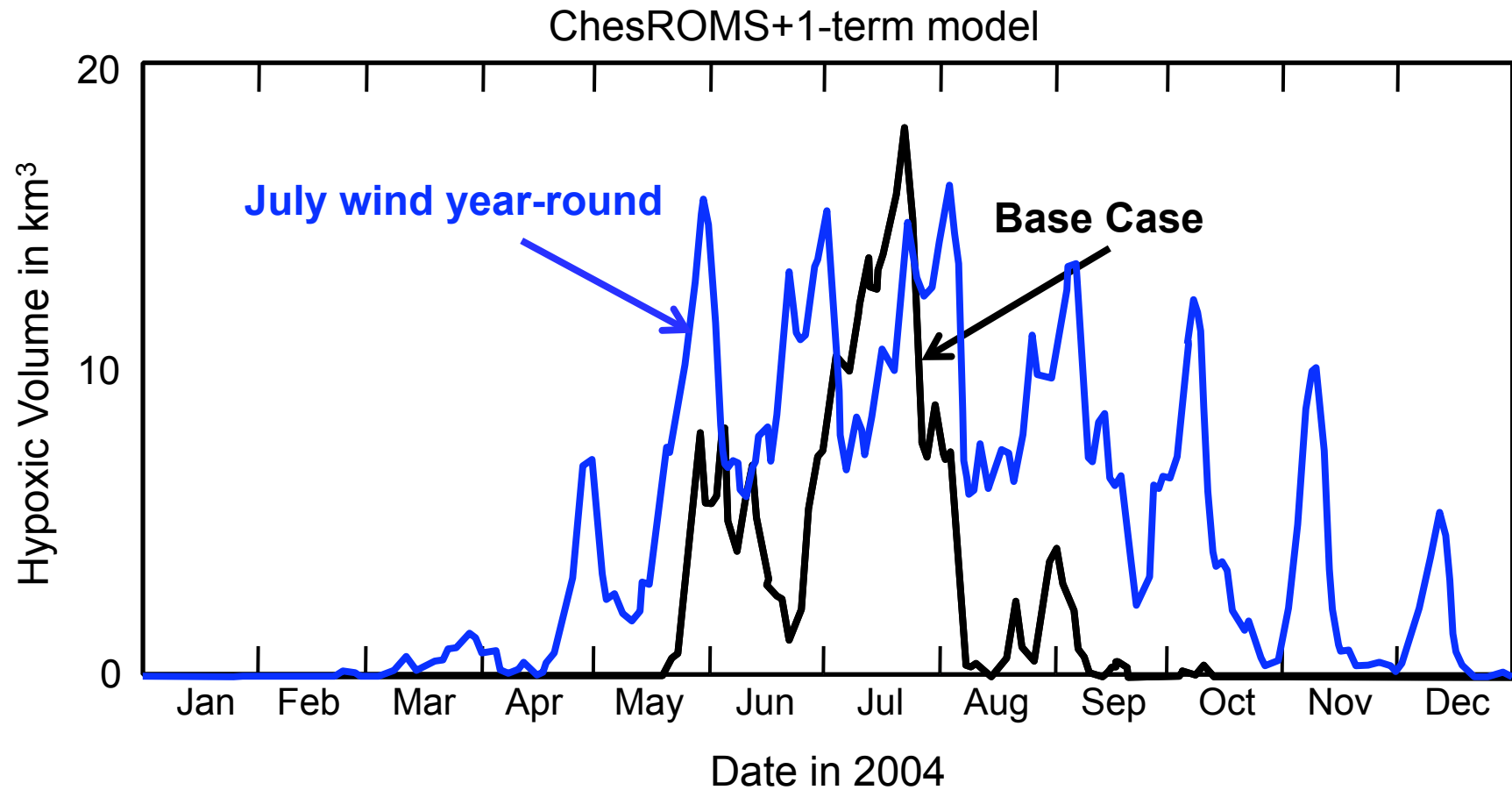


Effect of physical forcing on hypoxia



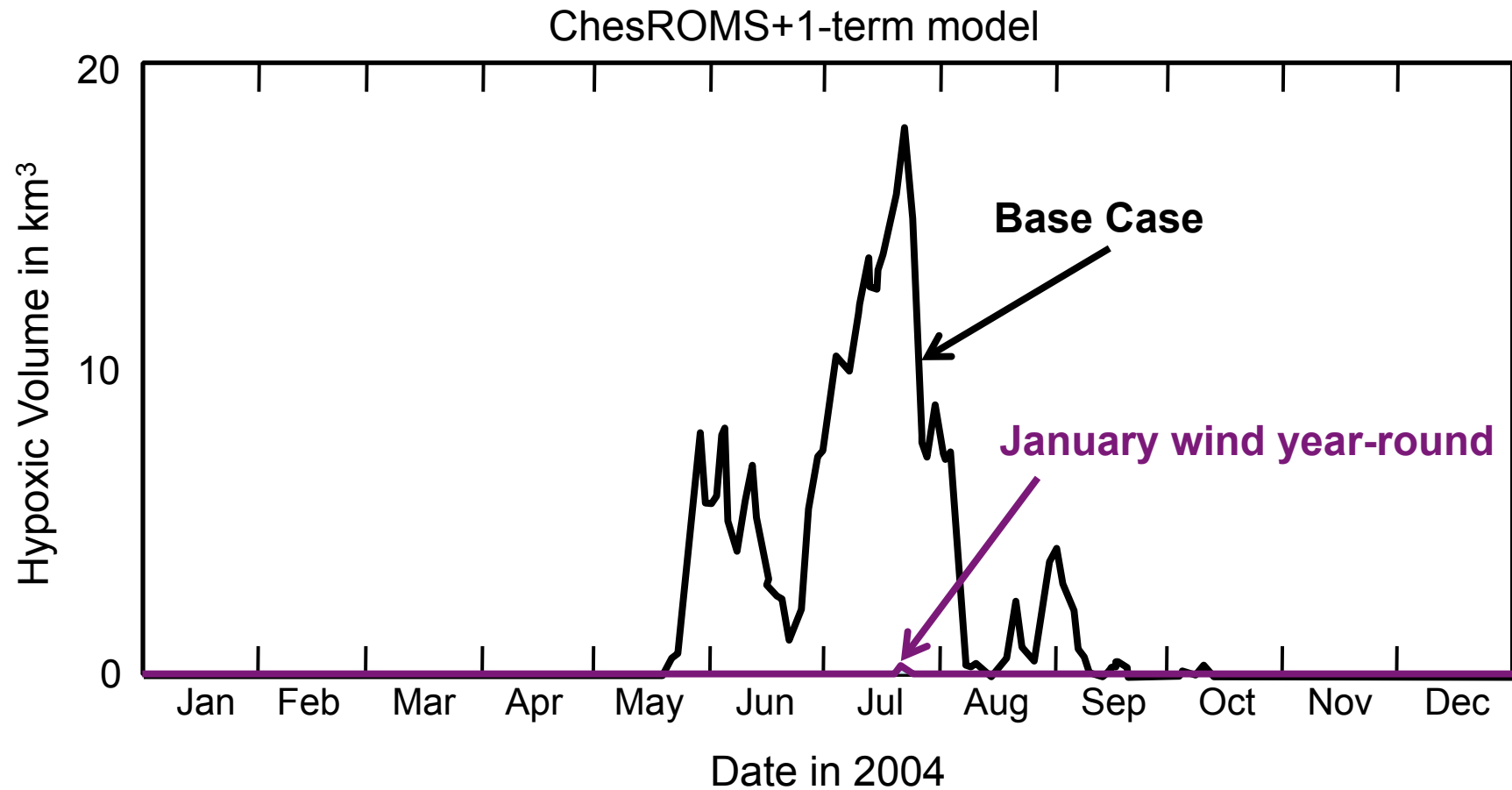
Seasonal changes in hypoxia are not a function of seasonal changes in freshwater.

Effect of physical forcing on hypoxia



Seasonal changes in hypoxia may be largely due to seasonal changes in wind.

Effect of physical forcing on hypoxia



Seasonal changes in hypoxia may be largely due to seasonal changes in wind.

Summary

- There currently exist multiple hydrodynamic and DO models for Chesapeake Bay
- Simple DO models can reproduce mean and seasonal and spatial variability in DO
- Output from multiple models can:
 - Provide information on sampling strategies
 - Provide estimates of uncertainties in hypoxic volumes
 - Identify causal mechanisms for seasonal variability in hypoxia
- **Lots of people implementing lots of CB models means lots of progress!**