Estuarine hypoxia comparisons 1985–2014: DLEM forcing vs. CBP-Phase6 forcing

Pierre St-Laurent[1],
M.A.M. Friedrichs[1]

[1] Virginia Institute of Marine Science

Annual CHAMP project meeting
Annapolis MD
October 30, 2019

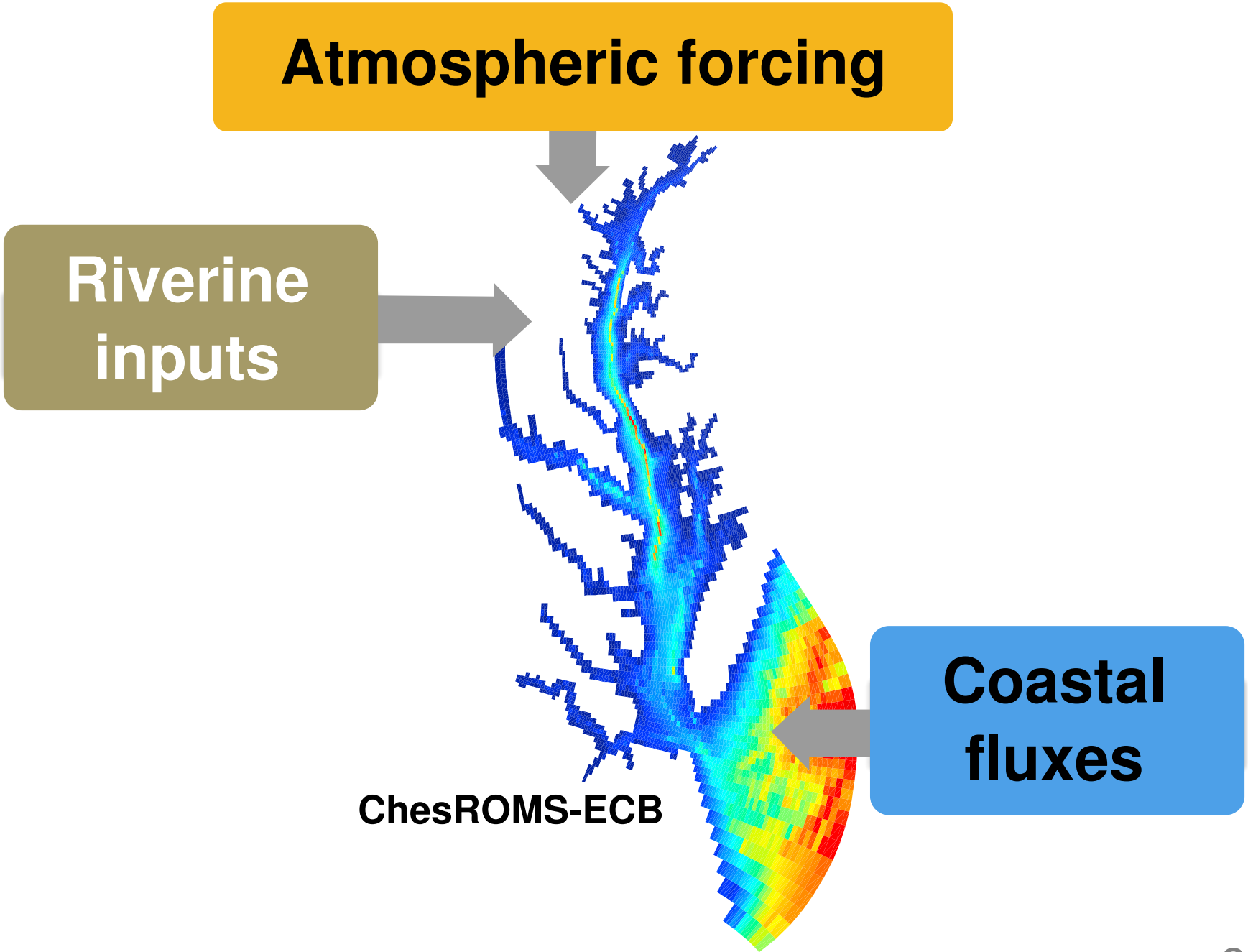
Overview

We conducted two simulations with the model ChesROMS-ECB over the period 1985–2014 to estimate the hypoxic volume of the Chesapeake Bay:

1. using Phase-6 of the CBP WSM for the riverine forcing;
2. using DLEM for the riverine forcing.
3. A third comparison point comes from an interpolation of the oxygen data from WQMP (1985–2014) by A.Bever.

(Bever et al. 2013, 2018)

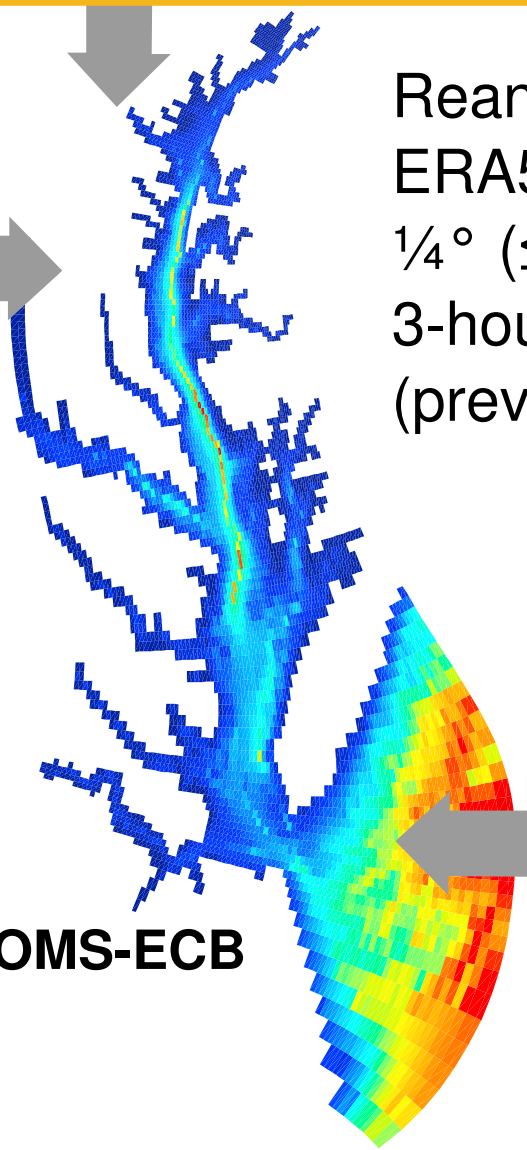
Method: Model ChesROMS-ECB



Method: Model ChesROMS-ECB

Atmospheric forcing

Riverine inputs



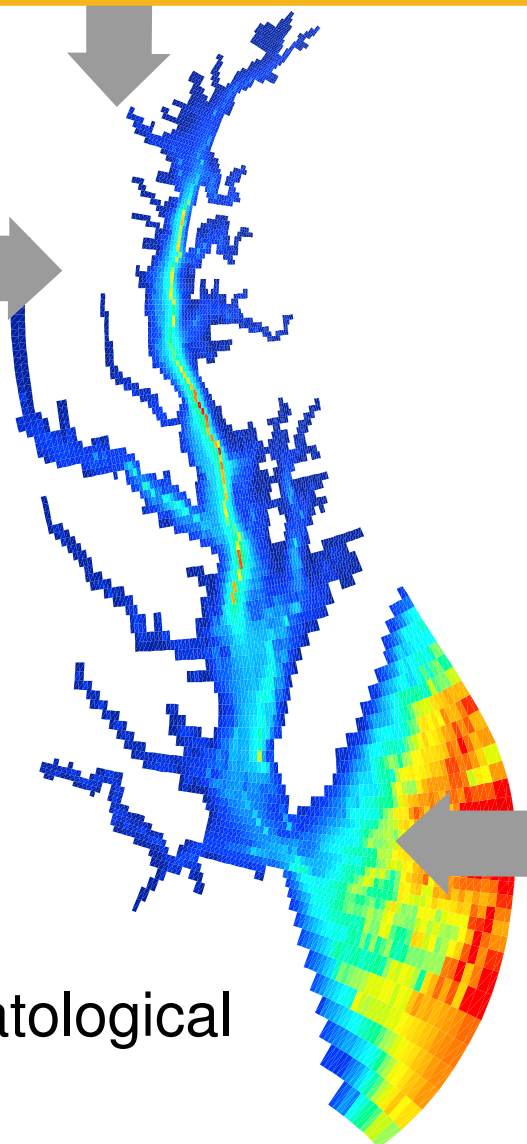
ChesROMS-ECB

Reanalysis:
ERA5 (ECMWF 2019)
¼° (≤ 28 km)
3-hourly, 1979–2018
(previously: NARR)

Coastal fluxes

Method: Model ChesROMS-ECB

Atmospheric forcing



Riverine inputs

Phase-6 of CBP WSM
CFBASE30Y20180615
(1985–2014)

or

DLEM 20180525
(1900–2015)

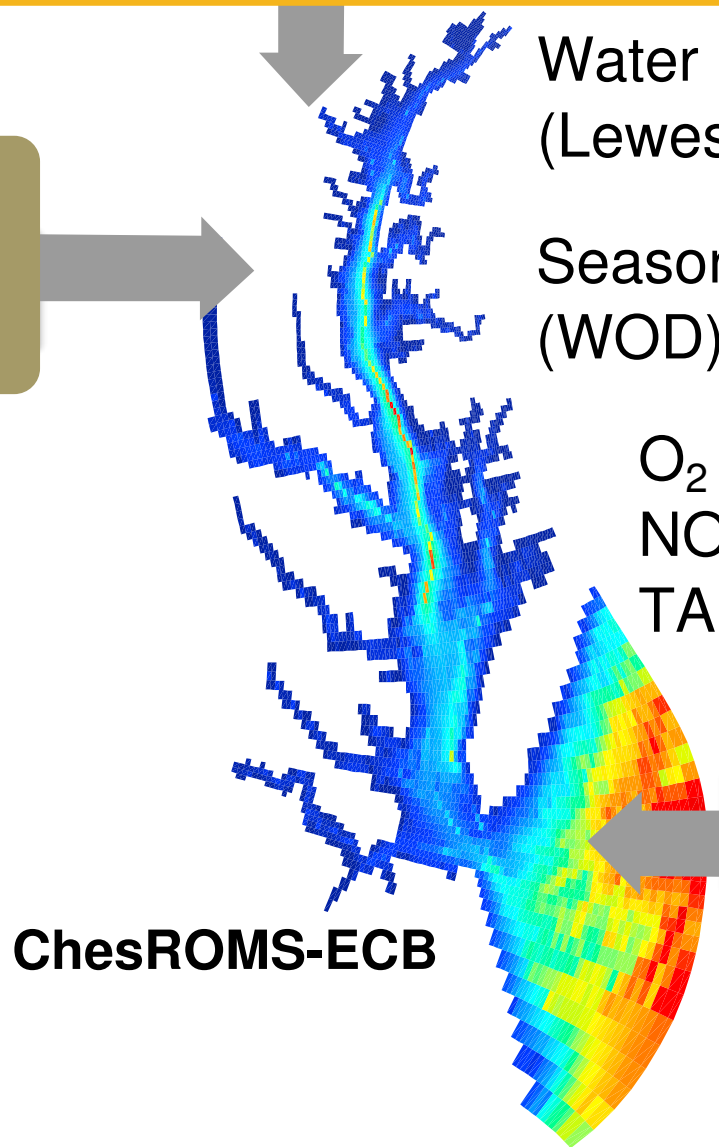
After 2014:
USGS discharge + climatological concentrations

Coastal fluxes

Method: Model ChesROMS-ECB

Atmospheric forcing

Riverine inputs



ChesROMS-ECB

Water levels from NOAA (Lewes DE, Duck NC)

Seasonal climatology S, T (WOD) + long-term trend

$O_2 = O_2^{saturation}(S, T)$
NO_3, NH_4 from NOAA
TA, DIC from OADS

Coastal fluxes

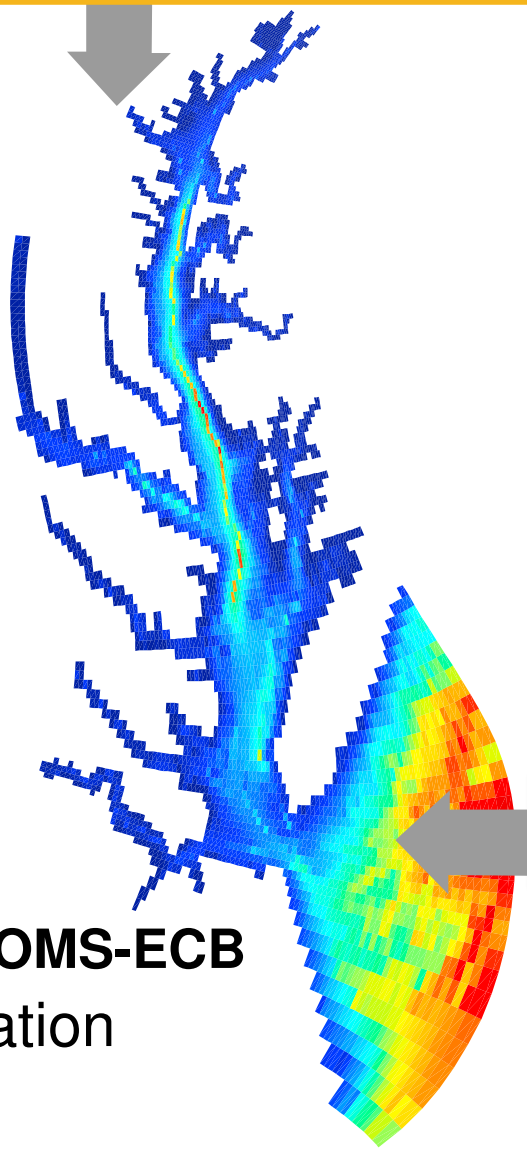
Method: Model ChesROMS-ECB

Atmospheric forcing

Based on ROMS
20 topo-following levels
1–2 km resolution

NPZD + C, O_2, DOM
Coupled every 1 min.
Q_{10}^{resp}, Q_{10}^{prod} from
Lomas et al. 2002

Resuspension, burial,
remineralization
(Druon et al. 2010)

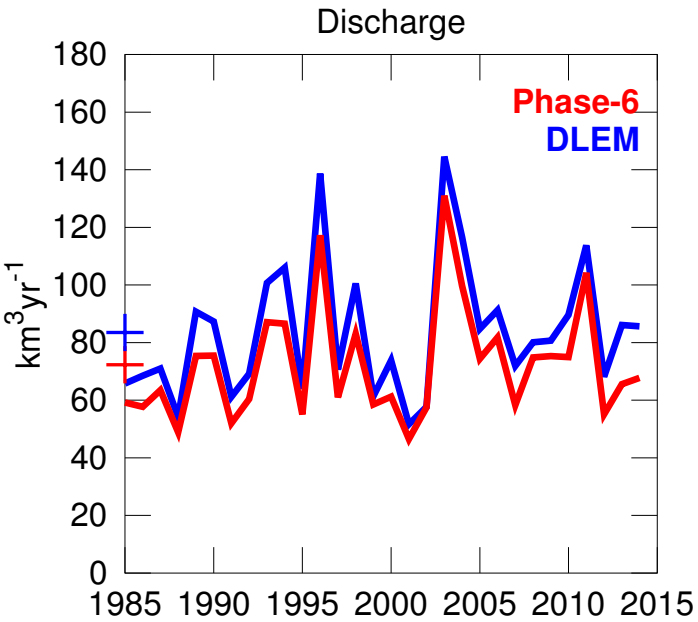


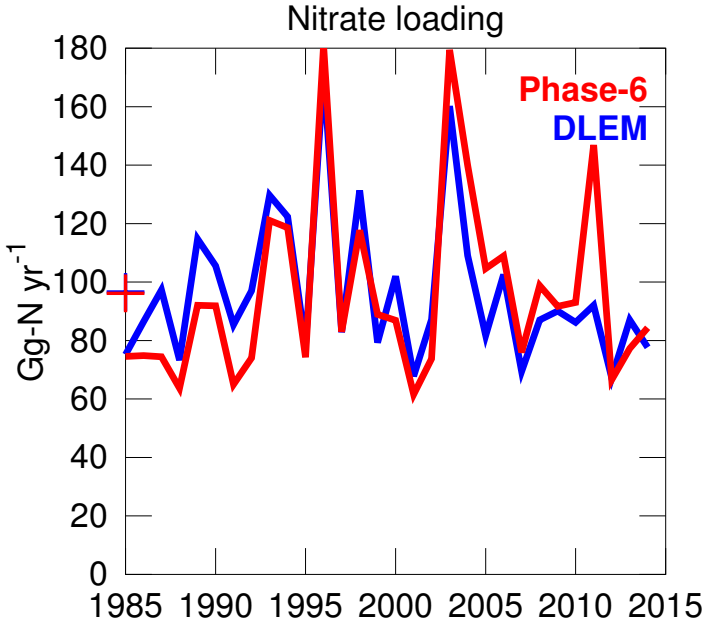
ChesROMS-ECB

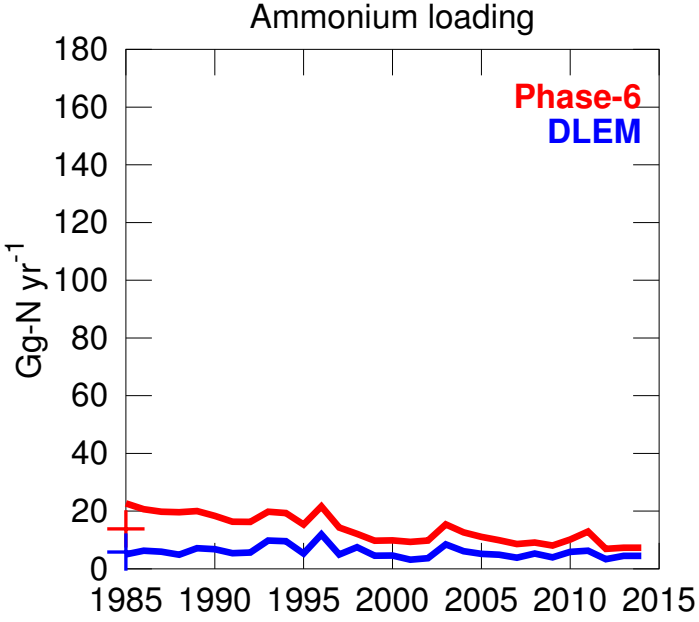
Water-column denitrification
(Feng et al. 2015)

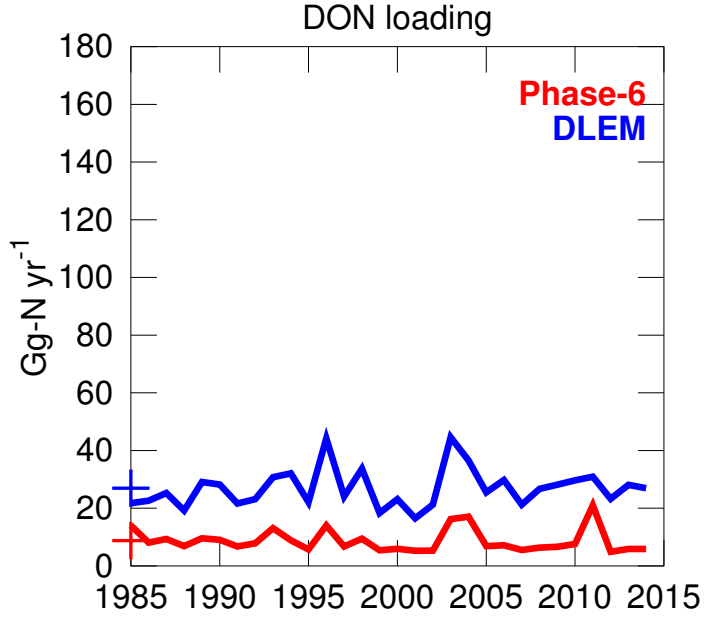
Coastal fluxes

Riverine forcing: Phase-6 vs. DLEM









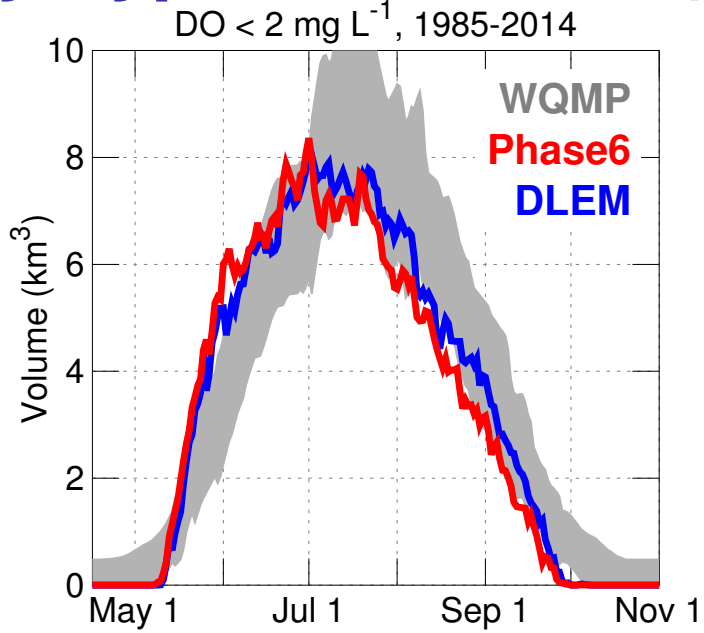
Discharge DLEM 15% > Phase-6

Nitrate: Same mean value; first DLEM > Phase-6 then < Phase-6

Ammonium Phase-6 is more than twice that of DLEM

DON DLEM is 3x that of Phase-6

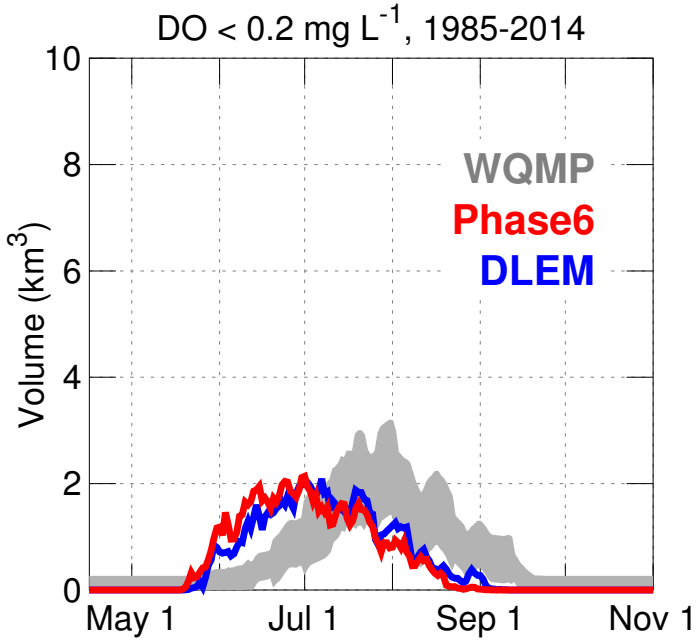
Daily hypoxic volume (climatology 1985–2014)



Modeled hypoxia begins/ends early compared to WQMP.

This bias in timing is slightly worse with Phase-6 (NH_4^+?).

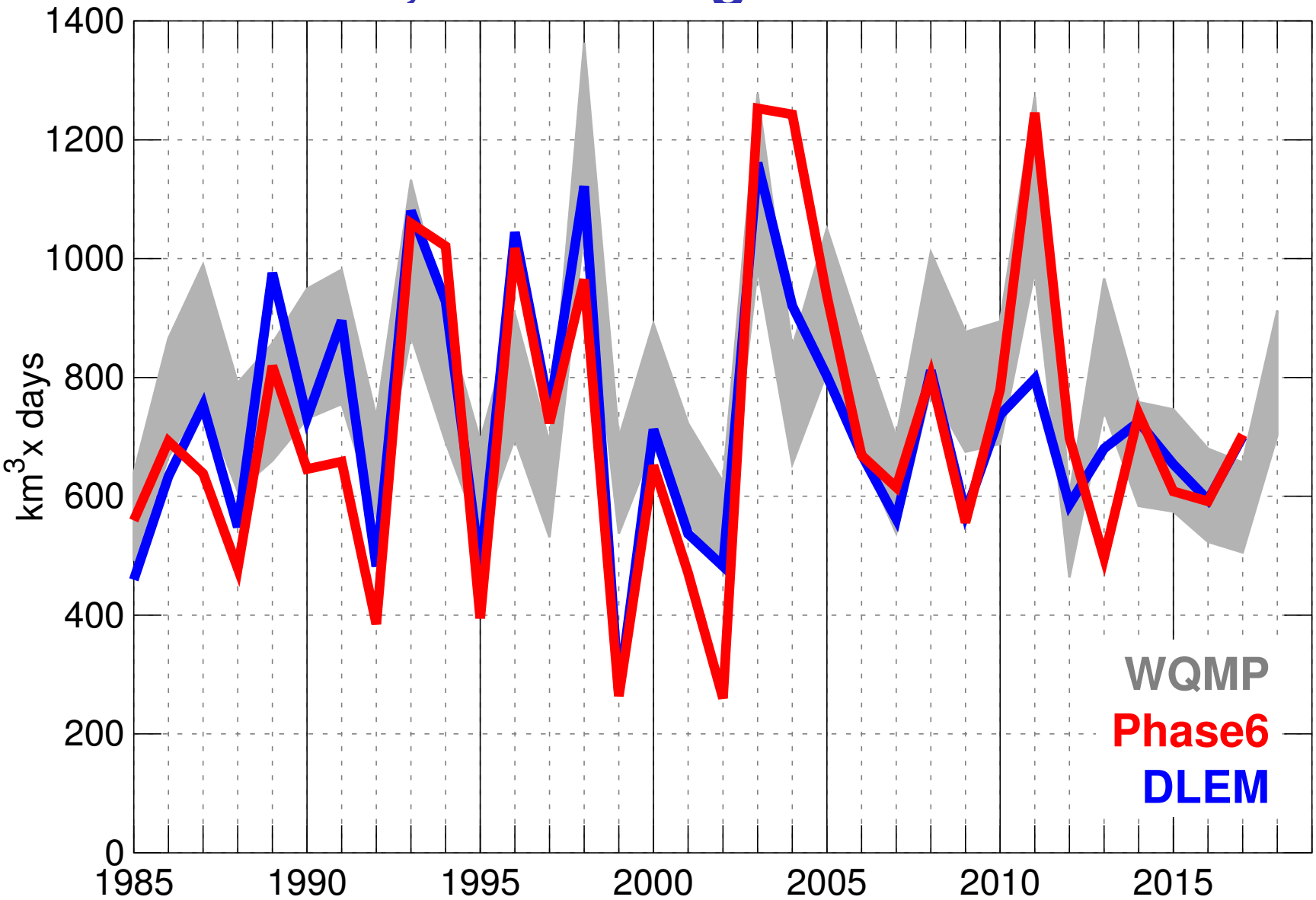
Volumes are very similar in magnitude and width (duration).



Modeled anoxia is of right magnitude but it begins/ends early compared to WQMP.

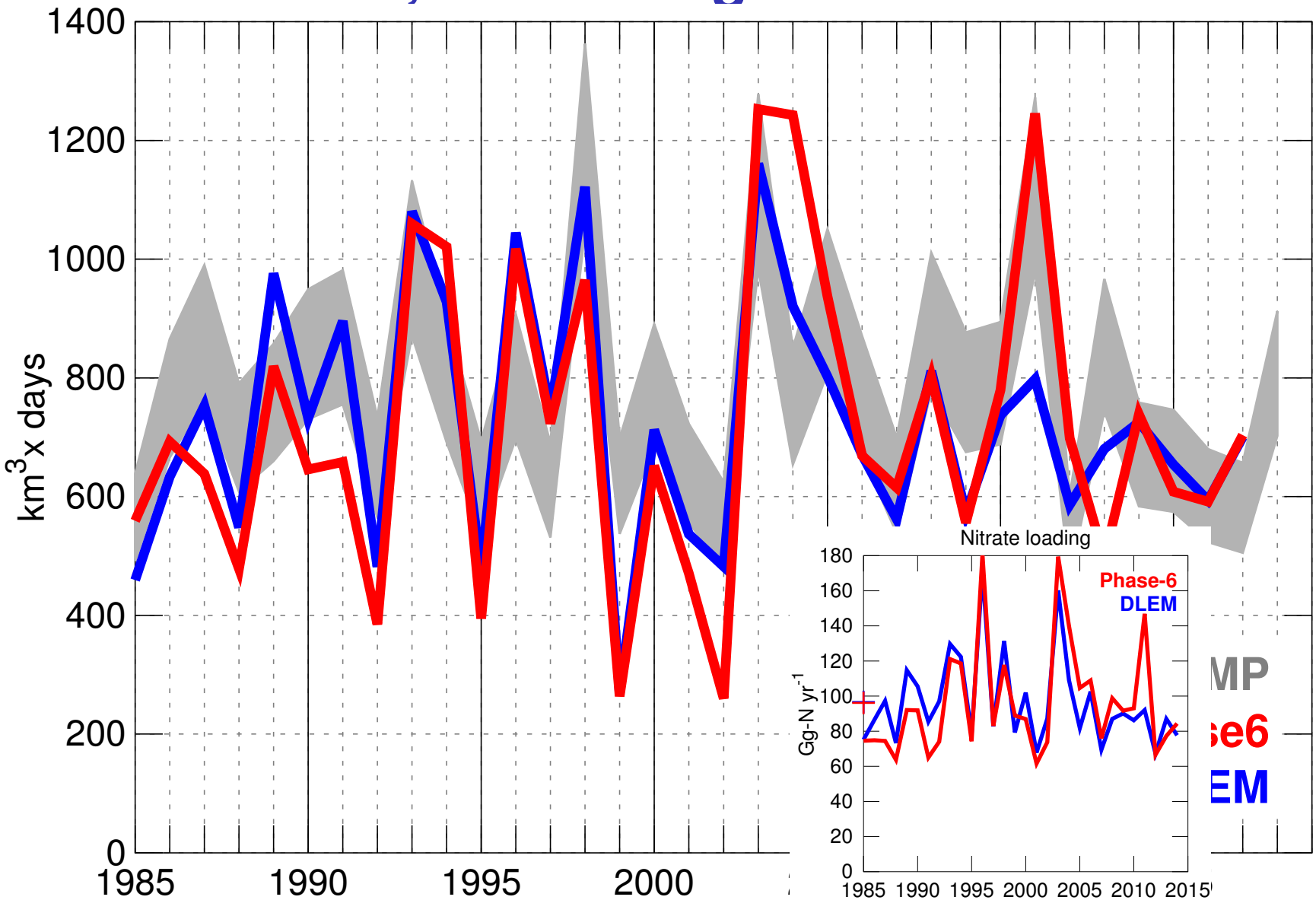
Again, this bias is slightly worse with Phase-6.

Annual volume, DO < 2 mg L^{-1}



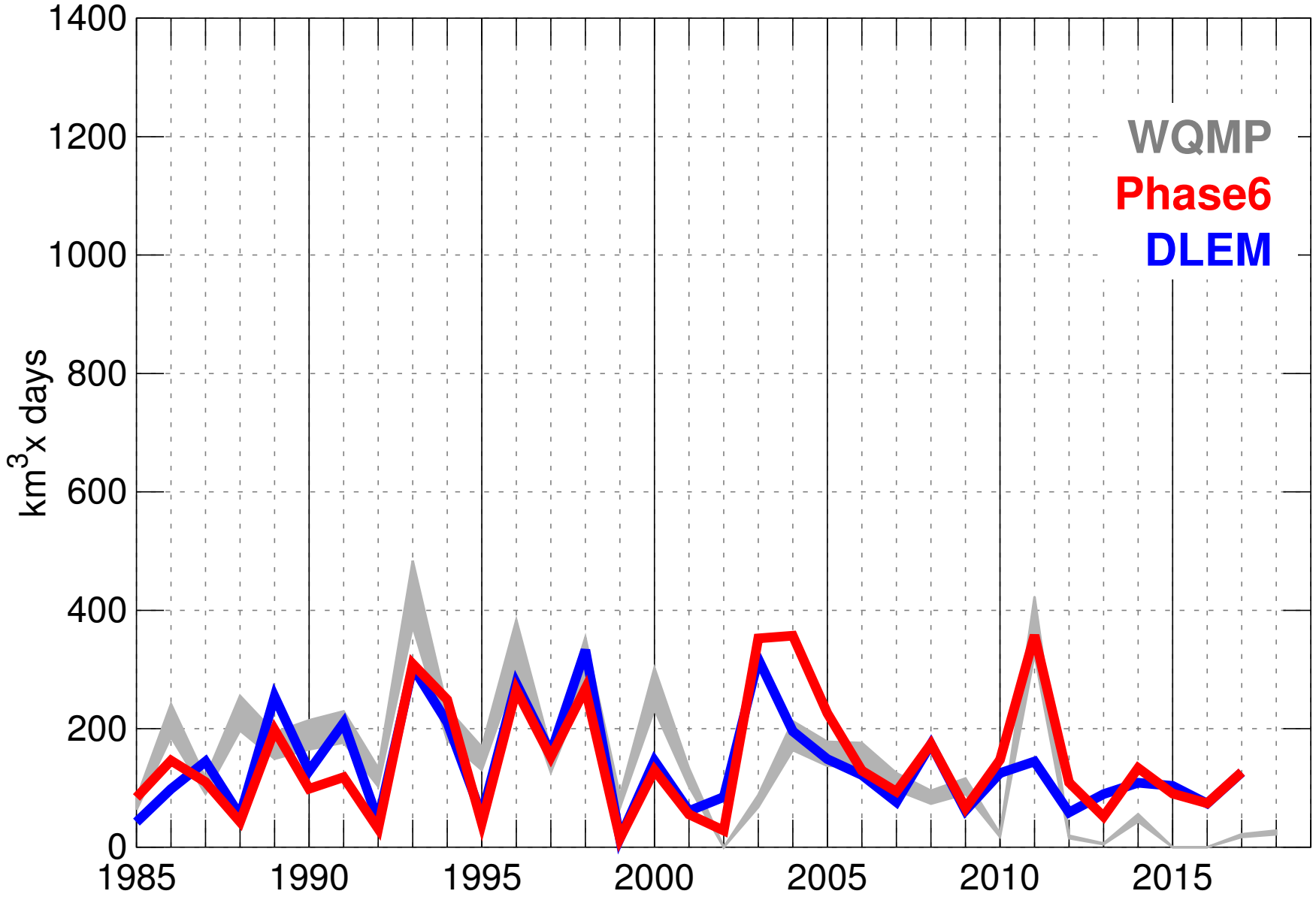
Differences in volume reflect differences in NO_3^- loading.

Annual volume, DO < 2 mg L^{-1}



Differences in volume reflect differences in NO_3^- loading.

Annual volume, DO < 0.2 mg L^{-1}



Good match with WQMP until 2014 (Phase-6 not available after 2014.)

Annual volume

- Correlation between model and data of WQMP is relatively high $\rightarrow$
- Highest correlation can be with Phase-6 or DLEM; depends on threshold.

Table: Pearson's correlation (r) when comparing with data of **WQMP**. All values significant at $p < 0.01$ level.

$DO_{hypoxia}$ mg L^{-1}	Phase-6	DLEM
< 2	0.69	0.76
< 1	0.74	0.82
< 0.2	0.66	0.55

Conclusions

1. Differences between riverine forcings (Phase-6/DLEM) are minor.

2. Differences between results obtained with the two forcings are smaller than the differences from **WQMP**.

3. Model reproduces interannual variations quite well ($0.55 < r < 0.82$) with both Phase-6 and DLEM. Differences in hypoxic volume reflect differences in the NO_3^- loading of the two forcings.

4. Biases (both datasets): Hypoxia and anoxia begin/end too early. More likely due to the model than the riverine forcings.

5. Modeled anoxia worsens after 2014—extending Phase-6/DLEM beyond 2014 would be very, very helpful.