Multiple Tributary Model (MTM) Development – Initiation of Fine-scale Tributary Models in the Tidal James River

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Modeling Quarterly Review, January 5, 2022

Outline

- Review of the current main Bay model and James River model
- Progress update on the James River model development
- Preliminary results
- Discussions and plans
- Summary

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Review of the current main Bay model and James River model

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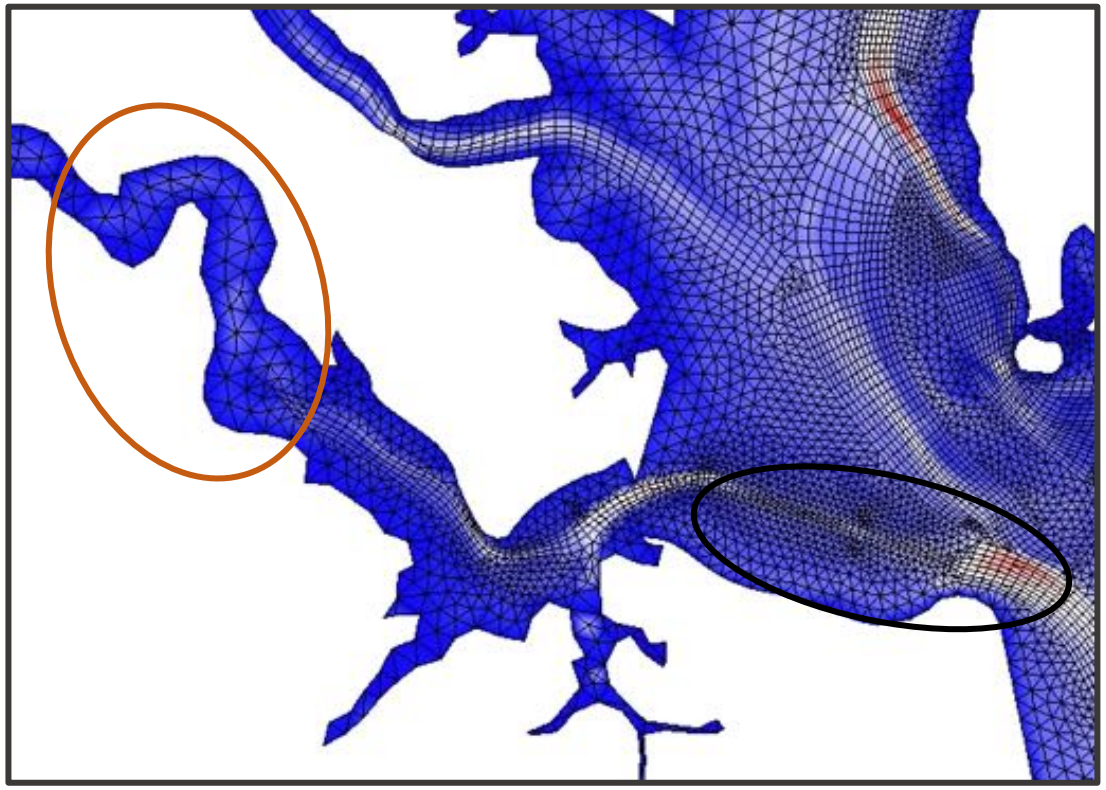
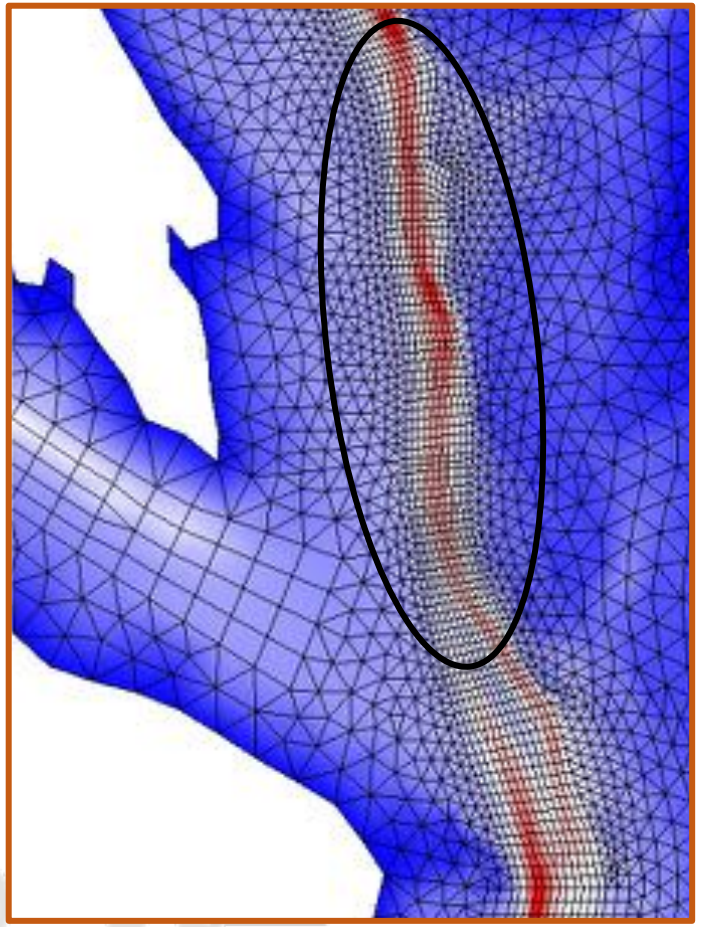
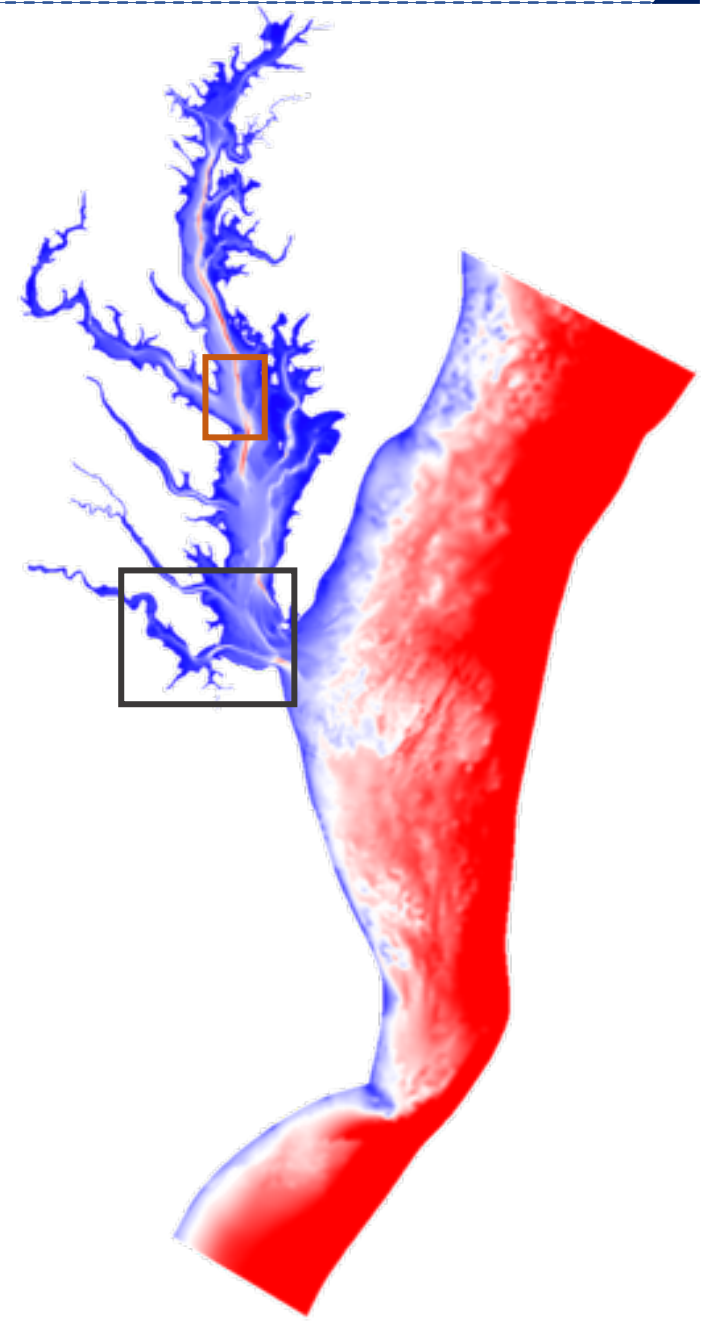
Current Chesapeake Bay grid







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AMERICAN WATER RESOURCES ASSOCIATION

A Numerical Study of Hypoxia in Chesapeake Bay Using an Unstructured Grid Model: Validation and Sensitivity to Bathymetry Representation

Xun Cai, Yinglong J. Zhang, Jian Shen, Harry Wang, Zhengui Wang, Qubin Qin, and Fei Ye

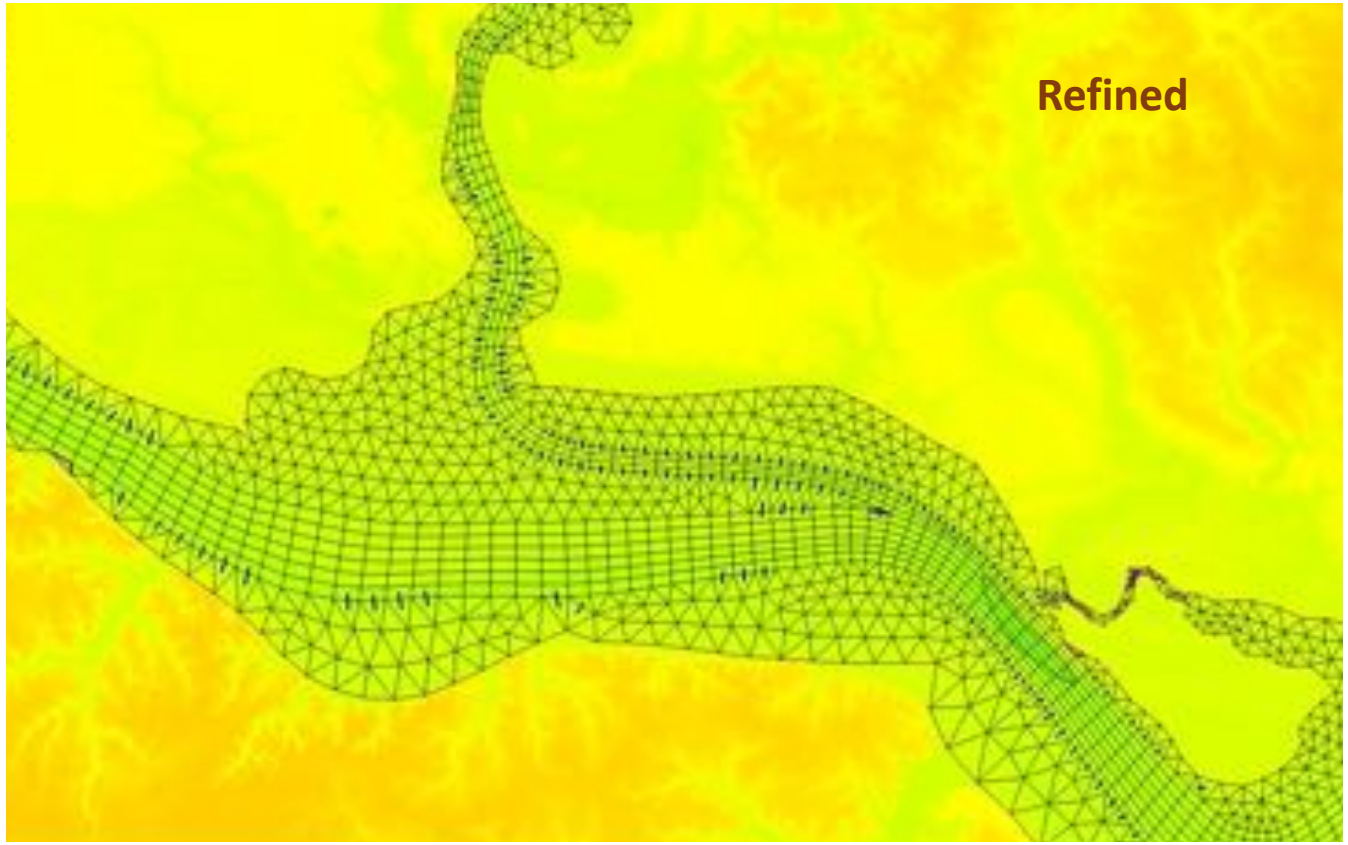
Initiation of the James River model from the MBM

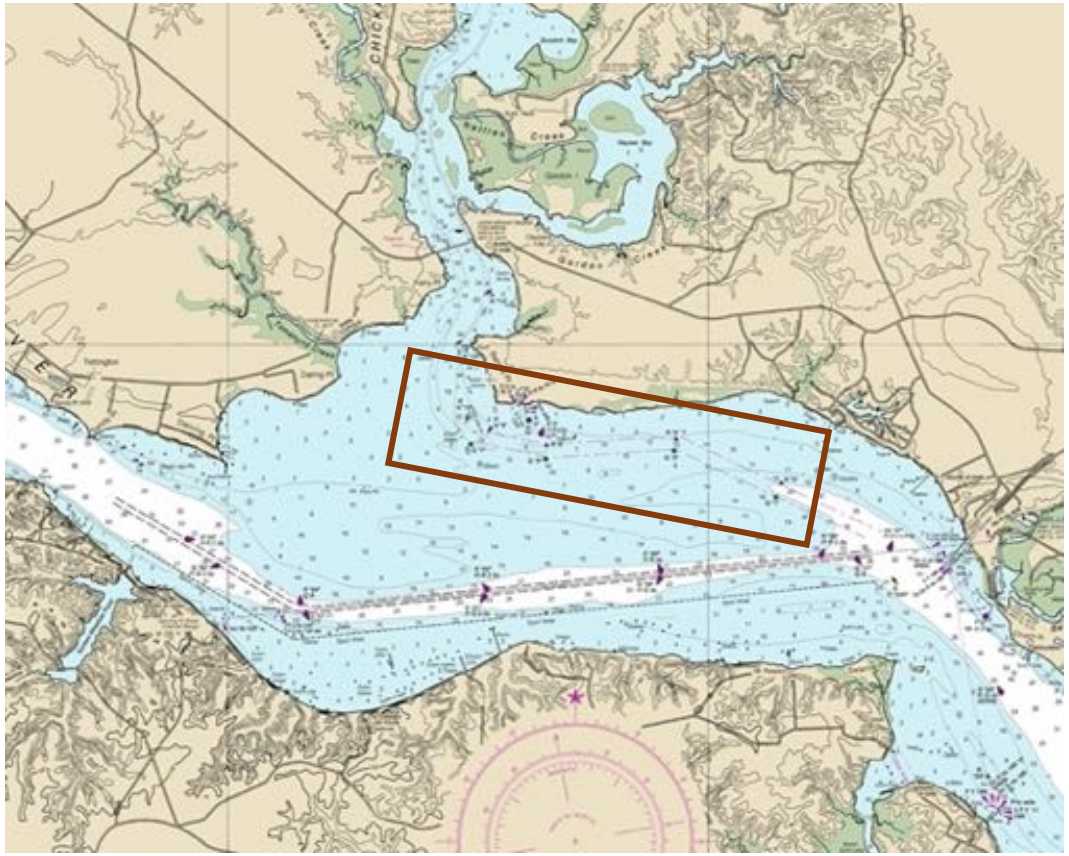
A process of learning and trying!!

Along counters (e.g., 9 m and 6 m) to have arcs capture the major channels all the way from the shipping channel to the fall line.

- Construct sufficient quals to capture major sub-tributaries (e.g., Elizabeth R.)
- Refine **cross-channel** and along-channel resolutions

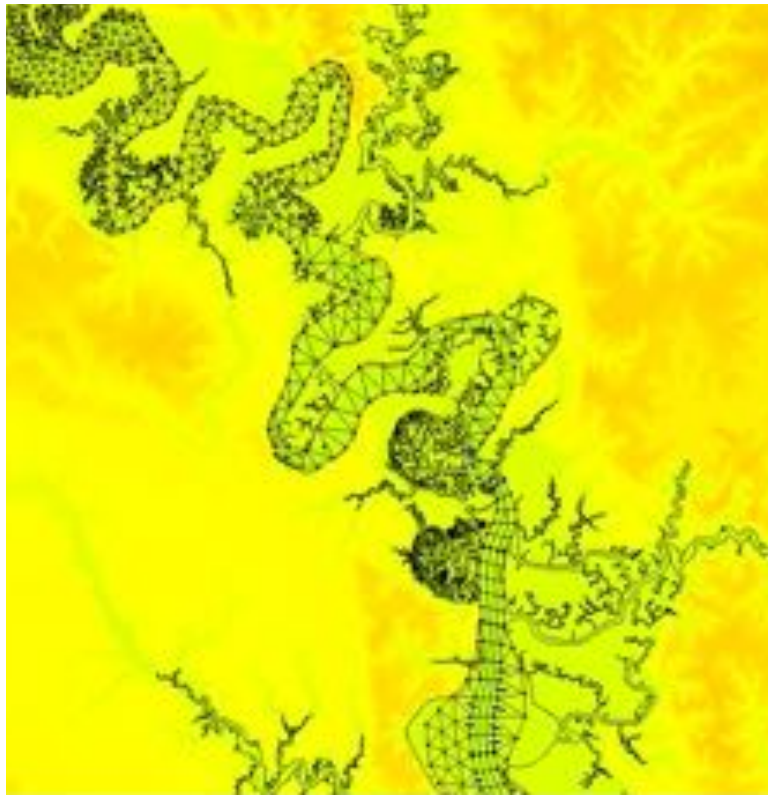
Initiation of the James River model



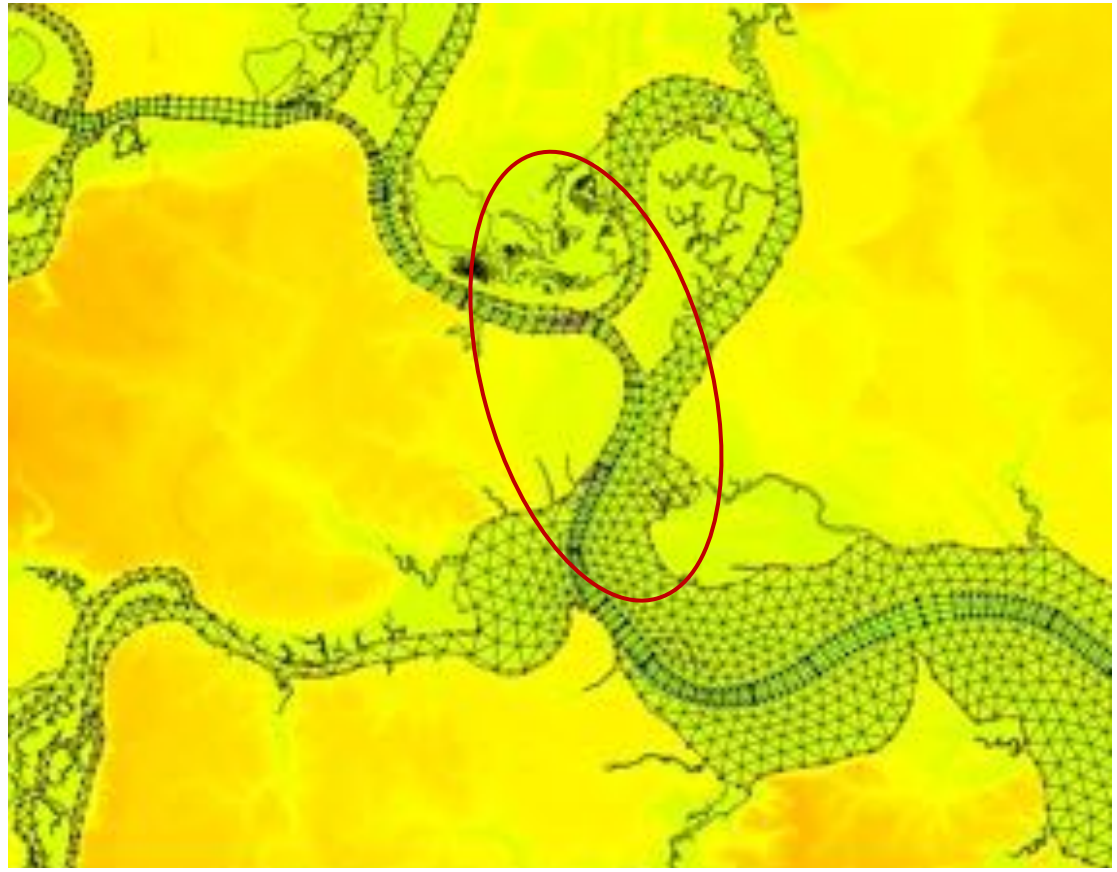


Construct sufficient quals to link the James and Chickahominy R. based on both DEM and nautical charts

Initiation of the James River model

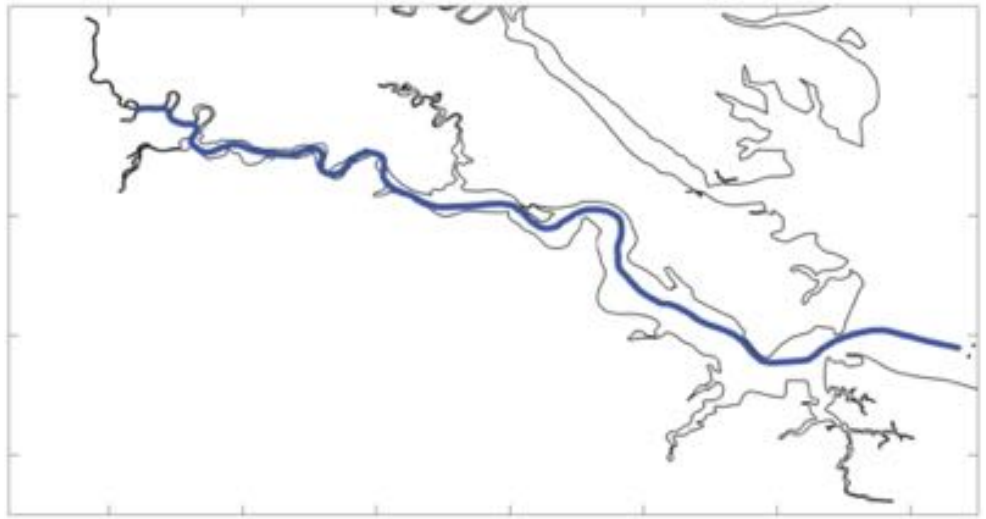


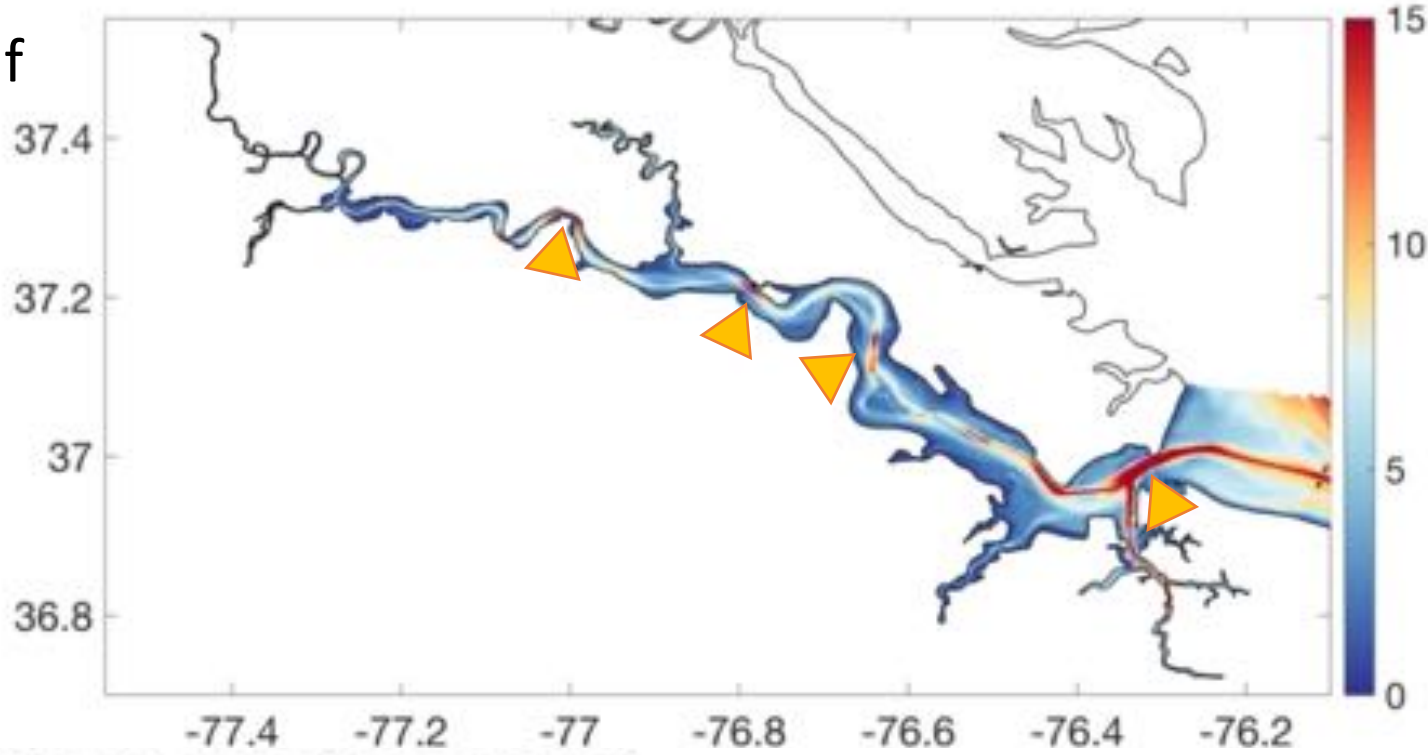
- The grid covers shoals and major channels within the 0 m contour
- Tidal wetlands are not included so far.
- Phase I James River grid will serve as a base for the next developments.



Hybrid shaved vertical grid system

- Maximum 52 layers for continental shelf
- Minimum one layer for shallow shoals



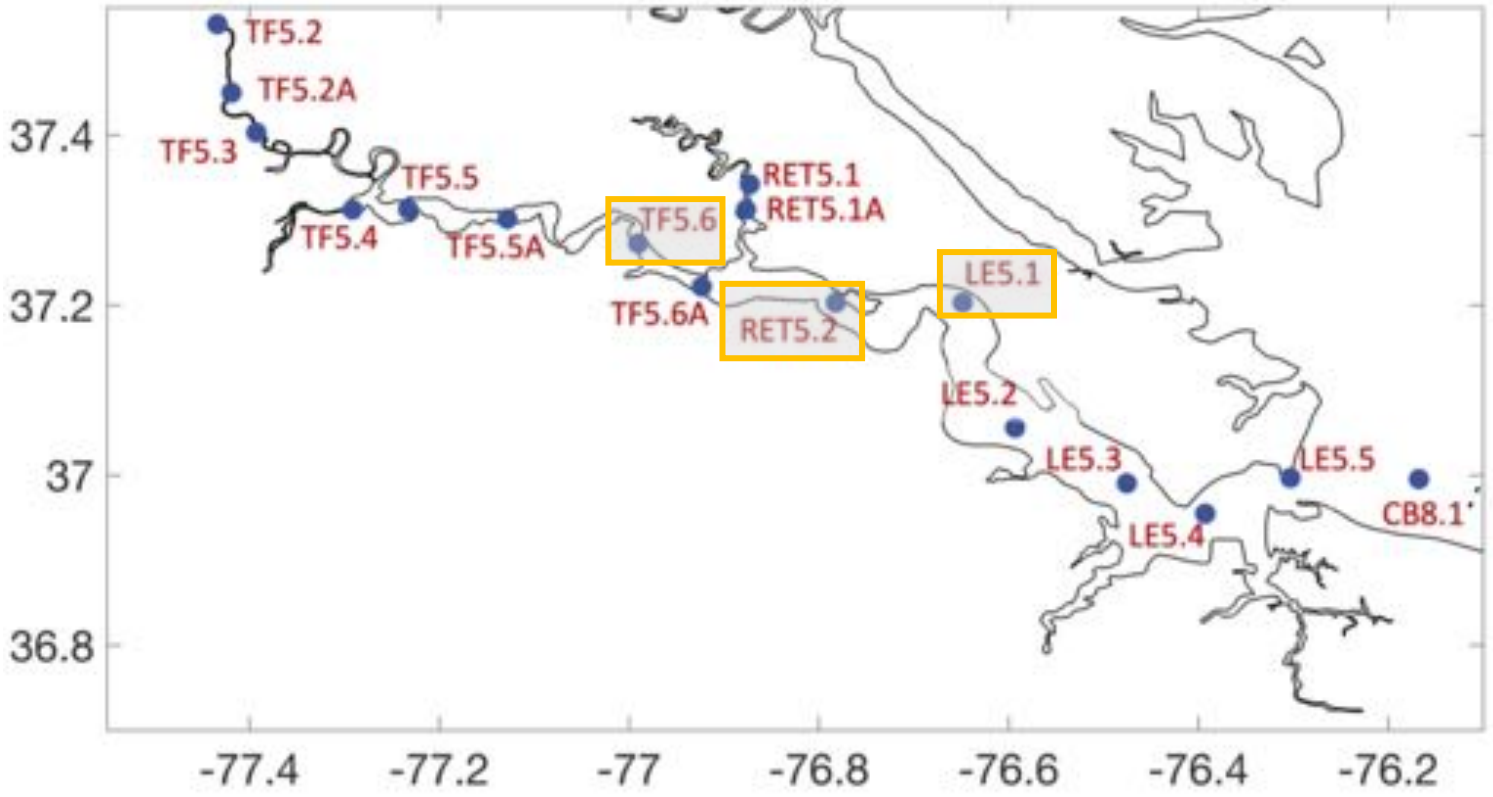


Model skills of hydrodynamics

Station	Layer	RMSE	CC	RE (%)
TF5.5A	S	0.33	1	94.61
TF5.5A	B	0.33	1	94.53
TF5.6	S	0.82	0.43	47.84
TF5.6	B	0.98	0.44	48.45
RET5.1A	S	1.25	0.68	42.45
RET5.1A	B	1.25	0.69	42.39
RET5.2	S	1.18	0.9	19.47
RET5.2	B	1.42	0.91	23.54
LE5.1	S	1.67	0.91	13.16
LE5.1	B	2.4	0.85	13
LE5.2	S	2.35	0.86	8.05
LE5.2	B	3.11	0.7	13.38
LE5.3	S	1.97	0.88	3.96
LE5.3	B	2.2	0.67	0.32
LE5.4	S	1.6	0.89	3.44
LE5.4	B	1.93	0.71	2.74

1.55

- Overall reasonable saltwater intrusion distance and stratification level
- Reasonable skills along the river cross the polyhaline, mesohaline, oligohaline, and tidal fresh zones.



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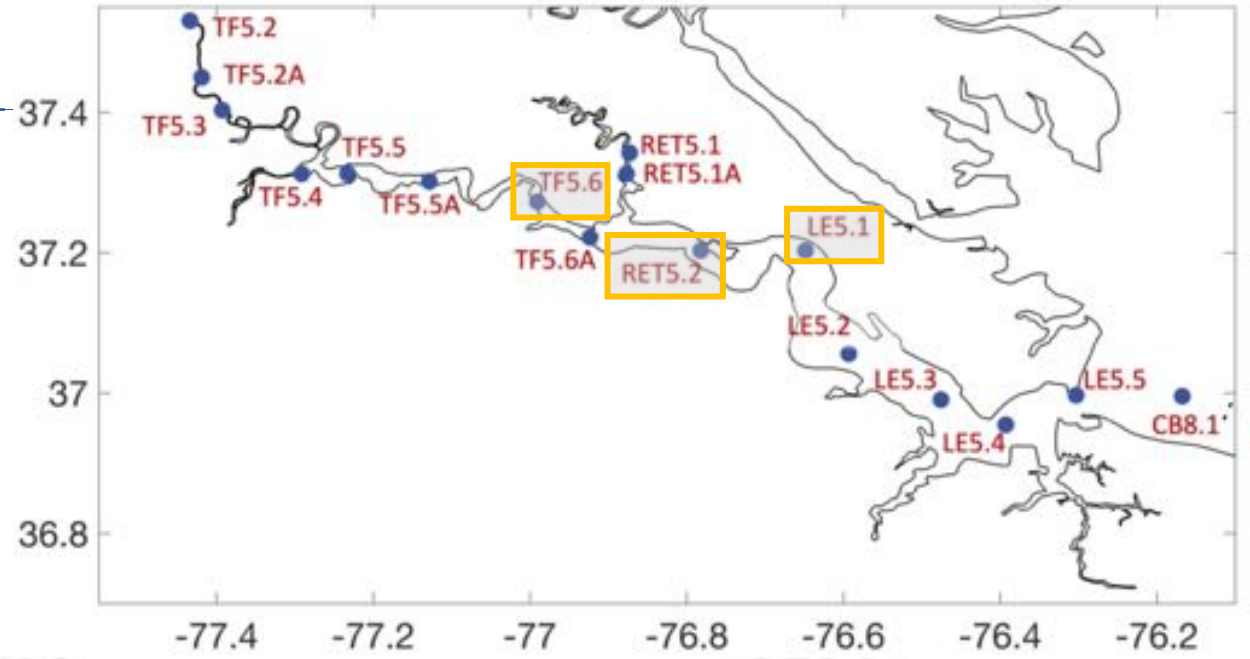

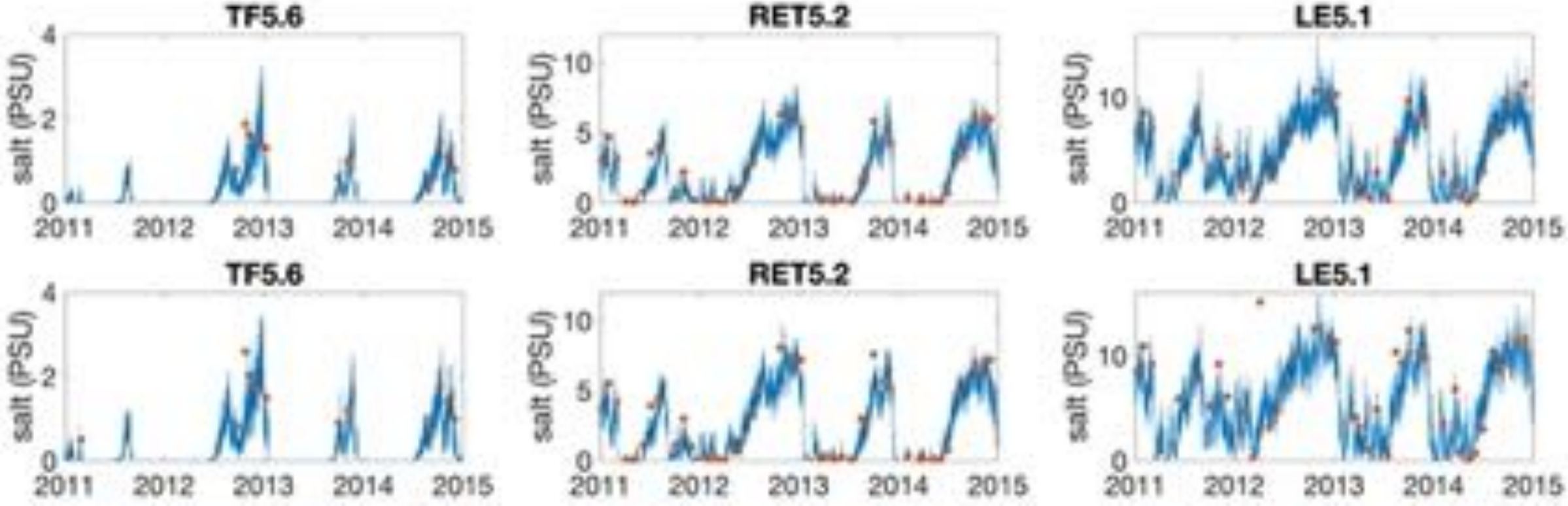

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- Review of the current main Bay model and James River model
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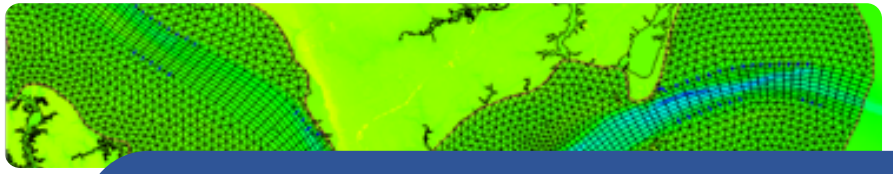
James River model development

Phase I James River grid

- Implement of water quality simulations in the phase I James River grid



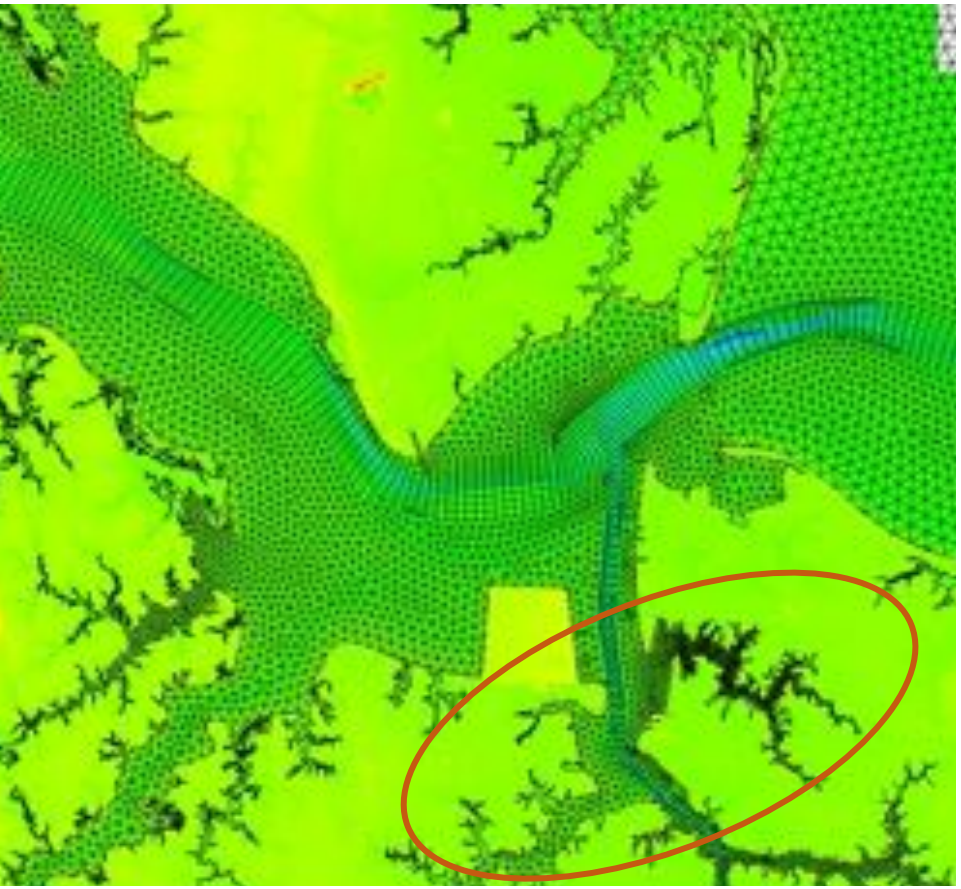
Phase II James River grid

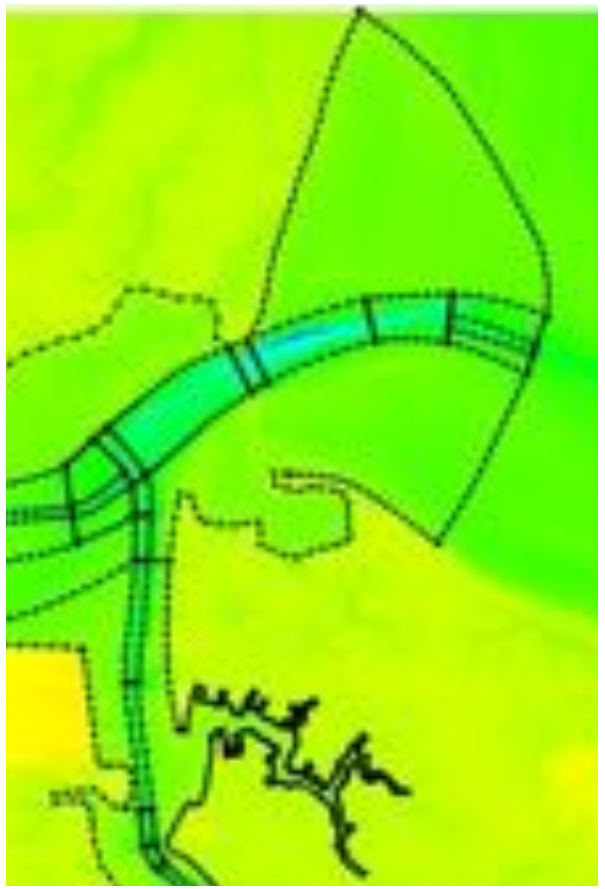
- Channel transplants and shoal refinements
- Boundary setup at the James River mouth
- Watershed loading in the James River

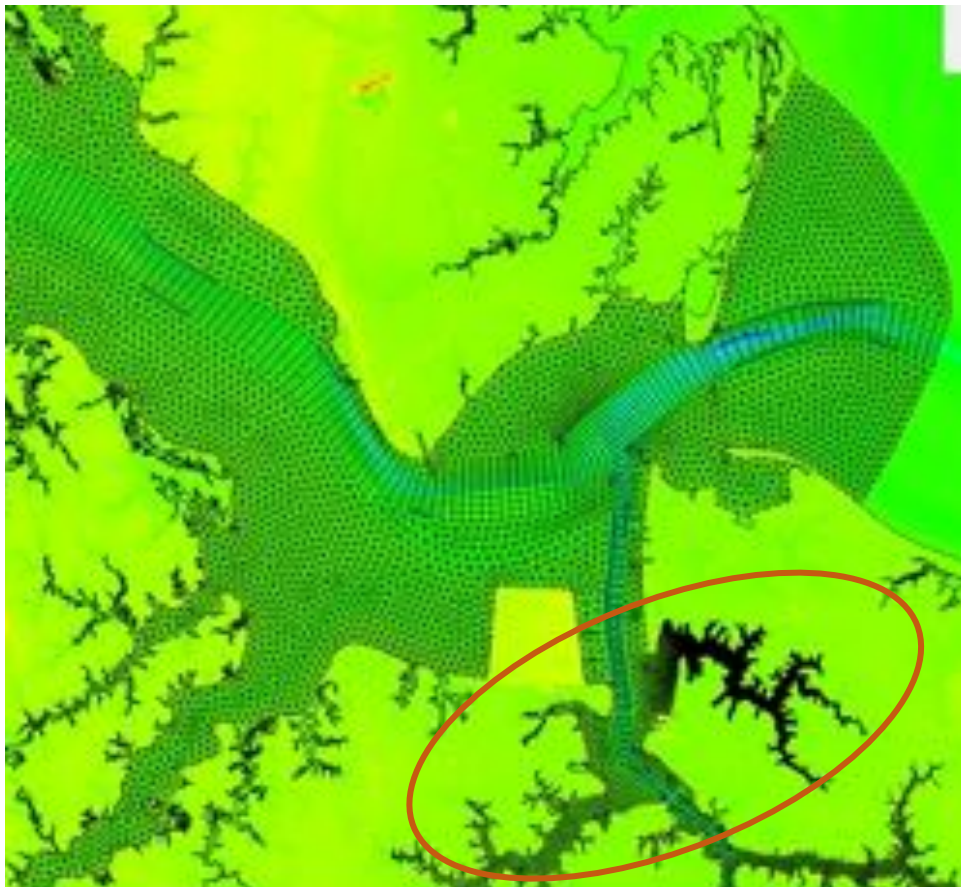
Cut-off from the MBM

Phase I: James River connected to the whole Bay grid

Phase II: single James River grid







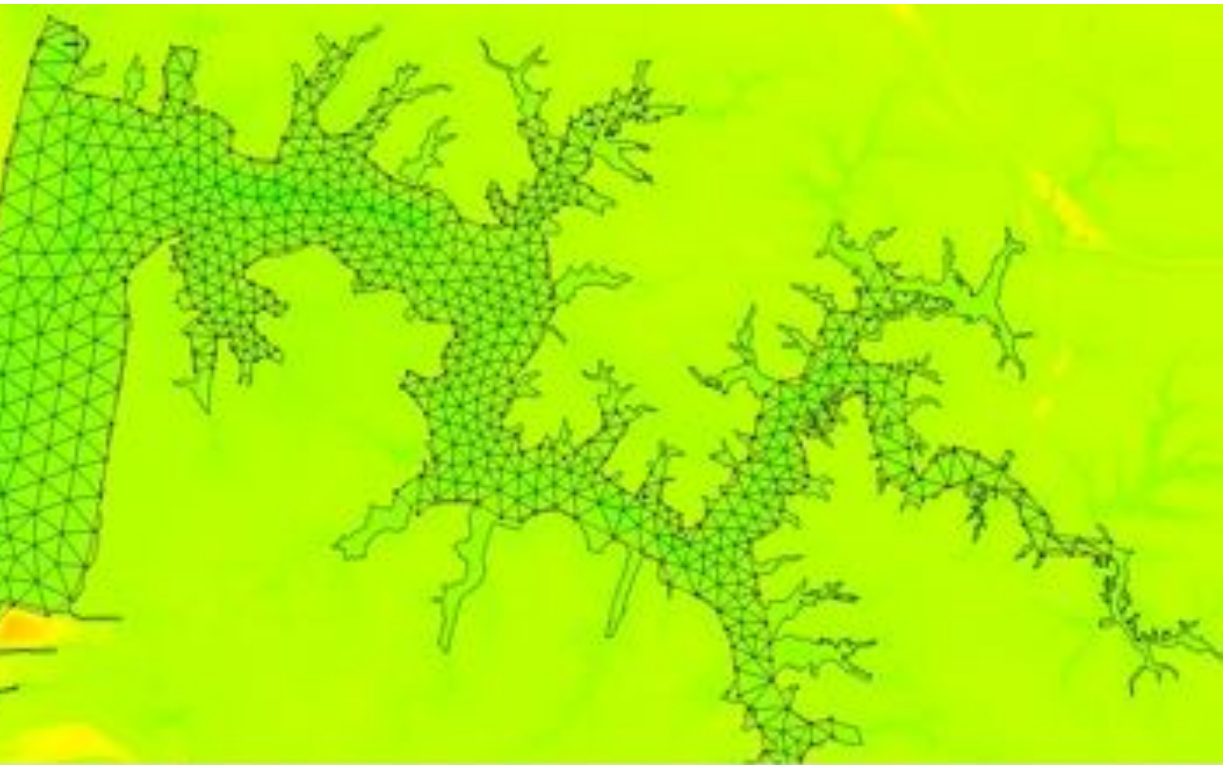
- Unchanged channel arc's
- Refined shoals and sub-tributaries

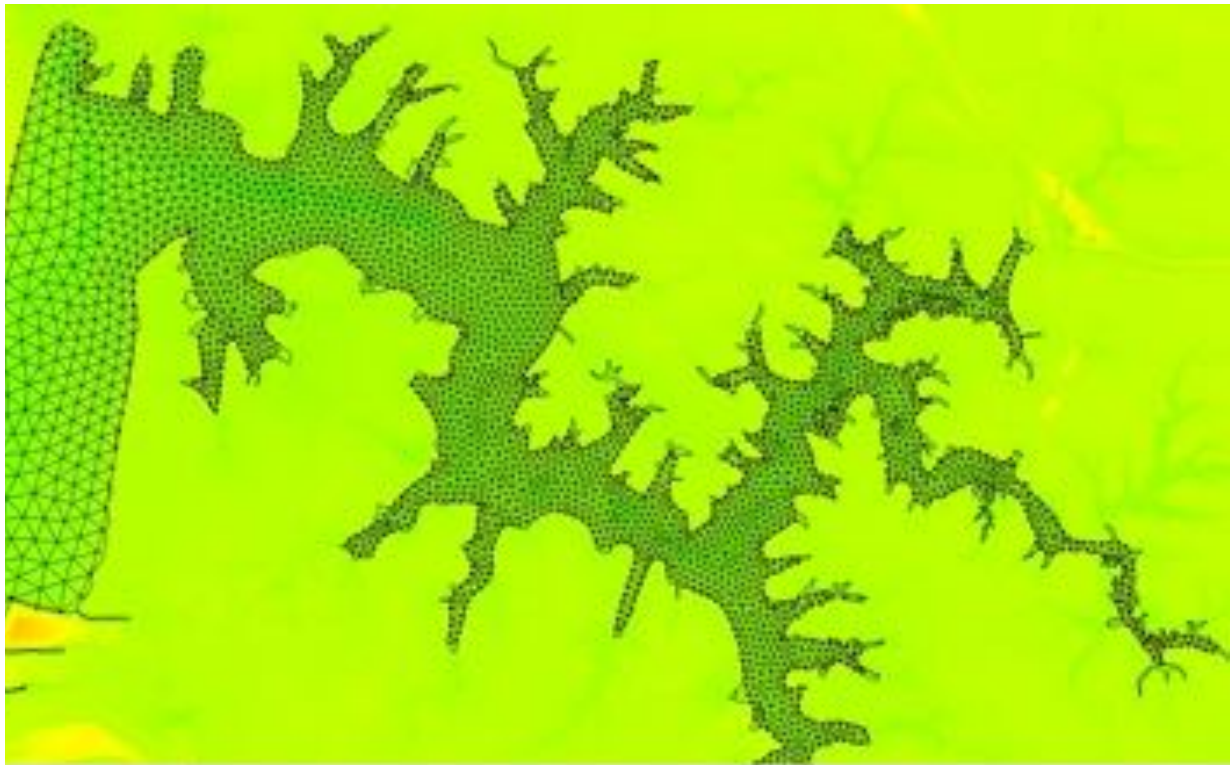
- #63 boundary nodes

- #17,305 nodes, #25955 elements
- Maximum #32 vertical layers

Refinement of Elizabeth River and Lafayette River

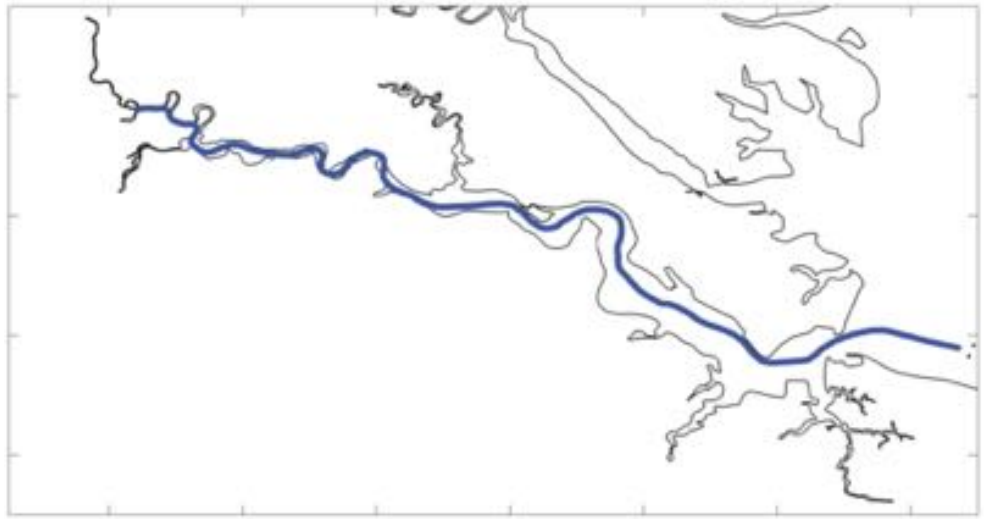
- Refine resolution to less than 50 m
- Based on NOAA shoreline (Fitch et al.)

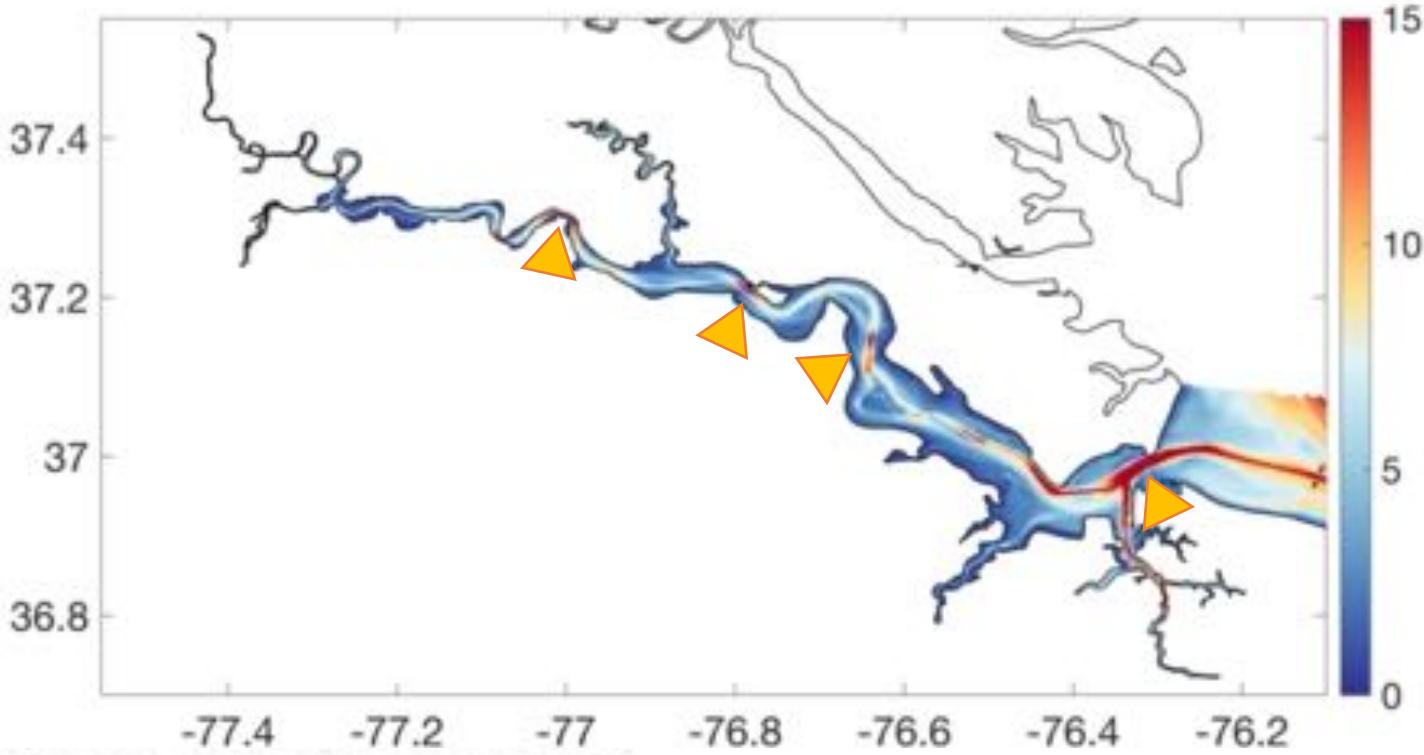




Hybrid shaved vertical grid system

- Maximum **32** layers in deep channels
- Minimum one layer for shallow shoals





Boundary setup (animation)

- #63 boundary nodes, #32 vertical layers
- Interpolate from phase I model results
- Vertical interpolation is based on elevation of each step

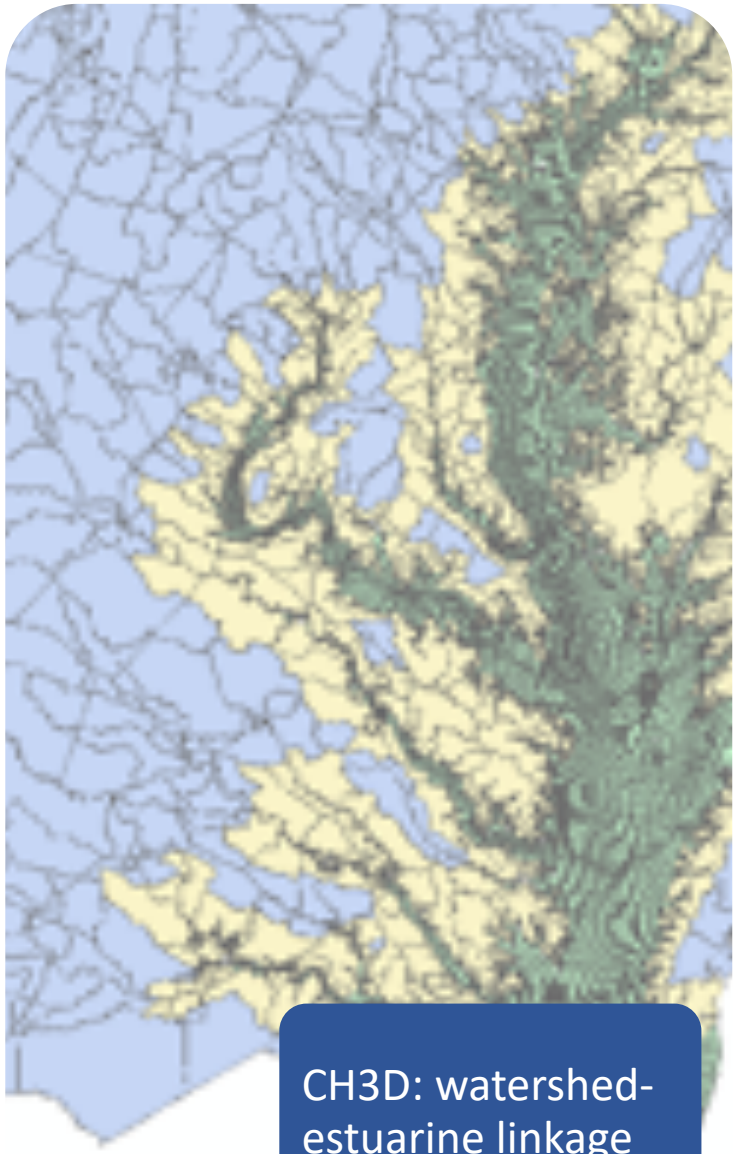
Upper James River

Elizabeth River

Saltwater intrusion

Watershed loading linkage

Phase 6 watershed loading



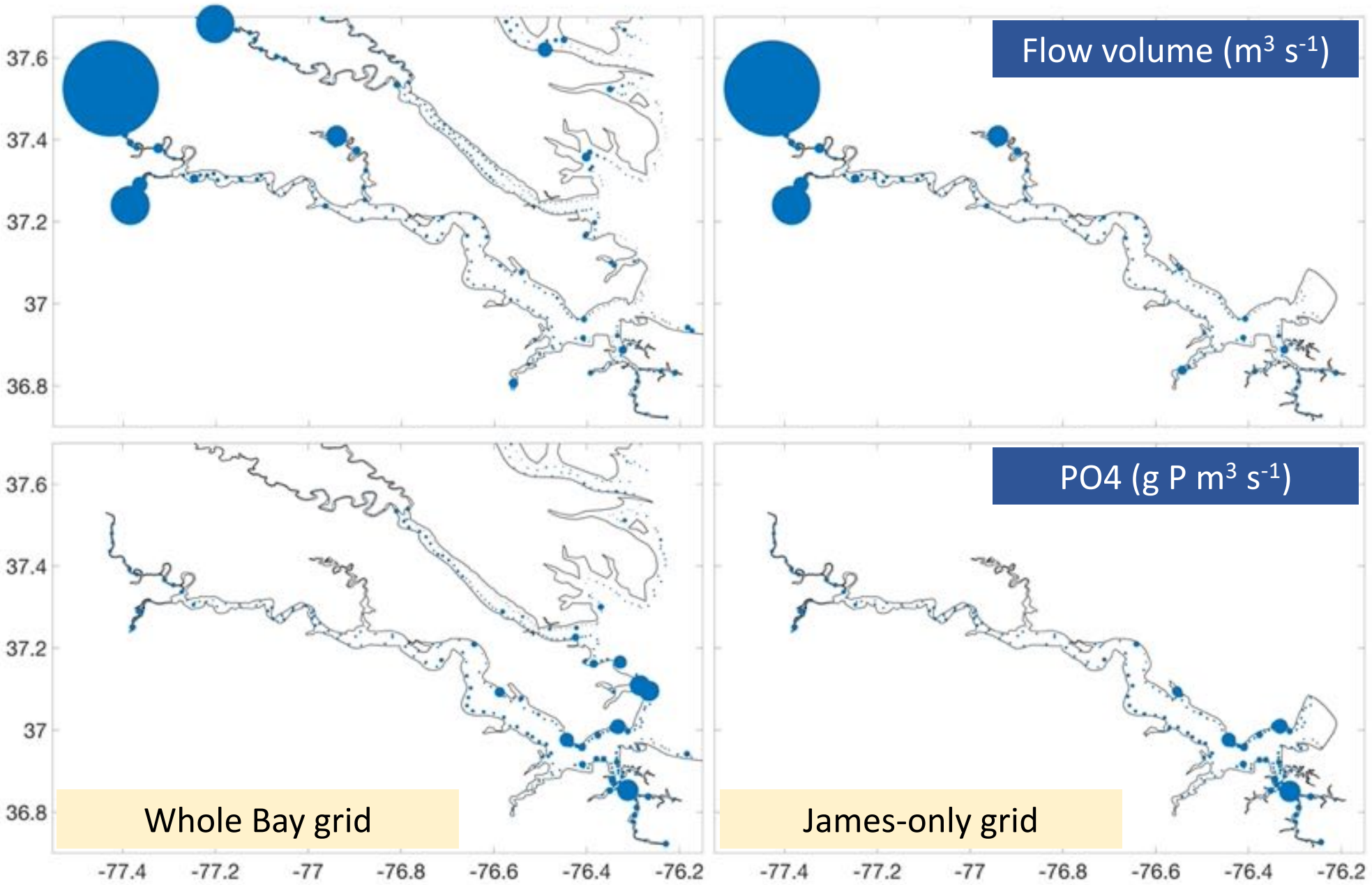
CH3D: watershed-estuarine linkage (Cerco et al.)

SCHISM

- MBM
- MTM

Watershed loading

Slight movement of certain loading locations due to the refinement of local grids, but the loading element is the nearest to the center of the CH3D loading cells.



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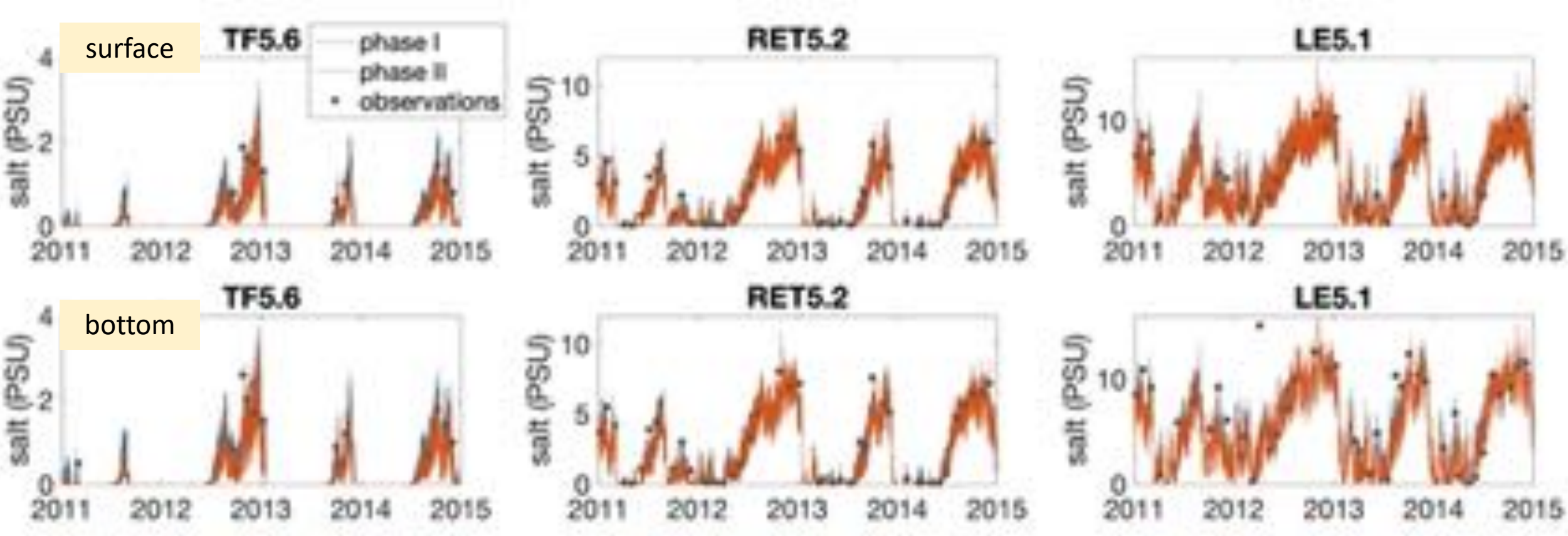
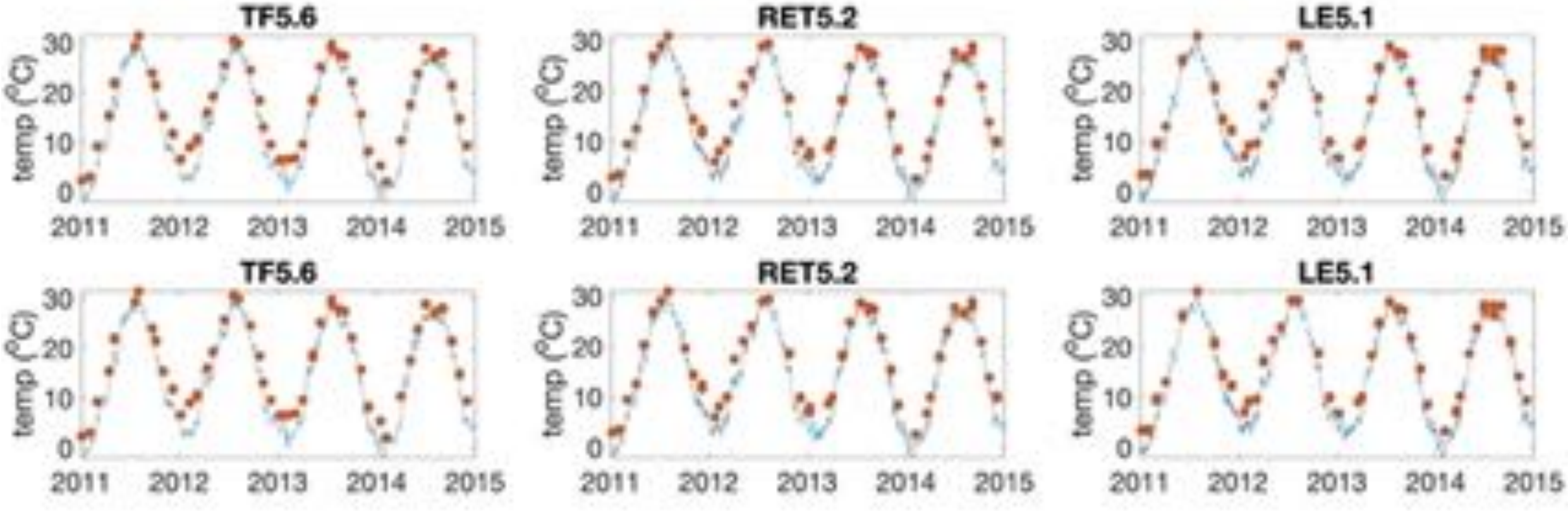
Preliminary results – salinity

- The phase II cut-off James River model is able to generally repeat the phase I model in the James channels
- Overall reasonable stratification, saltwater intrusion and seasonal variability

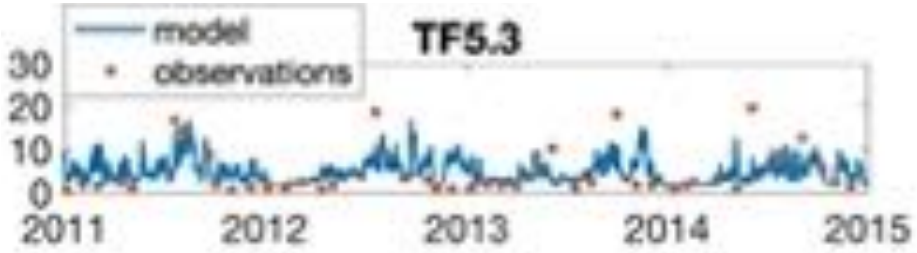


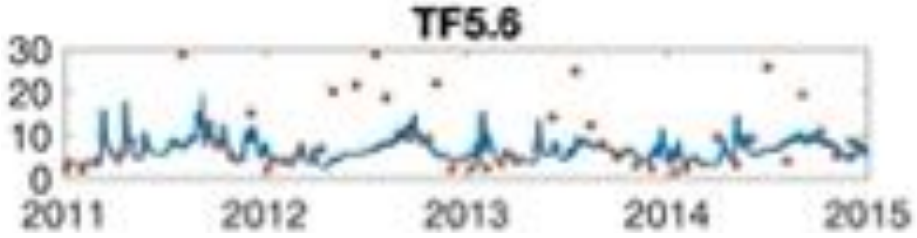
Preliminary results – temperature

- Reasonable simulation
- Overall slight under-estimation
- Attention to airshed model connection



Preliminary water quality results: surface chl-a





- Default setup identical to the Bay and York River
- No calibrations conducted yet
- No time-varying C:Chl-a ratio yet

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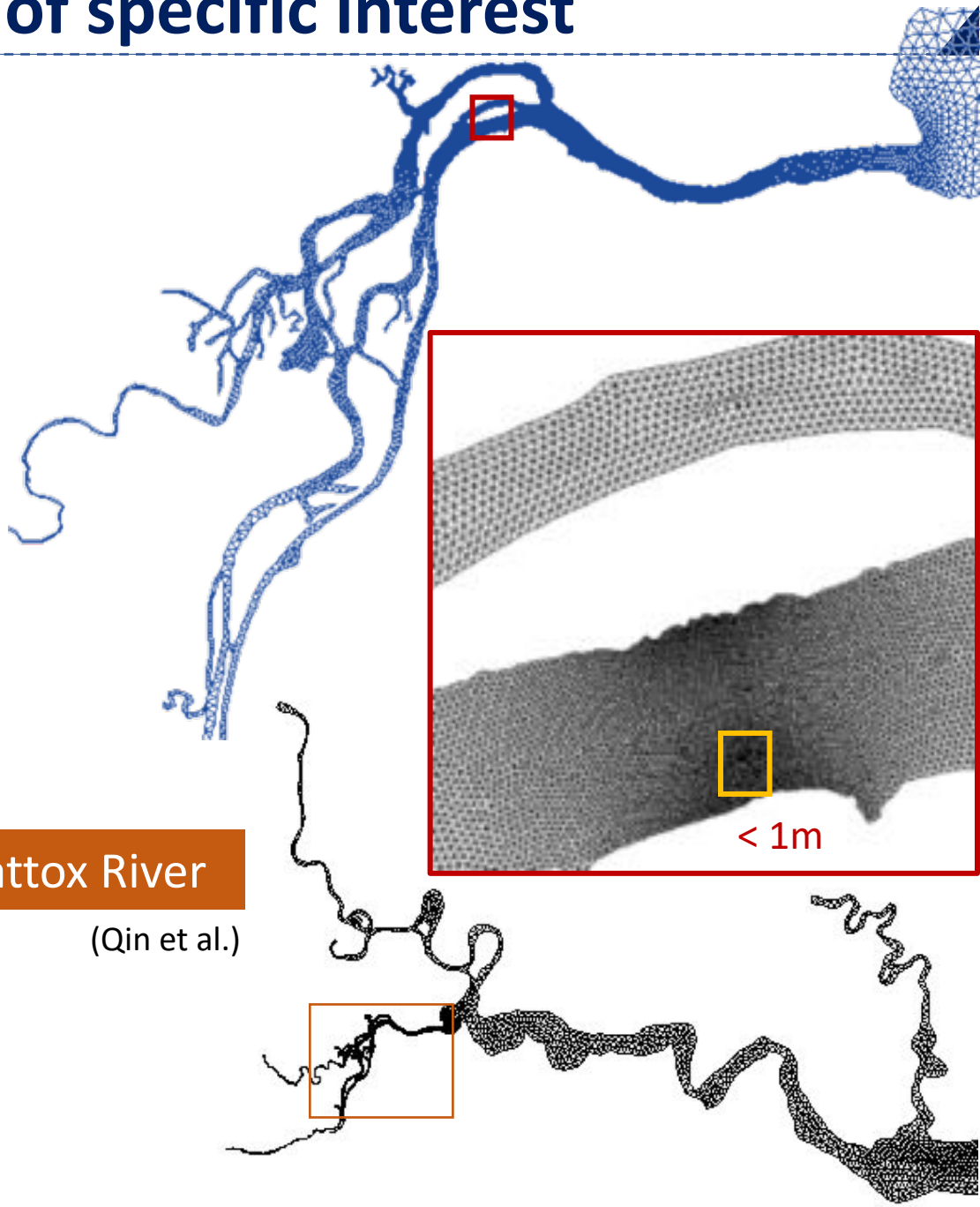
Examples of grid domains in the places of specific interest

Lynnhaven Bay

(Qin et al.)

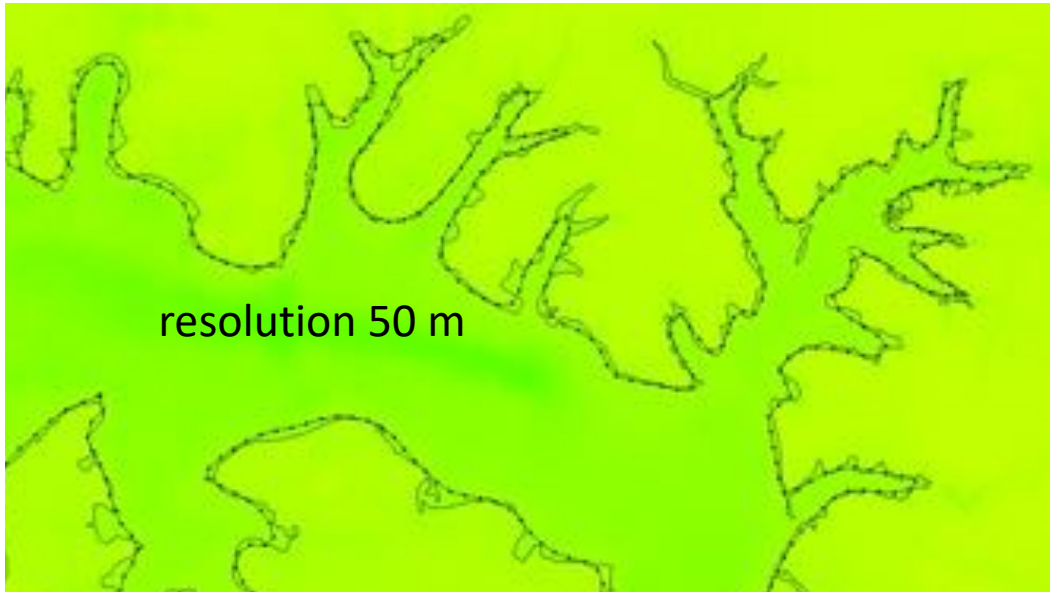


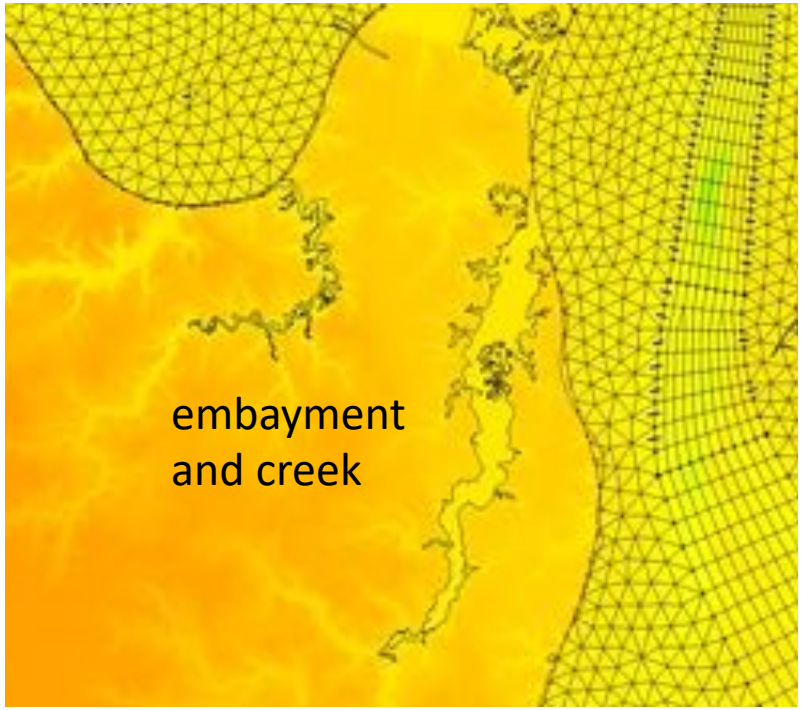
Appomattox River

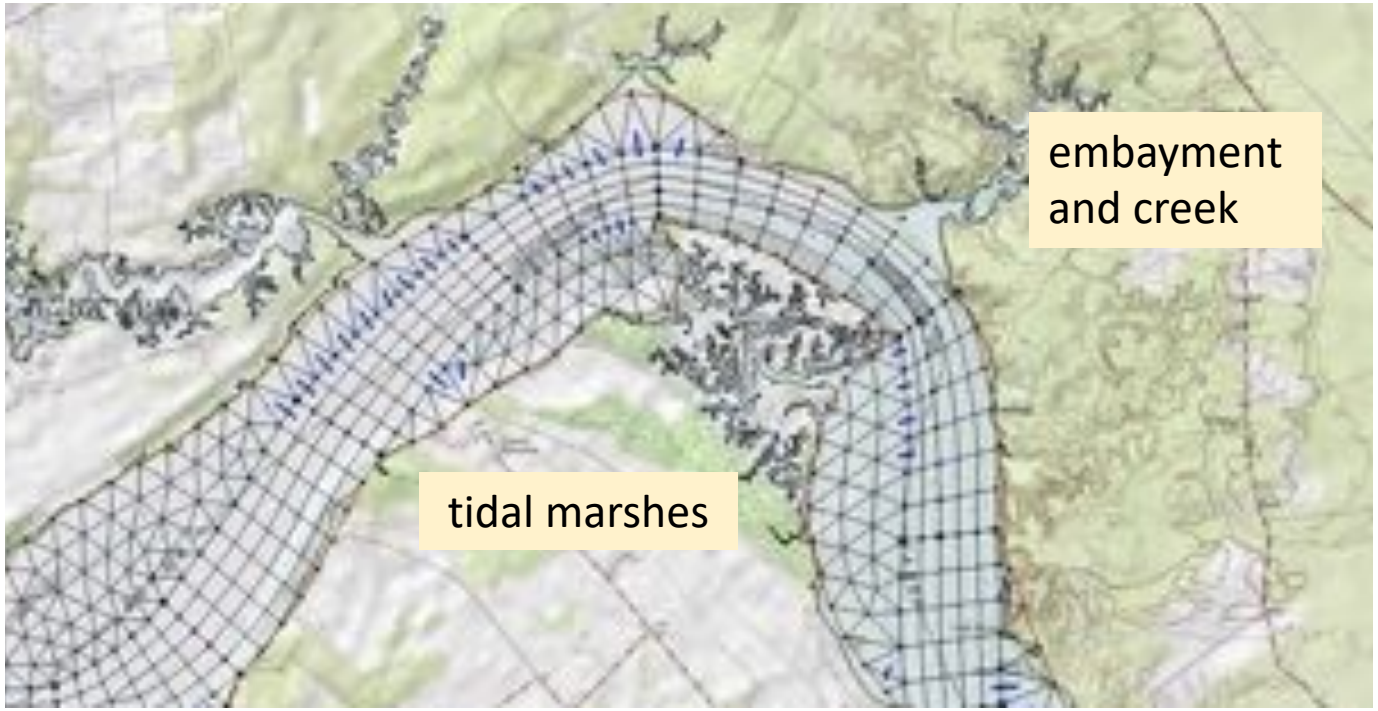
(Qin et al.)

Resolution and protocols

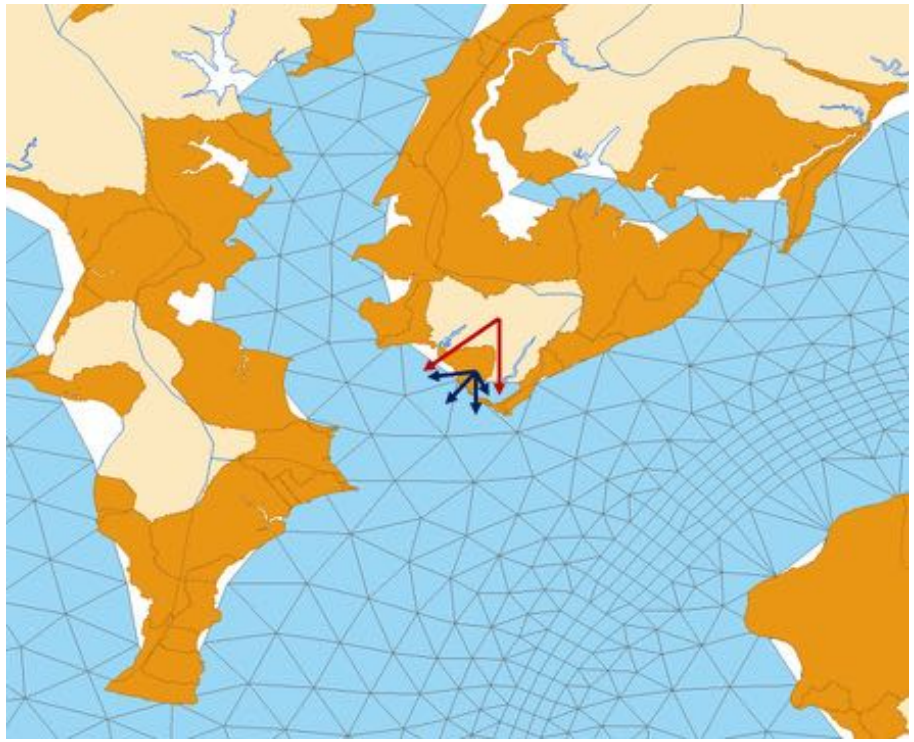
- What's the target resolution in MTM and MBM?
- What's the protocol to neglect certain embayment and small creeks?
- How is the tidal marshes included in the MTM or MBM?







Development of the linkage between the watershed and estuarine model



Old algorithm

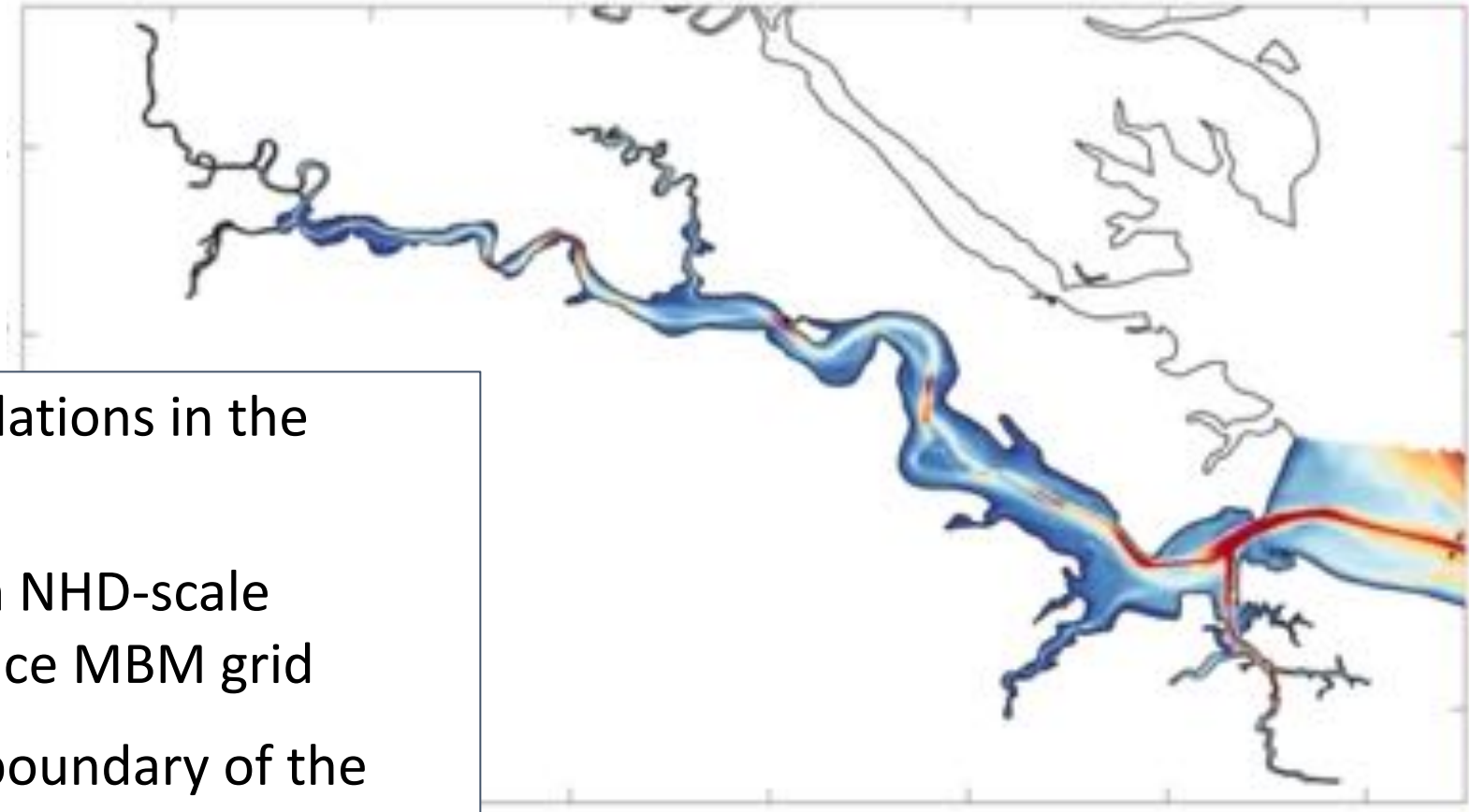
Does the NHD segment touch the land boundary?

- Yes: split the loading evenly to number of boundary elements adjacent to the segment
- No: find the nearest land boundary element and assign the flow

Plans

- Take the location (triangles) of stream mouth from the watershed model (Bhatt and Shenk)
- Determine the element receiving the largest amount of loadings

Next steps

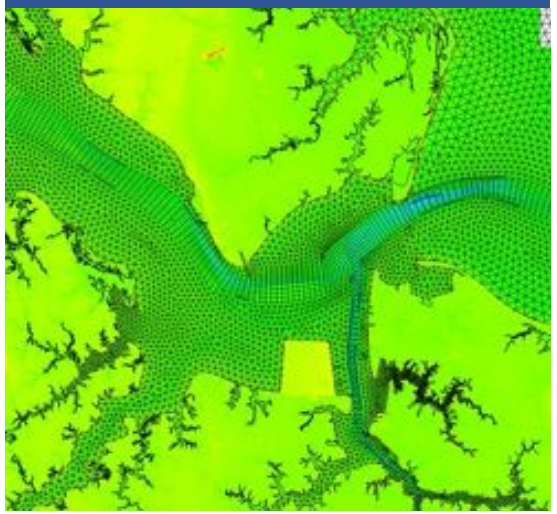


- Calibration of water quality simulations in the James River
- Development of the linkage from NHD-scale watershed segments to a reference MBM grid
- Development of shoreline/land boundary of the MBM/MTM model
- Investigations on the airshed loadings to the system

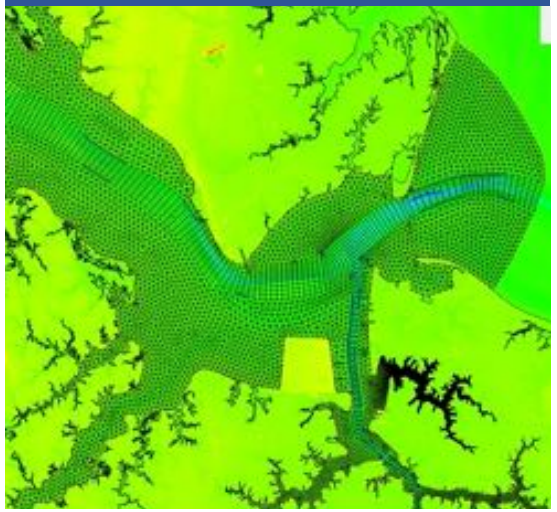
Suggestions on locations of interest?

Summary

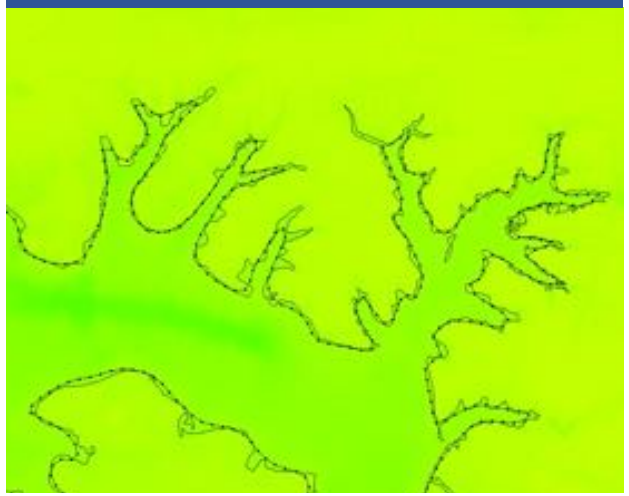
James R. Phase I



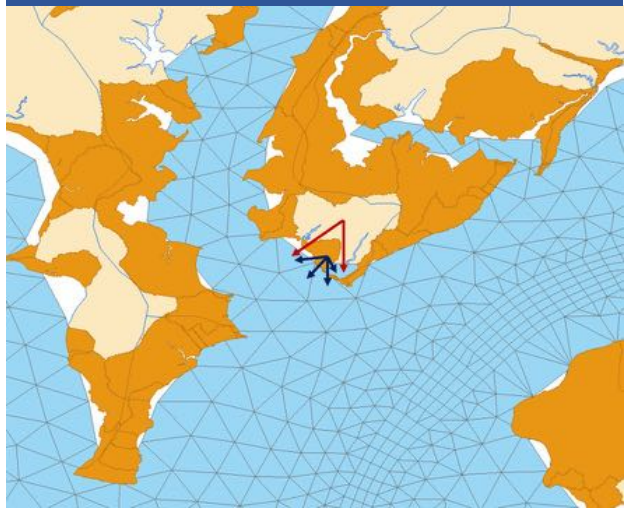
James R. Phase II



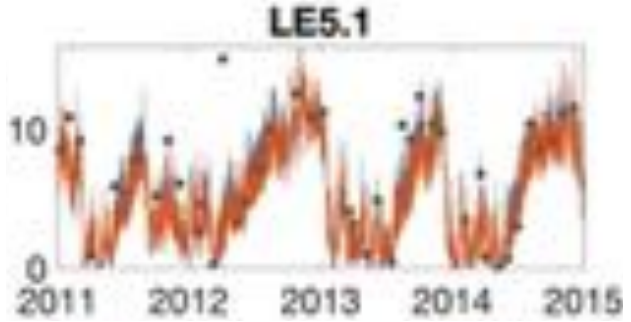
Shoreline development



Watershed linkage



Calibrations



Airshed connection

Sub MTM

Questions?

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