

Fine-scale Patapsco/Back River Tributary Model for Simulating Effect of Sanitation Sewage Overflow (SSO) under Climate Change Conditions

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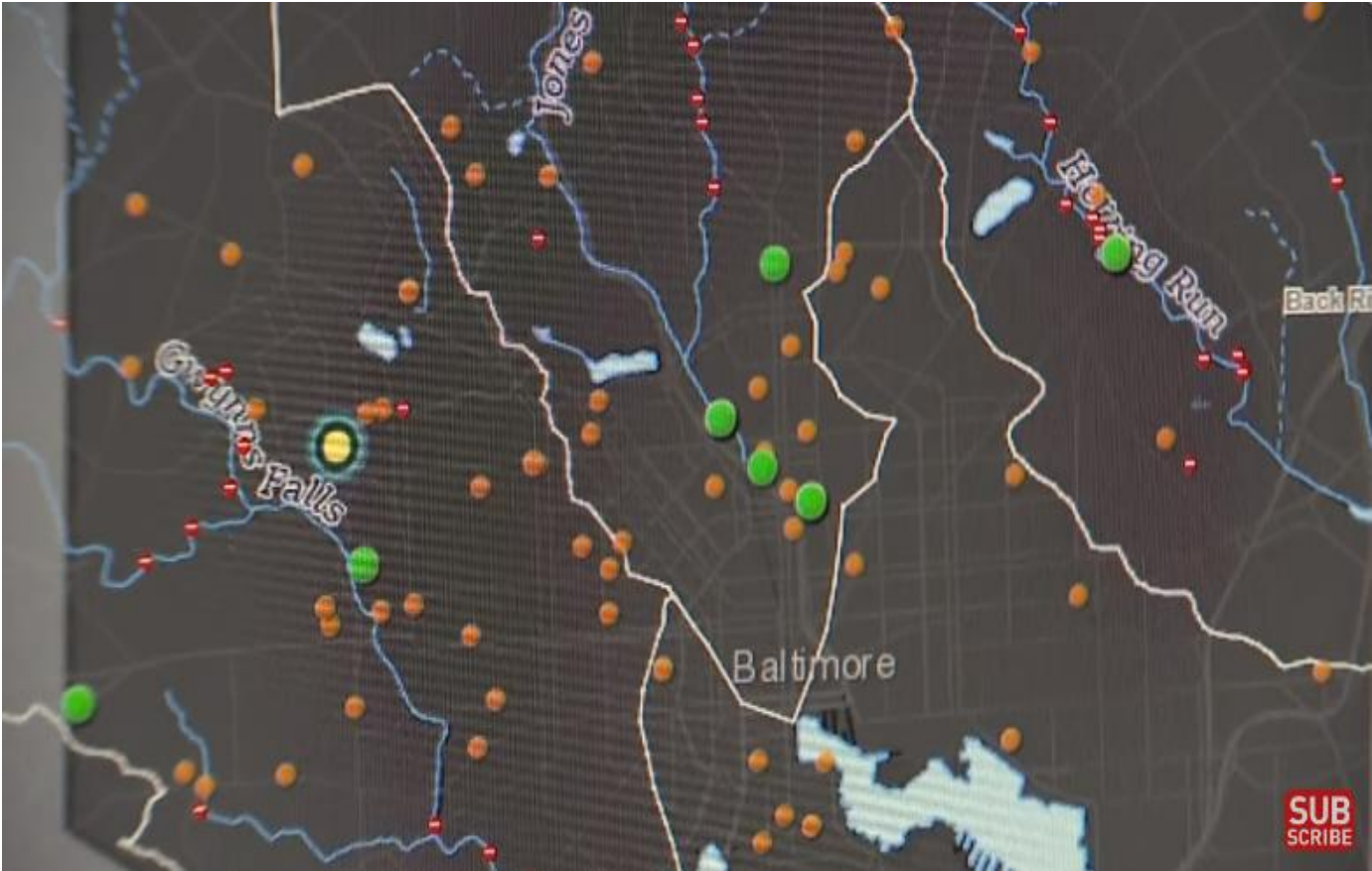
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Chesapeake Bay Symposium, 6/2024, Annapolis, Maryland


Motivation – two folds

1. BALTIMORE urban runoff -- Present Condition

Jan 18, 2024: Baltimore City's sewage systems were overwhelmed and overflowing. According to Baltimore City Department of Public Works (DPW), the combination of heavy rain and snowmelt spilled 14 million gallons of raw sewage into surrounding streams and rivers.



14 million gallons of sewage overflow spills into Baltimore waterways in one day (1 million Herring run, 4 million Jones Falls, 9 million Gwynns Falls) <https://www.youtube.com/watch?v=cyKtOt5vbE4>

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sanitary sewer overflow

Final Totals for Sewer Overflows from Historic July Rainfalls

Aug 7th, 2018

Rain reports are in for sewerstormwater overflows that occurred during the last weeks of July. These resulted from the heaviest rainfall in Baltimore in July on record. Much of this overflow was released through structures built, designed as part of Baltimore's sewer system more than 100 years ago. The City will close the last of these structures once the new Headworks project is operational at Back River in late 2020.

[View more details](#)

DPW Reports Additional Sewer Overflows Related to Weekend Heavy Rains

Jun 1st, 2018

The Baltimore City Department of Public Works (DPW) estimates that two additional sewer overflows of well over 10,000 gallons of stormwater mixed with sewage have been reported, as a result of the weekend rains.

[View more details](#)

DPW Reports Sanitary Sewer Overflows

Feb 5th, 2018

The Baltimore City Department of Public Works estimates that over 2.3 million gallons of storm water combined with wastewater overflowed into the Jones Falls river between 6:00 p.m. and 11 p.m. Sunday, February 4. The cause of these overflows was wet weather infiltration of the sewer mains.

[View more details](#)

Sanitary Sewer Overflow Numbers in Steady Decline

Dec 12th, 2017

Sanitary sewer overflows (SSOs) in Baltimore have been in decline for five consecutive years, falling 21 percent since Fiscal Year 2012, according to a review by the Baltimore City Department of Public Works (DPW). In the fiscal year concluded June 30, 2017, Baltimore recorded 464 SSOs. That is down from 670 SSOs in Fiscal 2012.

[View more details](#)

DPW Repairs Leaking Portions of Aged Sewer Pipe

Oct 27th, 2017

A rubblison discharge from a series of breaks in an 80-year-old sewer pipe under the 2500 block of W. Lexington Street has been stopped, about a month and a half after the breaks were diagnosed.

[View more details](#)

A photograph showing a sewage overflow into the Jones Falls river. The water is murky and brown, indicating raw sewage. A concrete structure, identified as Manhole 67, is visible in the foreground, with water overflowing from it. The surrounding area is grassy and has some trees in the background.

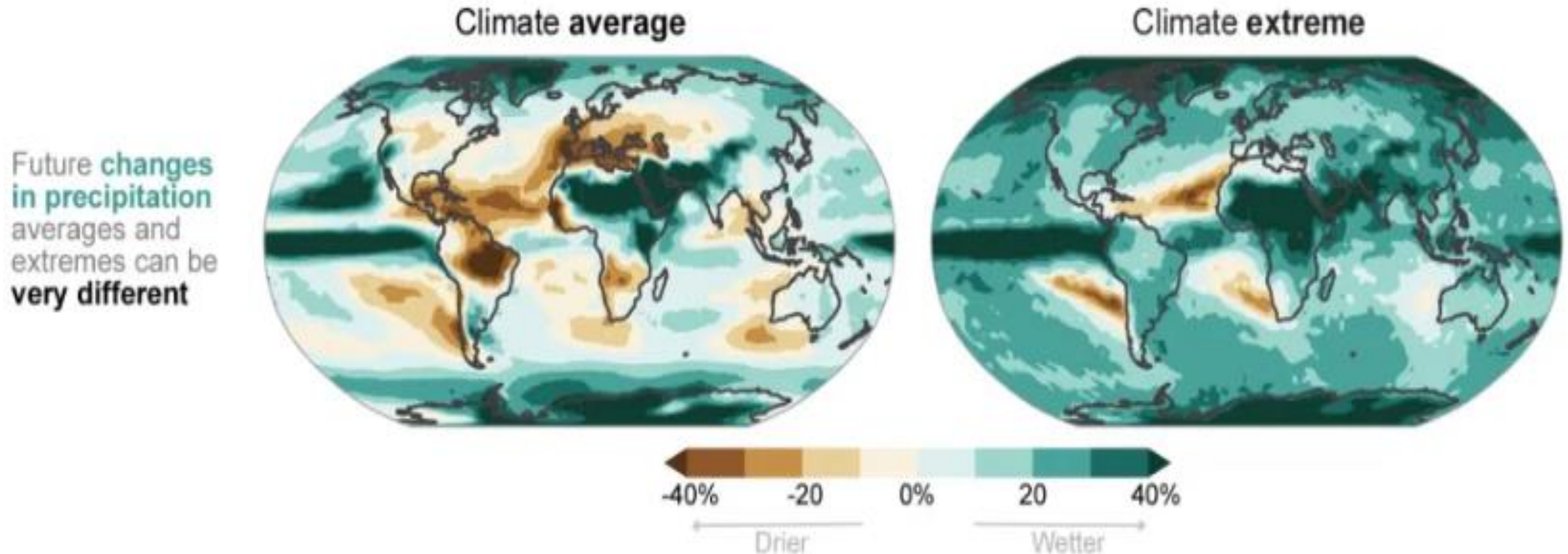
Sewage overflow into the Jones Falls -Baltimore MD at manhole overflow 67, April 6, 2017

<https://publicworks.baltimorecity.gov/taxonomy/term/2439>

2. Baltimore urban runoff under Climate Change

Changing Precipitation

A warmer average global temperature will cause the water cycle to “speed up” due to a higher rate of evaporation. More water vapor in the atmosphere will lead to more precipitation. Global average precipitation can increase by 7% for each degree of warming, which means we are looking at a future with much more rain and snow, and a higher risk of flooding to some regions. With 2°C temperature increase, heavy rain events are expected to become 1.7 times more likely, and 14% more intense. However, changes in precipitation will not be evenly distributed. Some locations will get more, and others will see less.

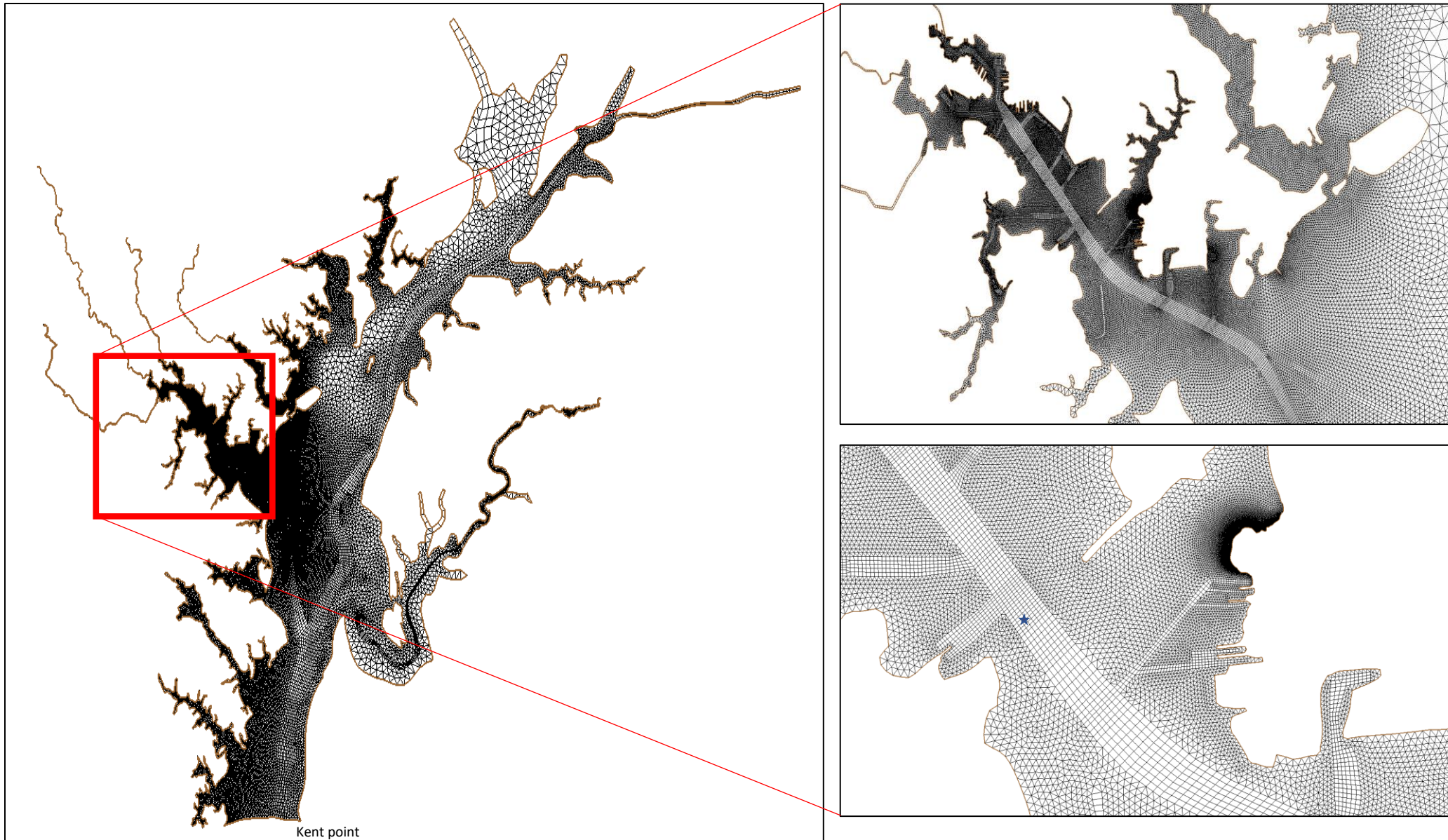


Outline:

- I. Fine-scale Patapsco/Back River Tributary Model
- II. Preliminary calibration
- III. Applications
- IV. Summary

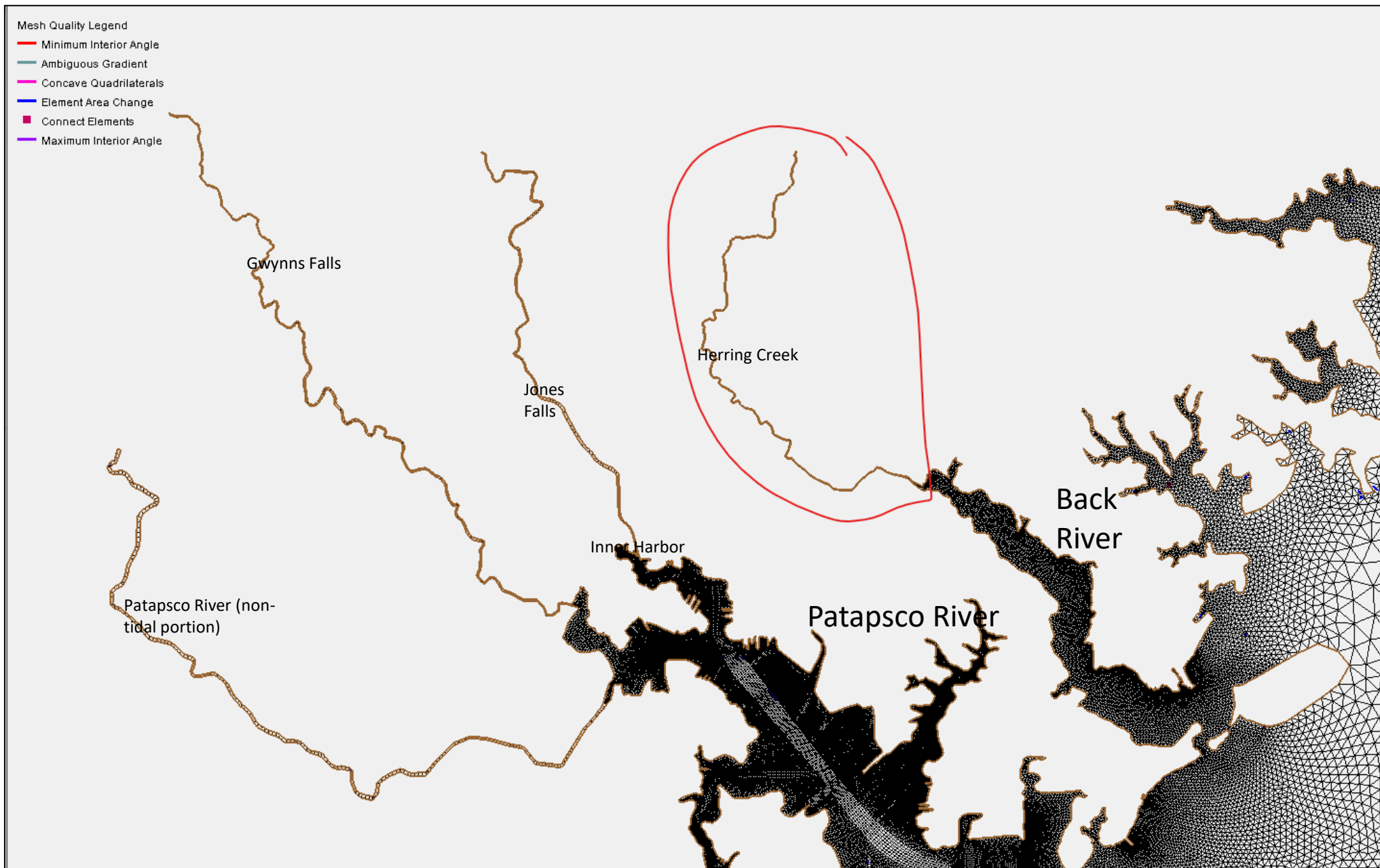
I. Fine-scale Patapsco/Back River modeling

(1) 3D SCHISM model domain



Overall resolution
50-100 m with a
total of 61 k grid
cells

Figure 1: The model domain to be used in evaluating near-field mixing and far-field dilution factors in (a) Upper Chesapeake Bay (b) Baltimore Harbor (c) Sparrow Point and Bear Creek.



The MTM fine-grid includes 4 major streams in Baltimore area: Herring Creek, Jones Falls, Gwynns Falls, and non-tidal Patapsco River, intended for receiving urban watershed loads.

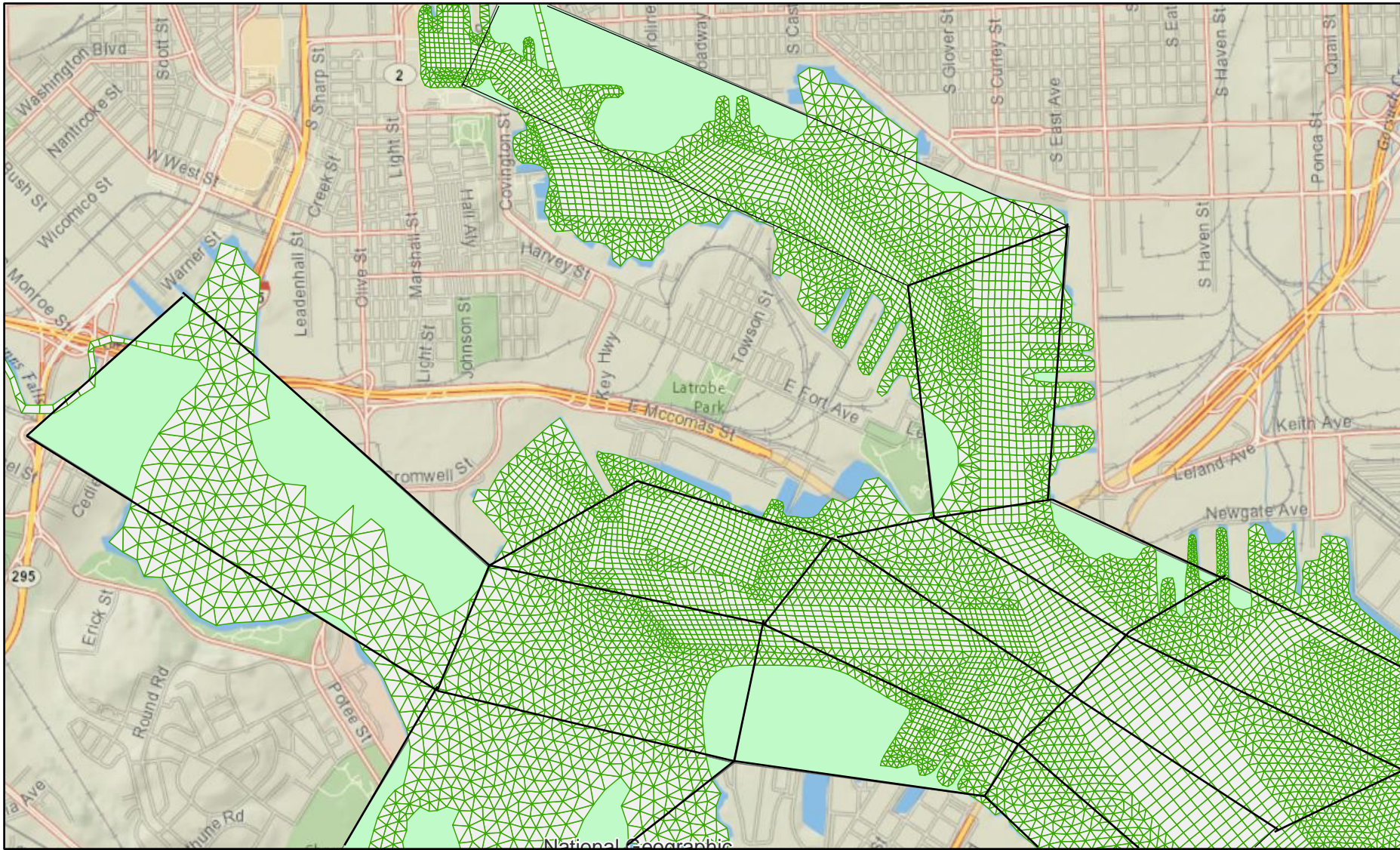
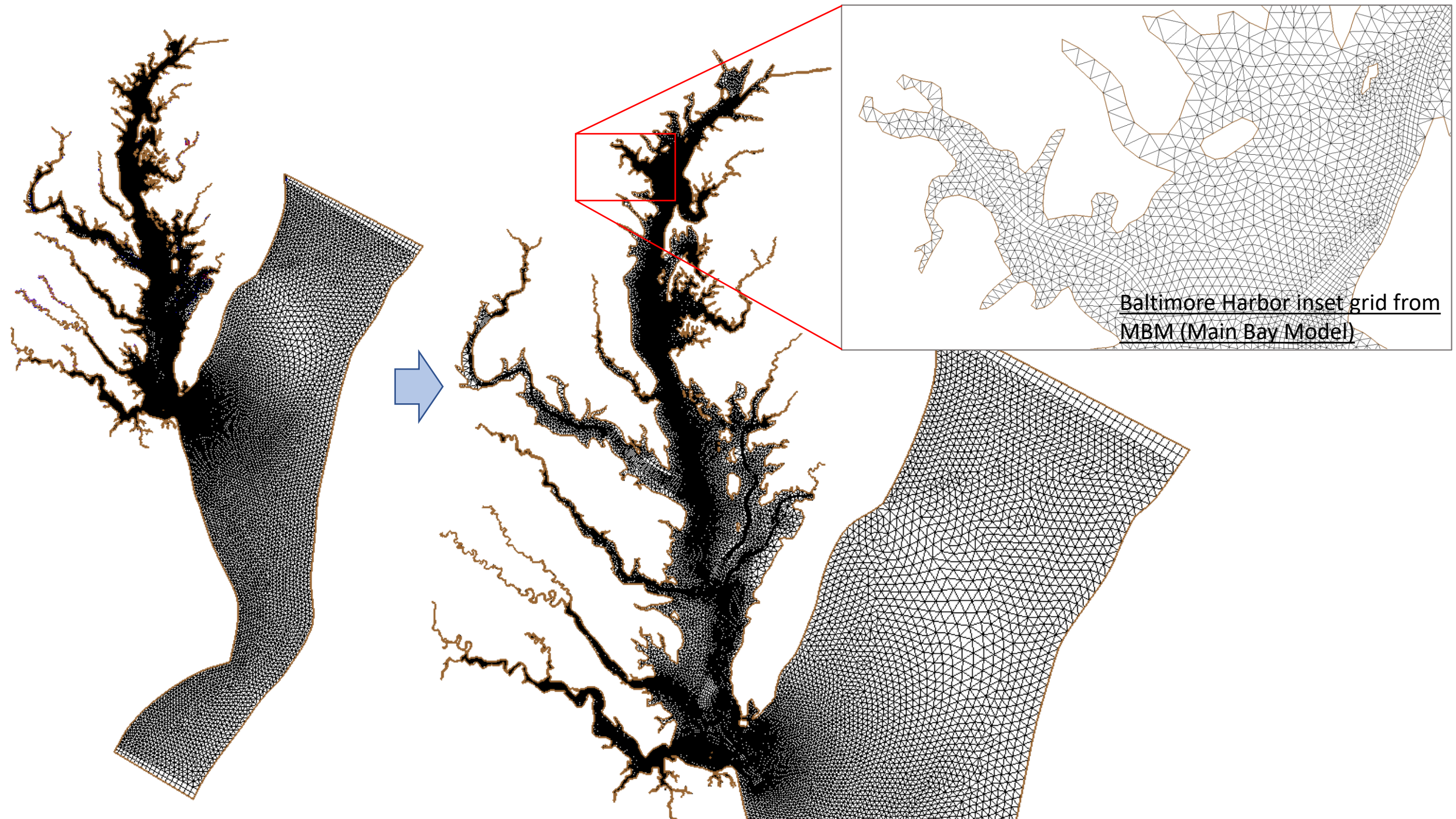


Figure 2 (a): Coarse Black quadrilateral cells are CH3D grid; the Green is MTM fine-unstructured-grid with mixed triangle/quadrilateral grids. Blue is additional areas fine grid covered.



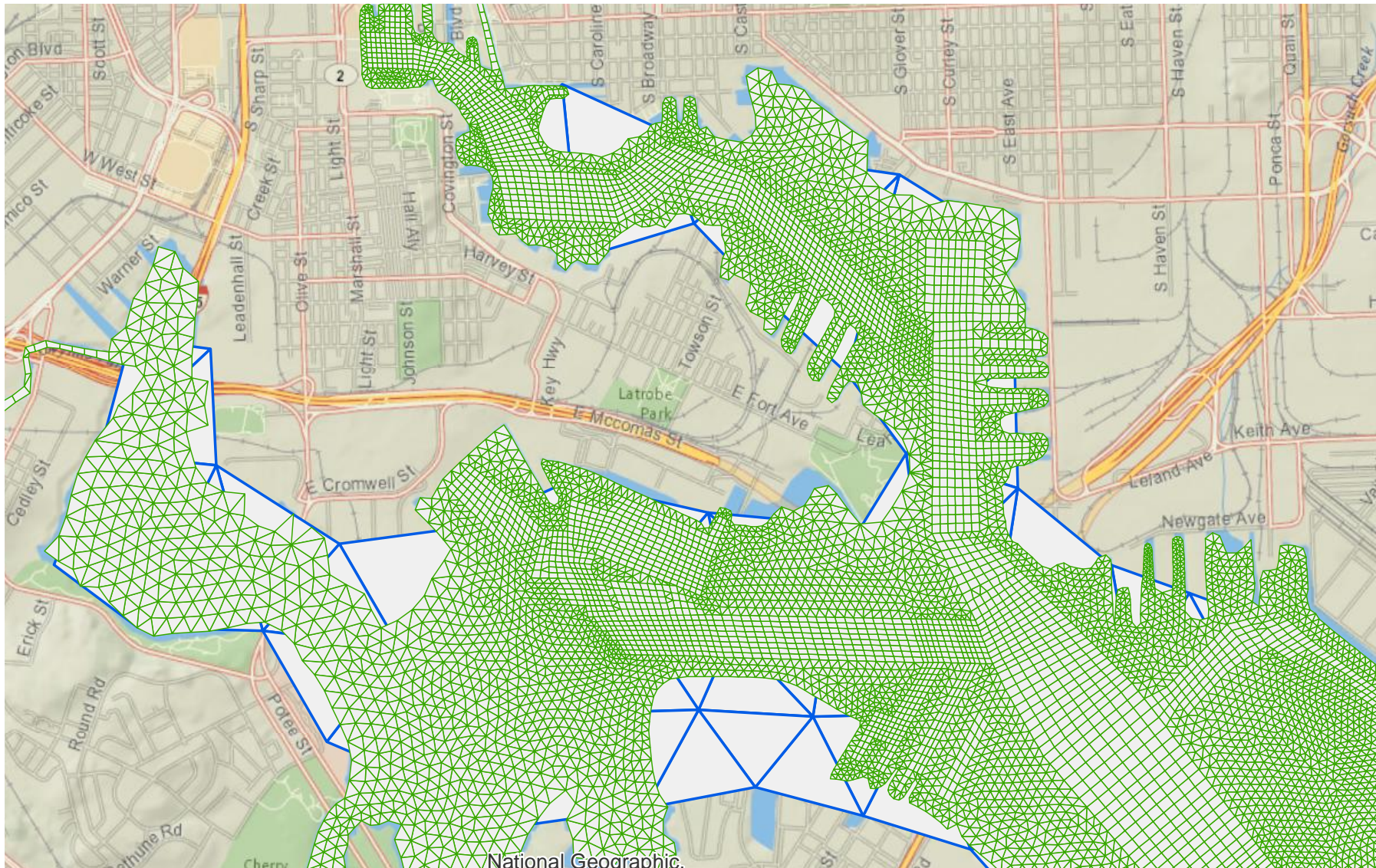
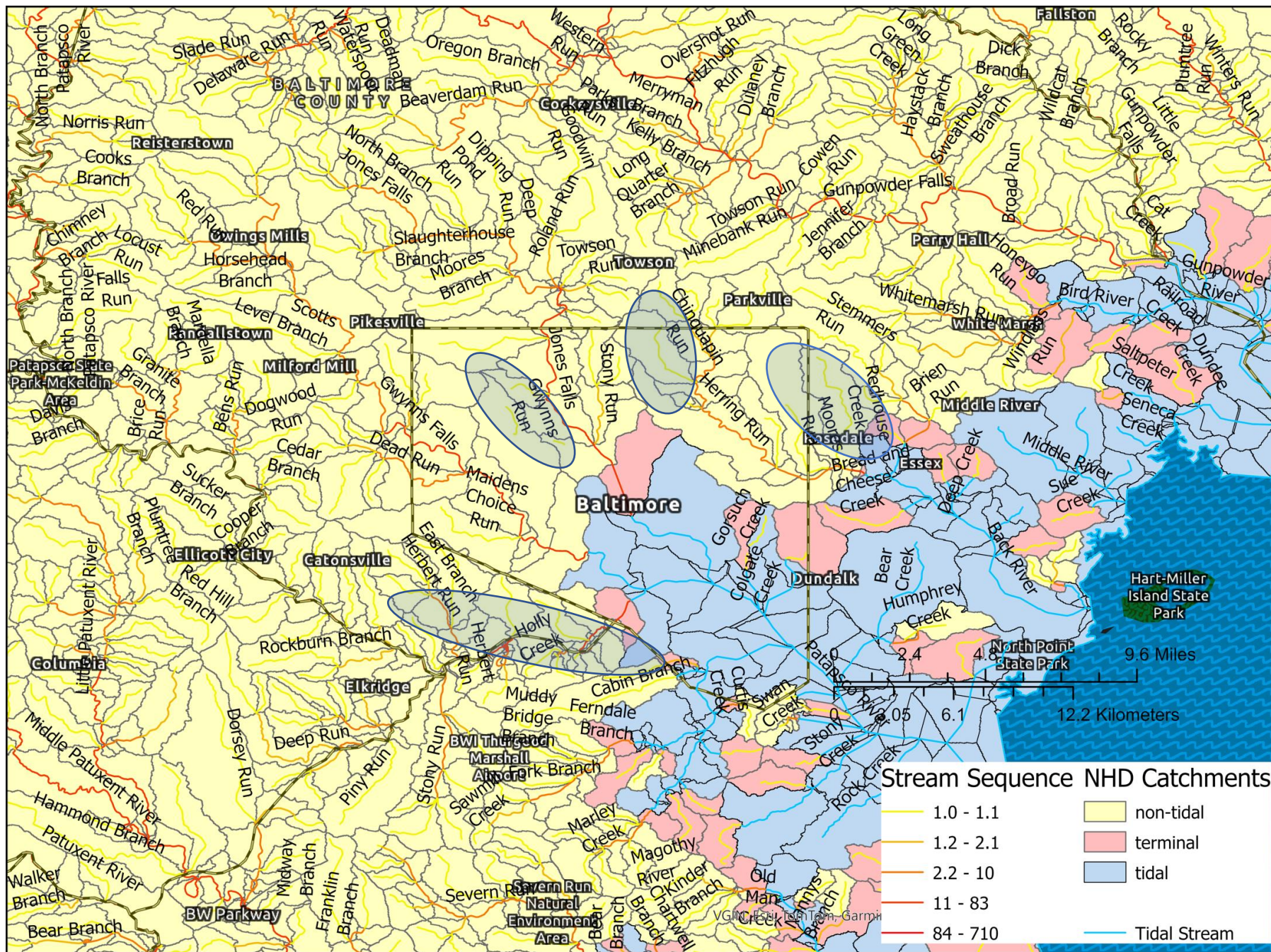
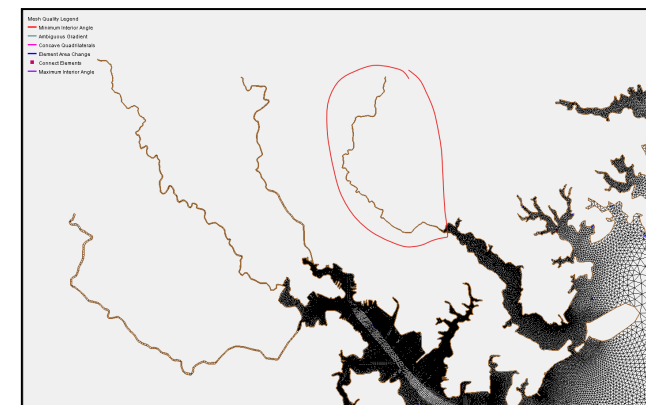


Figure 2(b): **Blue lines are MBM grid; the Green is MTM fine-unstructured-grid with mixed triangle /quadrilateral grids.**

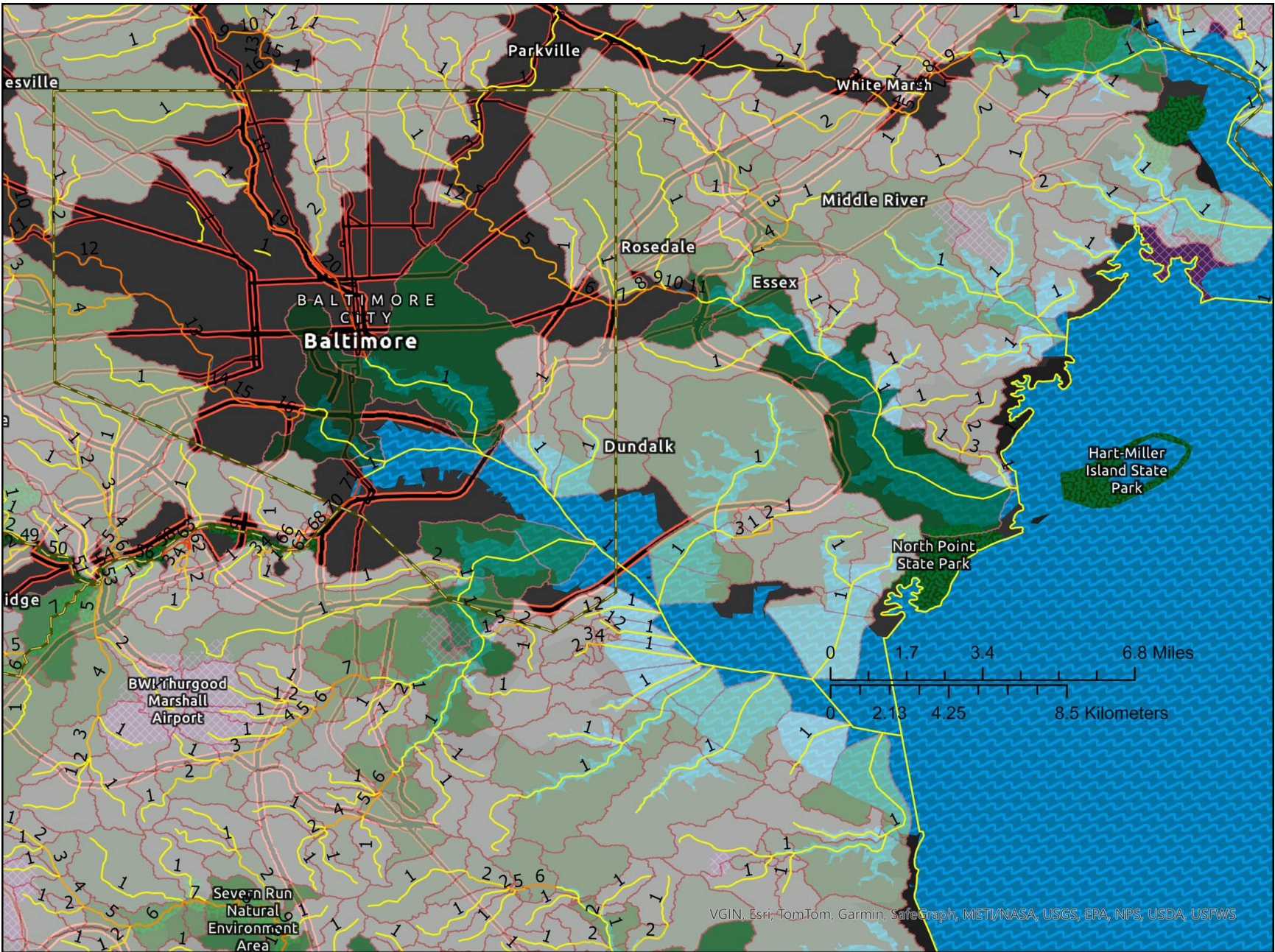


Receiving EPA phase-7 urban watershed flow



Provided by EPA Chesapeake Bay Program

Figure 3 (a): Baltimore Harbor watershed NHD (National Hydrography Data) catchment map



Receiving EPA phase-7 urban
watershed flow

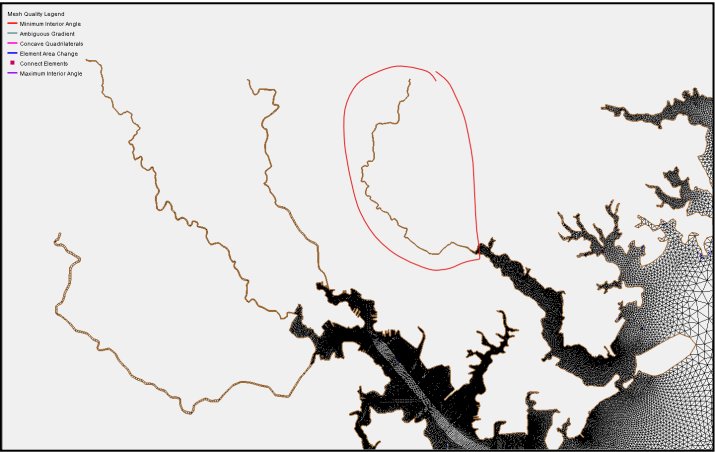


Figure 3(b): Baltimore Harbor watershed and drainage network based on Strahler ordering of streams

Provided by EPA Chesapeake Bay Program

II. SCHISM hydrodynamic model preliminary calibration

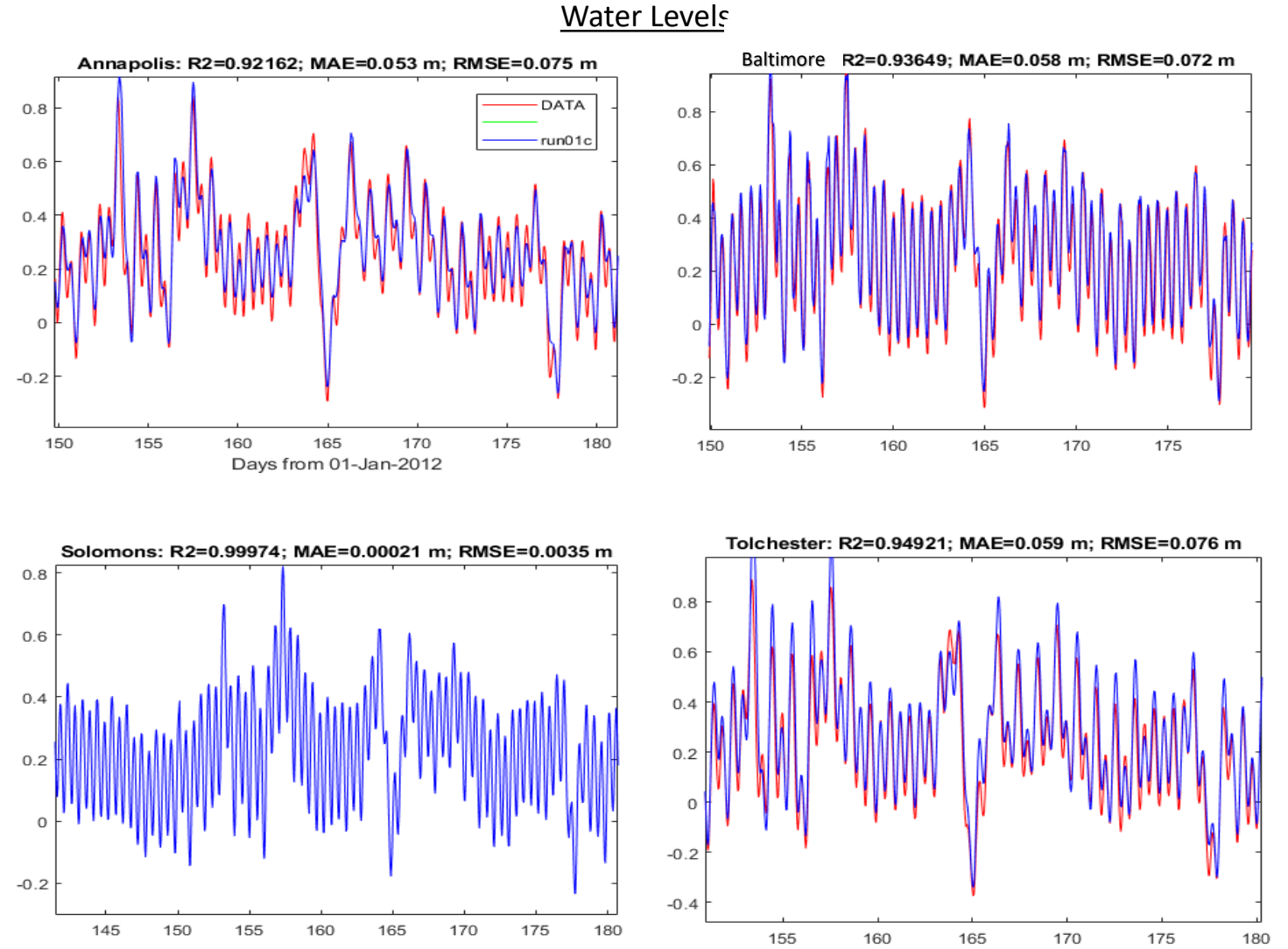
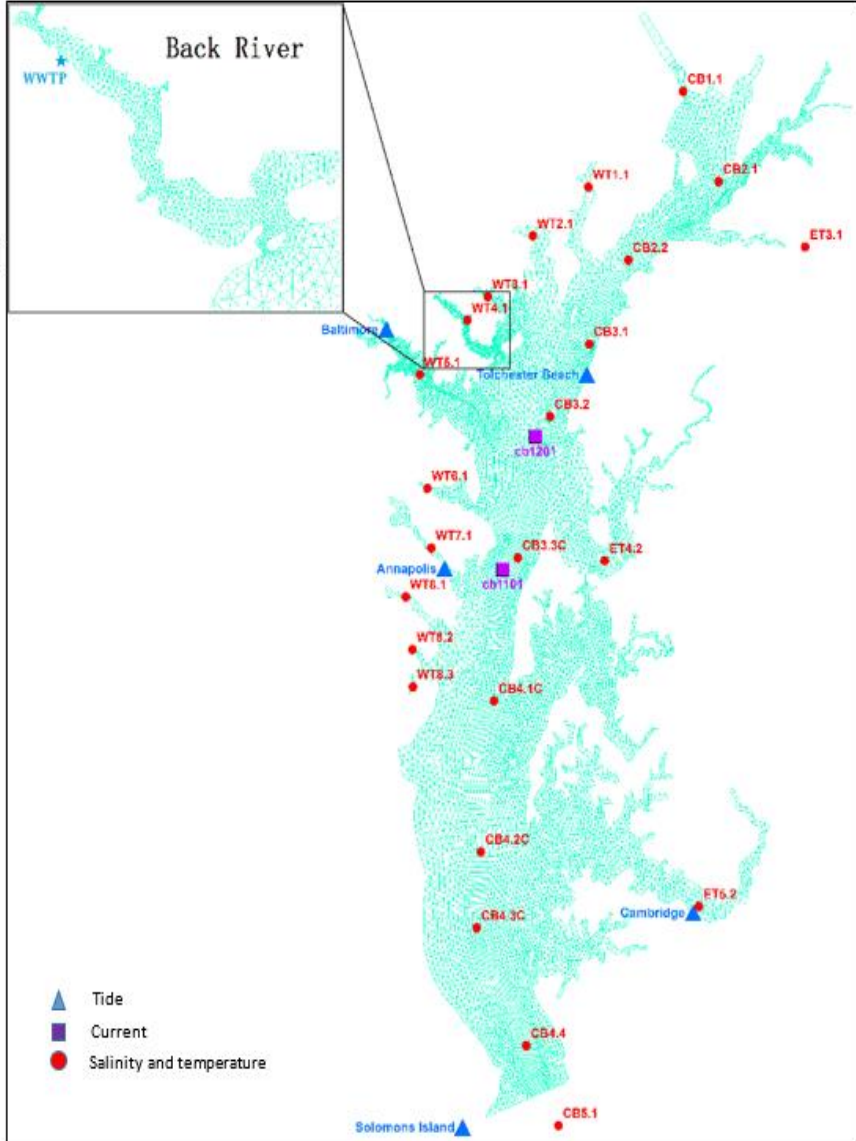
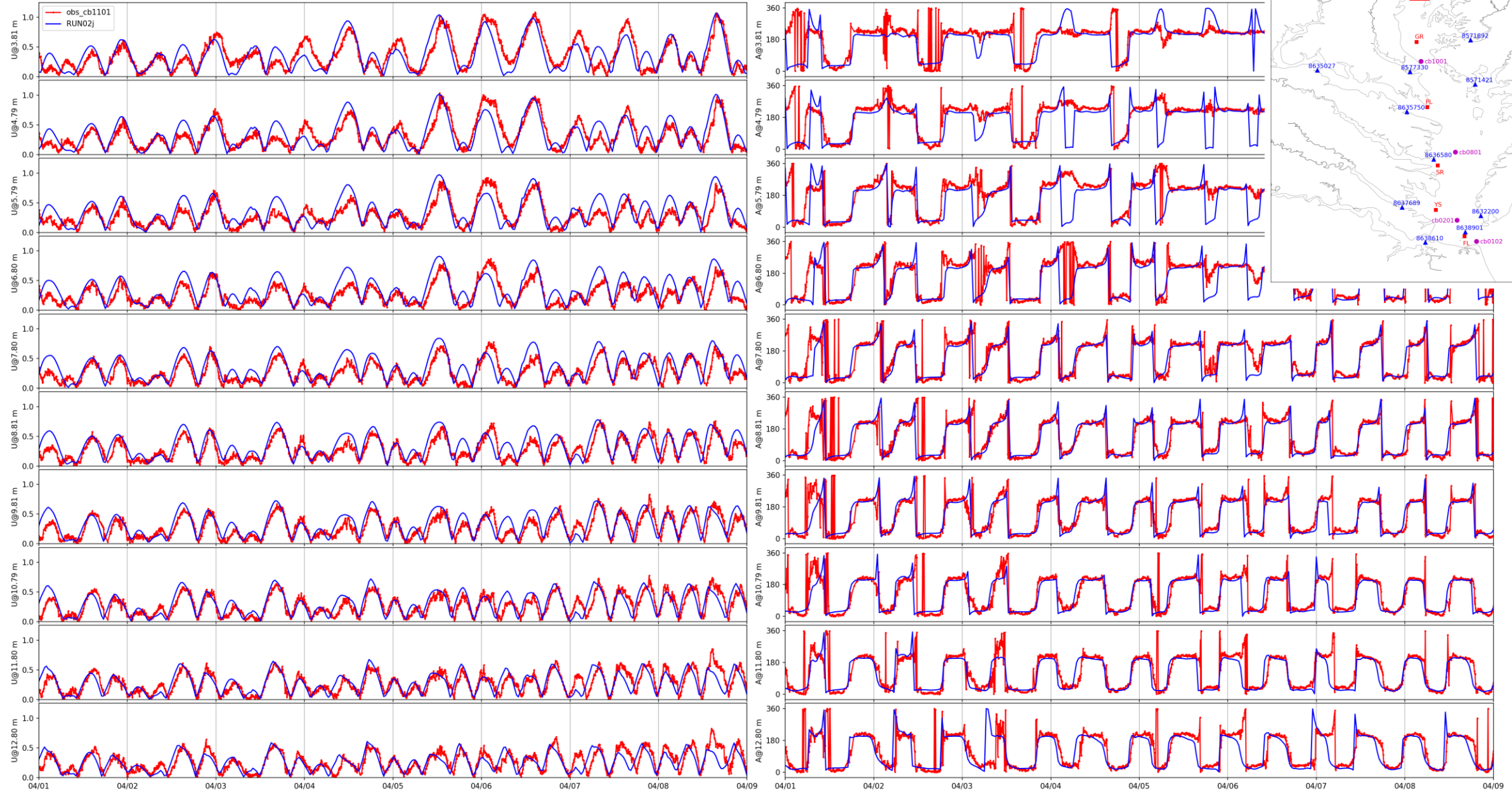


Figure 5(a) : The modeled versus observed water elevation during June and July, 2012

Figure 4: The Upper Bay SCHISM modeling grid with observation stations locations

Calibration: current profile @NOAA



Along channel Velocities

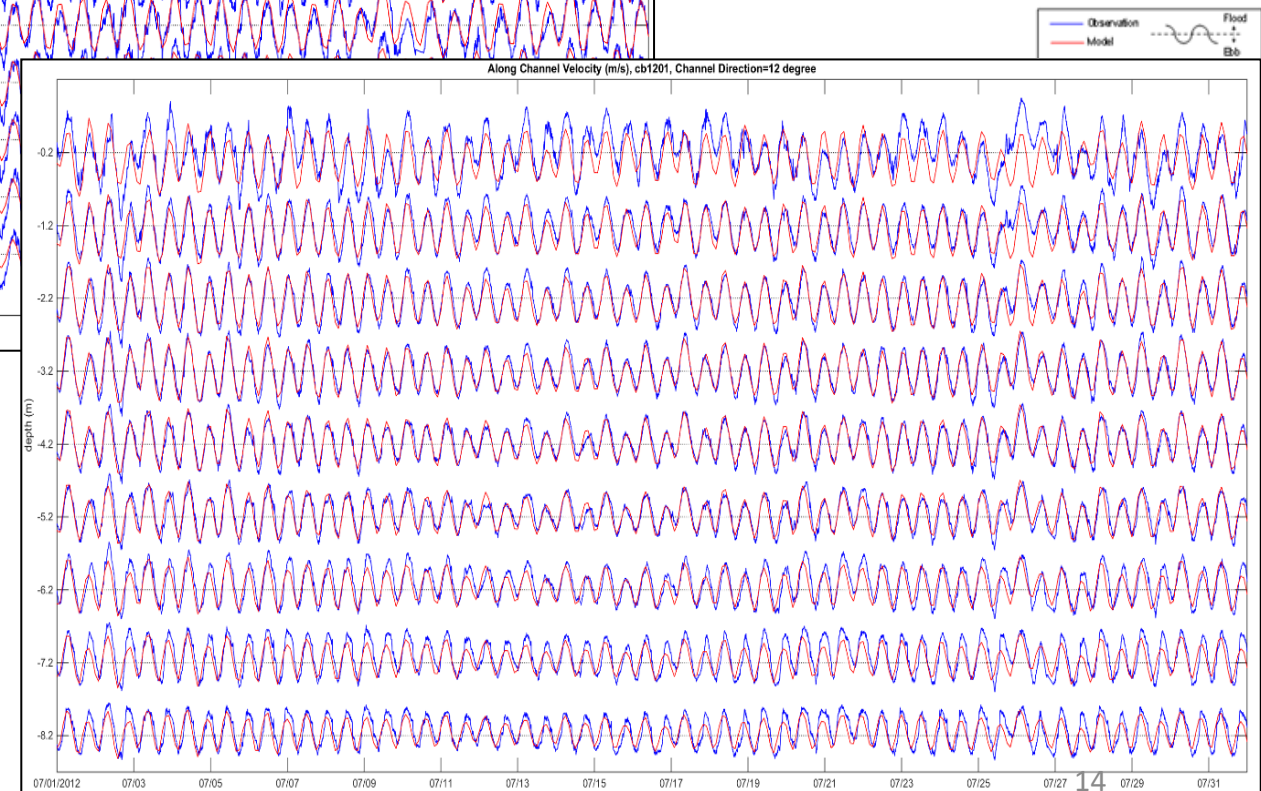
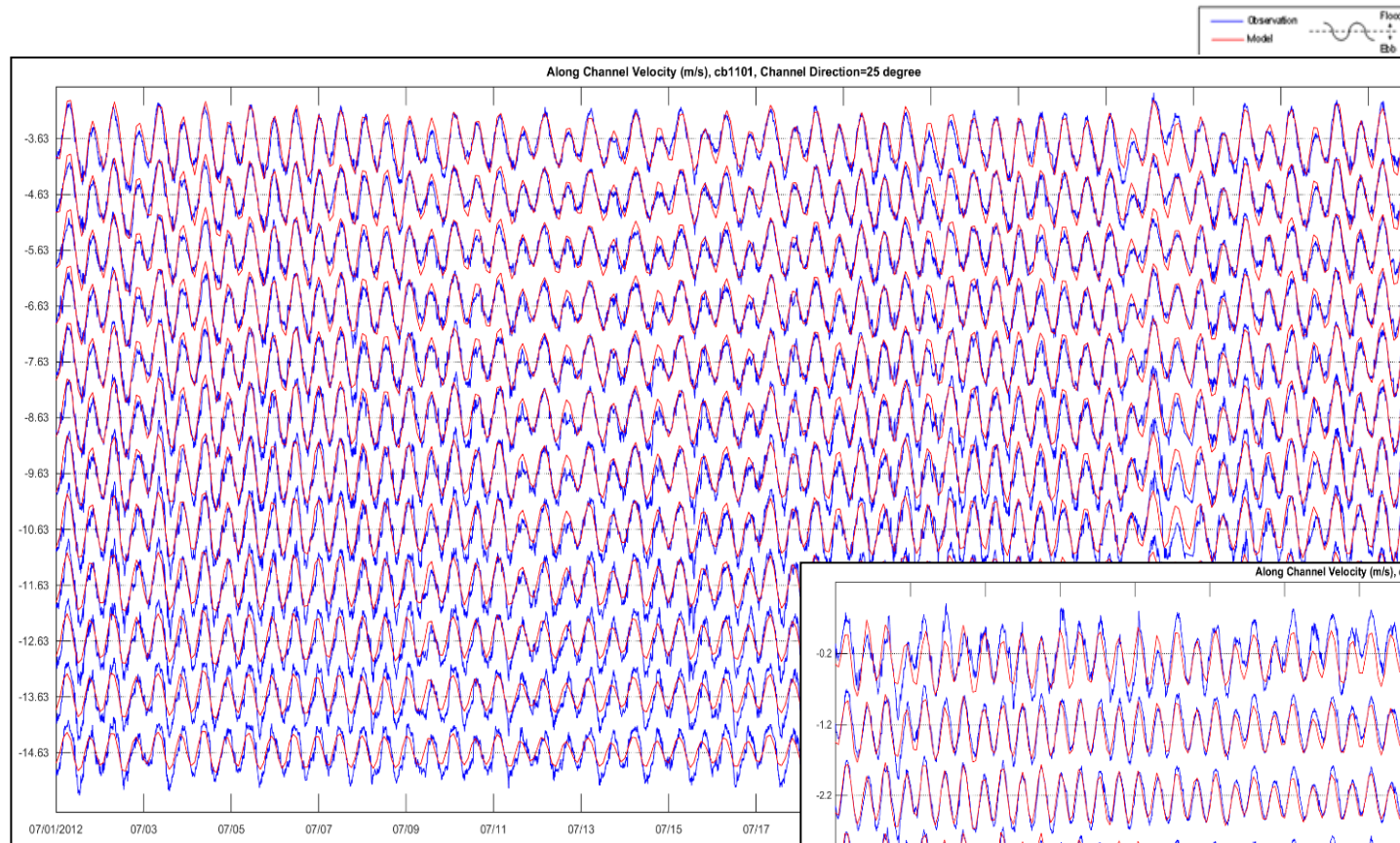
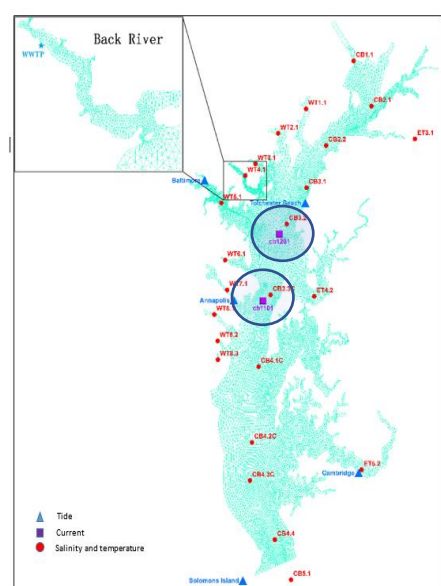


Figure 5(b) : The modeled versus observed ADCP along channel current velocity during June and July, 2012 (top) at station cb1201 (bottom) at cb1101.

Temperatures

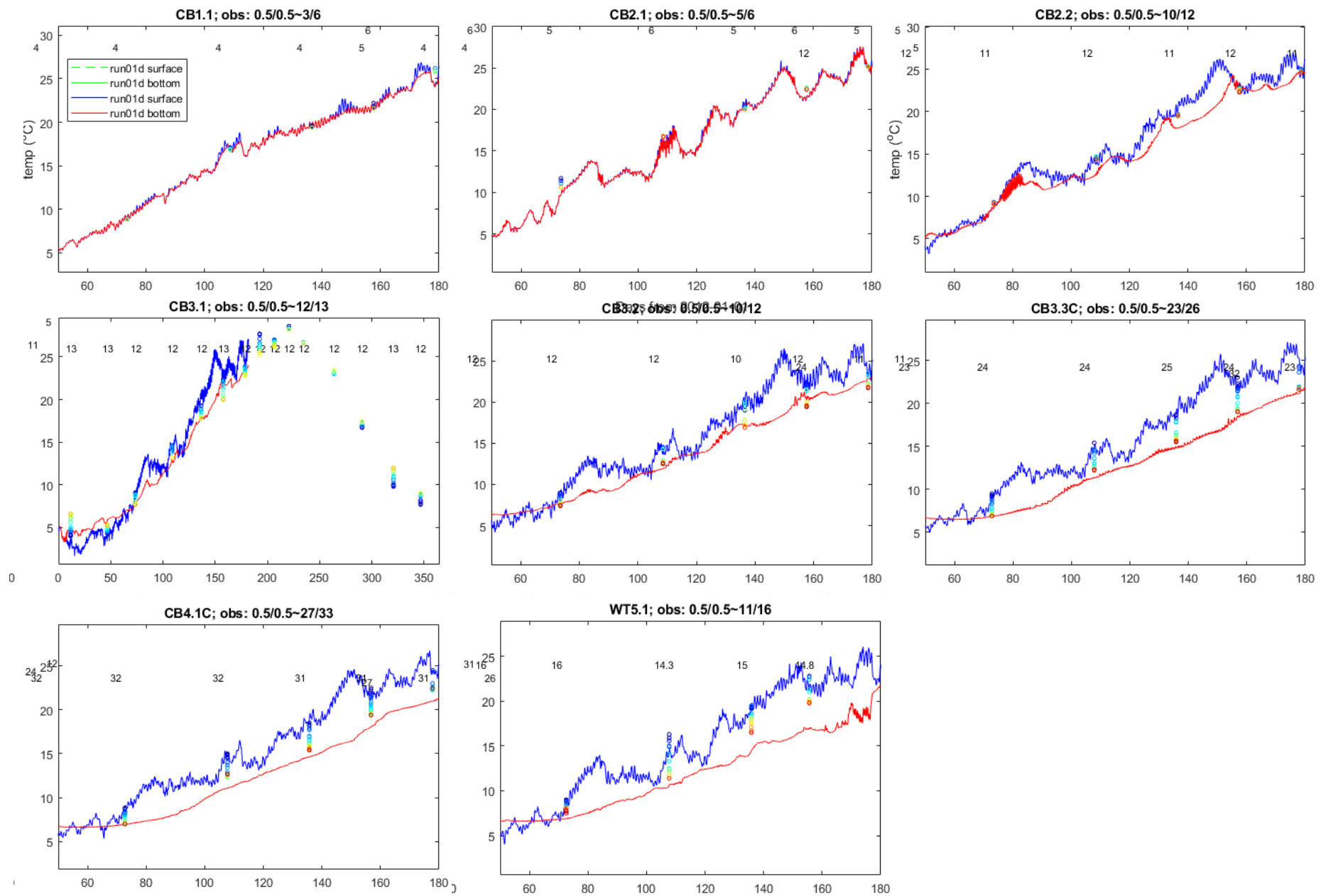


Figure 5 (c): The modeled versus observed temperature in the Upper Bay during 2012

Salinities

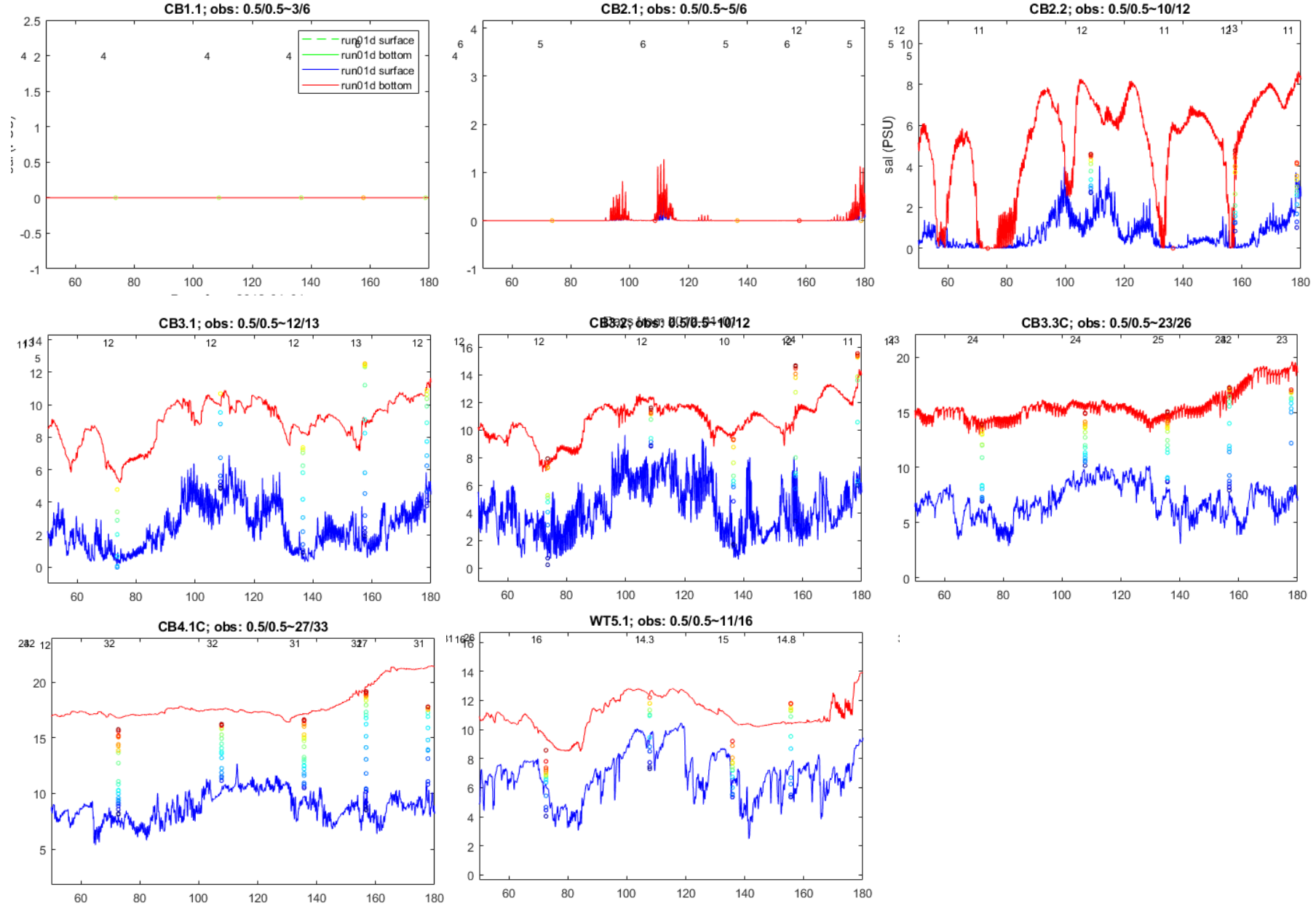
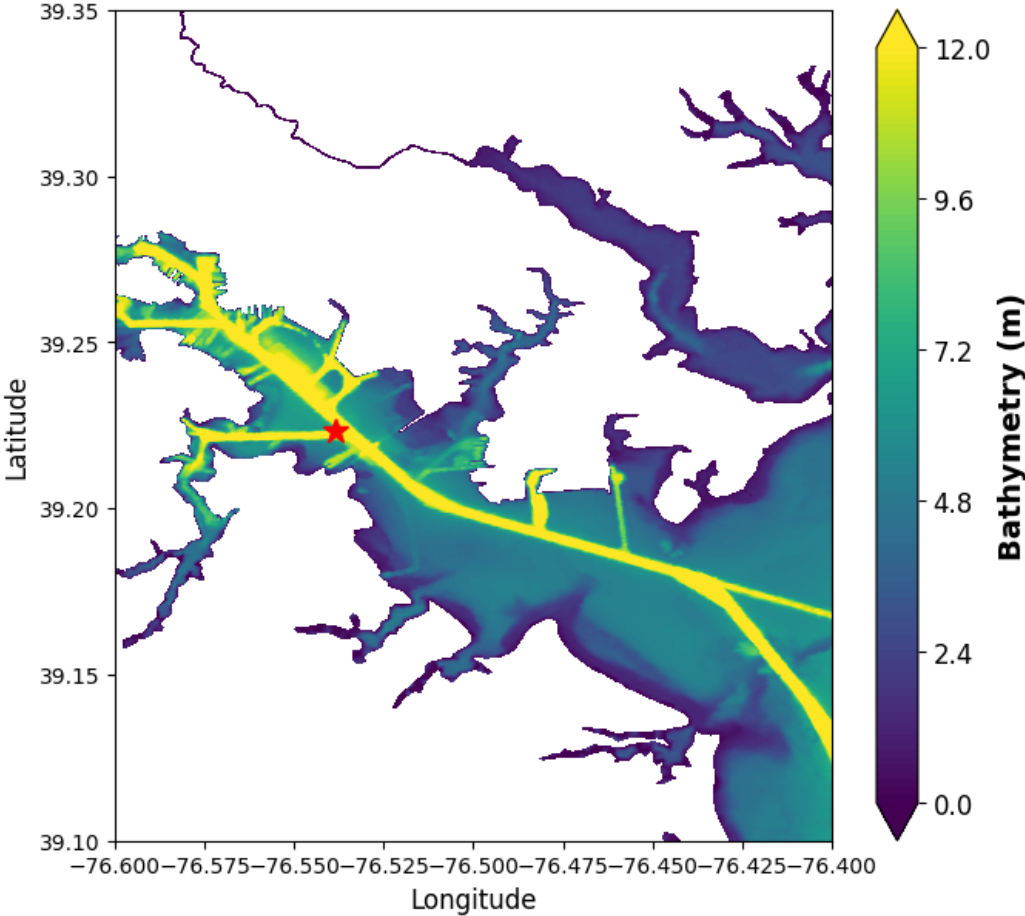


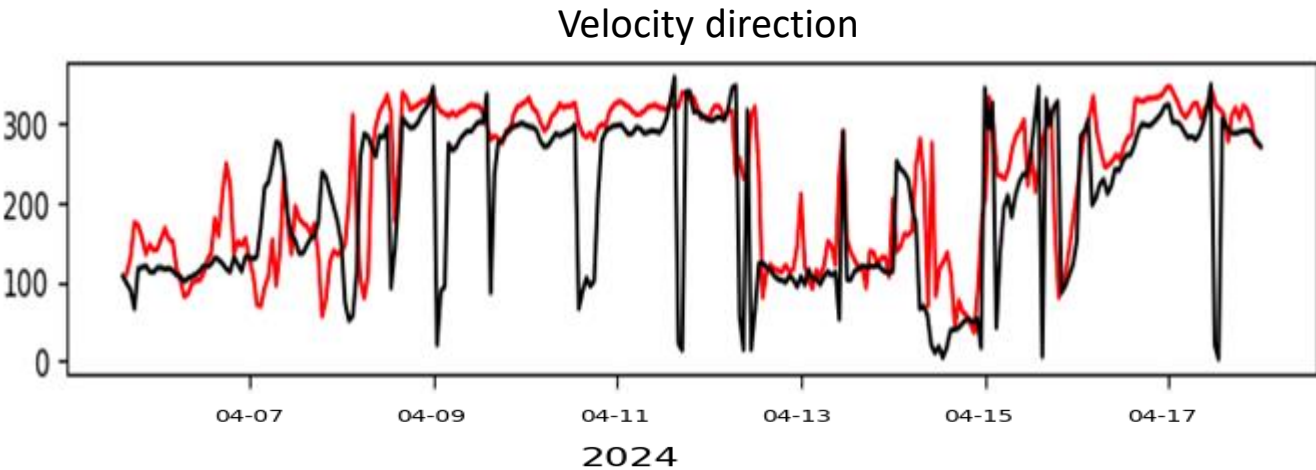
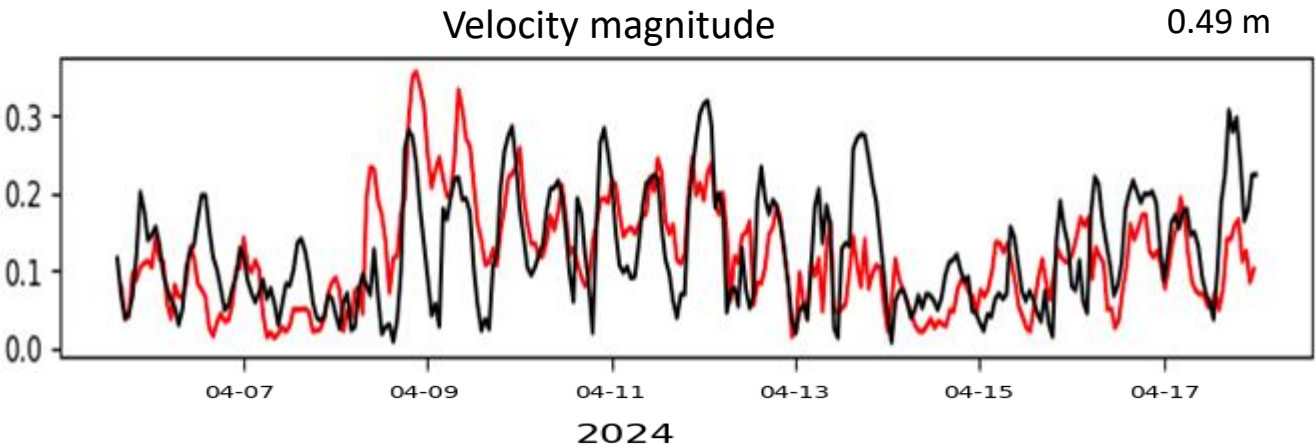
Figure 5 (d): The modeled versus observed salinities in the Upper Bay during 2012

III. Application - in 1/2024 - 4/2024

Station Location:



cb1501 station



- **Mean three-layered circulation**

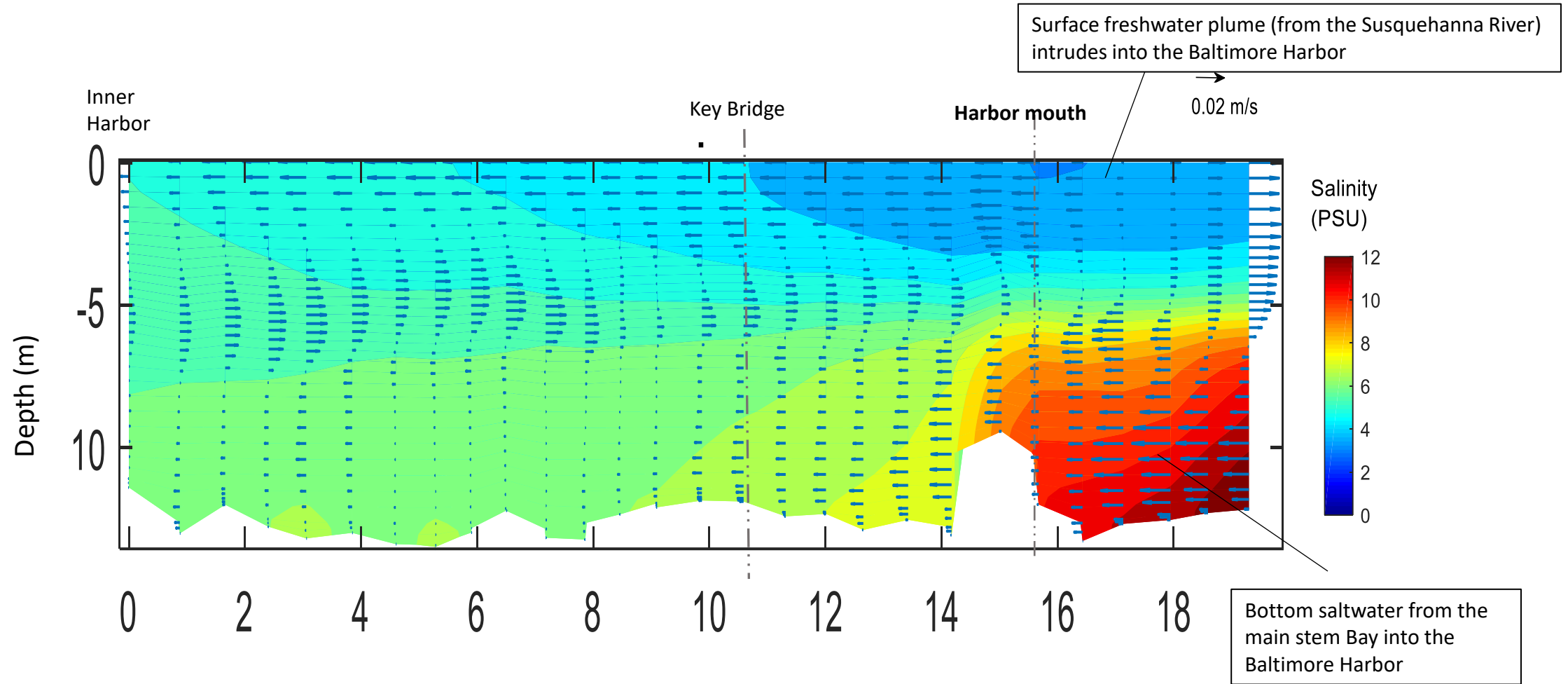
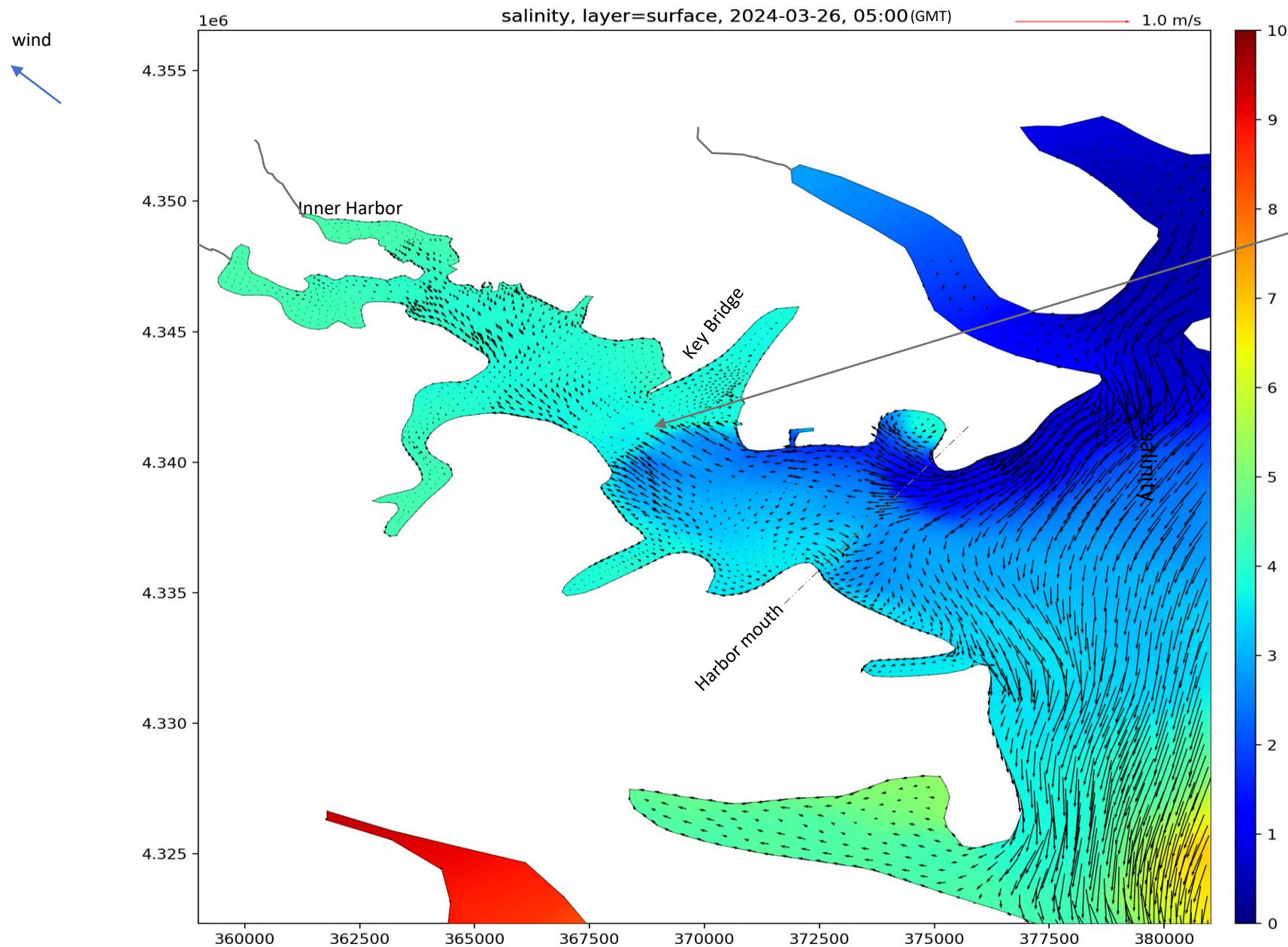


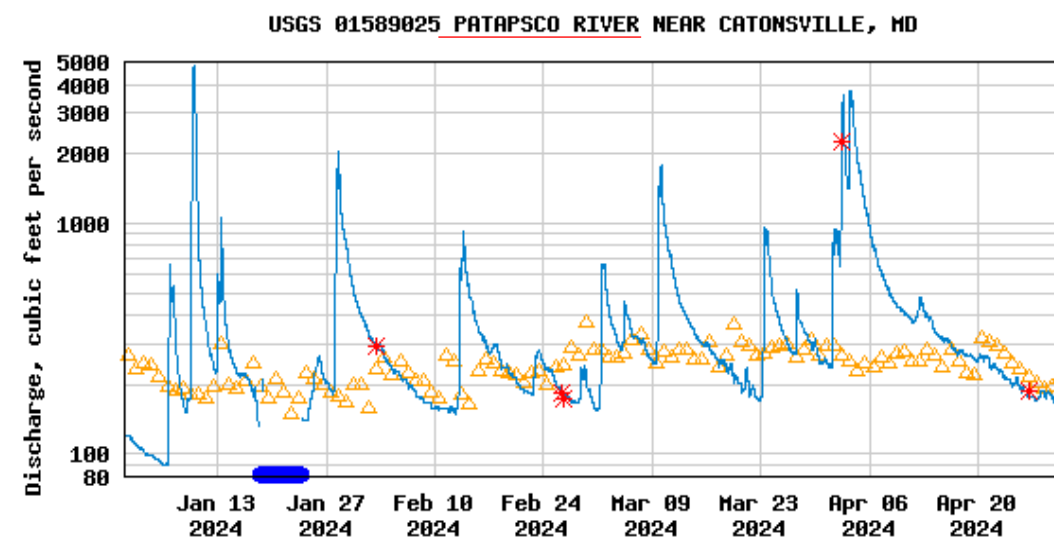
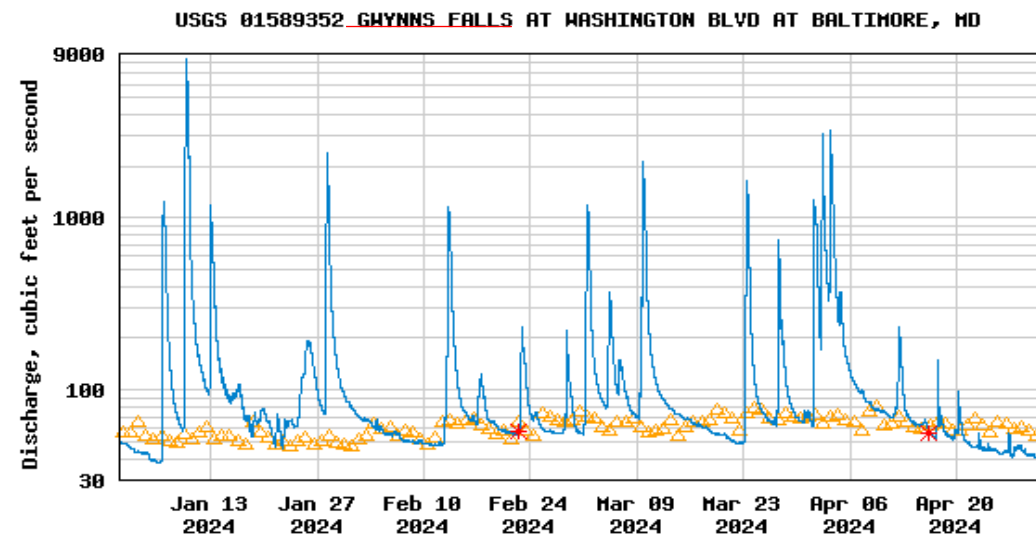
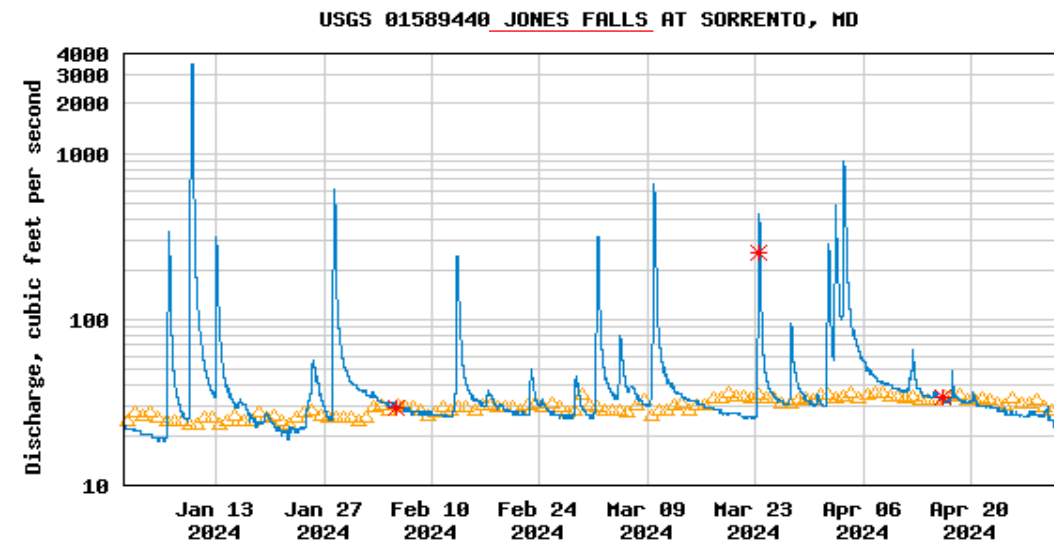
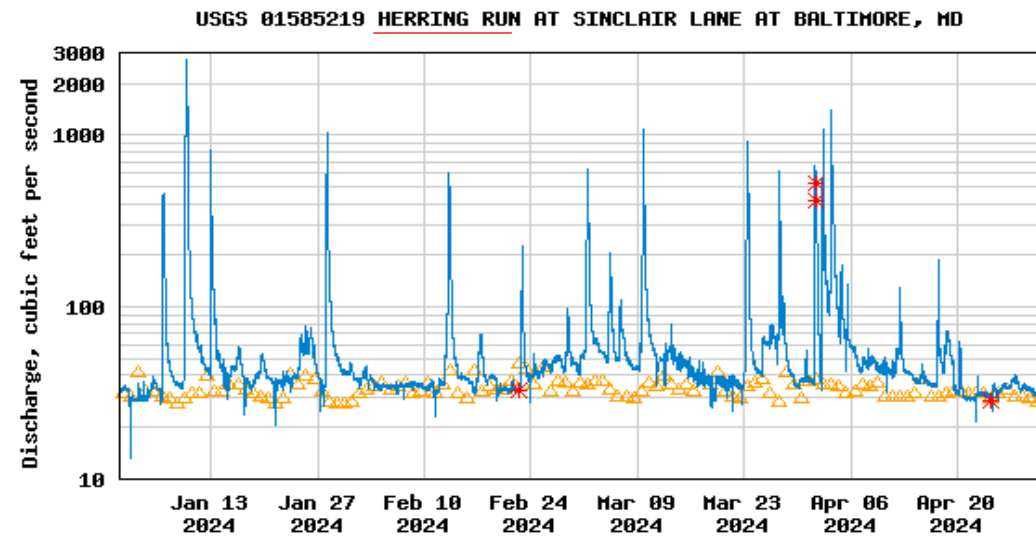
Figure: Simulated monthly (50 tidal cycle) mean average salinity distribution and 3-layered circulation pattern inside the Baltimore Harbor (0-15 km) and the adjacent Bay (15-18 km) during April, 2024

- **Surface current in the Harbor (during slack before ebb)**



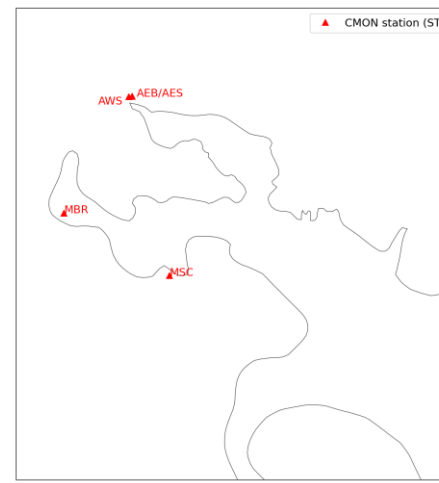
- The strong front/eddy existed near the Key bridge
- Showing the intrusion of the surface current for a three-layer circulation

- Flashy river discharges from Herring Run, Jones Falls, Gwynns Falls, and Patapsco River – Urban Runoffs

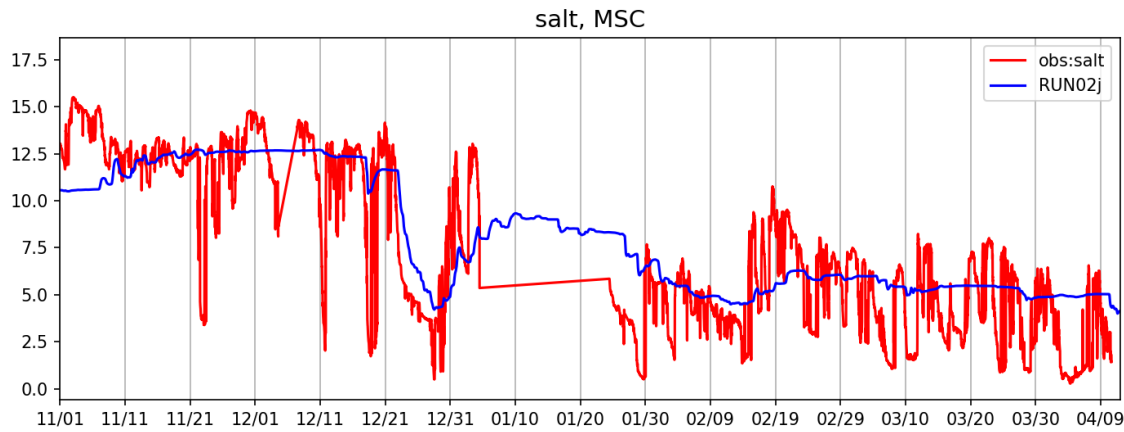


Salinity comparison at Inner Harbor

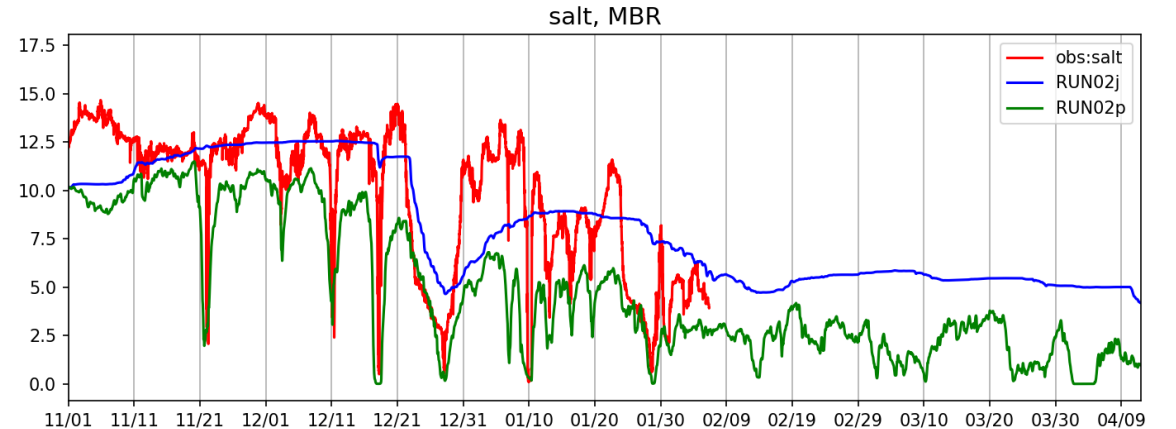
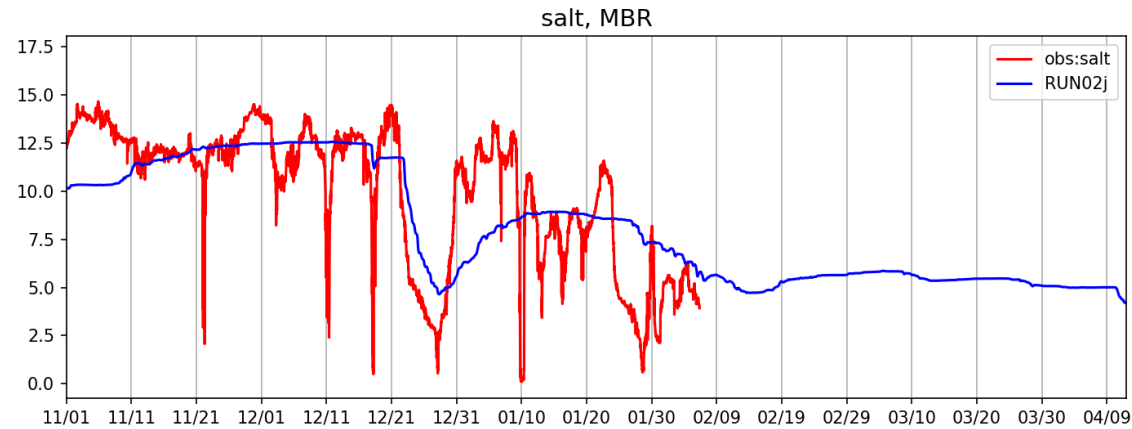
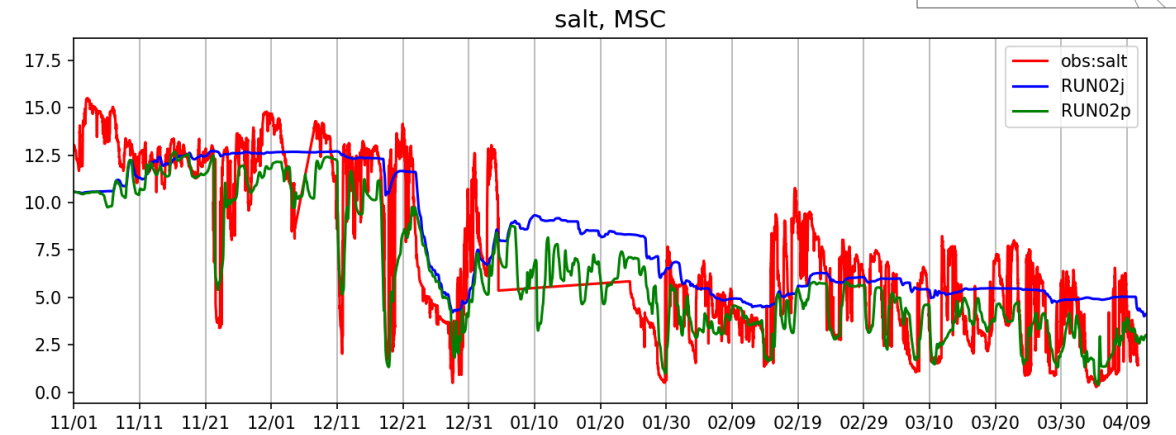
Zhengui Wang and Joseph Zhang



Without urban stream flow

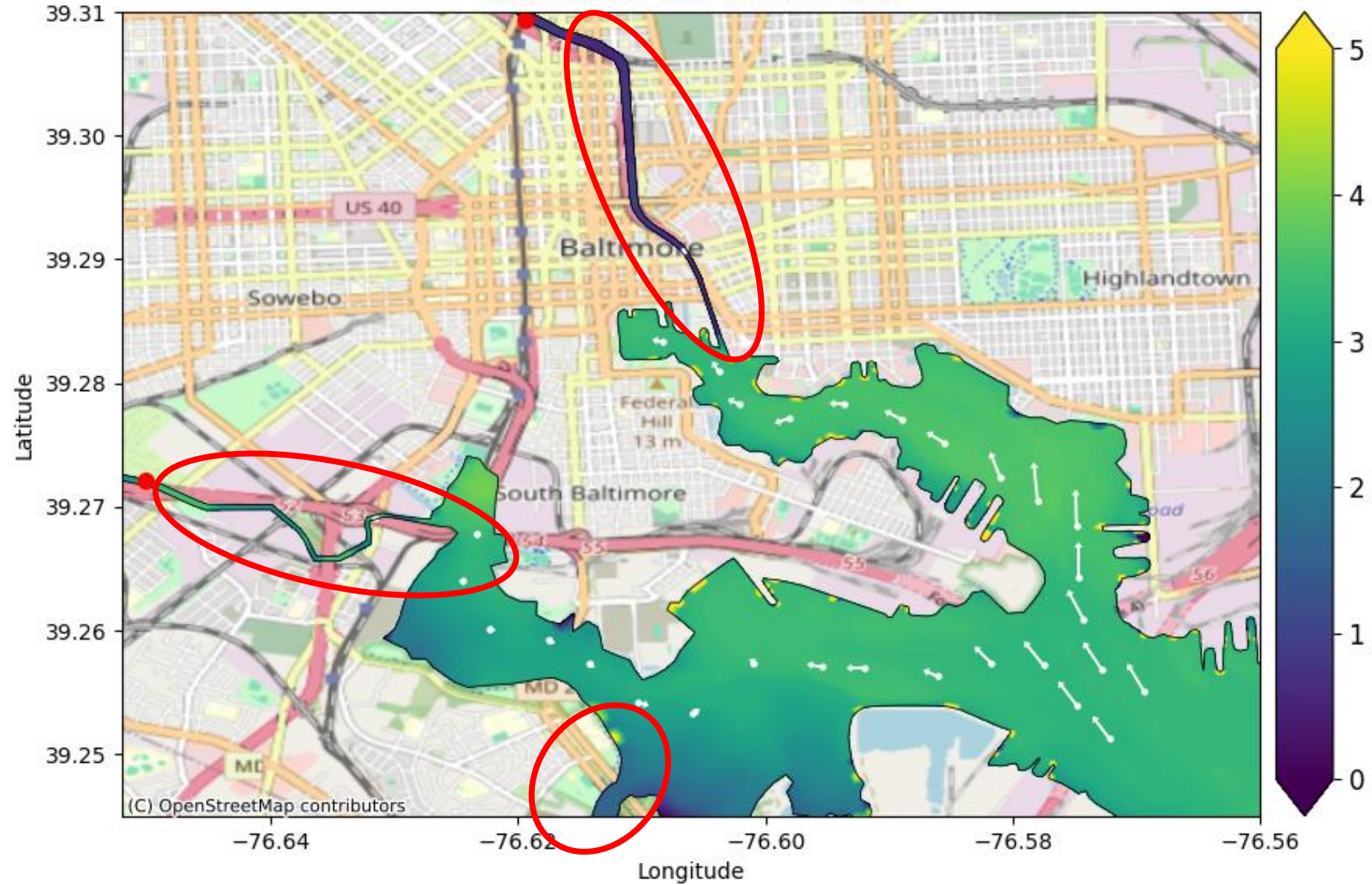


With urban stream flow inputs



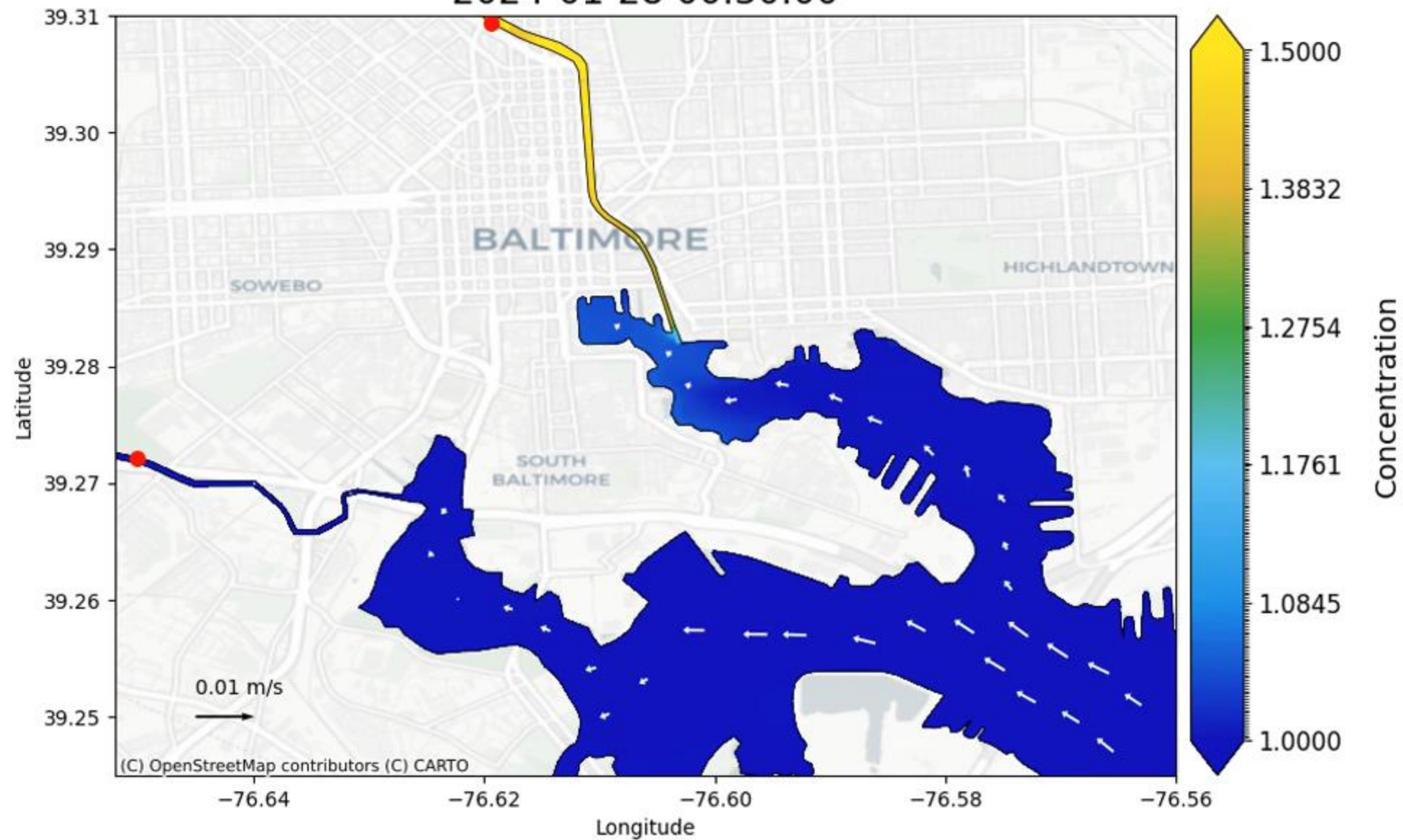
Nitrogen

2024-02-08 00:30:00



Nitrogen

2024-01-28 00:30:00



IV. Summary:

1. The Patapsco/Back MTM fine-resolution model was generated, including 4 urban streams as part of the MTM tributary model. The overall resolution ranges from 50 – 100 m with total number of grid cells close to 61k grid cells.
2. The model was calibrated for January 2012 – June 30 2012 and verified for April 2024 with reasonable skill on water level, velocity, salinity, temperature, and mean three-layered circulation.
3. The model was used to simulate SSO events in late January and early February 2024 and demonstrated impact on the Inner Harbor.