Assessing 2035 Climate Change Risk to the Chesapeake TMDL using a next-generation unstructured-grid model

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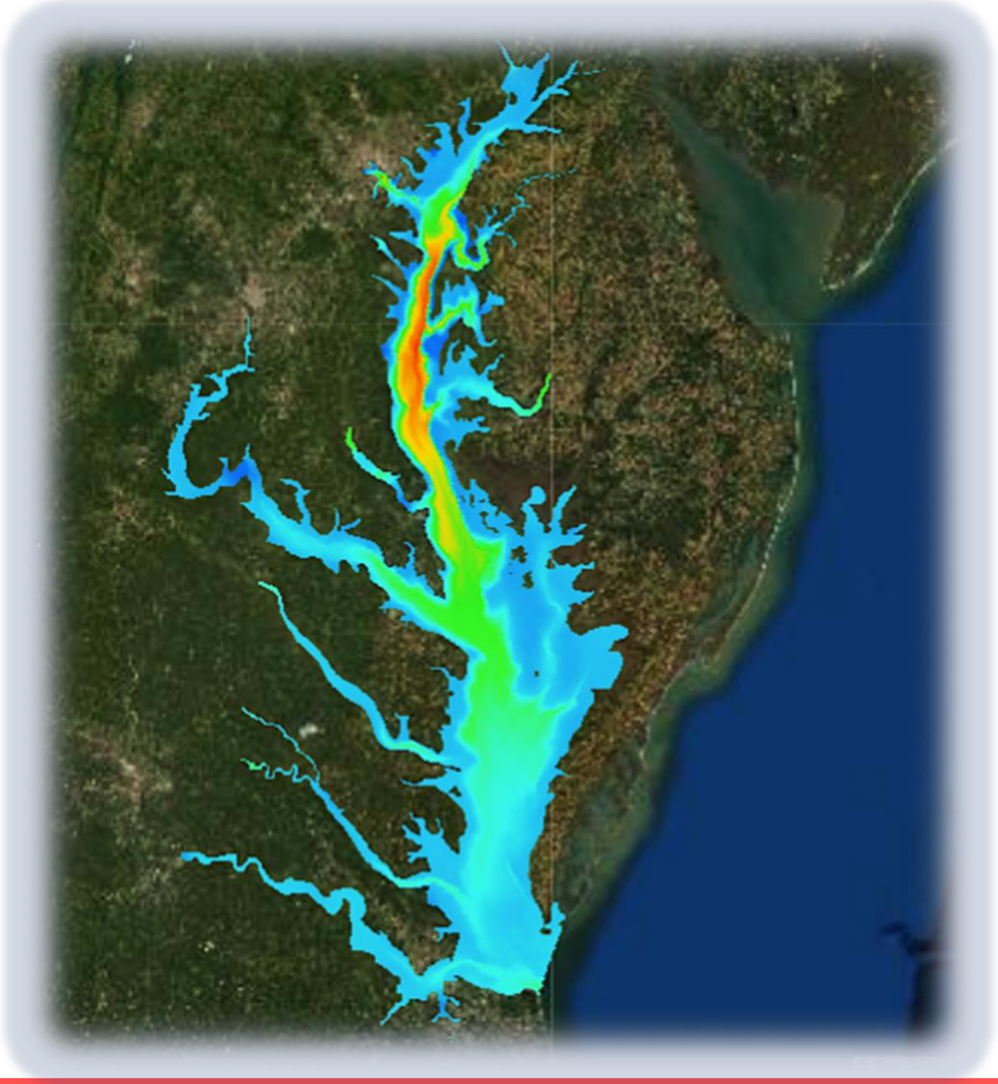

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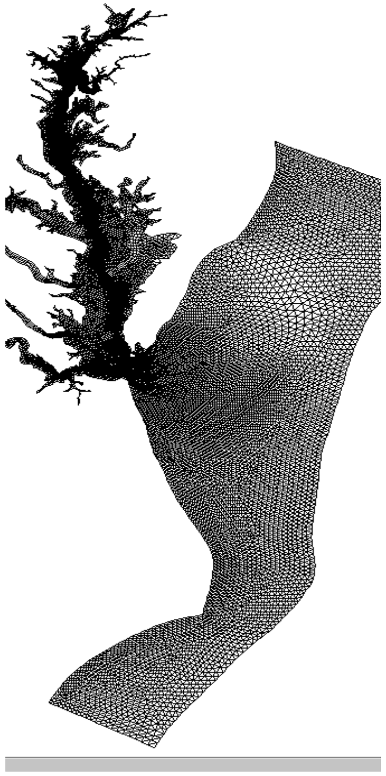
Outline

- Progress summary
- Focal studies during this period
- Next phase

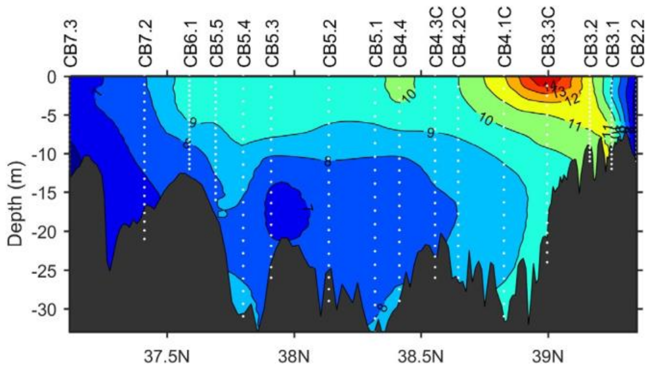
Project Progress

Hydrodynamic model



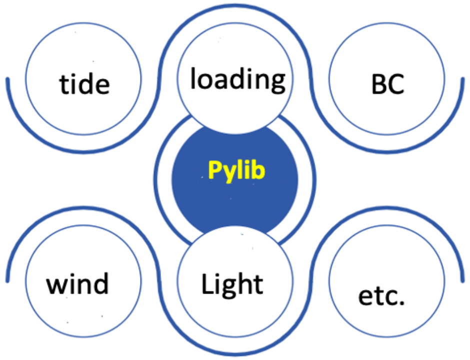
- Finalized model grid
- Conducted model calibration
- Tested wave model
- Tested sediment model

Water quality model



- Updated model code to include Bay ICM modification of kinetic processes
- Completed coding of water quality simulation in decoupled mode.

Tool box



- Developed toolbox
- Developed Pylib
- Automictically process MBM setup
- Model plots
- Model visualization tools

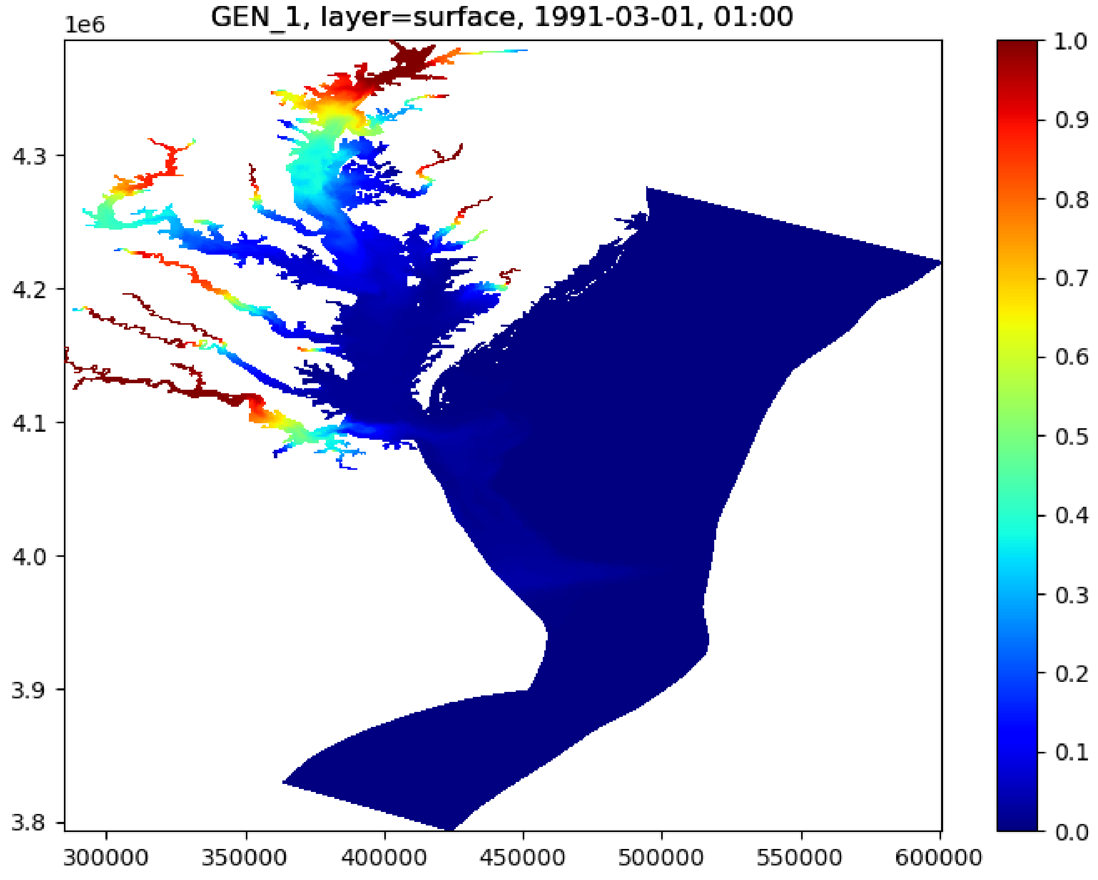
Study during this period: update ICM model

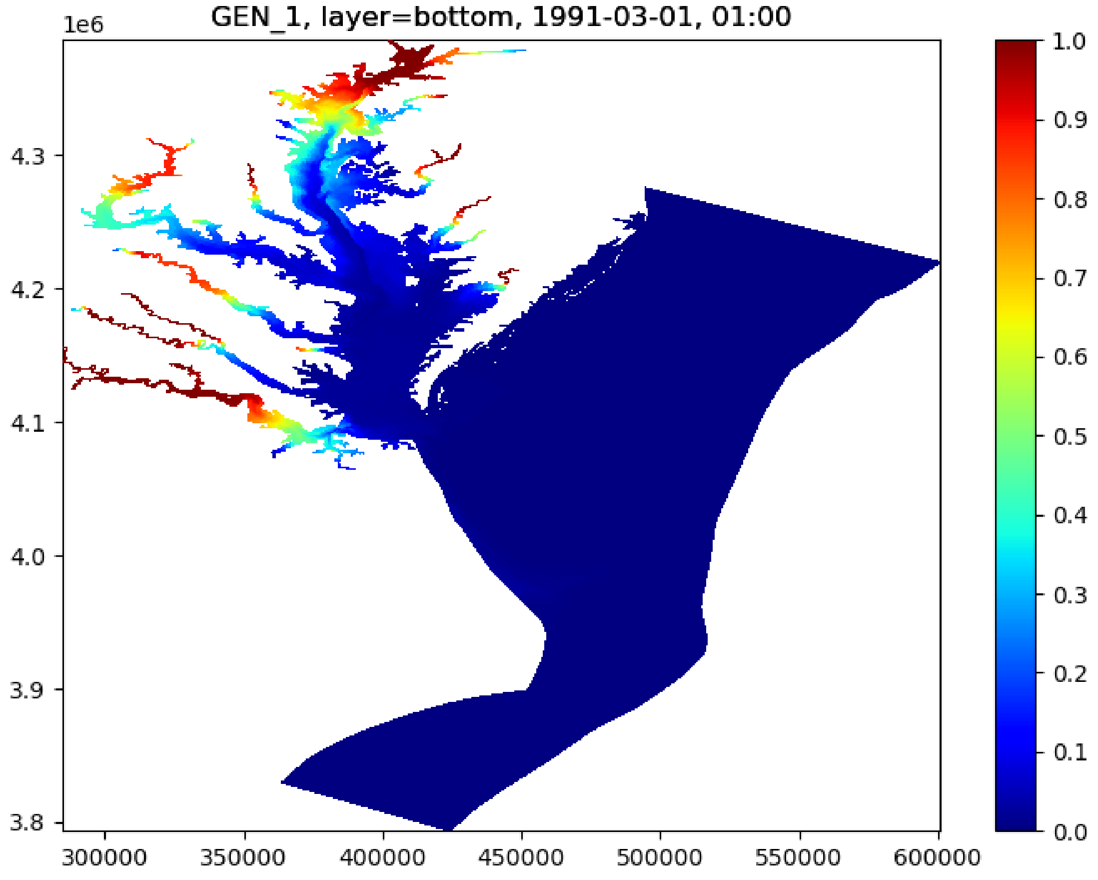
- ICM code update (kinetics)
  - Algal respiration
  - Grazing model
  - Light attenuation
  - Separate particulate and dissolved inorganic P
  - Add slow decay particulate P (i.e. bank erosion)
  - Varying model parameters by region (i.e. settling velocity, growth rate etc.)
  - Spatial varying parameters are handled by input file '*ICM_parameter.nc*'

Study during this period: test decoupled simulation

- Testing decoupled modeling approach of ICM
  - Save hourly dynamic fields for current, elevation, diffusion, wave, and suspended sediment
  - Use small time-step to run water quality model to maintain mass balance
  - Implemented TVD in transport algorithm
  - Use dye release at upstream to verify the accuracy of decoupled model transport

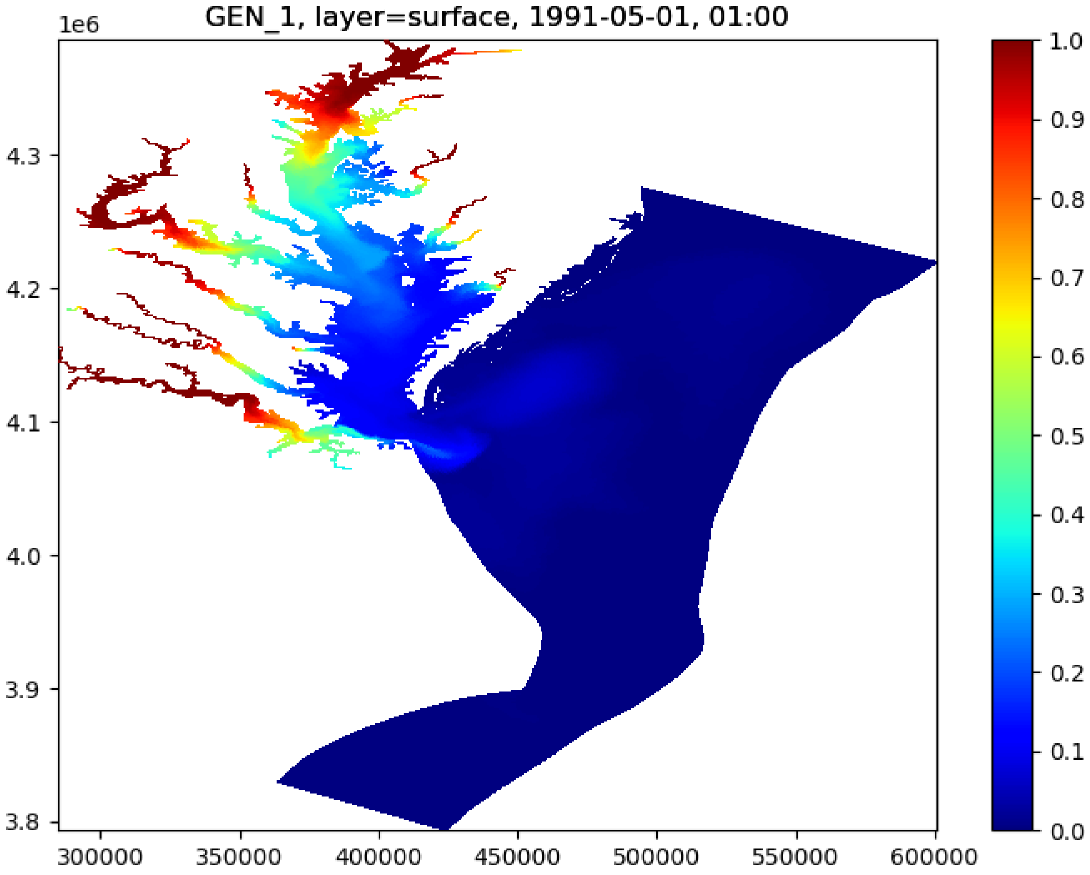
Horizontal dye distribution

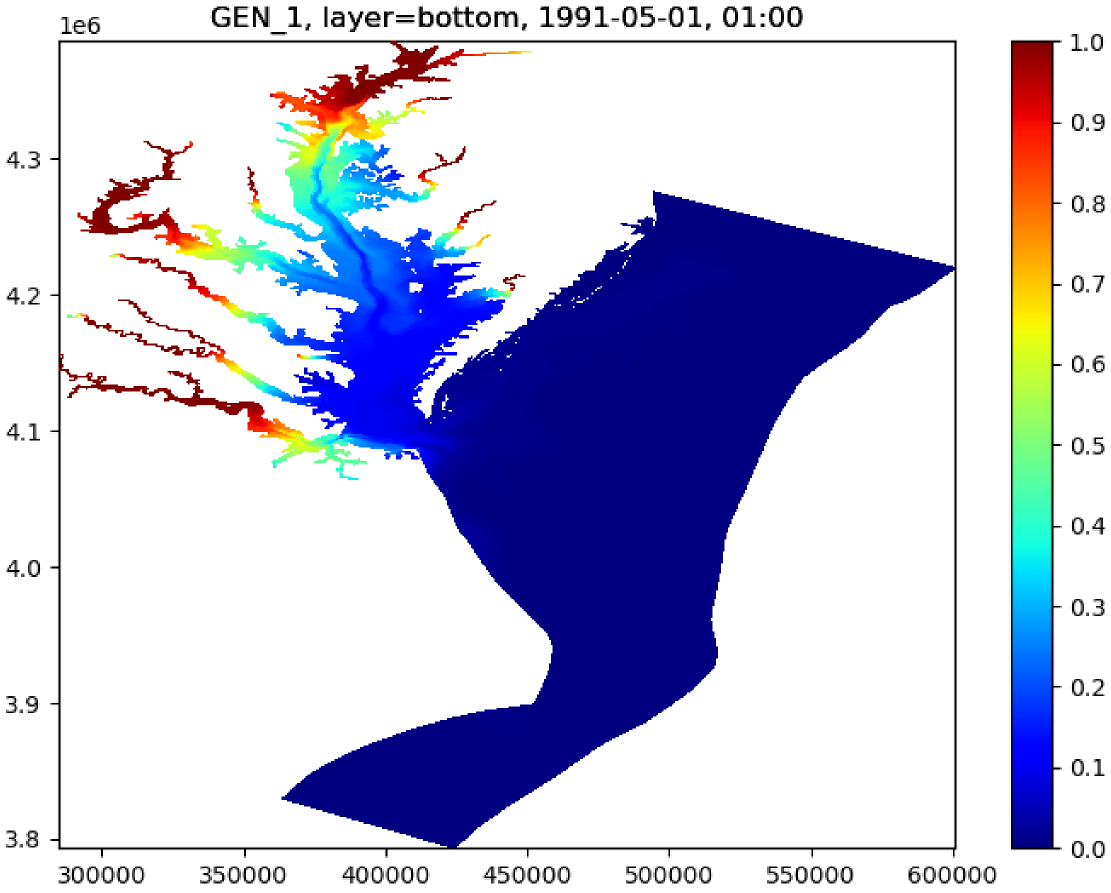




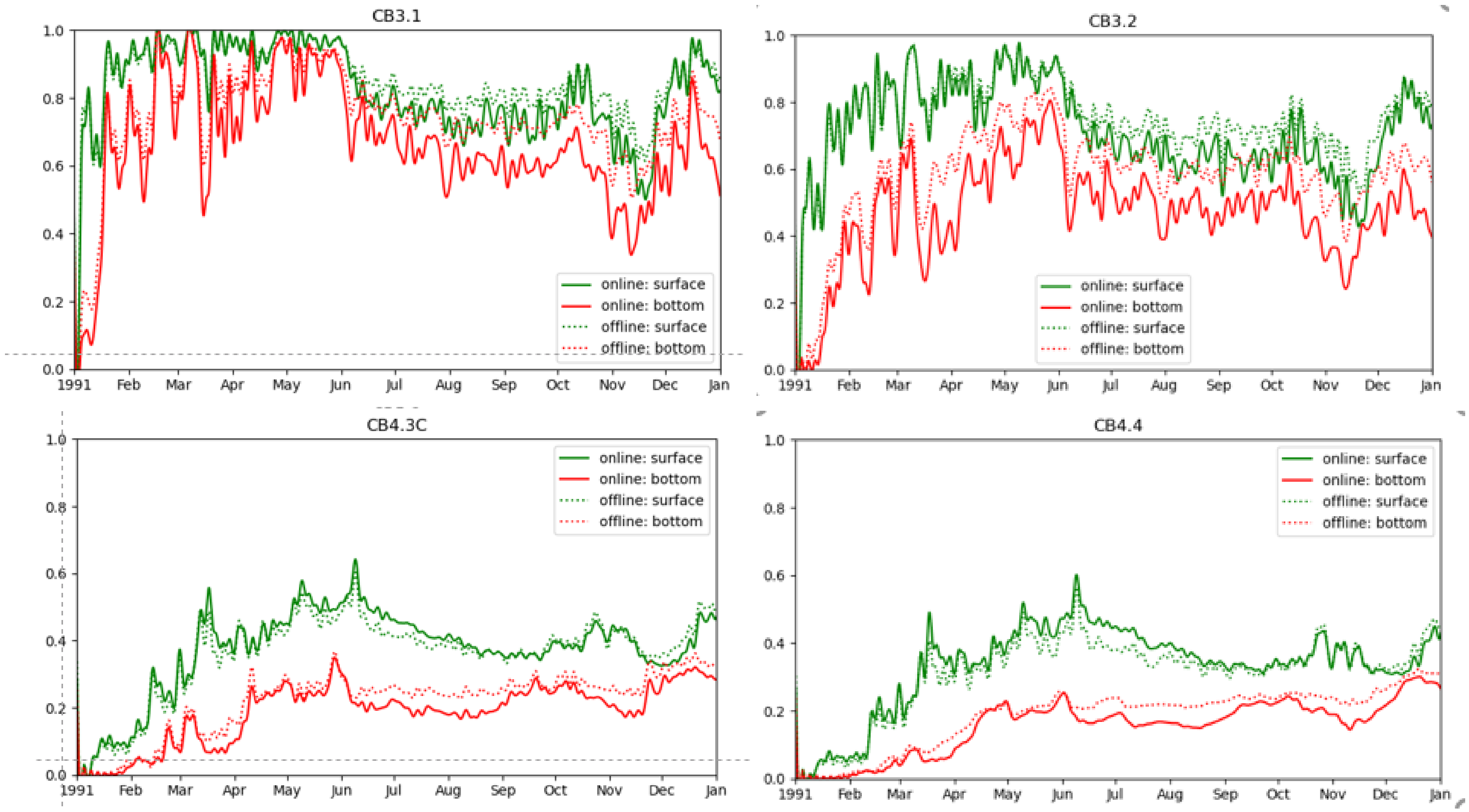
Decoupled model result

Horizontal dye distribution

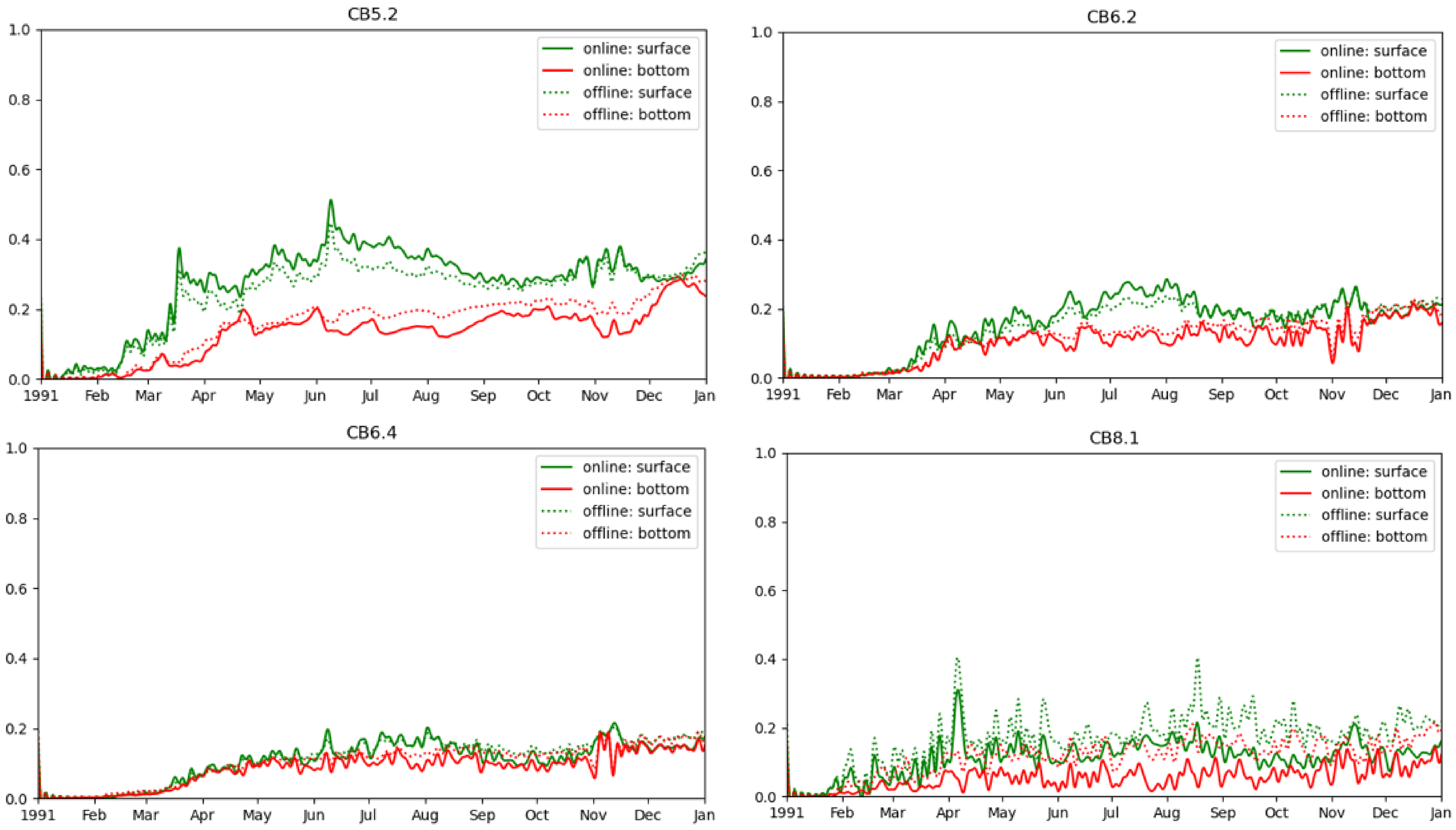




Compare time series at selected stations



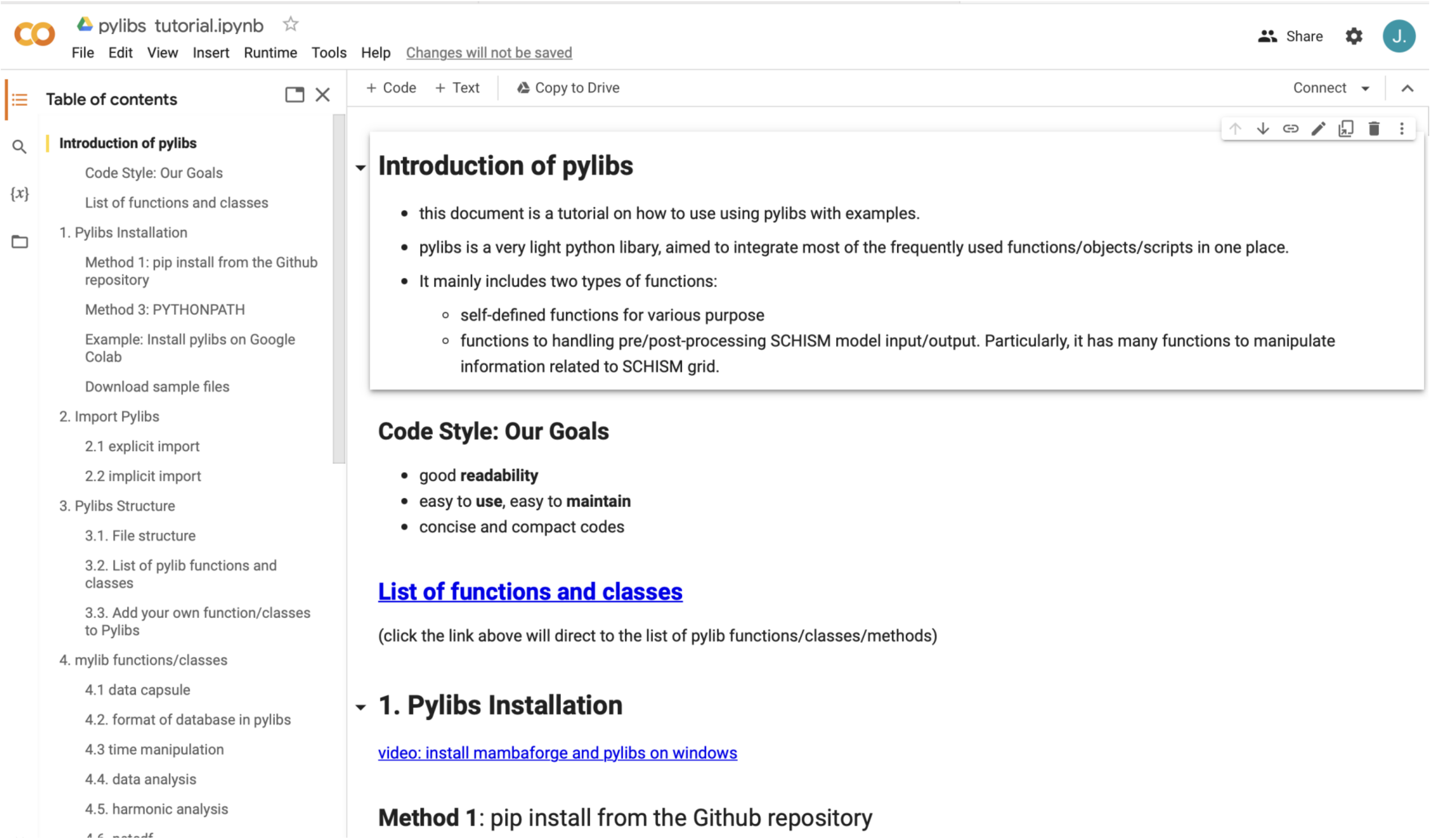
Compare time series at selected stations



Toolbox

- Pylib
  - Python library tools for managing SCHISM model workflow
  - Data processes
  - Grid related tools
    - Set ocean boundary and river boundary conditions
  - Model set-up tool
    - Automatically processing boundary, flow, loading, surface fluxes with visualization tools
  - Visualization of water quality model results
    - Horizontal plots of model state variables
    - Animation of model results
    - Time series at selected location

Pylib online documentation and examples



Examples

pylibs_tutorial.ipynb

File Edit View Insert Runtime Tools Help Changes will not be saved

+ Code + Text Copy to Drive

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[1]

```
#Examples 5.1.2.1.1
#usage of plot

figure(figsize=[18,12])
#method 1: grid
subplot(2,3,1)
gd.plot()

#method 2: bathymetry
subplot(2,3,2)
gd.plot(fmt=1)

#method 3: combine specifications
subplot(2,3,3)
gd.plot(fmt=1,ec='k',lw=0.05,clim=[0,50],ticks=11)
setp(gca(),xticks=[],yticks=[],xlim=[3.5e5,4.5e5],ylim=[4.05e6,4.3e6])
gcf().tight_layout()


#method 4: plot with other value
pvi=gd.dp.copy()
fpz=pvi<5; pvi[fpz]=1
fpz=(pvi>=5)*(pvi<10); pvi[fpz]=2
fpz=(pvi>=10)*(pvi<30); pvi[fpz]=3
fpz=(pvi>=30)*(pvi<100); pvi[fpz]=4
fpz=pvi>=100; pvi[fpz]=5
```

Add more tools to Toolbox

- Tested automatic setup model and workflow
  - Combine all tools include tide, salinity, temperature at open boundary and heat flux at surface to generate boundary condition
  - Revise the tool to convert watershed model output (phase 6) to ICM loading input
  - The tool allows to set model for online coupled and decoupled modes to run ICM model
  - It is convenient when changing model grid

Model setup tool: Setup.py

- **p.StartT=datenum(1991,1,1); p.EndT=datenum(1992,12,31) #simulation time**
- **p.base='../RUNbase'**
- **p.grid_dir='/sciclone/data10/wangzg/CBP/grid/v3' #directory of hgrid & vgrid; p.grid_dir=p.base if it is None**
- **p.flag['ICM']= 1 #ICM model (1: 21 variables; 10: 21-variable offline mode; 2: 17 variables; 20: 17-variable offline mode)**
- **p.flag['SED']= 0 #SED3D model**
- **p.flag['WWM']= 0 #Wave model**

- **p.flag['elev2D.th.nc'] = 1 #hydro**
- **p.flag['TEM_3D.th.nc'] = 1 #hydro**
- **p.flag['TEM_nu.nc'] = 1 #hydro**
- **p.flag['SAL_3D.th.nc'] = 1 #hydro**
- **p.flag['SAL_nu.nc'] = 1 #hydro**
- **p.flag['sflux'] = 1 #hydro**
- **p.flag['albedo.gr3'] = 1 #hydro**
- **p.flag['drag.gr3'] = 1 #hydro**
- **p.flag['watertype.gr3'] = 1 #hydro**

- For large files, the tool use soft link to provide link between database and current run directly
- It is easy to build workflow to conduct model model calibrations and scenario runs

Develop data-driven wave model to improve efficiency

- Wave model simulation has a high computation cost
- Previous studies used empirical wave model to save computation time
- Is it feasible to build a data model to simulate wave with high spatial resolution?

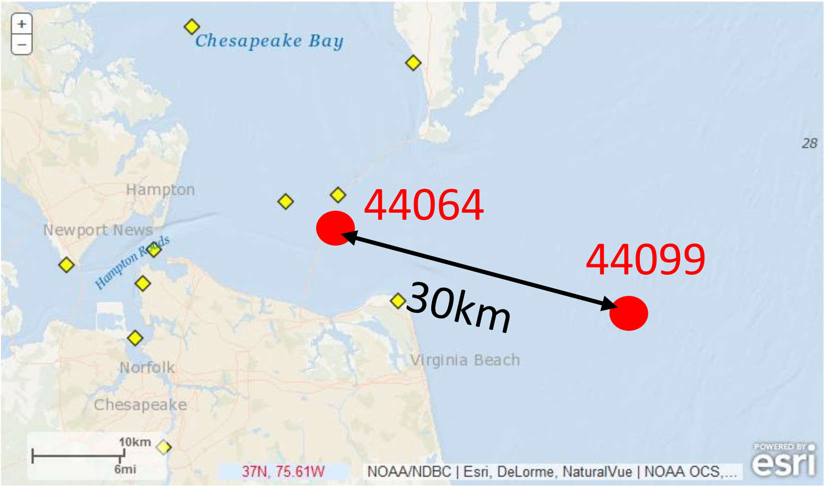
- Use 5-year daily mean significant wave height (1991-1995) to train data model with same high spatial resolution of MBM model grid
- Use different model simulations to test data model
- Use NOAA buoy data to verify the data model
- It has the potential to use data model for suspended sediment model

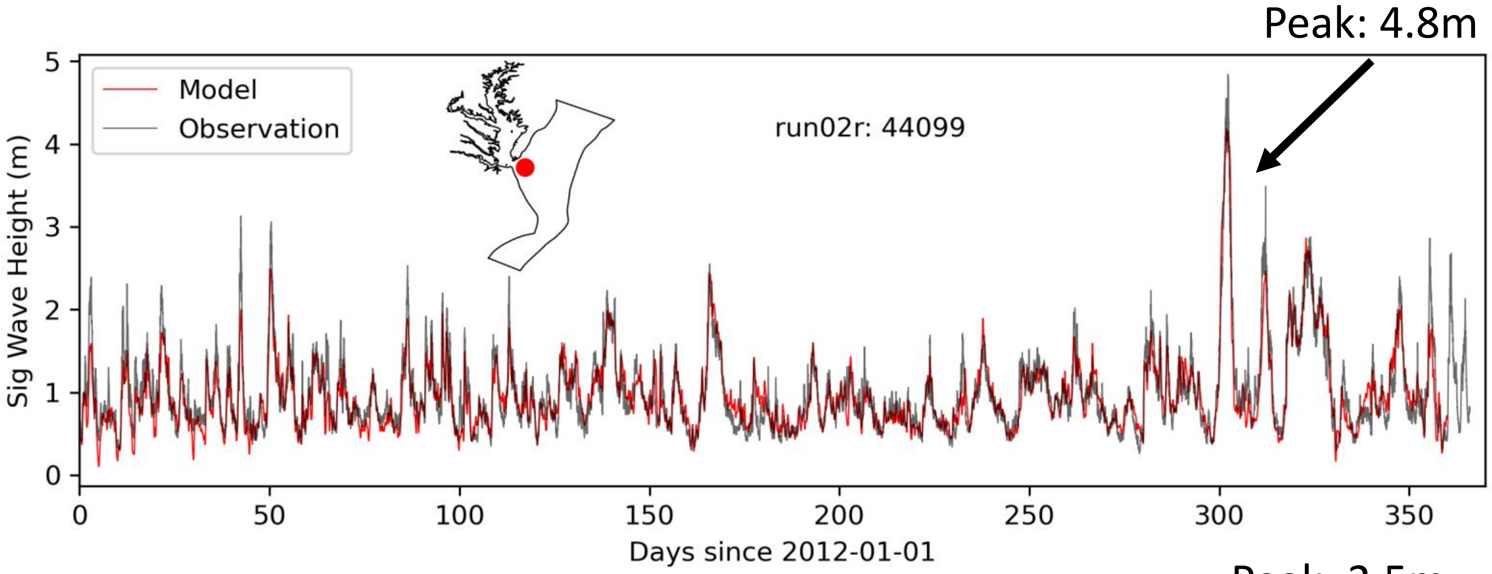
Numerical wave model simulation results

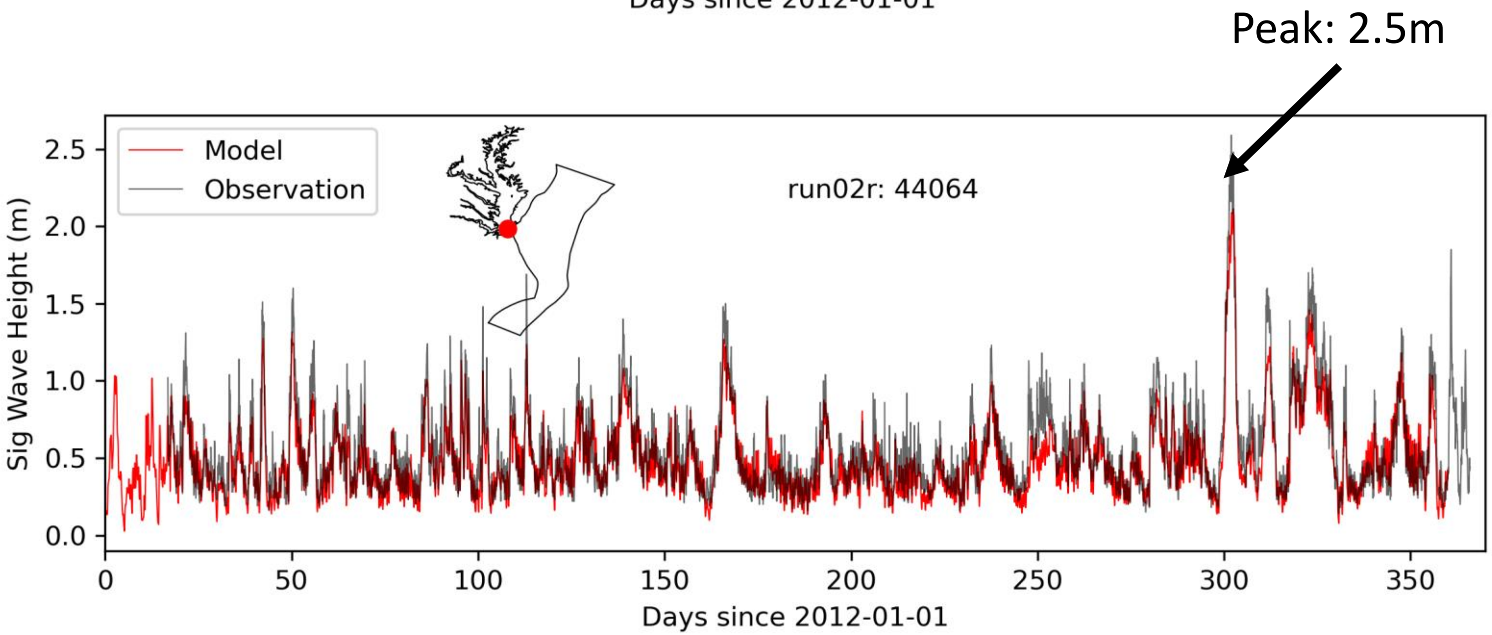
Quick attenuation of wave near the mouth

- Within ~30km, significant wave height decreases from 4.8m to 2.5m during Sandy

- Well reproduced by the model

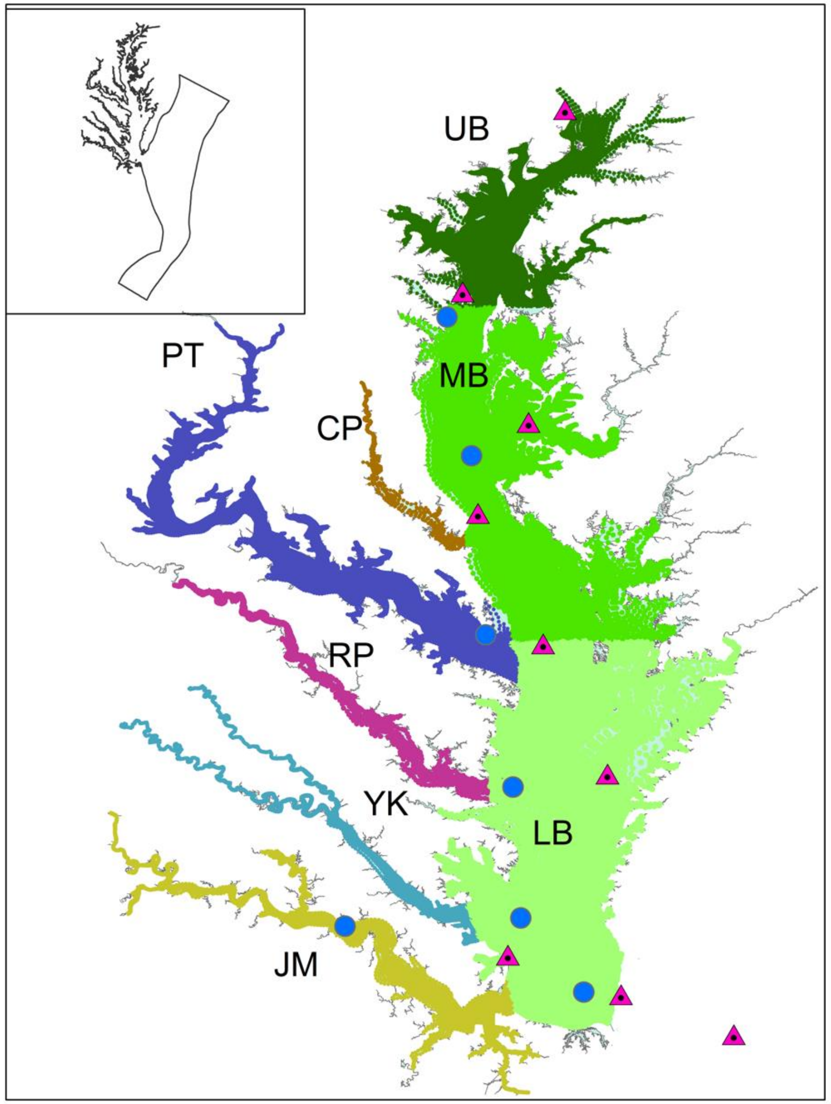




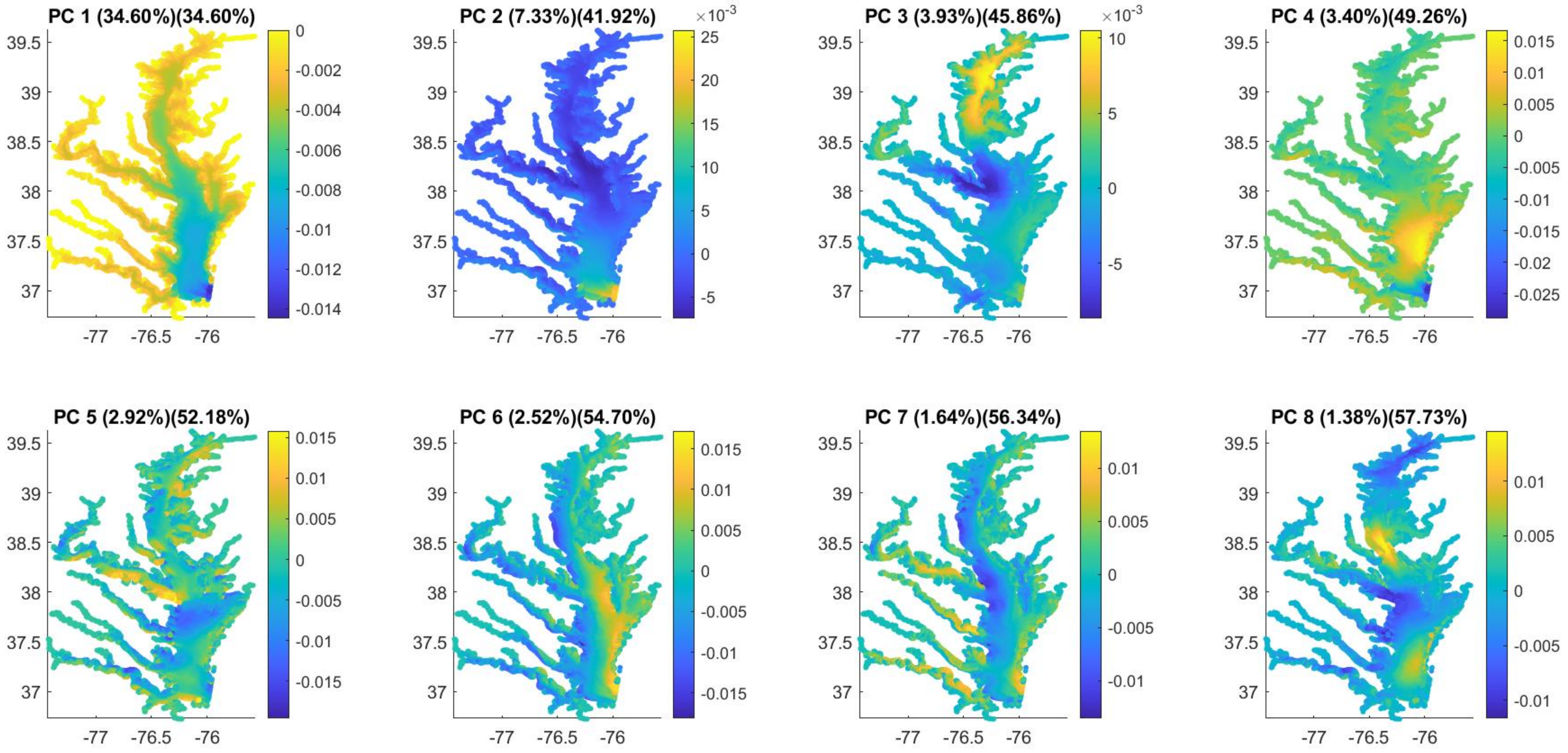


Data wave model

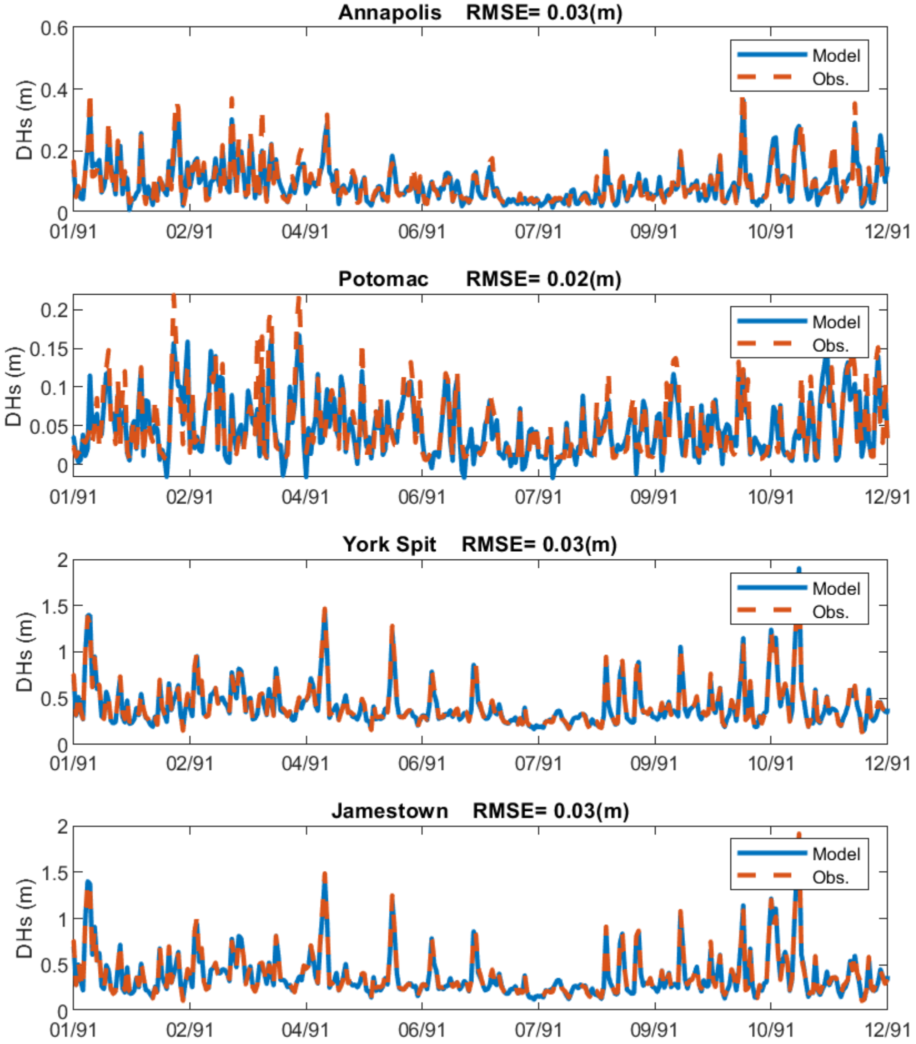
- Use SVD to reduce dimension and separate both spatial and temporal principal components
- Train dominant temporal principal components
- Train model use daily wind at 9 wind stations

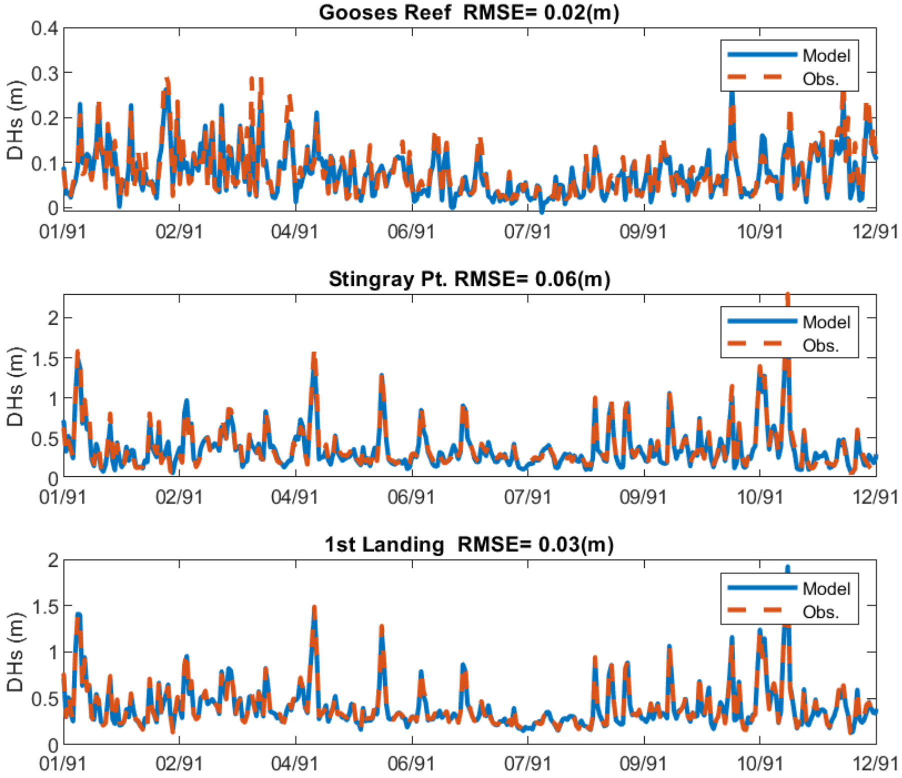


Spatial distribution of principal components



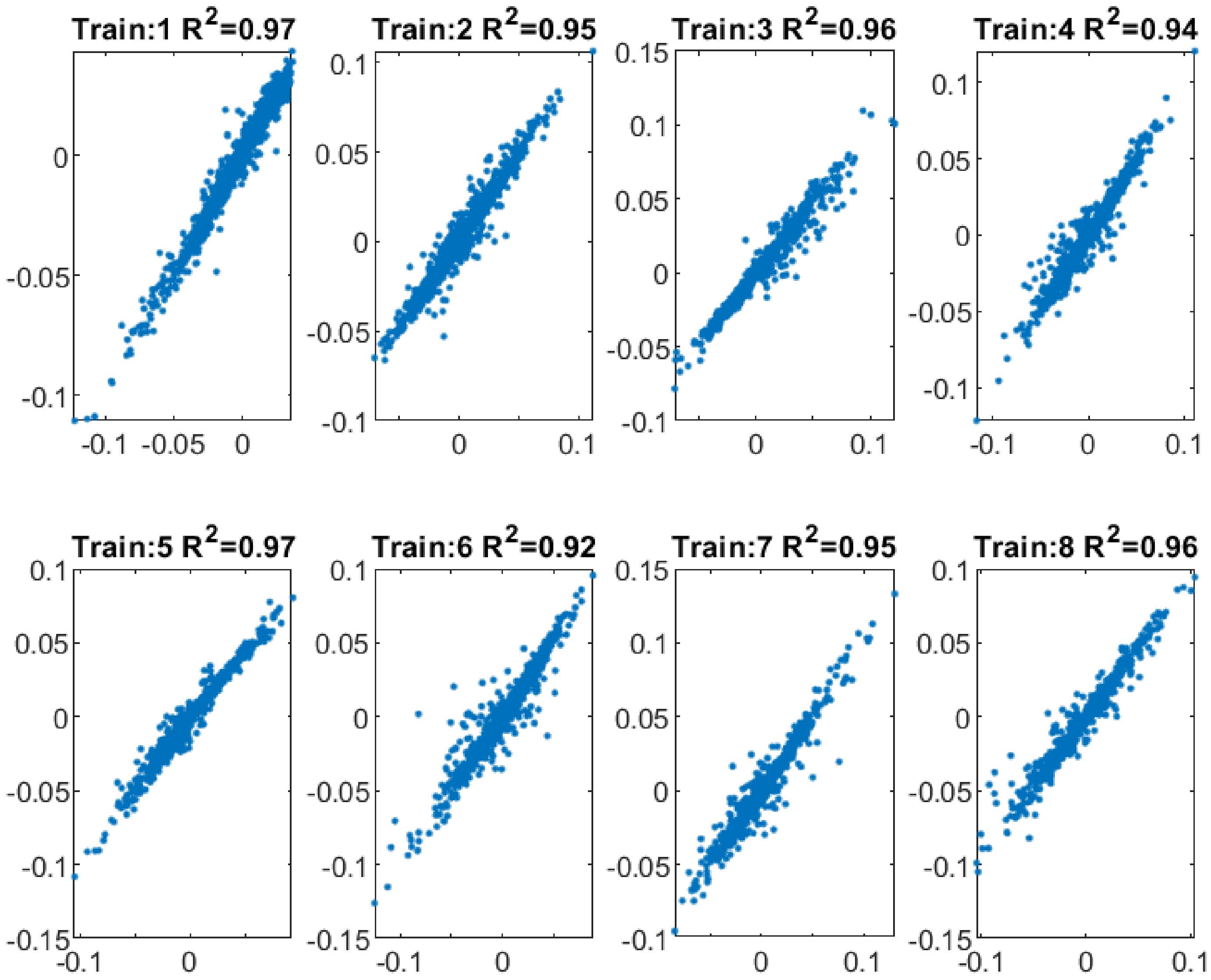
Compare 8-PCs against numerical model results



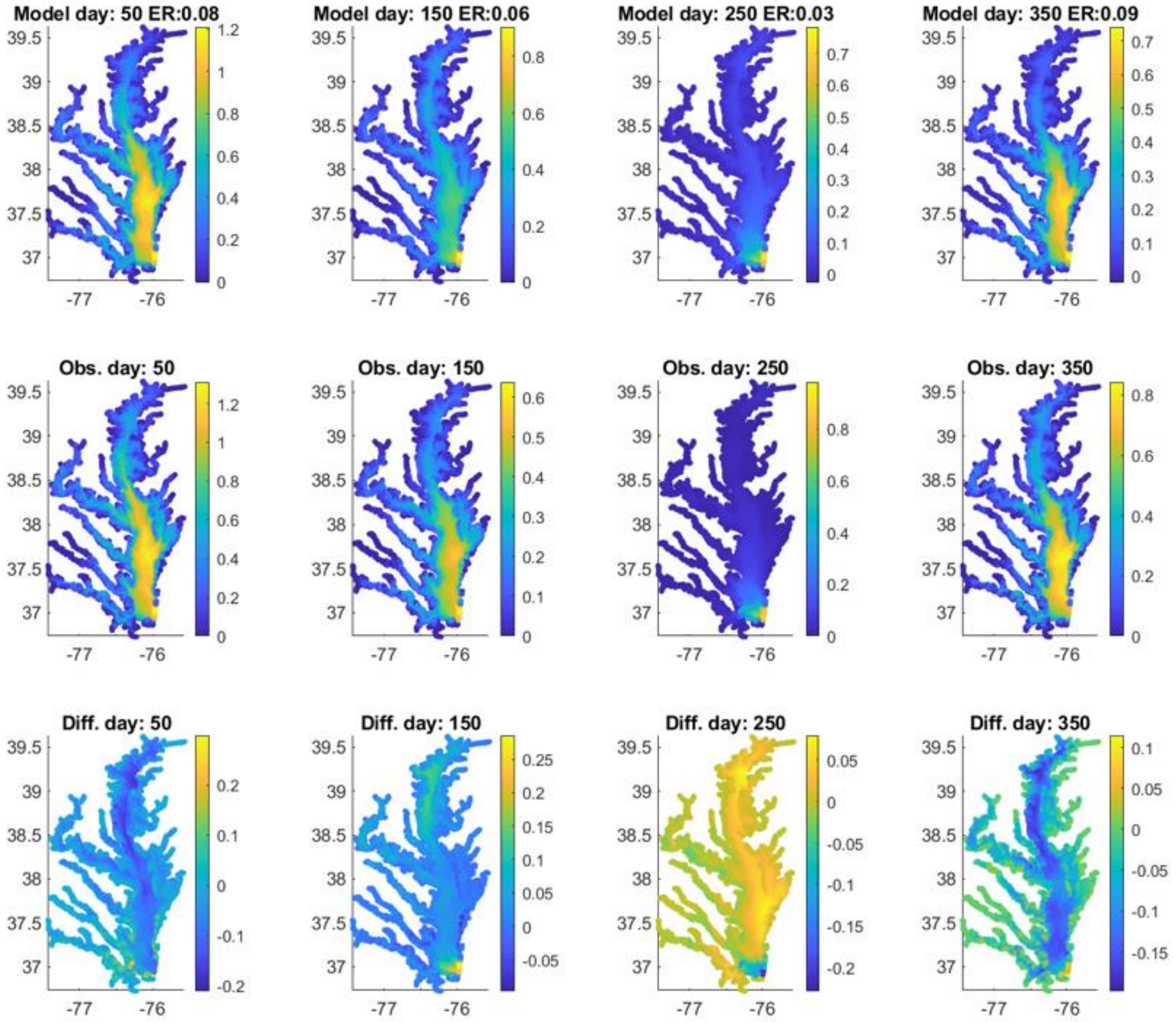


Obs. Referred numerical model outputs (used as observation for modeling training)

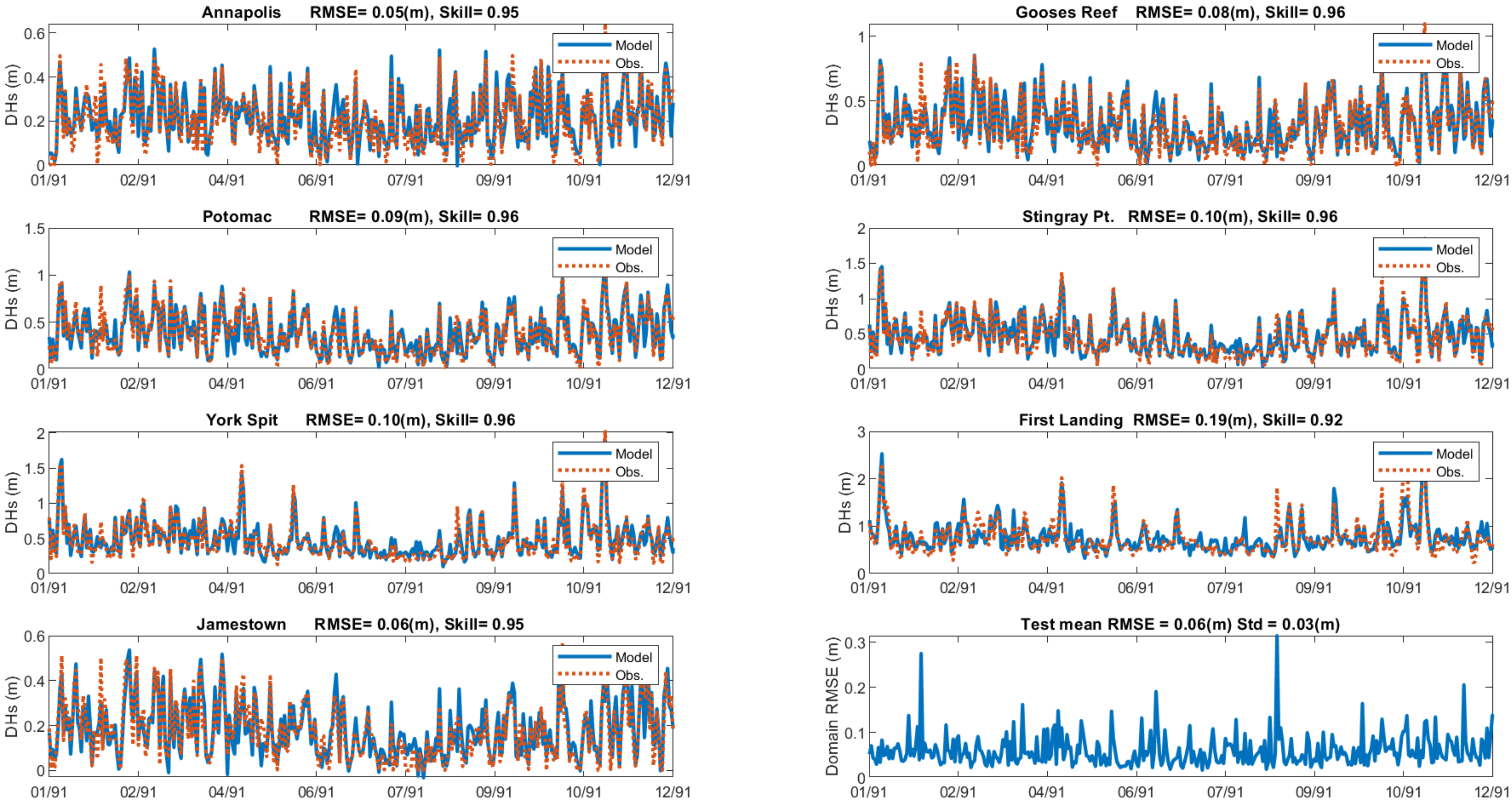
Training results



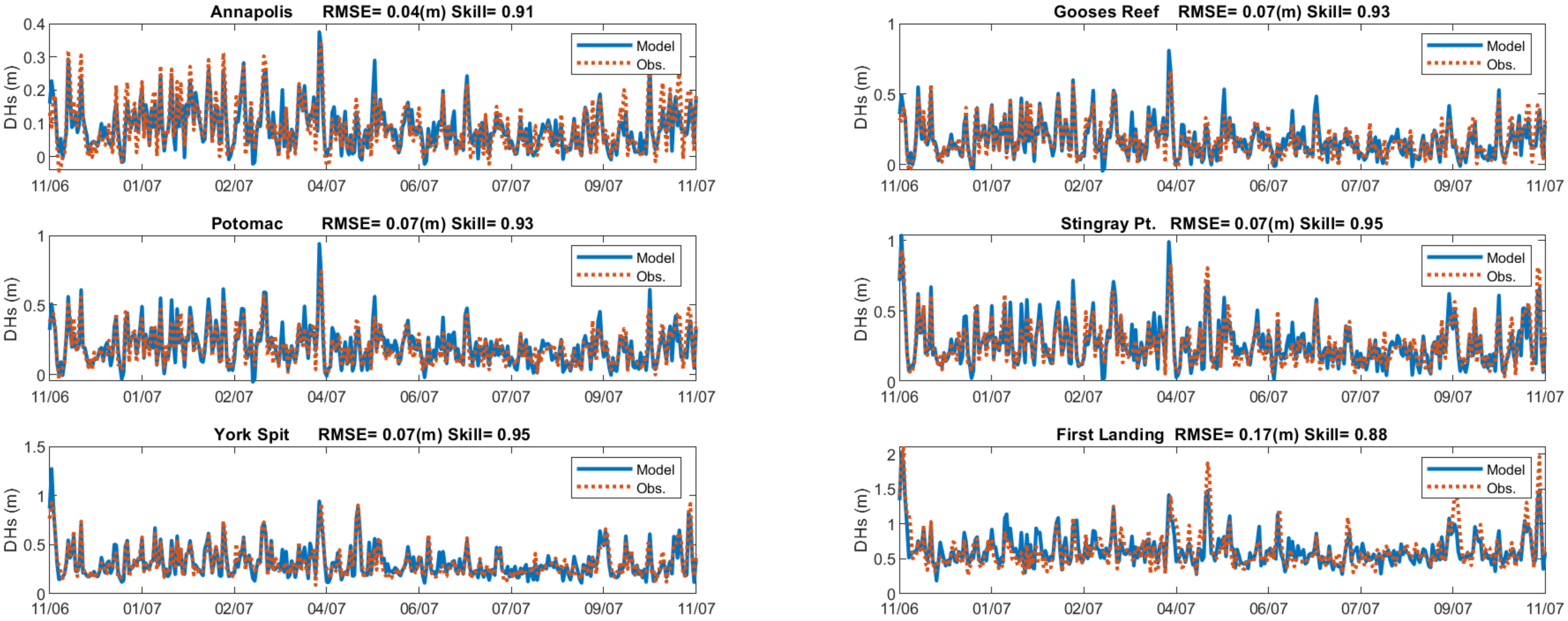
Comparison of data model and numerical model



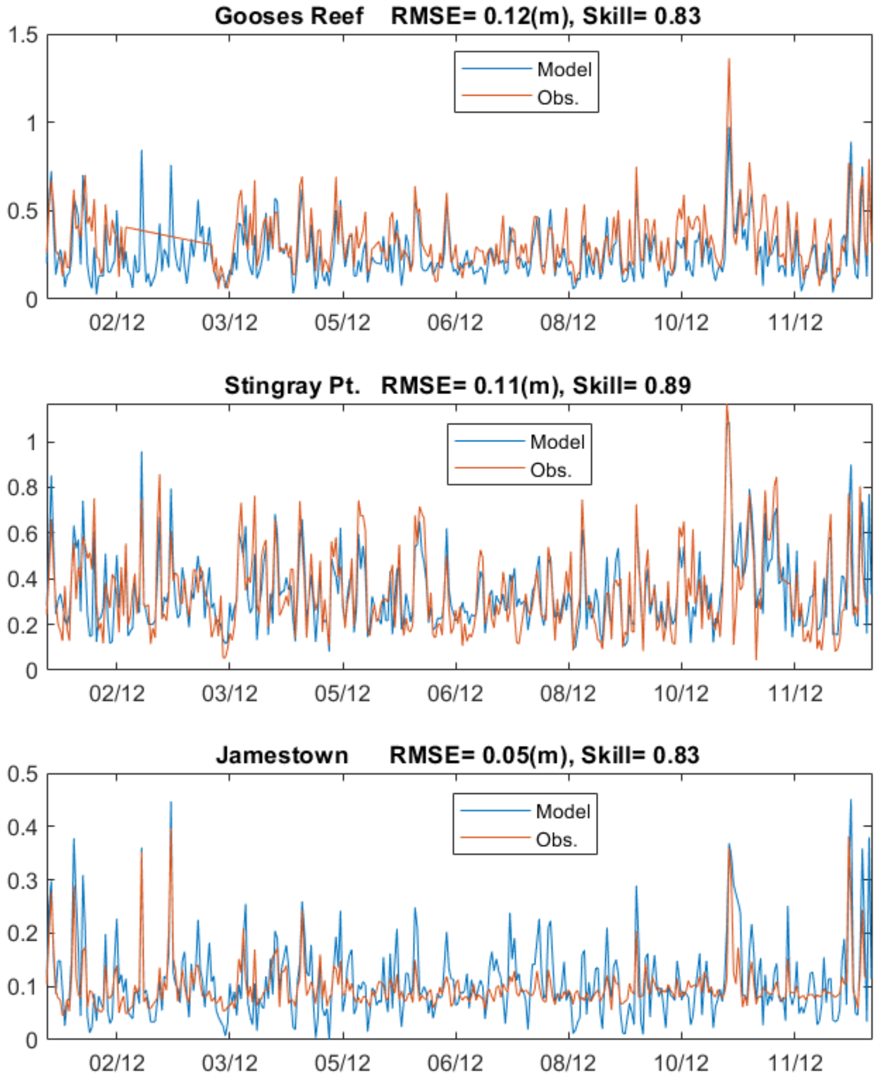
Comparison of data model and numerical model

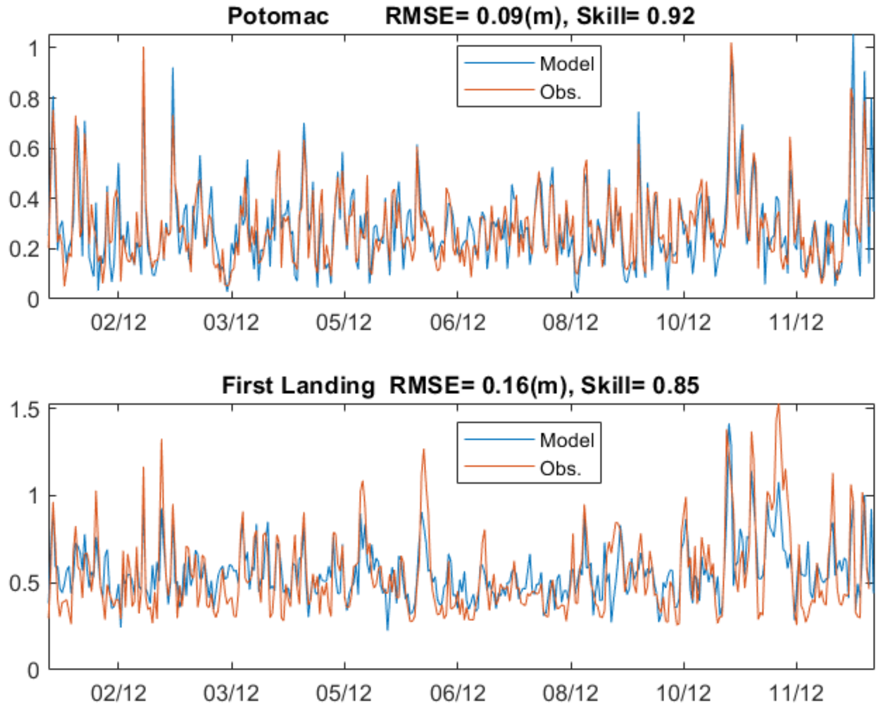


Comparison of data model and 2nd numerical model



Comparison of data model and NOAA buoy station





Obs. Are NOAA buoy real time observations

Next phase: ICM model calibration

- Calibration of water quality model (phase 1)
  - Use phase 6 watershed loading
  - Calibrate model without including wetland (DO or nutrient loos)
  - Calibrate model without including SAV and oyster
  - Using spatial settling velocity and growth rate if it is needed

- Calibration of water quality model (phase 2)
  - Calibrate water quality model including wetland
  - Calibrate water quality model including SAV

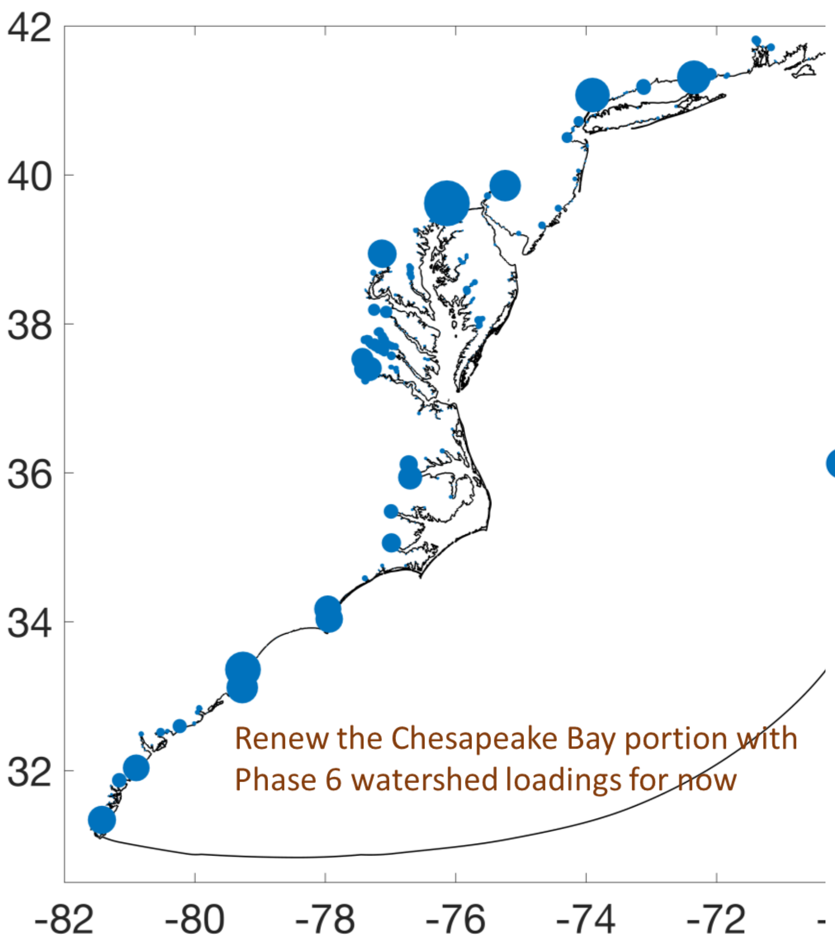
- Calibration of water quality model (phase 3)
  - Calibrate of water quality including oyster

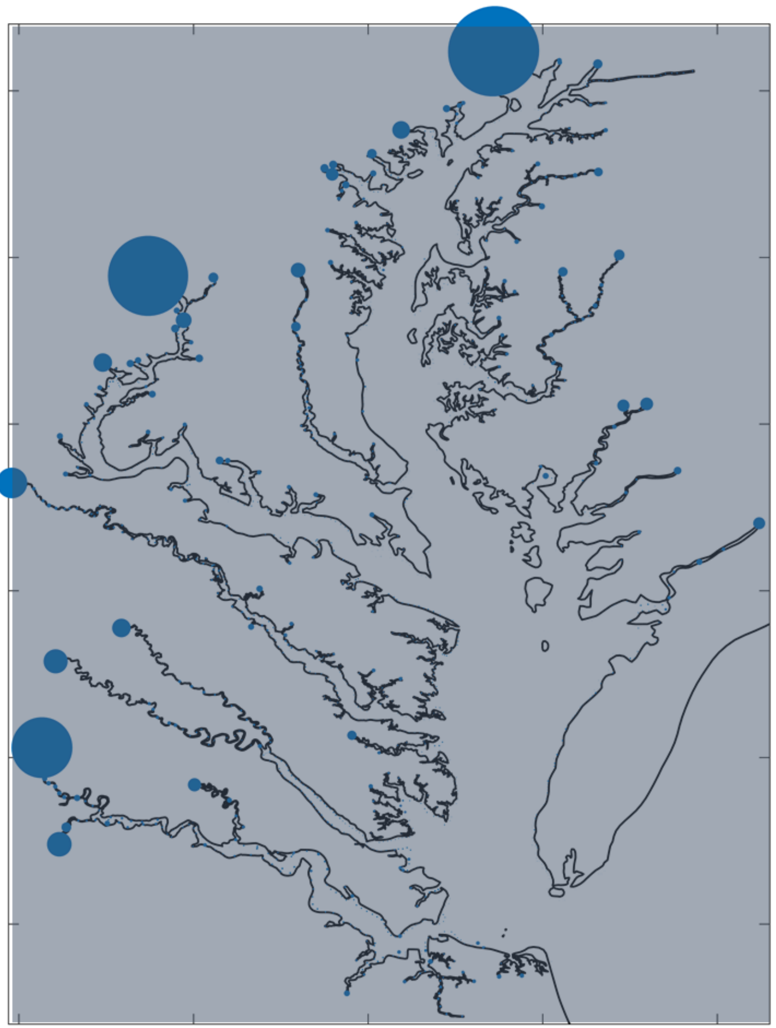
Next phase: Source contribution

- We know the characteristics of sources contributions from major rivers inside Bay and how materials are transported

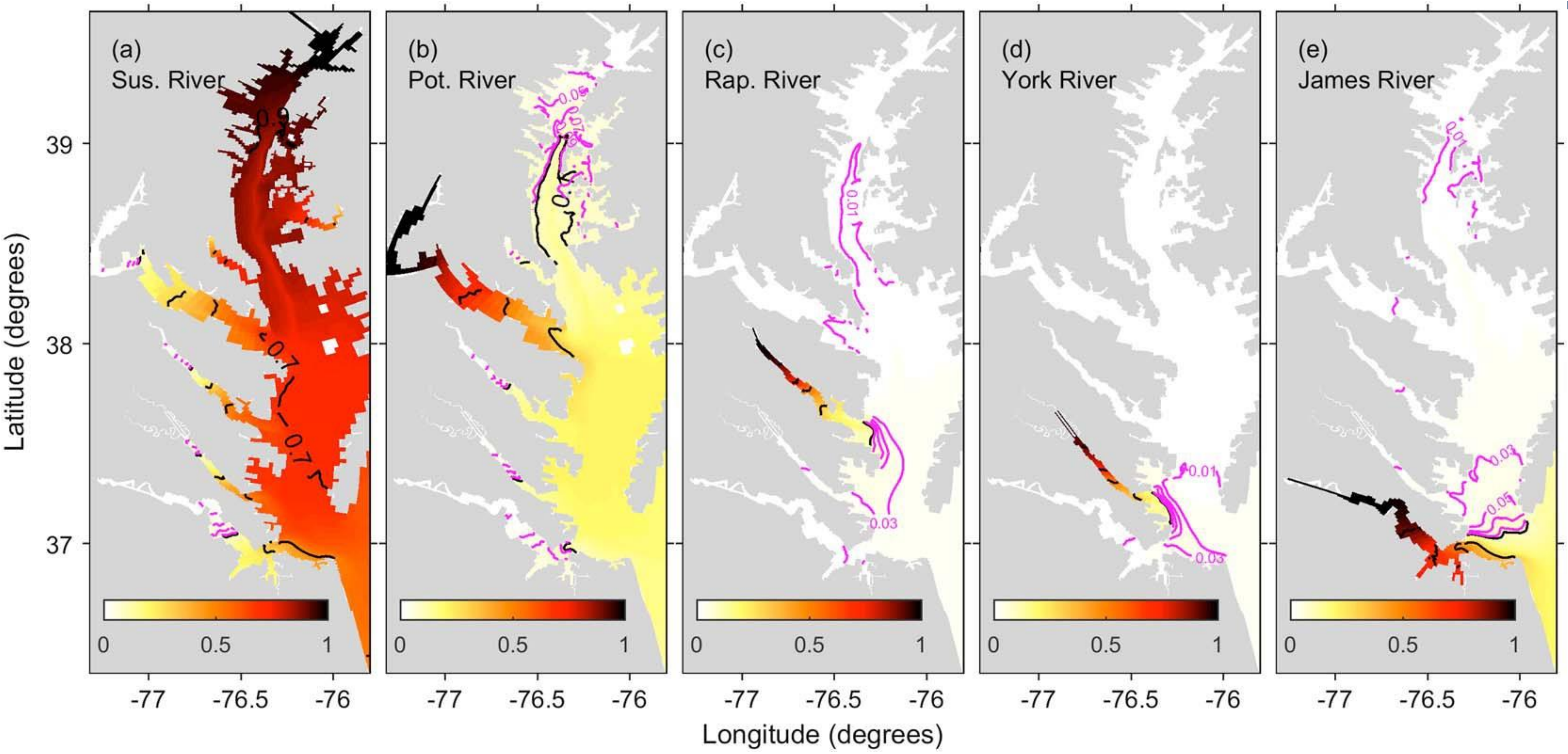
- We are less clear about the source contributions outside of the Bay

- We have MAB mesh, which is running for other projects



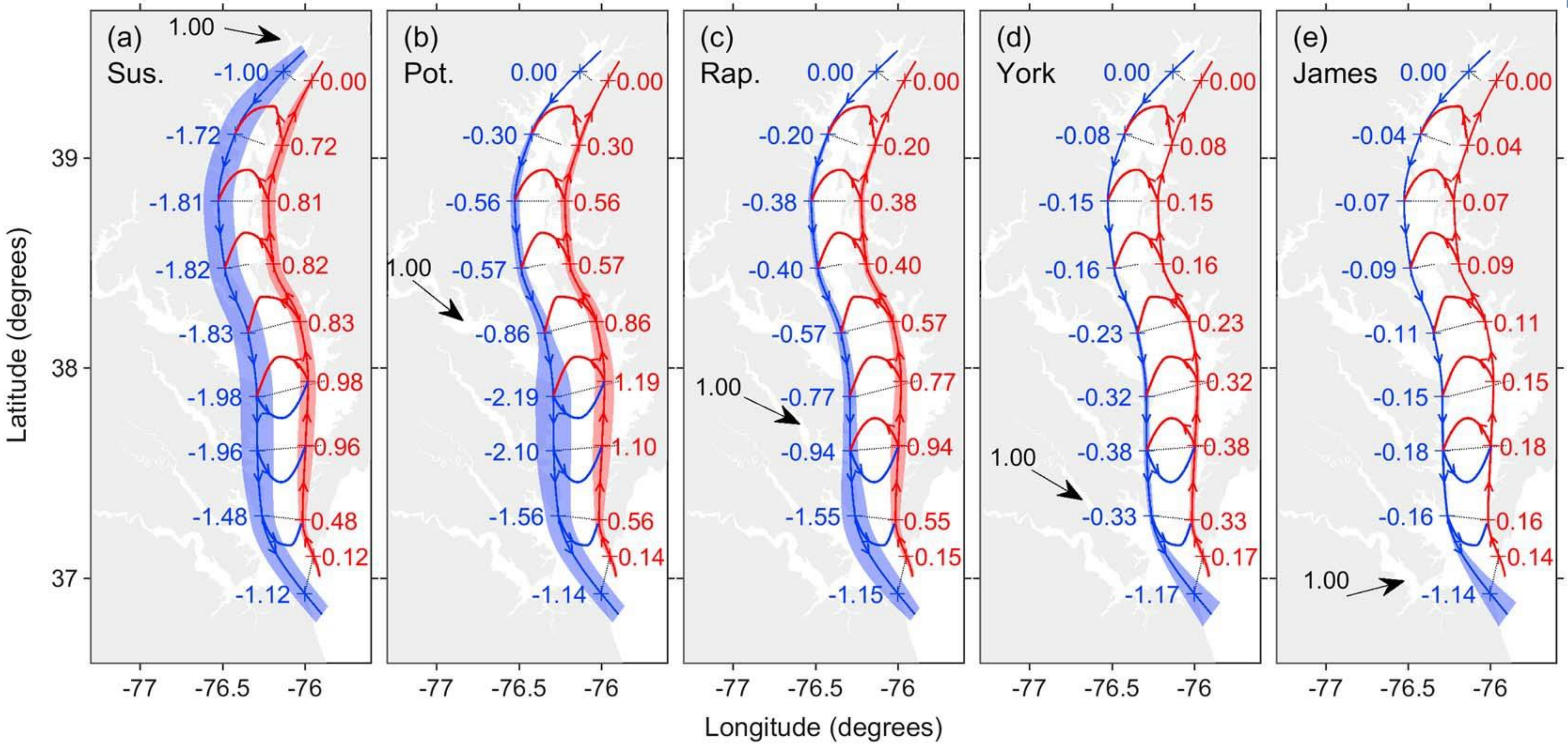


Next phase: Source contribution



Du and Shen, 2017 JGR Bio.

Next phase: Source contribution



Next phase: Source contribution

- Use dye study to understand the source contribution
  - Delaware Bay (CN cannel)
  - Contribution of Delaware loading from open boundary
  - Contribution of East costal embayments
  - Contribution of open boundary condition (climate change)

Comments and Suggestions