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

Progress Report

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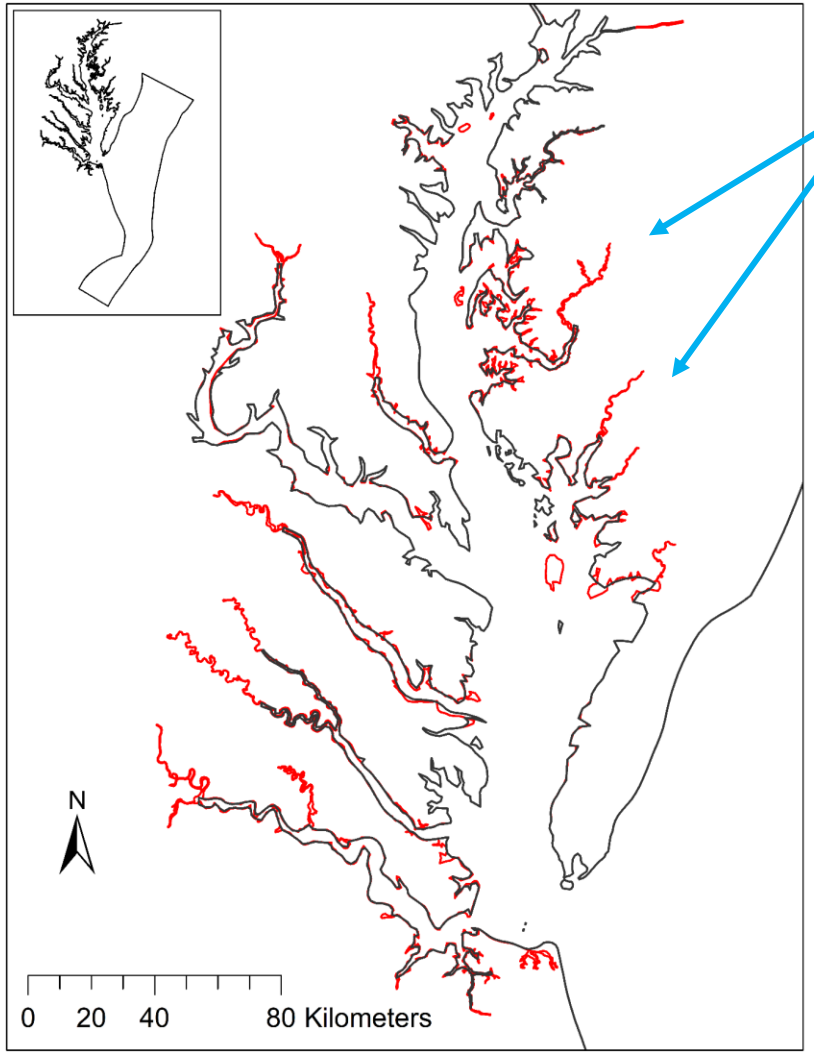
VIRGINIA INSTITUTE OF MARINE SCIENCE

Outline:

1. **Revise the model grid**
2. **Conduct preliminary model calibration using the new grid**
3. **Generate python tools for workflow**
4. **Enable the model to run in decoupled mode**

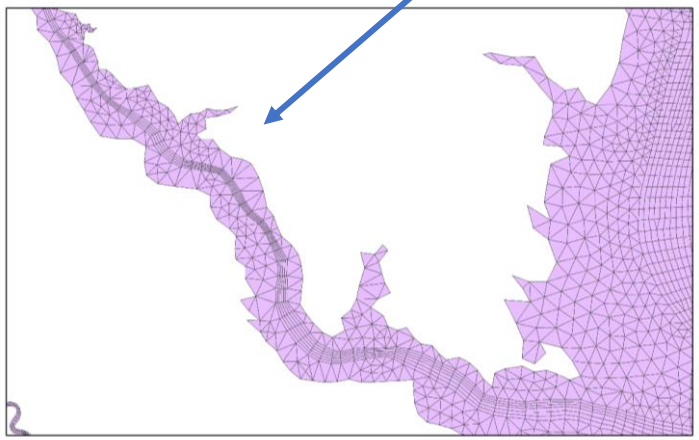
1. Revise the model grid

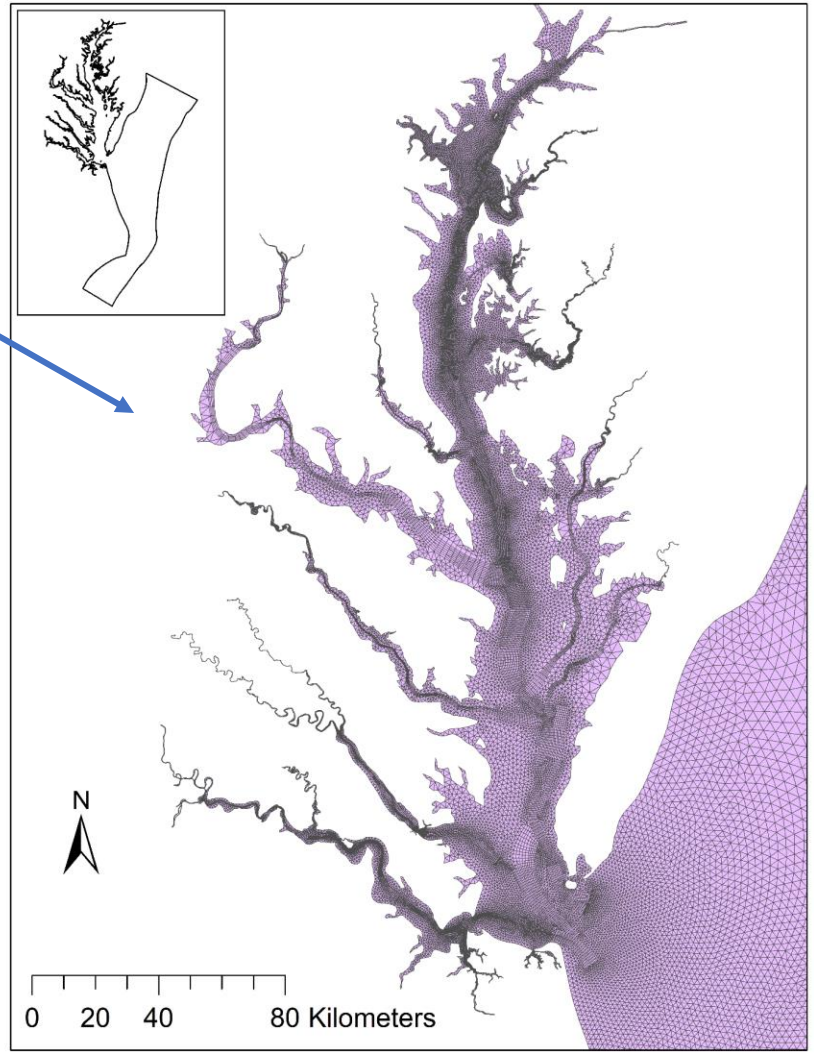


1. Extend the grid to upstream to improve tidal propagation and reflection

2. Increase grid resolution
Total elements: 66,739
Old grid: 43,009

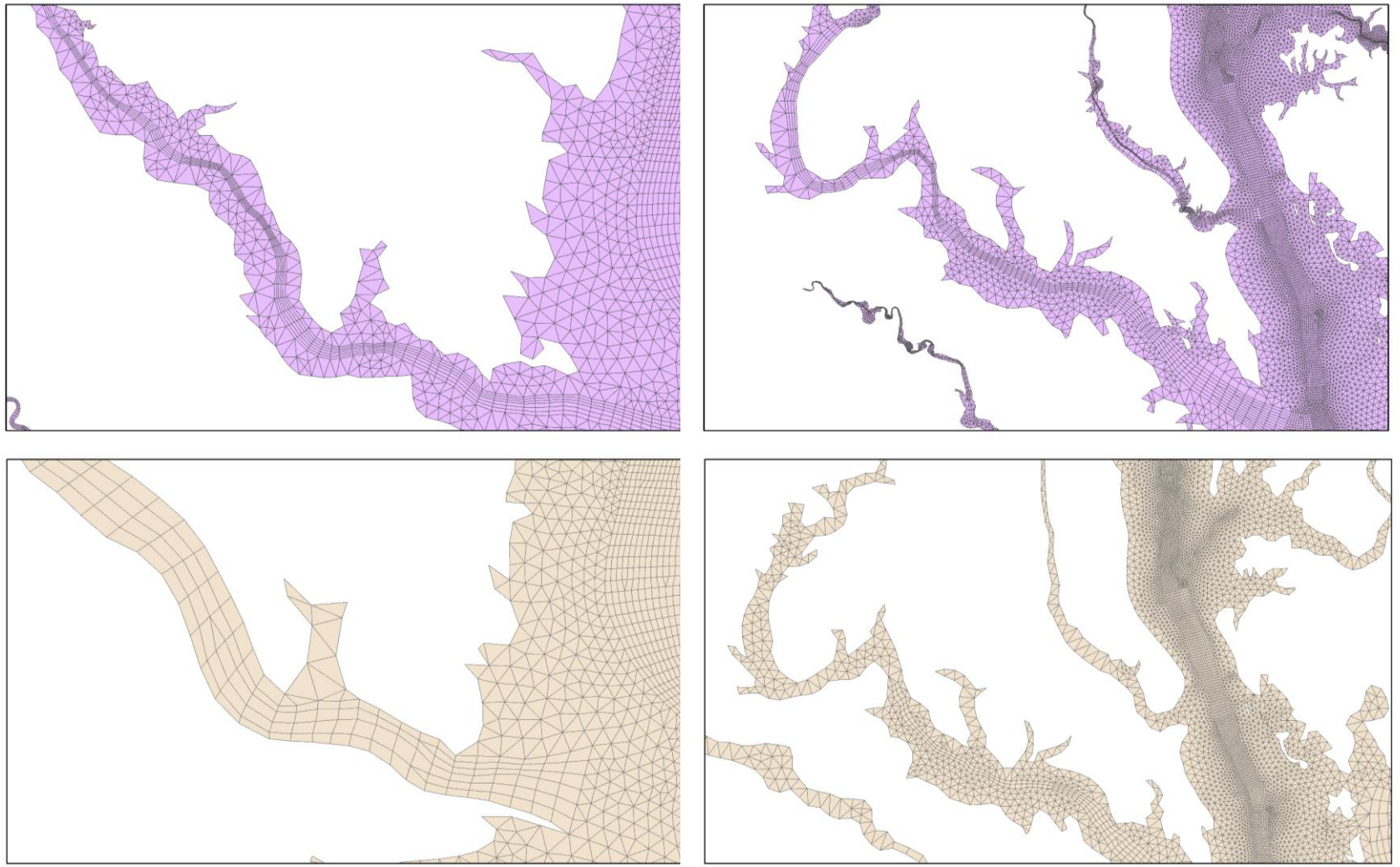
3. Follow deep channel using 4-side grids





1. Revise the model grid

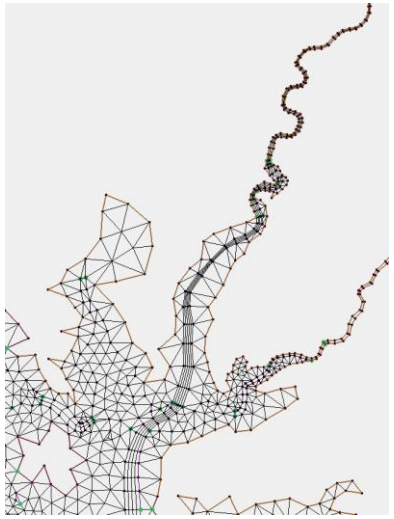
Rappahannock River



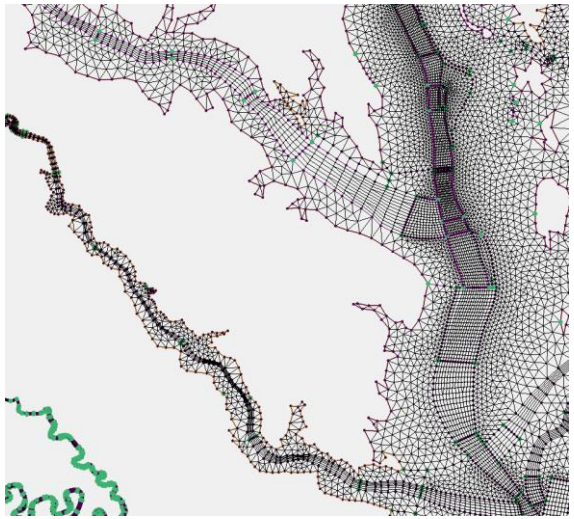
Potomac River

1. Revise the model grid

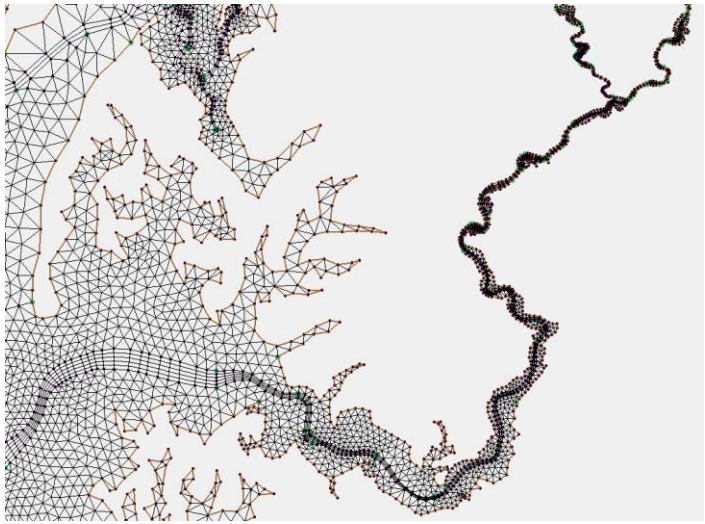
Nanticoke



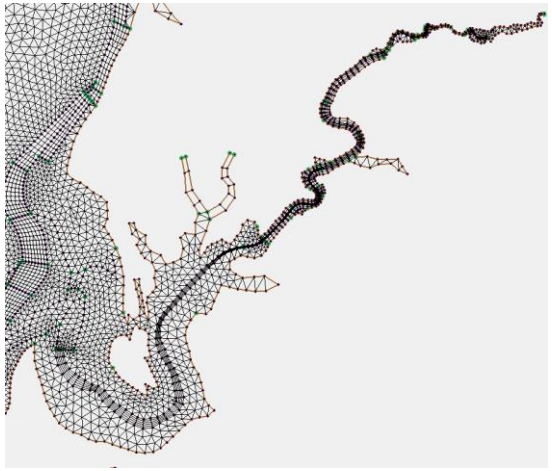
Rappahannock and Potomac



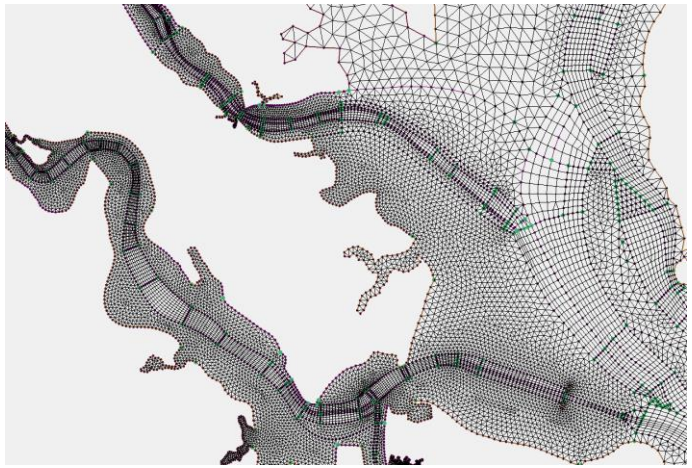
Choptank



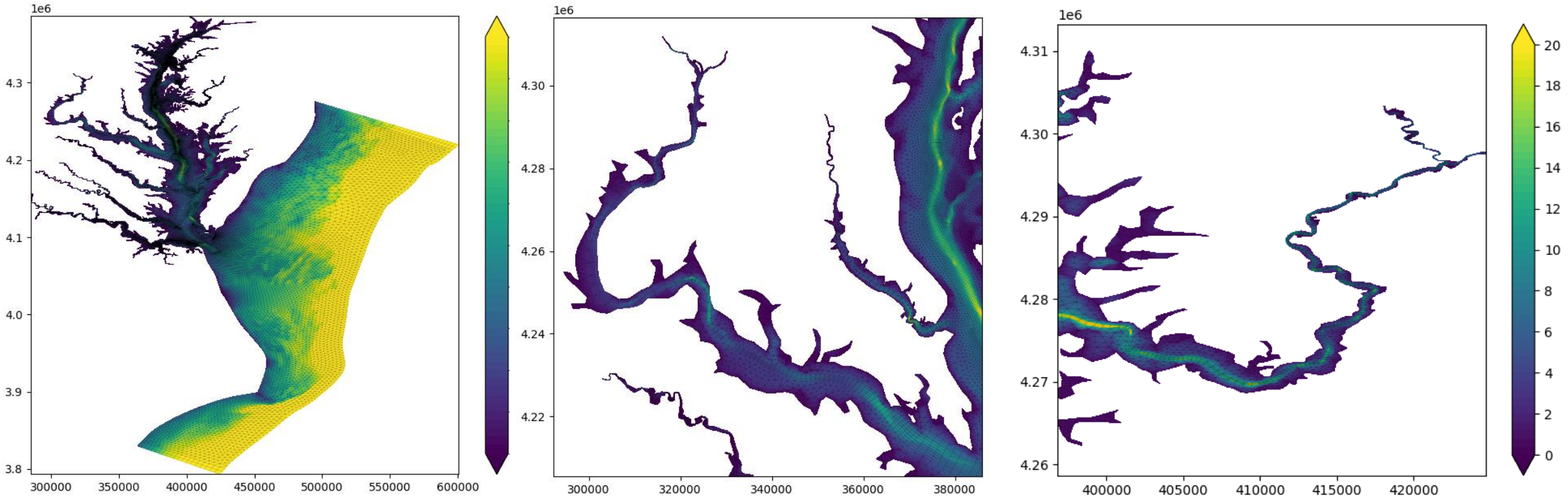
Chester



New mesh: York and James

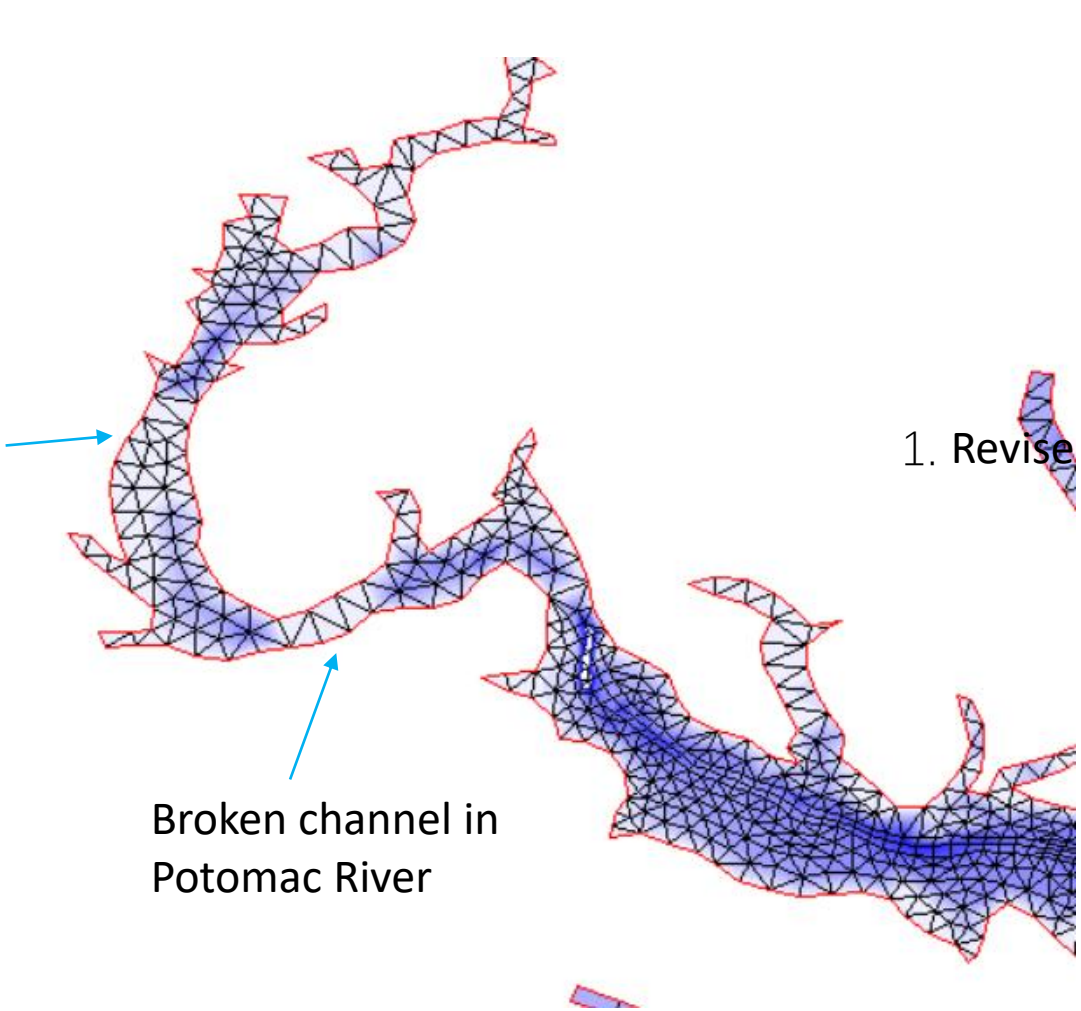


1. Revise the model grid



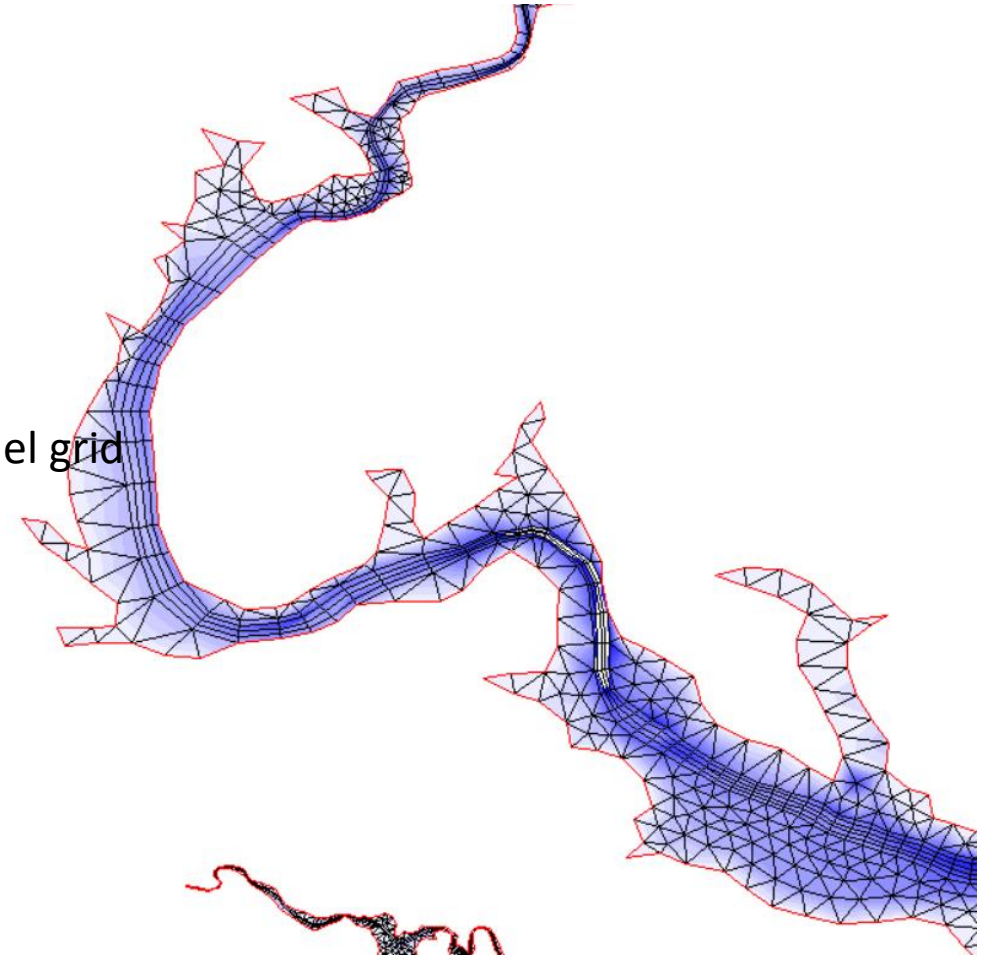
Major effort on faithfully representing the deep channel

1. Revise the model grid



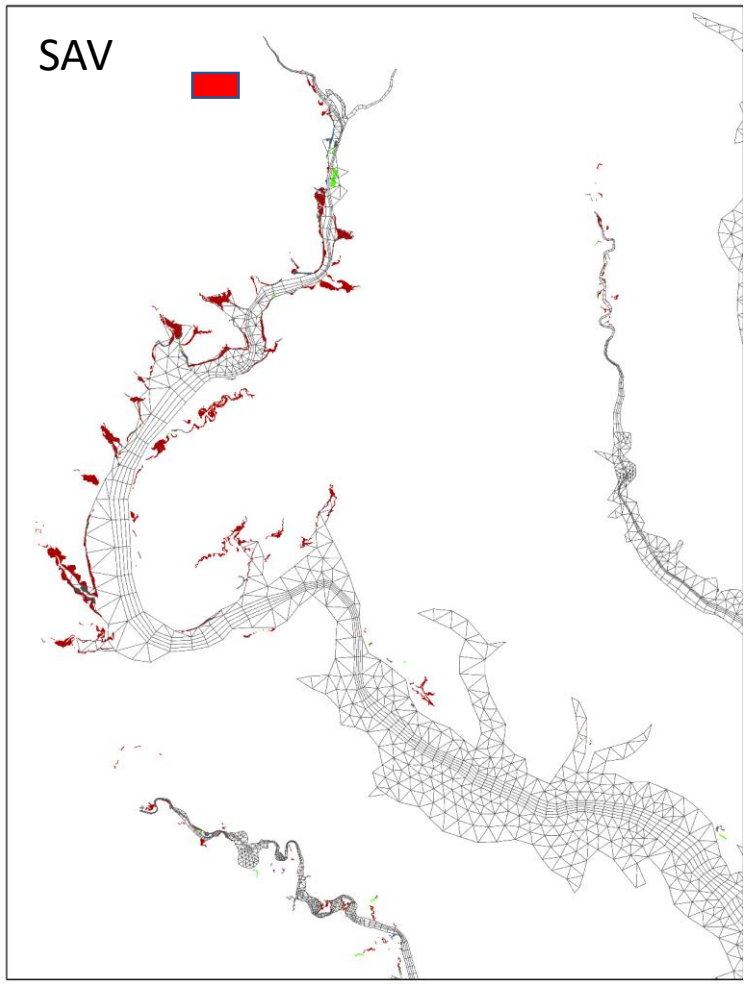
Broken channel in Potomac River

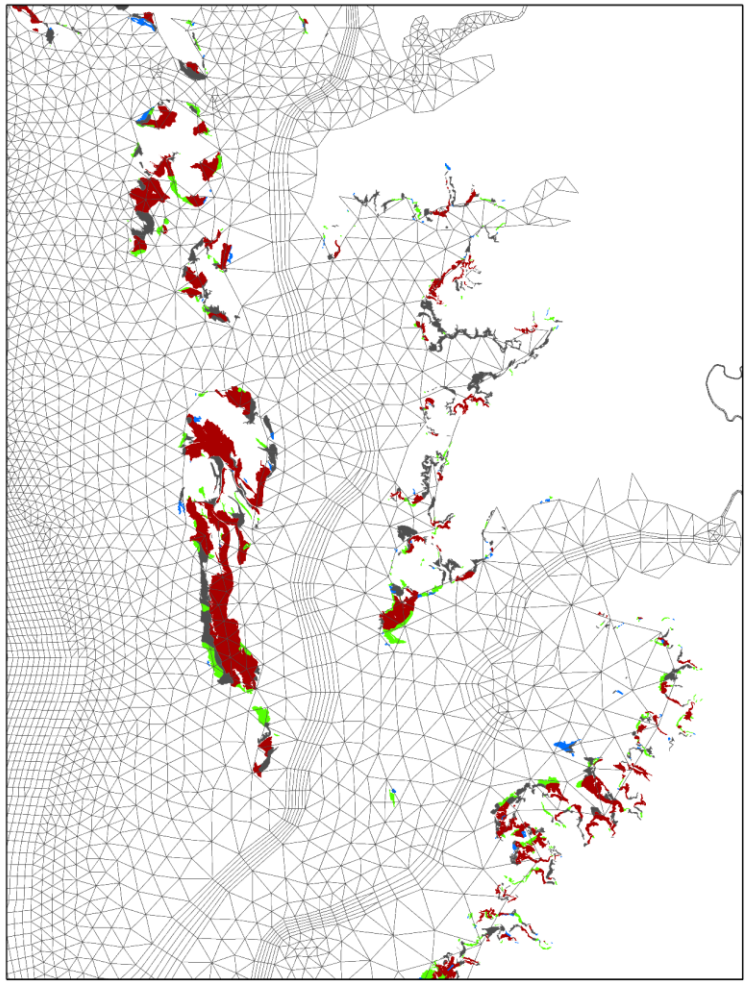
1. Revise the model grid



Filled color indicate bathymetry, with white color denoting depth larger than 15m

1. Revise the model grid: SAV





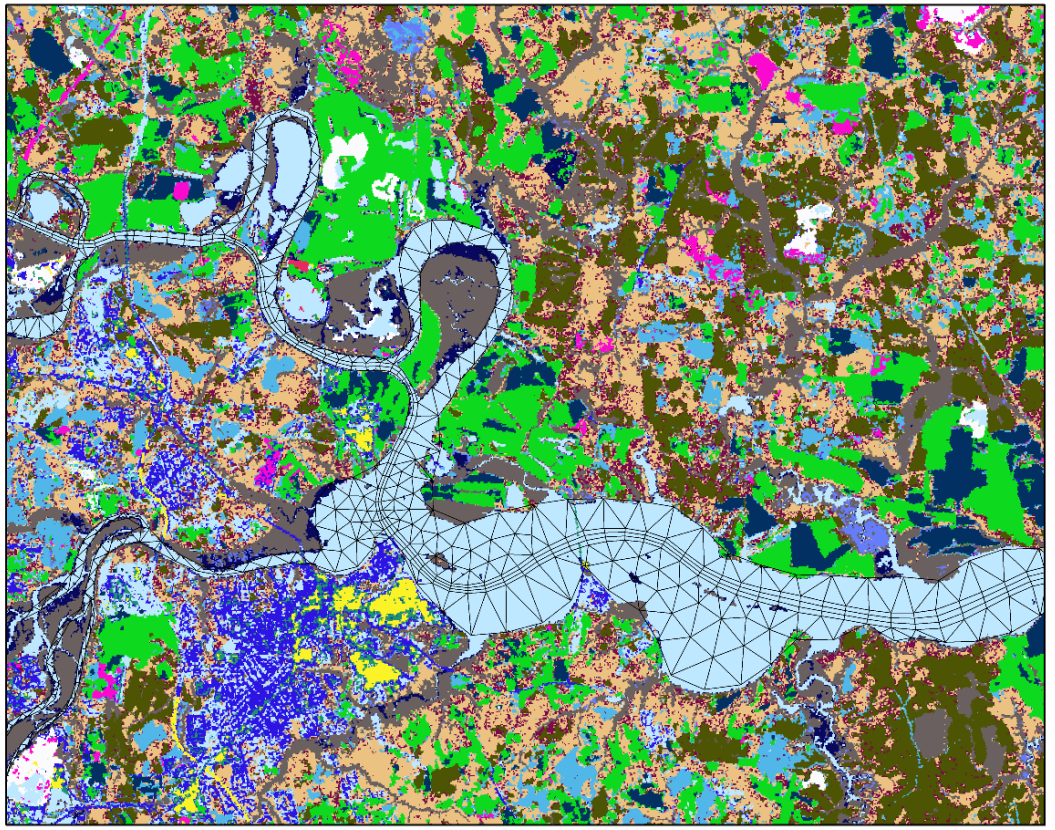
SAV implementation

1. SAV will be assigned to the adjacent grid based on the proportional area of SAV and grid

2. Leave detailed simulation to the tributary model

1. **Revise the model grid Next Phase**

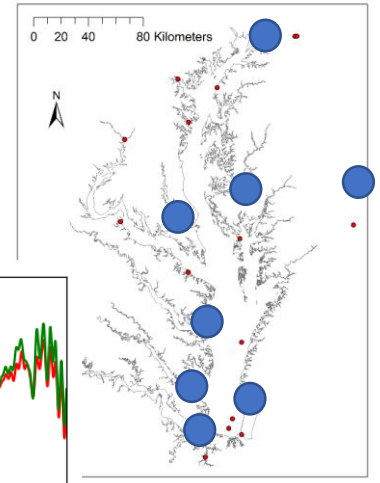
- Revise grid locally when it is needed (based on model calibration)
- Revise the grids in the Eastern Shore region
- Run model using phase 7 flow
- Link wetland to model
  - Determine boundary for wetland (USGS?)
  - No wet-dry in wetland
    (leave to tributary models)

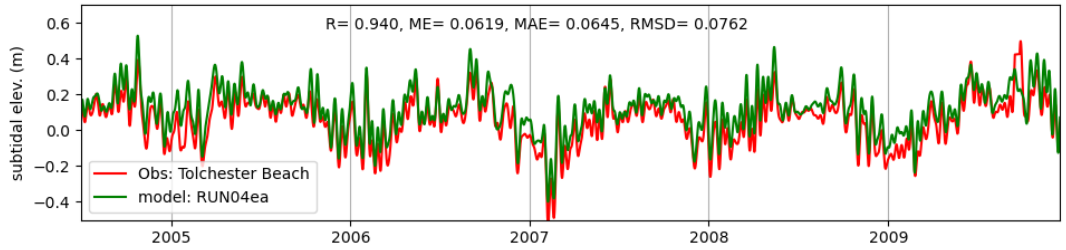


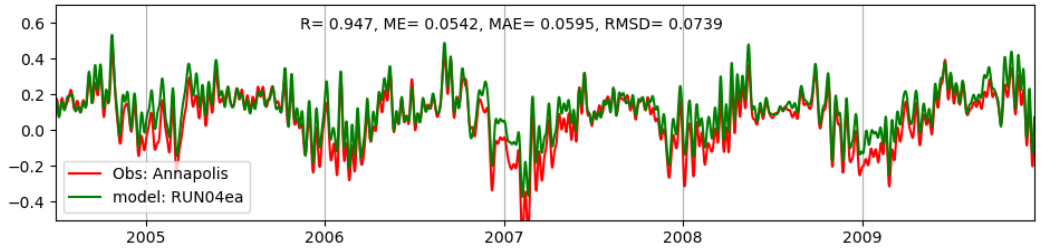
2. **Model calibration using the new grid**

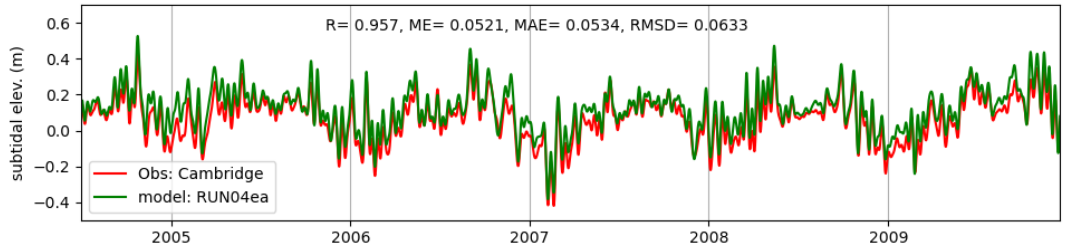
- Major issues to be improved when using the old grid
  - Stratification
  - Salinity intrusion
  - Model simulation in tributaries

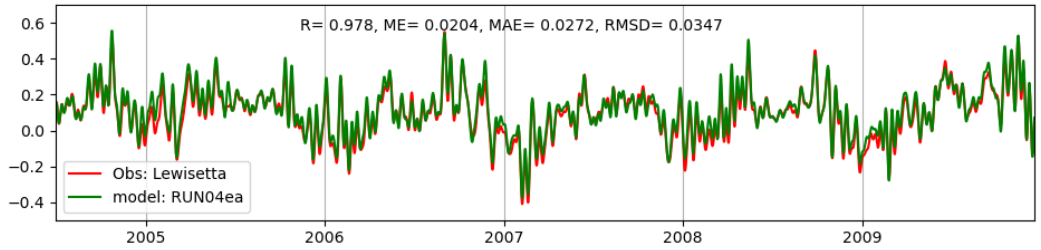
2. Model calibration: Subtidal elevation

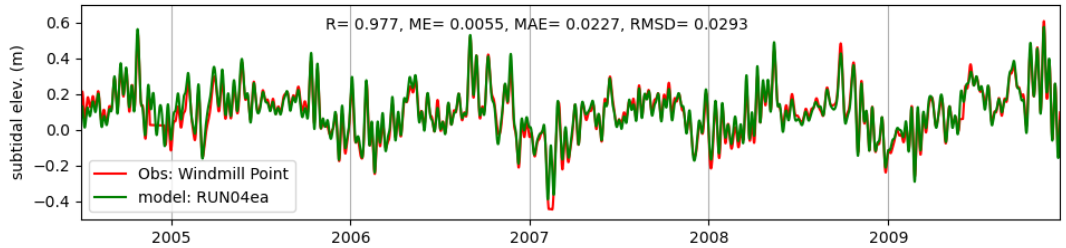


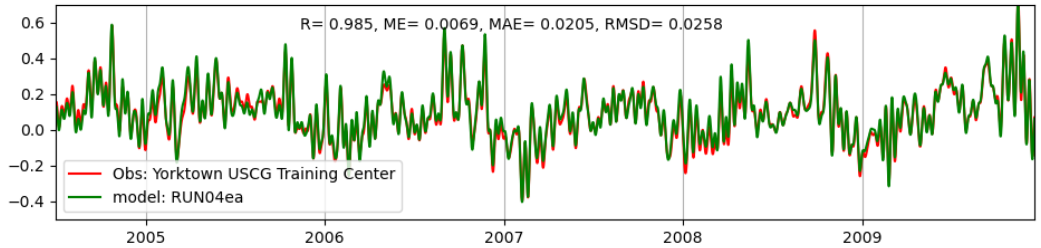


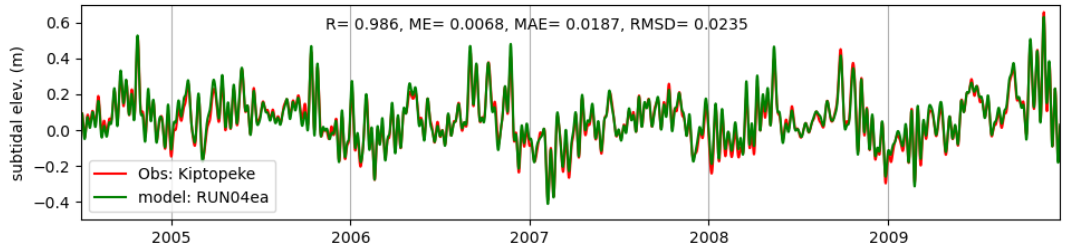


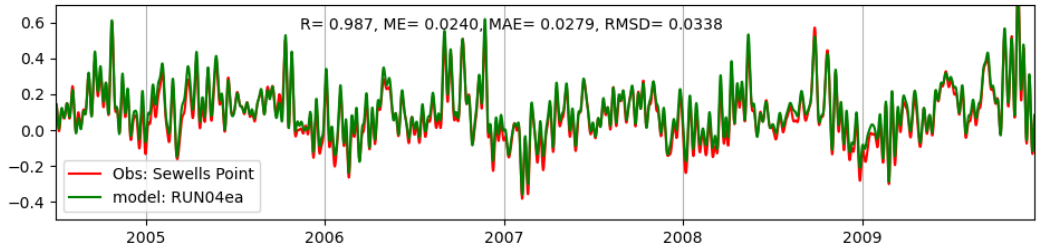




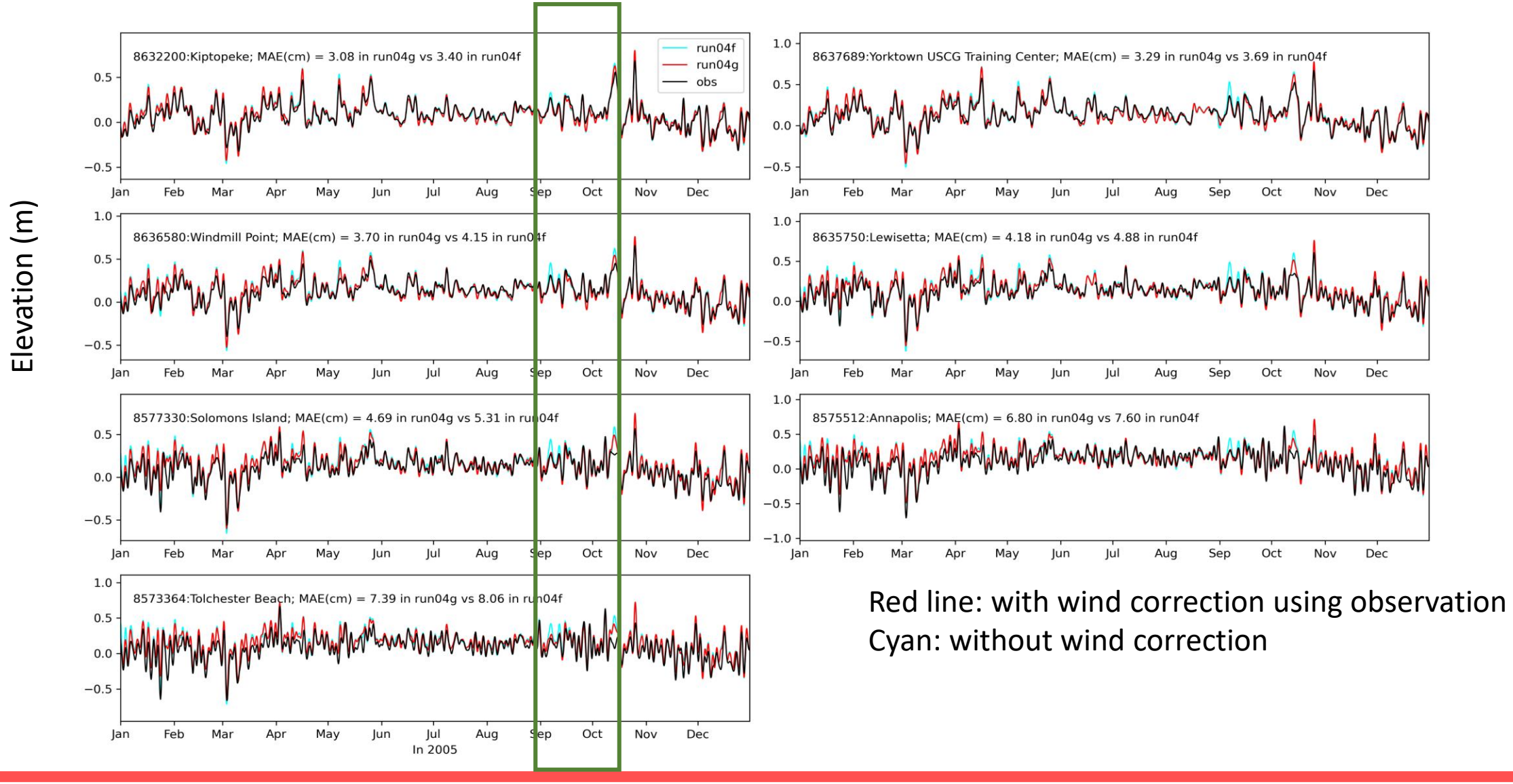






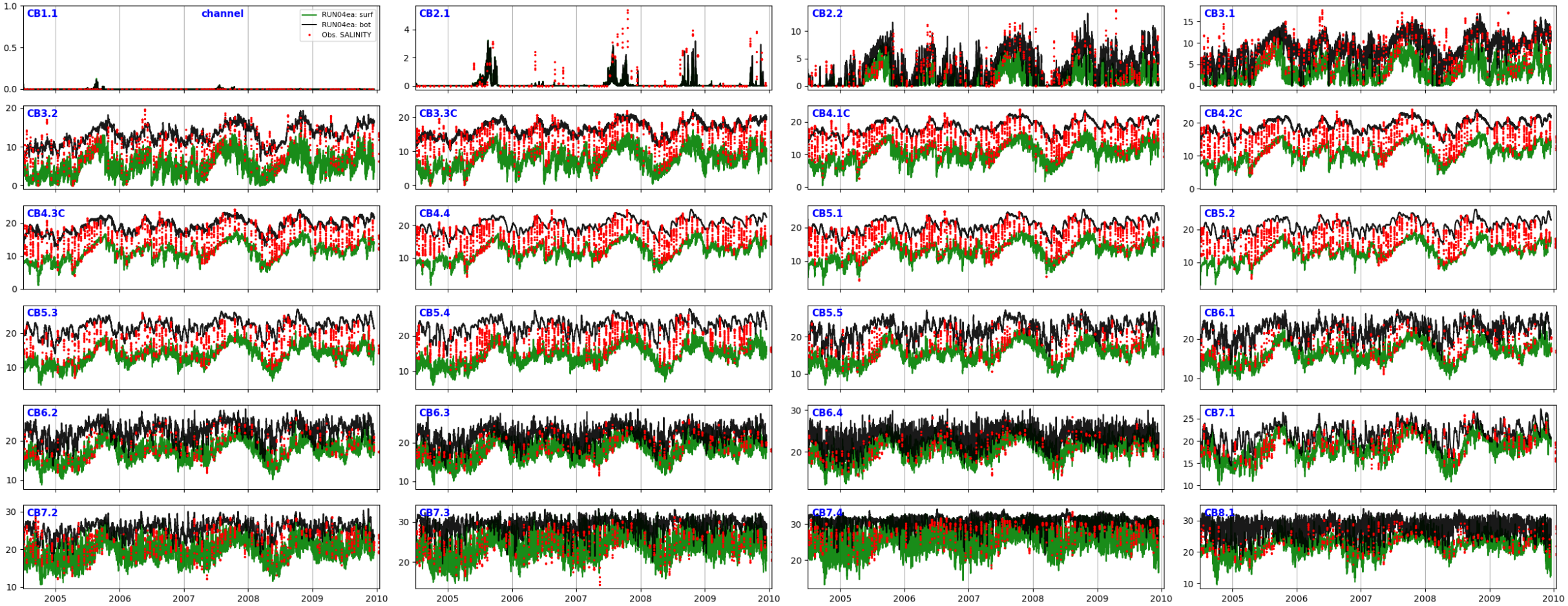


2. Model calibration: Subtidal elevation



Red line: with wind correction using observation
Cyan: without wind correction

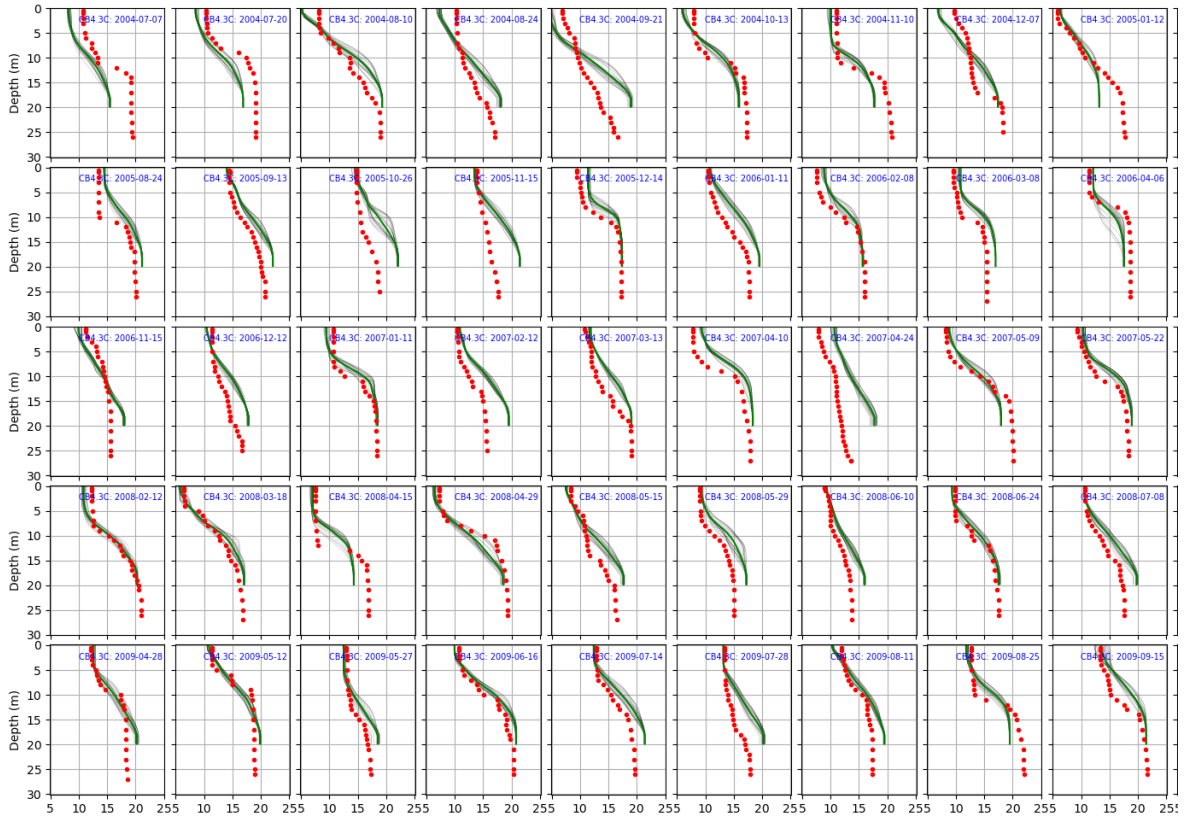
2. Model calibration: Bay salinity



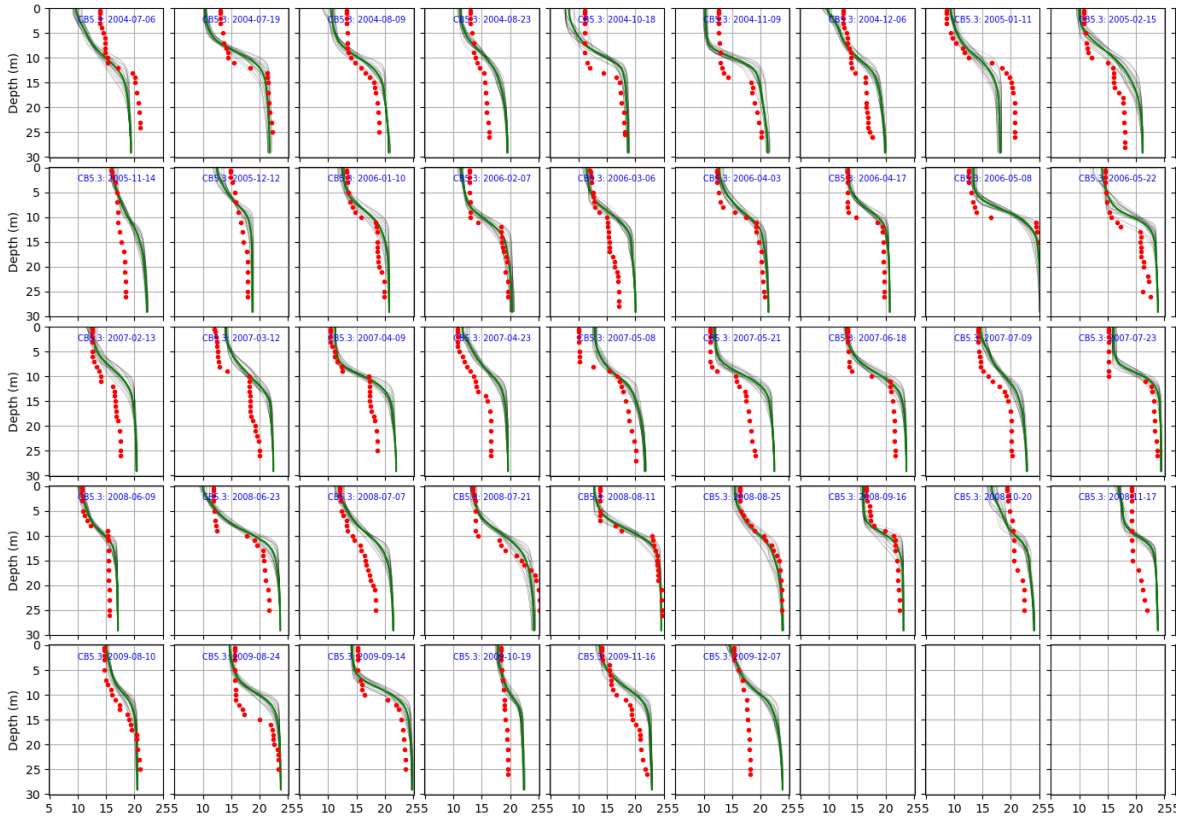
Rad dots: observation, Black lines: surface, Green lines: bottom

2. Model calibration: Bay salinity profile

CB4.3

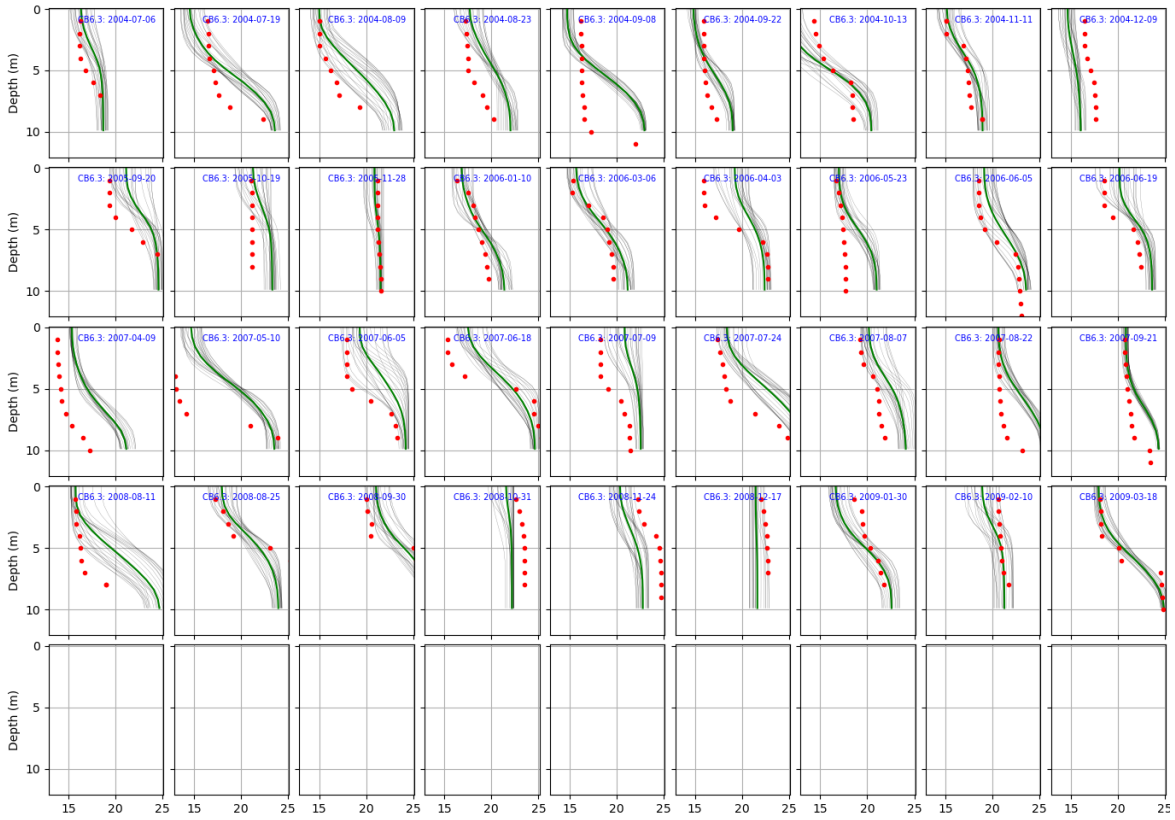


CB5.3

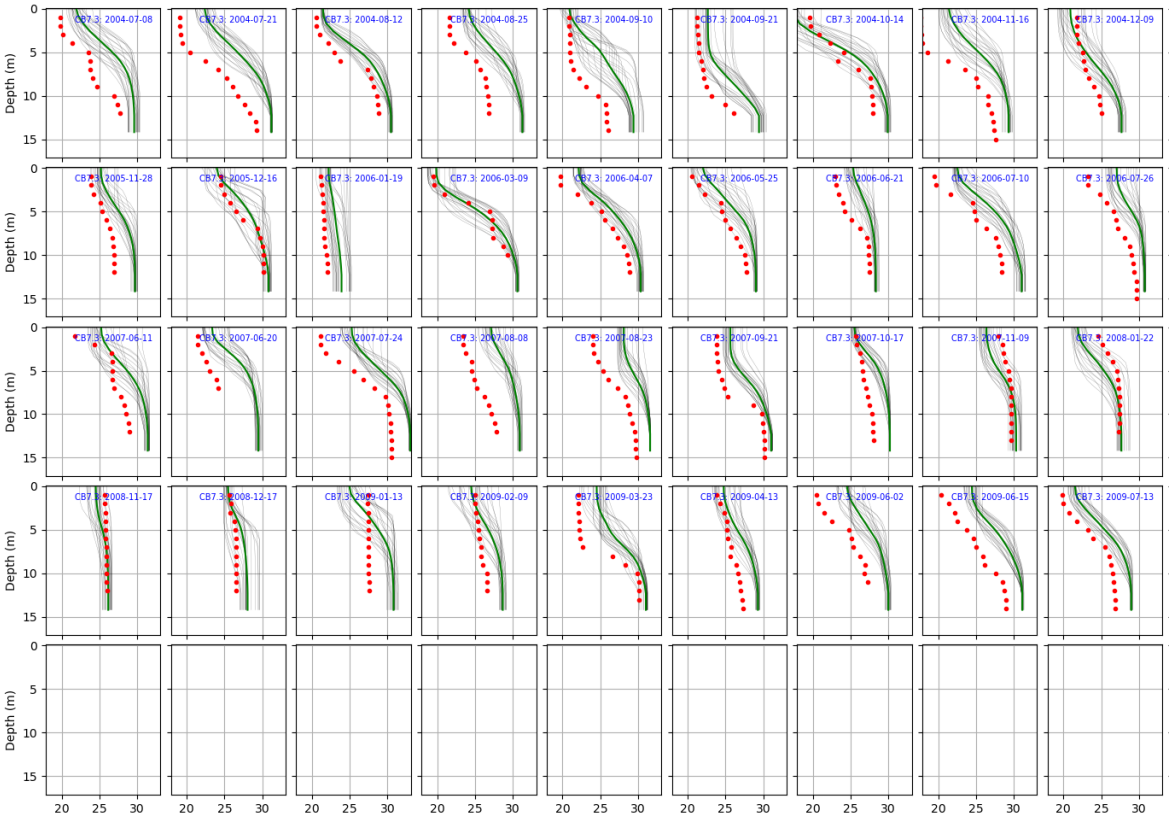


2. Model calibration: Bay salinity profile

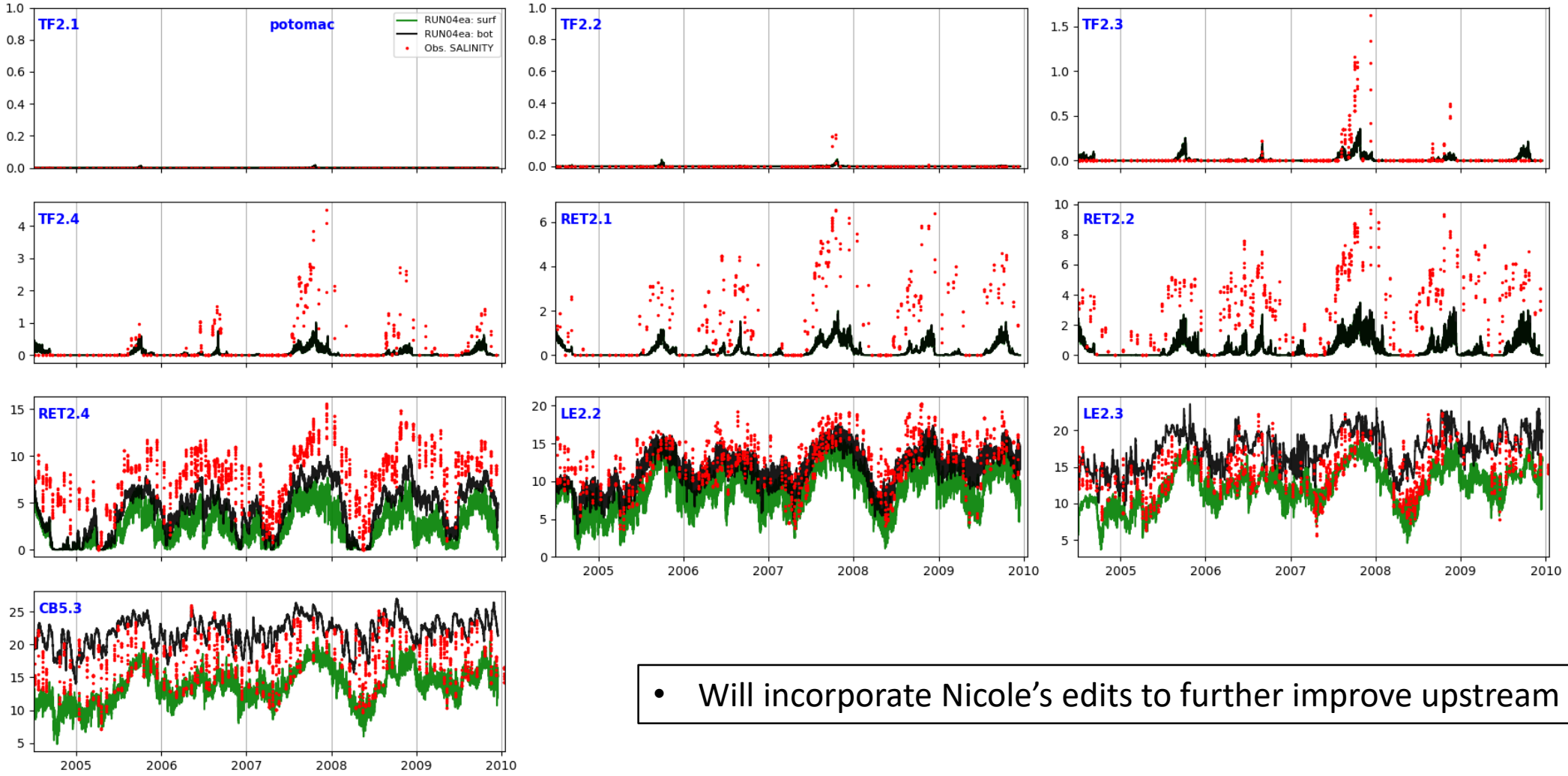
CB6.3



CB7.3

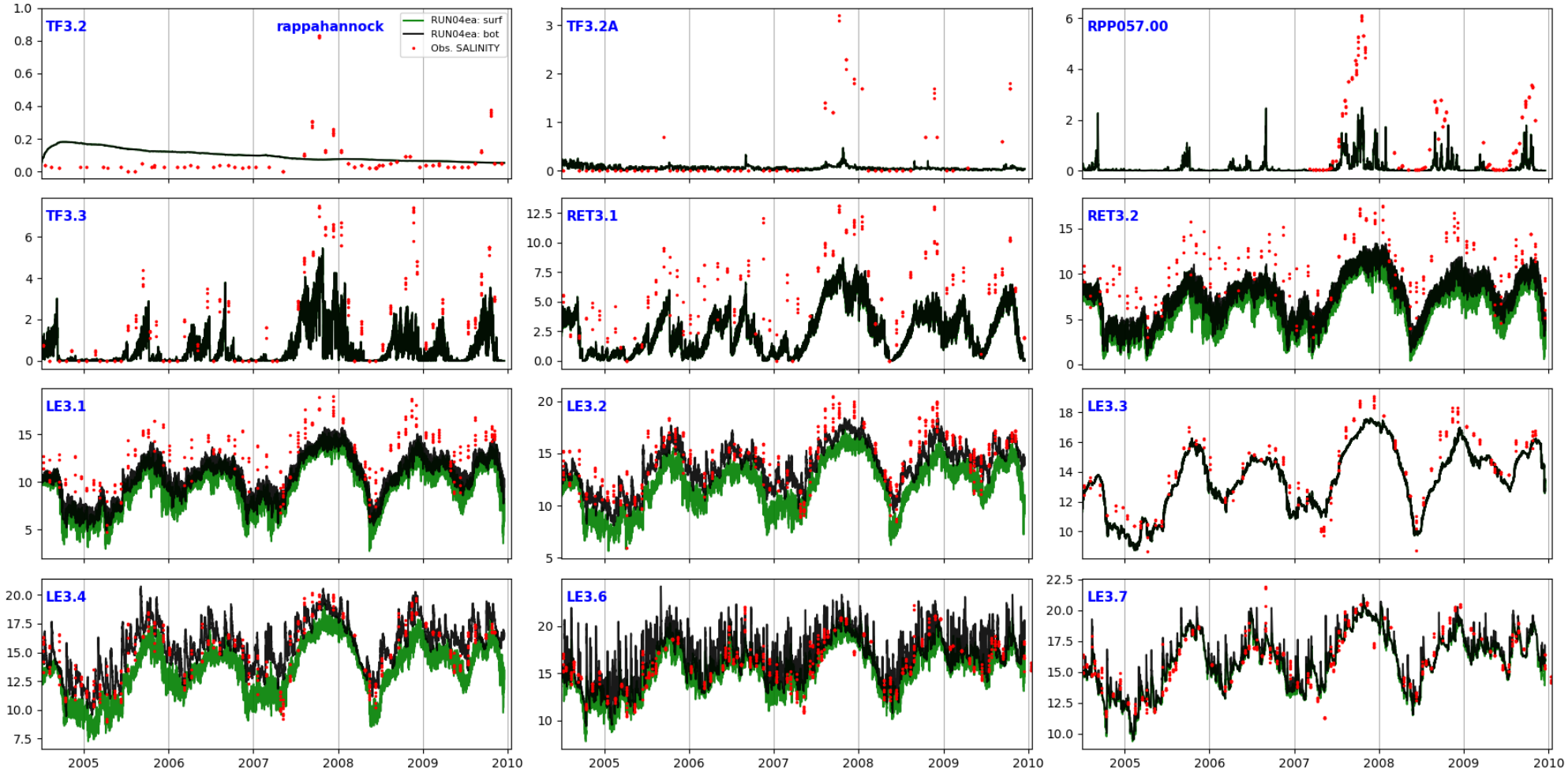


2. Model calibration: Potomac salinity

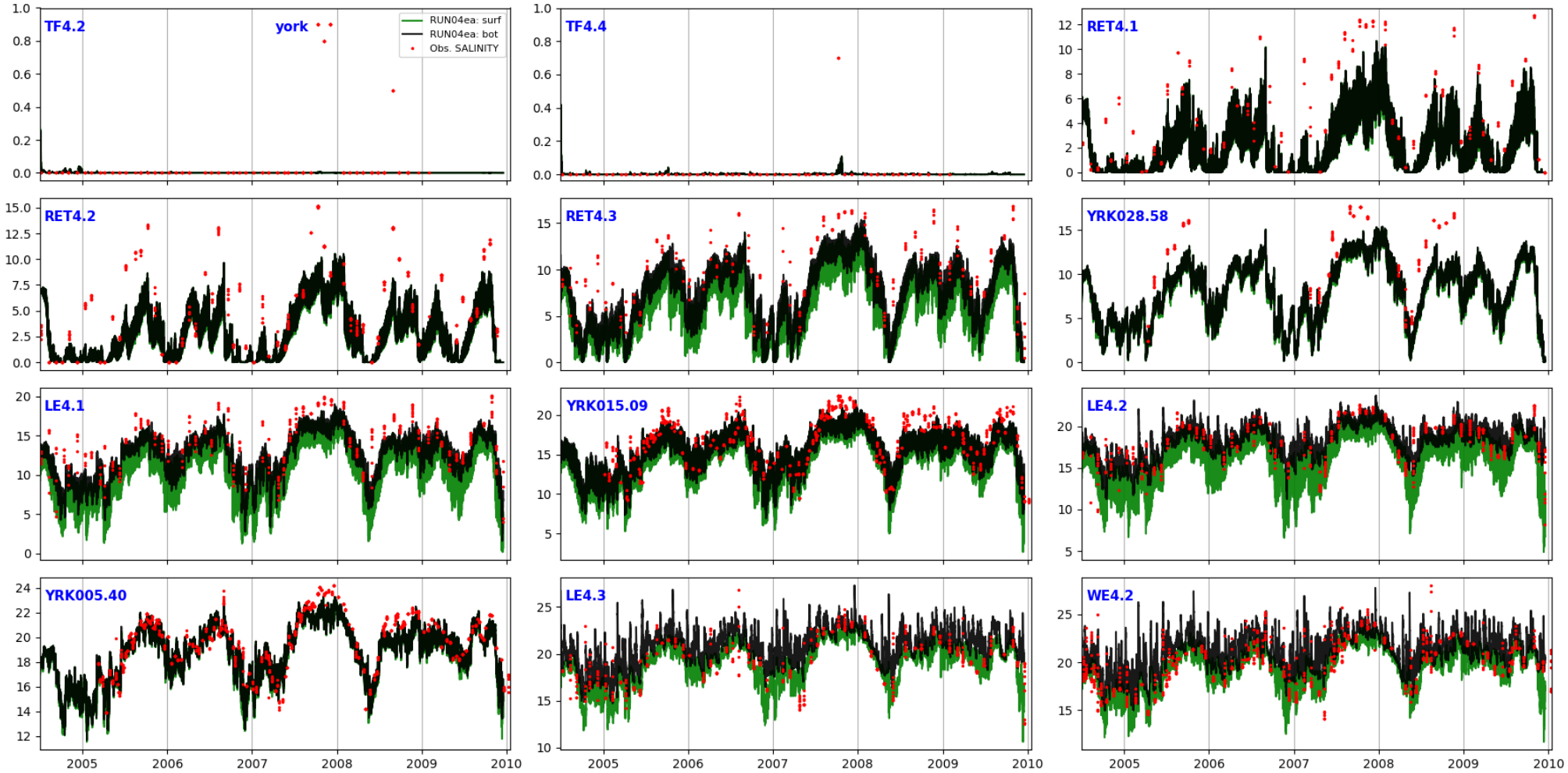


- Will incorporate Nicole's edits to further improve upstream skills

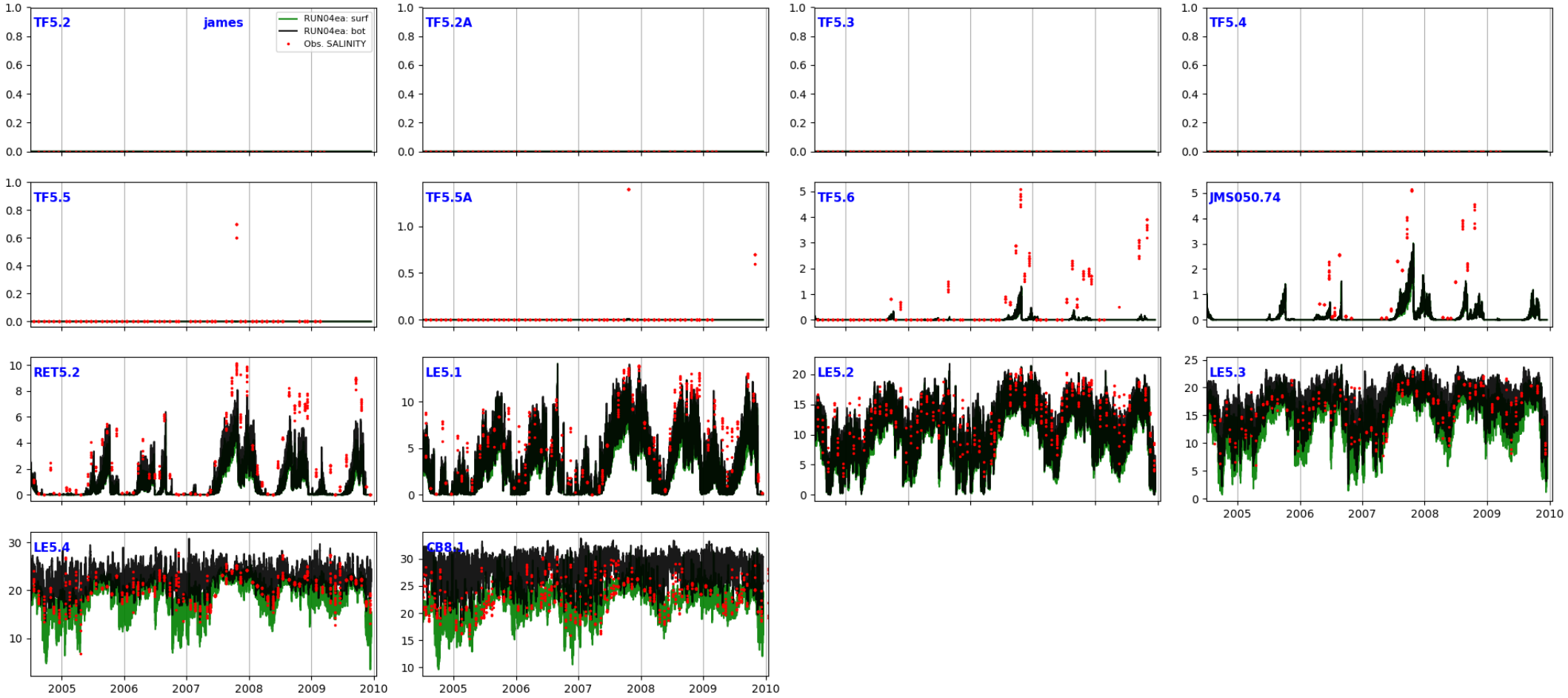
2. Model calibration: Rappahannock salinity



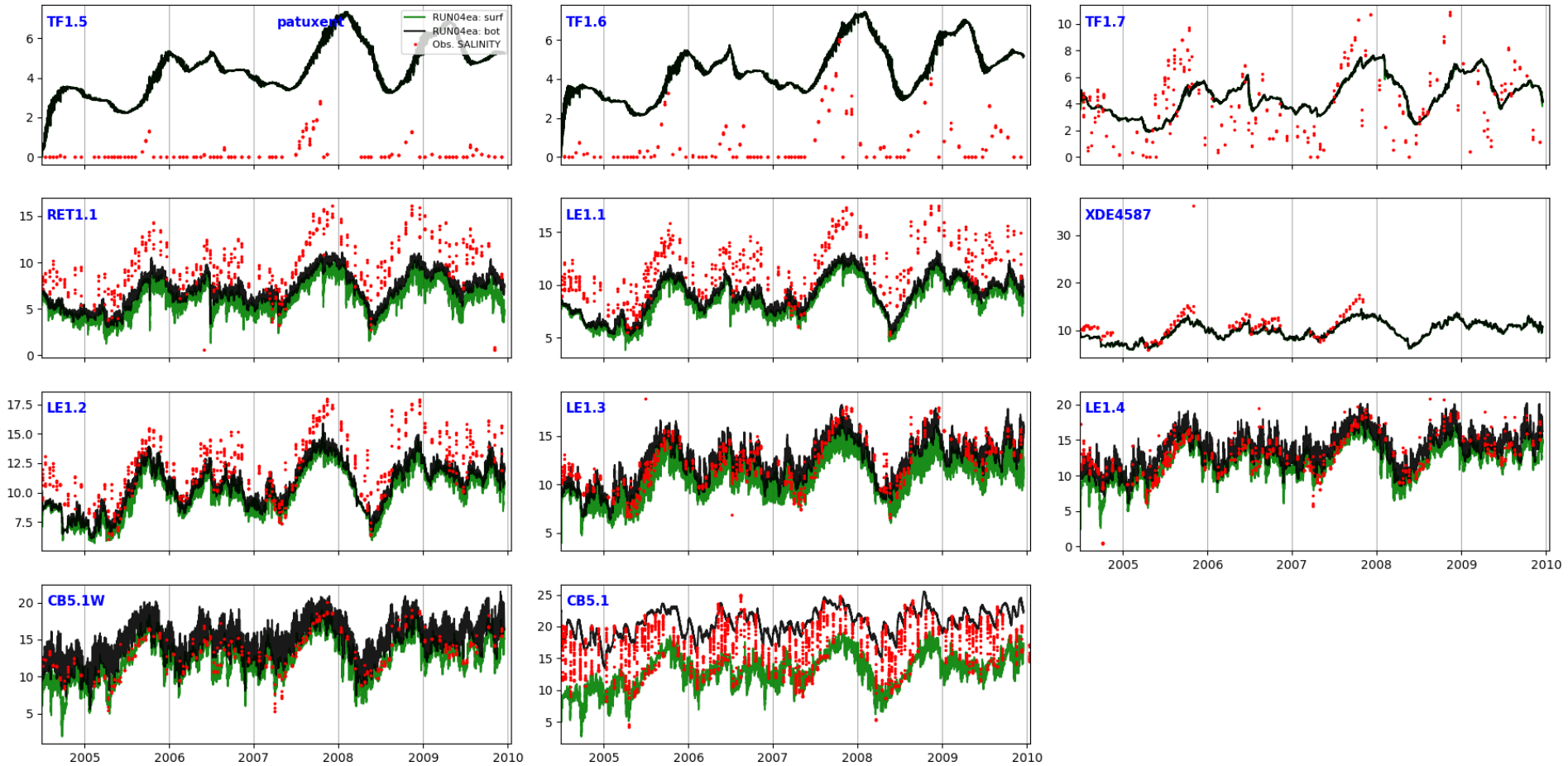
2. Model calibration: York salinity



2. Model calibration: James salinity



2. Model calibration: Patuxent salinity



2. Model calibration: Improved wave simulation

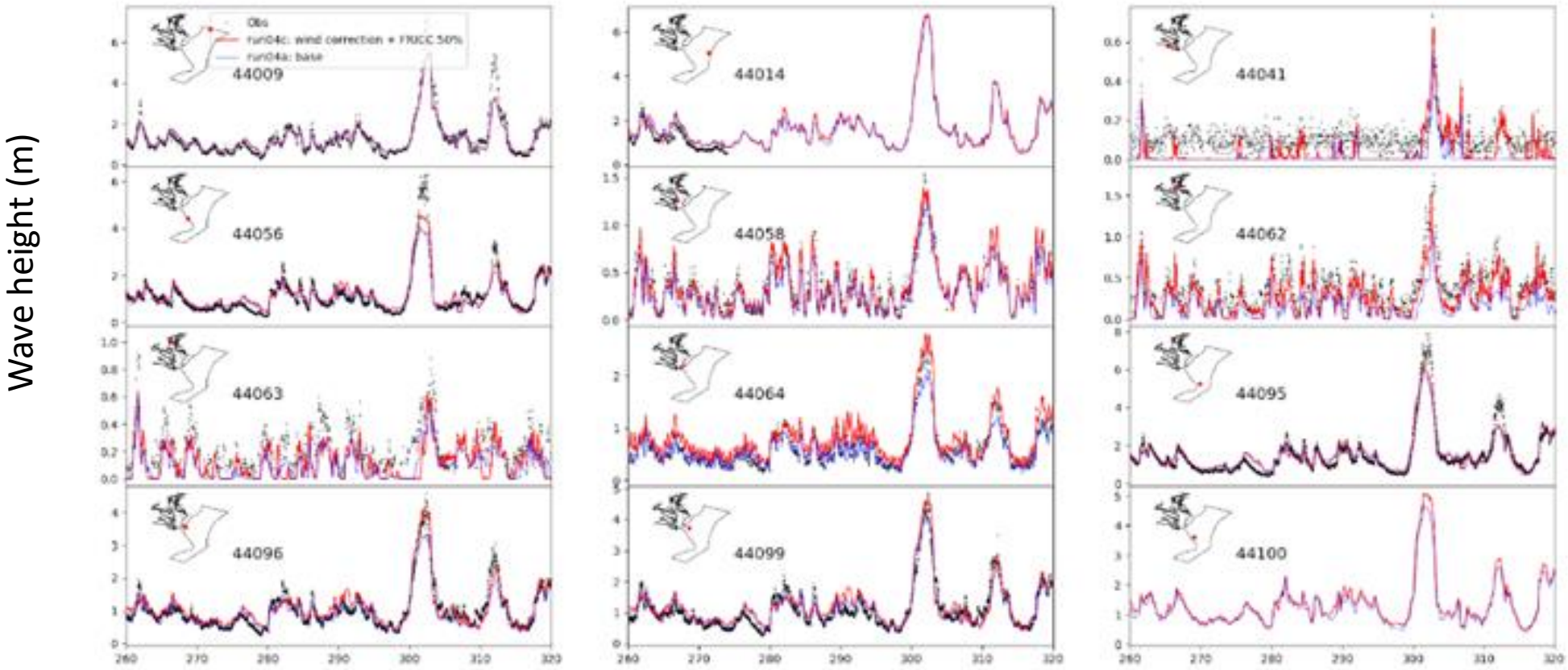


Figure b6: when using corrected wind and smaller friction. The best results for both lower and upper bay (e.g., 44062 and 44063). Esp., upper bay wave is much improved, even though it needs to be further improved.

3. Generate python tools for workflow

workflow

Grid Generation

- Generate grid
- Modify grid
- Reload grid depth

Model Setup

- **Open boundary**
  tide, salinity (2D), temperature (2D), water quality (2D-21 variable)
- **Surface forcing**
  Wind, solo radiation, etc.
- **Initial condition**
  all state variables
- **Flow and loading**
- **Hydrodynamic related parameters**
  roughness
- **Transport related parameter**
  mixing parameters, nudging parameters
- **Wave/ sediment**

Model Run

- Set model location
- Copy control files
- Link model forcing
- Link boundary condition input
- Link/copy loading files
- Set up multiple runs
- Run model in HPC

Process Result

- **Combine model output**
- **Plot model results**
  time series
  profile
  horizontal distribution
- **Analyze model results**
  statistics

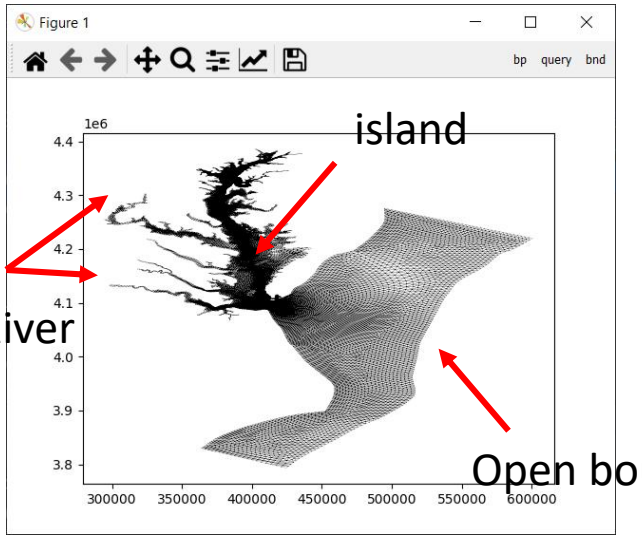
3. Generate python tools for workflow: Pre-processing

Grid Generation

Mapping local and long., lat. coordinates

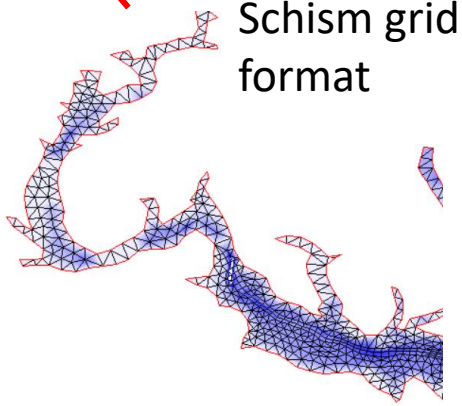
SMS → Model grid (2dm) → Schism grid (hgrid.gr3, hgrid.ll, vgrid.in)

Interactive tool to set the boundary



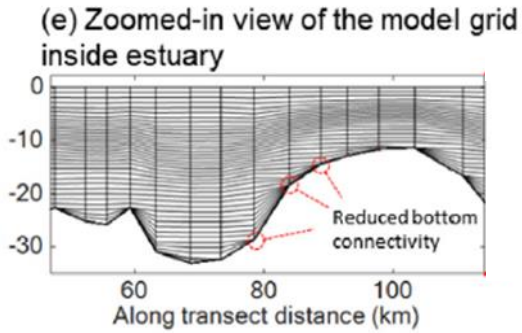
Projection
Grid quality check
Boundary specification
- Open boundary
- River boundary
- island boundary
- shoreline

Format



Schism grid format

Vertical grid



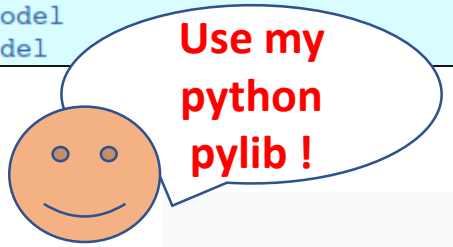
We have tools
Everything in Python !

3. Generate python tools for workflow: Input files

Grid Generation → **Model Setup**

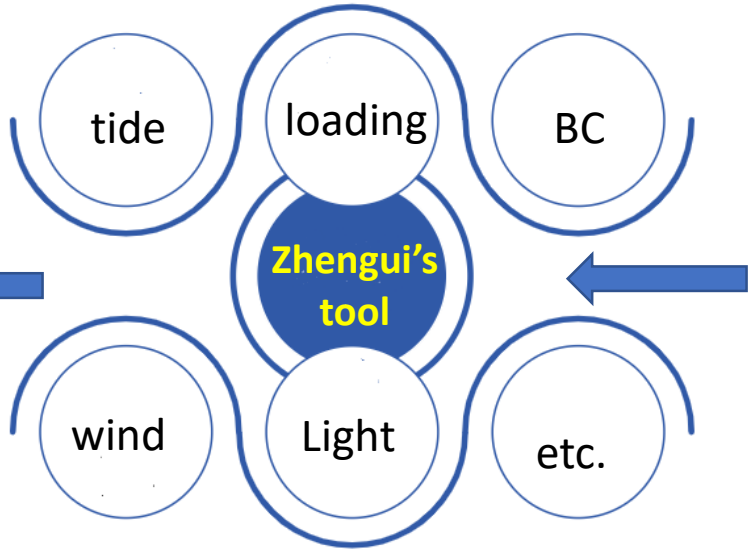
General inputs

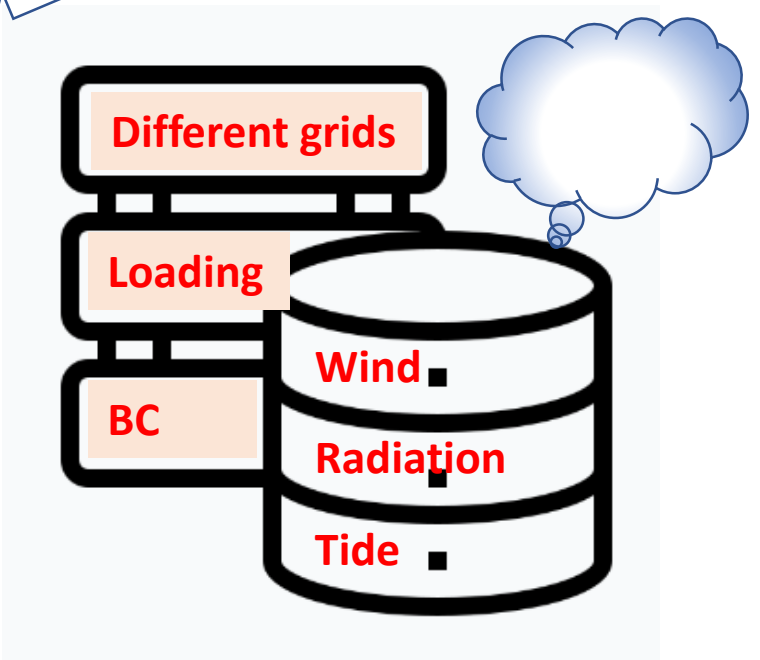
```
p.StartT=datenum(2004,7,1);  p.EndT=datenum(2004,8,1) #simulation time

p.base=None #or p.base='../RUN01a'
p.grid_dir='/sciclone/data10/wangzg/CBP/grid/v0' #directory of hgrid &

p.flag['ICM']= 0  #ICM model (1: 21 variables; 2: 17 variables)
p.flag['SED']= 0  #SED3D model
p.flag['WWM']= 0  #Wave model
```



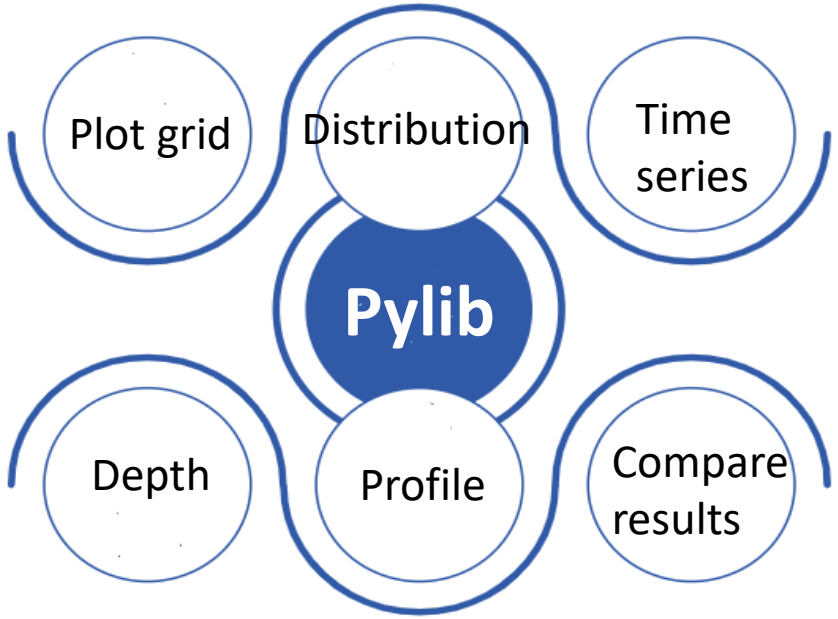
Input files

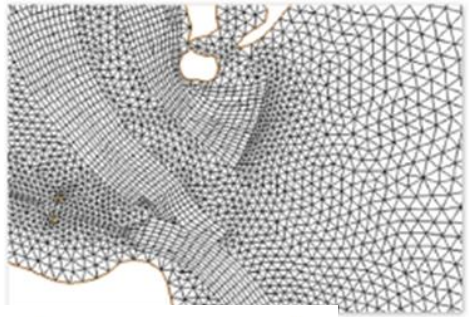
```
p.flag['elev2D.th.nc']          = 0 #hydro
p.flag['TEM_3D.th.nc']          = 0 #hydro
p.flag['TEM_nu.nc']             = 0 #hydro
p.flag['SAL_3D.th.nc']          = 0 #hydro
p.flag['SAL_nu.nc']             = 0 #hydro
p.flag['sflux']                 = 0 #hydro
p.flag['albedo.gr3']            = 0 #hydro
p.flag['drag.gr3']              = 0 #hydro
p.flag['rough.gr3']             = 0 #hydro,SED
p.flag['watertype.gr3']         = 0 #hydro
p.flag['diffmin.gr3']           = 0 #hydro
p.flag['diffmax.gr3']           = 0 #hydro
p.flag['shapiro.gr3']           = 0 #hydro
p.flag['TEM_nudge.gr3']         = 0 #hydro
p.flag['SAL_nudge.gr3']         = 0 #hydro
```

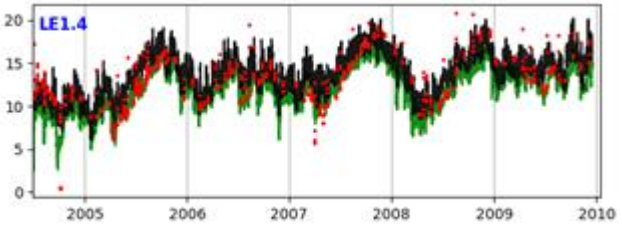


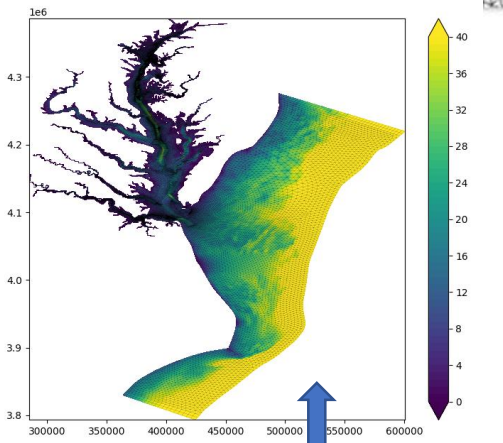


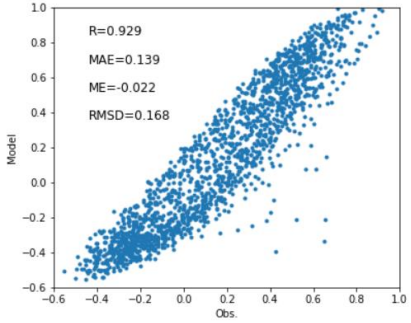
3. Generate python tools for workflow: post-processing

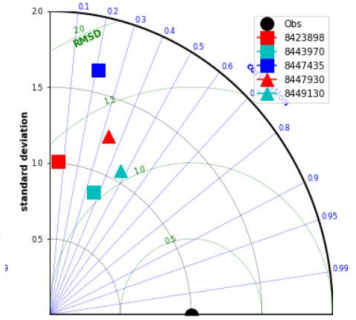


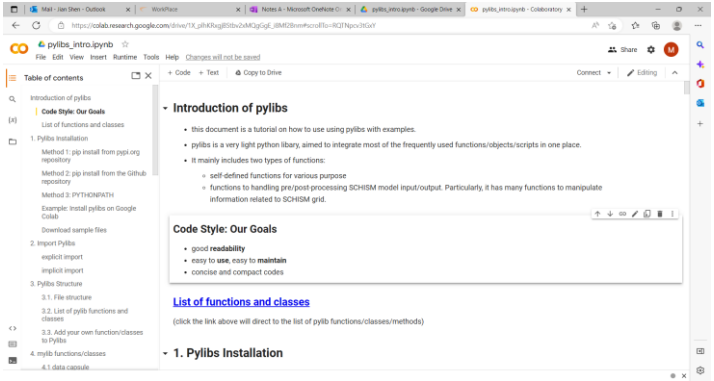




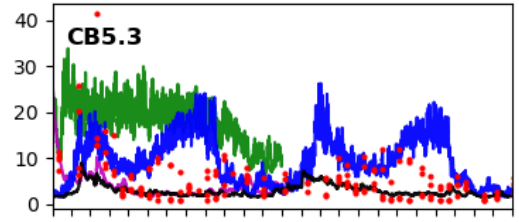









```
#!/usr/bin/env python3
from pylib import *
close("all")

gd=read_schism_hgrid('\Models\run3\hgrid.gr3')
gd.compute_all()
gd.plot(fmt=1,ec='k',lw=0.05,clim=[0,20],ticks=11)
show()
```



4. Enable the model to run in decoupled mode

- Completed coding to enable the model to run in decoupled mode
  - Maintain mass balance
  - Increase running speed (dynamic fields are saved hourly)
  - Tested code and started to work on water quality model test

One step
Run all modules together

- Hydrodynamic model
- Sediment transport model
- Wave model
- Water quality

Two step

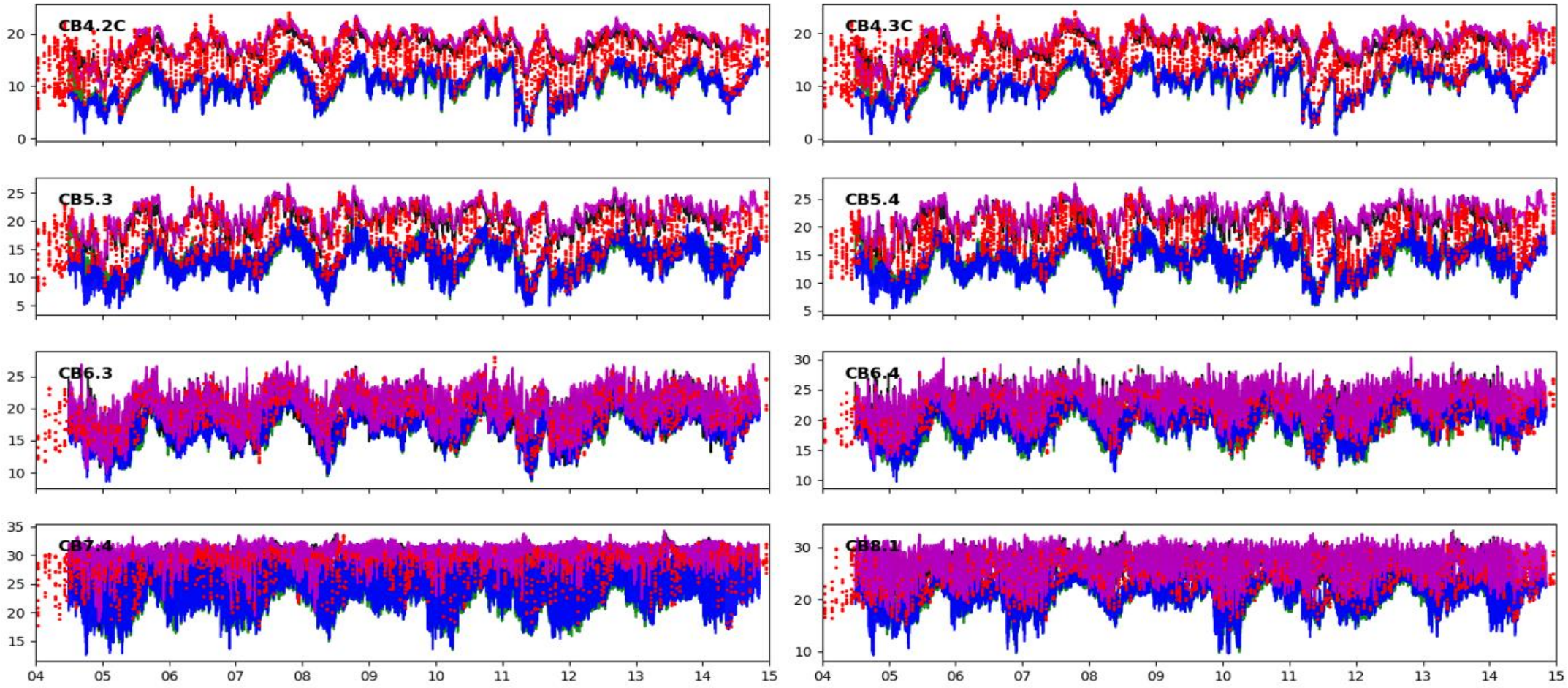
- Hydrodynamic model
- Sediment transport model
- Wave model
- Shear stress

Save dynamic field to the database

- Run ICM using saved dynamic fields
- Run sediment using saved shear stess

4. Enable the model to run in decoupled mode

10-year Salinity simulation



Discussion

1. **Revise model grid**
2. **Conduct preliminary model calibration using the new grid**
3. **Generate python tools for workflow**
4. **Enable the model to run in decoupled mode**