SCHISM Performance in Chester River: Implication for water quality simulations

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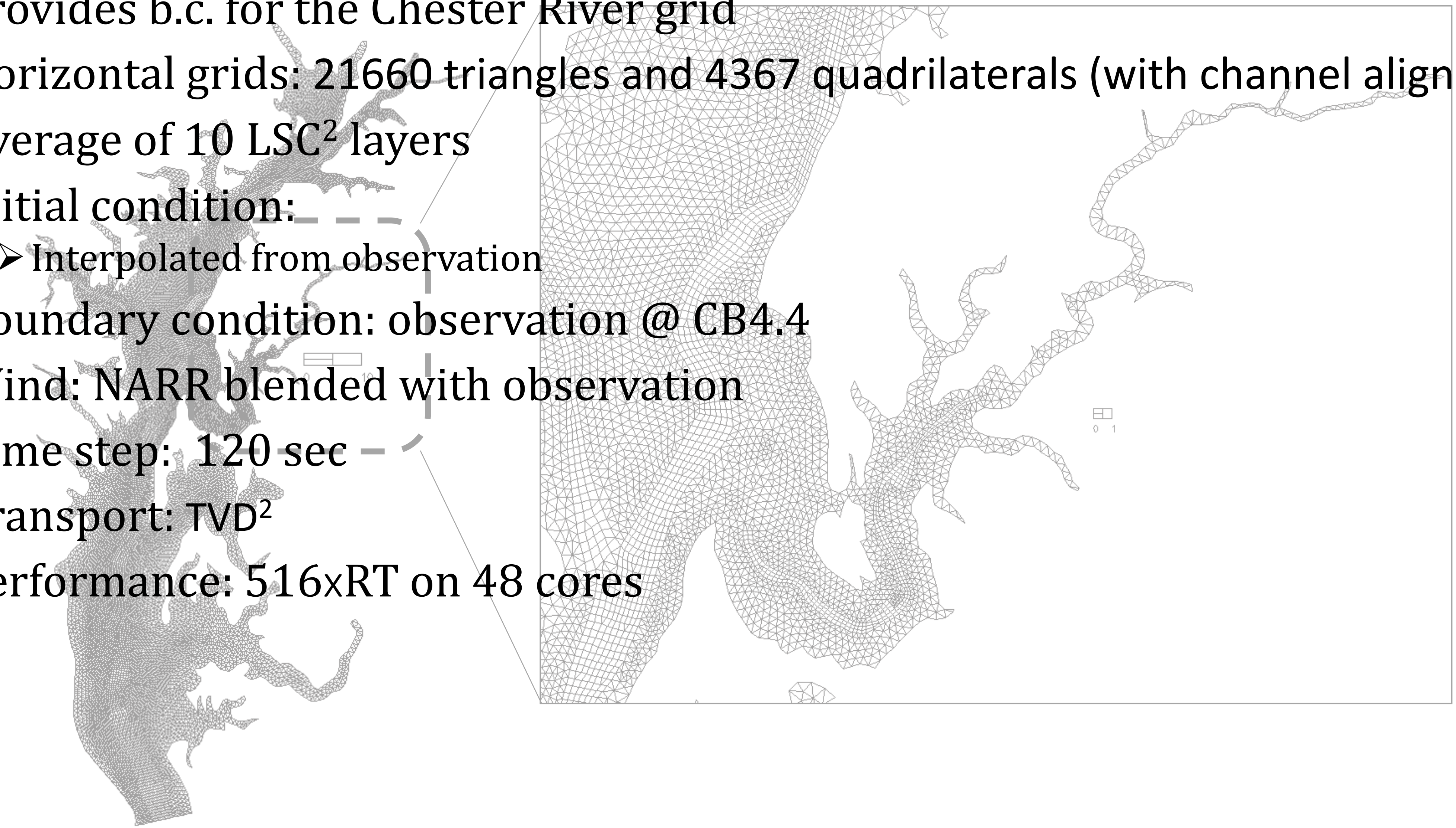
Outline

- Hydrodynamic model set-up: Upper Bay and Chester River
- Salt intrusion: implication for WQ
- Wave model calibration: whole Bay
- Sediment model calibration

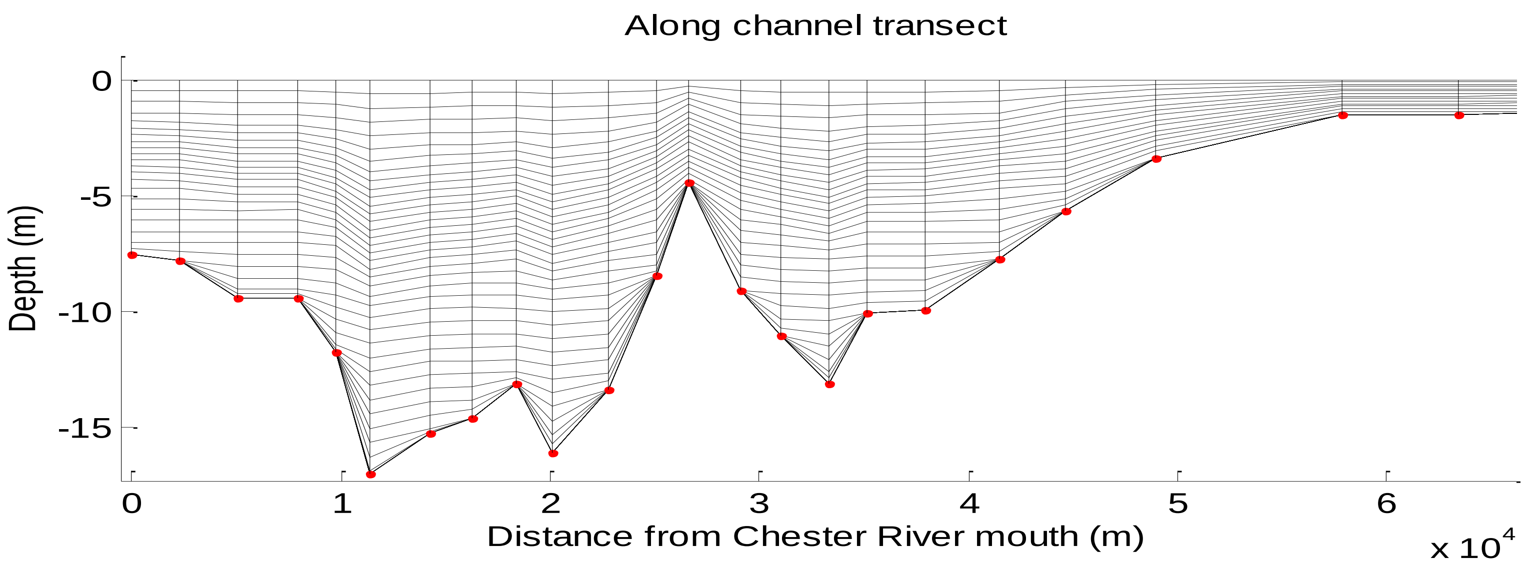
Upper Bay model setup

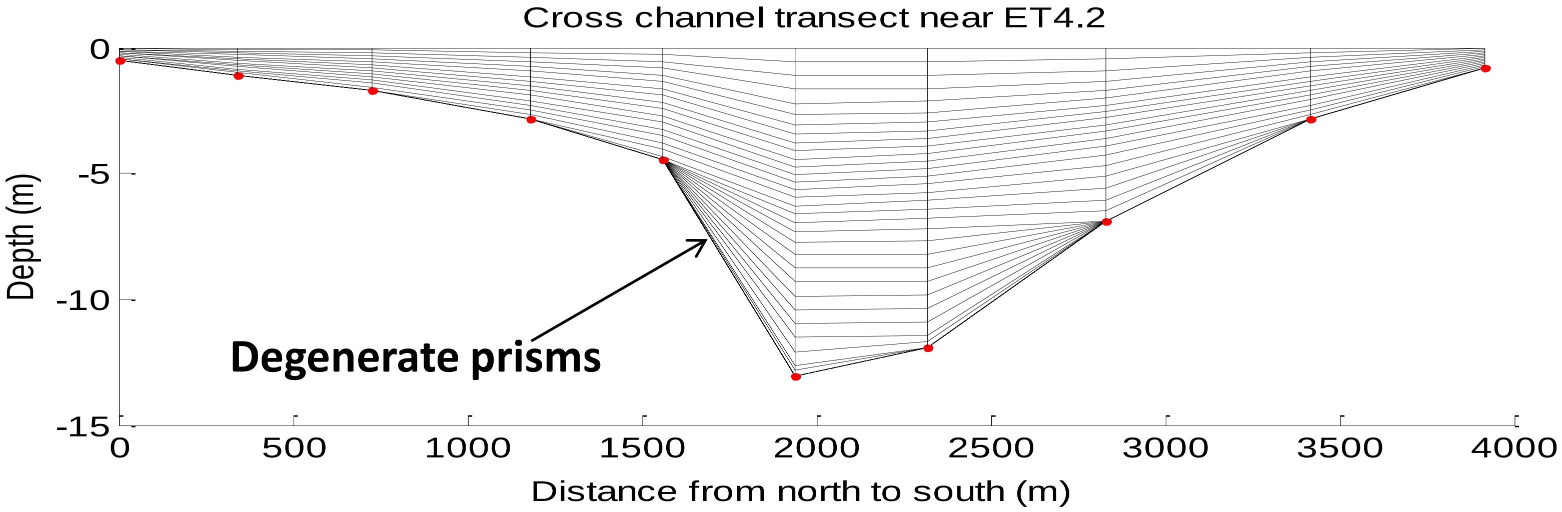
Ye et al. (submitted)

- Provides b.c. for the Chester River grid
- Horizontal grids: 21660 triangles and 4367 quadrilaterals (with channel alignment)
- Average of 10 LSC^2 layers
- Initial condition:
  - Interpolated from observation
- Boundary condition: observation @ CB4.4
- Wind: NARR blended with observation
- Time step: 120 sec
- Transport: TVD^2
- Performance: 516xRT on 48 cores



Vertical discretization in the Chester River





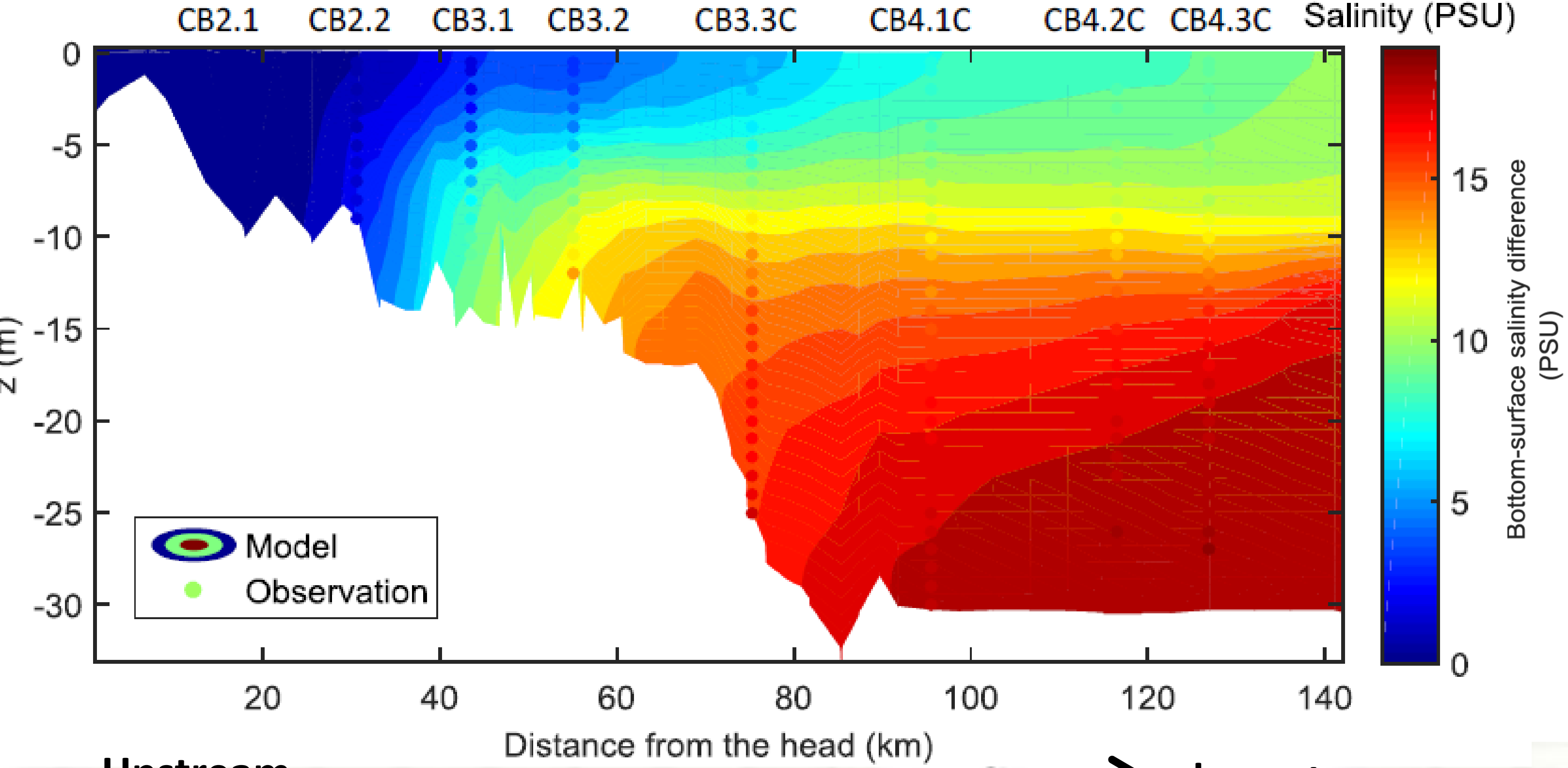
Ye et al. (submitted)

Zhang et al. (2015)

Salinity structure

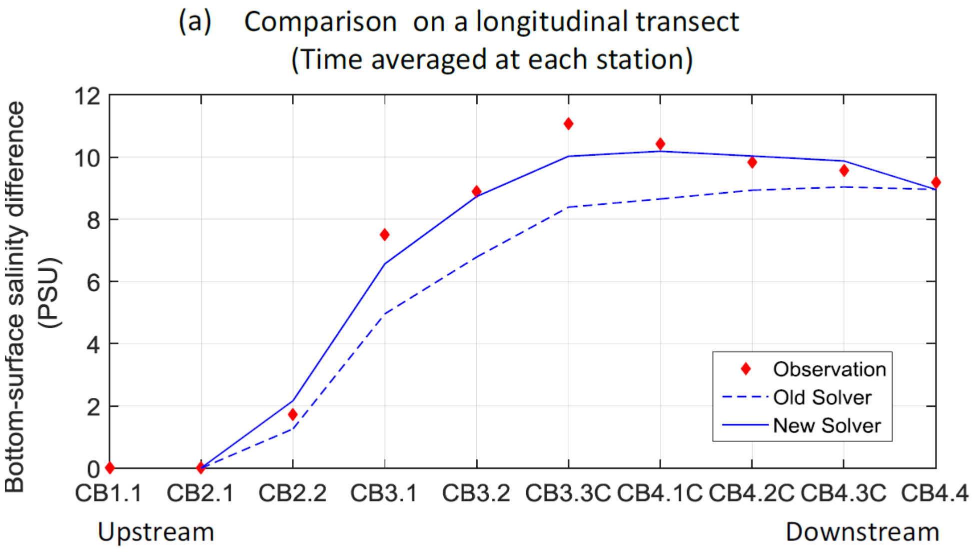
Ye et al. (submitted)

Time-averaged observation and model salinity in 2004



Upstream → downstream

Time-averaged observation and model salinity *stratification* in 2004



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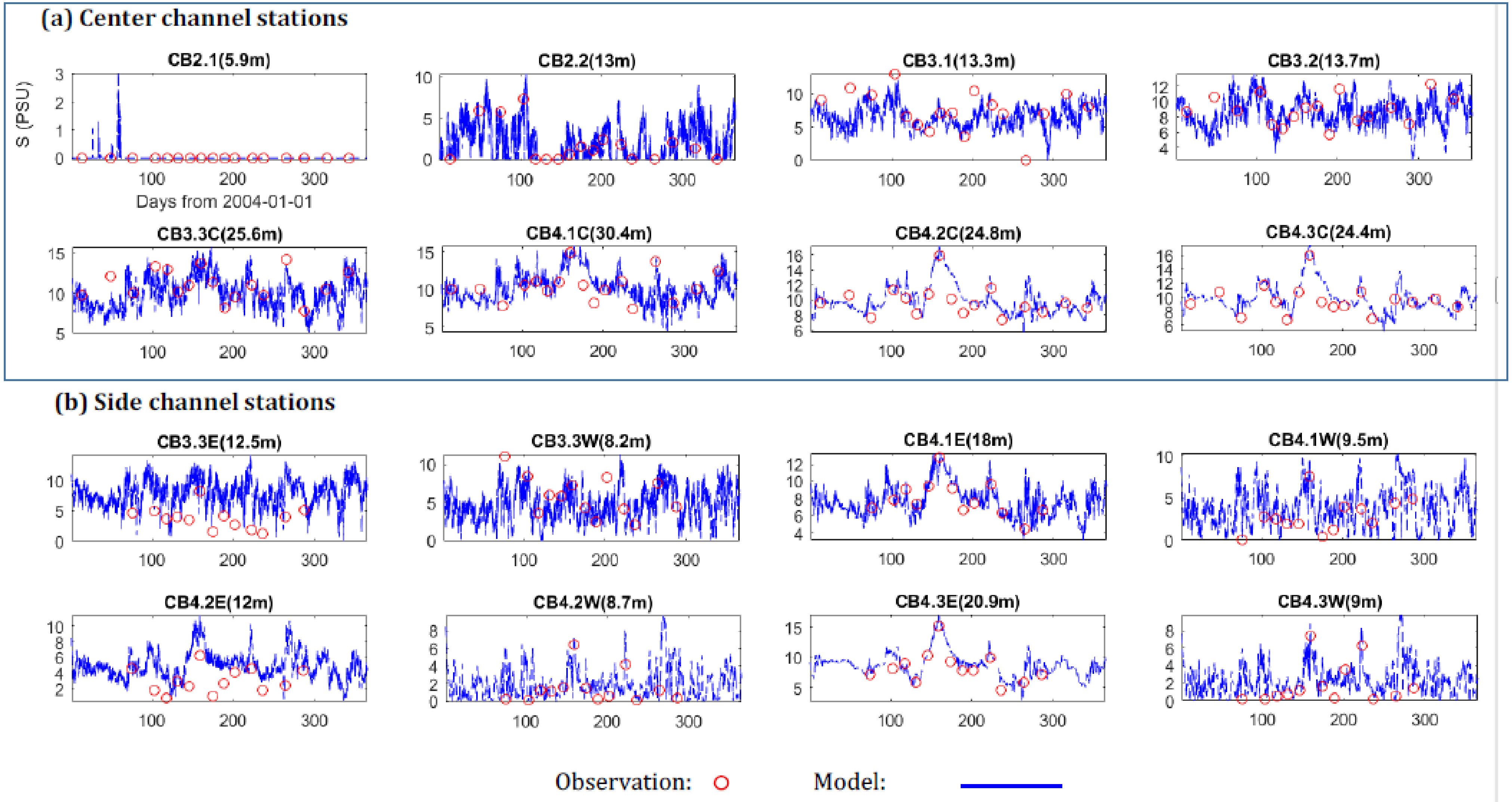
1940-2015 75 Years

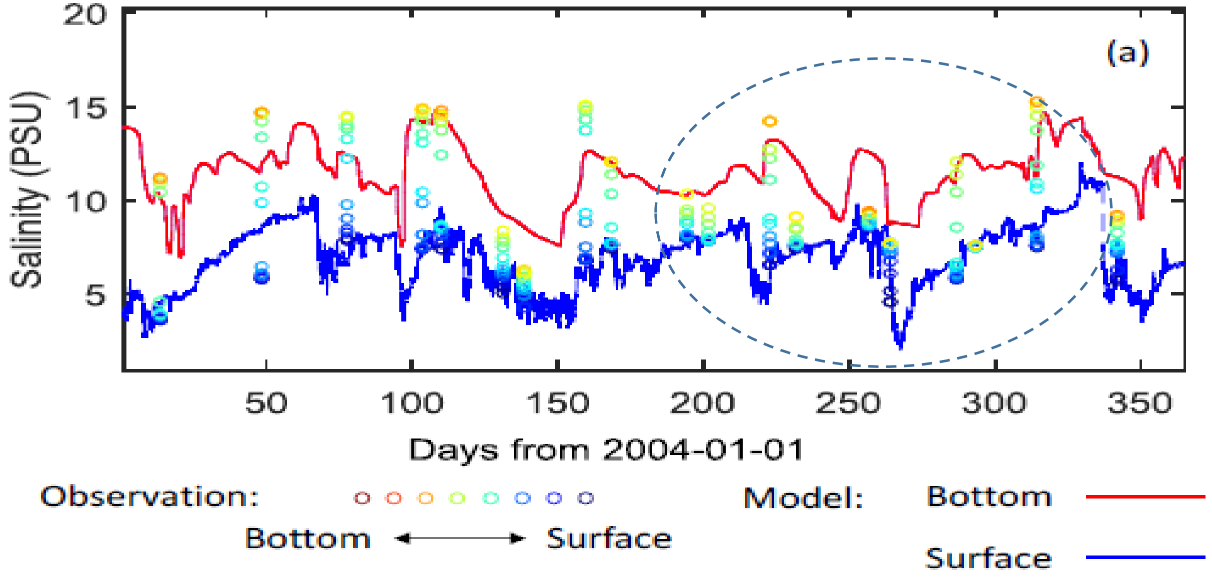
Salinity stratification

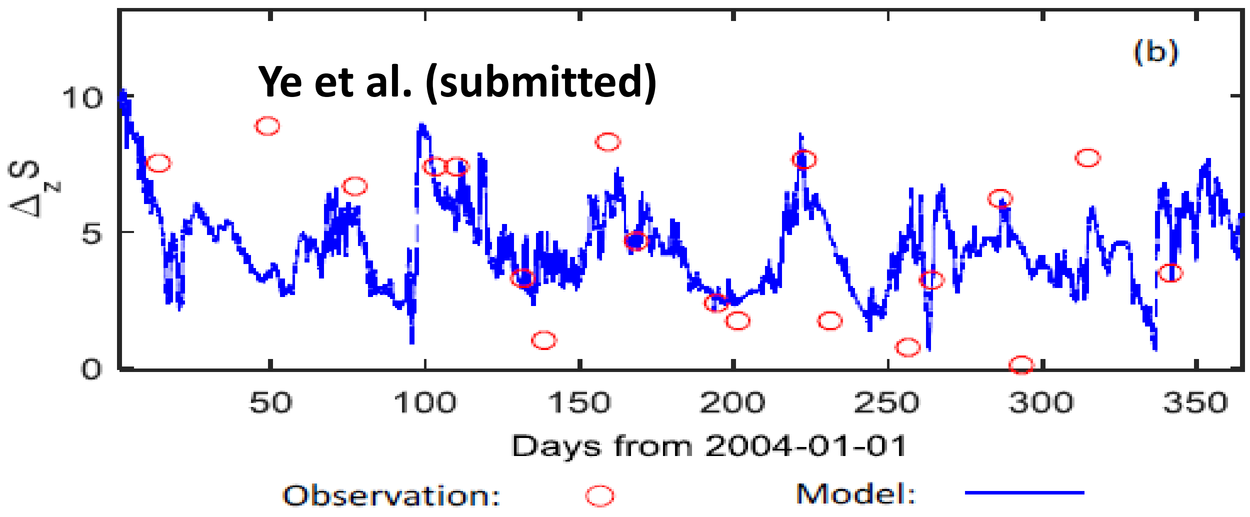
Ye et al. (submitted)

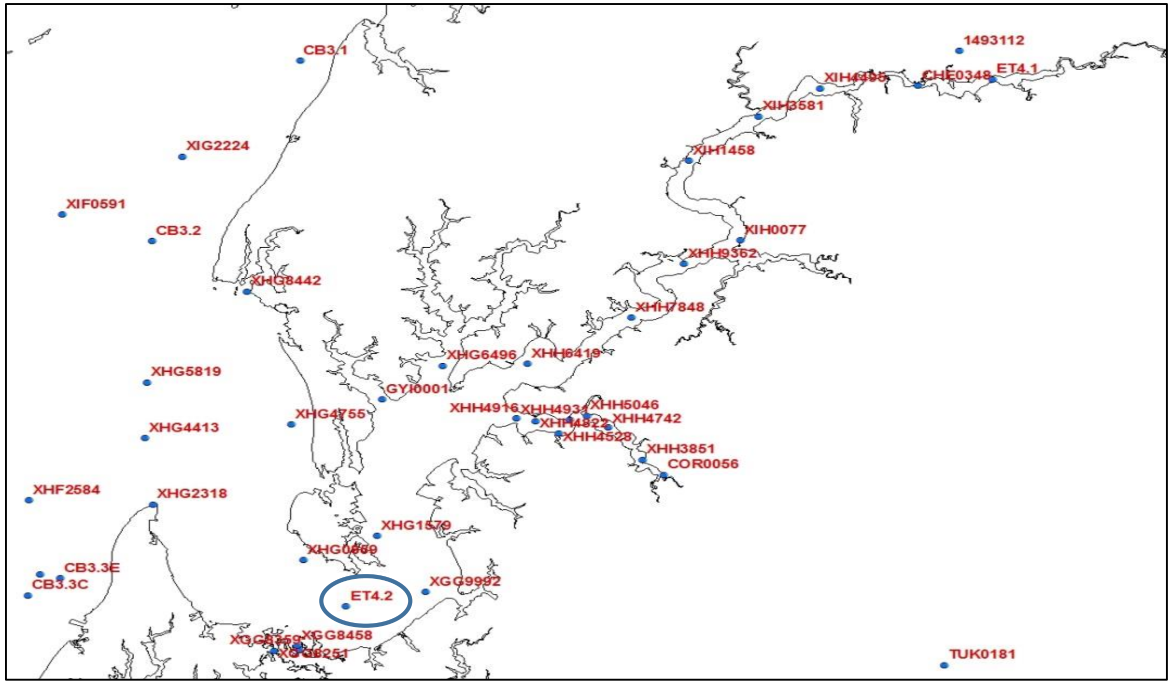
Upstream → downstream



ET4.2







- The improvement in the summer season proves important for WQ
- The flexible horizontal and vertical grid systems used in SCHISM, the new implicit TVD² transport method, and the blended NARR wind, are responsible for the improvement

JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 95, NO. C8, PAGES 13,357–13,371, AUGUST 15, 1990

Wind-Forced Salt Intrusion Into a Tributary Estuary

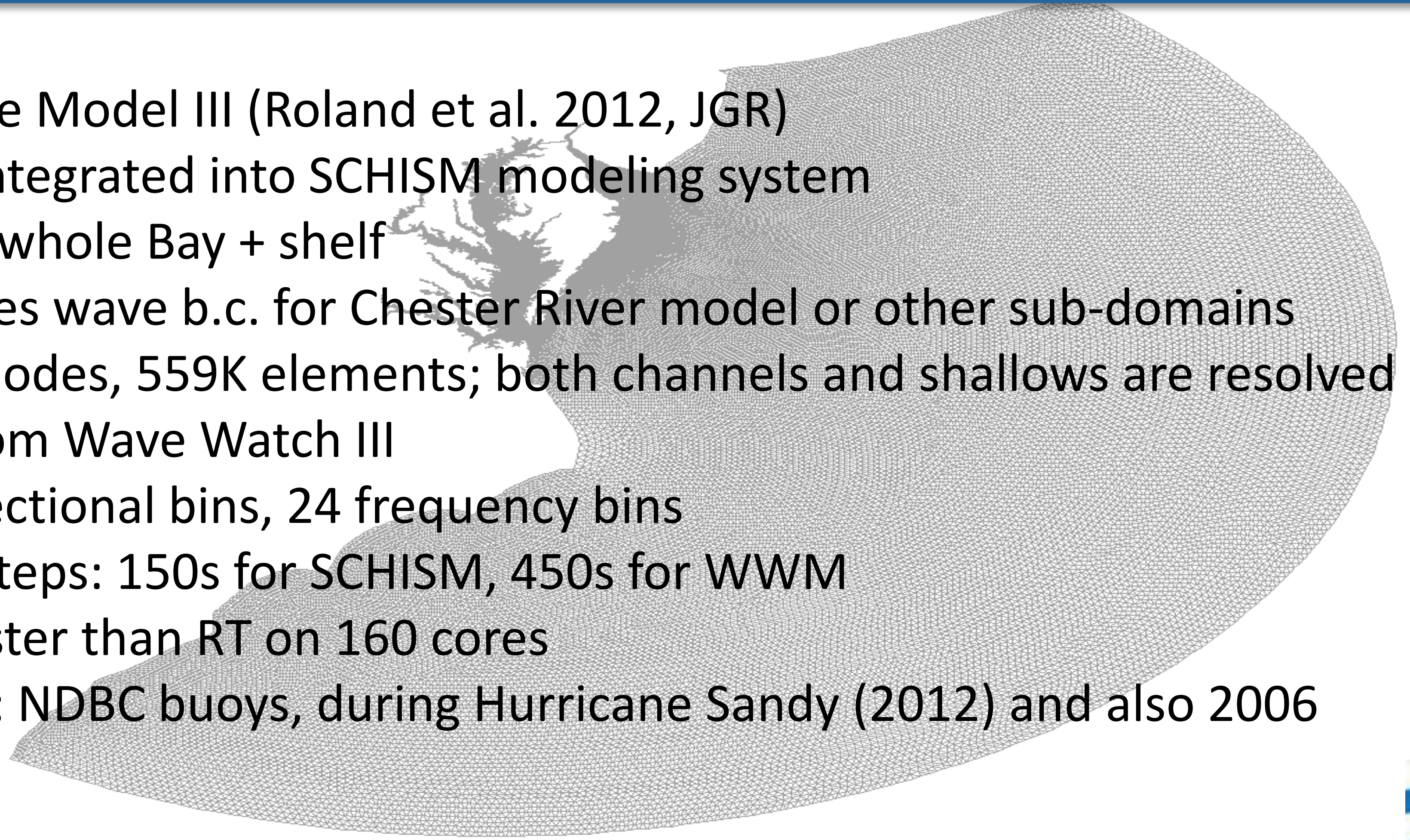
LAWRENCE P. SANFORD AND WILLIAM C. BOICOURT

University of Maryland System Center for Environmental and Estuarine Studies
Horn Point Environmental Laboratories, Cambridge, Maryland

Sanford and Boicourt (1990)

Moored measurements and hydrographic surveys were carried out during the summers of 1986 and 1987 to examine interaction between the mainstem of the Chesapeake Bay and the Choptank River, an eastern shore tributary estuary. The data show that an important mode of interaction is through wind-forced intrusion of saline, hypoxic water from below the pycnocline of the Bay into the lower river. Intrusions are driven by lateral tilting of the pycnocline in the Bay, when high salinity water is upwelled on the eastern side of the Bay in response to a southward pulse of wind stress. The resulting internal surges propagate up the relict Choptank entrance channel at a speed of about 20 cm/s and spill onto the broad sill inside the mouth of the river. Intrusion-favorable pycnocline tilts in the Bay do not always result in lower layer intrusion into the Choptank, but may be blocked or choked in the entrance channel on occasion. The data suggest that wind-forced intrusion of salt leads to increased gravitational circulation in the Choptank during the summer months, providing a mechanism through which high frequency energy may be directly translated into lower frequency motion.

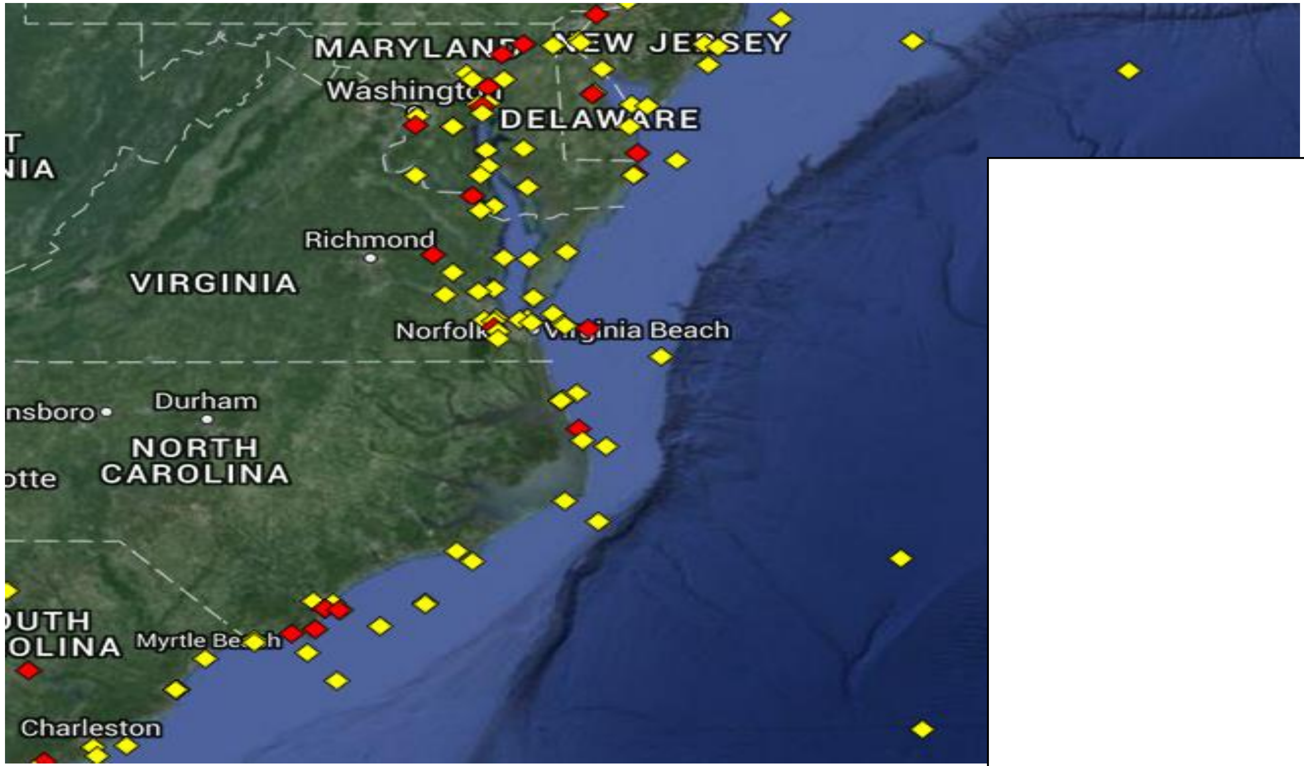
Wave model set-up: whole Bay

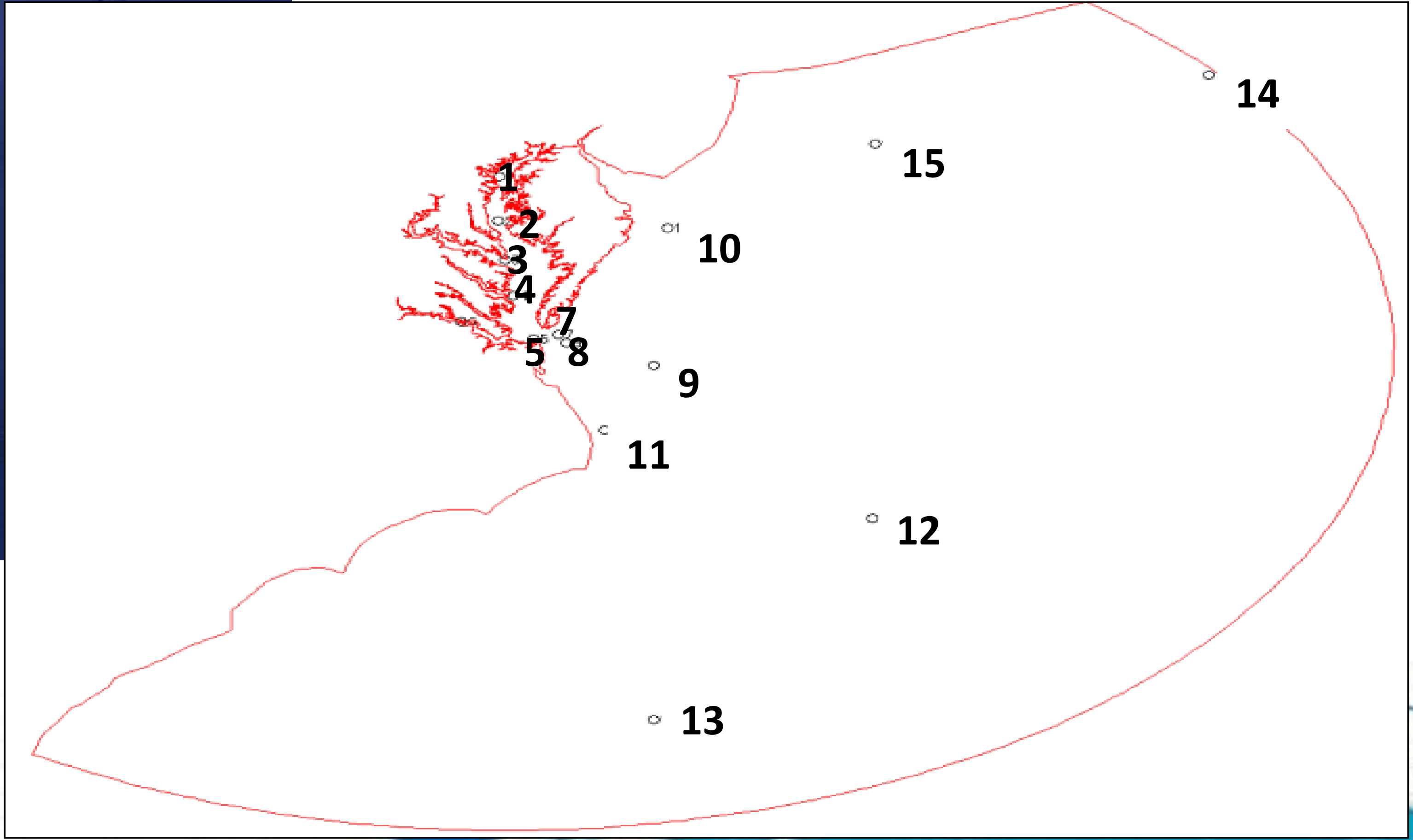


- Wind Wave Model III (Roland et al. 2012, JGR)
  - Fully integrated into SCHISM modeling system
- Set up for whole Bay + shelf
  - Provides wave b.c. for Chester River model or other sub-domains
  - 308K nodes, 559K elements; both channels and shallows are resolved (~50-100m)
  - B.c. from Wave Watch III
  - 30 directional bins, 24 frequency bins
  - Time steps: 150s for SCHISM, 450s for WWM
  - 90x faster than RT on 160 cores
- Validation: NDBC buoys, during Hurricane Sandy (2012) and also 2006

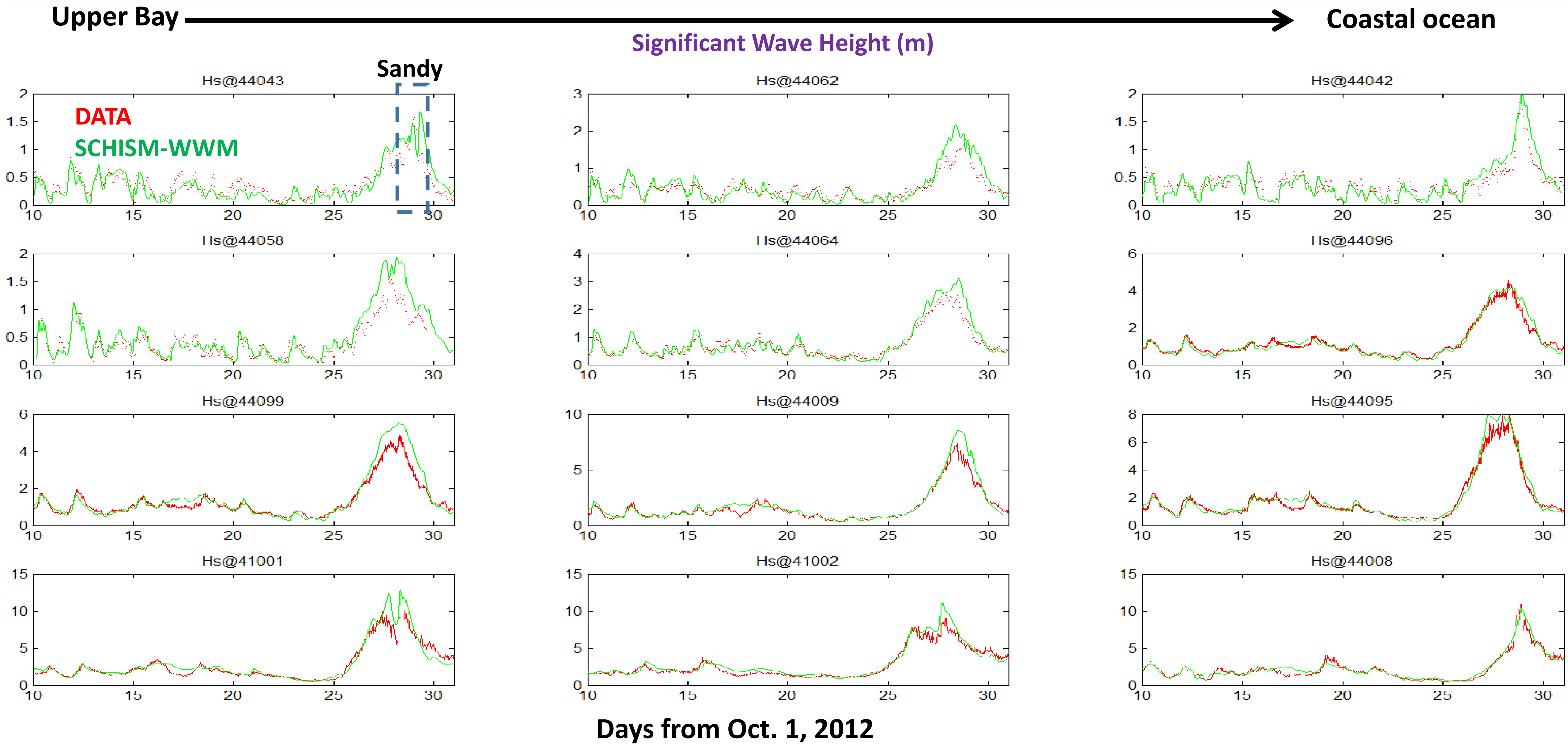
NDBC buoys

- Many buoys are inside the model domain
- But many have missing data



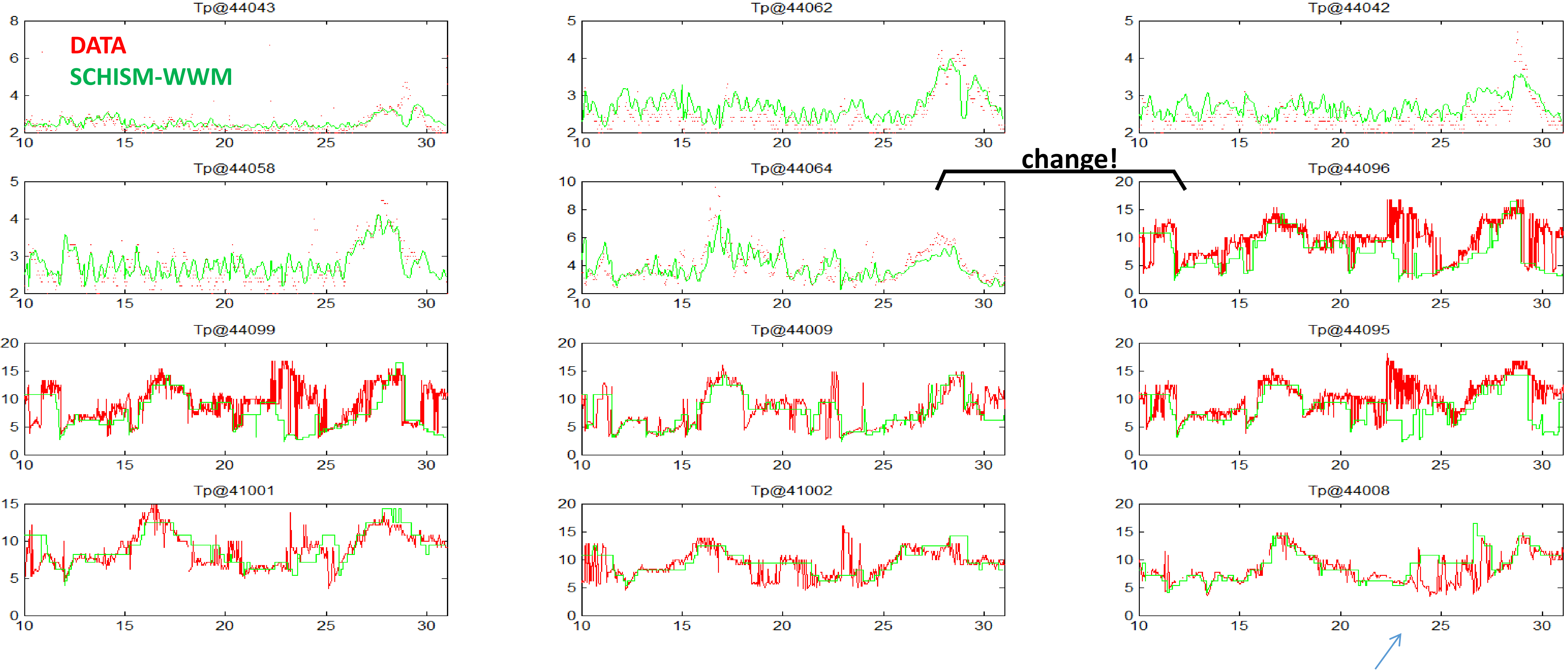


Wave model validation (Sandy)



Peak period

Peak period (sec)

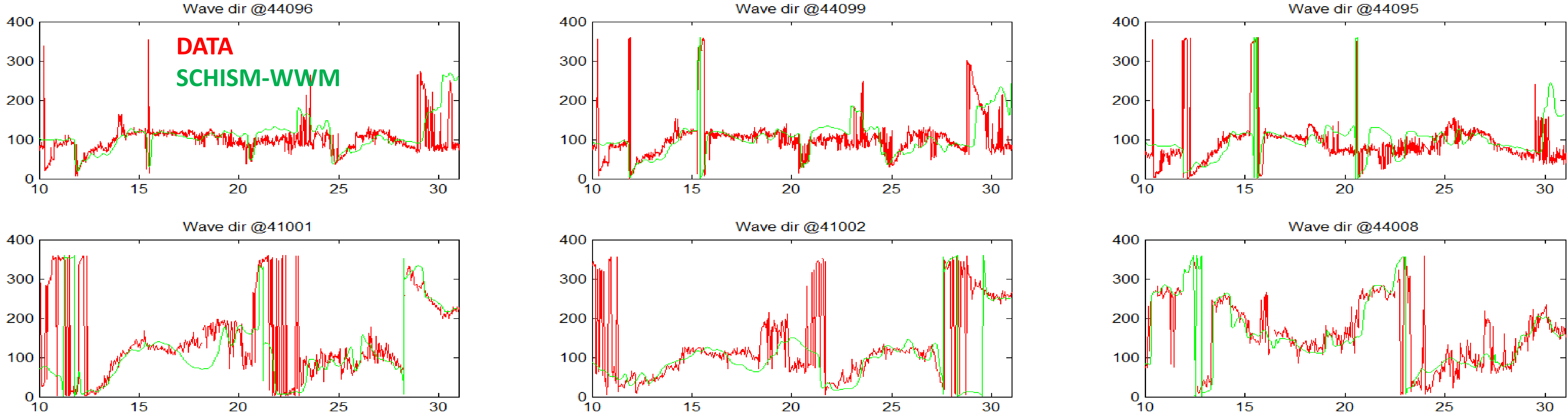


*cut-off frequency in buoys important for comparison

Error in b.c.

Wave model validation (Sandy)

Mean Wave Direction (degrees)



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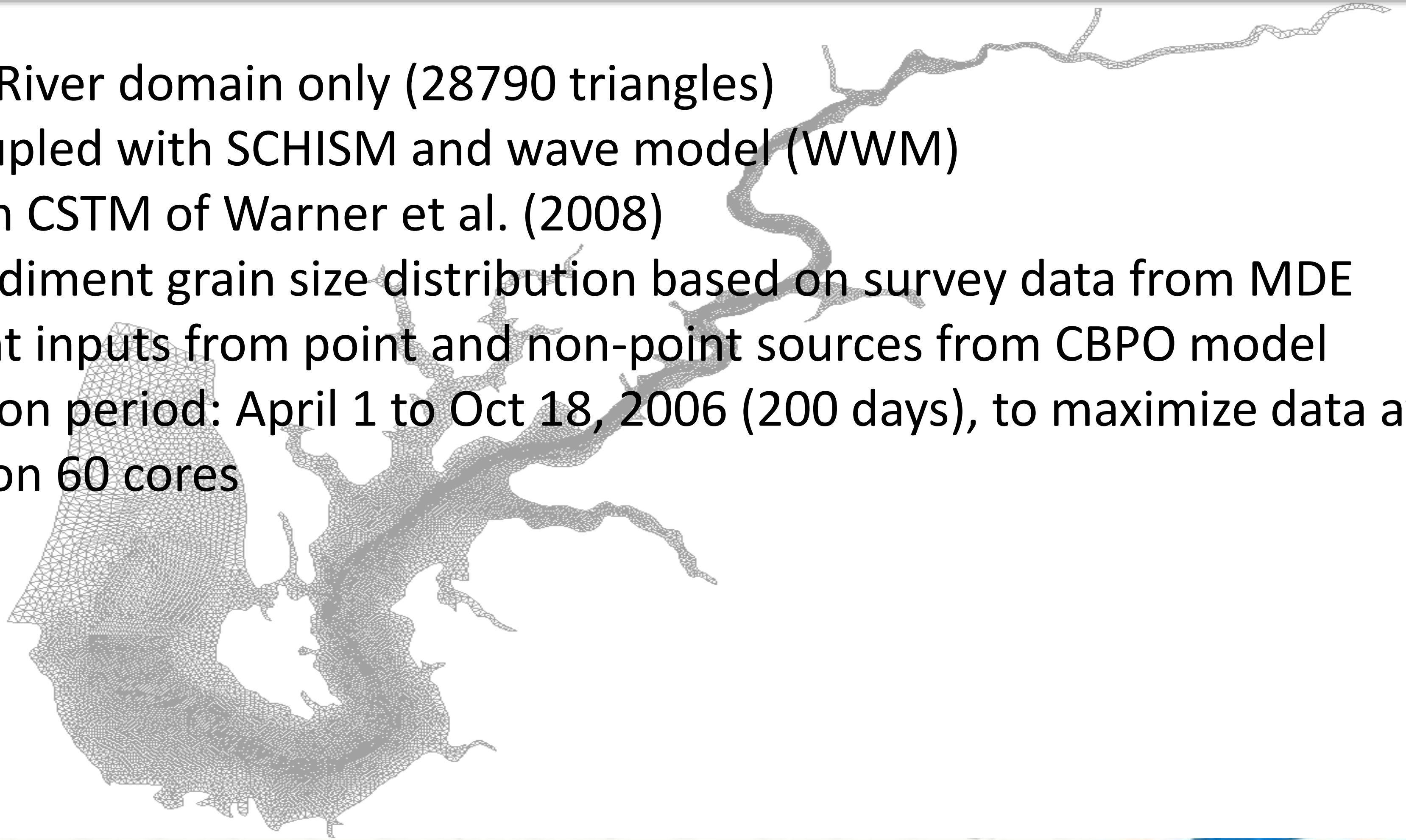
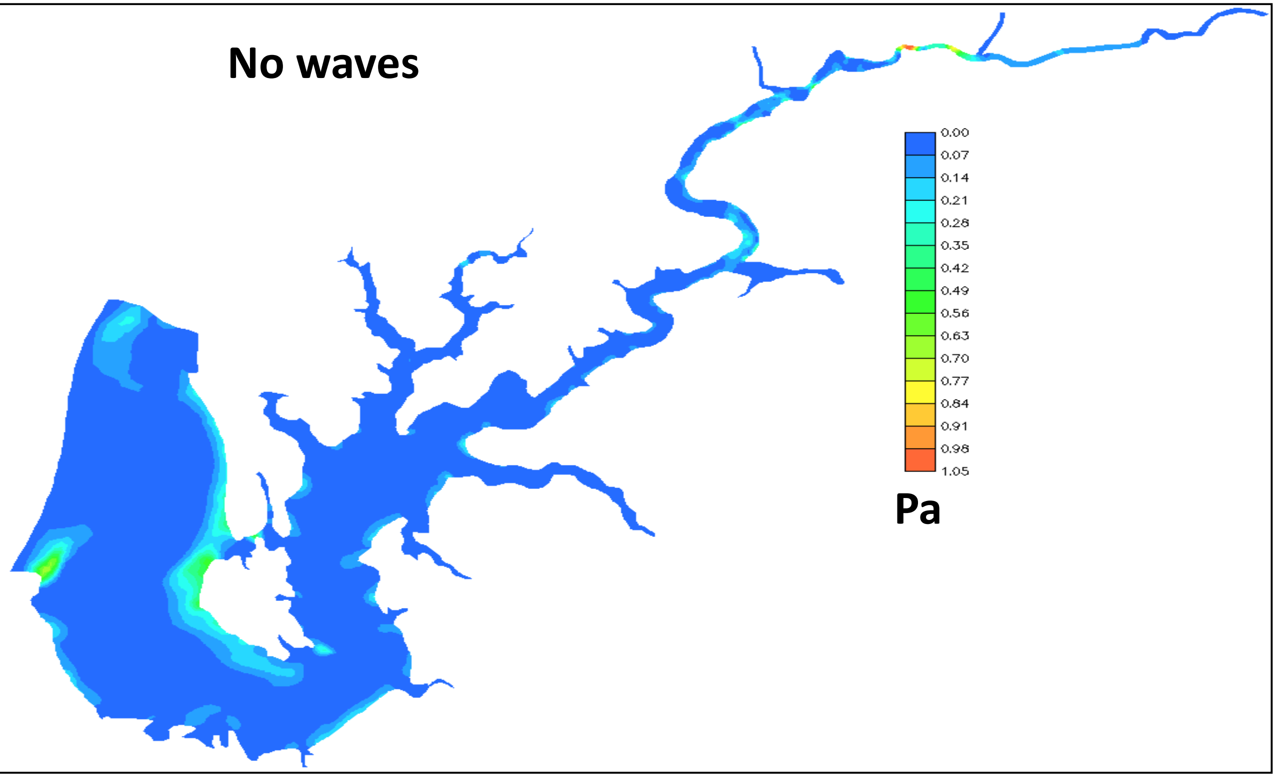
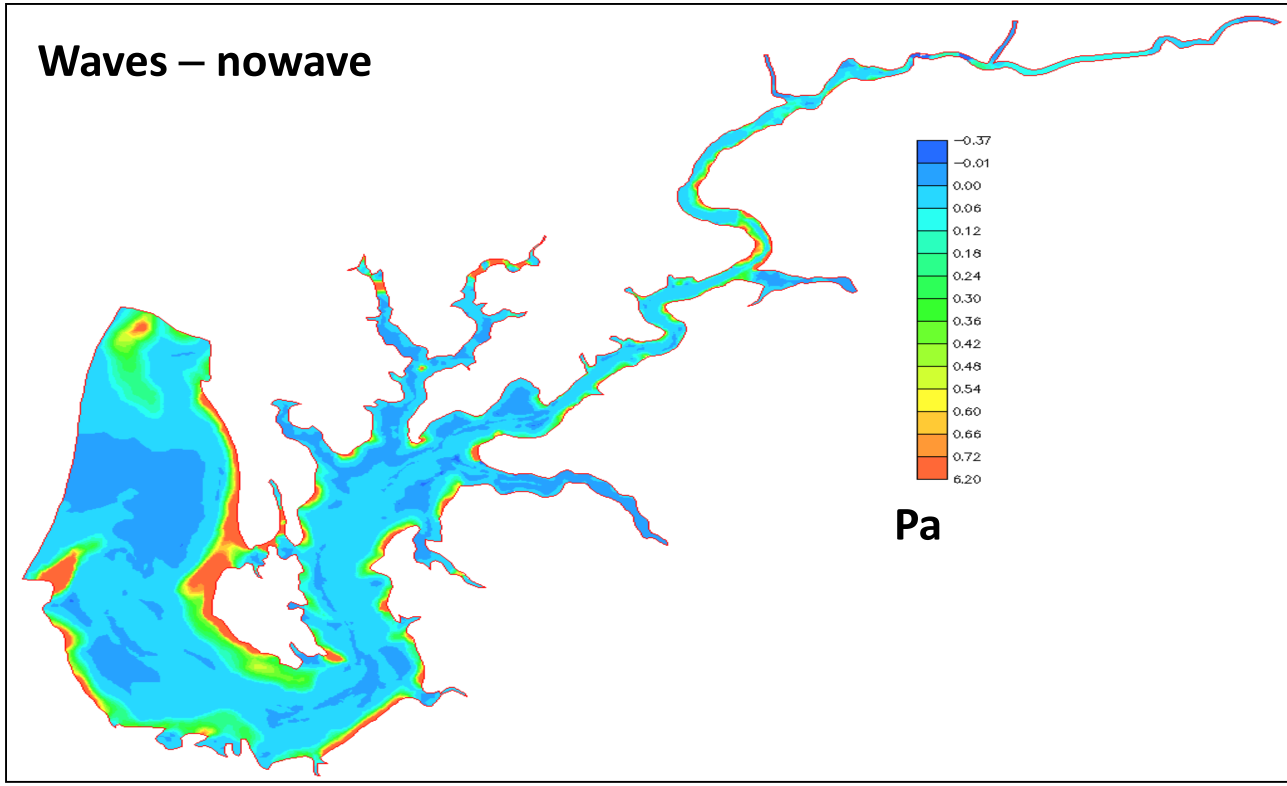
Sediment model set-up

- Chester River domain only (28790 triangles)
- Fully coupled with SCHISM and wave model (WWM)
- Based on CSTM of Warner et al. (2008)
- Initial sediment grain size distribution based on survey data from MDE
- Sediment inputs from point and non-point sources from CBPO model
- Calibration period: April 1 to Oct 18, 2006 (200 days), to maximize data availability
- 223xRT on 60 cores



Bottom stress





- **Averaged from May to Oct 2006**
- **Waves enhance bottom stress especially in the shallows**

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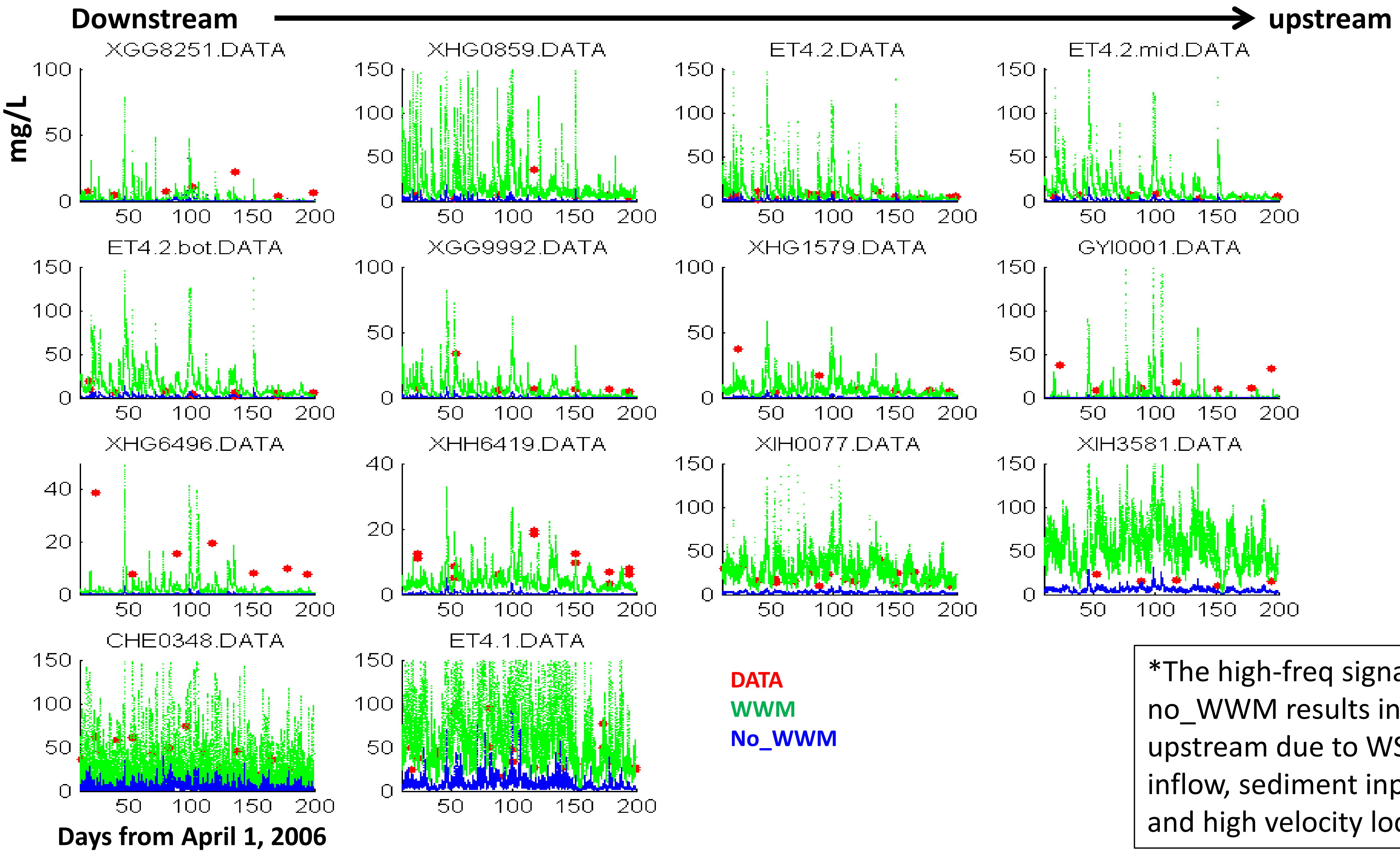
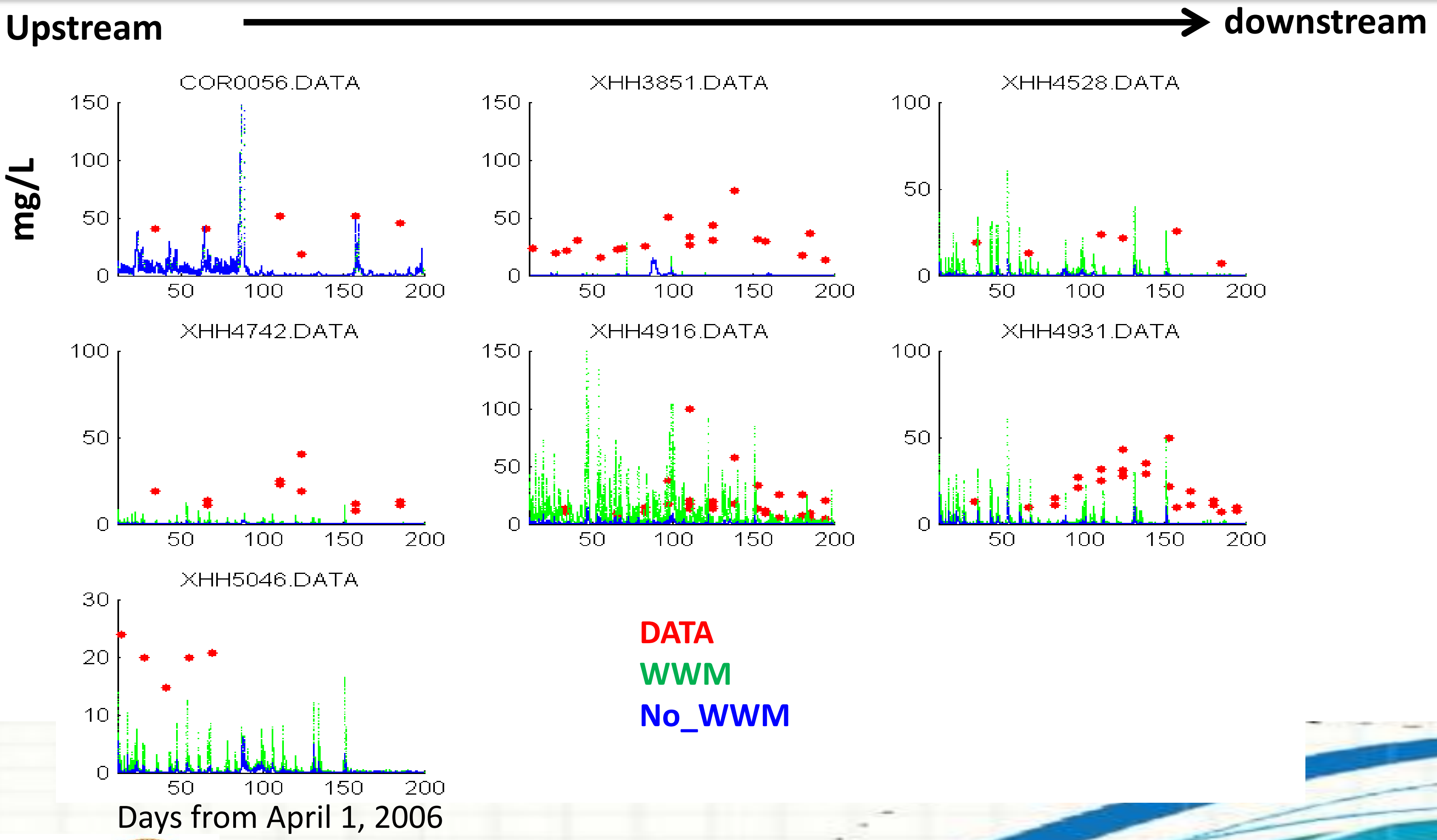
Sediment: mainstem



*The high-freq signal in no_WWM results in upstream due to WS inflow, sediment inputs and high velocity locally

Sediment: Corsica River



Conclusions

- Salt intrusion is improved with new work on horizontal and vertical grids; this proves important for WQ simulations (Harry's talk)
- Fully coupled SCHISM-WWM-SED3D has been applied to Chester River, to explain the hydrodynamic, wave and sediment responses
- Results from waves are good and the model is able to resolve the sharp transition of wave period near the Bay mouth
- Results from sediment transport model are reasonable and capture some high-frequency oscillations observed in the field; waves are found to be important for resuspension process
- Sediment inputs from watershed model are important as well
- Future work: couple with WQ model to include the effects of TSS in ICM