

# Wind-driven circulation, wave and sediment transport in Chesapeake Bay

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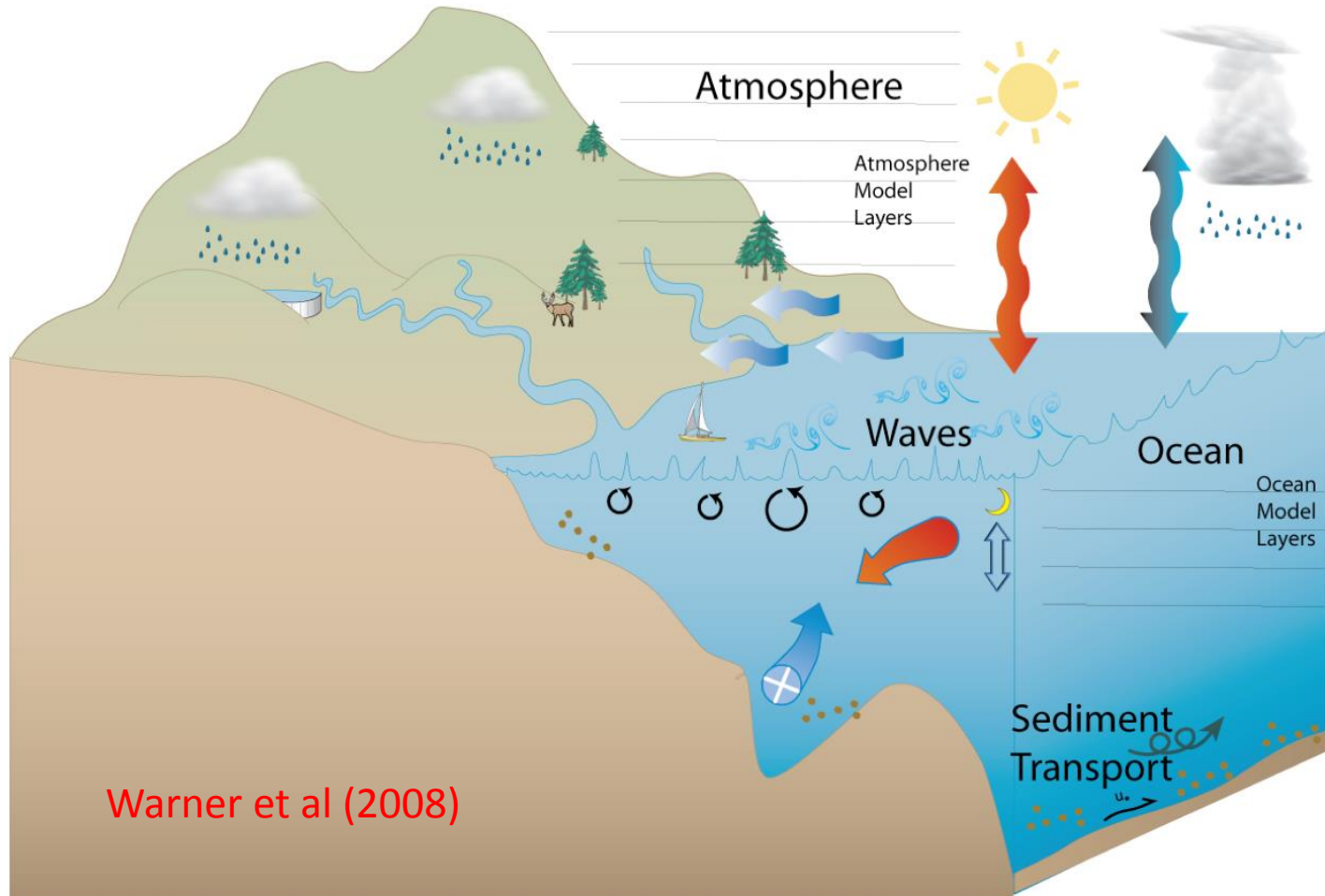
# Outline

- **Introduction of a coupled model**
- **Wind-driven estuarine circulation**
- **Surface wave and sediment transport**
- **Conclusions**

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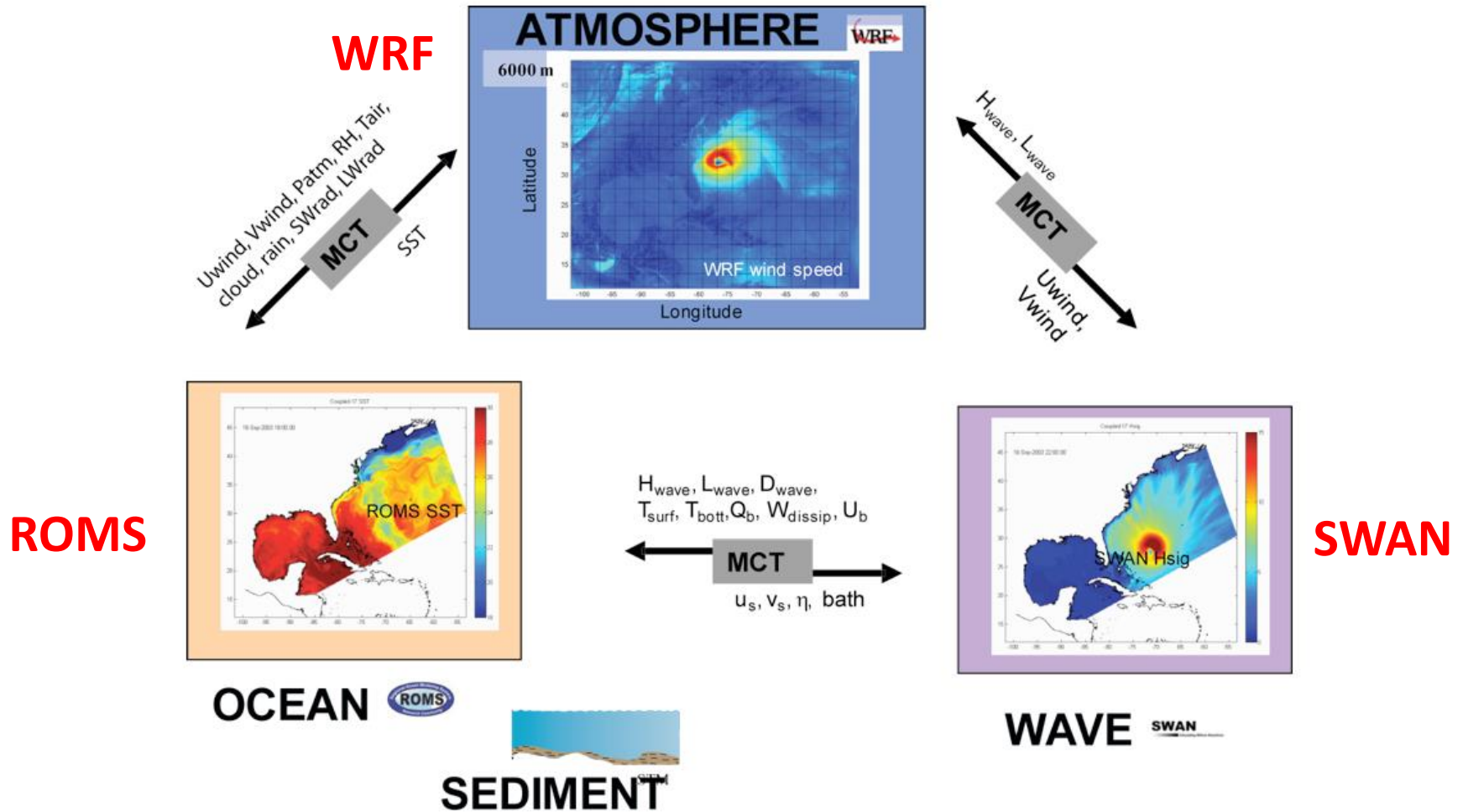
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# COAWST Modeling System



Development of a coupled modeling system (COAWST) of Chesapeake Bay to investigate how currents and waves affect sediment transport and deposition during storms.

# Modeling Components in COAWST



The COAWST modeling system consists of atmospheric (WRF), hydrodynamic (ROMS), surface waves (SWAN), and sediment-transport (CSTM) models. In our implementation, atmospheric forcing is obtained from wind observations and NARR, although WRF forecast is available during storms.

# Coupled model configuration

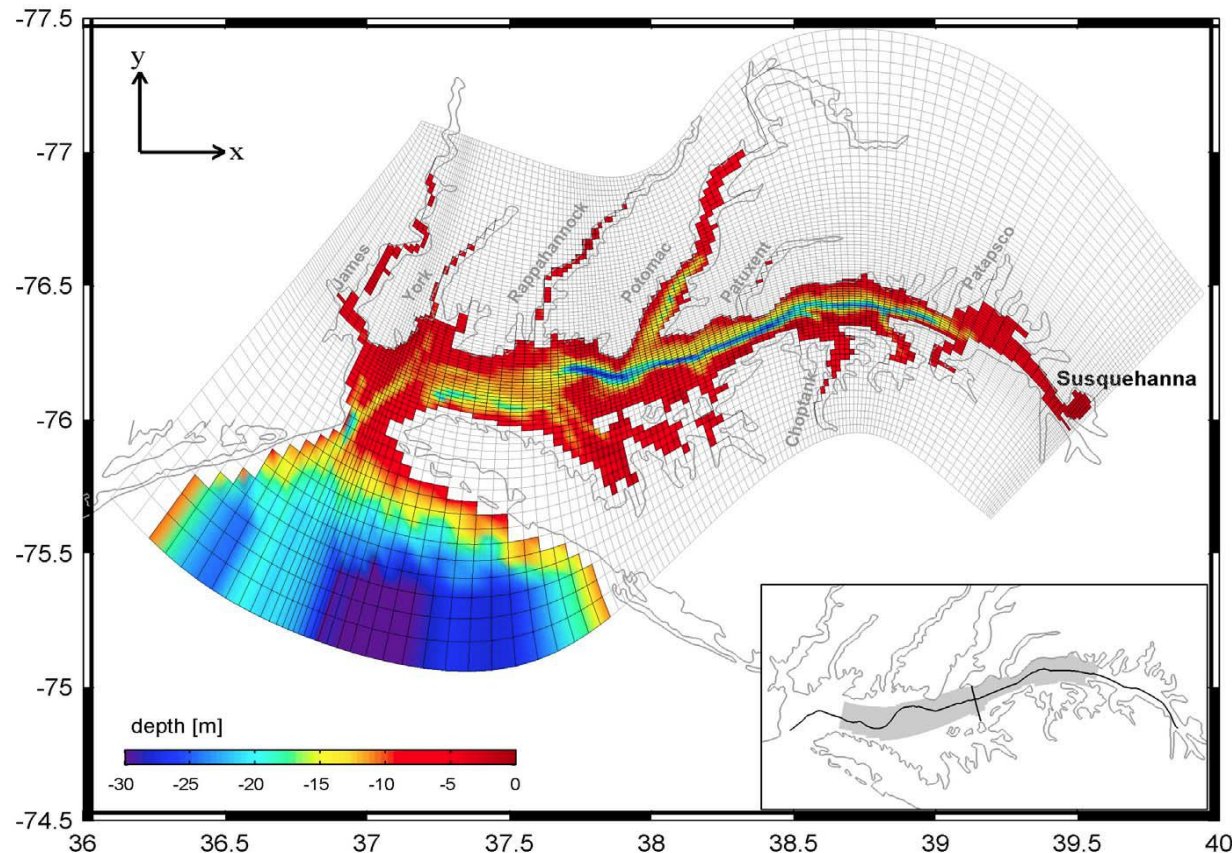
Wind and air-sea flux: NARR data. River discharge: USGS. Tidal forcing: TPX07.0.

Sediments: Fluvial sediments (river discharge and empirical formula) and bottom sediments (simplified and initialized with uniform distribution)

Grid size: 242\*162  
(SWAN and ROMS)

Horizontal resolution:  
100-500 m

Vertical layer: 20  
(ROMS)

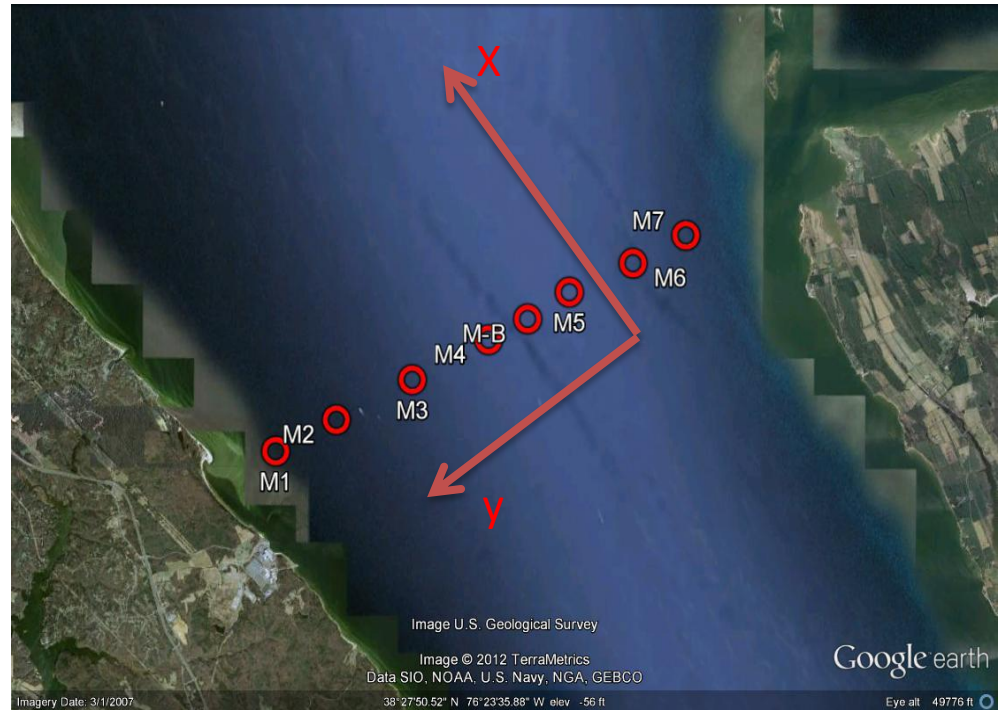
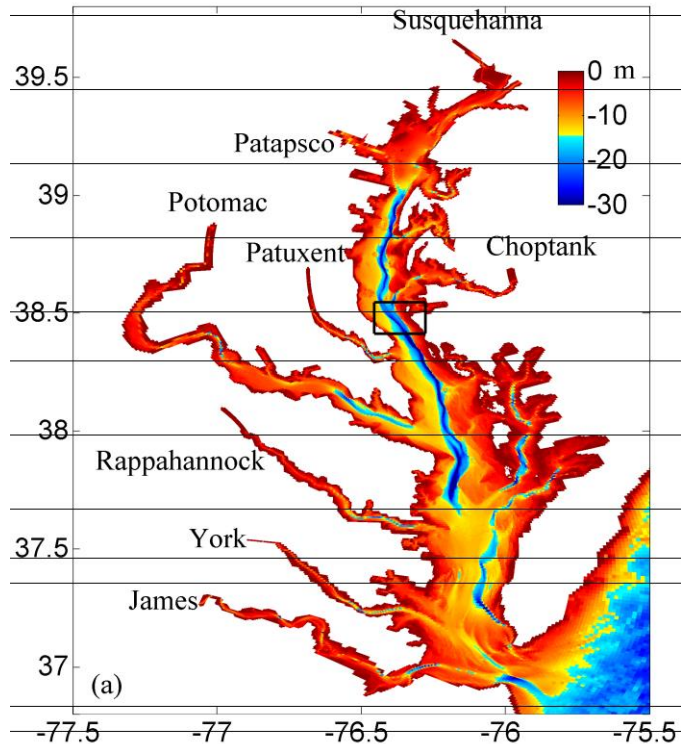


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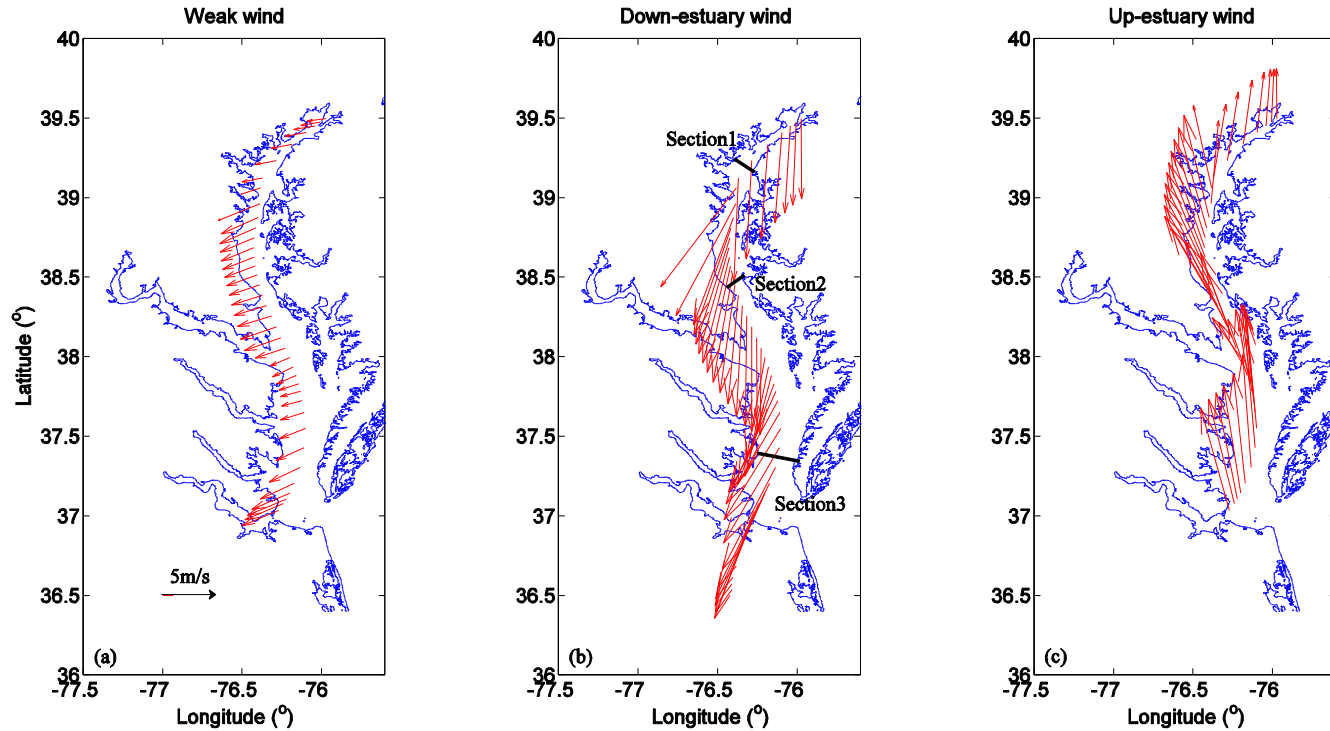
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# Data collection

- To confirm model validation against the observations, we used data collected in the middle Bay during the spring of 2012 (March-June).

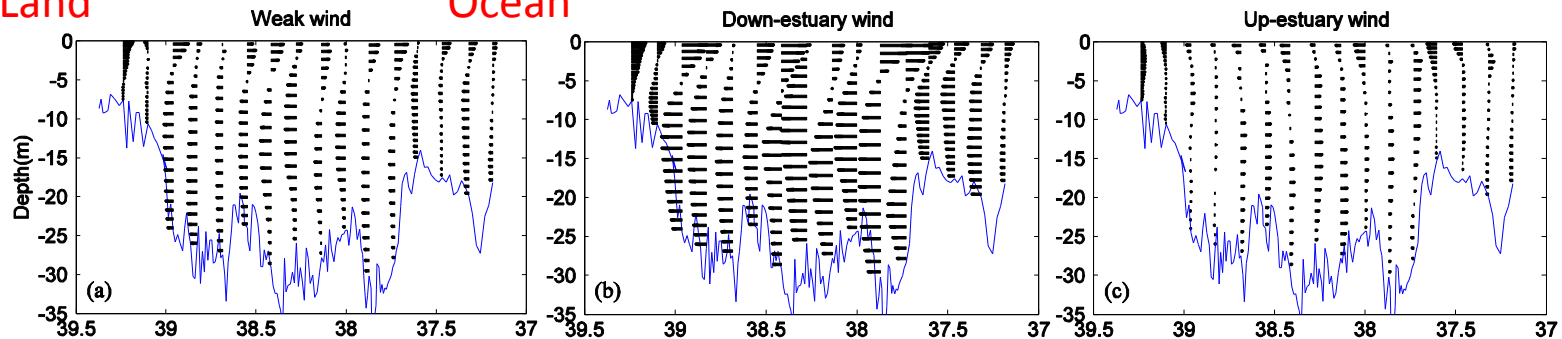


# Wind effects on estuarine circulation

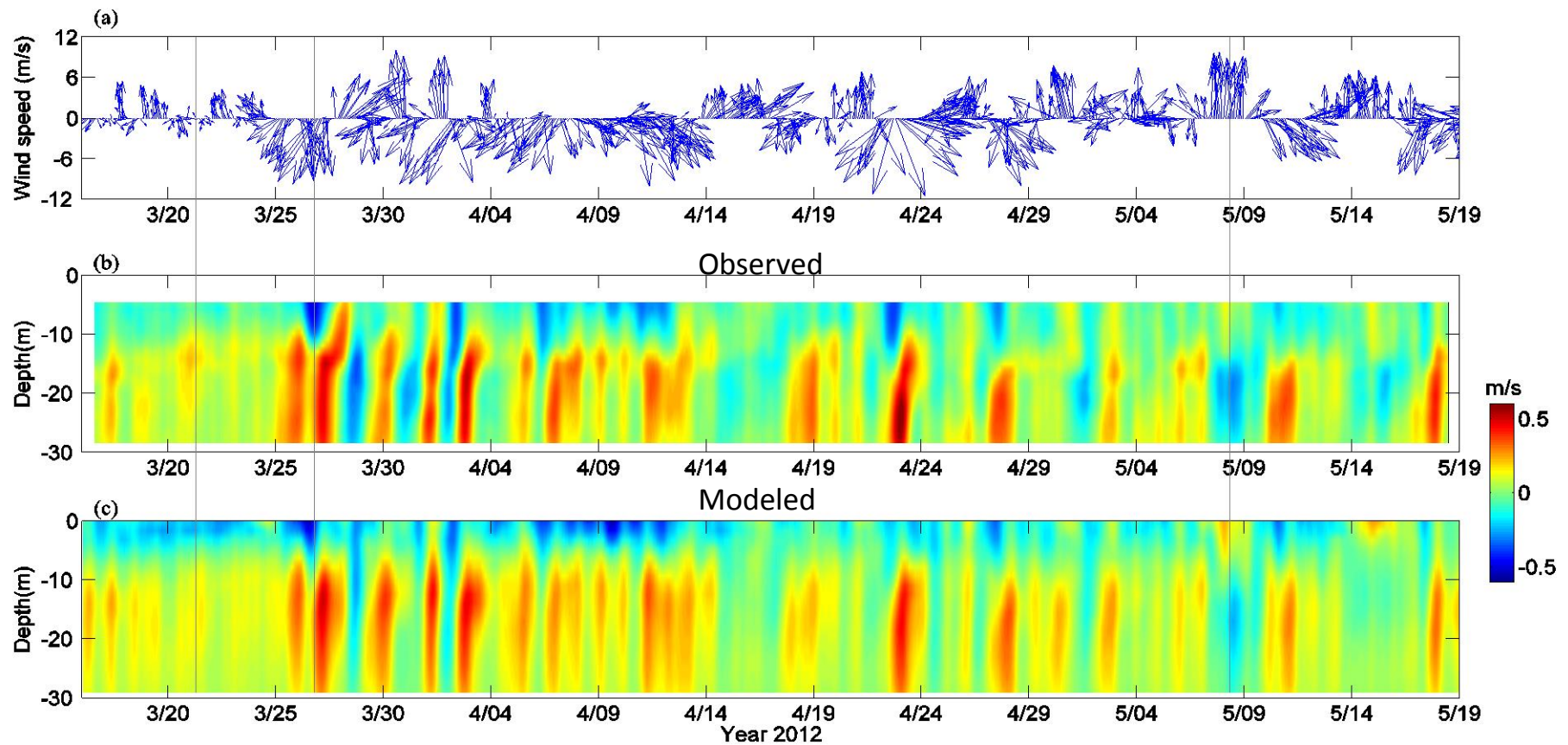


Land

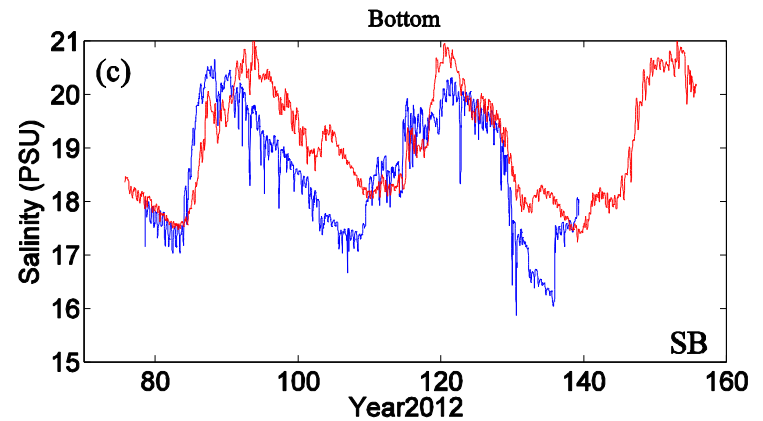
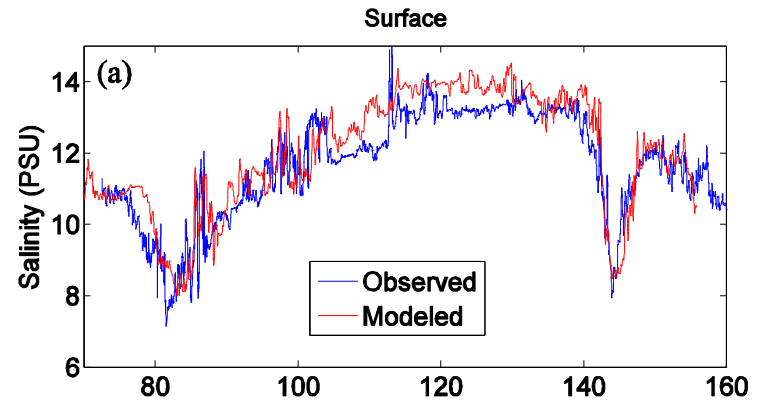
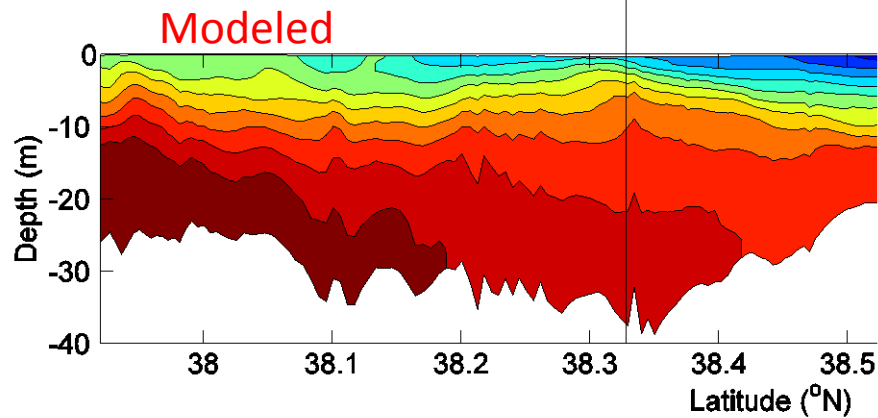
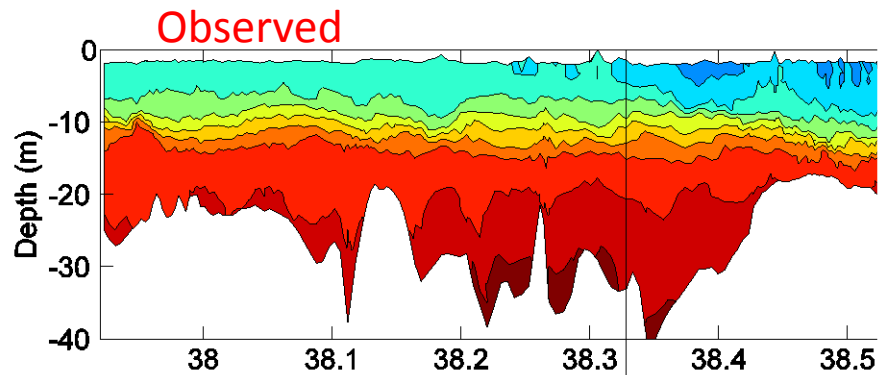
Ocean



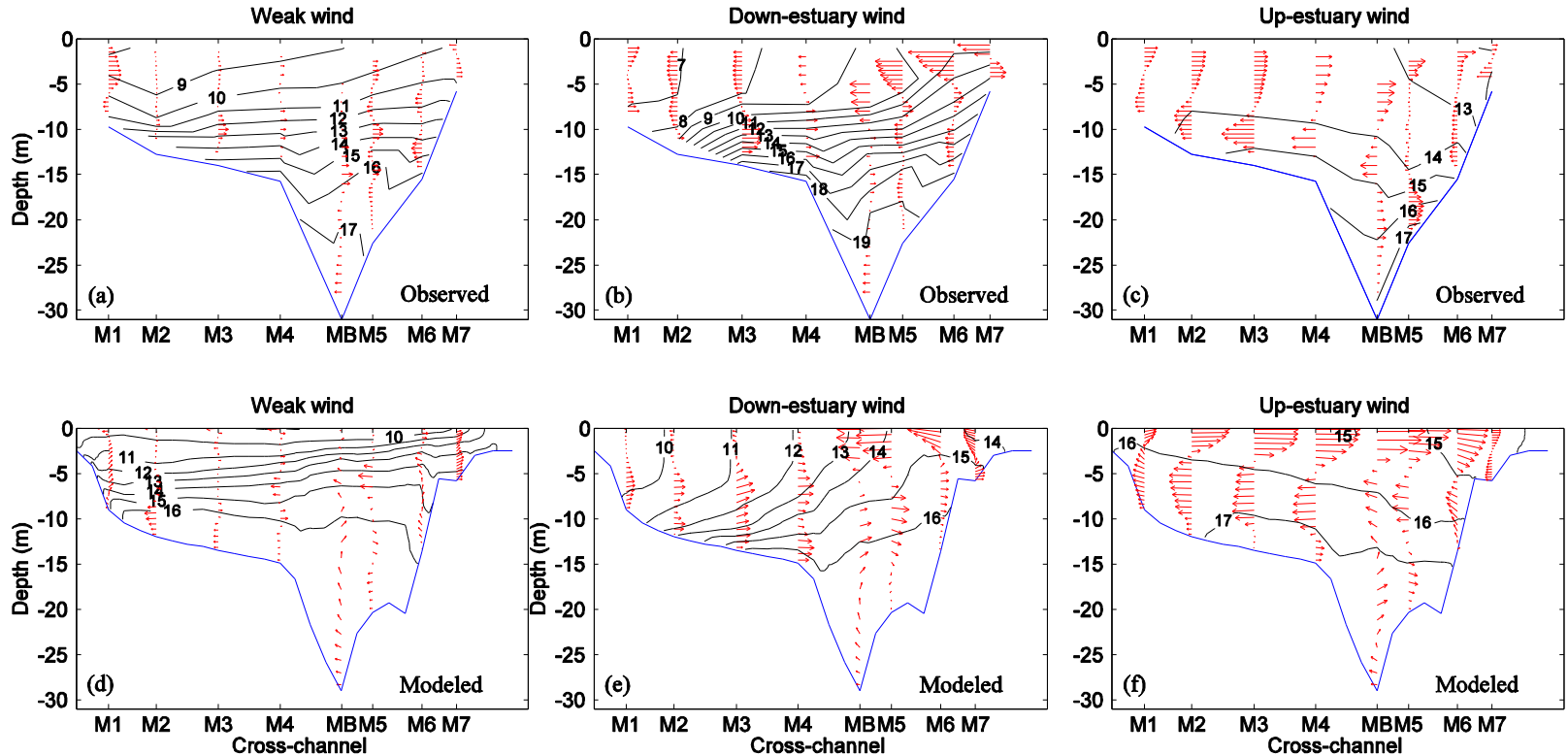
# Along-channel flow: two-layer gravitational circulation



# Along-channel distribution of salinity



# Wind-driven lateral circulation

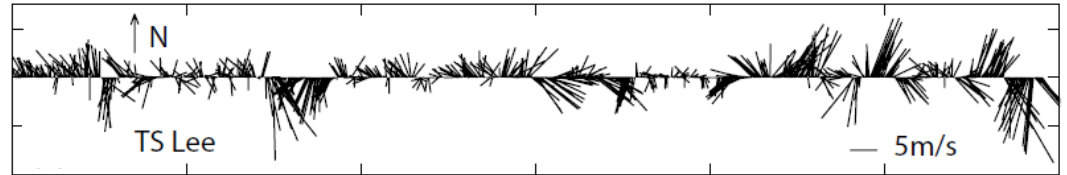


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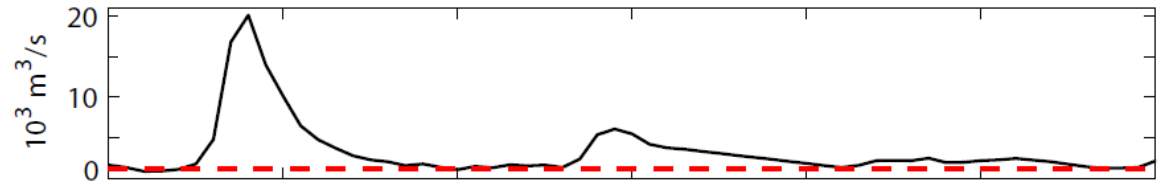
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# Simulating Tropical Storm Lee (2011)

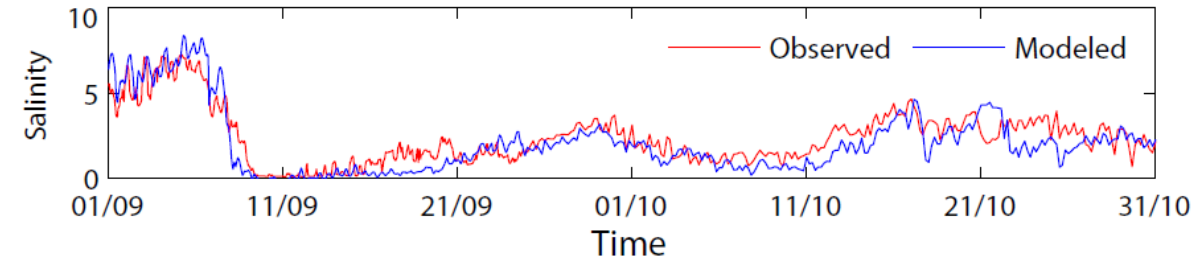
Wind vector



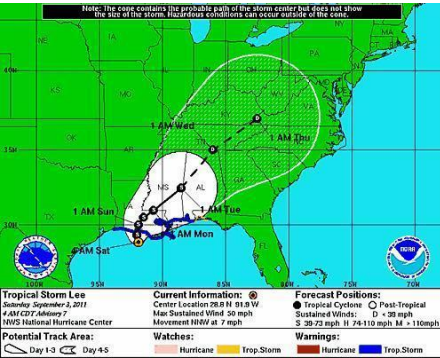
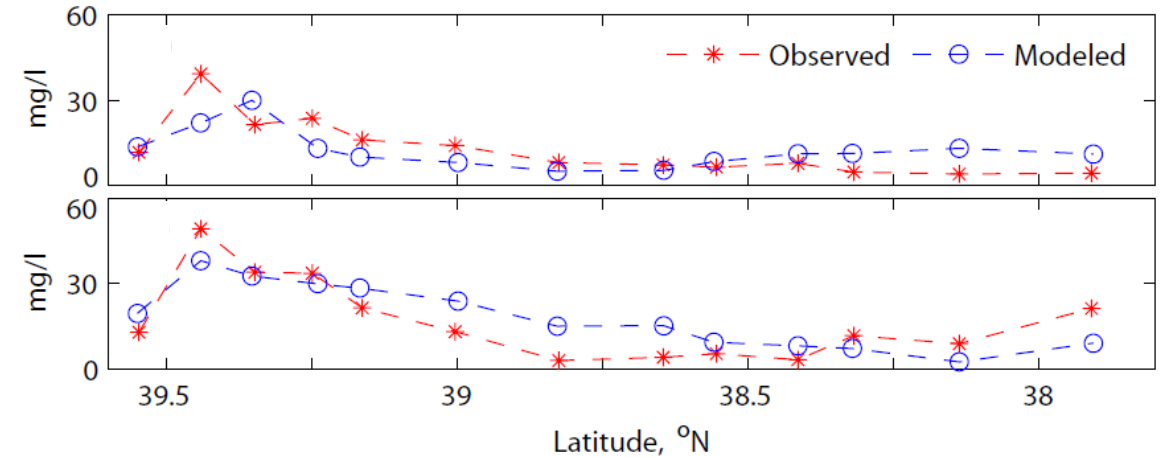
River flow



Salinity

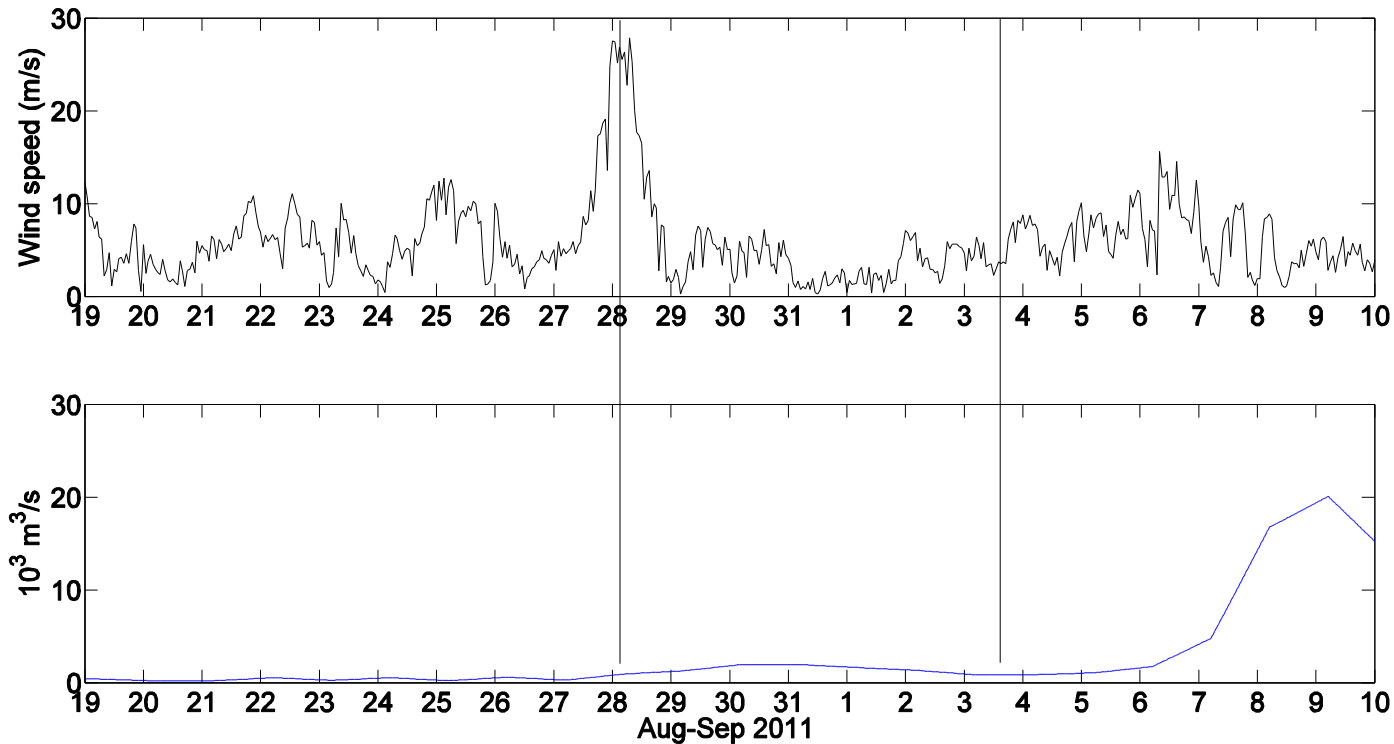
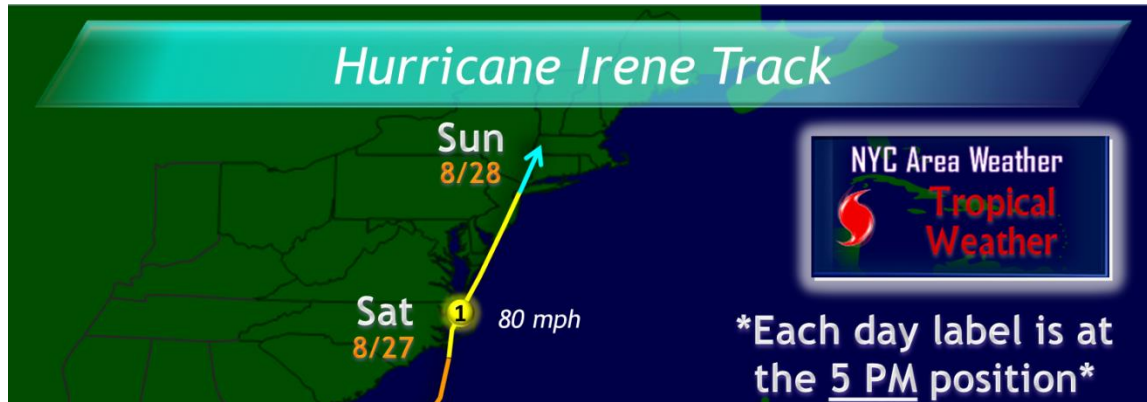


Suspended sediment

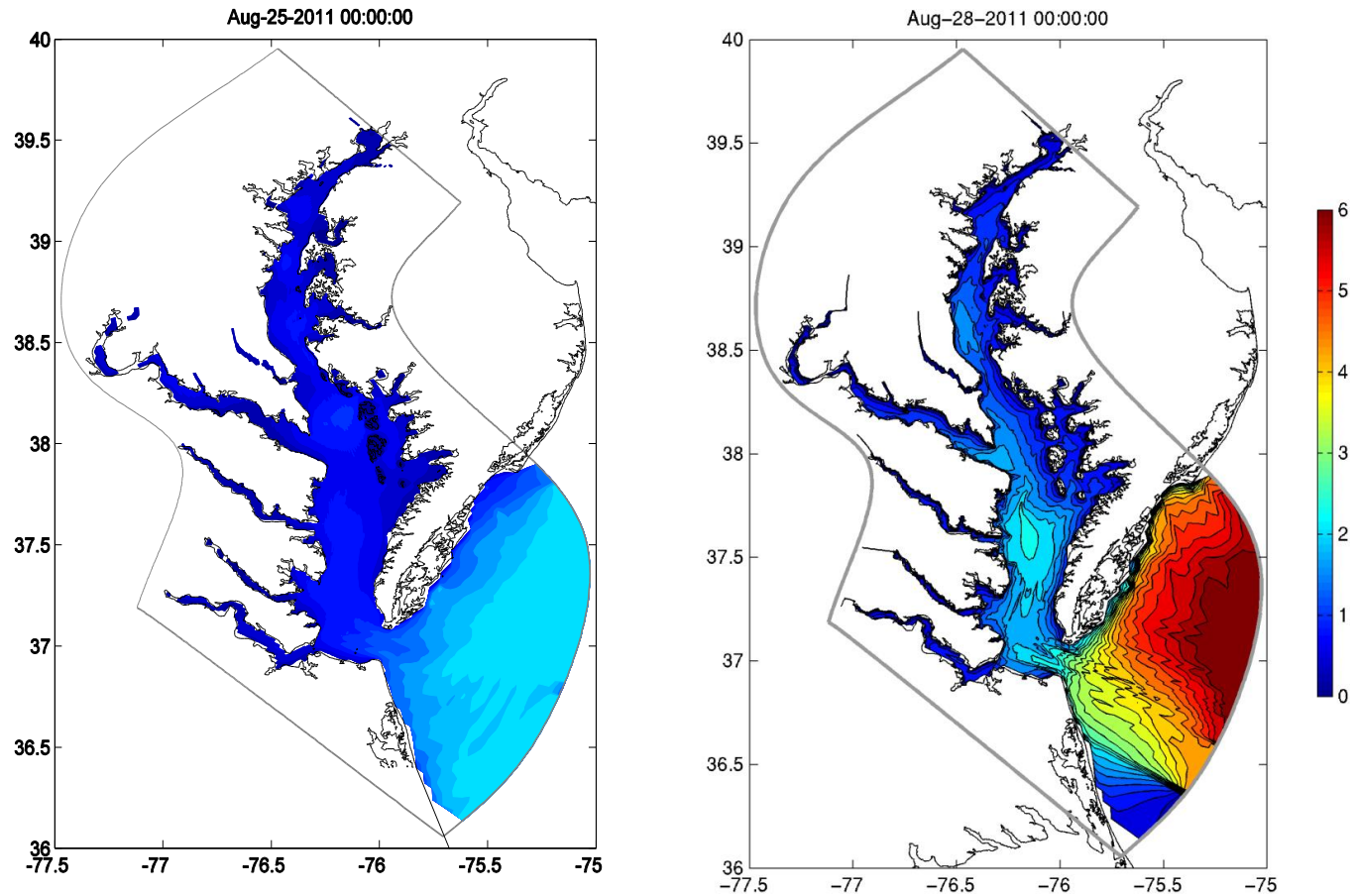


Model captures rapid salinity decrease due to the flood and reproduces observed suspended sediment concentrations.

# Storm Irene August 2011

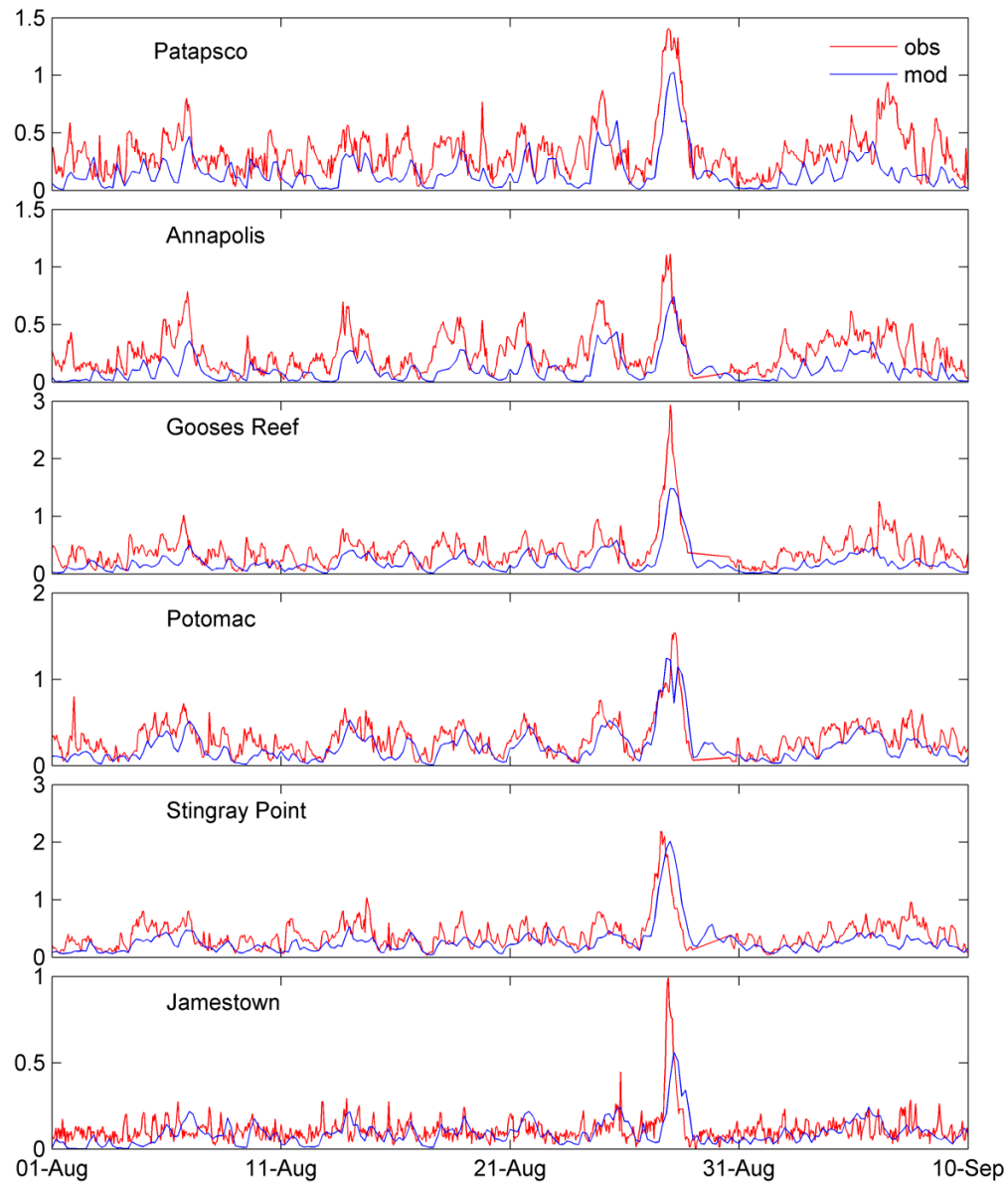


# Surface waves



Modeled significant wave height during the storm

# Comparison between observed (CBIBS) and modeled significant wave height.



# Sediment parameters

**Table 1.** Parameters for the Sediment Transport Model

Sediment Parameters	Fluvial Sediment			Bay Bottom Sediment
	Clay	Silt	Sand	
Grain size (mm)	0.004	0.008	0.069	0.022 <sup>a</sup>
Settling velocity (mm/s) <sup>ab</sup>	0.02	0.03	1	0.31
Critical shear stress (N/m <sup>2</sup> ) <sup>c</sup>	0.013	0.022	0.09	0.049
Erosion constant (kg/m <sup>2</sup> /s) <sup>a</sup>	$4 \times 10^{-5}$	$4 \times 10^{-5}$	$4 \times 10^{-5}$	$5 \times 10^{-5}$
Fraction (%) <sup>b</sup>	40	50	10	100
Bottom porosity <sup>d</sup>	0.91	0.91	0.91	0.91

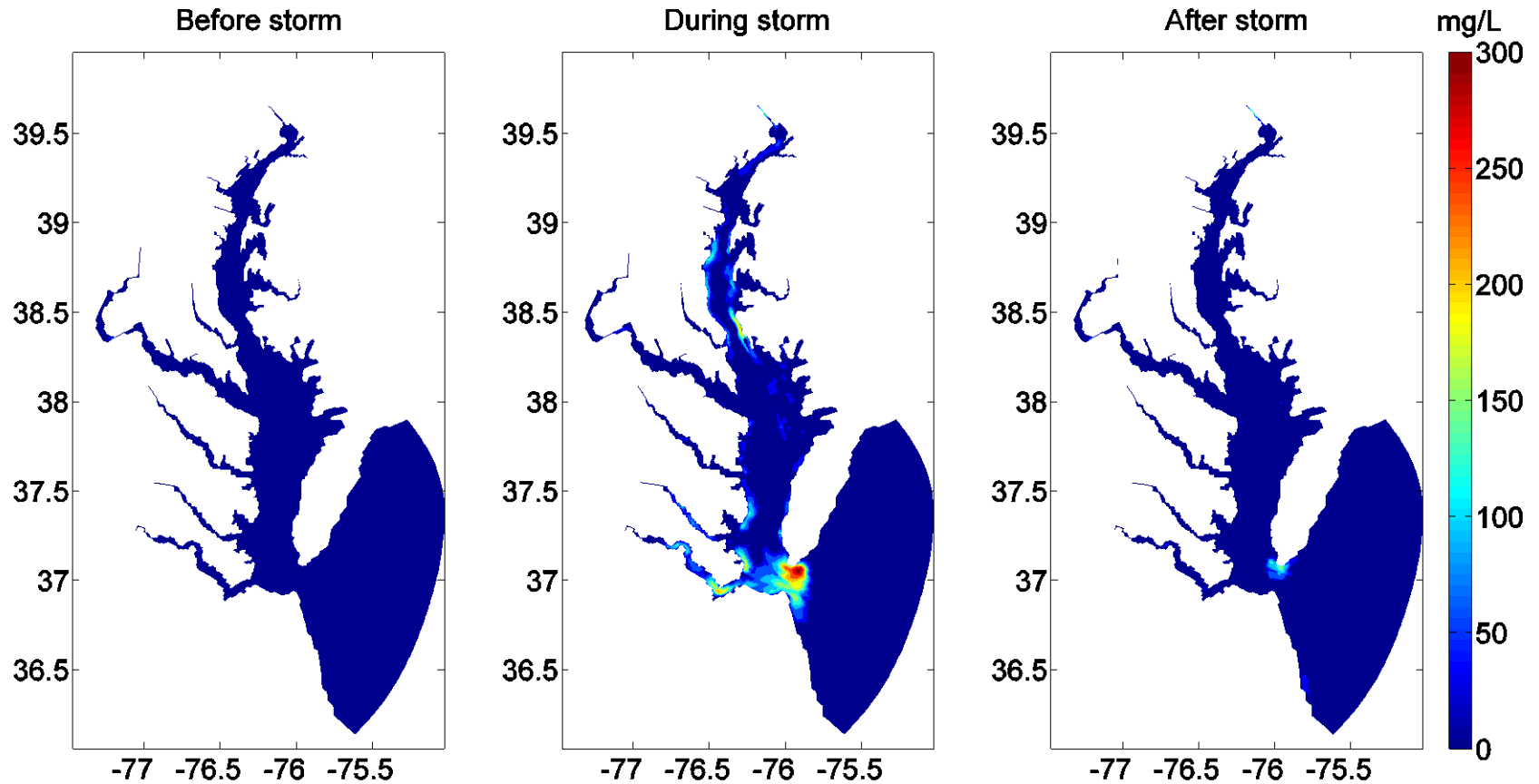
<sup>a</sup>*North et al.* [2004].

<sup>b</sup>*Gross et al.* [1978].

<sup>c</sup>*Gelfenbaum and Smith* [1986].

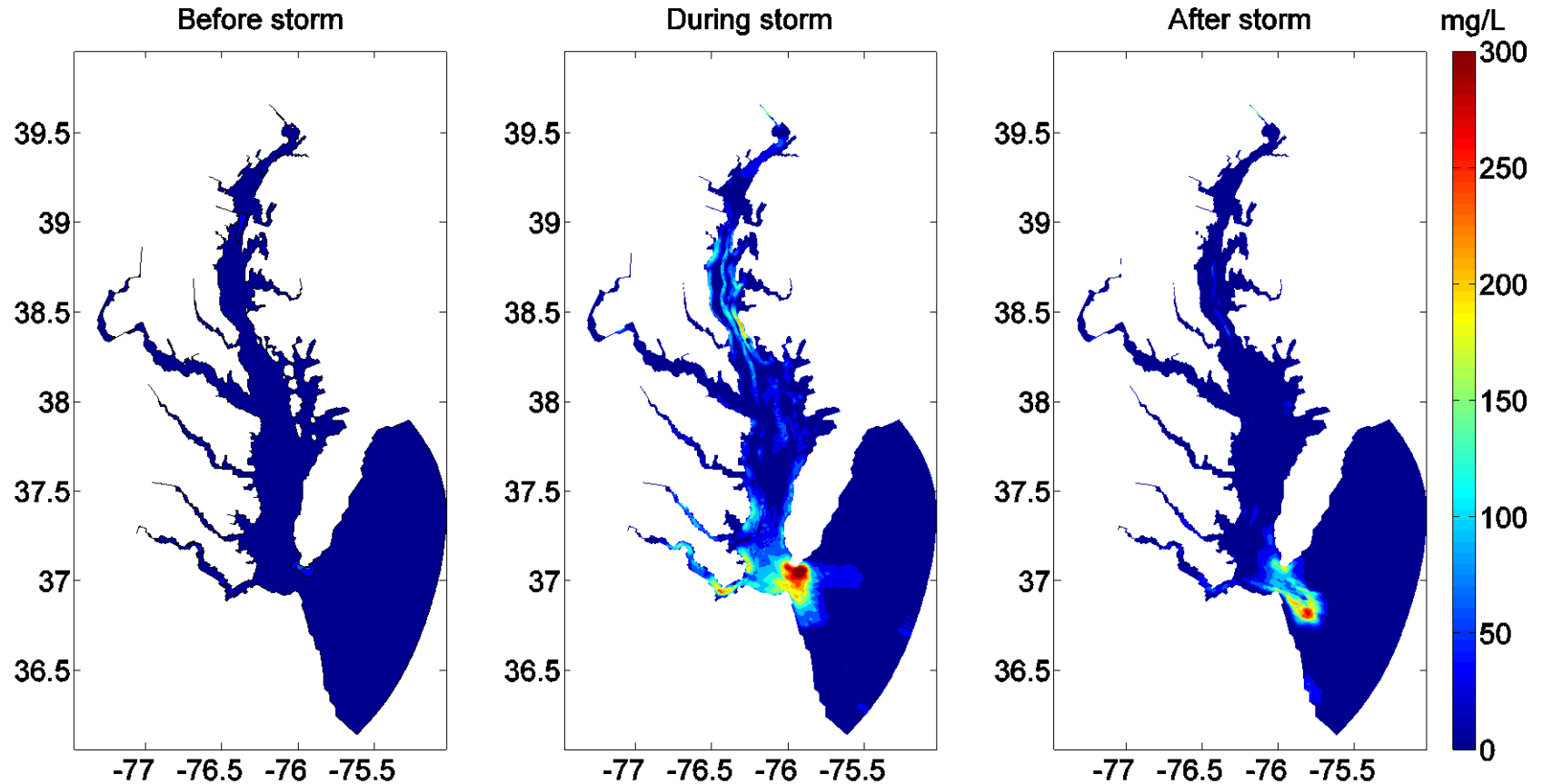
<sup>d</sup>*Sanford et al.* [1991].

# Surface distribution



Surface distribution of suspended sediment concentrations

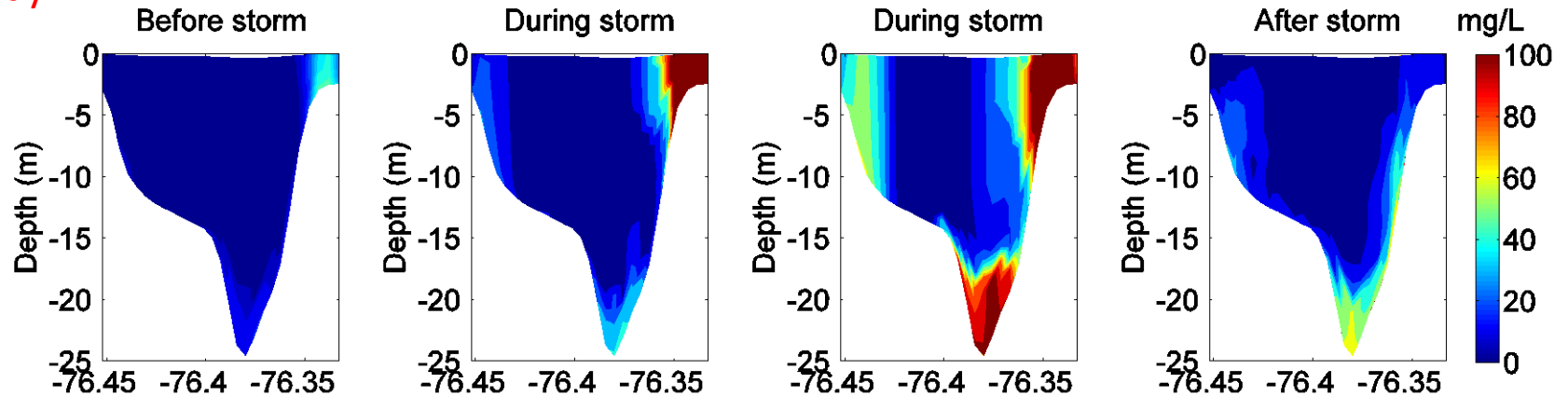
# Bottom distribution



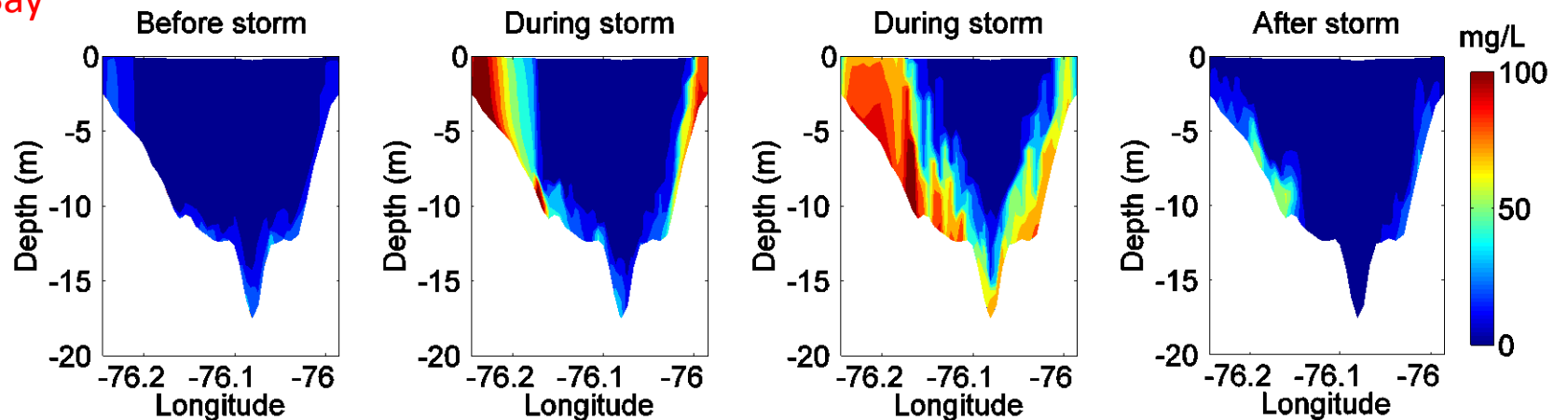
Bottom distribution of suspended sediment concentrations

# Lateral distribution of suspended sediments

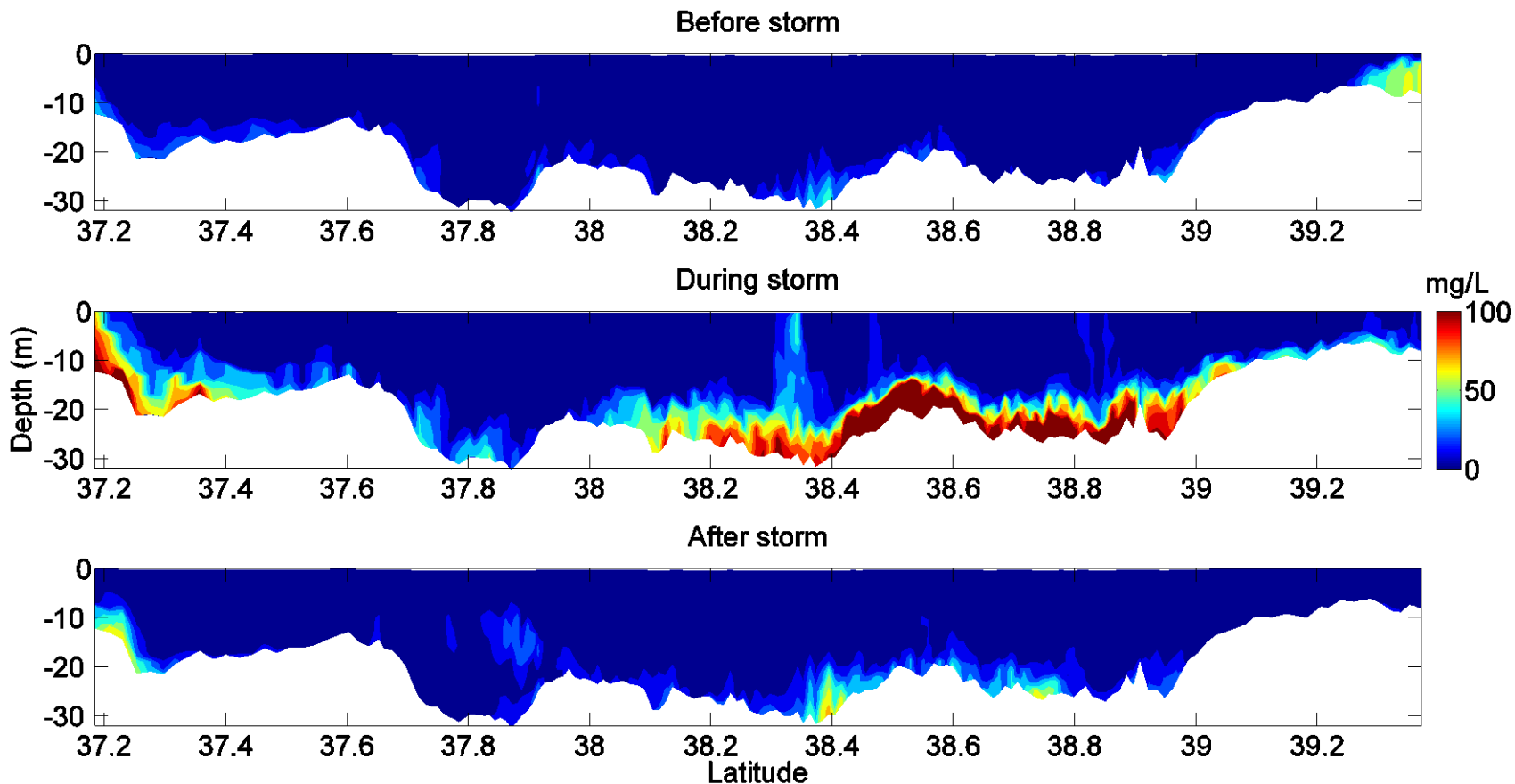
Upper Bay



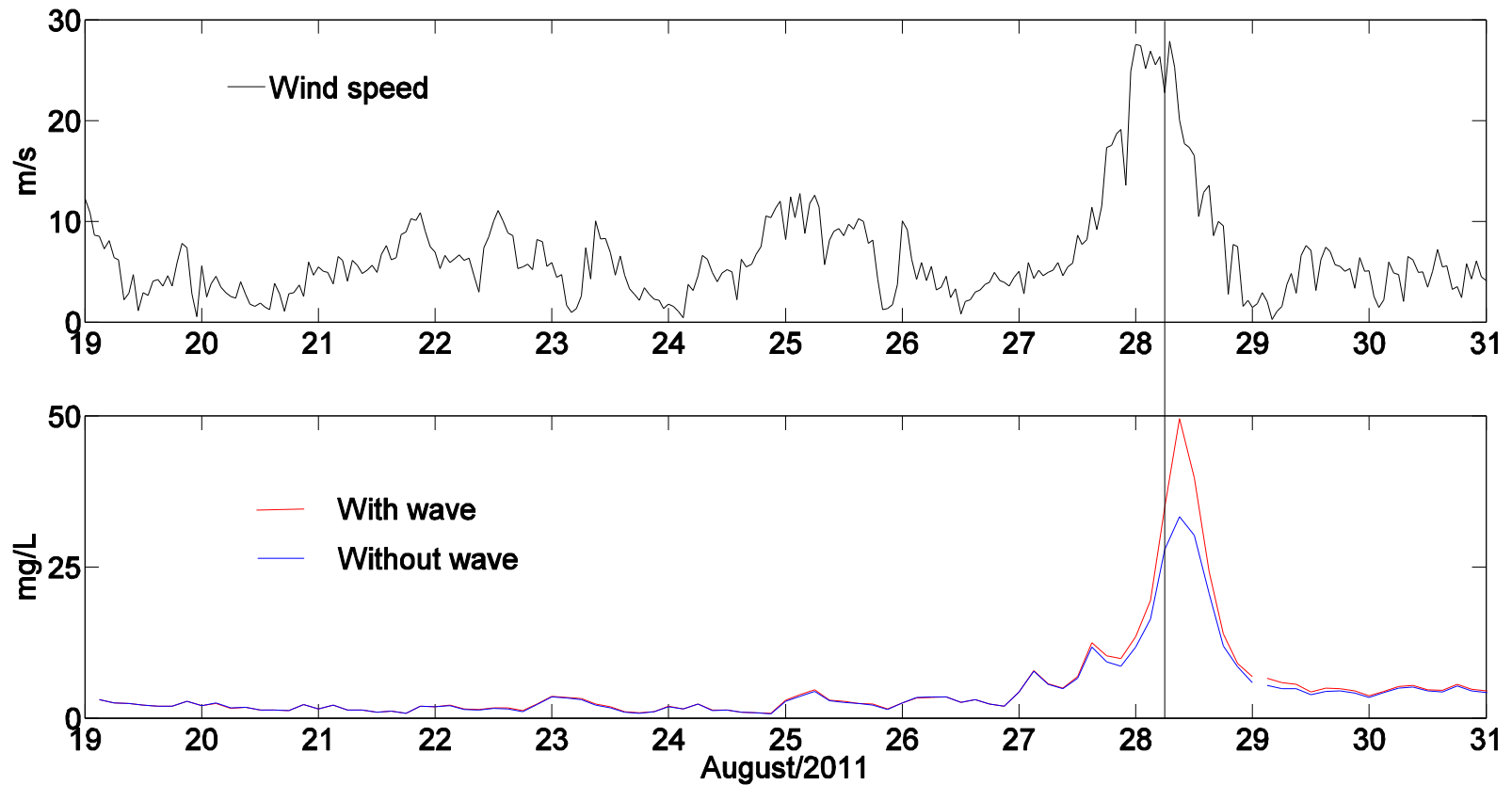
Lower Bay



# Along deep-channel distribution of suspended sediments



# Influence of waves on resuspension of bottom sediments



Suspended sediment concentration in the case with surface waves is larger than that without waves.

# Preliminary Conclusions

- The employed coupled model reproduces salt intrusion and wind-driven estuarine circulation including along-channel and lateral circulation.
- The coupled model also predicts surface wave activity well, but underestimates amplitude of waves. Adjustment of parameters and more observational data are necessary to address it.
- Surface waves can produce increased suspended sediments and may play an important role on sediment erosion in Chesapeake Bay.

# Future work

- Good predictions for wind-driven circulation and surface waves in the model provide a good opportunity to investigate sediment transport and deposition associated with wind-driven circulation and surface waves.
- Configuring the model with non-uniform distribution of bed sediments that have multiple grain sizes.

Thank you for your attendance