

# The Predictability of Near-Coastal Environments using Unstructured Grid Models

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# Prediction Challenges in Coastal Waters

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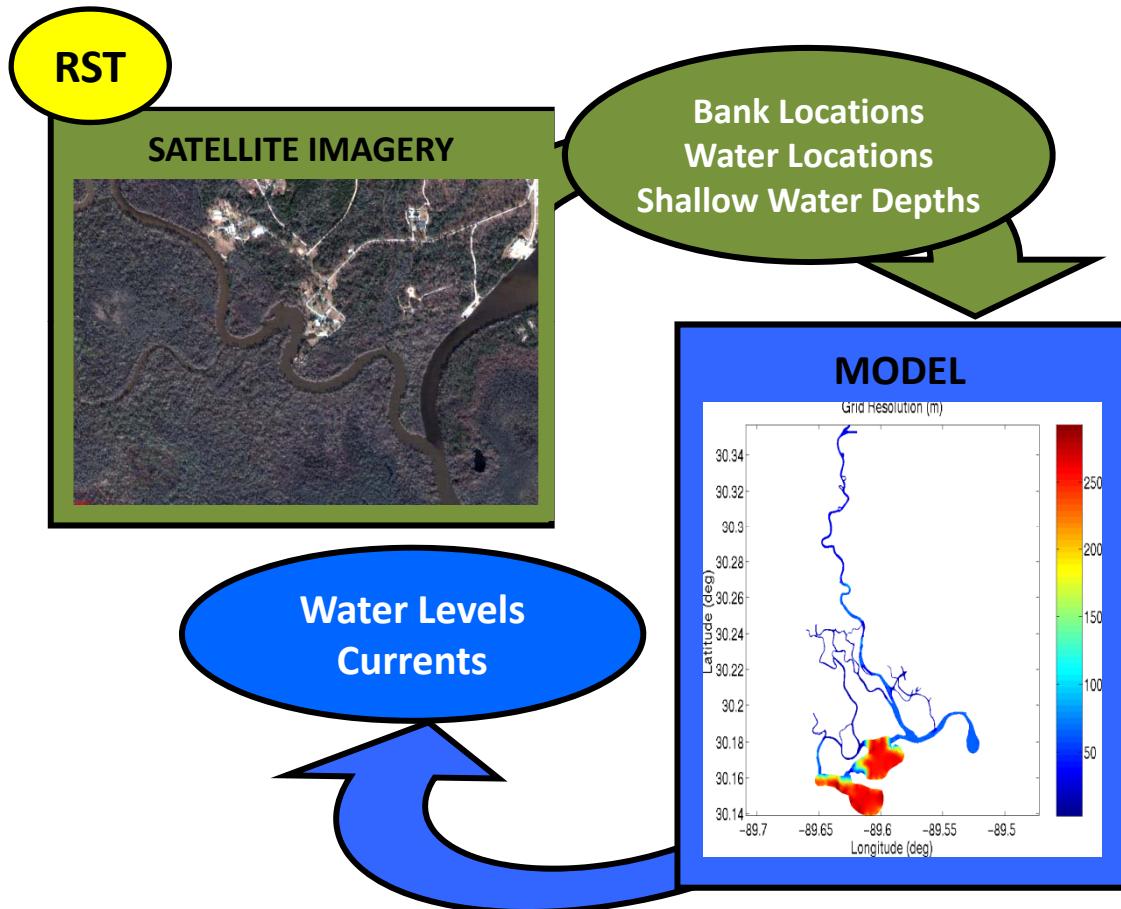


- Complex shorelines and waterway geometry
- Wide range of spatial and temporal scales
- Lack of appropriate data
  - bathy/topo, forcing, ...

## Objective:

- Demonstrate a strategy to overcome these issues in rivers
- Explore the effect of wind resolution on localized current forecasts

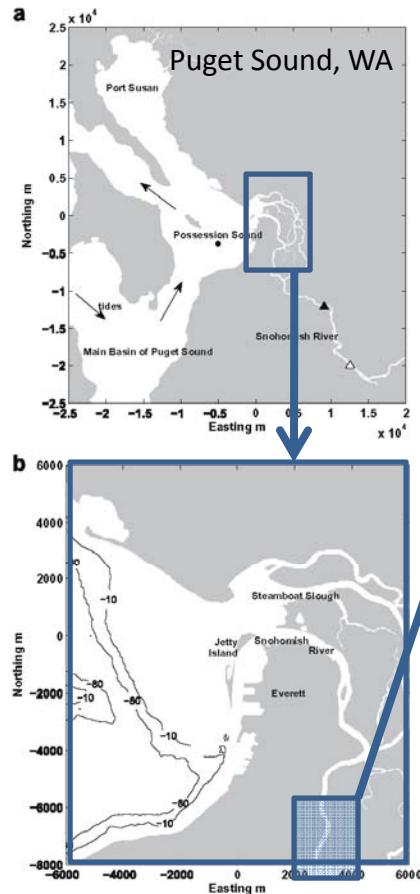
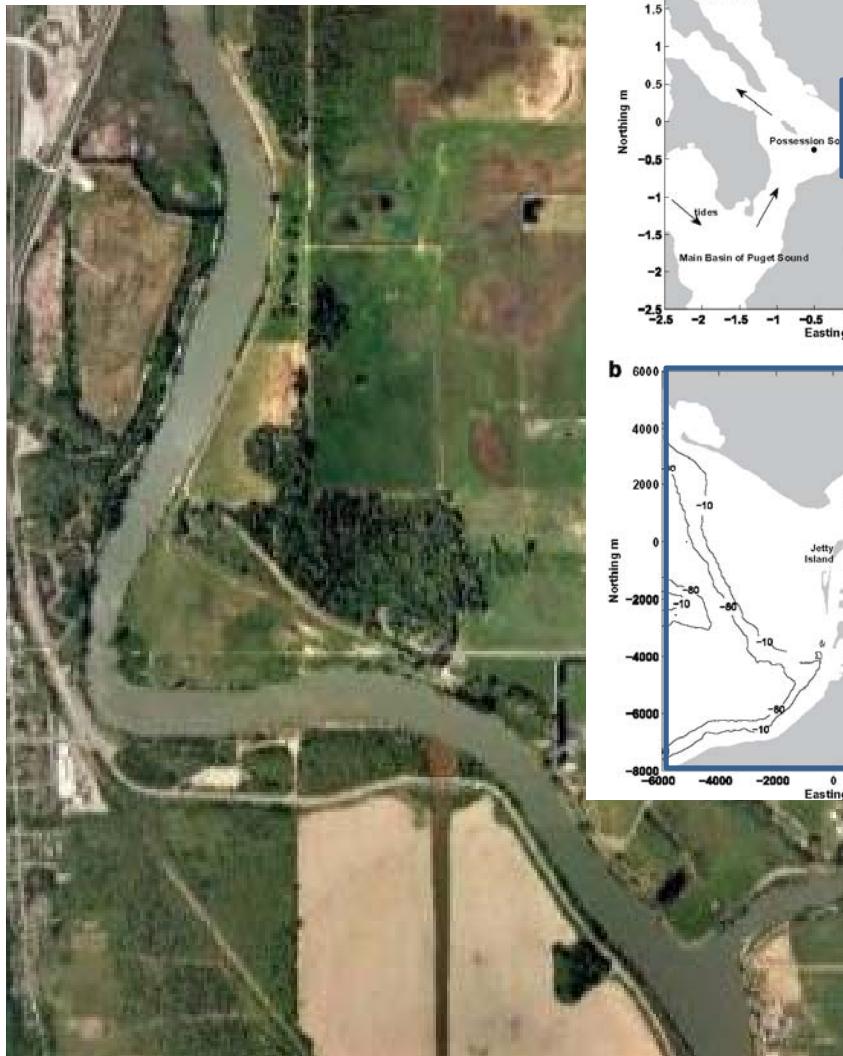
# Rapid Environmental Assessment: Rivers



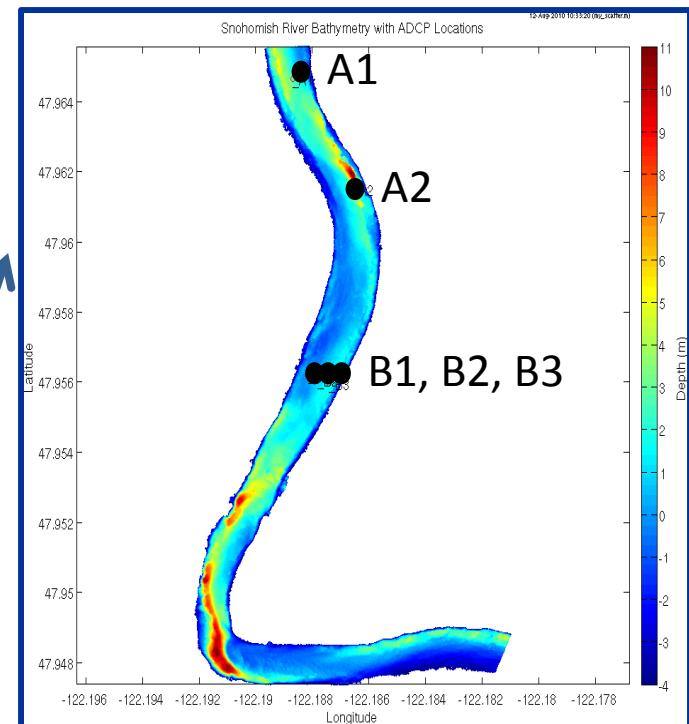
## River Simulation Tool

- Automates the extraction of geometry from imagery
- Automates generation of model unstructured mesh
- Applies contingencies for missing data
  - synthetic bathymetry
  - sediment type selection
- Allows ensemble configuration

# Snohomish River, WA



ADCP current data  
5 locations, 9-26 Sep 2009



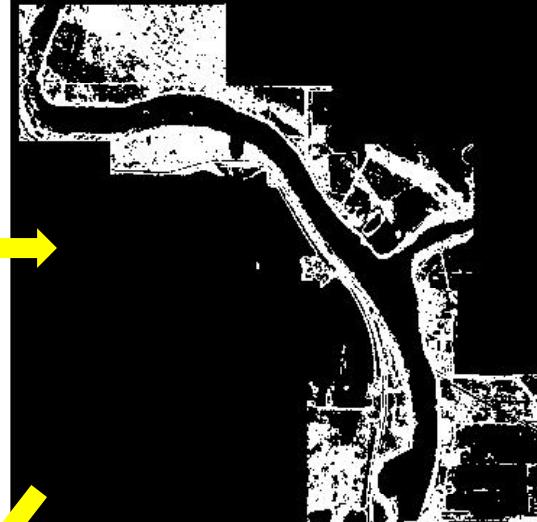
# Automated Shoreline Extraction

Automated river edge and water point extraction from imagery

Entropy  
Filtering



Despeckling



Thresholding

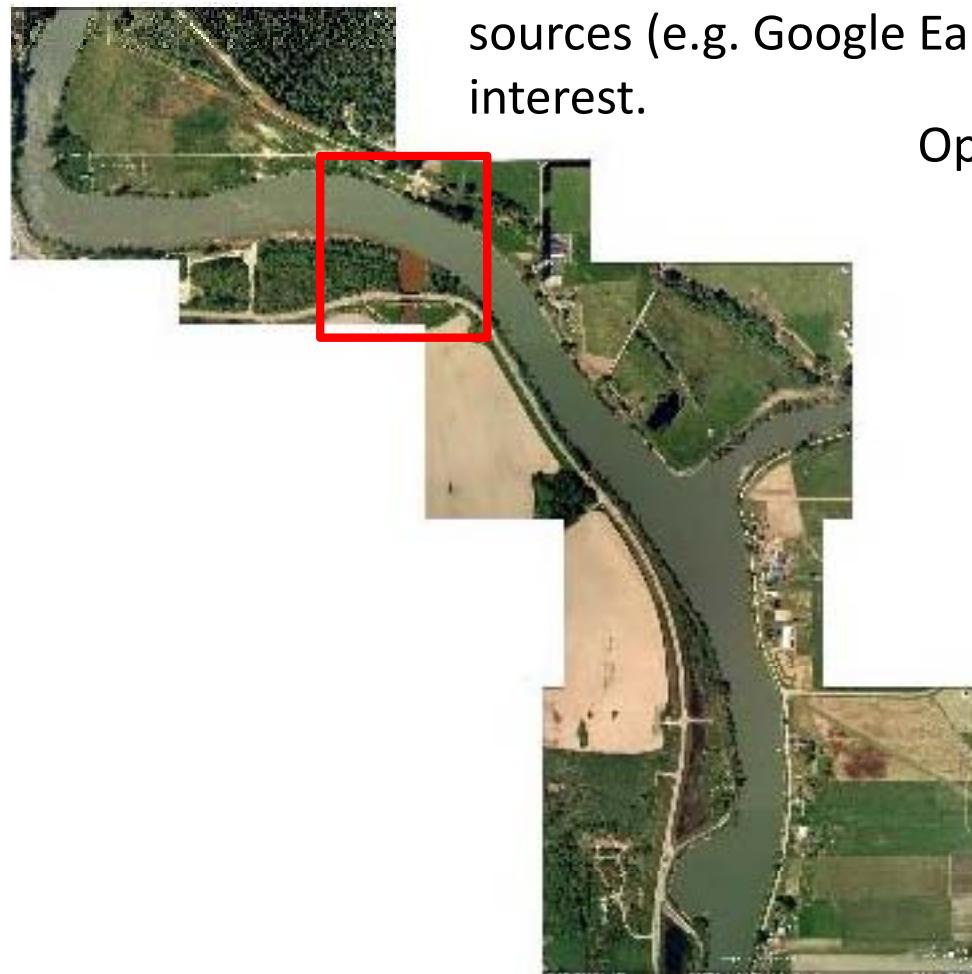


Binarized,  
Masks applied



# Snohomish River, WA

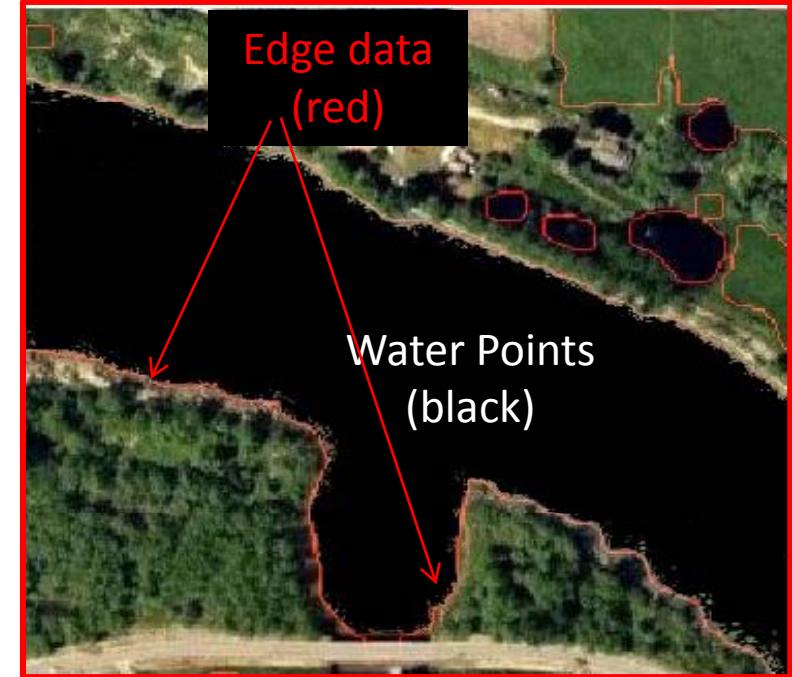
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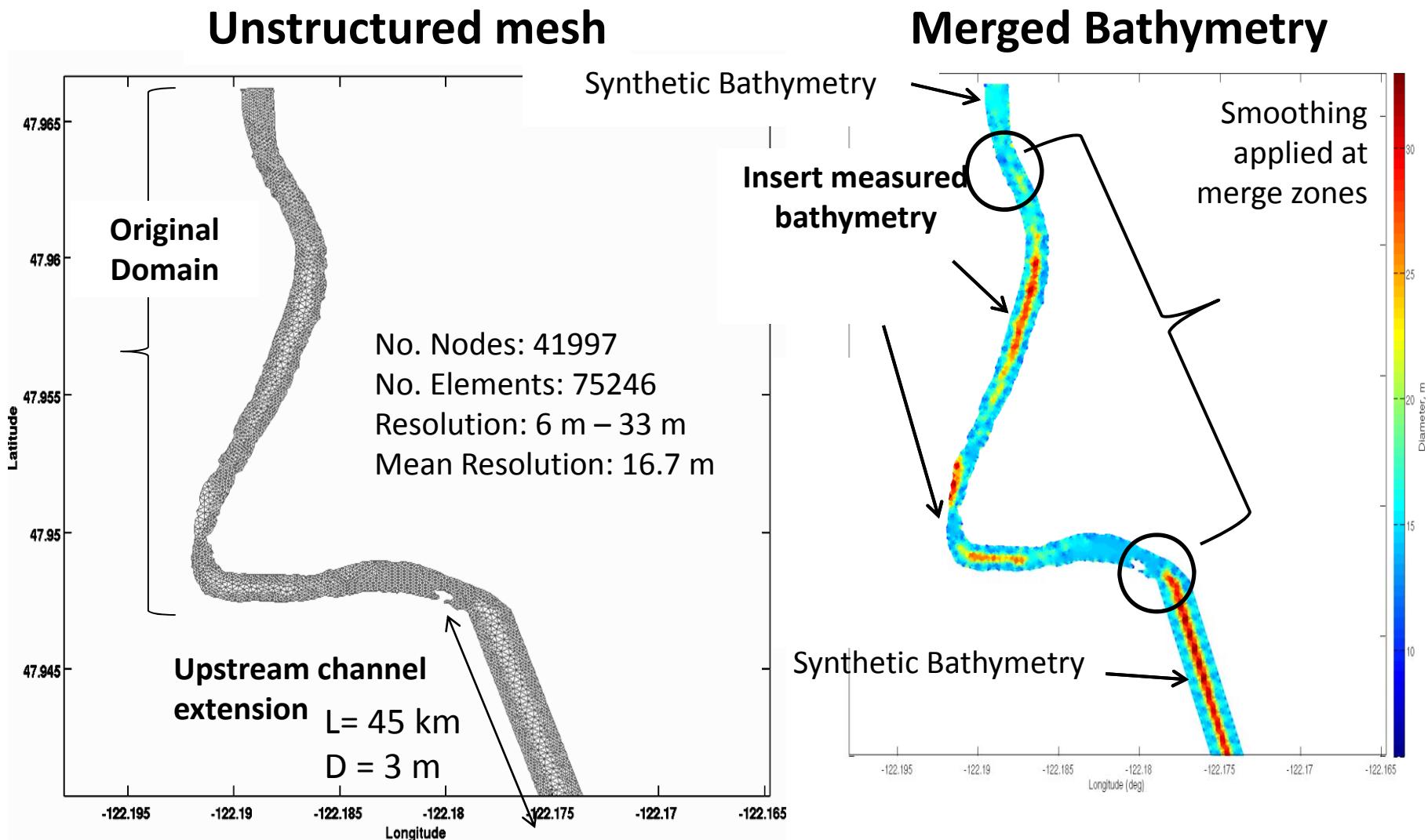
Uses any high resolution imagery from publically available sources (e.g. Google Earth) are tiled to cover the entire area of interest.

## Operational Implementation:

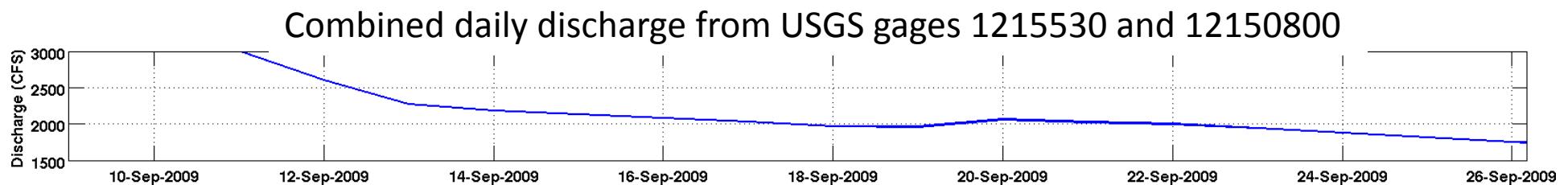
- 6 minutes to locate and tile images
- 3 minutes for processing



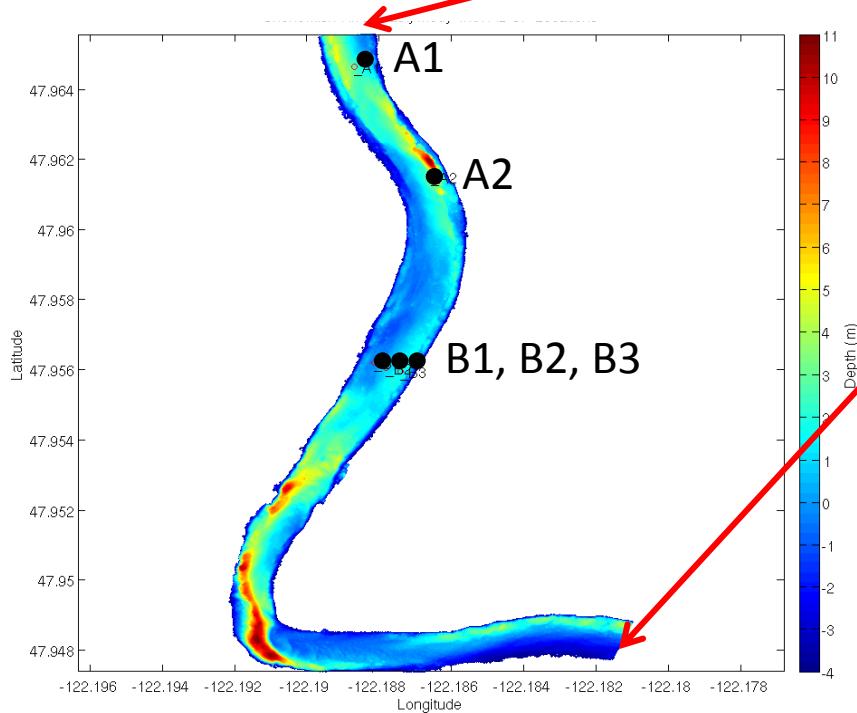
# Snohomish River, WA



# Snohomish River, WA



ADCP current data  
5 locations, 9-26 Sep 2009

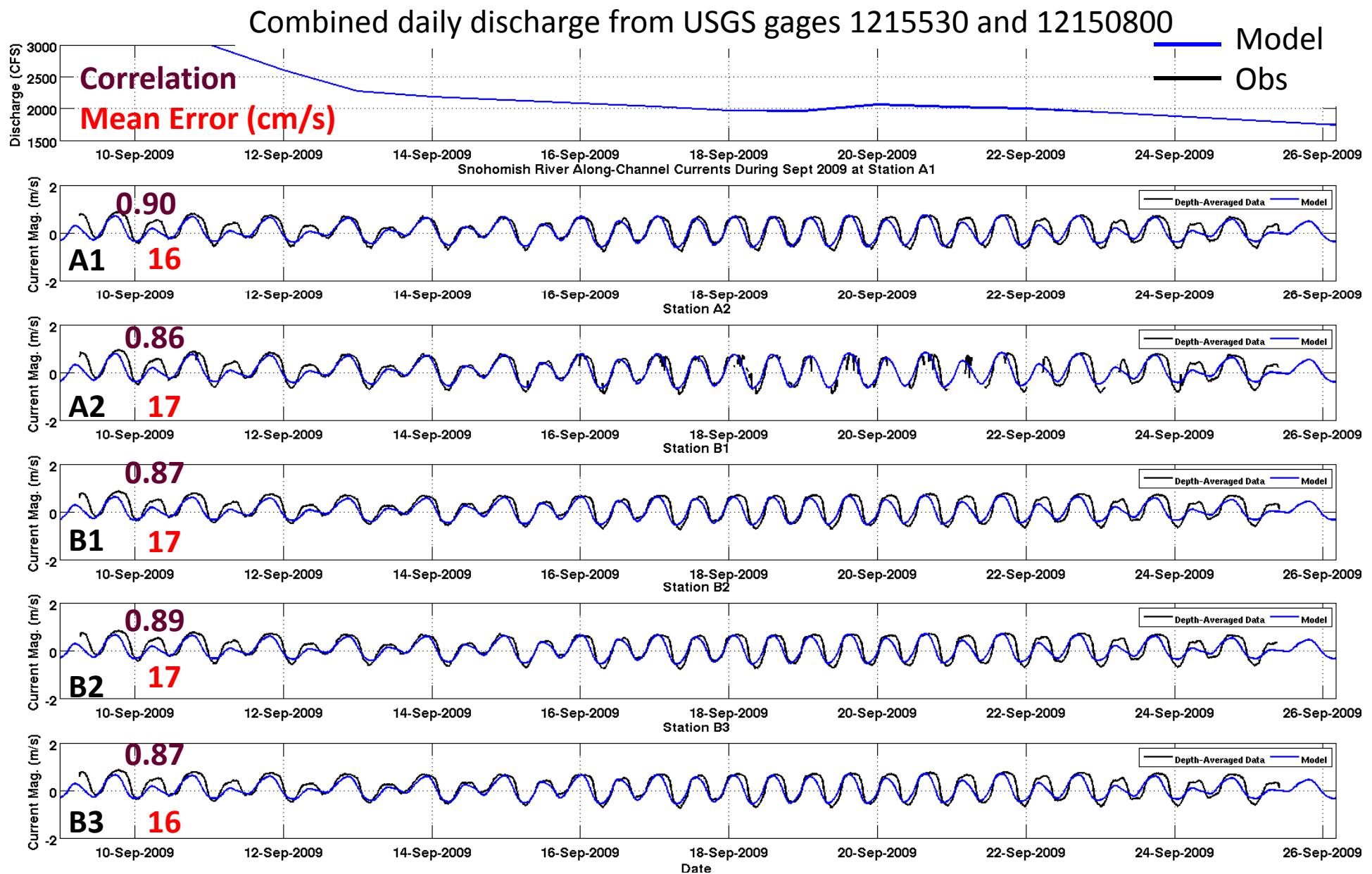


Downstream forcing:  
Tides from the Juan De Fuca Strait  
Extracted from FES2004 tidal database

Upstream forcing:  
Daily discharge from Pilchuck and Snohomish Rivers

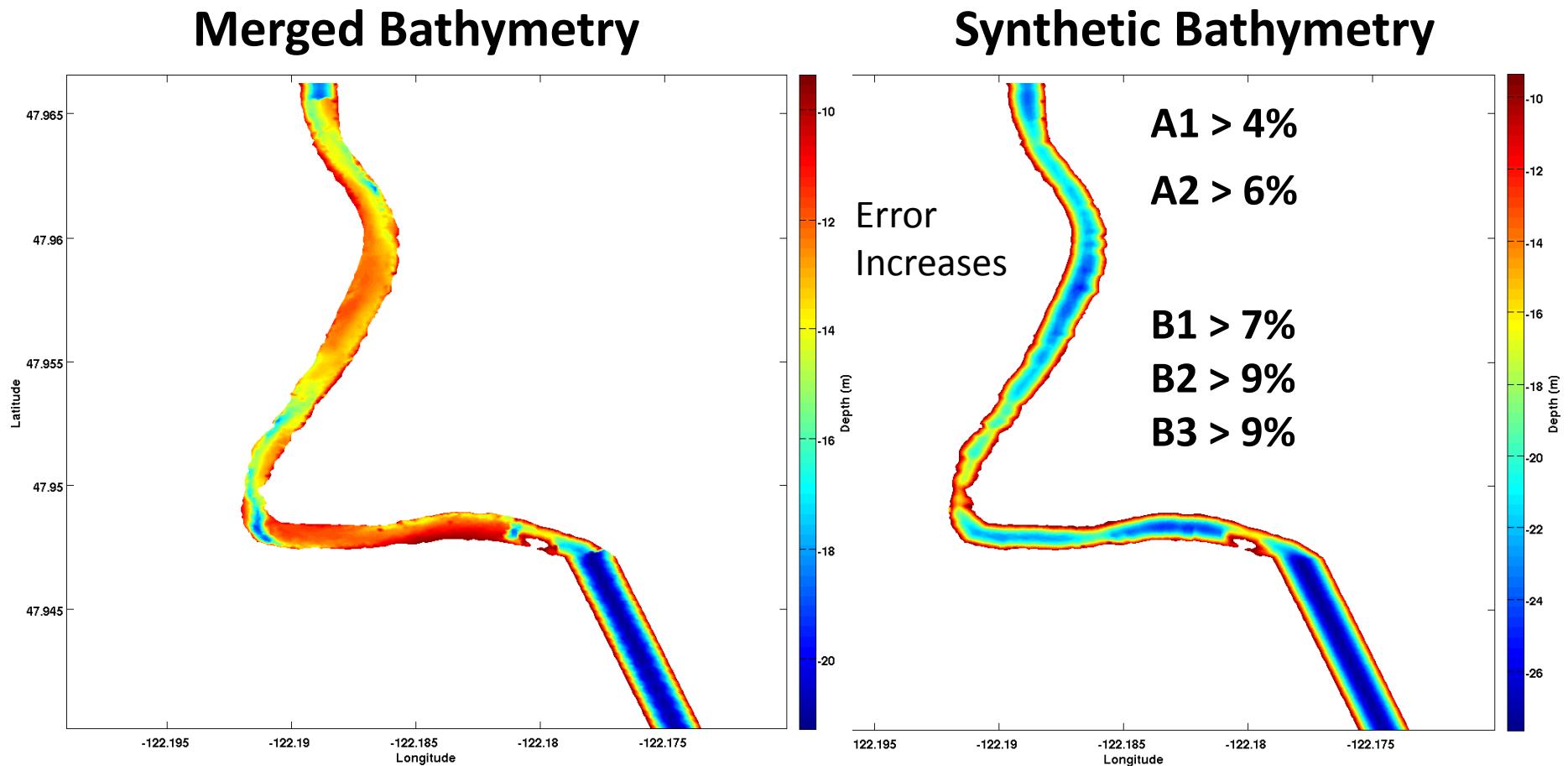
5.5 hr computation time for 2 month simulation on 44 CPUs

# Snohomish River, WA



# Performance of Synthetic Bathymetry

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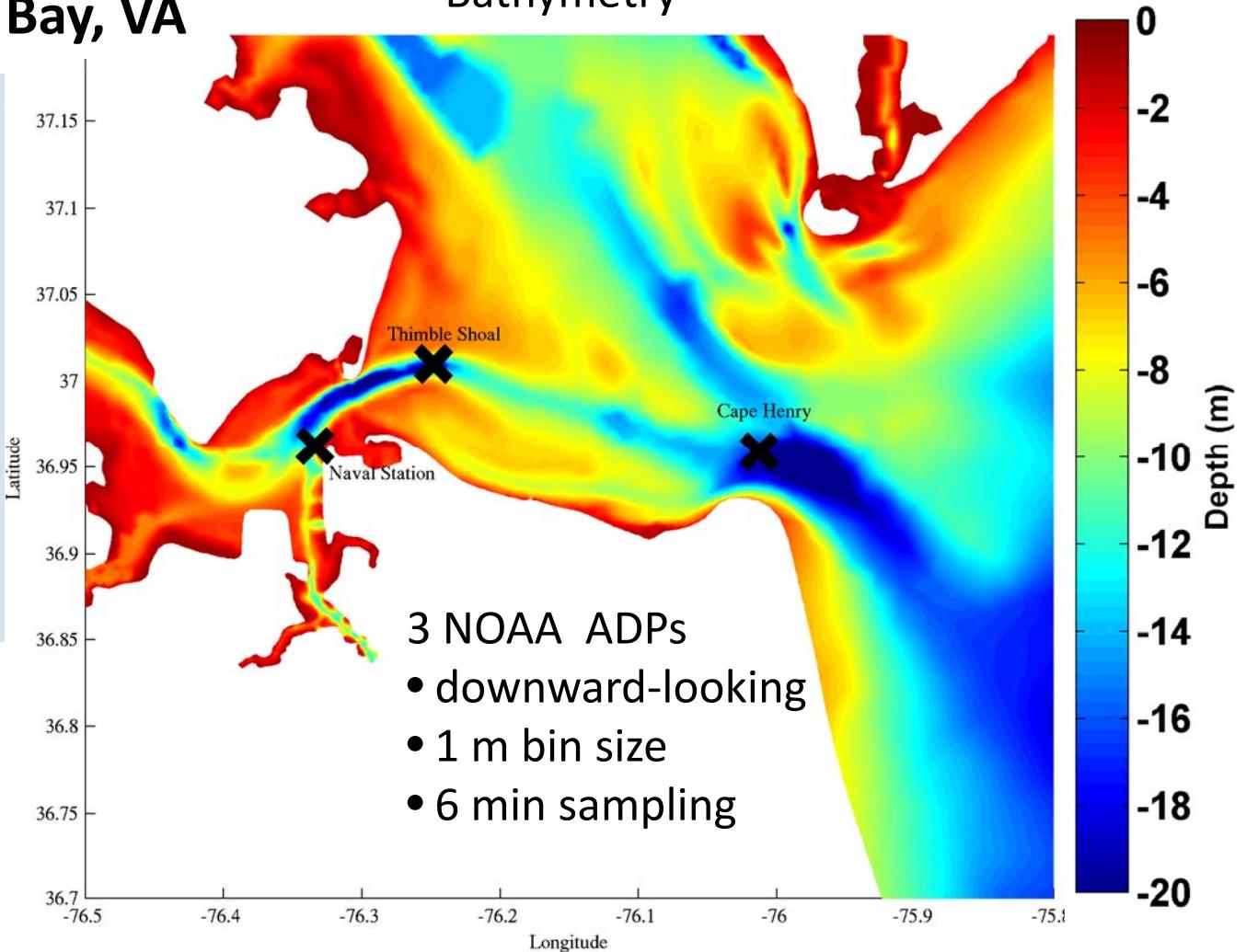
# Sensitivity of Currents to Wind Resolution

## Lower Chesapeake Bay, VA



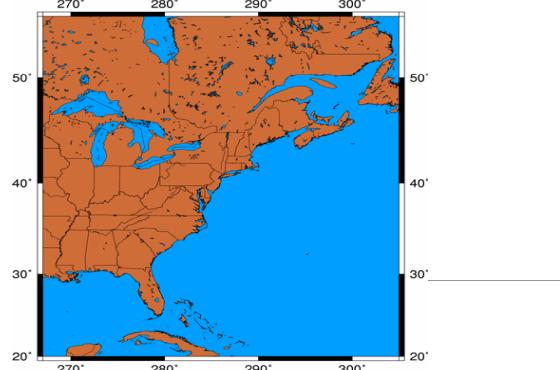
**72-hr forecasts  
4-14 June 2010**

Bathymetry

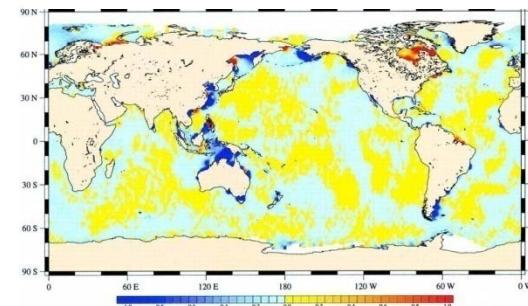


# Coastal Model System

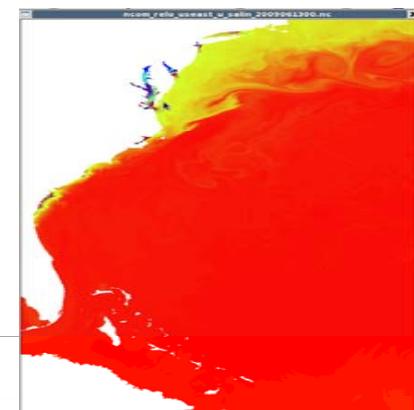
COAMPS 27 km



Global Tides FES2004



NCOM-Eastcoast 3km



Surface forcing

Heat Flux

Wind Stress

Tidal Boundary Conditions

Elev ( $\zeta$ )

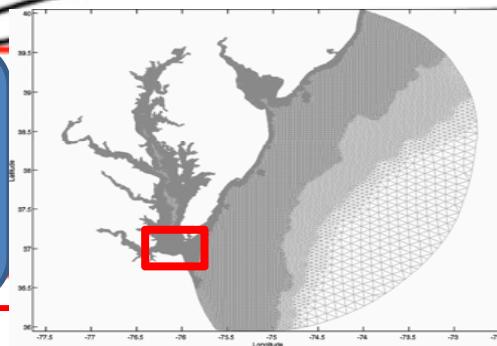
Open Boundary Conditions

$T$   $s$   $\zeta$

Initial condition

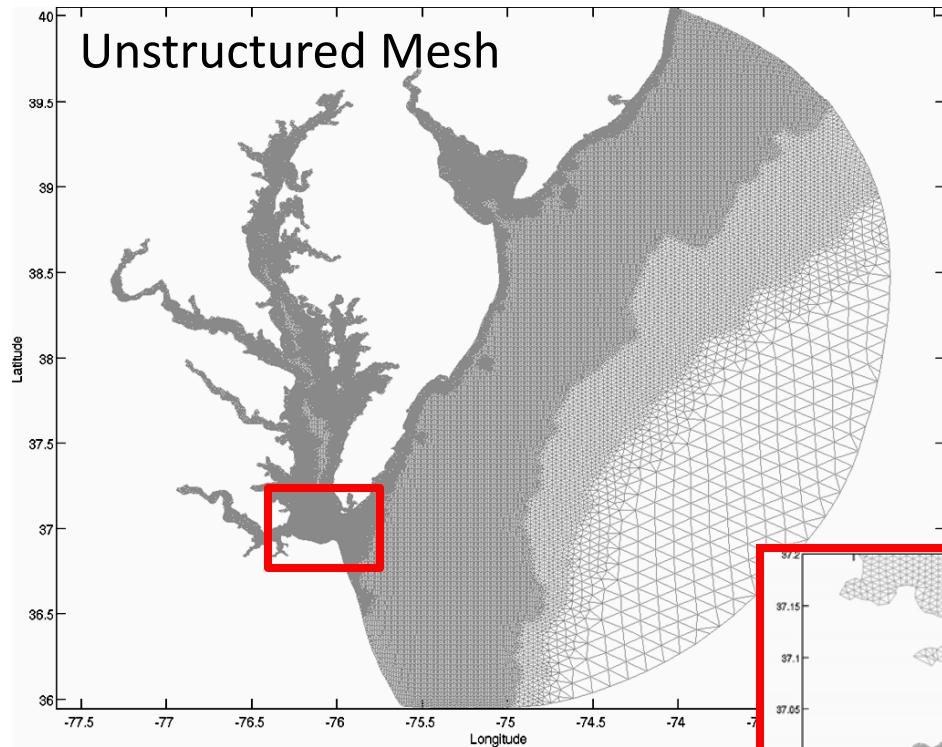
Full set of fields

ADCIRC  
3D Baroclinic  
Model

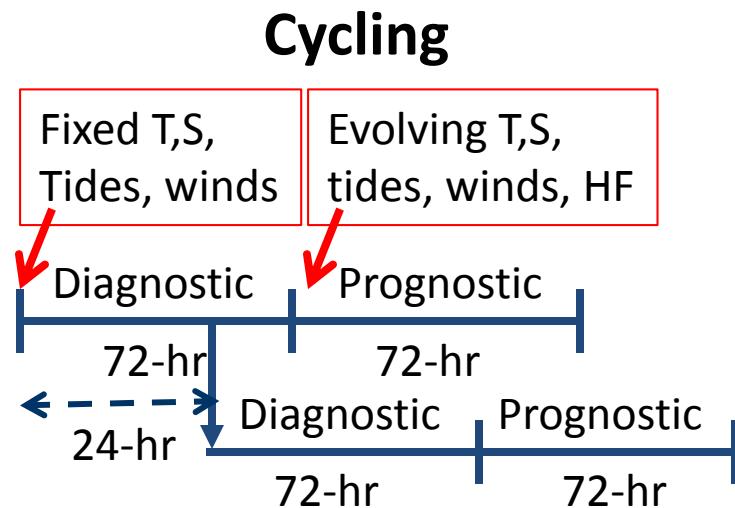


99,309 Nodes  
192,051 Elements  
120 m -14 km Resolution

# Real-time Implementation



99,309 Nodes  
192,051 Elements  
120 m -14 km Resolution

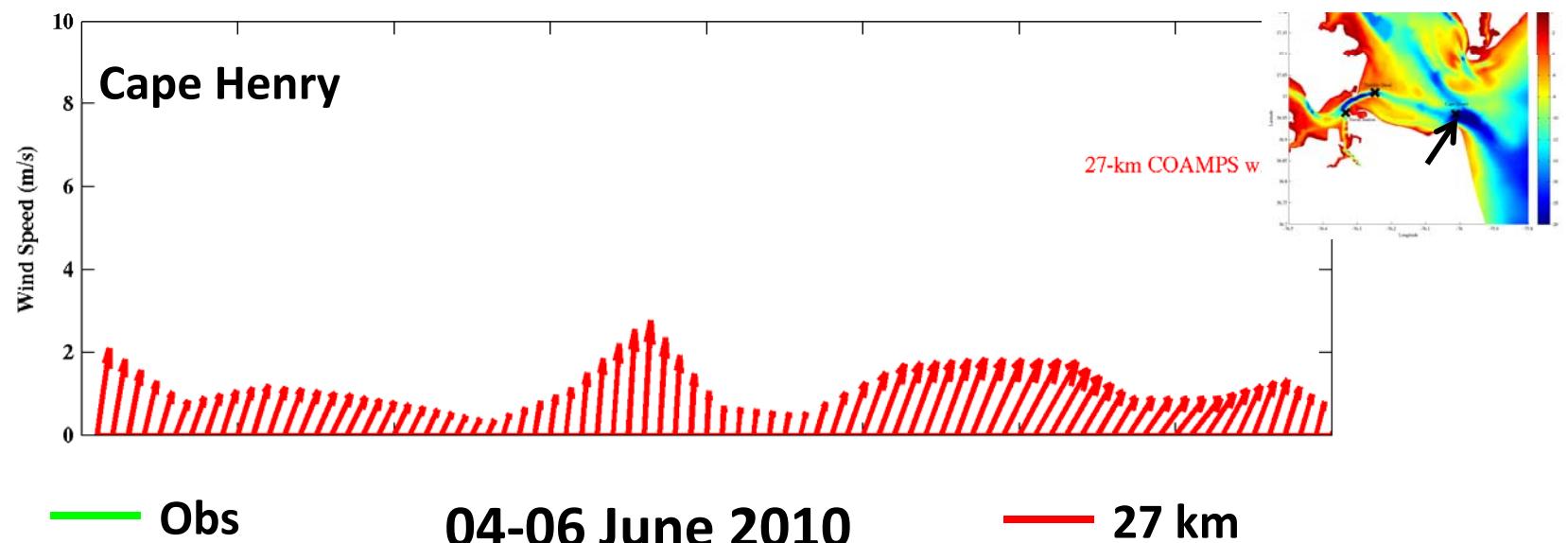


4 hr CPU/ cycle  
on 64 2.8 GHz  
processors

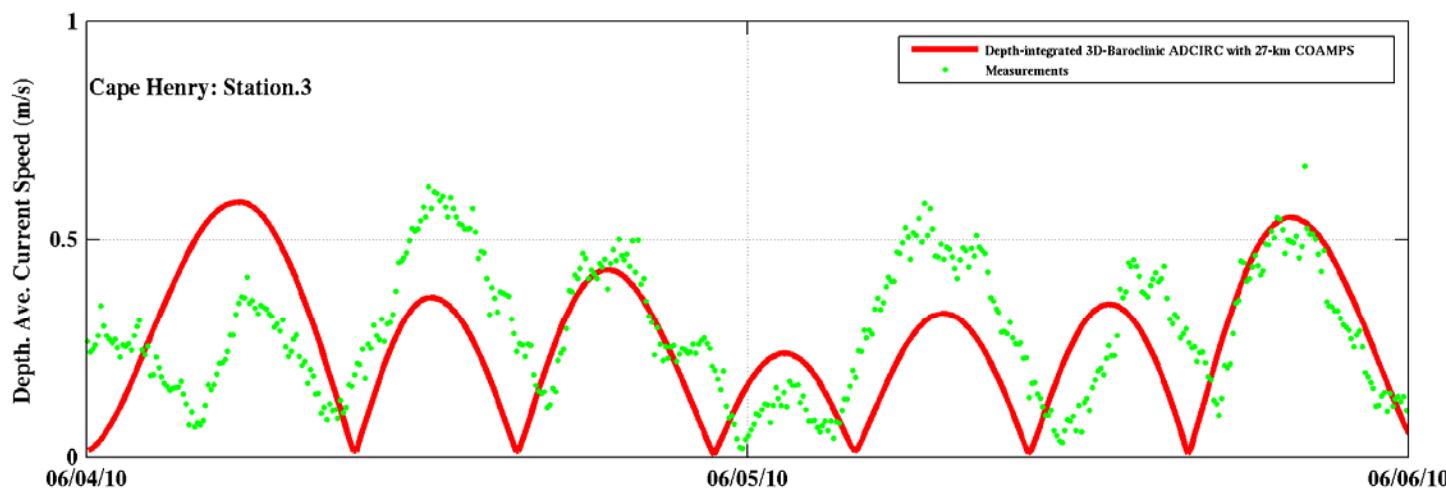
# Current Forecasts vs. Observations

## Depth Avg Currents

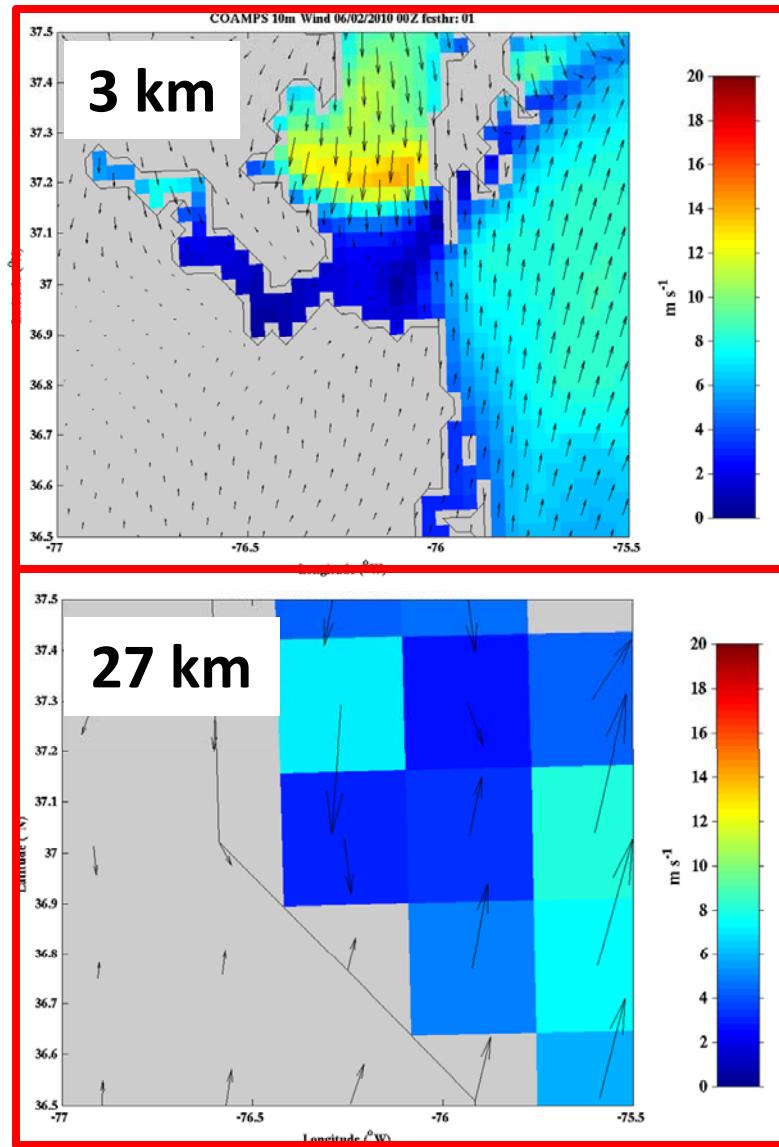
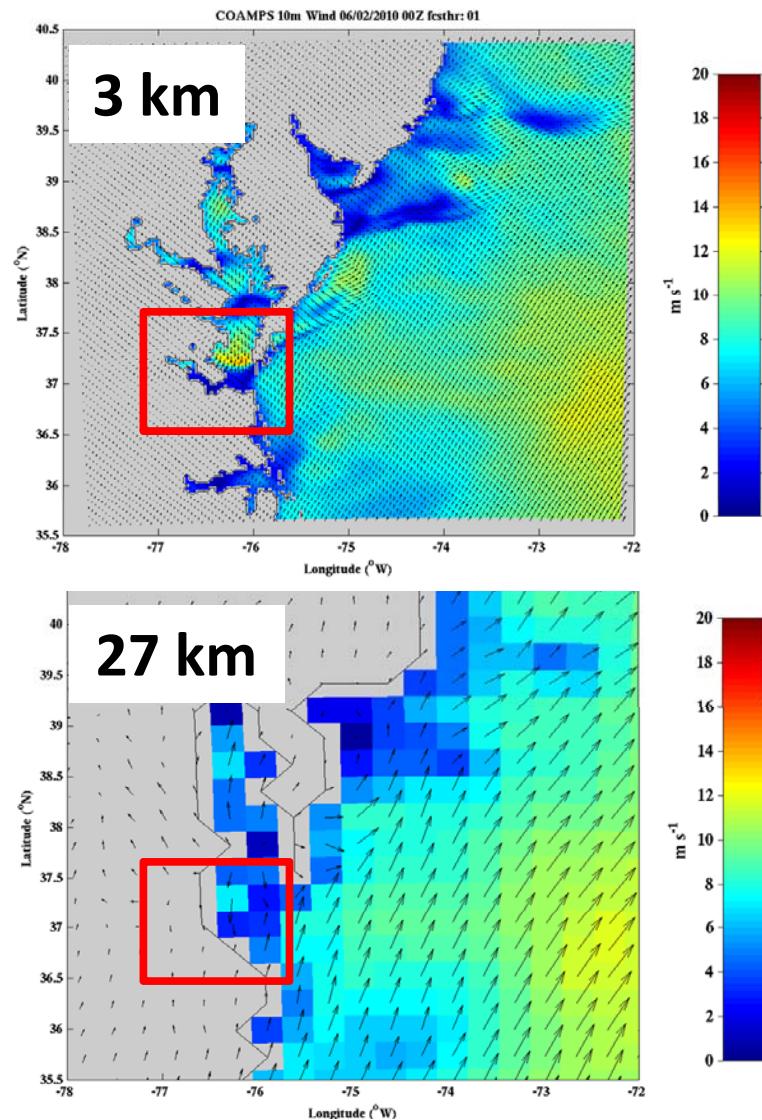
Winds



Depth  
Avg  
Currents



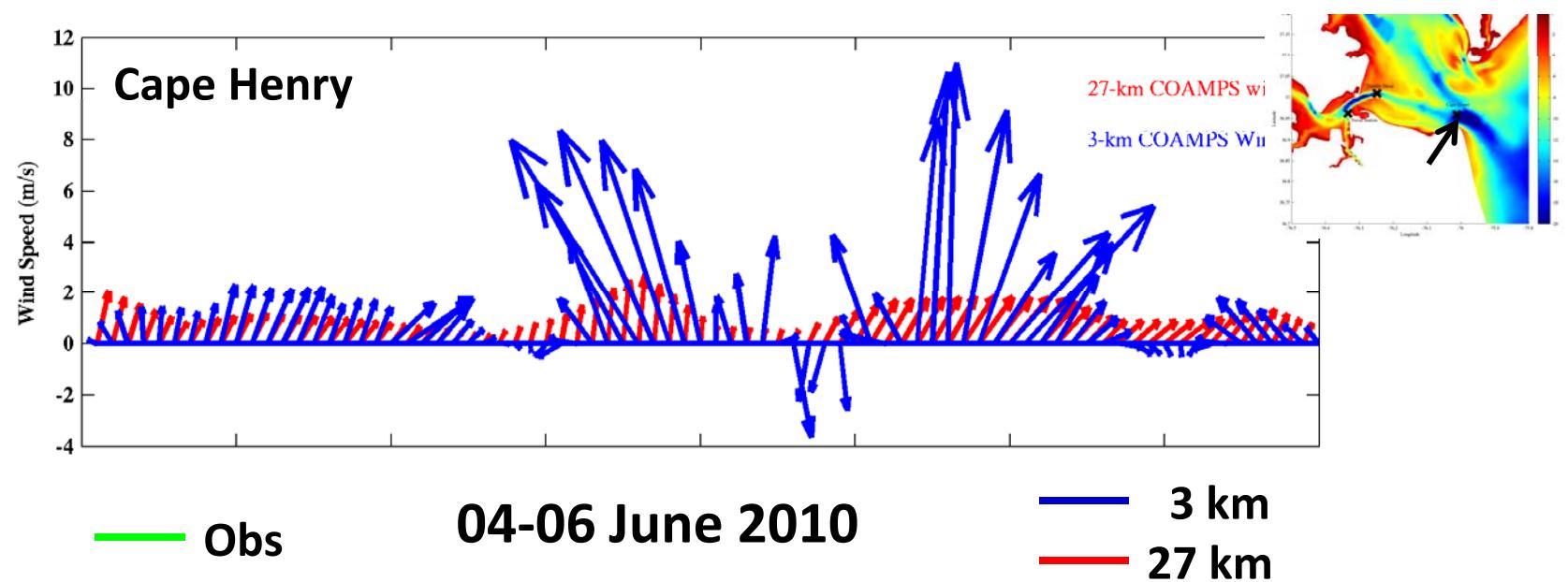
# Sensitivity to Wind Spatial Resolution



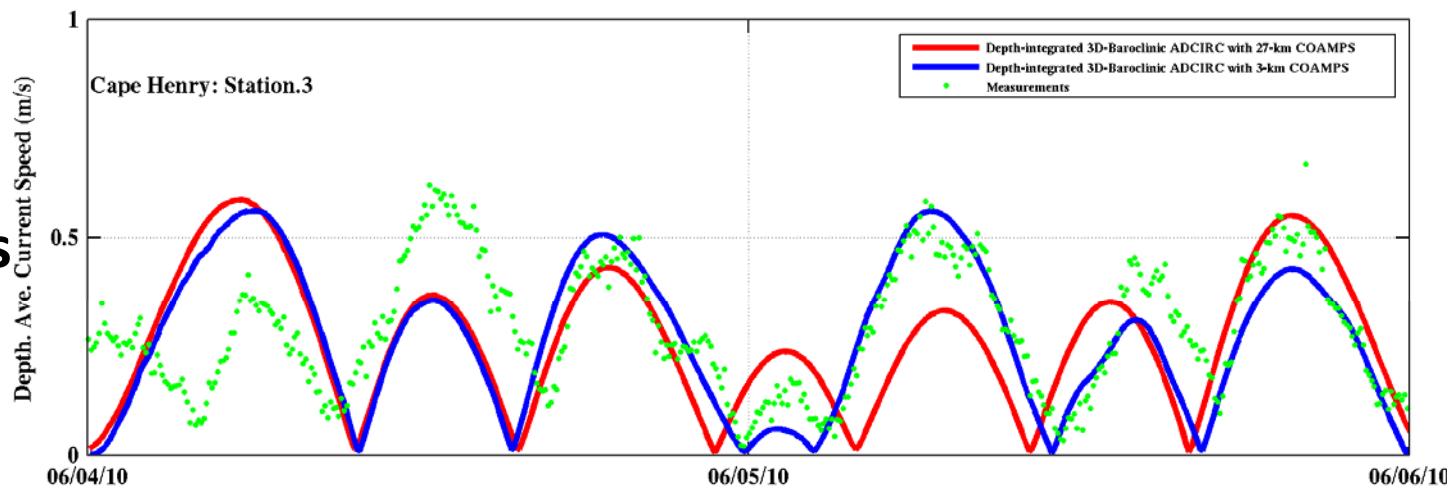
# Current Forecasts vs. Observations

## Depth Avg Currents

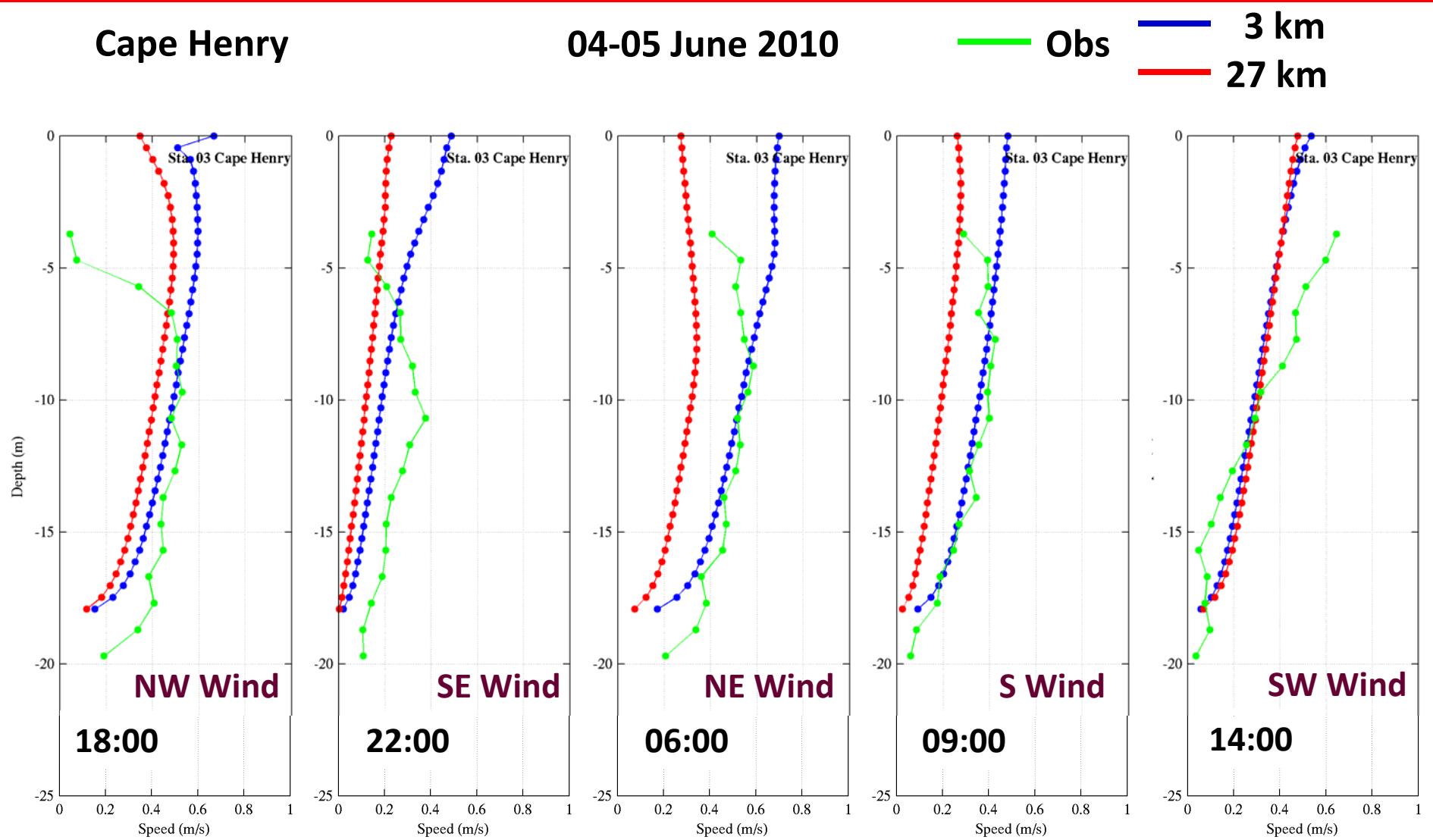
Winds



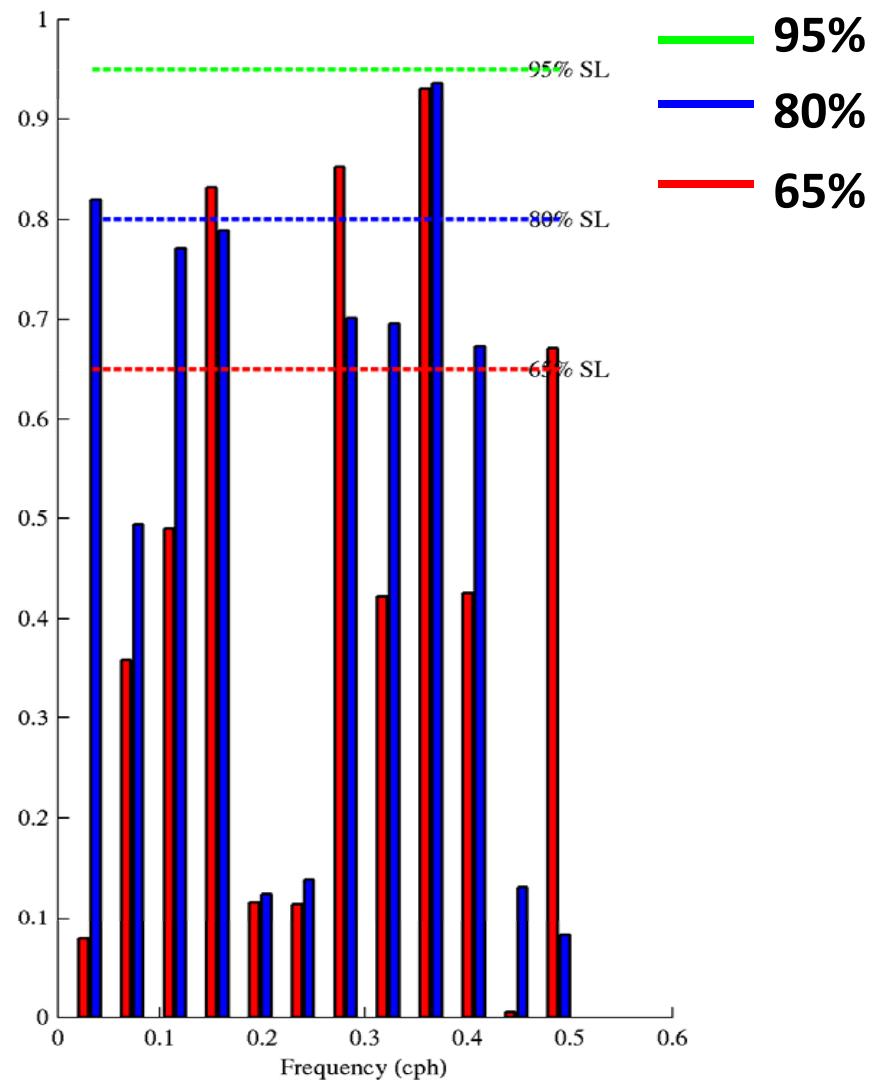
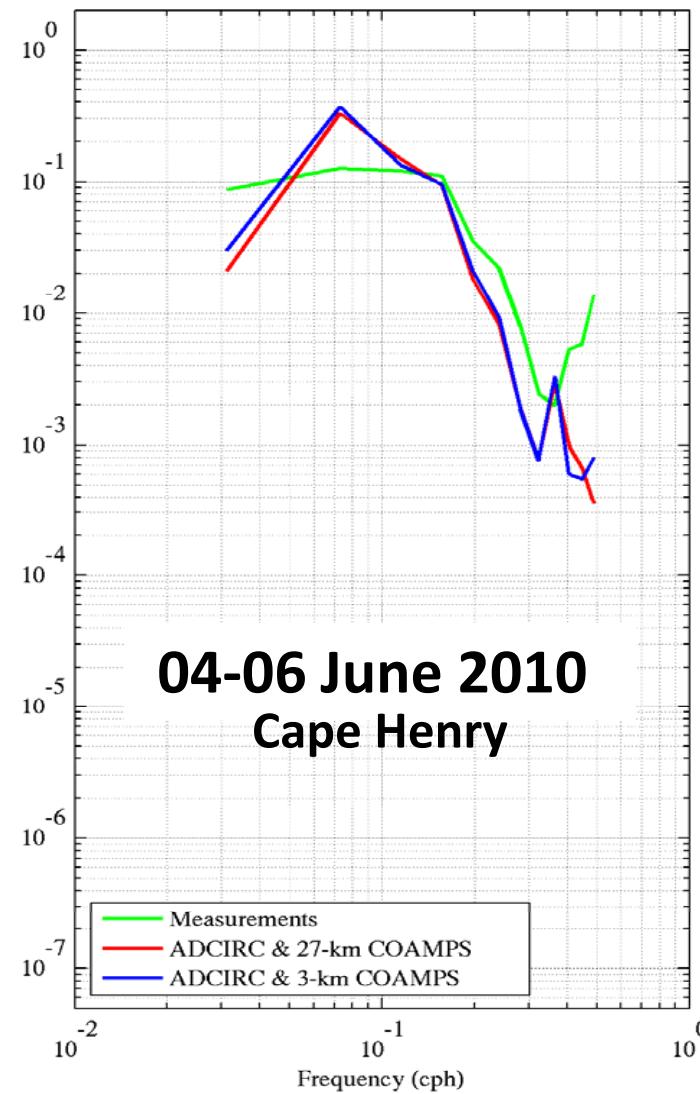
Depth  
Avg  
Currents



# Current Profiles for Varying Winds



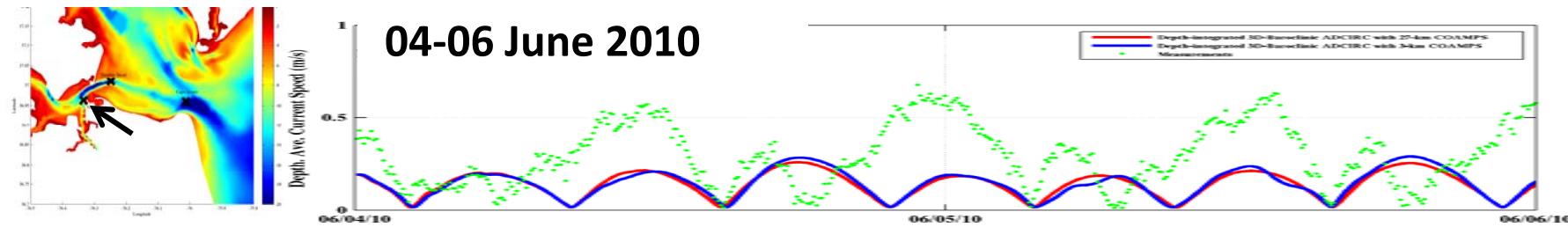
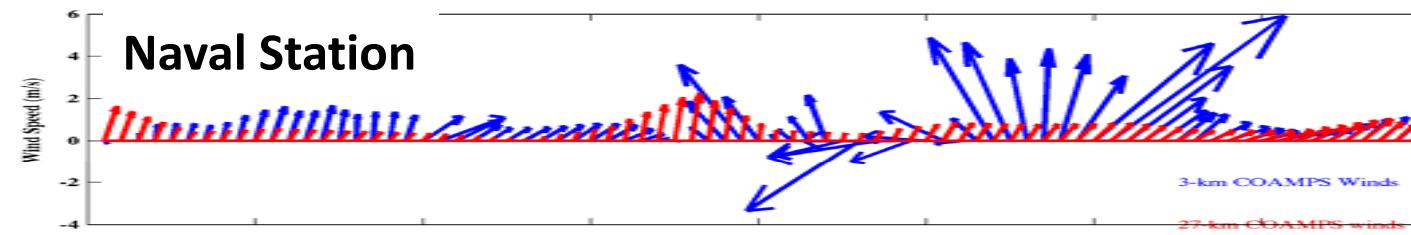
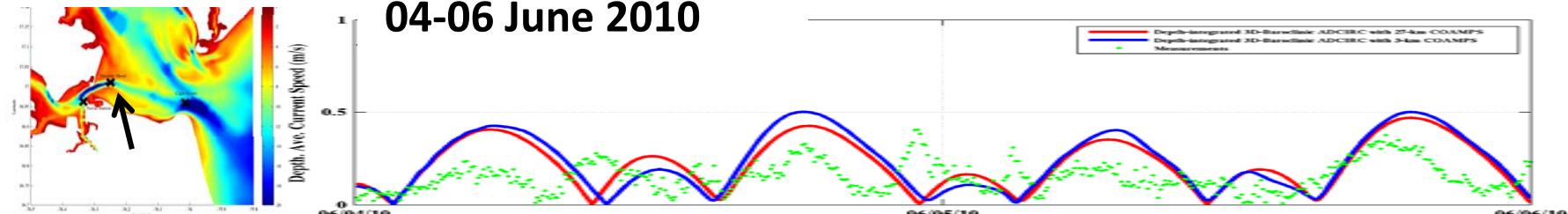
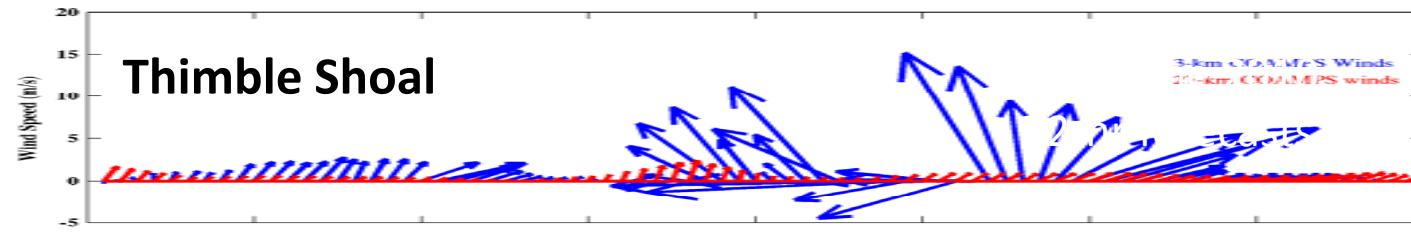
# Coherence of Model vs. Obs. Currents



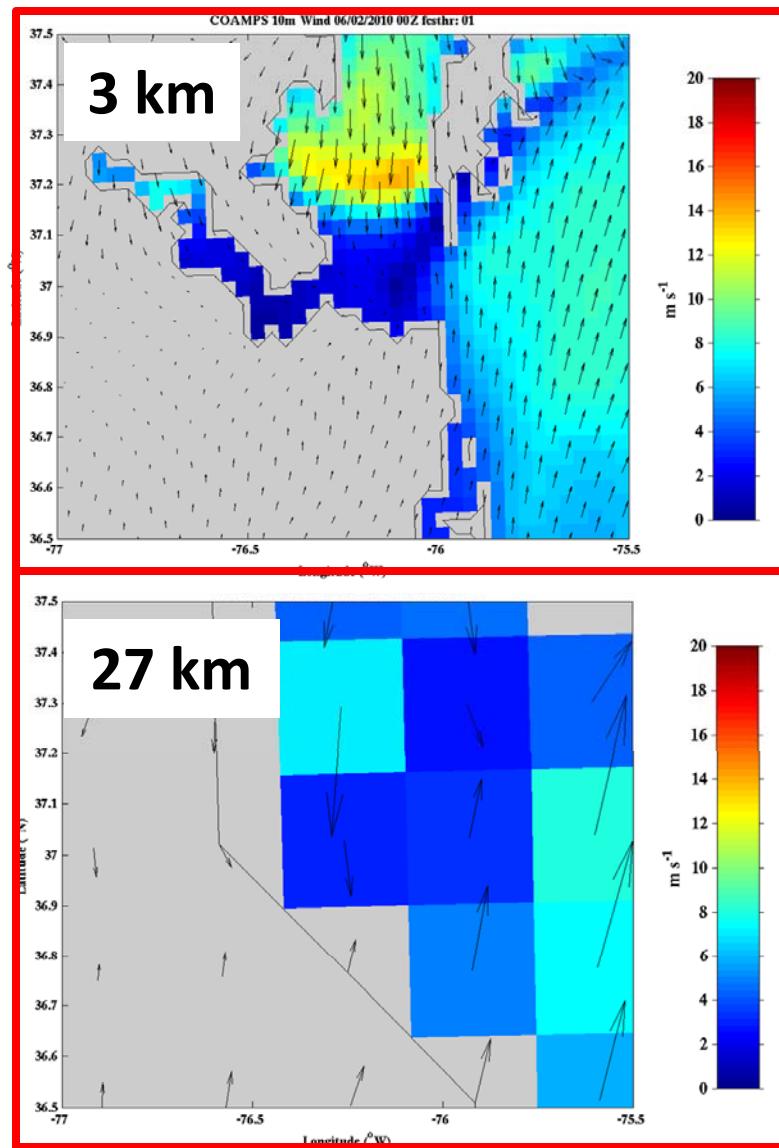
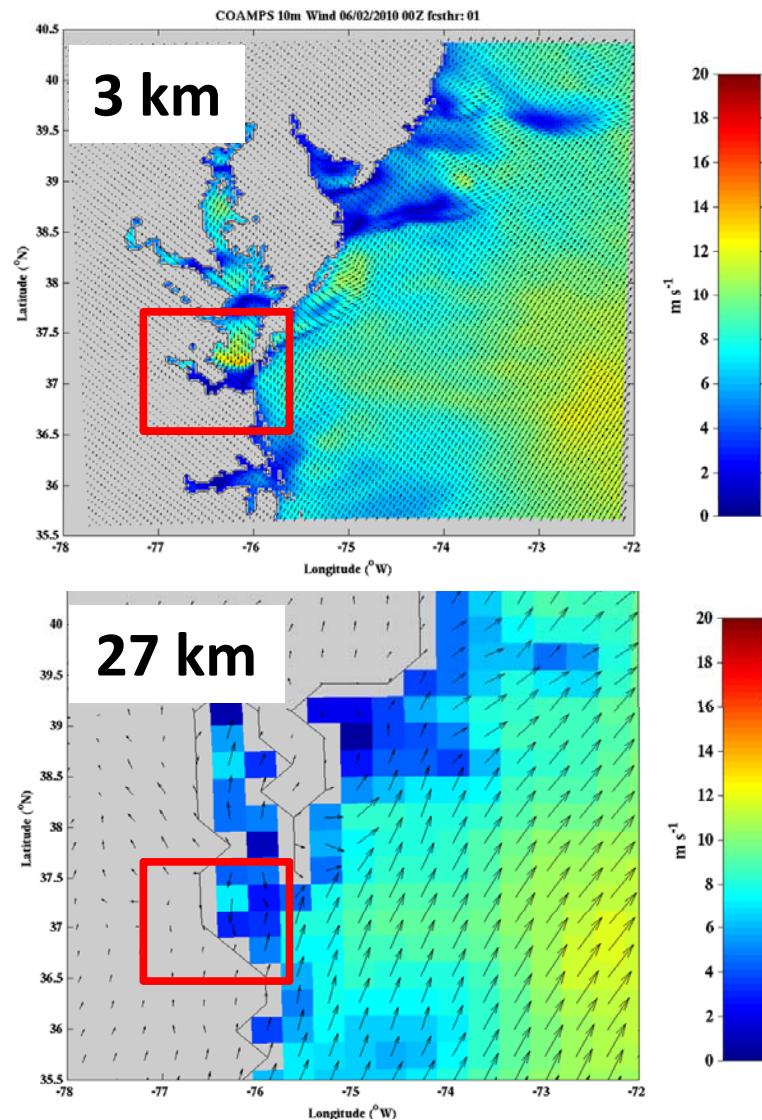
# Current Forecasts vs. Observations

## Depth Avg Currents

- 3 km
- 27 km
- Obs

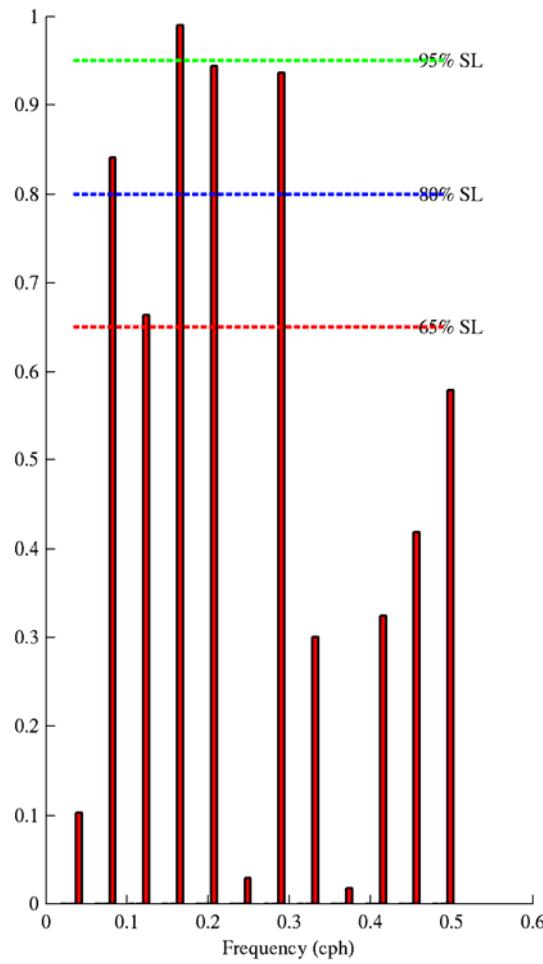


# Sensitivity to Wind Spatial Resolution

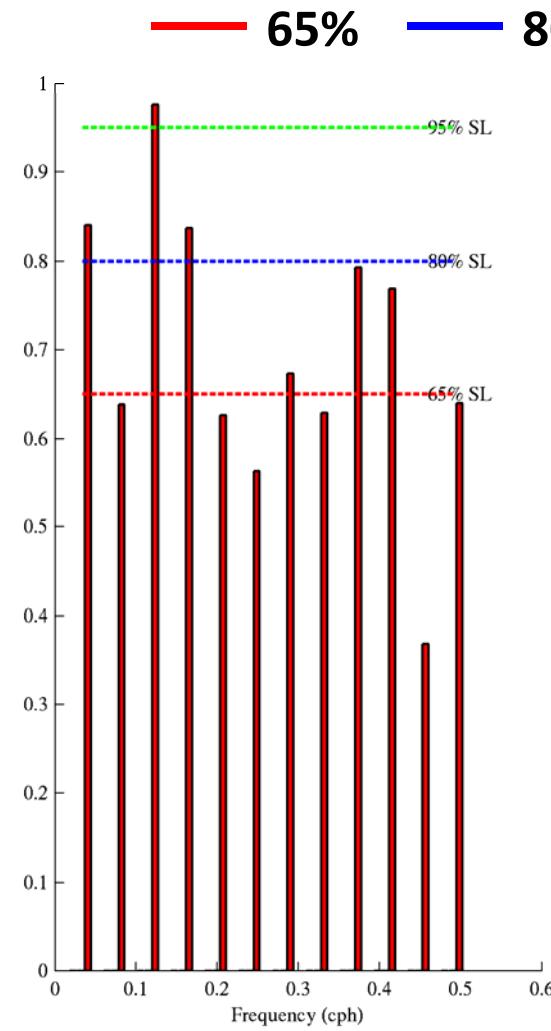


# Coherence of Wind and Currents

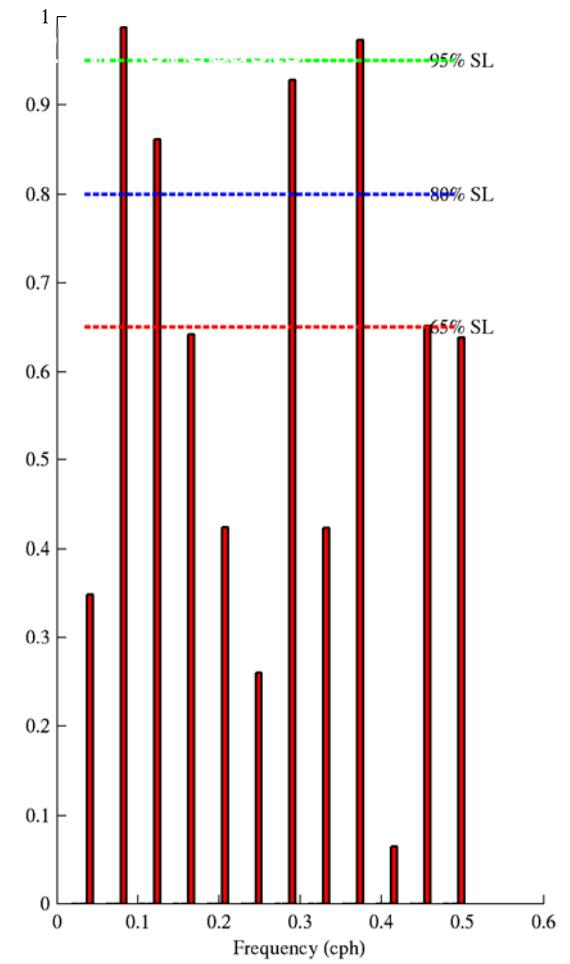
04-06 June 2010



Cape Henry



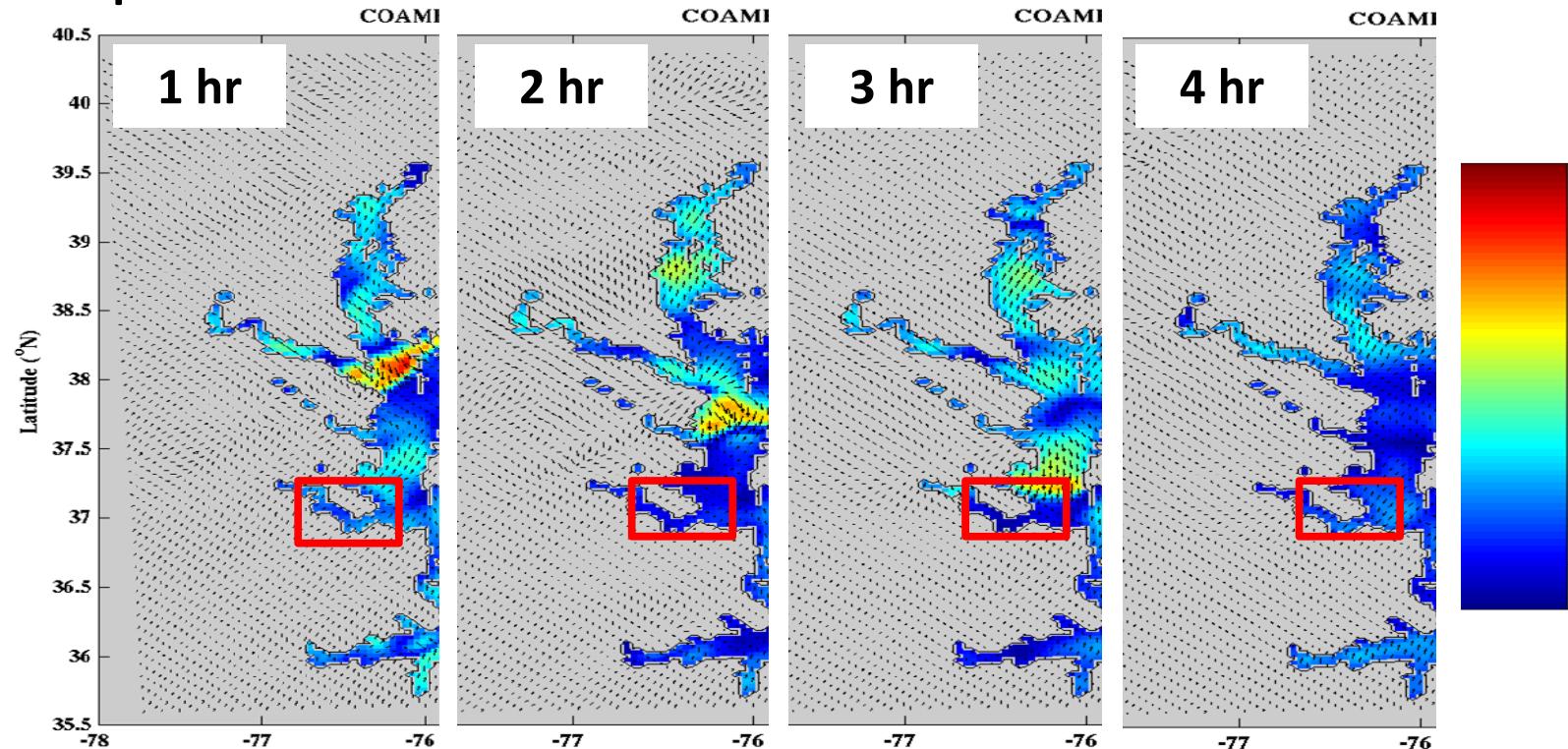
Thimble Shoal



Naval Station

# Other Forecast Considerations

## Temporal resolution of the winds:



## Influence of the Regional model forcing:

- Frequency – daily vs. hourly
- Resolution – 3 km vs. 500 m
- Initialization cycling – 1/day vs. every 3<sup>rd</sup> day vs. no cycling

# Summary

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- For rivers, we have developed an automated approach to extract geometric information and initialize a model from imagery
- The synthetic bathymetry for rivers is a viable alternative when true bathymetry is unknown
- Models based on unstructured grids can best represent local dynamics in geometrically complex environments
- Forcing including wind and regional model solutions must be consistent with the spatial and temporal scales of the near-coastal model forecasts
- Bathymetry and bed stress play an increasingly critical role in shallow waters