Overview of Surge Dynamics and Modeling

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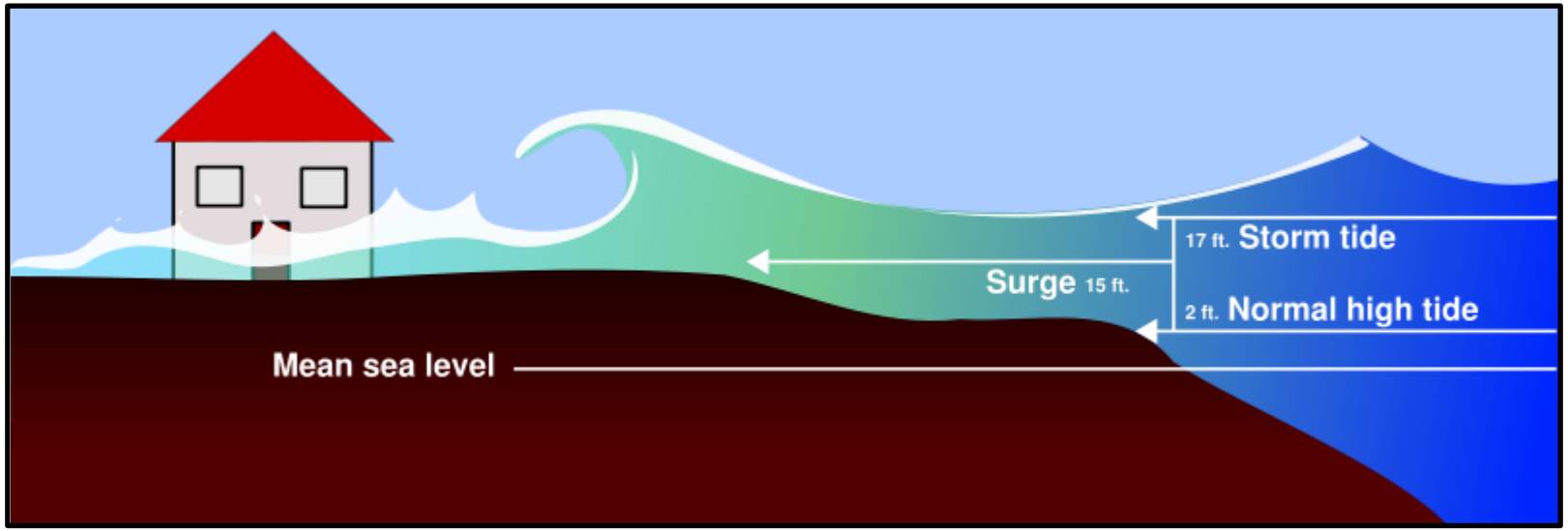
ARCADIS

Goals:

- Update existing surge/wave model
- Compare elevations to new LTER bathy-topo elevation model
- Select 4-5 representative storm scenarios
- Perform simulations with four RSLR scenarios:
  - Present Conditions
  - Low
  - Med
  - High
- How sensitive is surge/wave risk to RSLR?

What is Storm Surge?

- Elevated ocean surface due to wind and pressure
- Wind stress pushes water
- Wind stress generates waves
- Wave radiation stresses also push on water column

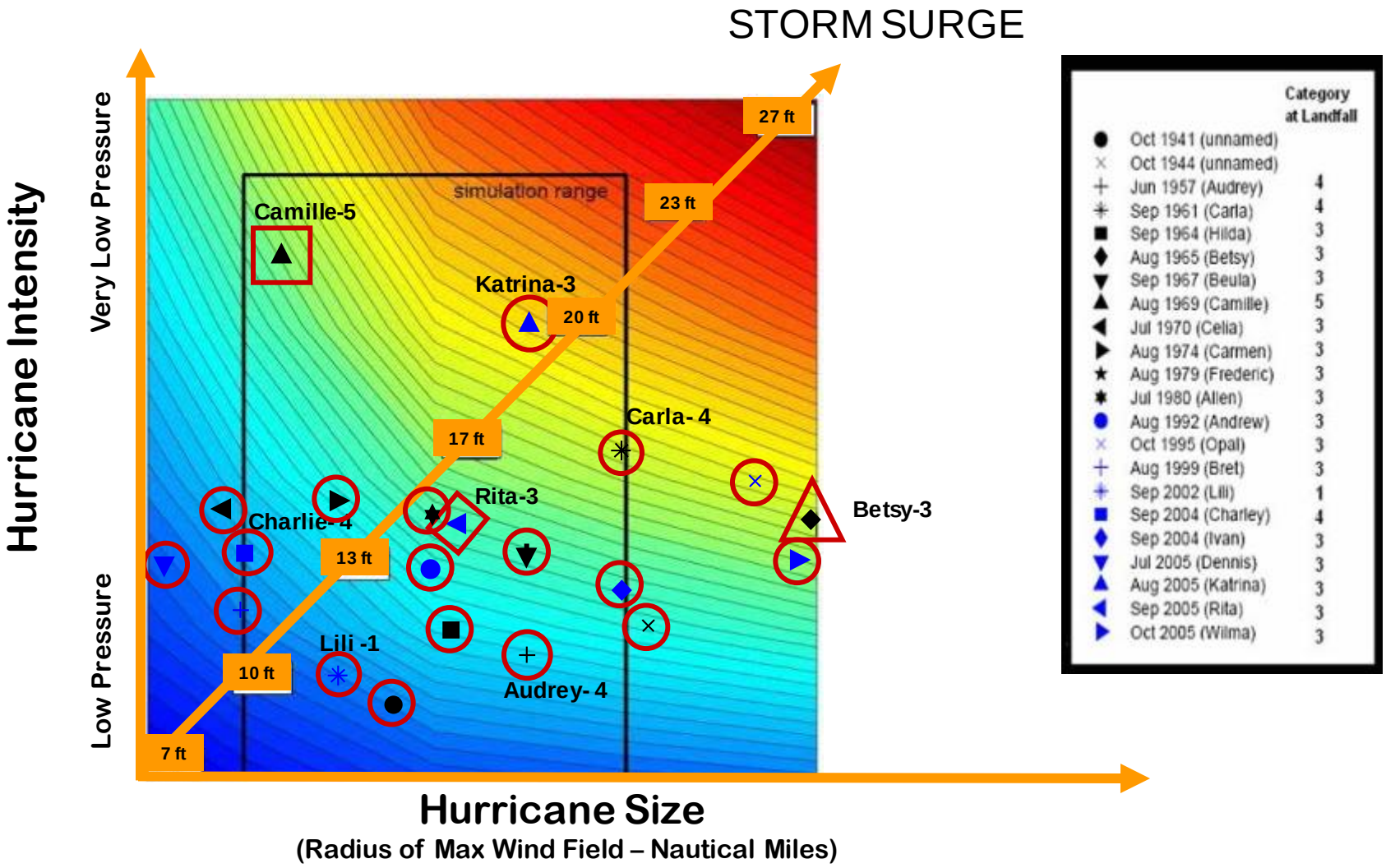


Factors that influence surge

- Wind speed
- Track angle
- Forward speed
- Radius to maximum wind

Saffir-Simpson is not adequate to predict surge

Factors that influence surge

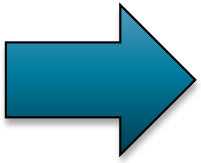
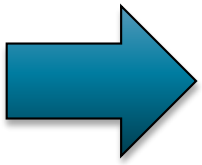


Accurate surge/waves modeling requires:

- Define the physical system
  - Topography and bathymetry
  - Local roughness
  - Critical hydraulic conveyances
  - Hydraulically relevant structures (roads, dunes, etc)
  - Accurate wind and pressure data
  - Wind-wave transformation

- Include all relevant flow scales

What is a model?

Data  Code  Output

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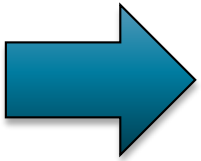
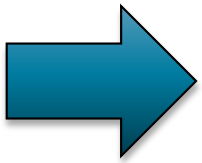
Data  Code  Output

bathymetry & topography

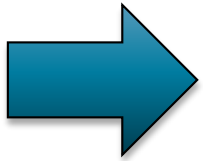
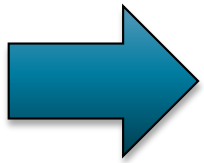
finite element mesh

friction parameters

wind data

river flow rates

What is a model?

Data  Code  Output

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} **Boundary Conditions**

ARCADIS

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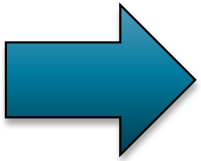
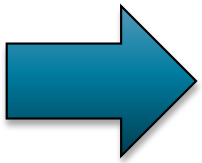
Data  Code  Output

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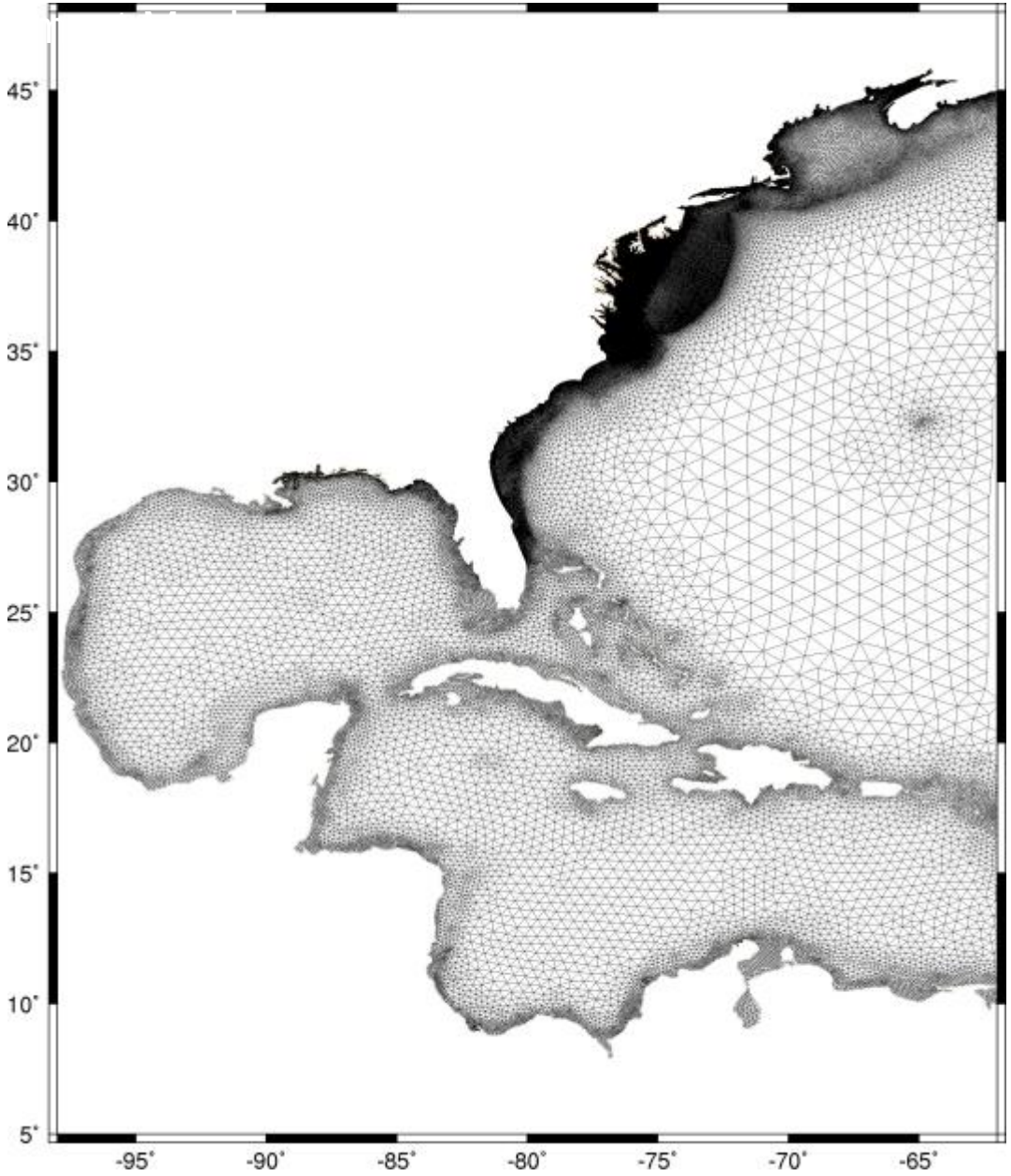
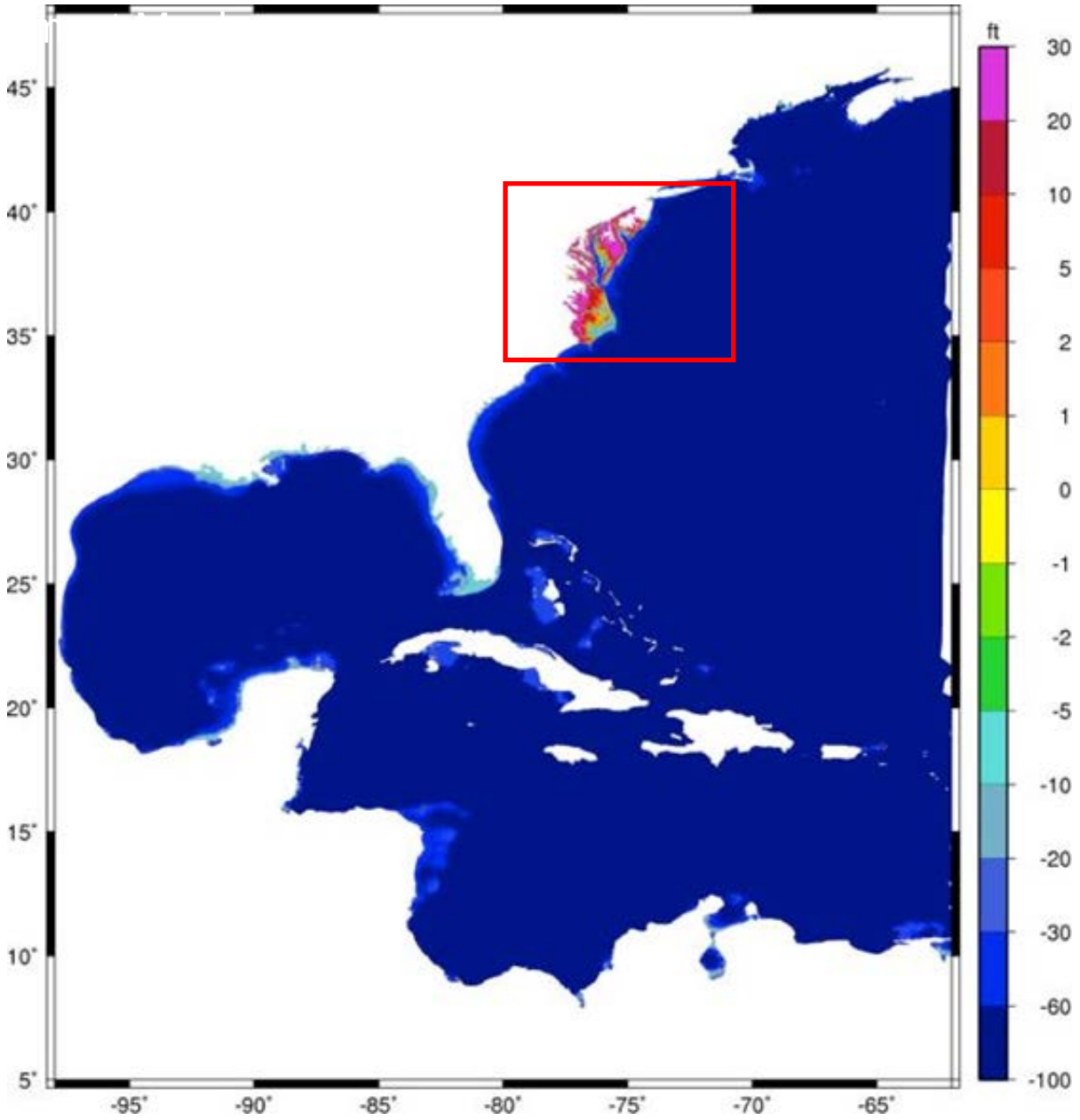
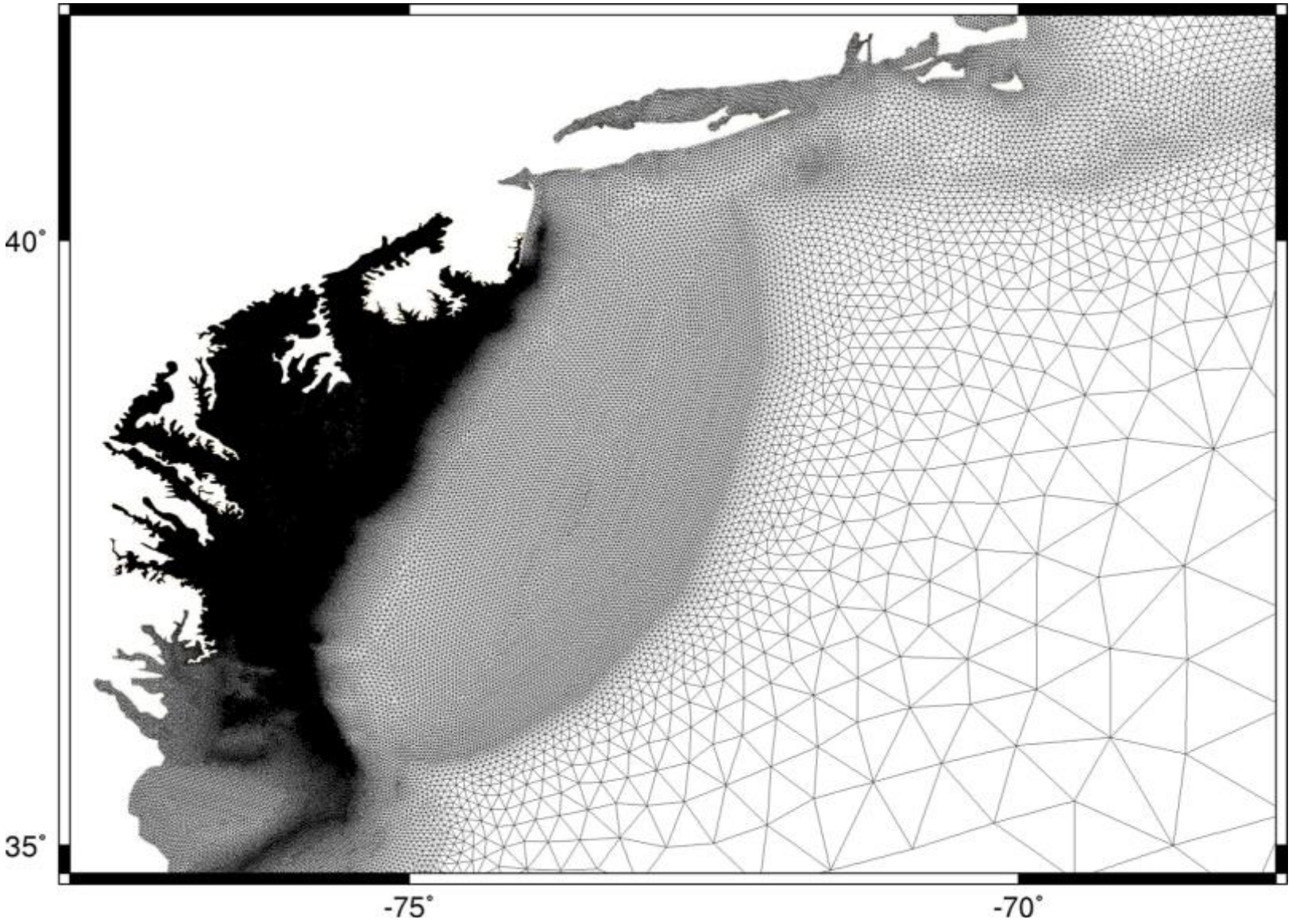
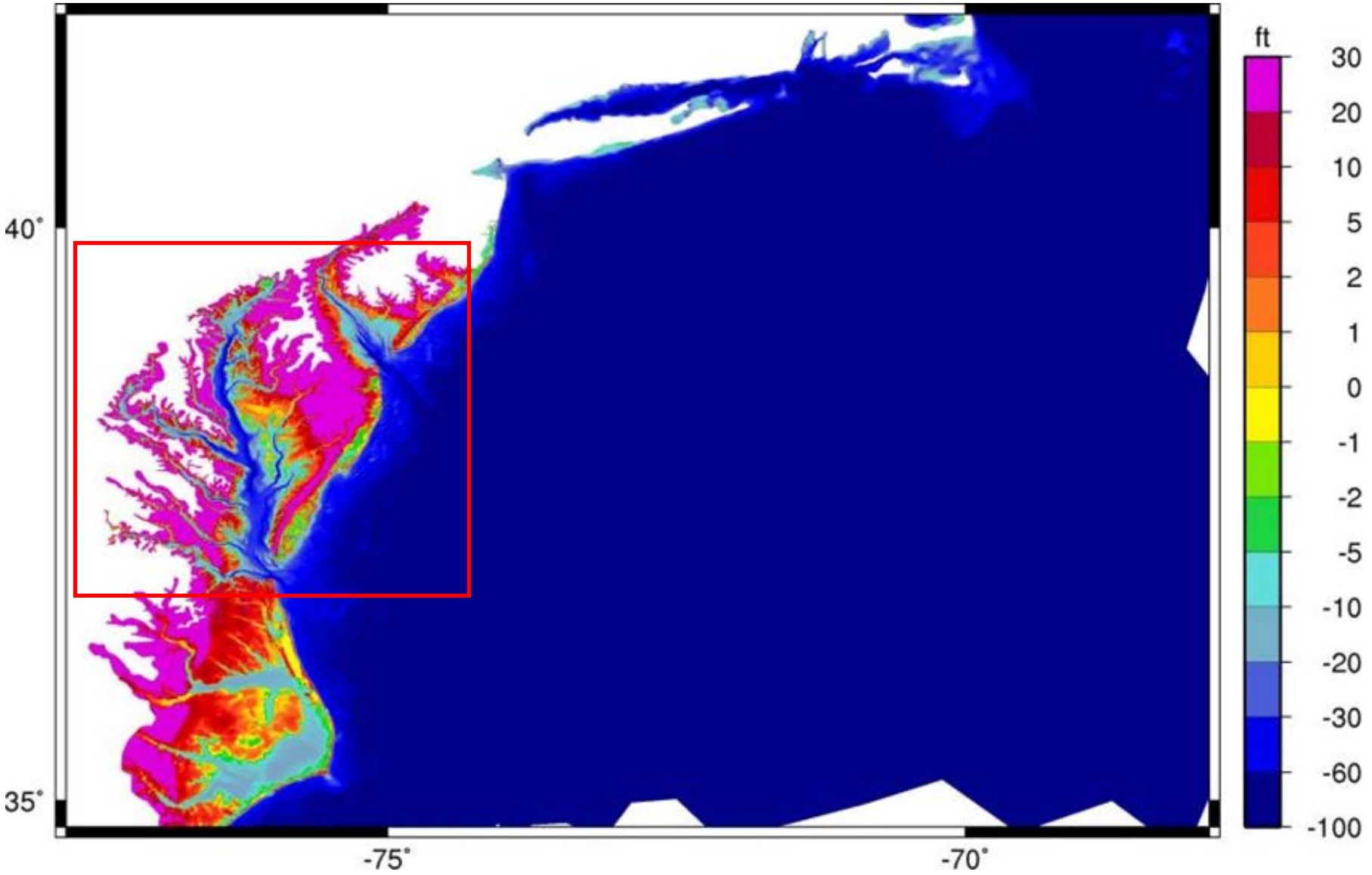
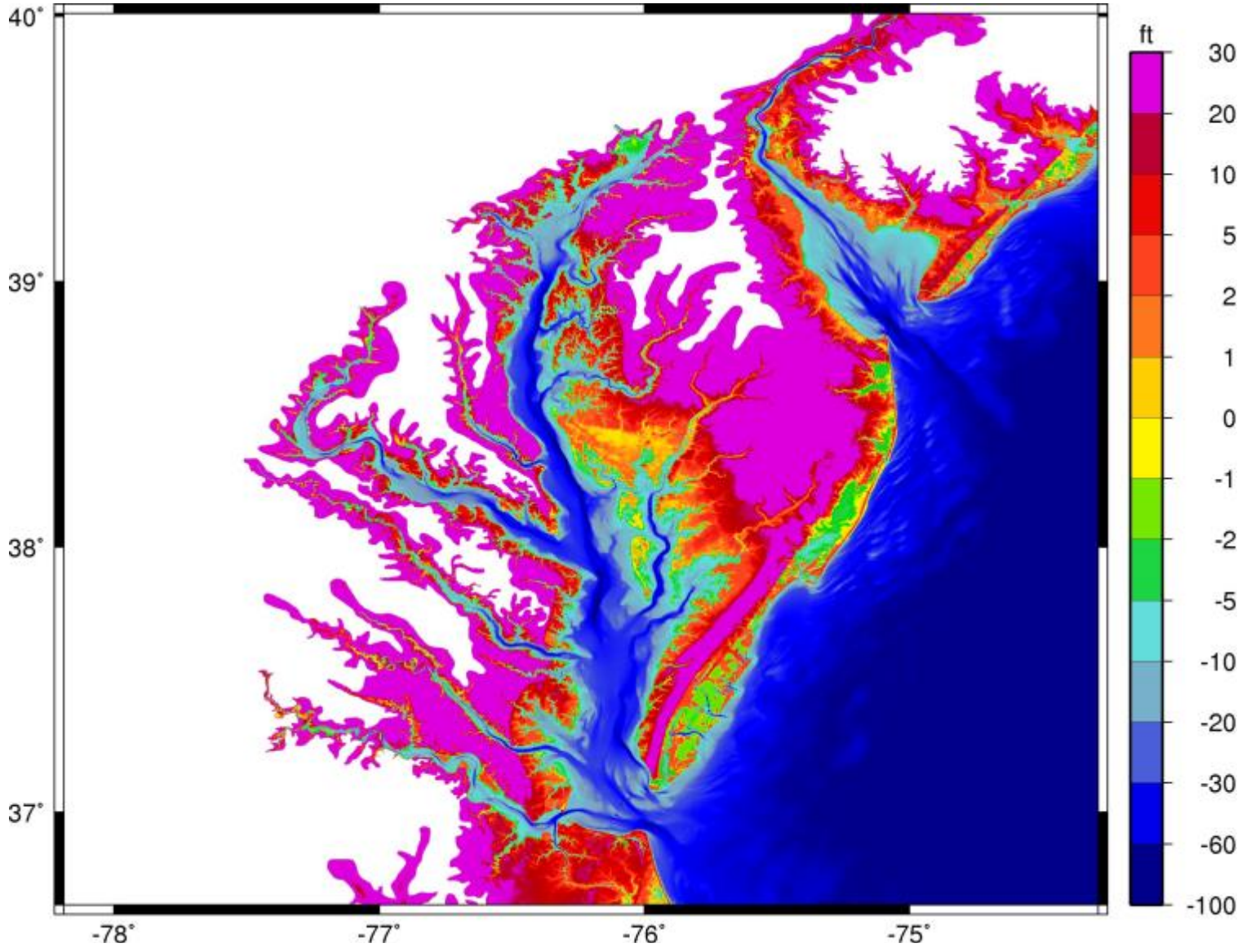
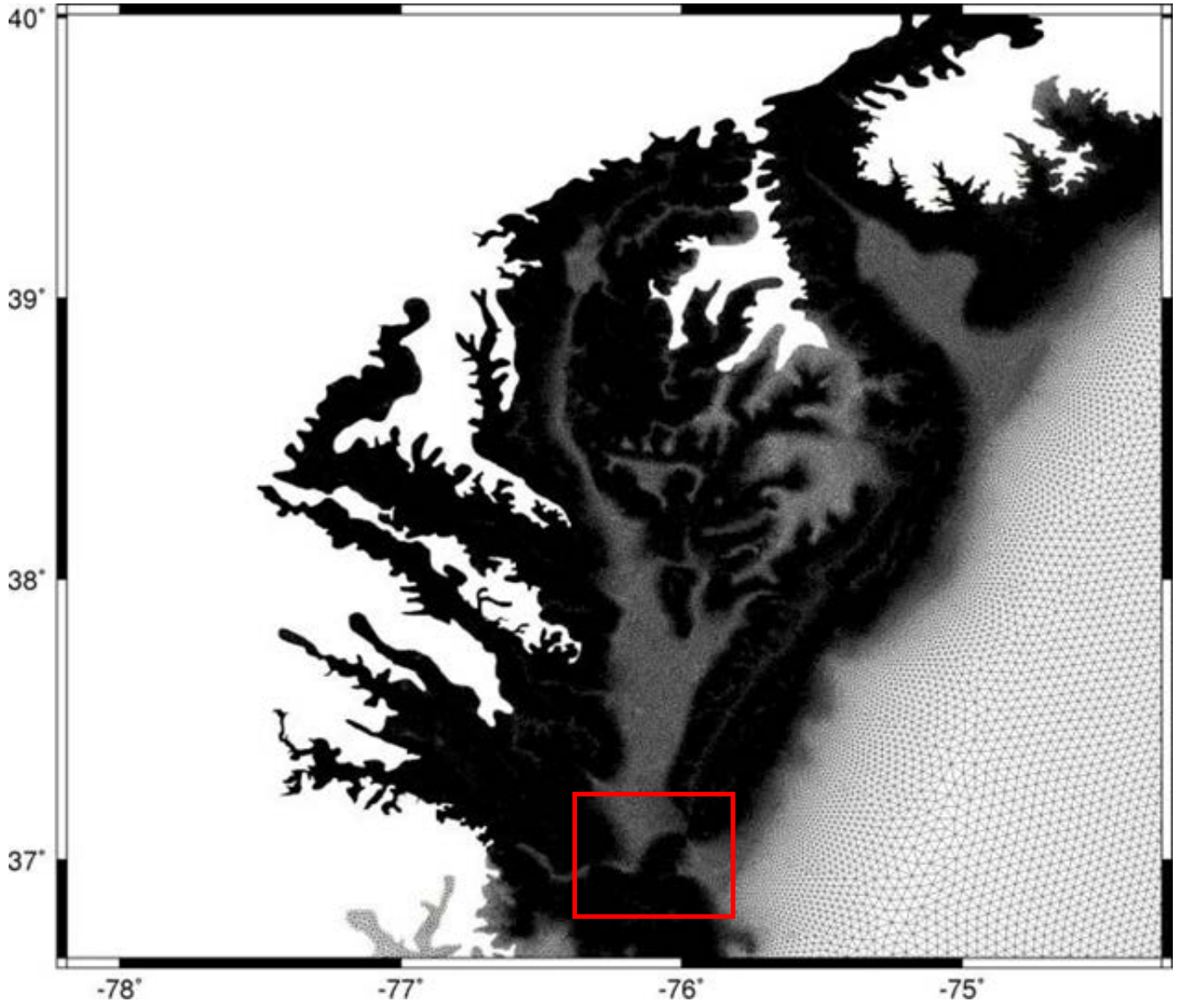


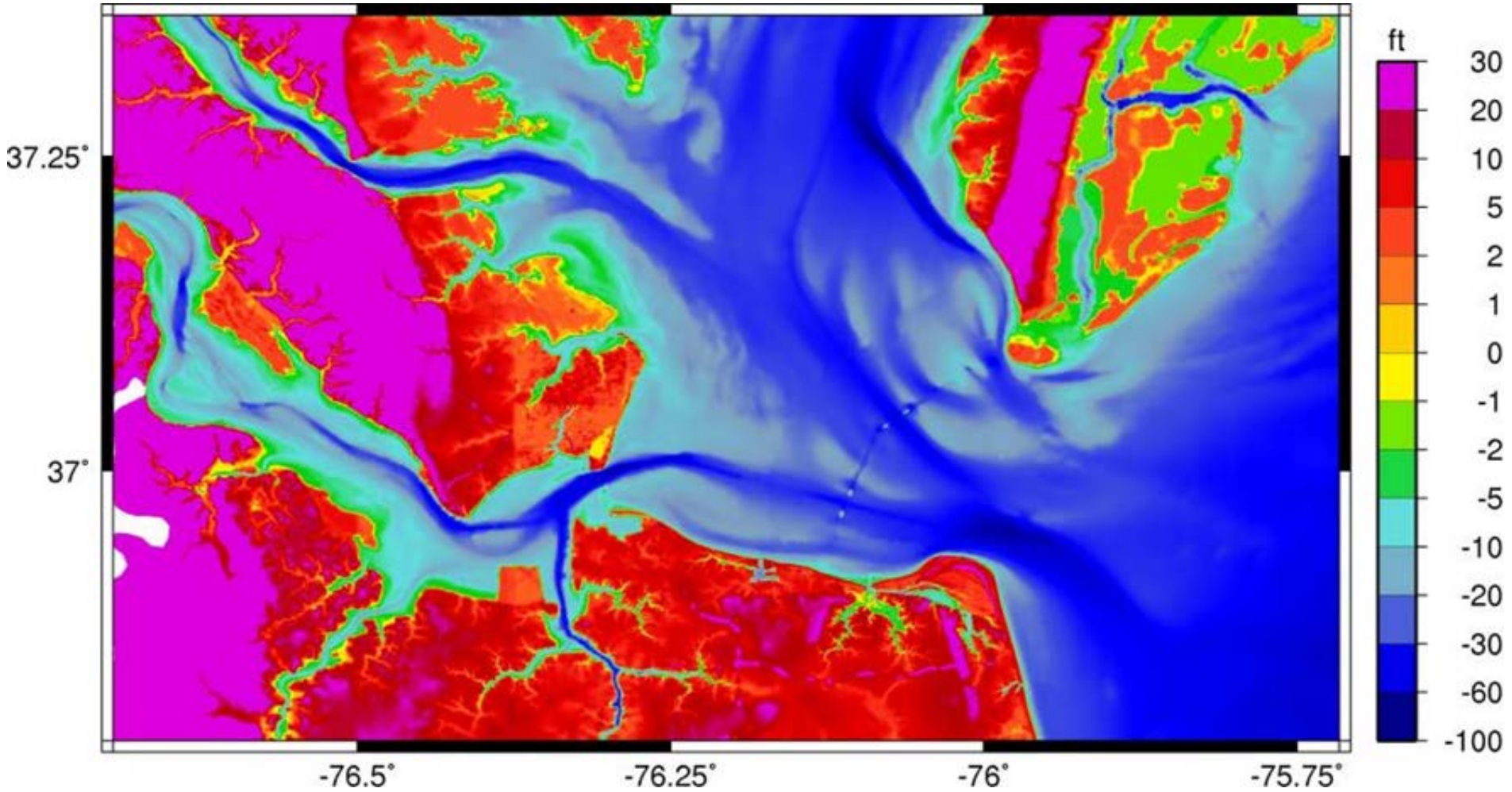


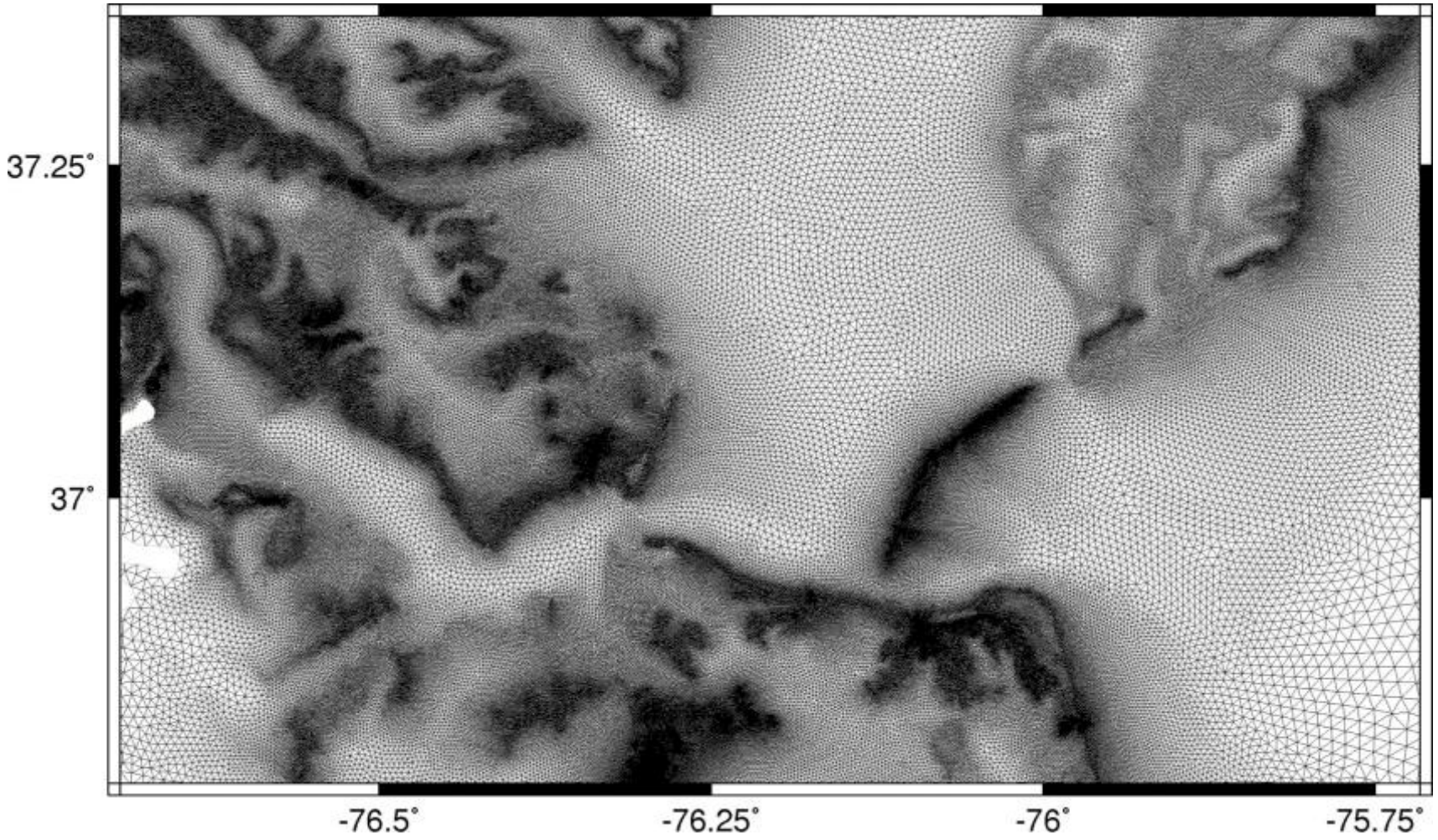


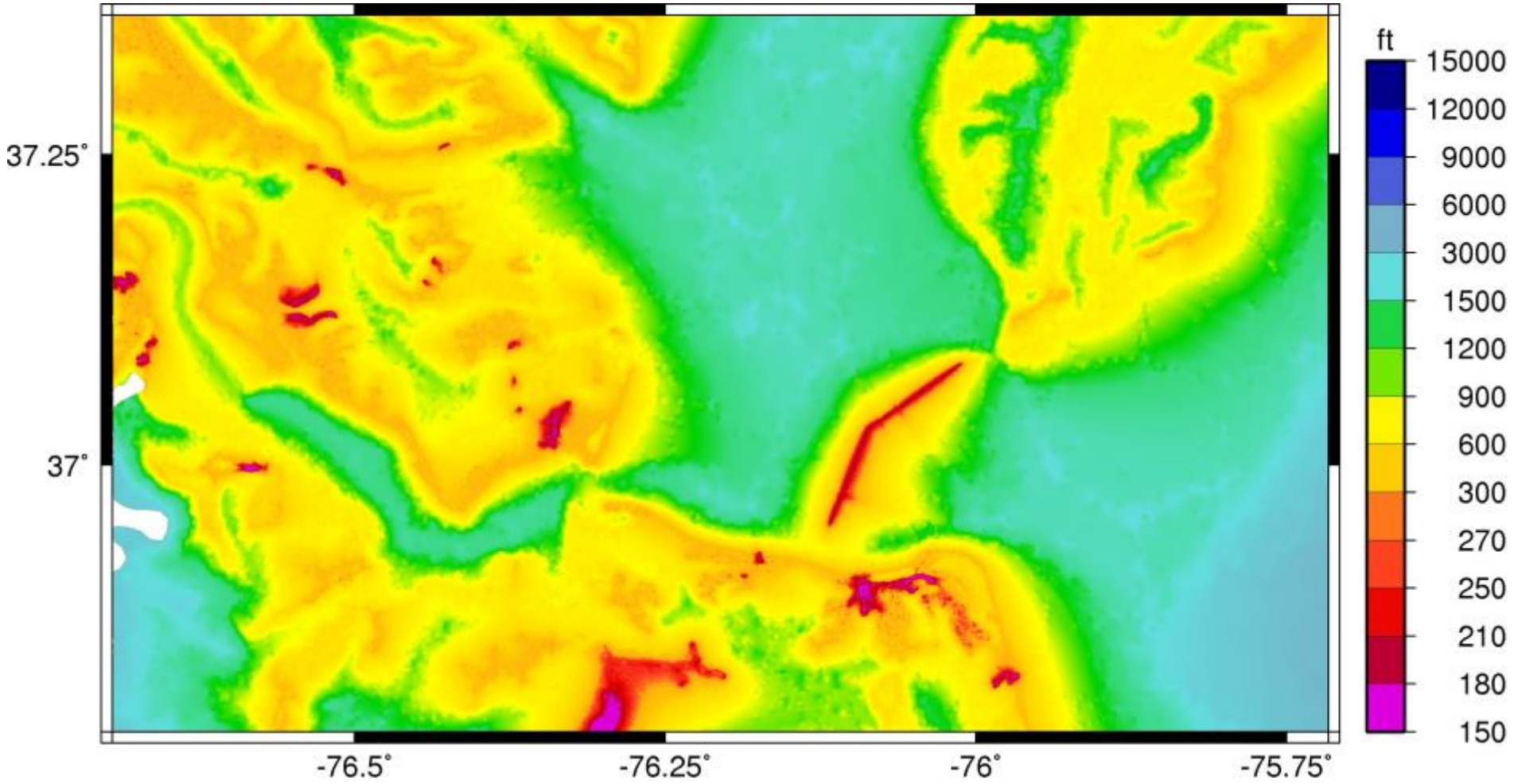


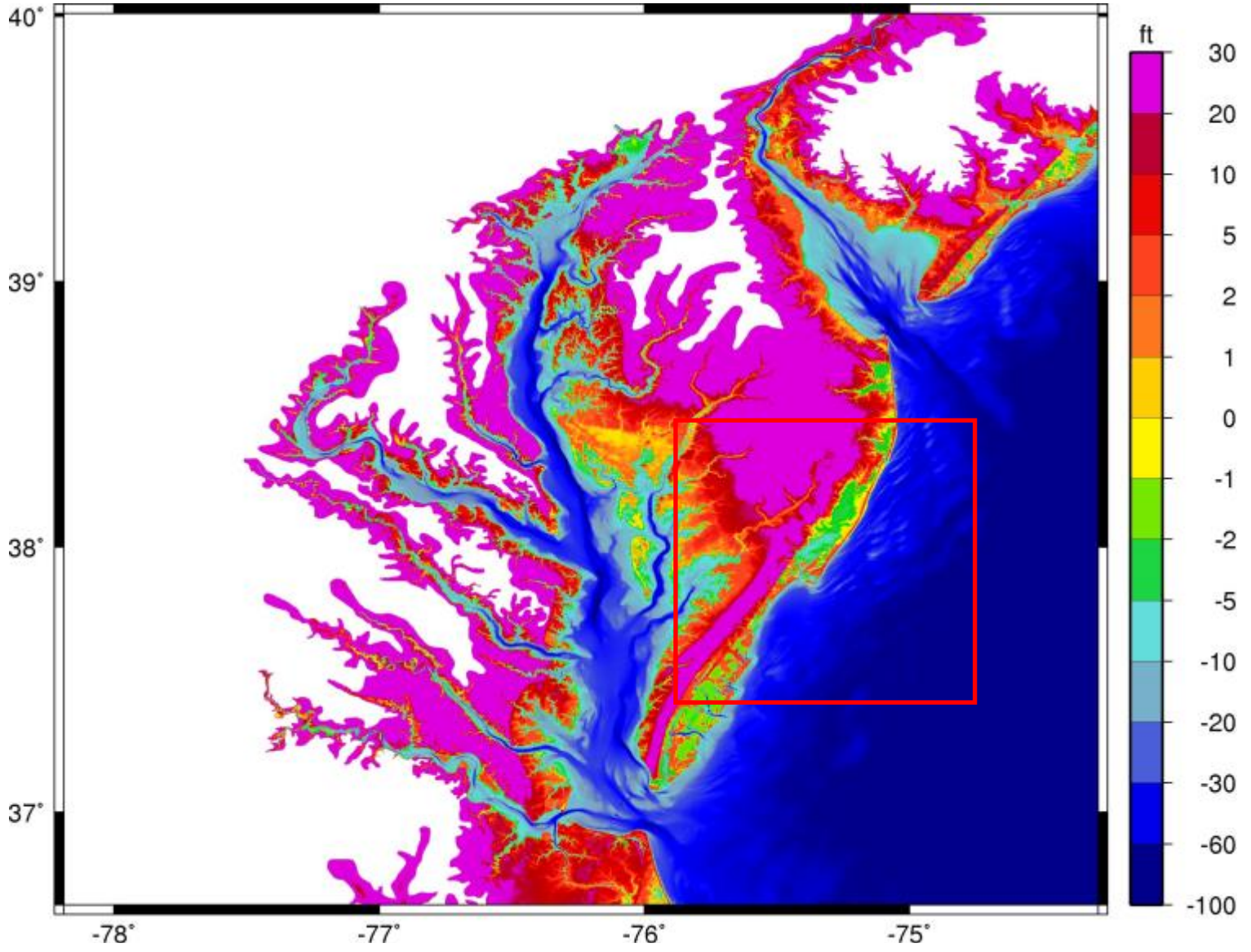


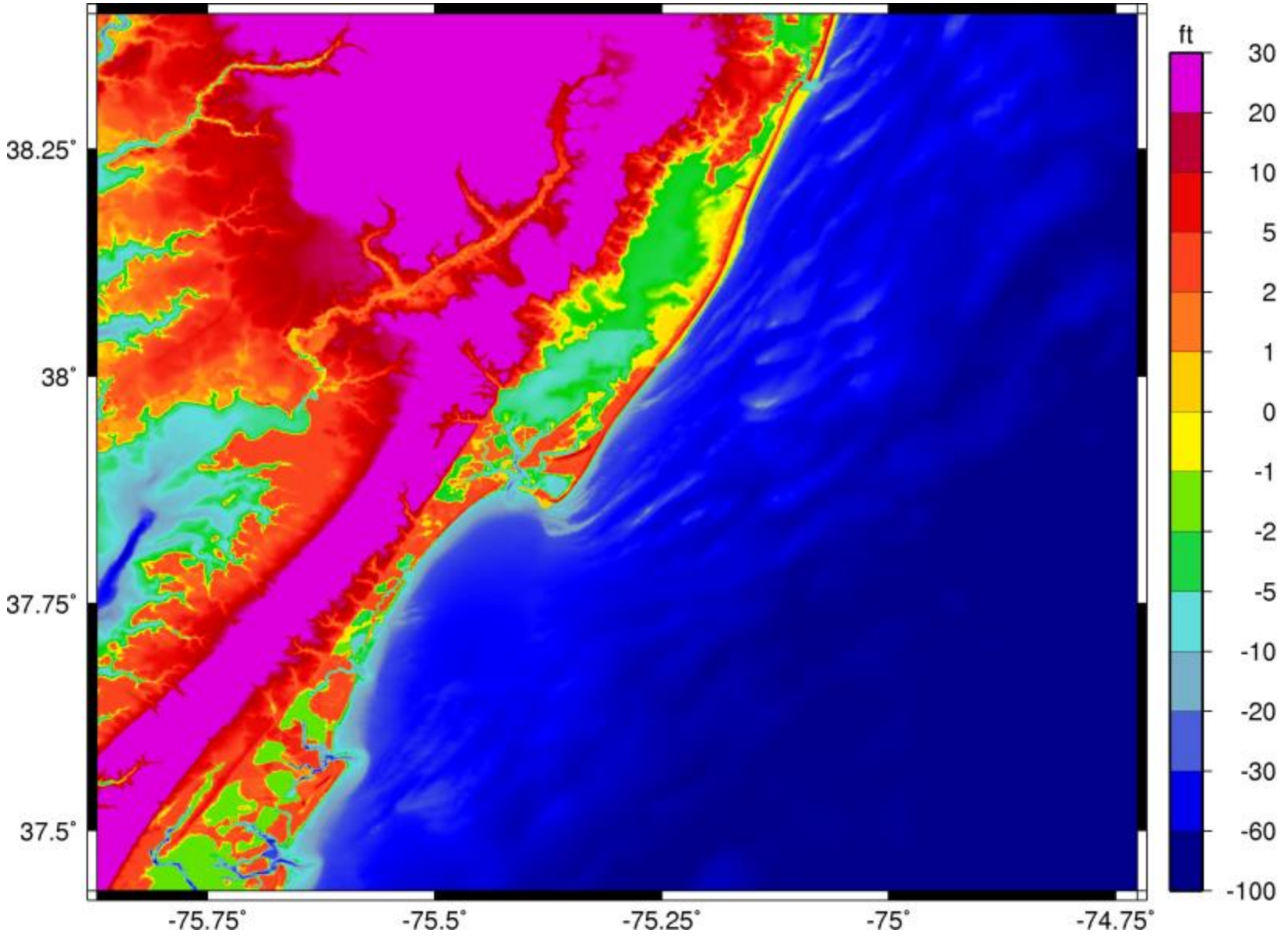


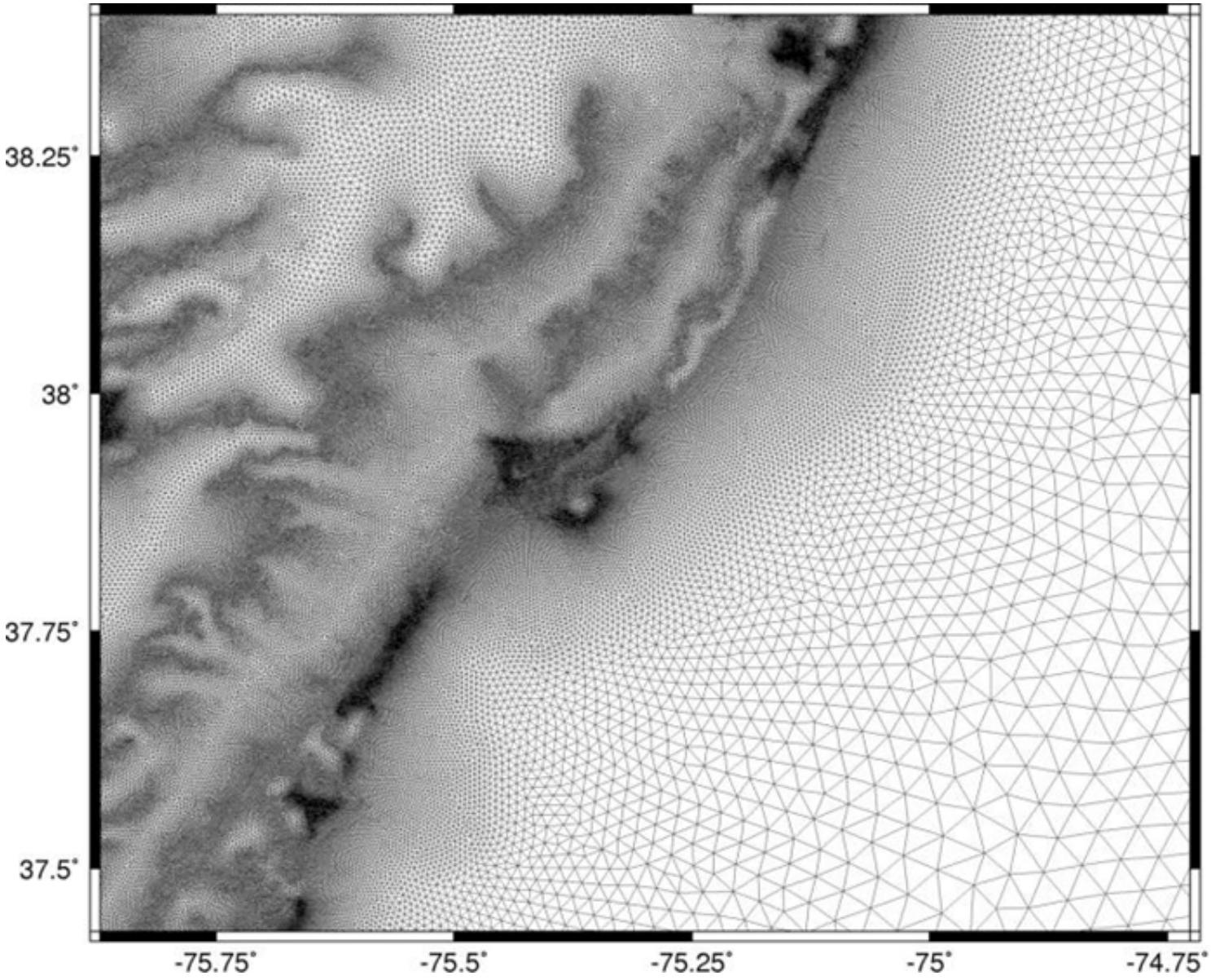


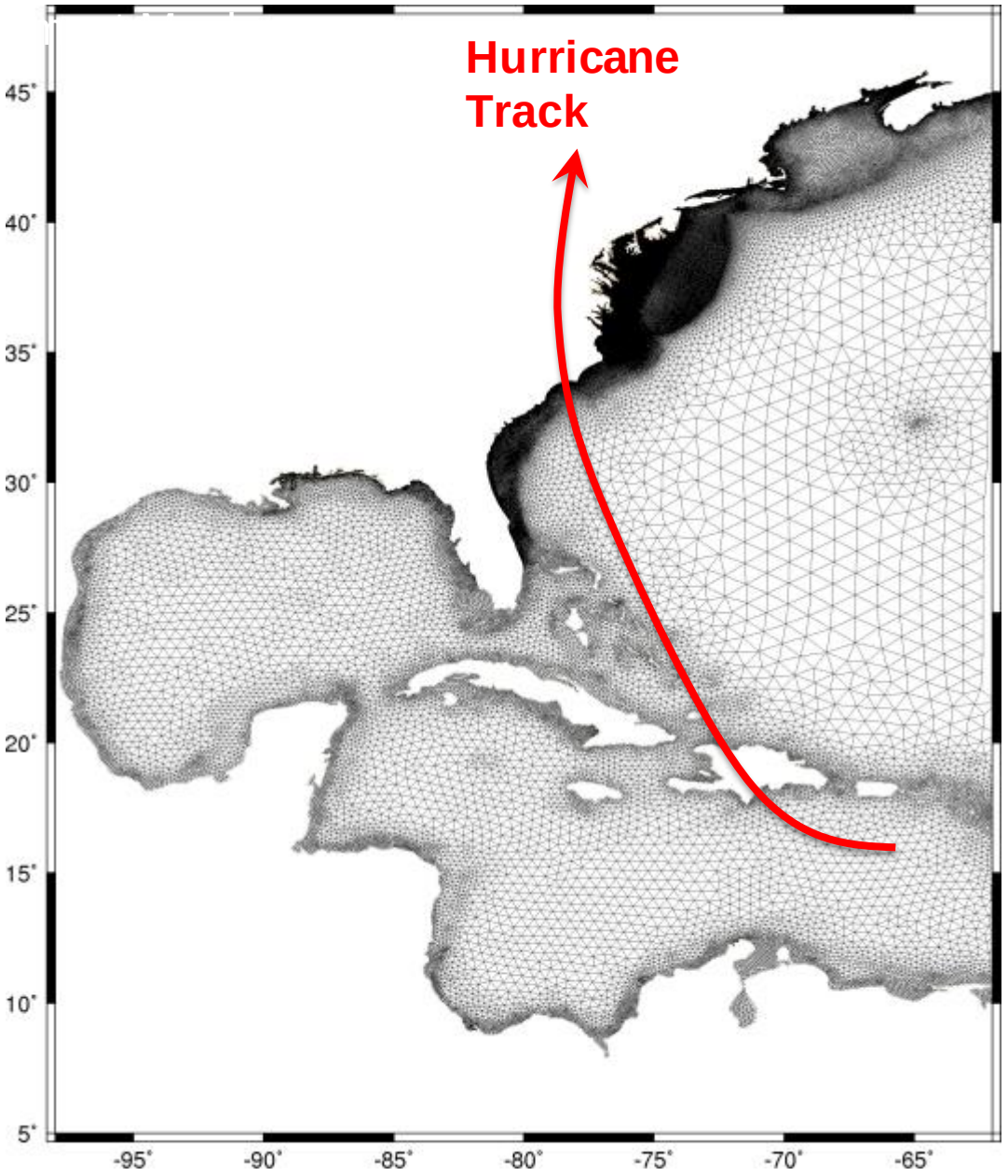




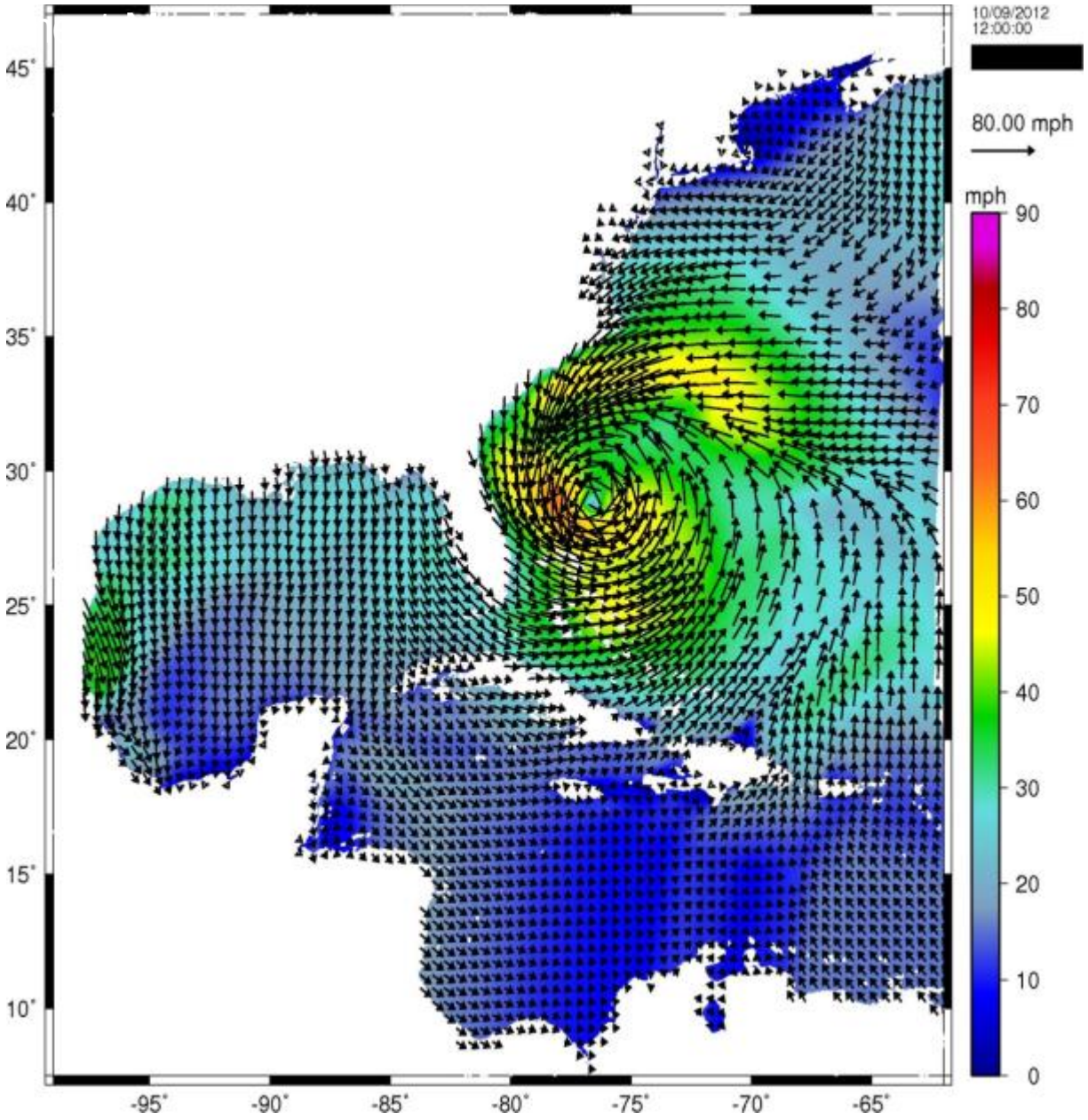








Hurricane Sandy



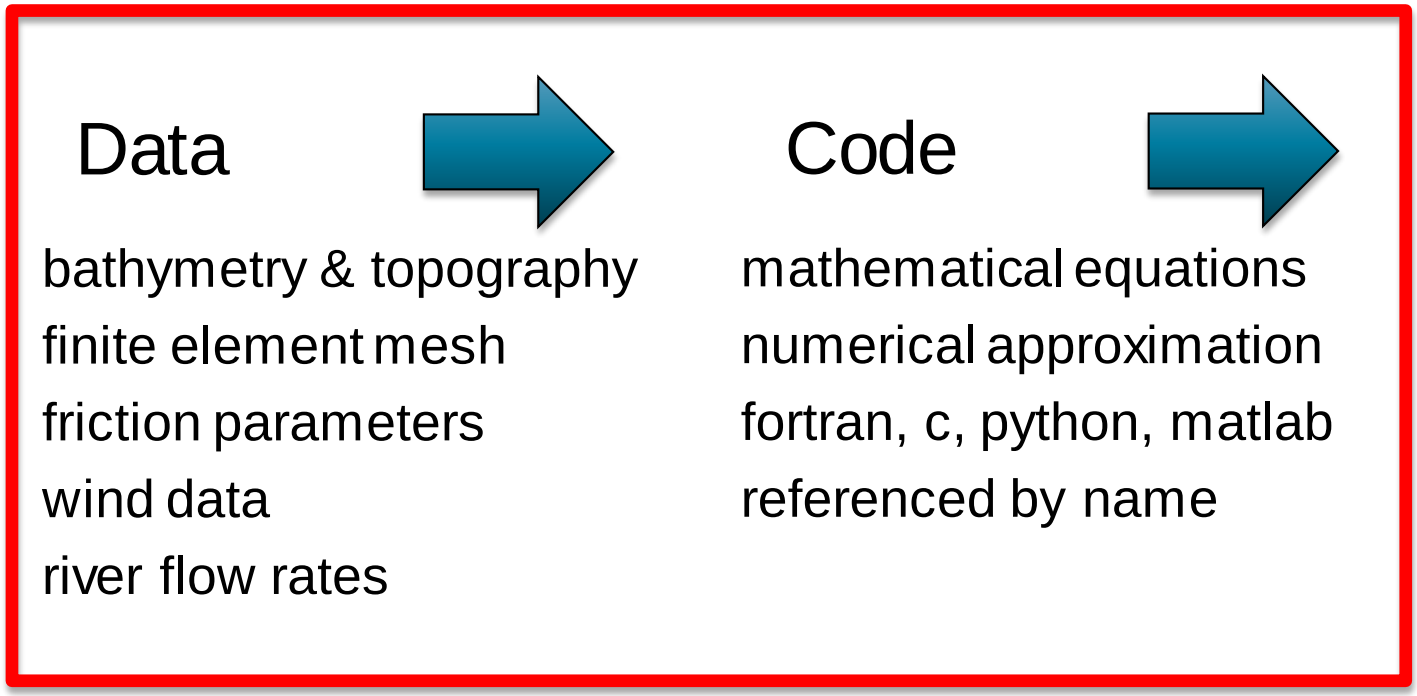
What is a model?

Data → **Code** → Output

bathymetry & topography
finite element mesh
friction parameters
wind data
river flow rates

mathematical equations
numerical approximation
fortran, c, python, matlab
referenced by name,
i.e. SLOSH
Delft3D,
ADCIRC
SWAN

What is a model?



This is what we call “The Model”

ADCIRC and SWAN

- ADCIRC is a calculates water surface elevation and currents
- SWAN is a spectral wave model that computes energy for a range of wave lengths
- Codes share the same input (mesh, winds, etc)
- Codes are dynamically coupled (run at the same time) to integrate evolution of surge and waves
- Captures wind-wave-surge interactions
- State of the art algorithm runs on massively parallel supercomputers

Supercomputing Asset

Athos 84 HP SL160z G6 servers Dual Six-Core Intel Nehalem processors - 996 total cores 24 GB RAM - 1992 GB total RAM 160 GB disk - 13280 GB total disk Infiniband connectivity

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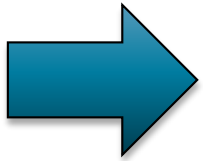
Data 

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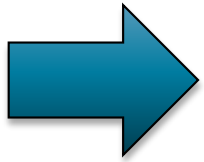
Code 

mathematical equations
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fortran, c, python, matlab
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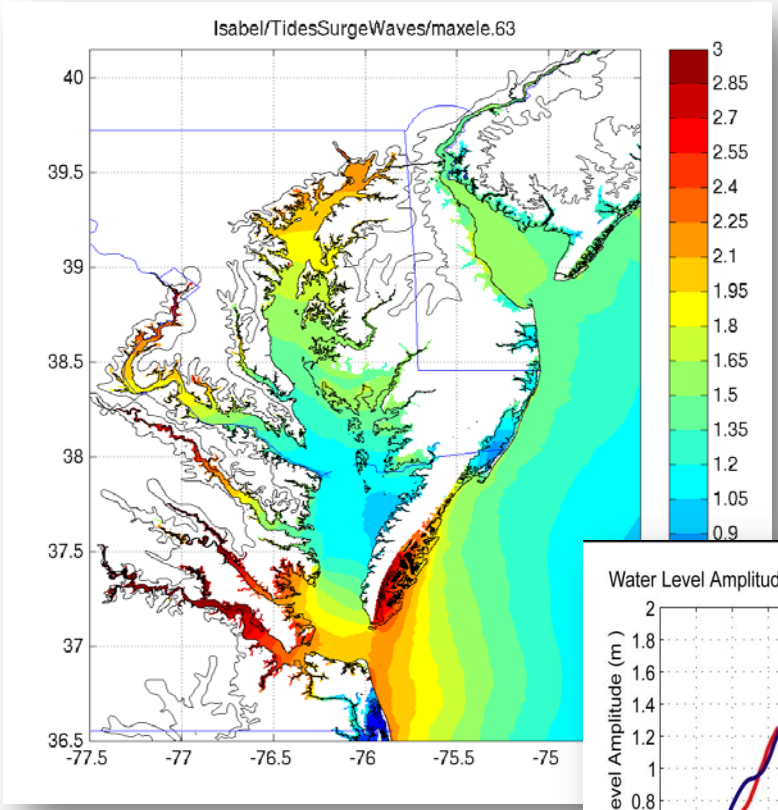
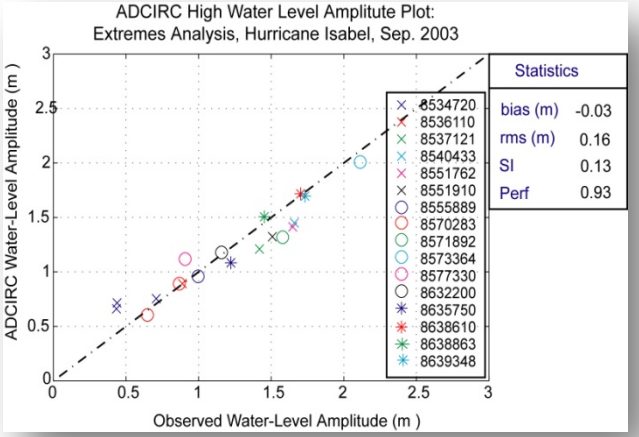
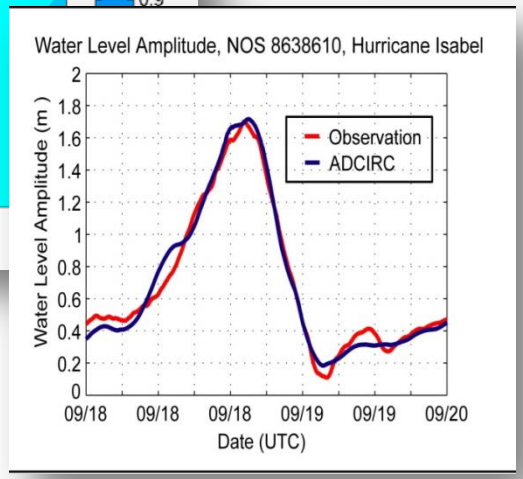
Output

time-series
maximums
graphics
maps
tables

Example Output



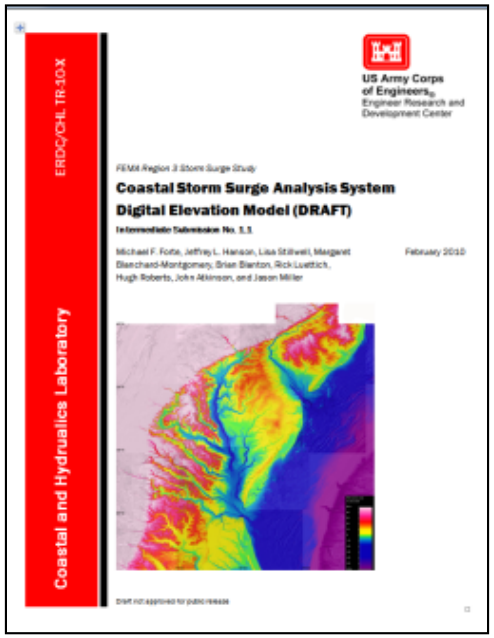




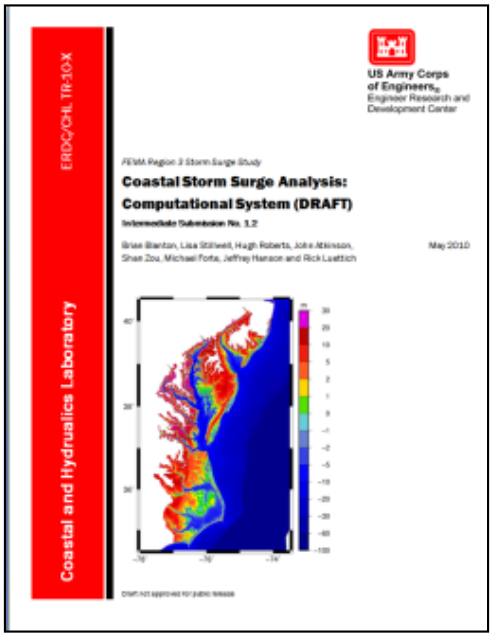
FEMA

- One of main missions is to inform flood risk
- NFIP
  - Develop Flood Insurance Rate Map (FIRM)
  - FIRM represents “present conditions”
  - Data goes stale as landscape changes
  - Data goes stale if meteorology changes
- FEMA periodically updates FIRM with latest tools
- Update of Eastern Shore VA
- Funded development & validation (2011-2012)

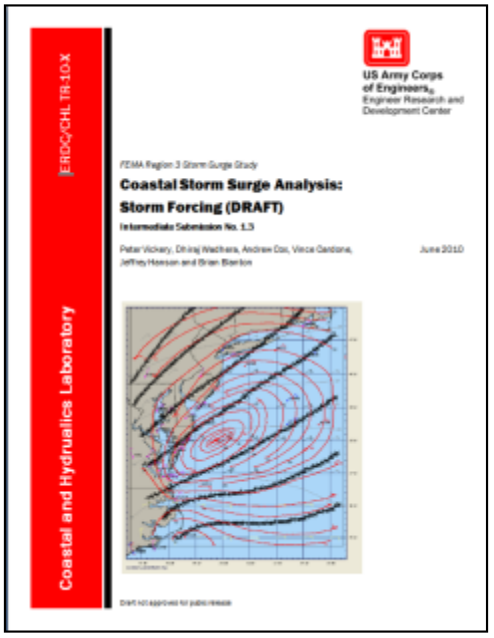
FEMA



Submittal 1.1 DEM



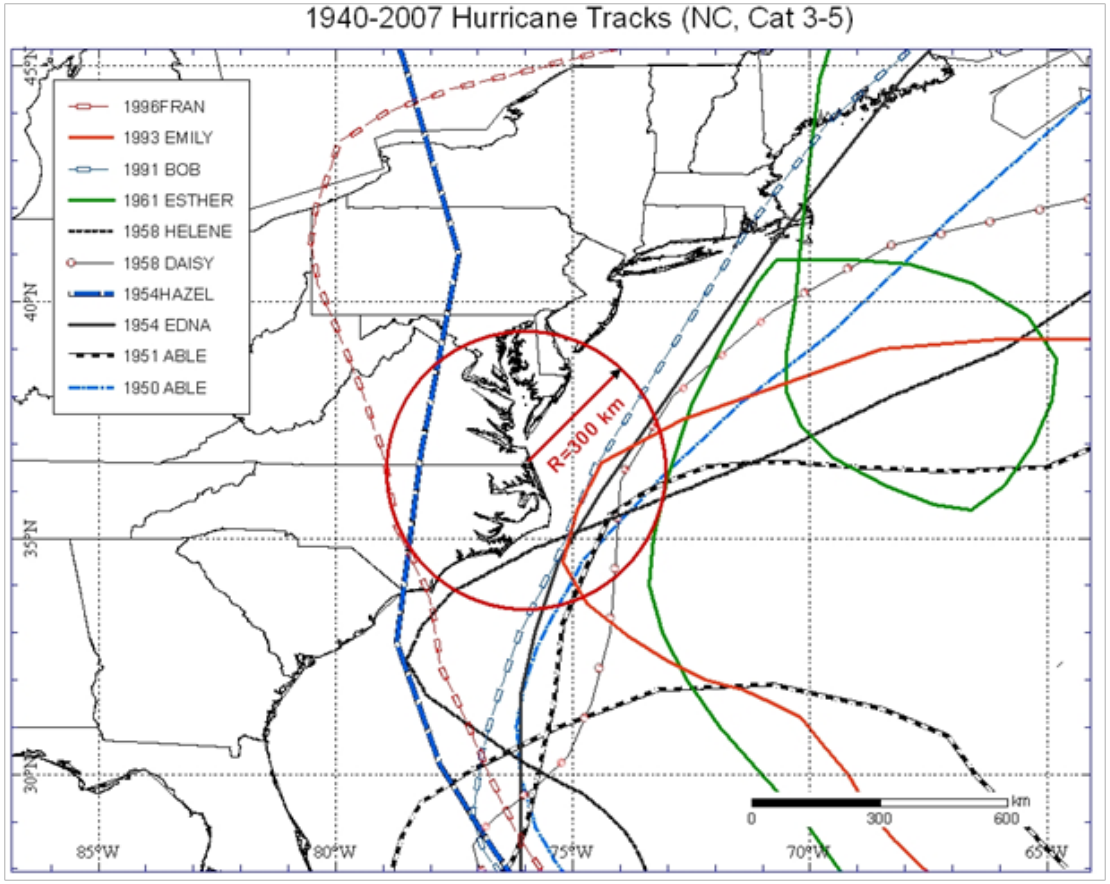
Submittal 1.2 Modeling Mesh



Submittal 1.3 Storm Forcing

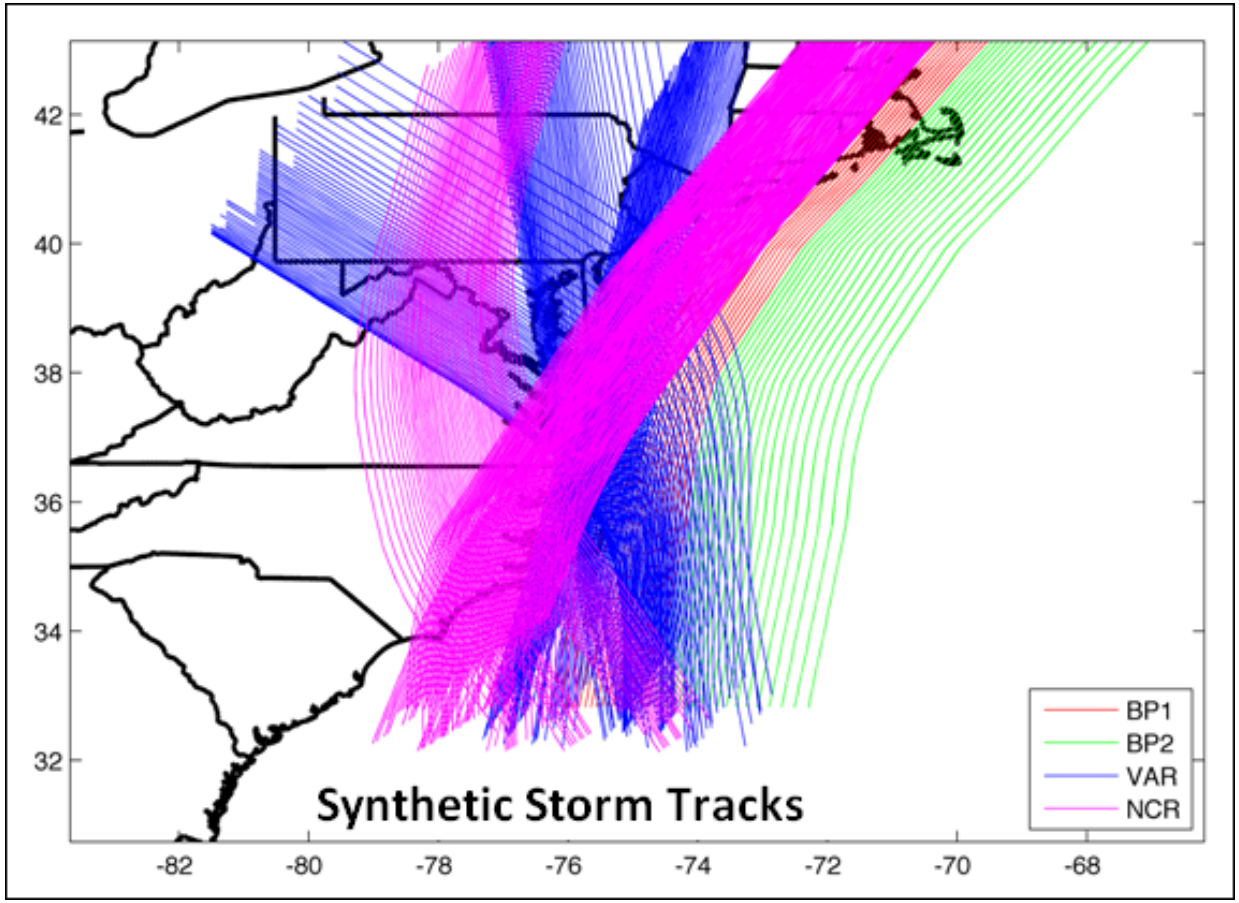
FEMA Coastal Flood Mapping

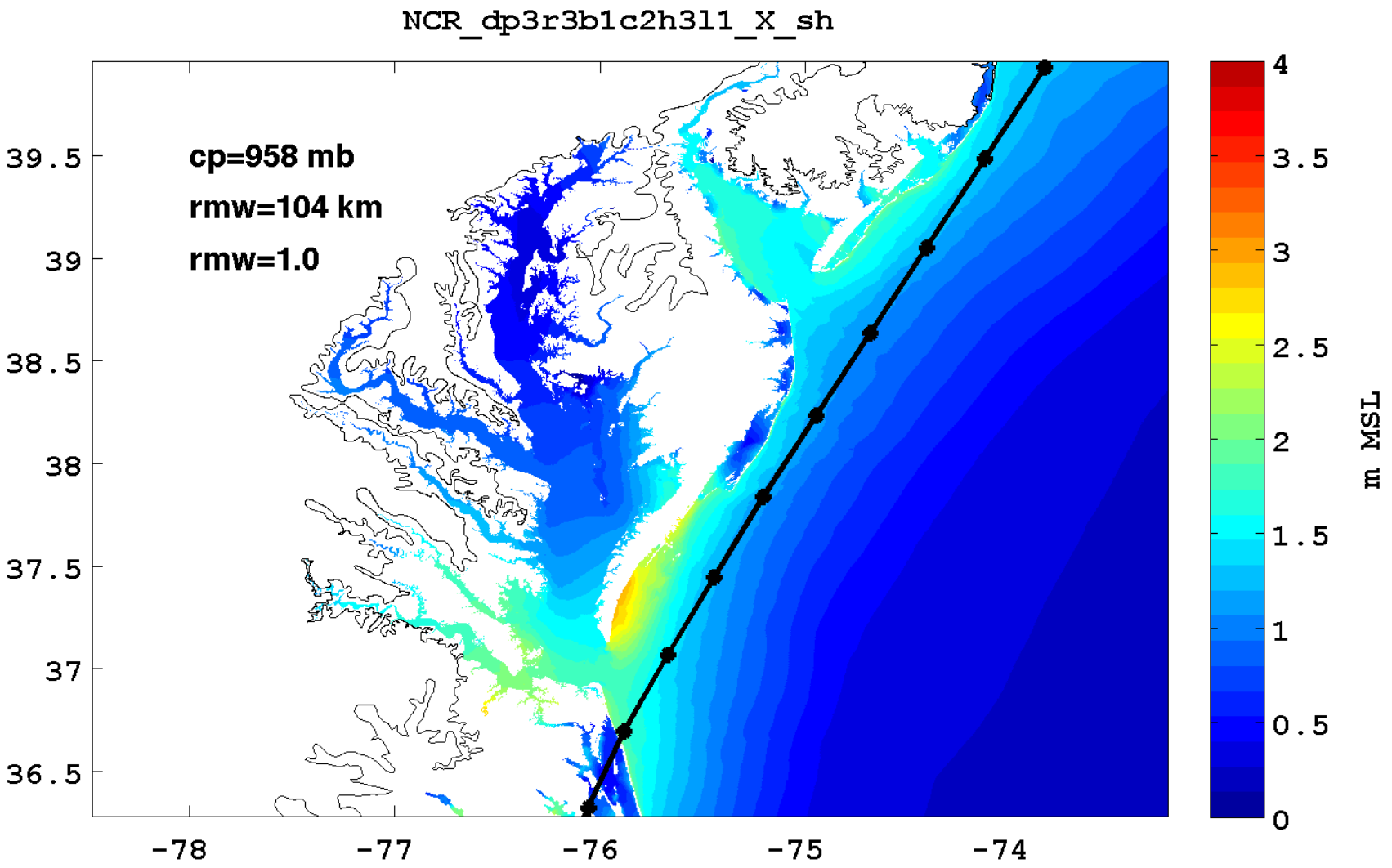
- Historical surge/wave data is sparse



FEMA Coastal Flood Mapping

- Simulate 1000's of hypothetical hurricane scenarios
- Ensemble represents a "synthetic history"

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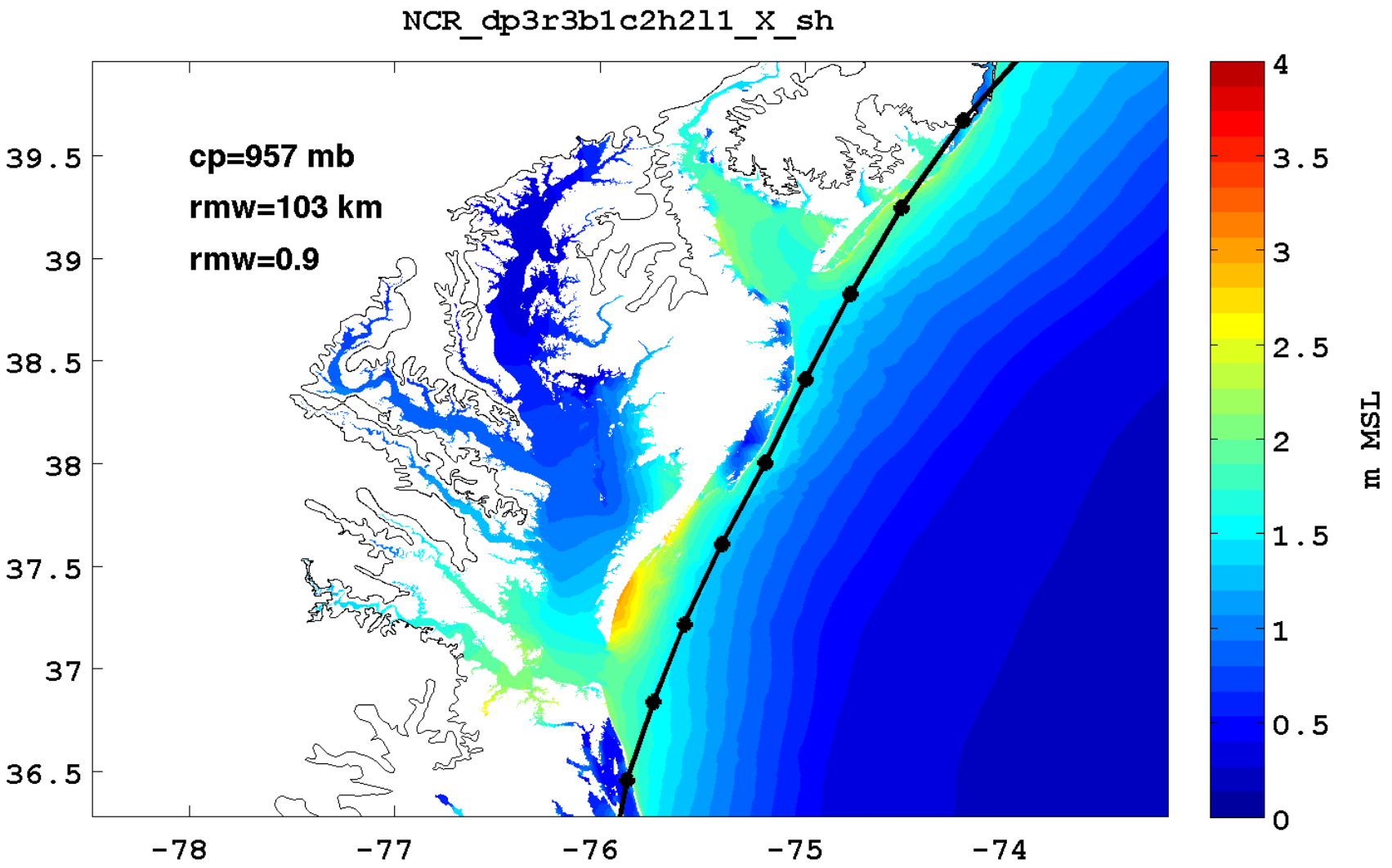
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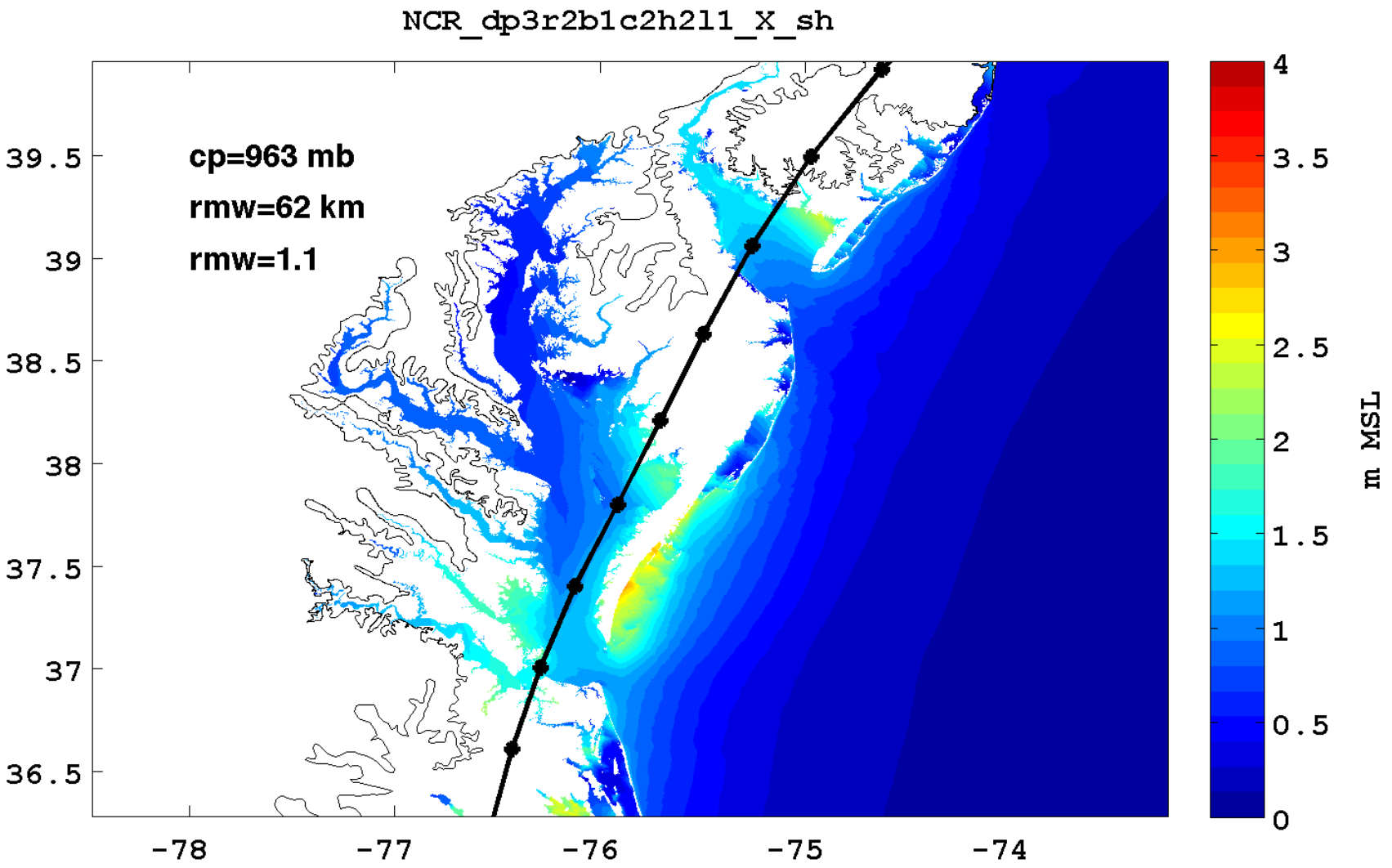
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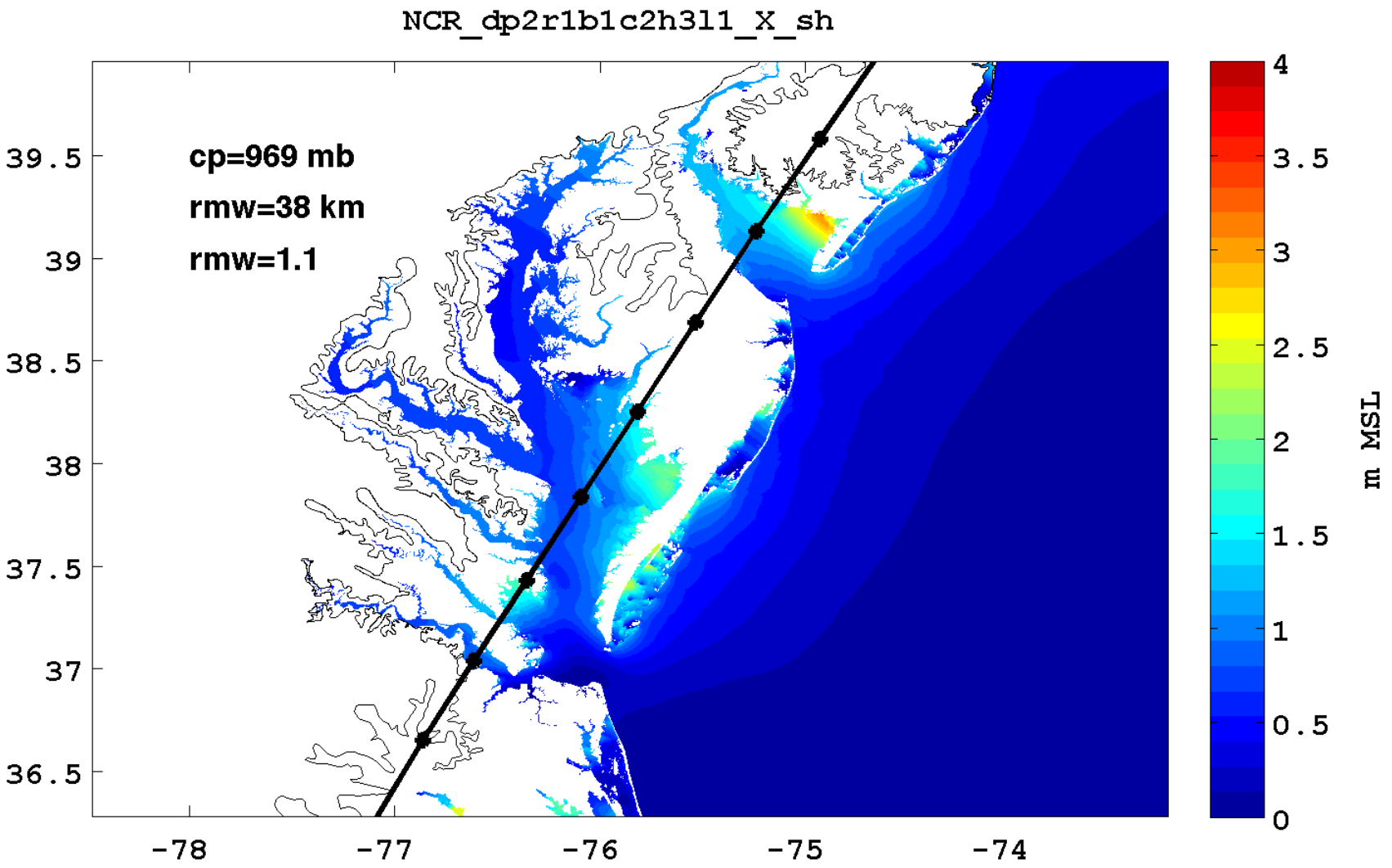
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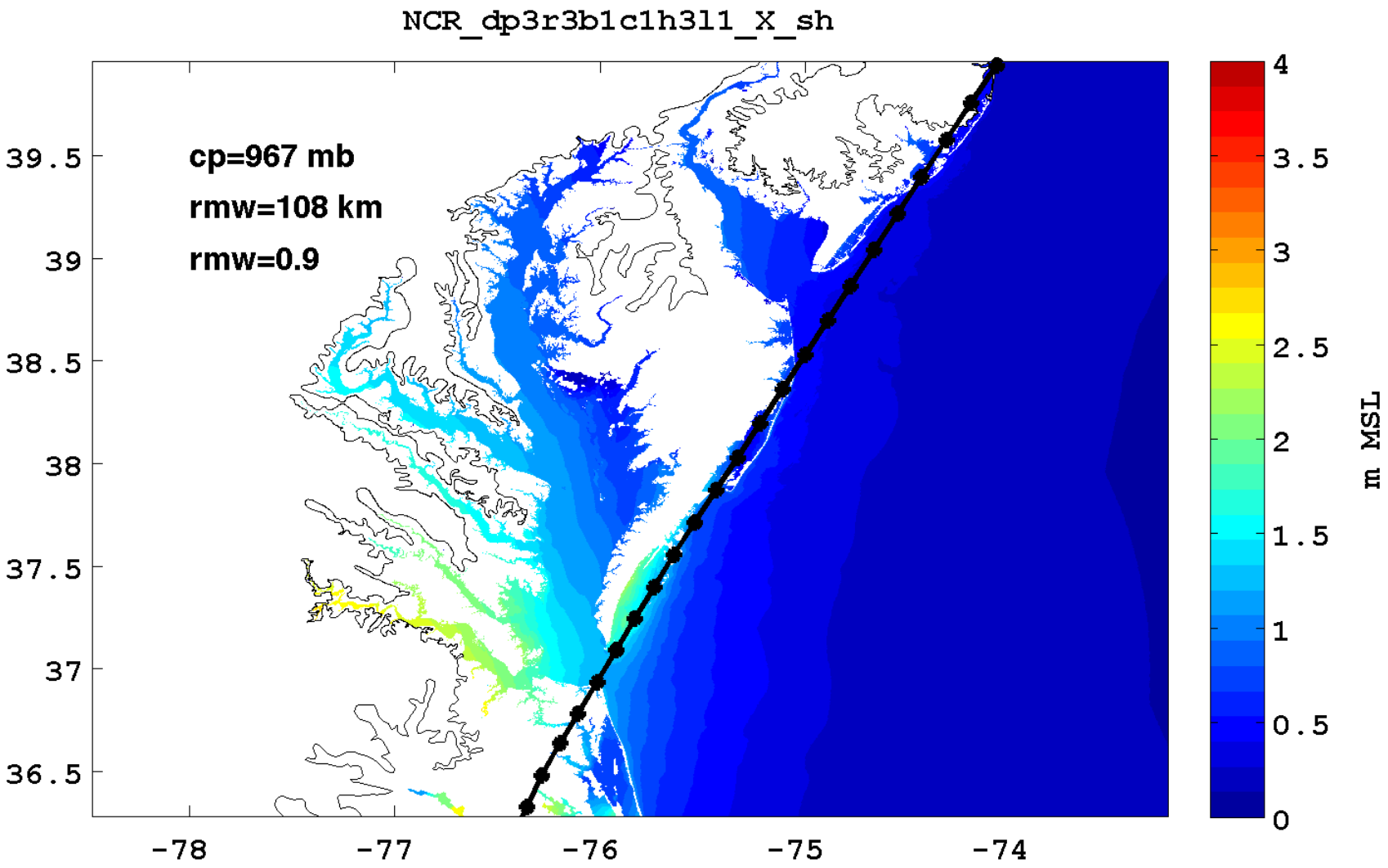
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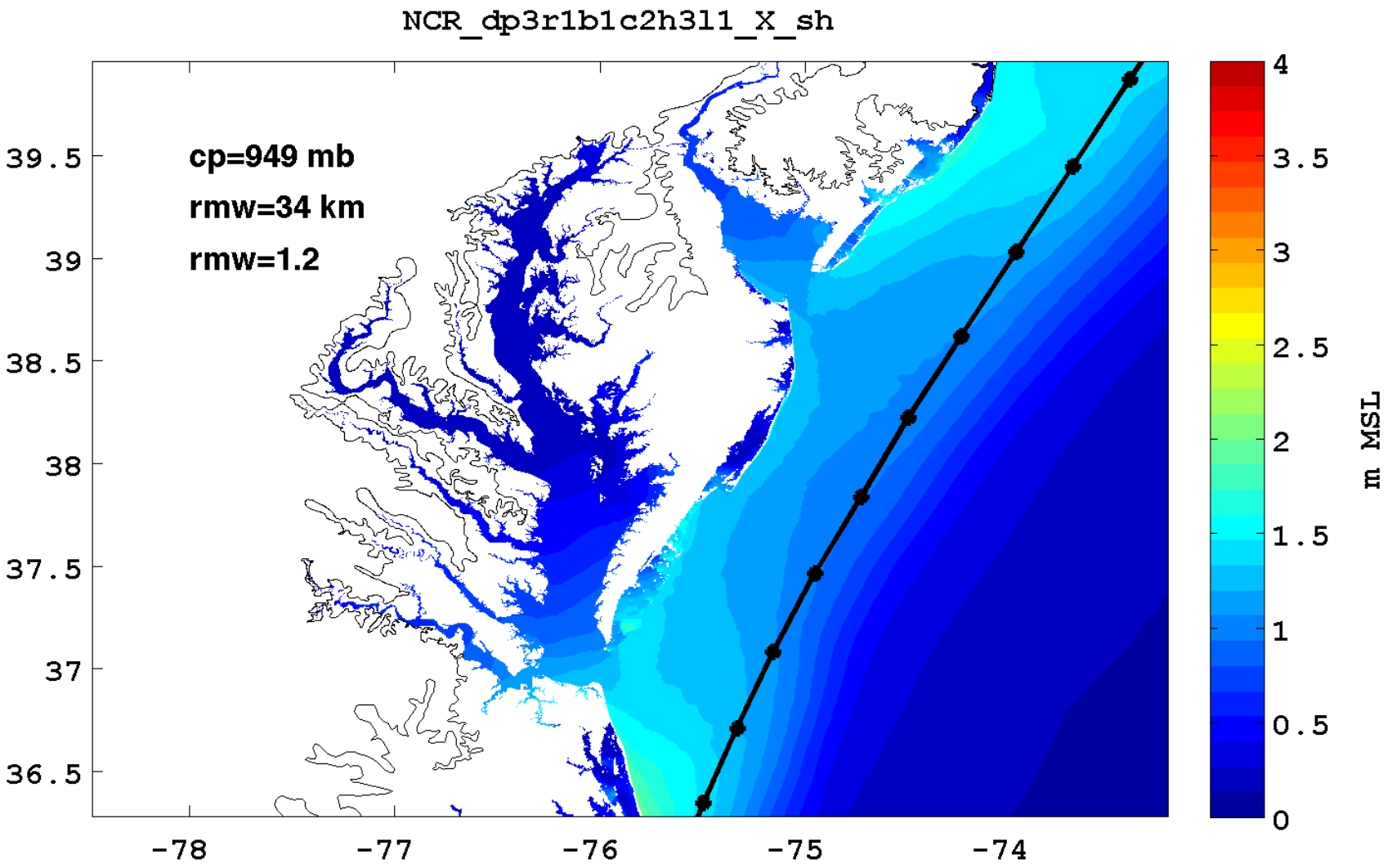
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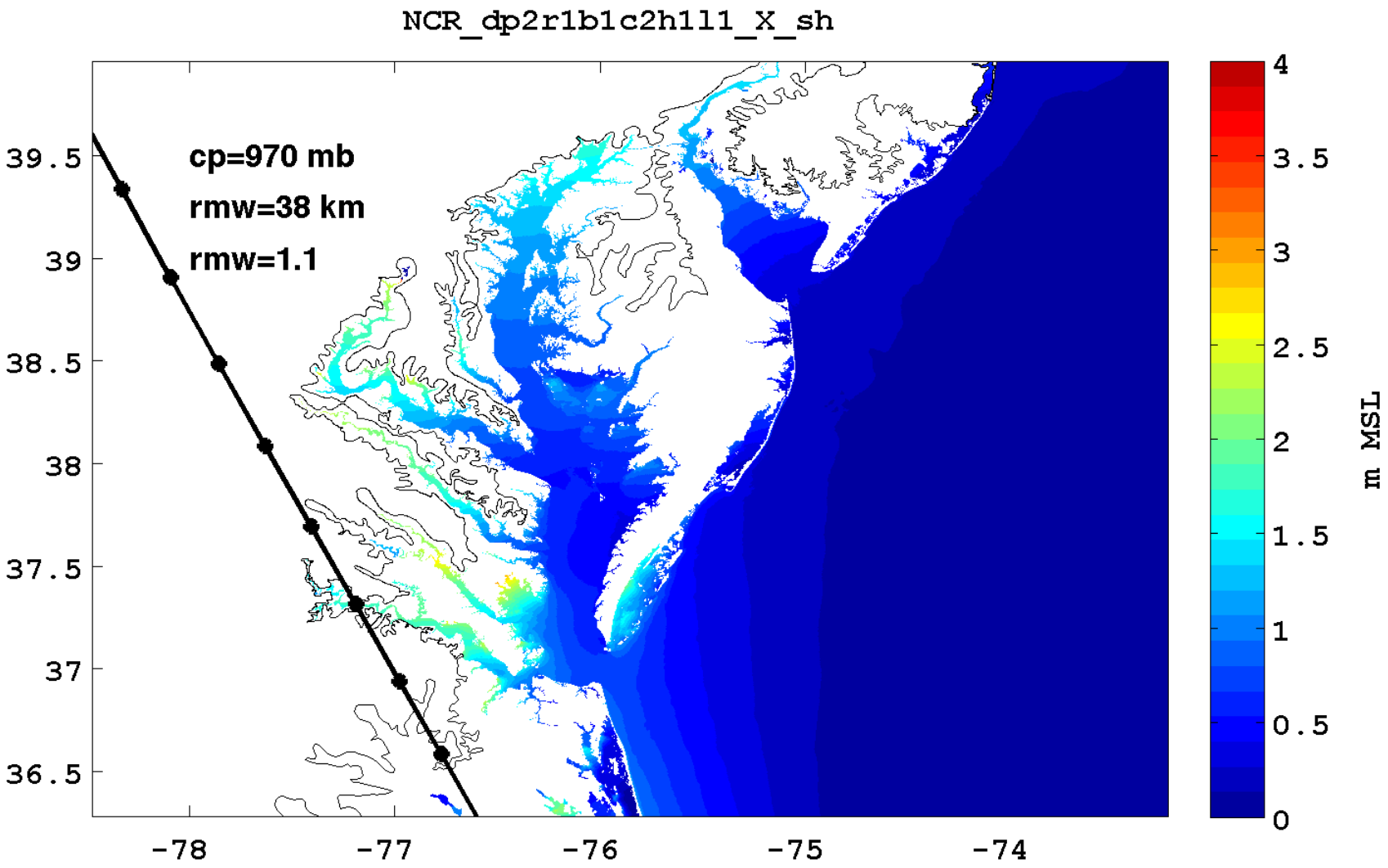
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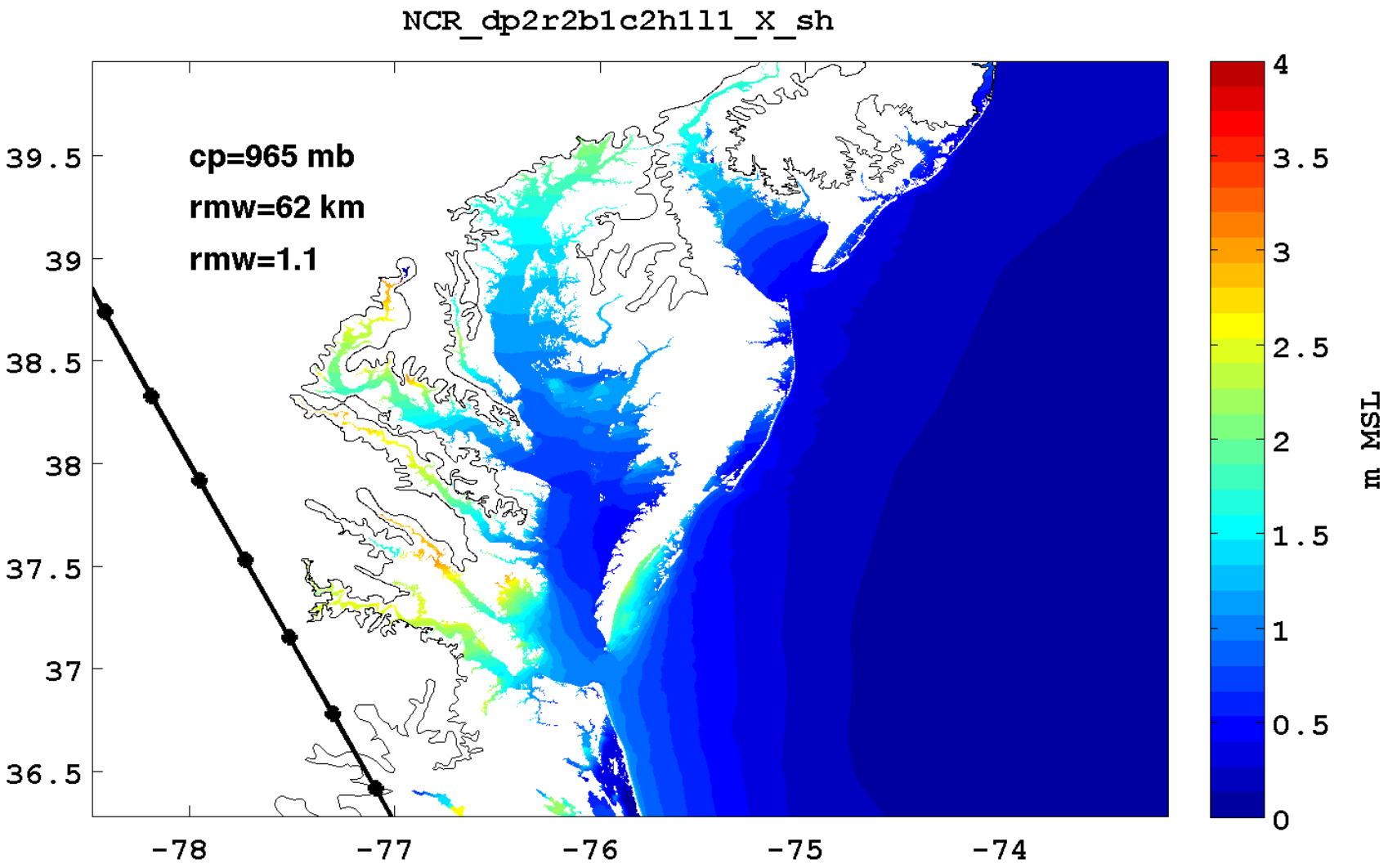
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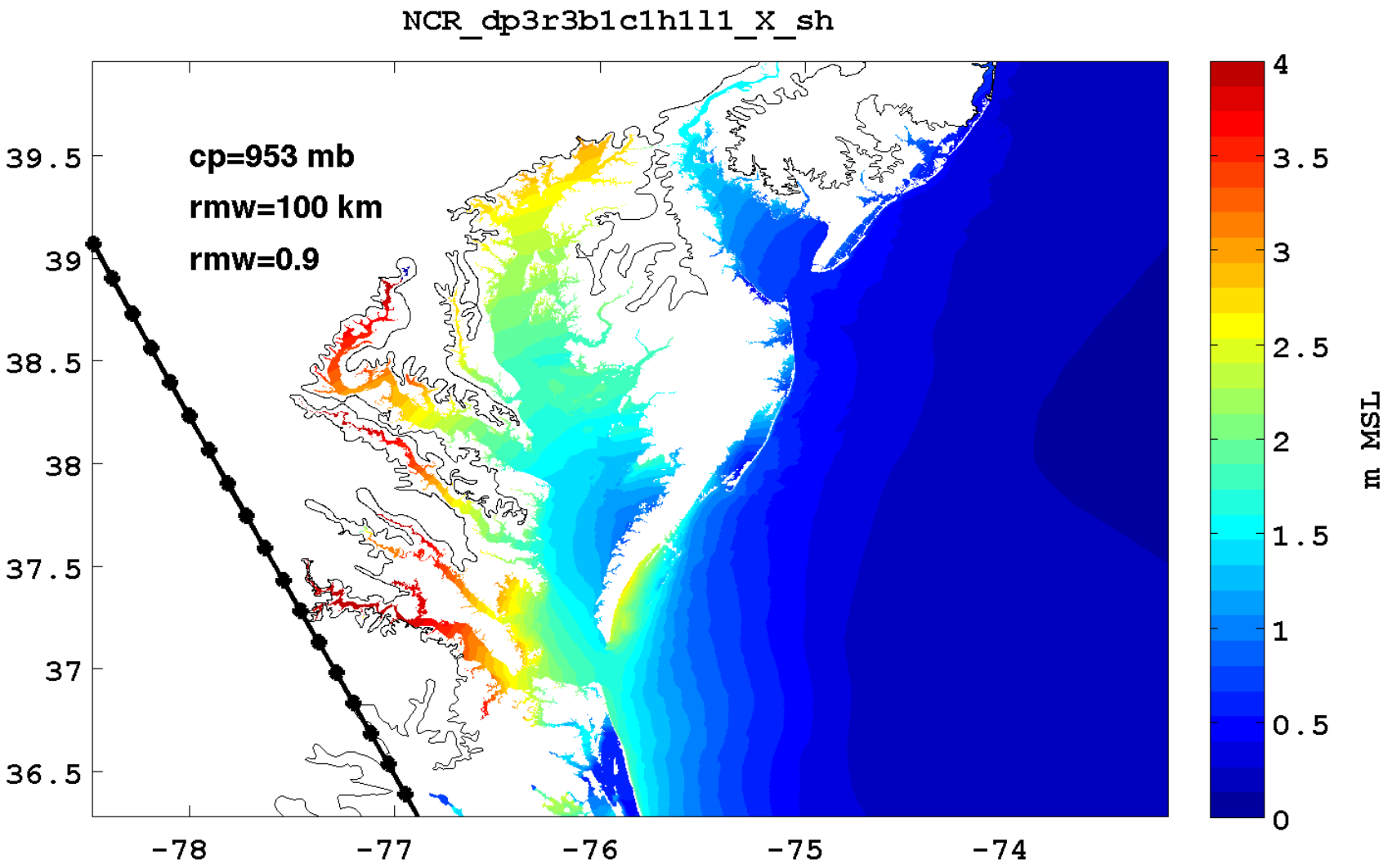
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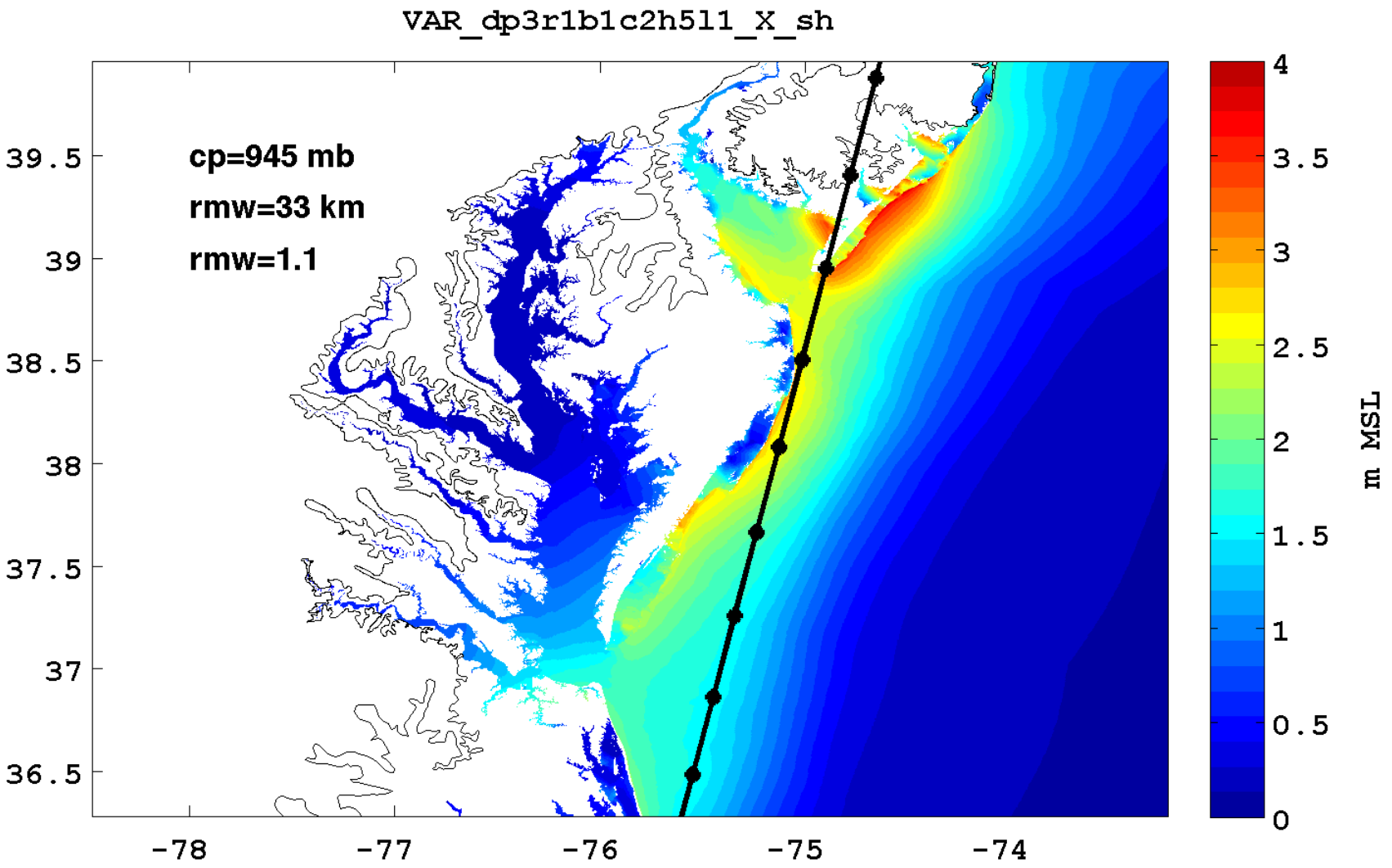
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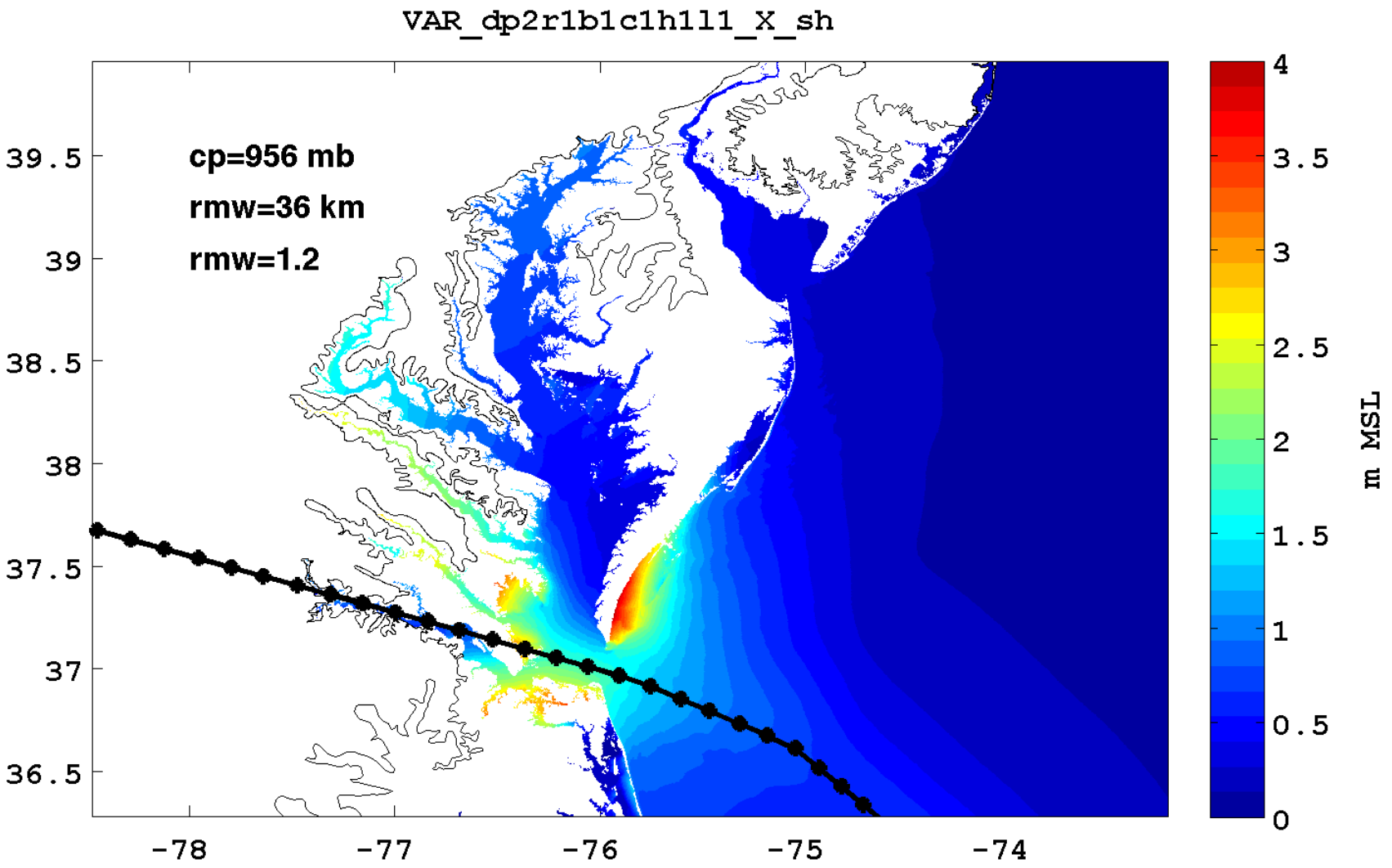
m MSL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37
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3
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2
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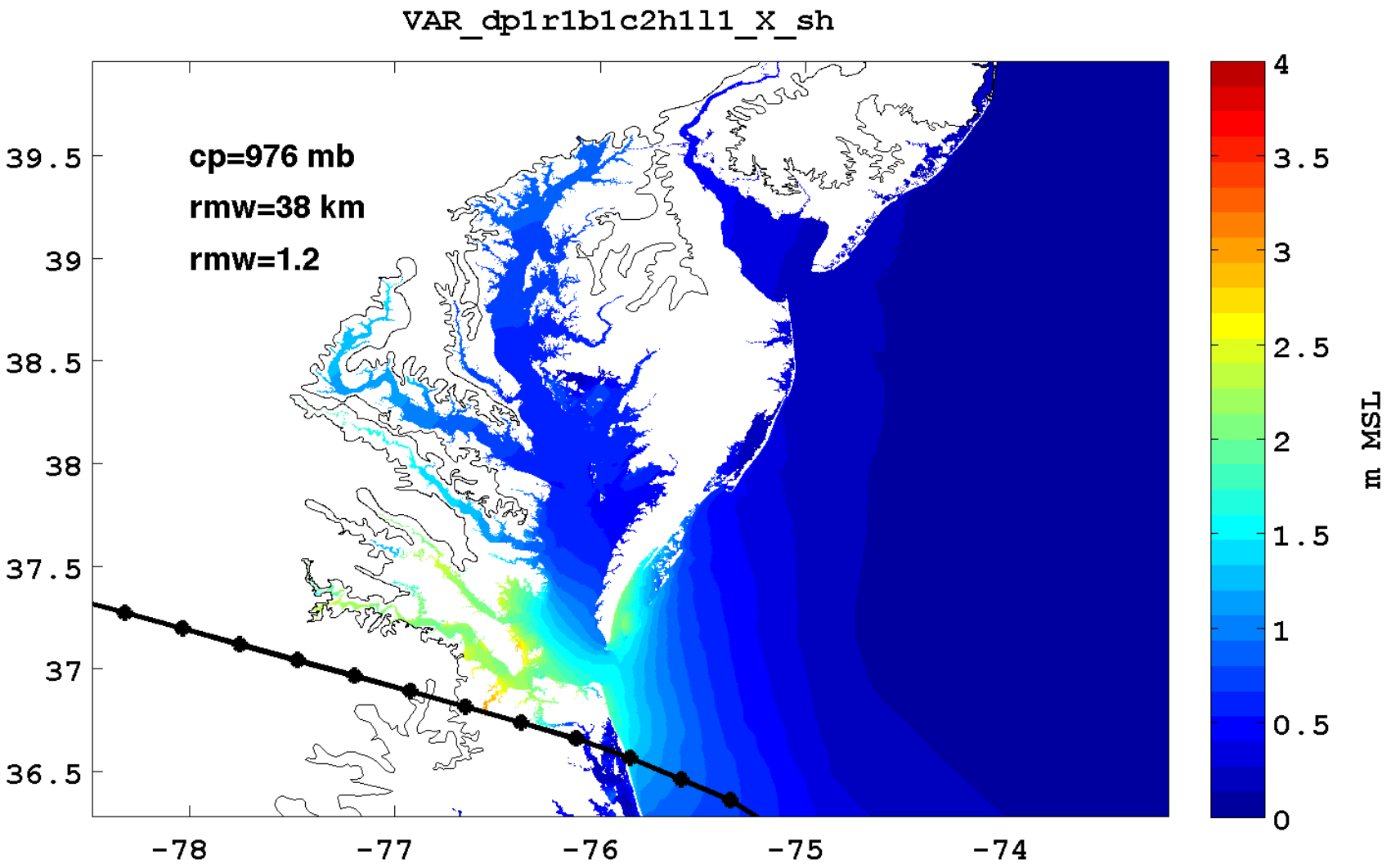
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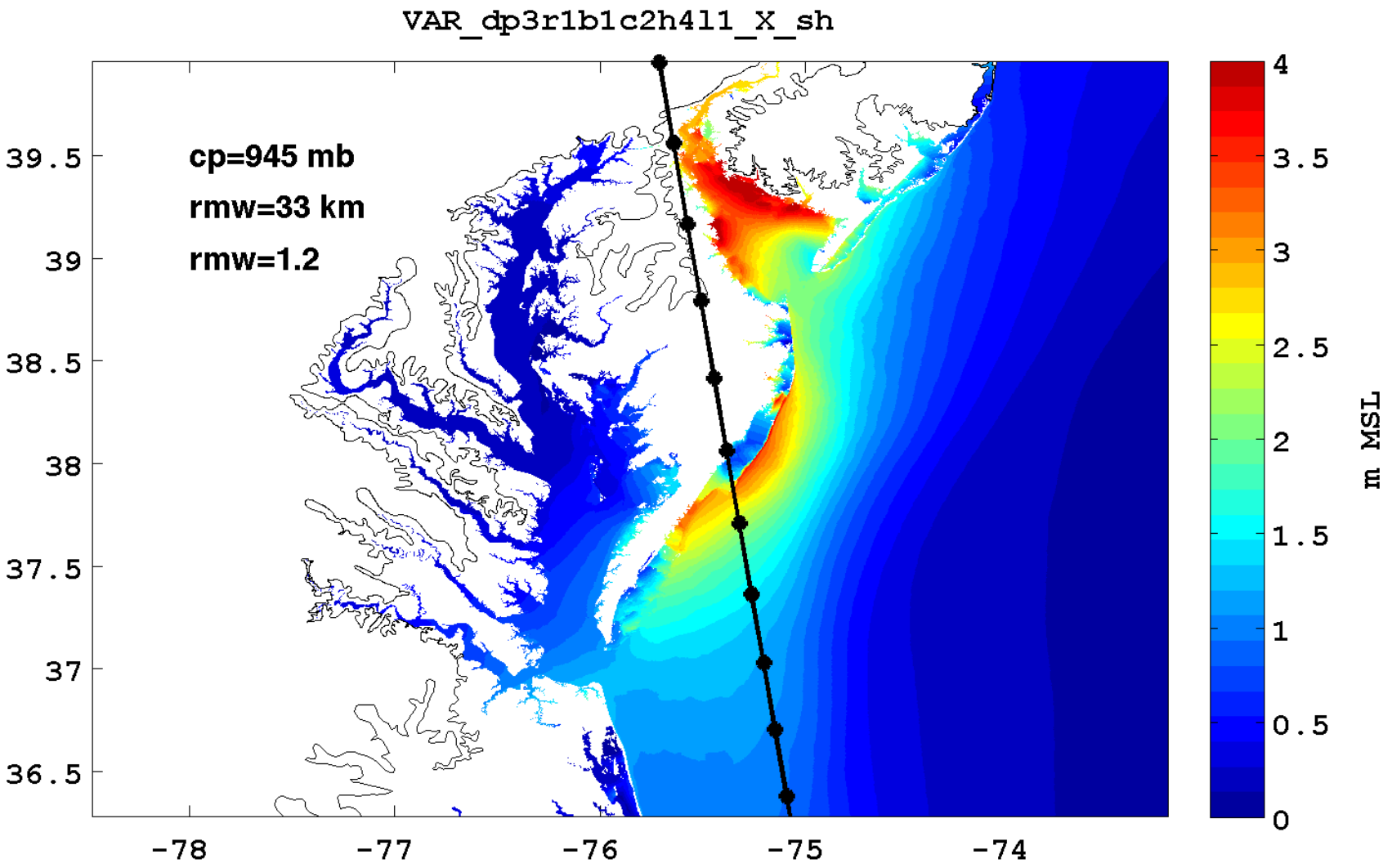
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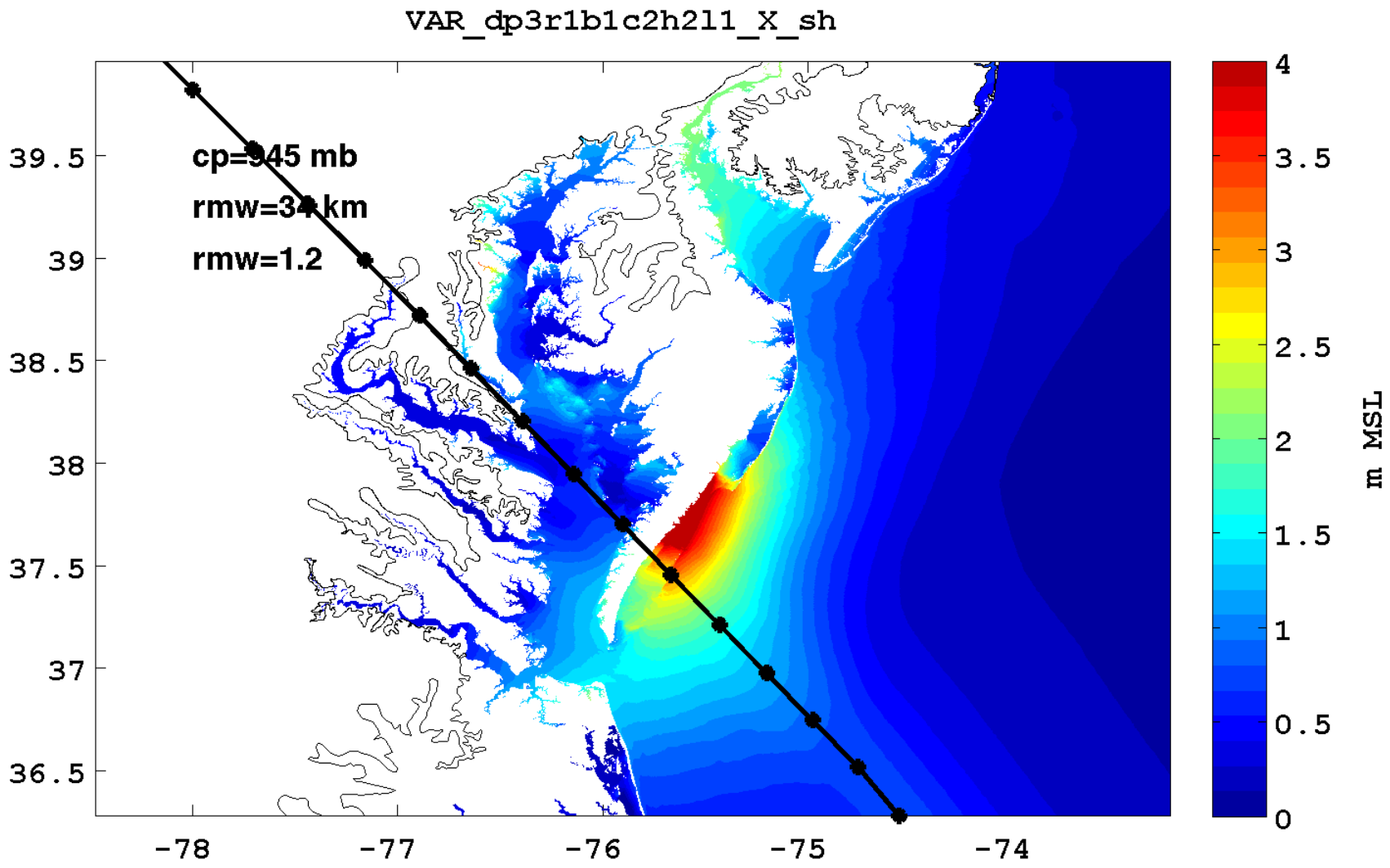
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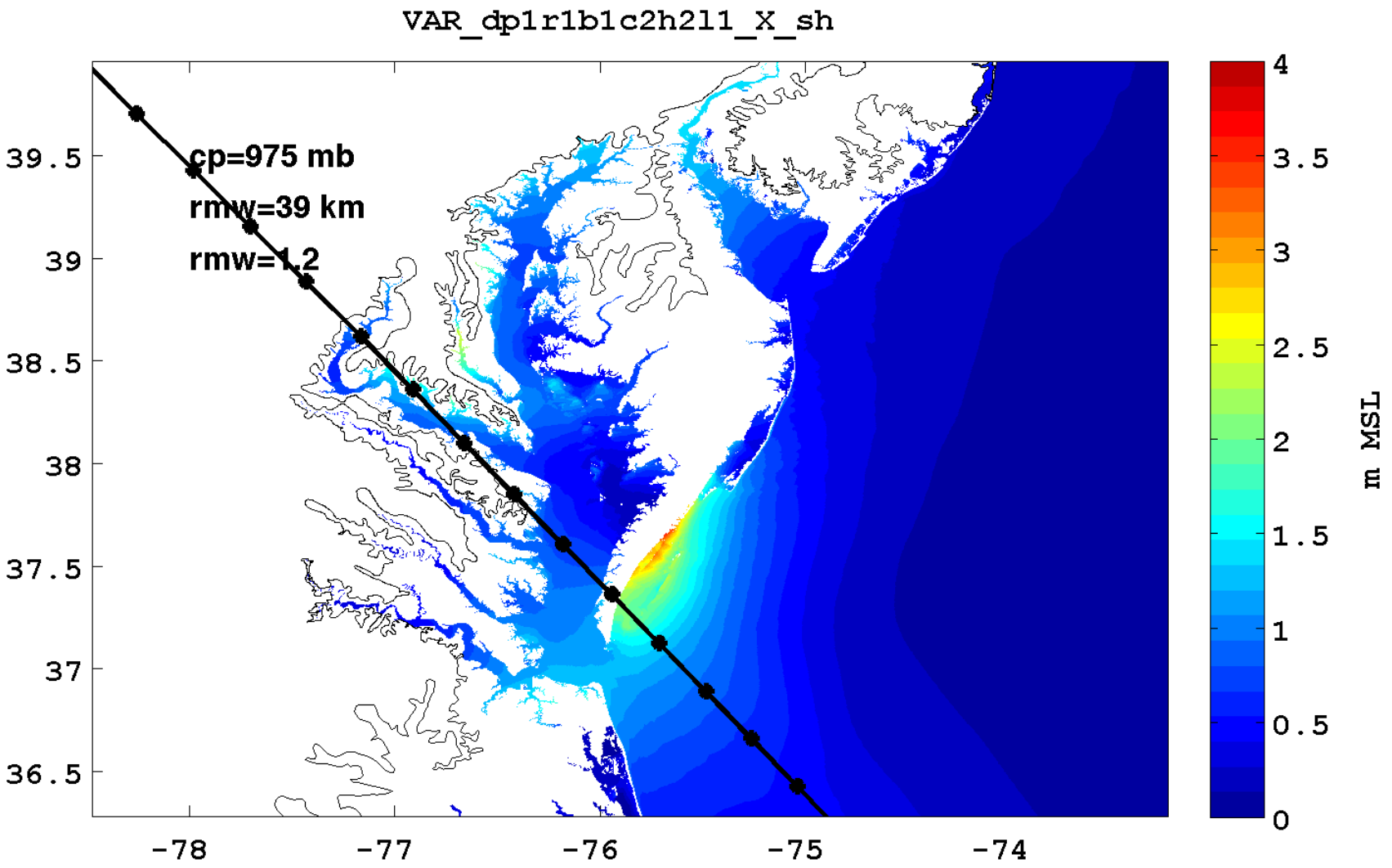
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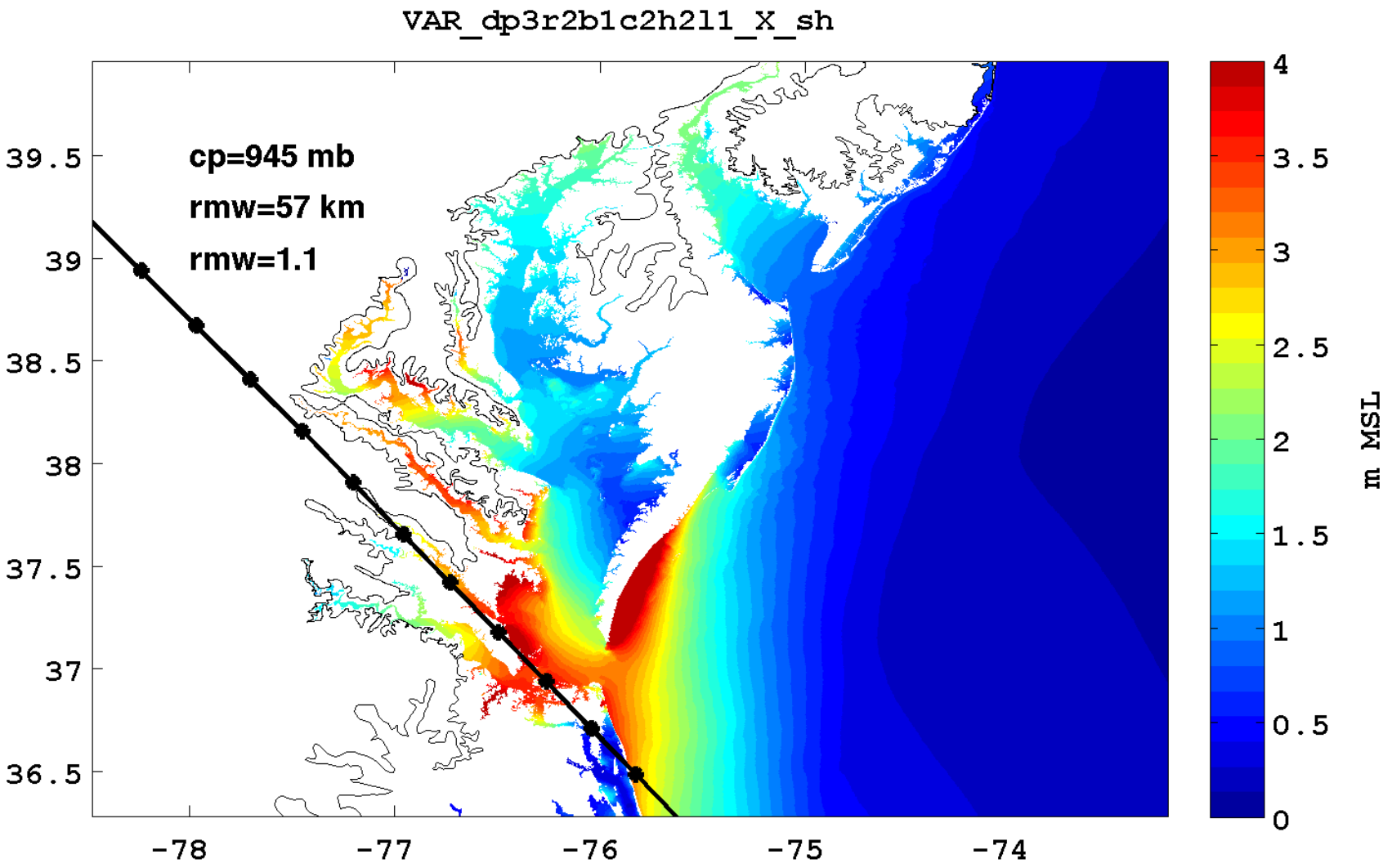
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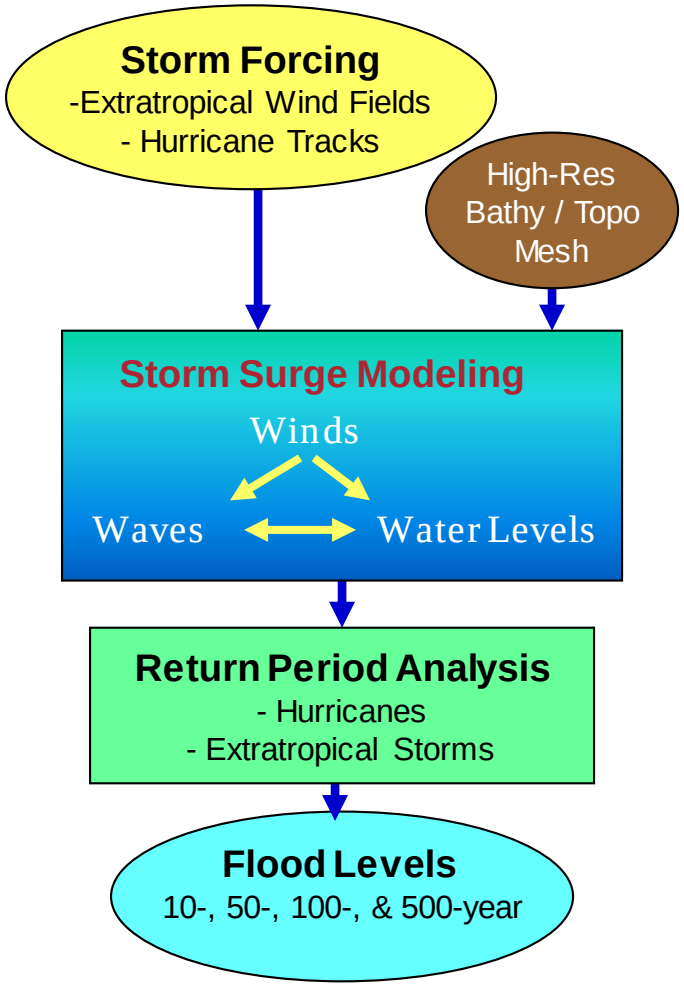
2.5
2
1.5
1
0.5
0
m MSL

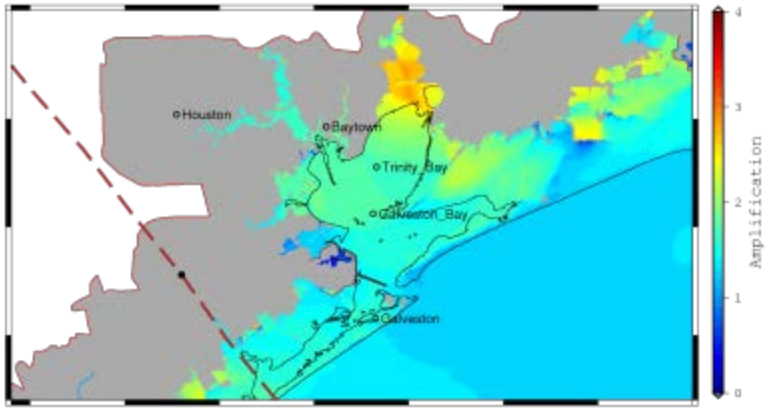
FEMA Coastal Flood Mapping



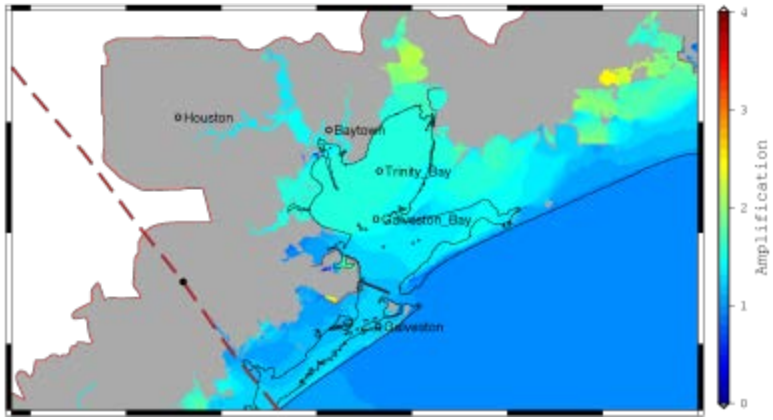
Statistics are derived from the synthetic history

We can select individual storms that match 100-yr return at locations of interest

Previous Studies of RSLR on Surge



Amplification for 0.25m SLR



Amplification for 1.0m SLR

amplification = Δsurge / SLR

Implications

- Response is non-linear
- Strong topographic control
- A 25% increase in storm strength equals effect of 0.5m SLR,
- Not all regions are equally vulnerable to future flooding increases.

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Strategy

- Leverage all the previous work
  - FEMA model development and synthetic storms
  - SLR studies in GoMex w/ TNC and USACE
- Define future landscape and RSLR scenarios
- Re-run selected storms
- Compute spatial variability of amplification
- Inform TNC tools

Discuss

- Locations of importance
- Return period to target

