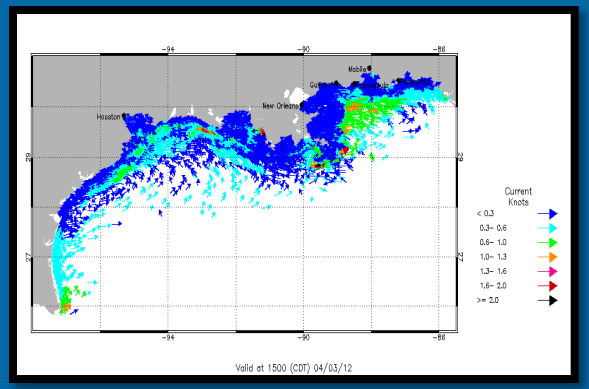
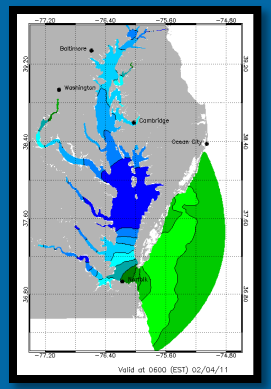
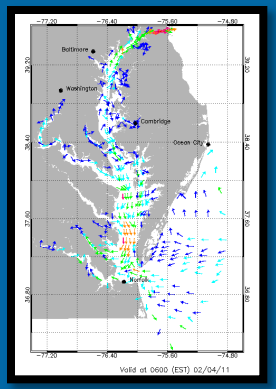
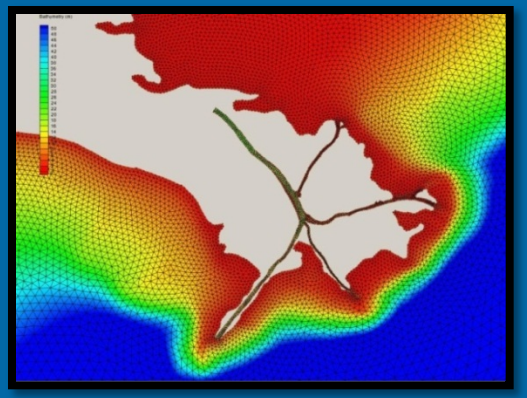






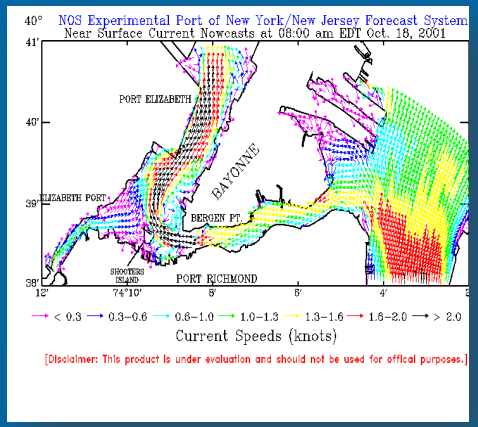


Hydrodynamic Modeling in NOAA's National Ocean Service in Support of Operational Forecast System Development and Storm Surge Forecasting

Edward Myers
NOAA's Coast Survey Development Laboratory
16 September 2015

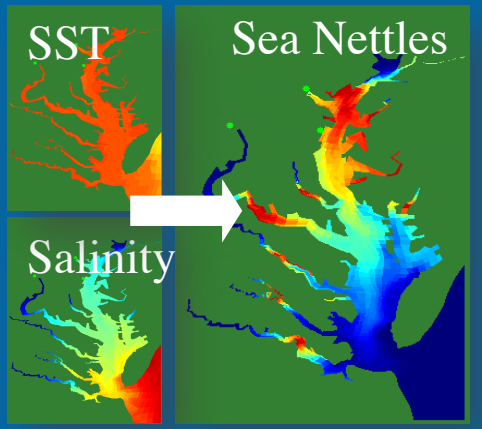
Objectives of NOS Operational Forecast Systems

- **Support of safe & efficient navigation**
  - Water levels for under-keel clearance
  - Currents for right-of-way, maneuverability



- **Emergency response**
  - Oil spills (OR&R)
  - Search & Rescue
  - Homeland Security

- **For environmentally sound management of the coastal zone**
  - Ecological: hypoxia, HABs, pathogens, …
  - Marine geospatial applications



NOAA Partnership for Coastal OFS Projects

Concept of Operations (CONOPS)

NOS/CO-OPS

- Mission and Requirement Analysis
- NOS OFS Framework Development (COMF)
- System Transition to Operations
- Operation, Maintenance and Routine Update
- Product generation and Service Delivery
- Outreach and User Services

NOS/OCS/Coast Survey Development Lab

- Requirement Analysis
- NOS OFS Framework Development (COMF)
- OFS Development and Testing
- Routine Updates

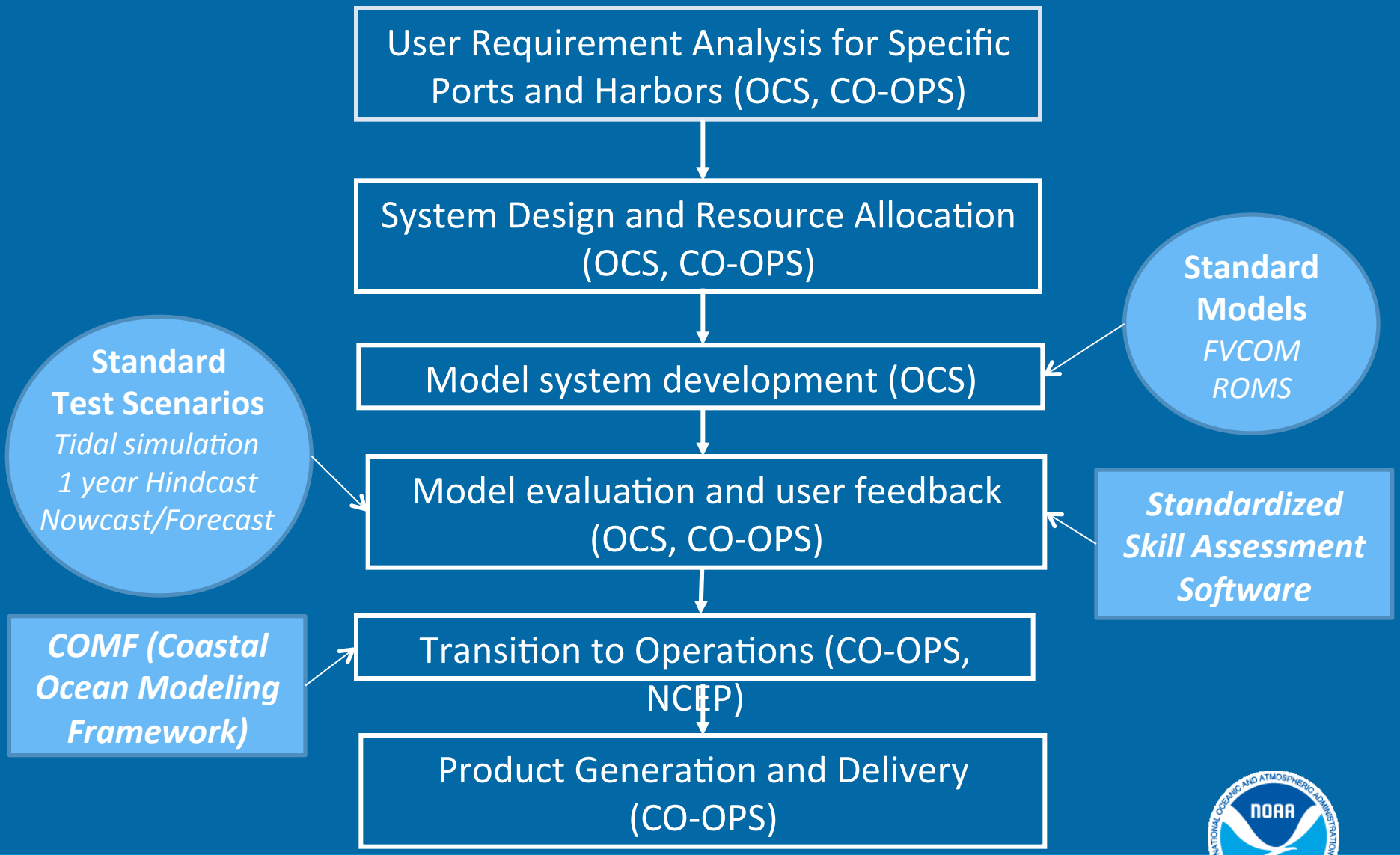
NWS/NCEP

- Computer System Technical Support
- Implement NOS OFS on NOAA's operational computing system
- NCEP Central Operations manages operation, maintenance and routine updates
- Output Delivery on WOC or Dbnet

NOAA Operational High Performance Computing

- 2 identical, mirrored high performance IBM computers provide 99+% uptime

Operational Forecast System Development Cycle

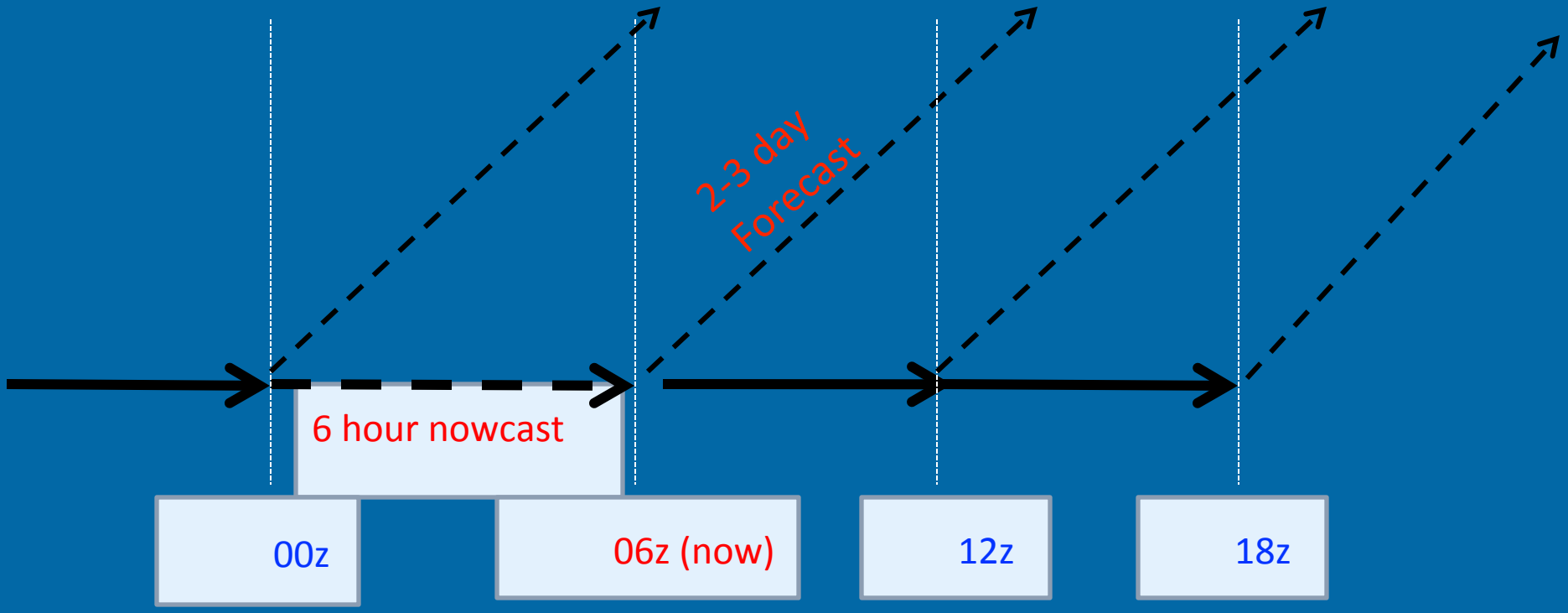


Forcing Data Used by NOS OFS
(Obtained from WCOSS Data Tank)

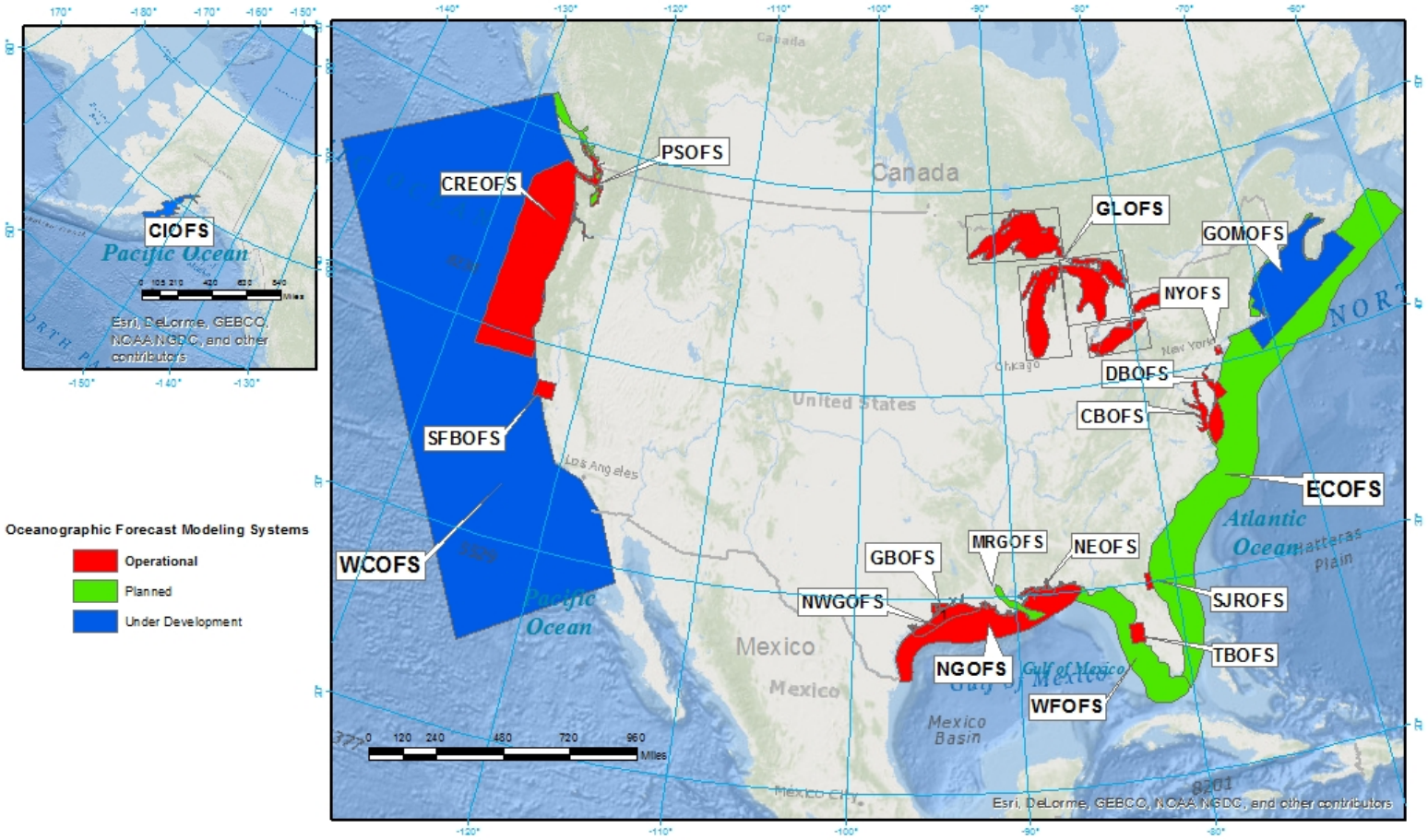
CYCLE	SURFACE FORCING	OCEAN BOUNDARY CONDITIONS	RIVER FORCING
NOWCAST	REAL-TIME Observations NAM4/NAM/GFS RTMA	GRTOFS/HYCOM ETSS	USGS River real – time discharge observations
FORECAST	NAM4/NAM/GFS NDFD	GRTOFS/HYCOM ETSS	Persistence of river observations NWS/RFC AHPS River Forecasts (in future)

Black: Primary Forcing; Blue: Backup Forcing; Red: Future plan

Typical OFS Nowcast/Forecast Schedule



2-3 day forecast updated 4 times per day



NOAA/National Ocean Service
Operational Coastal Modeling Implementation Strategy

Subject to Revision by NOS Management Based Upon Stakeholder Needs & Budget Opportunities.
December 2014

JGW Kelley, NOS/CSDL/MMAP

Strategy Of Developing Hydrodynamic Operational Forecast Systems

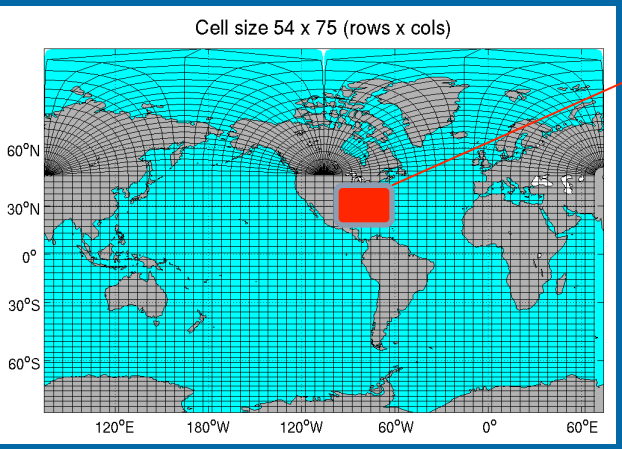
Global Model (G-RTOFS and Navy's HYCOM)

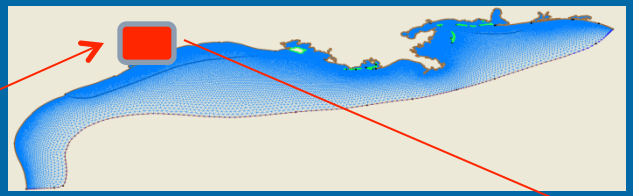
→

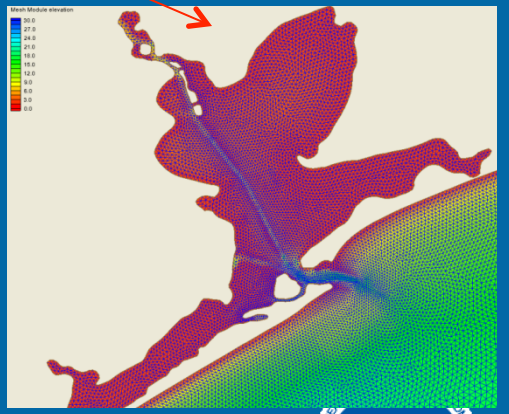
Coastal/Shelf Models (Bridge between Global model and Estuarine/ Bay models)

→

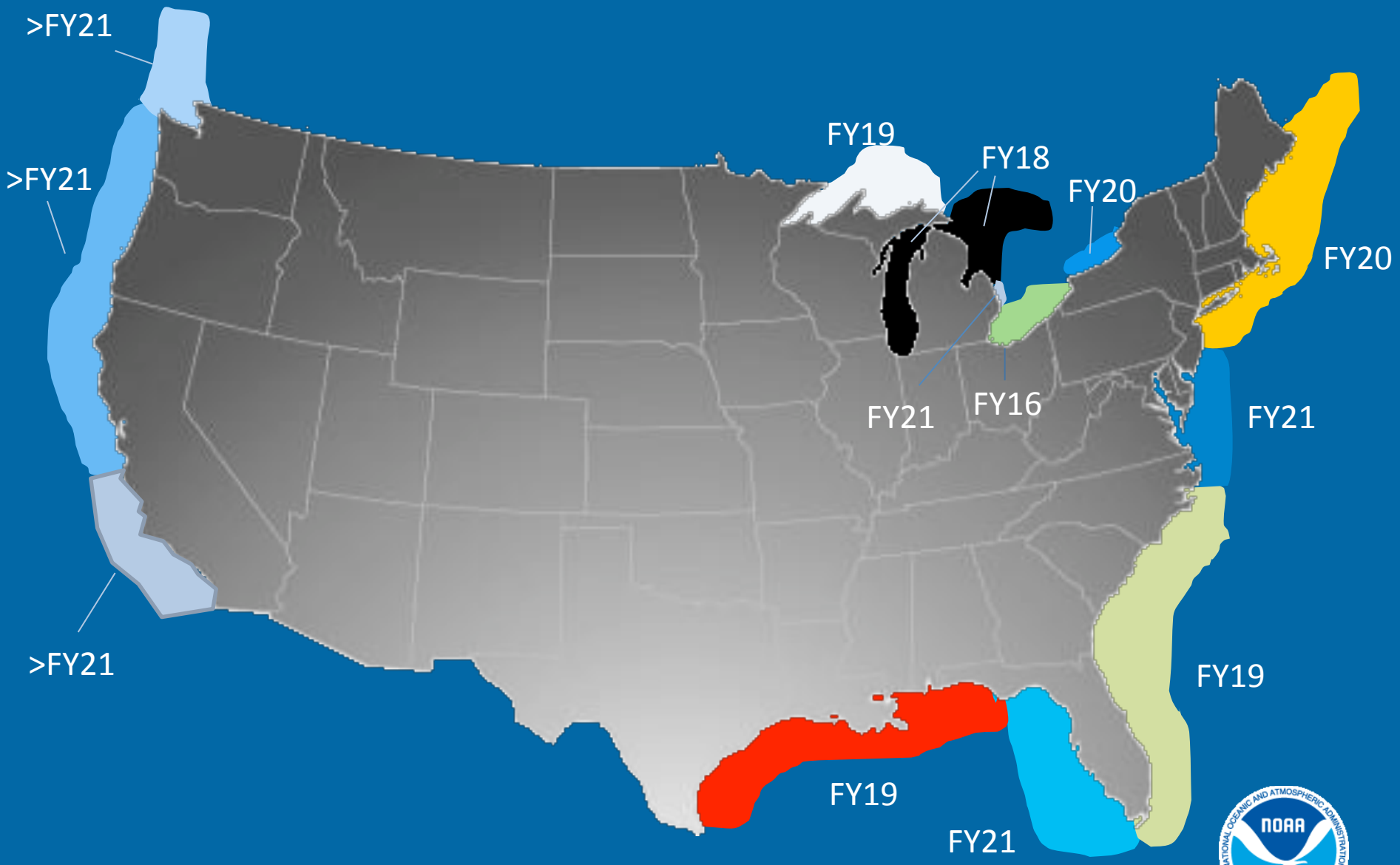
Bay/Estuarine Models (high-resolution to resolve navigational needs)

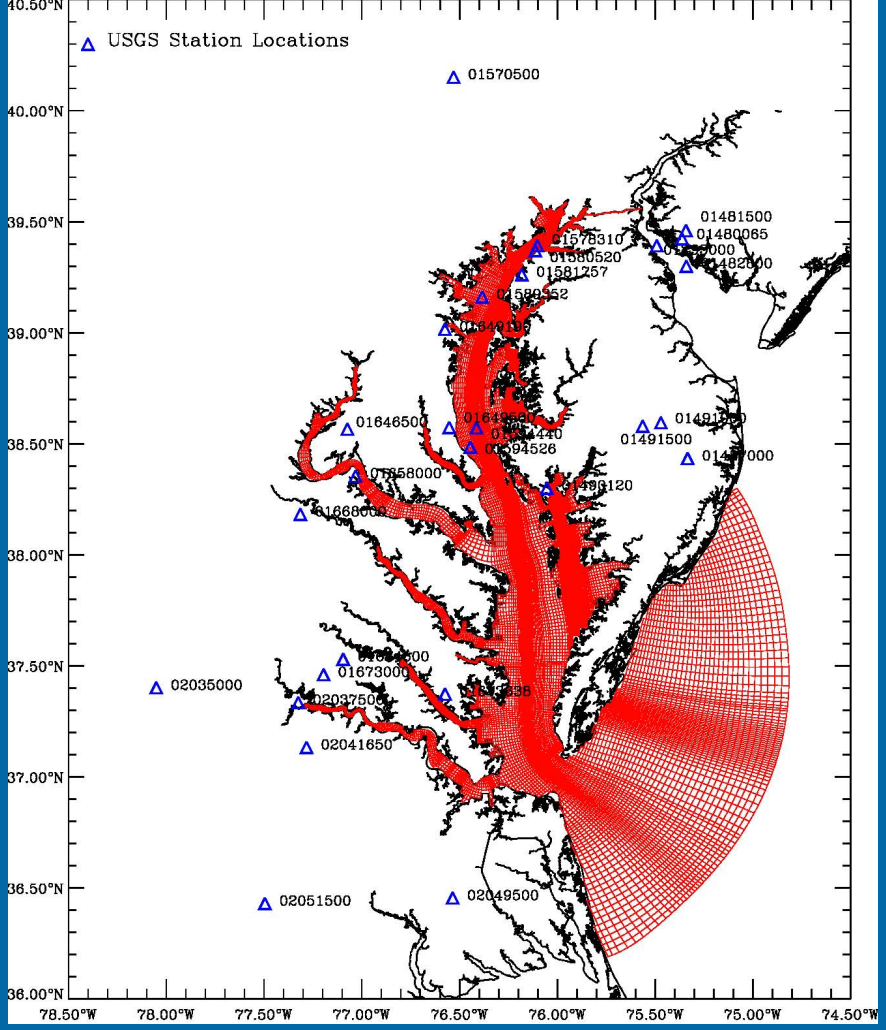


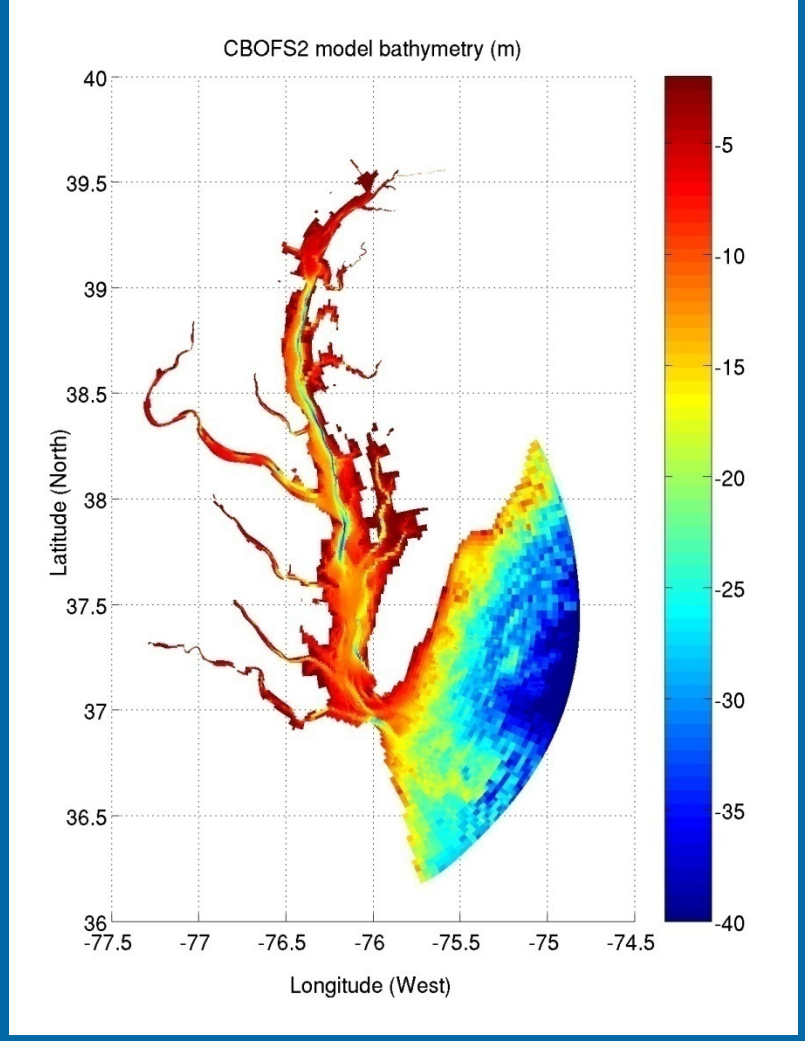




Proposed CONUS Regional Models – 12 to 13



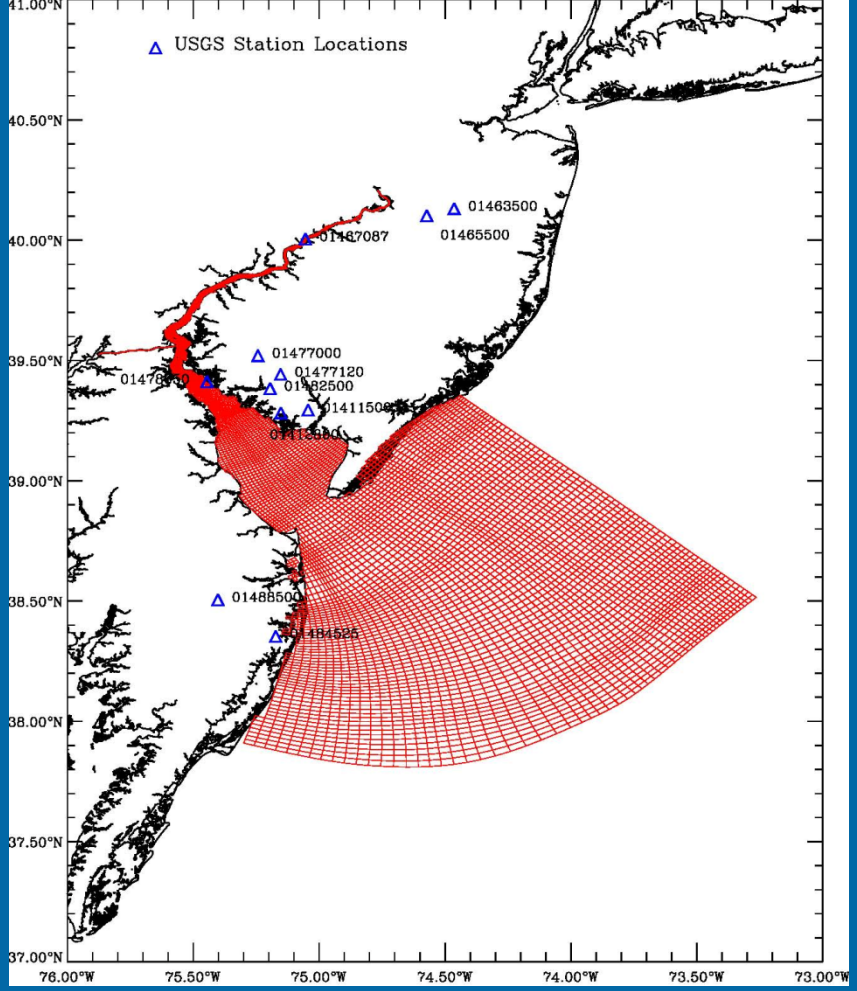


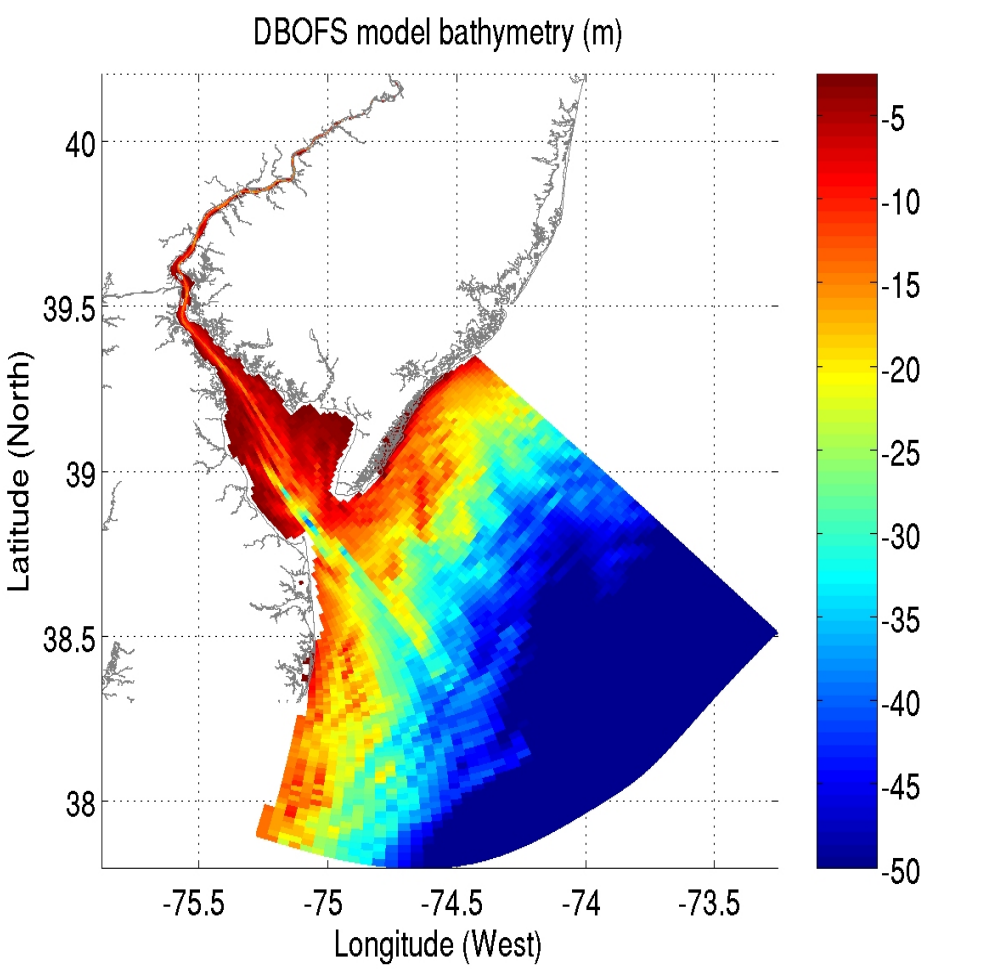


Chesapeake Bay Operational Forecast System (CBOFS)

Dimensions: 291 x 332 x 20
Res. 50 m – 5 km

- 48 hour forecasts of water levels, currents, T & S
- ROMS model implementation



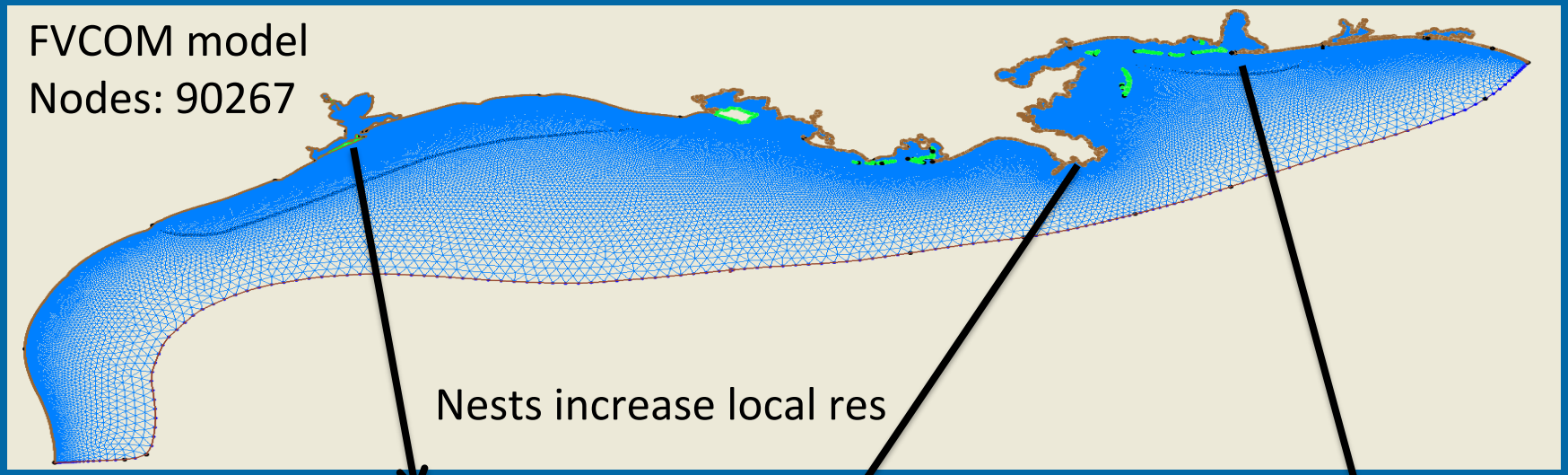


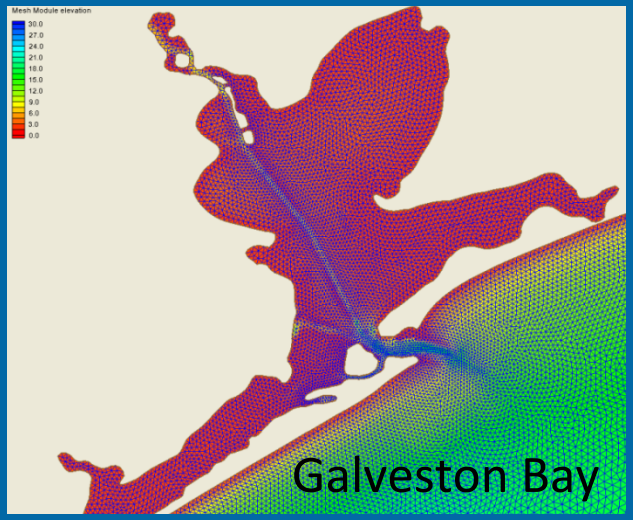
Delaware Bay Operational Forecast System (DBOFS)

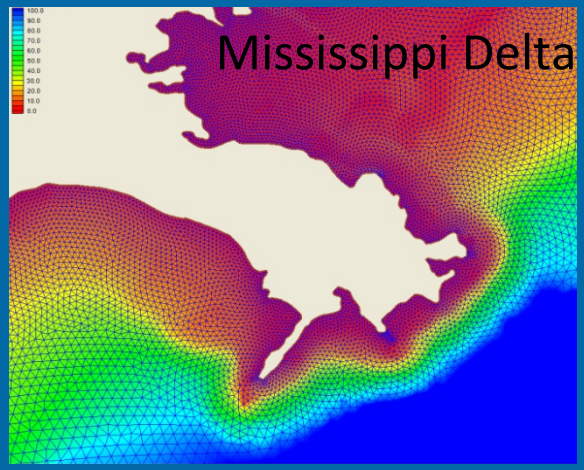
Dimensions: 119 x 732 x 10
Res. 100 m – 3 km

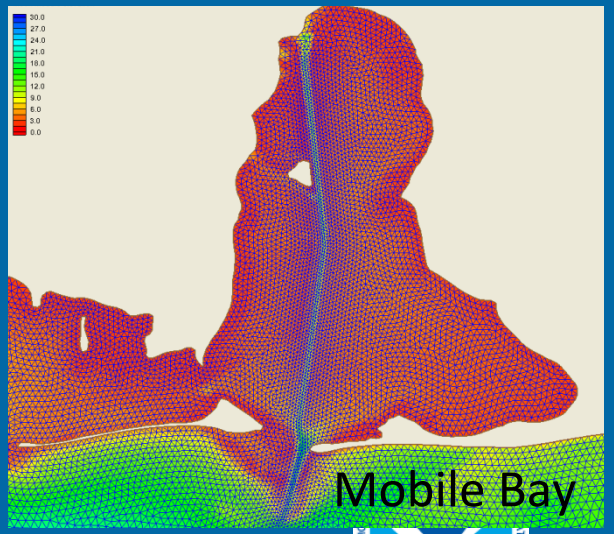
- 48 hour forecasts of water levels, currents, T & S
- ROMS model implementation

Northern Gulf of Mexico Operational Forecast System (NGOFS)

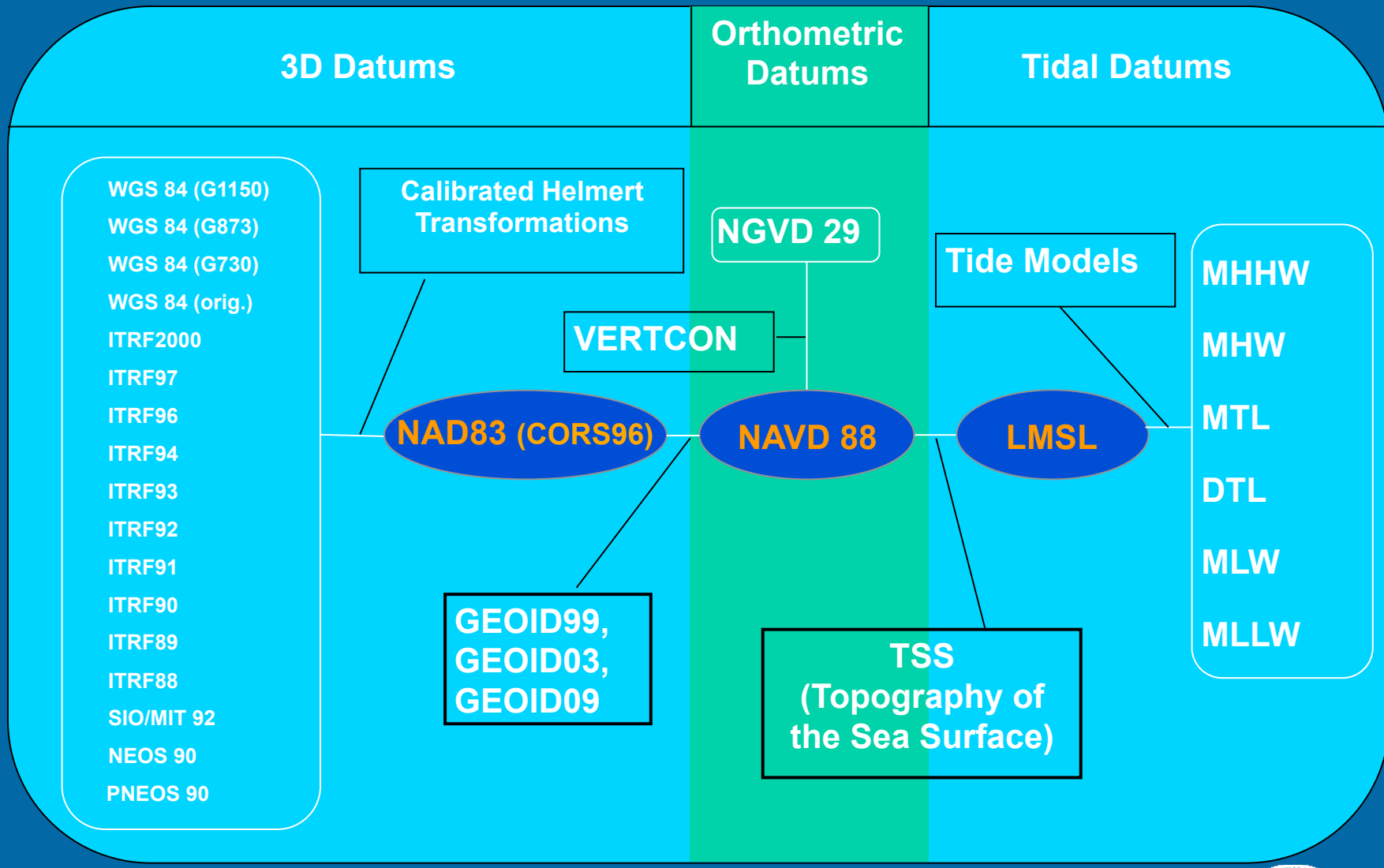


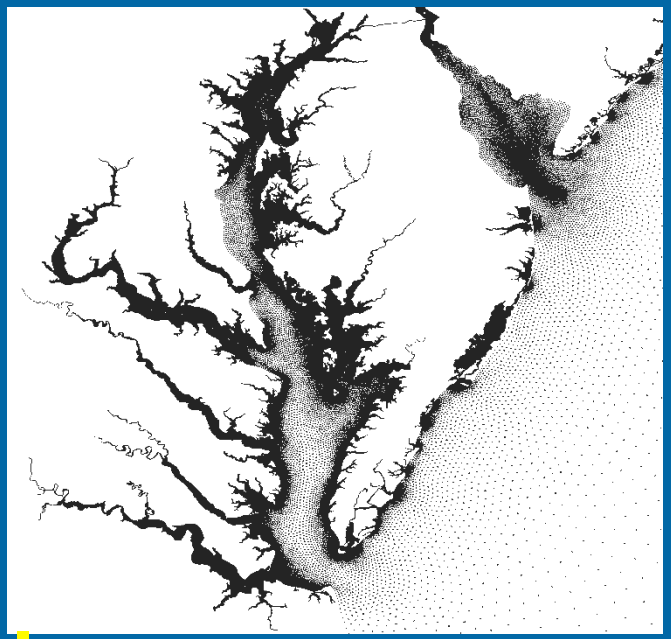




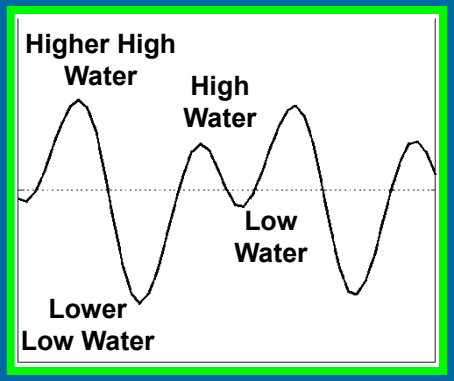


NOAA's VDatum Software for Vertical Datum Transformations

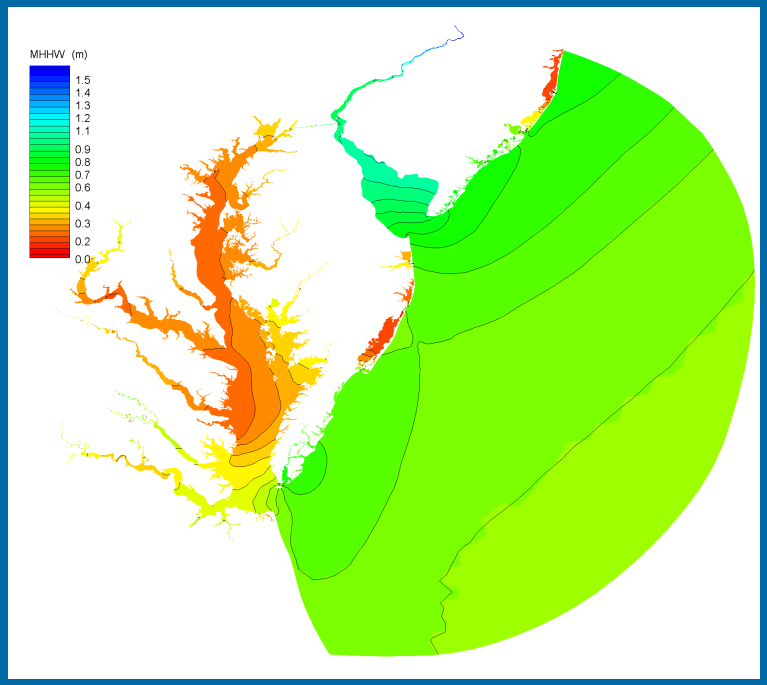




ADCIRC model is used to generate time series of the tides at each grid point.



Tidal datums are computed from the time series at each grid point.

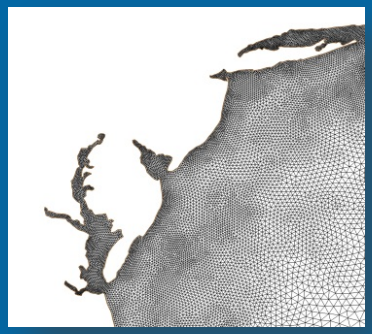


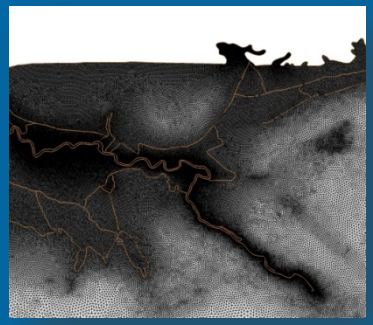
- Final tidal datum fields are corrected to match observations at CO-OPS water level stations.
- Corrections are made using TCARI, an interpolation tool based on solution of Laplace's equation.

Current VDatum Availability

CSDL Storm Surge Modeling Efforts

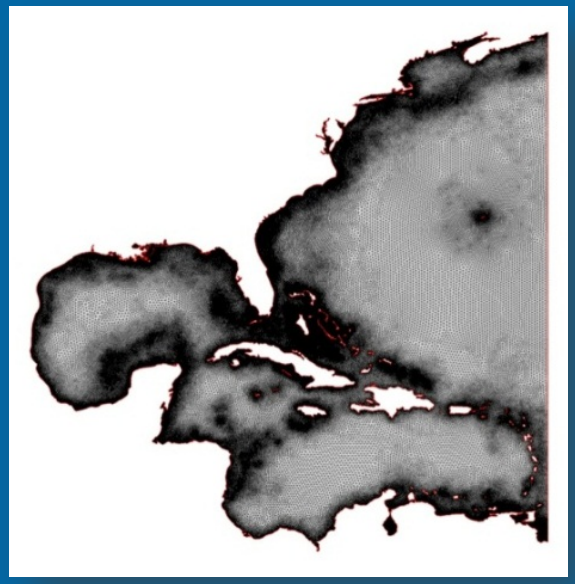
- Using ADCIRC model for extratropical (e.g., nor'easter) and tropical (e.g., hurricane)
  - State of the art model in active development and use by academia, private industry, USACE, FEMA, Navy
  - Uses large scale unstructured triangular grids with efficient localized resolution
  - Combines surge, tides, rivers and wave model input
  - Surge model upgrades coordinated with NWS (i.e., Sandy Supplemental)

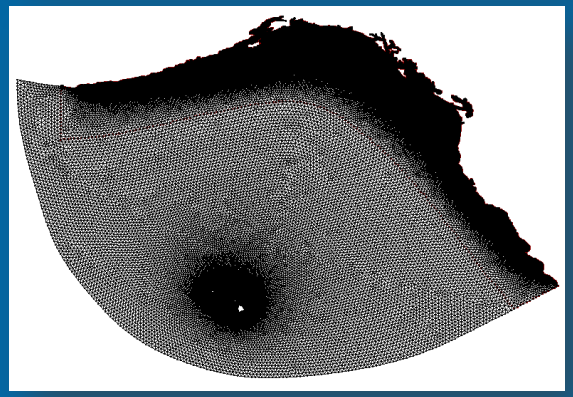




Extratropical Surge and Tide Prediction

- Extratropical Surge + Tide Operational Forecast System (ESTOFS)
- Computes surge *with* tides for forecasting and for coupling to Nearshore Wave Pred. System
- NOS developed using ADCIRC
  - Coastal resolution ≈ 3 km, GFS forcing, 6-hr nowcast followed by 180-hr forecast
- Atlantic operational October 2012, Pacific operational June 2014

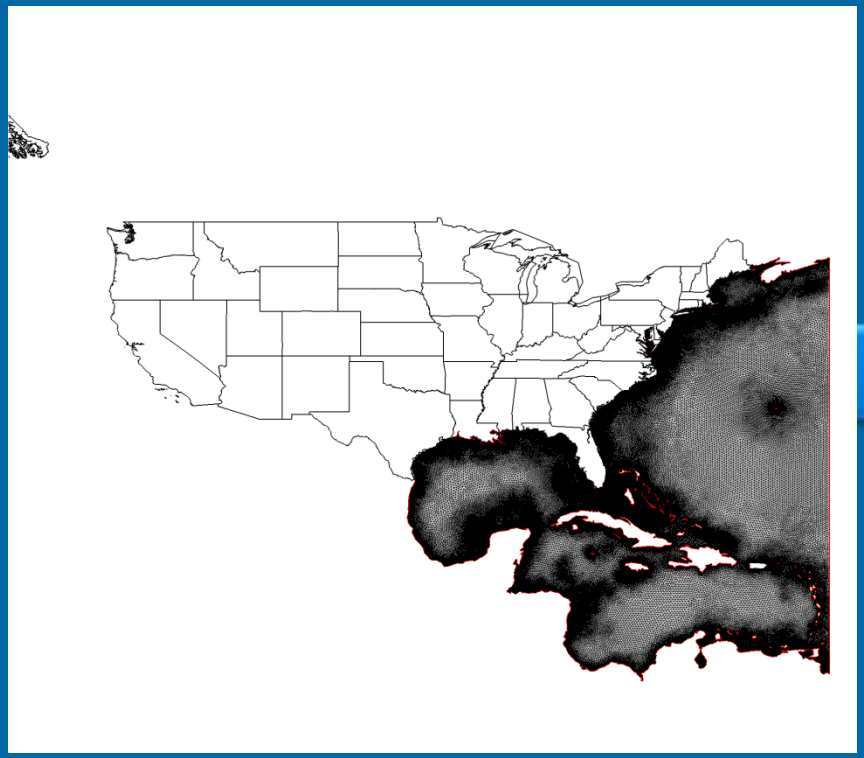




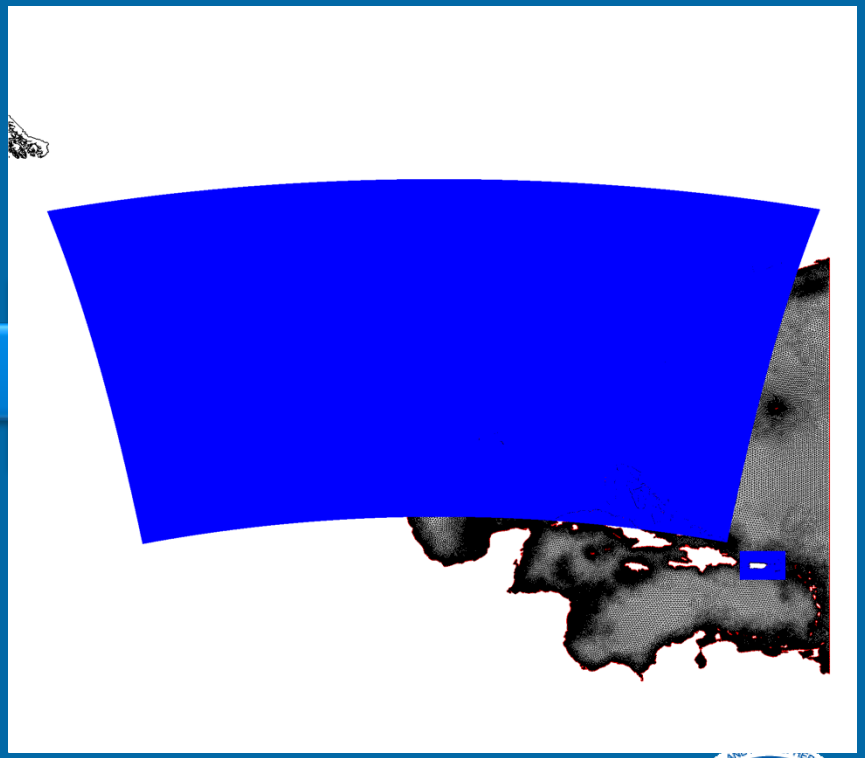
http://www.opc.ncep.noaa.gov/estofs/estofs_surge_info.shtml

Grid Interpolation

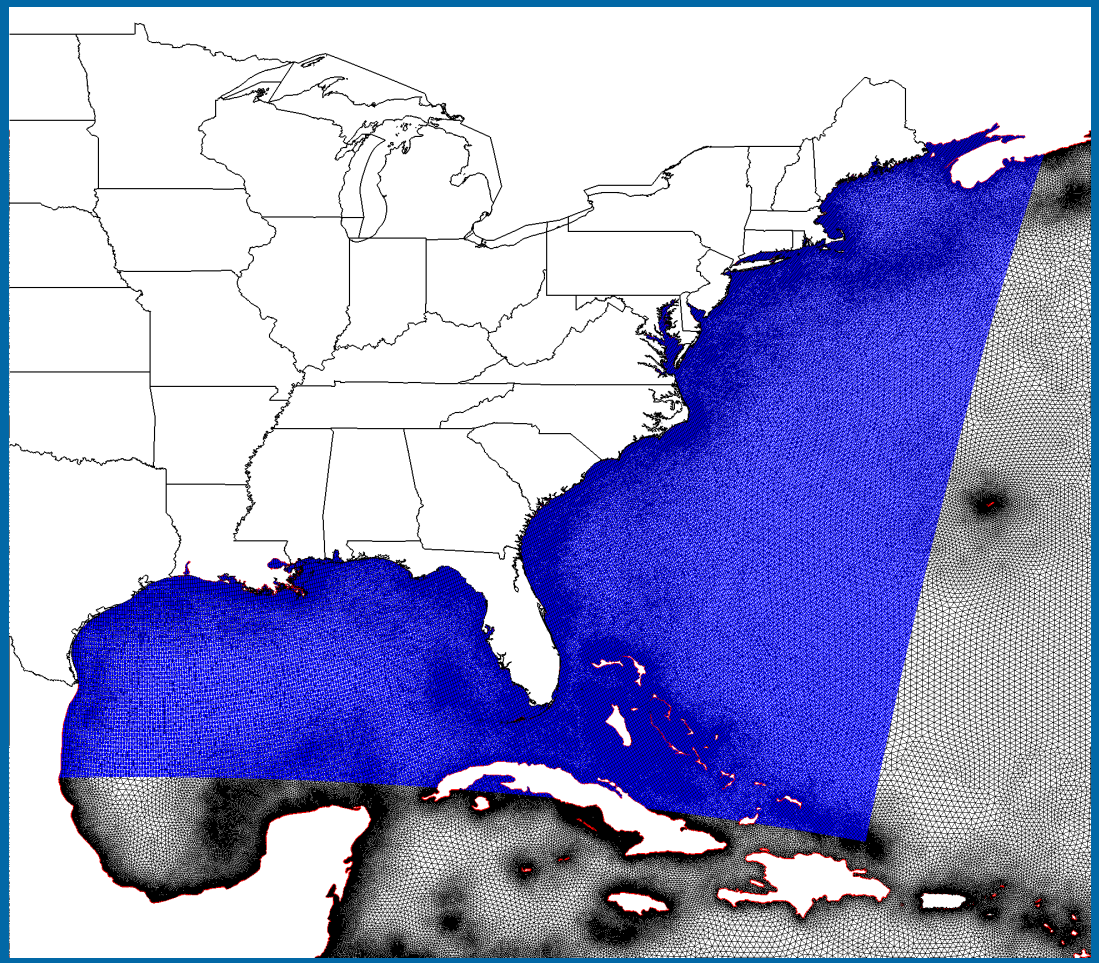
EC2001 grid



NDFD CONUS and Puerto Rico grid

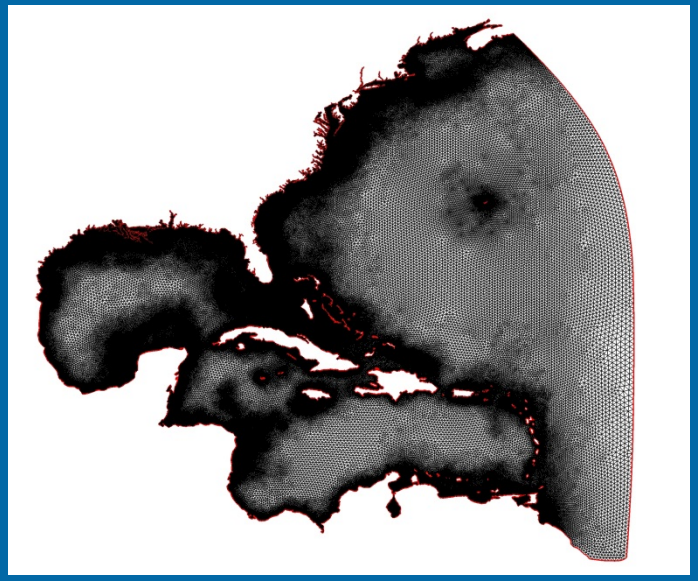


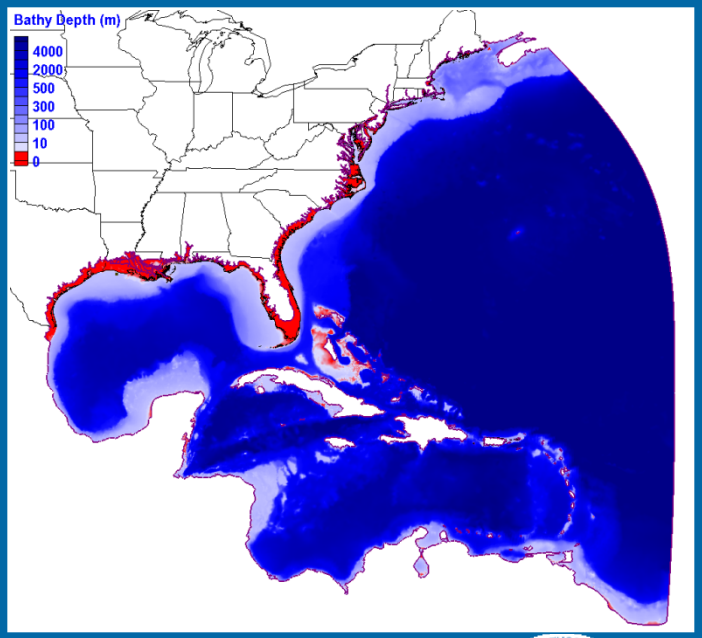
NDFD CONUS



Tropical Surge Modeling

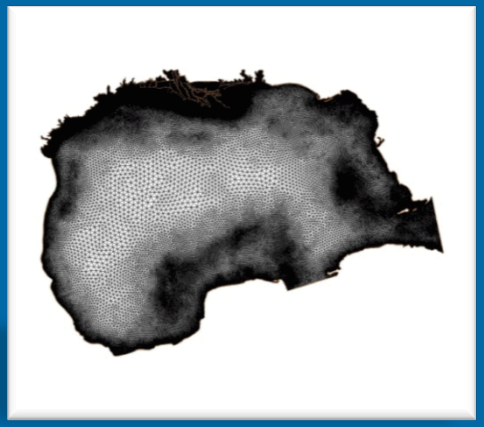
- Developing ensemble storm surge guidance for surge with tide for Atlantic tropical cyclones
  - Forced by perturbations of Official Forecast Track or HWRF Output
- Using ADCIRC to run a large scale domains with local resolution down to 200 m, employing advanced physics
- Downstream boundary conditions for hydrologic models
- In experimental testing for future operations

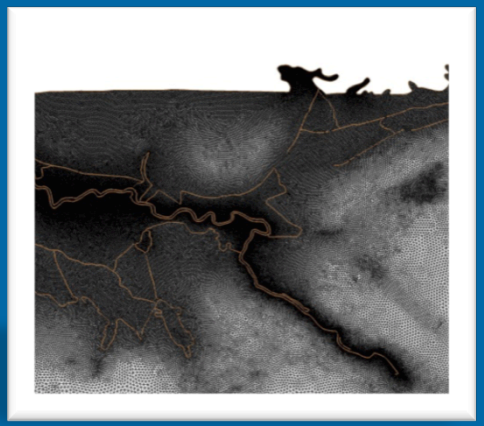




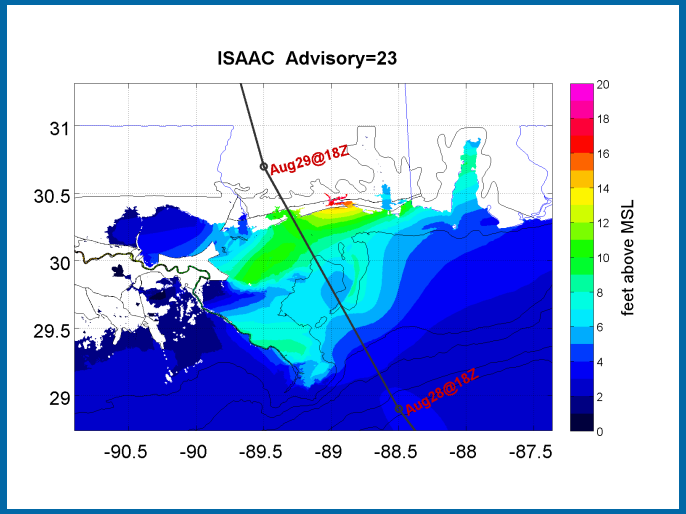
Experimental High Res Surge Ensemble

- ADCIRC Surge Guidance System
  - Automated system for ADCIRC
- NOAA tested in 2012 on experimental Hurricance Forecast Improvement Project (HFIP) computer “tjet”
  - 5 to 10 member ensemble
  - Began with grid from IOOS testbed
- Expanding Sandy Supplemental effort to prepare for transition to operations

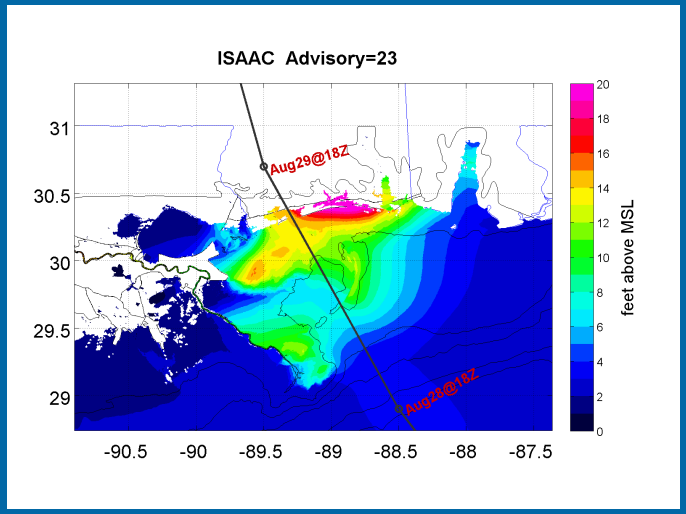




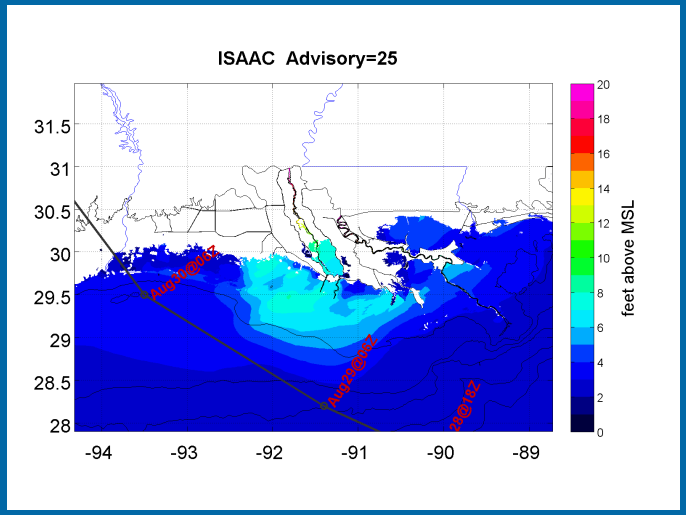
Ensemble of Predictions due to Track Uncertainty



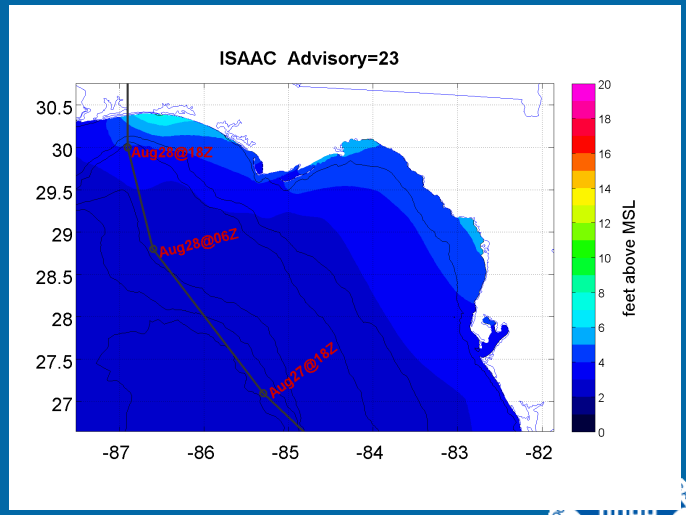
Official Track



20% More Intense



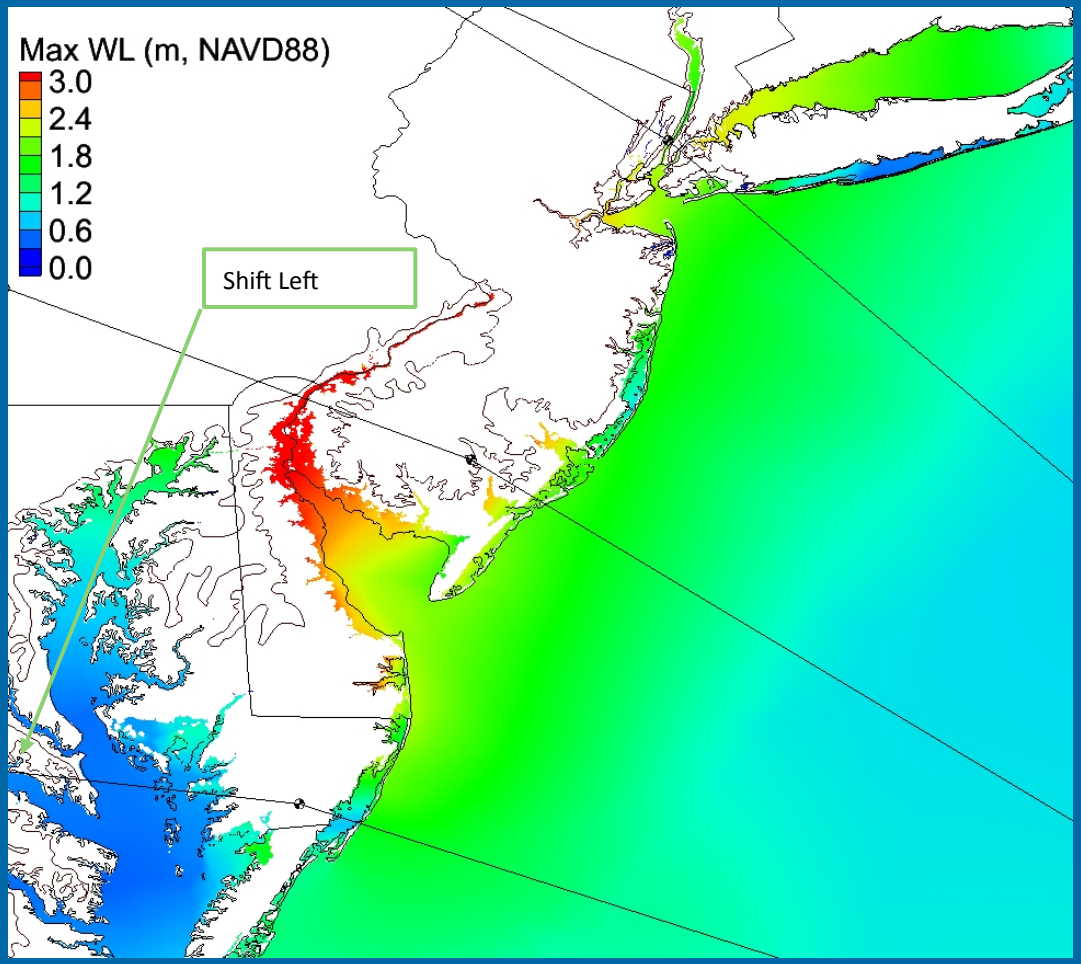
Left shift

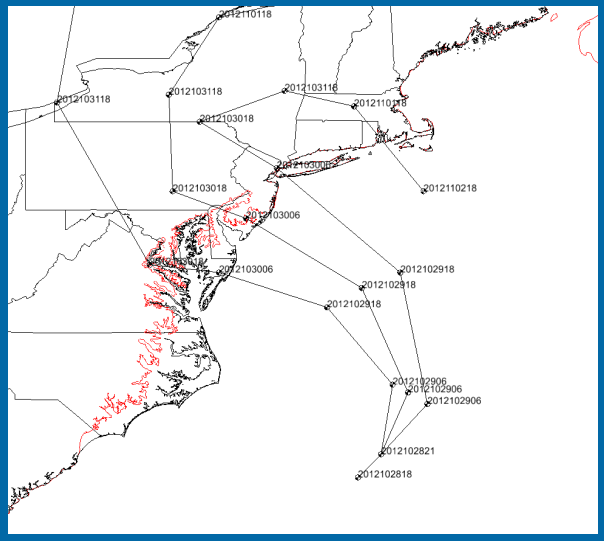


Right Shift

ASGS Ensemble Testing: Sandy

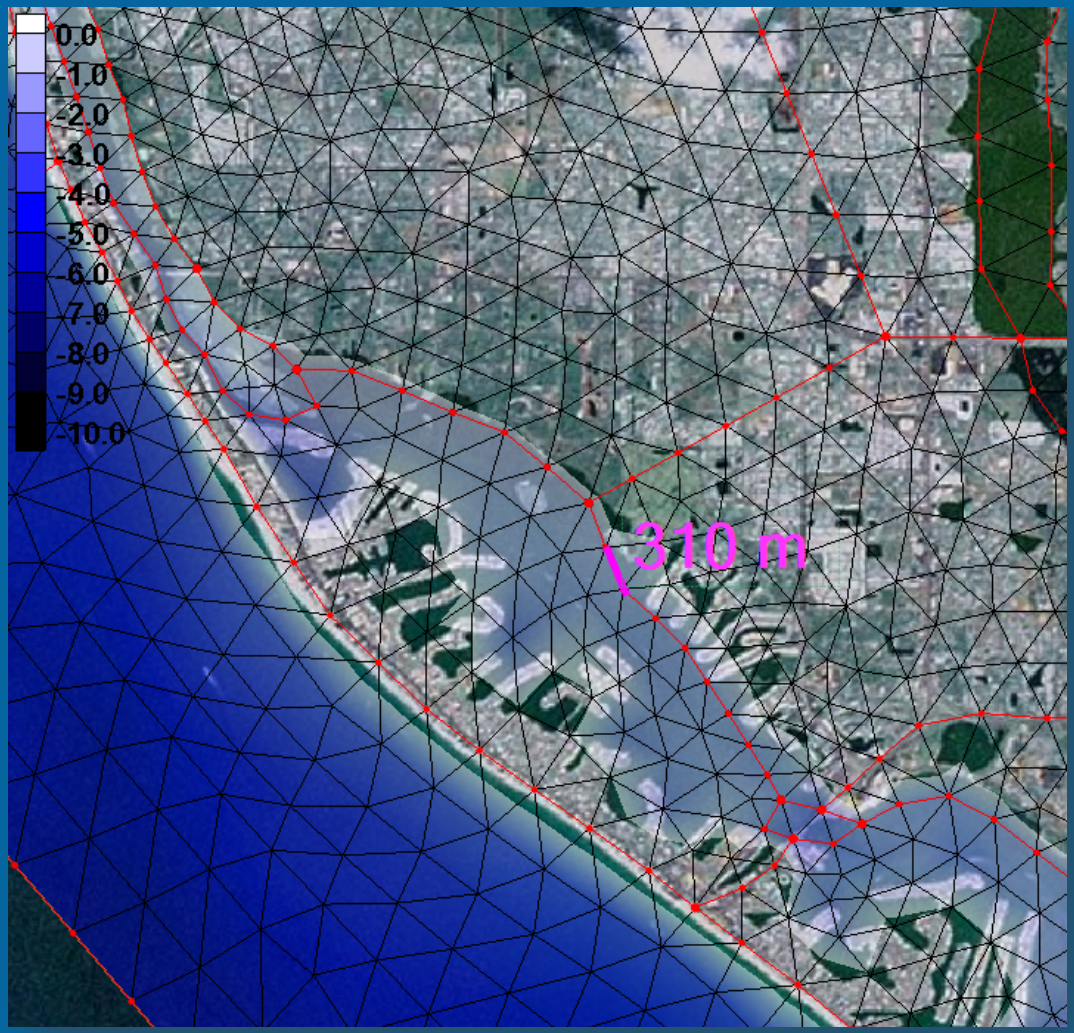
Advisory 26 (10/28/2012 18Z)





- NHC OFCL track forecast perturbed to create ensemble members
- Parametric Holland B hurricane model forcing

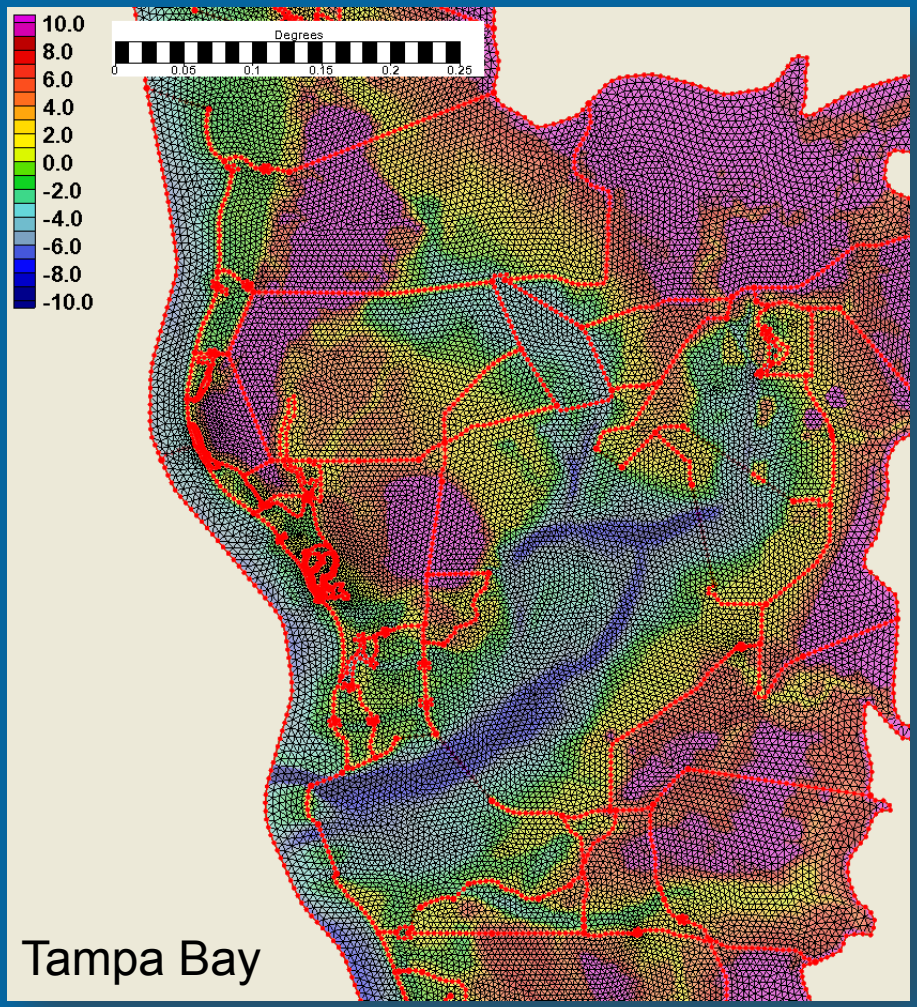
Developmental Hurricane Storm Surge Operational Forecast System

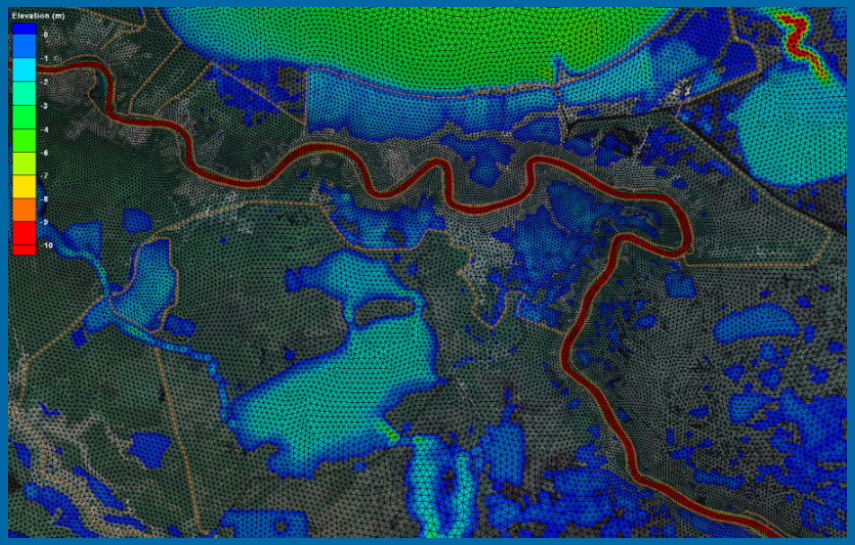


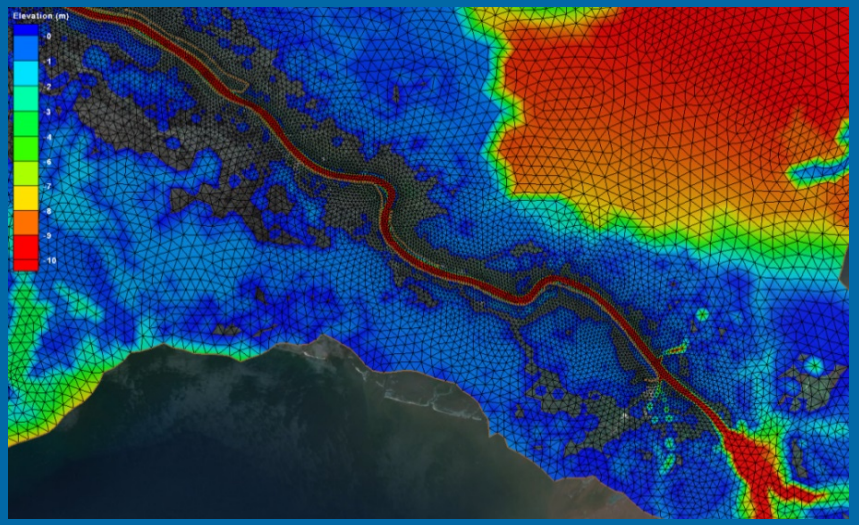
Grid resolution:

- From 500 m to 200 m at coast
- Extends up to 10 m inland contour and up major rivers to provide downstream boundaries
- Roughly 1.8 million nodes

HSSOFS Beta Domain

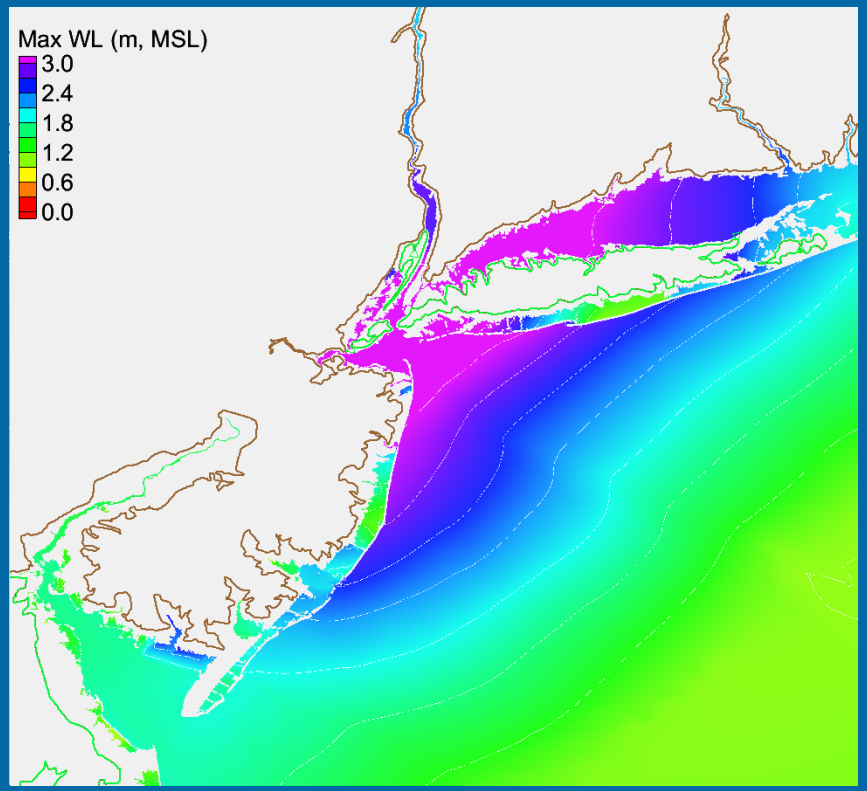






HSSOFS Validation – 2012 Sandy

- Meteorological forcing from HWRF hindcast
- Model skill generally good, low bias ~0.15 m



peak surge (m)

Questions?