Recent Developments in Probabilistic Hurricane Storm Surge (P-Surge 2.0)

Estuarine and Coastal Modeling 13

San Diego, CA (November 4, 2013)

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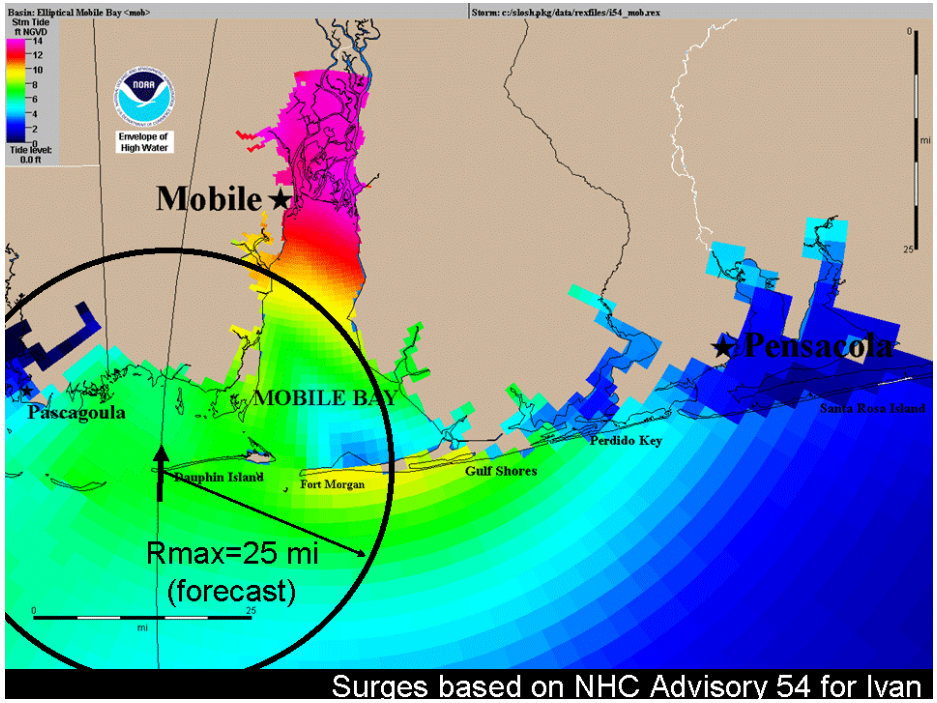
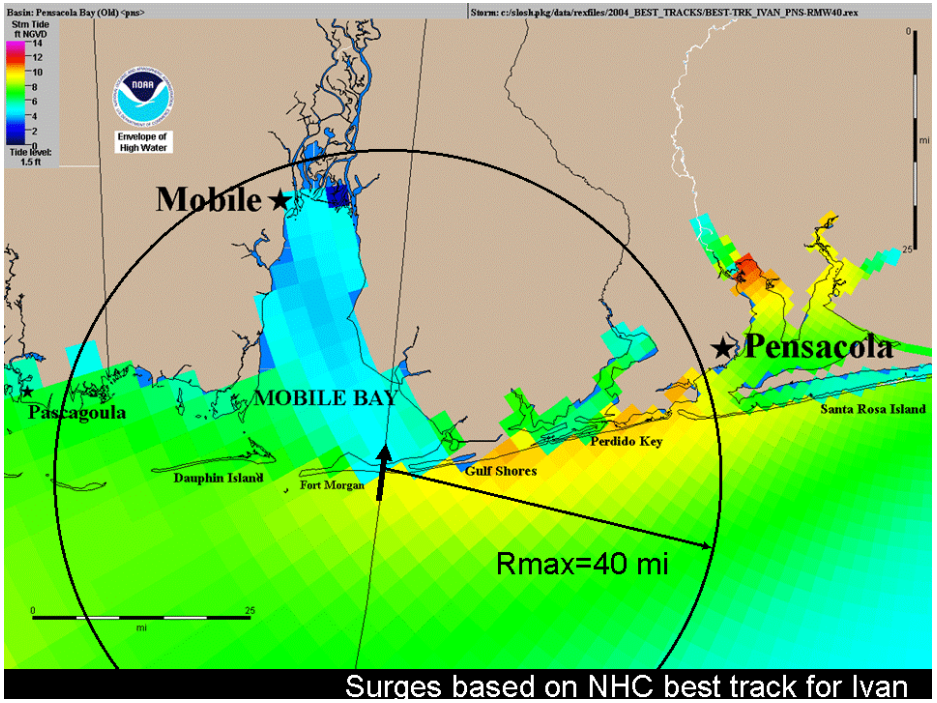
Hurricane Ivan: A case study



Surges based on NHC Advisory 54 for Ivan



Surges based on NHC best track for Ivan

P-Surge Methodology

Need: Probabilistic information within 1 hour of advisory

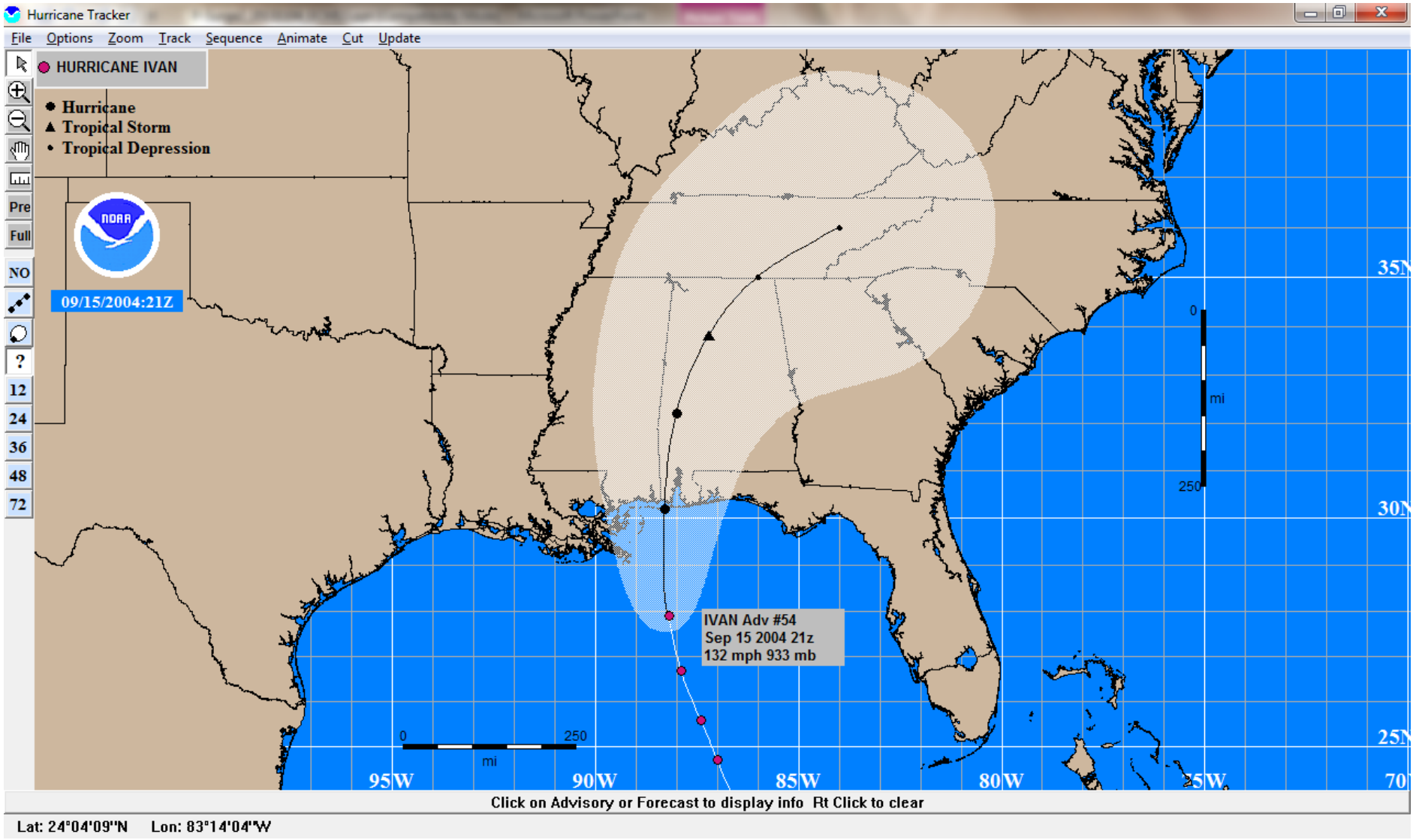
Derive probabilistic guidance from a set of SLOSH (Sea Lake and Overland Surges from Hurricanes) model runs

- Ensemble is centered on NHC's official advisory
- Error space is based on 5-year Mean Absolute Error (MAE); assumed normal distribution; and that MAE = 0.7979 sigma
- Error space is sampled via representative storms rather than via random sampling

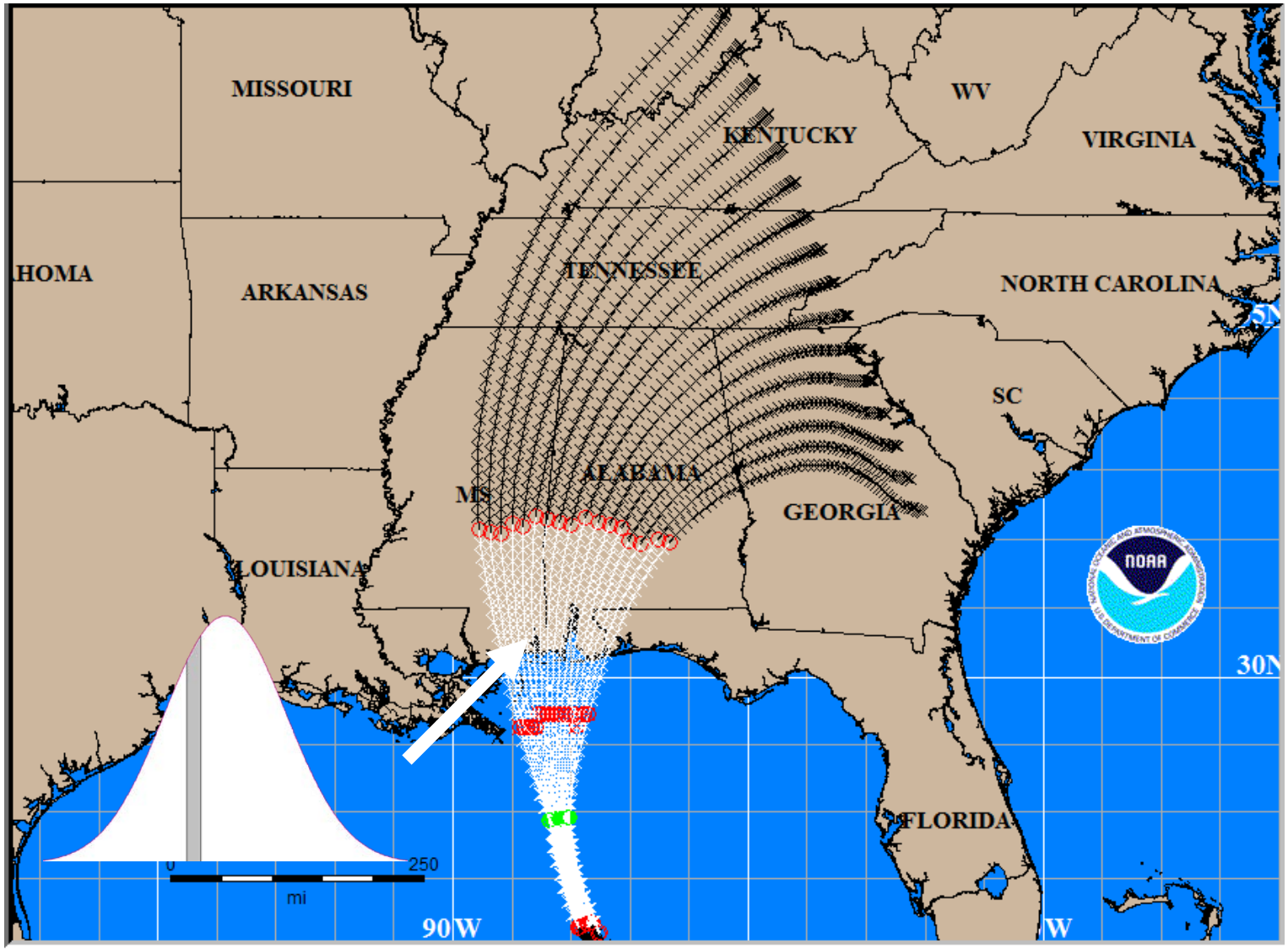
Why SLOSH?

- Efficient (100s of runs in 30 minutes with few CPU)
- Maintained as part of hurricane evacuation studies
- Parametric wind model for forcing
- Overland flooding

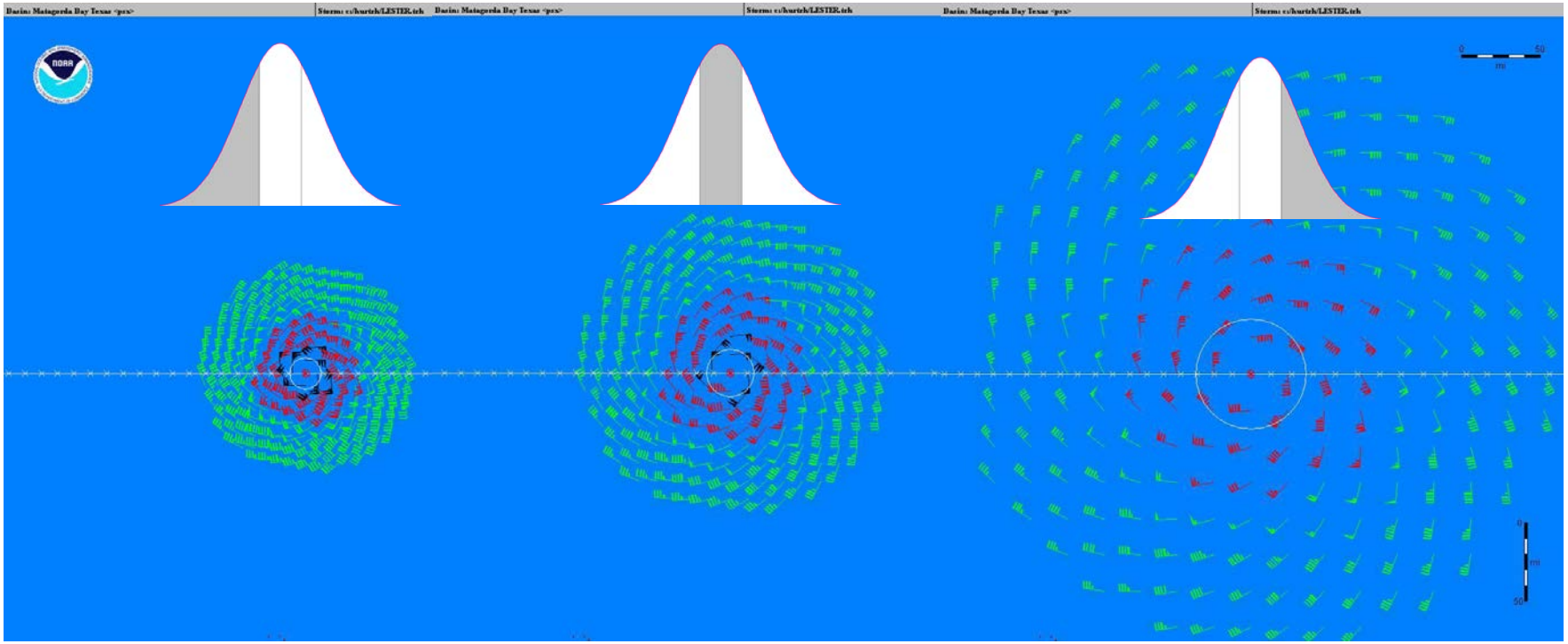
Ivan Advisory 54



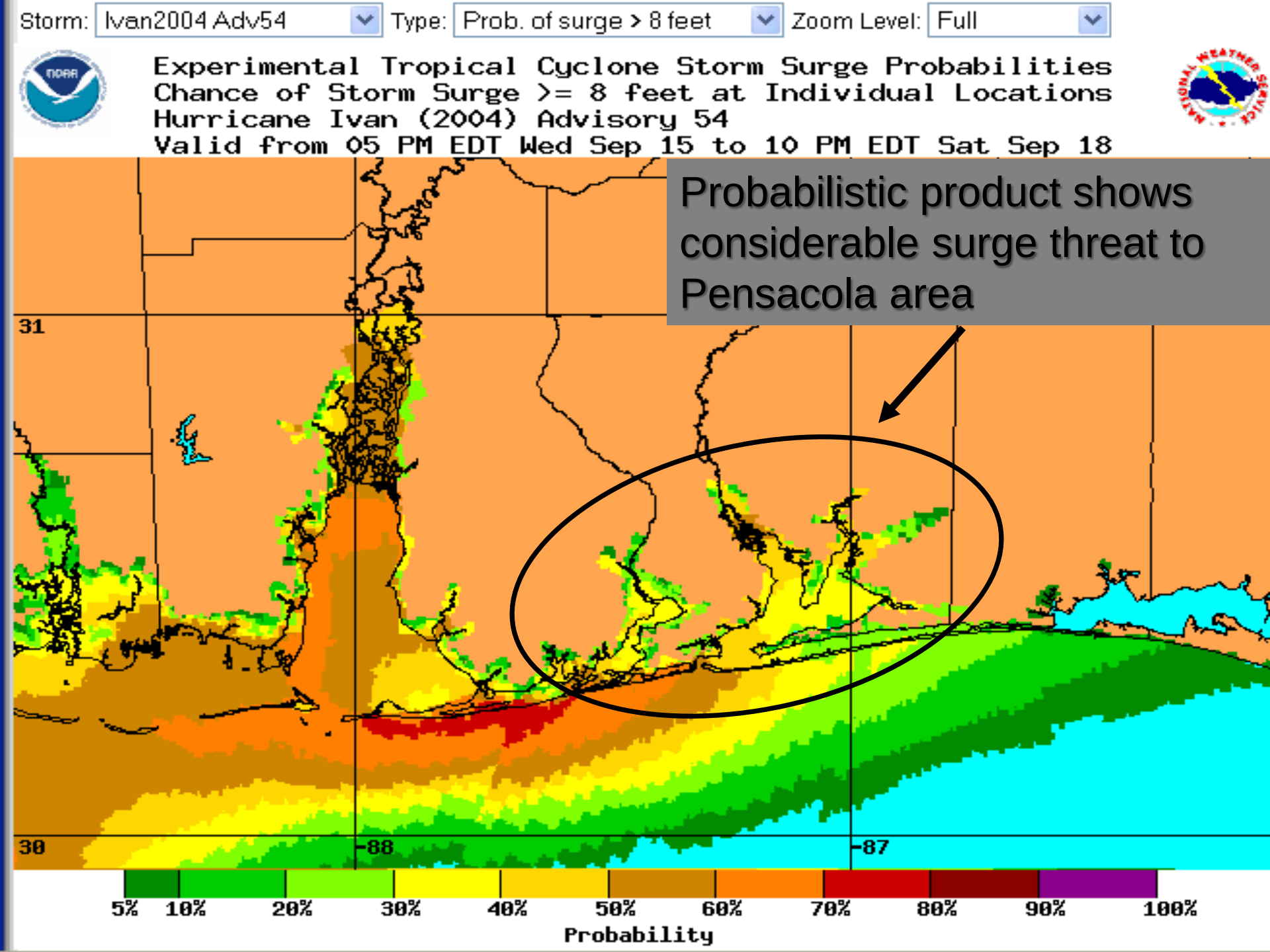
P-Surge - Vary Cross Track



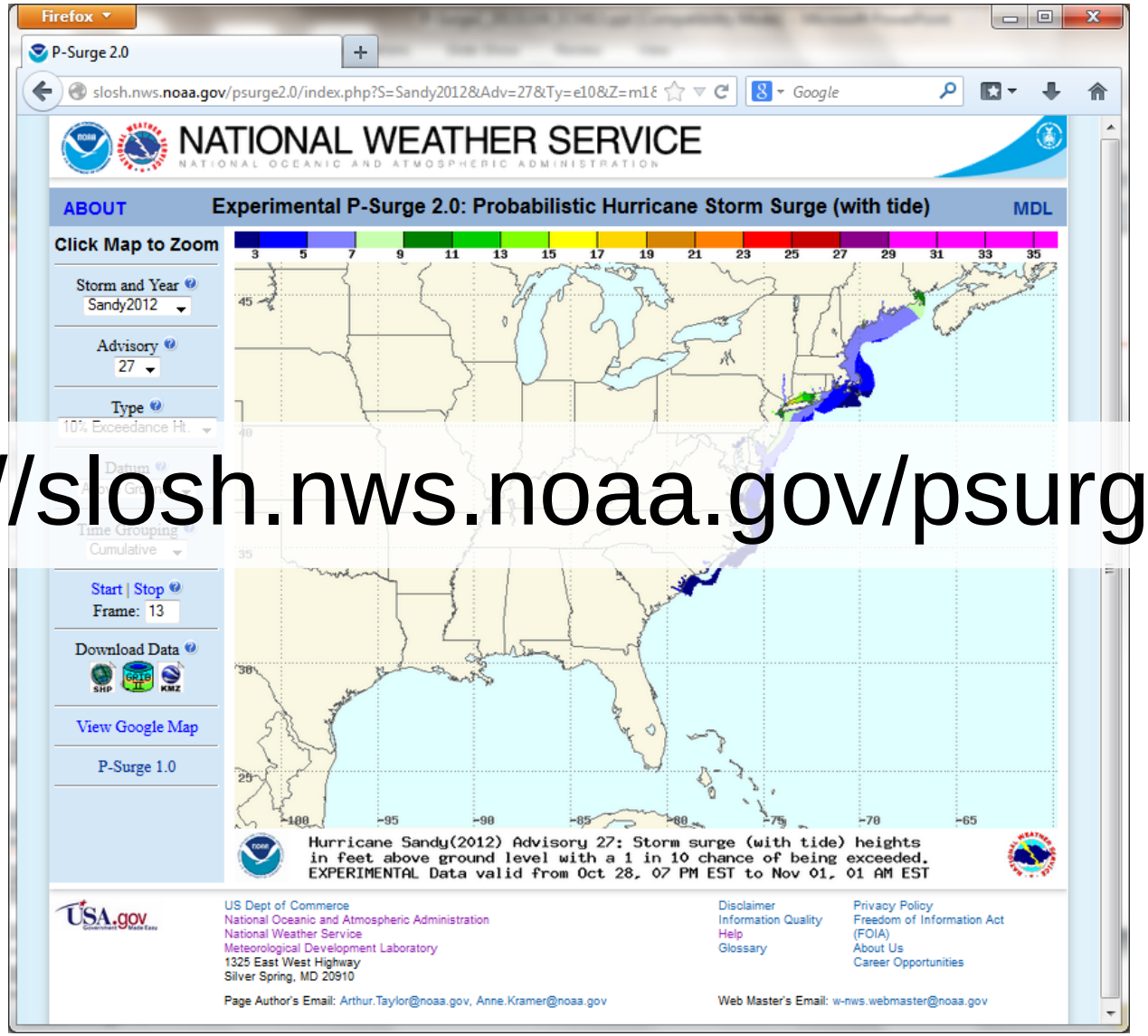
P-Surge – Vary Other Variables



- Size: Small (30%), Medium (40%), Large (30%)
- Forward Speed: Fast (30%), Medium (40%), Slow (30%)
- Intensity: Strong (30%), Medium (40%), Weak (30%)


Storm: Ivan2004 Adv54
Type: Prob. of surge > 8 feet
Zoom Level: Full
Experimental Tropical Cyclone Storm Surge Probabilities
Chance of Storm Surge >= 8 feet at Individual Locations
Hurricane Ivan (2004) Advisory 54
Valid from 05 PM EDT Wed Sep 15 to 10 PM EDT Sat Sep 18
Probabilistic product shows considerable surge threat to Pensacola area
31
30
88
87
5%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Probability

P-Surge 2.0



http://slosh.nws.noaa.gov/psurge2.0

P-Surge 2.0 Enhancements

1. Most recent SLOSH basins
   - **Advantage**: More accurate storm surge using modern vertical datum (NAVD-88)
   - **Impact**: Slower run times due to higher resolution

2. Above ground level as well as above datum
   - **Advantage**: Enhanced communication as general users do not understand datums
   - **Impact**: More files to process

P-Surge 2.0 Enhancements

3. SLOSH + Tide
   - Each ensemble member defines time allowing addition of a gridded tide
   - **Advantage**: More accurate overland inundation
   - **Impact**: More along track error samples (from 3 to 7)

4. Time component
   - Create (13) 6-hour cumulative and (13) 6-hour incremental probability products rather than (1) 80-hour cumulative probability product
   - **Advantage**: Provides timing guidance
   - **Impact**: Larger and more numerous files to process

SLOSH + Tides

- Extract tidal constituents at every SLOSH grid cell from EC2012

- Version 1
  - Run SLOSH, add tide to wet cells, output result
  - **Issue:** Tide not considered during inundation step
  - **Issue:** Extrapolated tidal values overland

SLOSH + Tides

- Version 2
  - Initialize with tide (time = t0), SLOSH moves tide and surge to time = t1, subtract tide (time = t0) and add tide (time = t1), Repeat
  - **Issue:** Extrapolated tidal values overland
  - **Issue:** Wetting/Drying impacts computation

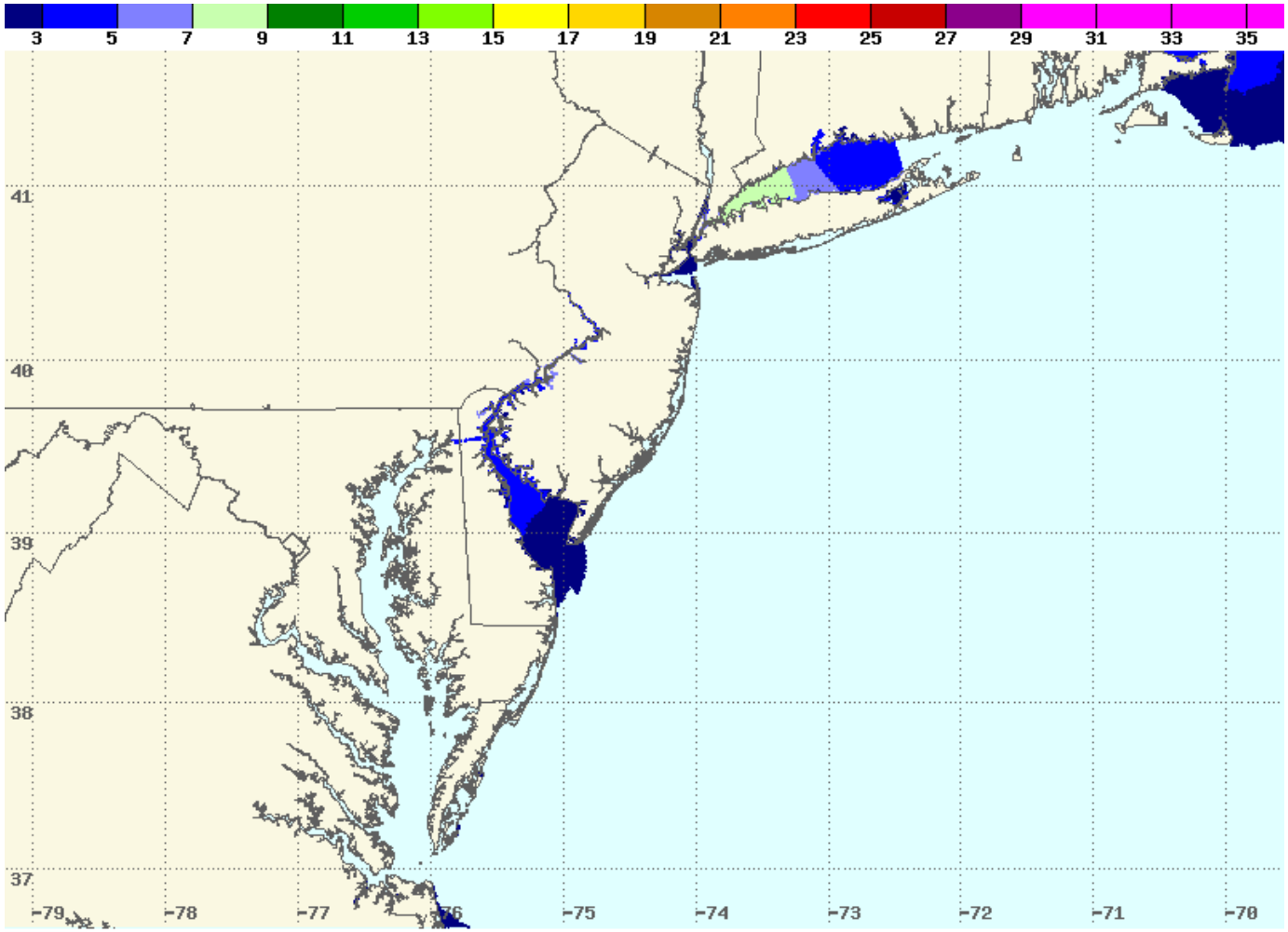
- Version 3
  - Use constituents to compute tide on boundary
  - **Issue:** Getting tide through narrow mouths into estuaries
  - **Issue:** Need to be more efficient about spin-up time

SLOSH + Tides

- Version 2.1.x
  - Restrict Version 2 to values deeper than x feet
  - **Issue 1:** Tidal constituents still extracted for rivers
  - **Issue 2**: Penobscot Bay tides incorrectly propagated
  - **Solution 2:** treat values less than -290 feet as hydrostatic heights (only barometric pressure forcing)

- Version 2.2.x
  - Restrict Version 2.1.x to full width grid cells
  - **Issue:** The -290 feet restriction caused instability in most recent New Orleans basin

Storm Surge with Tide Exceeded by 10% of Ensemble Members



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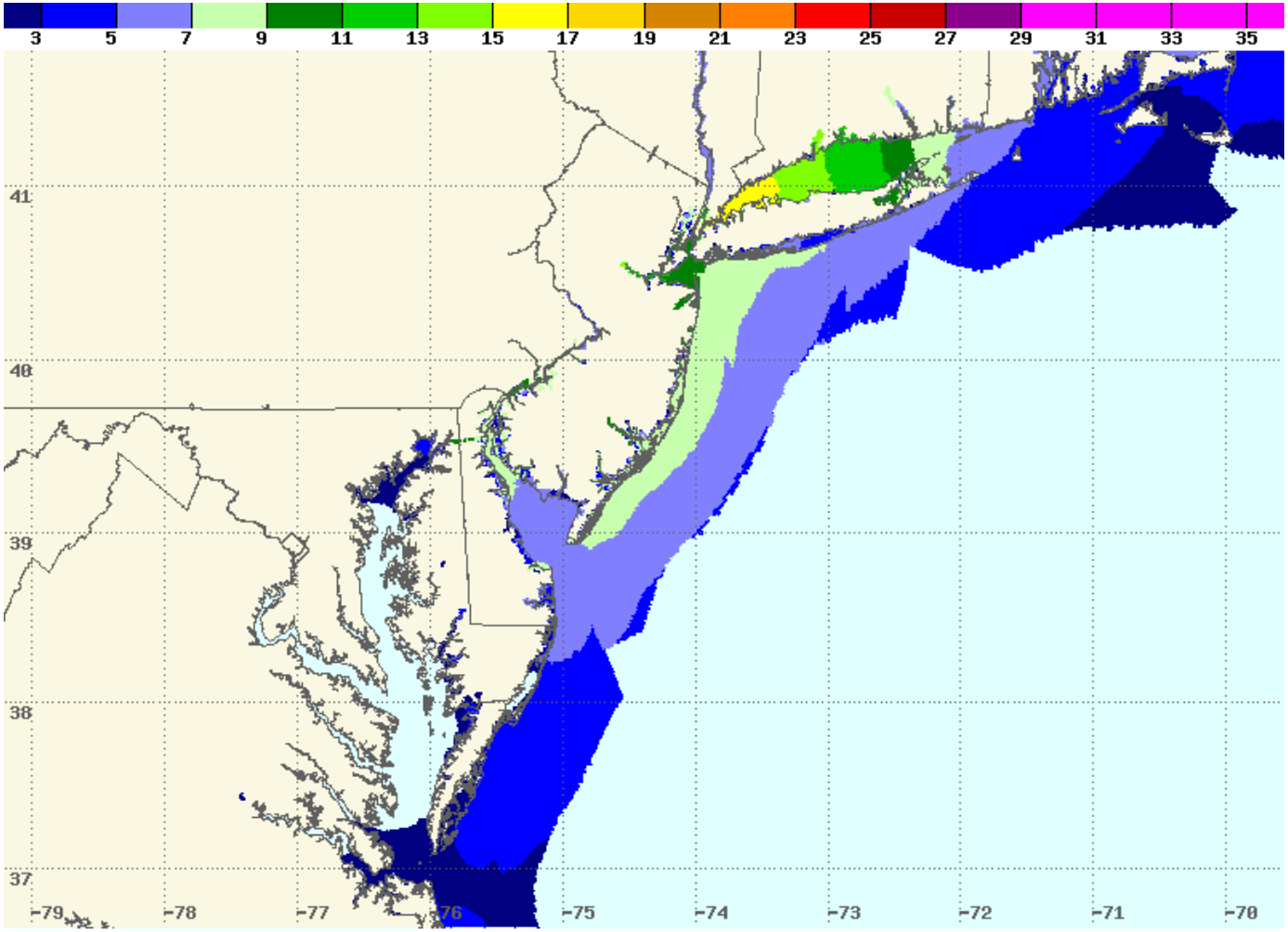

Examples of Future Work

- SLOSH + tide Version 3 (Arakawa C-Grid)
- Handle Tropical Storms
- Increase the 48-hour forecast time range
- Increase temporal resolution from 6-h to 1-h
- Handle multiple storms simultaneously
- Nest smaller finer tropical basins within larger coarser extra-tropical basins
- SLOSH + waves
- Handle Puerto Rico and Virgin Islands
- Validation