Model Simulations of Hurricane Sandy

Led by:

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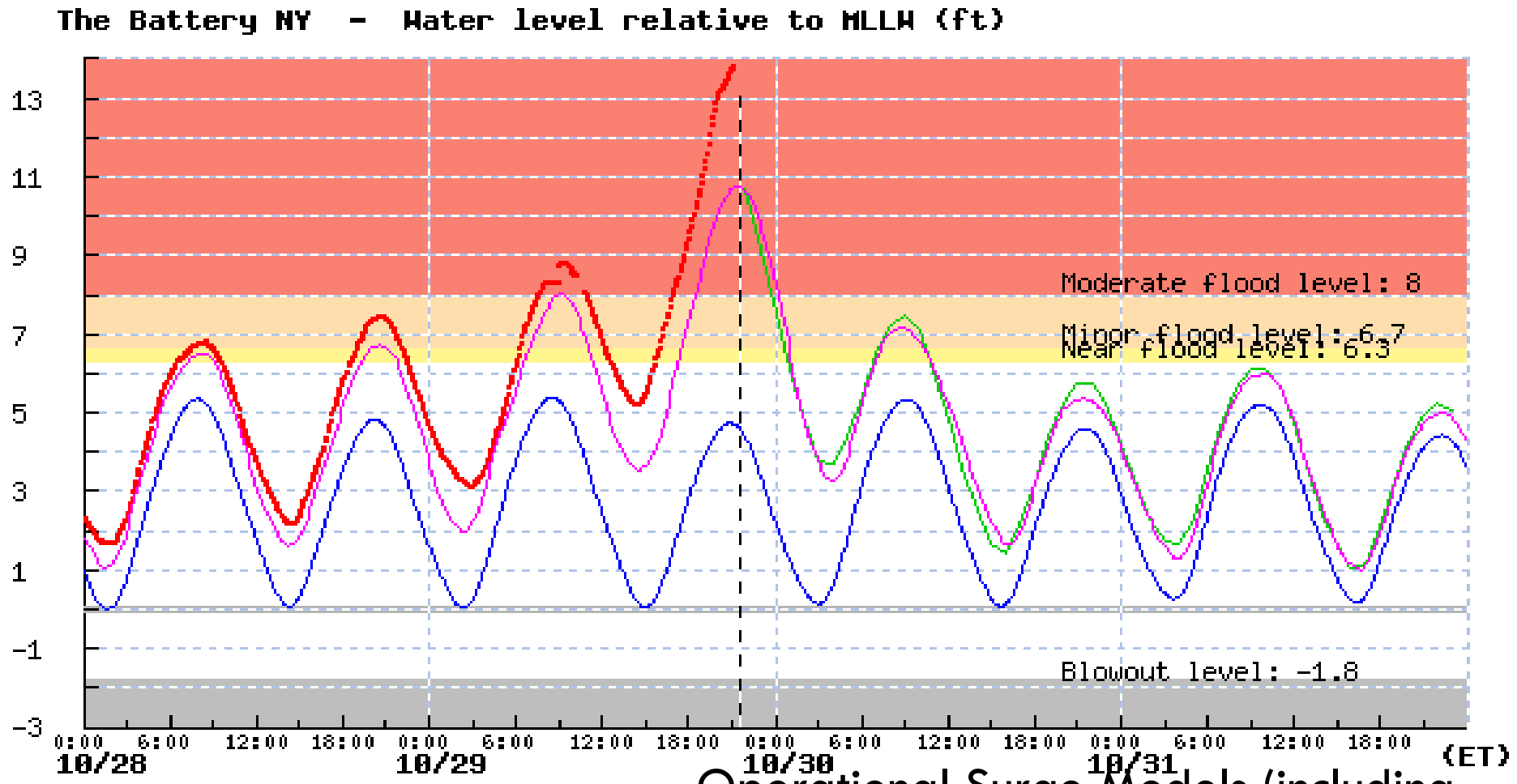
NYS RISE

Resiliency Institute for Storms & Emergencies

Background/Motivation



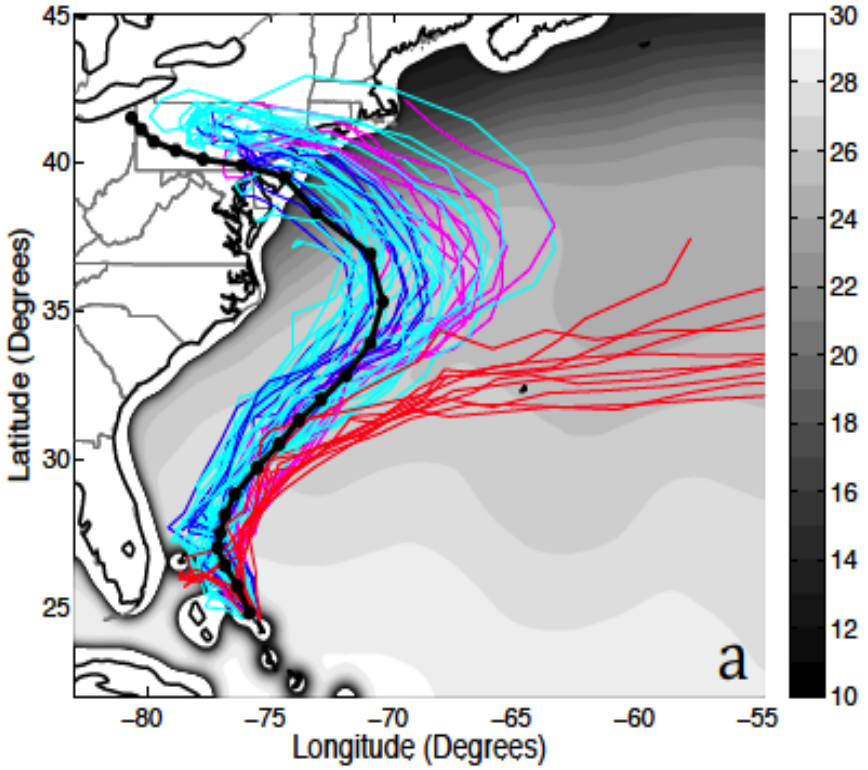
Operational Surge Models (including Stony Brook – not shown) underpredicted water levels at 2-day lead time.

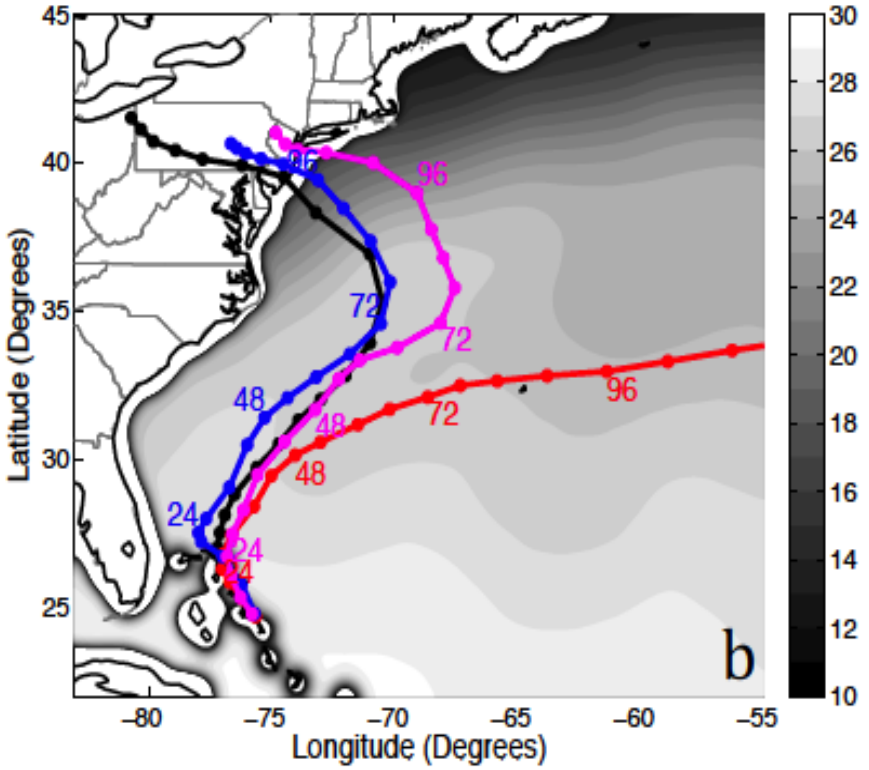
Project Scope

- Construct proof of concept dataset for evacuation and graphical display: Ensemble WRF/ADCIRC simulations of hurricane Sandy.
- Illustrate how relatively small changes in the track and intensity can lead to relatively large water level differences– good for evacuation scenario tests.
- Develop a mapping approach using LIDAR data and predictions to flood at street level for various storm surge scenarios.
- Display water level predictions in Virtual Reality Deck.

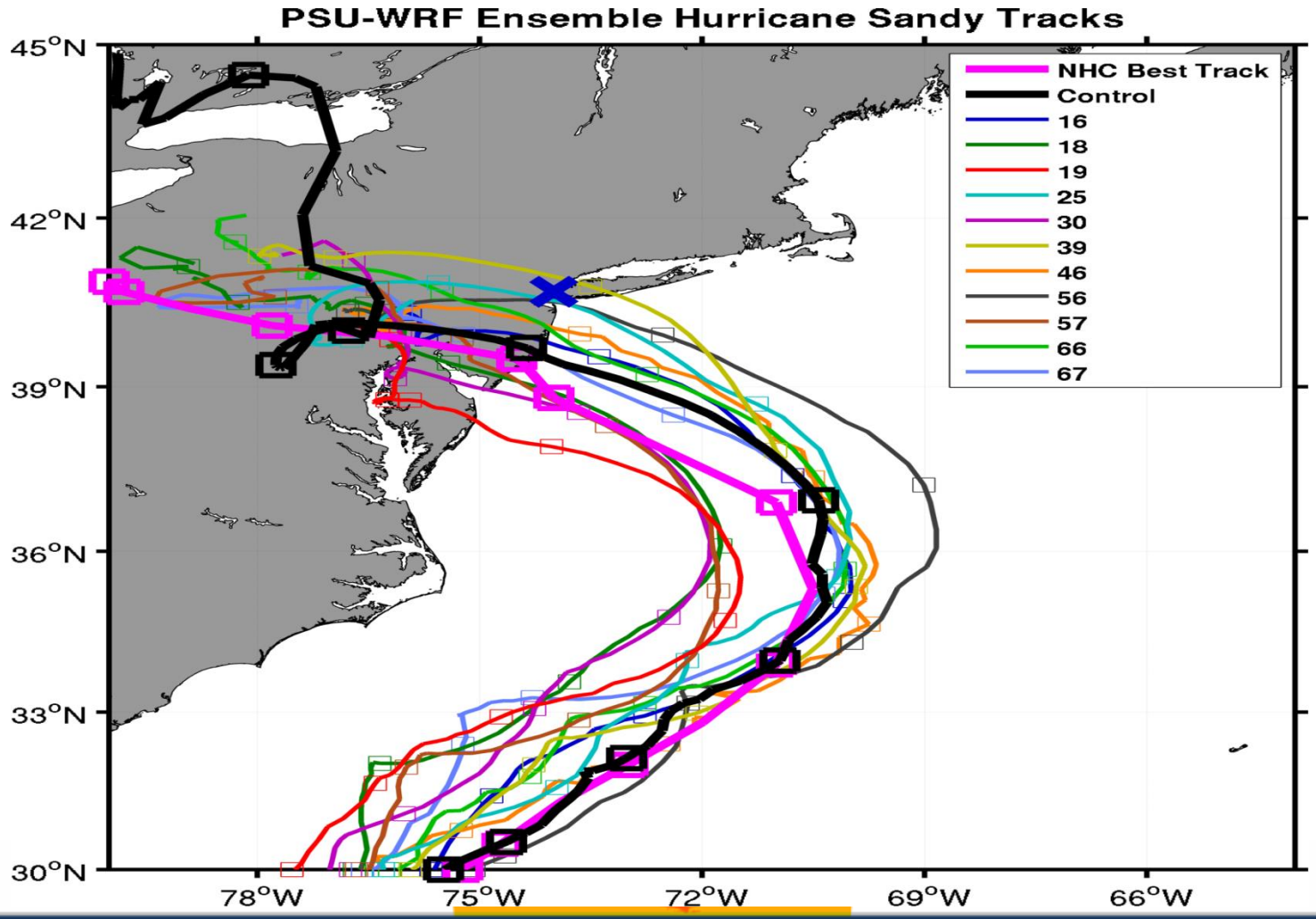
Data/Methods

Weather Research and Forecasting Model Predictions:
*** 60-member EnKF starting at 0000 UTC 26 Oct 2012 (Assimilates aircraft tail Doppler radar-- Zhang et al. 2011; Weng and Zhang 2012)**
*** 27 and moveable 9/3-km nests with 44 levels up to 10 hPa.**
*** ICs: GFS analysis 6-12 h prior to Doppler data; BC's from GFS**
*** YSU PBL, WSM6 micro, Grell Devenyi CP on 27/9km**





3-km WRF EnKF Runs Analyzed
Control: 26/00Z – 28/00Z + 28/00-31/00Z Runs
Random 11 "Good" Members from 26/00Z

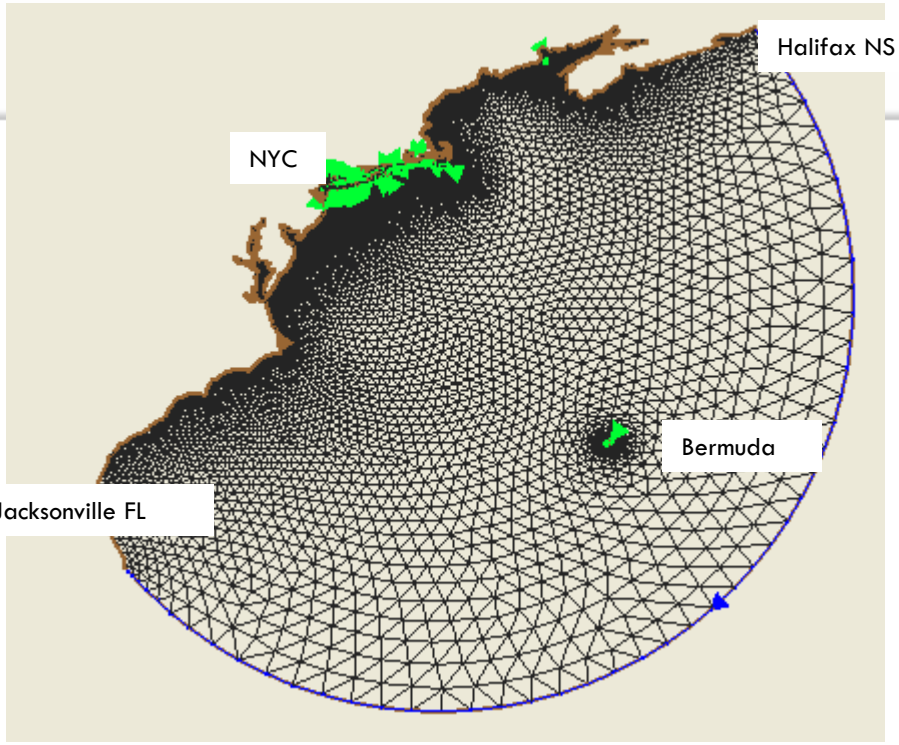


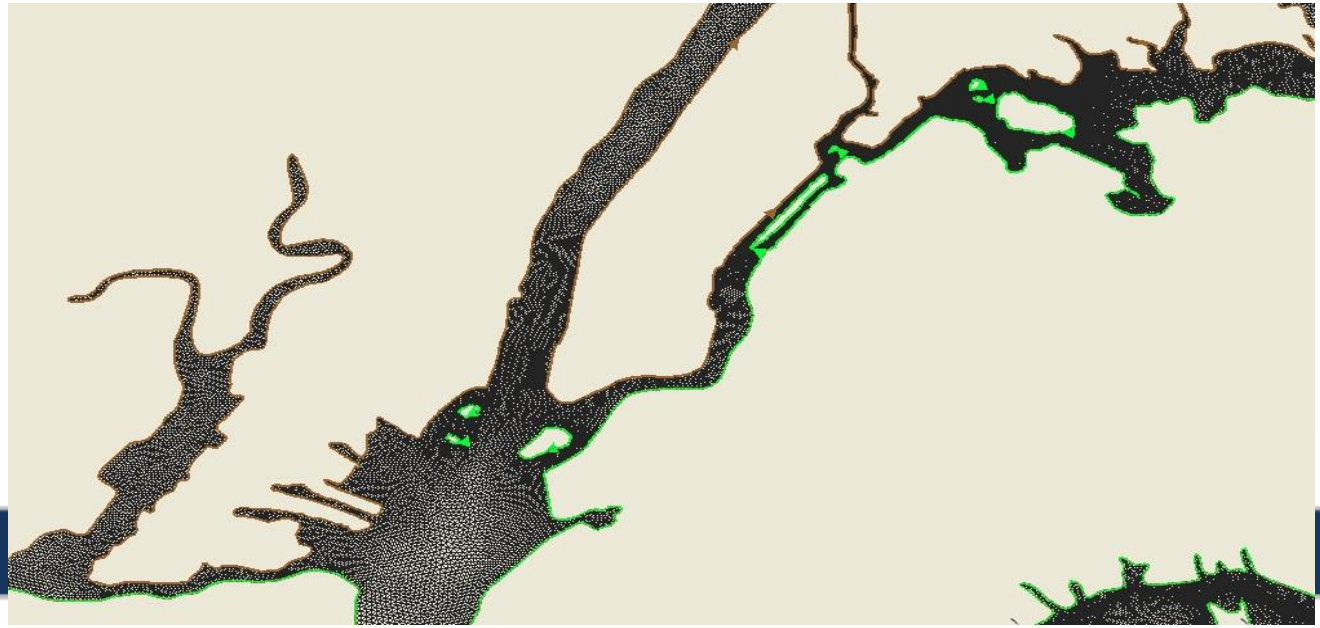
Advanced Circulation Model (ADCIRC)

* Using WRF forcing every 30 min starting 26/00Z (spinup of tide, pressure, winds starting 25/00Z)

- **Run 3D**, 3-levels, and 5-levels (CTL)
- 184,534 nodes
  - 20 m to 70 km
- Tide only BC's
- **Coupled with**

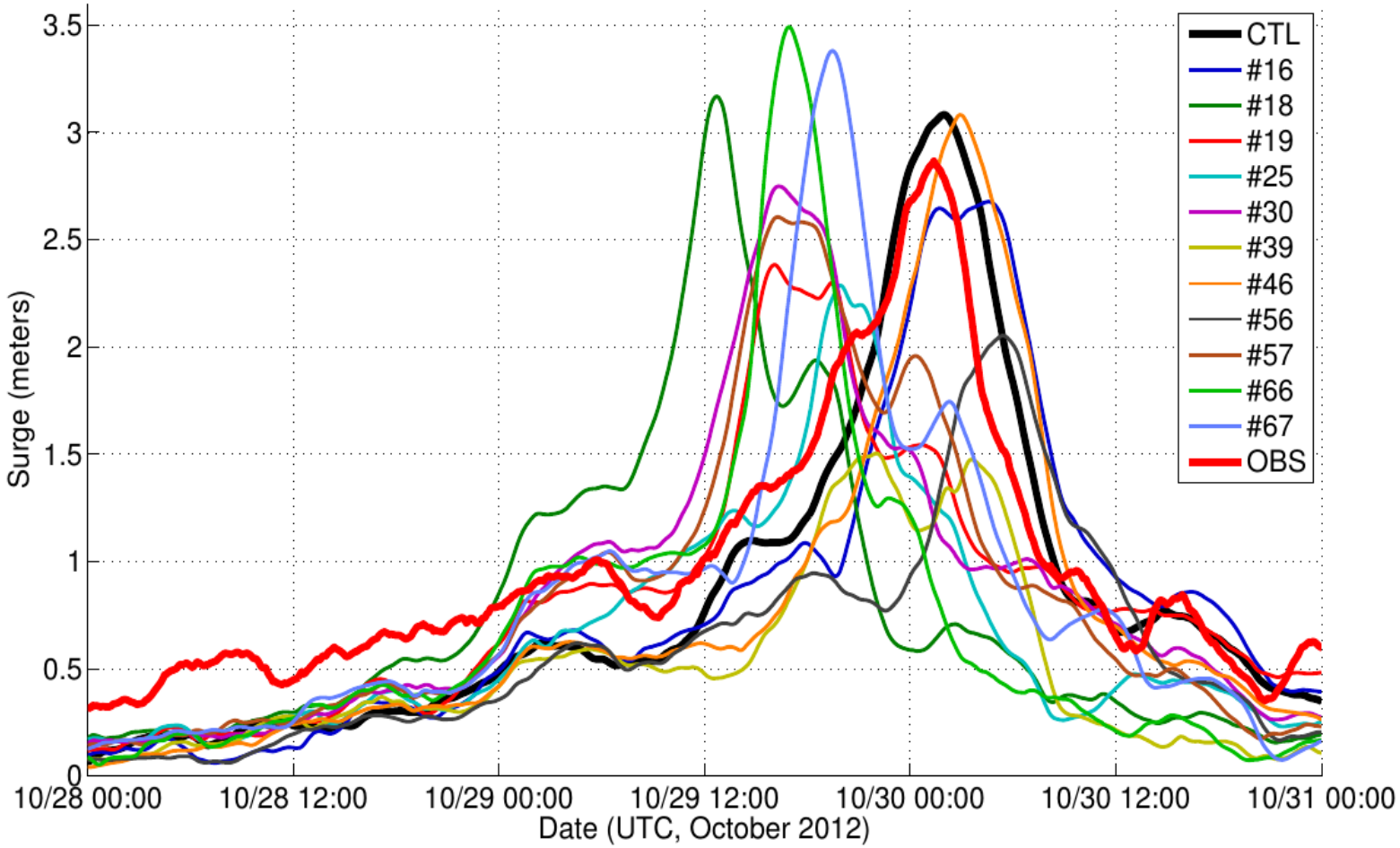
SWAN wave model





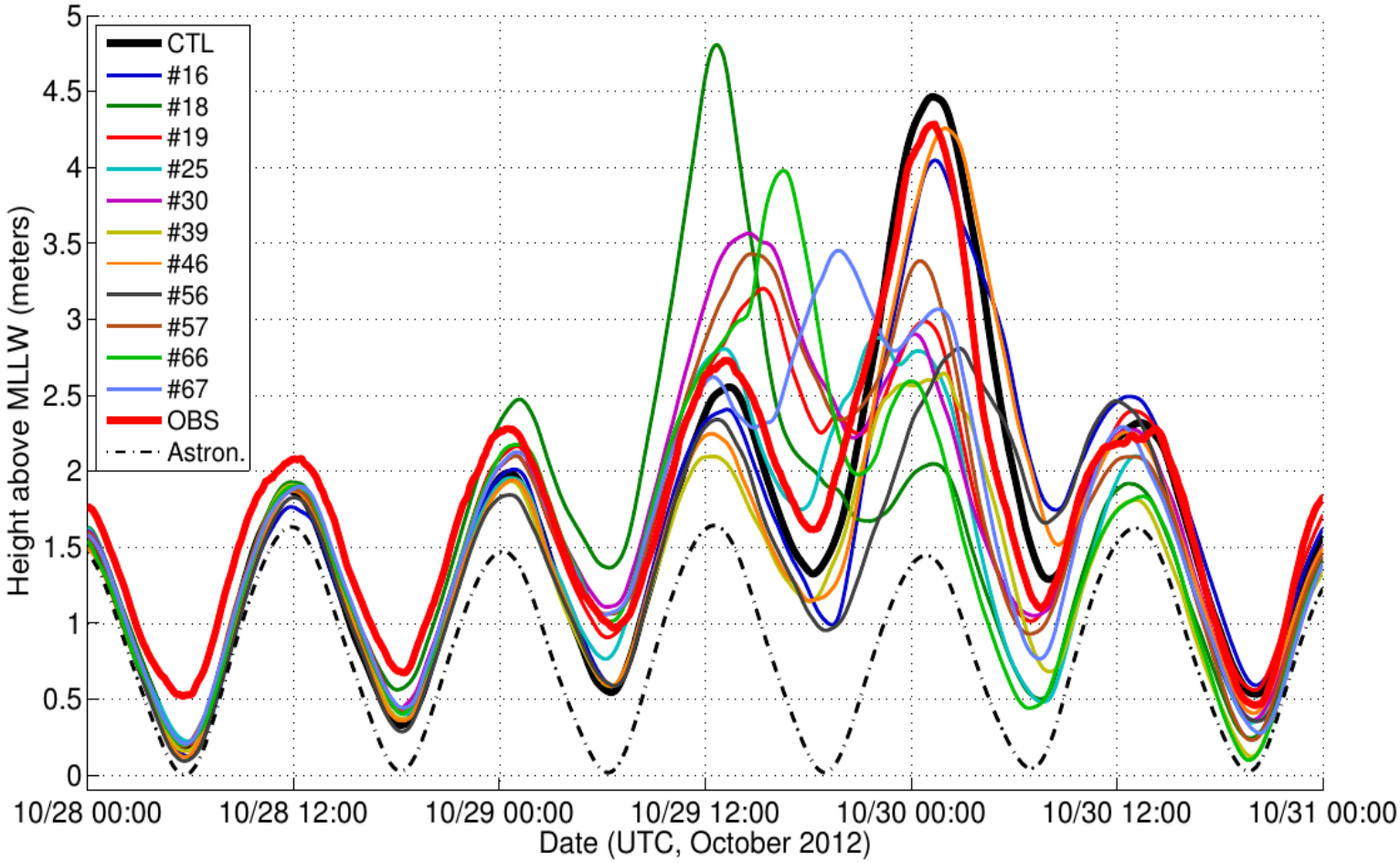
RESULTS

Battery: Ensemble Storm Surge (in meters)

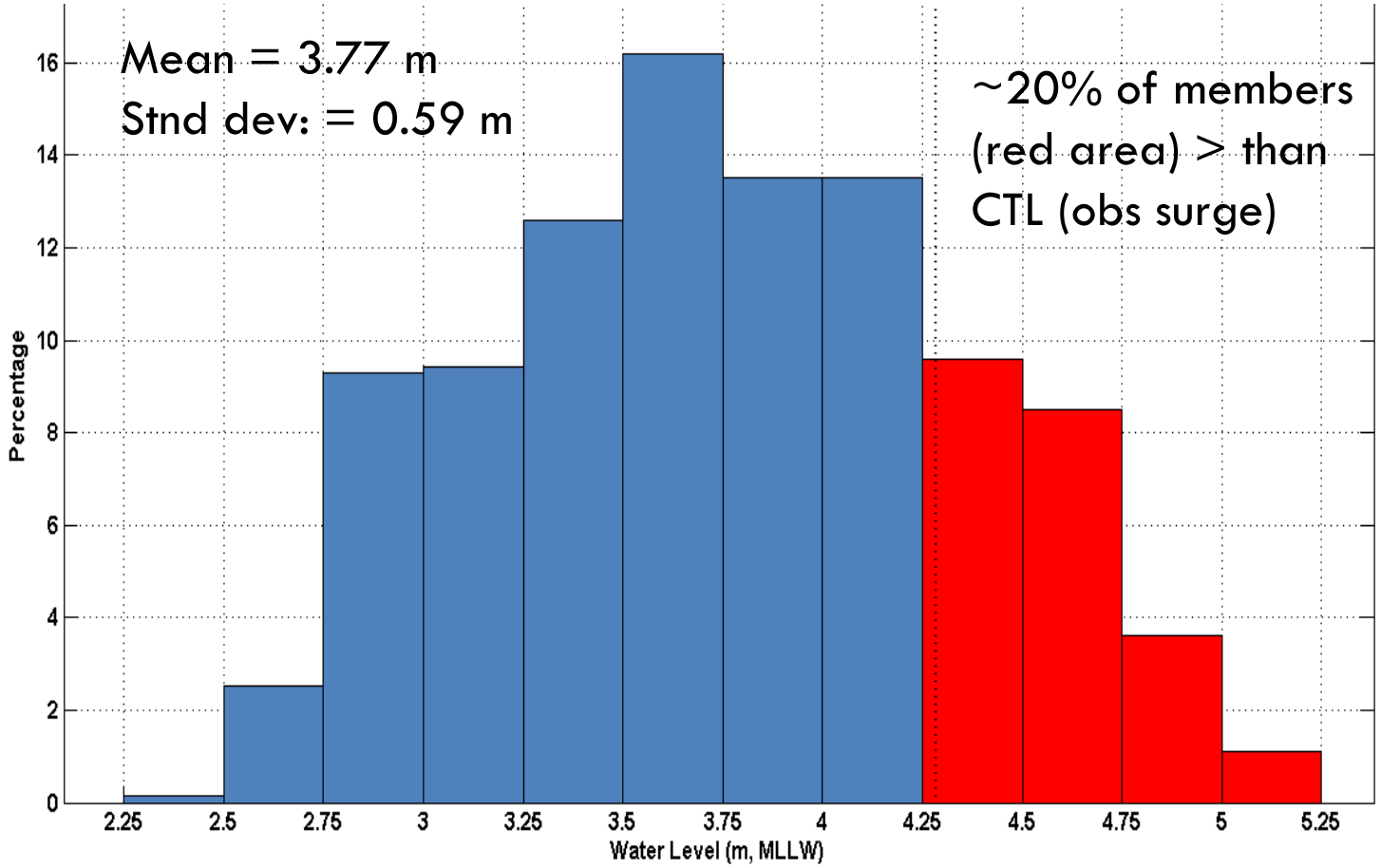


RESULTS

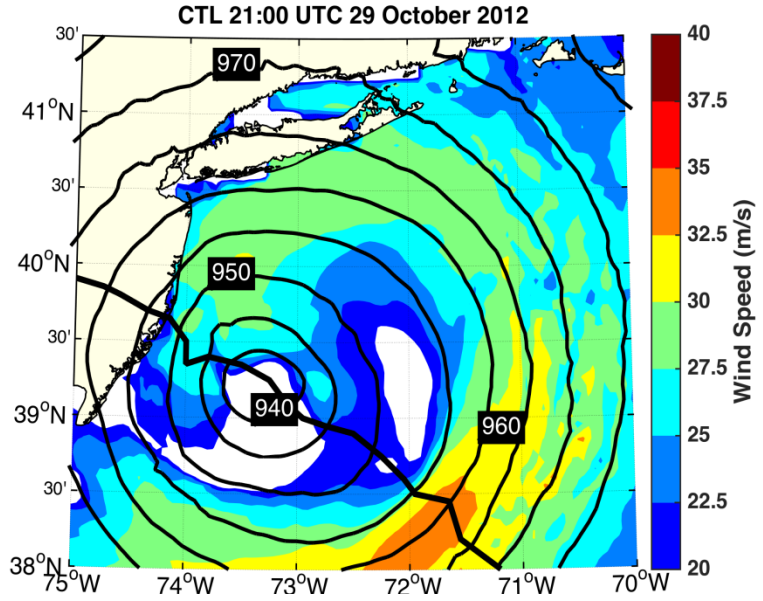
Battery: Ensemble Total Water Level (MSL)

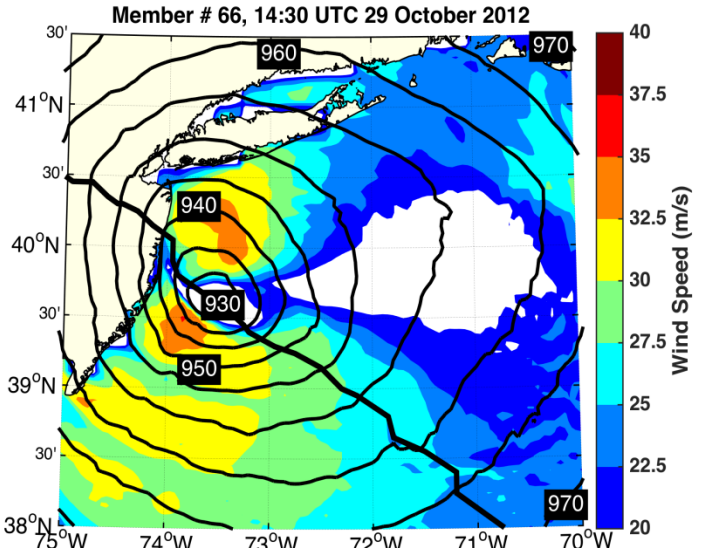


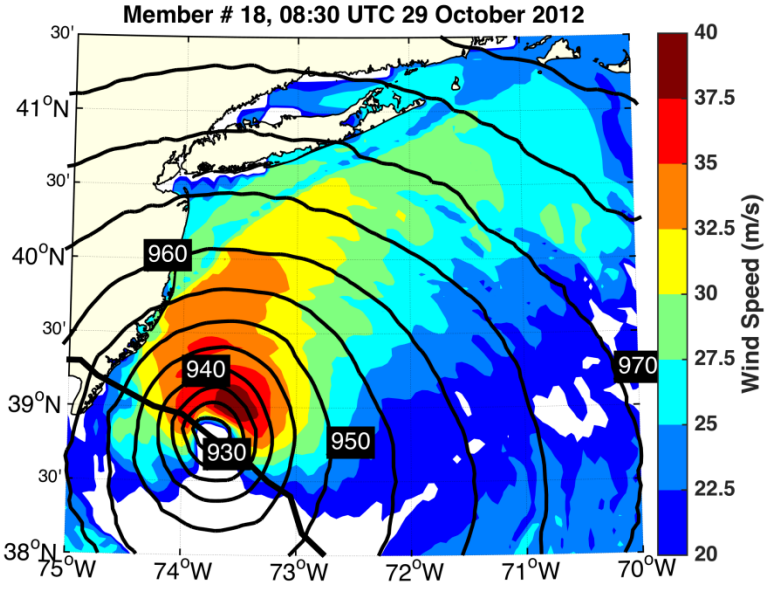
Storm Tide Timing Uncertainty
Landfall +/- 13 h around CTL (one tidal cycle on either side)
27 storm tides x 11 members

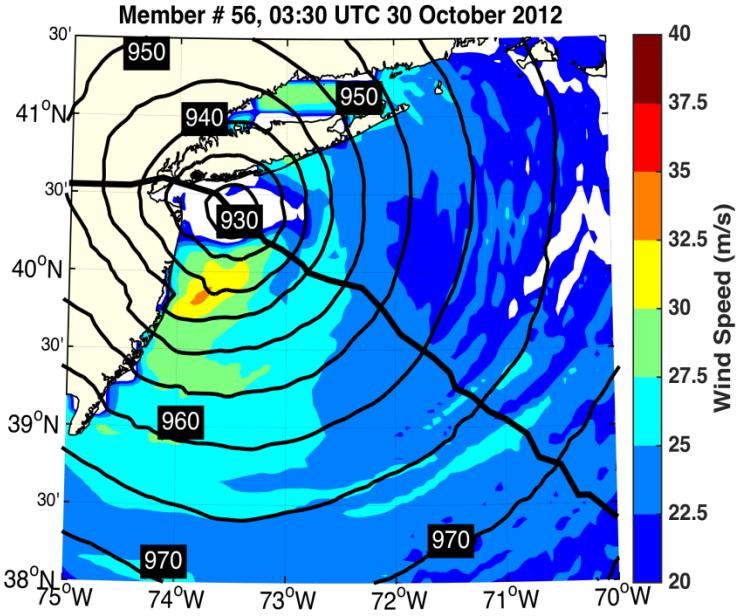


Impact of Wind/Pressure/Track Variations





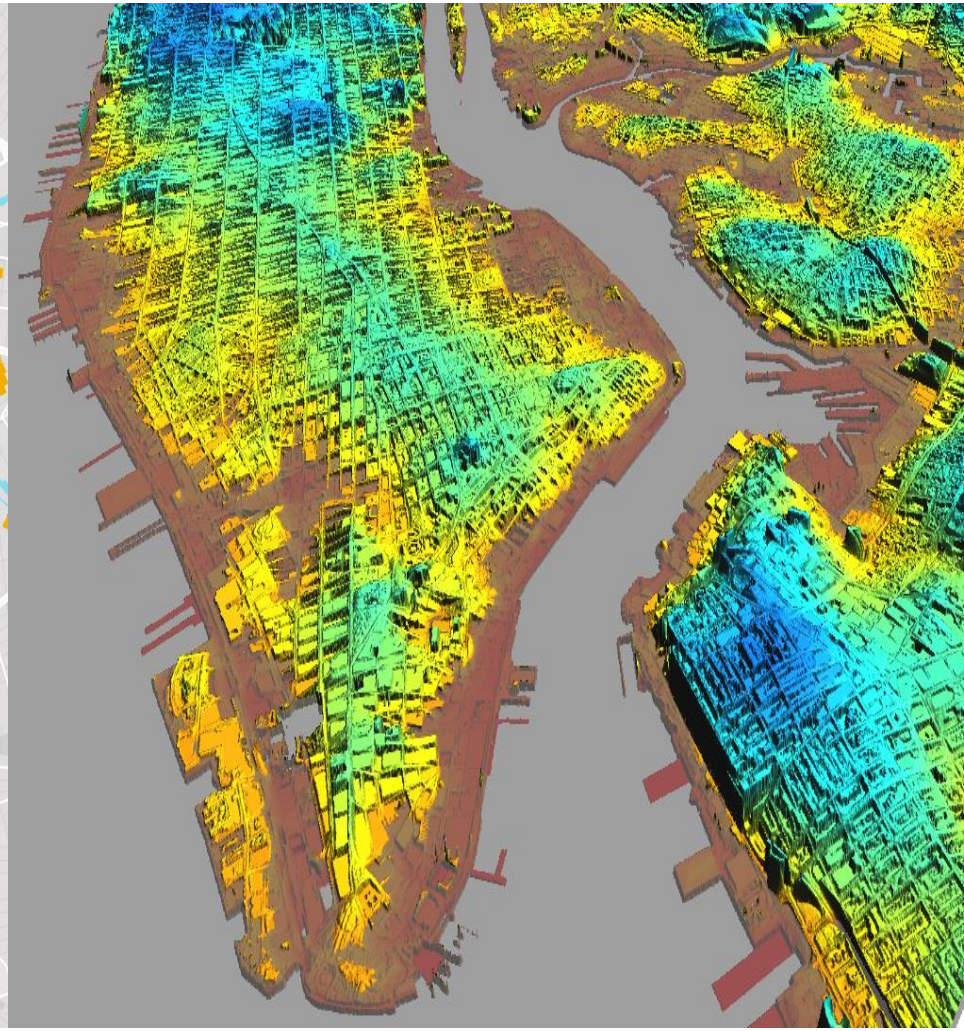




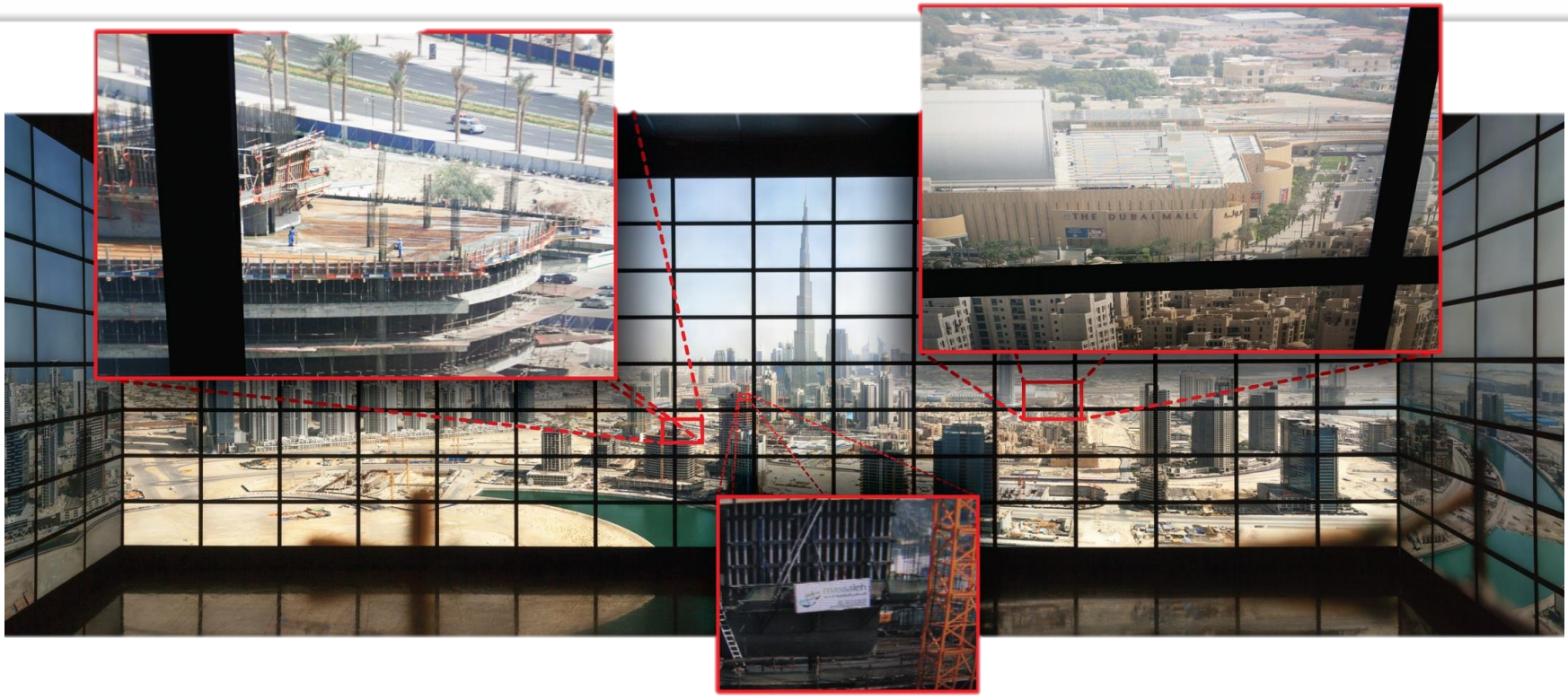
NYC Observed flooding vs ADCIRC for CTL run (using 1-ft DEM from LIDAR)

Obs Flooding (NY Times/USGS)

ADCIRC CTL run (brown = flood)

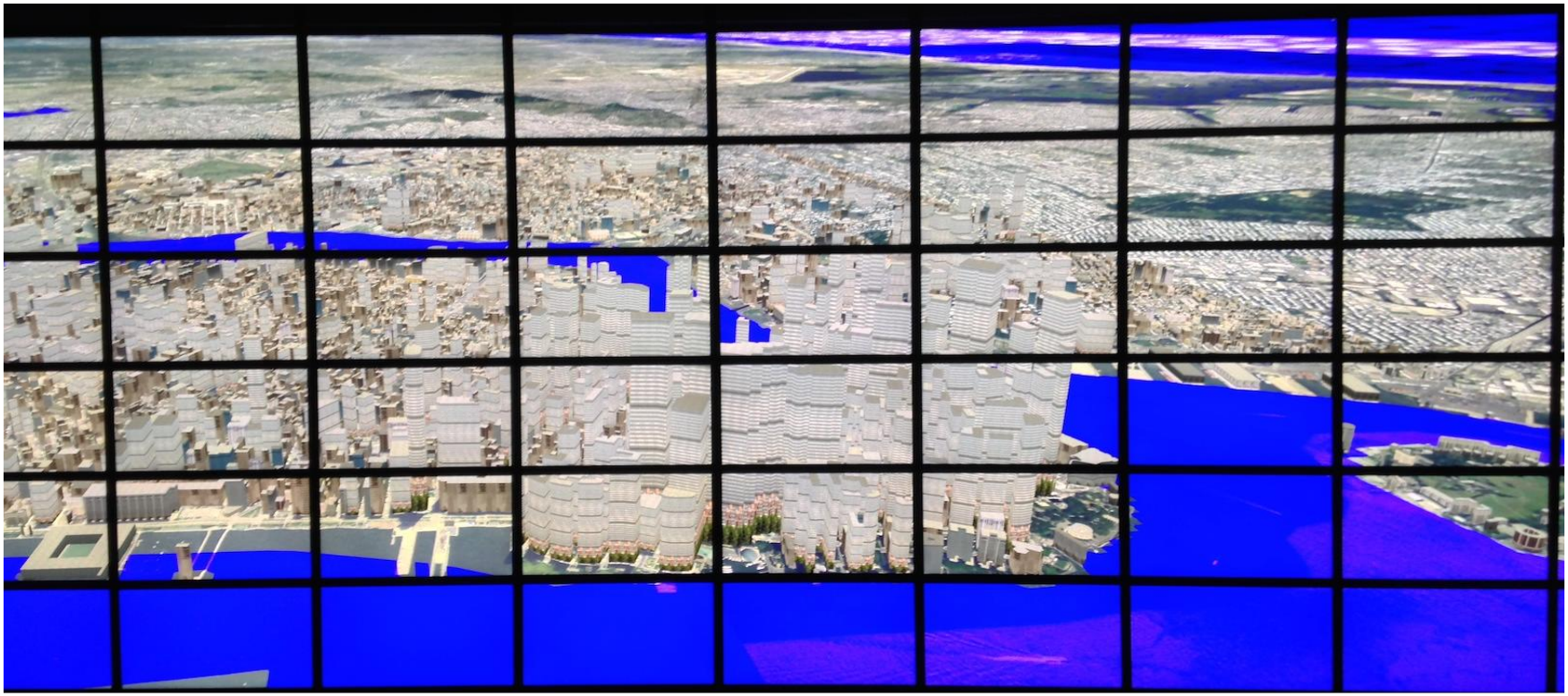


The Reality Deck



- Reality Deck – Immersive Gigapixel Display
- 416 Monitors – 18-node cluster
- Supports interactive 3D visualization applications
- Data: ADCIRC, LIDAR DEM, Tiled imagery, Building Outlines

The Reality Deck



ADCIRC Visualization rendering of downtown Manhattan. A 3 ft LIDAR DEM is utilized. Ground imagery is provided by Mapquest Open. The buildings are generated procedurally using building outlines available on NYC OpenData.

Reality Deck: Street Flooding

- Can flood using single value + tide, or ADCIRC values along coastline extended inland using DEM.
- Can shade different colors areas that exceed certain water level thresholds.

Animation: https://www.youtube.com/watch?v=YMI9uLWF6Mg

Conclusions

- ADCIRC forced by the control WRF member was able to realistically simulate the Sandy storm surge (required going to 3D ADCIRC and include wave coupling).
- Relatively small changes in the track (50-100 km) and intensity (4-5 m s^{-1}) of Sandy leads to relatively large storm surge variations of 0.5-1.5 m.
- Landfall timing relative to high tide is important. Had the storm arrived during low tide there would have been drastically less flooding.
- The ensemble also illustrates that Sandy's storm tide was not worst case. More specifically, about 20% of the scenarios using the ensemble had a greater water level than the observed.
- The Reality Deck is a powerful visualization tool to explore inland flooding at street scale resolution.