SUPERSTORM SANDY

THE PERFECT SURGE

AMERICAN METEOROLOGICAL SOCIETY ANNUAL MEETING 2014

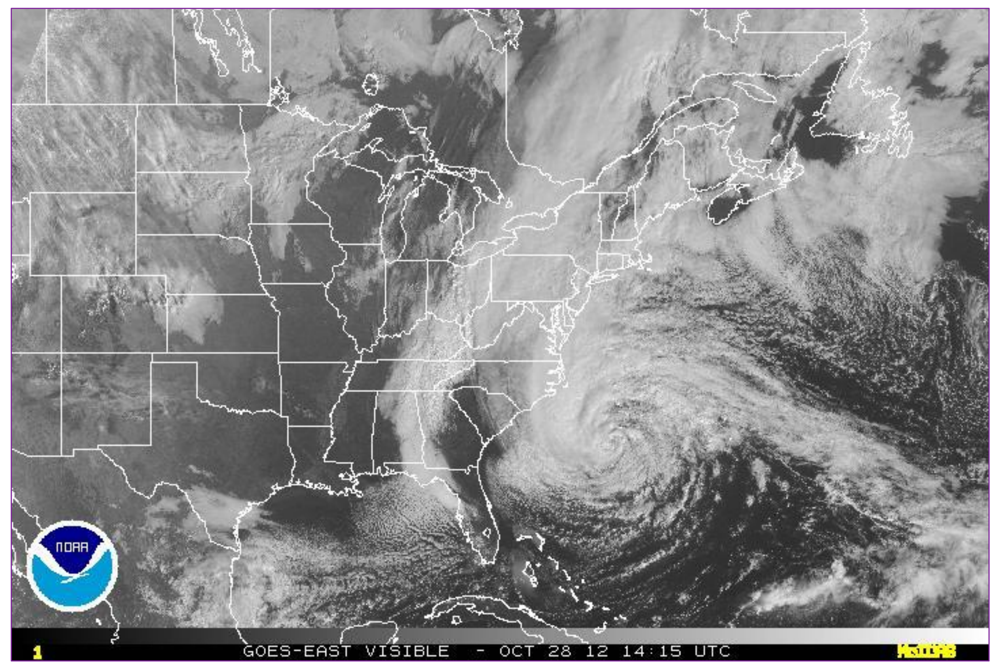
Robbie Munroe
munroer08@students.ecu

Chris Zarzar
zarzarc12@students.ecu

East Carolina University

ABSTRACT

The record-breaking storm surge experienced during Sandy resulted from the rare combination of atmospheric, geomorphic, and tidal factors. The seamless evolution of Sandy from a hurricane to an extratropical cyclone enabled the system to maintain hurricane intensity while expanding to the size of a nor'easter producing significant surge and waves up and down the Eastern Seaboard of the United States. These and other storm characteristics conducive to widespread coastal inundation will be examined using spatial and statistical software. Additionally, we will compare the surge characteristics of Sandy to other high magnitude events. This work will provide information that will assist in storm surge prediction and preparation practices.



BACKGROUND

Hurricane Sandy, later dubbed 'Superstorm Sandy' as the storm transitioned to a post tropical system, caused death and destruction stretching from the Caribbean to southeastern Canada. The United States was arguably the hardest hit by Sandy with 159 deaths and 65 billion dollars in direct damages (NOAA). Sandy's extraordinary life cycle intrigued the atmospheric science community, leading members of the community to reconsider hybrid cyclones and extratropical transition (ET). Sandy, as measured by standard metrics used for tropical cyclones, was a category 1 hurricane with sustained winds of 85 mph prior to landfall in New Jersey. Sandy was re-categorized as an extratropical cyclone just before landfall, but Sandy still exhibited hurricane force winds and rainfall totals, with the vast size, movement, and even snowfall of an extratropical cyclones or Nor'easters. The intensity, size and movement of Sandy lead to record precipitation totals and widespread wind damage. Possibly the most impressive facet of Sandy was the magnitude, duration, and extent of storm surge along the east coast. Incredibly, this storm made landfall during several astronomical high tide cycles along a funnel shaped coastline which exacerbated storm induced surge, leading to all time water level records, some beyond worse case scenario estimations. This work supplements findings related to Sandy's unique evolution and related storm surge with geospatial analyses targeting the storms characteristics that lead to this historic storm surge event.

STORM SURGE DEFINED

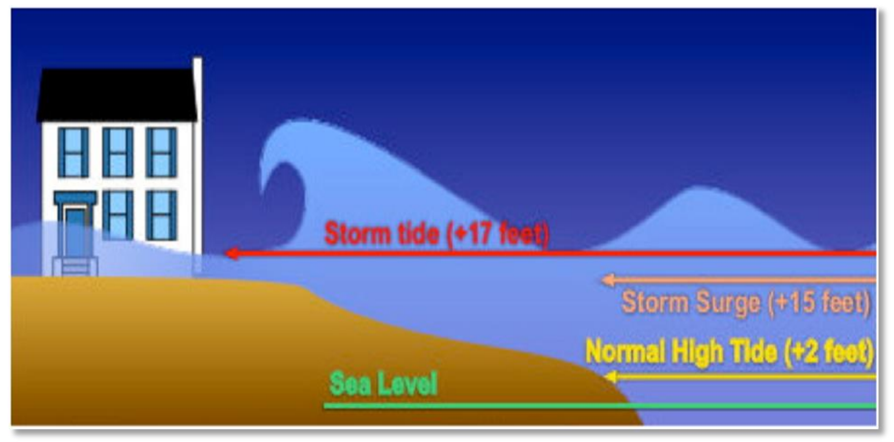


Figure 1. Storm surge versus storm tide (NOAA).

- Meteorologically forced rise in water level above the predicted tide (figure 1)
- Storm TIDE is the actual water level during a storm
  Dependent relationship between tide and surge – higher tides lead to high surges
- Maximum water level does not always coincide with maximum storm surge. For example, Kings point, NY received the greatest storm surge during sandy ~12 ft, however, the greatest water level at this location occurs a couple hours after exceeding ~14ft

SURGE FACTORS

Tropical	Extratropical	Other
Central Pressure	Size	Spring Tide
Wind Speed	Track	Surge Perturbation
Perpendicular Landfall	High Latitudes	Funnel Shaped Coast
	Pressure Gradient	

Table 1. Surge factors. Red font indicates research focus.

- Blocking High to the north slowed Sandy's march northward and increase coastward fetch
- Shallow continental shelf
- Forward speed and perpendicular track enhanced onshore winds
- ETC track Movement up east coast enabled surge
  Along shore track with other factors led to surge along entire east coast
- Low central pressure
- Pressure Gradient (blocking high & open ocean low) – long fetch to winds
- Semi-diurnal surge perturbation: high tide not only increased water level but also makes more water available to push onshore (~0.5 m during Sandy) (Valle-Levinson et al. 2013)

SANDY EVOLUTION

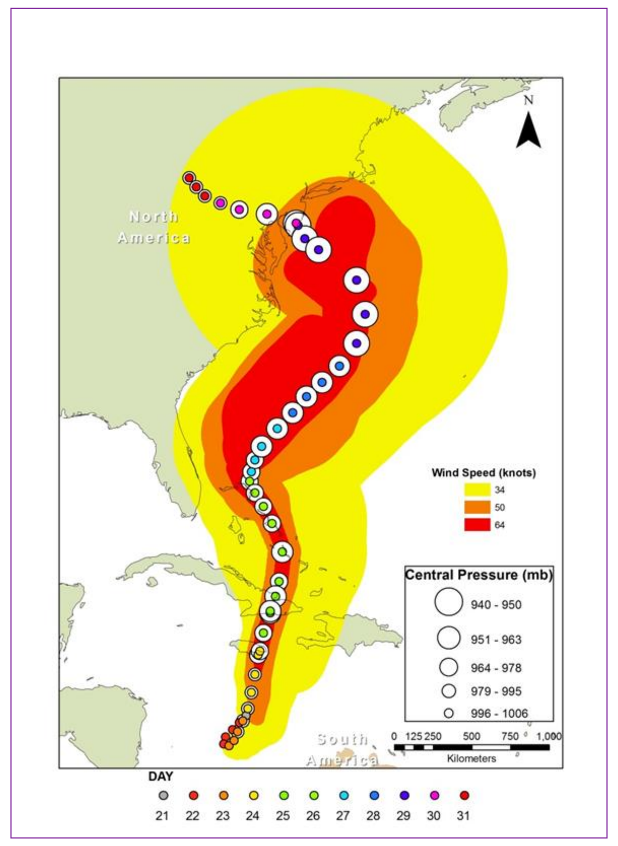


Figure 2. Sandy wind field extent, intensity, and track.

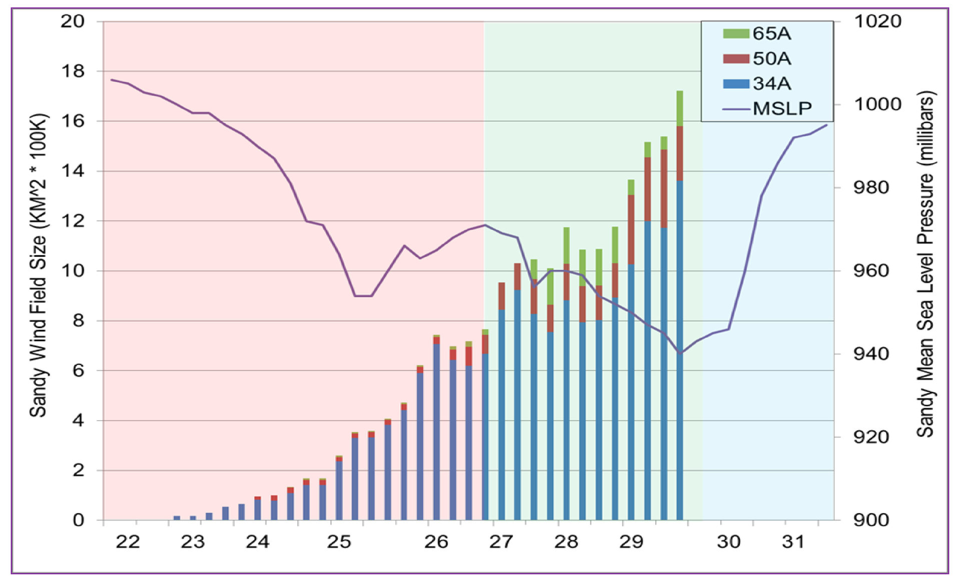


Figure 3. Sandy temporal evolution.

- Cuba on the 25th – weakened from a major hurricane (115 mph winds) to a cat 1 hurricane (relative minimum in pressure (figures 2, 3)
- Trough/frontal interaction joined the action late on the 26th (00 UTC on 27th according to the NHC tropical report) – largely responsible for large increase in storm and hurricane force winds north of the Bahamas (figures 2, 3)
- Generally over open water before hook movement and eventual perpendicular landfall which maximizes onshore flow (storm movement + wind)
- August 27th Reestablished as a hurricane, however, Sandy began to also take on extratropical properties (became a hybrid system) as it interacted with the midlatitude trough
- Rapidly grew in size between the 25^{th} and 27^{th} (quadrupling extent of tropical force winds – Halverson and Rabenhorst 2013) (figures 2, 3)
- Secondary trough intercepted system on the 28th/29th leading to a continued drop in storm pressure and a final increase in storm size. In concert with blocking high to the north the trough allowed for hook movement and perpendicular landfall
- October 29^{th} marked the transition from hybrid system to extratropical cyclone or nor'easter

PRELIMINARY RESULTS

- Figure 4 portrays the amount of time areas experienced tropical storm force winds
- Calculated through the intersection of polygon centroids with polygons then multiplied by 6 hour periods
- Longer duration (allows for build up of water/waves)
- Number of high tides critical to account for when evaluating SLOSH surge estimates and assessing potential impacts (erosion, inundation flooding, damage, & deaths)
- We are working on a product that will estimate and visually depict the number of high tides cycles

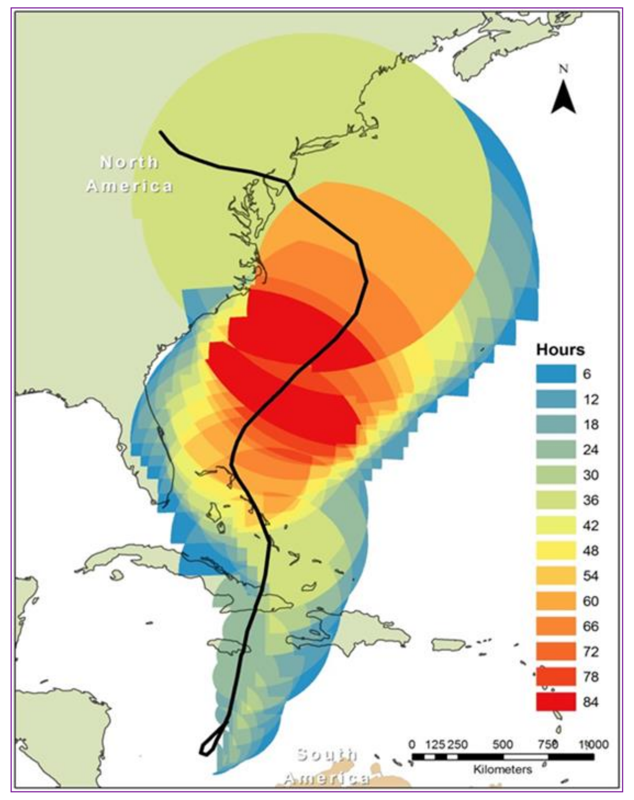


Figure 4. Duration of tropical storm force winds.

- Use NCEP reanalysis wind field for more accurate estimates
- Use NOAA Water Level Station data to depict evolution of storm surge
- Assess which meteorological factors are most influential in generating Sandy's historic storm surge

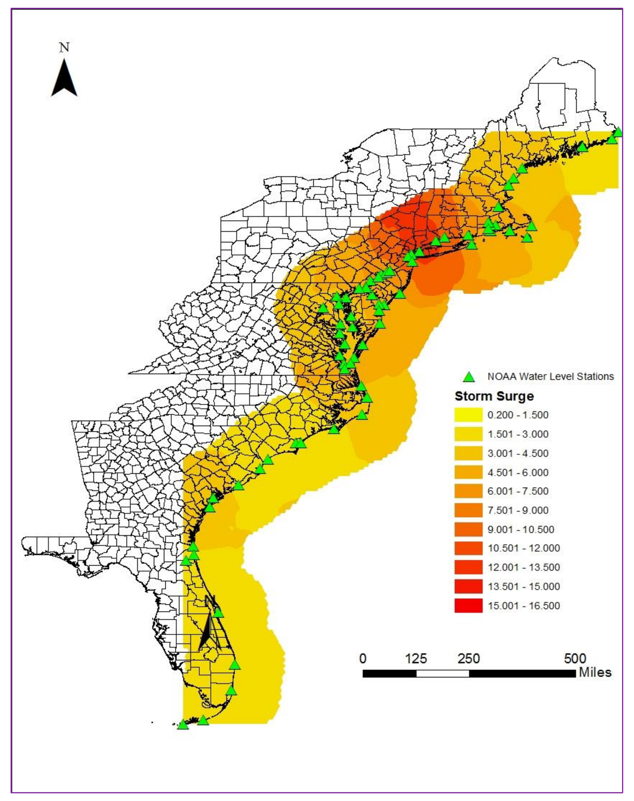


Figure 5. Interpolation of storm surge.