United States East Coast Storm Surge and Cyclone track Characteristics: Differences and Similarities for Extratropical Cyclones and Hurricanes

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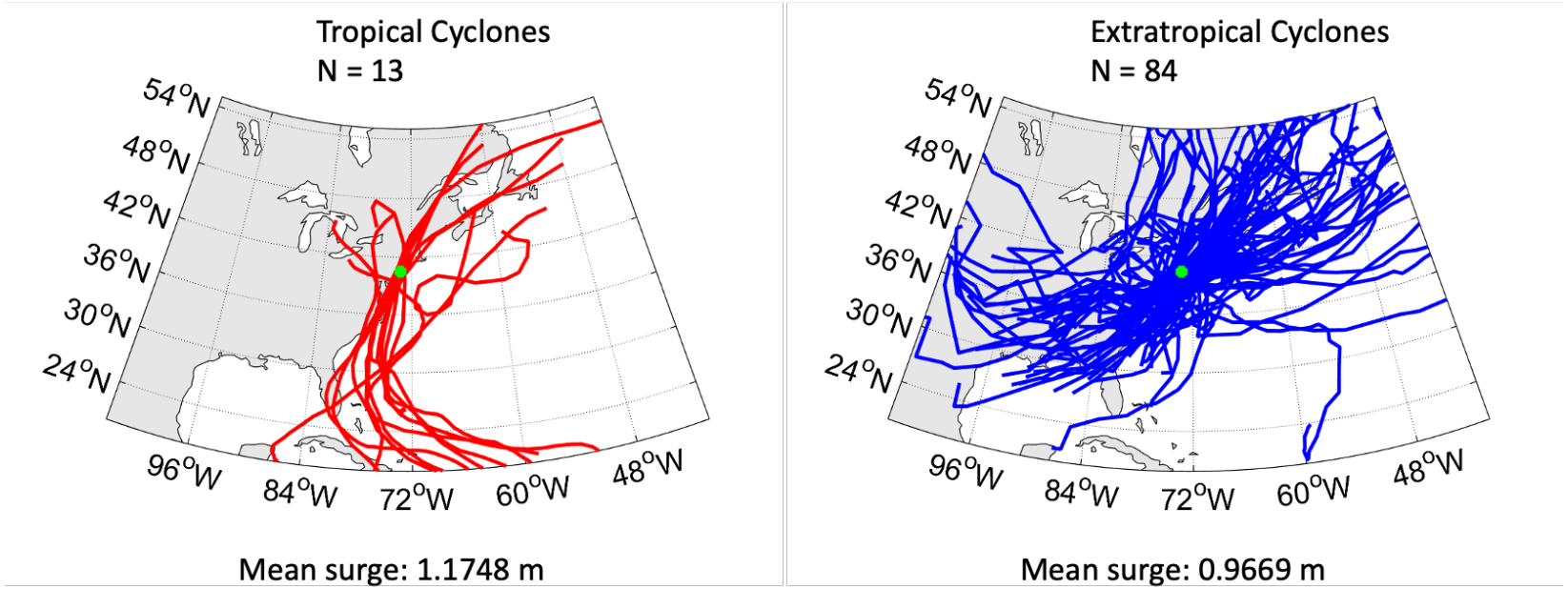
Figure at right:
Tropical and Extratropical Cyclone Tracks for the top 100 surge events for 1979 - 2015



This presentation is a combination of results from Booth et al. ERL, 2016, and new unpublished results.

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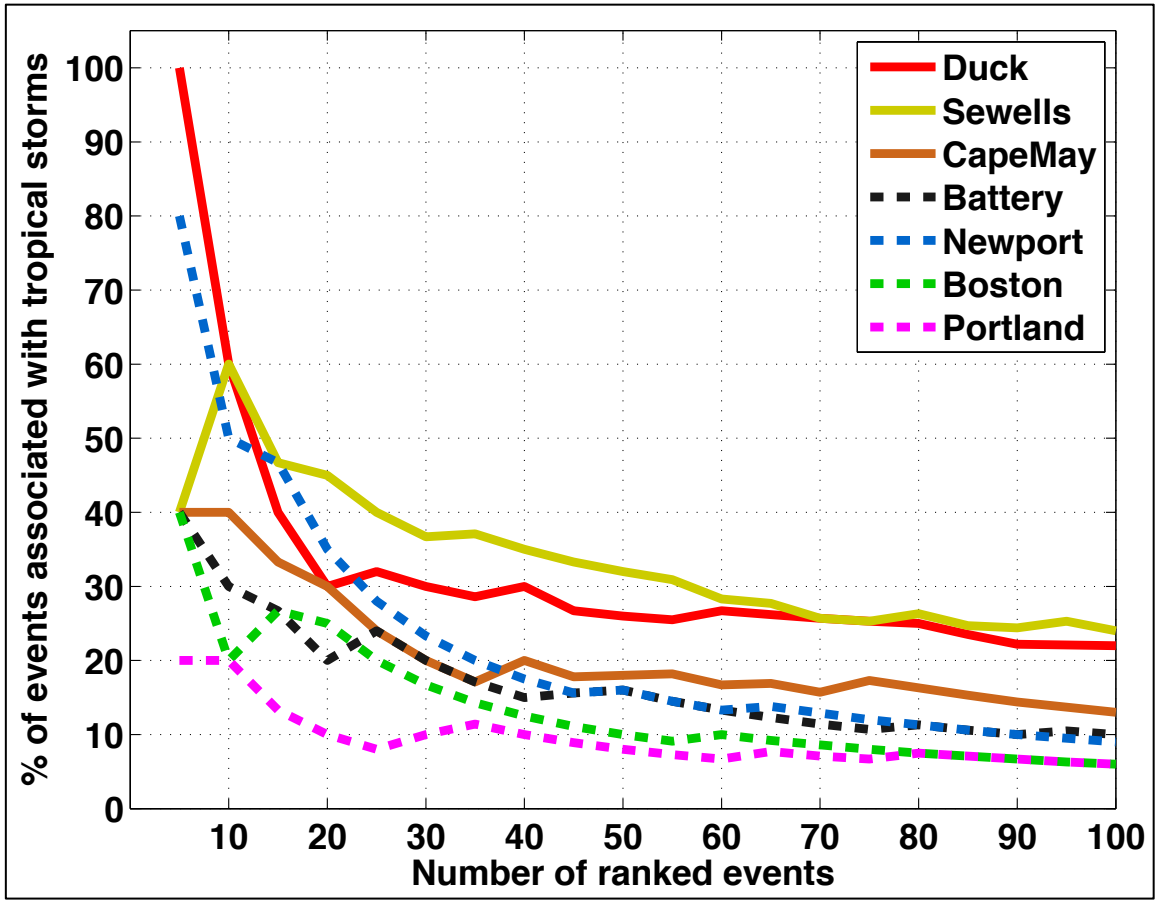
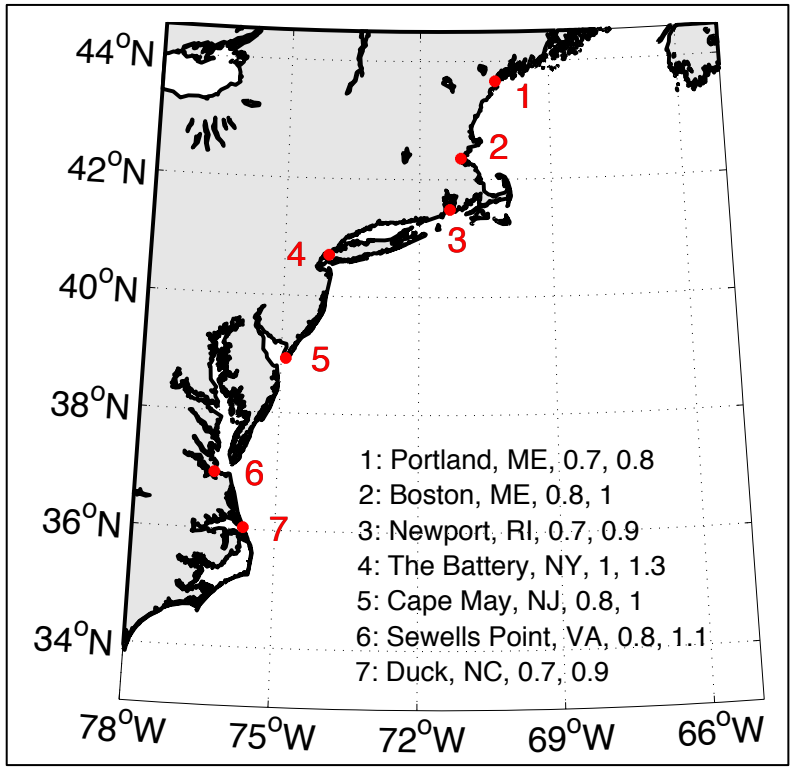
Percentage of surge events that are caused by hurricanes (y-axis) versus number of ranked events considered (x-axis), per station.



The solid lines indicate stations located south of New York City. The dashed lines indicate those north of New York City.



Numbers give 1- and 3-year return levels

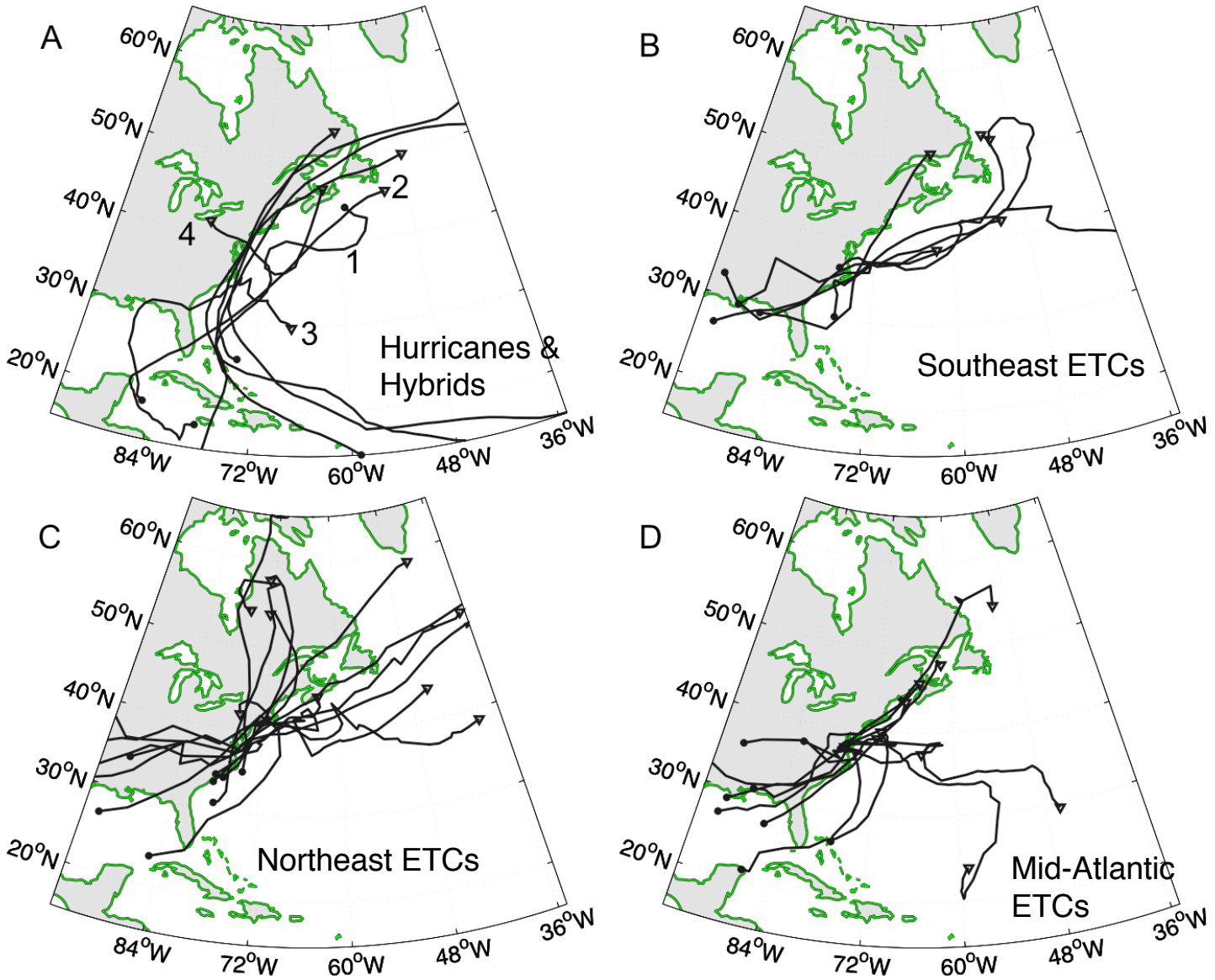
Take home messages:

- For top 10 events, TC contribution is large.
- For top 50, ETCs take over.

- Newport RI stands out: it is farther north, but TCs play an important role. The reason is because of the orientation of the coastline at the site (#3 in the figure above).

Adapted from: Booth et al. *ERL*, 2016

Cyclone tracks for strongest multi-station surge events



Circles on the track lines indicate the storm genesis location while triangles indicate the lysis locations.

Number in panel A:

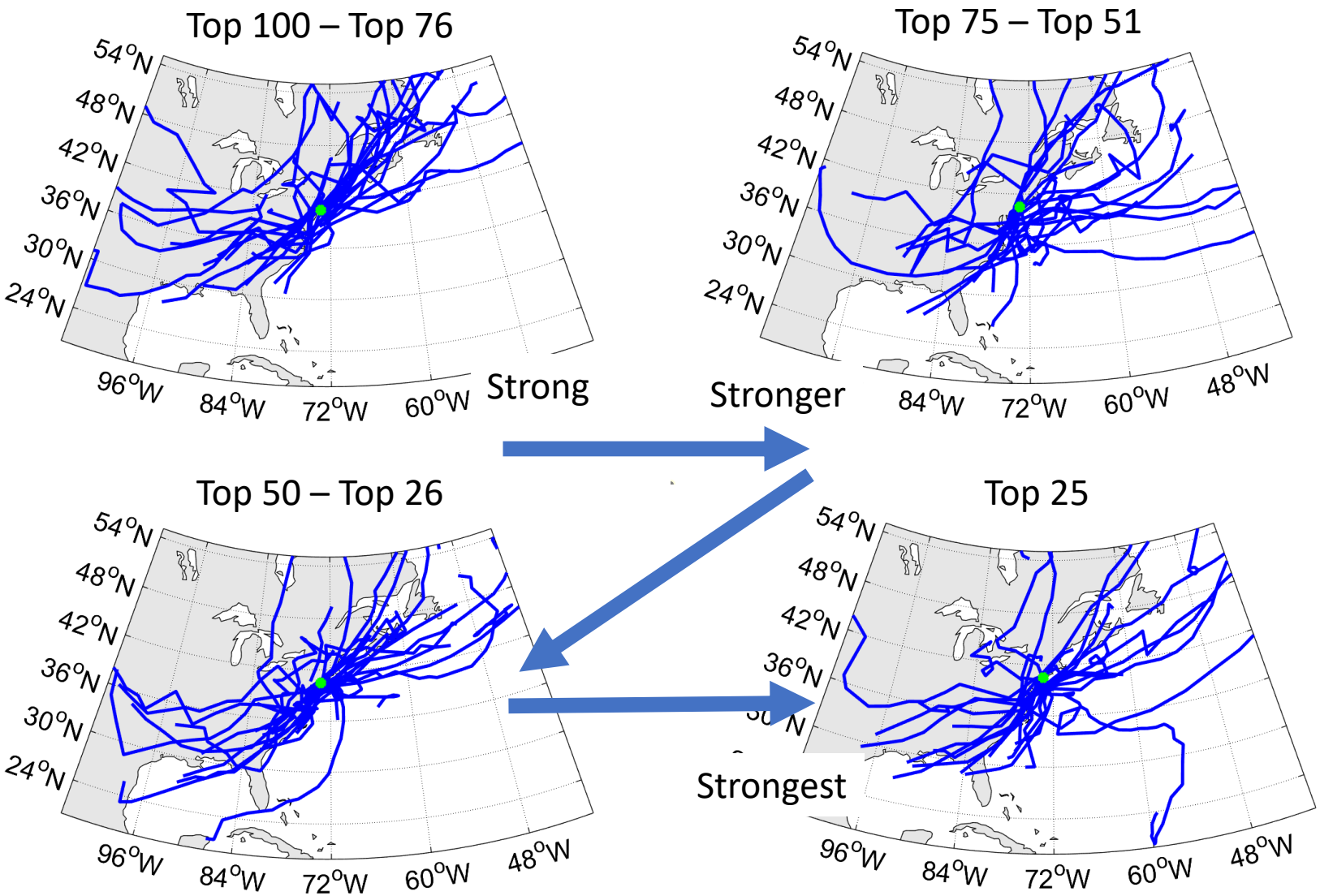
1. The “perfect storm”
2. Hurricane Wilma
3. Hurricane Ida (“Nor’Ida”)
4. Hurricane Sandy

Take home messages:

- On average the ETCs centers travel closer to the impact site than TCs.
- There are multiple different tracks ETCs that cause extreme surge can take.

Adapted from: Booth et al. *ERL*, 2016

Understanding the role of the cyclone characteristics in setting surge characteristics, focusing on surge at the battery (extending work by Colle et al. 2010)

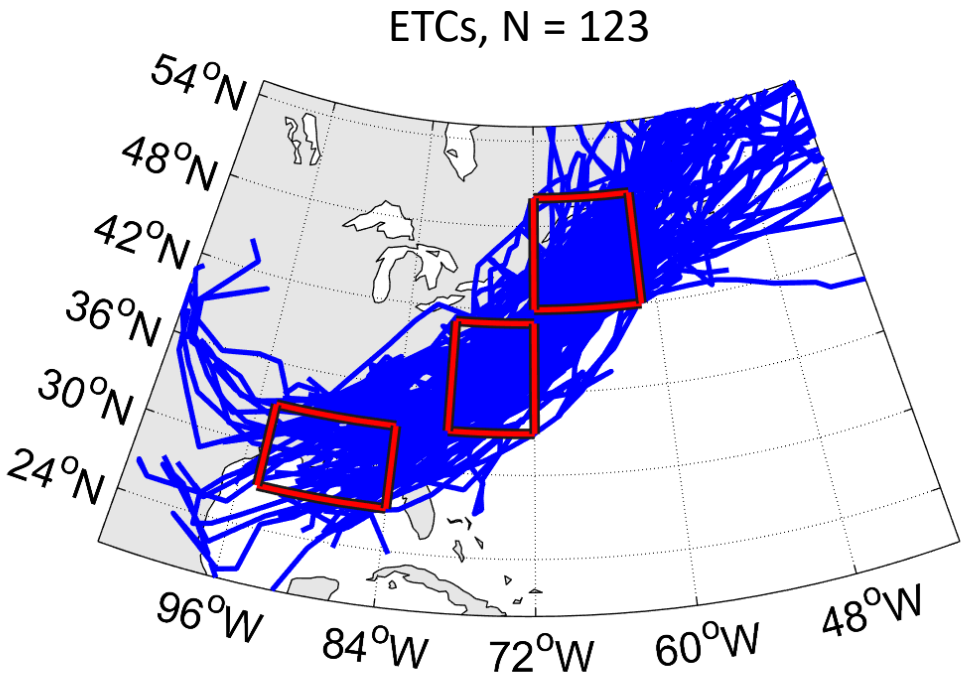


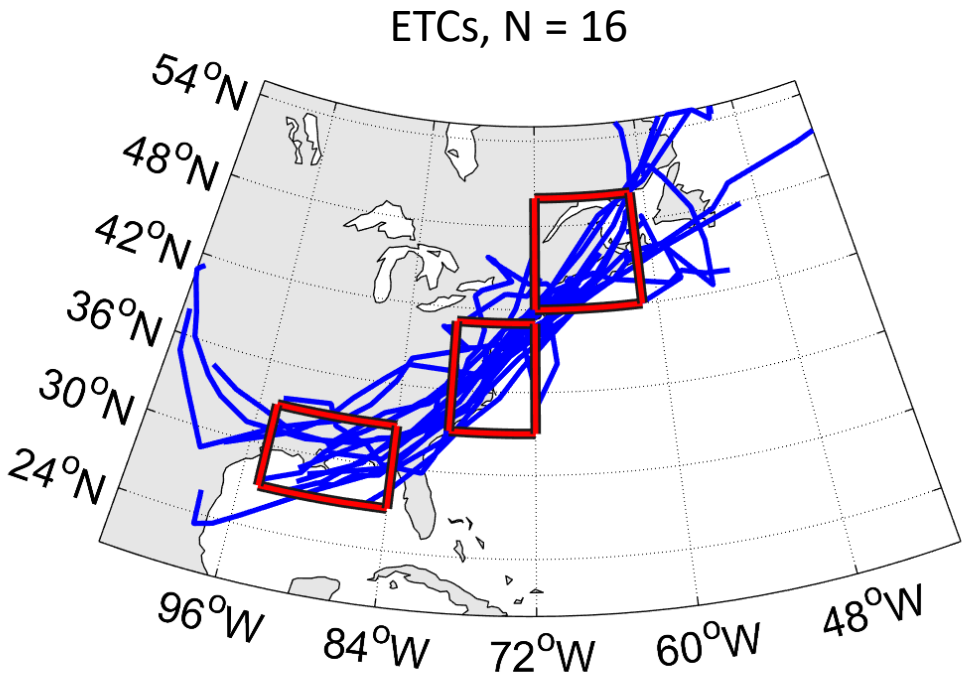
There are not differences in the characteristic paths for the strongest surge events.

What else might be unique about these cases?

Can we leverage all of these tracks in another way?

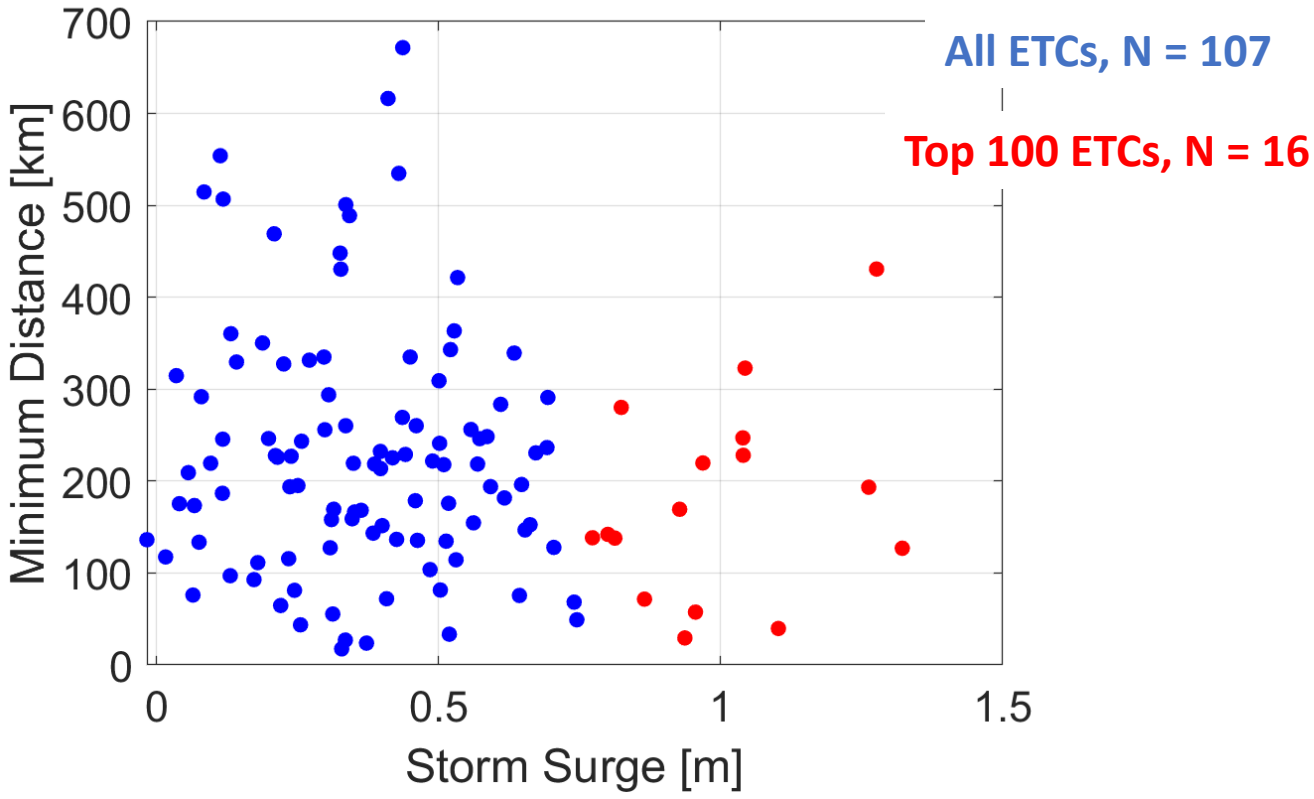
For cyclones that take the same path, is there something special about those that cause surge?



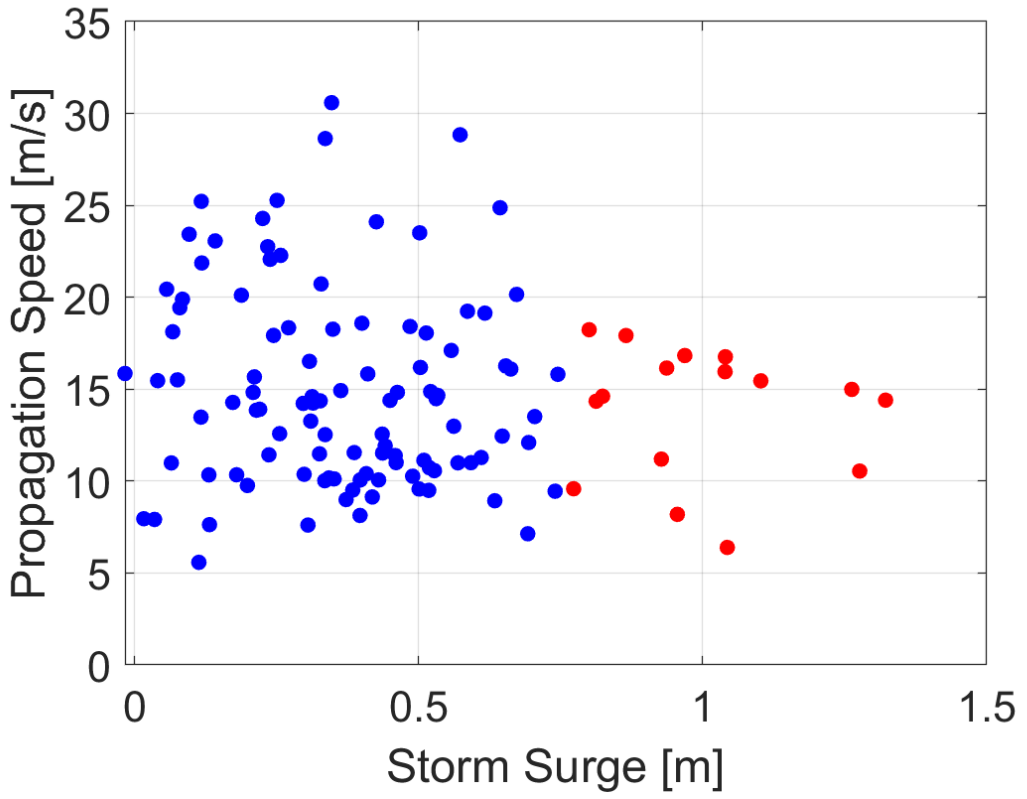


Focusing on a specific Track Path

Minimum Distance to Surge Max



Mean 48-hr Propagation Speed



Red vs blue show: cyclones causing extreme surge tend to be closer to the event and move slower. However, these conditions do not guarantee that there will be large surge

1. Hurricanes create the strongest events, in terms of surge amplitude and spatial extent.

2. For 1- to 3-year timescales, ETCs are equally important as hurricanes and should be considered when planning for the dangerous storm surge events.

3. If we examine the regional footprints of storms, we find an equal importance of ETCs and hurricanes.

4. Newport, R. I. stands out because hurricanes cause a large portion of its strong surge events despite its high latitude.

ADDITIONAL SLIDES

Data

Surge

- The water level data used in this analysis is provided by the NOAA Center for Operational Oceanographic Products and Services (http://tidesandcurrents.noaa.gov).
- We remove the astronomical tide and extract daily maxima of the non-tidal component of the water level.
- We remove the long-term trend by subtracting the trend in surge for each station from the data

Cyclones

- For the hurricanes, the NOAA Atlantic hurricane database (HURDAT2; Landsea and Franklin, 2013) is used.
- For the ETCs, the NASA Modeling Analysis Program (MAP) Climatology for Midlatitude Storminess (MCMS) tracking algorithm (Bauer et al. 2016) is applied to ERA-Interim reanalysis to identify cyclone tracks.

ABSTRACT

Storm surge on the east coast of the United States can be generated by hurricanes or extratropical cyclones (ETCs). Understanding the differences in the impacts of these two phenomena is important for improving strategies to mitigate the damage created. As such, this work examines the magnitude, spatial footprint, and paths of hurricanes and ETCs that caused strong surge along the east coast of the US. Lagrangian cyclone track information, for hurricanes and ETCs, is used to associate surge events with individual storms. First, hurricane influence is examined using ranked surged events per site. The fraction of hurricanes among storms associated with surge decreases from 20-60% for the top 10 events to 10-30% for the top 50 events, and a clear latitudinal gradient of hurricane influence emerges for larger sets of events. Second, surge on larger spatial domains is examined by focusing on storms that cause exceedance of the probabilistic 1-year surge return level at multiple stations. Results show that if the strongest events, in terms of surge amplitude and spatial extent, are considered hurricanes are most likely to create the hazards. However, when slightly less strong events that still impact multiple areas during the storm life cycle are considered, the relative importance of hurricanes shrinks as that of ETCs grows.

Next we examine the details of the tracks of the storm events that cause strong surge events. We find that paths for ETCs causing multi-site surge at individual segments of the US east coast pass very close to the regions of impact. We find that the paths of hurricanes that cause the strongest multi-site surge are often influenced by nearby large-scale circulation patterns. We also examine the relationship between the storm surge time-evolution and the propagation speed of the low-pressure center of the storm events. For extratropical cyclones, slower moving events have weaker cyclonic winds which offsets the enhanced surge associated with the longer duration of the cyclone influence on surge. For hurricanes, there is less correlation between propagation speed and cyclonic wind motion, meaning slower moving events can still generate very strong winds. However, slow moving events still don’t cause the absolute largest events.