2025 HURREVAC Training Webinar Series

Day 3 – Storm Surge and Flooding Hazards

July 30, 2025

FEMA NATIONAL HURRICANE PROGRAM

HURREVAC
HURRICANE DECISION SUPPORT TOOL

Attendee information

Registration

- You are automatically signed in when you join
- Registration is still open for Day 4

Audio

- All attendees are muted
- If having audio issues, restart webinar or try watching link on a different device (laptop/desktop strongly recommended)

Live Transcription

- Available in English and Spanish
- Opens in a separate browser window
- Links are in the chat window and reminder email from 1 hour ago

Downloadable handouts

- Today's slides
- HURREVAC Workspace Guide
- Also available from hurrevac.com in the **Learning Resources** section

NATIONAL HURRICANE PROGRAM

Attendee information

Questions

- Submit in the question box

Recording

- Will be posted by tomorrow morning on our YouTube channel and the **Learning Resources** tab of hurrevac.com
- Available if you miss a session, or as a year-round resource

Feedback

- Daily survey launches after webinar
- Link also in follow-up email

Certificate

- One for each day attended
- Emailed from GoToWebinar about one hour after conclusion
- If missing, check junk/spam first
- Certificates cannot be generated for groups, or makeup viewing on YouTube

NATIONAL HURRICANE PROGRAM

THIS WEEK'S AGENDA

MON. JULY 28: Introduction to HURREVAC *(on YouTube)*

TUES. JULY 29: Wind Forecast Features *(on YouTube)*

WED. JULY 30: Storm Surge and Flooding Hazards

THURS. JULY 31: Evacuation Timing Features

Registration is still open for Day 4 at webinars.hurrevac.com

Today's Presenters

Cassandra Mora
Storm Surge Specialist
NOAA National Hurricane Center

Owen Shieh, Ph.D.
Warning Coordination Meteorologist
NOAA / NWS Weather Prediction Center

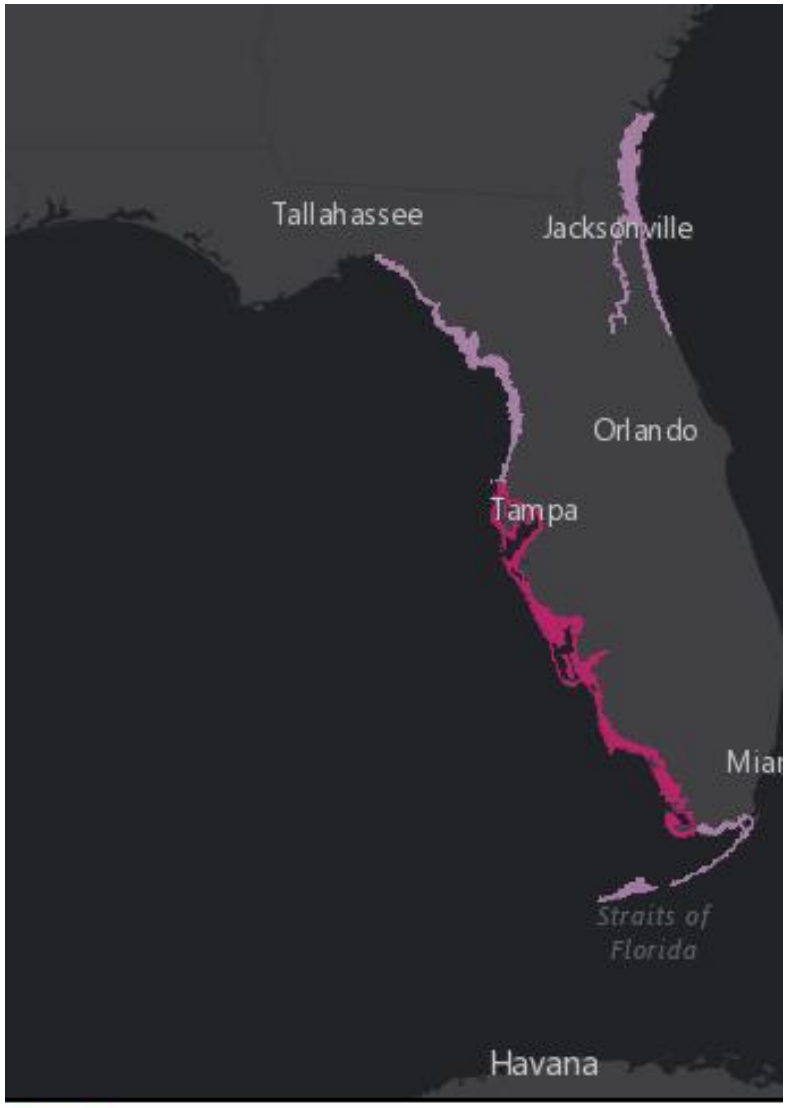
John Boyer
Sea Island Software

NATIONAL HURRICANE PROGRAM

2025 HURREVAC WEBINAR – STORM SURGE

CASSANDRA MORA
STORM SURGE UNIT - NATIONAL HURRICANE CENTER

Credit: Max Olson



OBJECTIVE:

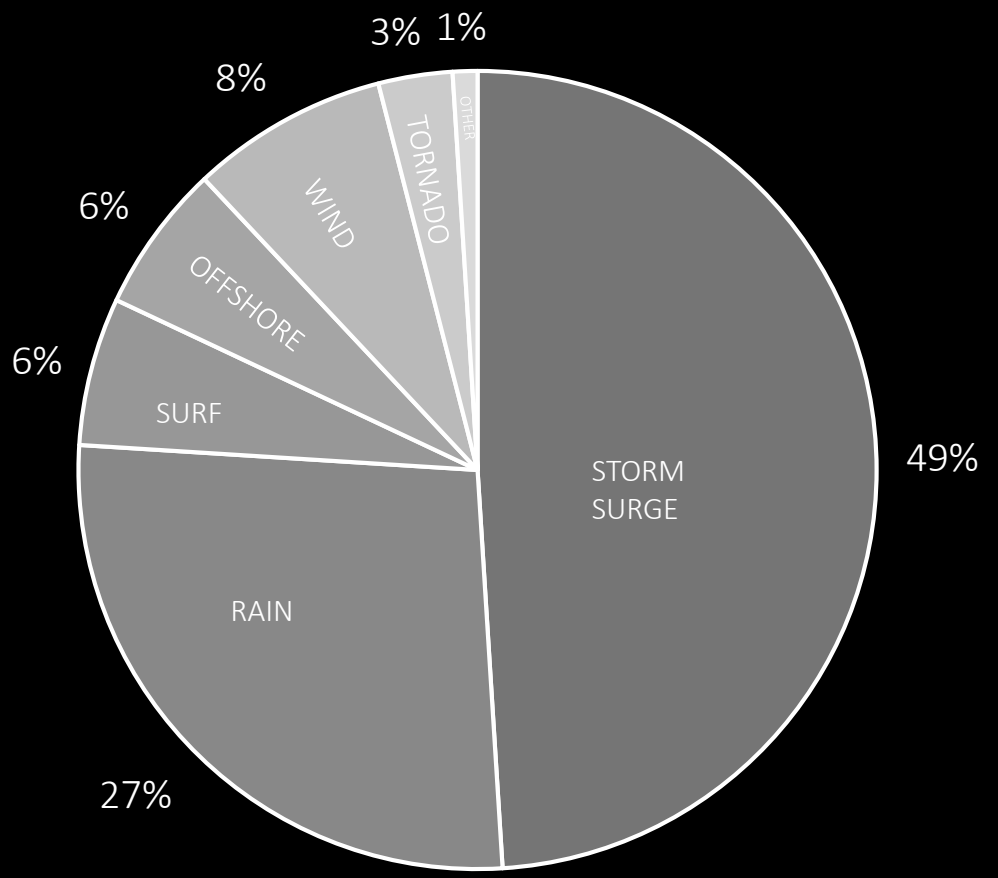
- To communicate the danger of storm surge caused by tropical cyclones
- To highlight the products available for planning and response to storm surge

Cause of death in the United States directly attributed to Atlantic tropical cyclones (1963-2012)

[Rappaport 2014]

- Almost 50% the deaths are due to storm surge
- More than 80% of deaths are due to water
- Wind causes less than 10% of deaths

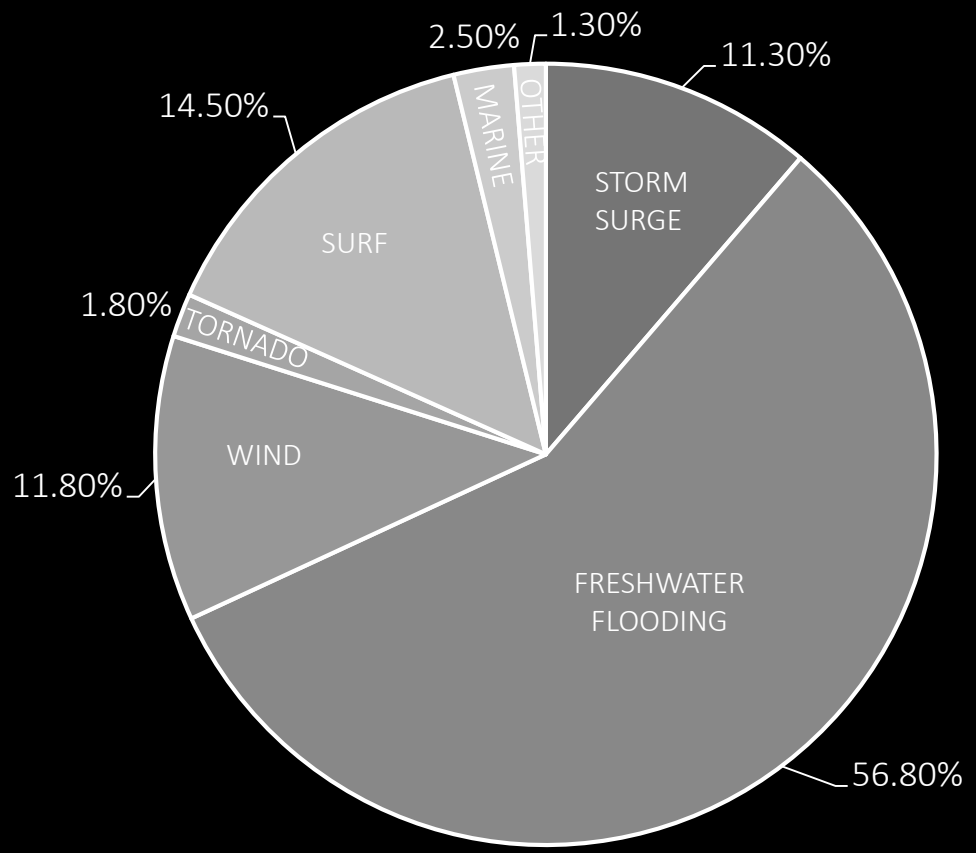
2,544 Fatalities From 1963–2012



Edward N. Rappaport, 2014: Fatalities in the United States from Atlantic Tropical Cyclones: New Data and Interpretation. Bull. Amer. Meteor. Soc., 95, 341–346.

Cause of death in the United States directly attributed to Atlantic tropical cyclones (2013-2022)

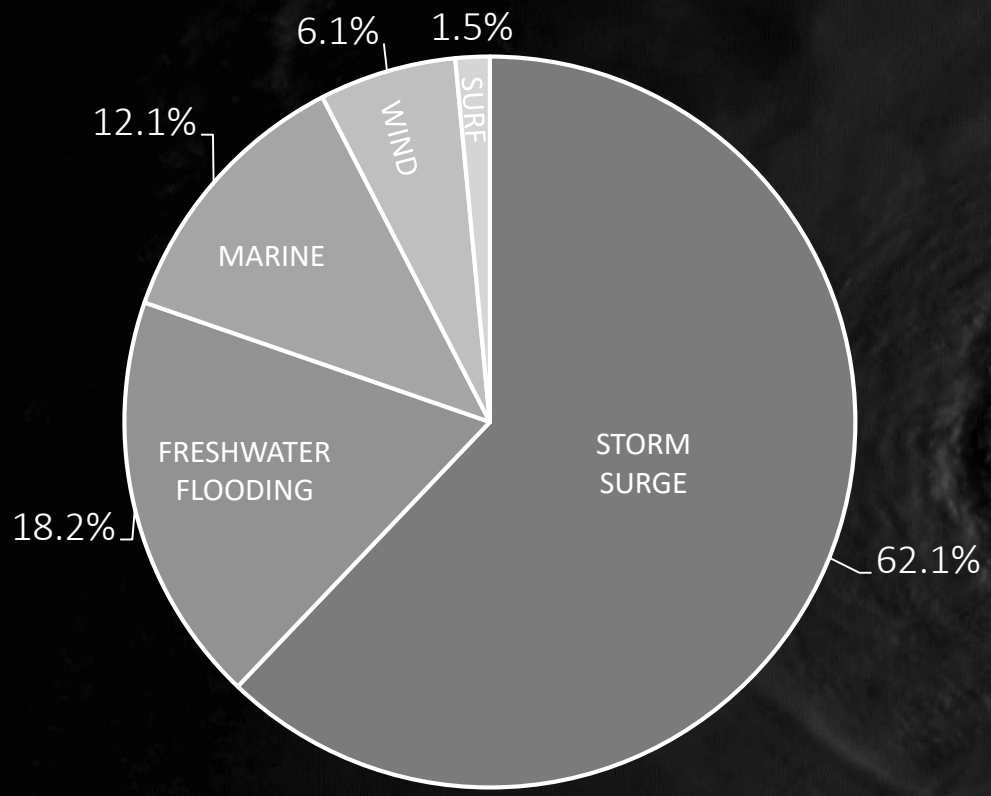
- Storm surge accounts for only 11.3% of direct deaths
- Freshwater now leads tropical hazards with 56.8% of storm related direct deaths
- Wind still a small percentage of storm related deaths with 11.8%



BRENNAN ET AL. 2022

442 – direct fatalities 415 – indirect fatalities

…and then there was Hurricane Ian (2022)



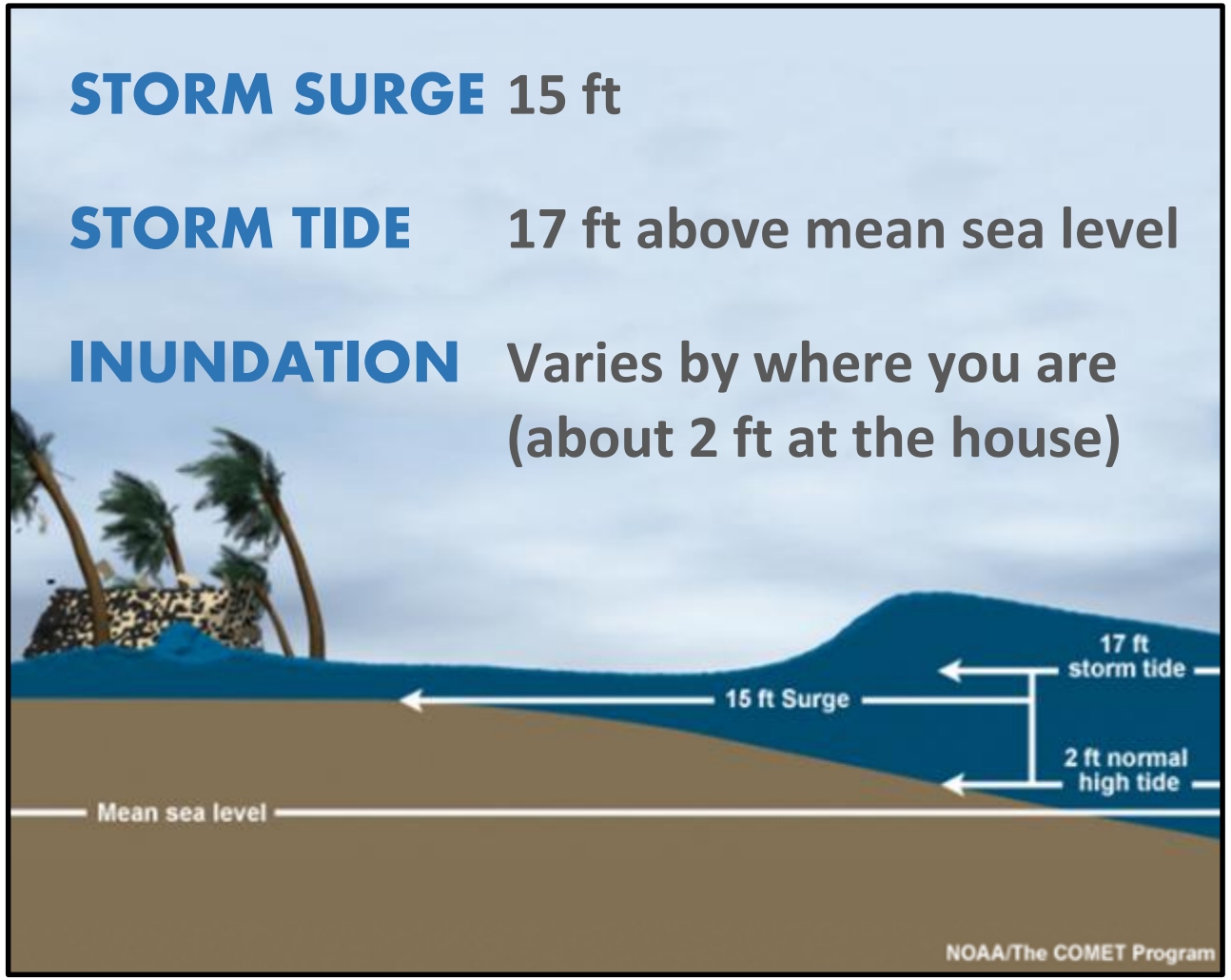
- 41 lives were lost to storm surge, whereby 36 lives were directly lost in Lee County alone
- 15 feet of storm surge [above ground level] inundated Fort Myers Beach, Florida

STORM SURGE
Storm Surge vs Storm Tide vs Inundation

STORM SURGE
An abnormal rise of water generated by a storm, over and above the predicted astronomical tide.

STORM TIDE
Water level due to the combination of storm surge and the astronomical tide.

INUNDATION
The flooding of normally dry land, resulting from storm tide and possibly other factors.



Factors Affecting Storm Surge

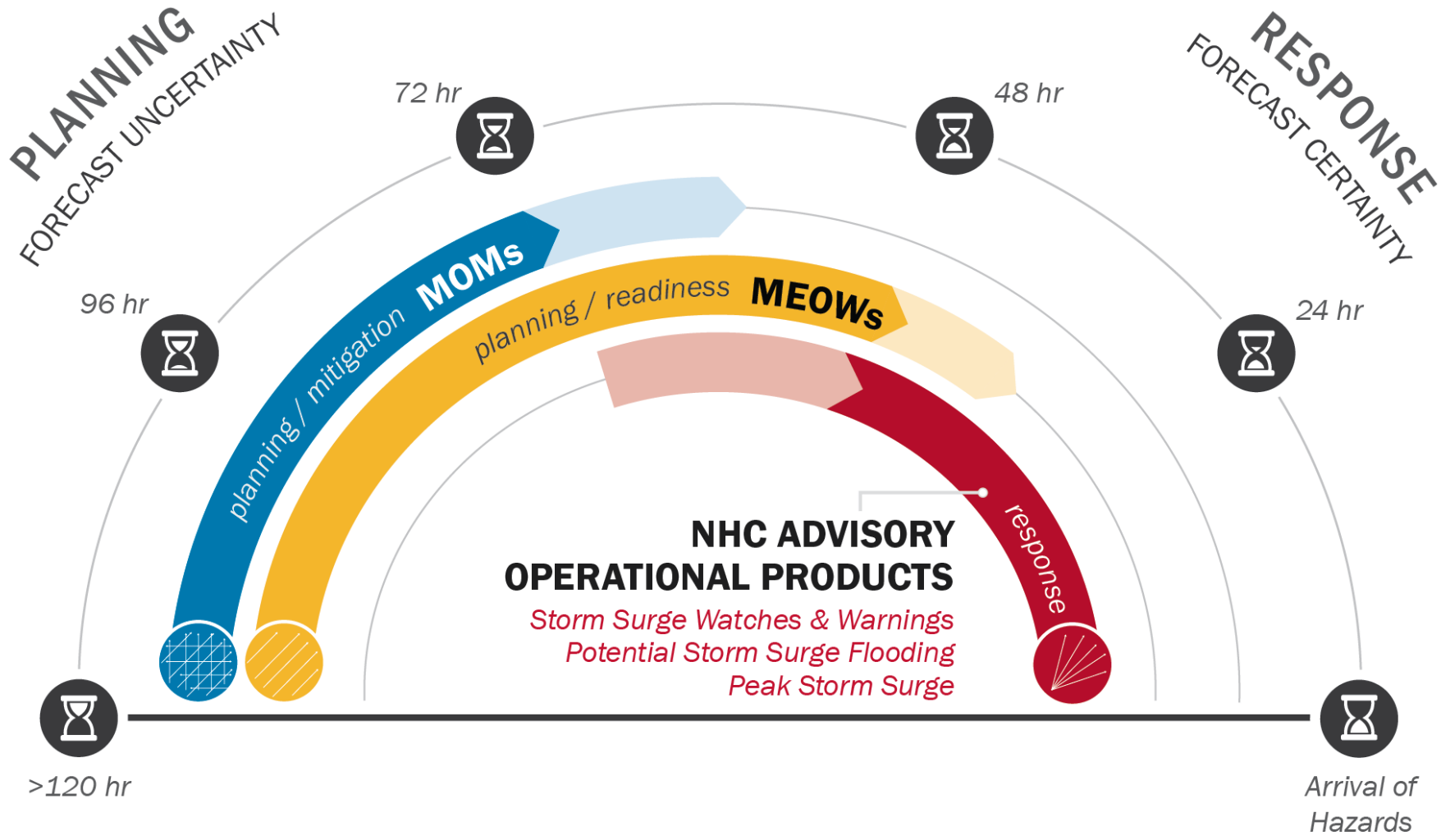
- **Intensity**
  Stronger storm = More storm surge
- **Size (Radius of Maximum Winds)**
  Larger = More storm surge
- **Forward Speed**
  Slower storm = Storm surge farther inland
- **Width and Slope of Shelf (Bathymetry)**
  Gradual sloping shelf = More storm surge
- **Angle of Approach**
  Alters focus of storm surge

STORM SURGE
SLOSH Model

Sea,
Lake, and
Overland
Surges from
Hurricanes

A numerical model used to estimate storm surge heights for historical, hypothetical, or predicted hurricanes

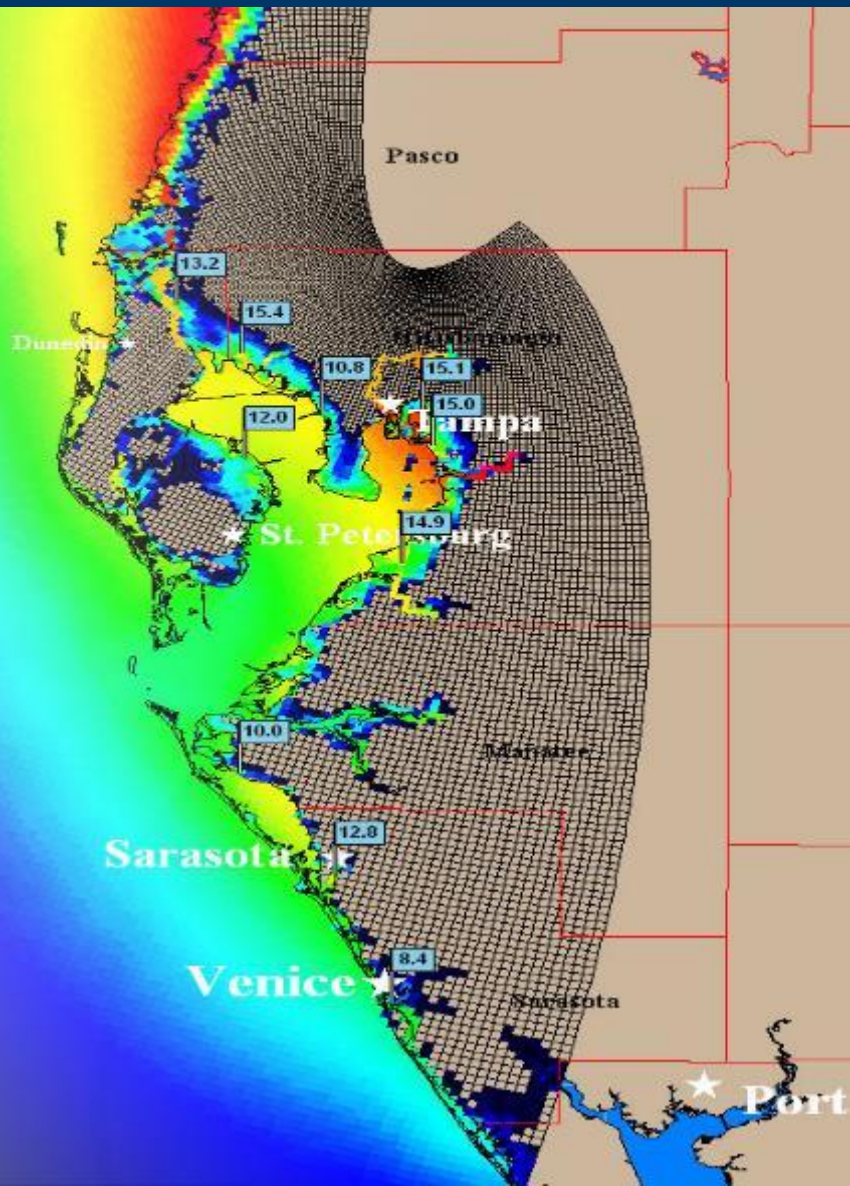
STORM SURGE
Storm Surge Risk Tools



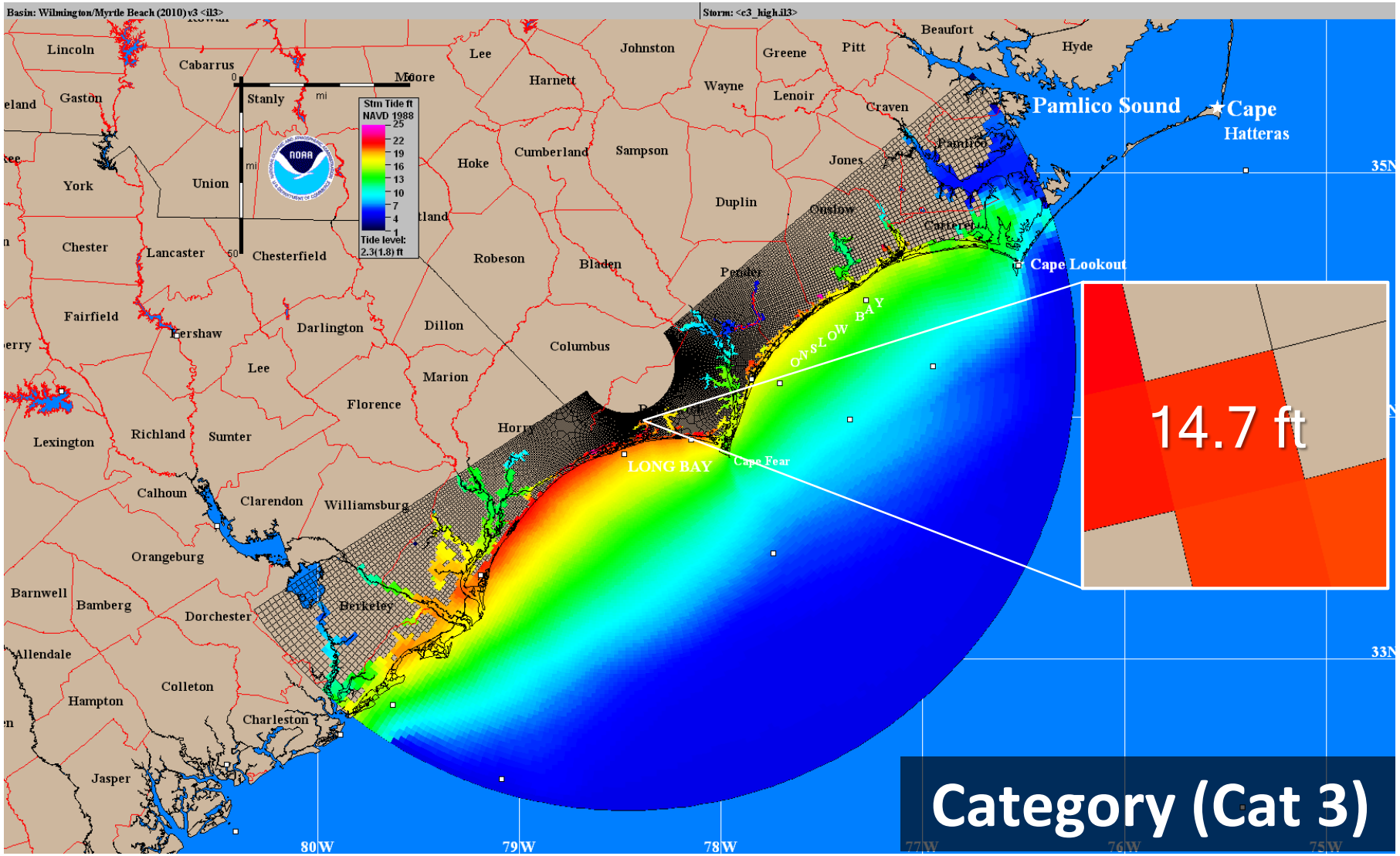
STORM SURGE
Maximum of Maximums (MOM)

MOMs

- **Worst-case for a particular category storm**
- **Combination of many scenarios**
  - Forward speed
  - Angle of approach
  - Size (Radius of maximum wind)
  - Initial tide level
- **No single hurricane will produce the regional flooding depicted in a Maximum of Maximums (MOMs)**



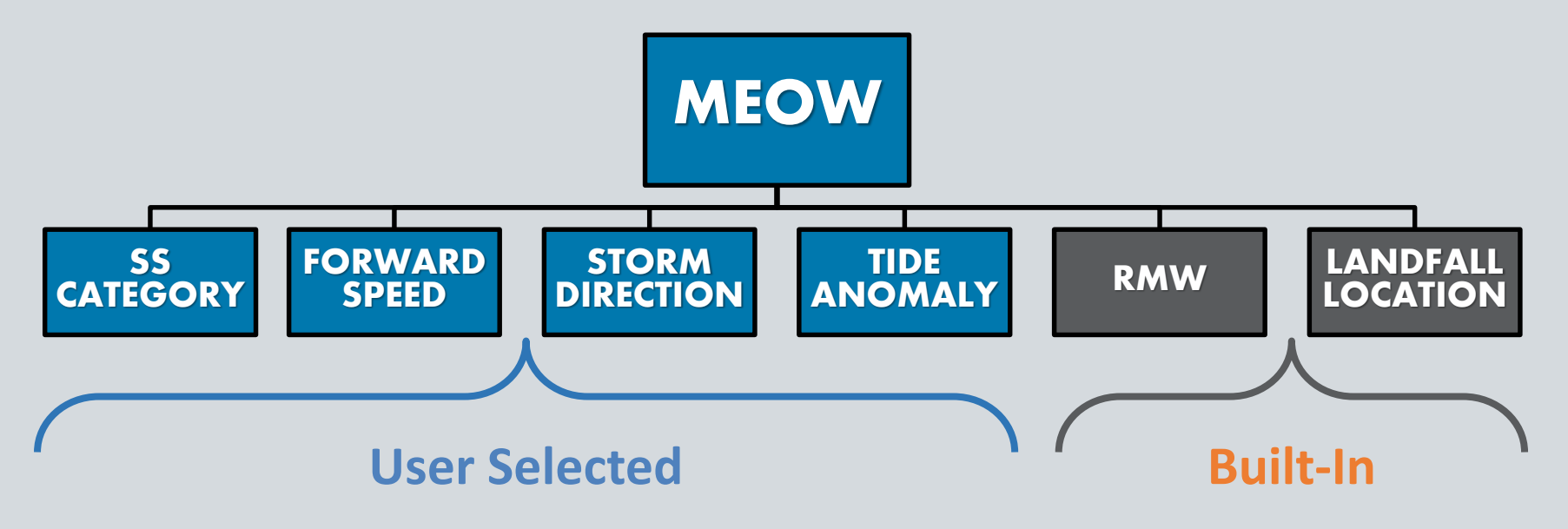
STORM SURGE
Maximum of Maximums (MOM)



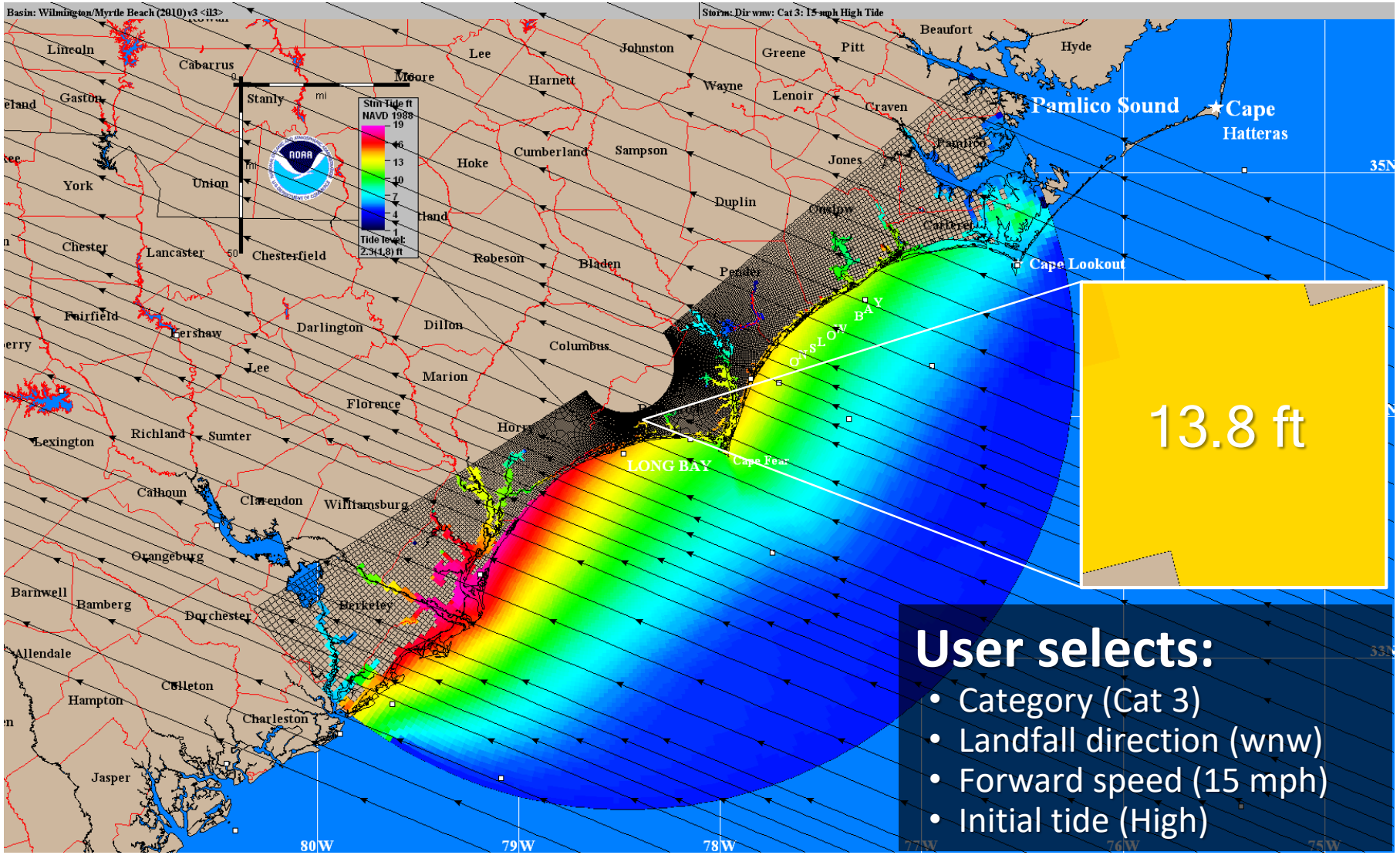
STORM SURGE
Maximum Envelope of Water (MEOW)

MEOWs

- Composite of the maximum storm surge for a given set of parameters (by basin)
- Used as guidance of planning and operations

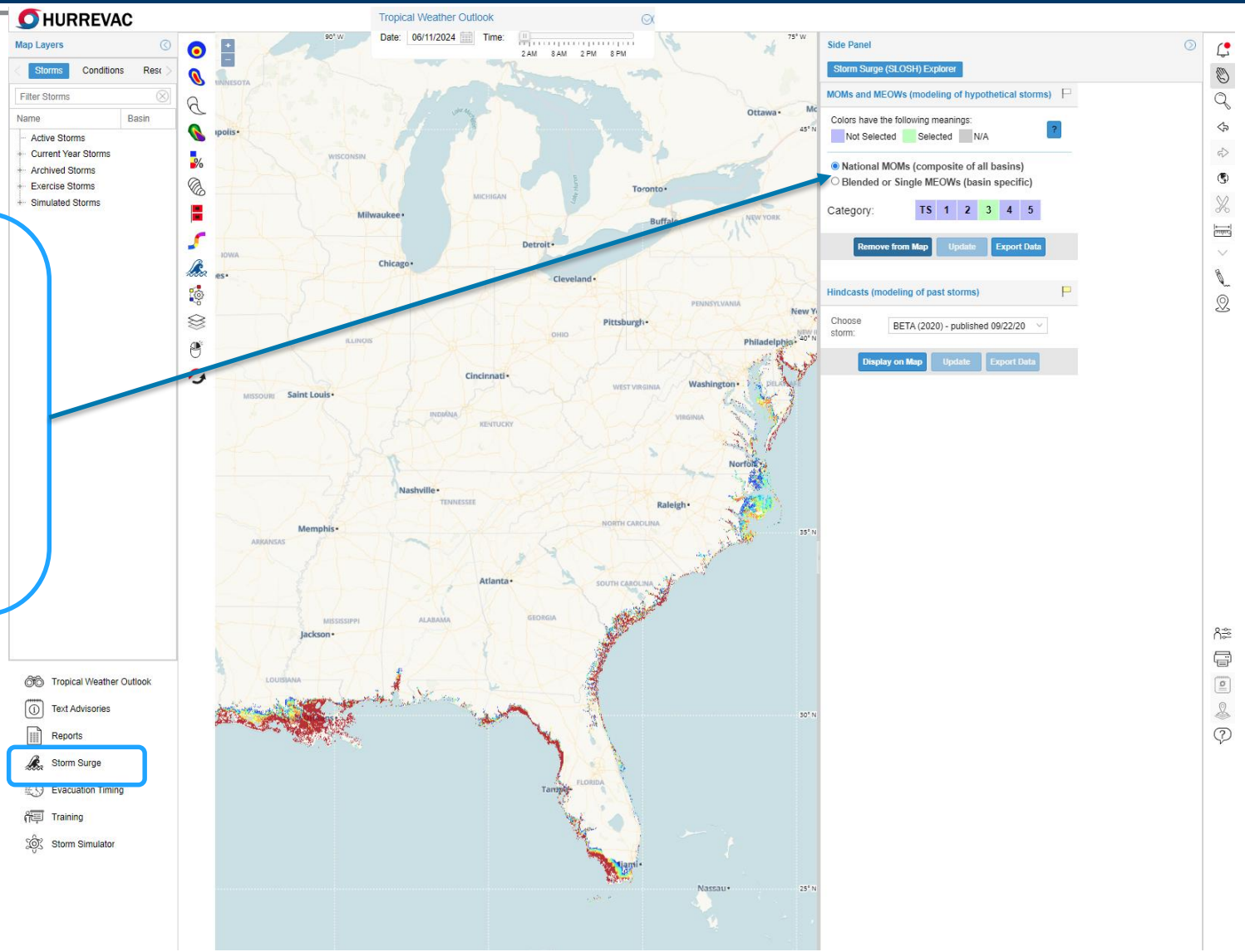


STORM SURGE
Maximum Envelope of Water (MEOW)



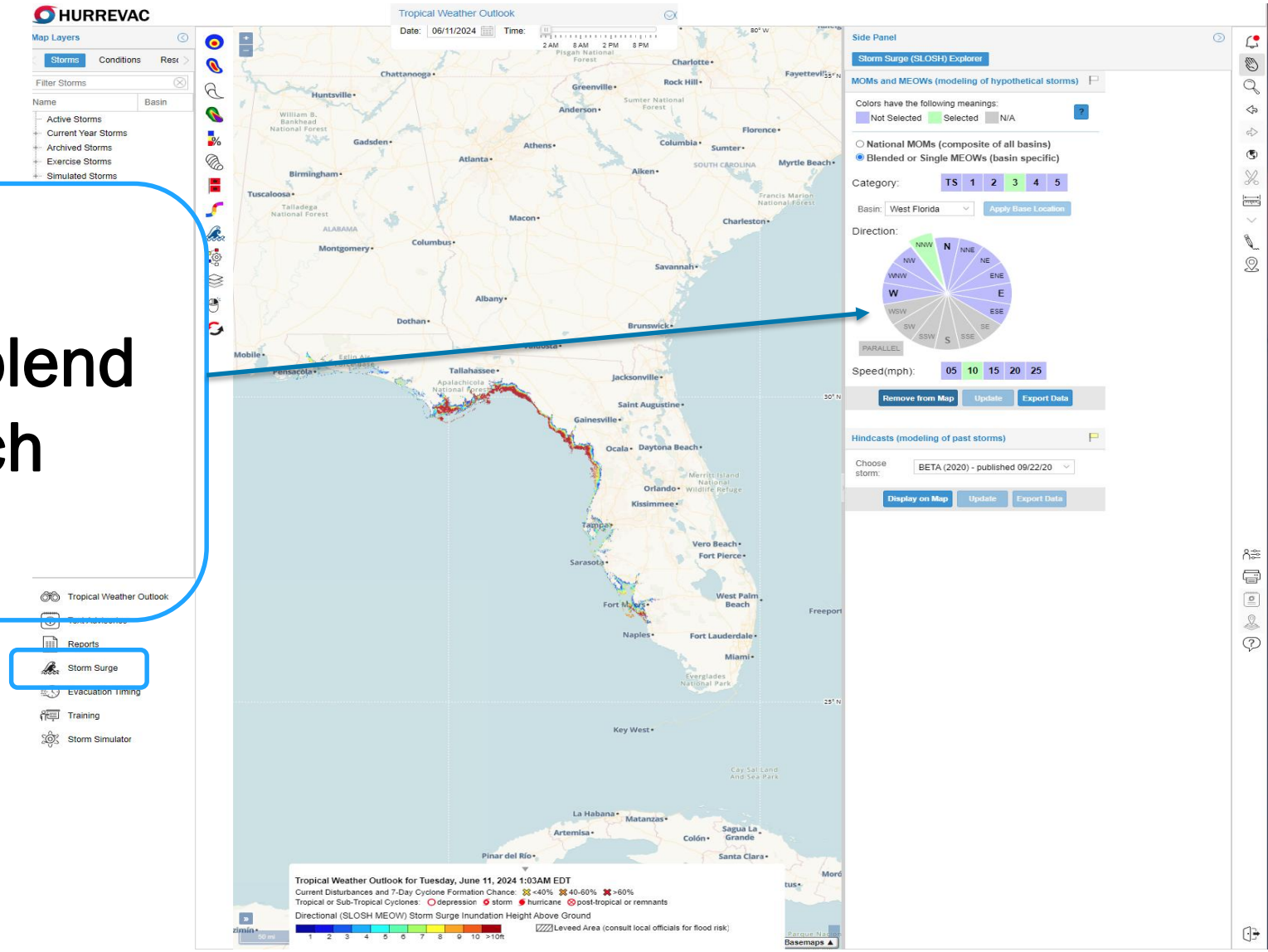
SURGE EXPLORER IN HURREVAC

Viewing the National MOM in HURREVAC, which is a composite of all basins



SURGE EXPLORER IN HURREVAC

Viewing MEOWS in HURREVAC, which can blend directions or look at each direction independently



PROBABILISTIC STORM SURGE
Multiple Tracks and Landfall Locations

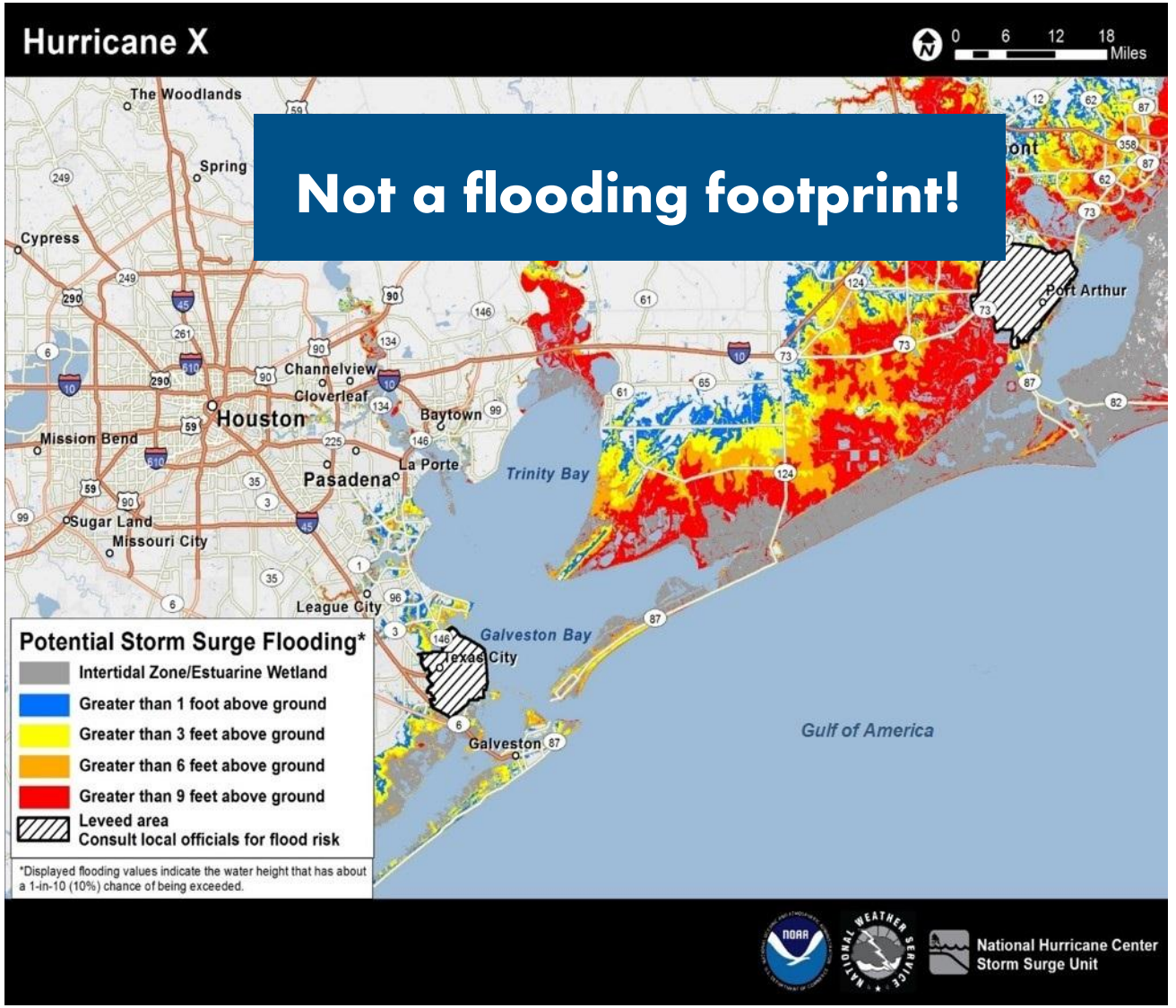
P-SURGE

- **Based on NHC official advisory**
  - Uncertainties based on historical errors
- **Accounts for uncertainty in:**
  - Track (landfall location)
  - Size (Radius of Maximum Winds)
  - Forward speed
  - Intensity
- **Accounts for tide**
- **Heights above ground level**

STORM SURGE
Potential Storm Surge Flooding Map

INUNDATION MAP

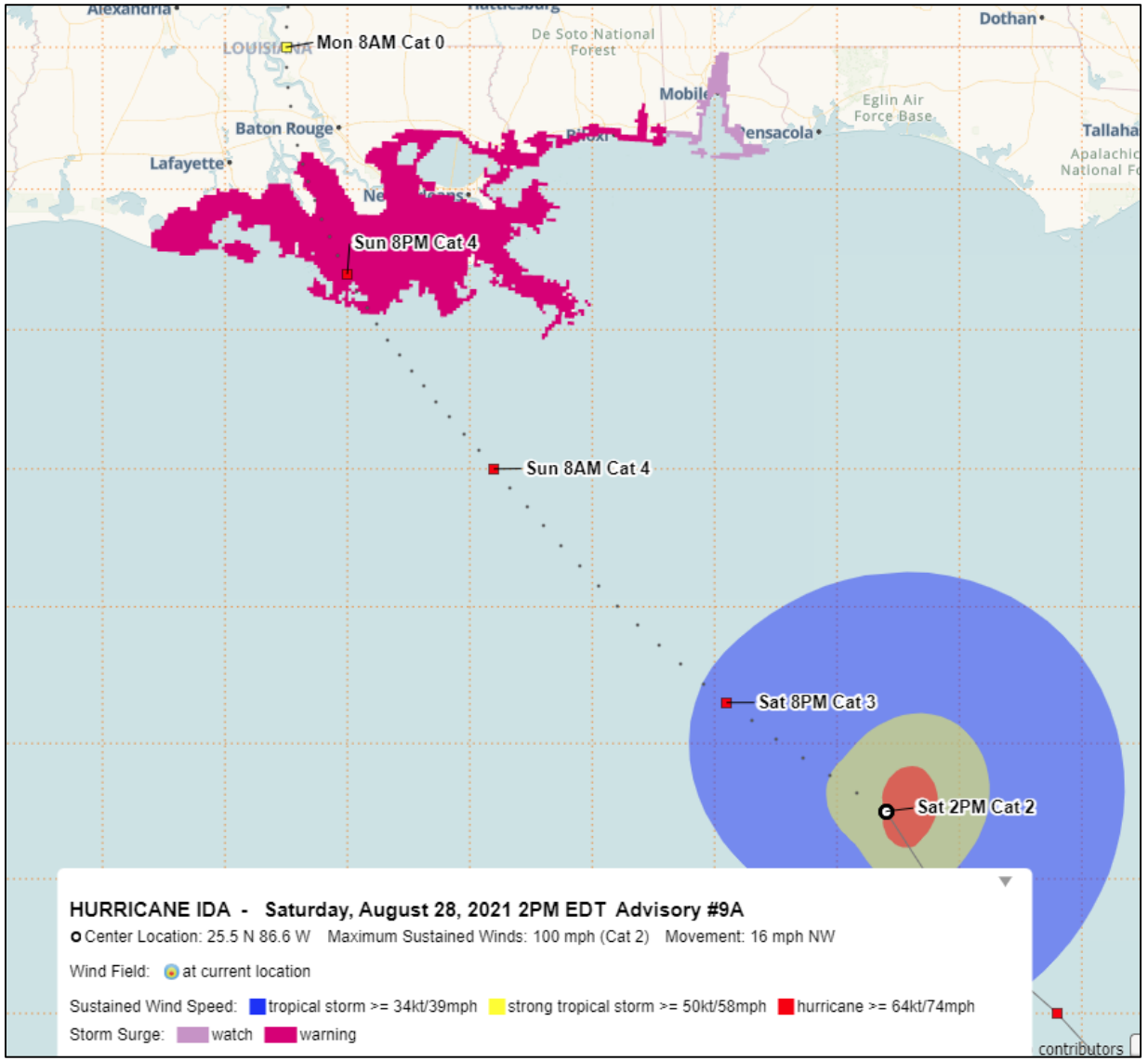
- **Height above ground that the water could reach**
  - Reasonable worst-case scenario for any individual location
  - Values have a 10% chance of being exceeded
- **Issued up to ~72 hours prior to the onset of the hazard**
- **Available ~60-90 minutes after the advisory release**



STORM SURGE
Watches and Warnings

- A **Storm Surge Watch** means there is a possibility of life-threatening inundation from rising water moving inland from the coastline in the indicated locations during the next 48 hours.

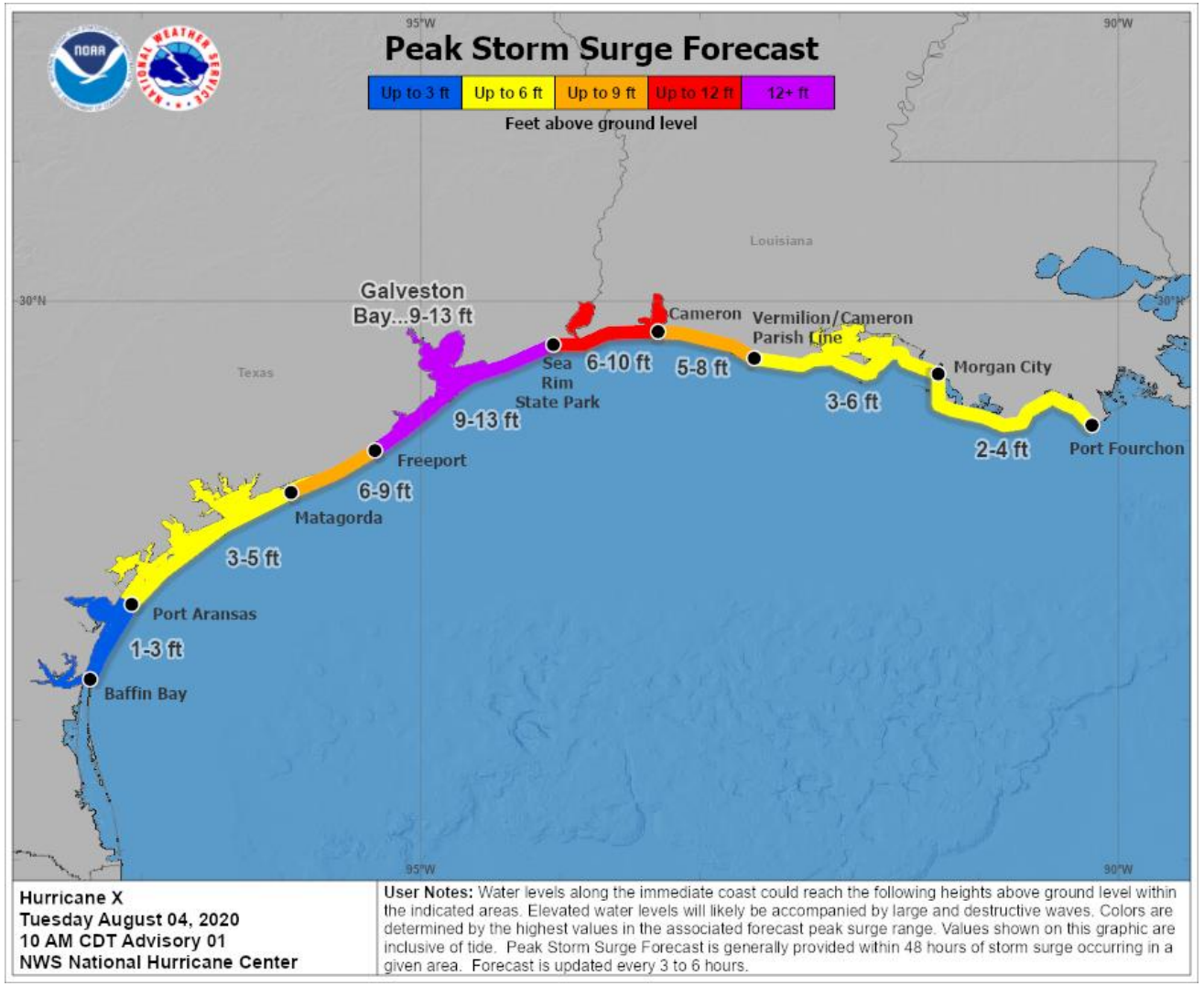
- A **Storm Surge Warning** means there is a danger of life-threatening inundation from rising water moving inland from the coastline during the next 36 hours in the indicated locations.



STORM SURGE
Peak Storm Surge Forecast Graphic

Peak Surge Forecast

- **Forecast for peak inundation along the immediate coast from storm surge and tides within the next 48 hours**
  - Height water could reach above normally dry ground, occurring somewhere between 2 points
  - Not location specific
- **Introduced when Watch/Warning is in effect**
- **May differ from potential storm surge flooding map**

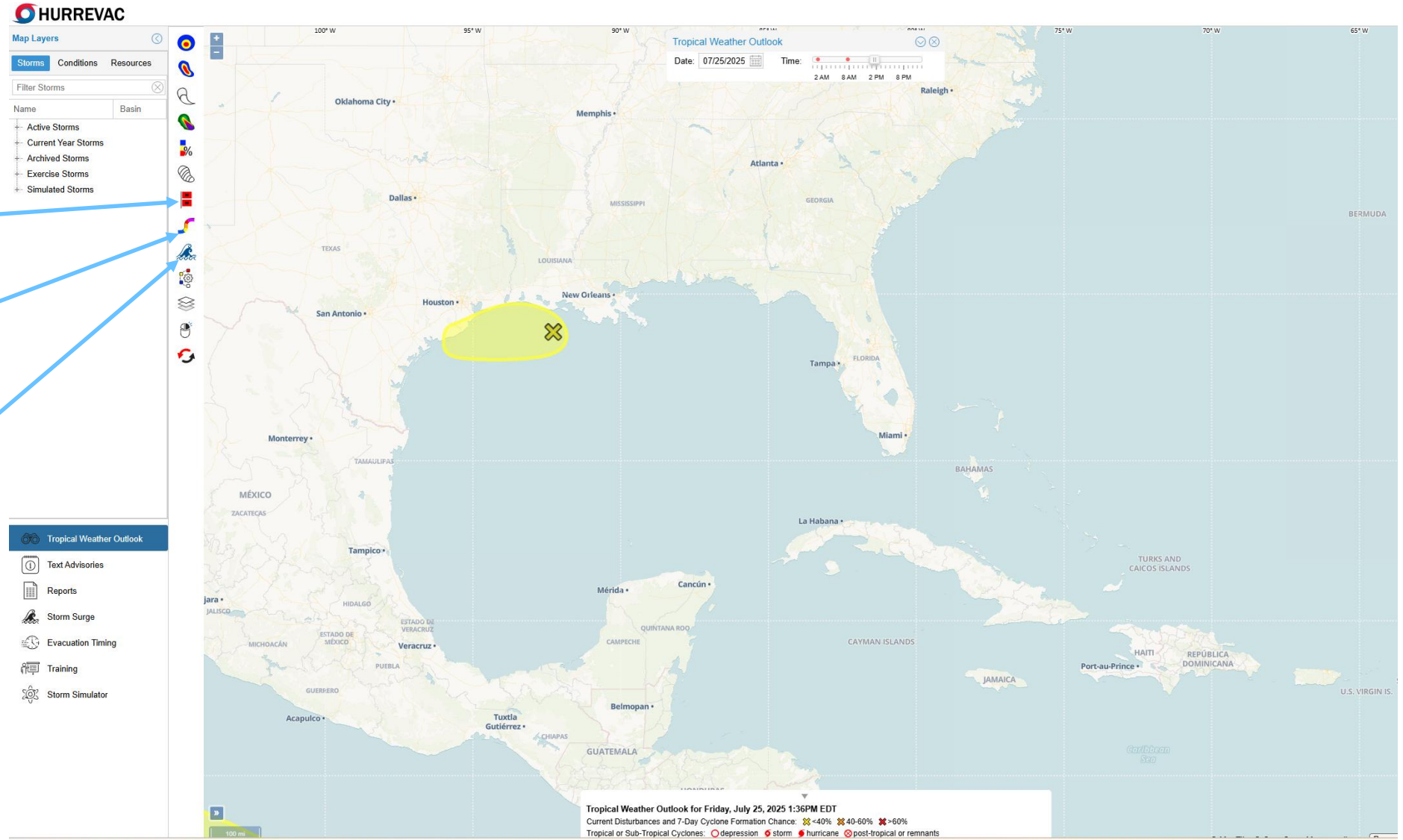


STORM SURGE
Real-time products in HURREVAC

Watches and Warnings

Peak Storm Surge Graphic

Potential Storm Surge Flooding Map



Questions?

Cassie Mora

2025 Hurrevac webinar – Storm Surge

Storm Surge Unit - National Hurricane Center

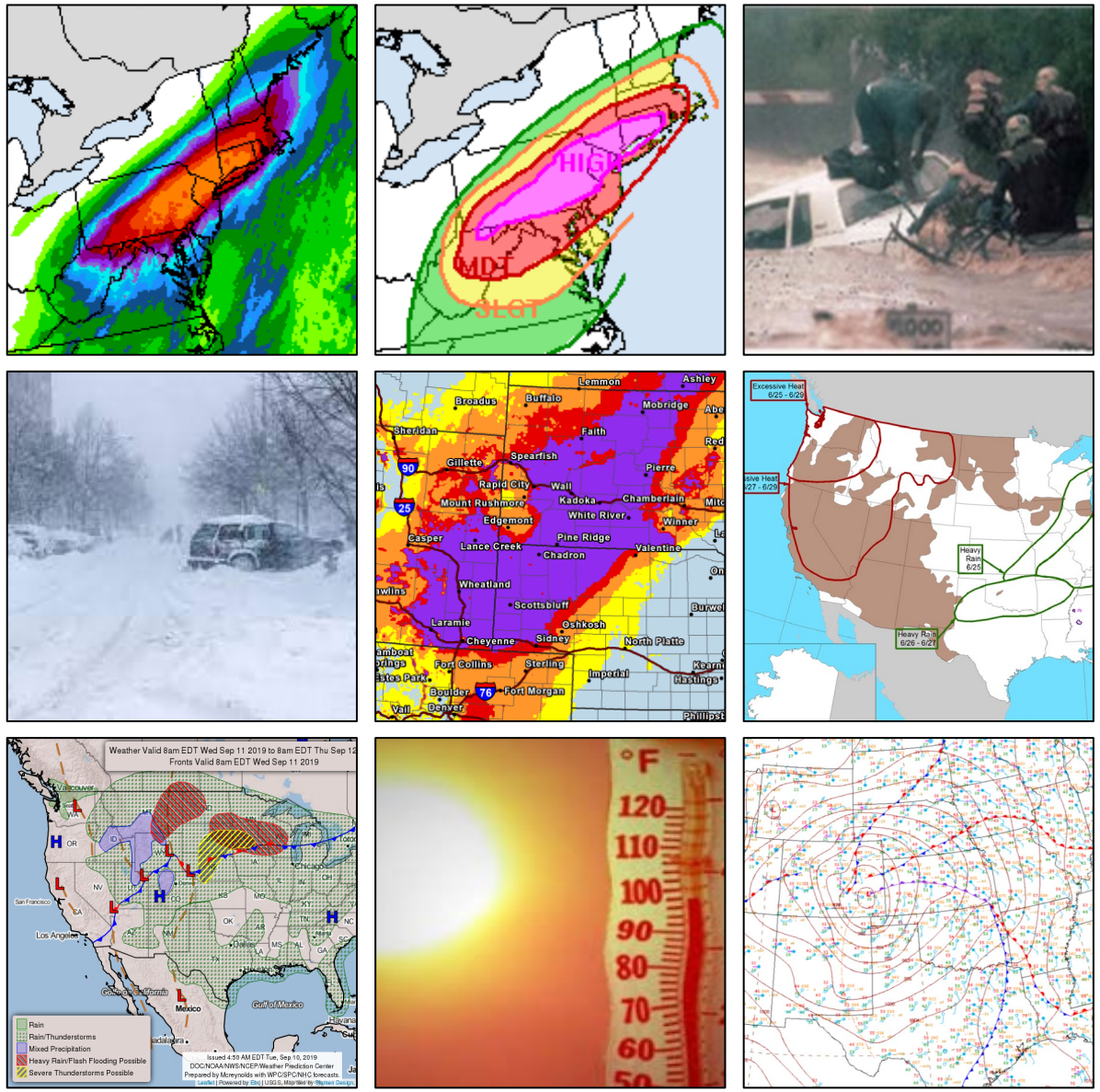
www.nhc.noaa.gov/surge/

NHC_Surge

Tropical Cyclone Rainfall

Owen Shieh, Ph.D.
Warning Coordination Meteorologist

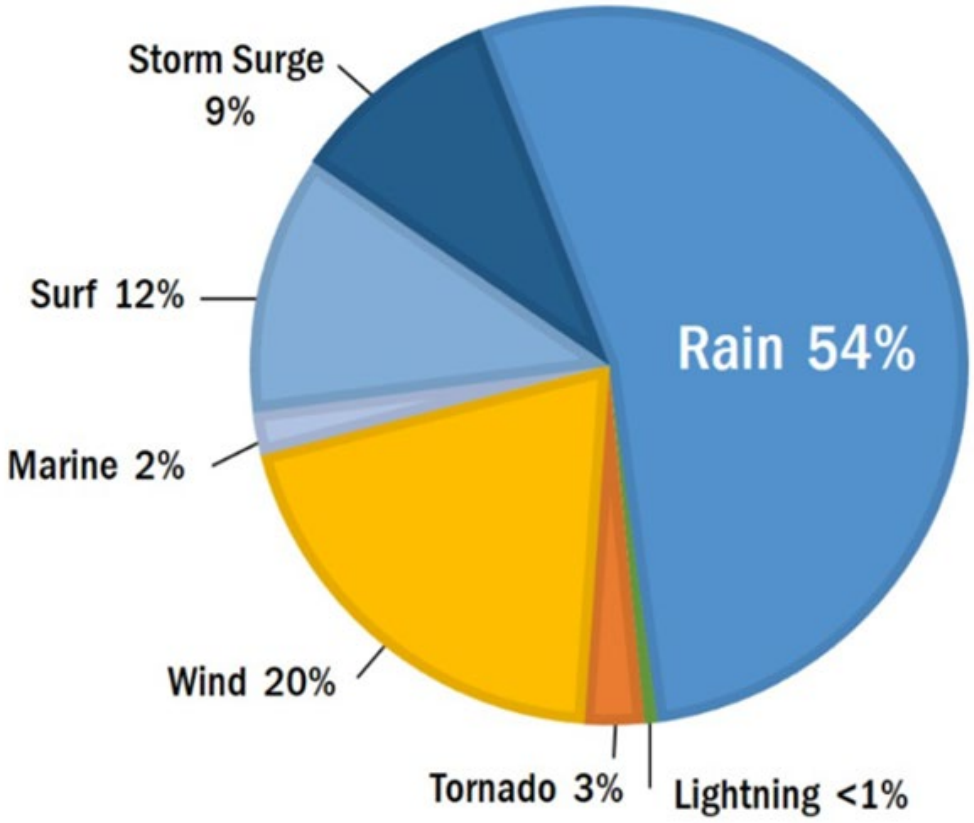
NWS Weather Prediction Center
College Park, MD



WPC: What do we do?

- **Short answer: a lot!**
- Precipitation forecasting expertise including rainfall and snow/ice
- Growing role in extreme temperatures, from heat to cold
- Foundation of the national weather story
- Continuing the 150+ year legacy of surface weather map analysis
- National Hurricane Center backup

U.S. Direct Tropical Cyclone Fatalities (2013-2024)



Since 2013, most fatalities have been due to **drowning due to freshwater flooding (rainfall).** Helene was the deadliest hurricane to affect the mainland U.S. since Katrina and a majority of those direct fatalities were due to freshwater flooding.

“An almost absurdly simple concept”

The heaviest rain falls where it rains hardest for the longest time.

(Paraphrase of Doswell, 1996)

Rainfall rate, or intensity

Related to the magnitude of…

- Forcing
- Moisture
- Instability

Rainfall duration

Related to the…

- Persistence of forcing
- Areal extent of rainfall
- Storm motions
- Backbuilding potential

The *duration aspect* makes this a tough forecasting challenge!

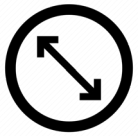
With most severe weather (tornadoes, hail, wind) the event is instantaneous. However with heavy rain, not only do we have to forecast the potential for instantaneous heavy rates, but also how long they will last. There’s a big difference between 3” per hour rates lasting fifteen minutes (0.75” total) or two hours (6” total)!

Key Factors that Affect TC Rainfall

1 **Movement**

Slow motion can lead to more rainfall. Storm track determines location of the rain footprint and heaviest rainfall.

2 **Storm Size**



Larger storm will lead to a greater area affected. For same forward motion, larger storm will produce more rainfall.

3 **Topography**

Enhances rainfall in upslope areas, decreases past the spine of mountains. Upslope depends on storm location.

4 **Moisture**

Increased moisture can increase rainfall. Entrainment of dry air can redistribute or reduce rainfall.

5 **Instability**

Greater instability will tend to support higher rainfall rates.

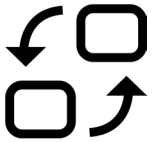
6 **Diurnal Cycle**

Heaviest rainfall will tend to occur near storm center overnight, and outer band rainfall favored during the daytime.

7 **Vertical Wind Shear**

In general, the heaviest rainfall will tend to be concentrated downshear of the storm center.

8 **Interactions**

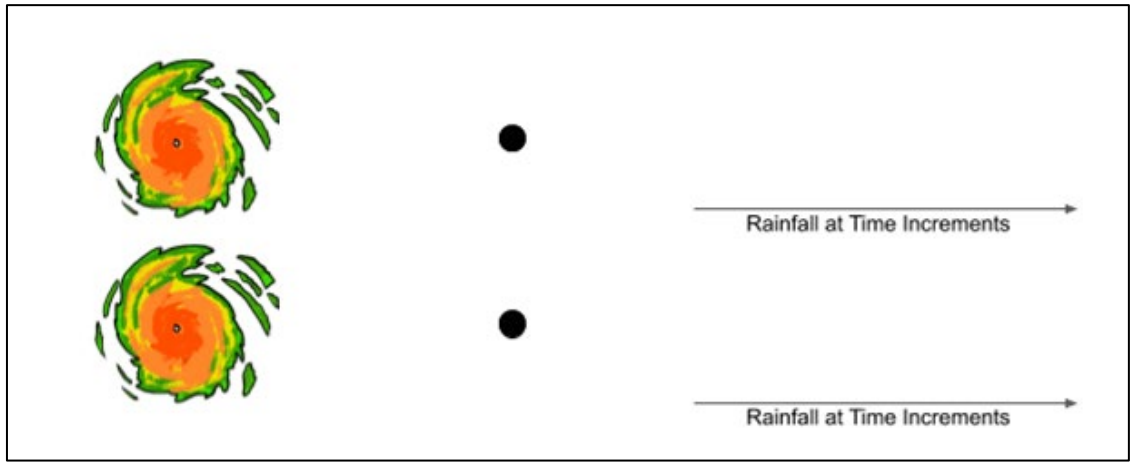


Interactions with troughs, fronts, and jets, and extratropical transition can greatly modify rainfall distribution

Key Factors that Affect TC Rainfall

The Speed Factor

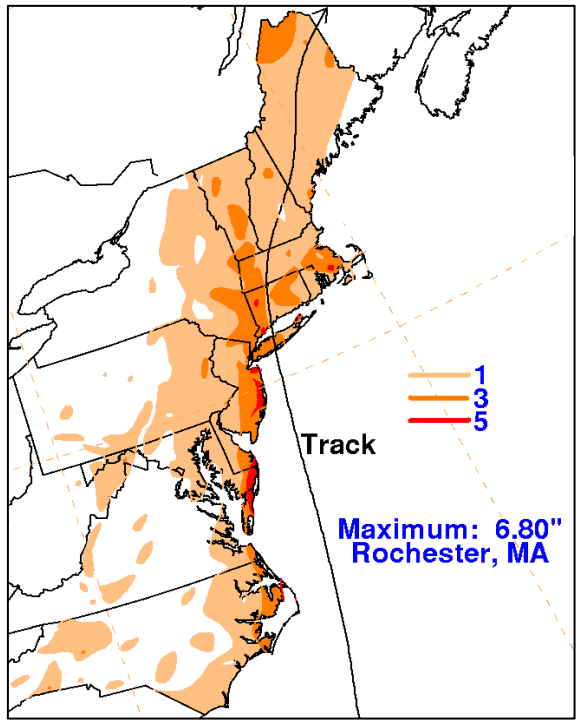
<u>Slow-moving tropical cyclones</u> that create longer duration opportunities for **repetitive, high-intensity rainfall**



Example for similar track

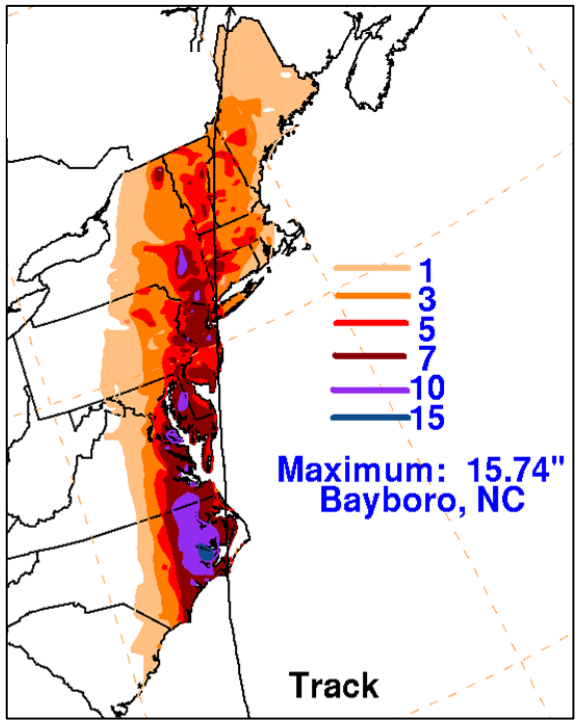
Belle (1976)

Forward speed near NJ:
26 MPH or ~70th percentile



Irene (2011)

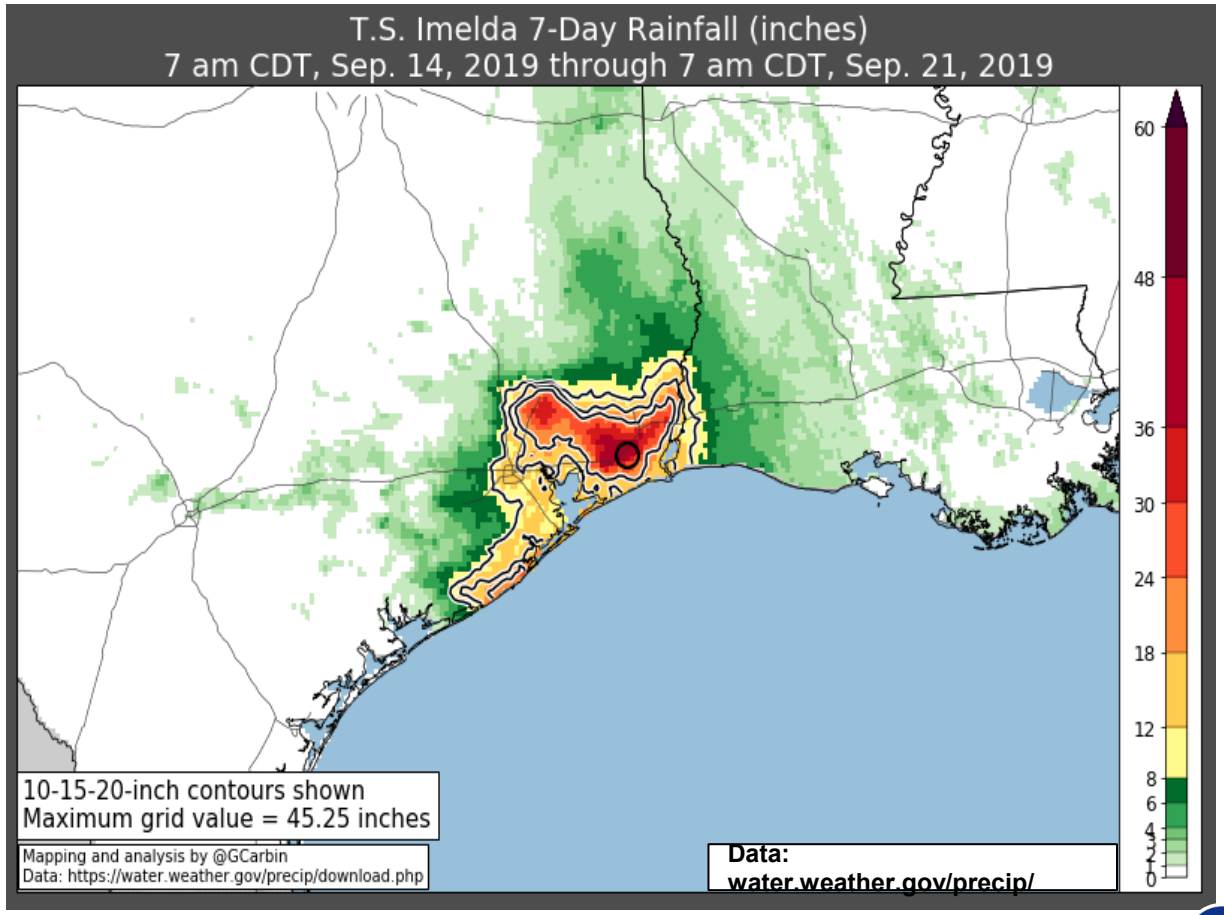
Forward speed near NJ:
18 MPH or ~20th percentile

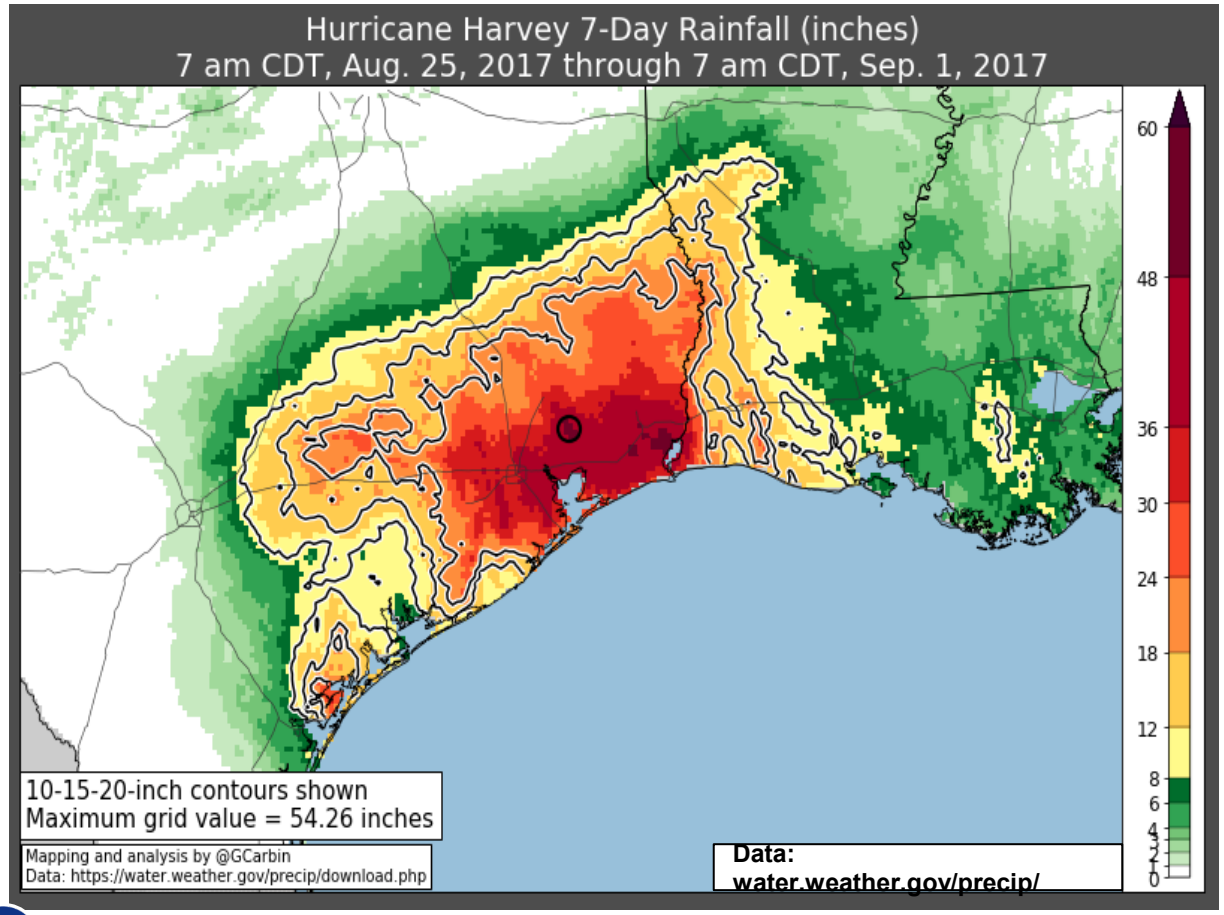


Key Factors that Affect TC Rainfall

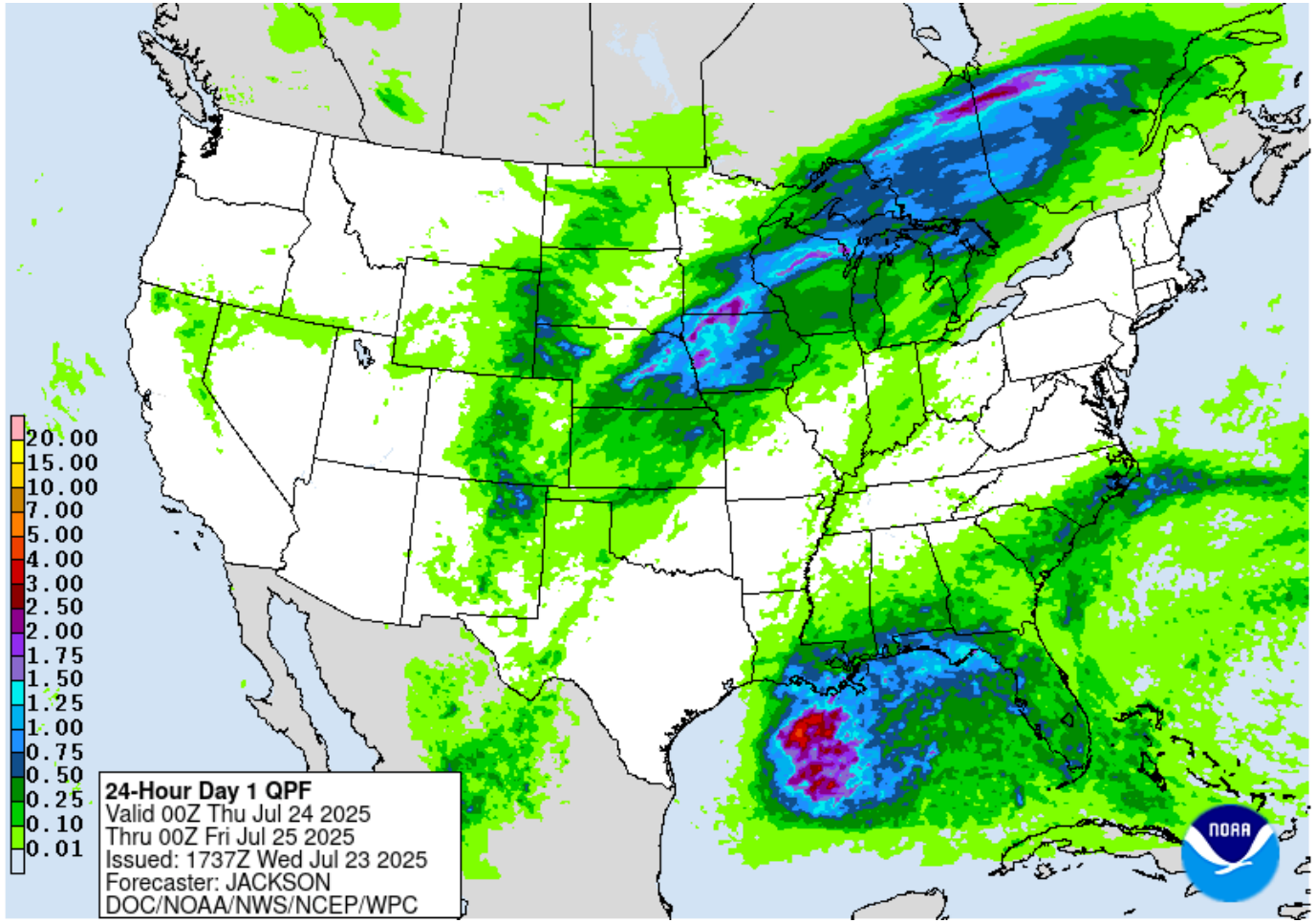
The Size Factor

Harvey and Imelda both moved at walking speeds in Texas, produced rainfall maxima of several feet, but Harvey was a ***MUCH bigger storm*** so extreme rainfall occurred at a much bigger scale.



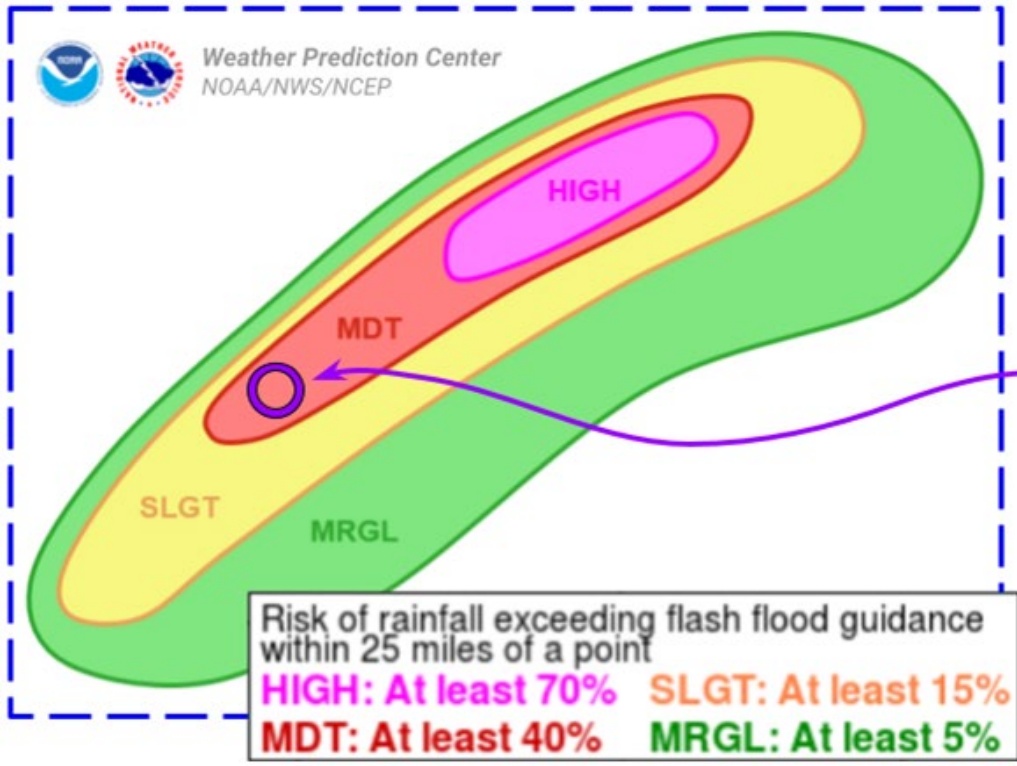


Quantitative Precipitation Forecast (QPF)



- Our “best guess” for rainfall totals
- Localized maxima will likely be higher
- Will correspond to the text rainfall statement in the official advisory
- 7 days of forecast precipitation always available on the WPC website
- QPFs are updated twice a day

Interpreting the Excessive Rainfall Outlook

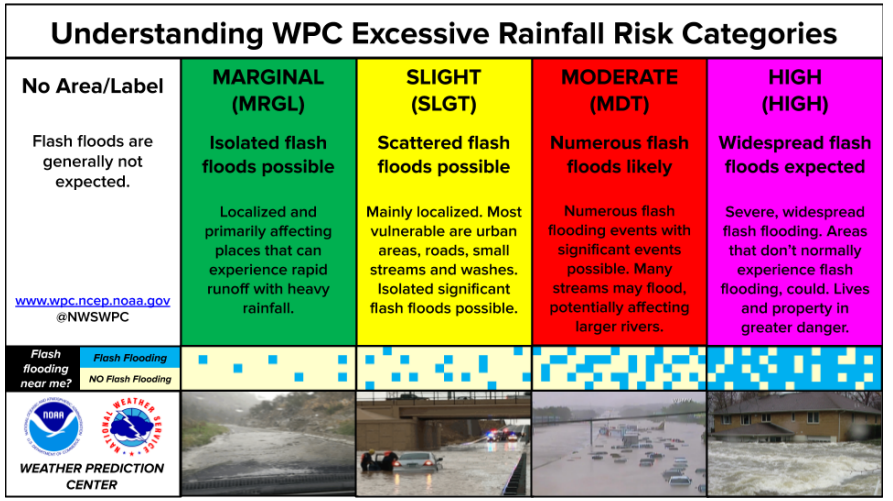


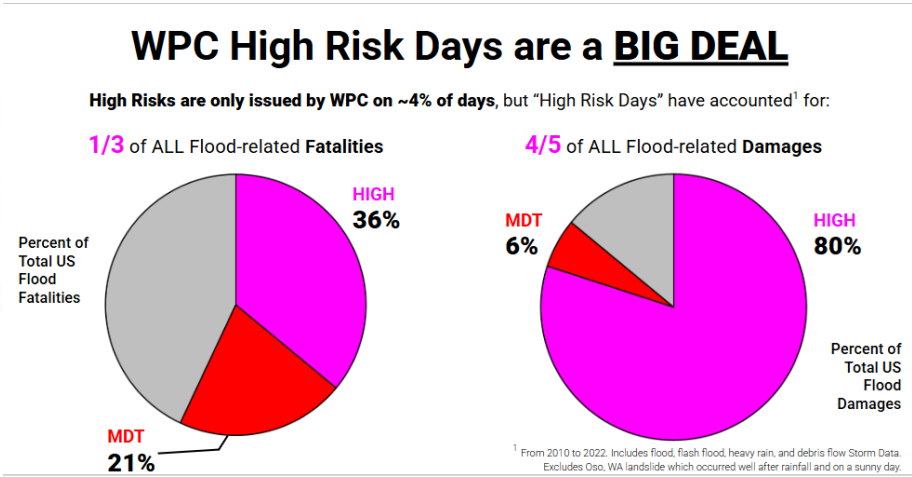
IN THE BIG PICTURE

- Orients you to potential problem spots for intense rainfall and resulting flash flooding
- Where is the risk relatively higher?

AT A LOCAL LEVEL

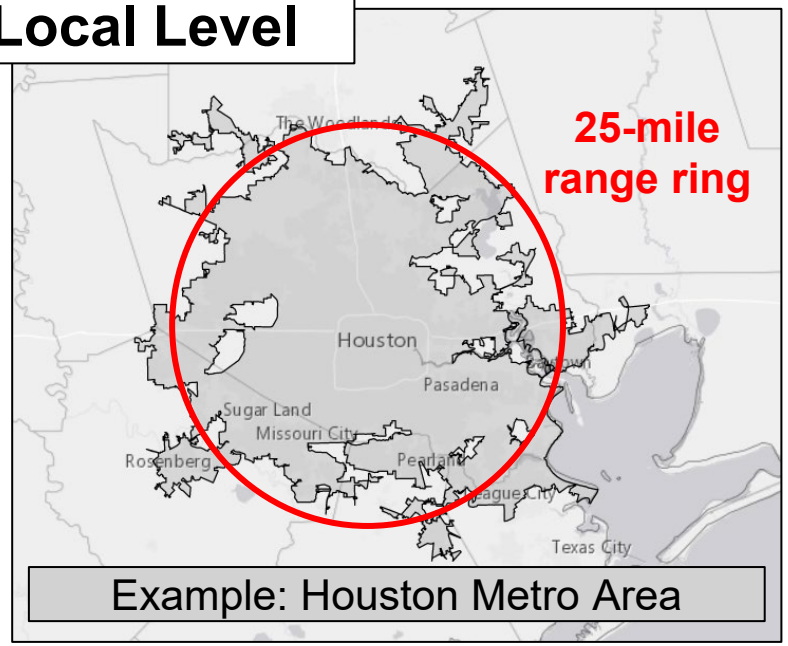
- Describes the probability (definition left) of intense rainfall leading to flash flooding within an area approximately the size of a large metro area or county/parish.
- "What are the chances I'll be dealing with flash flooding today?"





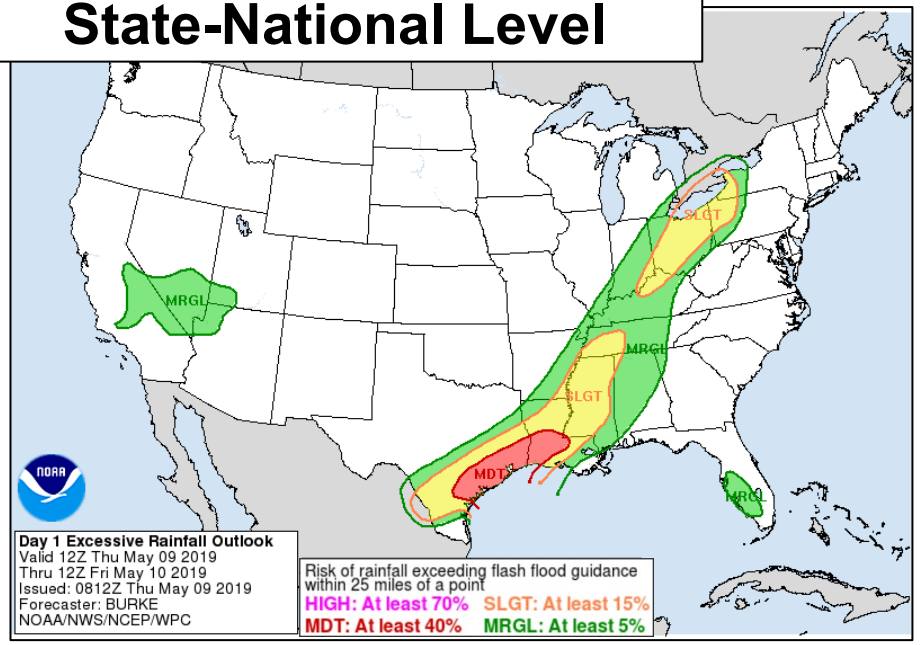
Interpretation of the ERO

Local Level



- Describes the probability of excessive rainfall leading to flash flooding within an area approximately the size of a large metro area or county/parish.
- "What are the chances I'll be dealing with flash flooding today?"

State-National Level



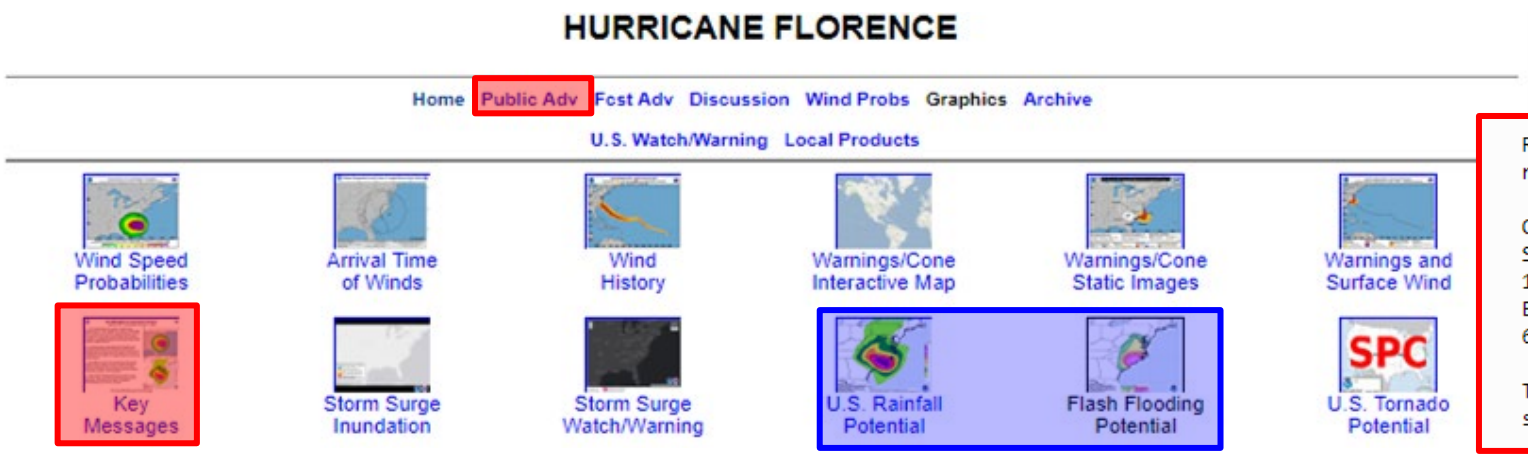
- Where are the potential problem spots for intense rainfall and resulting flash flooding, and where is the relative risk higher?
- Days with a much stronger signal, or higher risk levels, may generally require a greater response

IN THIS EXAMPLE

State Level: Texas
Flash flooding issues due to excessive rainfall are most likely in the southeast part of Texas. And the risk is at the second highest level, so overall confidence is higher than usual.

Local Level: Houston
The chances of excessive rainfall in Harris County and the Houston metro area would be about 40 to 70 percent on this day.

Integration with NHC Advisories



Public Advisory

RAINFALL: Florence is expected to produce heavy and excessive rainfall in the following areas...

Coastal North Carolina...20 to 30 inches, isolated 40 inches
South Carolina, western and northern North Carolina...5 to 10 inches, isolated 20 inches
Elsewhere in the Appalachians and Mid-Atlantic states...3 to 6 inches, isolated 12 inches

This rainfall would produce catastrophic flash flooding and significant river flooding.

Key Messages

1. A life-threatening storm surge is now highly likely along portions of the coastlines of South Carolina and North Carolina, and a Storm Surge Warning is in effect for a portion of this area. All interests from South Carolina into the mid-Atlantic region should complete preparations and follow any advice given by local officials.

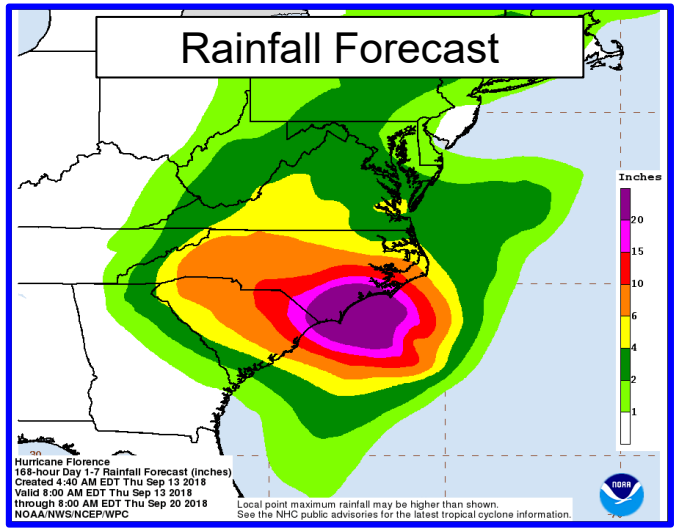
2. Life-threatening, catastrophic flash flooding and significant river flooding is likely over portions of the Carolinas and Mid-Atlantic states from late this week into early next week, as Florence is expected to slow down as it approaches the coast and moves inland.

3. Damaging hurricane-force winds are likely along portions of the coasts of South Carolina and North Carolina, and a Hurricane Warning is in effect. Strong winds could also spread inland into portions of the Carolinas.

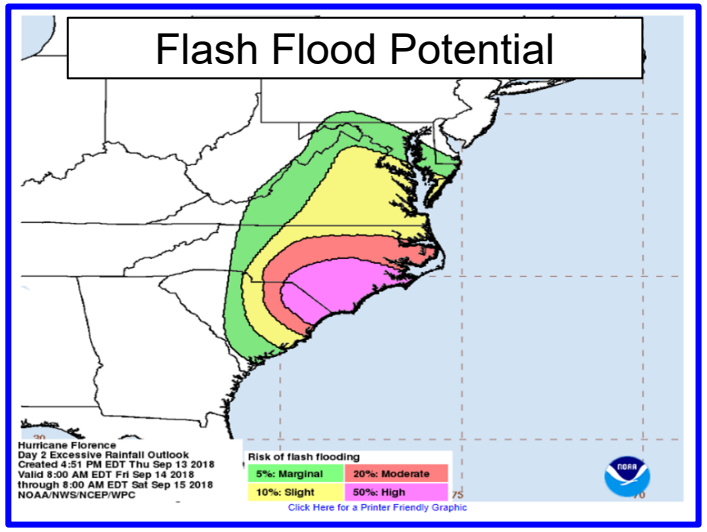
4. Large swells affecting Bermuda and portions of the U.S. East Coast will continue this week, resulting in life-threatening surf and rip currents.

For more information go to hurricanes.gov

Rainfall Forecast



Flash Flood Potential



Zoomed graphics are produced for the CONUS. *(Rainfall only for Puerto Rico and USVI)*

Thank You!

Owen Shieh, Ph.D.
Warning Coordination Meteorologist

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HURREVAC Demo

Goals for Today

1. Map all surge products issued by NHC
2. Access current rainfall and flooding layers from NOAA/WPC
3. Use the SLOSH Explorer to map worst-case surge scenarios
4. Explore differences between MOM and MEOW products
5. Interact with surge data using flags and points of interest (POI)

NATIONAL HURRICANE PROGRAM

COMING UP THIS WEEK

MON. JULY 28: Introduction to HURREVAC *(on YouTube now)*

TUES. JULY 29: Wind Forecast Features *(on YouTube now)*

WED. JULY 30: Storm Surge and Flooding Hazards

NEXT - THURS. JULY 31: Evacuation Timing Features

Registration is still open for Day 4 at webinars.hurrevac.com

Thank you!

HURREVAC Support Team

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FEMA

NATIONAL HURRICANE PROGRAM

HURREVAC

HURRICANE DECISION SUPPORT TOOL