2024 HURREVAC Training Webinar Series

Day 4 – Storm Surge and Flooding Hazards

June 13, 2024

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 5
- It is not necessary to attend all days

Audio

- All attendees are muted
- If having audio issues or video freezes, restart webinar or try watching link on a different device

Live Transcription

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

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 later today 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

JUNE 10: Intro to HURREVAC and the NHP *(available on YouTube)*

JUNE 11: Wind Forecast Features *(available on YouTube)*

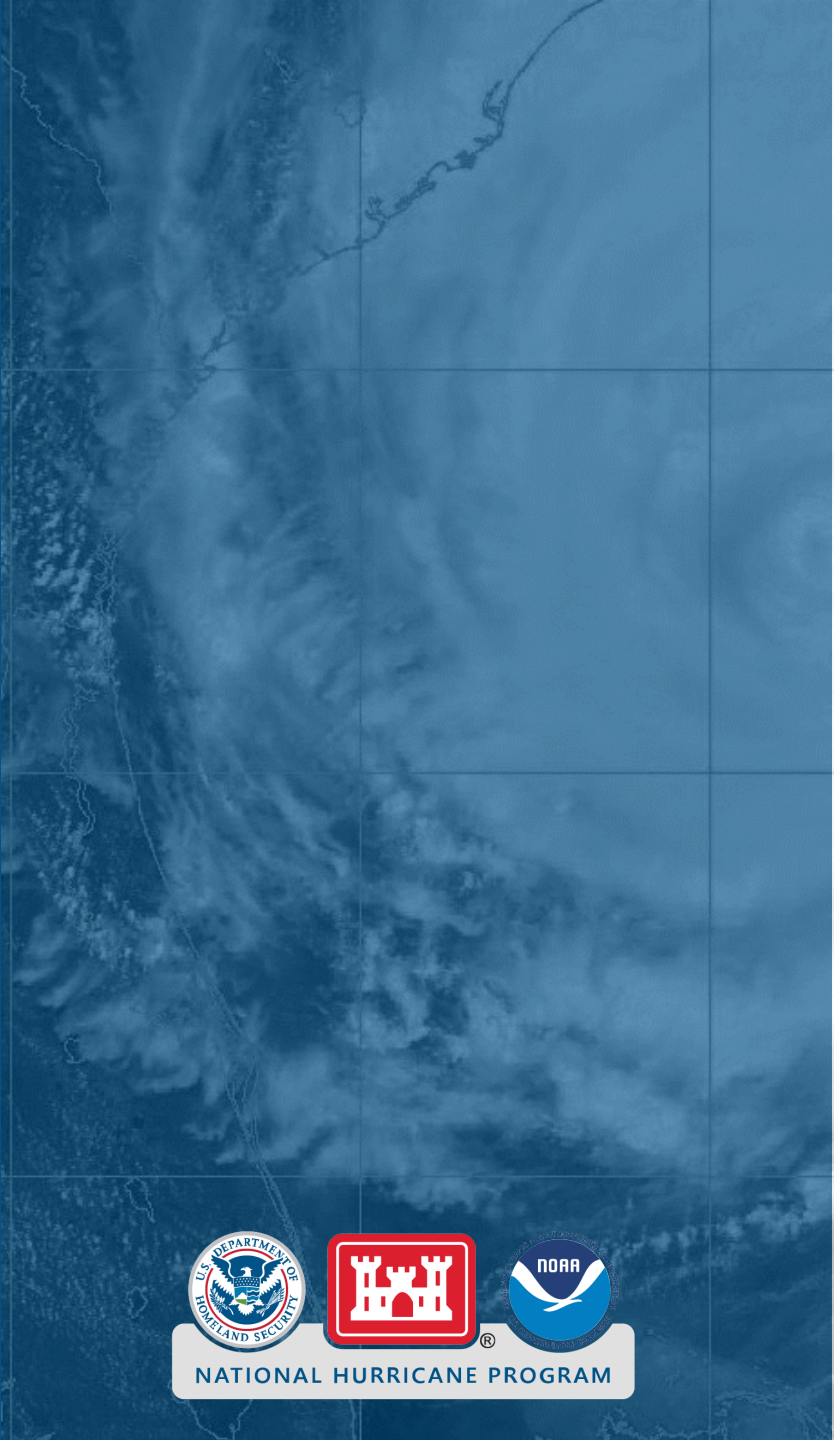
JUNE 12: Evacuation Timing Features *(available on YouTube)*

JUNE 13: Storm Surge and Flooding Hazards

JUNE 14: Applying HURREVAC for Planning and Operations

Registration is still open for Day 5 at webinars.hurrevac.com

Today's Presenters



Cody Fritz, Ph.D.
Storm Surge Specialist and Team Lead
NOAA/NWS National Hurricane Center

Bryan A. Jackson
Acting Warning Coordination Meteorologist
NOAA/NWS Weather Prediction Center

John Boyer
Sea Island Software

2024 HURREVAC WEBINAR – STORM SURGE

STORM SURGE UNIT - NATIONAL HURRICANE CENTER

OBJECTIVE:

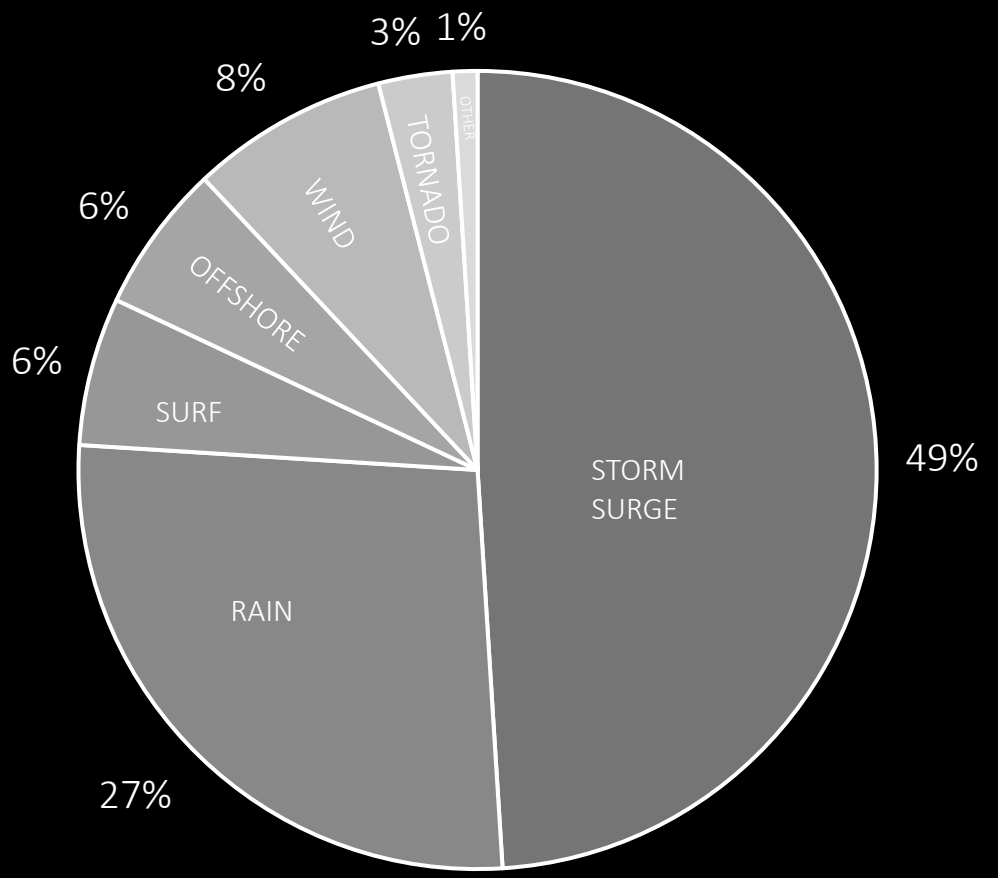
- To communicate the danger of storm surge caused by tropical cyclones
- To highlight the products available for planning and response to storm surge

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

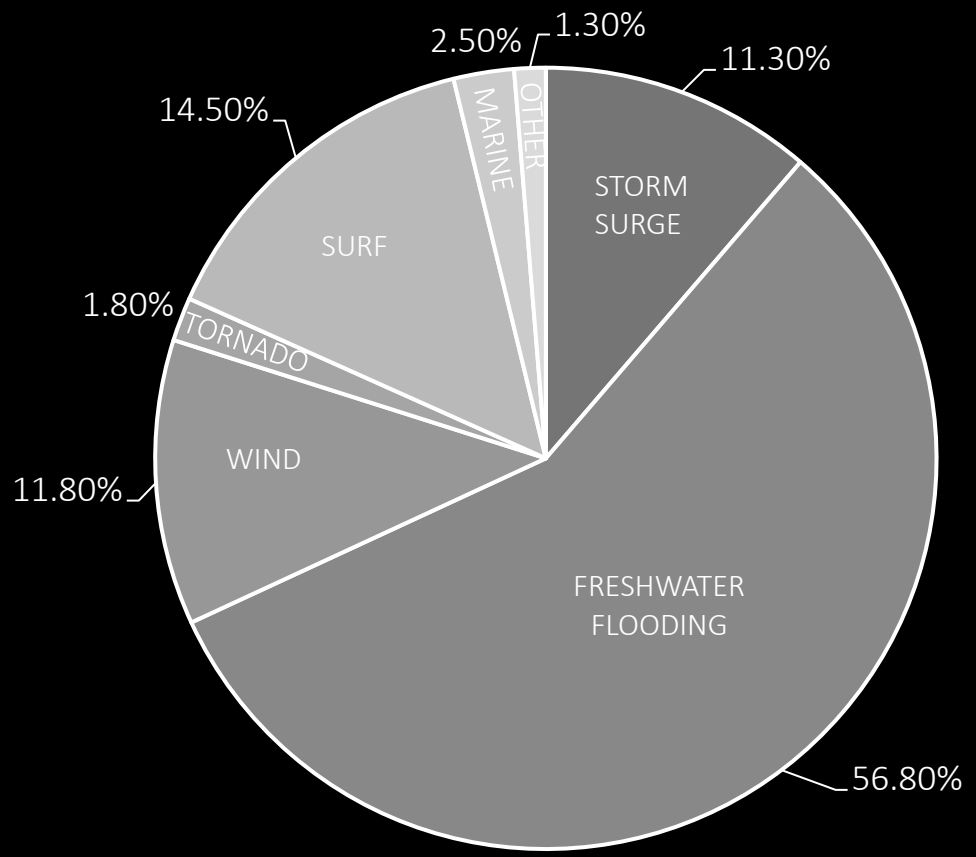
2,544 Fatalities From 1963–2012



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)

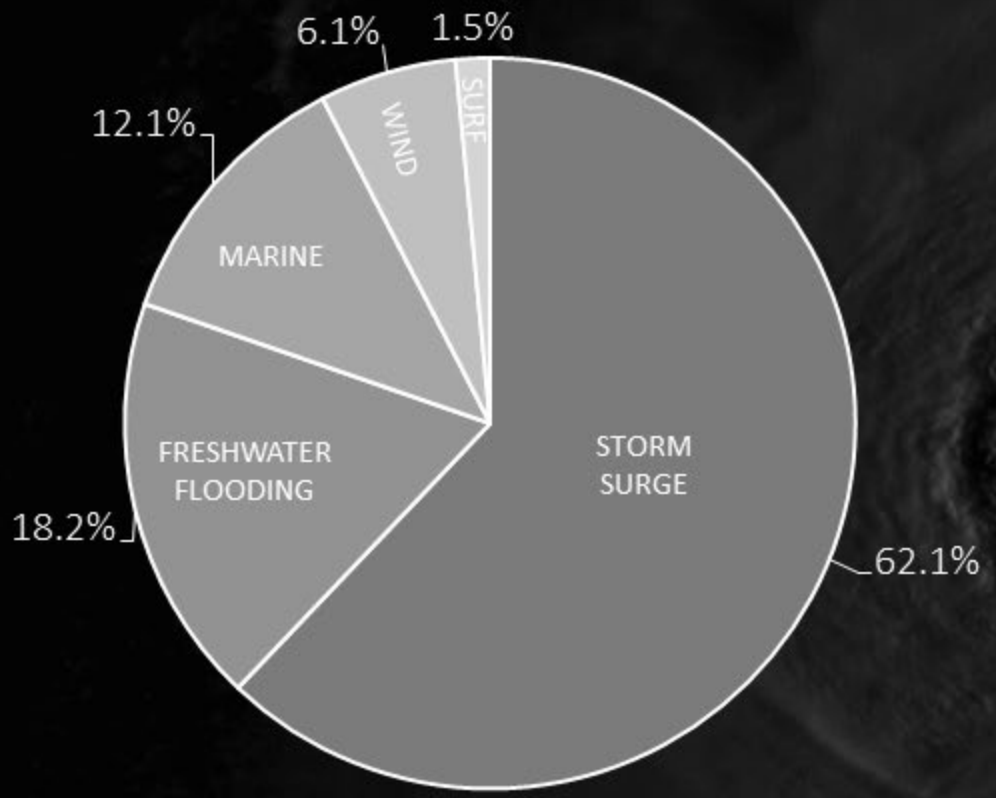
- Storm surge accounts for only 11.3% of direct deaths
- Freshwater now leads tropical hazards with 56.8% of storm related direct deaths
- Wind still a small percentage of storm related deaths with 11.8%



BRENNAN ET AL. 2022

442 – direct fatalities 415 – indirect fatalities

...and then there was Hurricane Ian (2022)



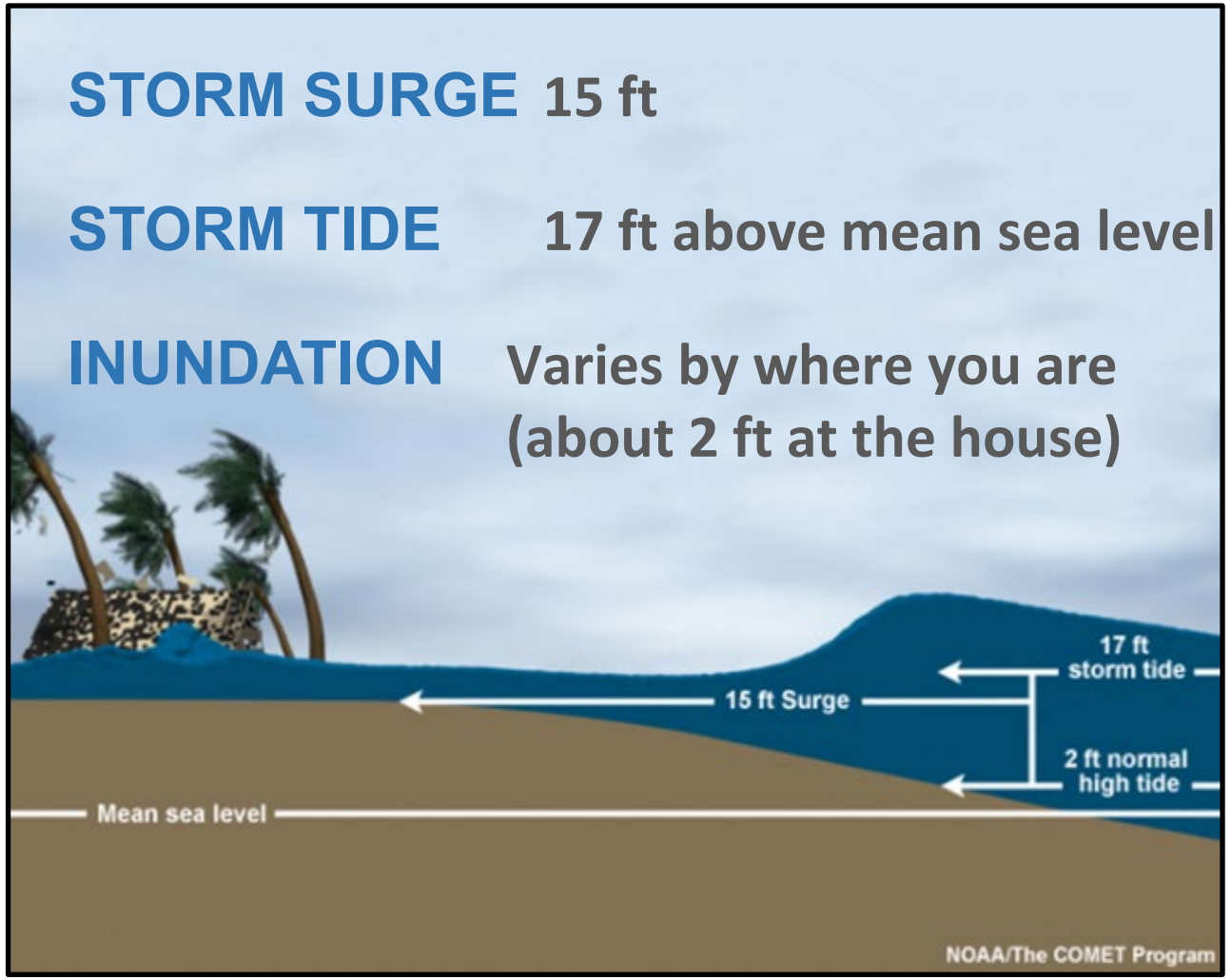
- 41 lives were lost to storm surge, whereby 36 lives were directly lost in Lee County alone
- 15 feet of storm surge [above ground level] inundated Fort Myers Beach, Florida

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

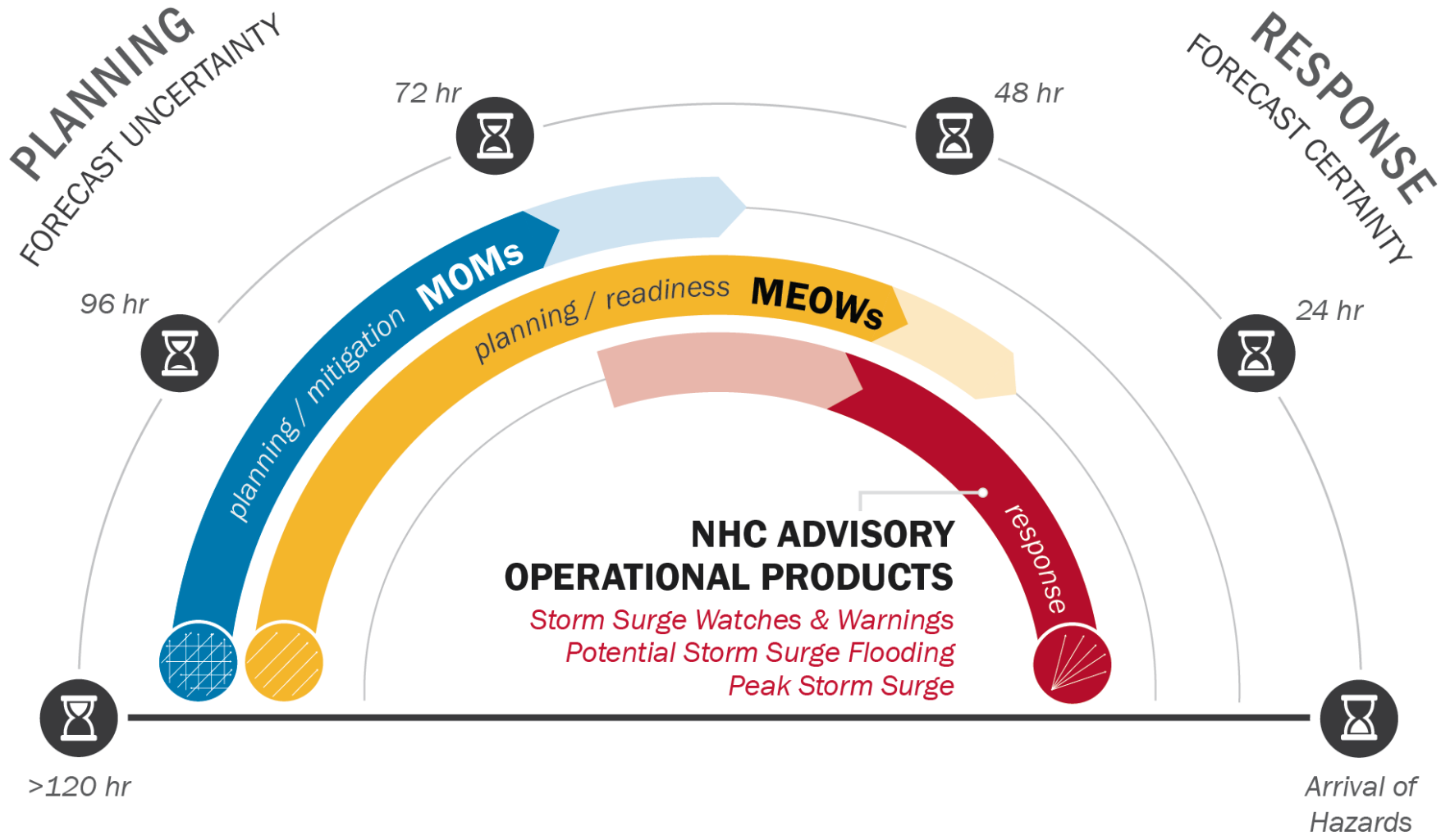
- **Intensity**
  Stronger storm = More storm surge
- **Size (Radius of Maximum Winds)**
  Larger = More storm surge
- **Forward Speed**
  Slower storm = Storm surge farther inland
- **Width and Slope of Shelf (Bathymetry)**
  Gradual sloping shelf = More storm surge
- **Angle of Approach**
  Alters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

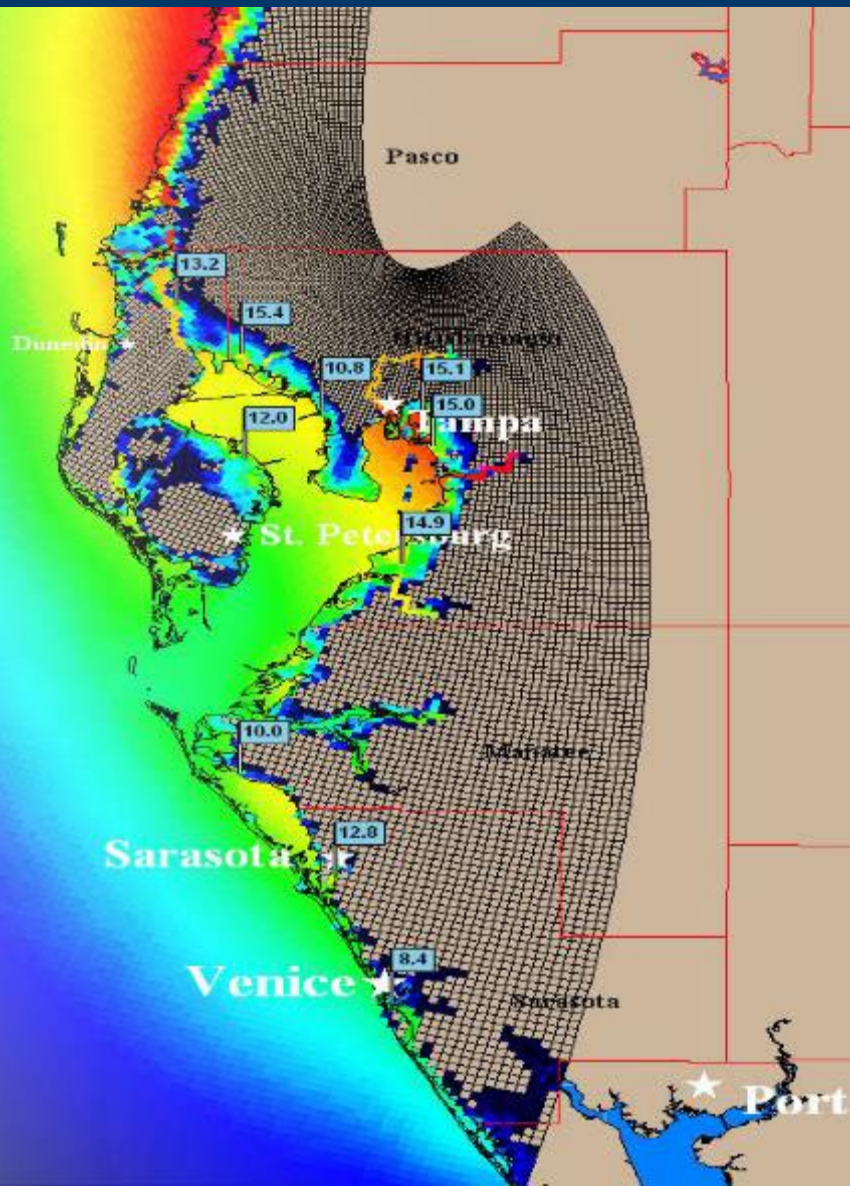
STORM SURGE
Storm Surge Risk Tools



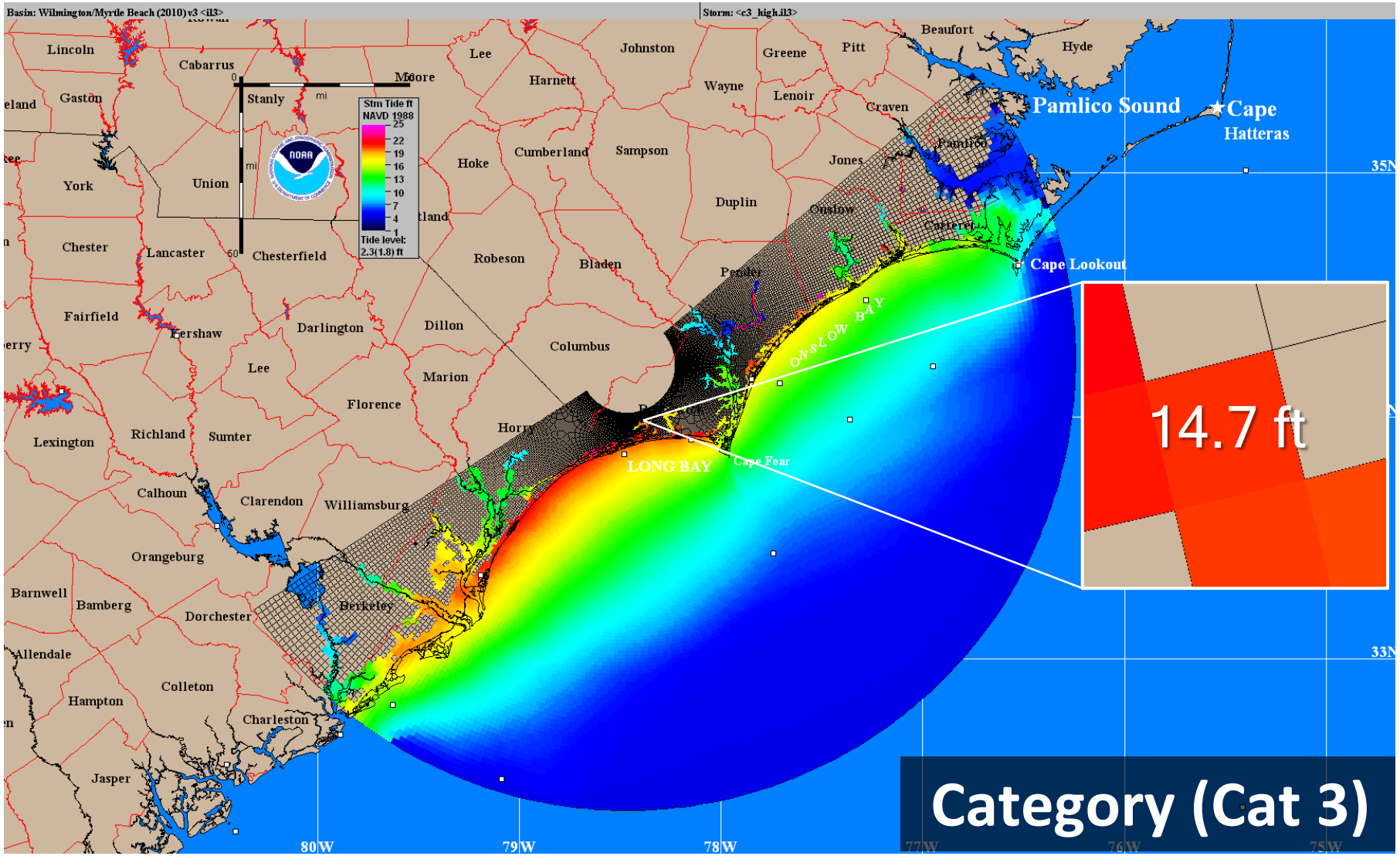
STORM SURGE
Maximum of Maximums (MOM)

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)**



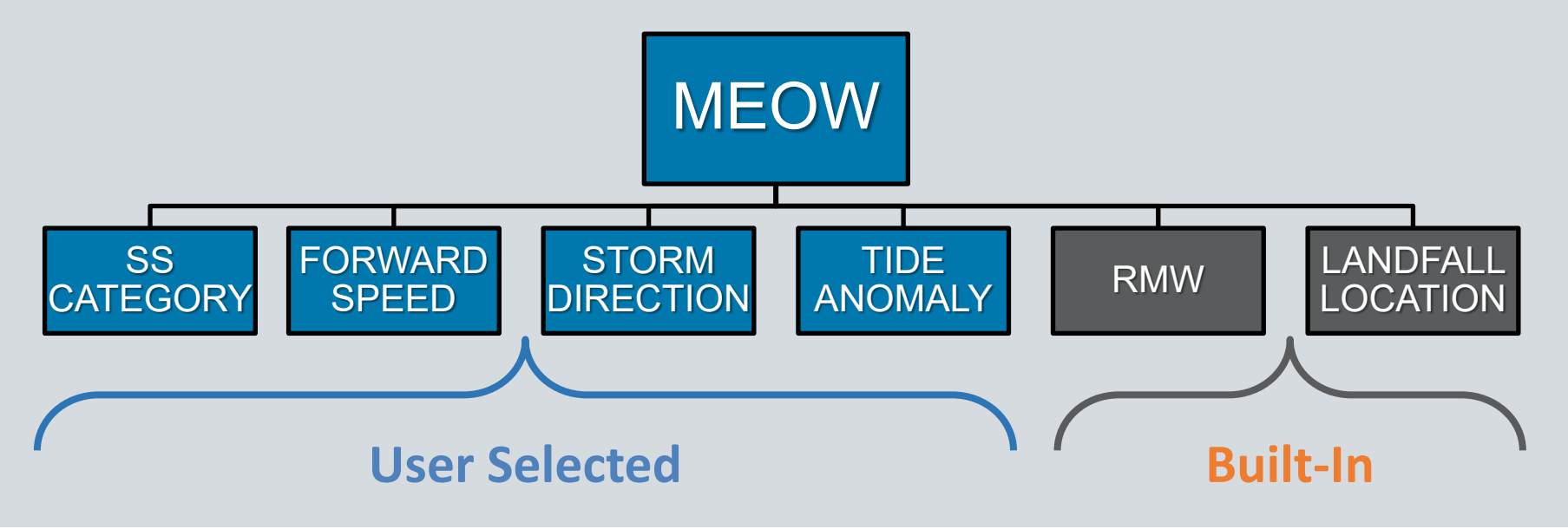
STORM SURGE
Maximum of Maximums (MOM)



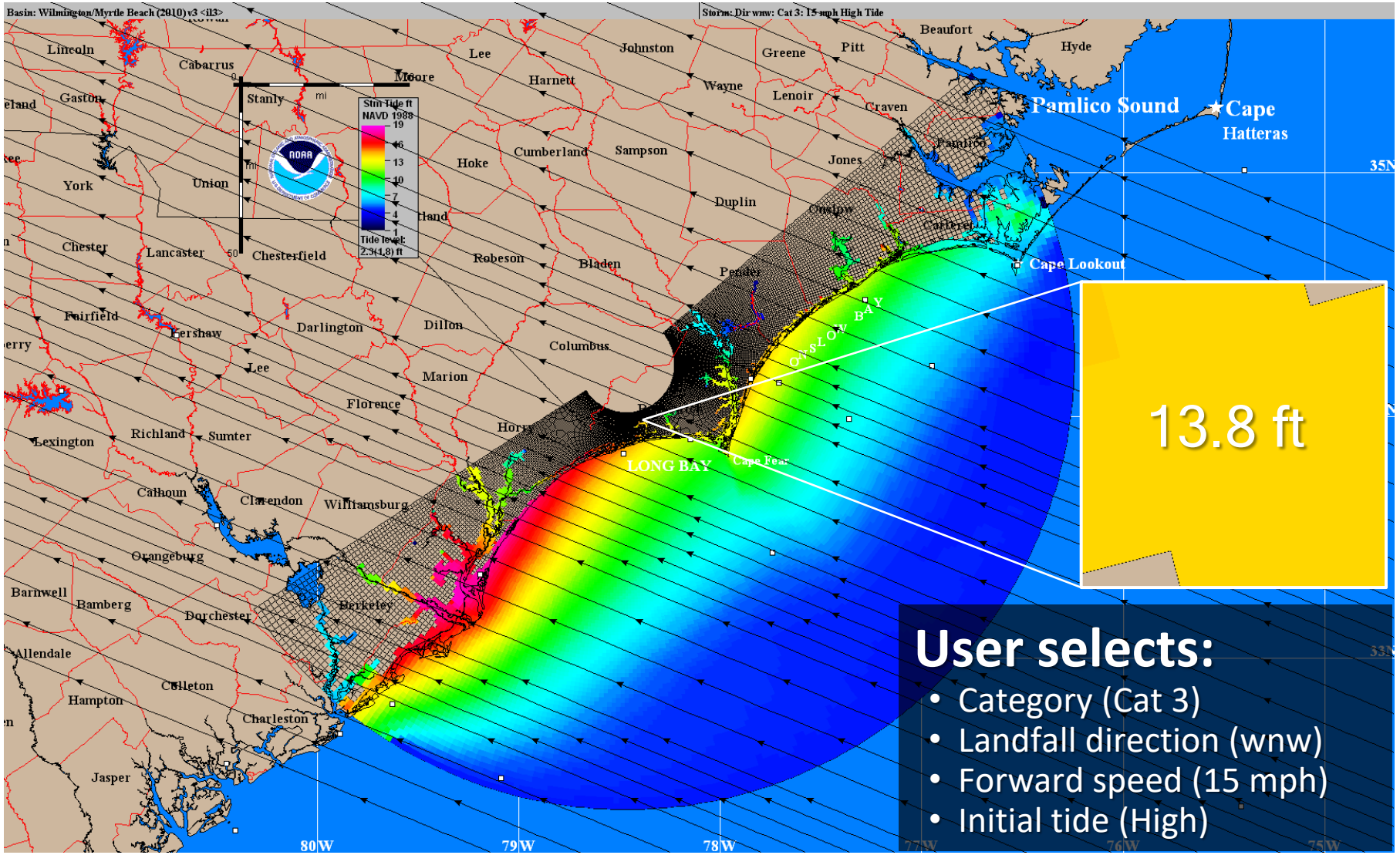
STORM SURGE
Maximum Envelope of Water (MEOW)

MEOWs

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

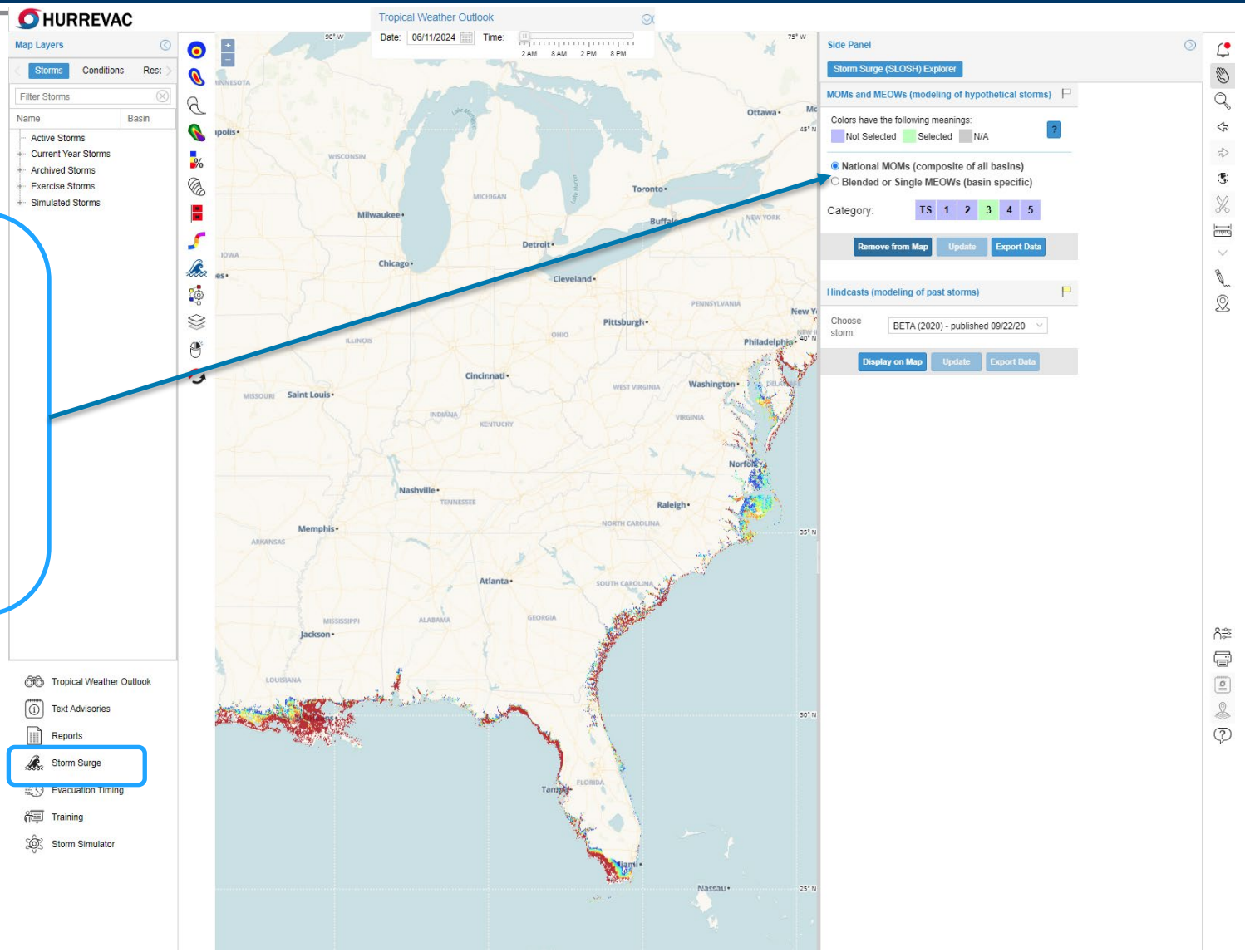


STORM SURGE
Maximum Envelope of Water (MEOW)



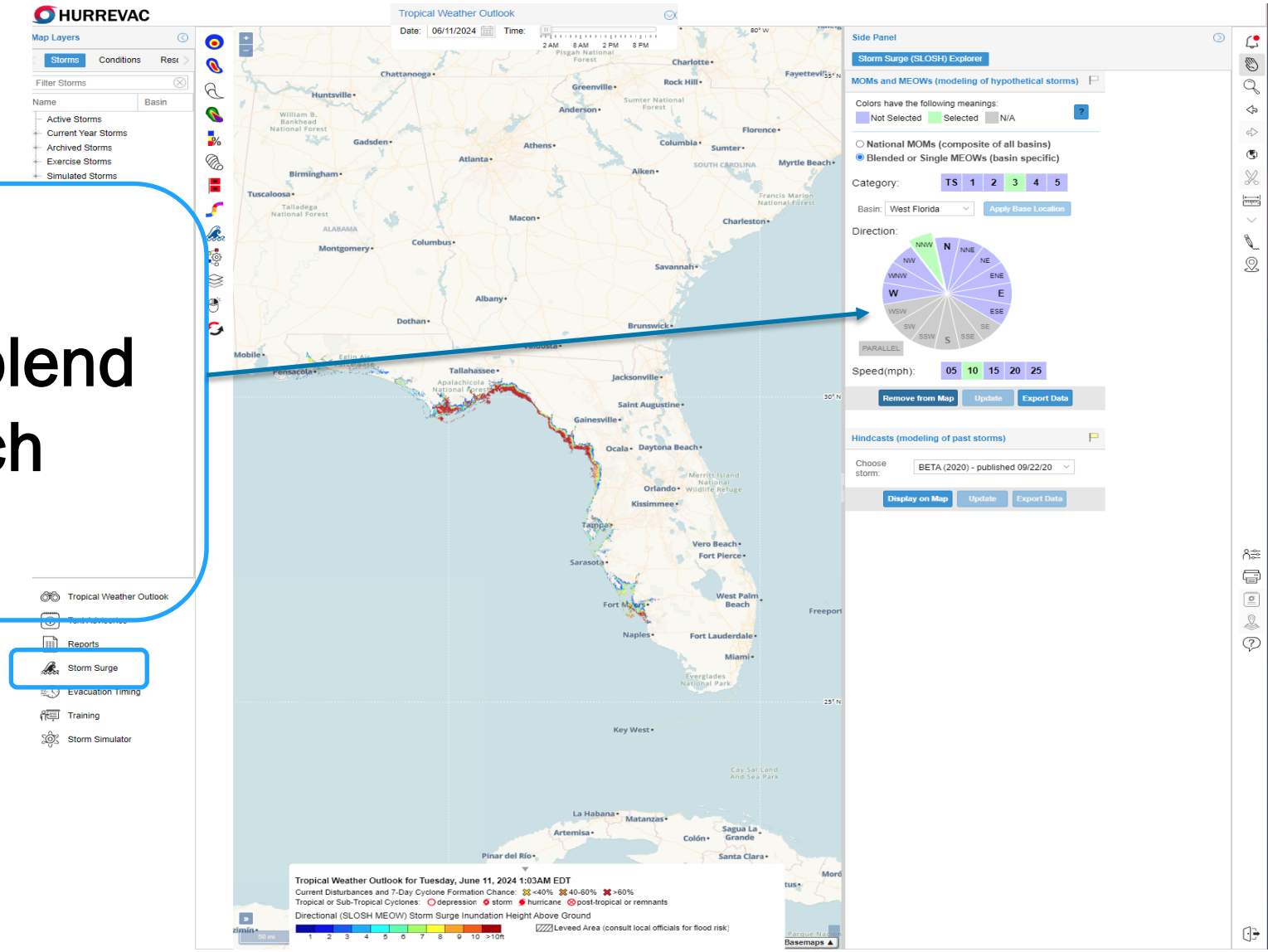
SURGE EXPLORER IN HURREVAC

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

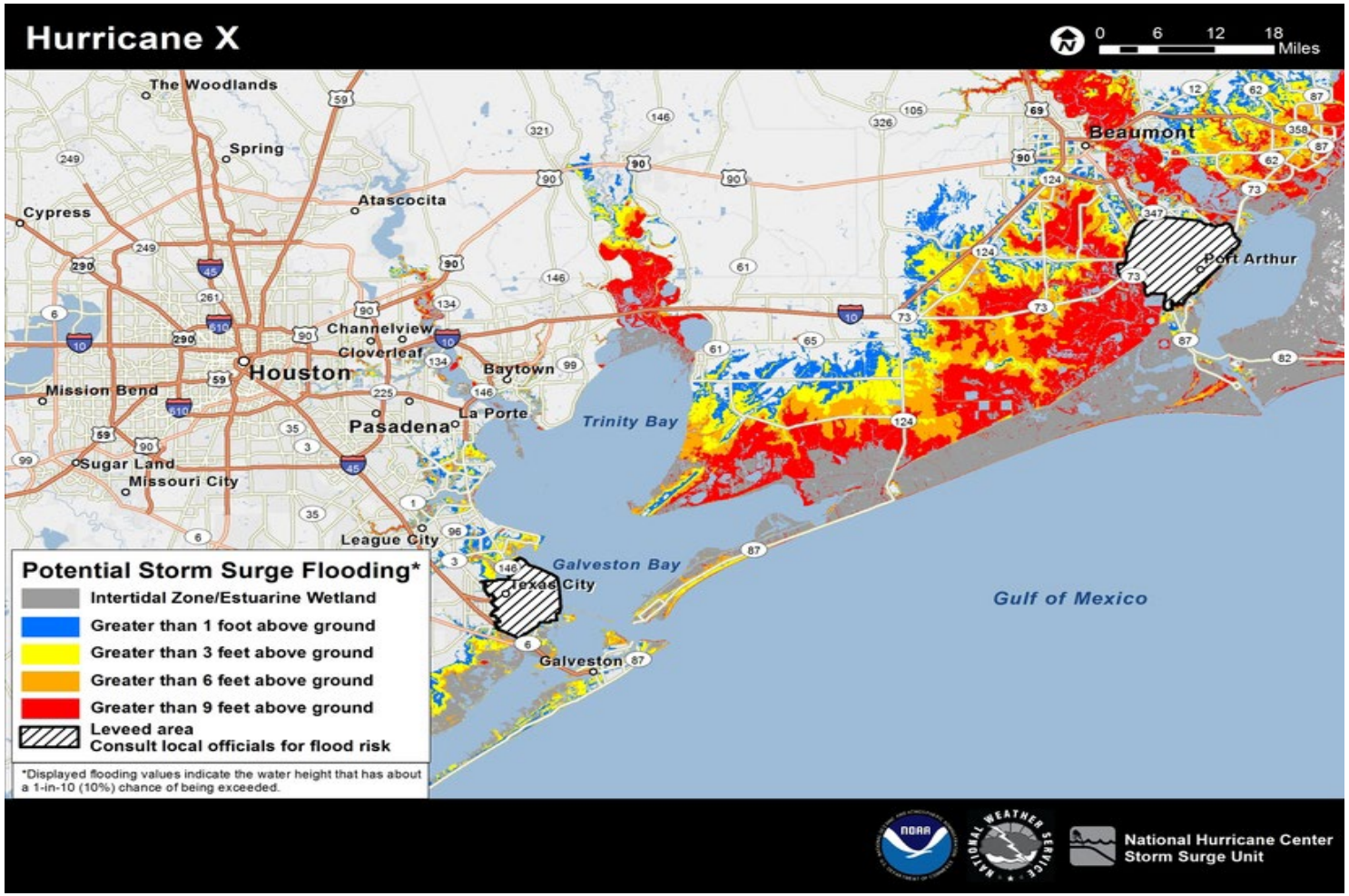
P-SURGE

- **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

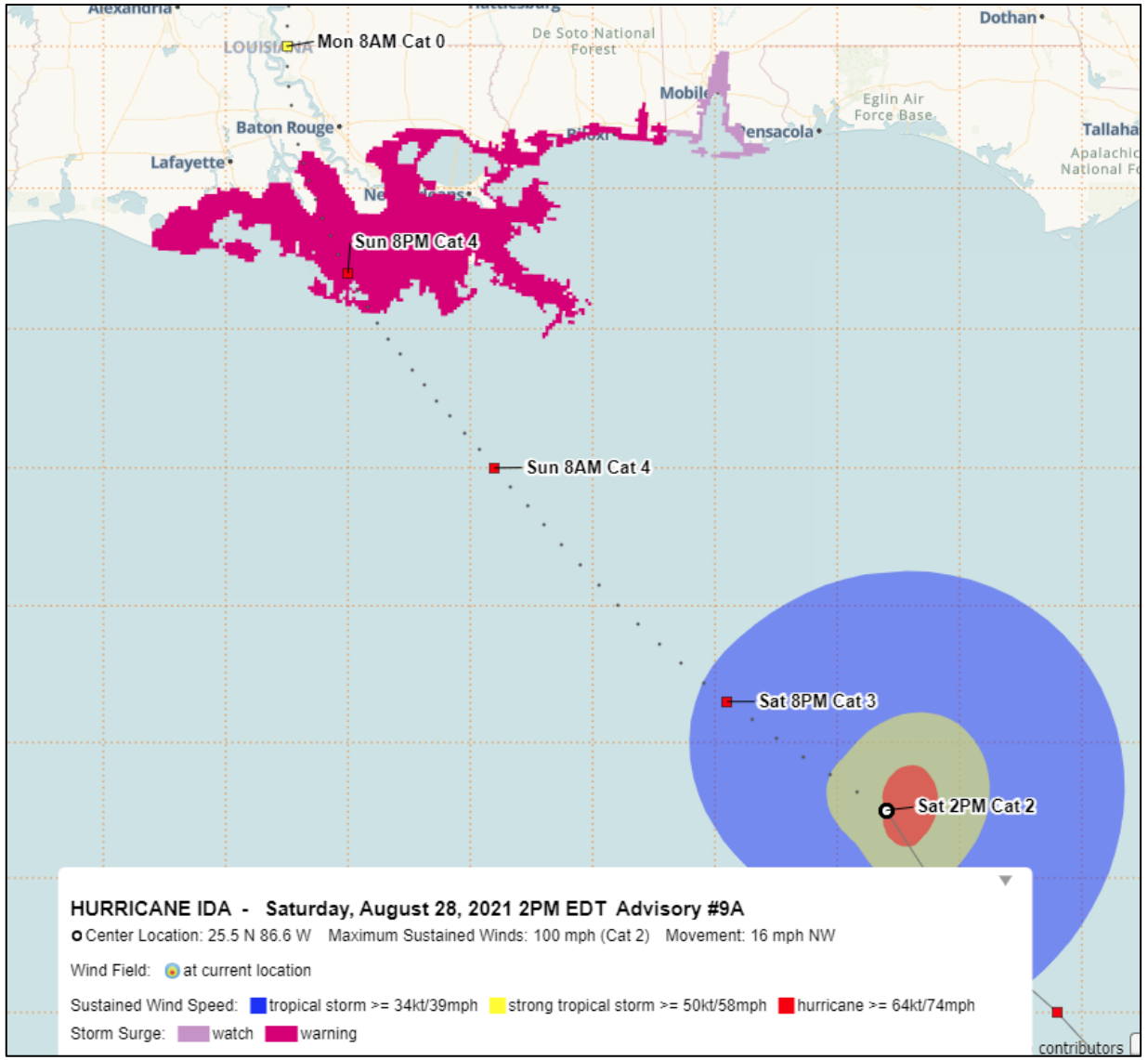
- **Height above ground that the water could reach**
  - Reasonable worst-case scenario for any individual location
  - Values have a 10% chance of being exceeded
- **Issued up to ~72 hours prior to the onset of the hazard**
- **Available ~60-90 minutes after the advisory release**



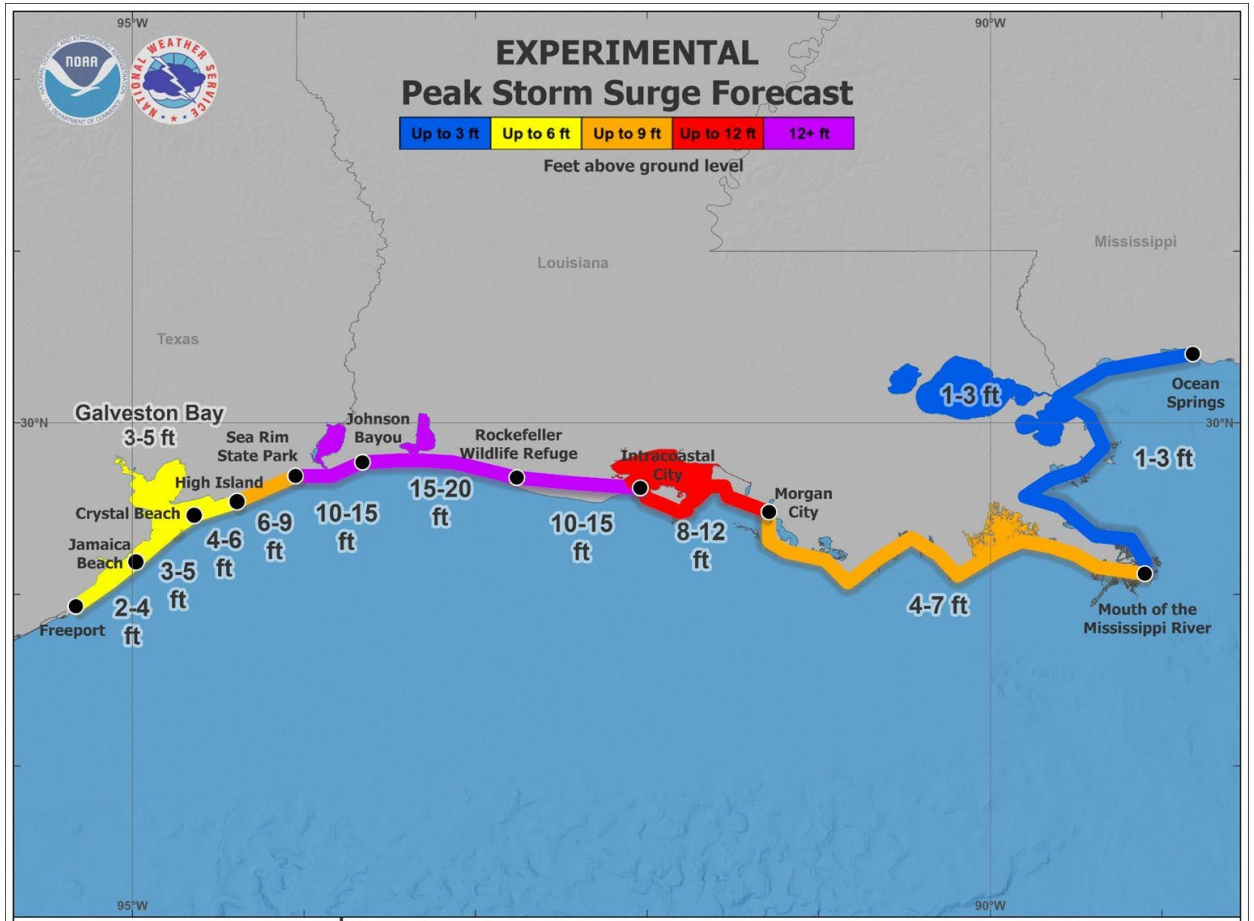
STORM SURGE
Watches and Warnings

- 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.

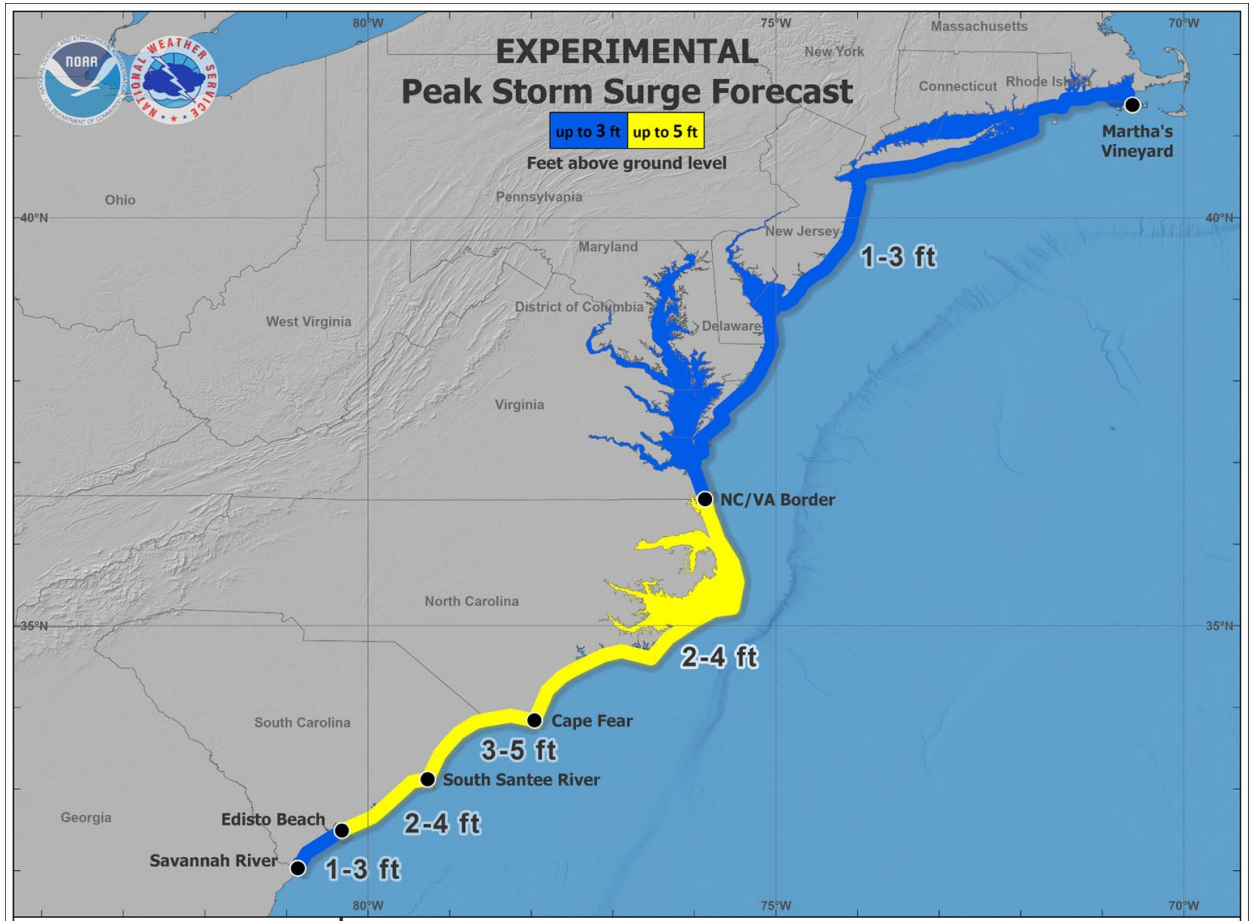


STORM SURGE
Peak Storm Surge Forecast Graphic



Hurricane X
Wednesday August 26, 2020
04 PM CDT Advisory X
NWS National Hurricane Center

User Notes: Water levels along the immediate coast could reach the following heights above ground level within the indicated areas. Elevated water levels will likely be accompanied by large and destructive waves. Colors are based off the highest values in the associated forecast peak surge range. Values shown on this graphic are inclusive of tide.



Hurricane X
Monday August 03, 2020
05 PM EDT Advisory X
NWS National Hurricane Center

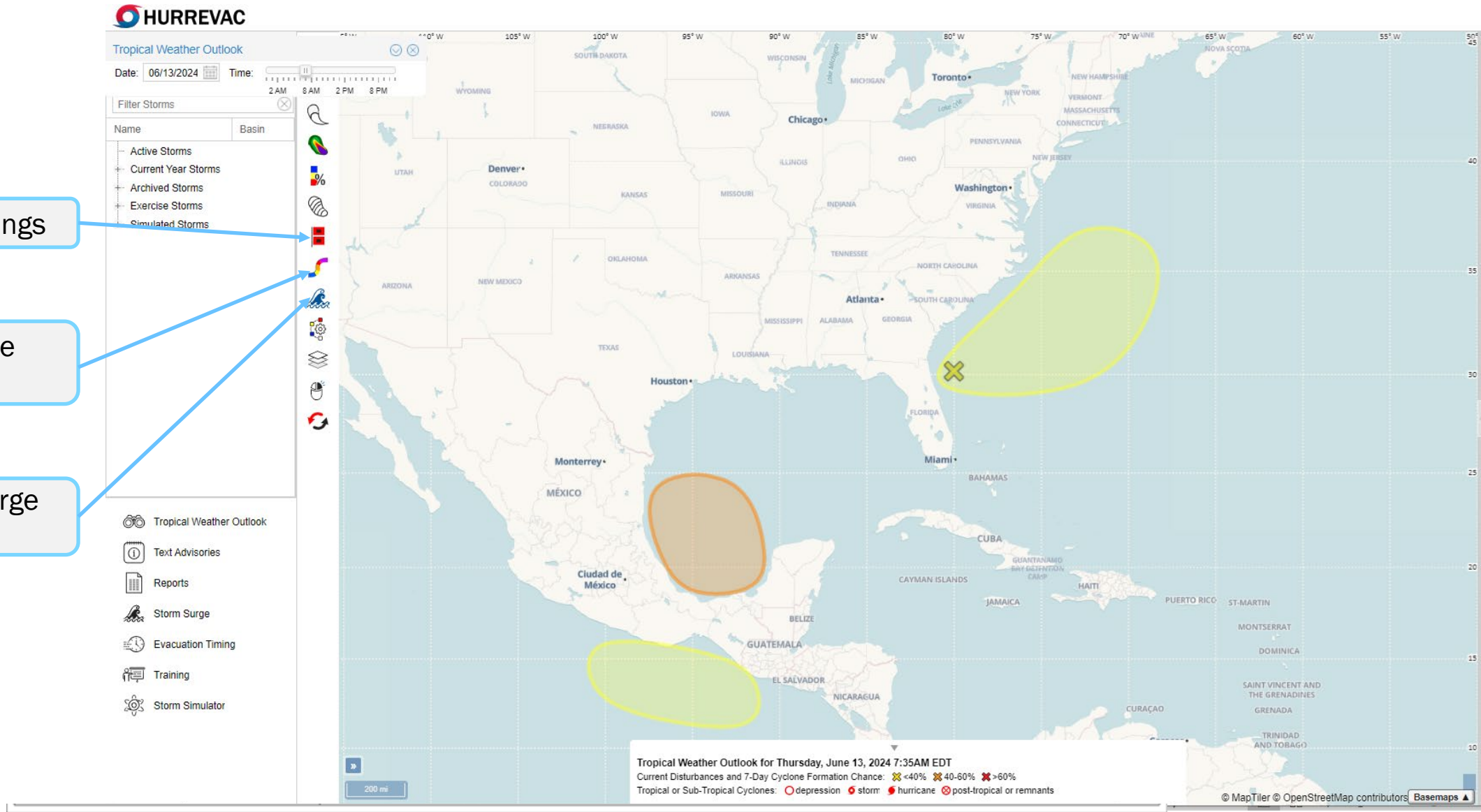
User Notes: Water levels along the immediate coast could reach the following heights above ground level within the indicated areas. Elevated water levels will likely be accompanied by large and destructive waves. Colors are based off the highest values in the associated forecast peak surge range. Values shown on this graphic are inclusive of tide.

STORM SURGE
Real-time products in HURREVAC

Watches and Warnings

Peak Storm Surge Graphic

Potential Storm Surge Flooding Map



Cody.Fritz@NOAA.GOV

HURREVAC Contributions from the Weather Prediction Center

Bryan A. Jackson, Acting Warning Coordination Meteorologist

Acknowledgements:
David Novak, WPC Director
Alex Lamers, New Forecast Operations Branch Chief
Greg Carbin, Previous Forecast Operations Branch Chief

NOAA/NWS Weather Prediction Center

HURREVAC Webinar
June 13, 2024 | Virtual Conference Session

The Utah Statesman

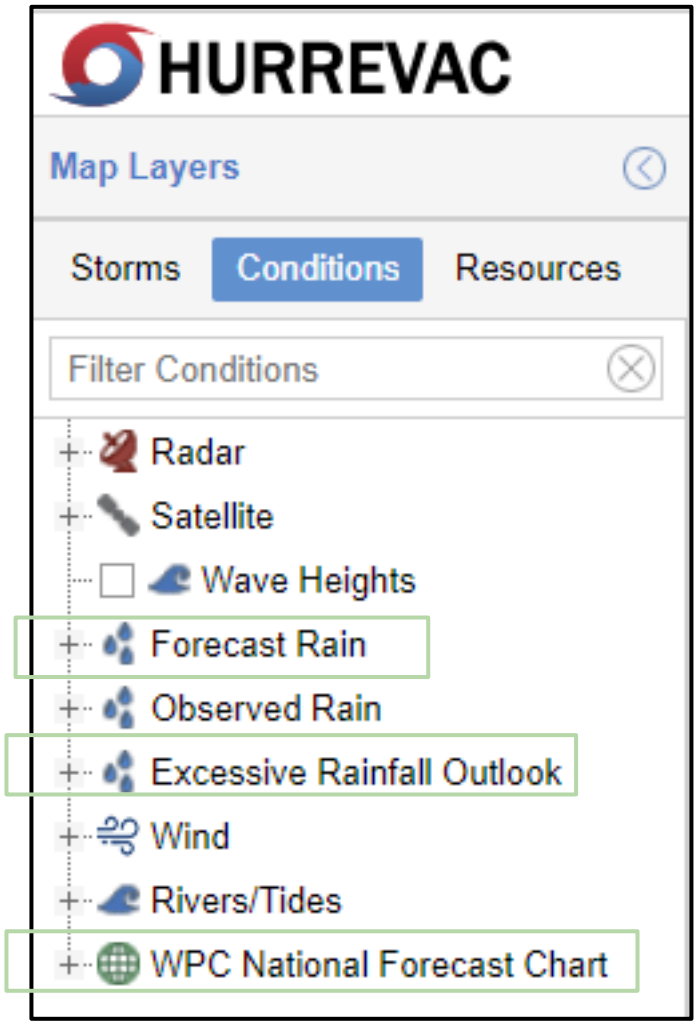
Outline

WPC products in Hurrevac

- Forecast Rain
  - Quantitative Precipitation Forecast (QPF)
- Excessive Rainfall Outlook (ERO)
- National Forecast Chart
- Inland Tropical Advisories and Discussions

Potential Additions

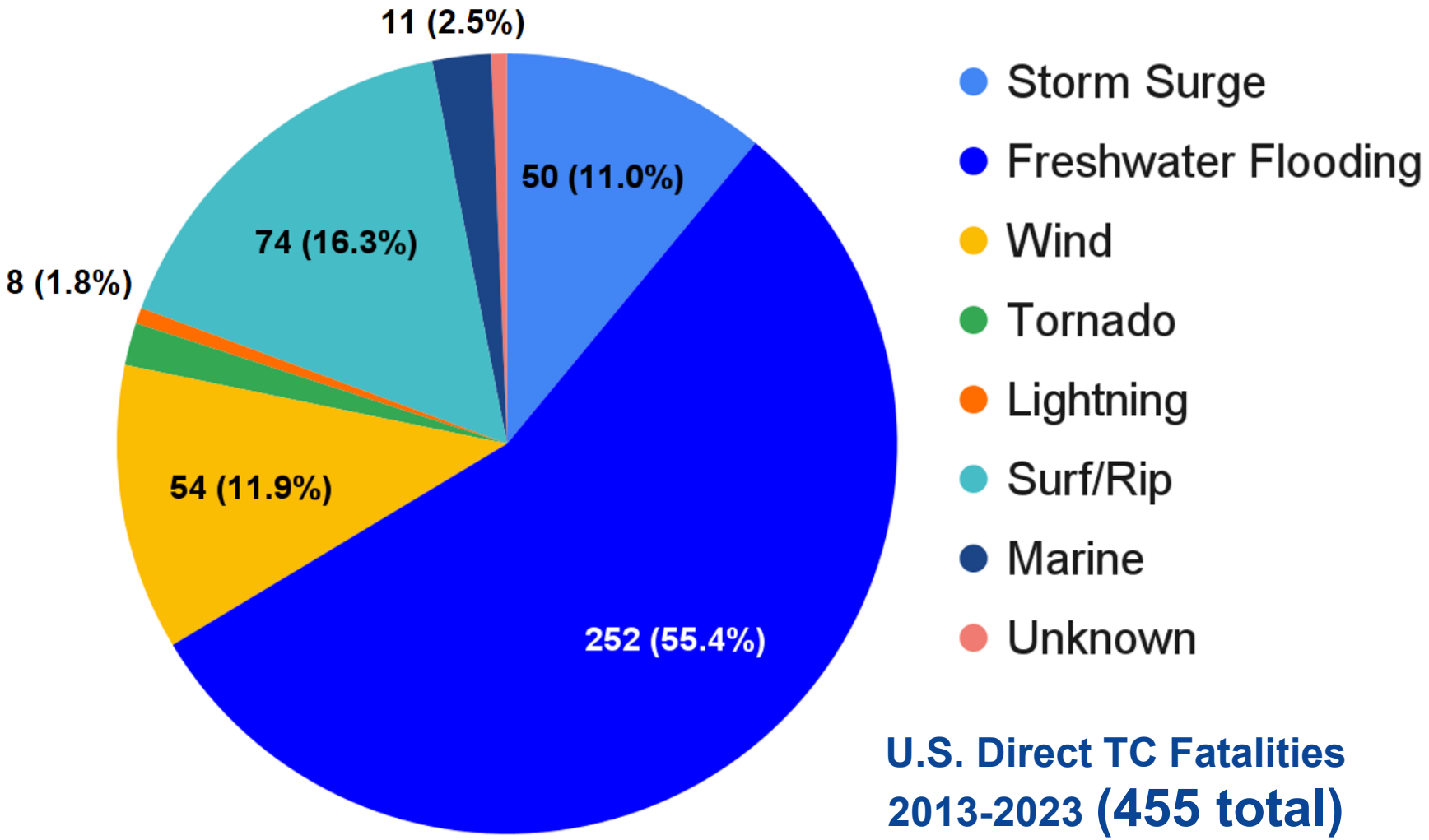
- Mesoscale Precipitation Discussion (MPD)
- Extreme Precipitation Monitor



- **WPC provides tropical cyclone rainfall information for land areas in the highlighted domain**
- This information is inserted into the official advisory products and Key Messages via coordination with NHC, CPHC, and the National Water Center
- For the CONUS, we provide QPF, ERO, MPD that help illustrate the rainfall-related threats

Rainfall: Most Consistently Deadly TC Hazard

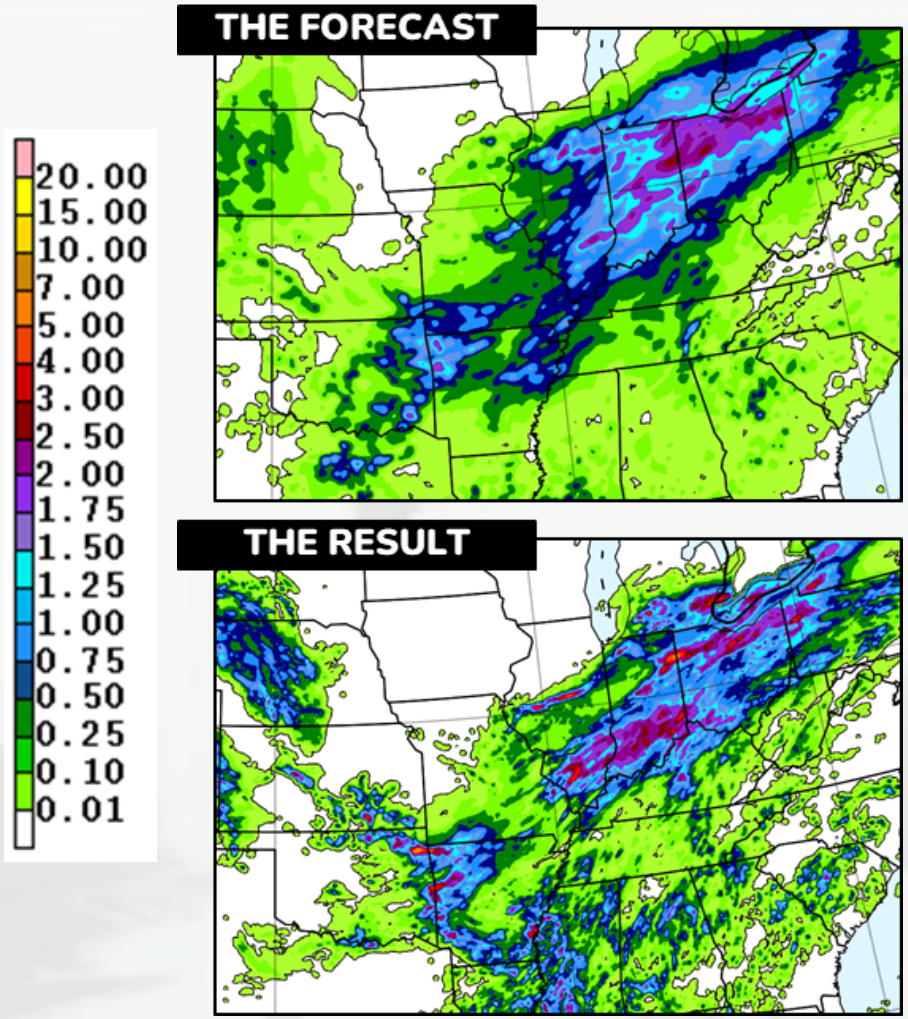
- Storm surge still has the potential to cause the greatest single event fatalities, but…
- Rainfall-induced flooding is the most consistently deadly hazard
- 55% of all direct U.S. tropical cyclone fatalities in the past 11 years
- ***Follows Rappaport (2014) study that found freshwater flooding was the most common cause***



U.S. Direct TC Fatalities 2013-2023 (455 total)

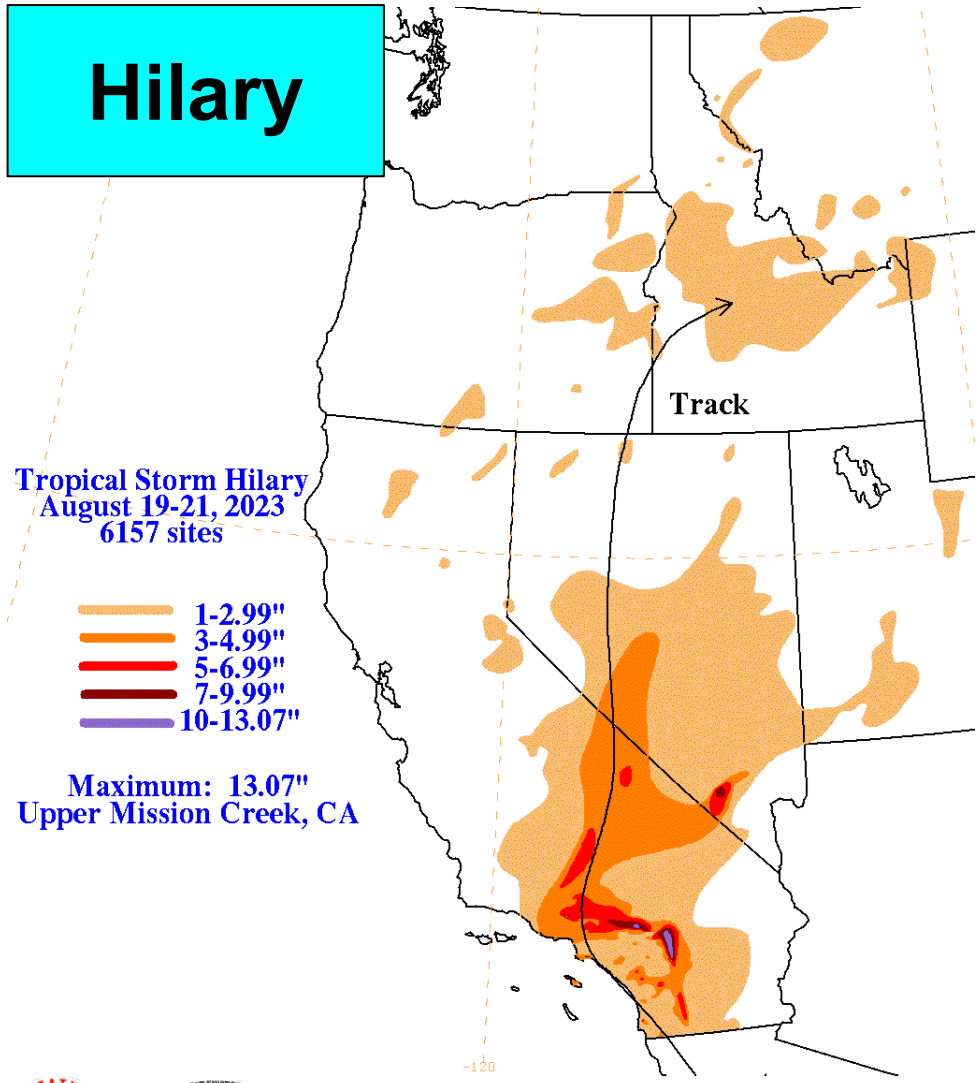
Source: National Hurricane Center

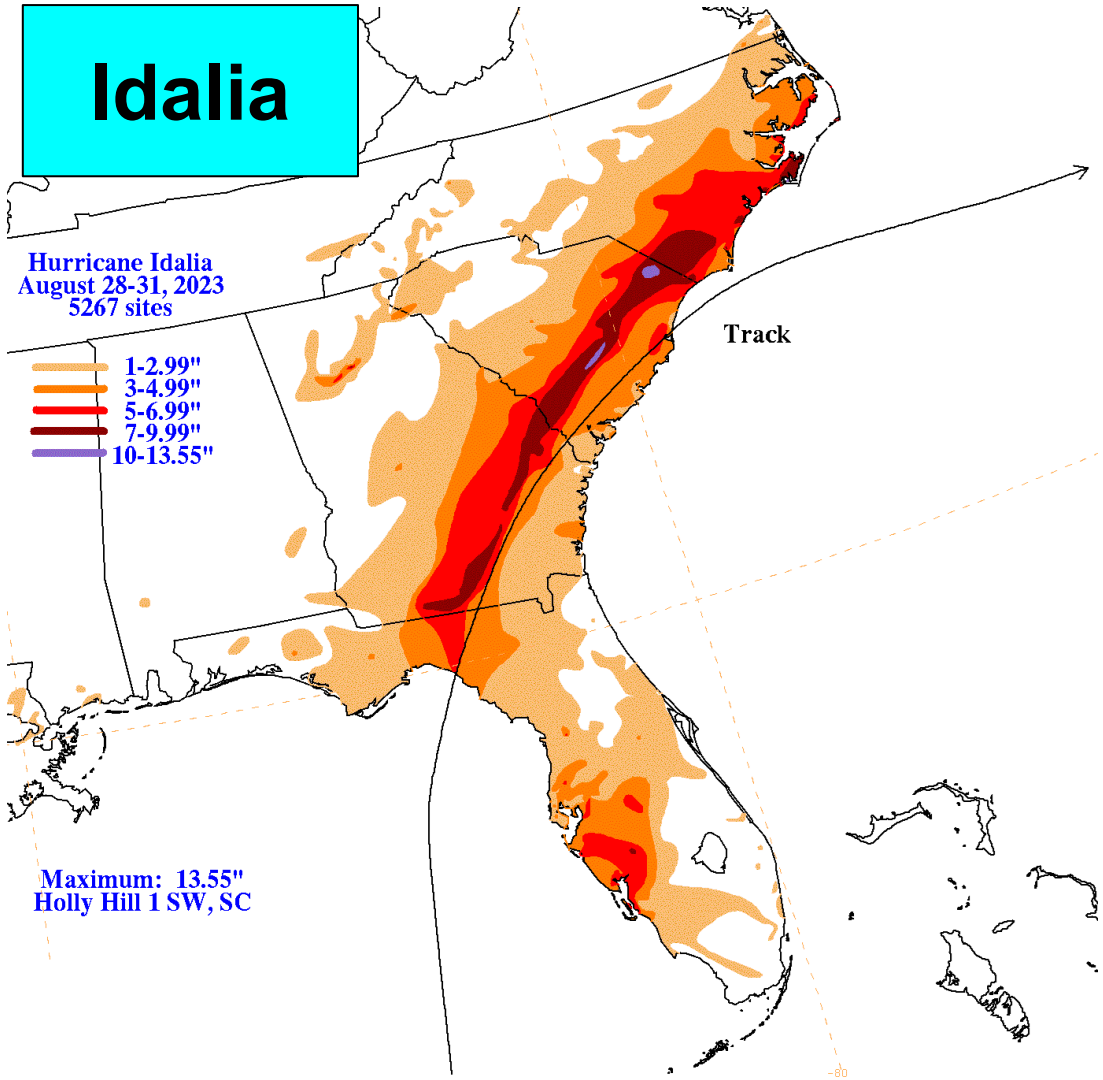
Quantitative Precipitation Forecast (QPF)



- QPF is **Forecast Rain** magnitude over a given period of time.
- WPC QPF depicts areal average amounts, a general idea of what to expect, but not localized minimum or maximum.
- Is generally more accurate in situations with large, organized weather systems as compared to scattered, summertime thunderstorms.
- In the example shown, the forecast had areas of heavy rain in generally the correct regions, but did not capture the extremes, as that is not the intent of the product.

2023 Cyclones With Notable Rainfall Impacts

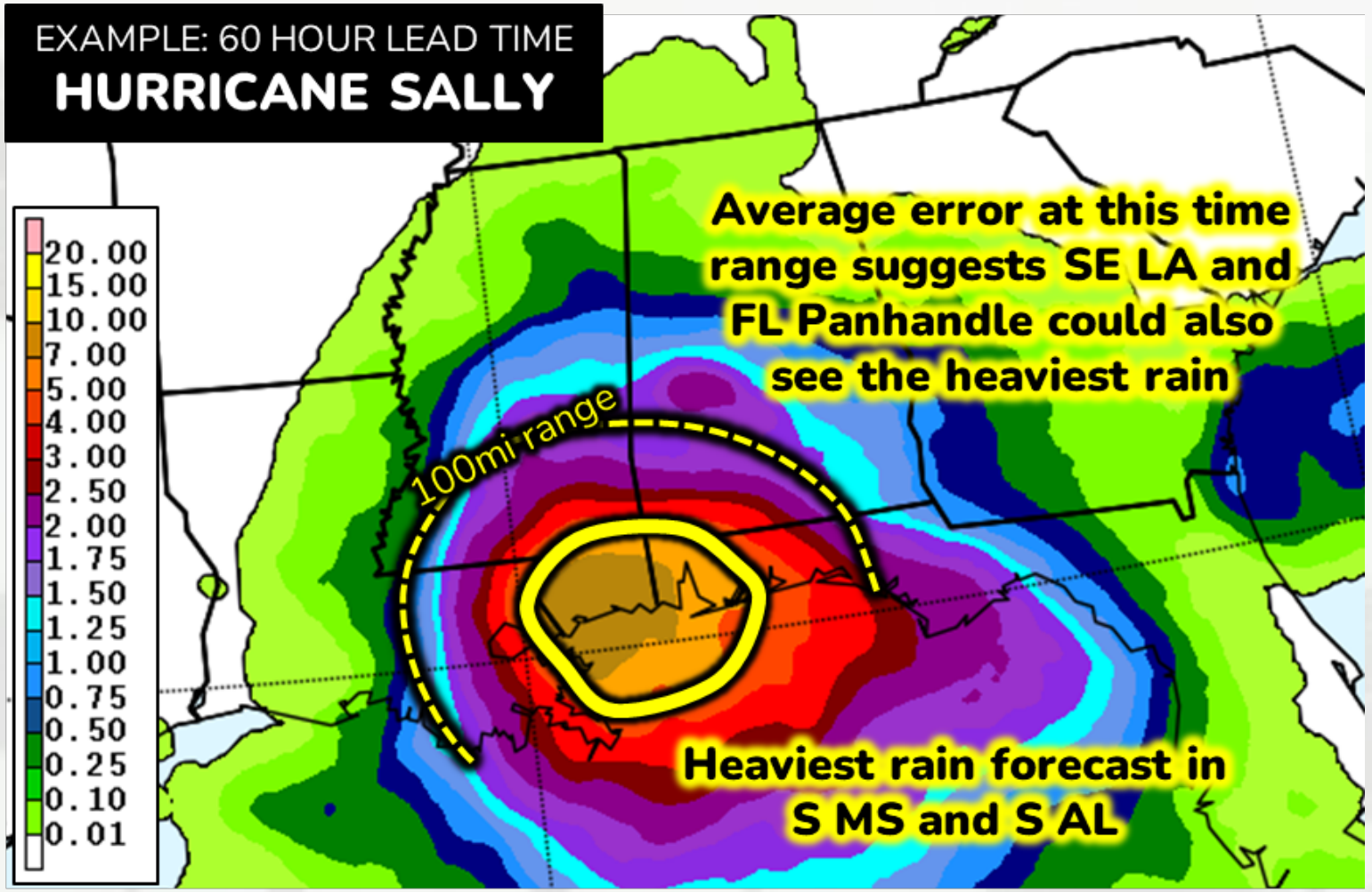




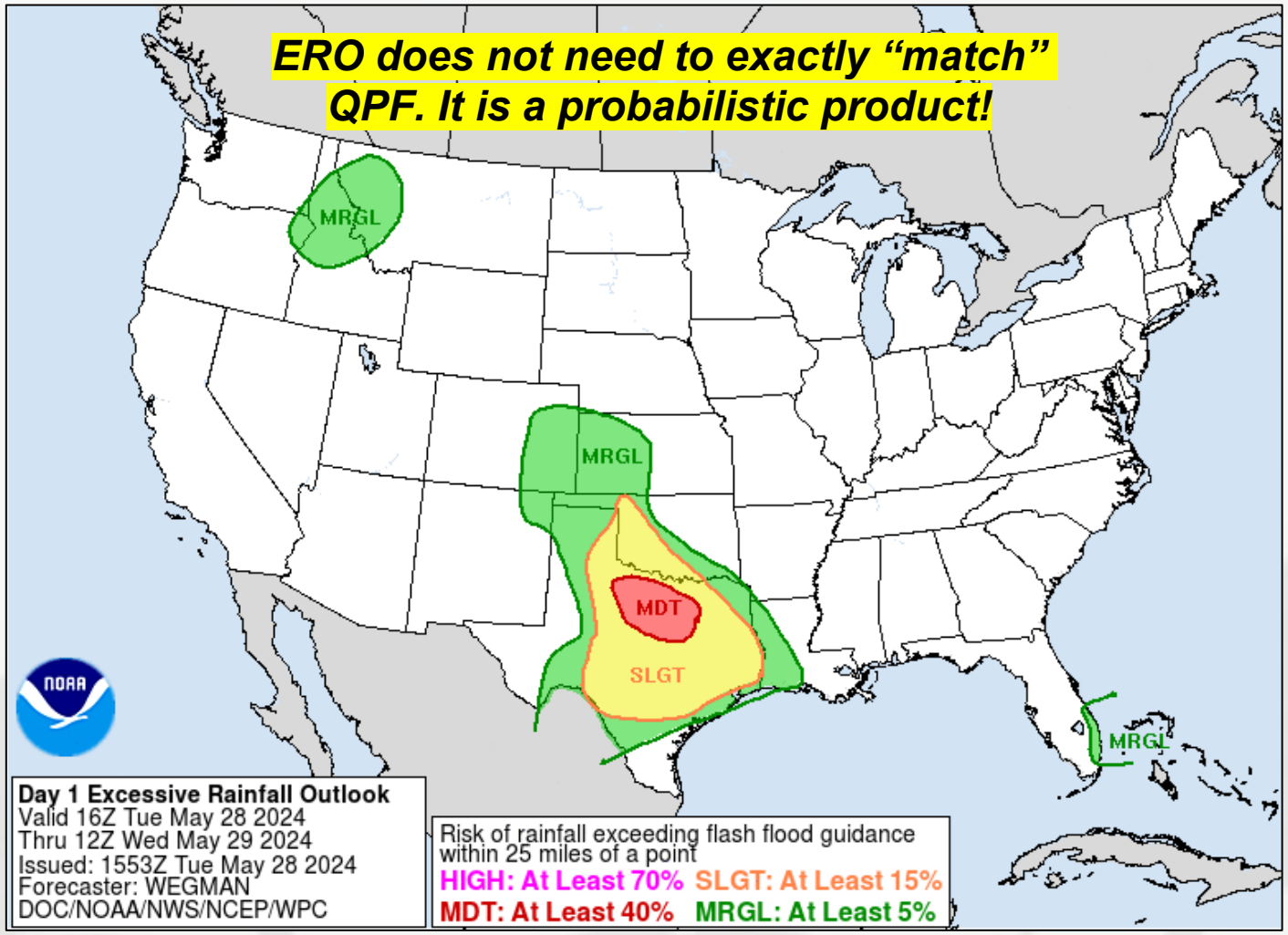
Tropical Rainfall Error Statistics

Official rain forecast is the "most likely", but can end up displaced from what you see on the map!

2016-2023 Displacement Error of 2" Rainfall Forecast Contour	
Lead Time	**Avg. Error**
12 hours	**53 miles**
36 hours	**69 miles**
60 hours	**95 miles**
84 hours	**130 miles**
108 hours	**151 miles**



Excessive Rainfall Outlook (ERO)



The chances for rainfall to be intense enough to cause flash flooding.

- 24 hour windows for Days 1-5
- Issued: 09 and 21 UTC
  - Day 1 updates 16 and 01 UTC
- Accounts for both rain rates and ground susceptibility

Please know EROs are:

✓ A situational awareness and planning tool that "gets your head in the game"

✗ Not an explicit forecast of flash flooding at a specific location

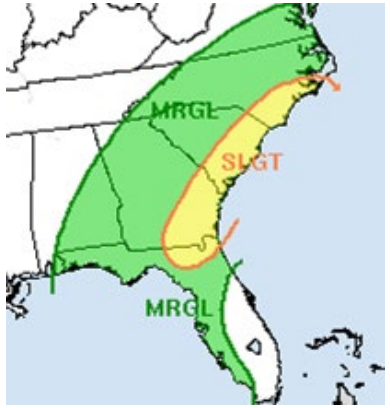
✓ Accounts for uncertainty in placement, timing of intense rainfall and summarizes the larger scale risk factors.

Idalia Forecast Progression

Lead time values are presented prior to the first Flash Flood Warning issuance from WFO Tallahassee

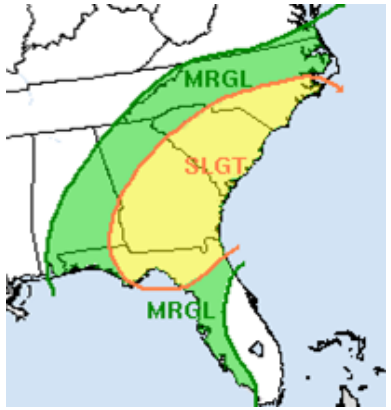
Day 5 ERO

101hr Lead Time



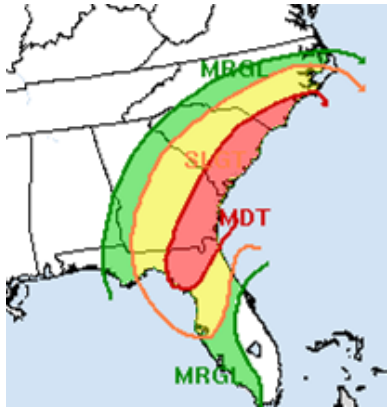
Day 4 ERO

77hr Lead Time



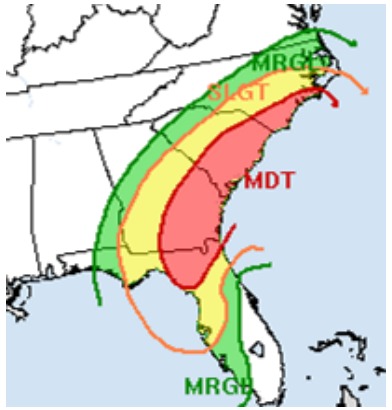
Day 3 ERO

53hr Lead Time



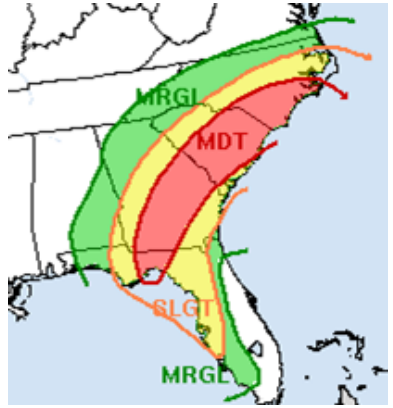
Day 2 ERO

29hr Lead Time

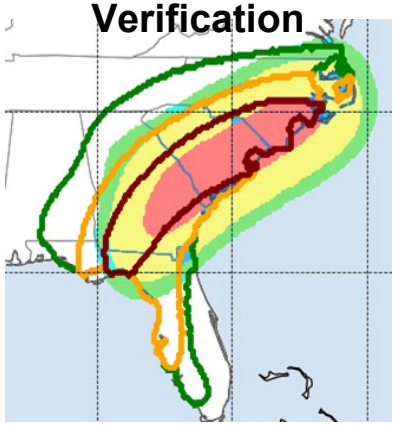


Day 1 ERO

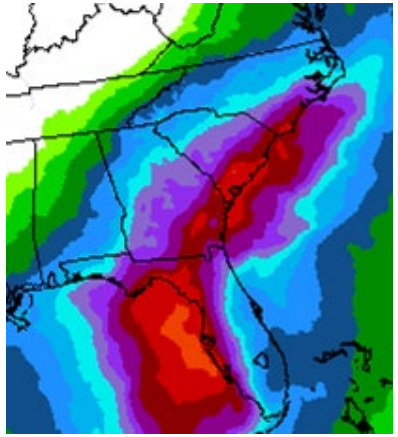
5hr Lead Time



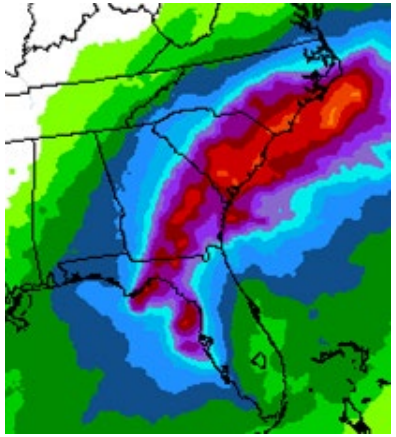
Practically Perfect Verification



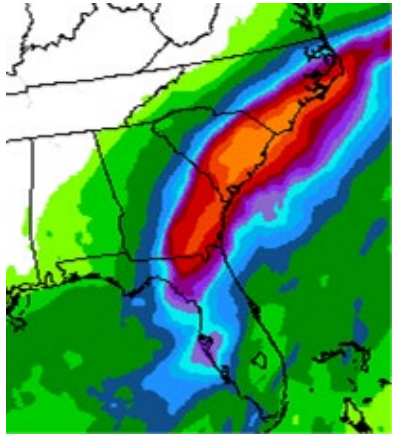
Day 5 QPF



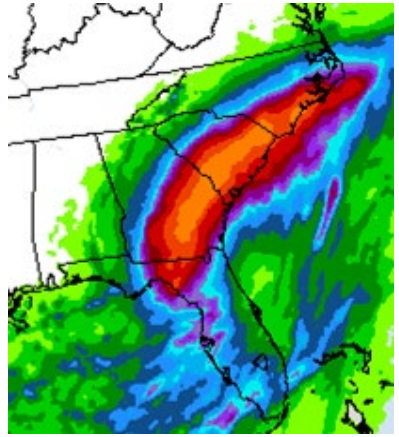
Day 4 QPF



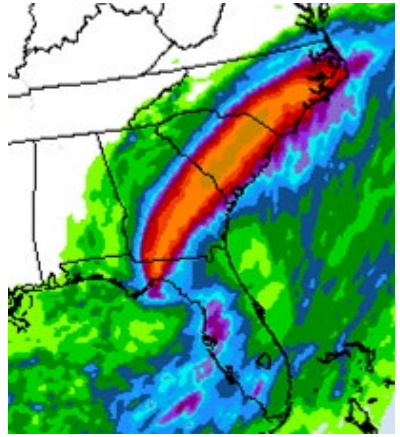
Day 3 QPF



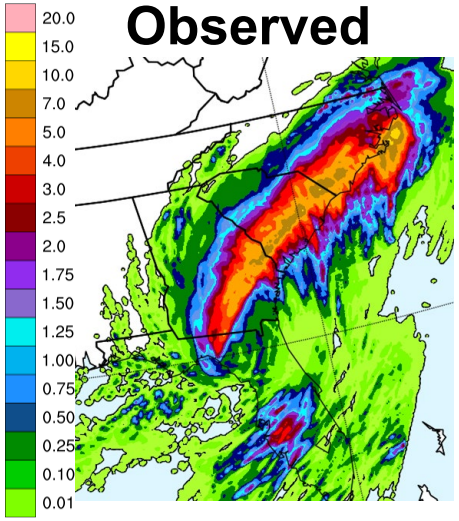
Day 2 QPF



Day 1 QPF



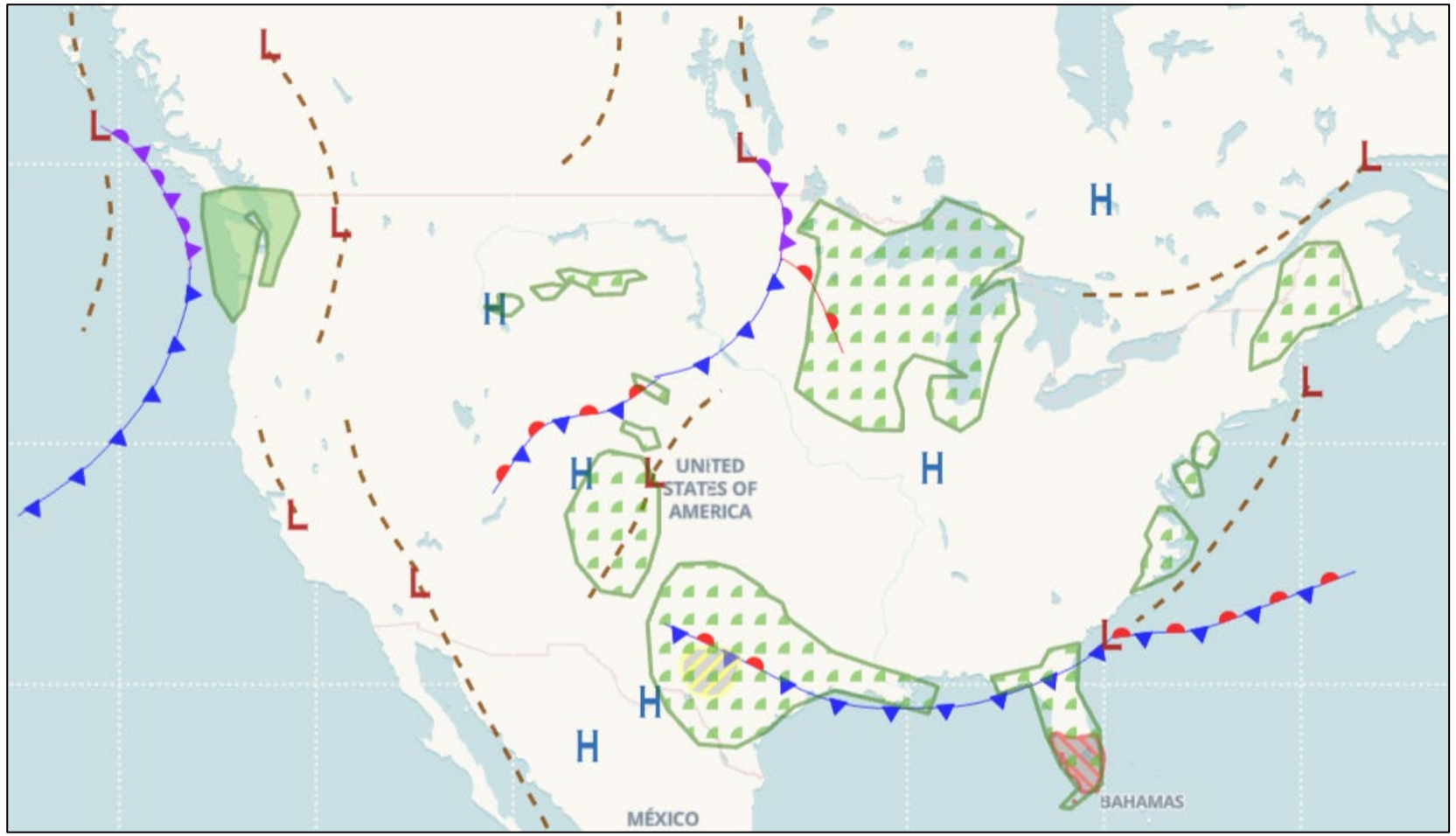
Observed

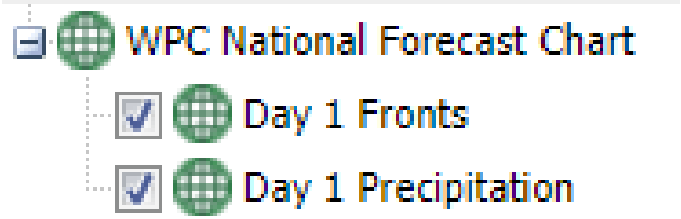


WEATHER PREDICTION CENTER
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

HURREVAC Webinar, Day 4
June 13, 2024 | Virtual Conference Session

National Forecast Chart





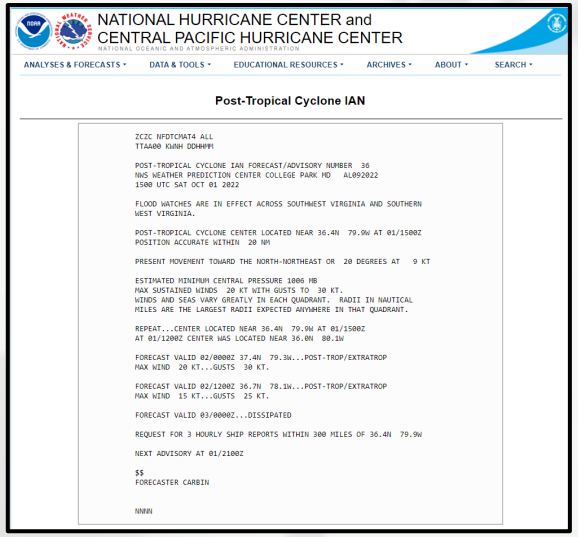
- Fronts (and lows) Precipitation areas
- Day 1 in Hurrevac
- Days 1-3 on WPC site

https://www.wpc.ncep.noaa.gov/

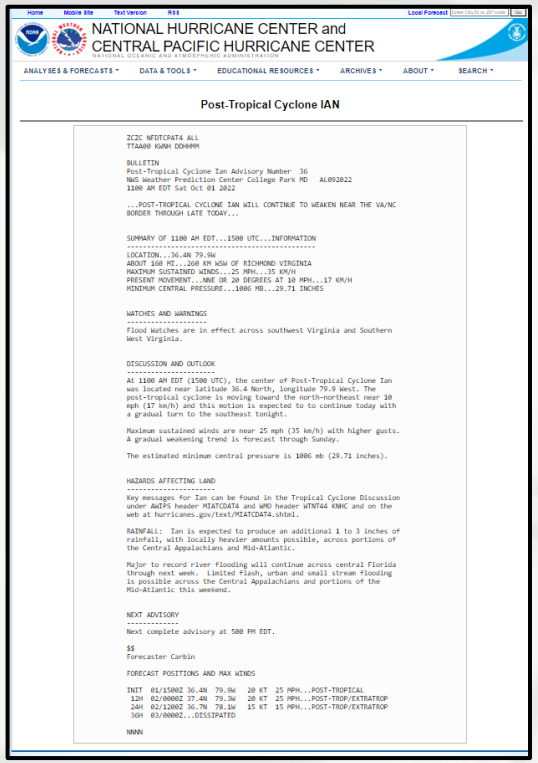
Inland Tropical Advisories and Discussions

WPC continues to issue Forecast and Public Advisories as needed, along with Discussions detailing the Key Messages pertaining to inland hazards (e.g. excessive rainfall and tornadoes) which gets into HURREVAC. Graphical information regarding rainfall, ERO, and Key Messages remain on hurricanes.gov.

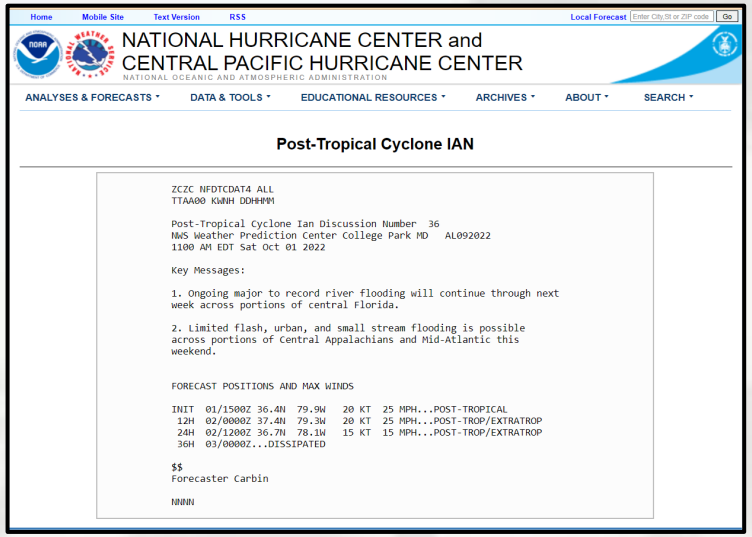
Forecast Advisory



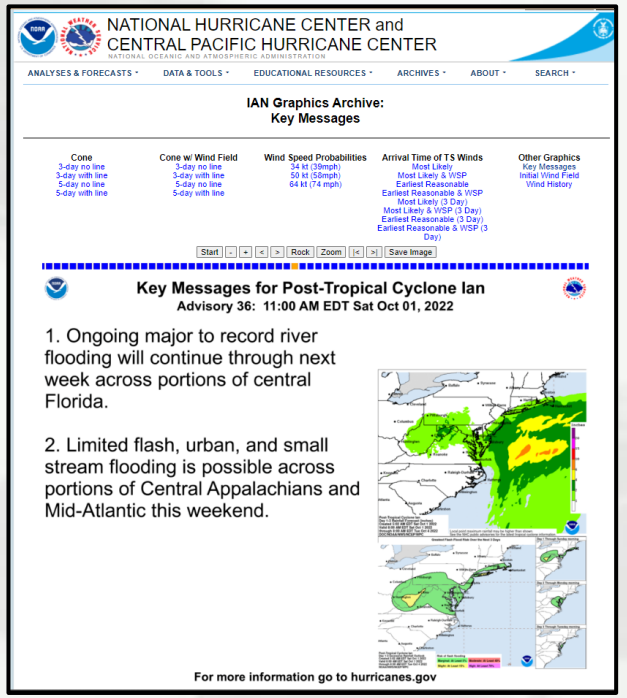
Public Advisory



Discussion (Key Messages)

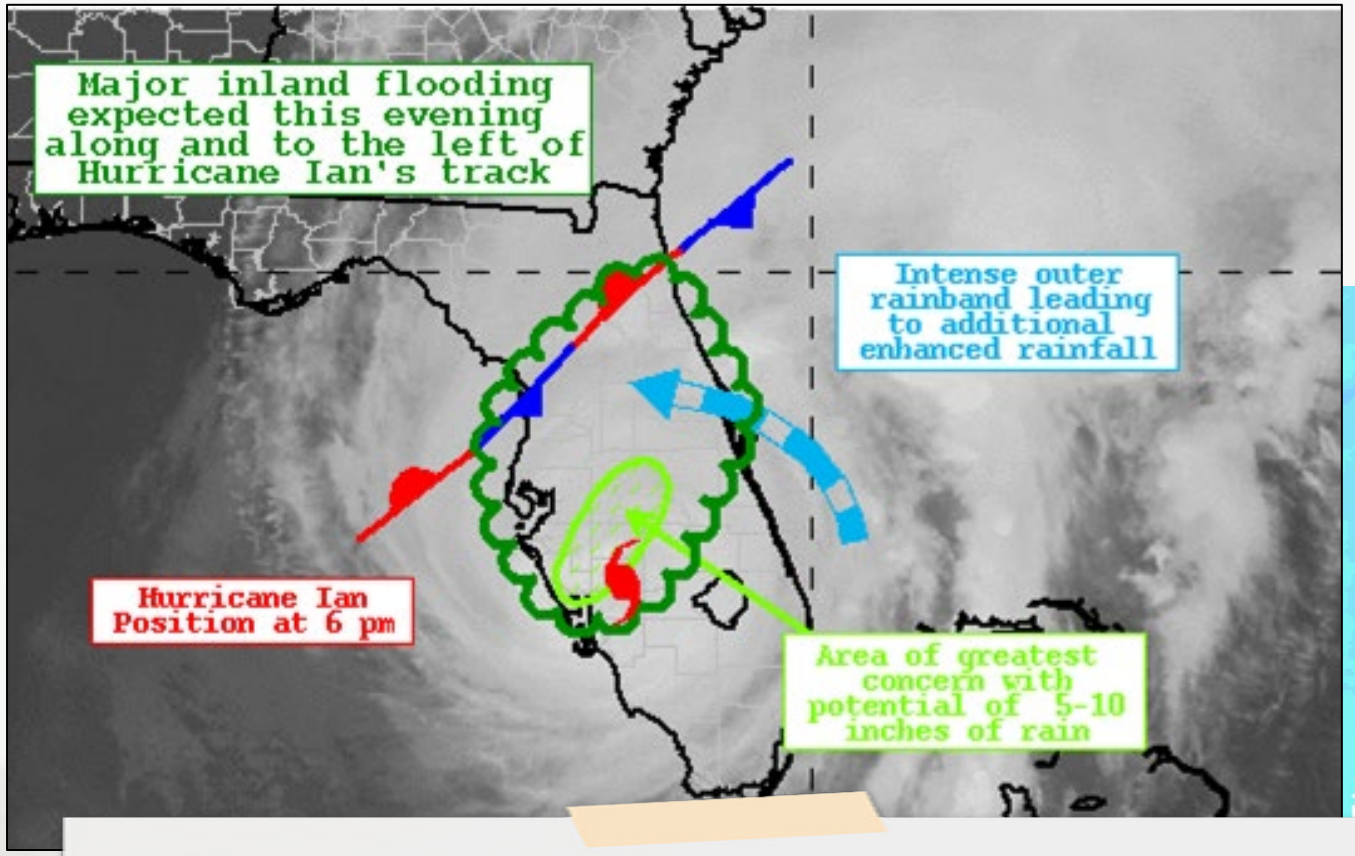


Graphical Key Messages



Not Yet in HURREVAC…

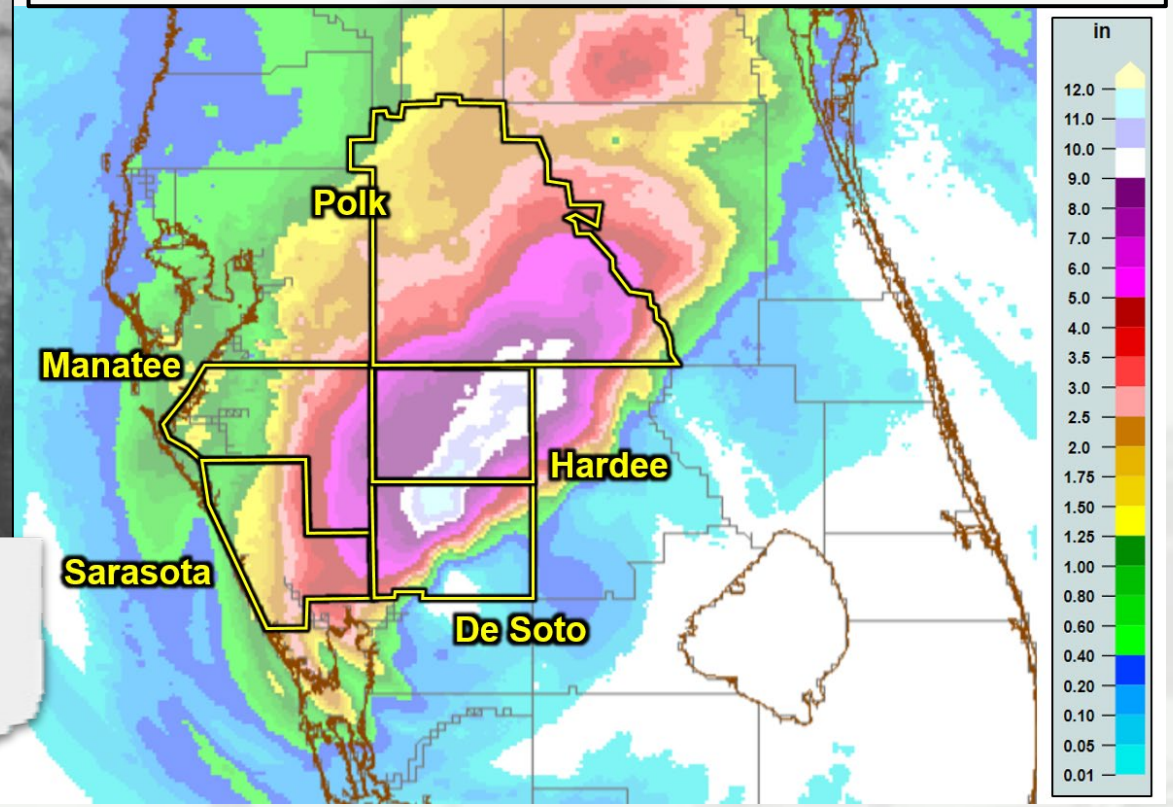
Mesoscale Precipitation Discussion (MPD)



with Manatee, Sarasota, De Soto, Hardee, and Polk counties expected to get hammered the most with a good probability of 5-10 inches of rainfall through midnight local time. There is the potential for some instances of life-threatening flooding

WPC tool to hone in on highest threat areas for intense rainfall that may lead to flash flooding in the next 1-6 hours. Can be helpful for tactical decision-making.

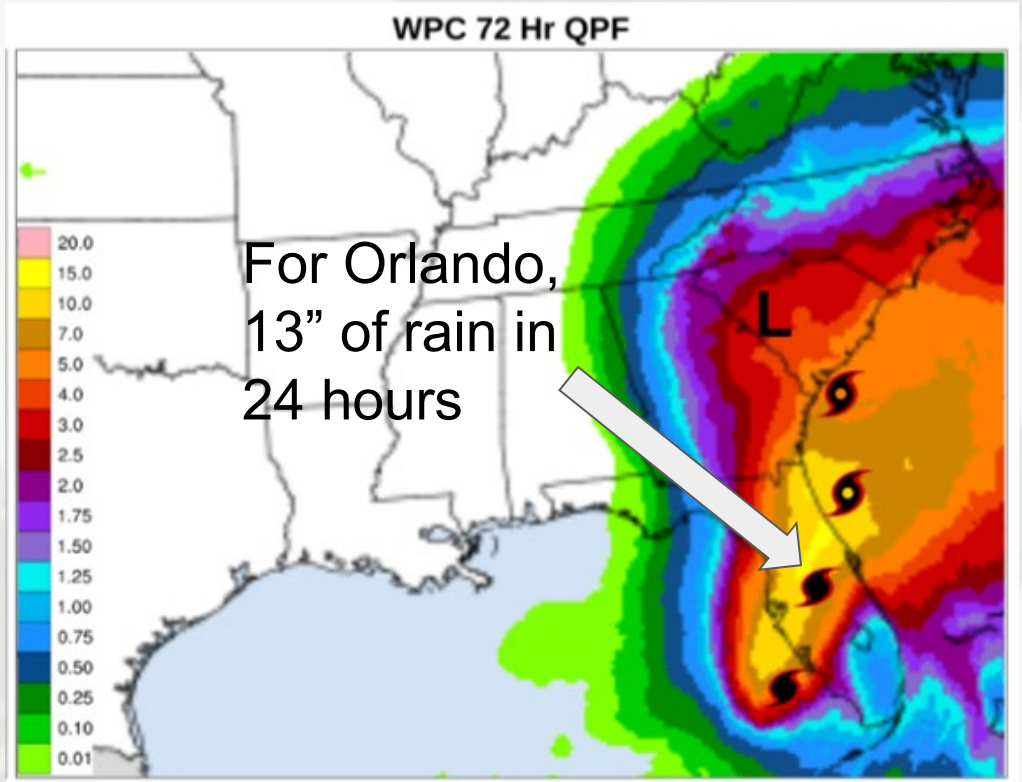
New WPC is creating KML/shapefiles for the MPD

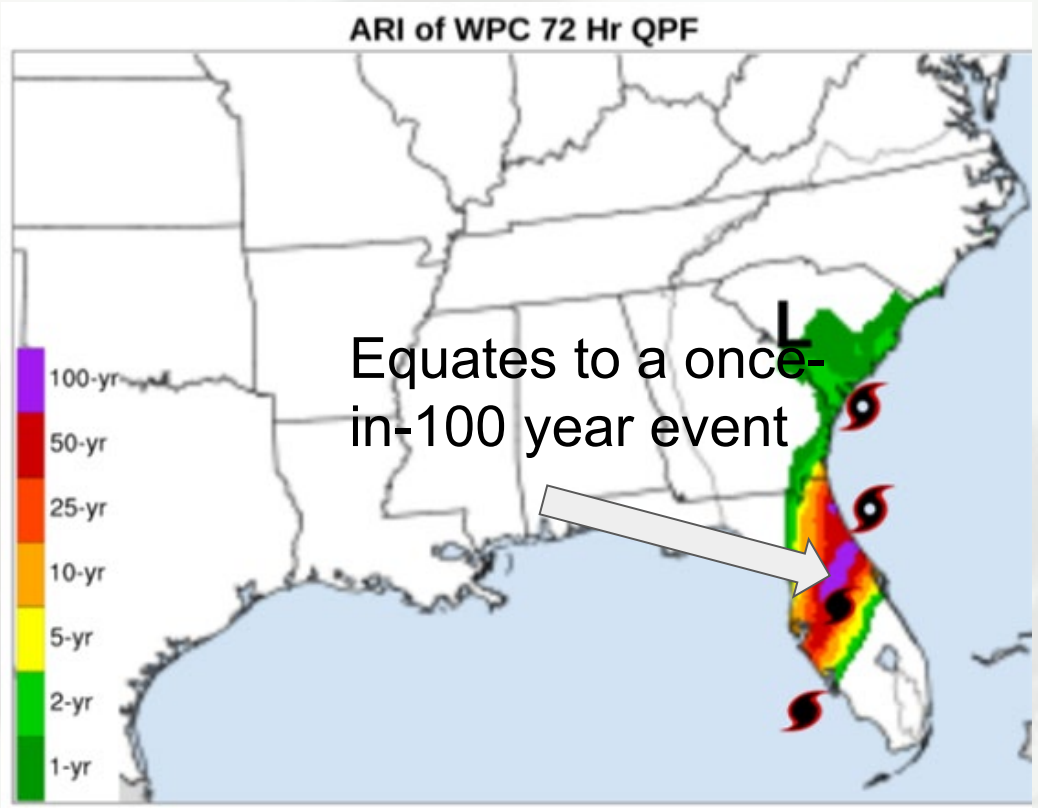


Not Yet Available for HURREVAC…

The Extreme Precipitation Monitor

- Answers the question: “How rare is that rainfall forecast?”
- Tool provides both the most likely and the reasonable-worst case.
- Helps distinguish between a ‘bad event’ and a ‘REALLY bad event’.
- WPC currently working on KML/shapefiles.





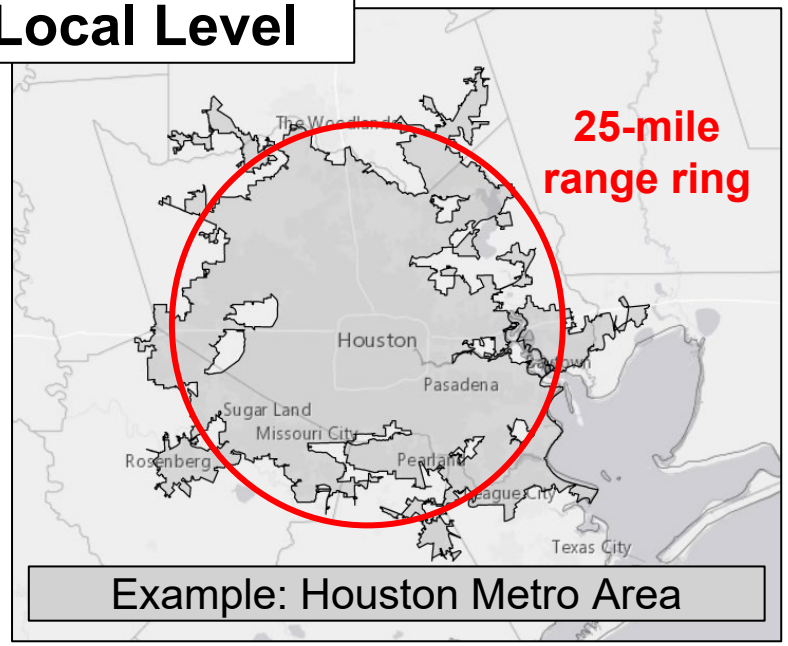
Questions or Comments?

Email:

Bryan.Jackson@noaa.gov
David.Novak@noaa.gov
Alex.Lamers@noaa.gov

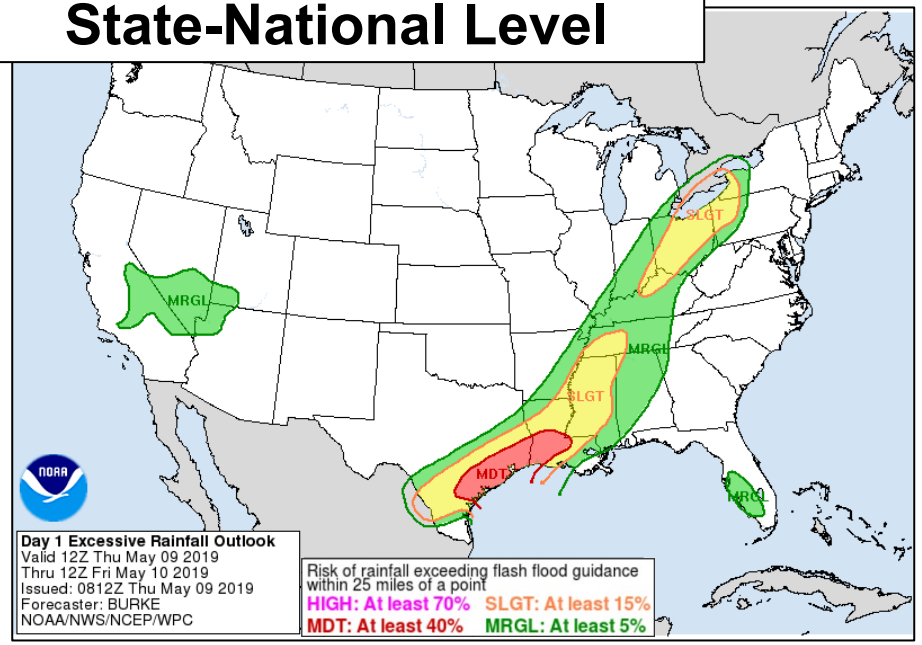
Background: Interpretation of the ERO

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.

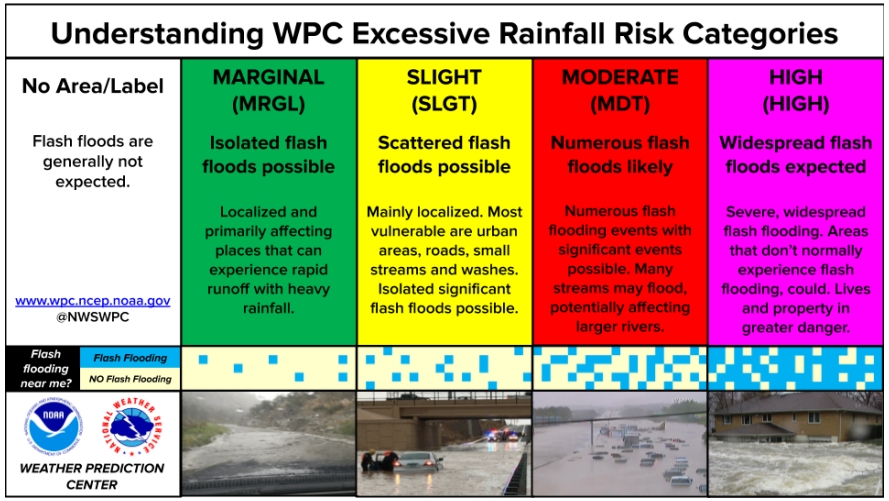
ERO Explainer Graphics

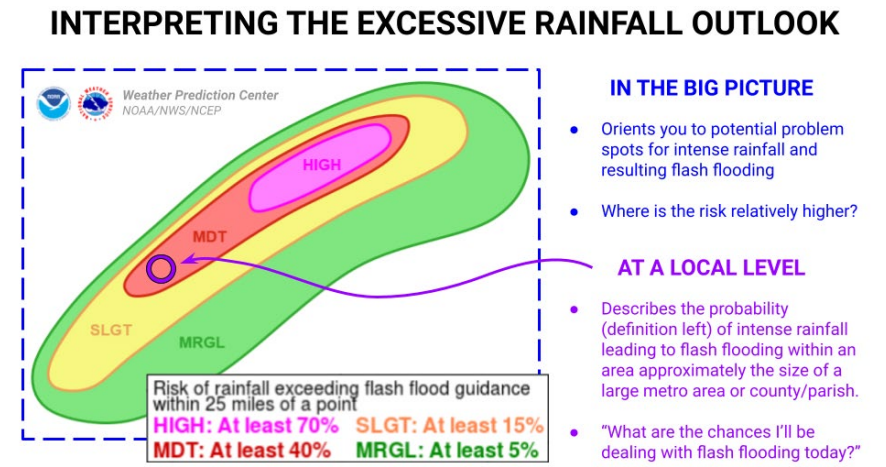
WPC now has a series of graphics that can be used to accompany the ERO

Two graphics, one in English, one in Spanish, describing the different risk categories

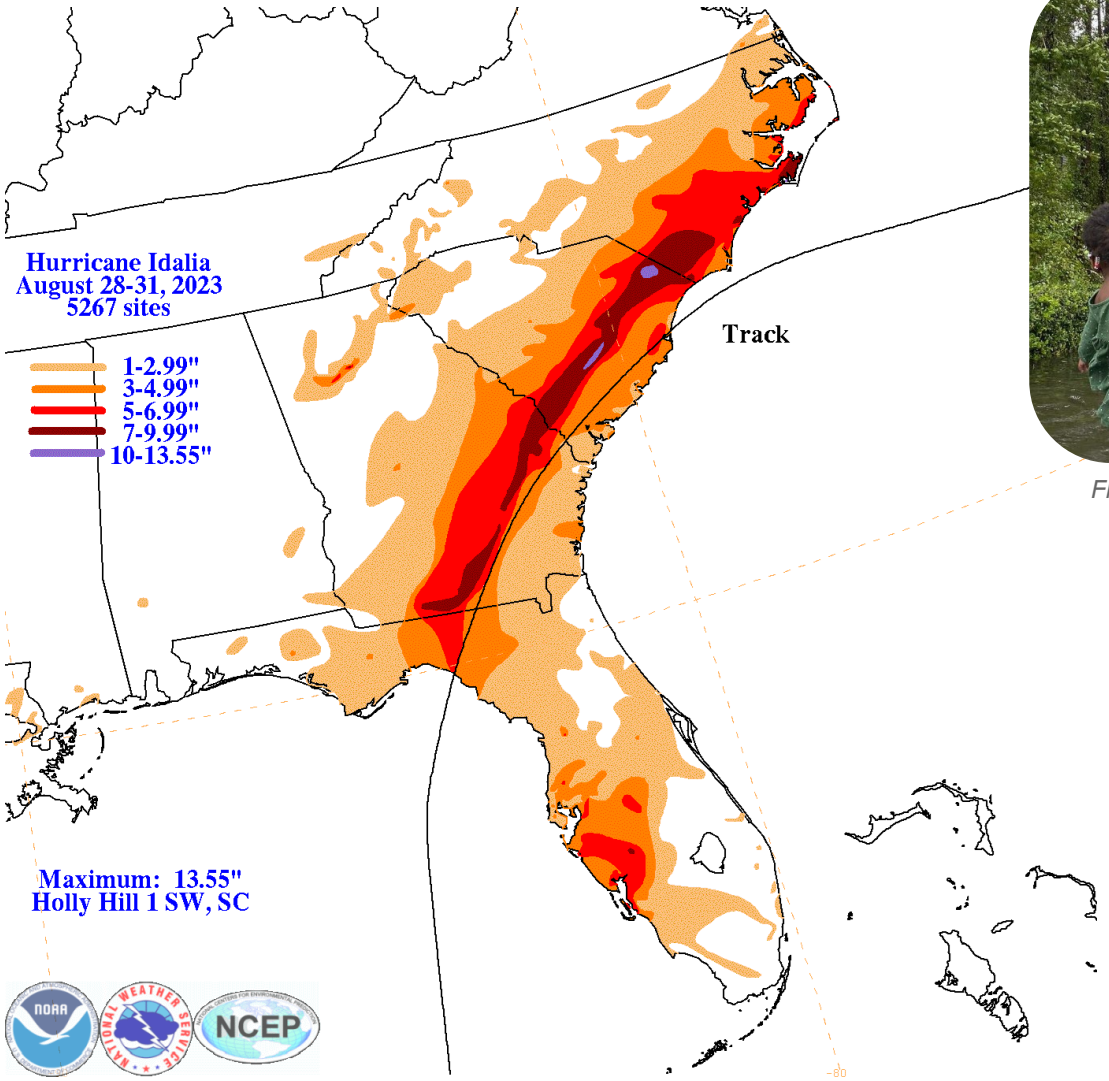
One graphic with some suggested actions during High Risk situations

One graphic providing an interpretation guide

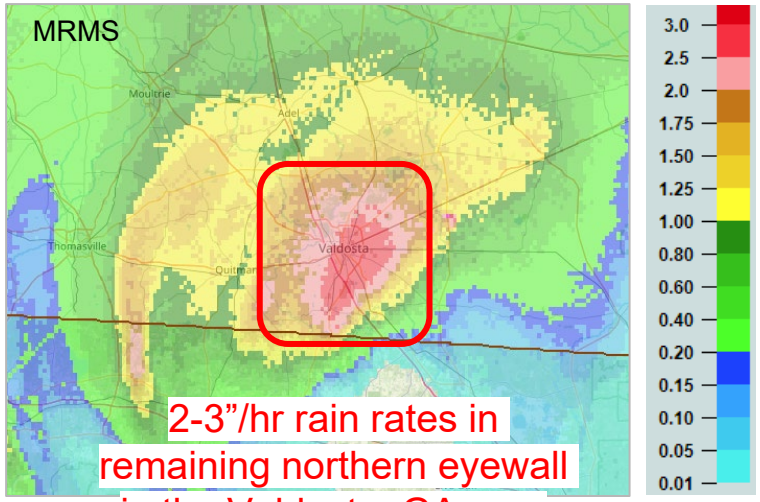




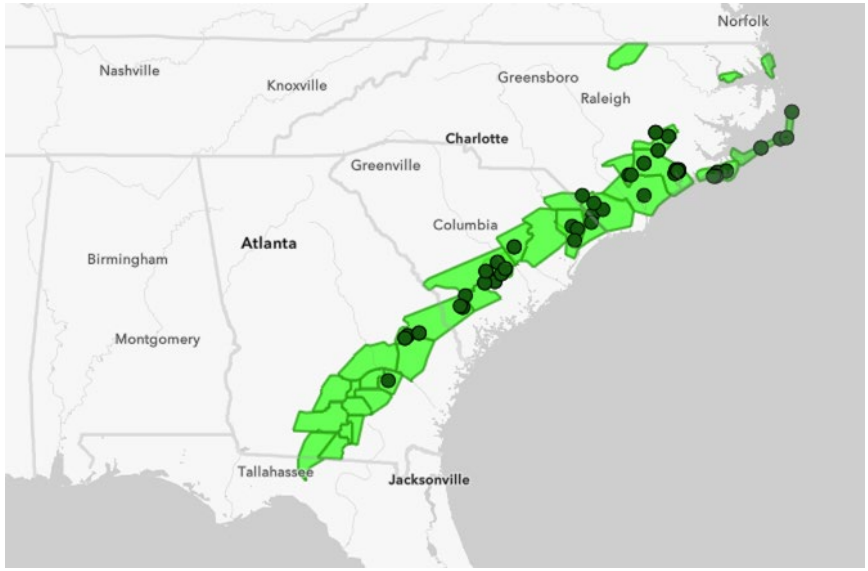
Hurricane Idalia Rainfall Impacts



Flooding in Valdosta, Georgia (Valdosta Fire Dept)



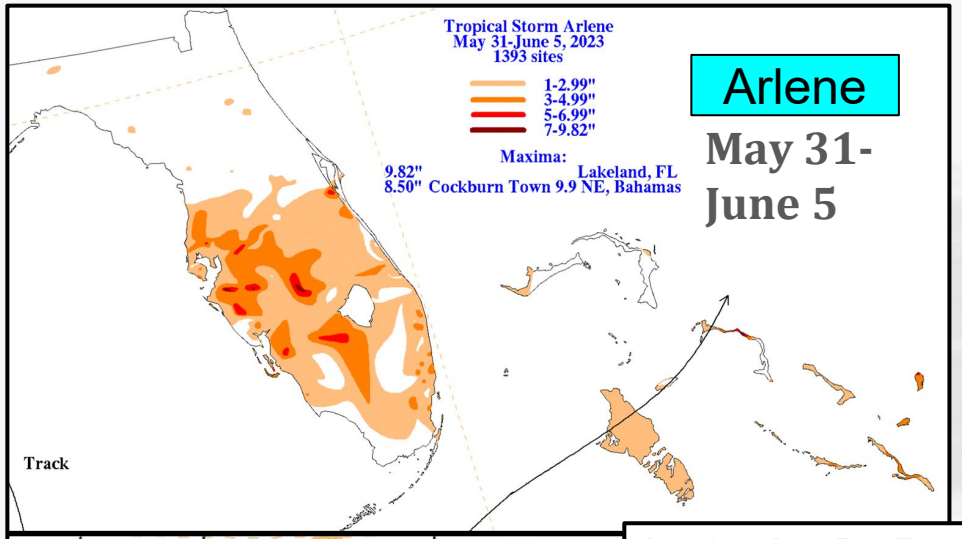
2-3"/hr rain rates in remaining northern eyewall in the Valdosta, GA area

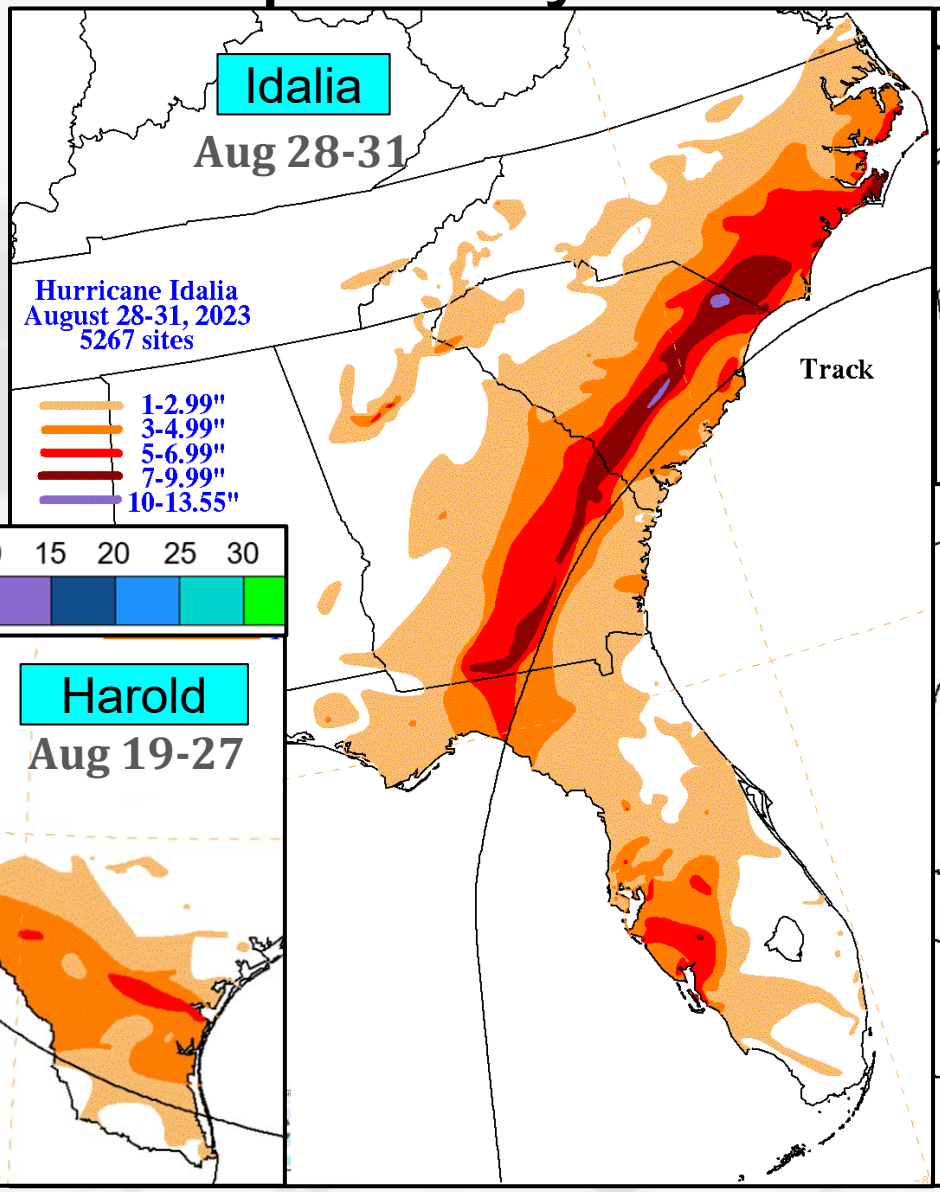


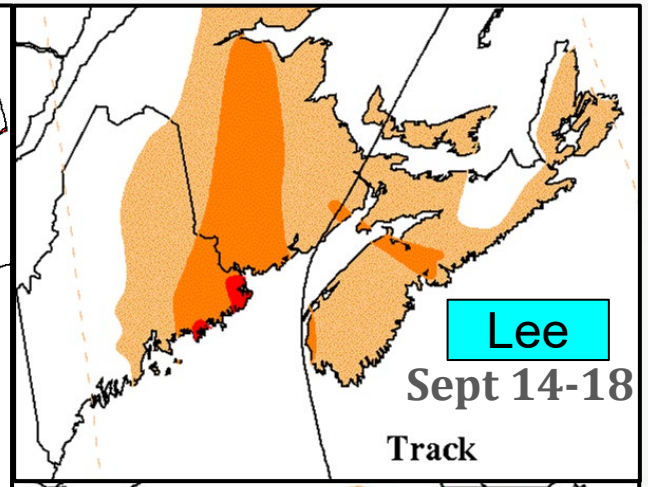
Flash Flood Warnings and **Reports** for the 24-hour period

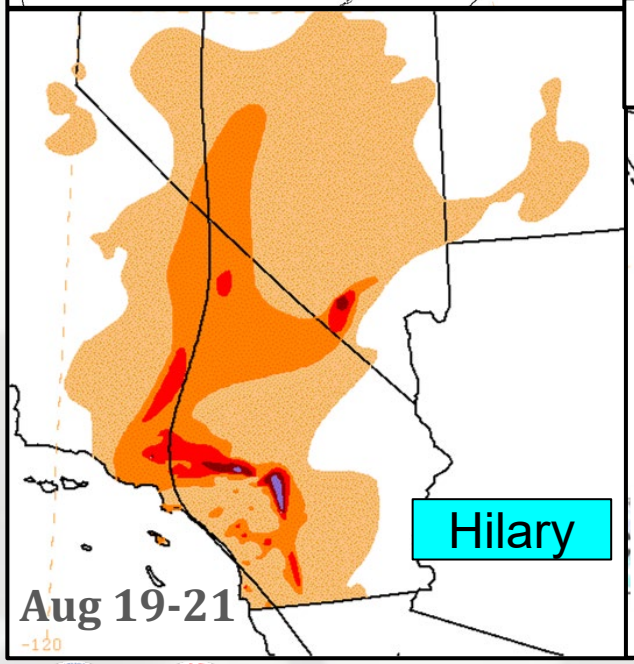
12 UTC 30 Aug to
12 UTC 31 Aug

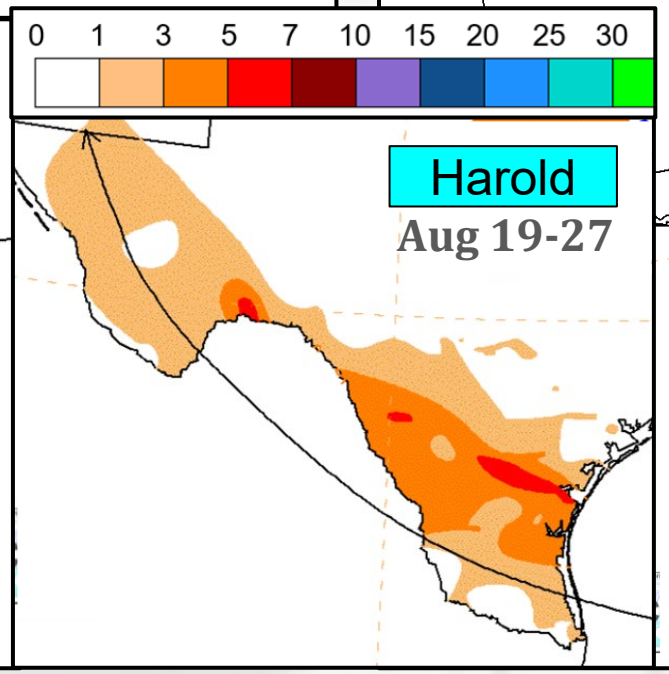
2023 Review: Lower 48 Tropical Cyclone Rainfall Events

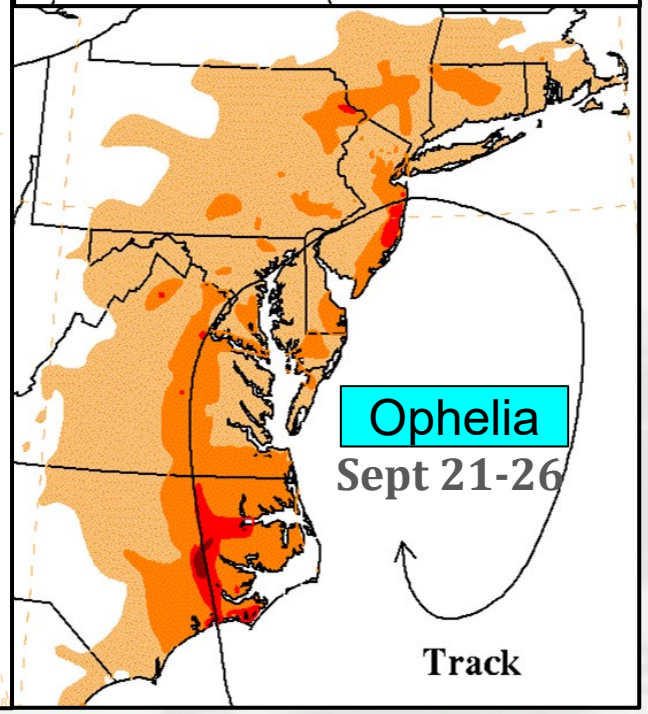




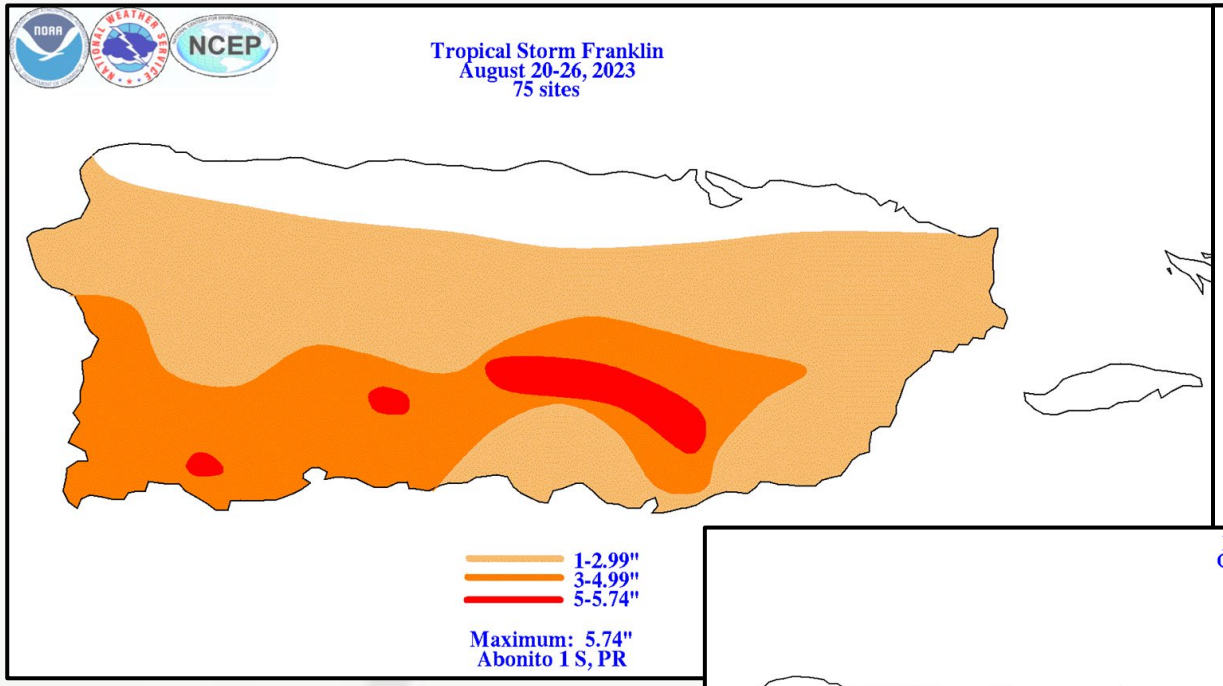


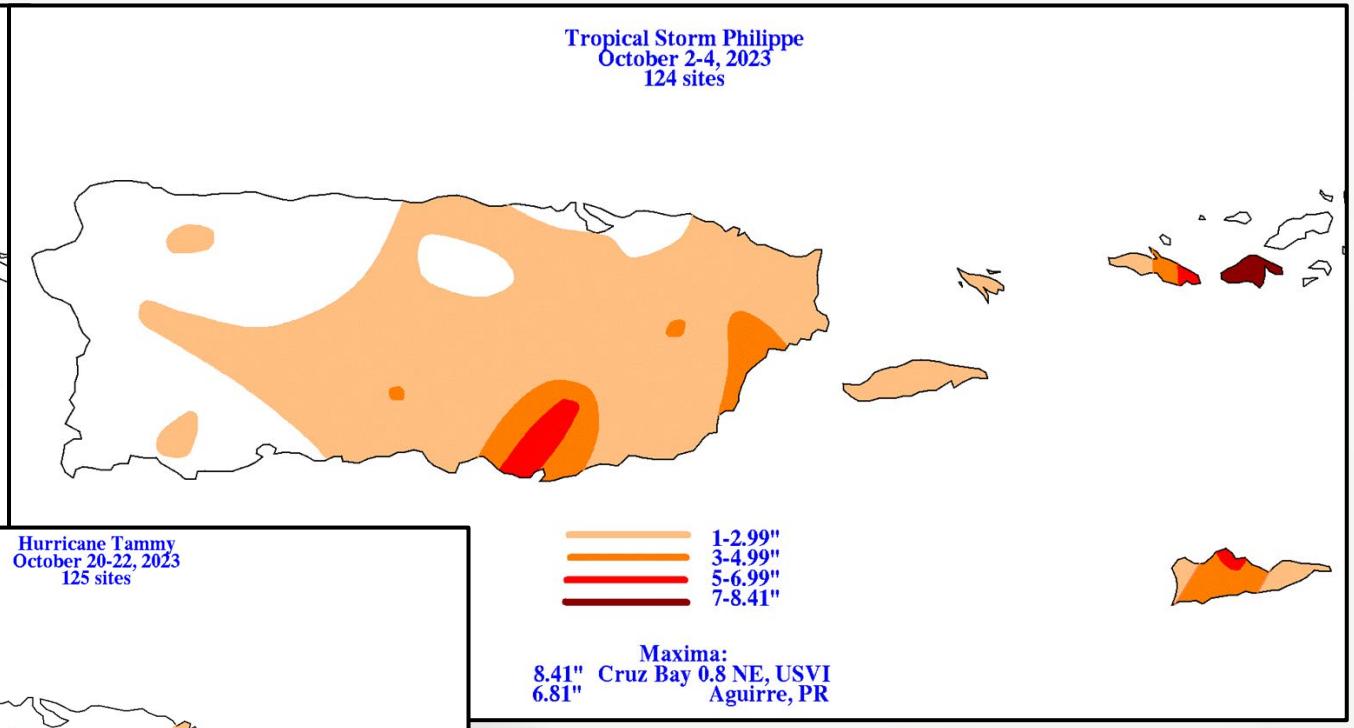


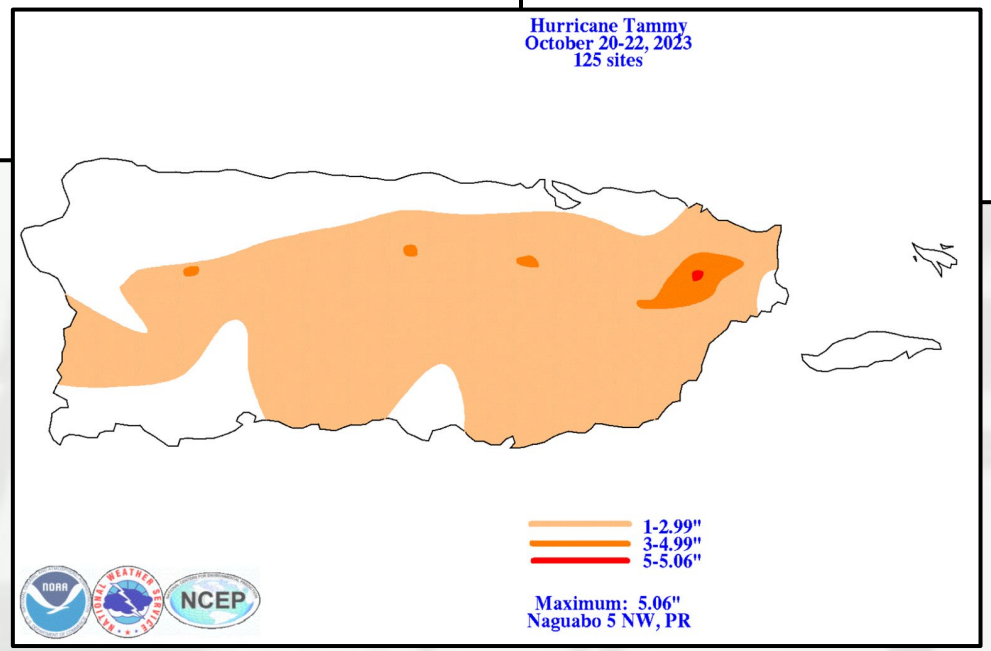




2023 Review: P.R./V.I. Tropical Cyclone Rainfall Events







Hilary

HURREVAC Demo

THIS WEEK'S AGENDA

JUNE 10: Intro to HURREVAC and the NHP *(available on YouTube)*

JUNE 11: Wind Forecast Features *(available on YouTube)*

JUNE 12: Evacuation Timing Features *(available on YouTube)*

JUNE 13: Storm Surge and Flooding Hazards *(on YouTube later today)*

NEXT >>>>> JUNE 14: Applying HURREVAC for Planning and Operations

Registration is still open for Day 5 at webinars.hurrevac.com

Thank you!

HURREVAC Support Team

support@hurrevac.com

FEMA

NATIONAL HURRICANE PROGRAM

HURREVAC

HURRICANE DECISION SUPPORT TOOL