

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

Attendee information



Questions

- Submit in the question box

Feedback

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

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

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



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



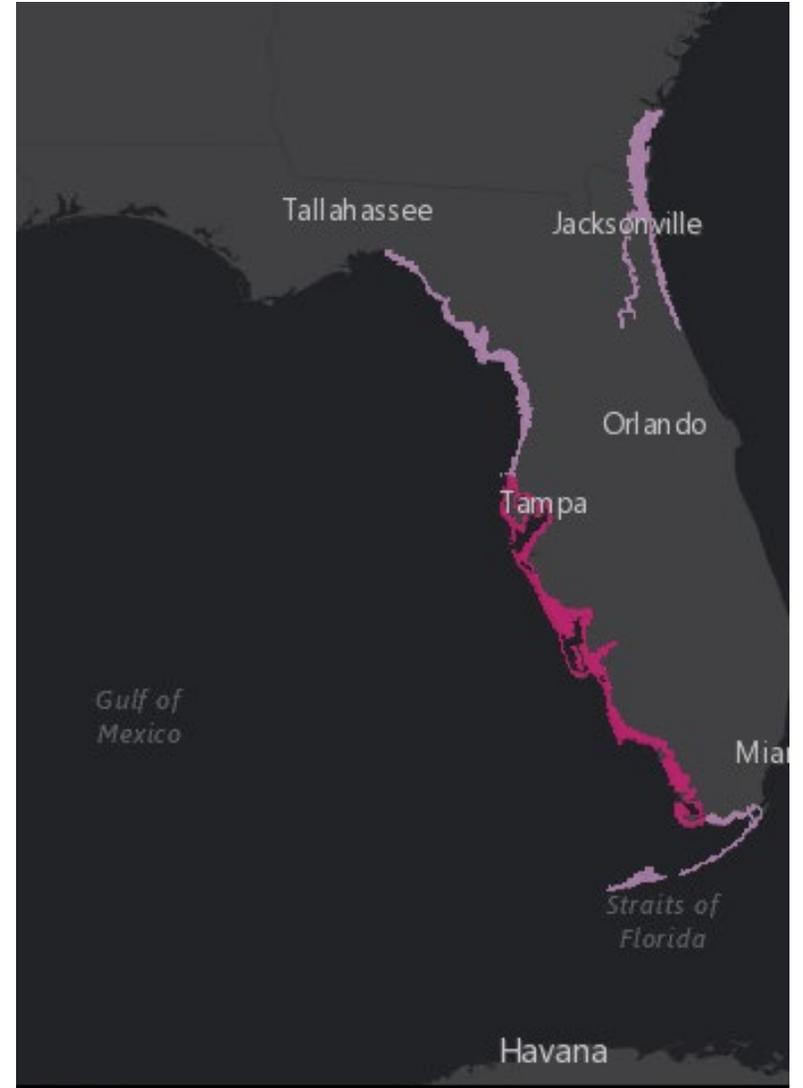
NATIONAL HURRICANE PROGRAM

2024 HURREVAC WEBINAR – STORM SURGE

STORM SURGE UNIT - NATIONAL HURRICANE CENTER



Credit: Max Olson



Storm Surge Warning
Storm Surge Watch





OBJECTIVE:

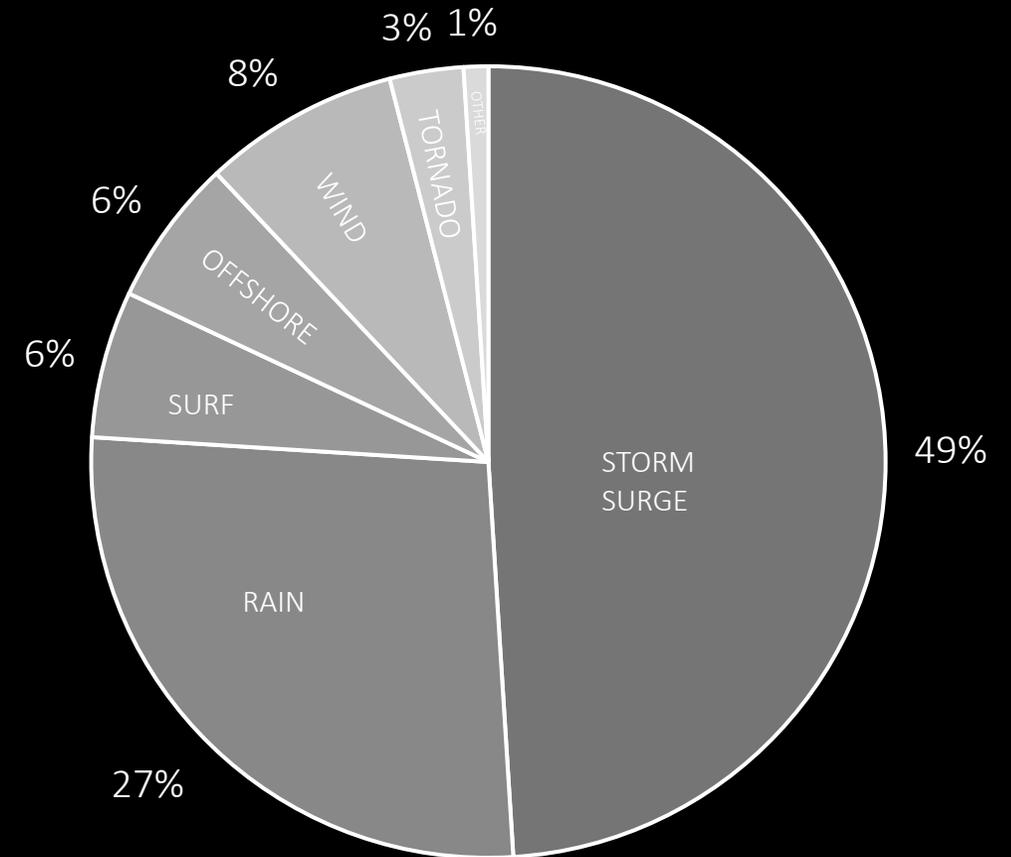
- To communicate the danger of storm surge caused by tropical cyclones
- To highlight the products available for planning and response to storm surge

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

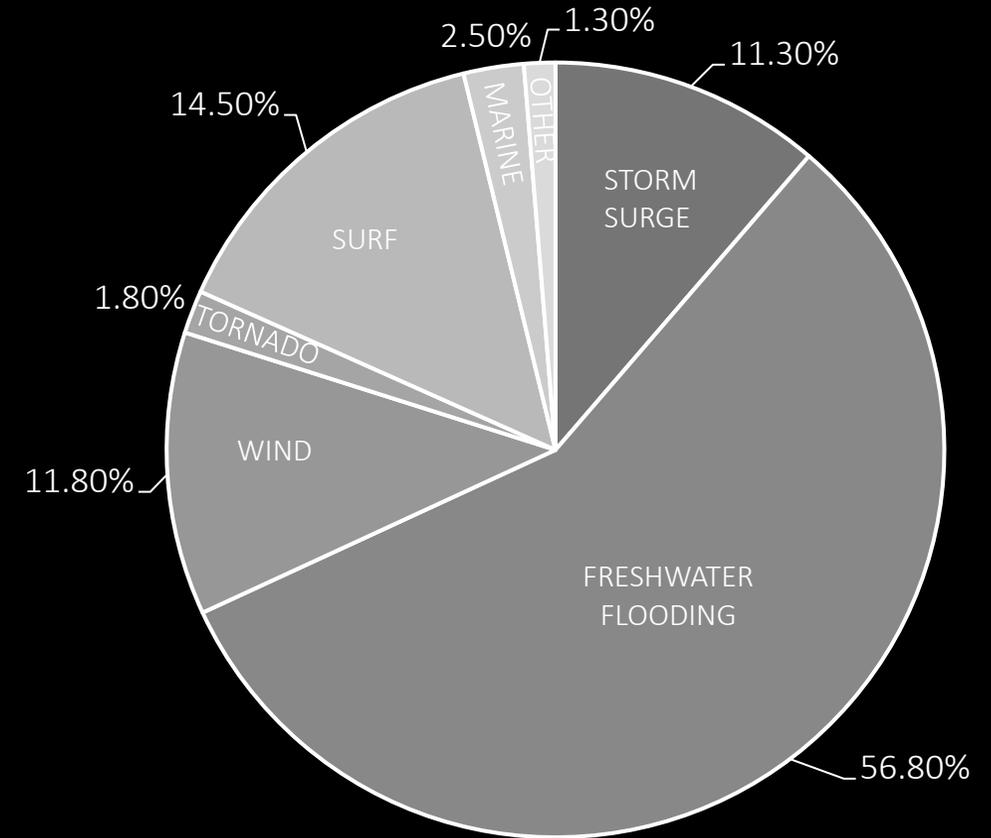
2,544 Fatalities From 1963–2012



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)

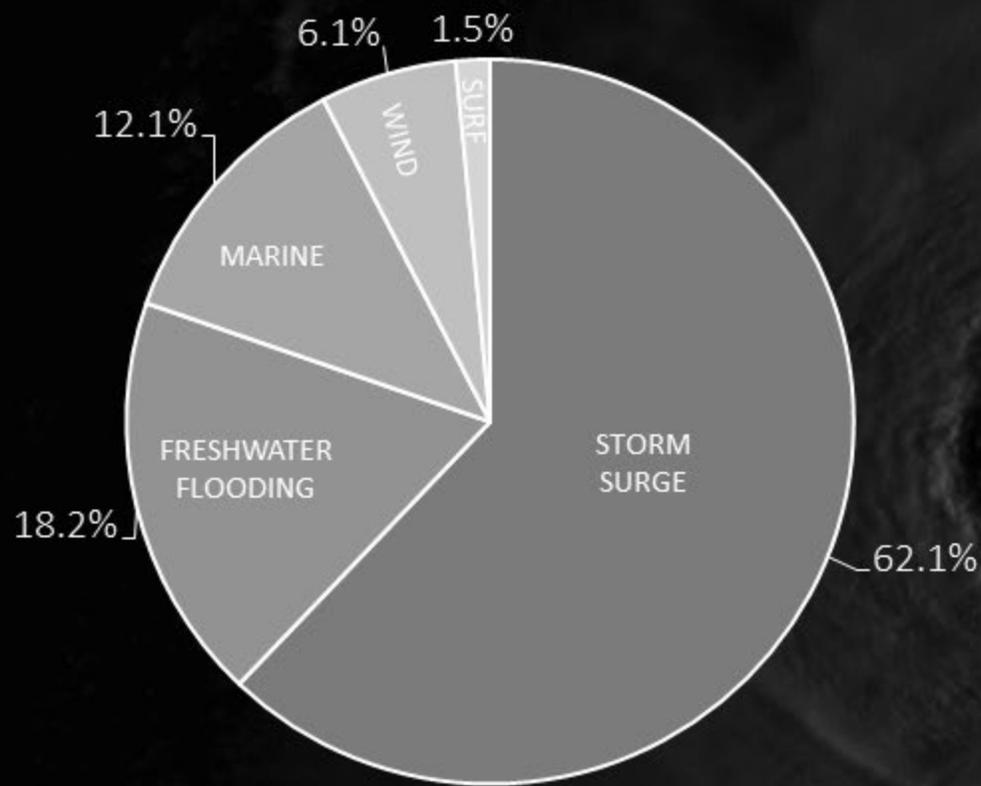
- Storm surge accounts for only 11.3% of direct deaths
- Freshwater now leads tropical hazards with 56.8% of storm related direct deaths
- Wind still a small percentage of storm related deaths with 11.8%



442 – direct fatalities 415 – indirect fatalities

BRENNAN ET AL. 2022

...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

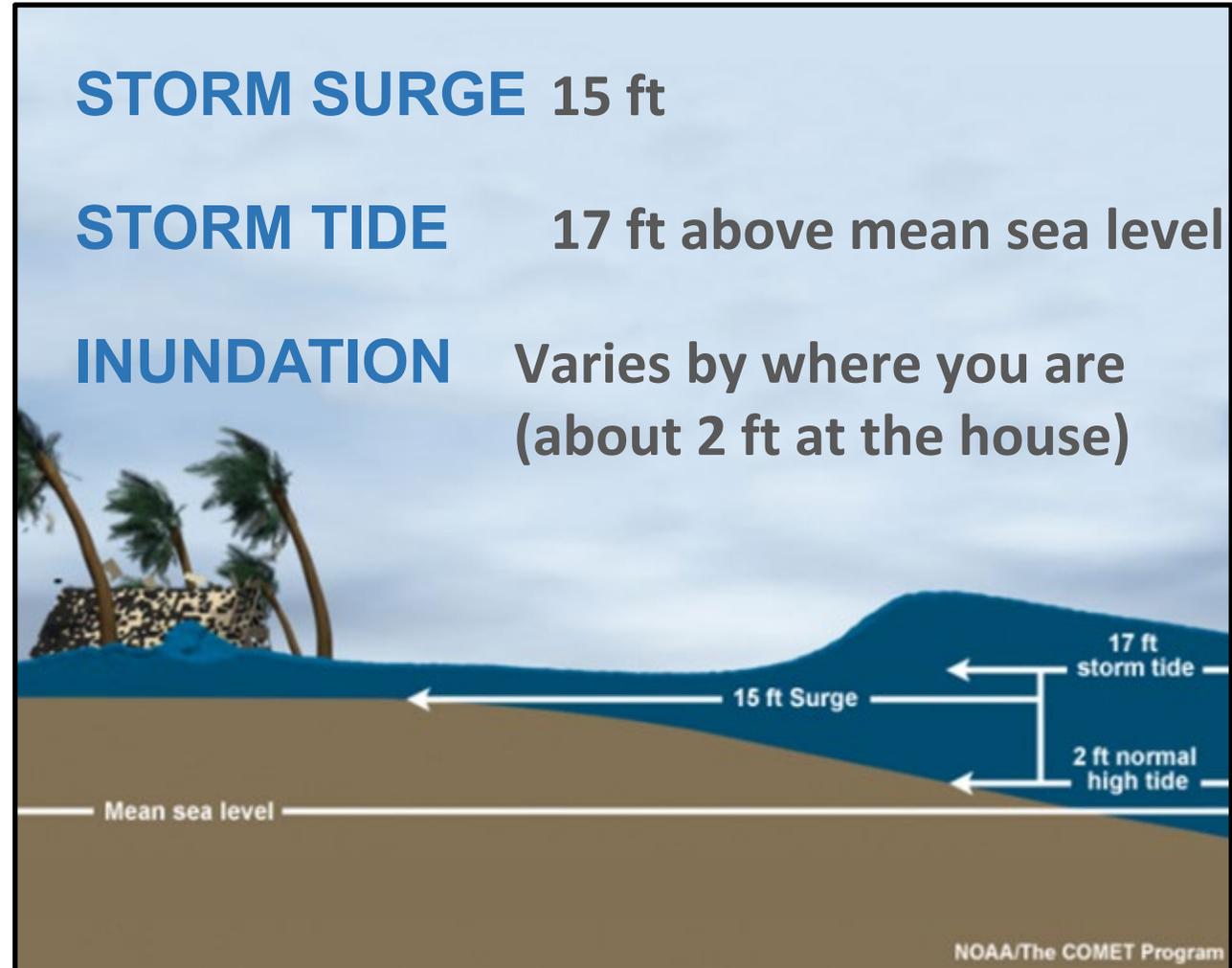
An abnormal rise of water generated by a storm, over and above the predicted astronomical tide.

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

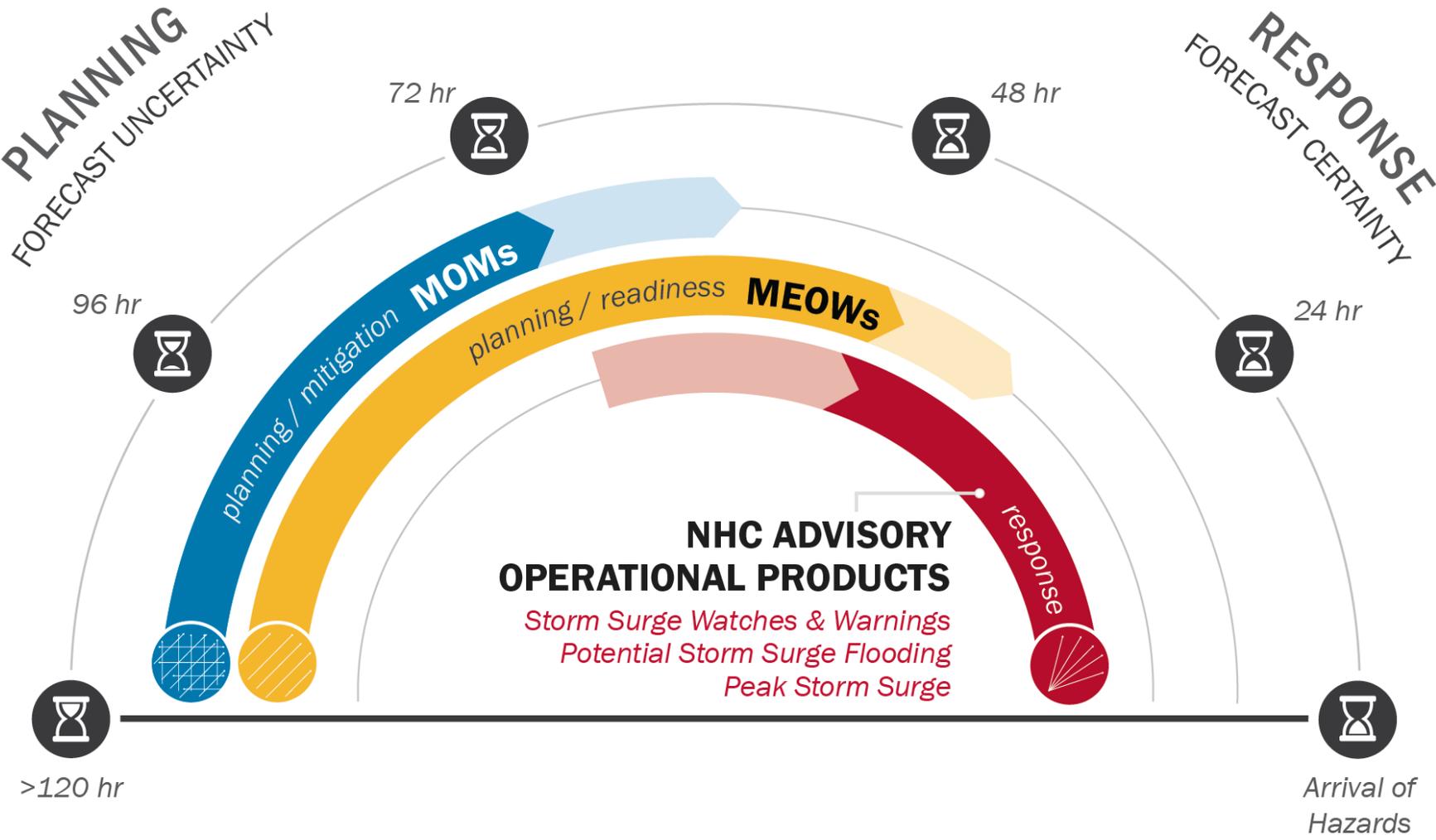
Sea, Lake, and Overland Surges from Hurricanes

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



STORM SURGE

Storm Surge Risk Tools

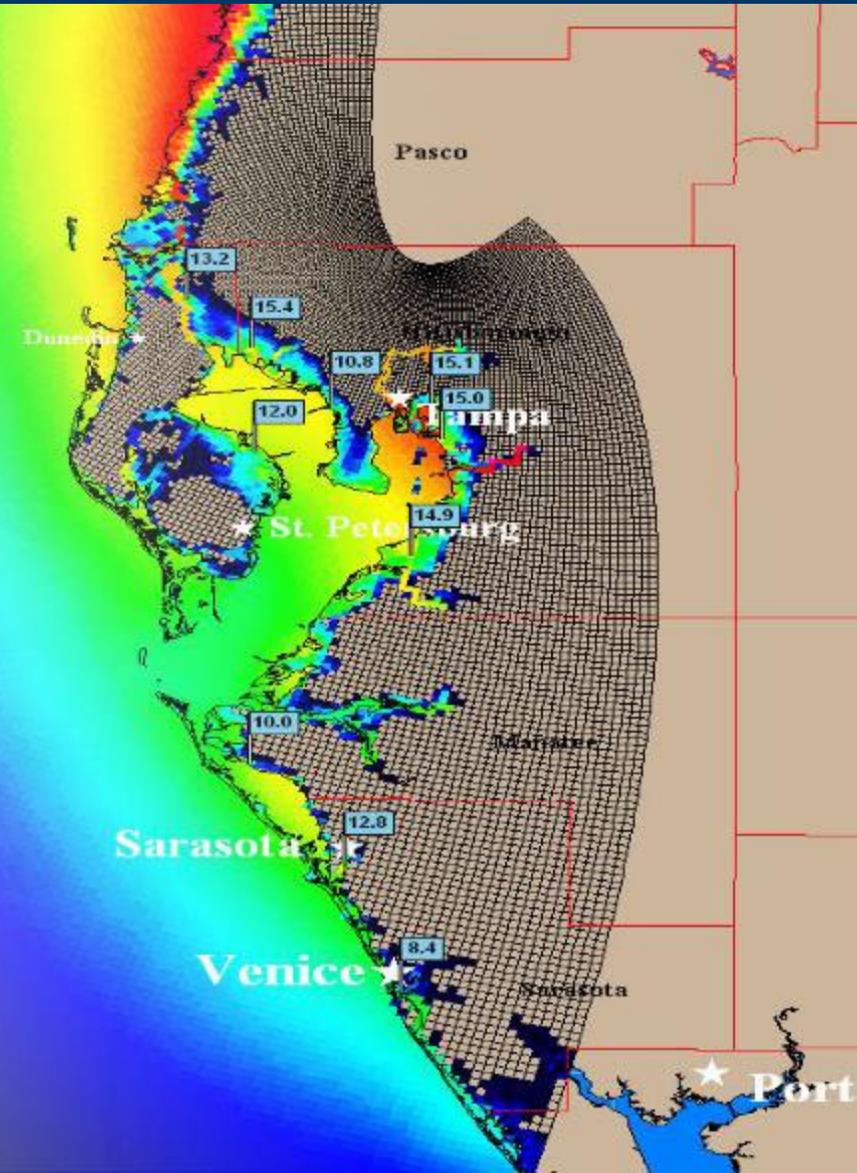


STORM SURGE

Maximum of Maximums (MOM)

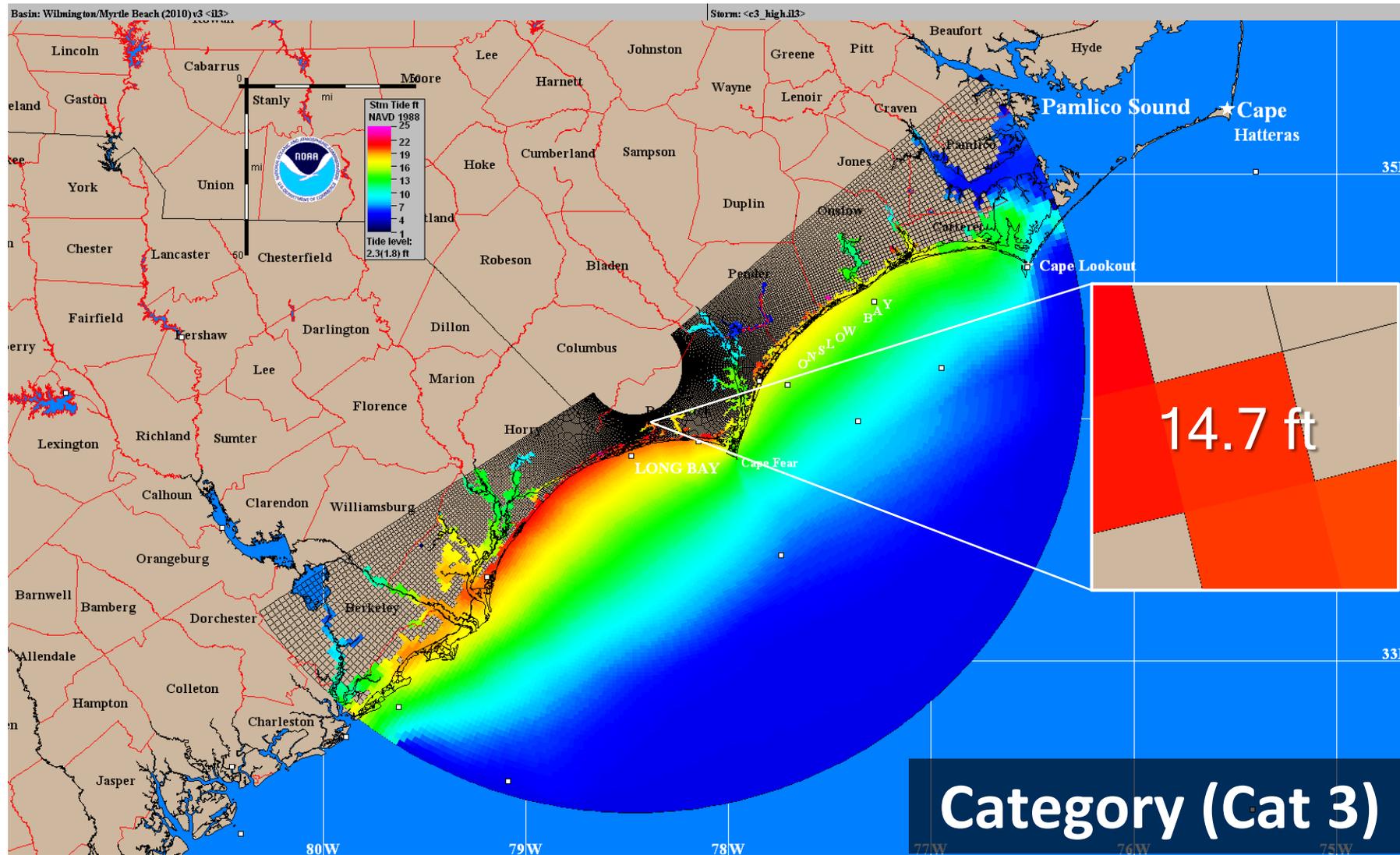
MOMs

- 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)

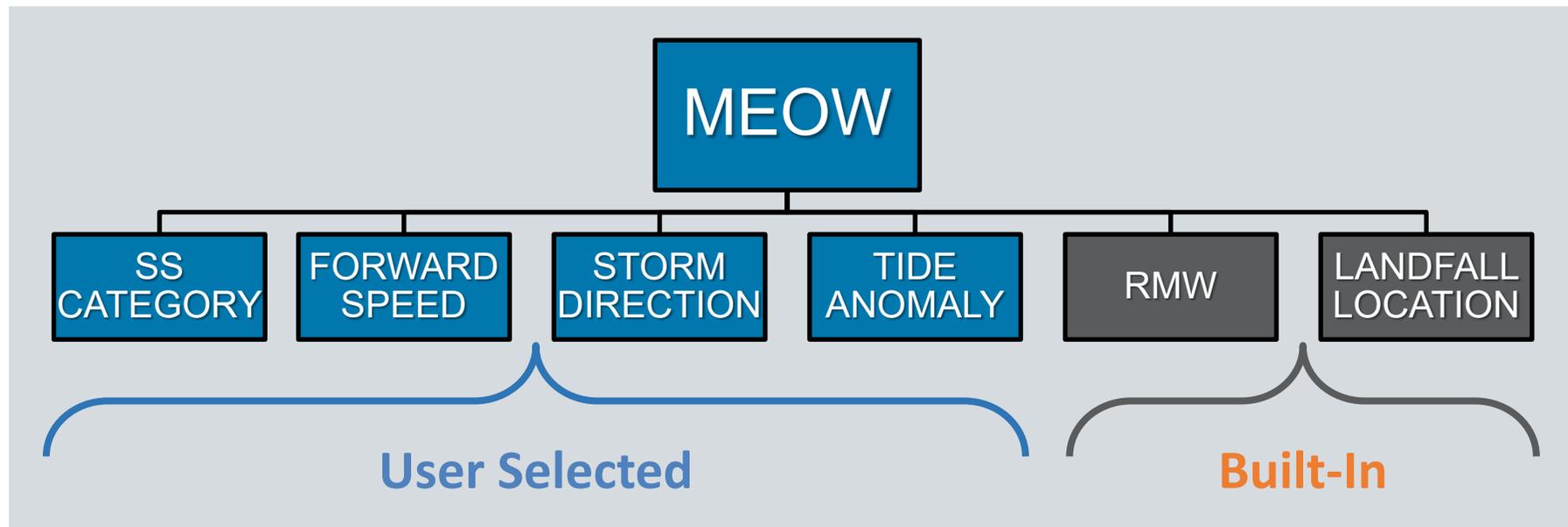


STORM SURGE

Maximum Envelope of Water (MEOW)

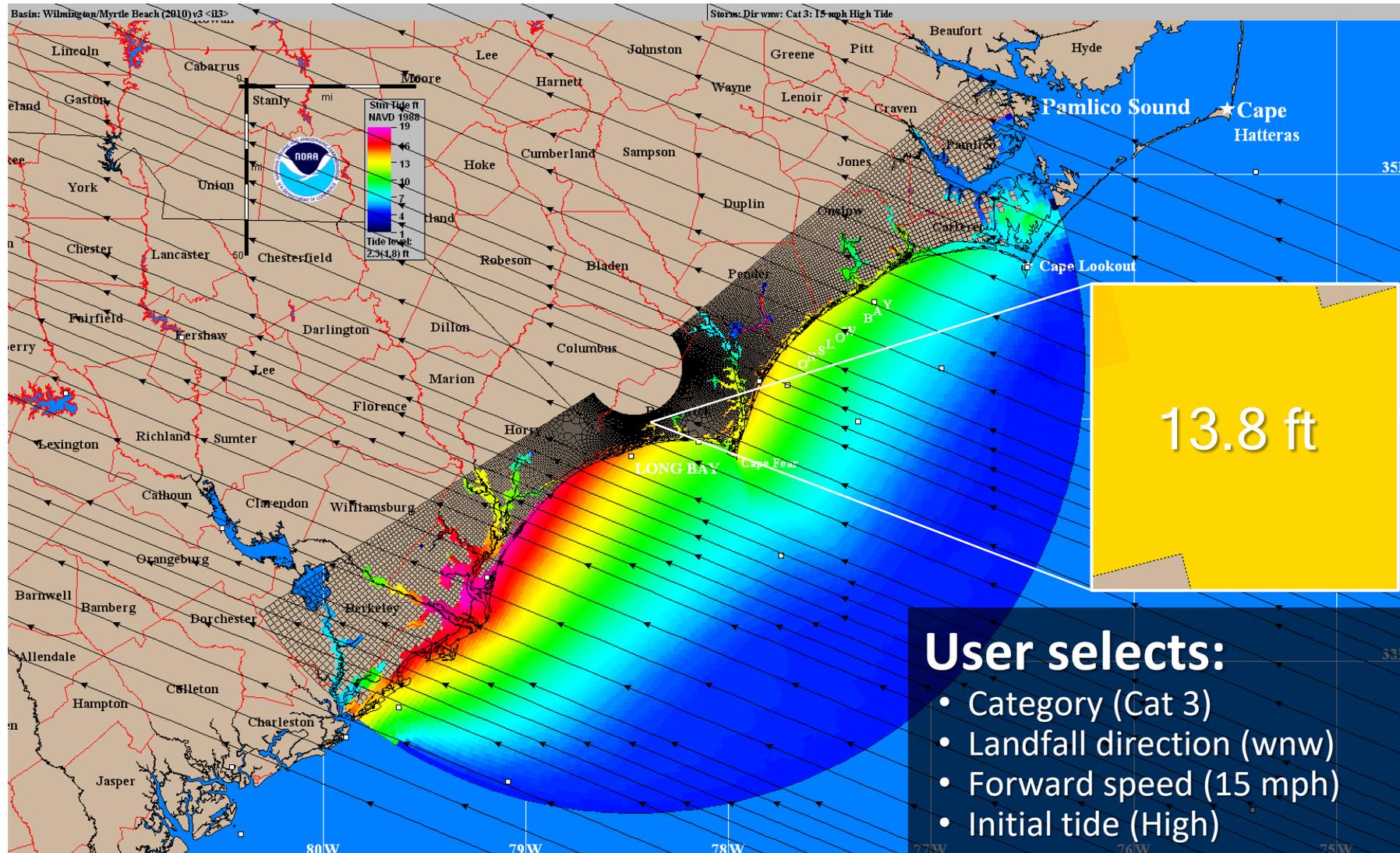
MEOWs

- 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)



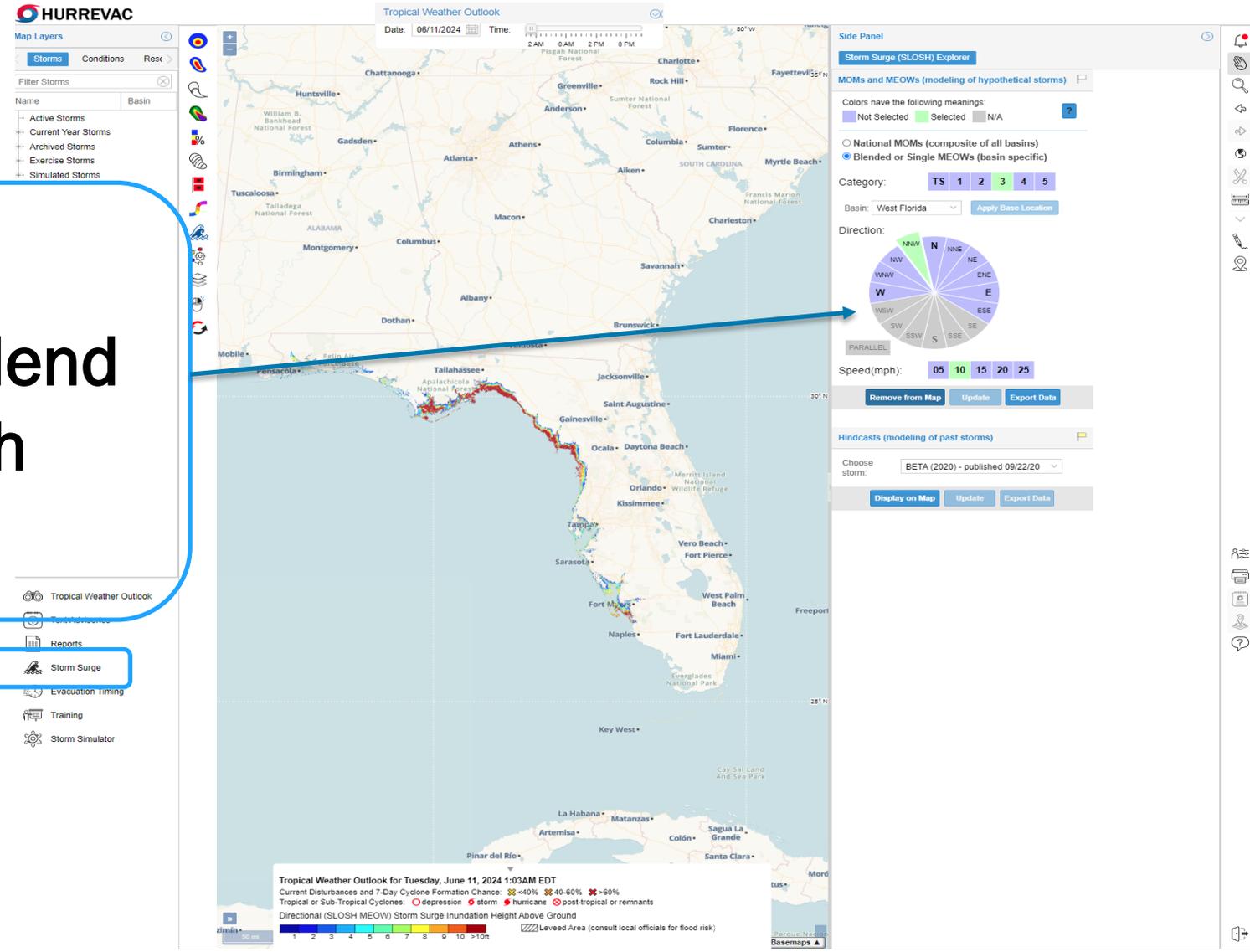
SURGE EXPLORER IN HURREVAC

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

The screenshot displays the HURREVAC (Hurricane Risk Evaluation and Visualization) interface. At the top, it shows the date as 06/11/2024 and a time range from 2 AM to 8 PM. The main map shows the United States with a color-coded storm surge overlay, primarily concentrated along the East and Gulf coasts. On the left, the 'Map Layers' panel includes a 'Storms' filter and a list of storm categories: Active Storms, Current Year Storms, Archived Storms, Exercise Storms, and Simulated Storms. Below the map, a navigation menu lists various tools: Tropical Weather Outlook, Text Advisories, Reports, Storm Surge (highlighted with a blue box), Evacuation Timing, Training, and Storm Simulator. On the right, the 'Side Panel' is titled 'Storm Surge (SLOSH) Explorer' and contains sections for 'MOMs and MEOWs (modeling of hypothetical storms)' and 'Hindcasts (modeling of past storms)'. The 'MOMs and MEOWs' section includes a legend for colors (Not Selected in purple, Selected in green, N/A in grey) and radio buttons for 'National MOMs (composite of all basins)' (selected) and 'Blended or Single MEOWs (basin specific)'. It also features a 'Category' selector with options TS 1, 2, 3, 4, 5, and buttons for 'Remove from Map', 'Update', and 'Export Data'. The 'Hindcasts' section has a 'Choose storm:' dropdown menu set to 'BETA (2020) - published 09/22/20' and buttons for 'Display on Map', 'Update', and 'Export Data'.

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**

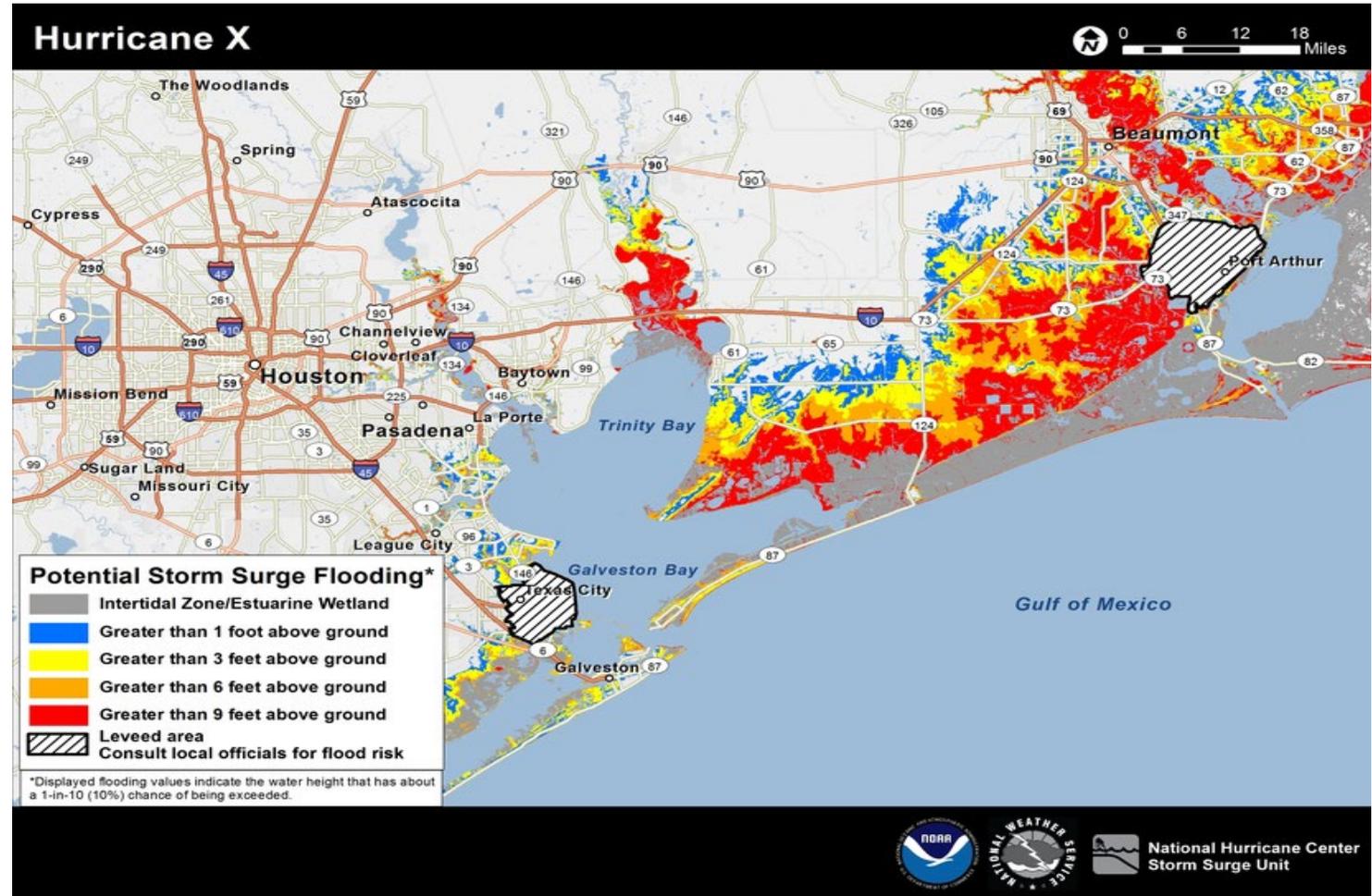


STORM SURGE

Potential Storm Surge Flooding Map

INUNDATION MAP

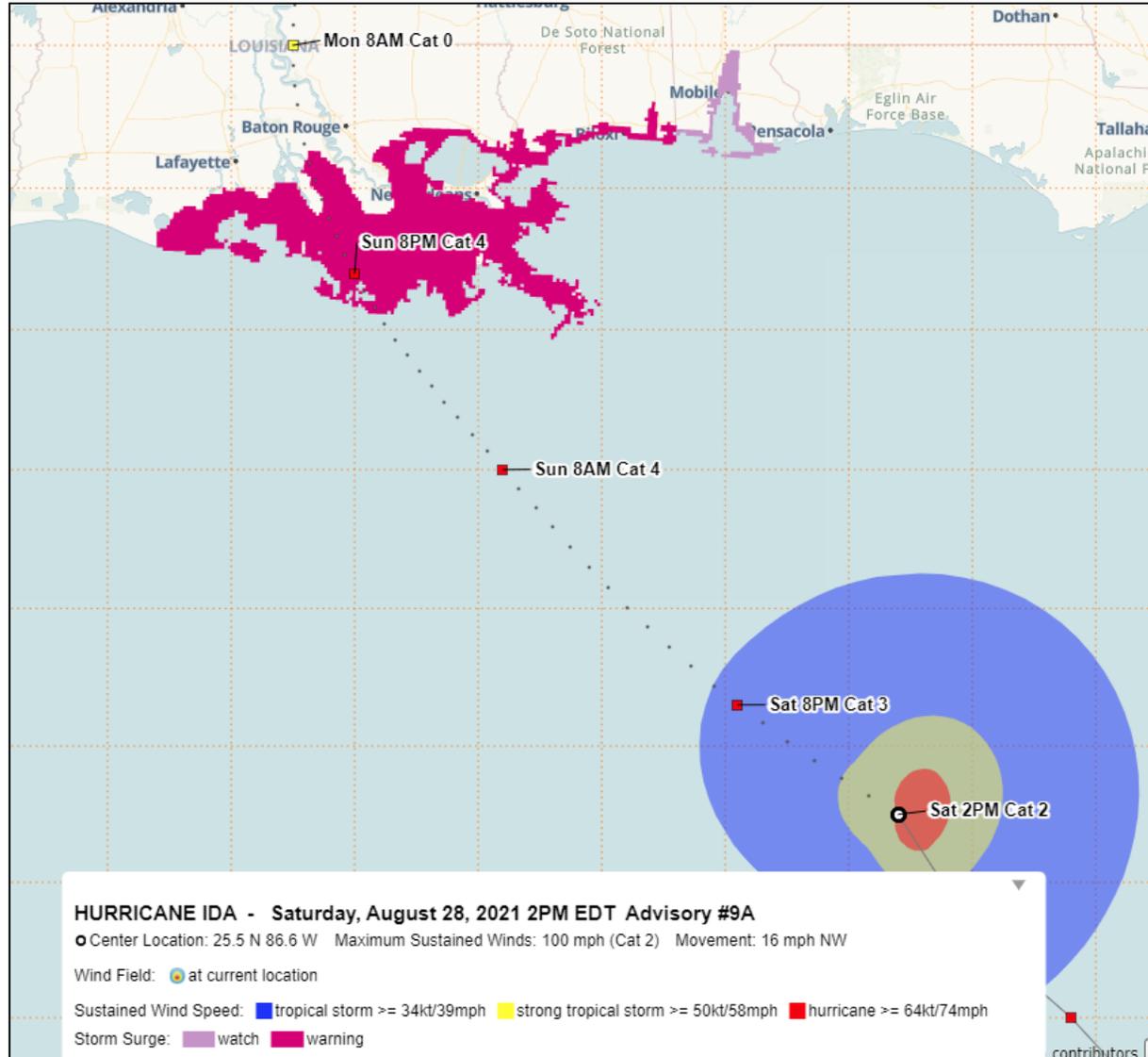
- Height above ground that the water could reach
 - Reasonable worst-case scenario for any individual location
 - Values have a 10% chance of being exceeded
- Issued up to ~72 hours prior to the onset of the hazard
- Available ~60-90 minutes after the advisory release



STORM SURGE

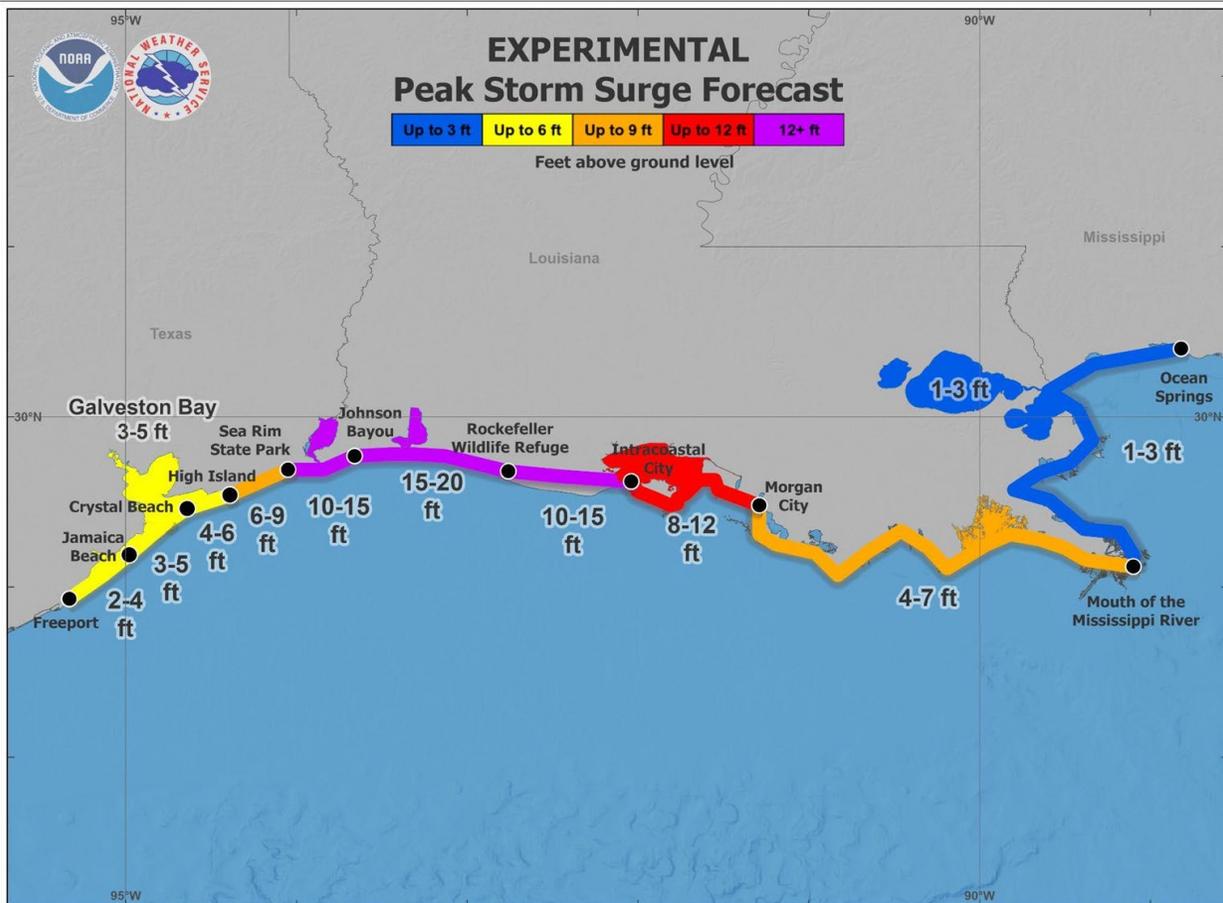
Watches and Warnings

- 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.



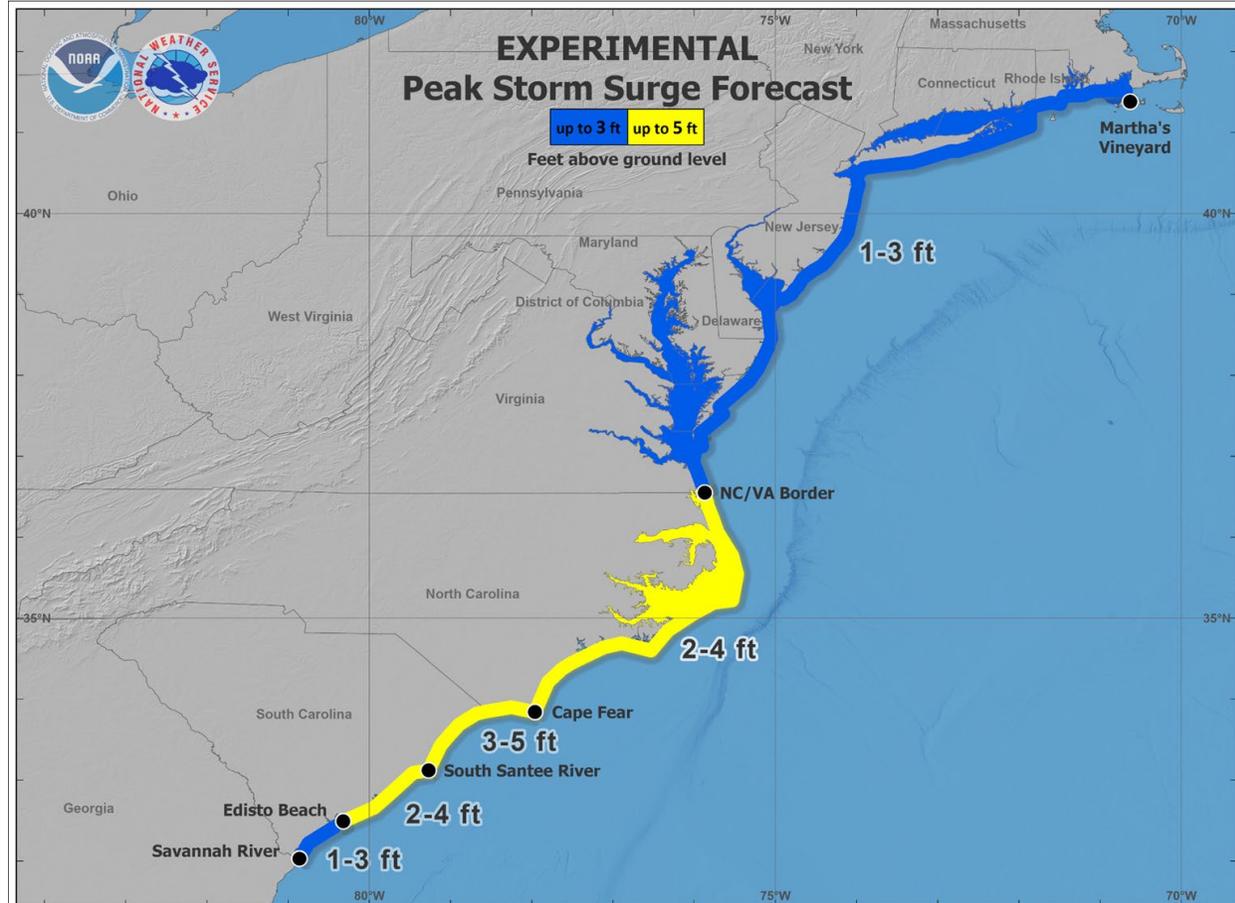
STORM SURGE

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

The screenshot displays the HURREVAC Tropical Weather Outlook interface. The main map shows the Americas with several colored overlays: a large yellow-green area in the Atlantic Ocean, a brown oval in the Gulf of Mexico, and a smaller yellow-green oval in the Caribbean. A red 'X' is located in the Atlantic. The interface includes a sidebar with a 'Filter Storms' section and a 'Tropical Weather Outlook' section. Three callout boxes on the left point to specific features: 'Watches and Warnings' points to the 'Filter Storms' section, 'Peak Storm Surge Graphic' points to a storm surge icon in the sidebar, and 'Potential Storm Surge Flooding Map' points to a flooding map icon in the sidebar. The bottom of the screen shows a legend for 'Tropical Weather Outlook for Thursday, June 13, 2024 7:35AM EDT' and a copyright notice for MapTiler and OpenStreetMap contributors.

HURREVAC

Tropical Weather Outlook

Date: 06/13/2024 Time: 2 AM 8 AM 2 PM 8 PM

Filter Storms

Name	Basin
Active Storms	
Current Year Storms	
Archived Storms	
Exercise Storms	
Simulated Storms	

Watches and Warnings

Peak Storm Surge Graphic

Potential Storm Surge Flooding Map

Tropical Weather Outlook

- Tropical Weather Outlook
- Text Advisories
- Reports
- Storm Surge
- Evacuation Timing
- Training
- Storm Simulator

Tropical Weather Outlook for Thursday, June 13, 2024 7:35AM EDT

Current Disturbances and 7-Day Cyclone Formation Chance: <40% 40-60% >60%

Tropical or Sub-Tropical Cyclones: depression storm hurricane post-tropical or remnants

© MapTiler © OpenStreetMap contributors Basemaps

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



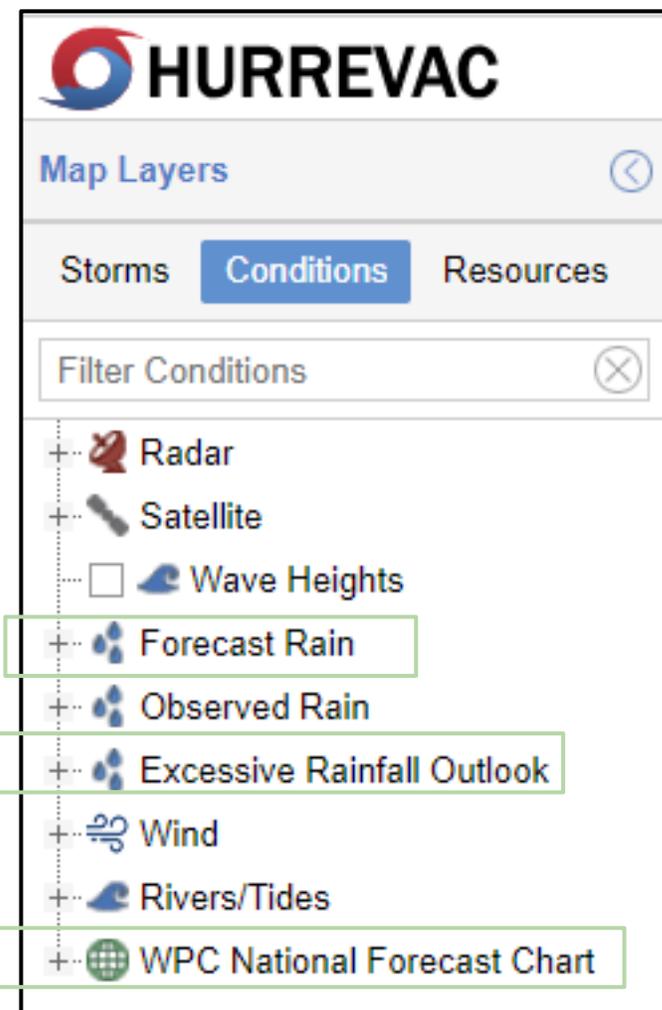
Outline

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



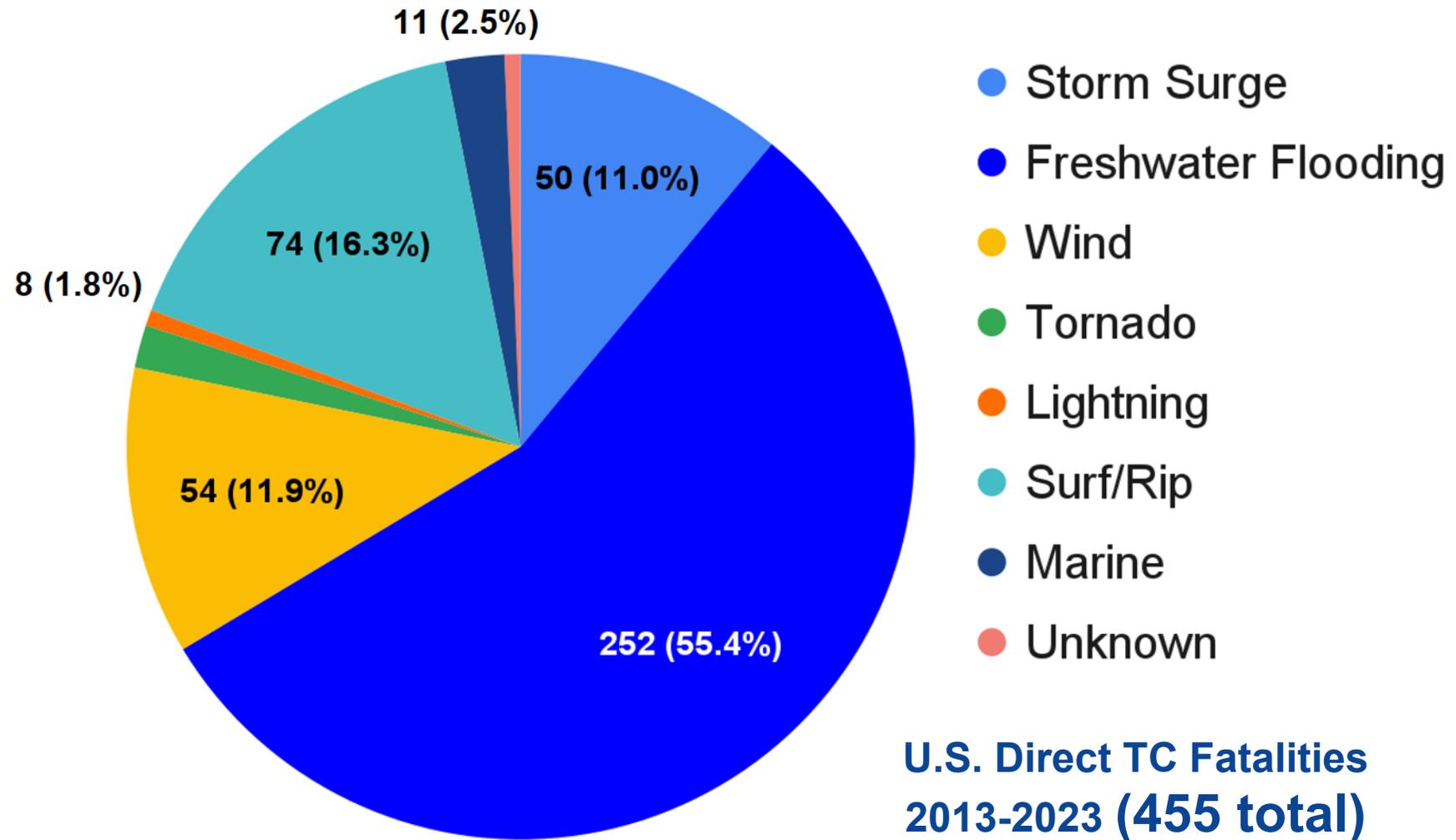


- **WPC provides tropical cyclone rainfall information for land areas in the highlighted domain**
- This information is inserted into the official advisory products and Key Messages via coordination with NHC, CPHC, and the National Water Center
- For the CONUS, we provide QPF, ERO, MPD that help illustrate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



Rainfall: Most Consistently Deadly TC Hazard

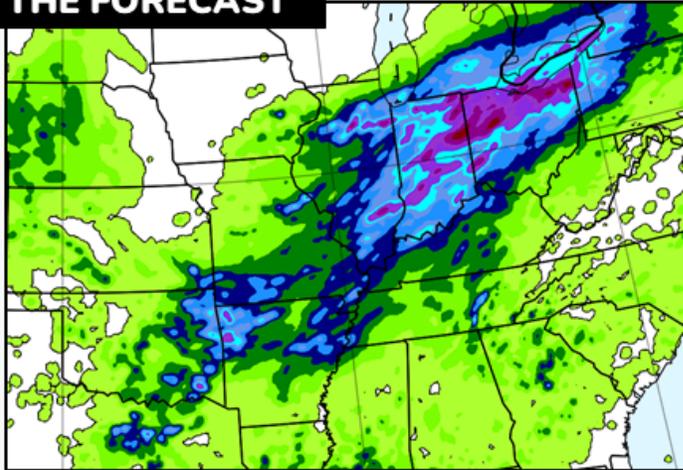
- Storm surge still has the potential to cause the greatest single event fatalities, but...
- Rainfall-induced flooding is the most consistently deadly hazard
- 55% of all direct U.S. tropical cyclone fatalities in the past 11 years
- ***Follows Rappaport (2014) study that found freshwater flooding was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



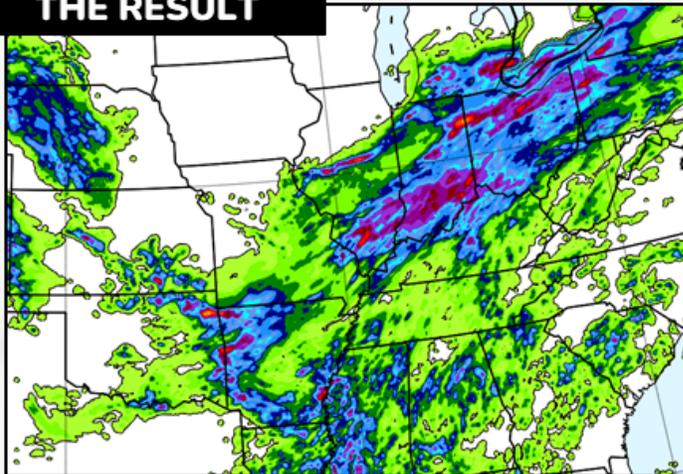
Source: National Hurricane Center

Quantitative Precipitation Forecast (QPF)

THE FORECAST

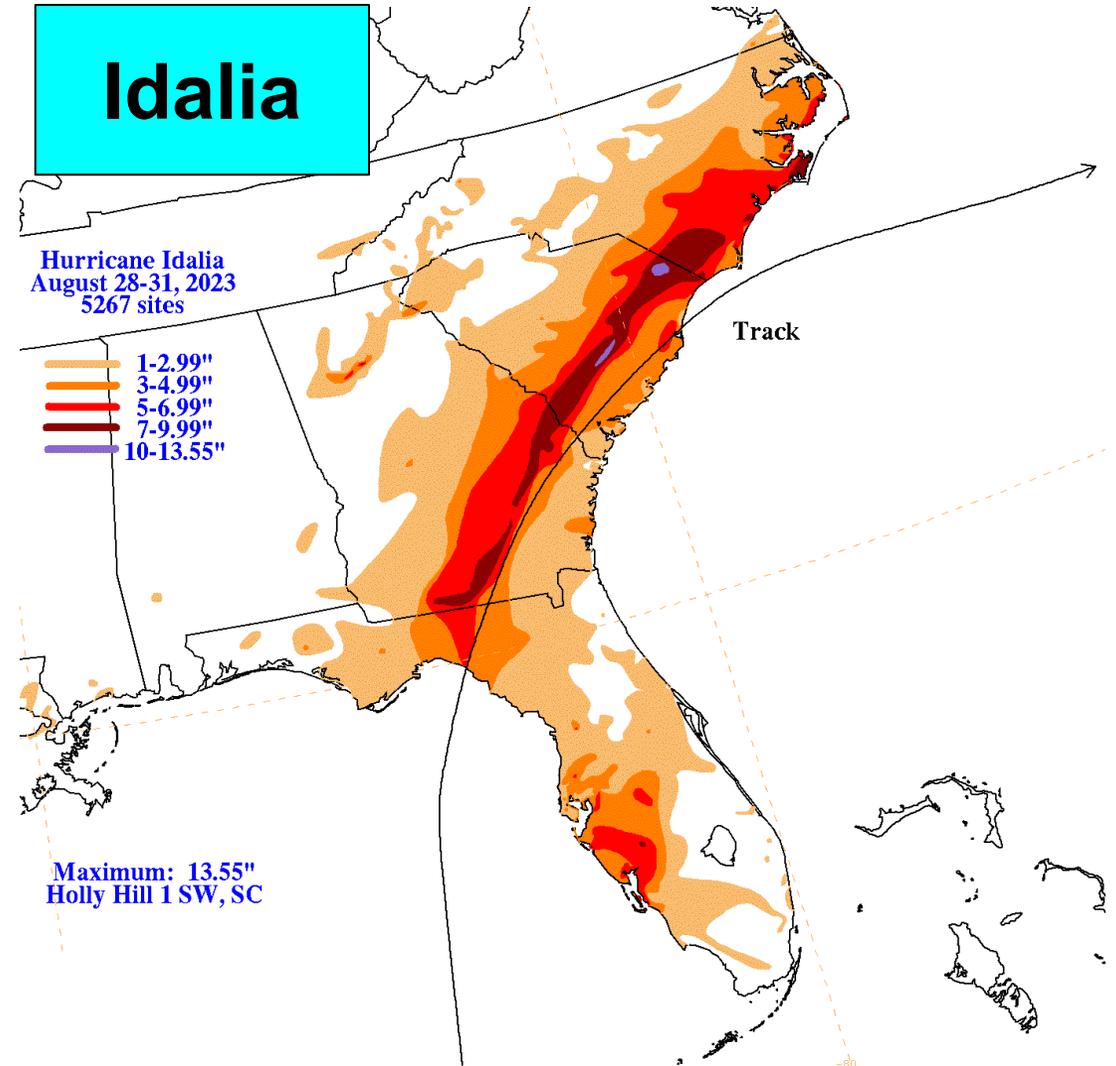
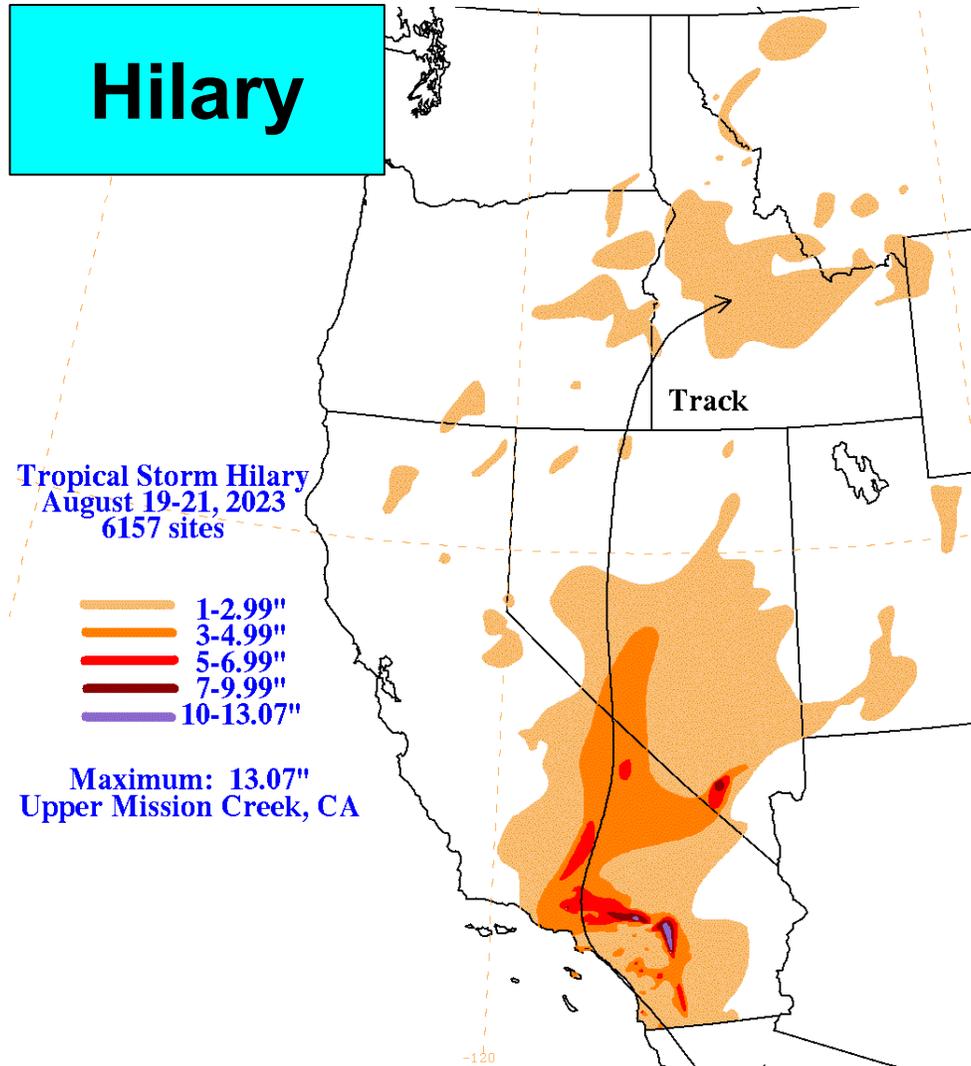


THE RESULT



- 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.

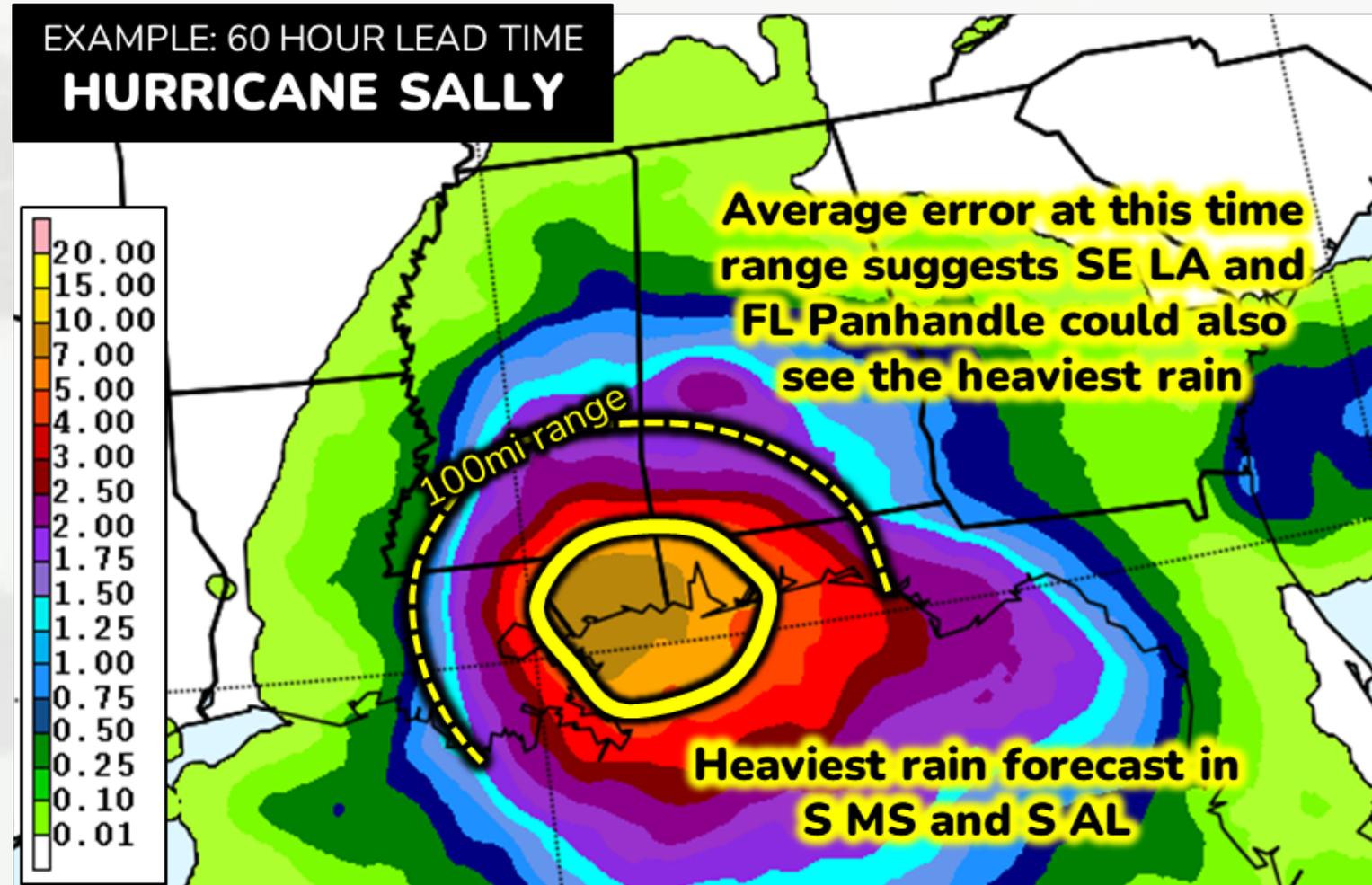
2023 Cyclones With Notable Rainfall Impacts



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)

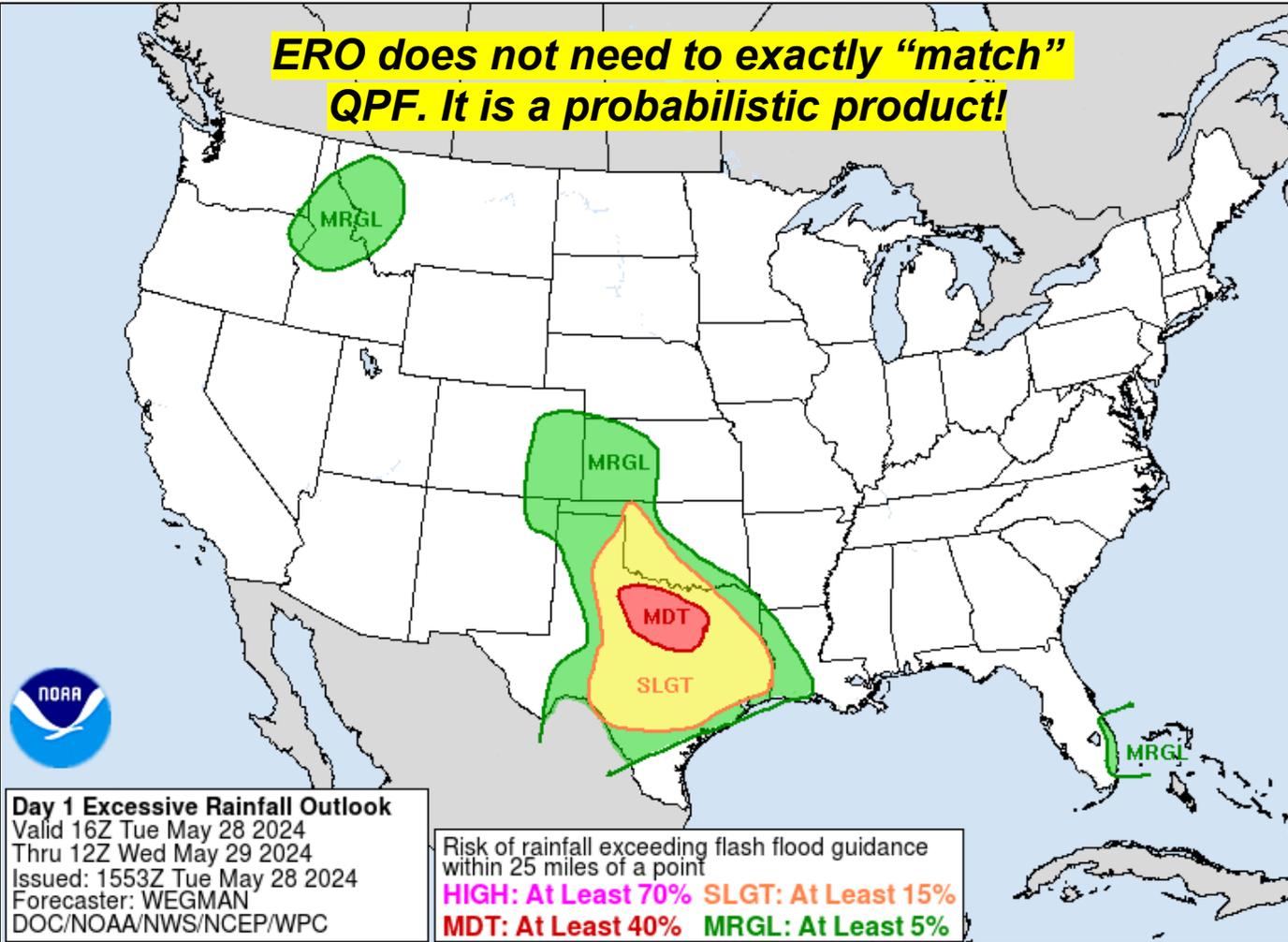
ERO does not need to exactly "match" QPF. It is a probabilistic product!

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

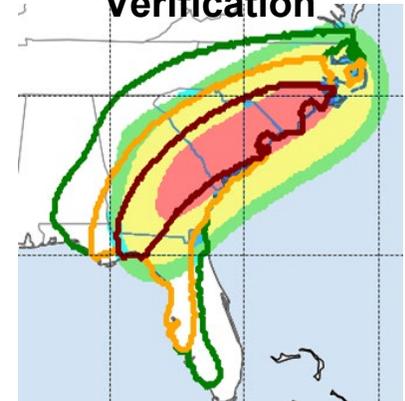


Day 1 ERO

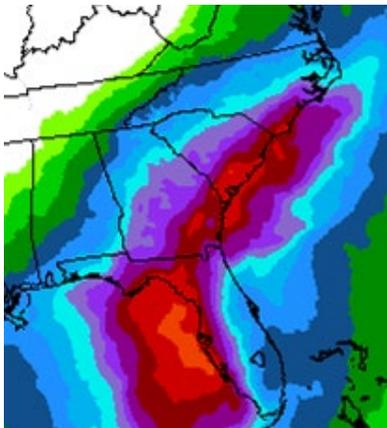
5hr Lead Time



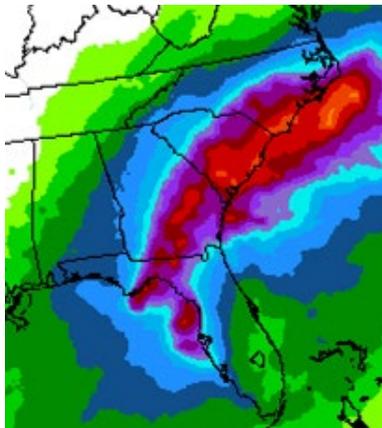
Practically Perfect Verification



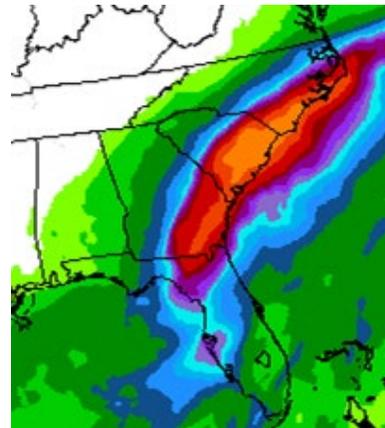
Day 5 QPF



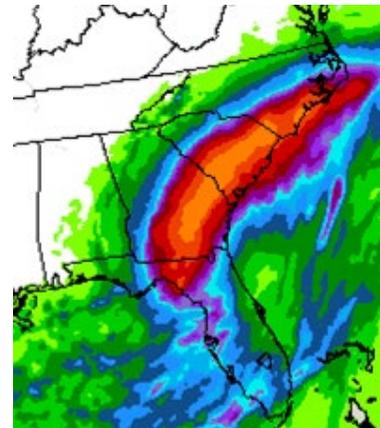
Day 4 QPF



Day 3 QPF



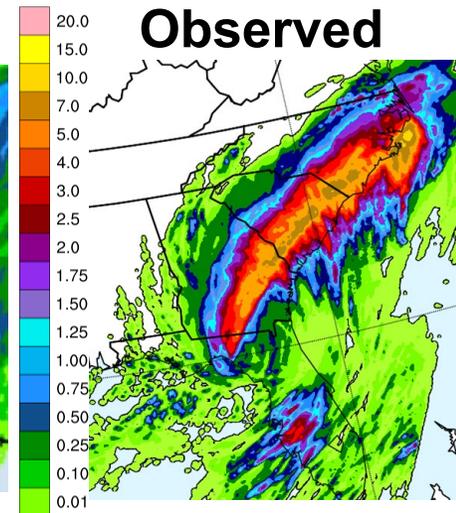
Day 2 QPF



Day 1 QPF

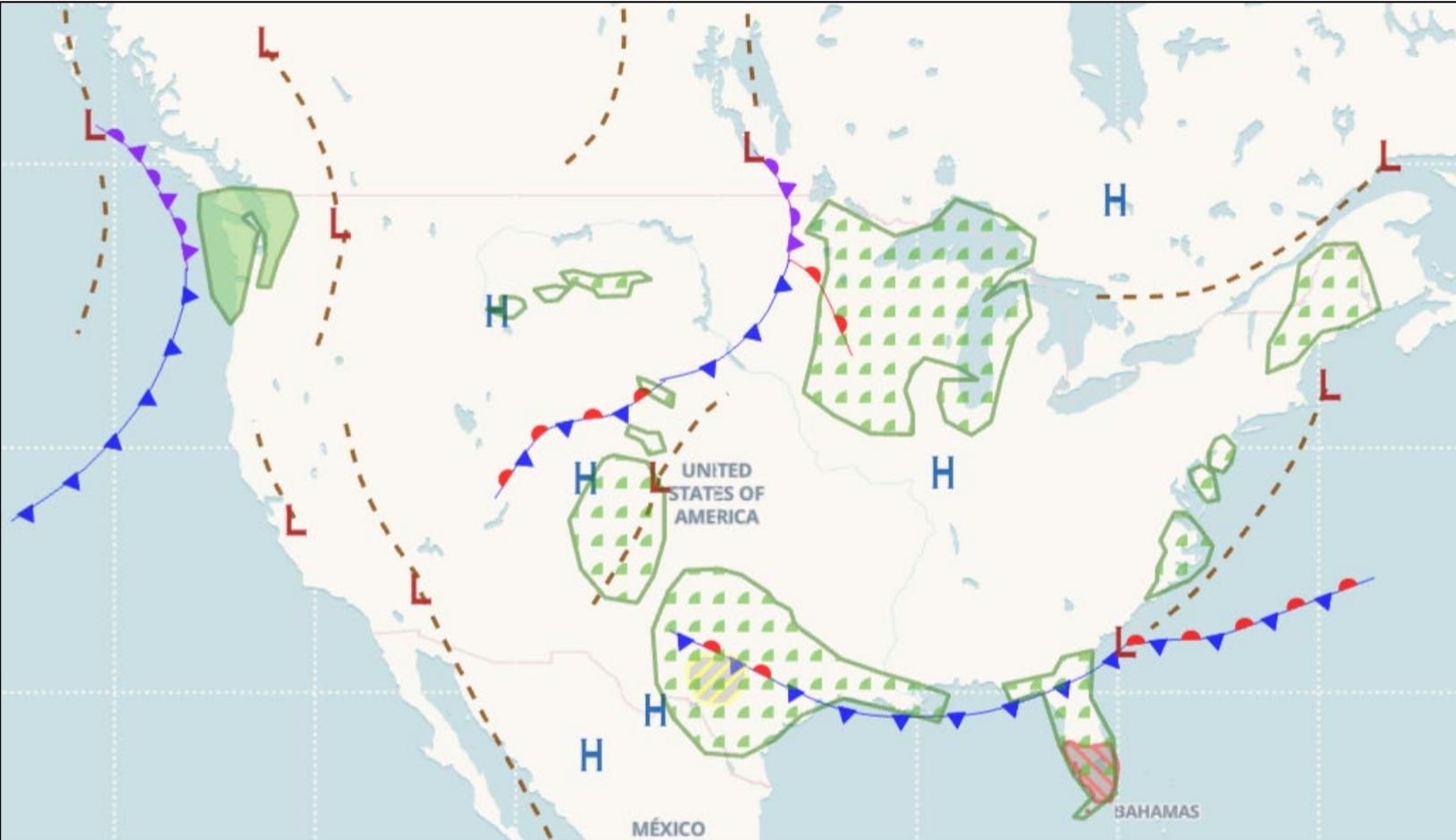


Observed



WEATHER PREDICTION CENTER
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

National Forecast Chart



- WPC National Forecast Chart
- Day 1 Fronts
- Day 1 Precipitation

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

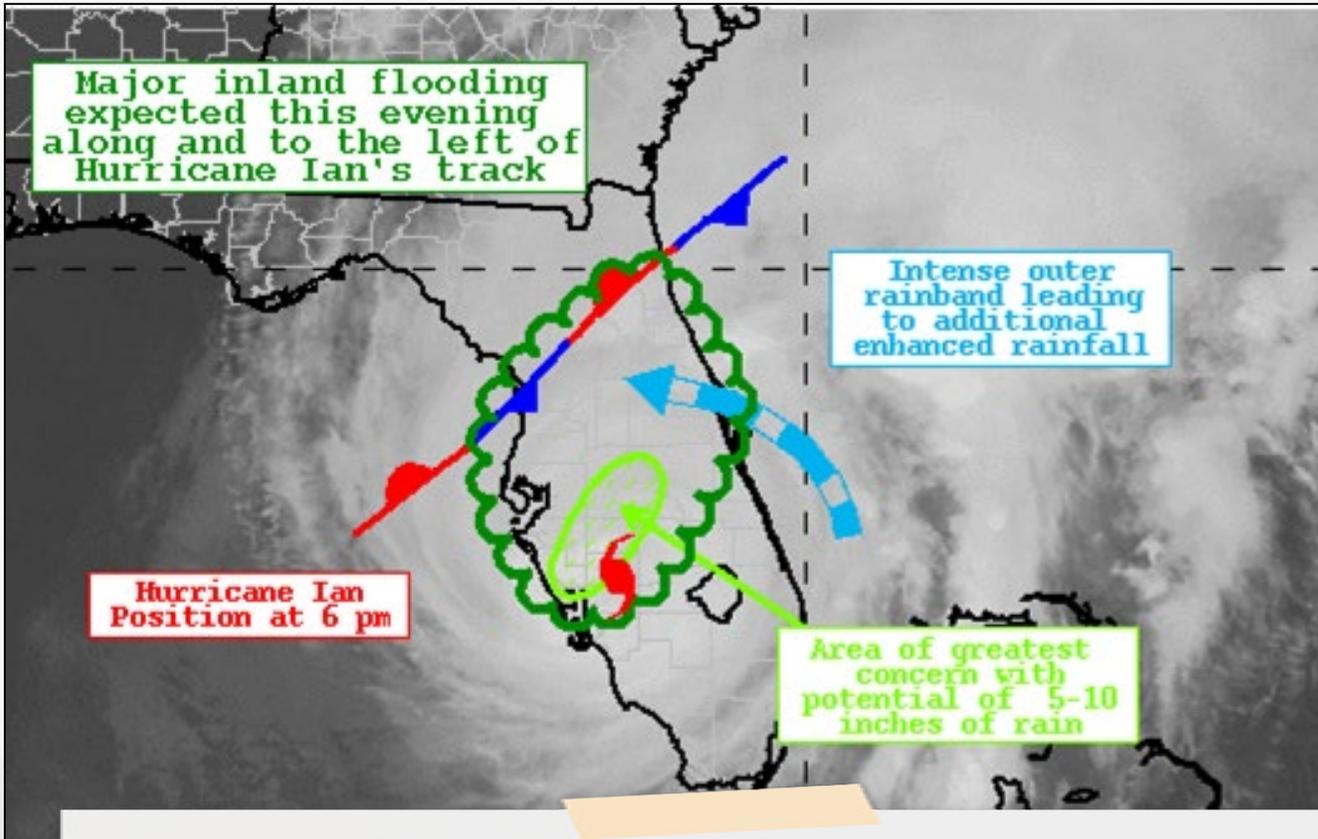
<https://www.wpc.ncep.noaa.gov/>



WEATHER PREDICTION CENTER
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

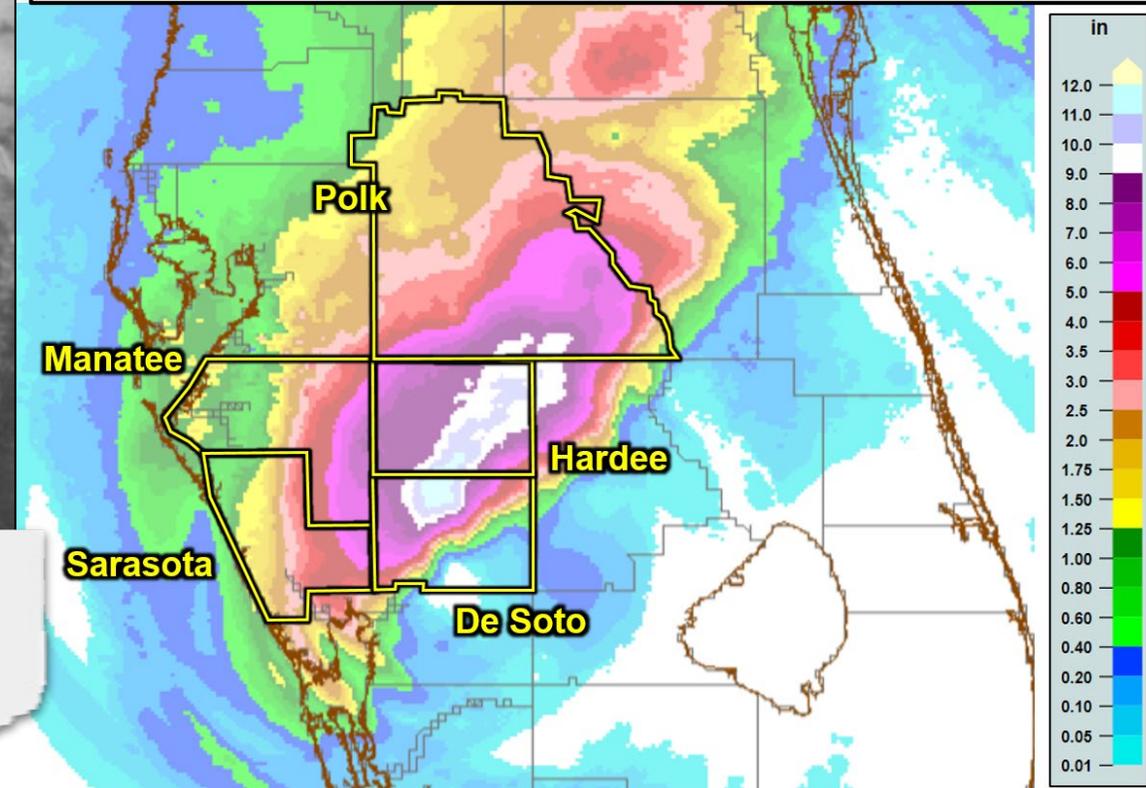
Not Yet in HURREVAC...

Mesoscale Precipitation Discussion (MPD)



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



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



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?

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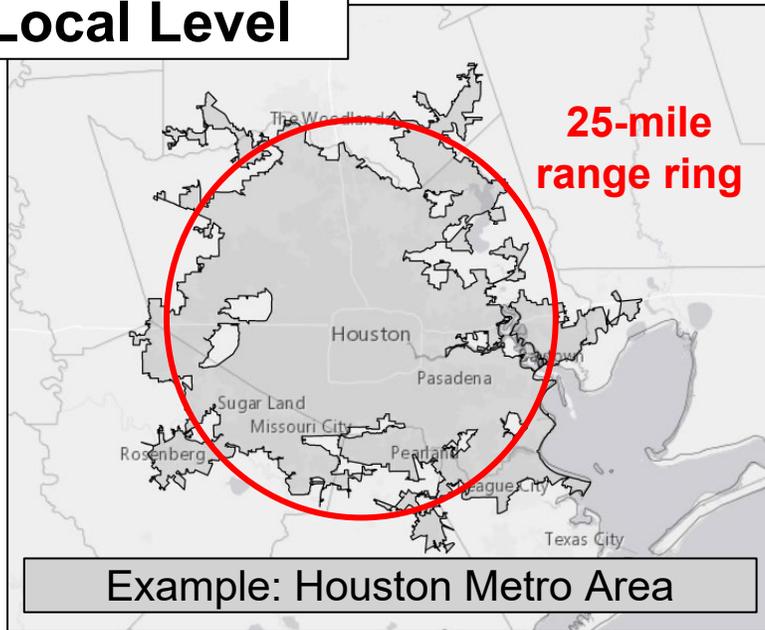


WEATHER PREDICTION CENTER
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

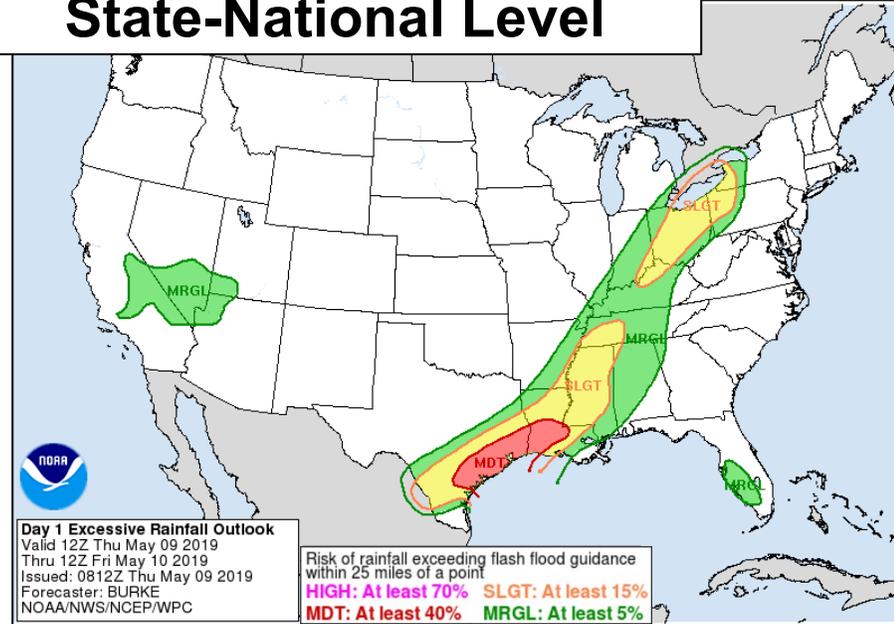
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Background: Interpretation of the ERO

Local Level



State-National Level



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.

- 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?”

- 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

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

Understanding WPC Excessive Rainfall Risk Categories				
No Area/Label	MARGINAL (MRGL)	SLIGHT (SLGT)	MODERATE (MDT)	HIGH (HIGH)
Flash floods are generally not expected.	Isolated flash floods possible	Scattered flash floods possible	Numerous flash floods likely	Widespread flash floods expected
	Localized and primarily affecting places that can experience rapid runoff with heavy rainfall.	Mainly localized. Most vulnerable are urban areas, roads, small streams and washes. Isolated significant flash floods possible.	Numerous flash flooding events with significant events possible. Many streams may flood, potentially affecting larger rivers.	Severe, widespread flash flooding. Areas that don't normally experience flash flooding, could. Lives and property in greater danger.
@NWSWPC				
Flash flooding near me?	Flash Flooding	Flash Flooding	Flash Flooding	Flash Flooding
NO Flash Flooding				

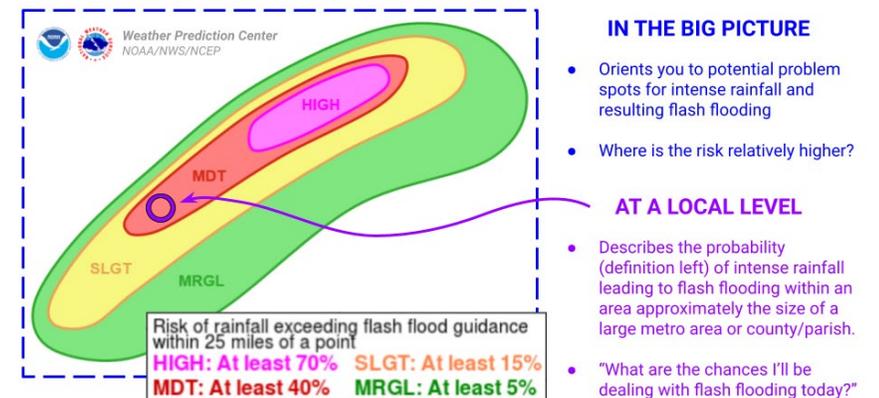
Comprendiendo las categorías de riesgos de lluvias excesivas de WPC				
(Sin área o etiqueta)	MARGINAL (MRGL)	LIGERO (SLGT)	MODERADO (MDT)	ALTO (HIGH)
No se esperan inundaciones repentinas en general.	Inundaciones repentinas aisladas posibles	Inundaciones repentinas dispersas posibles	Numerosas inundaciones repentinas probables	Inundaciones repentinas generalizadas
	Localizadas y primordialmente afectando lugares susceptibles a inundaciones cuando llueve fuerte.	Generalmente localizadas. Las áreas más vulnerables son las urbanas, caminos y arroyos pequeños. Son posibles inundaciones significativas aisladas.	Varios eventos de inundaciones, con algunas significativas posibles. Varios arroyos pueden inundarse, afectando ríos grandes.	Inundaciones severas generalizadas. Pueden inundarse áreas que normalmente no lo hacen. Vidas y propiedades en alto riesgo.
@NWSWPC				
Inundación cerca a mí?	SI	SI	SI	SI
NO cerca				

HIGH RISK OF EXCESSIVE RAINFALL

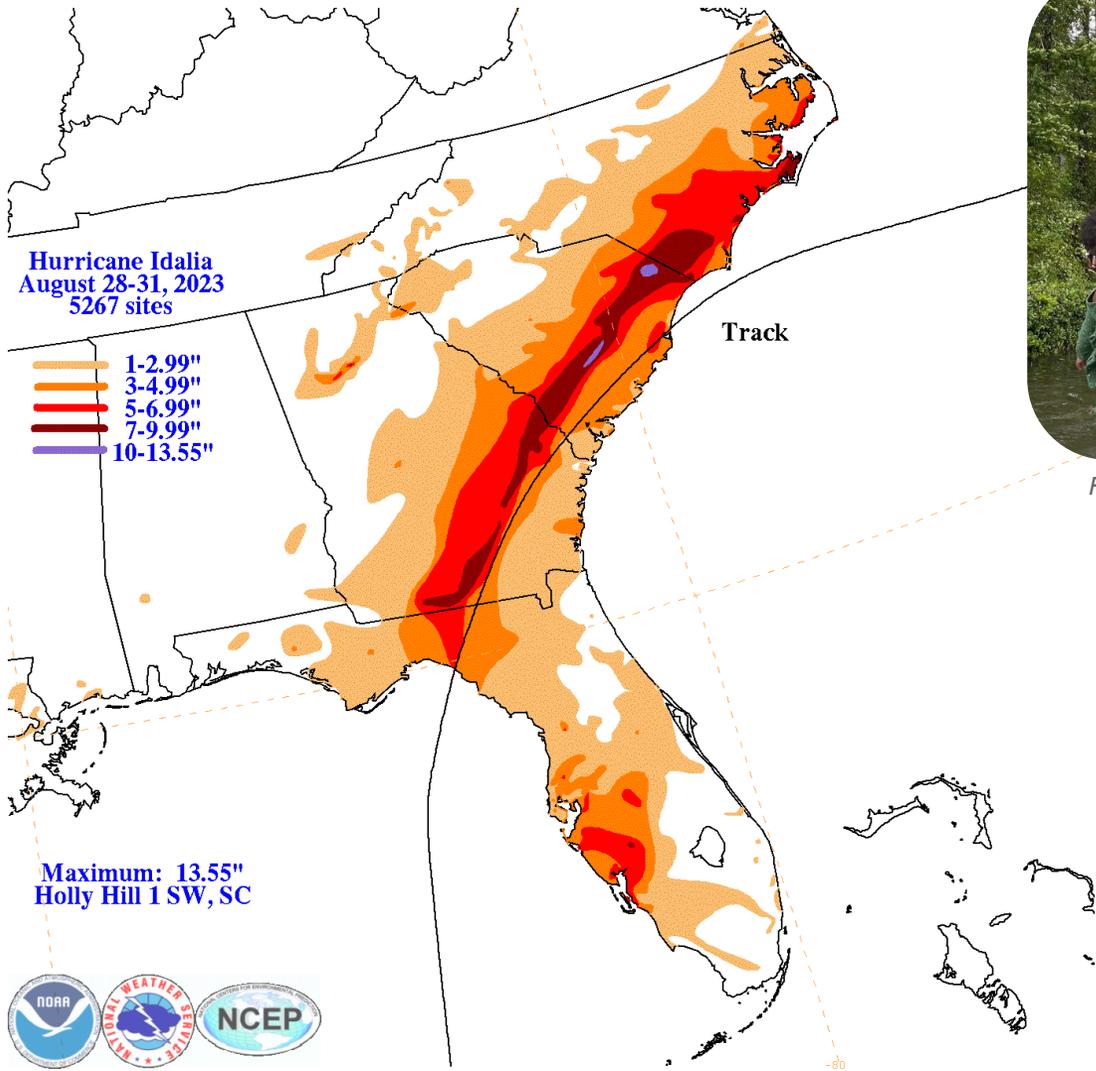
Potentially deadly and damaging flash flood day. Pay attention!

- Make sure emergency alerts are enabled on your smart phone for urgent Flash Flood Warnings
- Have multiple ways to receive a warning if you live in an area vulnerable to flash flooding
- Consider postponing non-essential road travel. The majority of flood deaths occur with vehicles.

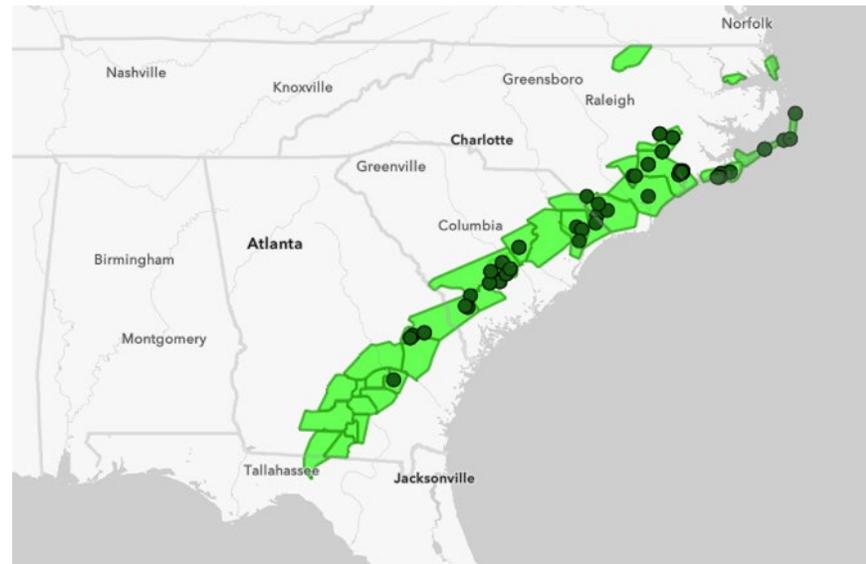
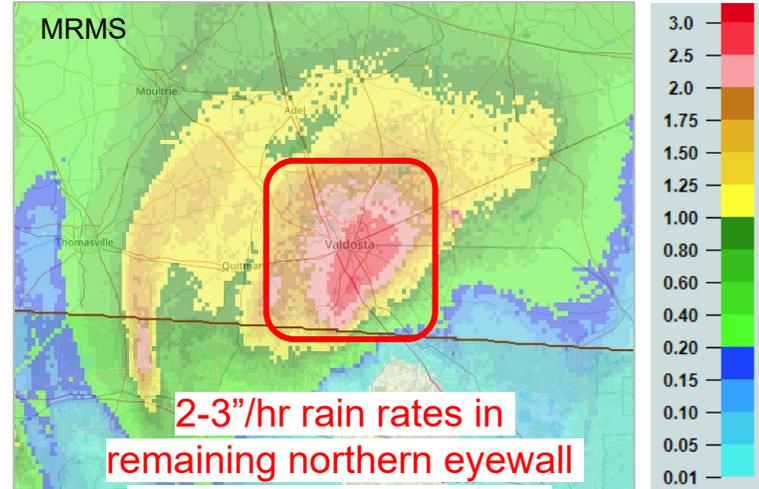
INTERPRETING THE EXCESSIVE RAINFALL OUTLOOK



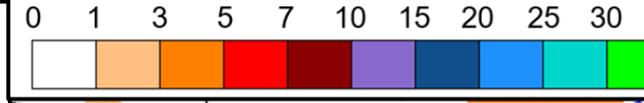
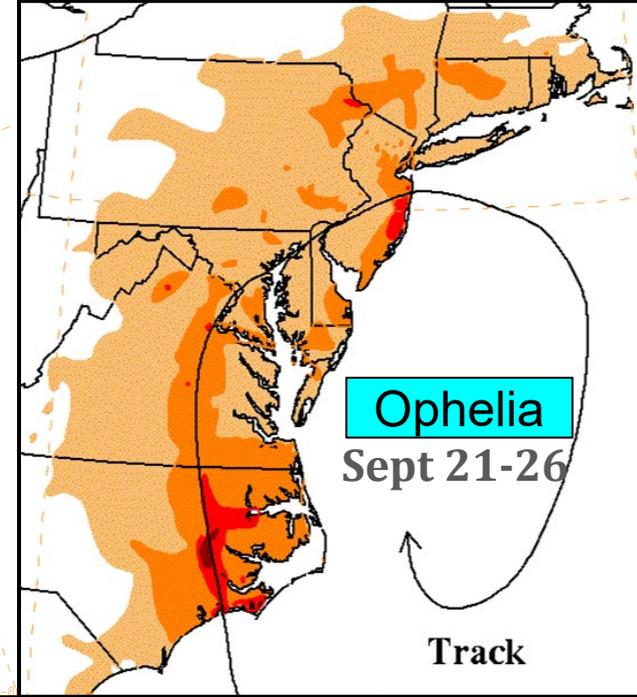
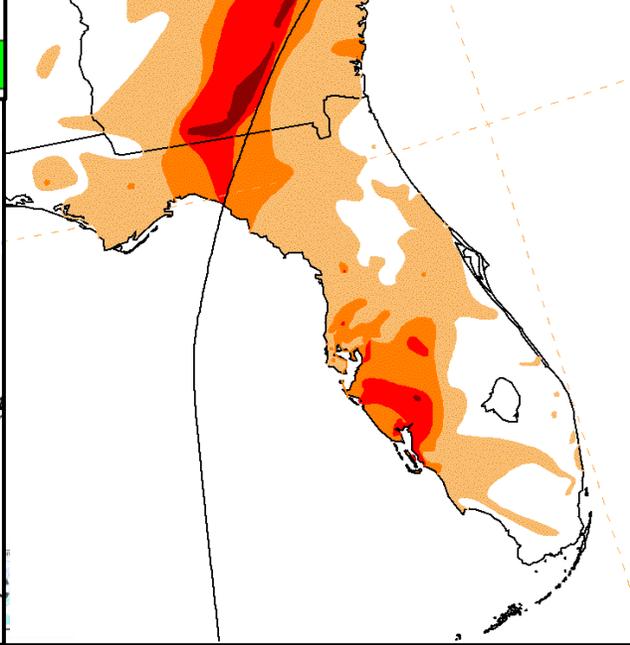
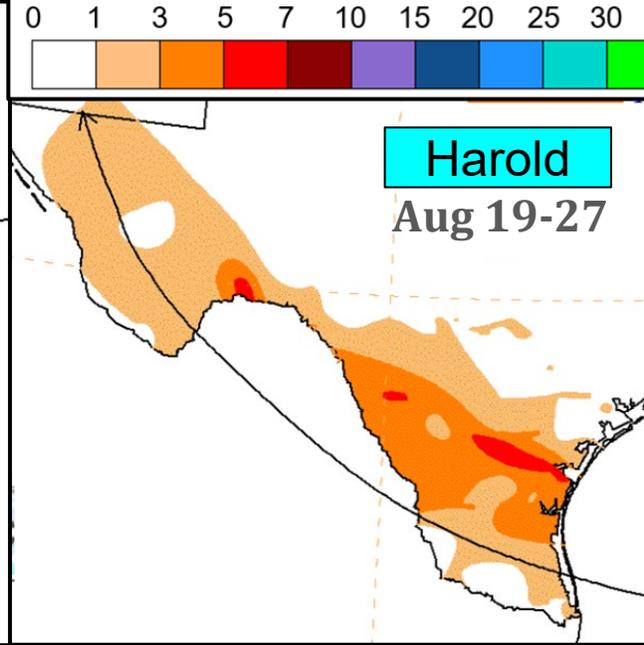
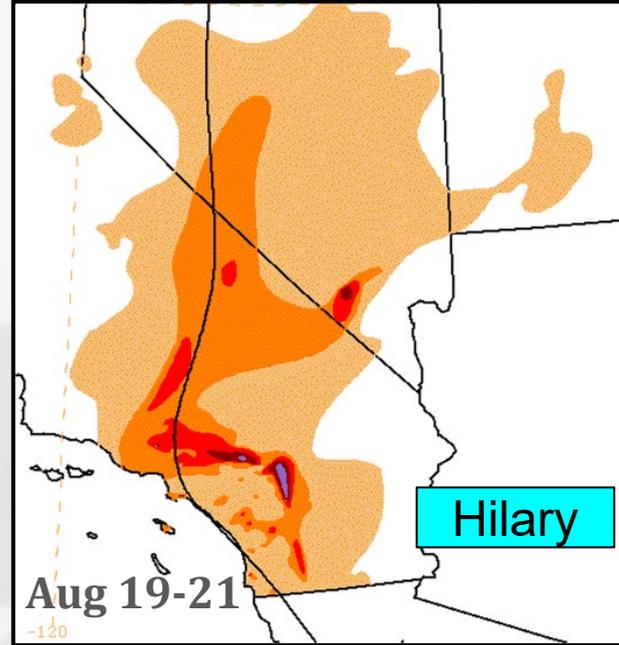
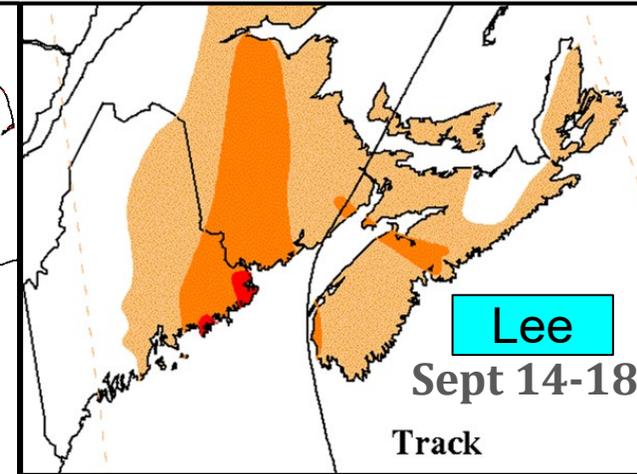
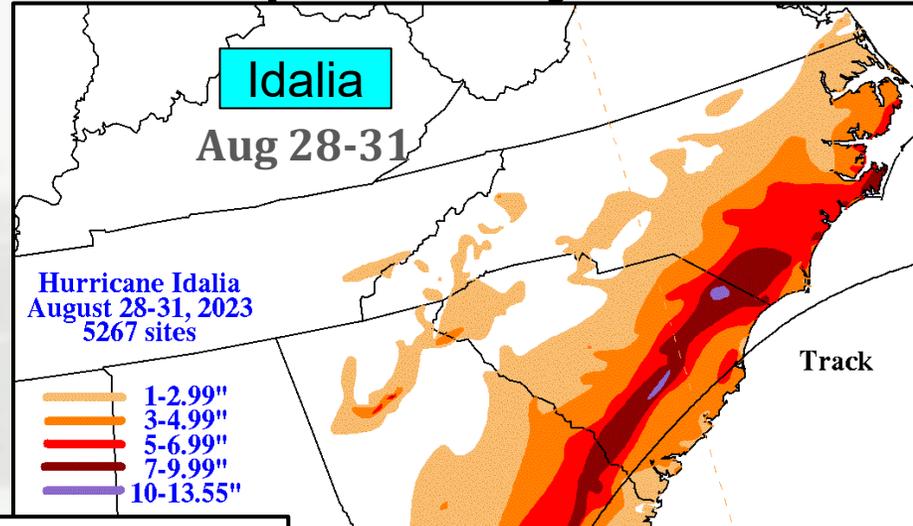
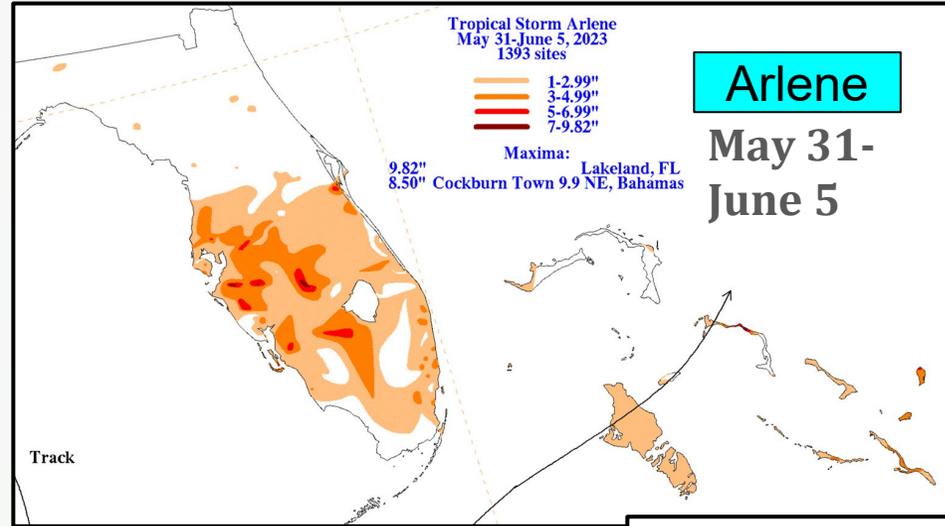
Hurricane Idalia Rainfall Impacts



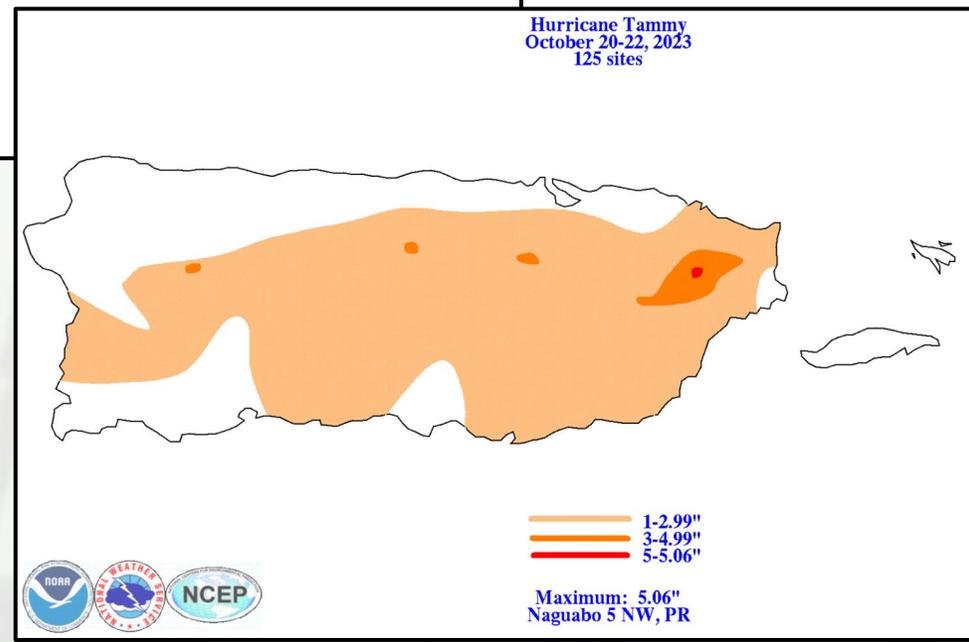
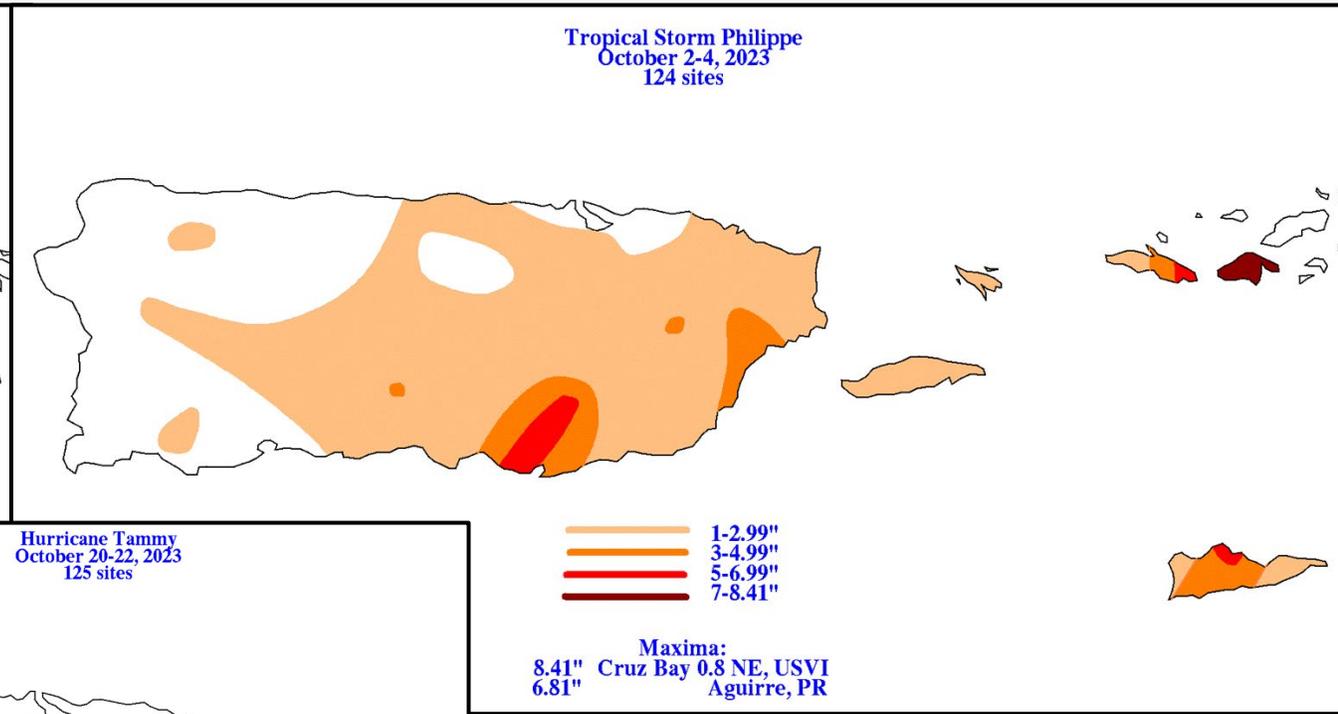
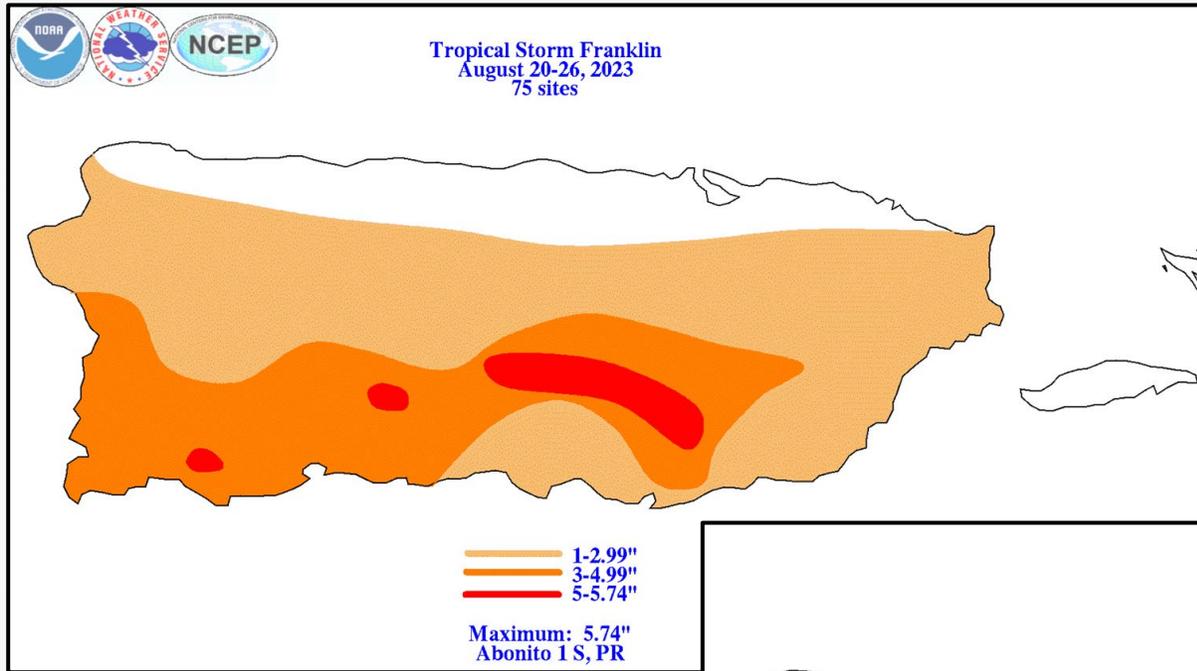
Flooding in Valdosta, Georgia (Valdosta Fire Dept)



2023 Review: Lower 48 Tropical Cyclone Rainfall Events



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



Hilary



WEATHER PREDICTION CENTER
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

HURREVAC Demo



◆ 100 Kilometers

986

992



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
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FEMA



NATIONAL HURRICANE PROGRAM



HURREVAC

HURRICANE DECISION SUPPORT TOOL