

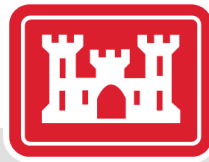
# 2023 HURREVAC Training Webinar Series

## Day 4 – Storm Surge and Other Water Hazards

June 15, 2023



**FEMA**



NATIONAL HURRICANE PROGRAM



**HURREVAC**

HURRICANE DECISION SUPPORT TOOL

# Administrative Details



## Downloadable handouts

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

## Live Transcription

- English / Español
- Links in the chat window

## Questions

- Submit in the question box
- All attendees are muted

## Registration

- Registration still open for Day 5

## Feedback

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

## Certificate

- One for each day attended
- Emailed about **one hour** after conclusion
- Goes only to the email used for signup

## Recording

- Will be on HURREVAC's YouTube channel
- Available as a year-round resource





## THIS WEEK'S AGENDA

**JUNE 12:** Introduction to HURREVAC and General Overview of the Program

**JUNE 13:** Wind Forecast Features

**JUNE 14:** Evacuation Timing Features

**JUNE 15: Storm Surge and Other Water Hazards**

**JUNE 16:** Exercise Tools and Applying HURREVAC

All sessions begin at 2 PM EDT and run for approximately 90 minutes.

Registration is still open for Days 5!



## Today's Presenters

### **Laura Alaka**

Storm Surge Specialist, National Hurricane Center

[laura.alaka@noaa.gov](mailto:laura.alaka@noaa.gov)

### **Heather Nepaul, Ph.D.**

Storm Surge Specialist, National Hurricane Center

[heather.nepaul@noaa.gov](mailto:heather.nepaul@noaa.gov)

### **Brian Hurley**

Senior Branch Forecaster, Weather Prediction Center

[brian.hurley@noaa.gov](mailto:brian.hurley@noaa.gov)

### **John Boyer**

Sea Island Software

[johnboyer@seaislandsoftware.biz](mailto:johnboyer@seaislandsoftware.biz)





# NHC Storm Surge Unit Presentation

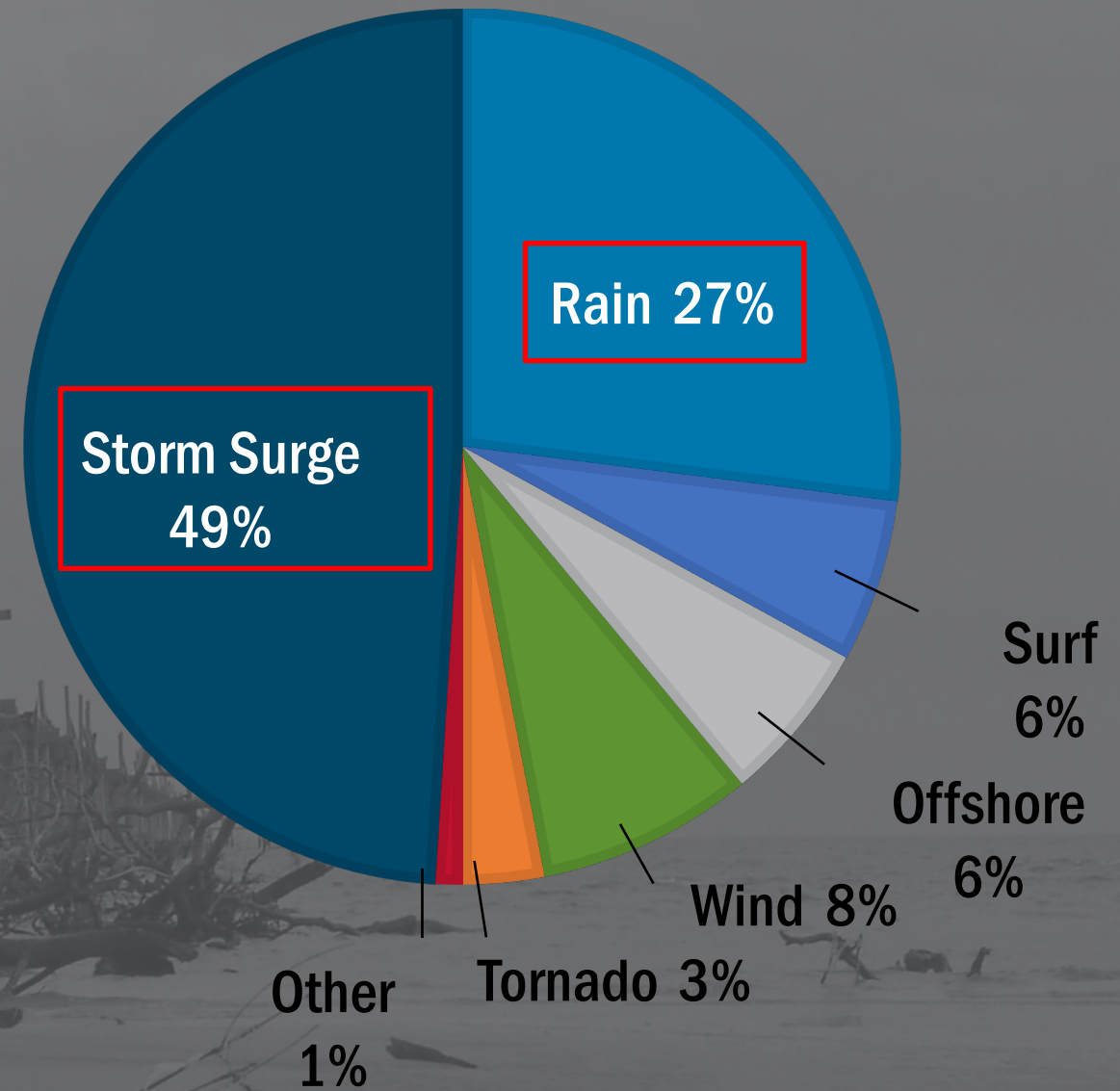


EVACUATION  
ROUTE



# US Tropical Cyclone Fatalities

(from 1963 to 2012)





# STORM SURGE

## *Storm Surge vs Storm Tide vs Inundation*

### STORM SURGE

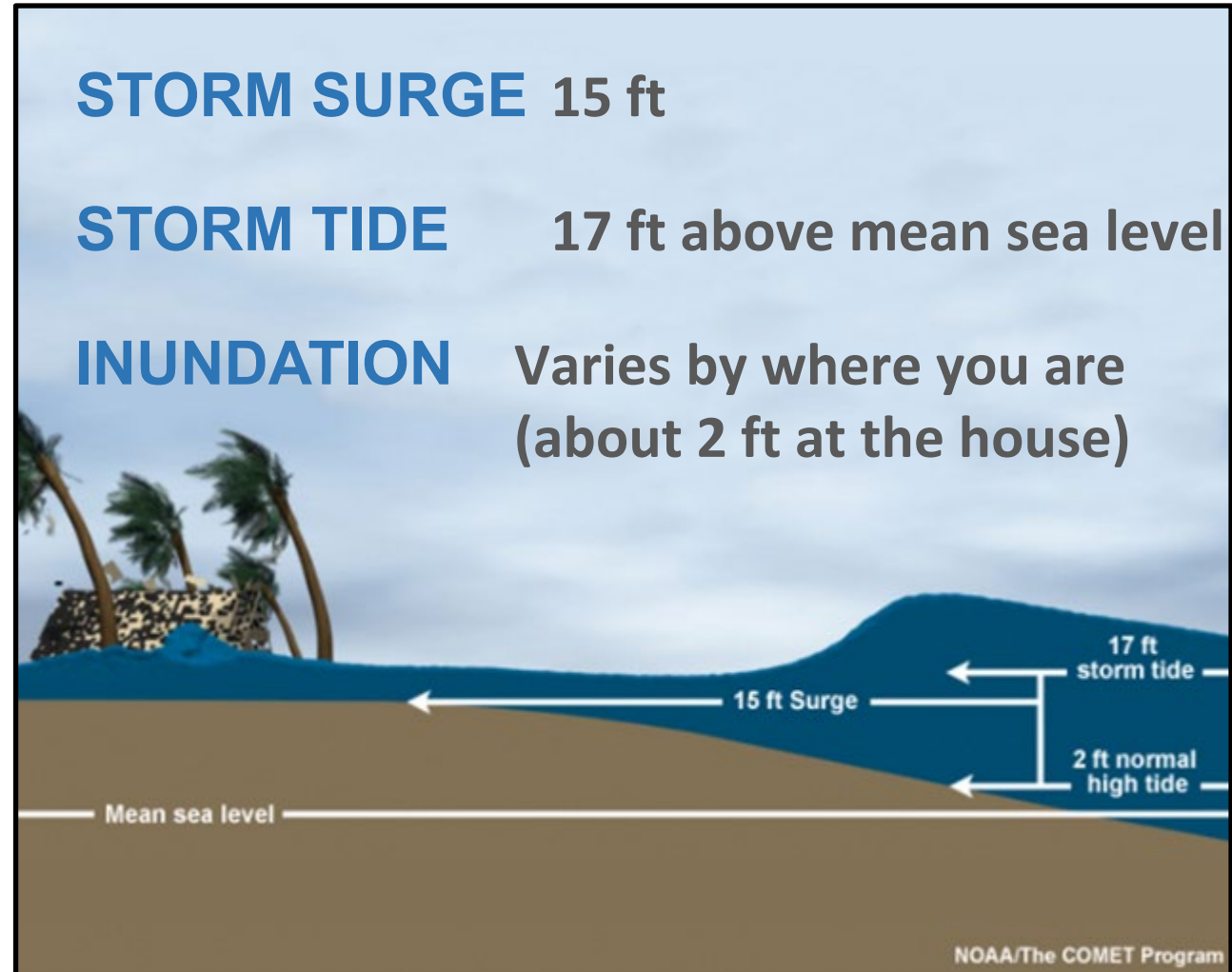
An abnormal rise of water generated by a storm, over and above the predicted astronomical tide.

### 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*

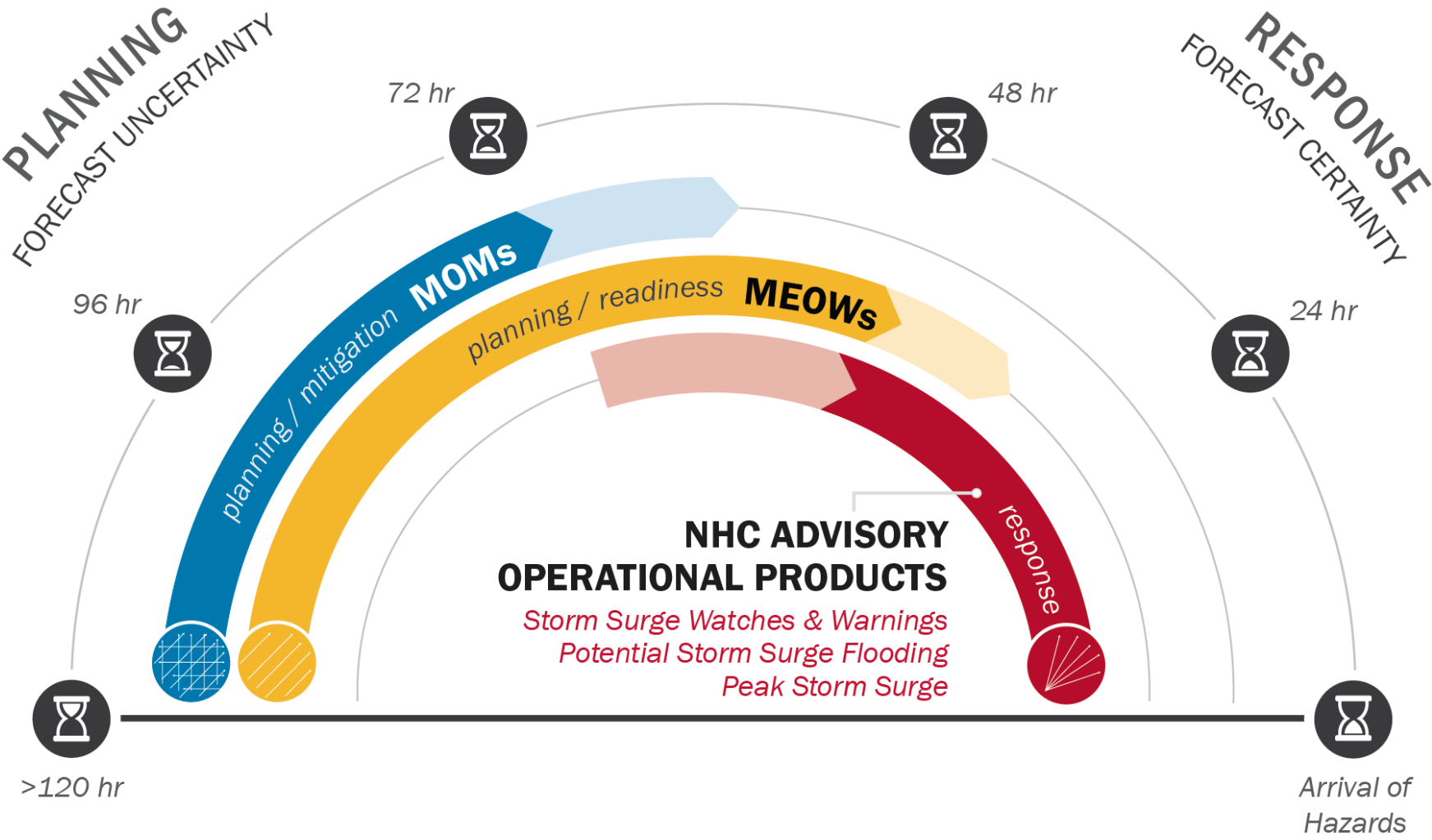
**S**ea,  
**L**ake, and  
**O**verland  
**S**urges from  
**H**urricanes

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



# STORM SURGE

## Storm Surge Risk Tools

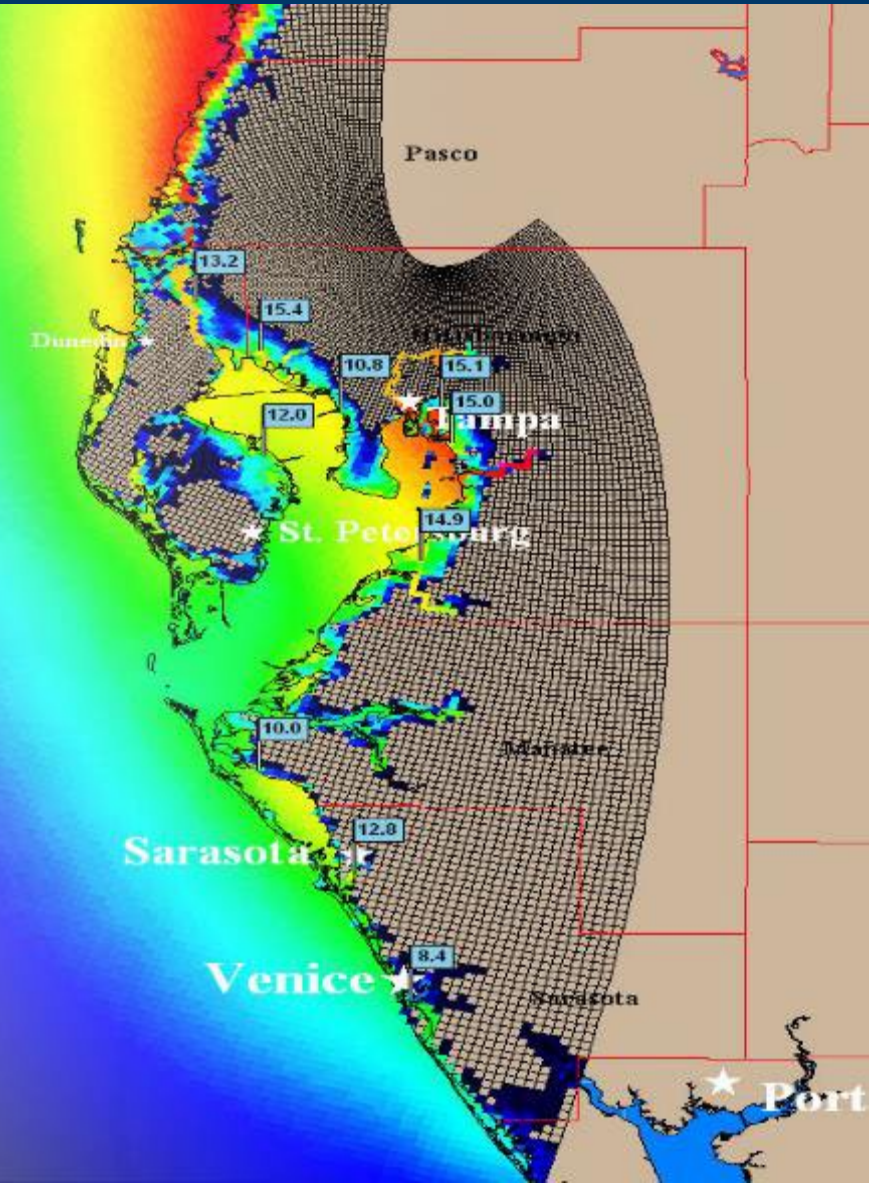


# STORM SURGE

## *Maximum of Maximums (MOM)*

### MOMs

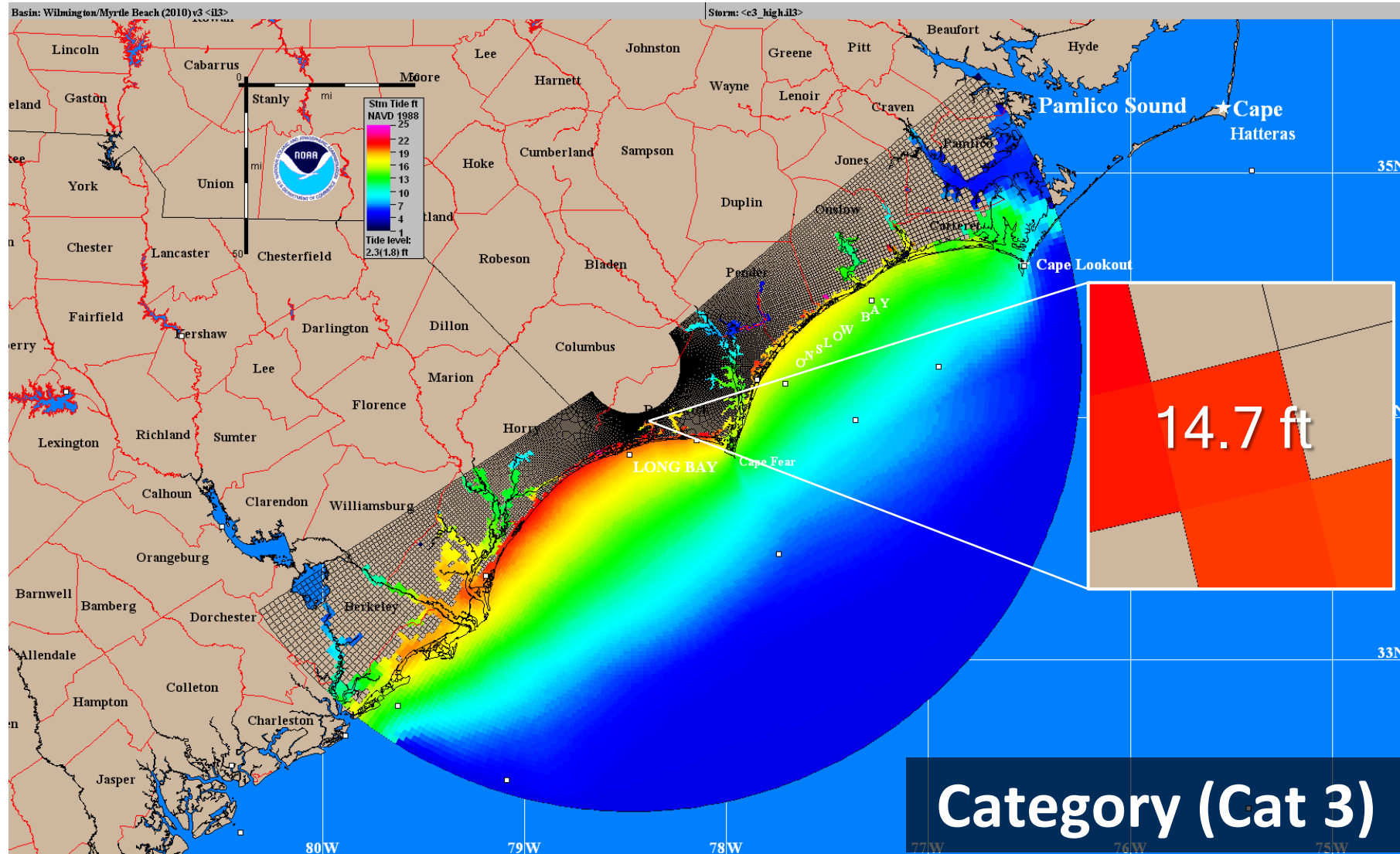
- Worst-case for a particular category storm
- Combination of many scenarios
  - Forward speed
  - Angle of approach
  - Size (Radius of maximum wind)
  - Initial tide level
- No single hurricane will produce the regional flooding depicted in a Maximum of Maximums (MOMs)





# STORM SURGE

## *Maximum of Maximums (MOM)*



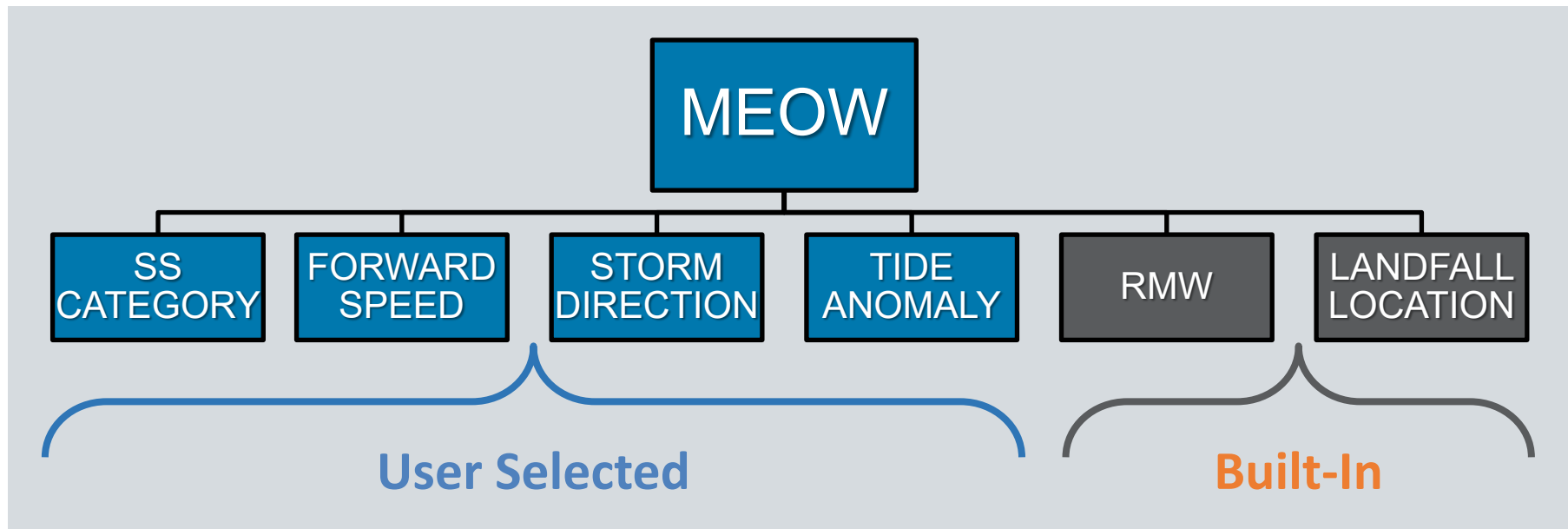


# STORM SURGE

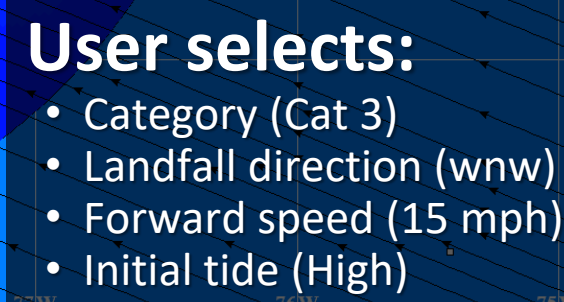
## *Maximum Envelope of Water (MEOW)*

### MEOWs

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



## Maximum Envelope of Water (MEOW)

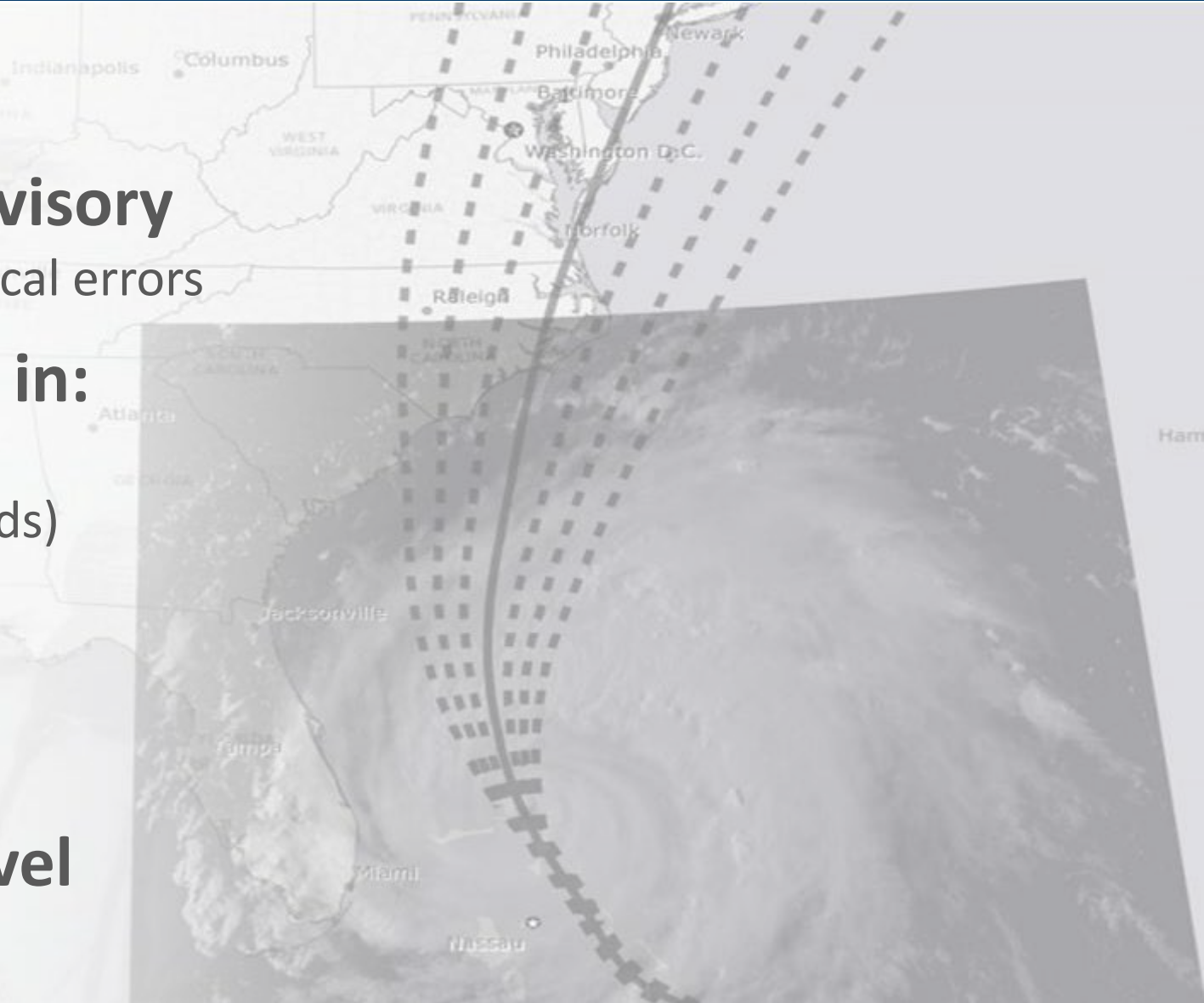


# PROBABILISTIC STORM SURGE

## *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**



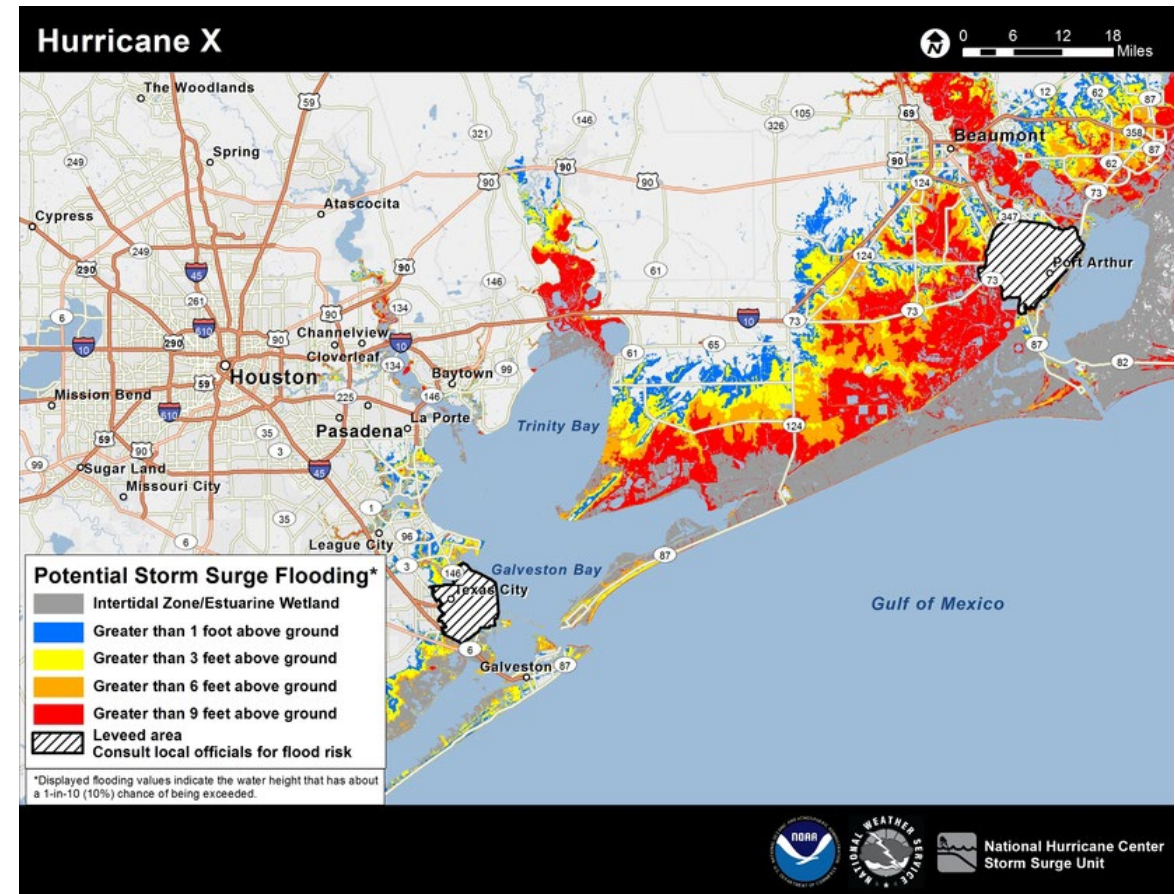


# STORM SURGE

## *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 ~60 hours prior to the onset of the hazard
- Available ~60-90 minutes after the advisory release

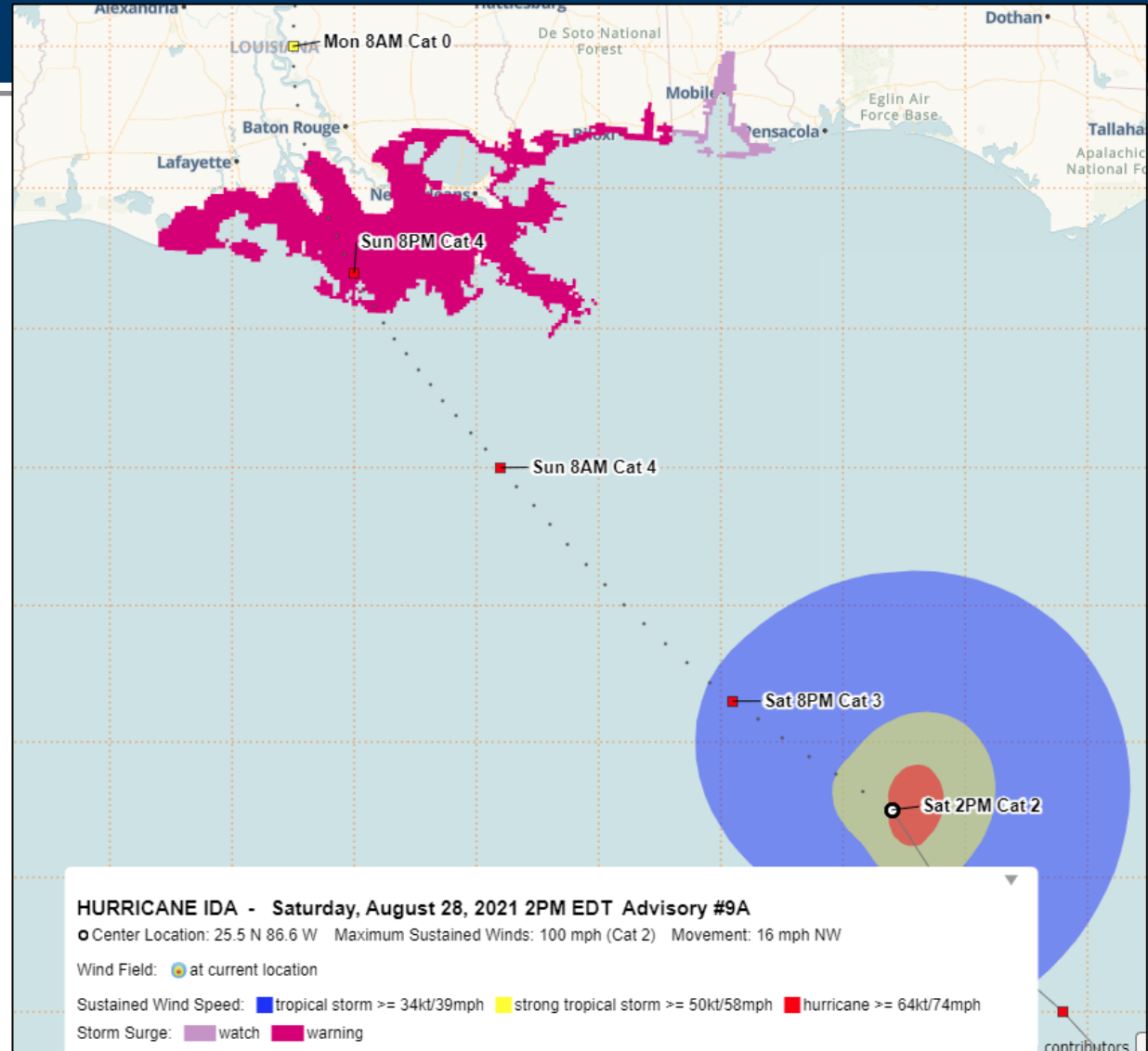




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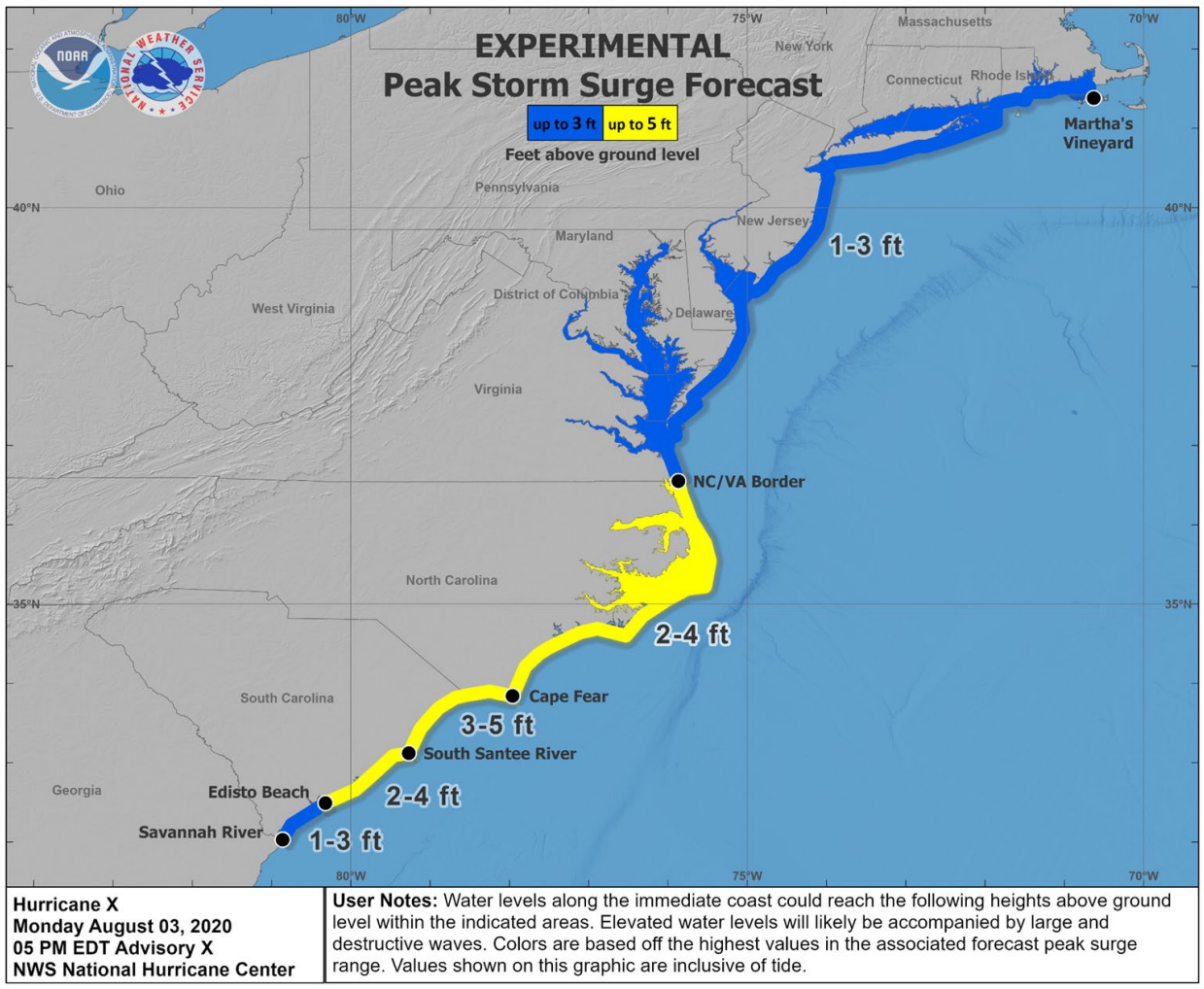
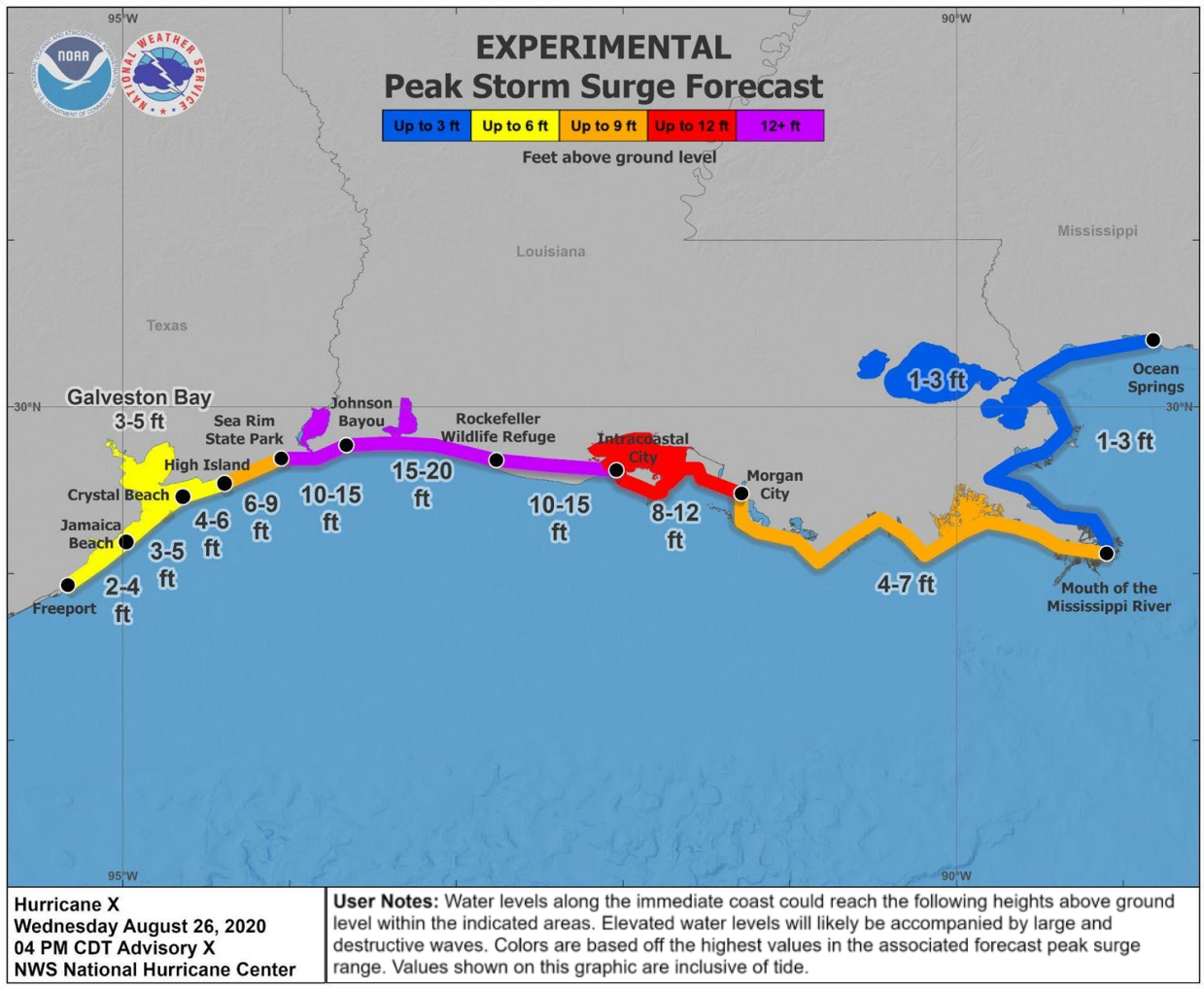
## *Watches and Warnings*

- 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





# WPC Presentation

EVACUATION  
ROUTE





# Tropical Rainfall Forecasts from the Weather Prediction Center

Brian Hurley, Senior Branch Forecaster

## Acknowledgements:

David Novak, Director

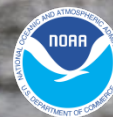
Greg Carbin, Forecast Operations Branch Chief

Alex Lamers, Warning Coordination Meteorologist

NOAA/NWS Weather Prediction Center

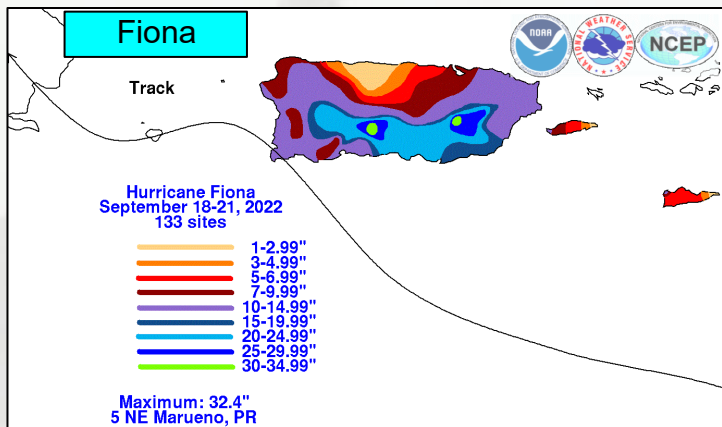
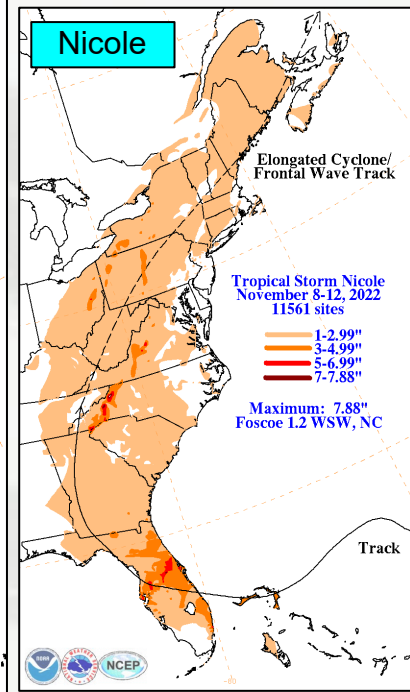
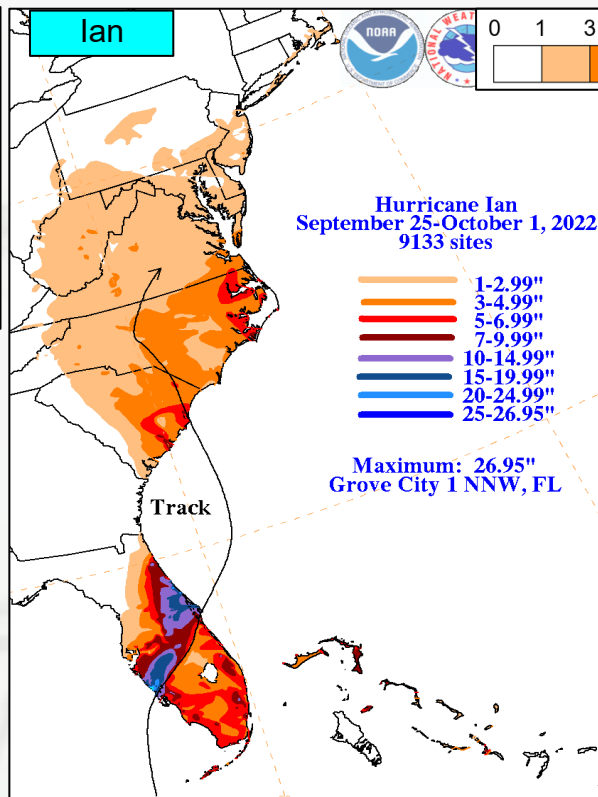
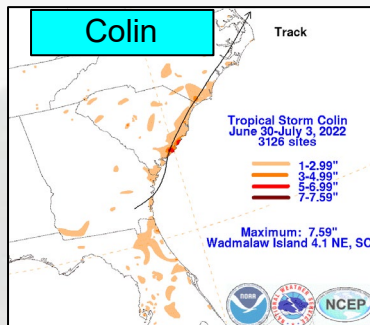
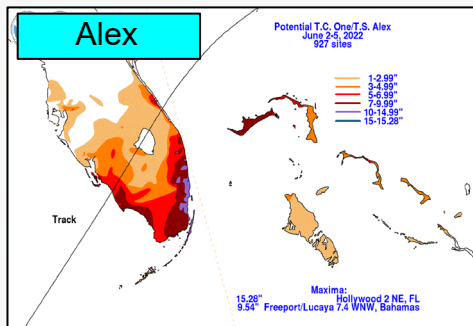
HURREVAC Webinar

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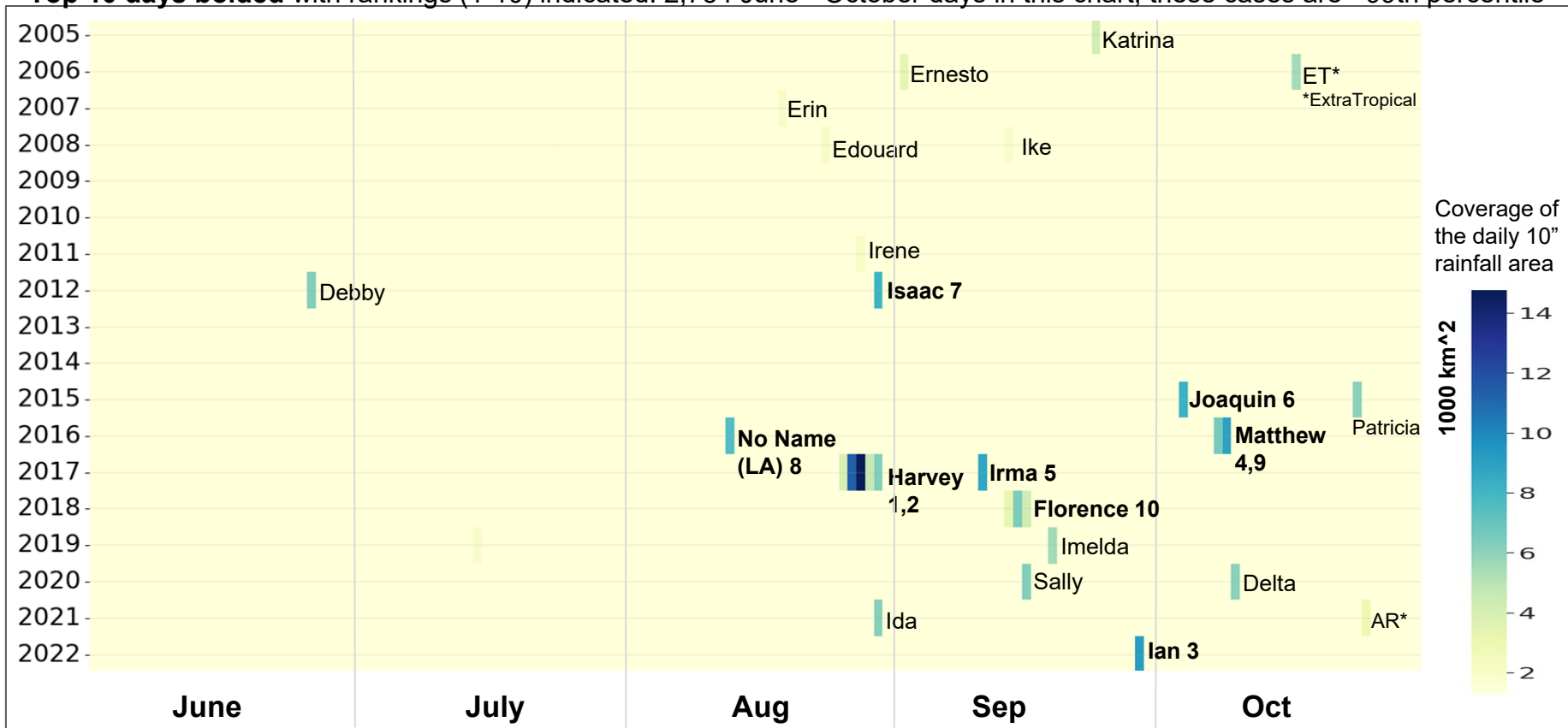


# 2022 in Review: U.S. Tropical Cyclone Rainfall Events



# Wettest U.S. Tropical Cyclones Since 2005

Top 10 days **bolded** with rankings (1-10) indicated. 2,754 June - October days in this chart; these cases are >99th percentile



WEATHER PREDICTION CENTER  
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

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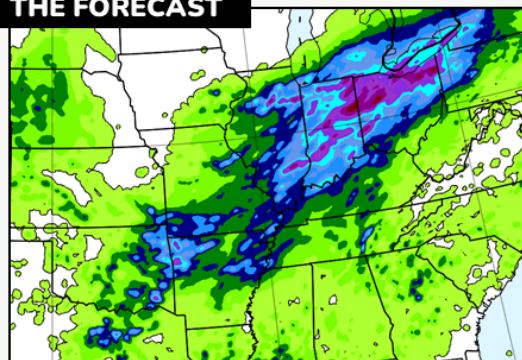
- Any time a tropical cyclone threatens land areas in the highlighted domain, WPC will provide rainfall information
- This information is inserted into the official advisory products via coordination with NHC and CPHC
- For the CONUS, we provide a wider array of information including rainfall forecast maps and Excessive Rainfall Outlooks (ERO) that help illustrate the rainfall-related threats



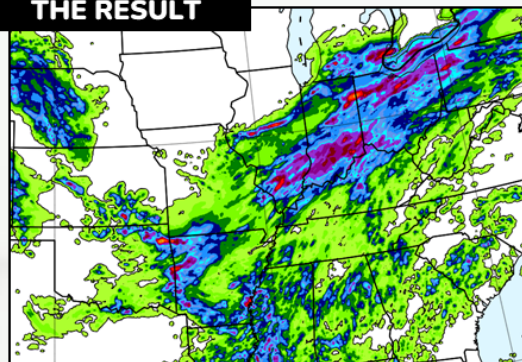


# Quantitative Precipitation Forecast (QPF)

**THE FORECAST**



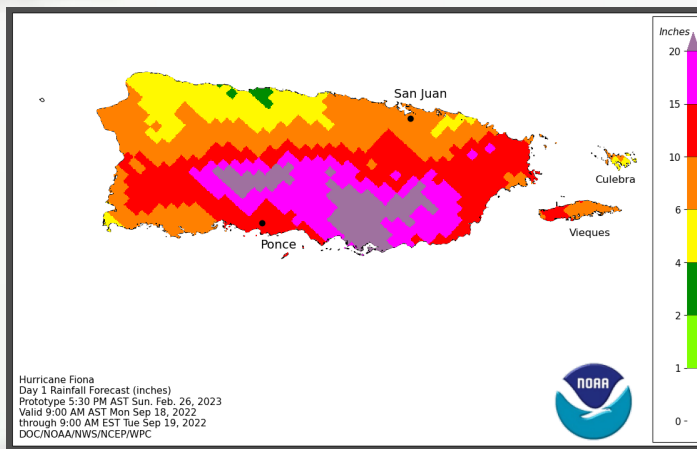
**THE RESULT**



- QPF is forecast precipitation over a given period of time. For tropical cyclones, with all rain precipitation type, this would just be forecast rainfall.
- The forecast depicts areal average amounts. It gives you a general idea of what to expect, but will not capture every localized minimum or maximum.
- Will generally be more accurate in situations with large, organized weather systems as compared to scattered, summertime thunderstorms.
- In the example shown here, the forecast had areas of heavy rain in the correct regions, but did not capture the extremes, as that is not the intent of the product.

# NEW : Rainfall Graphic for Puerto Rico/USVI

- Per request, developing consistent rainfall graphic for Puerto Rico / USVI as what is provided for CONUS
- Built from collaborated Day 1 -5 QPF among WFO San Juan and WPC International Desk
- To appear on Hurricanes.gov storm table and can be used in Key Messages, as with CONUS storms

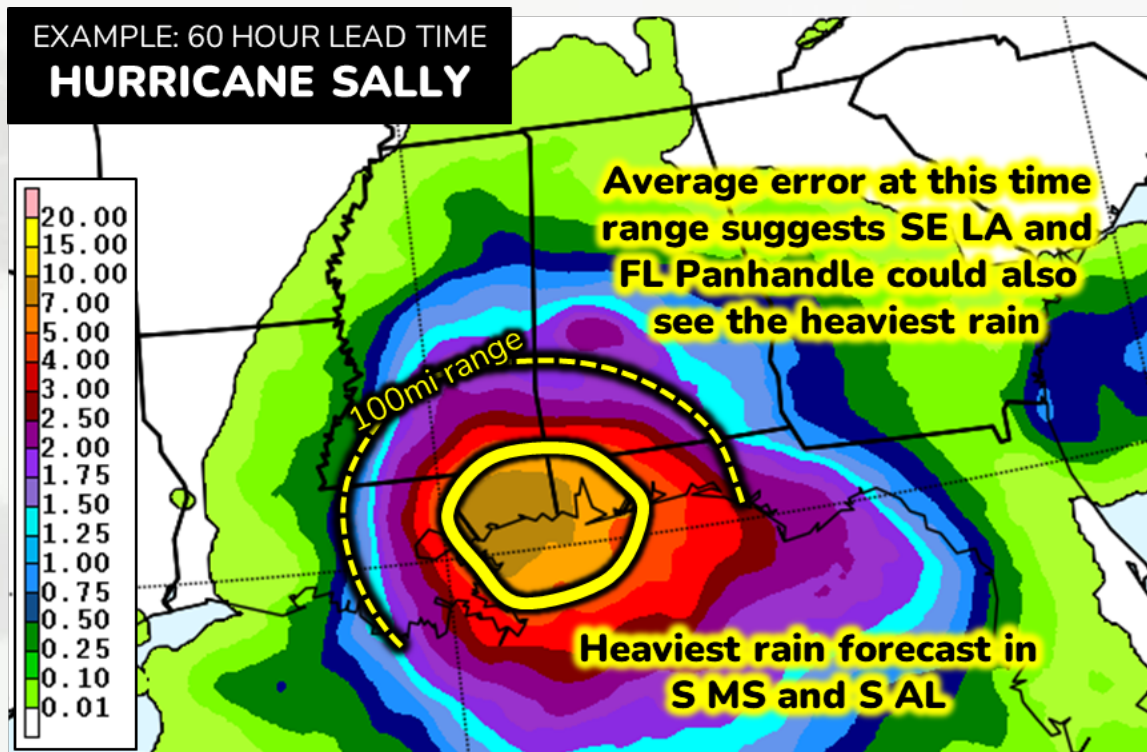


# Updated Tropical Rainfall Error Statistics

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

*2016 -2022 Displacement Error of  
2" Rainfall Forecast Contour*

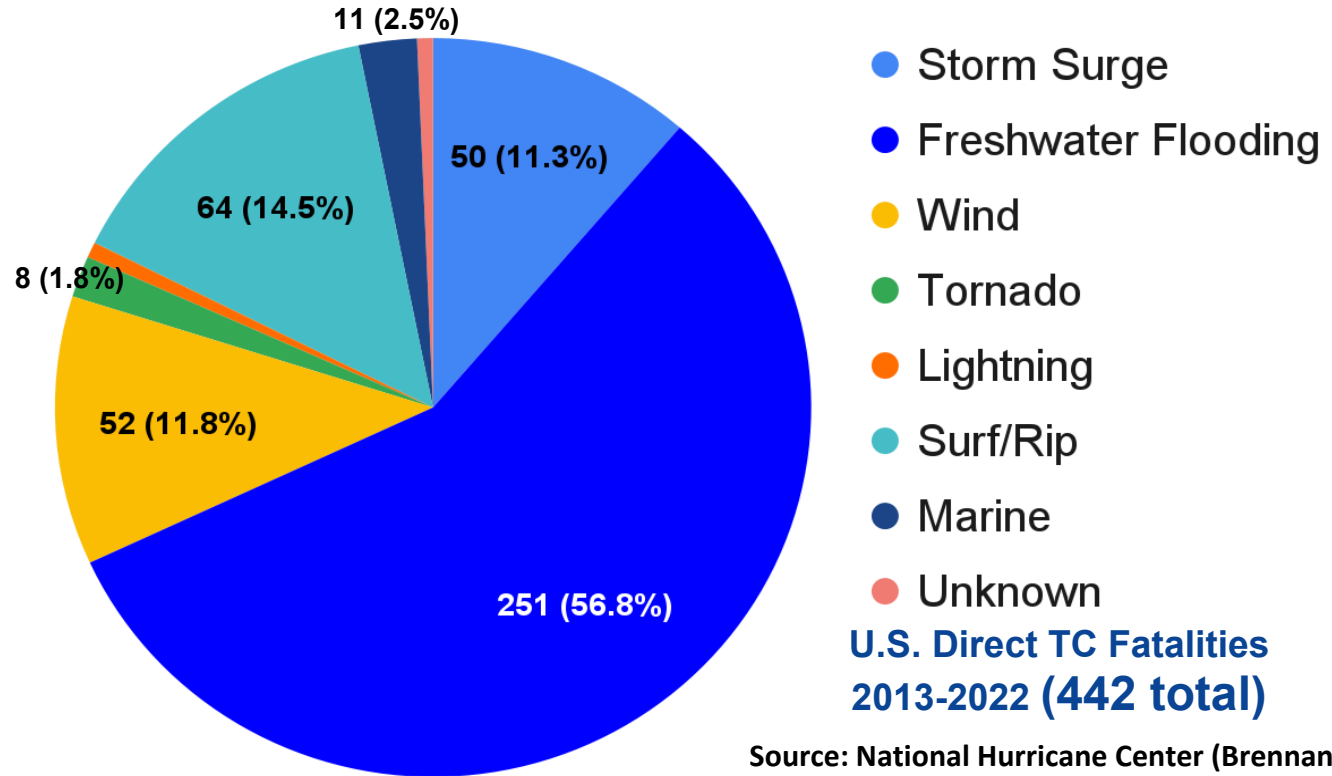
| Lead Time | Avg. Error |
|-----------|------------|
| 12 hours  | 54 miles   |
| 36 hours  | 70 miles   |
| 60 hours  | 98 miles   |
| 84 hours  | 132 miles  |
| 108 hours | 159 miles  |





# Rainfall: Most Consistently Deadly Hazard

- Storm surge still has the potential to cause the greatest single event fatalities, but...
- Rainfall-induced flooding is the most consistently deadly hazard
- 57% of all direct U.S. tropical cyclone fatalities in the past 10 years
- ***Follows Rappaport (2014) study that found freshwater flooding was the most common cause***



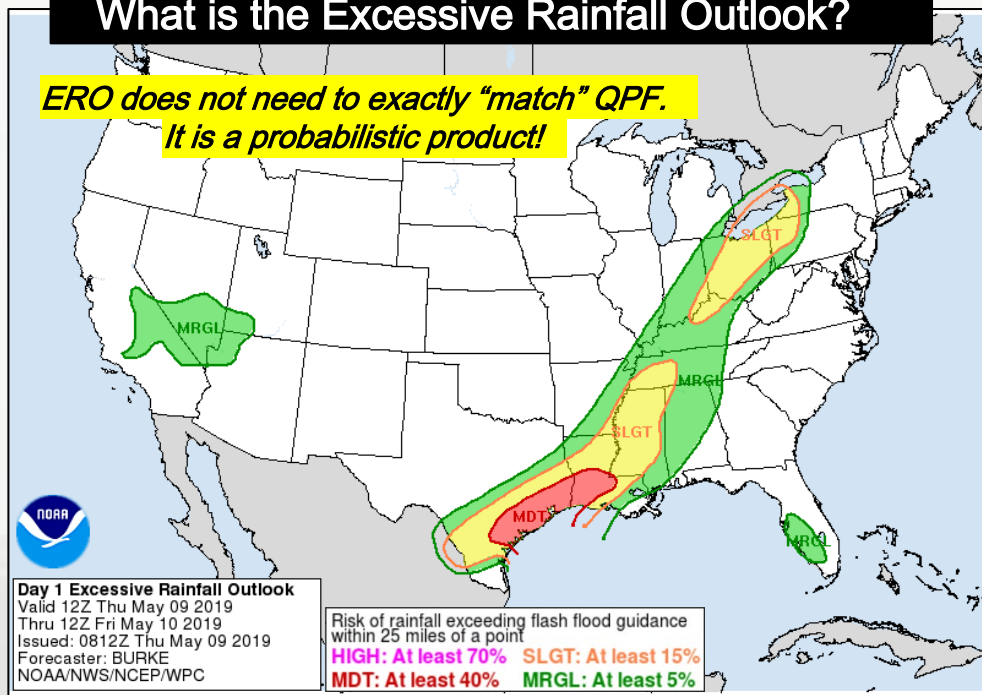
Source: National Hurricane Center (Brennan)



# Excessive Rainfall Outlook (ERO)

## What is the Excessive Rainfall Outlook?

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



Graphic legend updated for new probability definitions as of February 10, 2022

## Answers the question:

What are the chances of rainfall intense enough that it would be expected to cause flash flooding?

## Other things to know:

- ✓ 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. Issued for Days 1-3.

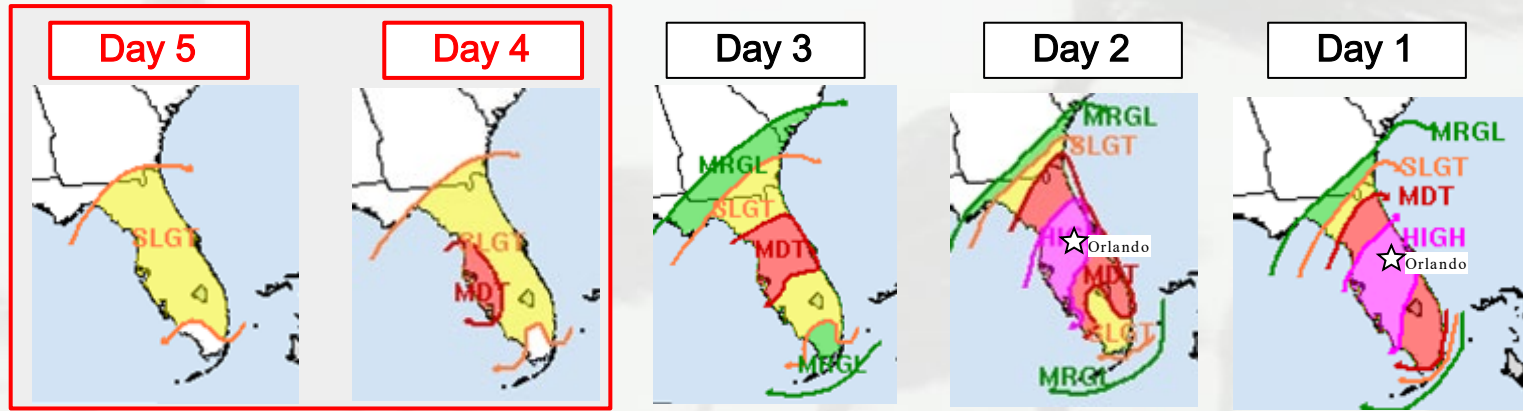


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# Days 4-5 ERO

- **Operational as of 06/01/2023**
- Same general look and feel of the Day 1-3 ERO
- Will include **Marginal Risks** (New in 2023)
- Introduces an earlier signal for more organized, widespread, and impactful events

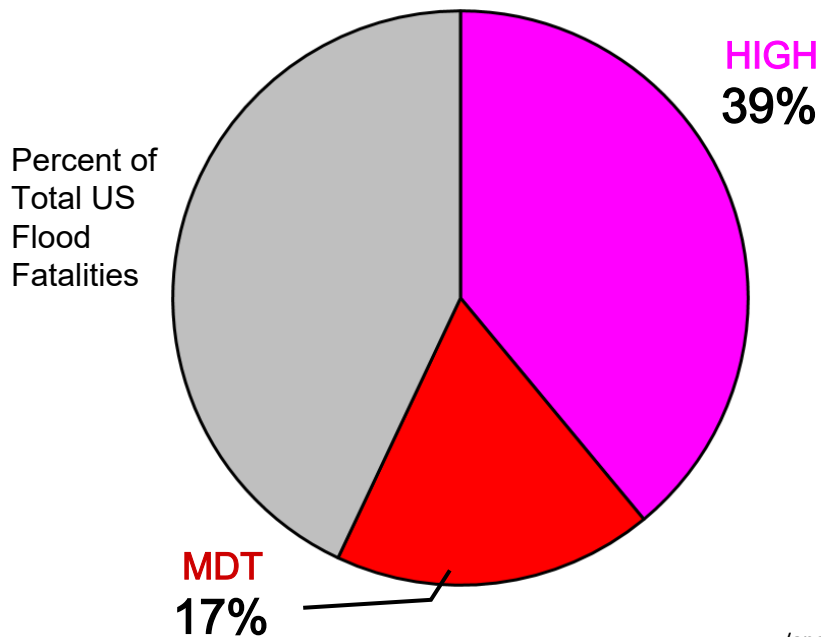




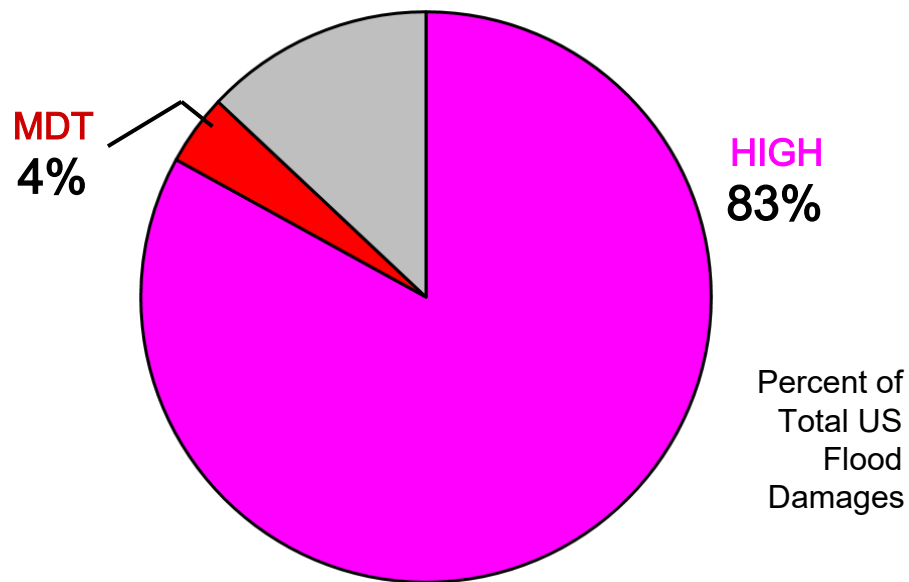
# WPC High Risk Days are a BIG DEAL

High Risks are only issued by WPC on ~4% of days, but “High Risk Days” have accounted<sup>1</sup> for:

**2/5** of ALL Flood-related Fatalities



**4/5** of ALL Flood-related Damages



<sup>1</sup> From 2010 to 2020. Includes flood, flash flood, heavy rain, and debris flow Storm Data. Excludes Oso, WA landslide which occurred well after rainfall and on a sunny day. Damage estimate used for Montecito debris flow.



# 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

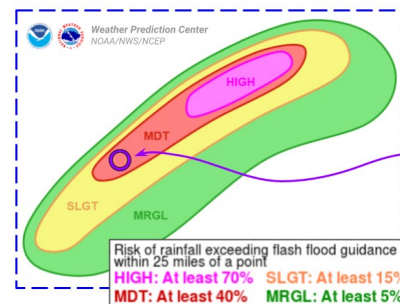
One graphic providing an interpretation guide

| 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. |
| <a href="http://www.wpc.ncep.noaa.gov">@NWSWPC</a>   |  |   |   |  |
| Flash flooding near you?                             | Flash Flooding   | Flash Flooding  | Flash Flooding  | Flash Flooding   |
| WEATHER PREDICTION CENTER                            |  |   |   |  |

| 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. |
| <a href="http://www.wpc.ncep.noaa.gov">@NWSWPC</a>                  |   |   |   |   |
| Inundación cerca o no?  | Si  | Si  | Si  | Si  |
| WEATHER PREDICTION CENTER   |   |   |   |   |



## INTERPRETING THE EXCESSIVE RAINFALL OUTLOOK



### IN THE BIG PICTURE

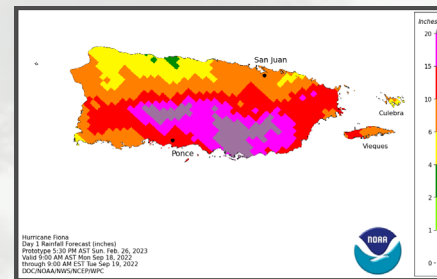
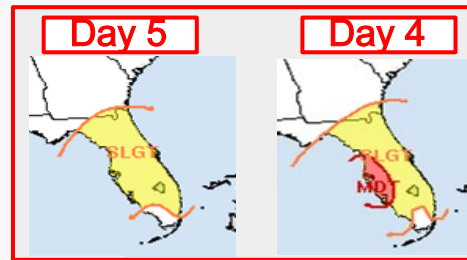
- Orients you to potential problem spots for intense rainfall and resulting flash flooding
- Where is the risk relatively higher?


### 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?"

# Summary of What's New

- Day 4-5 Excessive Rainfall Outlook now Operational (including Marginal Risks)
- Puerto Rico/USVI standard rainfall graphic
- After the NHC -WPC 'Handoff' retain Key Messages, Rainfall, and Excessive Rainfall Outlook information on the Hurricanes.Gov Storm Table



Post-Tropical Cyclone Ian  [Satellite](#) | [Buoys](#) | [Grids](#) | [Storm Archive](#)

...IAN'S HEAVY RAINS CONTINUE ACROSS THE CENTRAL APPALACHIANS AND MID-ATLANTIC...

The NHC has issued its final advisory on this system. The [Weather Prediction Center](#) will continue to provide updates as long as the system remains a flood threat.

5:00 AM EDT Sat Oct 1  
Location: 35.7°N 79.8°W  
Moving: NNW at 12 mph  
Min pressure: 1001 mb  
Max sustained: 35 mph

**Public Advisory #36**  
1100 AM EDT

**Forecast Advisory #36**  
1500 UTC

**Forecast Discussion #36**  
1100 AM EDT

[Warnings/Cone Interactive Map](#) [Warnings/Cone Static Images](#) [Key Messages](#) [U.S. Rainfall Potential](#) [Flash Flooding Potential](#)





# 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). Graphical information regarding rainfall and ERO key messages remain on the Hurricanes.Gov.

## Public Advisory

### Forecast Advisory

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ANALYSES & FORECASTS • DATA & TOOLS • EDUCATIONAL RESOURCES • ARCHIVES • ABOUT • SEARCH

#### Post-Tropical Cyclone IAN

2022 HURRICANE ALL THUNDER NAME CHANGES

POST-TROPICAL CYCLONE IAN FORECAST/ADVISORY NUMBER 36  
NWS HEADQUARTERS PREDICTION CENTER COLLEGE PARK MD AL090202  
1100 AM EDT SAT OCT 01 2022

...POST-TROPICAL CYCLONE IAN WILL CONTINUE TO WEATHER NEAR THE VA/NC BORDER THROUGH LATE TUESDAY...

SUMMARY OF 1100 AM EDT...1100 UTC... INFORMATION

LOCATION...36.40 79.50  
MAX SUSTAINED WINDS...25 MPH...20 KNOTS  
PRESENT POSITION...NEAR 36.40 79.50 AT 1100 AM EDT SAT OCT 01 2022  
FORECAST CENTRAL PRESSURE...1000 MB...29.73 INCHES

WATCHES AND WARNINGS

Flash watches are in effect across southeast Virginia and southern West Virginia.

DISCUSSION AND OUTLOOK

At 1100 AM EDT (1000 UTC), the center of Post-Tropical Cyclone Ian is located near latitude 36.4 north longitude 79.5 west. The post-tropical cyclone is moving toward the north-northwest near 10 mph (16 km/h) and this motion is expected to continue until a gradual turn to the southeast tonight.

Maximum sustained winds are near 25 mph (25 km/h) with higher gusts. A gradual weakening trend is forecast through Tuesday.

The estimated minimum central pressure is 1000 mb (29.73 inches).

NEARBY AFFECTING LAND

Heavy rain and flash flooding are being feared in the Tropical Cyclone Discussion area. Heavy rain, flash flooding, and wind are expected to affect the area from the Atlantic coast of Virginia and the Gulf of Mexico coast of Florida and the Gulf of Mexico coast of Texas.

RAINFALL: Ian is expected to produce an additional 1 to 3 inches of rain. Rainfall, with locally heavier amounts possible, across portions of the Central Appalachians and Mid-Atlantic.

RISK: To record river flooding will continue across central Florida through next week. Limited flash, urban, and small stream flooding is possible across portions of central Appalachians and portions of the Mid-Atlantic this weekend.

FORECAST POSITIONS AND MAX WINDS

12H 01/1500Z 36.4N 79.5W 20 KT 25 MPH...POST-TROPICAL  
24H 02/1200Z 36.7N 79.3W 20 KT 25 MPH...POST-TROP/EXT/INTROP  
36H 03/0000Z...DESSIPATED

\$\$  
FORECASTER CARLIN

###

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36H 03/0000Z...DESSIPATED

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FORECASTER CARLIN

###

### Discussion (Key Messages)

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ANALYSES & FORECASTS • DATA & TOOLS • EDUCATIONAL RESOURCES • ARCHIVES • ABOUT • SEARCH

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Post-Tropical Cyclone Ian Discussion Number 36  
NWS HEADQUARTERS PREDICTION CENTER COLLEGE PARK MD AL090202  
1100 AM EDT SAT OCT 01 2022

Key Messages:

- Ongoing major to record river flooding will continue through next week across portions of central Florida.
- Limited flash, urban, and small stream flooding is possible across portions of central Appalachians and Mid-Atlantic this weekend.

FORECAST POSITIONS AND MAX WINDS

12H 01/1500Z 36.4N 79.5W 20 KT 25 MPH...POST-TROPICAL  
24H 02/1200Z 36.7N 79.3W 20 KT 25 MPH...POST-TROP/EXT/INTROP  
36H 03/0000Z...DESSIPATED

\$\$  
FORECASTER CARLIN

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## Graphical Key Messages

**NATIONAL HURRICANE CENTER and CENTRAL PACIFIC HURRICANE CENTER**

ANALYSES & FORECASTS • DATA & TOOLS • EDUCATIONAL RESOURCES • ARCHIVES • ABOUT • SEARCH

#### Key Messages for Post-Tropical Cyclone Ian

Advisory 36: 11:00 AM EDT Sat Oct 01, 2022

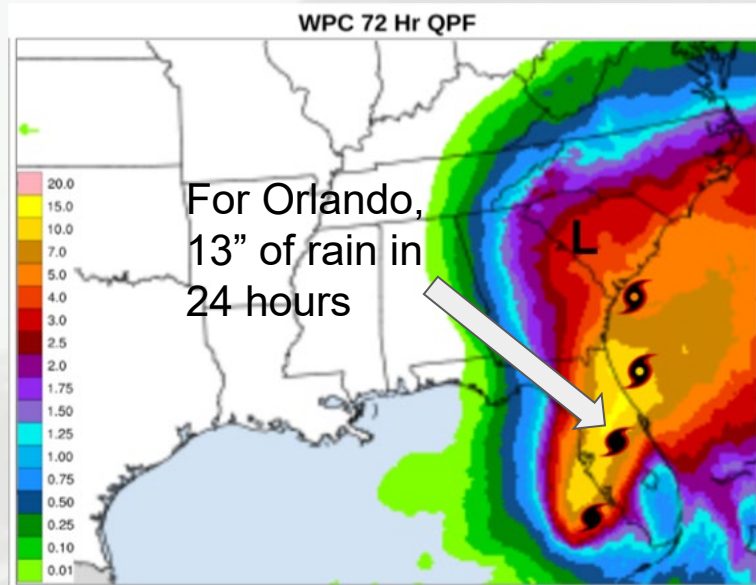
- Ongoing major to record river flooding will continue through next week across portions of central Florida.
- Limited flash, urban, and small stream flooding is possible across portions of central Appalachians and Mid-Atlantic this weekend.

For more information go to [hurricanes.gov](https://hurricanes.gov)

# Not Yet Available in HURREVAC...

## The Extreme Precipitation Monitor

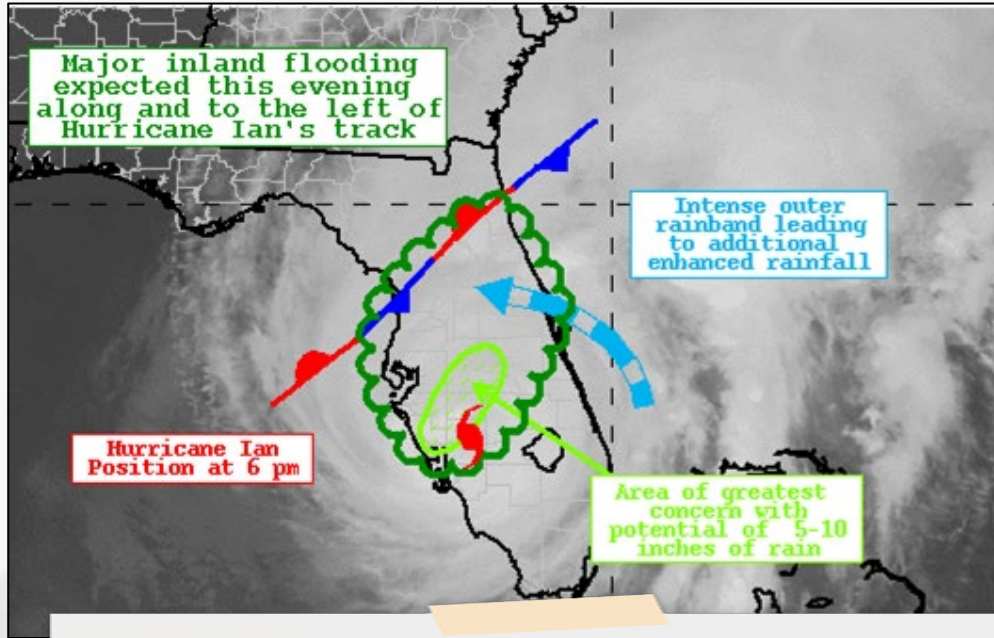
- Answers the question: “How rare is that rainfall forecast?”
- Tool provides both the most likely and the reasonable -worst case.
- Helps distinguish between a ‘bad event’ and a ‘REALLY bad event’.
- WPC currently working on KML/shapefiles.



WEATHER PREDICTION CENTER  
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

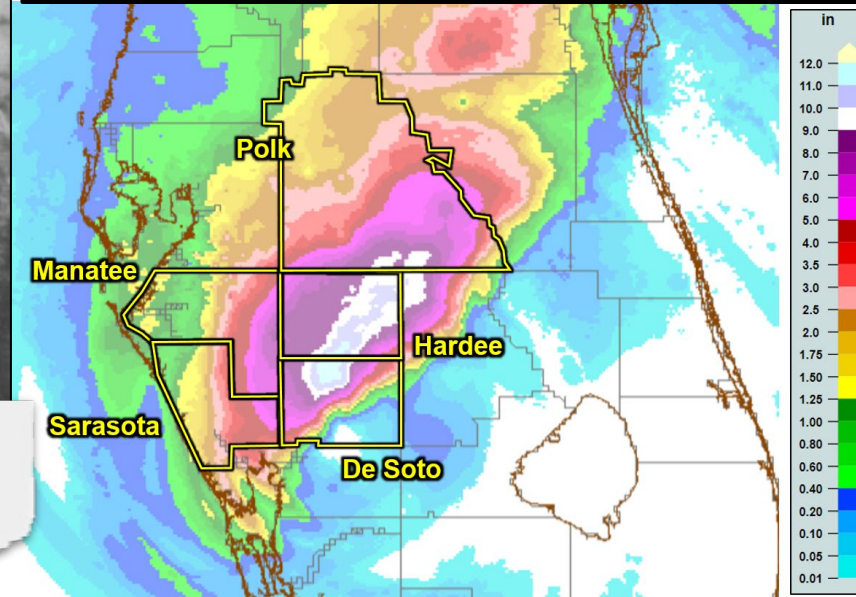
# Not Yet Available in HURREVAC...

## 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.

WPC currently working on 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



# Questions or Comments?

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**WEATHER PREDICTION CENTER**  
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

*HURREVAC Webinar, Day 4*  
*June 15, 2023 | Virtual Conference Session*

# HURREVAC Demo

EVACUATION  
ROUTE



# Thank you!

HURREVAC Support Team  
[support@hurrevac.com](mailto:support@hurrevac.com)



**FEMA**



NATIONAL HURRICANE PROGRAM



**HURREVAC**

HURRICANE DECISION SUPPORT TOOL