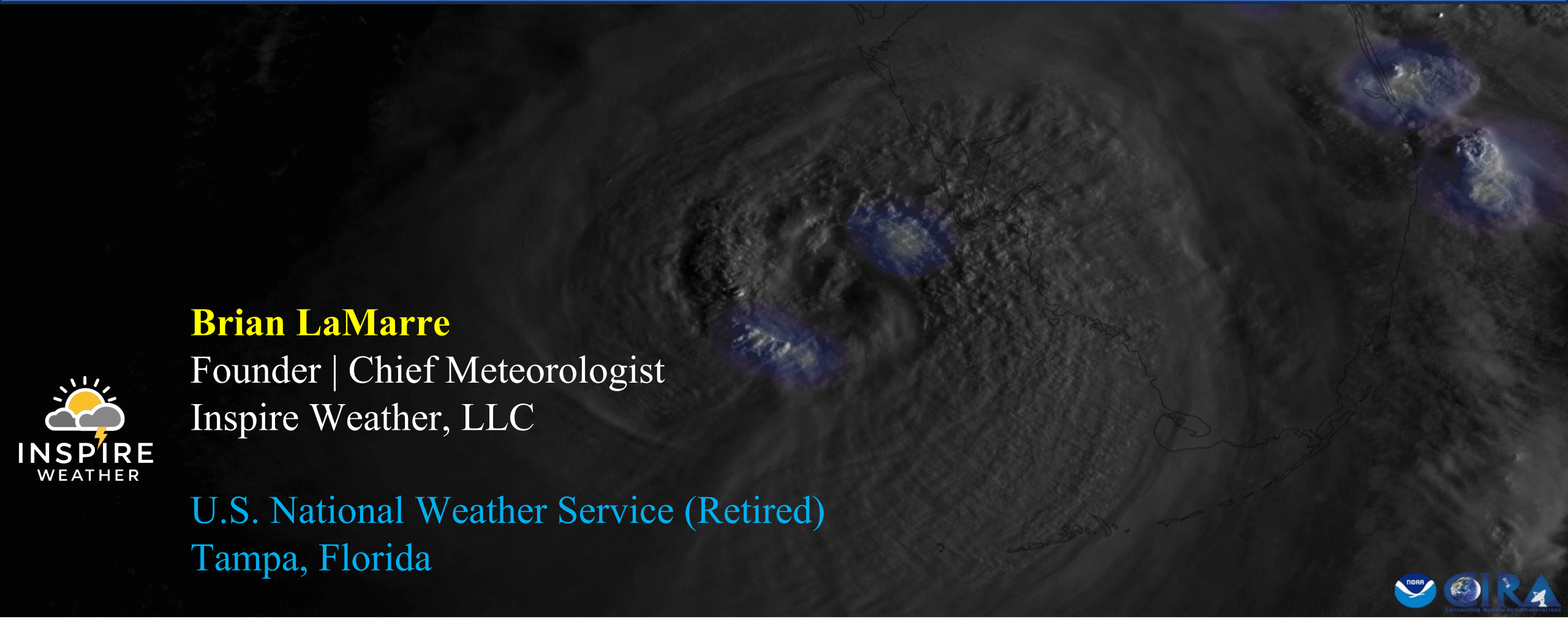
Hurricane Ian:

A Case for Impact-Based, Probabilistic Decision Support Services for Emergency Management and Public Safety.



Brian LaMarre
Founder | Chief Meteorologist
Inspire Weather, LLC

U.S. National Weather Service (Retired)
Tampa, Florida

What is the primary goal of public weather forecasts and warnings?

First, it should be understood that forecasts possess no intrinsic value. They acquire value through their ability to influence the decisions made by users of the forecasts. Various methods are available to estimate

Allan Murphy (1993) What is a good forecast? AMS, Weather and Forecasting. Oregon State University.

In a review of 300+ journal articles...

Nearly all of the studies ... indicate that people make better decisions, have higher trust in information, and/or display a greater understanding of forecast information when shown a probabilistic forecast instead of a deterministic one.

Joseph Ripberger et al. (2022), ***Weather Climate and Society, University of Oklahoma***

The goal is not just to make good forecasts, but…
to help people make good decisions.

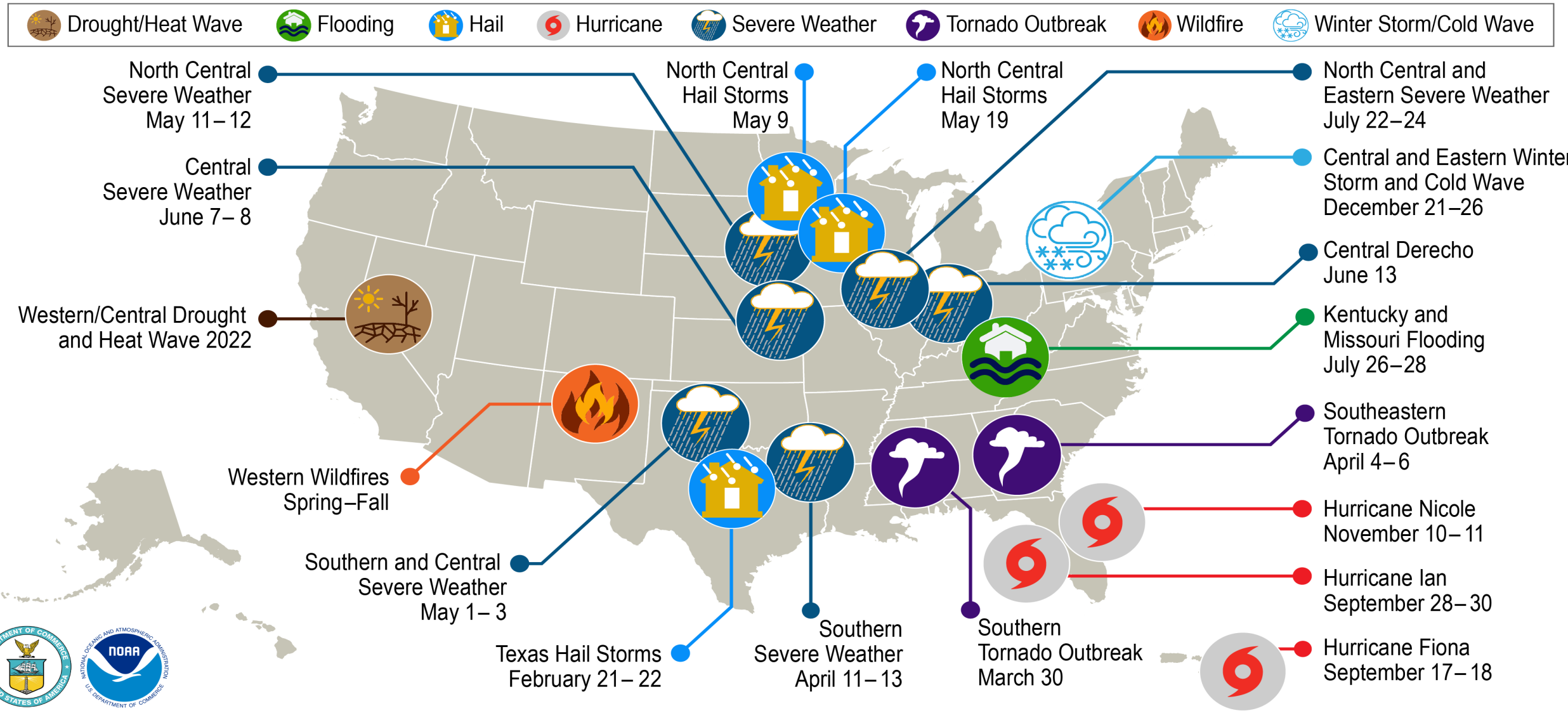
This is the core of Probabilistic impact-based decision support services.

It is a transition from asking:

What *services* do you want?
to:
What *decisions* do you need to make?

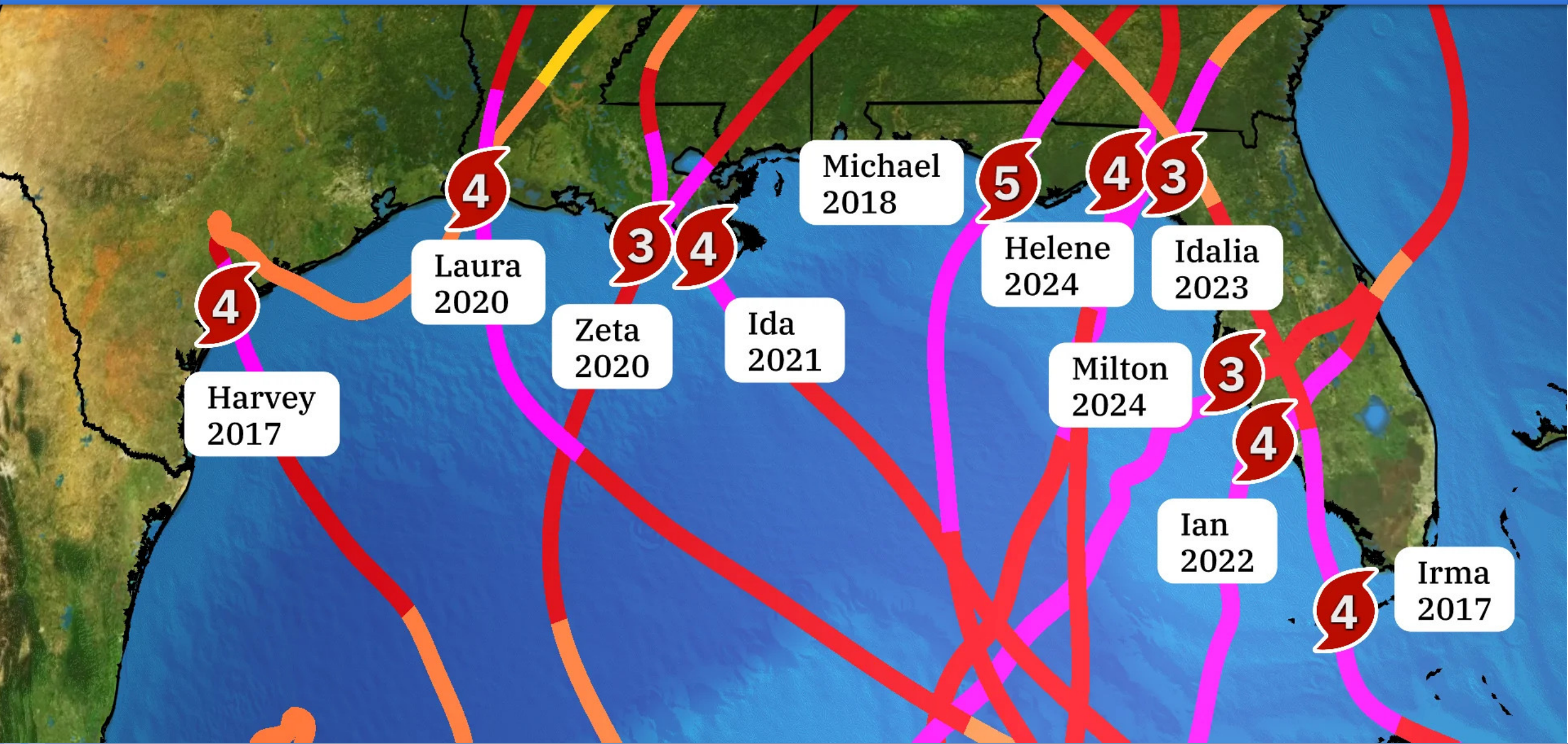
2022 Billion-Dollar Weather Disasters: 18 Disasters

U.S. 2022 Billion-Dollar Weather and Climate Disasters

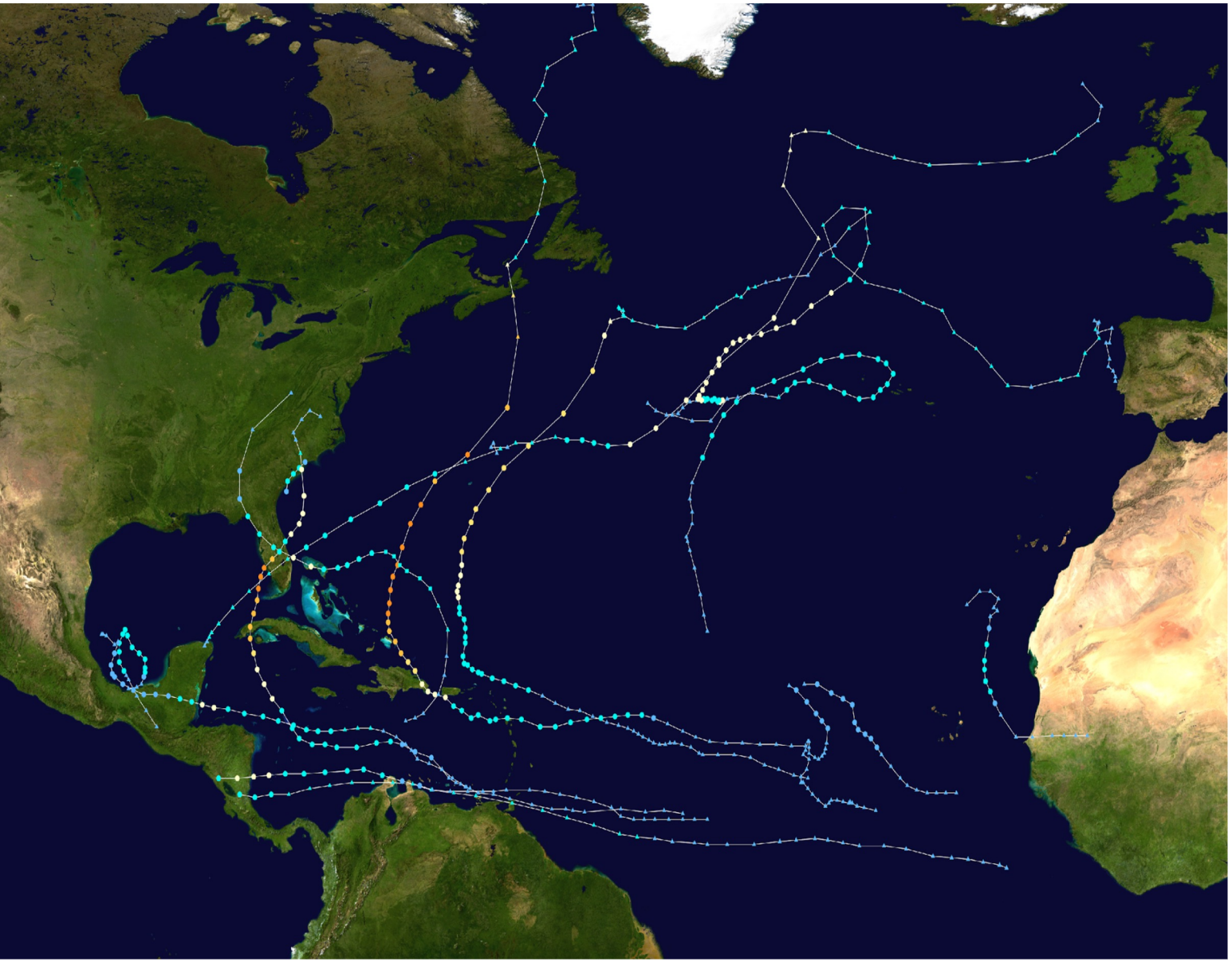


*This map denotes the approximate location for each of the **18 separate billion-dollar weather and climate disasters that impacted the United States in 2022.***

Gulf of Mexico: Major (Cat. 3-4-5) Hurricanes 2017-2025



2022 Hurricane Season: It only takes one!



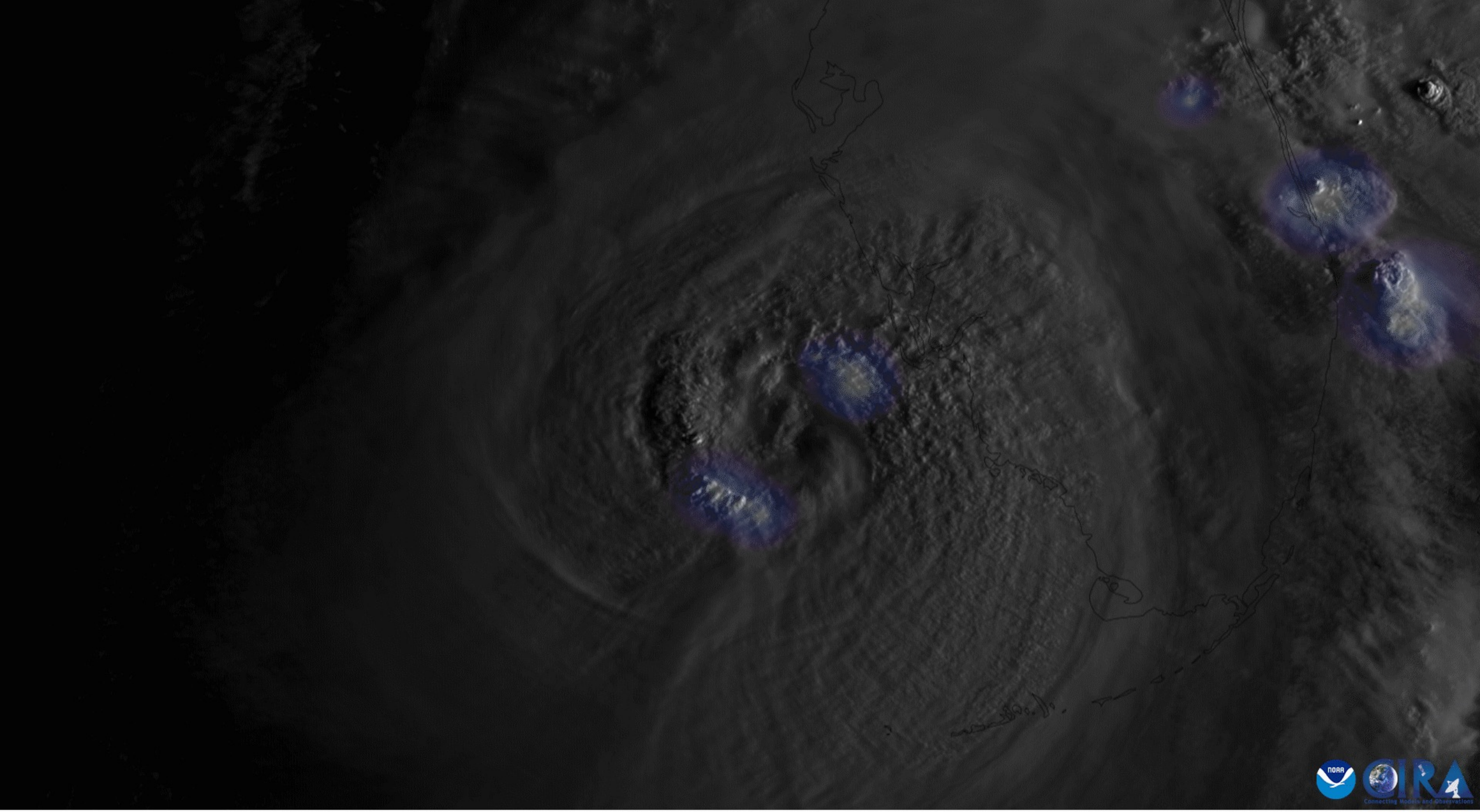
14 Named Storms *(14)*
8 Hurricanes *(7)*
2 Major Hurricanes *(3)*

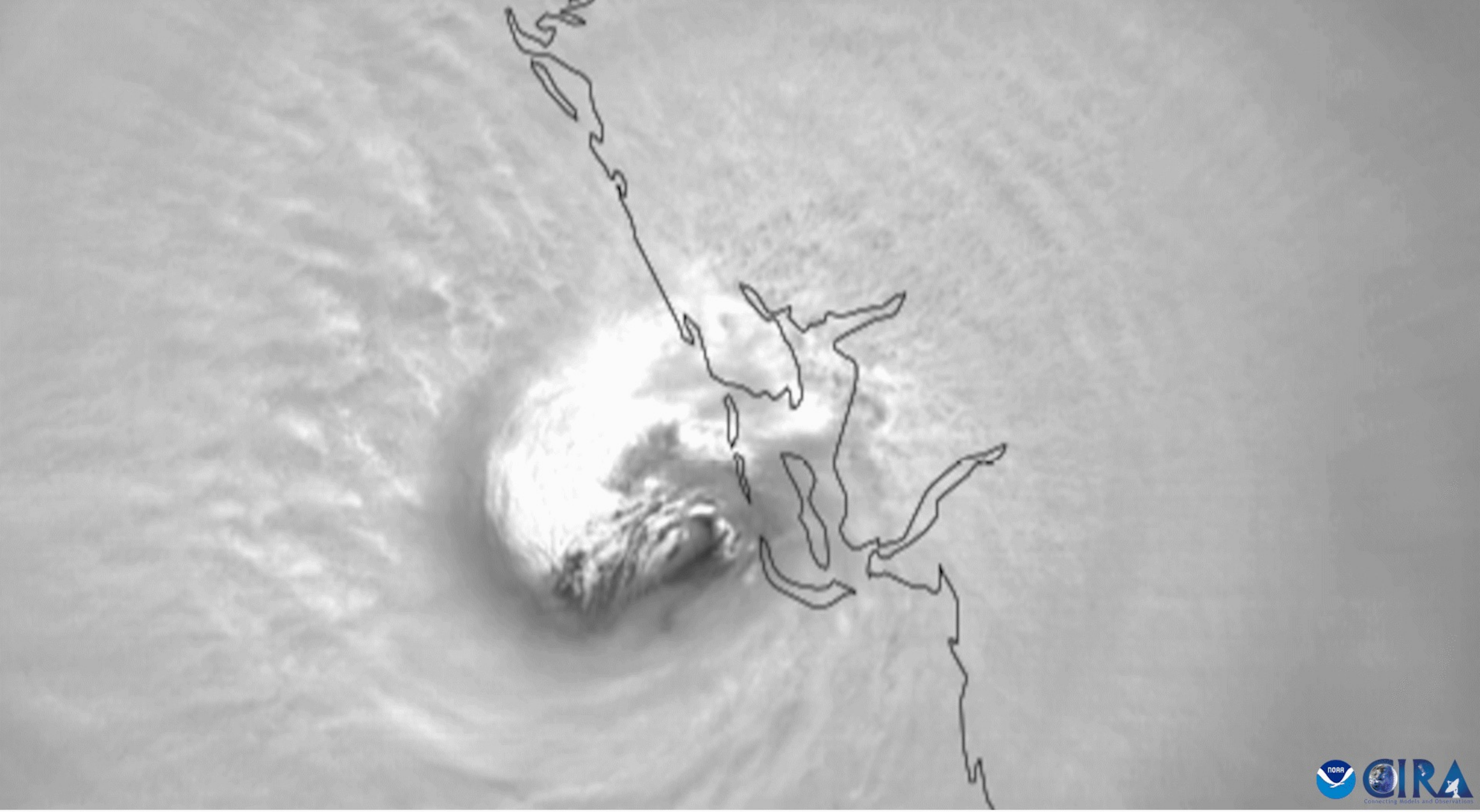
(Average 1991-2020 Season)

Season: June 1 – Nov 30

First Storm: June 5 (Alex)
Last Storm: Nov 7 (Nicole)

Significant impacts from Hurricanes **Ian**, Fiona, **Nicole**.

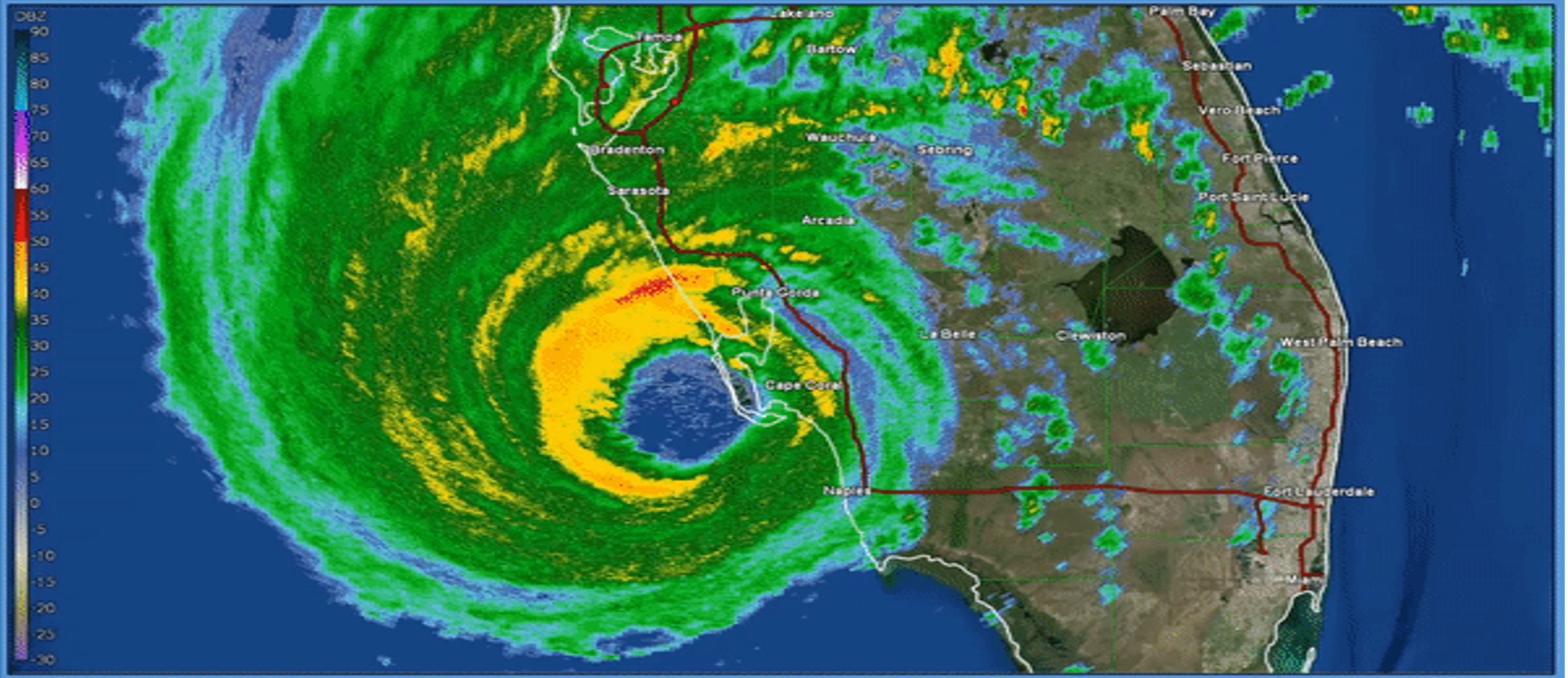

09-28-2022 | 12:00:55 UTC | GOES-16 | Visible (band 2) + GLM Group Energy Density
-6
-5
-4
-3
-2
-1
0
[pJ/min] (Log10)



09-28-2022 | 17:38:25 UTC | GOES-16 | Visible (band 2)

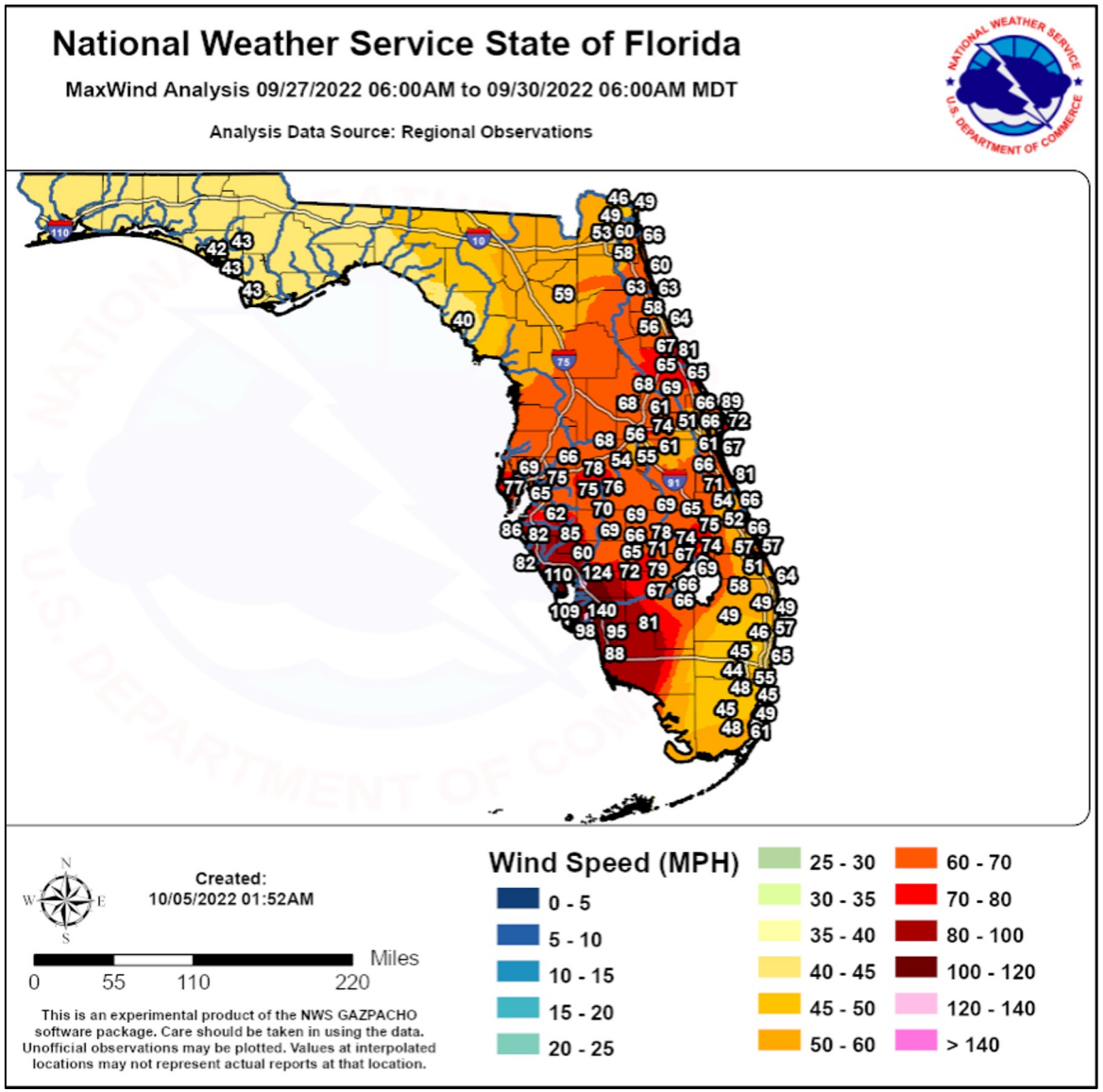
Hurricane Ian – 28 September 2022

1:30 – 4:00 PM EDT



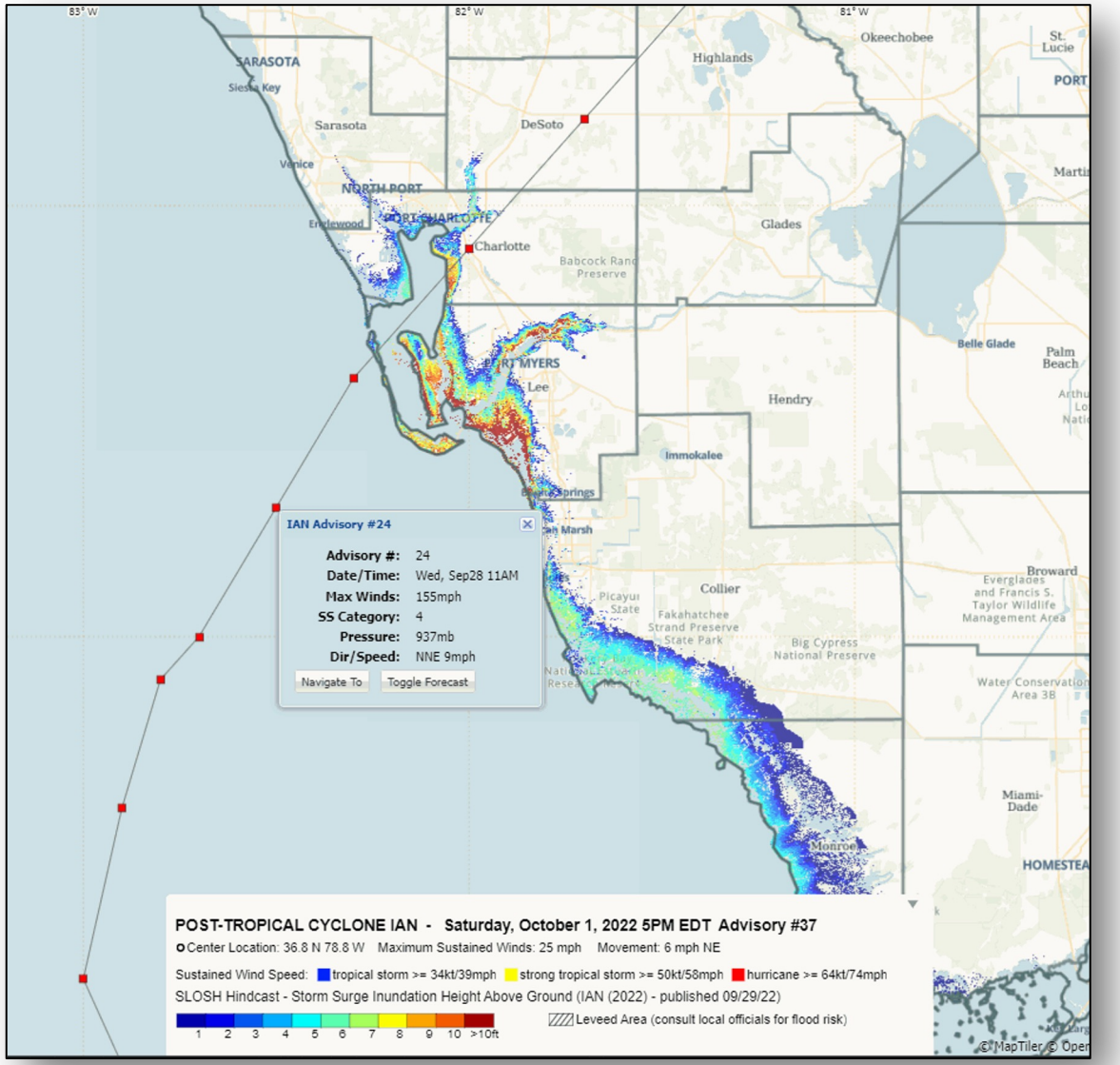
weather.gov/tampa @NWSTampaBay @NWSTampaBay

2022 Major Hurricane Ian – Max Wind Gust



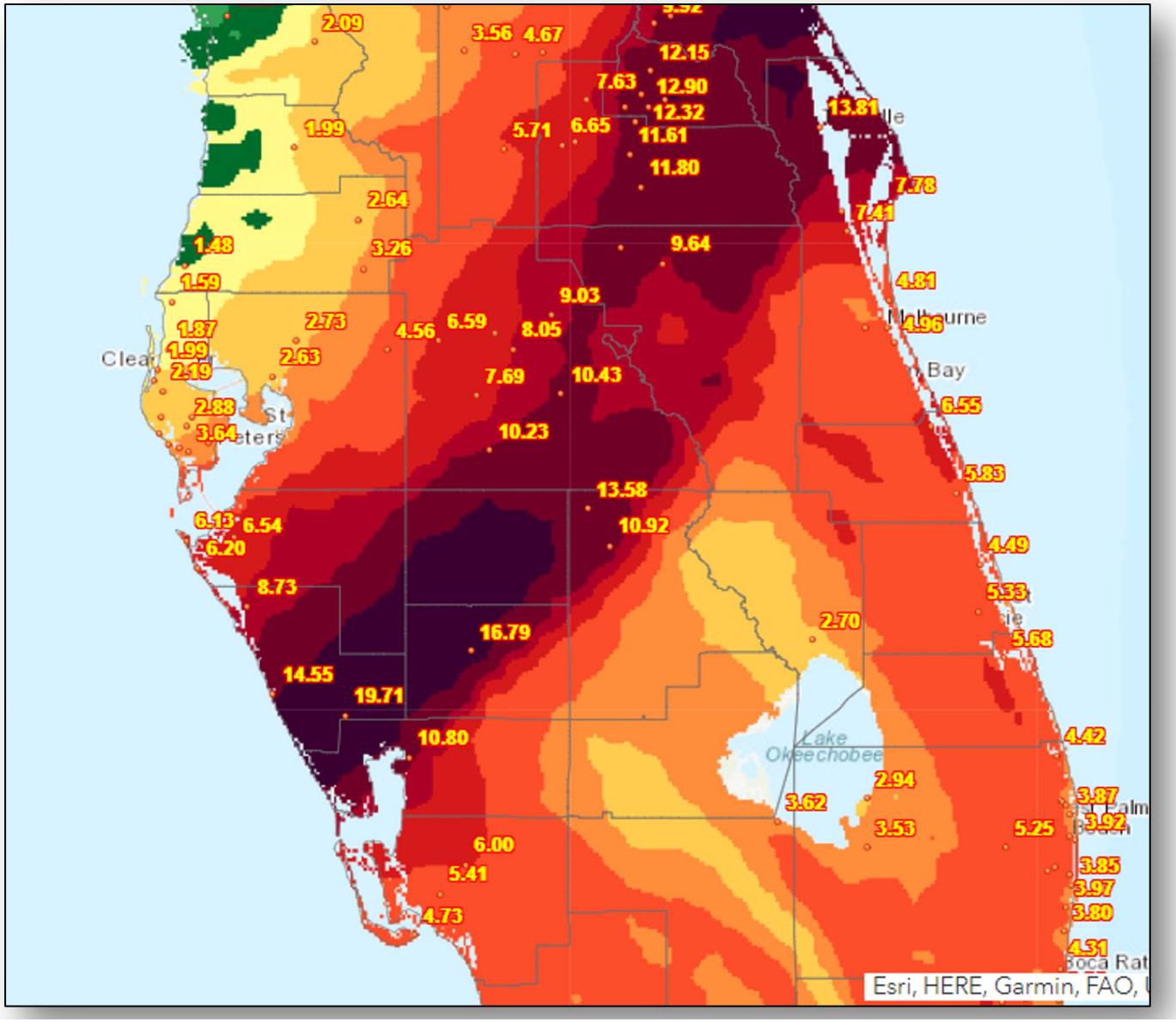
- Landfall is when the *center* of the eye wall crosses the beach
- Landfall at Cayo Costa - 305 PM ET Wed Sep 28, 2022
  - CAT 4, 150 mph, 940 mb
- Mainland Florida Landfall - Near Punta Gorda at Pirate Harbor
  - CAT 4, 435 pm Wed Sep 28, 145 mph, 942 mb
- Max Recorded Wind - 140 mph in Cape Coral

2022 Major Hurricane Ian - Storm Surge



- 6-10 feet water overtopped barrier islands
- Max surge 10 to 15 feet.
  - Structures washed off their foundation at locations where water was *flowing* over the barrier islands
  - Structures flooded with salt water on the inland side of the intercoastal
- Tides were 4-7 feet below normal north of the eye wall

2022 Major Hurricane Ian - Rain



C. STORM TOTAL RAINFALL FROM 1200 UTC SEP 27 UNTIL 1200 UTC SEP 30

CITY/TOWN LAT LON DEG DECIMAL	COUNTY	ID	RAINFALL (IN)
1 NNW GROVE CITY 26.93 -82.33	CHARLOTTE	25056	26.95
1 NW CHARLOTTE BEACH 26.94 -82.22	CHARLOTTE	25218	22.97
3 NE NORTH PORT 27.08 -82.15	SARASOTA	25835	21.45
2 S ZOLFO SPRINGS 27.46 -81.80	HARDEE	25195	20.13
3 E ZOLFO SPRINGS 27.50 -81.75	HARDEE	25172	19.97
10 WSW PINE LEVEL 27.19 -82.13	SARASOTA	25603	19.83

Weather: Impact-Based Decision Support Services

Table-Top Exercises
Severe Weather Drills
Tropical Classes
Safety Expos



Threat Identified & Monitored
Resource ‘Shuffle’ & Engagement
Shelter Considerations
Structure Protection
Evacuation Considerations

Resources Engaged
Evacuations
Rescues

Assessments
Restoration



Pre-Event Training & Exercises
Preparedness Phase

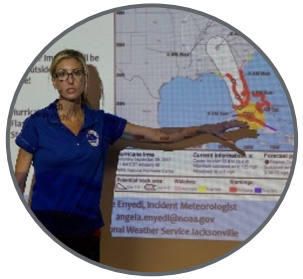
Event Briefings & Services
Planning Phase

Remote & On-Site Support
Response Phase

Ongoing Support Post-Event
Recovery Phase

Routine Weekly Briefings

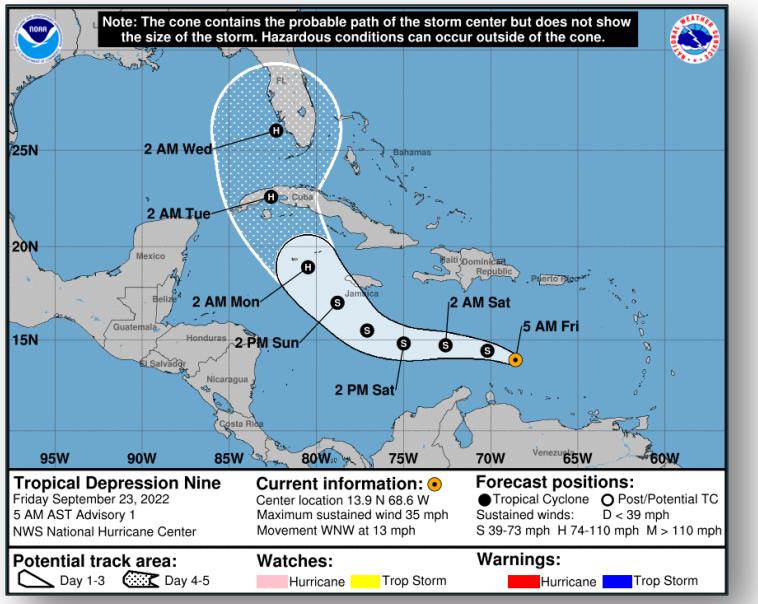
Emails & Webinars
NWS Support
Coordination

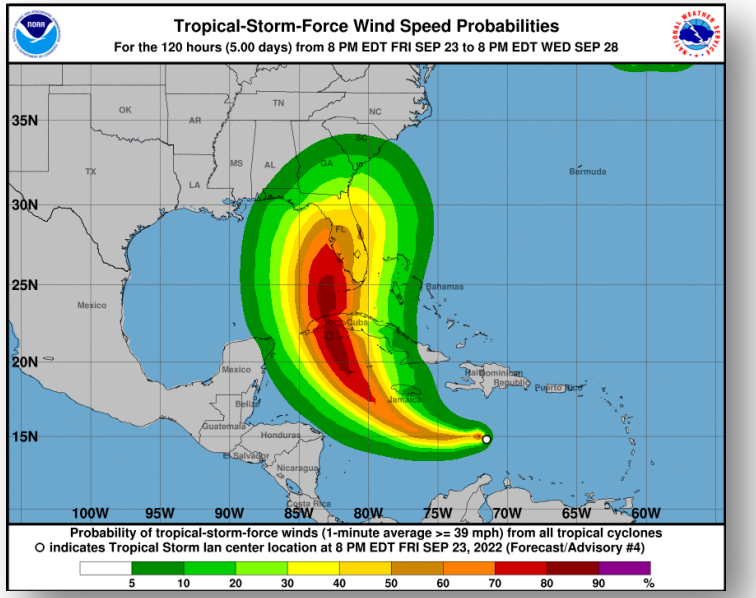


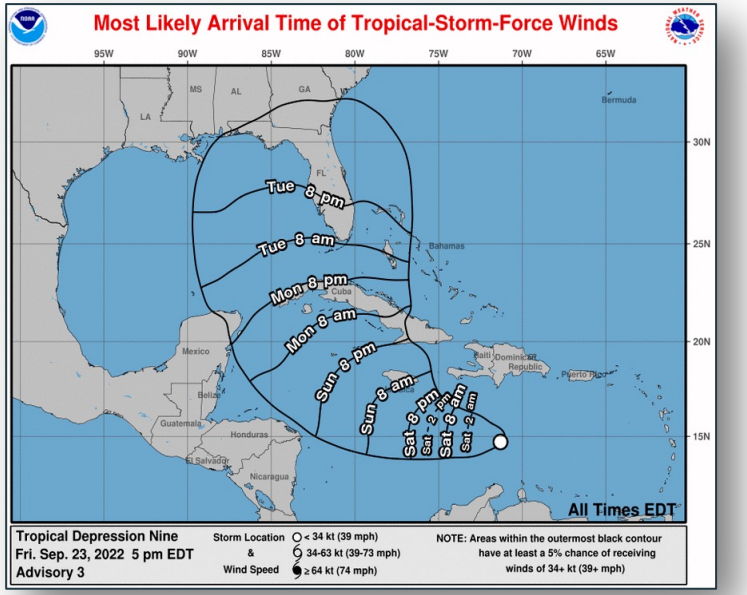
NWS Fully Engaged
Onsite or Virtual Support
NWS Chat / Google Chat

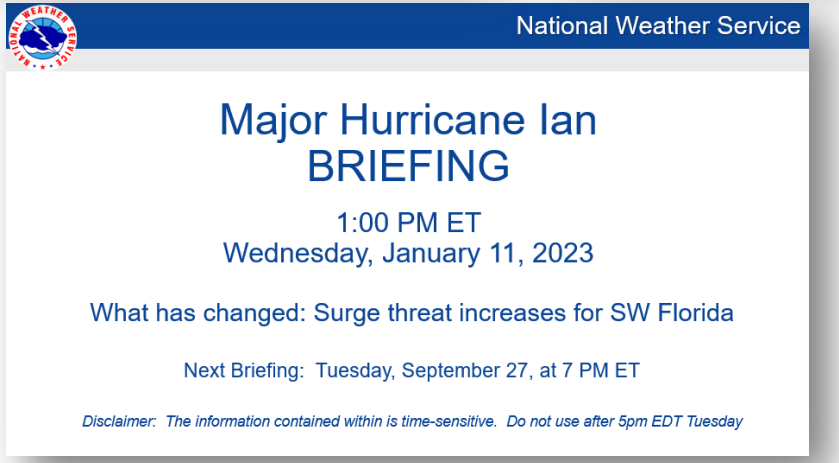
Recovery Forecasts
‘Eye in the Sky’

Decision Support: 3 to 5 Days Before Impact





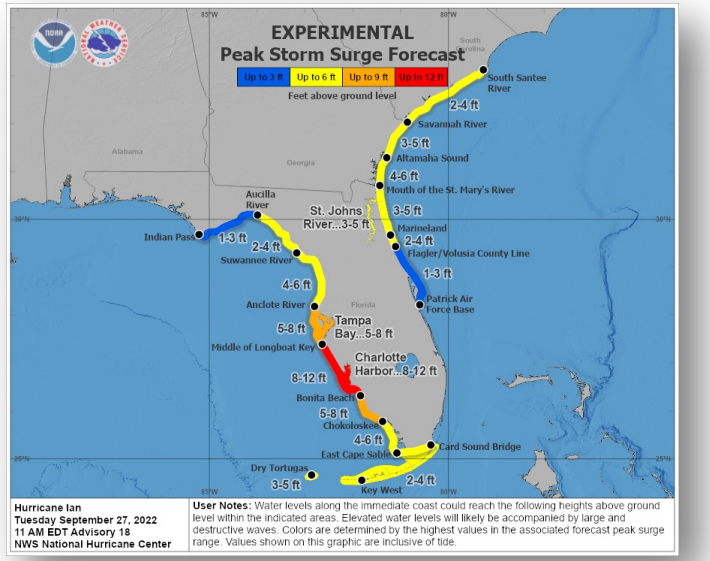


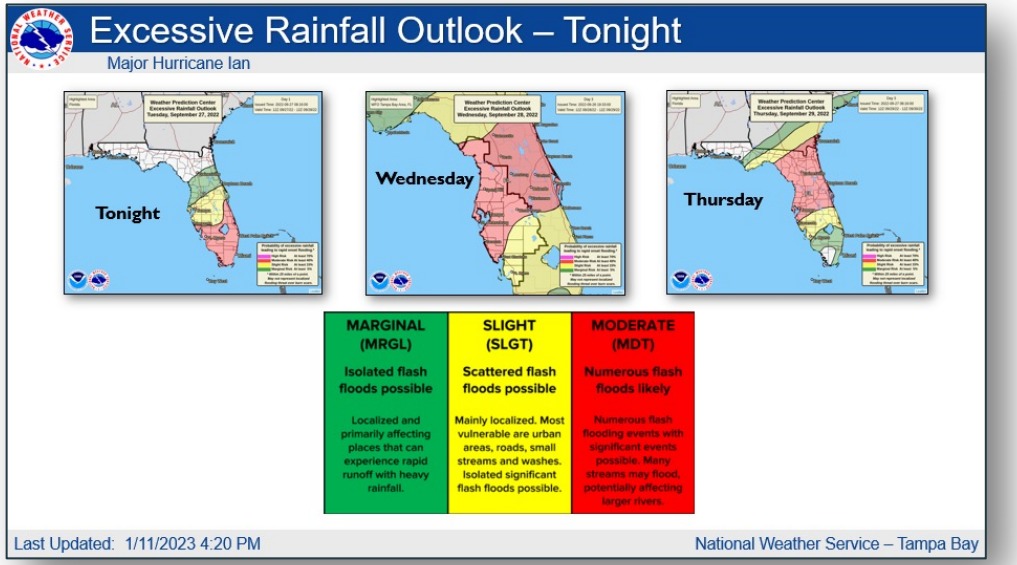


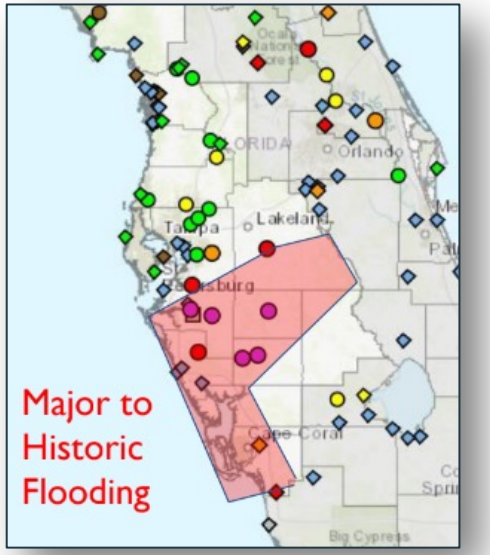
Tropical Email and/or Webinar briefings begin from NWS Tampa Bay (Ruskin) to both the local Media and Emergency Management

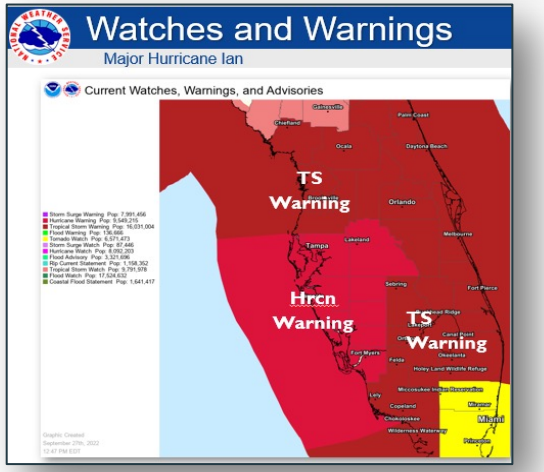
Briefing Times: 7 AM, 1 PM, 7 PM, 1 AM

Decision Support: 1 to 2 Days Before Impact







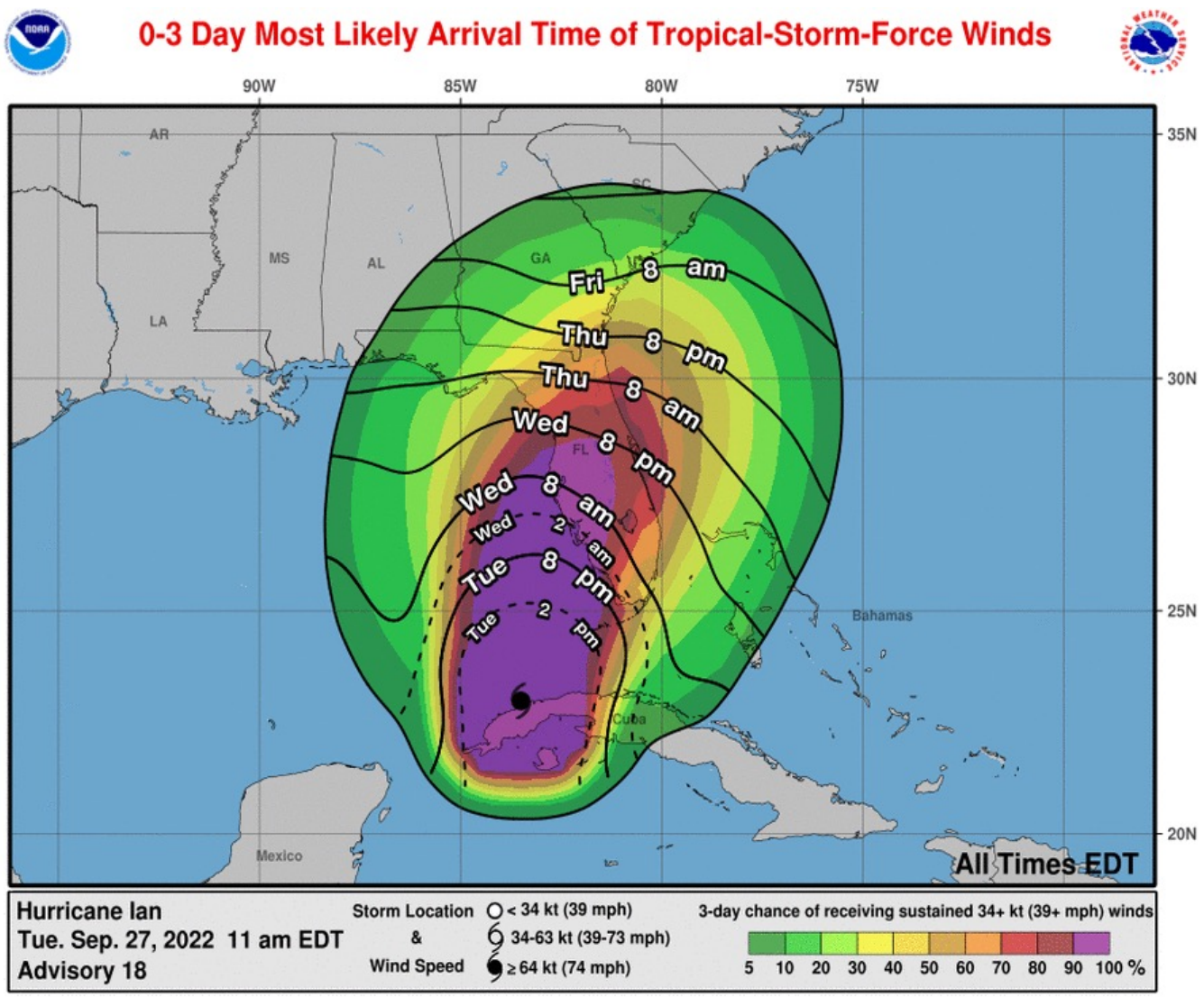




Tropical Email and/or Webinar briefings continue from NWS Tampa Bay (Ruskin) to both the local Media and Emergency Management

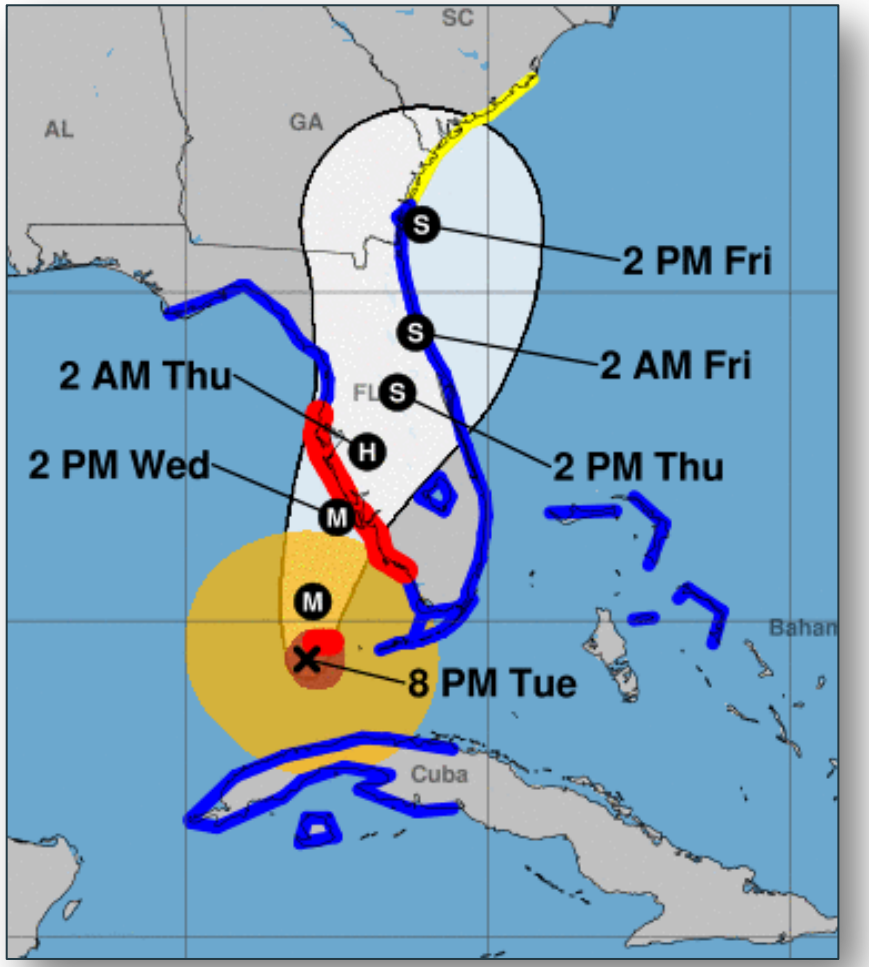
Time of Arrival of Tropical Storm Force Winds

Major Hurricane Ian



County	Earliest Arrival	Most Likely
Lee	8 pm Tue	11 pm Tue
Charlotte	7 pm Tue	10 pm Tue
Sarasota	10 pm Tue	1 am Wed
DeSoto	1 am Wed	5 am Wed
Hardee	1 am Wed	5 am Wed
Highlands	3 am Wed	7 am Wed
Manatee	12 am Wed	4 am Wed
Pinellas	1 am Wed	6 am Wed
Pasco	2 am Wed	8 am Wed
Hillsborough	2 am Wed	8 am Wed
Polk	4 am Wed	8 am Wed
Sumter	5 am Wed	1 pm Wed
Hernando	3 am Wed	7 am Wed
Citrus	5 am Wed	11 am Wed
Levy	7 am Wed	3 pm Wed

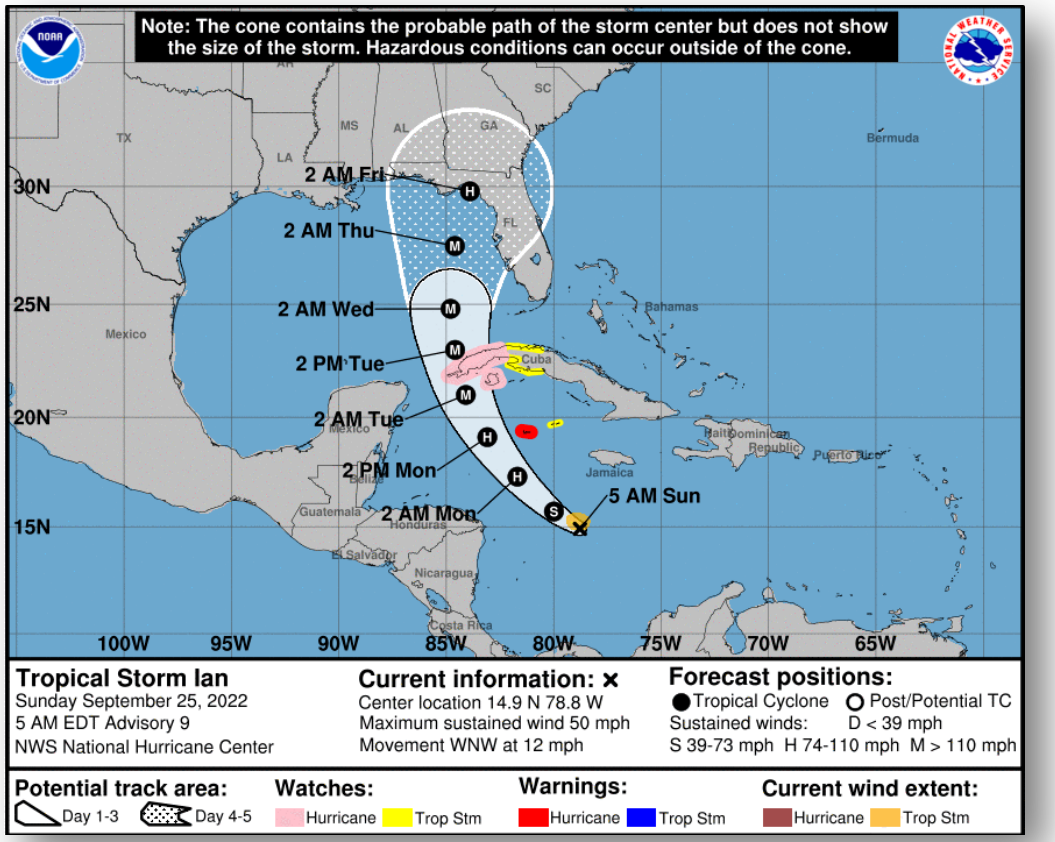
Understanding the Forecast “Cone” vs Impacts

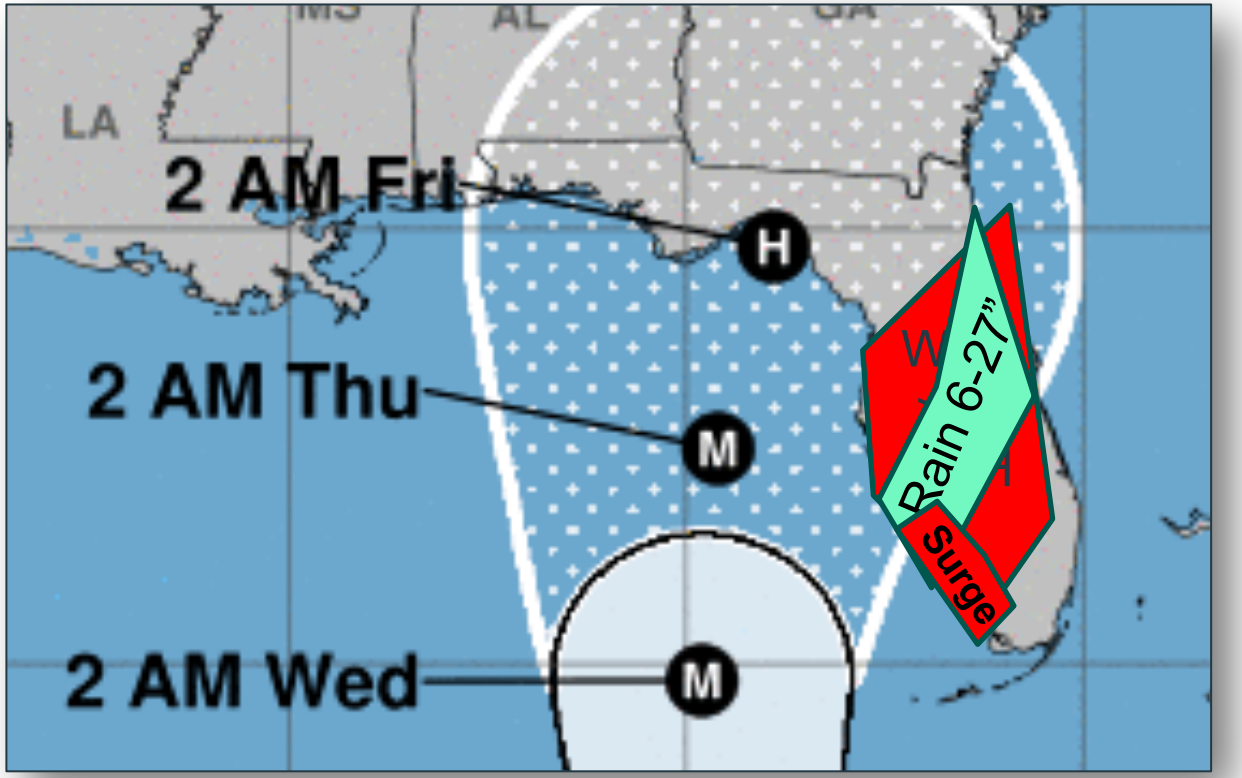


The forecast “Cone of Uncertainty” provides one piece to a much larger puzzle of threats and impacts.

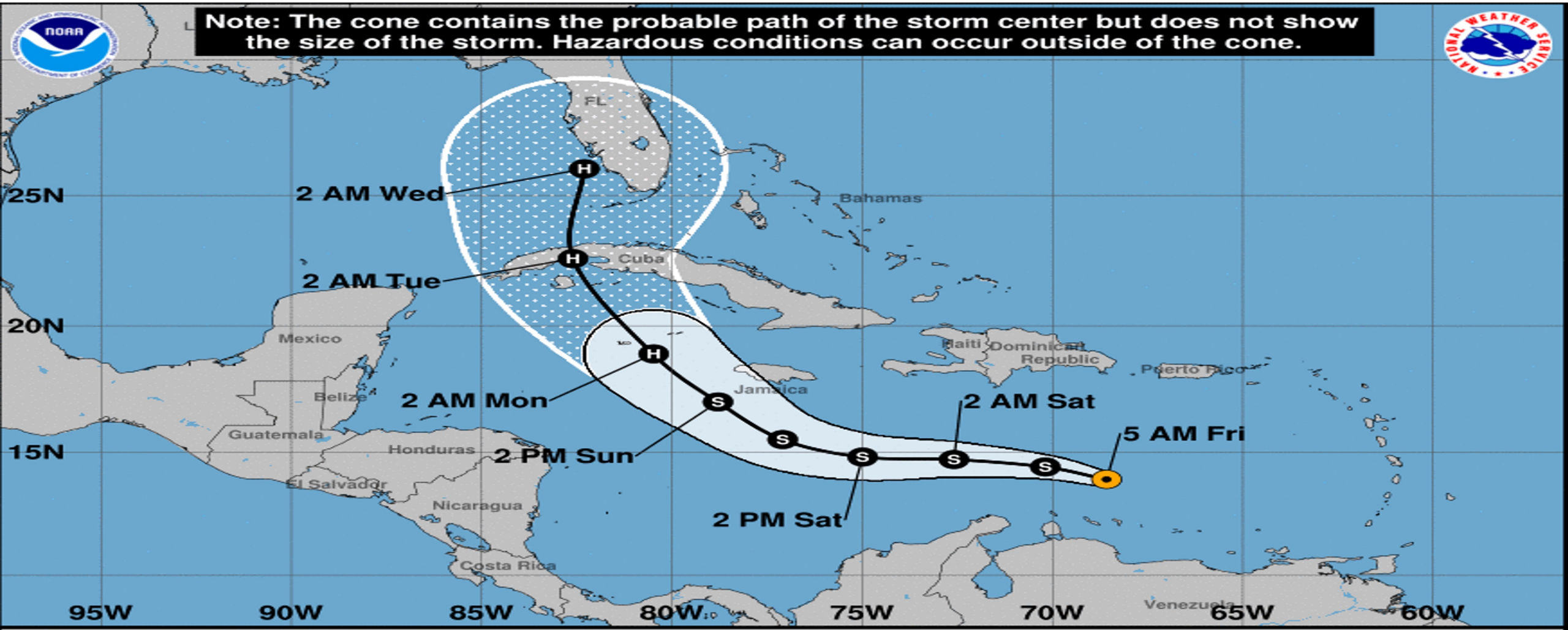
Note how watches and warnings are in effect outside the Cone of Uncertainty.

Be Careful with the Forecast Cone vs Impacts





Advisory 1 from the National Hurricane Center: Ian



Tropical Depression Nine
Friday September 23, 2022
5 AM AST Advisory 1
NWS National Hurricane Center

Current information:
Center location 13.9 N 68.6 W
Maximum sustained wind 35 mph
Movement WNW at 13 mph

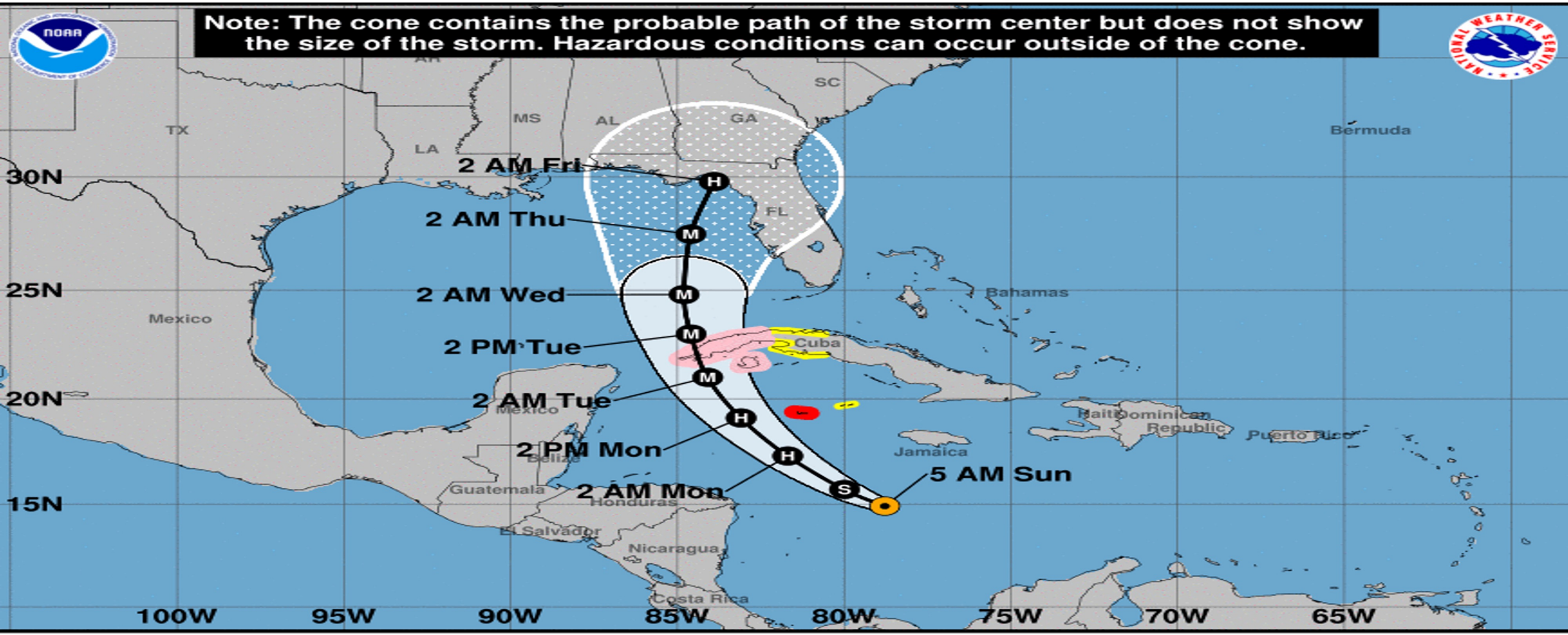
Forecast positions:
Tropical Cyclone Post/Potential TC
Sustained winds: D < 39 mph
S 39-73 mph H 74-110 mph M > 110 mph

Potential track area:
Day 1-3 Day 4-5

Watches:
Hurricane Trop Storm

Warnings:
Hurricane Trop Storm

Sunday 9/25/2022 at 5 AM Tropical Storm Ian



Tropical Storm Ian
Sunday September 25, 2022
5 AM EDT Advisory 9
NWS National Hurricane Center

Current information:
Center location 14.9 N 78.8 W
Maximum sustained wind 50 mph
Movement WNW at 12 mph

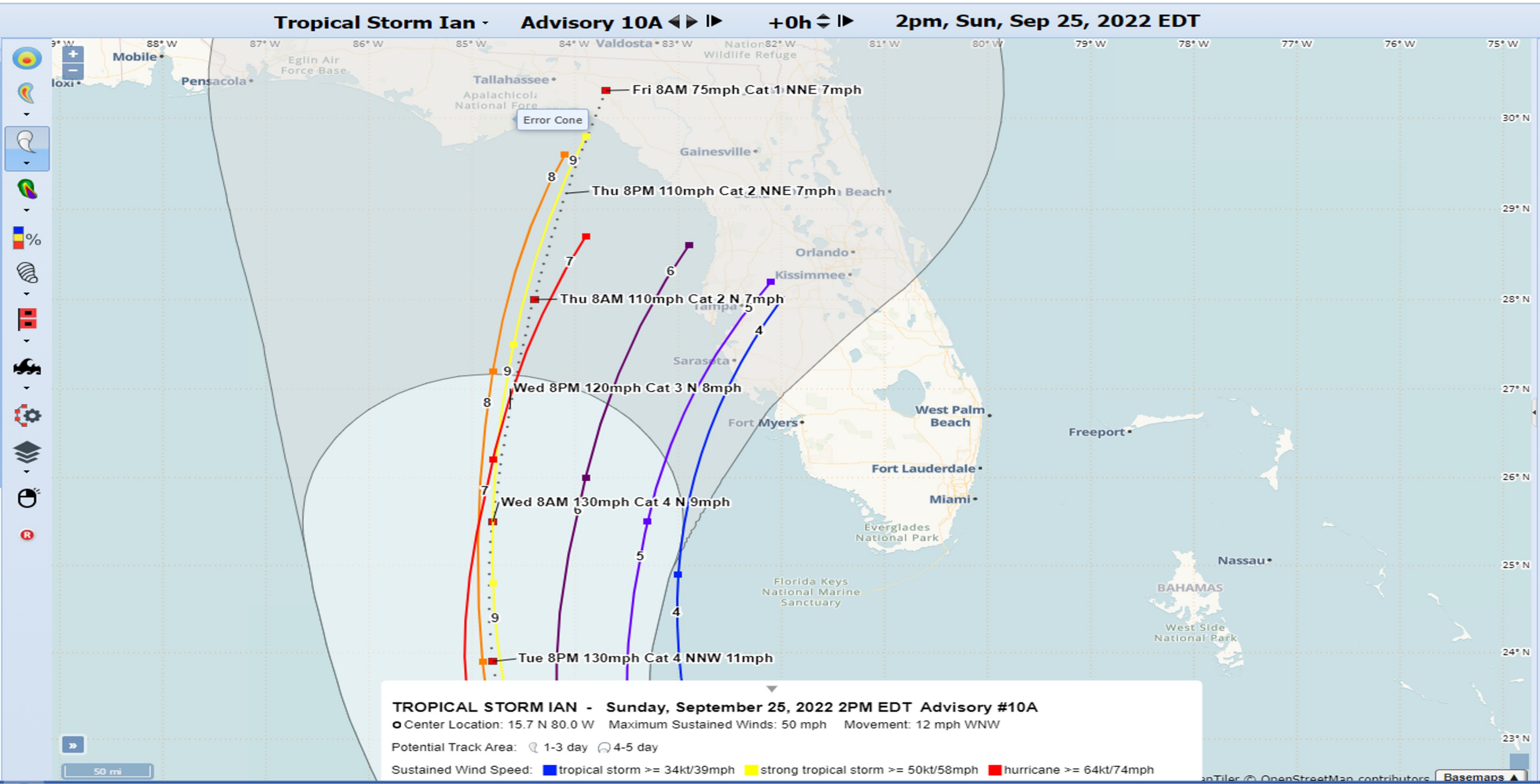
Forecast positions:
Tropical Cyclone Post/Potential TC
Sustained winds: D < 39 mph
S 39-73 mph H 74-110 mph M > 110 mph

Potential track area:
Day 1-3 Day 4-5

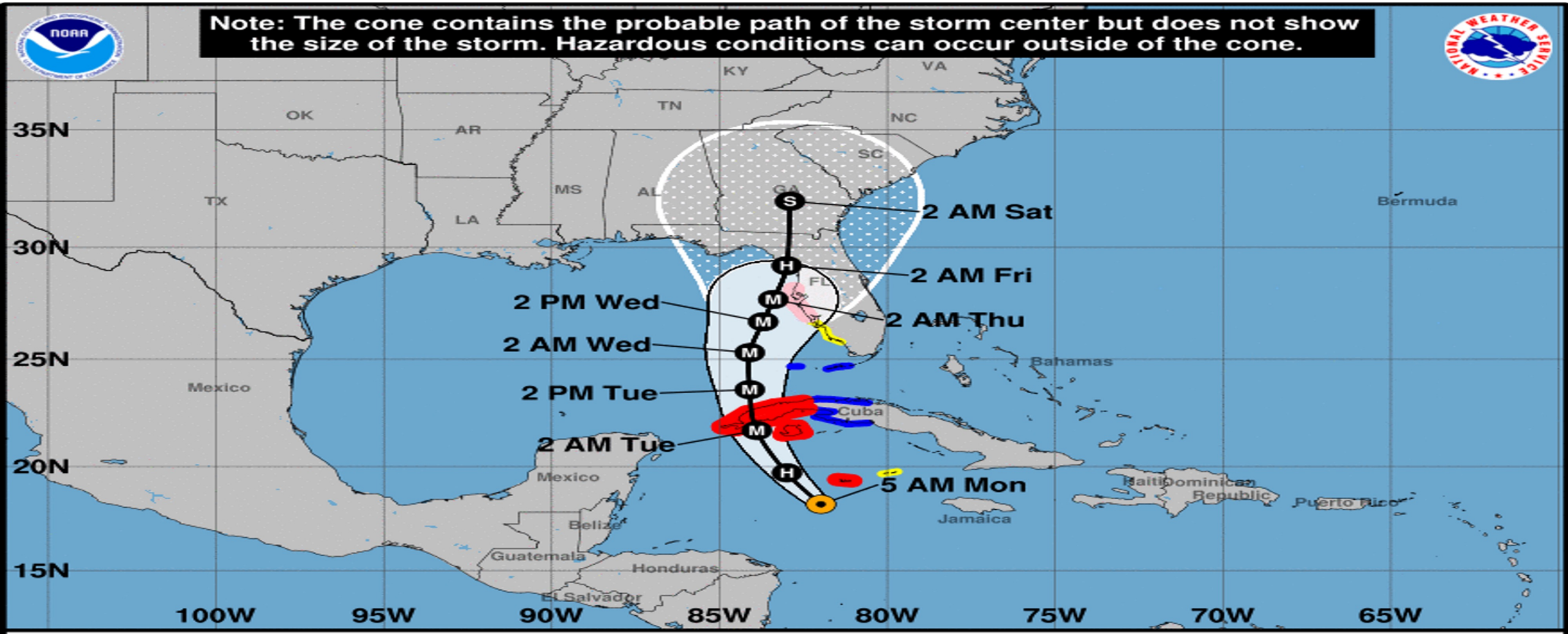
Watches:
Hurricane Trop Storm

Warnings:
Hurricane Trop Storm

Hurricane Ian Tracks Sat 2 AM to Sun 2 PM cone



Monday 9/26/2022 at 5 AM Hurricane Ian



Hurricane Ian
Monday September 26, 2022
5 AM EDT Advisory 13
NWS National Hurricane Center

Current information:
Center location 18.2 N 82.0 W
Maximum sustained wind 75 mph
Movement NW at 14 mph

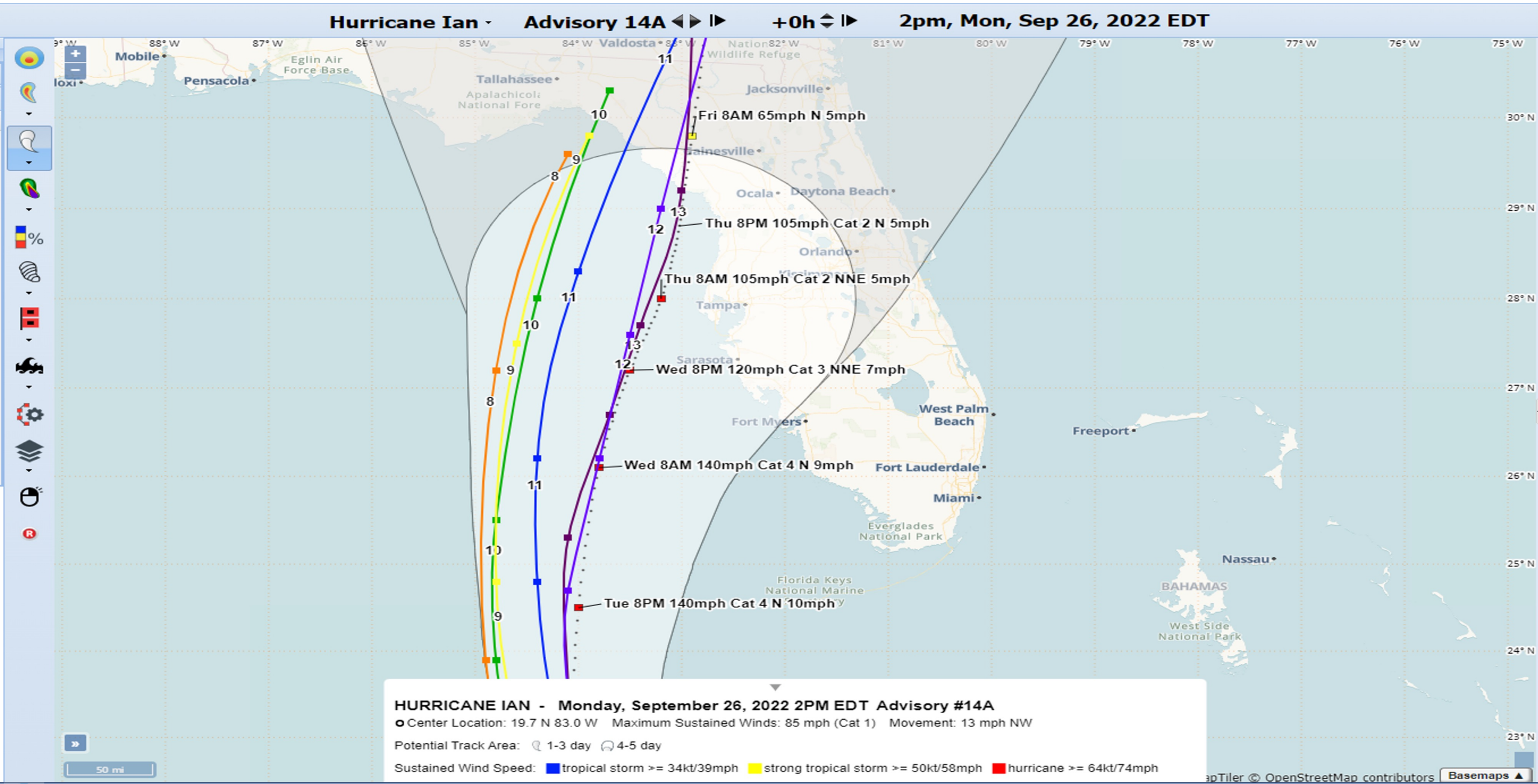
Forecast positions:
Tropical Cyclone Post/Potential TC
Sustained winds: D < 39 mph
S 39-73 mph H 74-110 mph M > 110 mph

Potential track area:
Day 1-3 Day 4-5

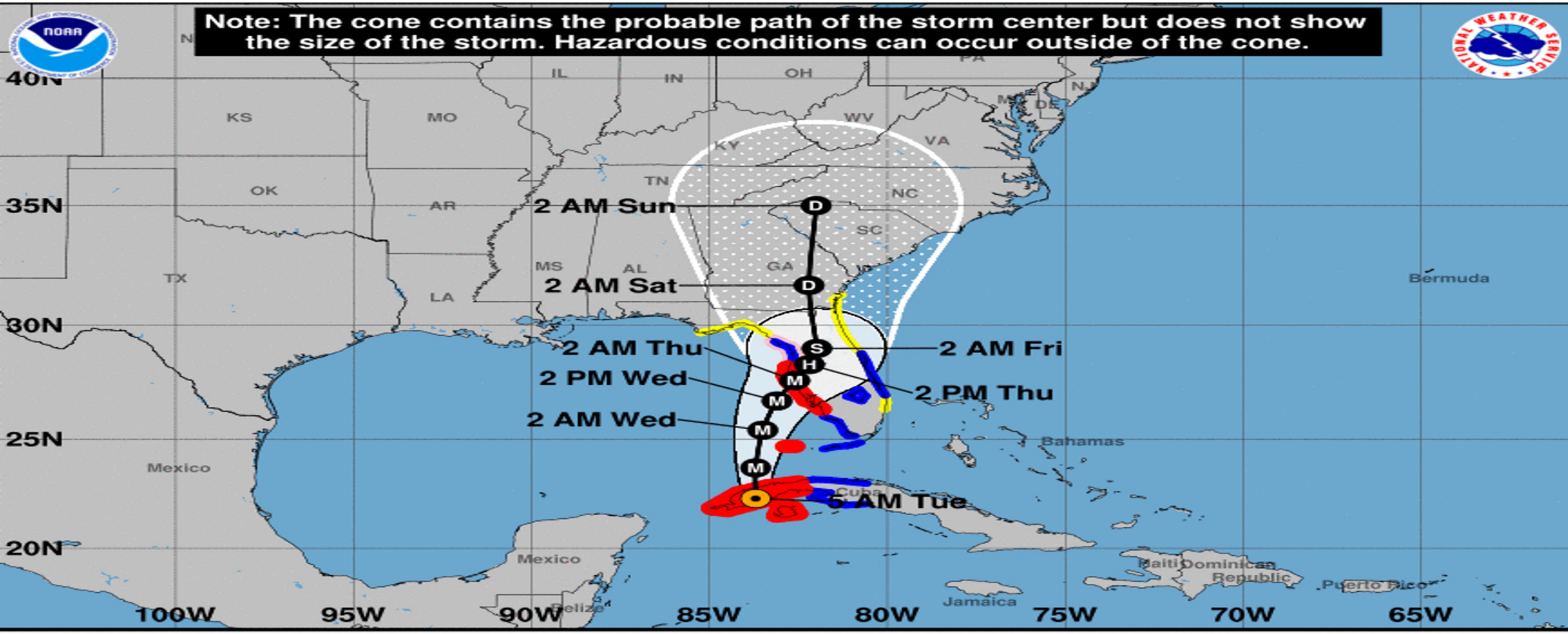
Watches:
Hurricane Trop Storm

Warnings:
Hurricane Trop Storm

Hurricane Ian Tracks Sun 2 AM to Mon 2 PM cone



Tuesday 9/27/2022 at 5 AM Hurricane Ian



Hurricane Ian
Tuesday September 27, 2022
5 AM EDT Advisory 17
NWS National Hurricane Center

Current information:
Center location 22.3 N 83.7 W
Maximum sustained wind 125 mph
Movement N at 12 mph

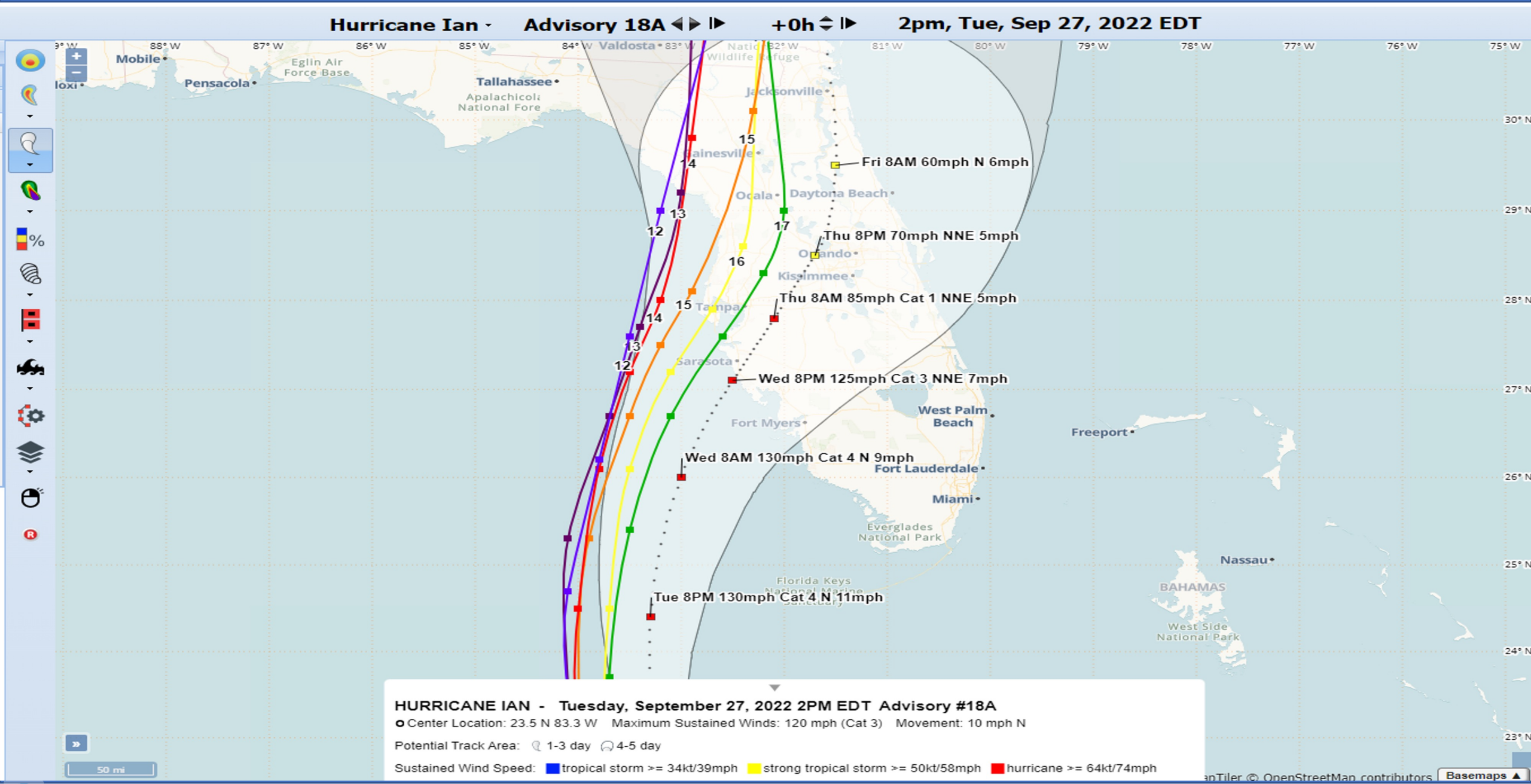
Forecast positions:
● Tropical Cyclone ○ Post/Potential TC
Sustained winds: D < 39 mph
S 39-73 mph H 74-110 mph M > 110 mph

Potential track area:
Day 1-3 Day 4-5

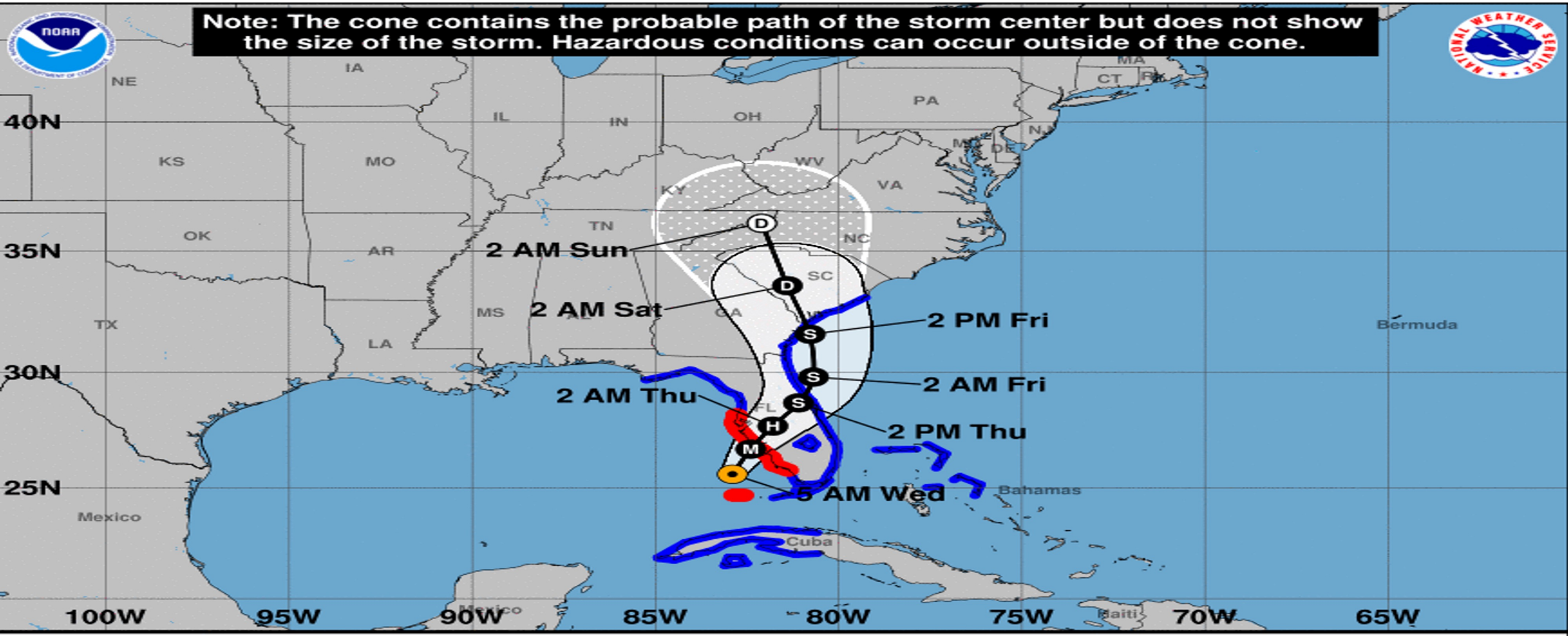
Watches:
Hurricane Trop Storm

Warnings:
Hurricane Trop Storm

Hurricane Ian Tracks Mon 2 AM to Tue 2 PM cone



Wednesday 9/28/2022 at 5 AM Hurricane Ian



Hurricane Ian
Wednesday September 28, 2022
5 AM EDT Advisory 22
NWS National Hurricane Center

Current information:
Center location 25.6 N 82.9 W
Maximum sustained wind 140 mph
Movement NNE at 10 mph

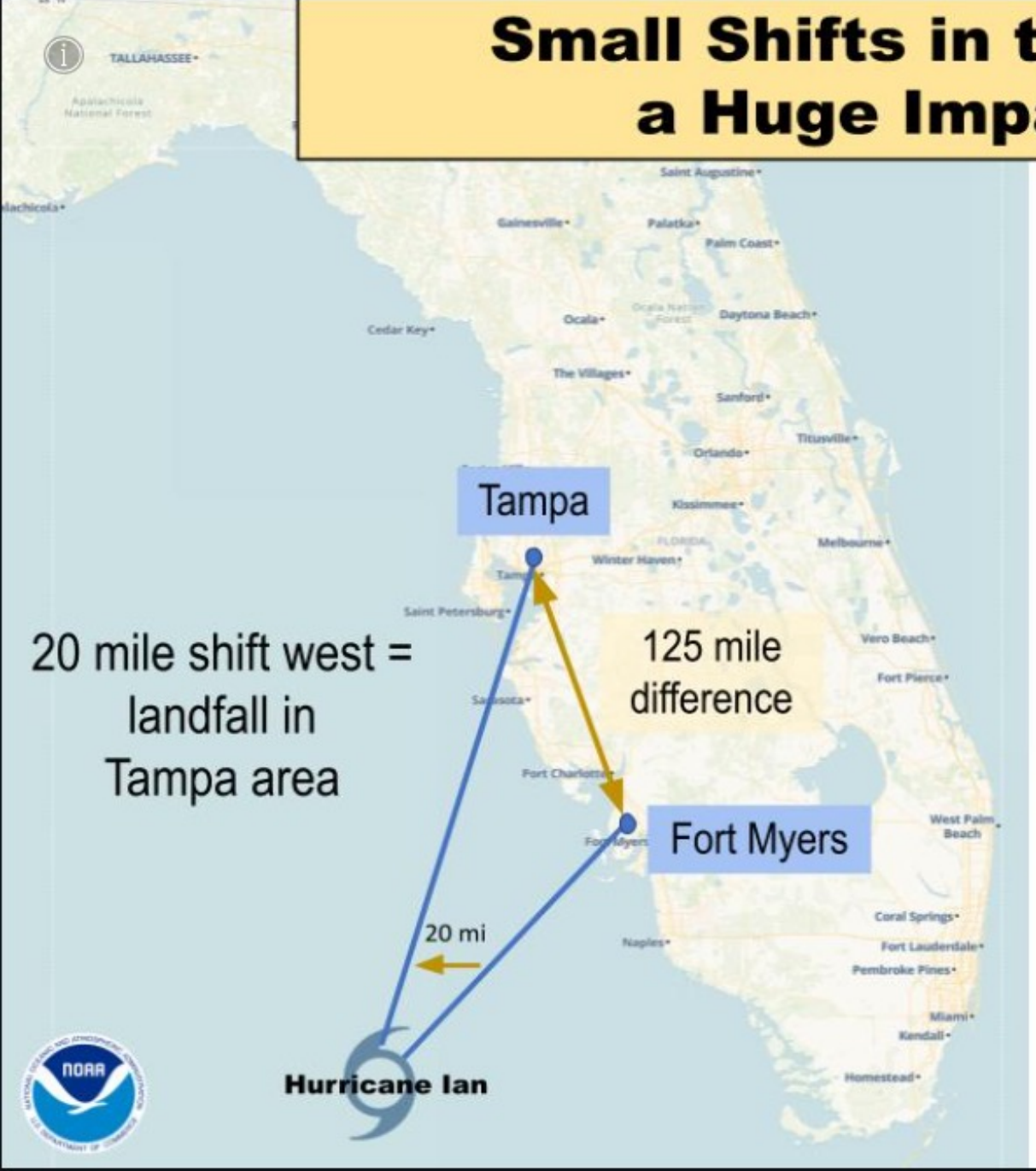
Forecast positions:
● Tropical Cyclone ○ Post/Potential TC
Sustained winds: D < 39 mph
S 39-73 mph H 74-110 mph M > 110 mph

Potential track area:
Day 1-3 Day 4-5

Watches:
Hurricane Trop Storm

Warnings:
Hurricane Trop Storm

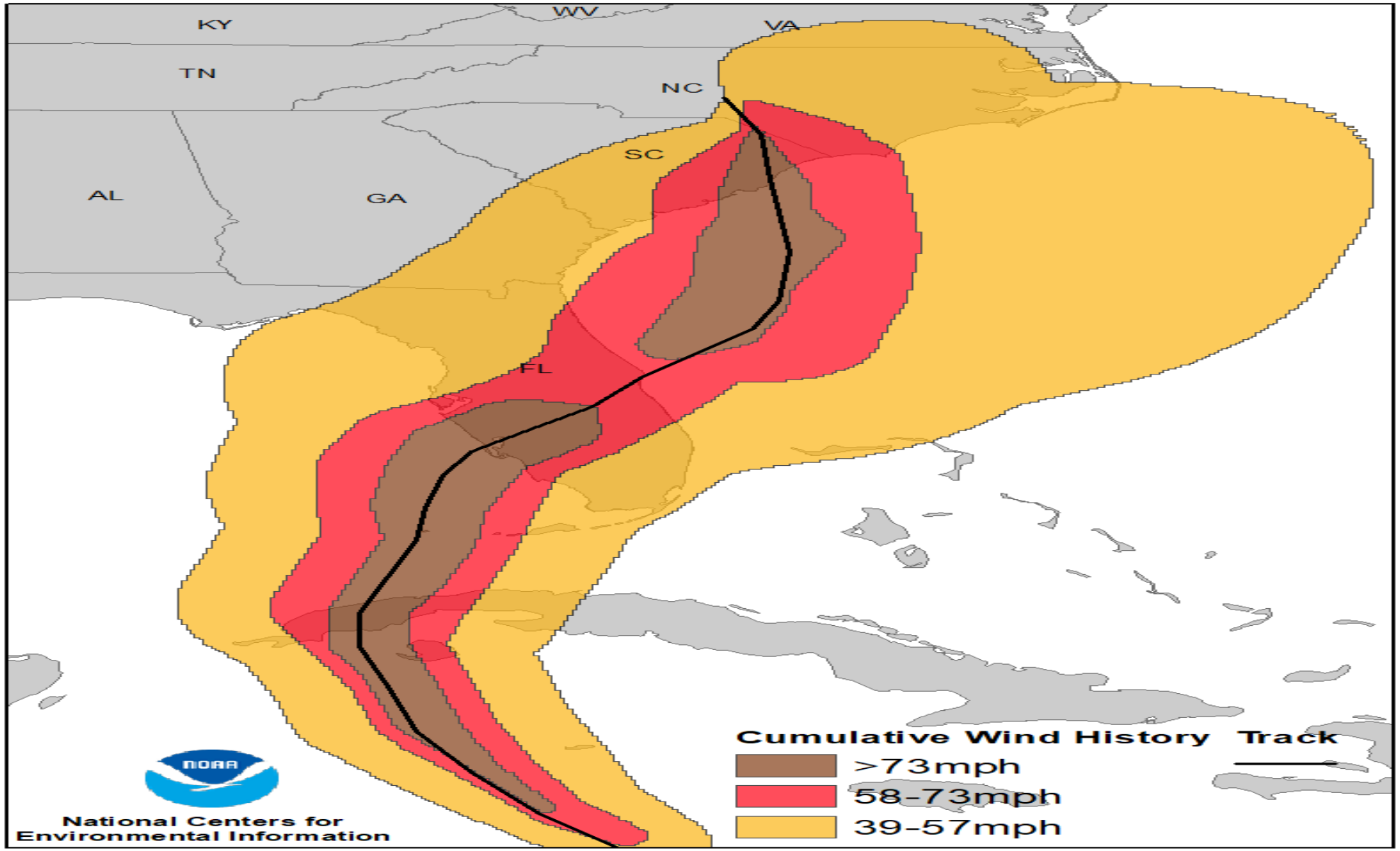
Small Shifts in the Track Can Have a Huge Impact on Landfall



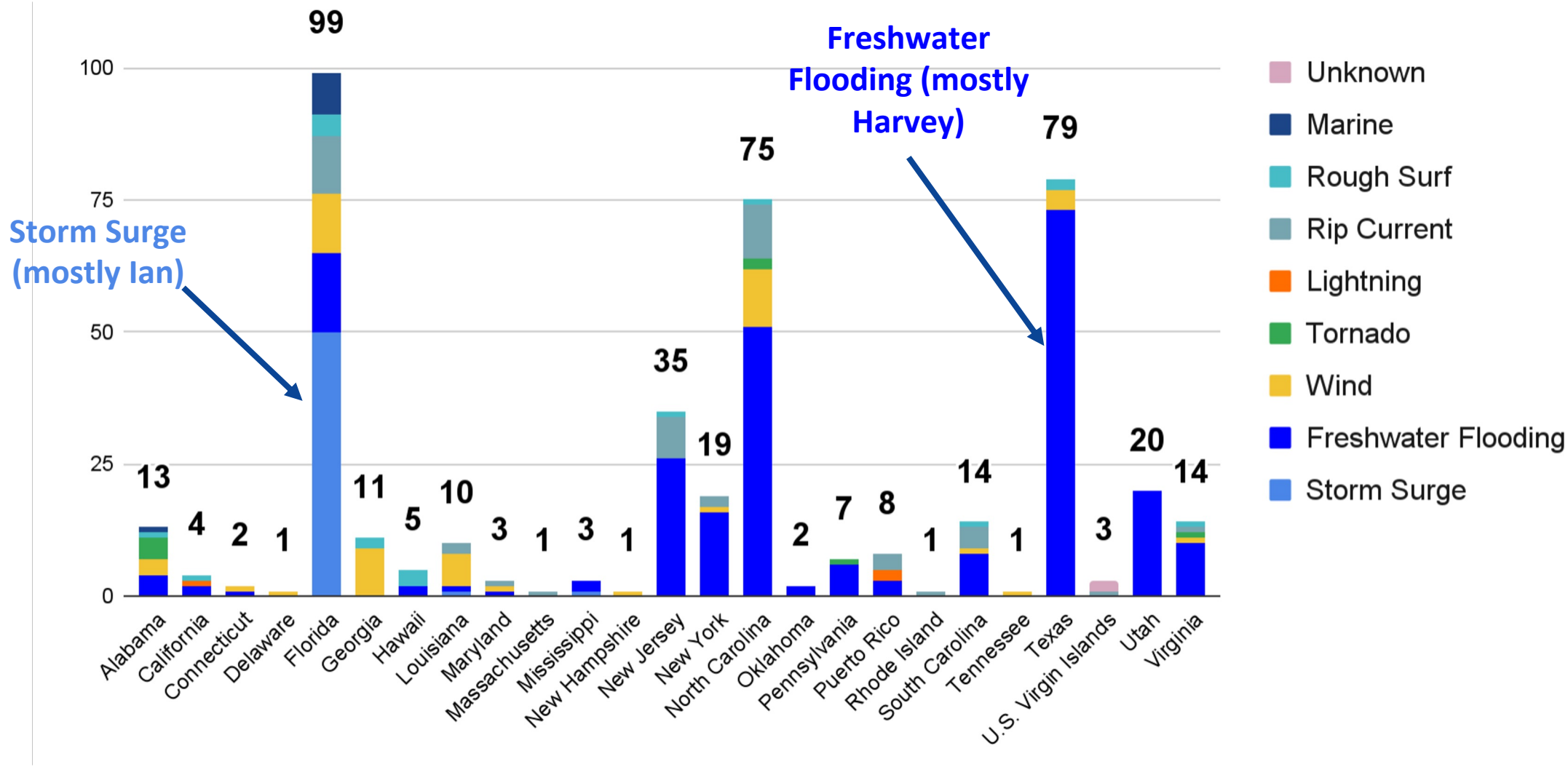


Small track changes can have a large impact on the eventual landfall point (and subsequent impacts) across the West Coast of Florida

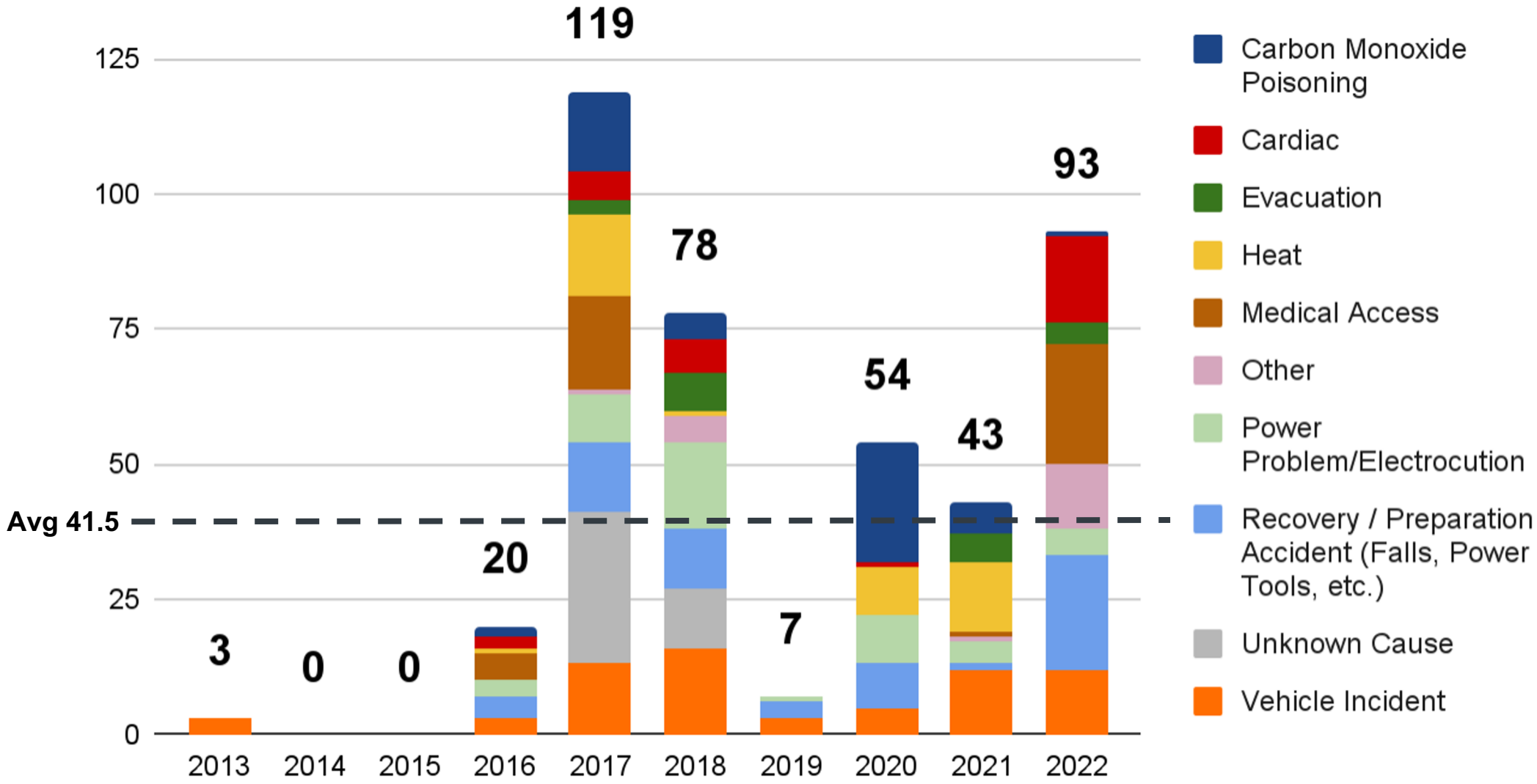
Hurricane Ian Track and Wind History



Direct Fatalities by State - 2013-2022



Indirect Fatalities by Year - 2013-2022

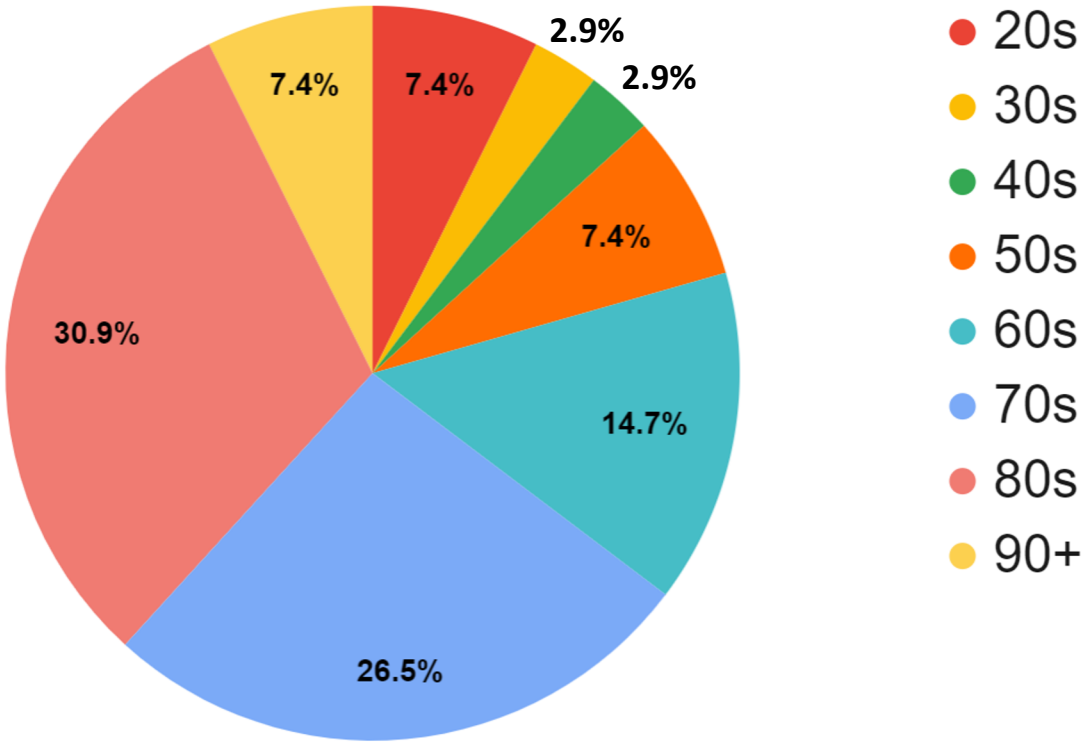


Ian Direct Fatalities

Demographics

74% of direct fatalities were 60+

52% were 70+



- Ian was responsible for 66 direct deaths - all in Florida
- Deadliest hurricane to affect the CONUS since Sandy (2012)

- Storm Surge: 41
- Freshwater Flooding: 12
- Marine: 8
- Wind: 4
- Surf: 1

Hurricane Ian – September 28, 2022

Top National Weather Service meteorologists scour damage zone to improve future hurricane forecasts

WGCU | By Tom Bayles
Published October 6, 2022 at 1:08 PM EDT



Tom Bayles /

Brian LaMarre, left, who is the National Weather Service's chief meteorologist in the Tampa Bay region, talks with Pablo Santos, who is in charge of the NWS in Miami-South Florida, this week along hard-hit San Carlos Island while looking for subtle clues left behind by Hurricane Ian that might help improve the forecast during future tropical cyclones

Hurricane Ian: The People and Their Stories







2022 Major Hurricane Ian - Impact









Casey Shannon
1d ·

I took this earlier today, around 4:30. This is highway 70 looking south east over the train tracks coming into Arcadia. I took some video too but I don't have a battery big enough to upload it over a mobile Hotspot. This is the highest I've ever seen the river...



6 2 shares

Like Comment Share

Hurricane Ian: The People and Their Stories




Storm Surge: High Water Mark

Social Science Research: Who Evacuates?

First Out 21%	Anxious and eager to leave if a hurricane is in the forecast
Constrained 14%	Aware of risks & willing to evacuate but face barriers
Optimists 16%	Doubt that a hurricane will occur but willing to evacuate
Reluctant 27%	Reluctant to evacuate but will leave if ordered to
Diehards 22%	Confident they can safely ride out hurricanes at home

Hurricane Sandy study by Jennifer Marlon, Yale University

Last Resort Safety Messaging

THE REALITIES OF STORM SURGE

- This is what surge can do to a home
- It is a constant onshore push of water, potentially for hours
- This is the main reason for evacuations. **Be sure to heed any evacuation orders from your county officials!**
- The water rises fast - like a tsunami. As a **last resort**, if caught in the surge, it is important to go vertical (example: second or third floor of the building you are sheltering in) instead of trying to evacuate in your vehicle once water has started to rise
- Be sure to include an axe or saw in your hurricane supply kit

NATIONAL WEATHER SERVICE
WEATHER FORECAST OFFICE
TAMPA BAY, FL



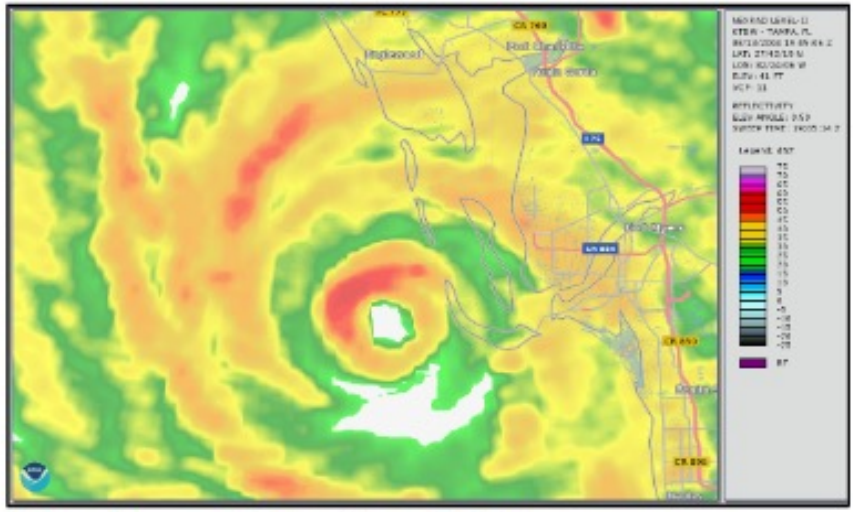


Hurricane Ian (Cat 4) 11.5 ft AGL storm surge in Fort Myers Beach, FL

Last Resort Safety Messaging

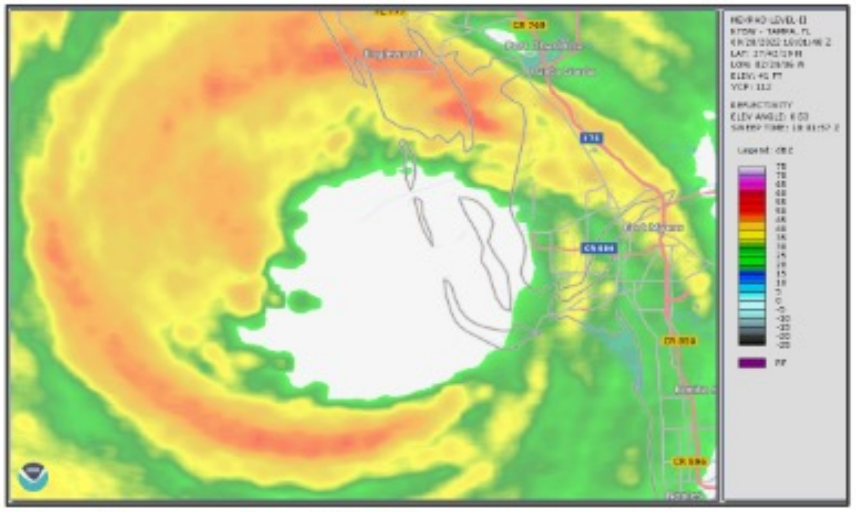
- Despite all of our best efforts, studies prove that some will choose to stay rather than evacuate - no matter what!
- We must therefore have some element of last resort safety within our messaging
- It should highlight going vertical rather than trying to escape in a vehicle
- Should also highlight having an axe or saw available if trapped

Hurricane Comparison: Category – Size – Impacts



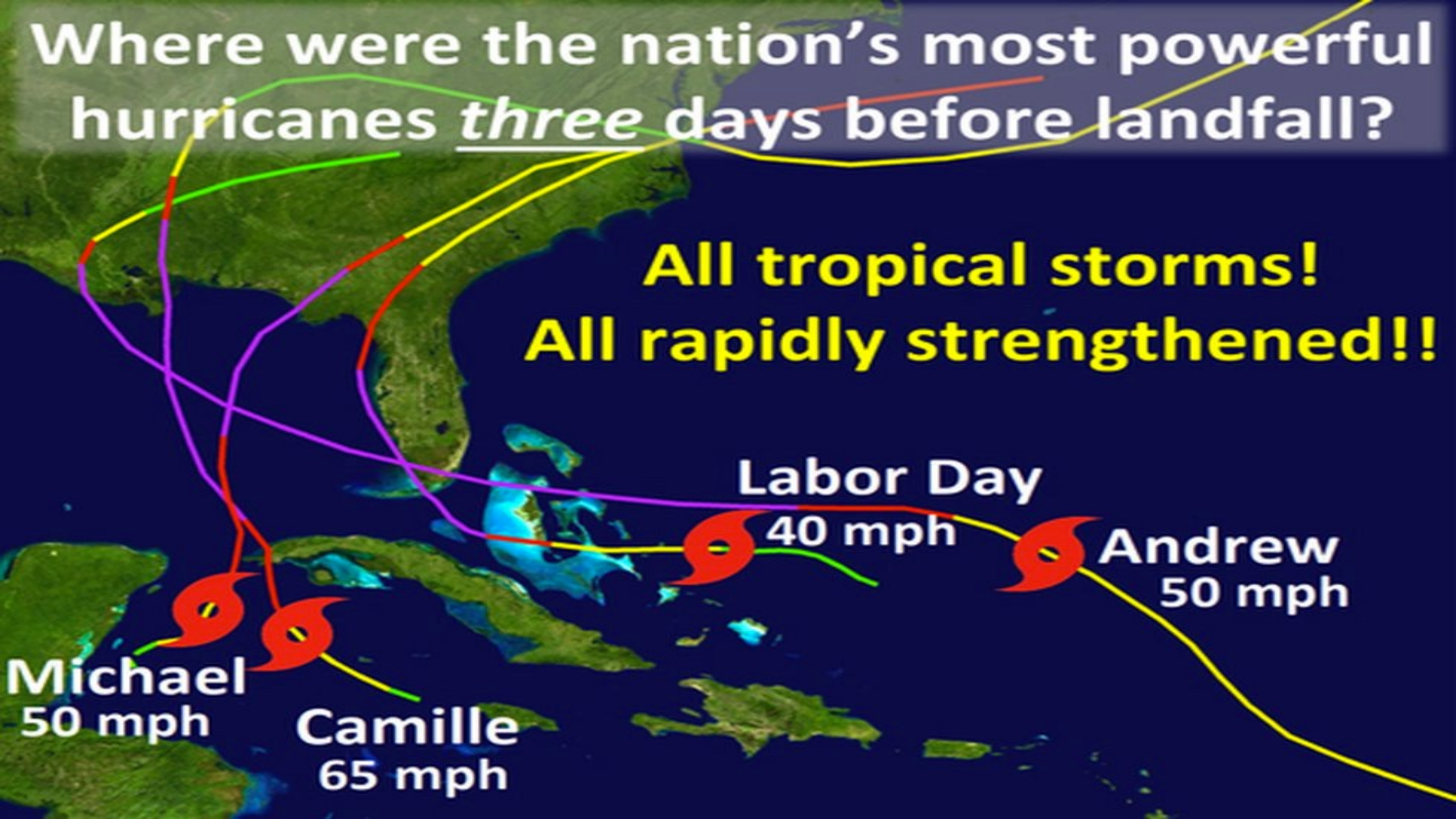
Hurricane Charley 2004

- Cat. 4 at landfall (141mph max wind)
- Landfall at Cayo Costa
- Eye was 10 miles wide
- Extreme winds were contained to within 10 miles of the eye
- Movement NNE at 21mph
- Minimum Central Pressure 940mb
- Max Storm Surge near **6ft** at Matanzas Pass FMB



Hurricane Ian 2022

- Cat. 4 at landfall (150mph max wind)
- Landfall at Cayo Costa
- Eye was 26 miles wide
- Extreme winds were contained to within 40 miles of the eye
- Movement NNE at 9mph
- Minimum Central Pressure 940mb
- Max Storm Surge near **15.5ft** at northern FMB


Where were the nation's most powerful hurricanes *three* days before landfall?
All tropical storms!
All rapidly strengthened!!
Labor Day
40 mph
Andrew
50 mph
Michael
50 mph
Camille
65 mph


THANK
YOU