



Hurricane Readiness in Complex Situations

Part 2: Hurricane Emergency Plans for the Tropical Tornado & River Flooding Hazards

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Marisa Shivers, Glades County Emergency Management





Tropical Rain Induced Riverine Flooding in Florida

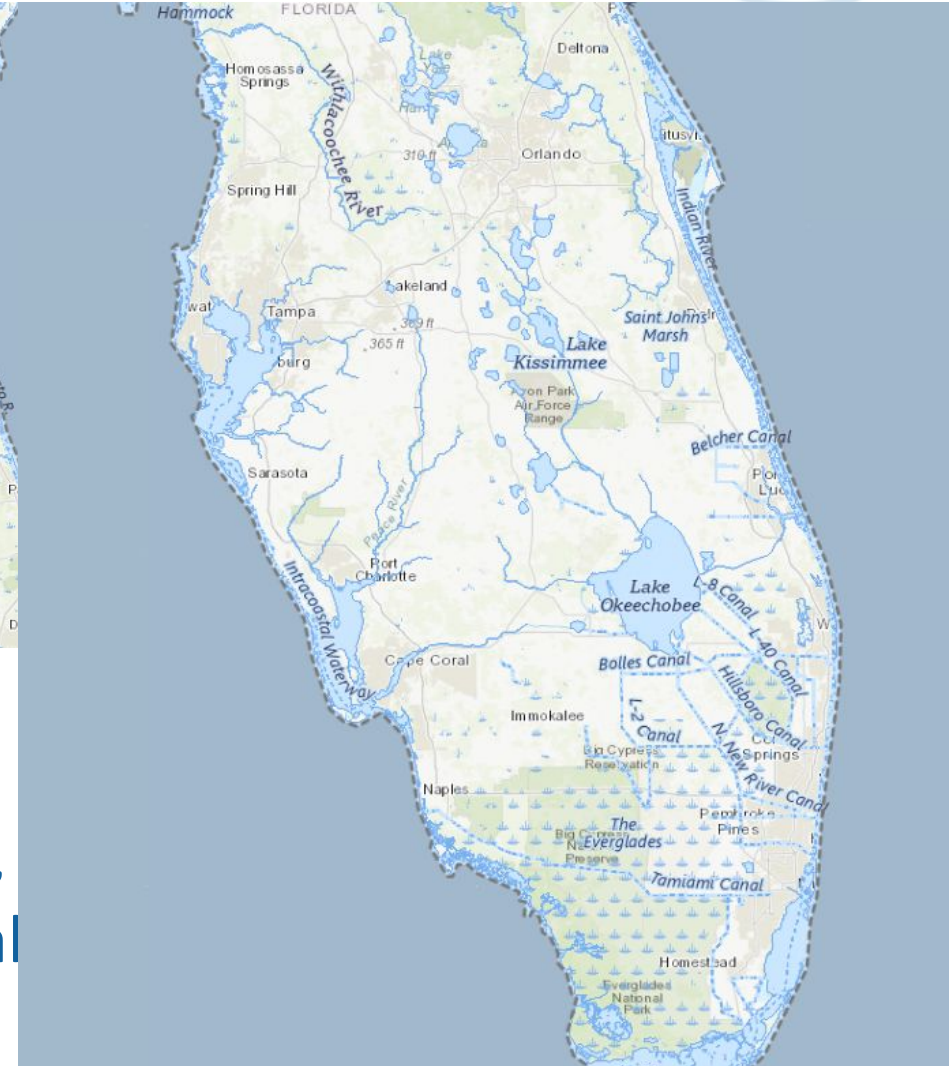
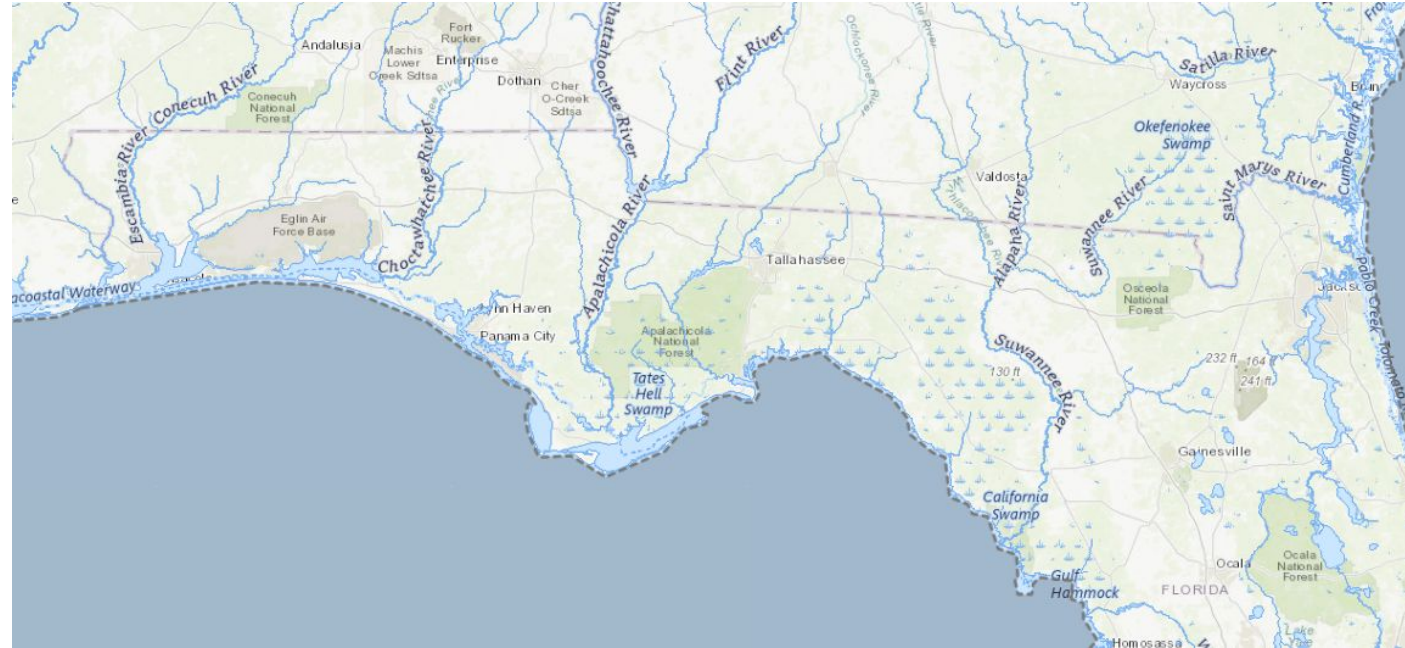
*Utilizing Flood Inundation Mapping
to Respond to Threats*

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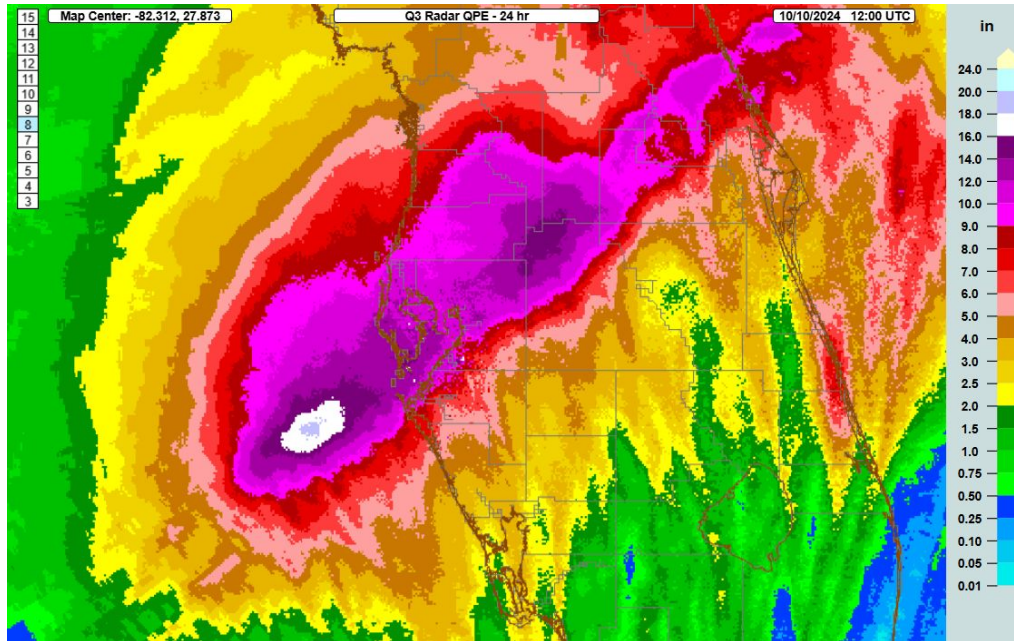


Just some basic geography



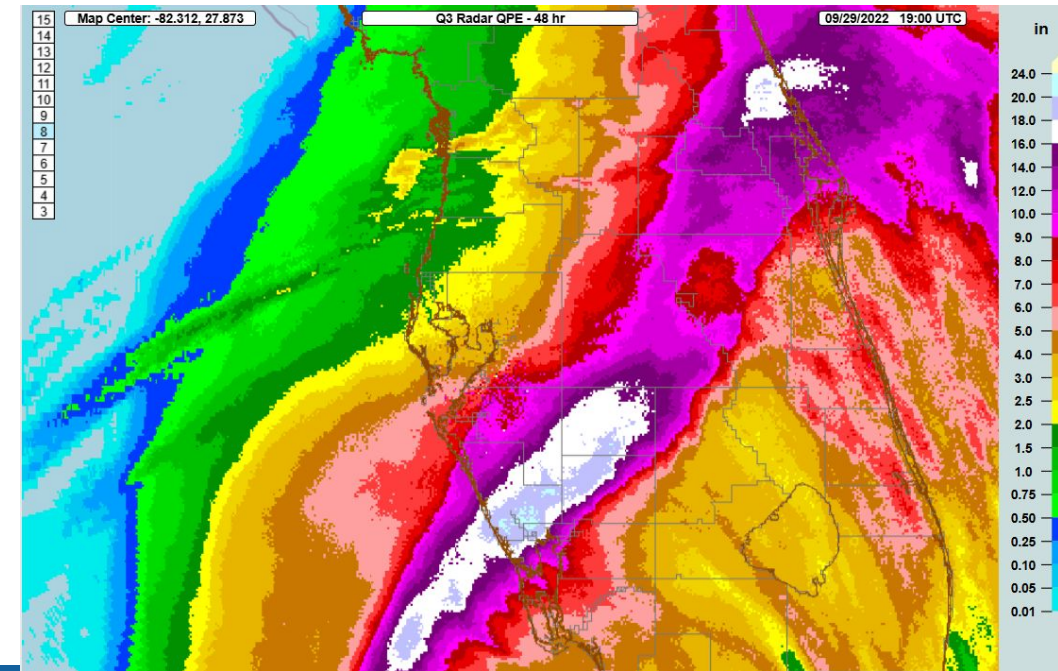
Most of North Florida is routed flow into river systems, with some uniqueness. Central and South Florida is completely different, with South-North flowing rivers, shorter and smaller basins with varying response times.

I think we all remember these!



← Milton (2024) Rainfall Footprint

Generally aligned with the entire I-4 corridor, centered about 50 mi north of the Ian footprint.



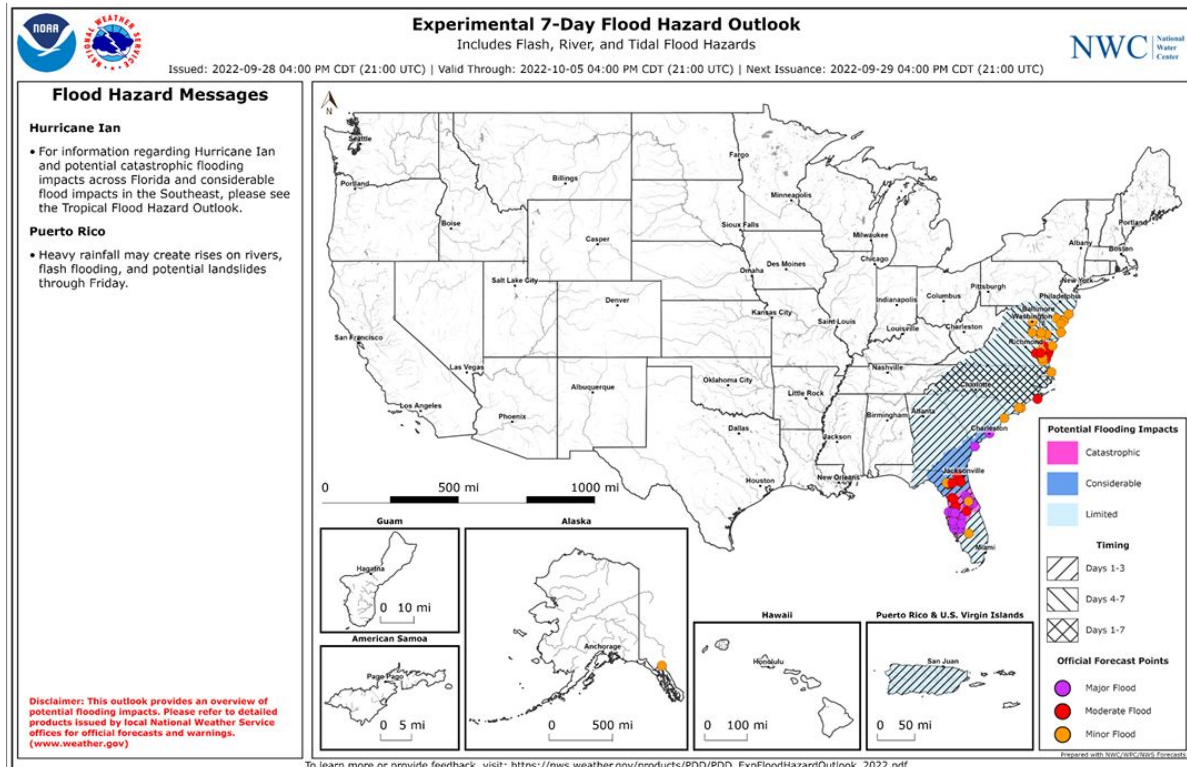
Hurricane Ian (2022) rainfall →

Extreme amounts southwest FL with heavy amounts in the headwaters of the St Johns River and metro Orlando.



Outlooks/Uncertainty

So I'm talking about flash flooding tomorrow, so I need to make an important distinction. One of these is not like the other. Why?



Excessive Rainfall Forecast

This web page depicts the Excessive Rainfall Outlook (ERO). In the ERO, the Weather Prediction Center (WPC) forecasts the probability that rainfall will exceed flash flood guidance (FFG) within 40 kilometers (25 miles) of a point.

[Product Info](#) | [Understanding ERO Categories](#) | [ERO Climatology](#) | [Day 1 threat area](#) | [Day 2 threat area](#) | [Day 3 threat area](#)

Day 1 Day 2 Day 3 Day 4 Day 5

Day 2 Excessive Rainfall Outlook
Valid 1200Z Wed May 06 2026 Through 1200Z Thu May 07 2026
Issued: 0818Z Tue May 05 2026
Forecaster: BANN
DOC/NOAA/NWS/NCEP/WPC

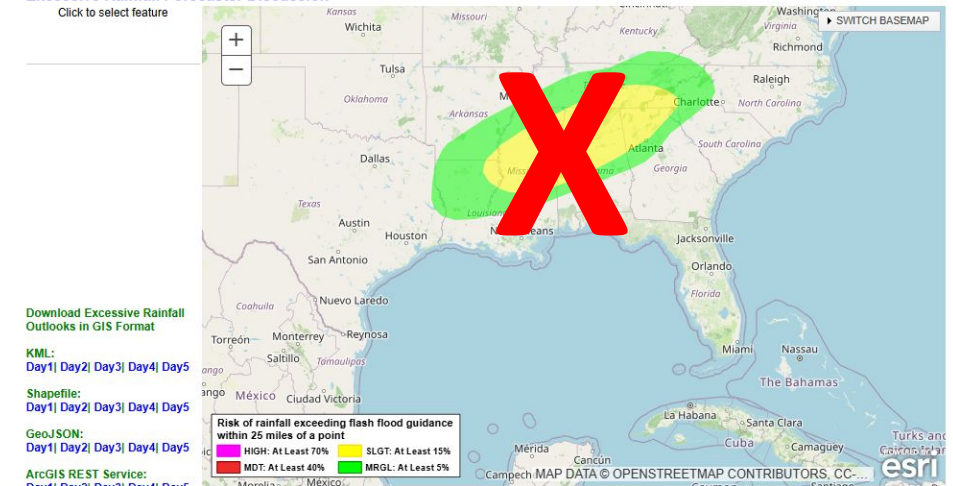
Map Overlays

CWAs Counties
 RFCs FEMA Regions
 States NWS Forecast Zones
 Urban Areas ARTCC/FIR

Select Zoom Area: CONUS

Excessive Rainfall Forecaster Discussion

Click to select feature



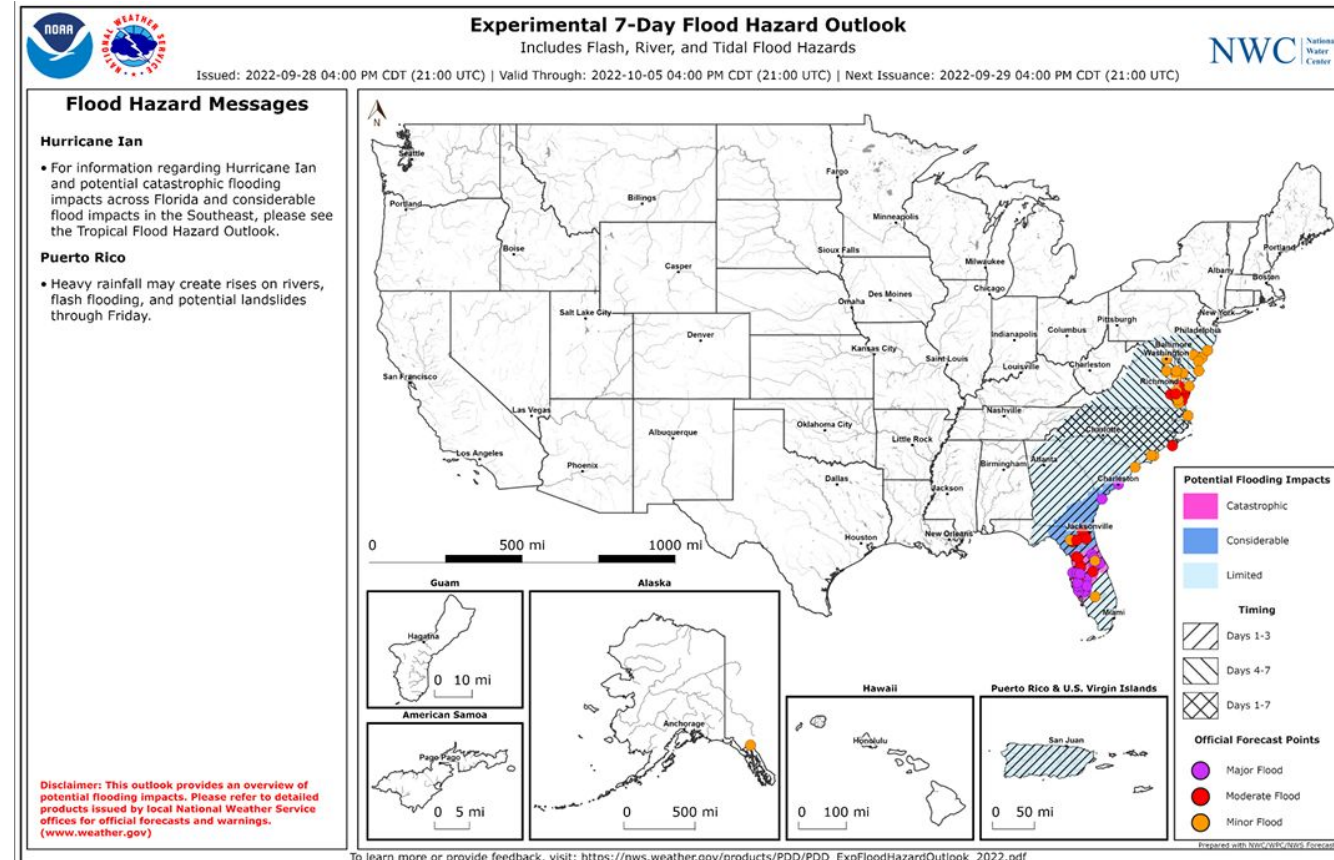
Change image opacity: 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Print Map



Outlooks/Uncertainty

- The flood hazard outlook is issued by the National Water Center and incorporates riverine and flash flooding into one product.
- It also provides key messages on the side.
- It does focus on temporal scales, but these can be challenging to interpret.
- This is a one stop shop for all inland flood hazards.

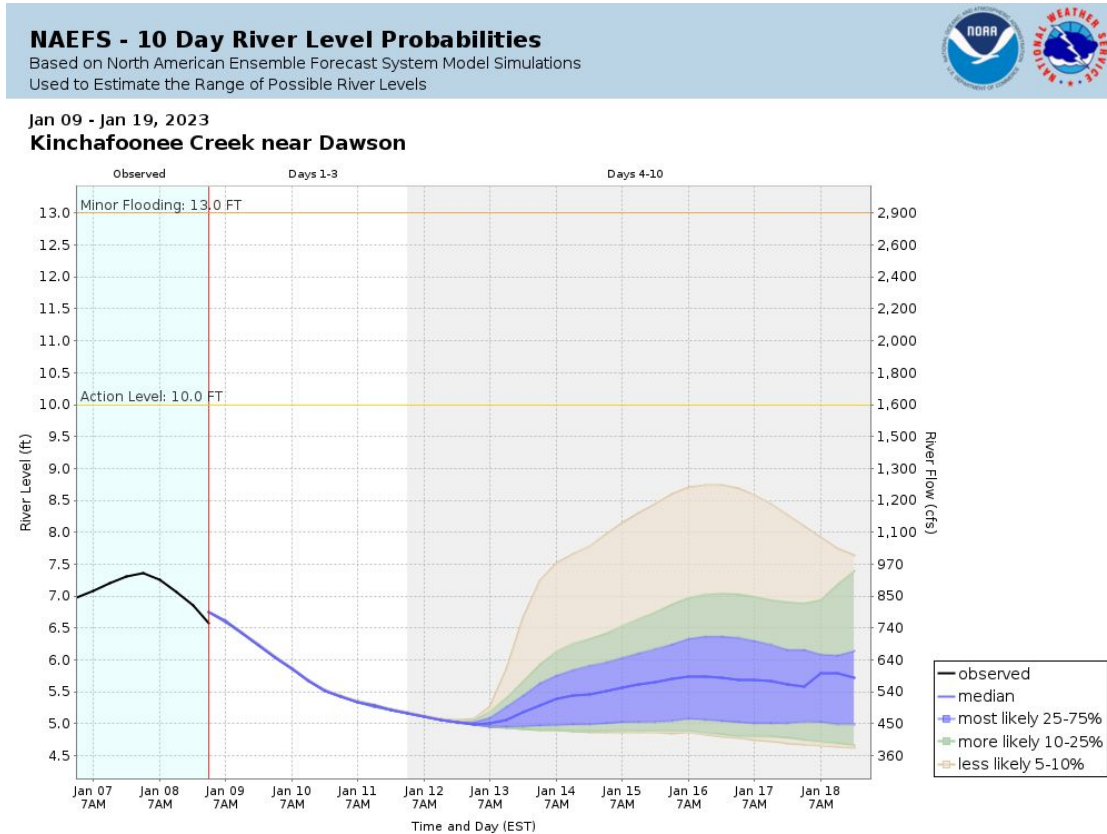


Does not account for storm surge!



Uncertainty - Ensembles

- A deterministic forecast only covers the first 48 hours.
- Ensemble forecasts are available and in some cases extend to 10 days
- Deterministic - single input, single forecast
- Ensemble - multiple inputs, multiple forecasts
 - Captures all *reasonable* outcomes for an event
 - Provides probabilities



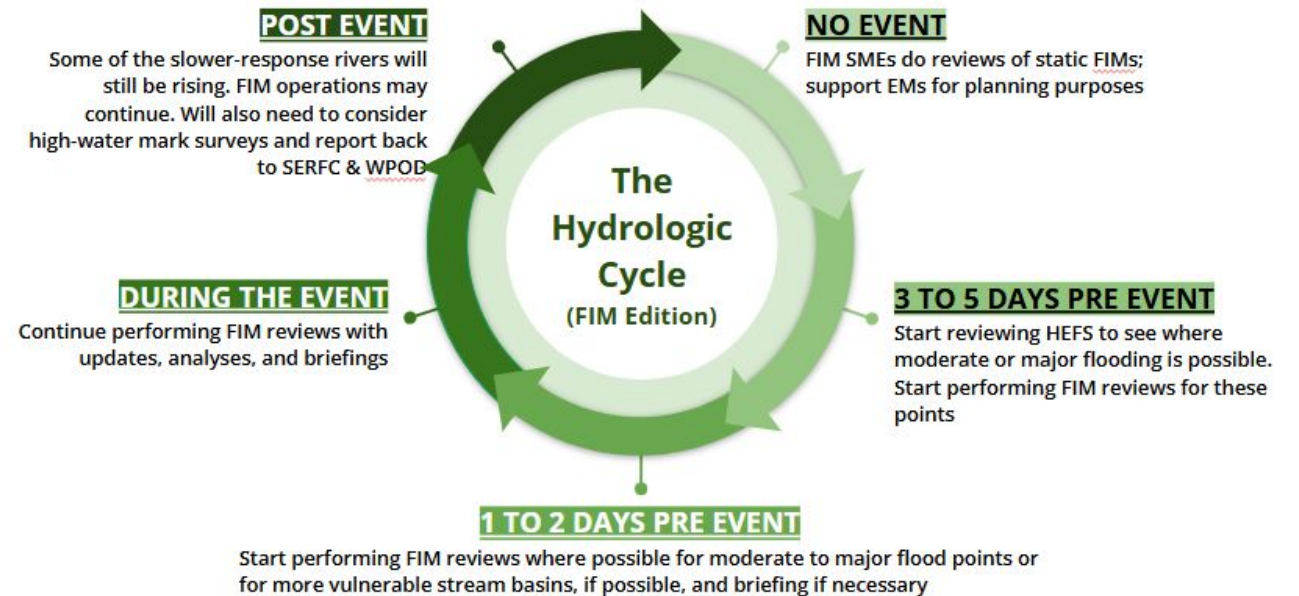
Model runtime: 01:00 AM EST Jan 09 2023
Southeast River Forecast Center



What is Flood Inundation Mapping

- Flood Inundation Mapping (FIM) is a depiction of what is expected to flood, based on the source used.
 - Static FIMs - Not focused on a specific event.
 - Dynamic FIMs - Uses precipitation for that specific event.

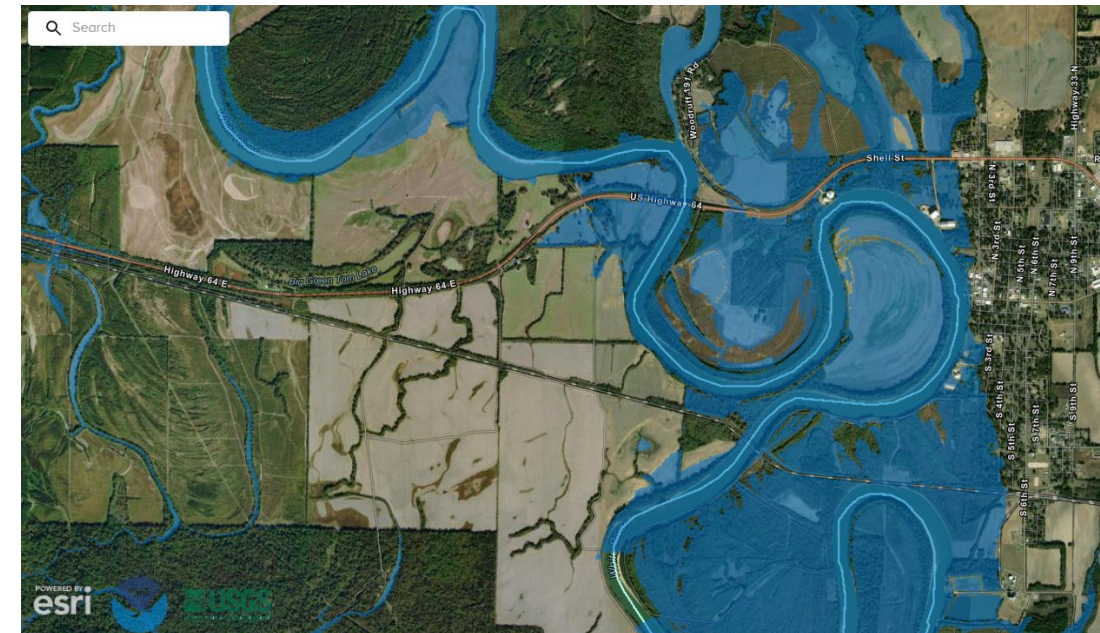
FIM Operational Cycle at NWS Offices





FIM is already in Florida, but...

- FIM is coming to all of Florida by the end of September, but you've probably already seen FIM. So what is coming?
- The National Water Model FIM and RFC FIM are coming to our public viewer.
- Specialized FIMs remain available to all EMs by request, with specific focus on moderate and major flood locations.
- The FIM EMs receive could differ from what is on the web - we'll discuss more on this in a moment.

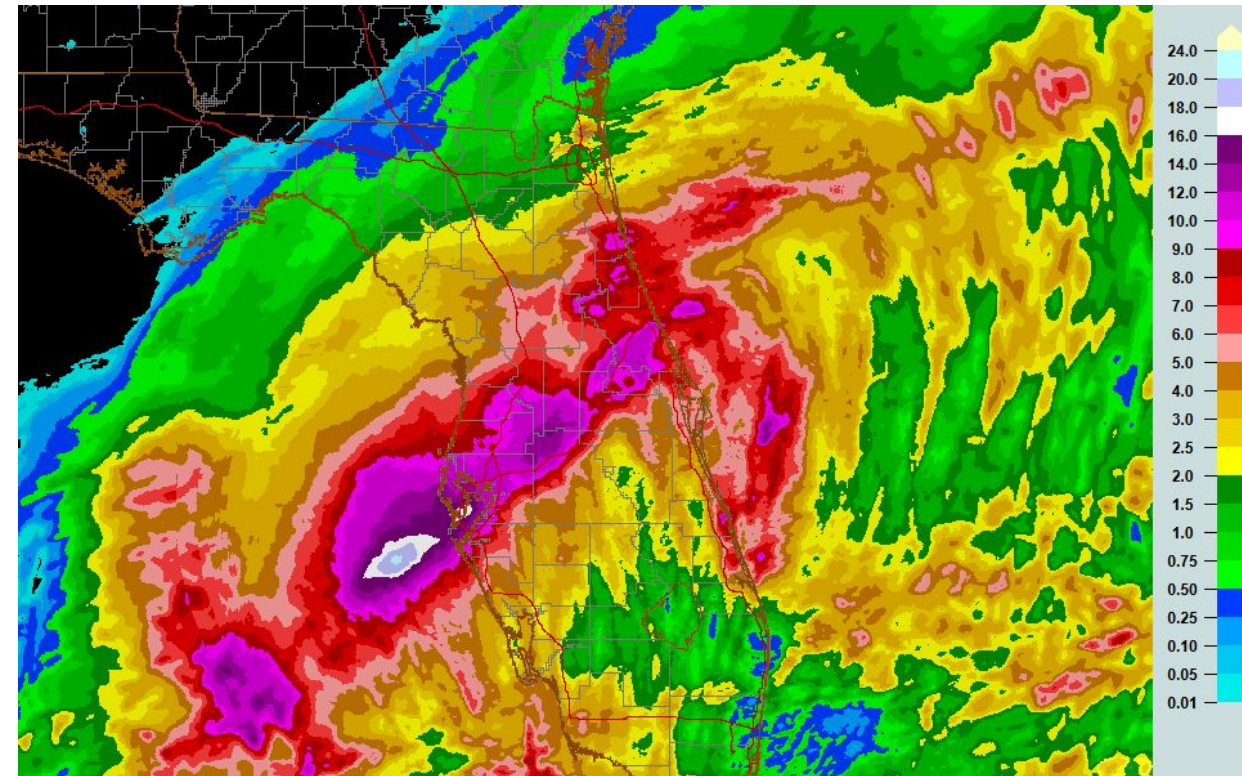


RFC FIM on NWPS

FIM Operations with Milton



- Milton had a huge rainfall footprint over an area that experienced flooding with two prior tropical systems.
- There were a lot of similarities to Ian (2022) with respect to the pattern of rainfall distribution, though some differences affected FIM operations.
- The team started FIM ops on Monday, October 7th.
- Landfall was the evening of October 9th.
- The last FIM delivered was October 31st.





Some Examples from Milton

In this example, we applied a buffer to this particular FIM.

In this case, the RFC FIM had areas that didn't match well with the Partner FIM (AHPS FIM). So we overlaid both in our delivery.

It was later reported the Partner FIM verified better (the outer buffer)

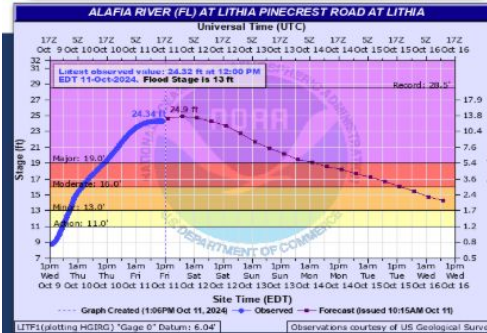


NWS Flood Inundation Mapping Services

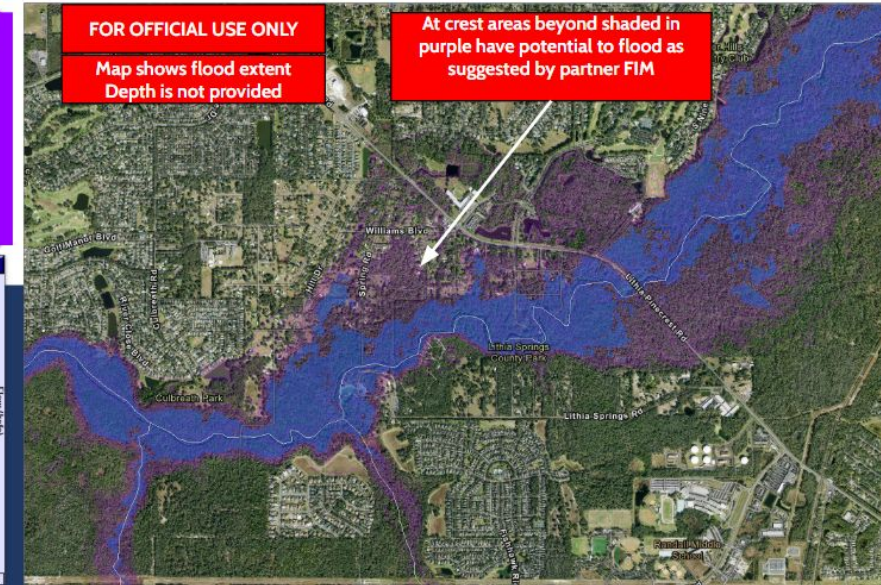
Disclaimer: This map is a flood extent map based on the current river forecast. It does not account for any additional rainfall or uncertainty in the river forecast and should be used conservatively.

Alafia River near Lithia (LITF1)

Crest Height: 24.9 ft (river may crest slightly lower, around 24.4 ft)
Map Height Shown: RFC FIM + Partner FIM
FIM Source: National Water Model
FIM Type: Dynamic (Depth is not shown)
FIM Creation Time: 10/11/2024 @ 1:20 PM ET



Link: <https://water.noaa.gov/gauges/LITF1>



10/11/24 @ 1:20 PM



Before the rain was on the ground



NWS Flood Inundation Mapping Services (A)

Disclaimer: This map shows the flood extent based on a river crest of 26.0 feet. This is an approximate-based FIM which should be used more conservatively.

Anclote River near Elfers (ELFF1)

Crest Height: 26.0 ft
Map Height Shown: 26.0 ft
FIM Source: NWM NBM FIM
FIM Type: Static (Depth is not shown)
FIM Creation Time: 10/08/2024 @ 10:40 AM ET



Link: <https://water.noaa.gov/gauges/ELFF1>



10/08/24 @ 11:15 AM



Before the rain was on the ground



NWS Flood Inundation Mapping Services (B)

Disclaimer: This map shows the flood extent based on a river crest of 26.0 feet. This is an approximate-based FIM which should be used more conservatively.

Anclote River near Elfers (ELFF1)

Crest Height: 26.0 ft
Map Height Shown: 26.0 ft
FIM Source: NWM NBM FIM
FIM Type: Static (Depth is not shown)
FIM Creation Time: 10/08/2024 @ 10:40 AM ET



Link: <https://water.noaa.gov/gauges/ELFF1>



10/08/24 @ 10:40 AM



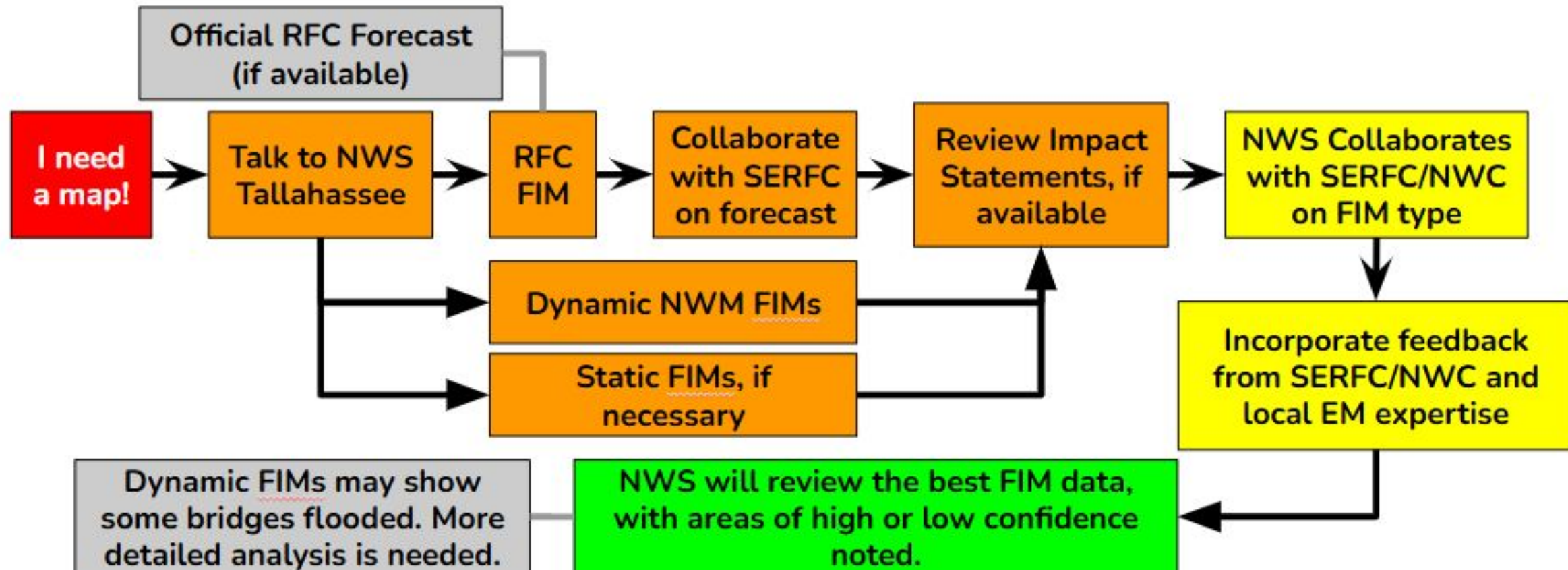
Drone Video Matched the FIM



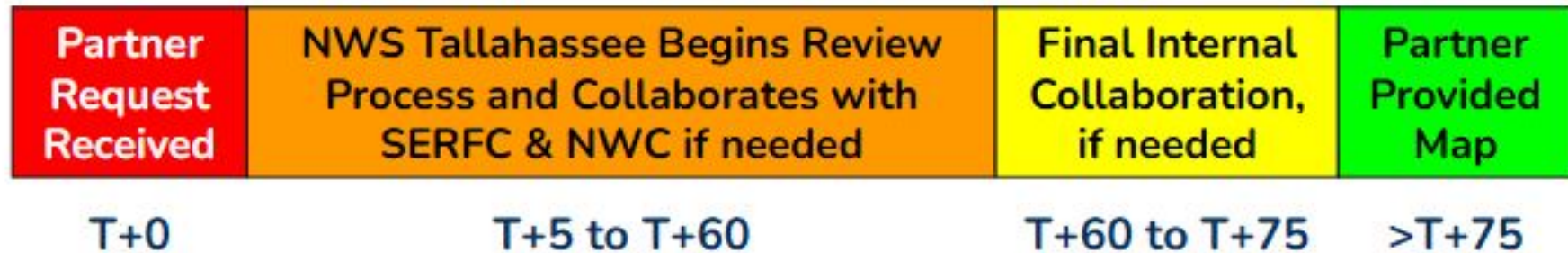


When it's flooding - Our Process

Scenario: A heavy rainfall event has moved into your county. A flood prone river is rising rapidly and the forecast suggests homes could be threatened.



How long does FIM development take?



- We want to provide the best possible maps, but it does take time.
- It may take up to 90 minutes for a single FIM, depending on location and level of collaboration needed.



What did Milton FIM Ops Look like?

- Over 500 FIM panels produced from Oct 7 - Oct 31
- Primary focus was on large basins
 - St Johns River (south of Lake George)
 - Withlacoochee River (the southern one)
 - Peace River
 - Hillsborough County River System
- Eventually, mutual aid took place with FIM specialists from non-impacted areas in the Western Gulf.





Final FIM Thoughts

- FIM is a process that takes time.
- Each Weather Forecast Office has FIM Subject Matter Experts
 - Look for more training from your local office this Summer
- We need you to make FIM work effectively.
 - Ground truth reports during and after an event improves FIM creation and upgrades (Milton)
- Don't wait until an event occurs to assess your flood risk. We can provide FIMs for planning too. Learn your riverine flood risk well in advance of **any** heavy rain event.



Tropical Rain Induced Riverine Flooding in Florida

Utilizing Flood Inundation Mapping to Respond to Threats

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Tornado Threats & Impacts with Hurricane Milton

Including Lessons-Learned

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A Quick Background of Tropical Cyclone Tornadoes



Collective Wind Hazard Risk



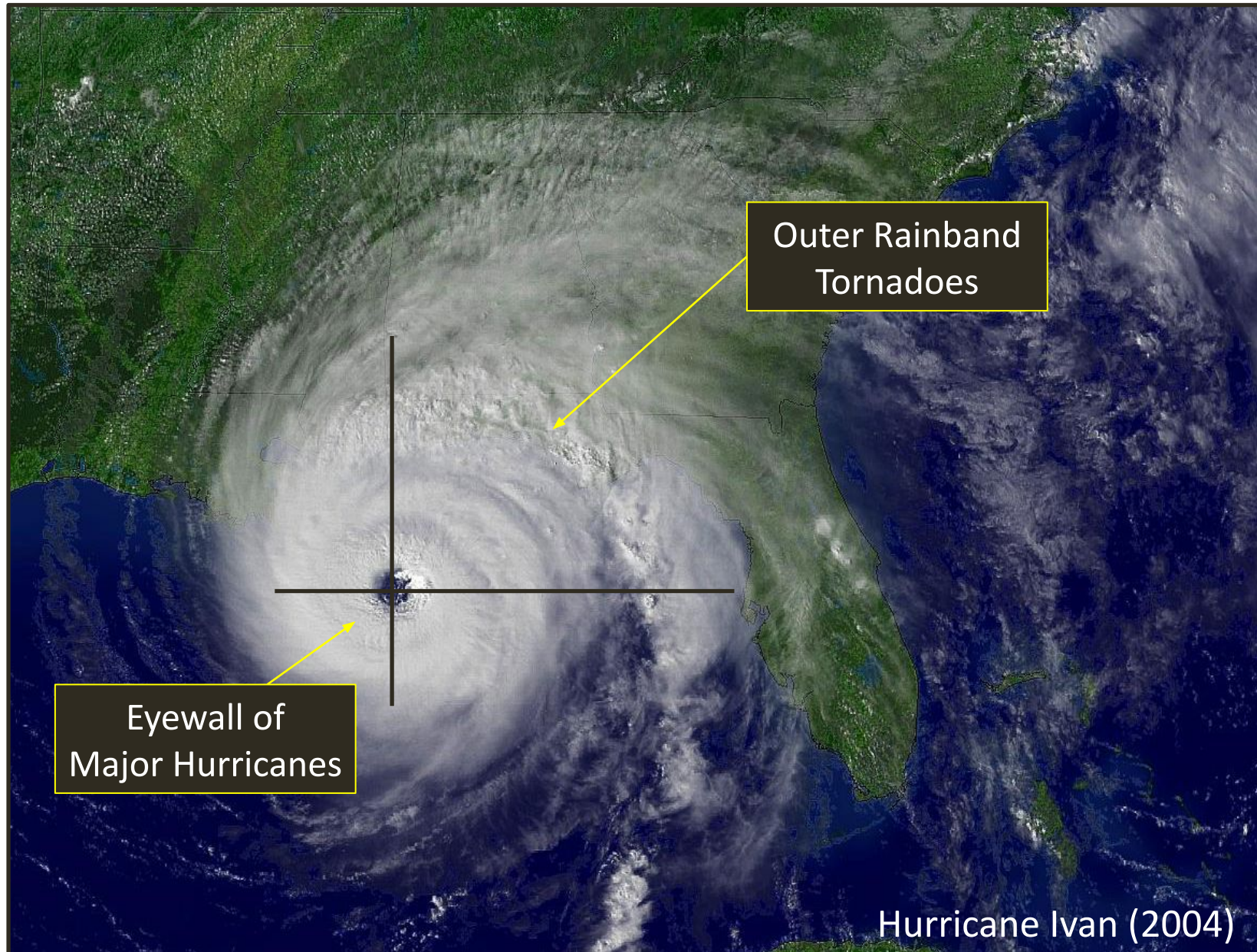
Consider: to most decision-makers, local assessments of the WIND hazard are thought to already contain the collective of wind concerns.



Damaging Winds & Higher Gusts



Tornadoes & Tornadic Waterspouts



Eyewall of
Major Hurricanes

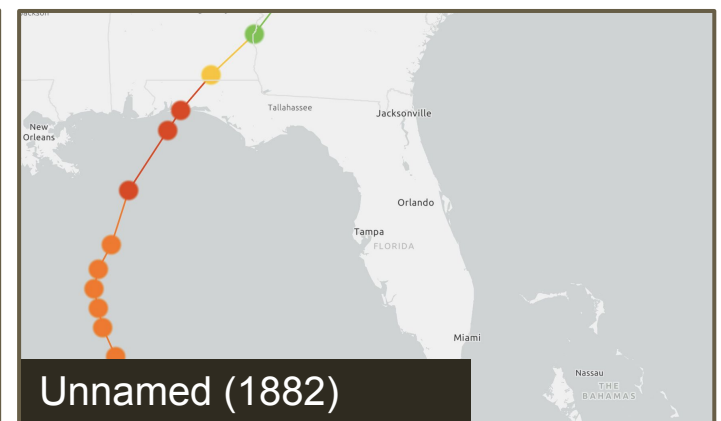
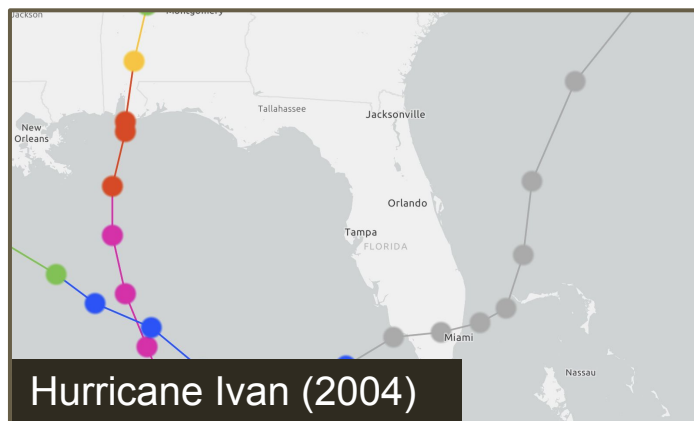
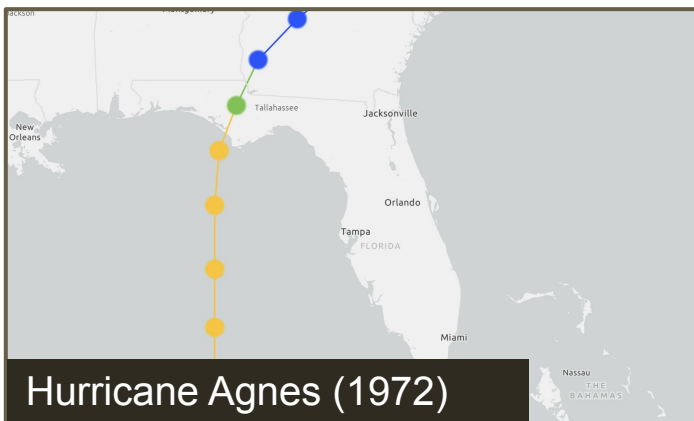
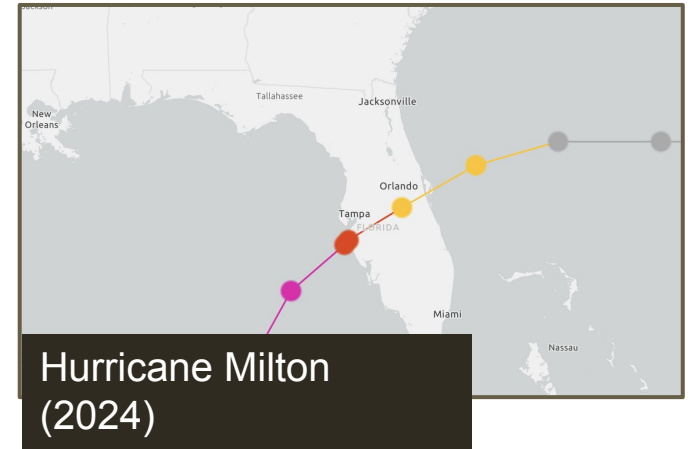
Outer Rainband
Tornadoes

Consider: *Wind-related blunt force trauma and violent deaths occur in two well-defined areas of a tropical cyclone.*

Deadliest Tropical Tornado Events



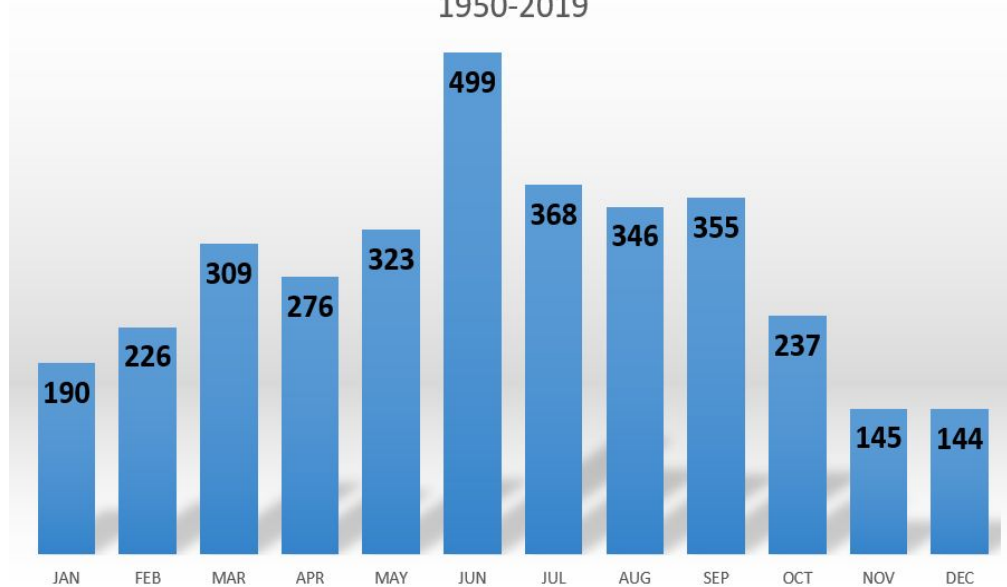
Event	Date	Deaths	Injuries
Hurricane Agnes	Jun. 1972	7	140+
Hurricane Milton	Oct. 2024	6	30+
Hurricane Ivan	Sep. 2004	6	15+
Hurricane (Unnamed)	Sep. 1882	6	15+



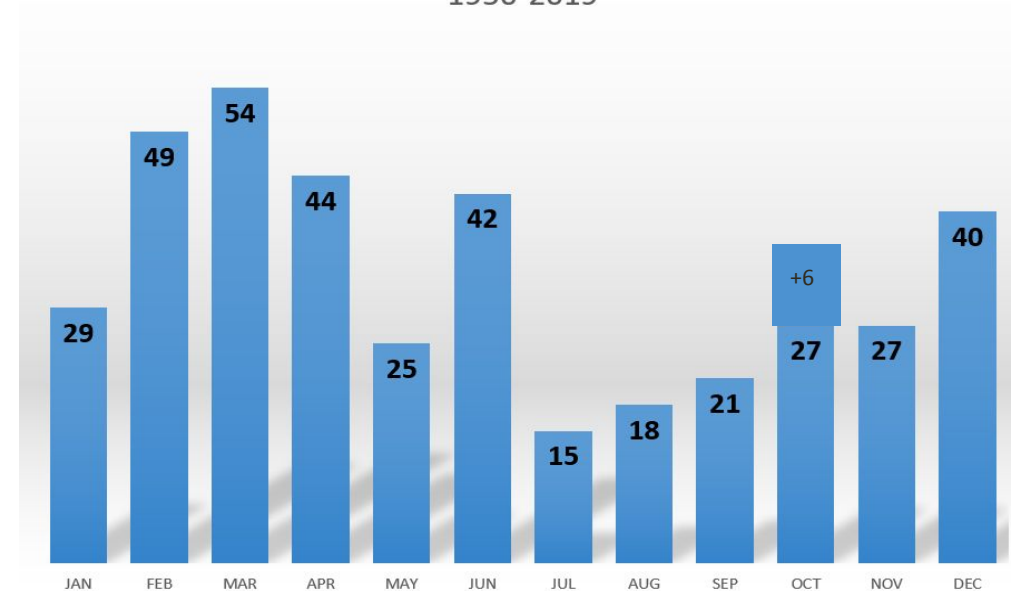
Understanding Tornadoes in Florida



All Tornadoes in Florida by Month
1950-2019



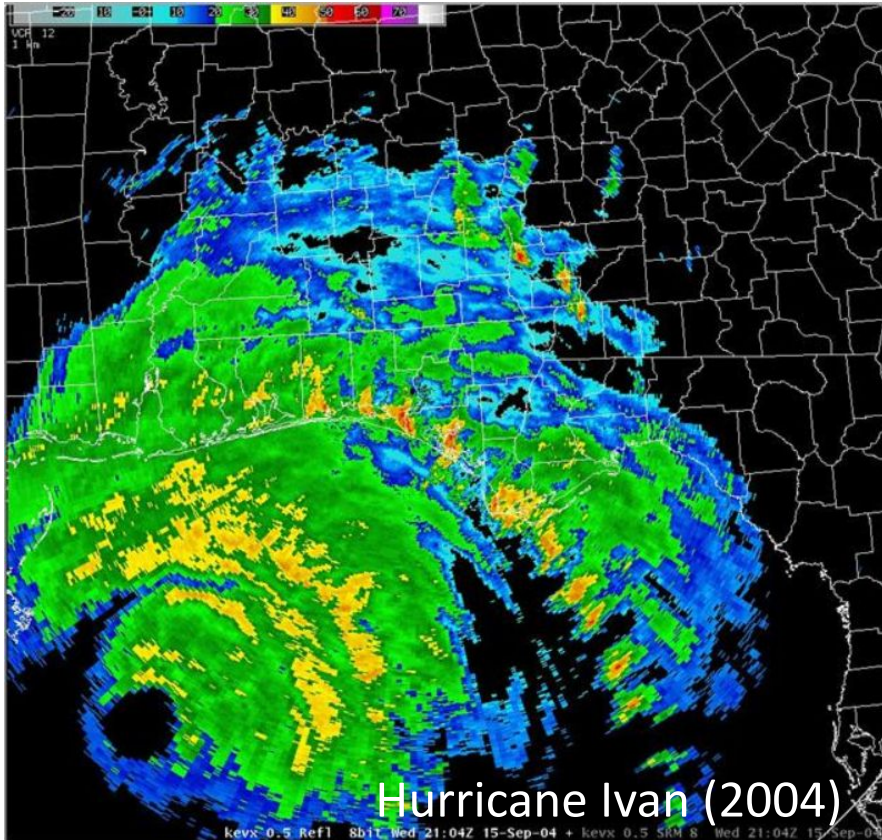
Strong Tornadoes (EF2+) in Florida by Month
1950-2019



- ❑ *Damage and loss of life potential grows exponentially as wind increases.*
- ❑ *94% of all Florida tornado fatalities associated with EF2+ or greater winds.*

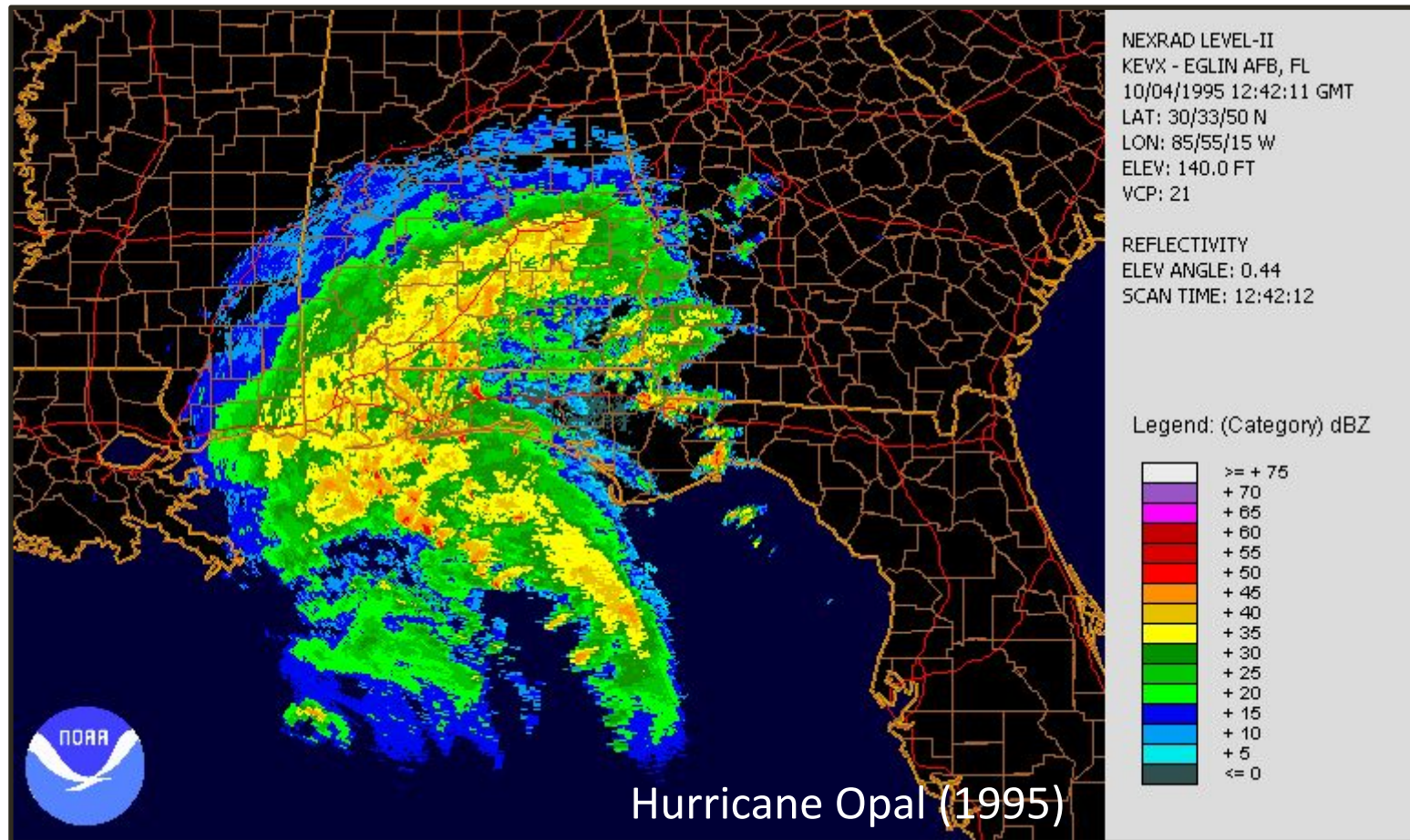


Conceptual Model(s) of Tropical Cyclone Tornadoes



Consider: Typically, counties/parishes or cities do not have a tornado contingency within their hurricane emergency plans.

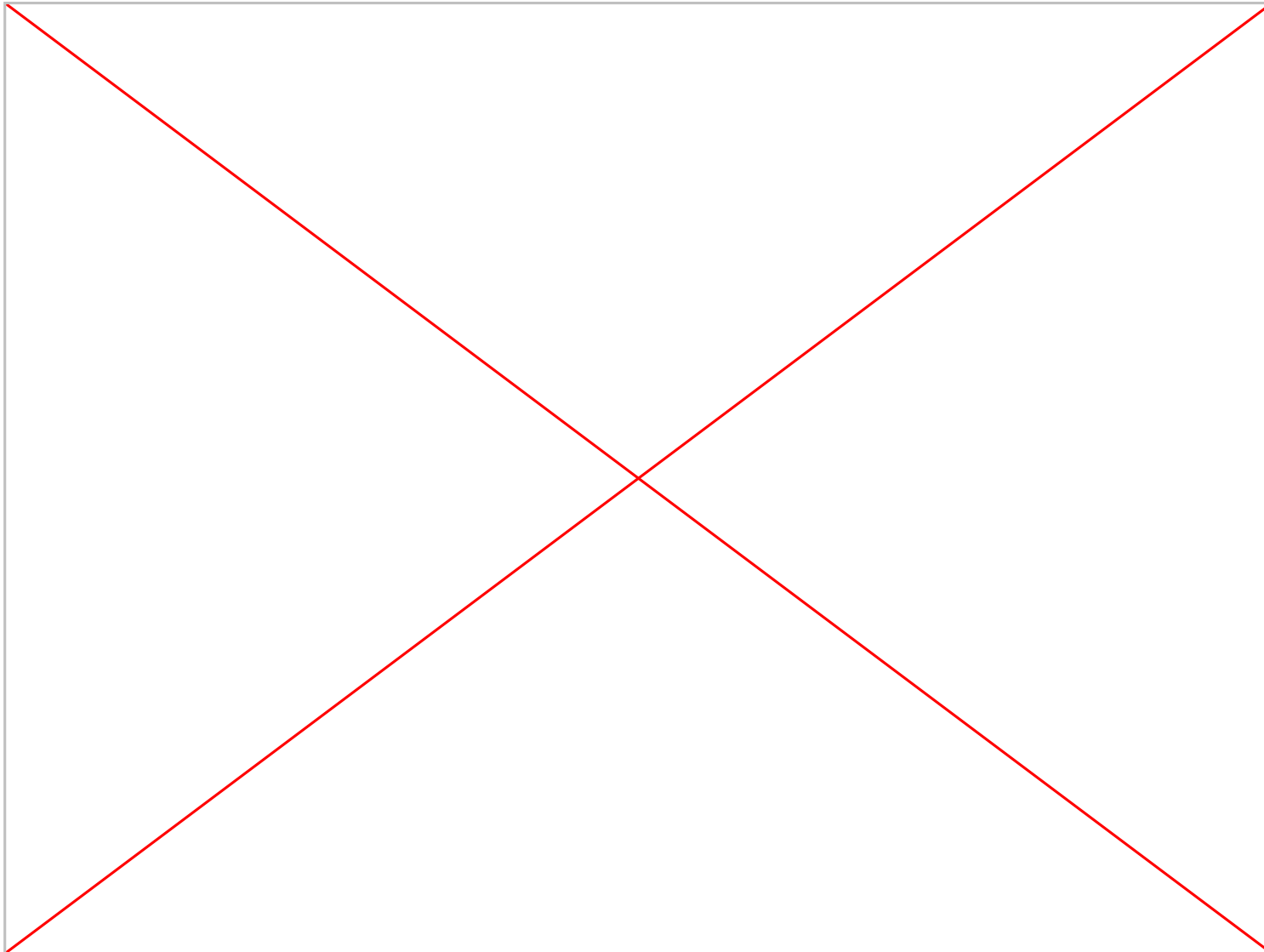
- Tornadoes that occur ***ahead of*** the main wind event.
- Tornadoes that occur ***amidst*** the main wind event.
- Tornadoes that occur ***after*** the main wind event.
- Tornadoes that occur ***in places away from*** the main wind event (in location and/or time); tornadoes are a primary hazard.
- Tornadoes that occur ***post-landfall*** over inland locations; tornadoes are a primary hazard.



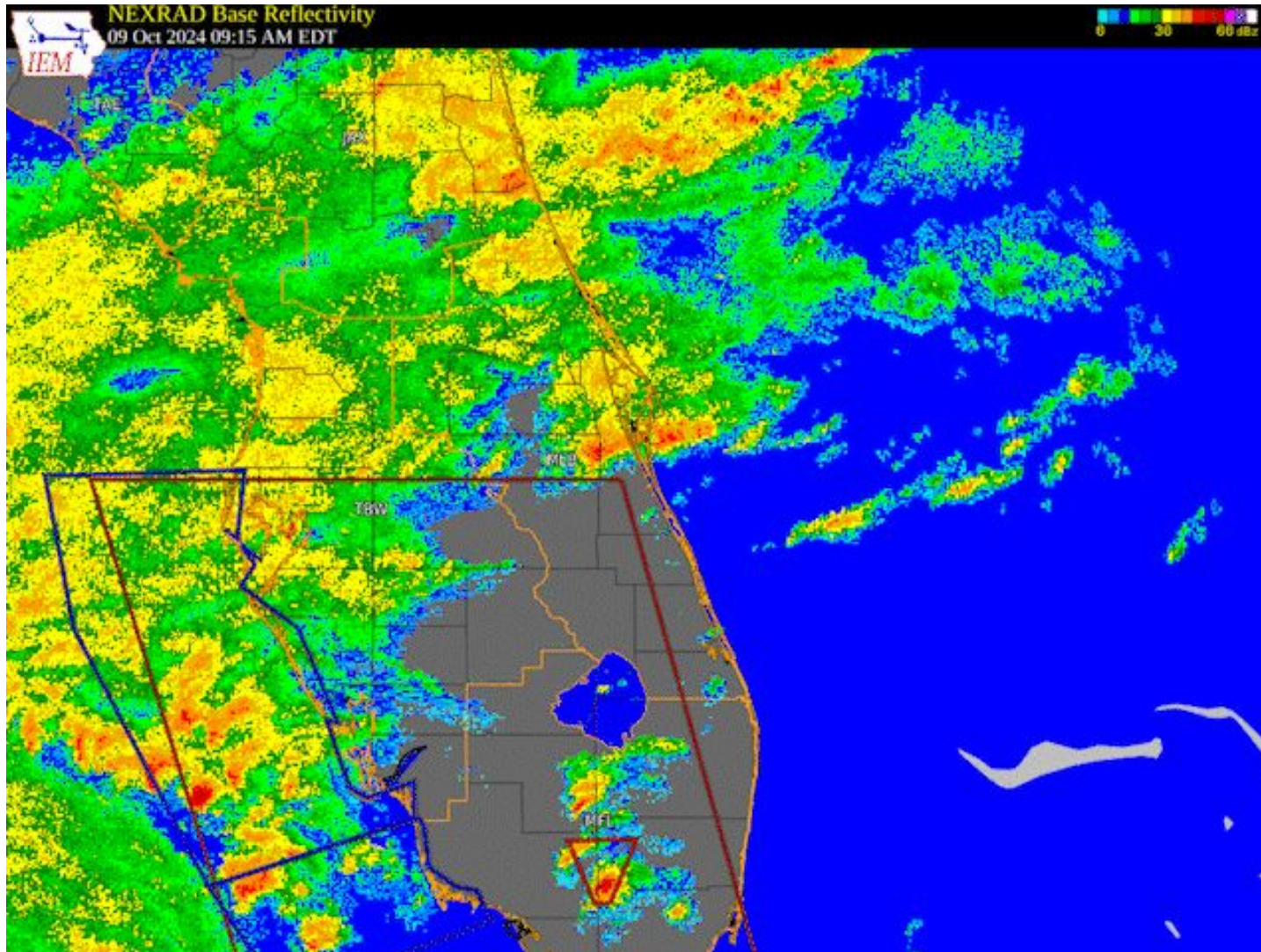
Tropical Cyclone Tornadoes

- Often occur in outer rainbands *and typically the right front quadrant*
- Often occur in families, *but can be isolated in occurrence*
- Often weaker, narrower, and brief, *but can be stronger, wider, and have longer tracks*

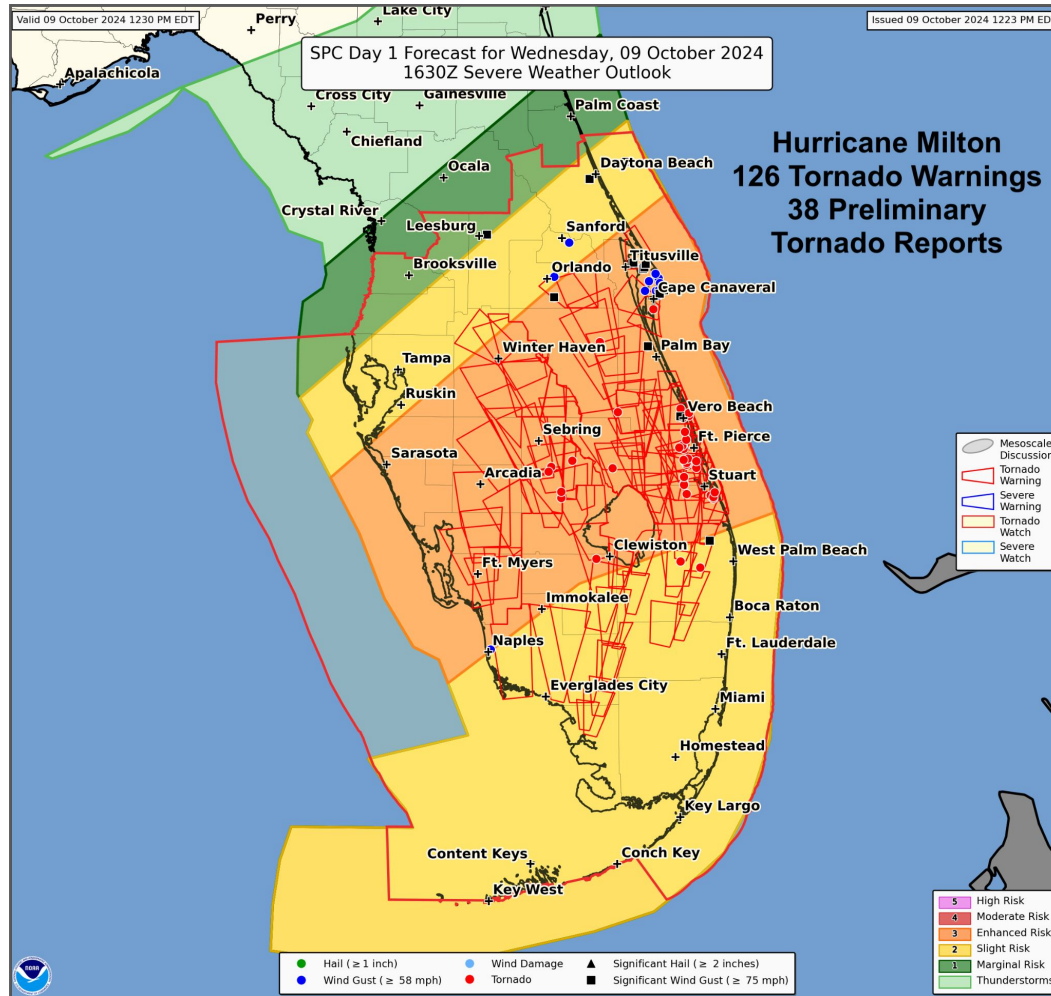
A Review: Hurricane Milton Tornadoes



A Review: Hurricane Milton Tornadoes



A Review: Hurricane Milton Tornadoes



Tornado Warnings

- NWS offices issued **126** tornado warnings, mostly within a 14-hour period
- The second largest number for a single state on a single day
 - 134 in Alabama on April 27, 2011



Utilizing Real-Time Data Sources



Several tornadoes were captured “live” via FDOT highway cameras

Severe Weather Statement
National Weather Service Miami FL
950 AM EDT Wed Oct 9 2024

FLC011-021-051-099-091400-
/O.CON.KMFL.TO.W.0047.000000T0000Z-241009T1400Z/
Collier FL-Hendry FL-Broward FL-Palm Beach FL-
950 AM EDT Wed Oct 9 2024

...A TORNADO WARNING REMAINS IN EFFECT UNTIL 1000 AM EDT FOR EASTERN COLLIER...SOUTHEASTERN HENDRY...NORTHERN BROWARD AND SOUTHWESTERN PALM BEACH COUNTIES...

At 949 AM EDT, a confirmed tornado was located over Miccosukee Indian Reservation, or 33 miles south of Montura, moving north at 25 mph.

HAZARD...Damaging tornado.

SOURCE...Video confirmed tornado.

IMPACT...Flying debris will be dangerous to those caught without shelter. Mobile homes will be damaged or destroyed. Damage to roofs, windows, and vehicles will occur. Tree damage is likely.

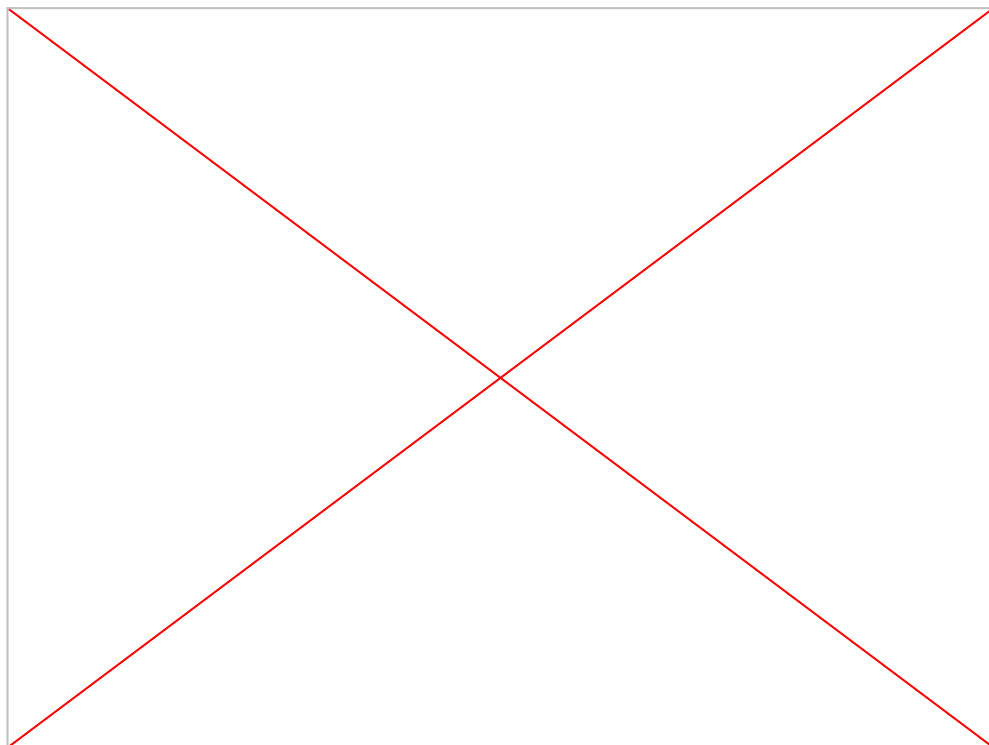
Locations impacted include...
Miccosukee Indian Reservation, Big Cypress Seminole Reservation, and Rotenberger Wildlife Refuge.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

To repeat, a tornado is on the ground. TAKE COVER NOW! Move to an interior room on the lowest floor of a sturdy building. Avoid windows. If you are outdoors, in a mobile home, or in a vehicle, move to the closest substantial shelter and protect yourself from flying debris.



Utilizing Real-Time Data Sources



Other videos received via social media and storm spotters & chasers

BULLETIN - EAS ACTIVATION REQUESTED
Tornado Warning
National Weather Service Miami FL
448 PM EDT Wed Oct 9 2024

The National Weather Service in Miami has issued a

- * Tornado Warning for...
Northeastern Palm Beach County in southeastern Florida...
- * Until 515 PM EDT.

* At 447 PM EDT, a reported large and extremely dangerous tornado was located near Wellington, moving north at 40 mph.

This is a PARTICULARLY DANGEROUS SITUATION. TAKE COVER NOW!

HAZARD...Damaging tornado.

SOURCE...Weather spotters reported tornado.

IMPACT...You are in a life-threatening situation. Flying debris may be deadly to those caught without shelter. Mobile homes will be destroyed. Considerable damage to homes, businesses, and vehicles is likely and complete destruction is possible.

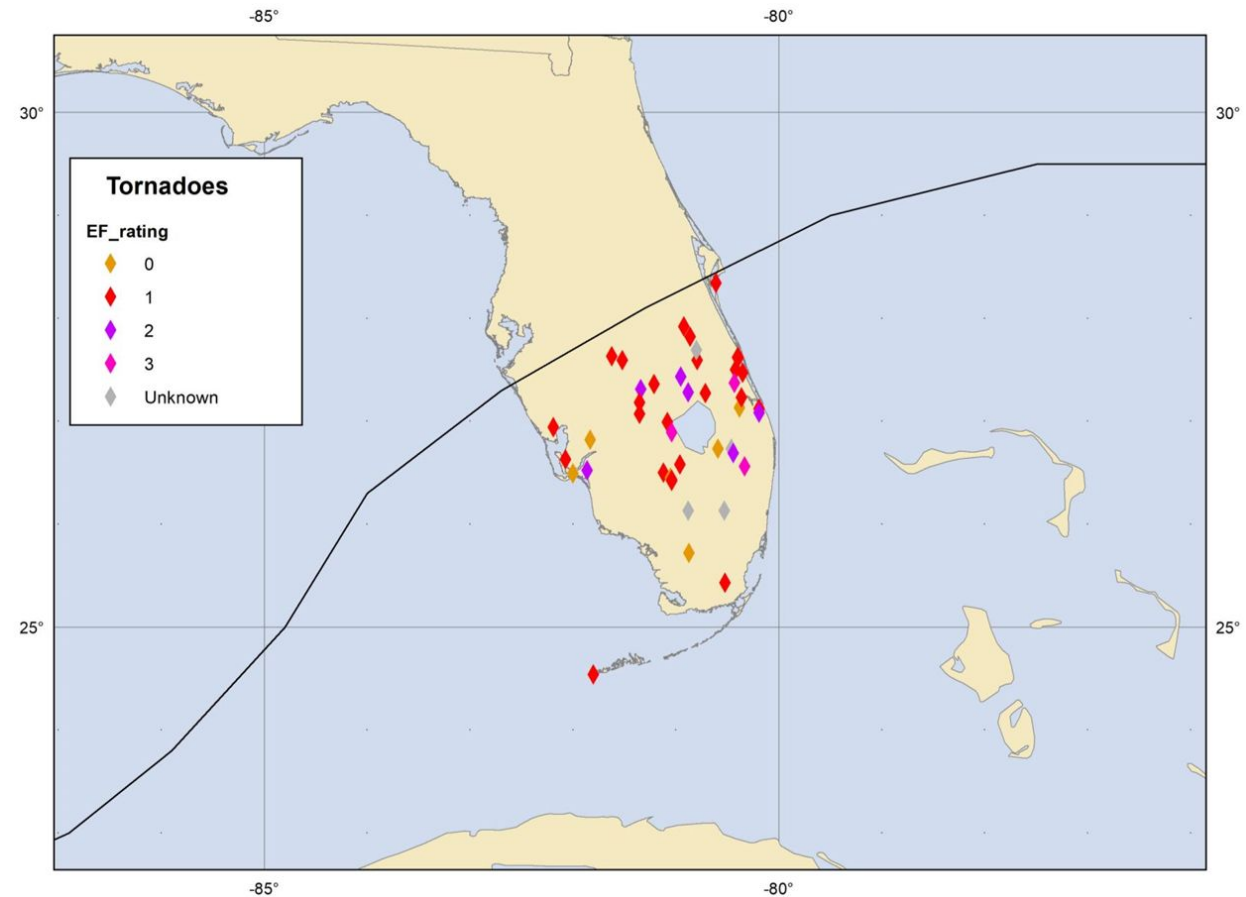
- * Locations impacted include...
Wellington, Palm Beach Gardens, Royal Palm Beach, The Acreage, Loxahatchee Groves, and Loxahatchee NWR.

A Review: Hurricane Milton Tornadoes



Confirmed Tornadoes

- NWS confirmed 45 tornadoes over central and south Florida
 - 6 EF-2s
 - 3 EF-3s
- 6 fatalities



A Review: Hurricane Milton Tornadoes



St. Lucie County
October 9, 2024 - Hurricane Milton
1 EF-3 (155 mph)
6 Fatalities



Wellington / Palm Beach Gardens EF-3 Tornado



- **Maximum Wind: 140 mph**
- **7 injuries**



Lakeport (Glades County) EF-3 Tornado



- **Maximum Wind: 140 mph**
- **3 injuries**

Surveying the Damage



St. Lucie County EOC



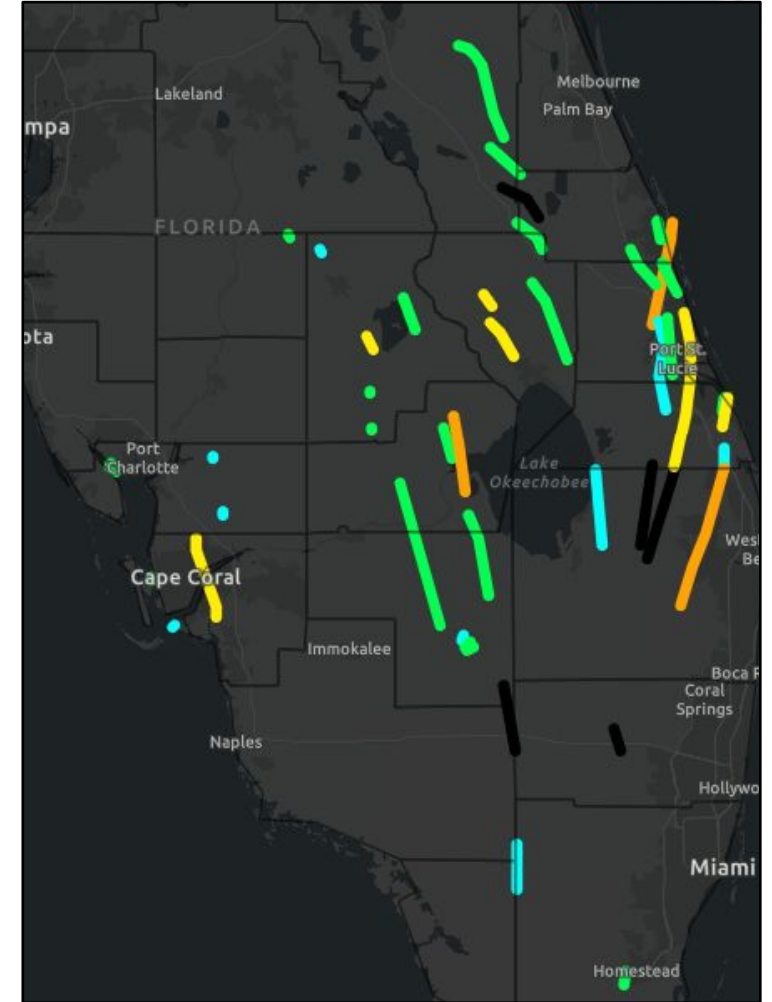
Okeechobee County EOC



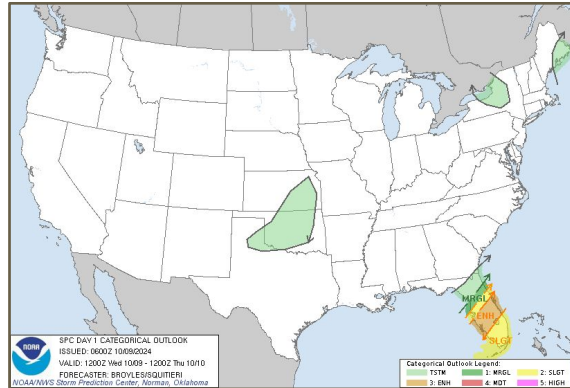
Cocoa Beach, FL



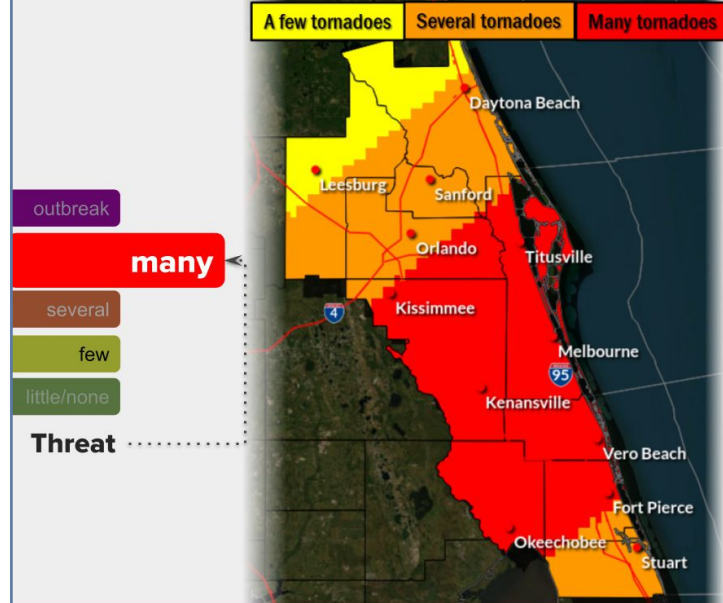
Fort Pierce, FL



Leveraging Informed Design Graphics



Tornado Threat



Several to many tornadoes can hinder emergency plans during tropical events.

Many places may experience...

- Tornado damage, with isolated immense destruction
- Power & communications failures

Examples of potential damage:

- Roof and wall failures of sturdy buildings. Some buildings may be leveled.
- Mobile homes obliterated
- Large trees snapped or twisted
- Vehicles & small boats tossed or destroyed

More Details: [weather.gov/mlb/hti](https://www.weather.gov/mlb/hti)



WEATHER FORECAST OFFICE

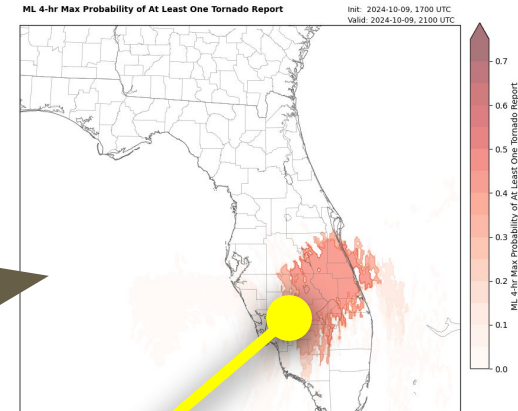
Melbourne Florida

Updated: October 9, 2024

Where We Are Headed...

Our Future, Driven By New Technology & More Frequent Communication

- **More High-Res Models.** Cutting-edge systems like Warn-On-Forecast rapidly integrate surface, radar, and satellite data for the most up-to-date forecasts.
- **Storm-Specific Hazard Predictions.** Using machine learning, we're delivering probabilistic forecasts for individual thunderstorms.
- **Bridging the Gap: Watch to Warning!** High-res data + forecaster expertise = faster, more targeted risk assessments for the public, partners, and media—*before* warnings are issued.



Increasing Tornado Threat

Through 5 PM Greatest Threat

What is Expected

- Rounds of storms developing along the Treasure Coast, moving northward toward Osceola & Southern Brevard Counties.
- Environment is **very favorable** for one or more tornadoes to develop.

Developing Hazards

- Tornadoes
- Localized flooding

Know what to do if a Tornado Warning Is Issued!
Visit [weather.gov/safety/tornado](https://www.weather.gov/safety/tornado)

WEATHER FORECAST OFFICE
Melbourne Florida

Updated: 1 PM Oct. 9, 2024

Tornado Threats & Impacts with Hurricane Milton

Including Lessons-Learned

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