Compound Tornado & Flash Flood Hazards

WHAT WE KNOW & STILL NEED TO KNOW

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NOAA VSE: NA18OAR4590309 (CIRES); NOAA SBES: NA21OAR4590214 (TTU); NOAA SBES: NA21OAR4590215 (TAMU)

THREE OBSERVATIONS:

1. Our prediction & warning systems are historically biased toward individual hazards.

2. The norm for most people is to experience hazards simultaneously or in close succession.

3. Physical and social drivers are interconnected for cascading and compound hazards.

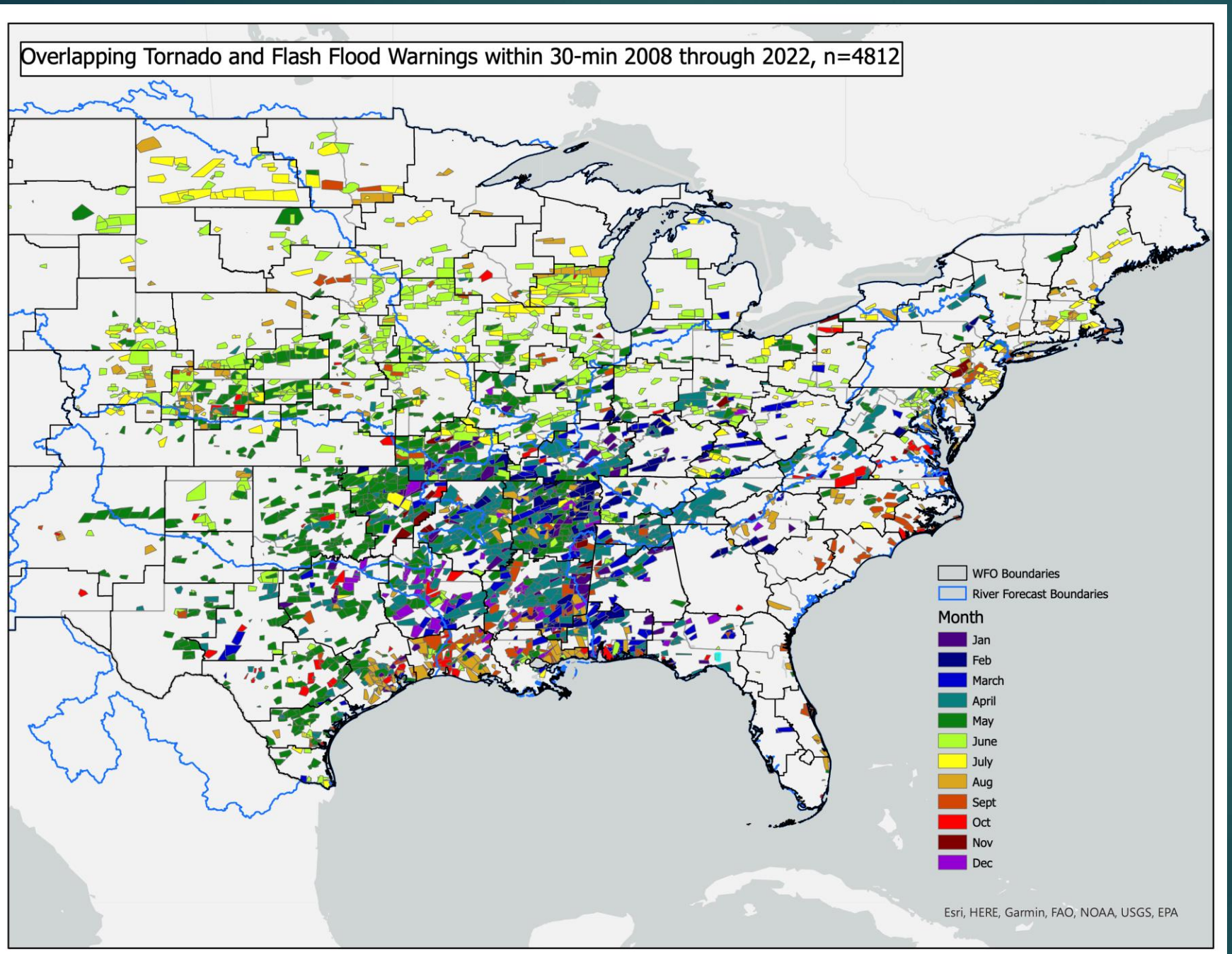
TORFF: Overlapping Tor & FF Warnings

Tornado Warning

Seek shelter in low places

Flash Flood Warning

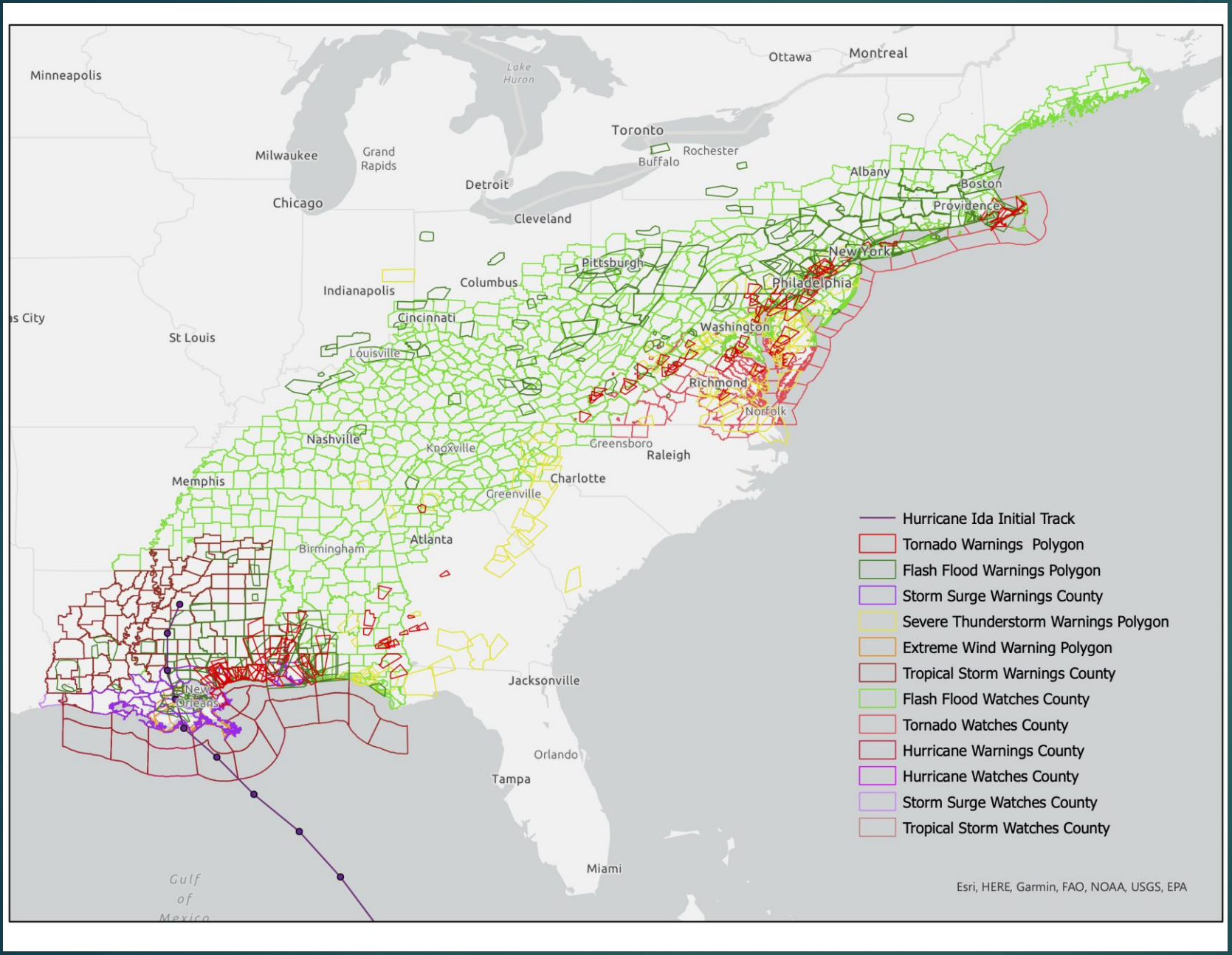
Seek shelter in high places



Definition originally in meso/storm scale context: an overlap of tornado and flash flood warning issued within 30 min of each other in same location (Nielsen et al 2015).

2008-2022

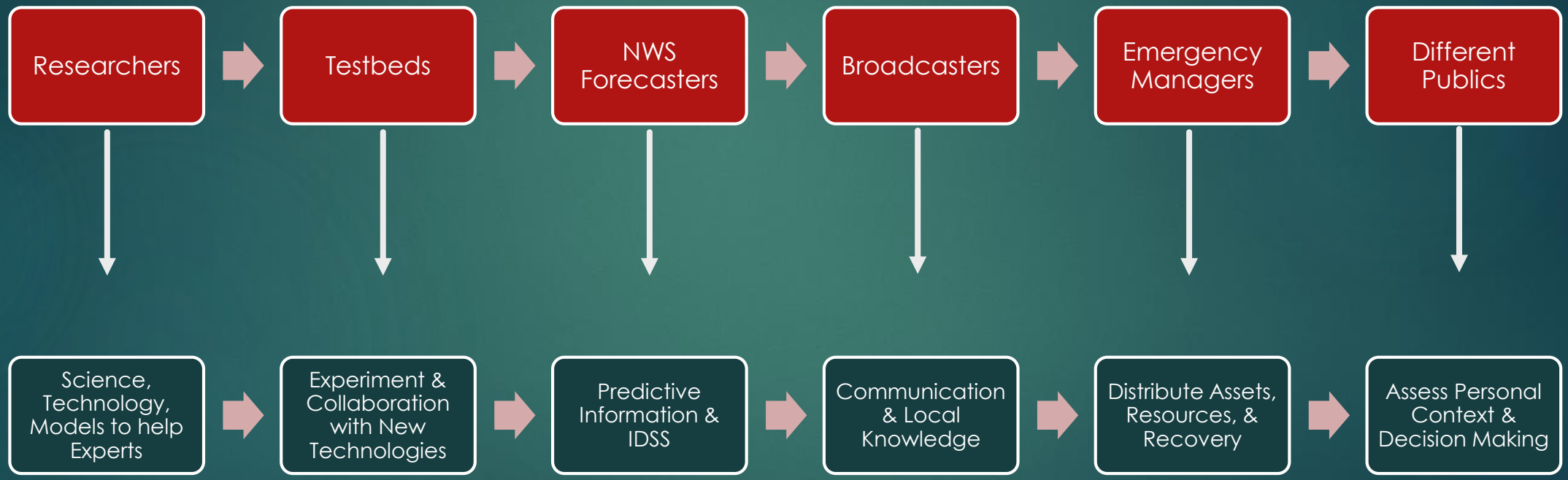
Shadings indicate common area between tornado and flash flood warning. 300-350 times a year for 30-min overlap.



Recent example in Hurricane Ida

- Complicated when in landfalling tropical cyclone
- Tropical cyclones bring not just Tornado and Flash Flood threats, but other wind and water hazards that are collocated and concurrent
- ***First time Flash Flood Emergency and Tornado Emergency overlapped (issued within 1-min)***

TORFF Relevance

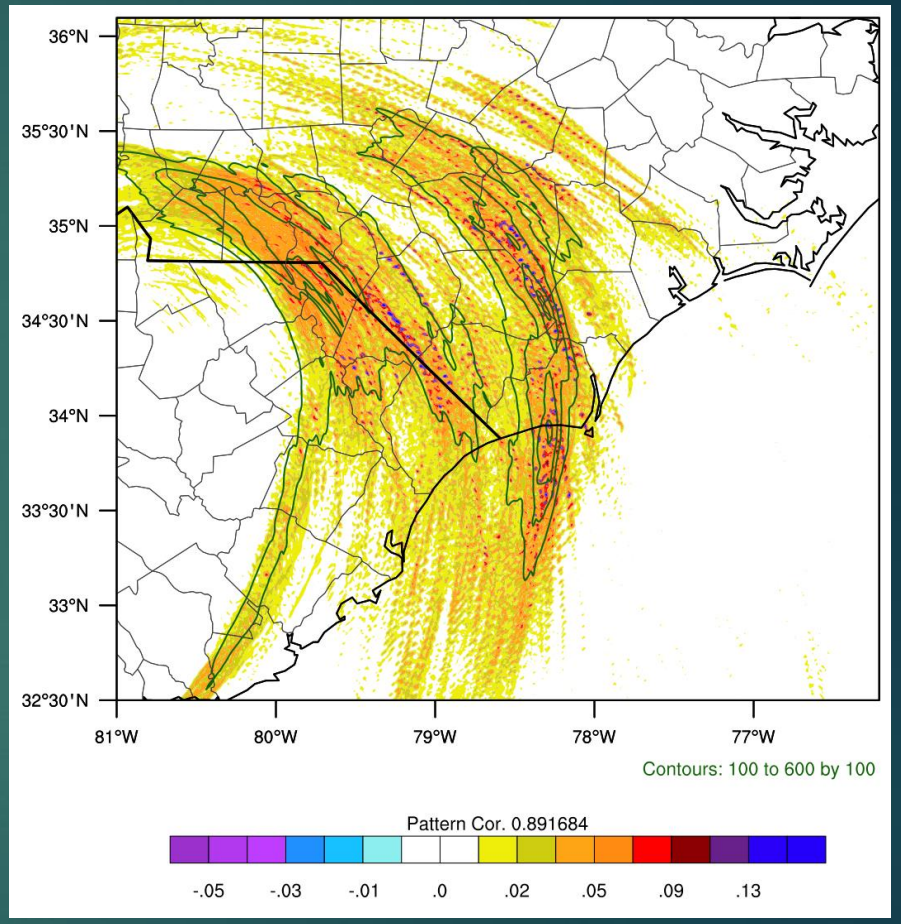


TORFFs: What We've Learned

- Why potentially are TORFFs so frequent?
  - Conventional forecasting thoughts might at first discount a high shear environment with fast storm speeds as being able to produce rain rates high enough to cause flash flooding
- It turns out the rotation and the production of intense rainfall rates are not independent from one another
  - Mesoscale rotation introduces dynamic pressure perturbations that can enhance the updraft (Nielsen and Schumacher 2018)
  - This enhancement leads to the ability to access sources of CAPE and moisture that might be thermodynamically inhibited (Nielsen and Schumacher 2018)
  - This enhancement can lower the updraft and increase warm cloud depth/time for warm rain processes to occur (Nielsen and Schumacher 2020a)
  - Around half of observed accumulations of 75 mm/hr over a 3-year period were associated with mesoscale rotation (Nielsen and Schumacher 2020b)

TORFFs: What We've Learned

- How does this relate then back to tornado formation?
  - This enhancement of rainfall rates does not necessarily preclude tornado formation, as both are favored when strong dynamically forced updrafts are present (Nielsen and Schumacher 2018)
- Do these same results hold in Tropical Cyclone (TCs)?
  - Yes, it appears so. Regions with most prevalent mesoscale rotation produce the most rainfall (see right)
  - Could argue that the strength of the updrafts are the "limiting" factor in rainfall production in TCs (In progress)



Above Example from Hurricane Florence

Shading = rotationally induced upward acceleration
Green Contours = precipitation accumulation every 100mm

TORFFs: What We've Learned

- Public
  - are aware of & attend to various threats in TORFF contexts
  - may experience higher tornado risk perception than flood risk perception
  - use dominant hazards of past hurricanes as proxies for understanding current hurricanes
  - use social media to help overcome the liminality of TORFF hazards in LTCs
- NWS
  - policies about flood / tor hazards contribute to unintentional magnification of one hazard
  - siloed expertise & technology can inhibit communication about compounds in messaging
  - may suspend tornado warnings to highlight extreme flooding in some instances of LTCs
  - may experience critical incident stress given complex impacts & fatalities
- Broadcasters & Emergency Managers
  - may favor coverage of tornadoes over flooding during supercell TORFF events
  - communicate threats based on timing first (usually wind then water) or impacts
  - need multi-language ability to communicate hazards to non-English populations
  - may experience critical incident stress when managing multiple language audiences

Current NOAA SBES Grants

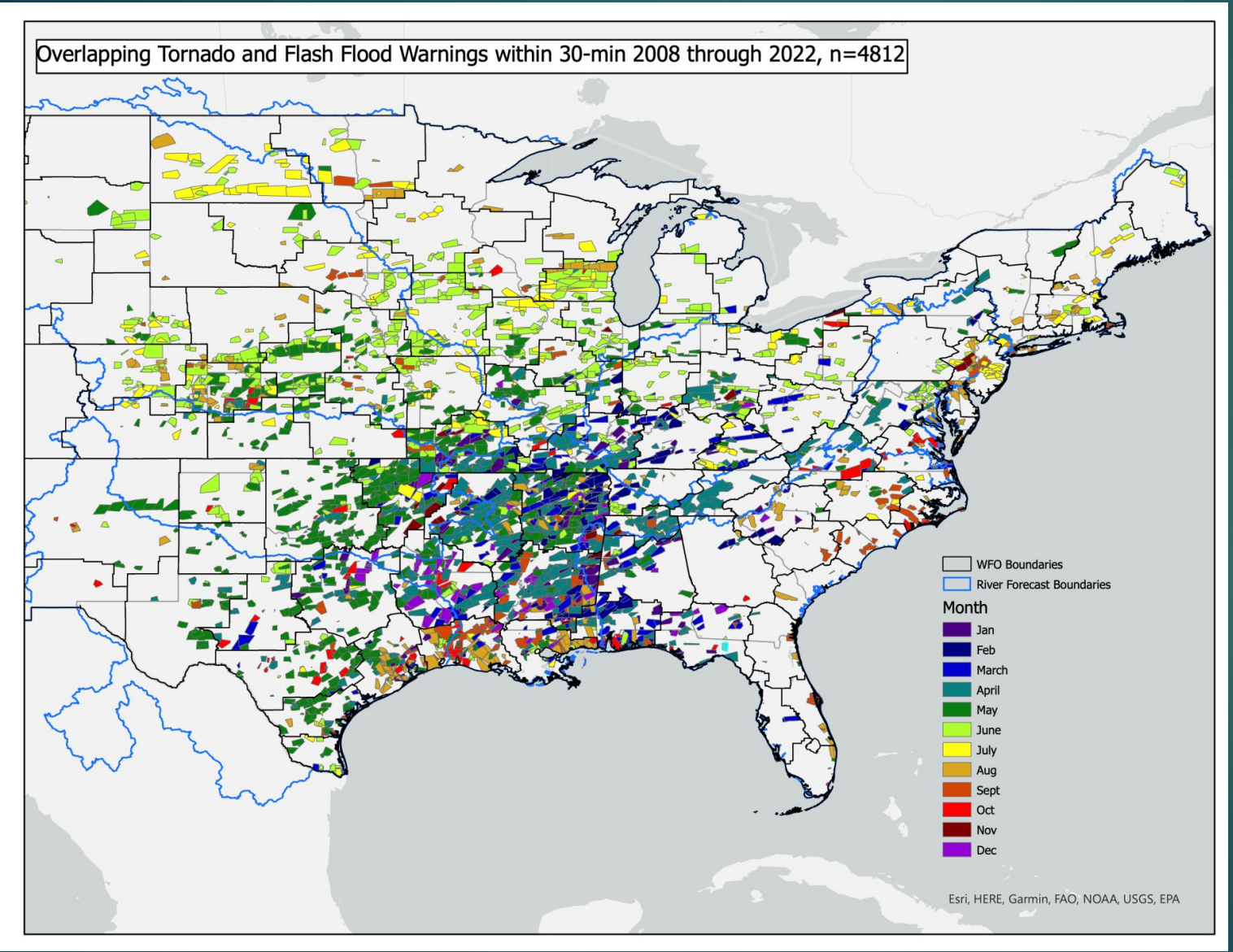
EM & Broadcasters with LTC TORFFs in Covid-19 (2021-2024)

- Semi-structured interviews (Y1)
- National online survey (Y 2-3)
- R2X Workshops (Y 2-3)
- Expansion of the "TORFF" database to other wind and water threats (Y3)
  - Open question on what the best R2X/R2O application is here
  - Has been used to justify investigation, identify case studies, create training materials, and provided general awareness

Spanish & Bilingual Broadcast Meteorologists Communication of TORFFs in LTCs (2023-2025)

- Observations of offices (Y1)
- Virtual focus groups (Y1)
- R2X design & prototypes (Y2)
- Workshop at AMS / NWA (Y2)

What about other wind/water threats?



- As with any phenomena that is researched, you must have a background knowledge on how often it occurs
- If you are looking for situations where multiple hazards are happening at the same time, you must deal with multiple dimensions (i.e., what threats over what length of time)
- These choices are somewhat arbitrary…
- Initially we said tornado and flash flood warnings issued within 30-minutes

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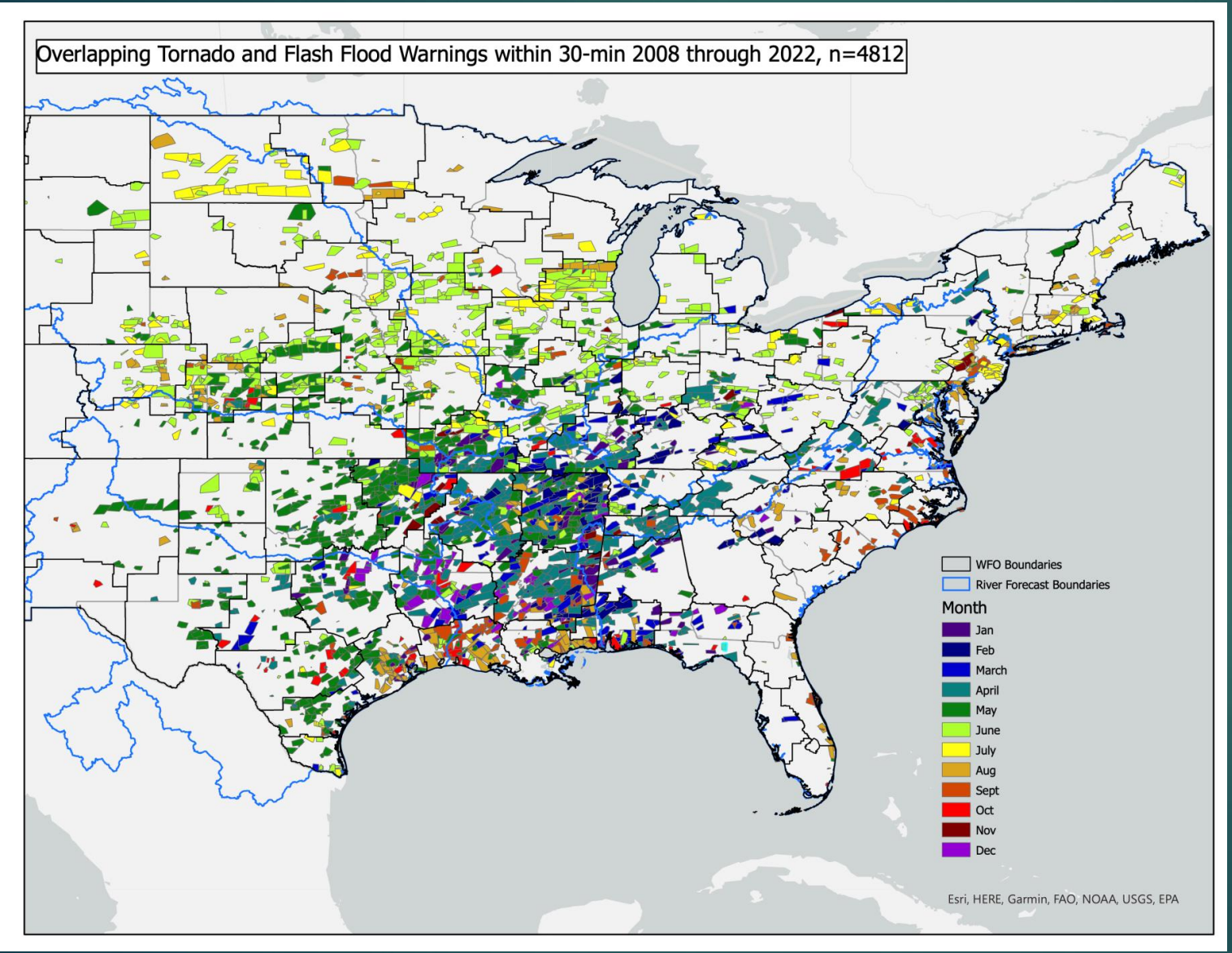

- While this initial definition might pick up on the most acute overlap of wind a water threats, it does not pick up on all situations where wind and water threats overlap.
- What if we change the map to the left to tornado and flash flood warnings issued within 60-minutes of one another over the same period?

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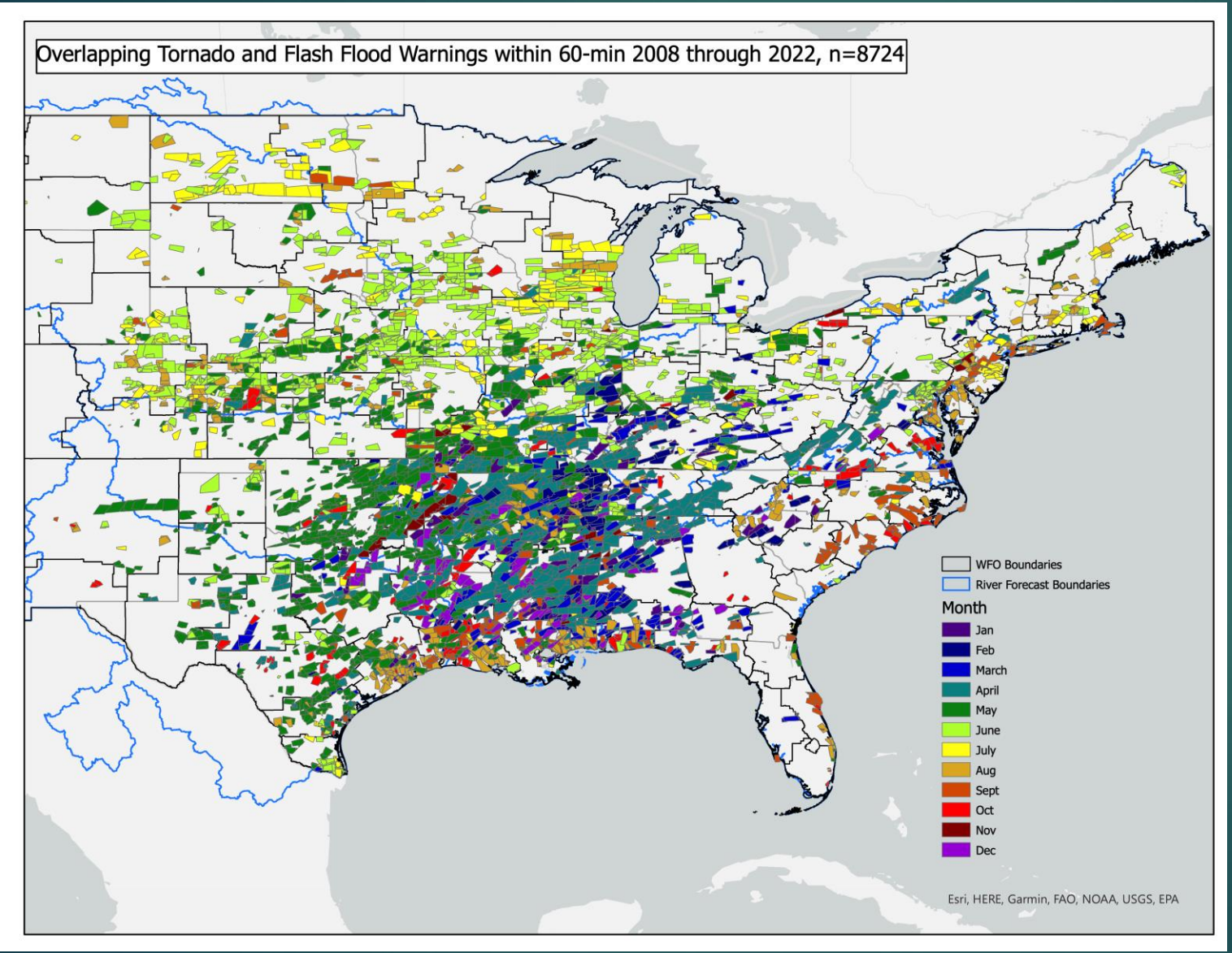

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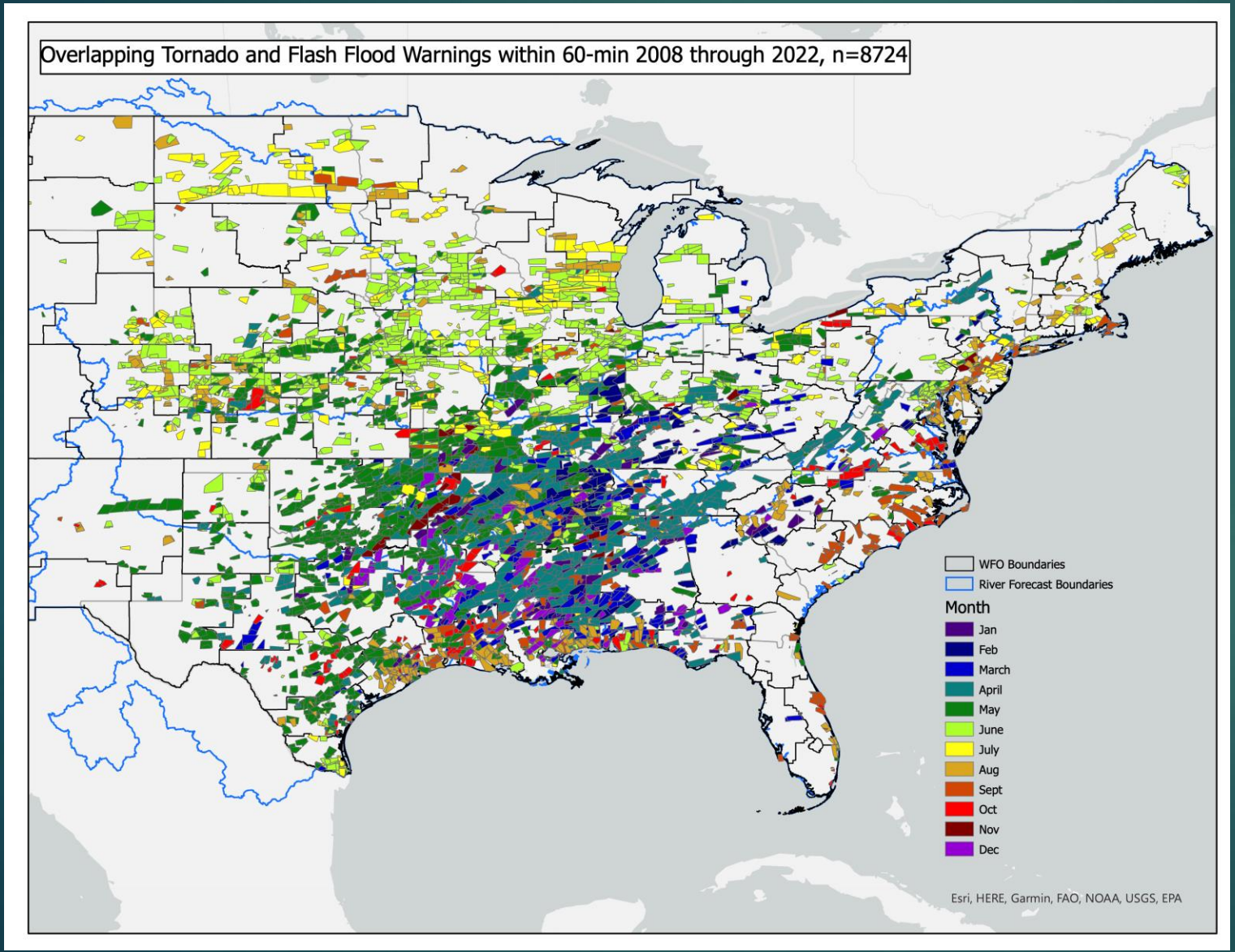
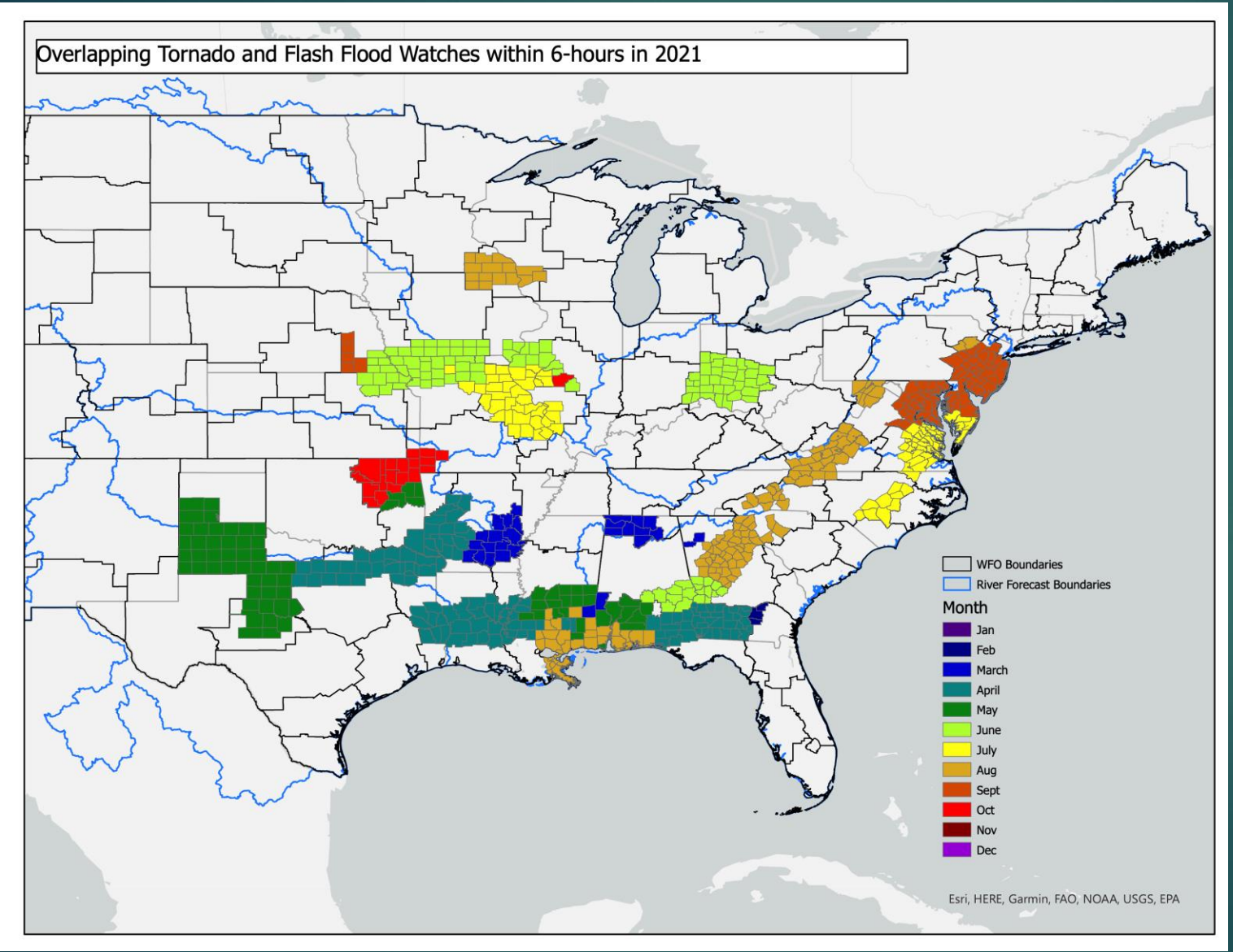


- What if we change the map to the left to tornado watches and flash flood watches issued within 6-hours of one another in 2021?

What about other wind/water threats?



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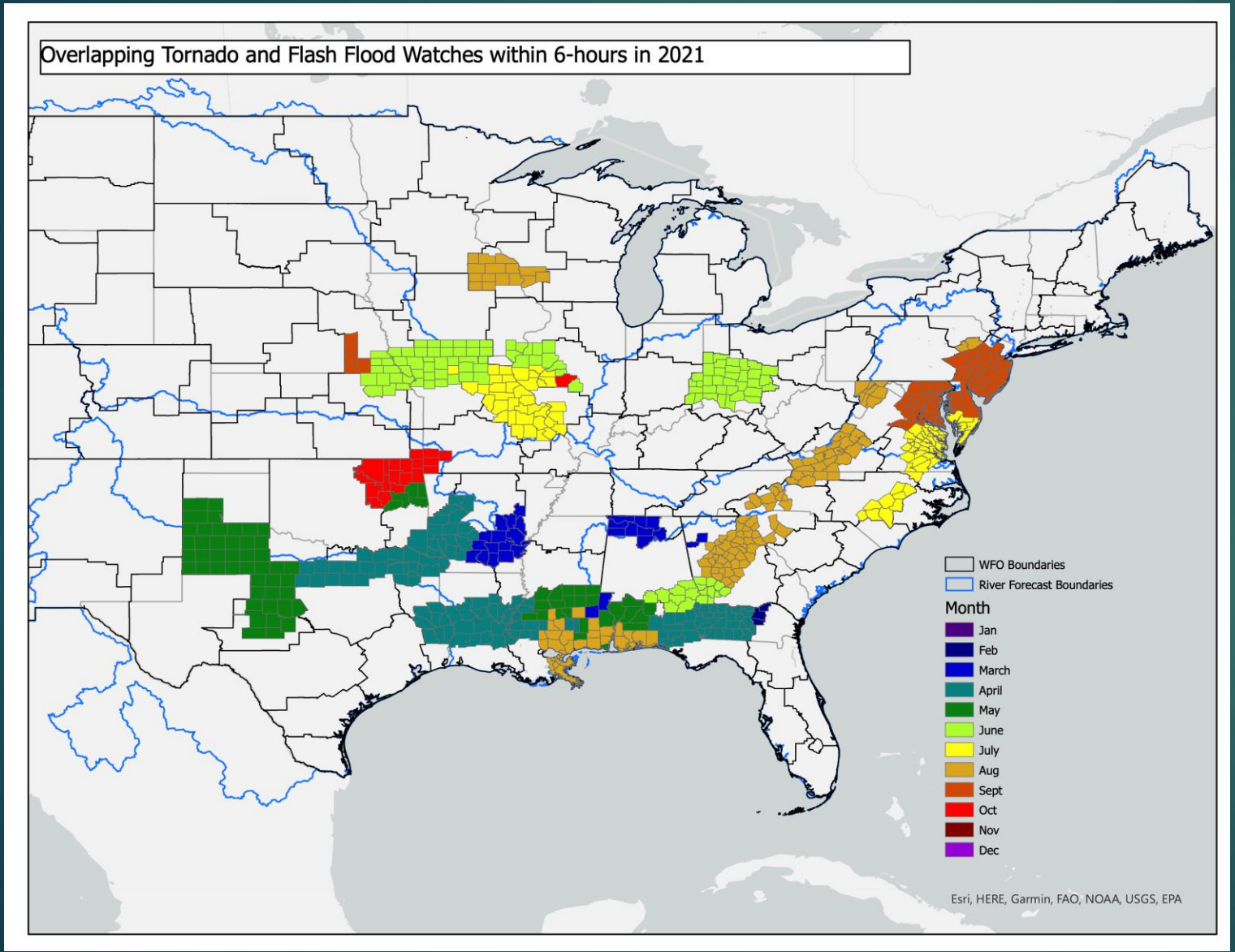
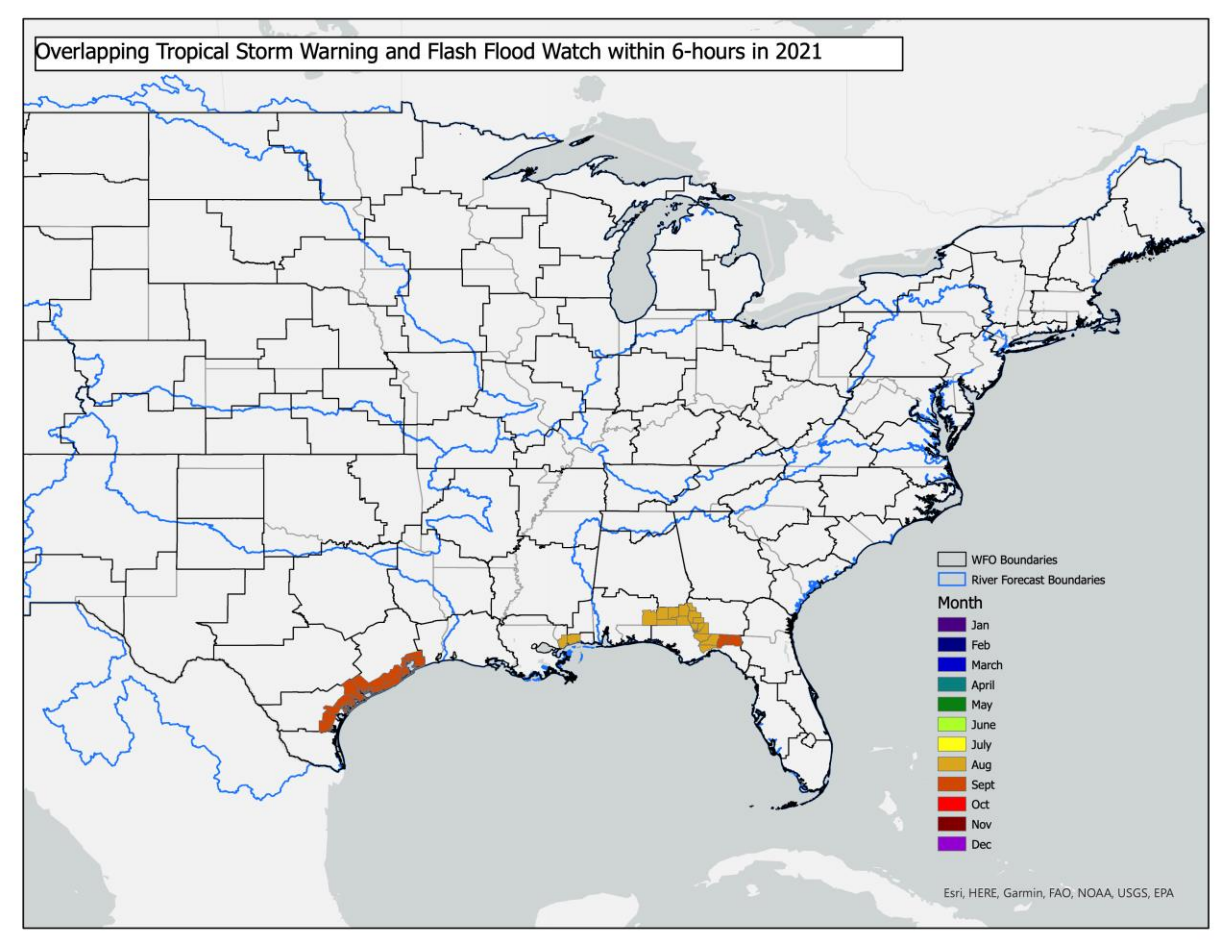
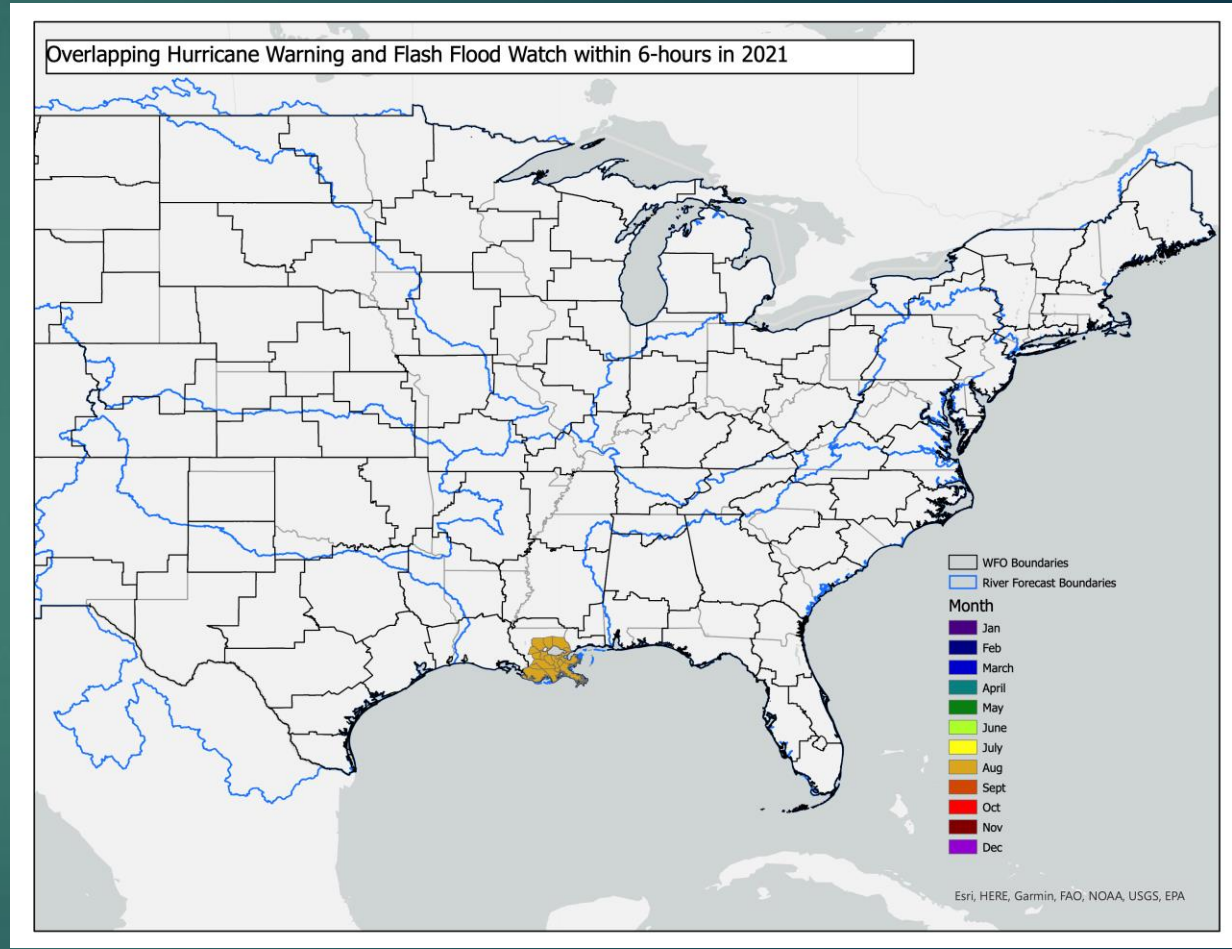


- What if we change the map to the left to more tropical focused wind and water hazards in 2021?

What about other wind/water threats?

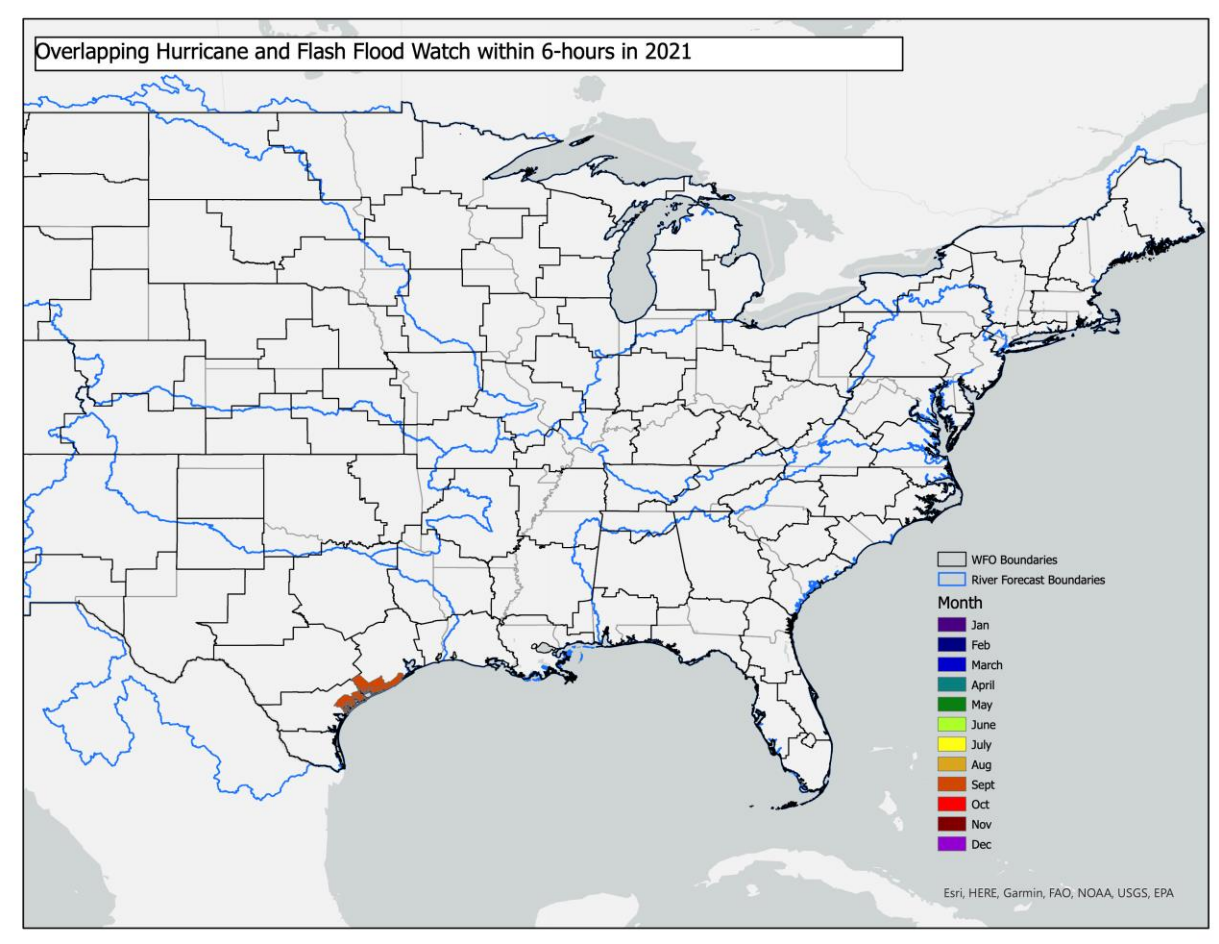


Tropical storm warning and flash flood watch overlap within 6-hours in 2021

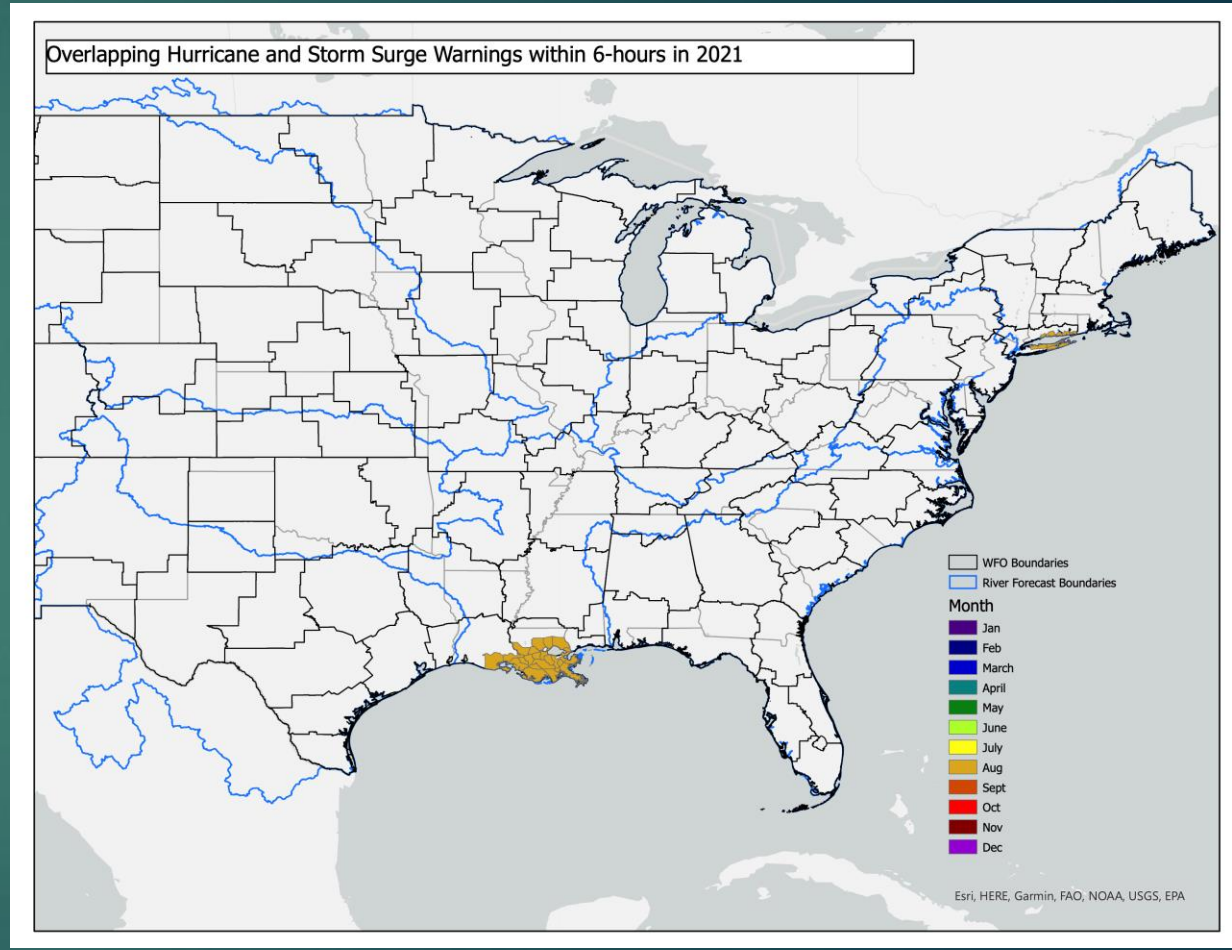


Hurricane warning and flash flood watch overlap within 6-hours in 2021

What about other wind/water threats?



Hurricane watch and flash flood watch overlap within 6-hours in 2021

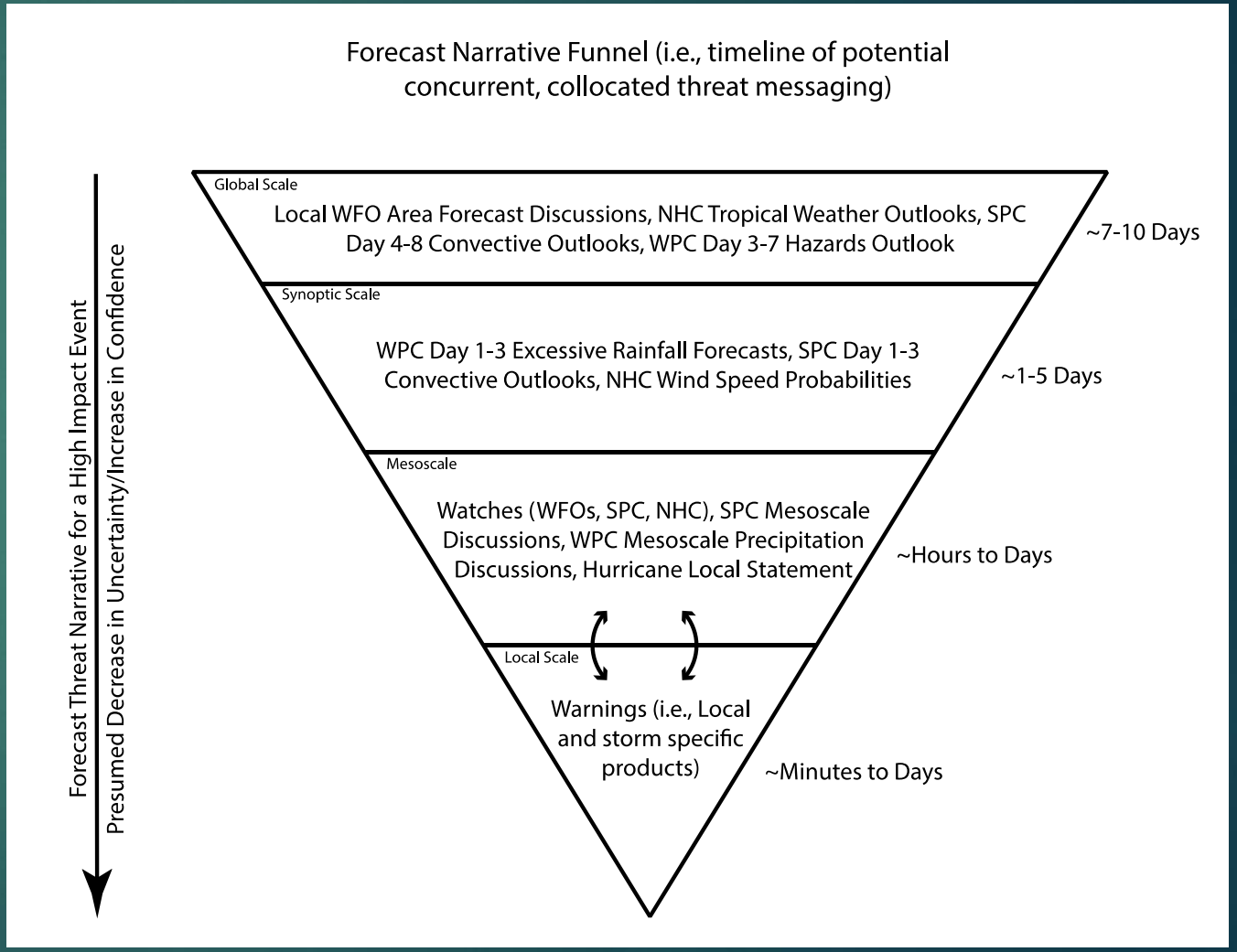


Hurricane warning and storm surge warning overlap within 6-hours in 2021

Other hazards, timeframes, overlaps

Throughout the forecast timeline overlapping hazard information can be communicated

- What type of threat overlaps are the most pertinent to investigate?
- How might a database or knowledge of these overlaps be most useful? Audience? Format? Content?
- Outside of watch/warning products, is there a <u>critical</u> timeframe in threat messaging when hazard prioritization takes place?



What We Don't Know

So, so much….

- What collaboration between WPC / SPC / NWS / NHC exists & might be leveraged for TORFF events?
- What information (e.g. onset / end timing) might be developed and useful to experts /publics about transition and duration of threats?
- How / when do experts / publics make decisions about prioritization of wind and water threats?
- How will changes to future warning paradigms impact already challenging decisions for compound events?
- How close is "concurrent" for overlaps?

Thank you!

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TORFF Pubs & Projects

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