



Unit 3: Understanding Forecast Uncertainty

Unit 3 Objectives



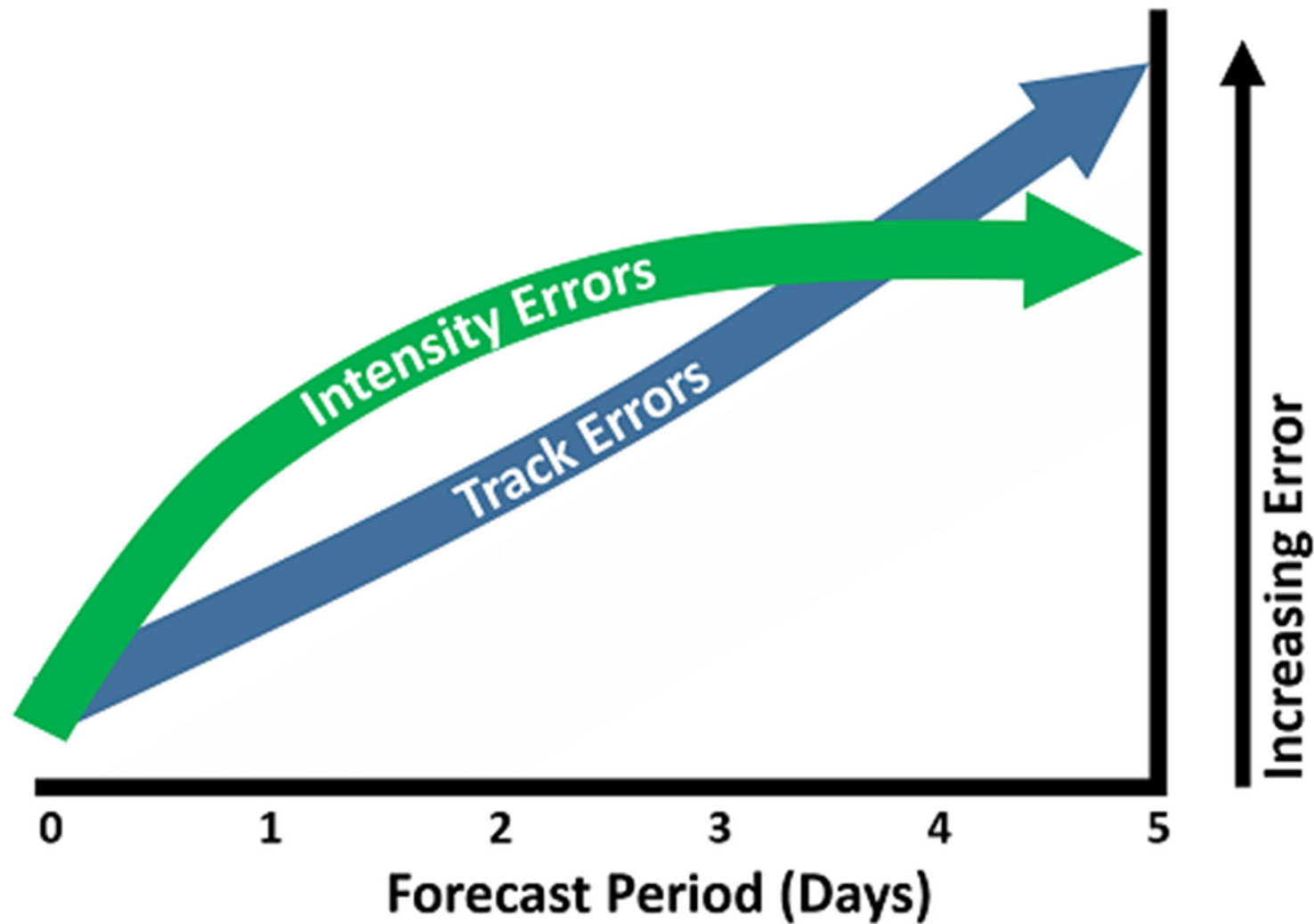
At the end of this unit, you should be able to:

1. Explain the meaning of “uncertainty” as it relates to NWS forecasts.
2. Explain what “59% chance of TS-force winds” (or similar probability) means.
3. Discuss the challenges inherent to rainfall and inland flooding forecasting.

Forecast Errors



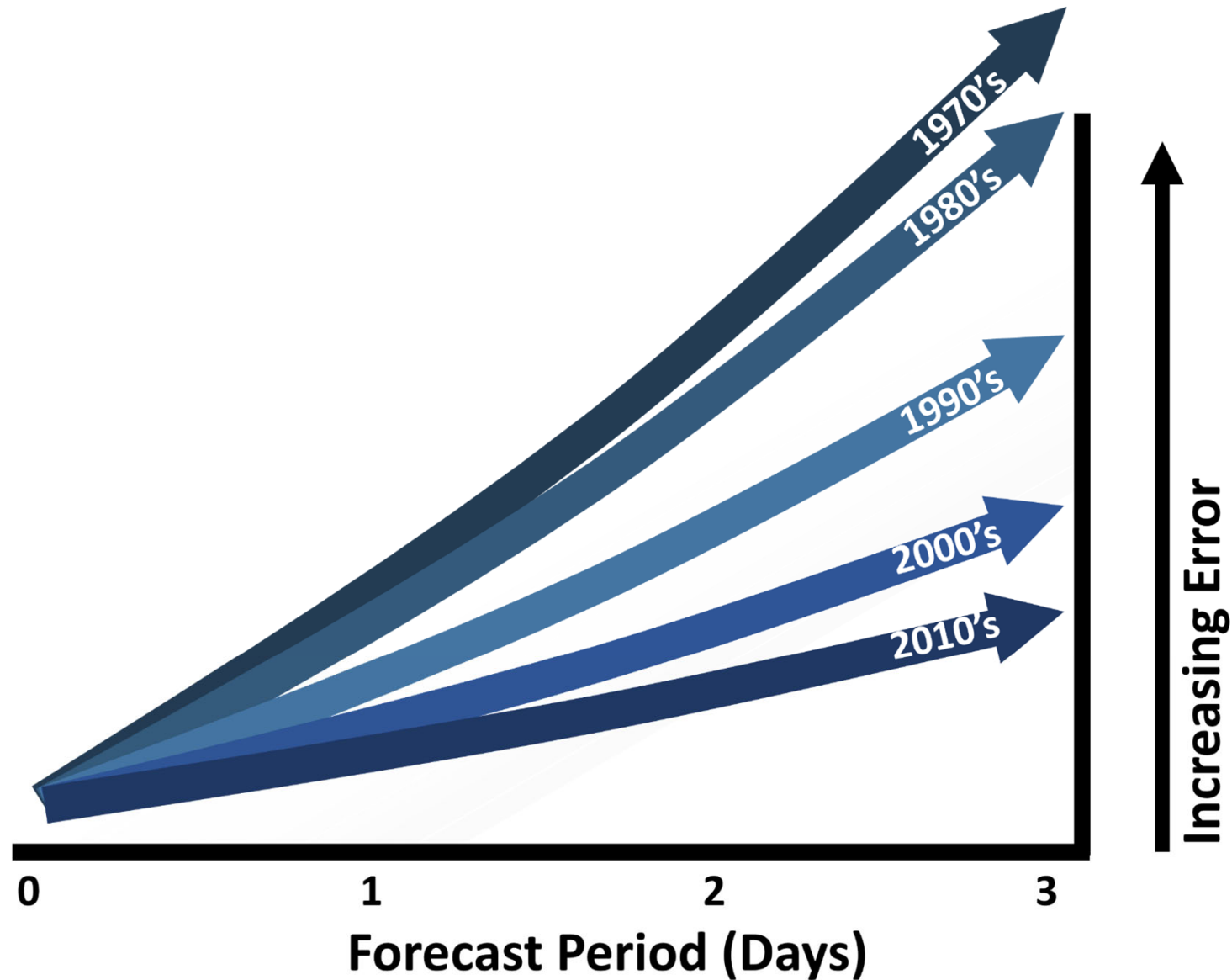
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Forecasts are Improving, But Not Perfect



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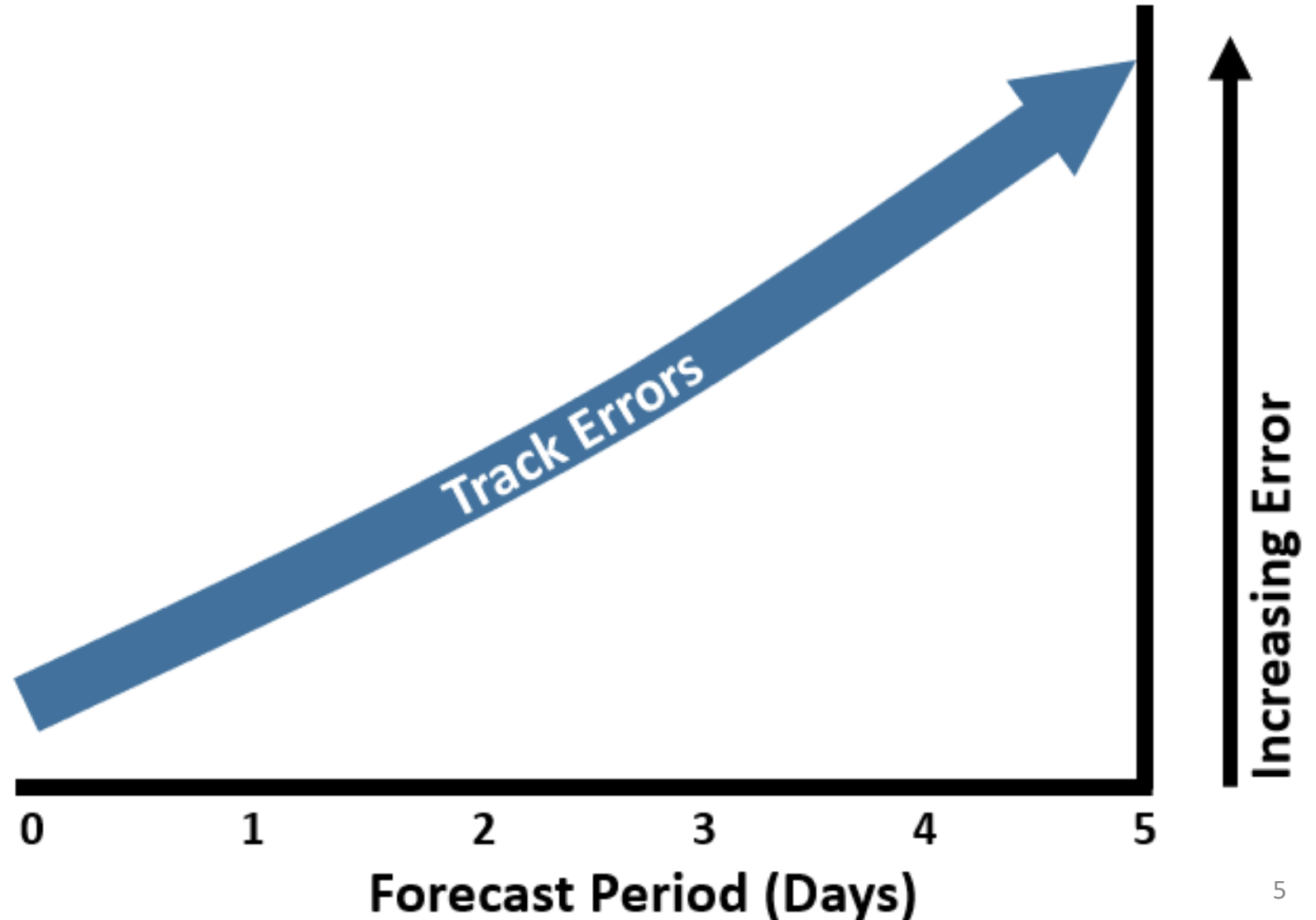
NHC 5-Year Averages: Track Errors



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Track Errors

- Increase 40 miles (35 nautical miles (nm)) per day

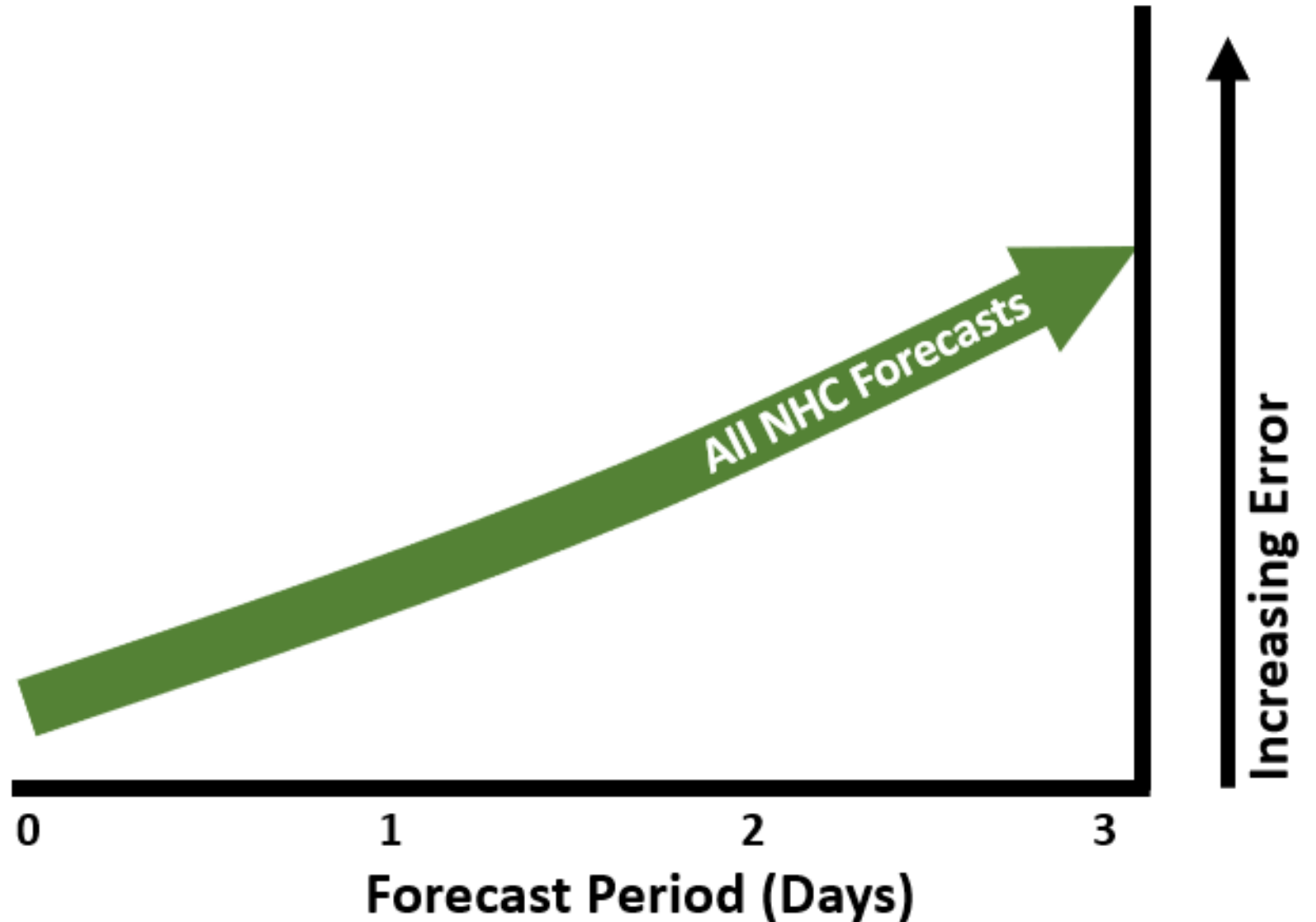


Track Errors – All NHC Forecasts



All NHC Forecasts

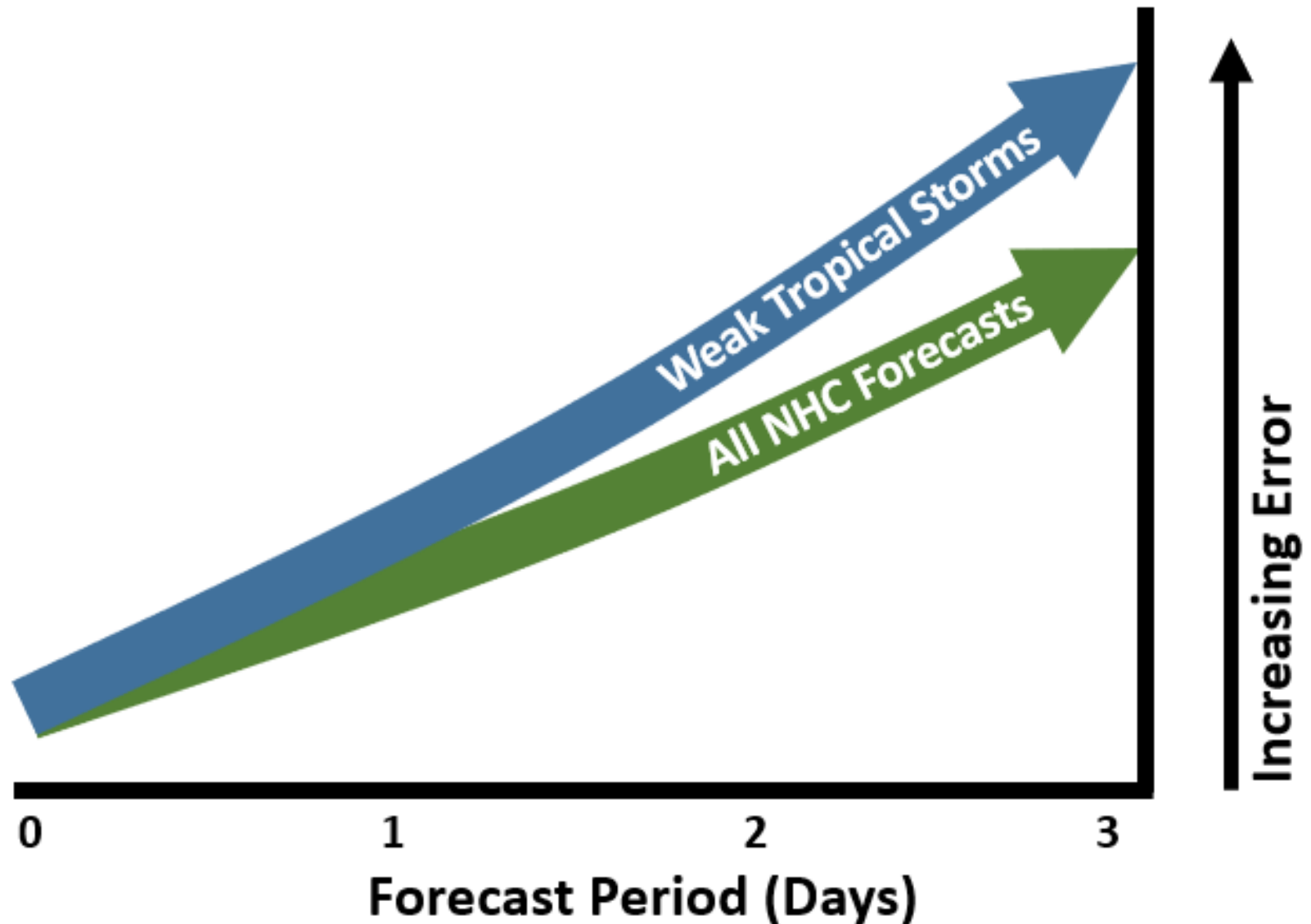
- Track errors increase about 35–40 miles per day



Track Errors – Weak TS

Weak Tropical Storms

- Track errors increase about 40–45 miles per day



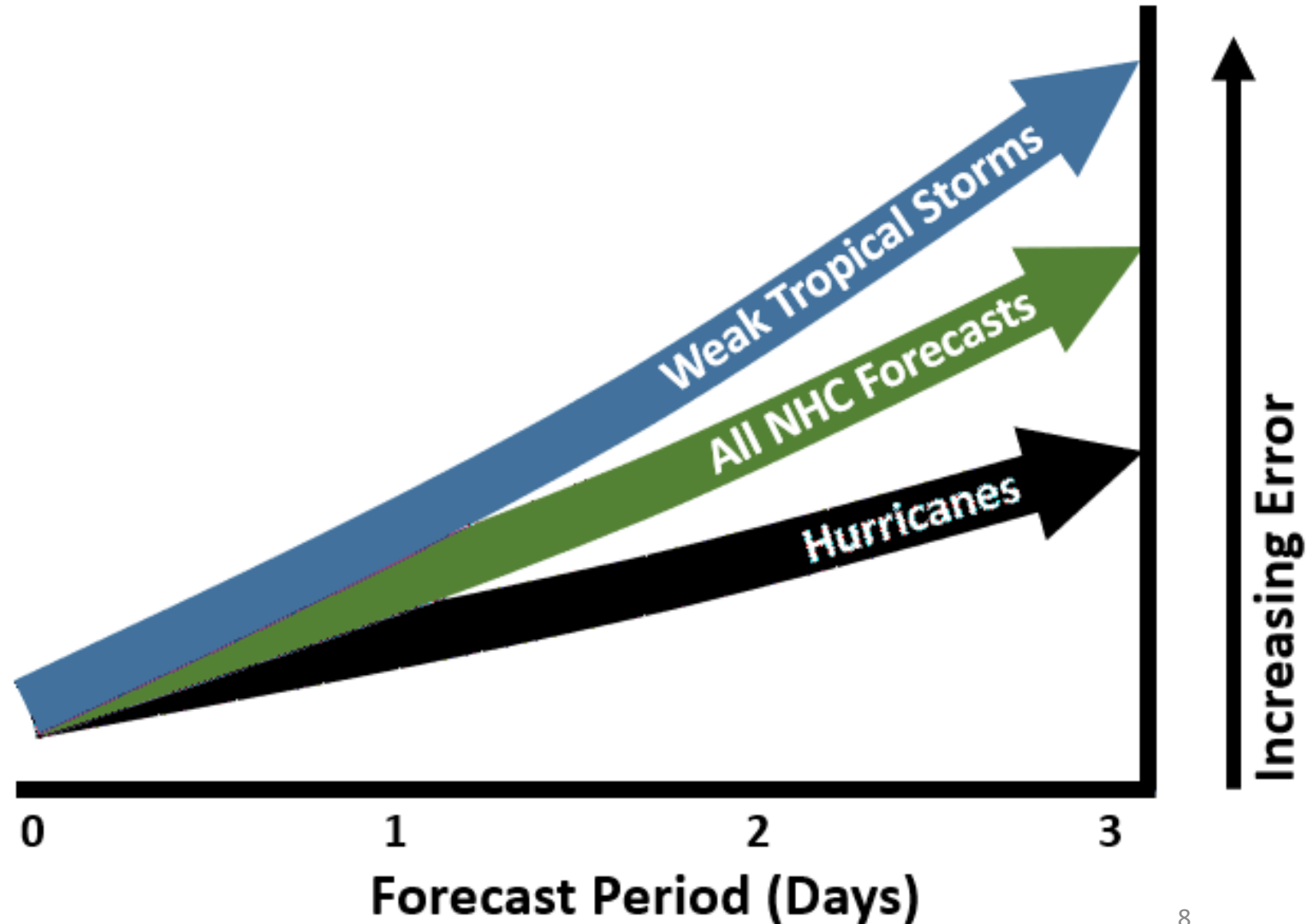
Track Errors – Hurricane



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Hurricanes

- Track errors increase about 25–30 miles per day



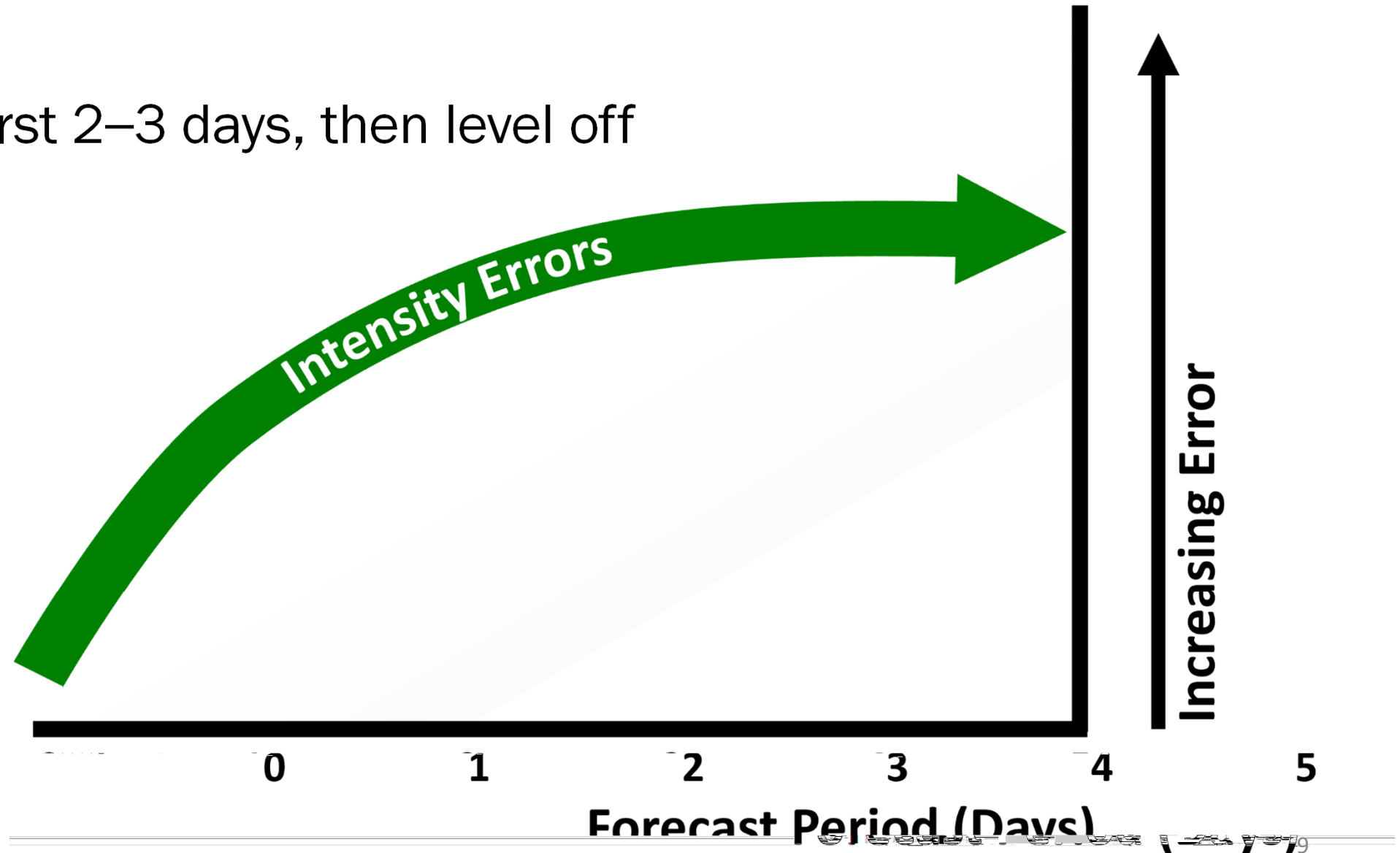
NHC 5-Year Averages: Intensity Errors



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Intensity Errors

- Increase the first 2–3 days, then level off

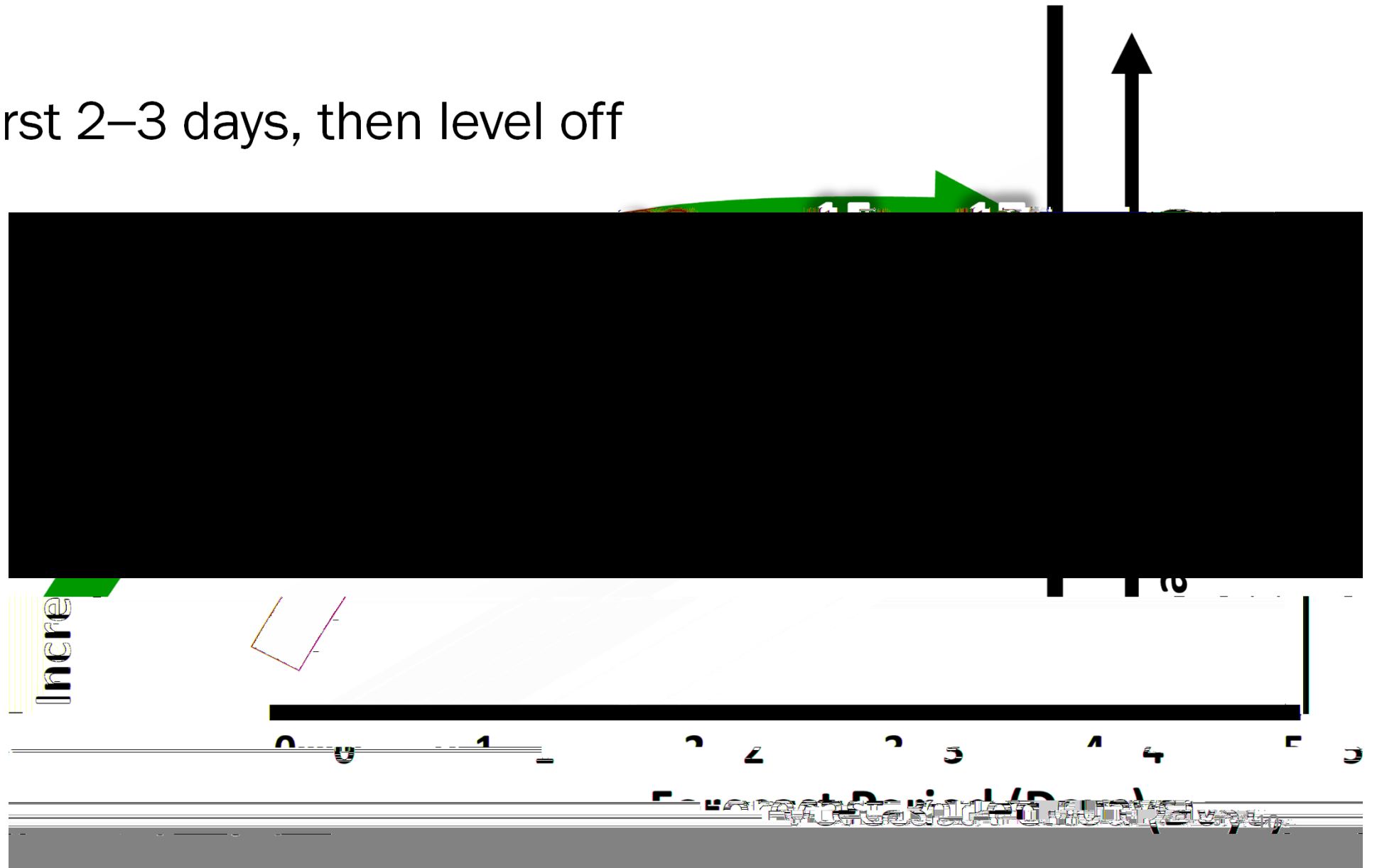


Intensity Errors Over 5 Days



Intensity Errors

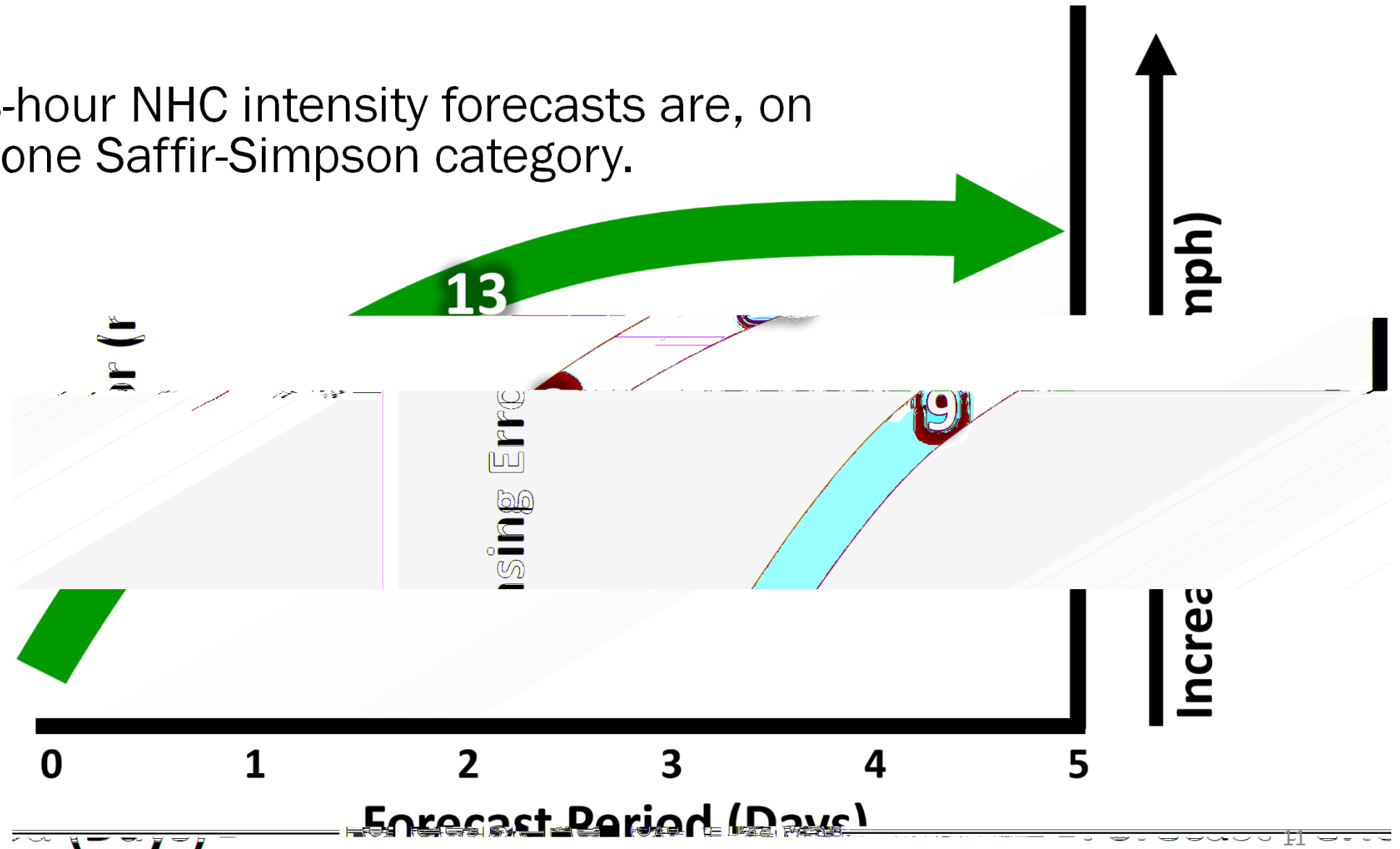
- Increase the first 2–3 days, then level off



Intensity Error Over 48 Hours

Intensity Errors

- The 24- and 48-hour NHC intensity forecasts are, on average, off by one Saffir-Simpson category.

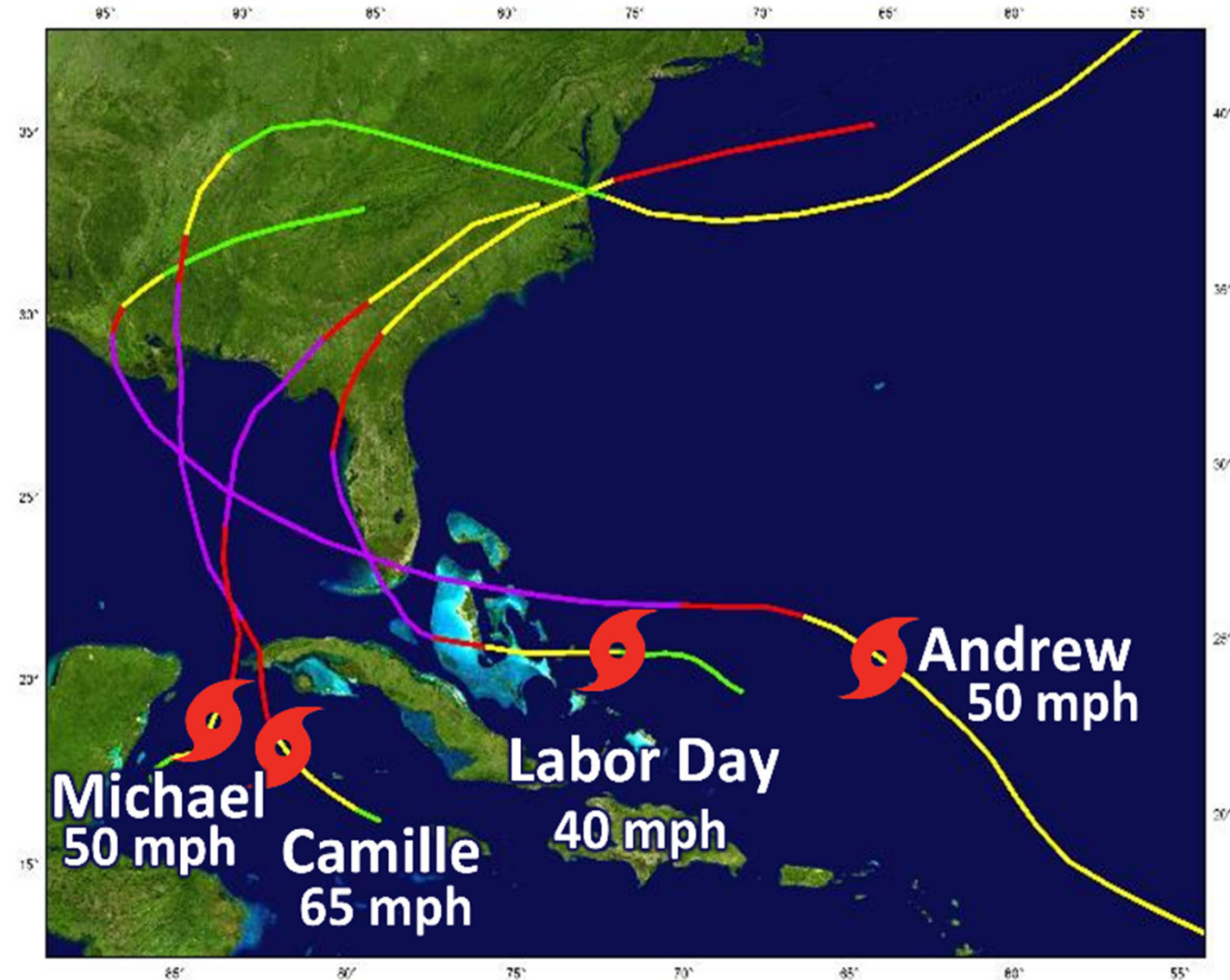


Rapid Intensification

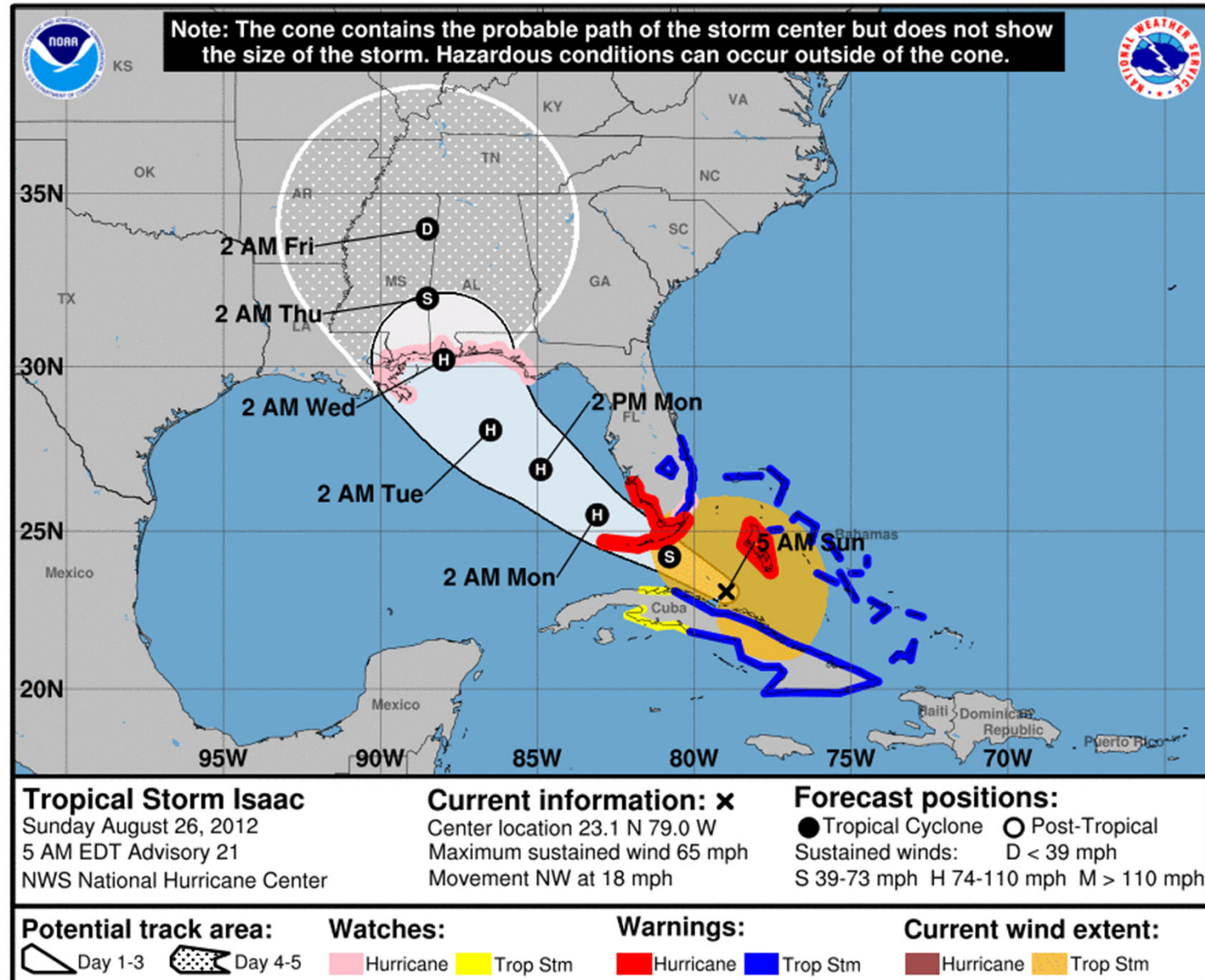
- Increase in the maximum sustained winds of at least 30 kts (35 mph) in a 24-hour period

Where were these Category 5 hurricanes 3 days before landfall?

- Labor Day (1935)
- Camille (1969)
- Andrew (1992)
- Michael (2018)



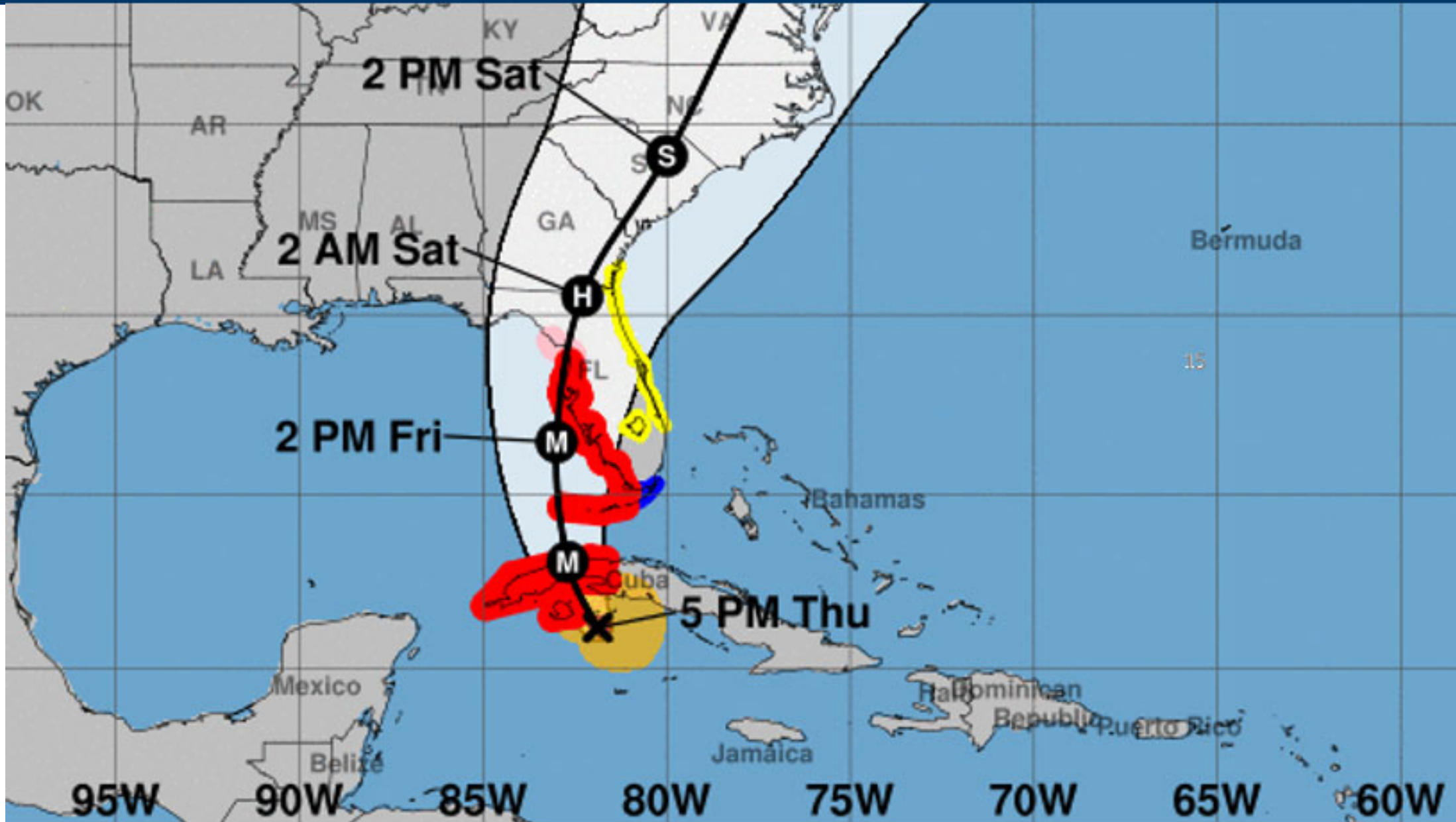
Forecast Error Cone – Probable Track, Watches, Warnings



Don't Focus on the Skinny Black Line



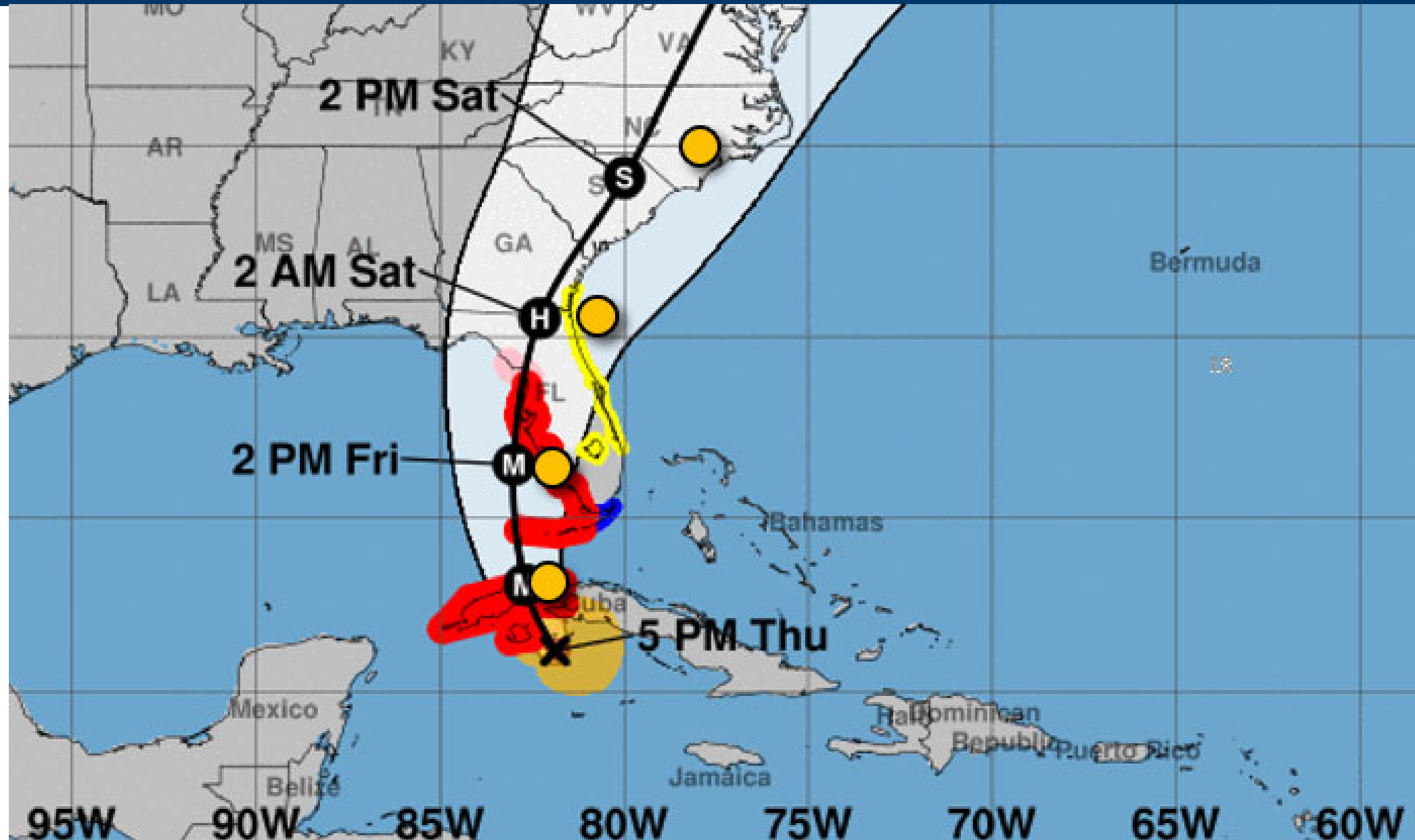
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Forecast vs. Observed



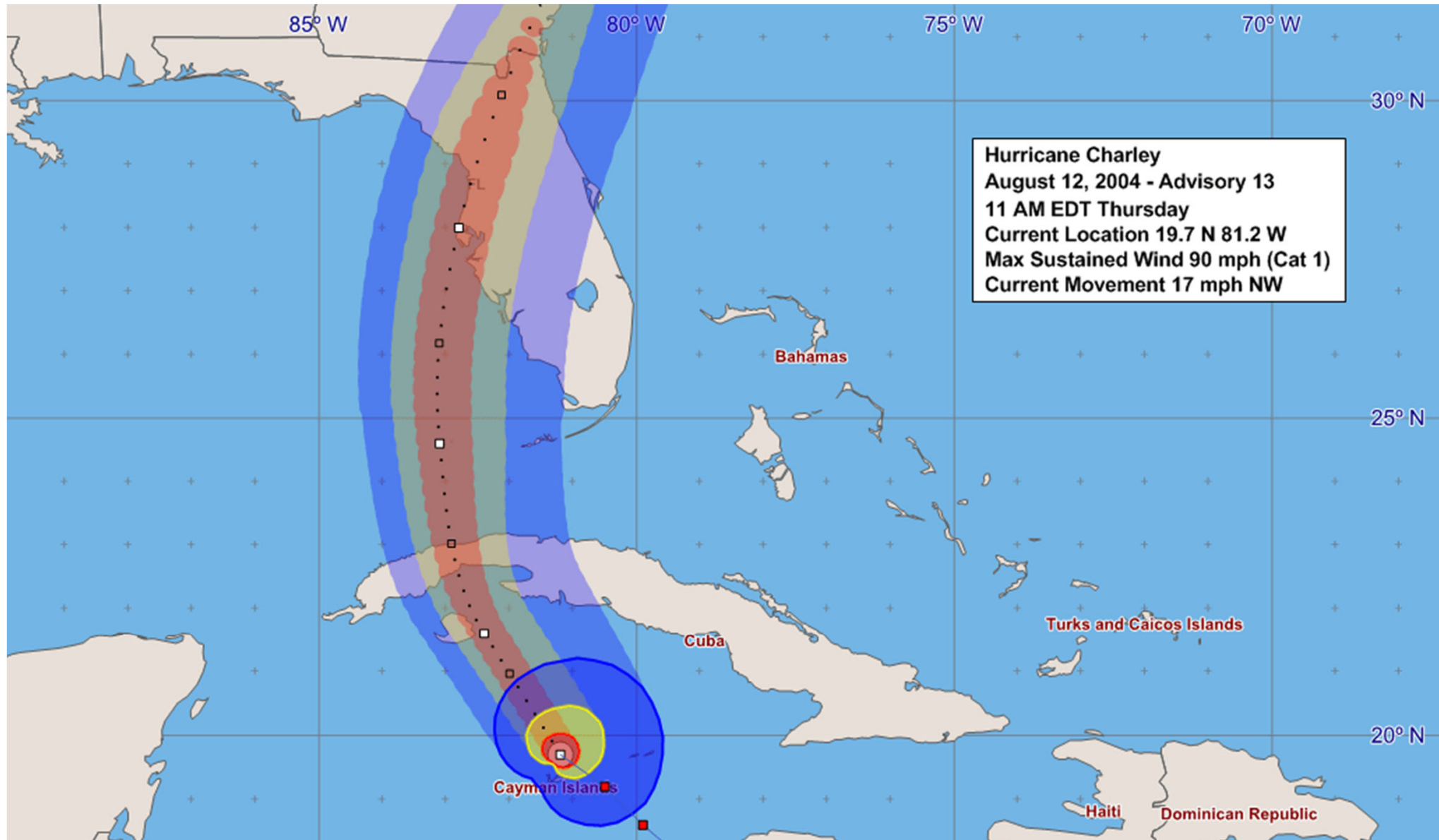
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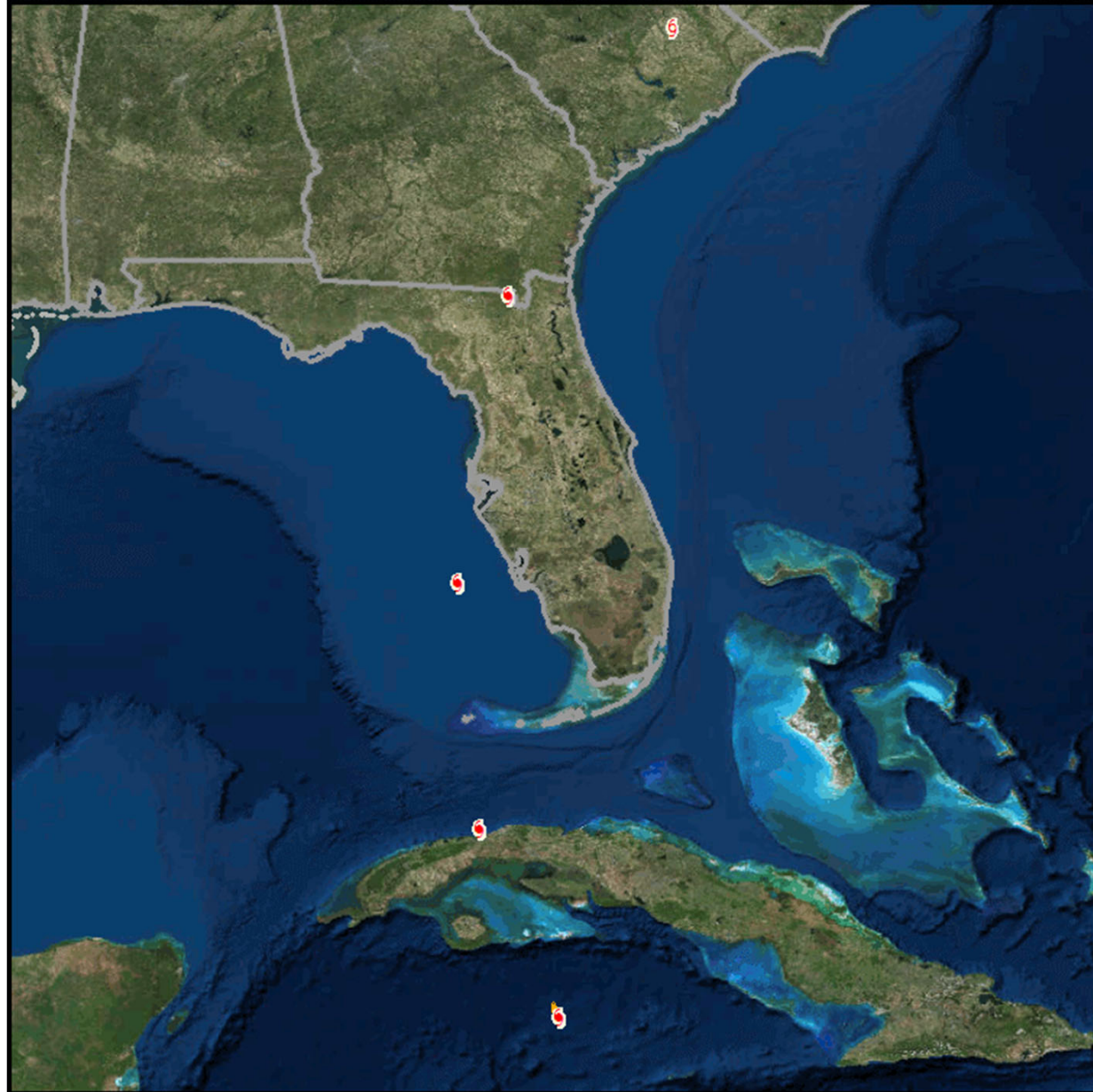
Hurricane Charley



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Would Alternate Scenarios Help?



What Does 59% Chance Mean?



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How Are WSP Generated? (1 of 3)

More scenarios

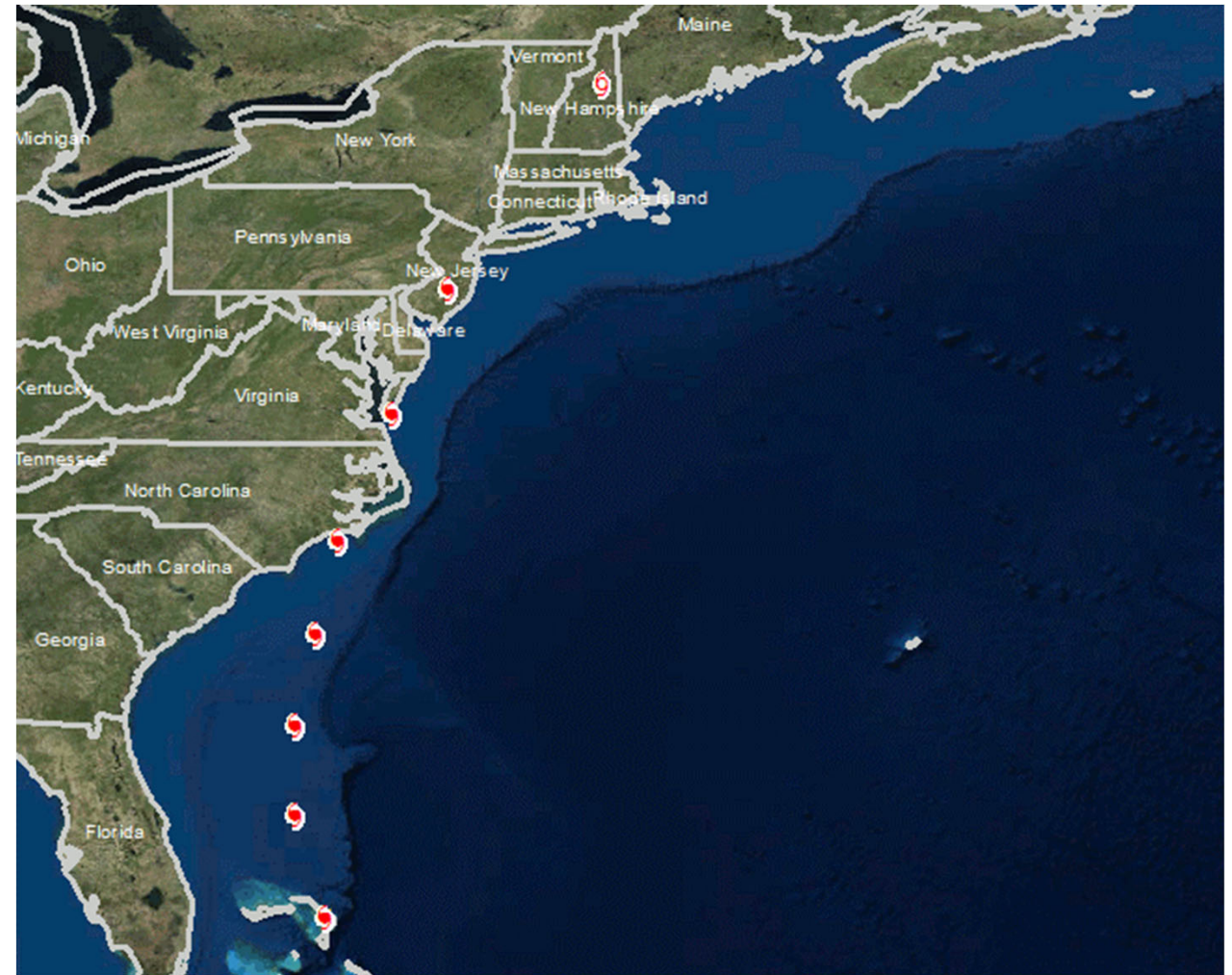
1,000 realistic alternative scenarios are generated

- Official NHC forecast
- Historical track and intensity forecast errors

Weakening over land

Track model spread

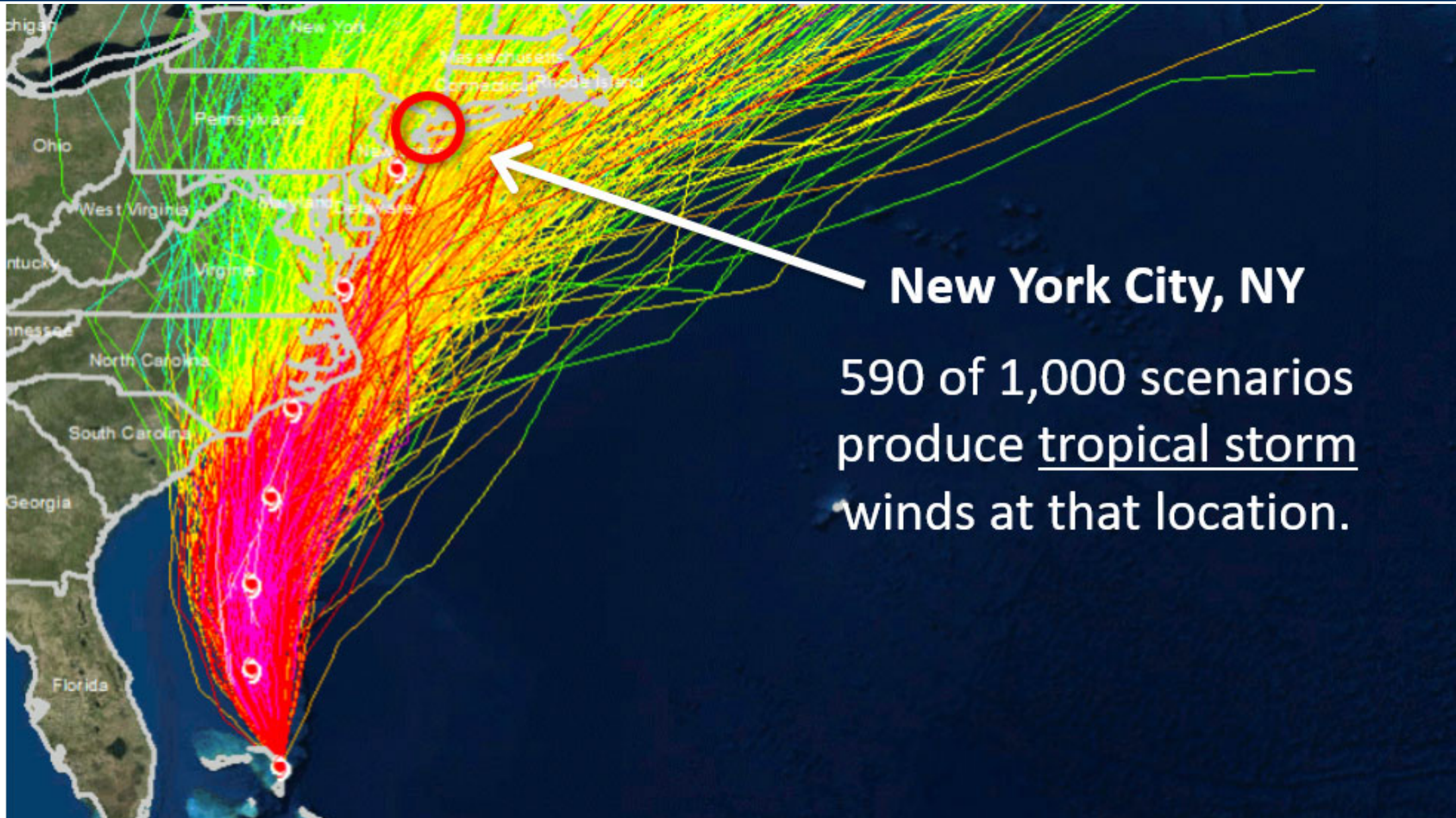
- Forecast track errors are correlated to the spread of model guidance



How Are WSP Generated? (2 of 3)

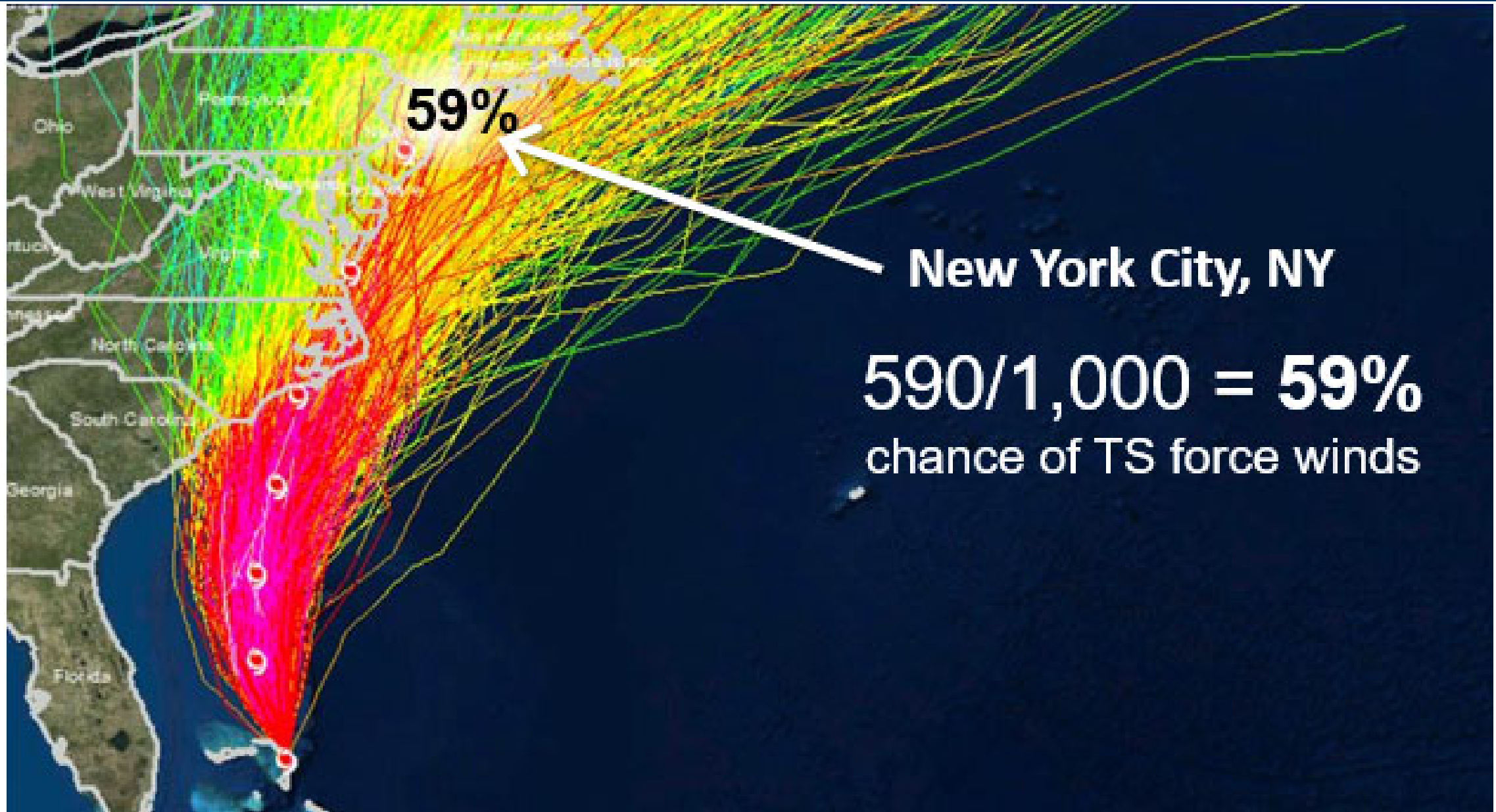


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New York City, NY
590 of 1,000 scenarios
produce tropical storm
winds at that location.

How Are WSP Generated? (3 of 3)



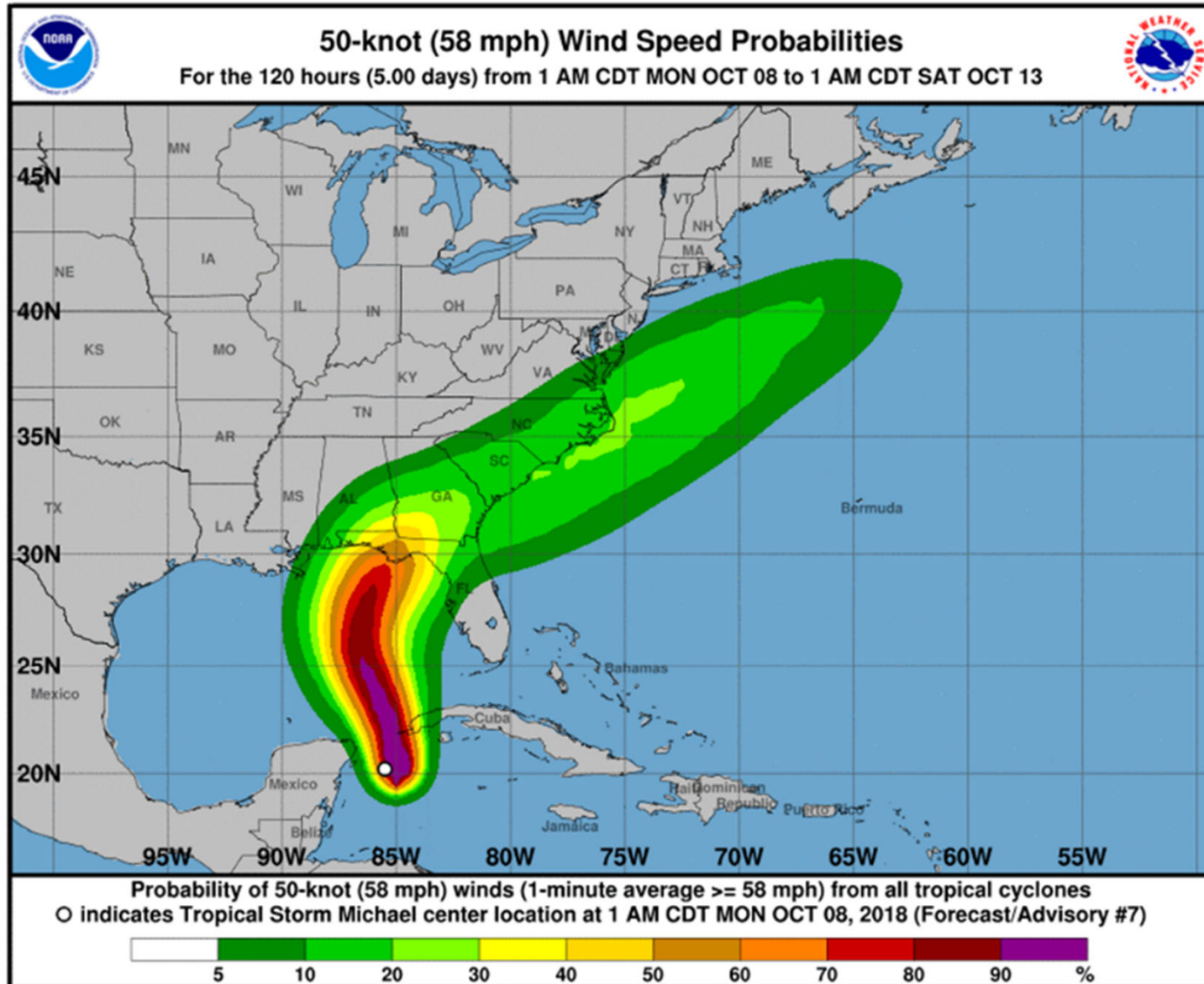
5-Day Cumulative Graphic: TS-Force



Location-specific Probabilities

- Tropical Storm-Force
- 58 mph (“Strong” Tropical Storm)
- Hurricane-Force

5-Day Cumulative Graphic: 58 mph



Location-specific Probabilities

- Tropical Storm-Force
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5-Day Cumulative Graphic: Hurricane-Force



Location-specific Probabilities

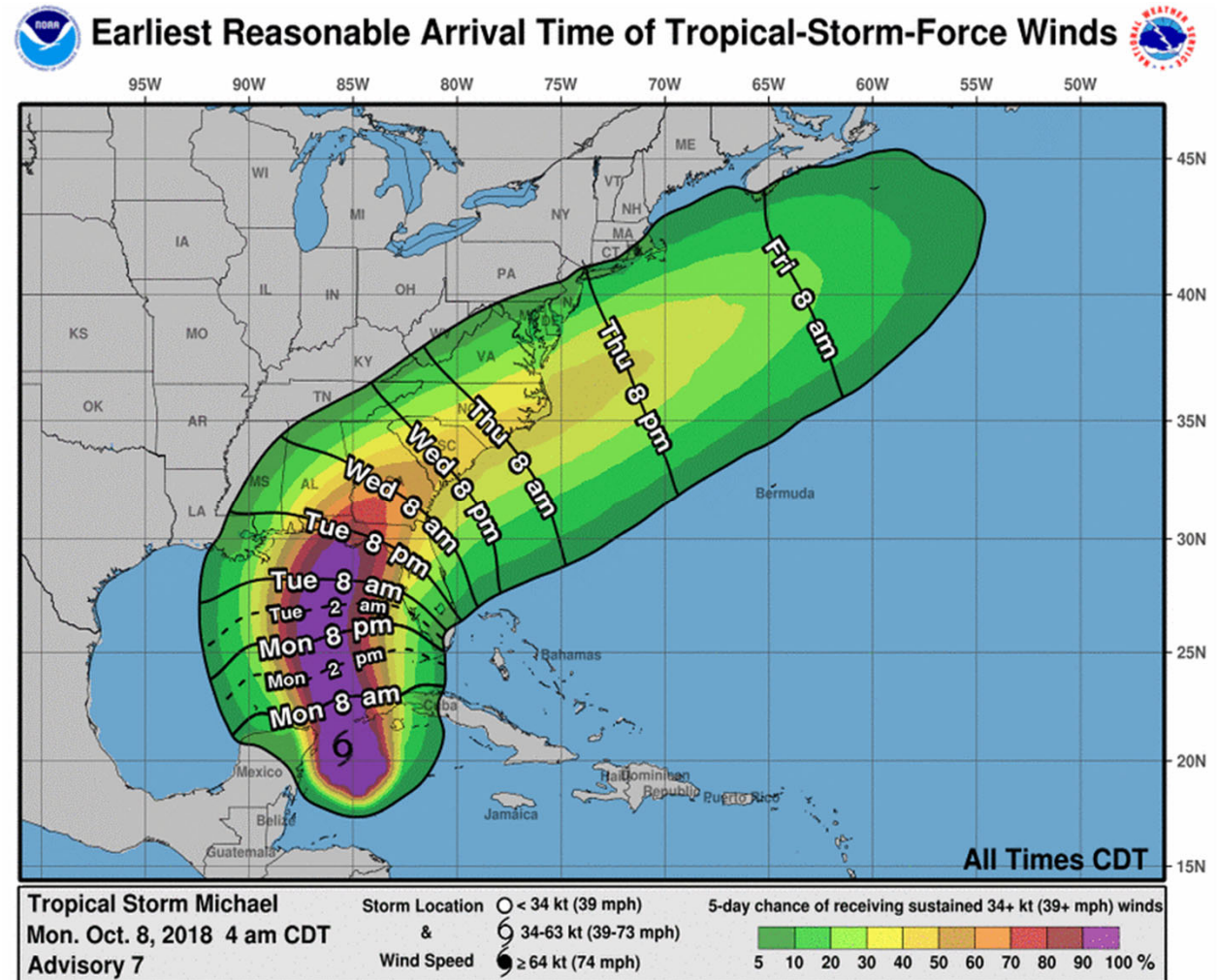
- Tropical Storm-Force
- 58 mph (“Strong” Tropical Storm)
- Hurricane-Force

Earliest Reasonable Onset of TS Winds



Earliest Reasonable

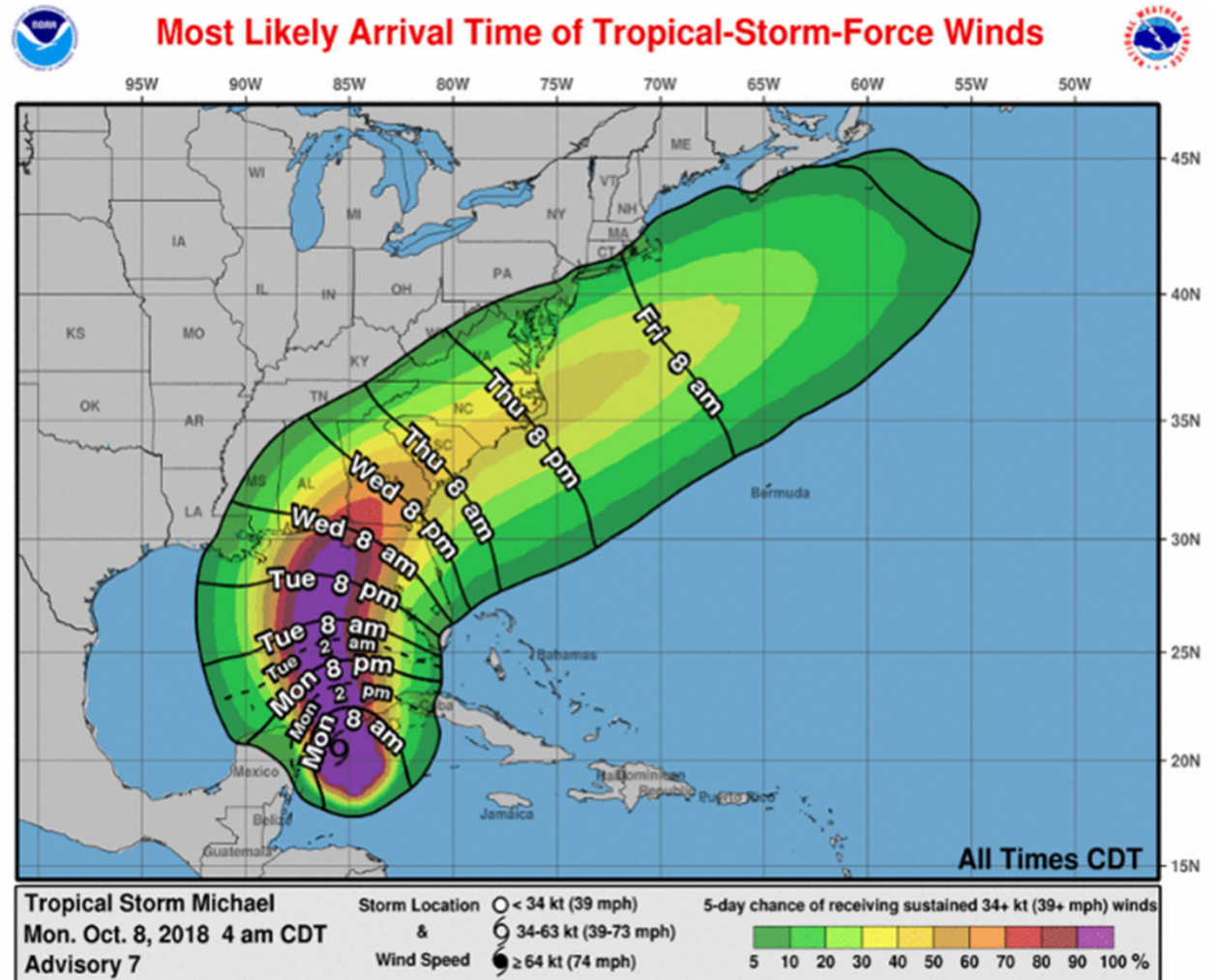
- 10% chance of onset (Most conservative timing)
- Black Contours: Arrival time of TS winds
- Color fill: 5-day cumulative TS probabilities



Most Likely Onset of TS Winds

Most Likely

- 50% chance of onset (Equally likely to occur before as after)
- Black Contours: Arrival time of TS winds
- Color fill: 5-day cumulative TS probabilities

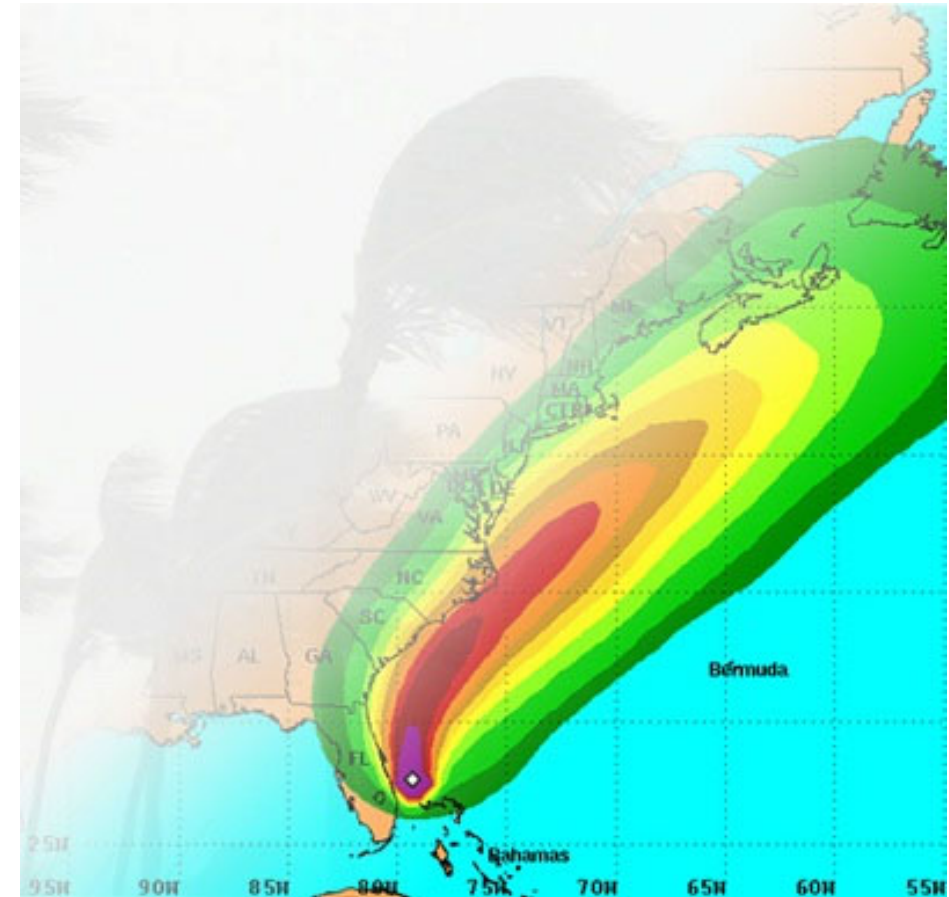


Wind Speed Probabilities – Summary

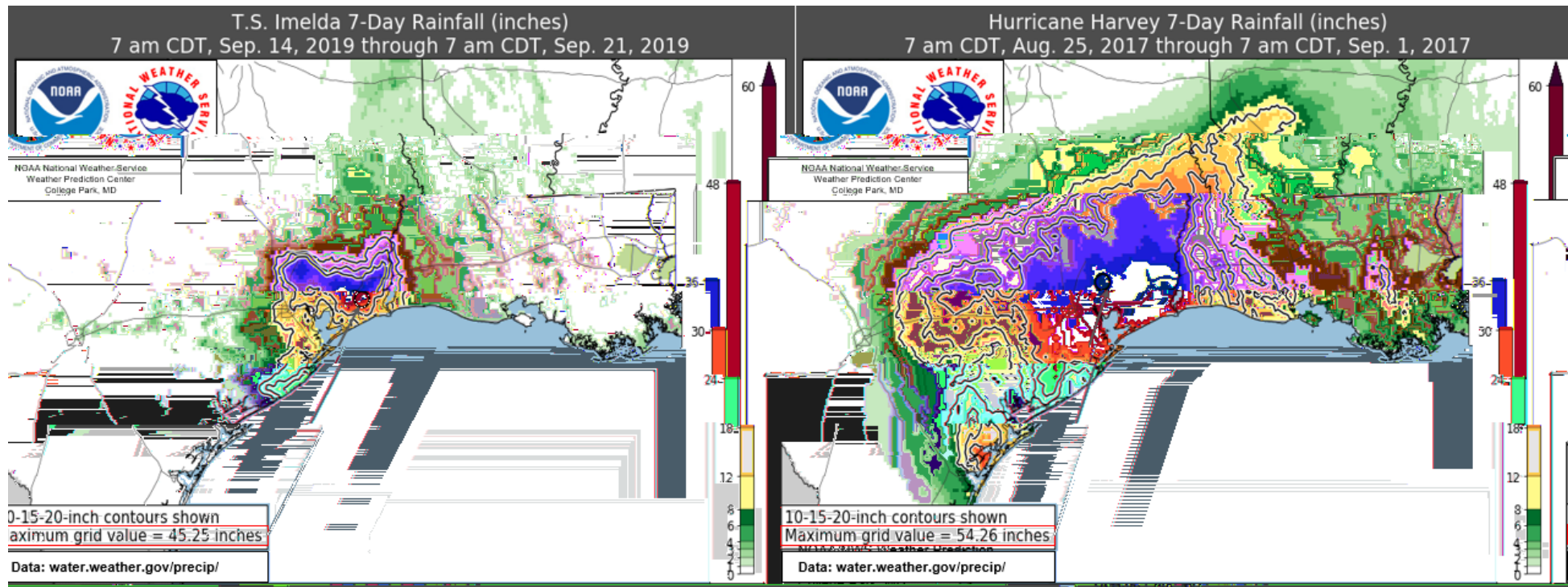


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- NHC's forecasts are improving, but errors remain
 - Error cone is not the cure for skinny black line
- Wind speed probabilities
 - Likelihood of tropical storm and hurricane winds
 - Onset timing of wind hazards
- Incorporates track, intensity, and size uncertainty
 - Includes weakening due to land
- Provides an assessment of wind timing and threat that accounts for NHC forecast errors



Rainfall Predictability Challenges

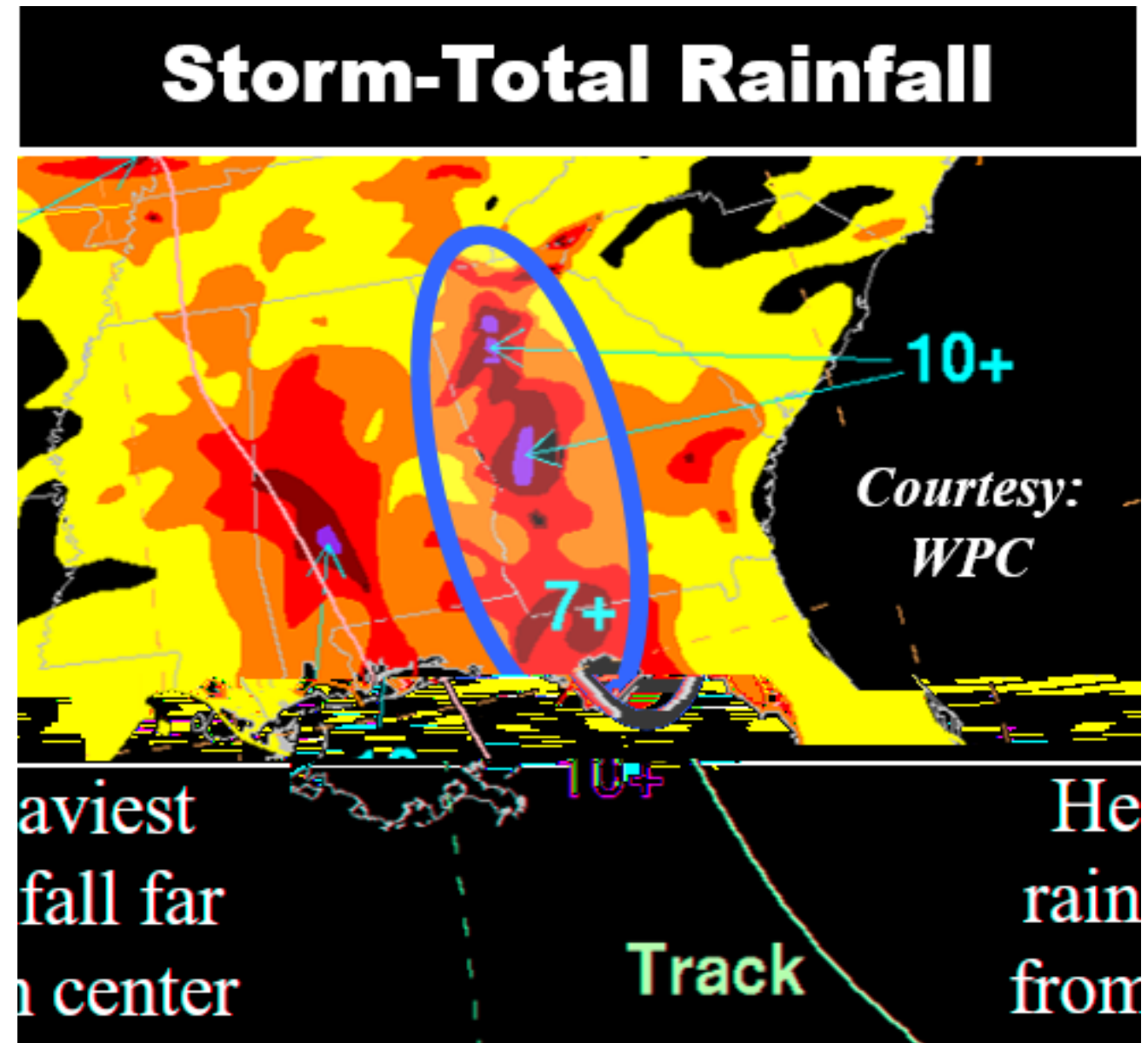
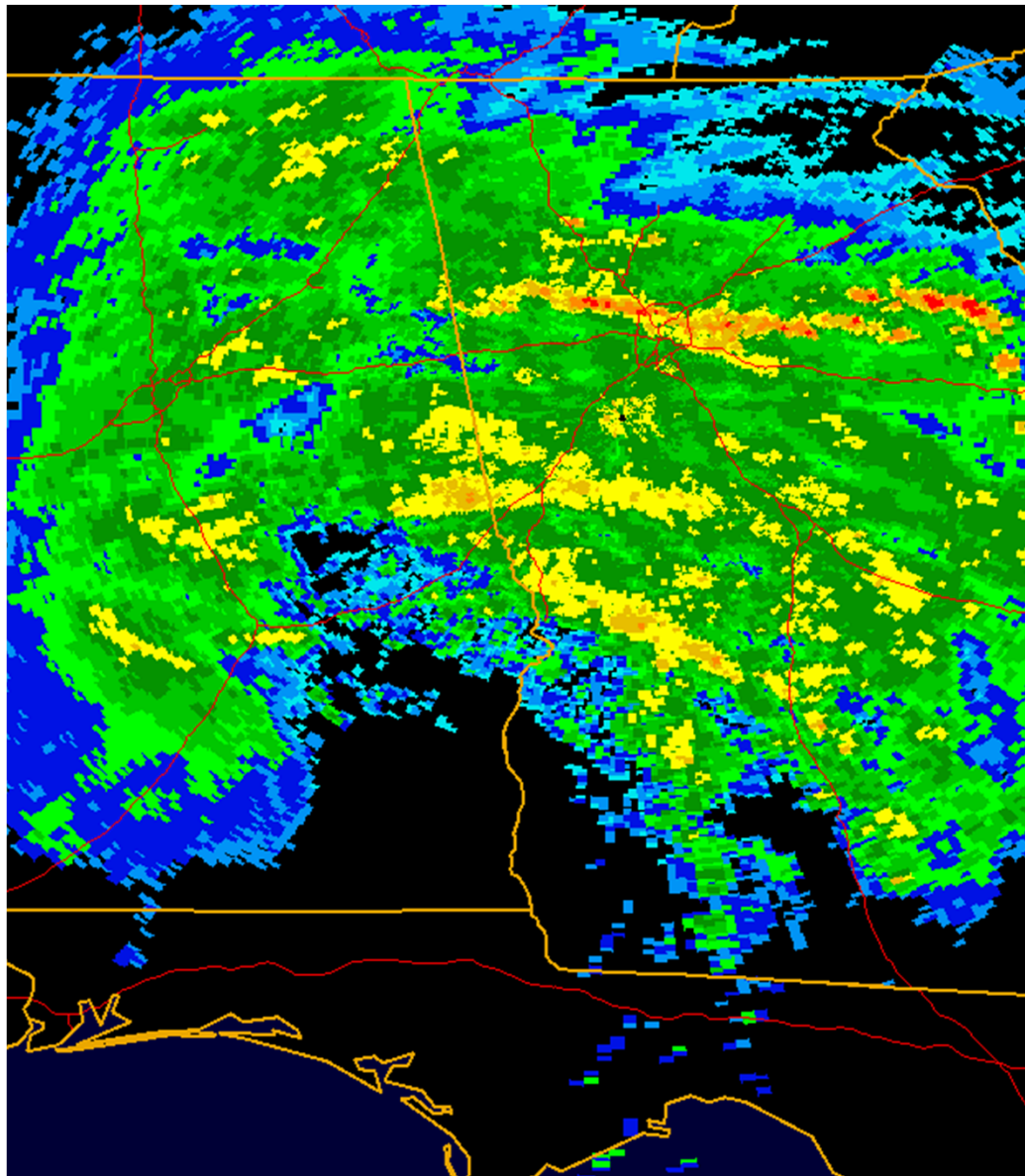


- Small, less organized storms can produce localized extreme rainfall maxima.
- Slow storm motion remains a factor.
- Less lead time and placement can make a big difference in impacts.
- Extreme events at this scale can be more obvious at longer lead times, but remember placement error.

Placement of Persistent Rain Bands?



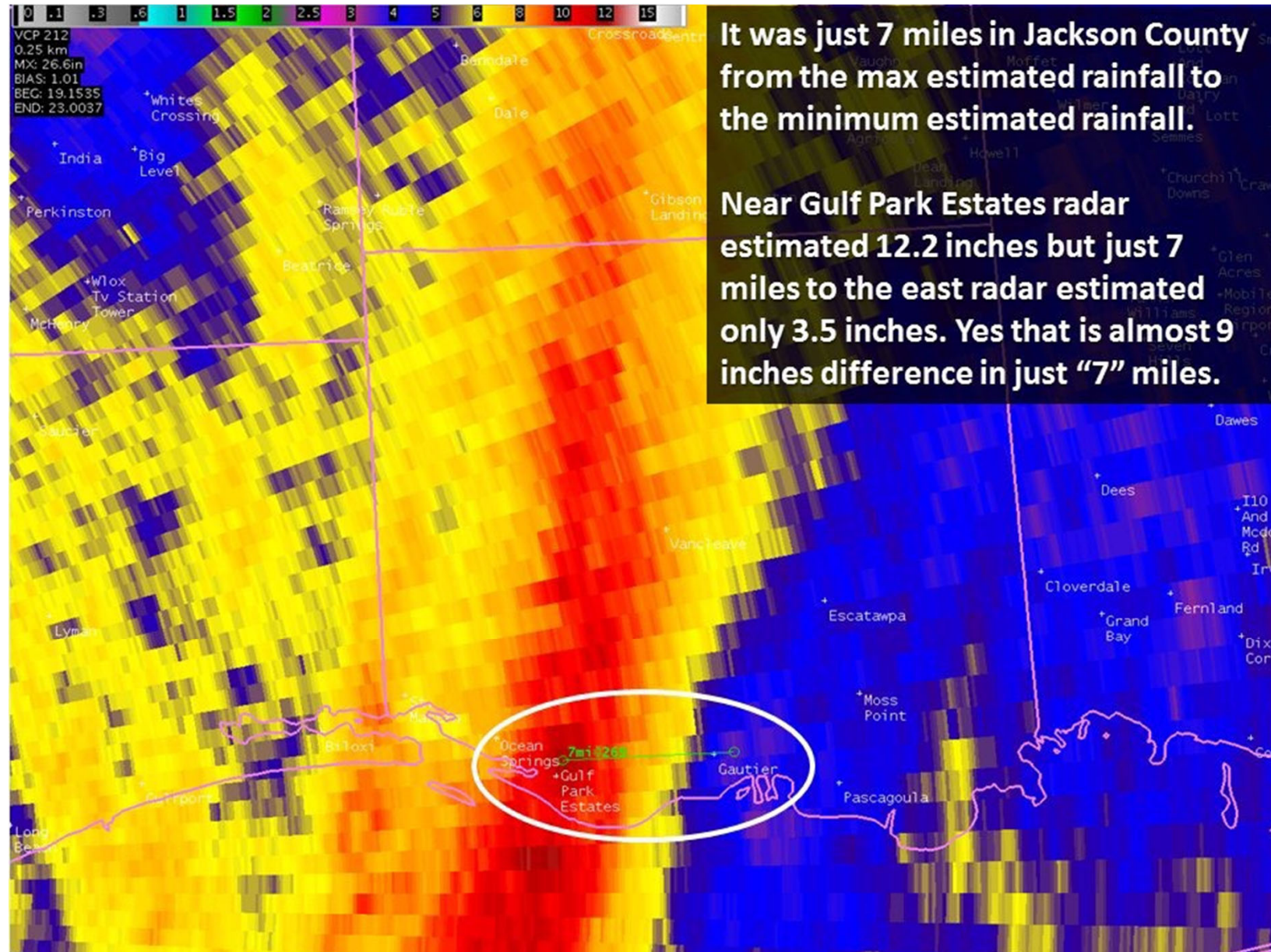
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TS Cindy (2017) Forecast Challenge



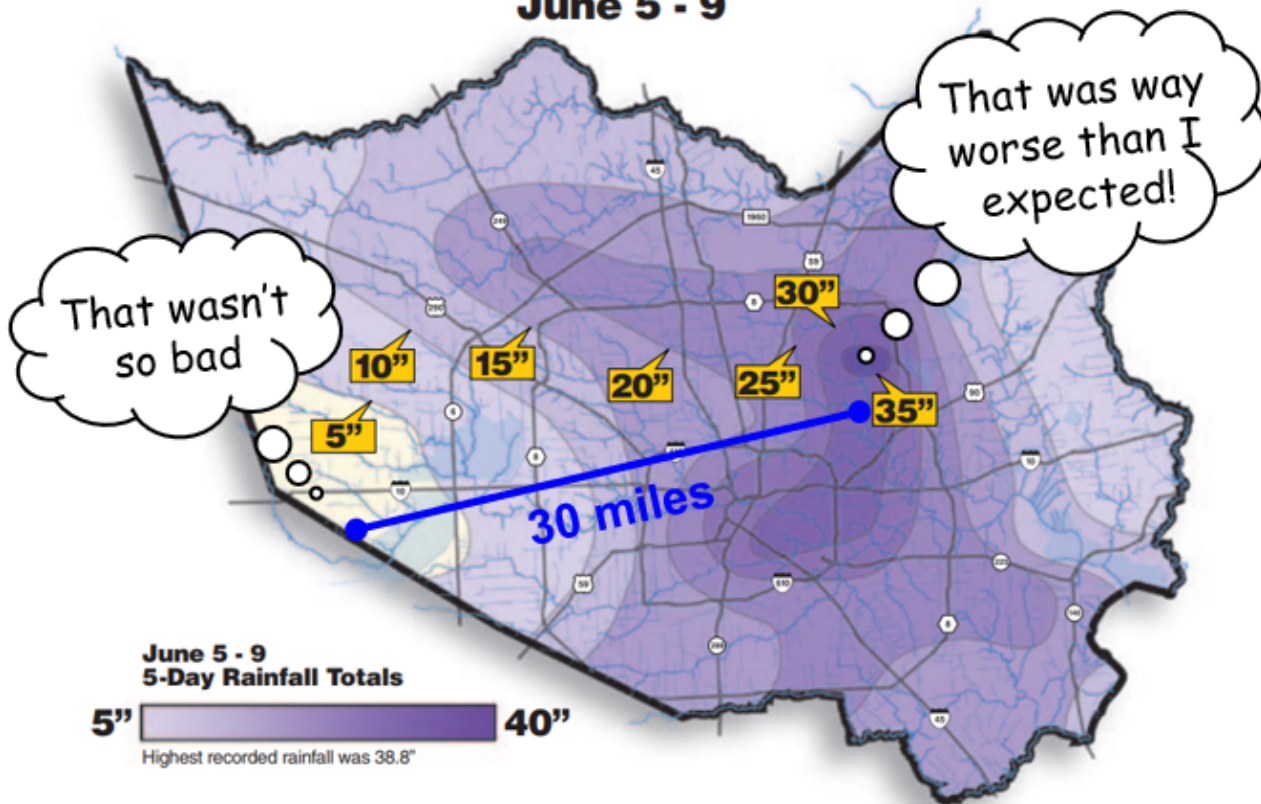
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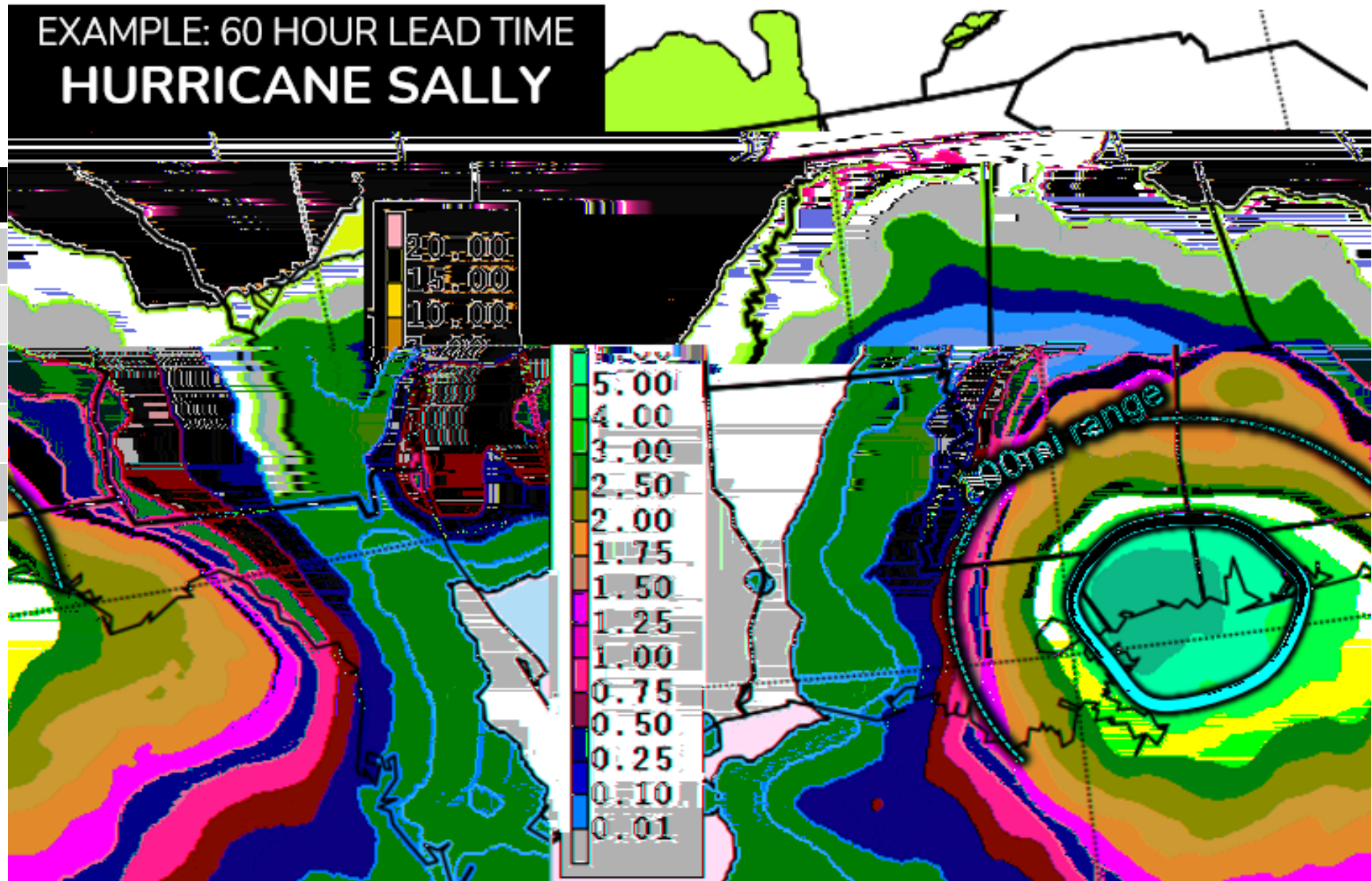
Messaging Issues

Extreme rain gradients in banding in slow-moving, disorganized storms present messaging issues.

5-Day Rainfall Totals
June 5 - 9



Rainfall Forecast Error

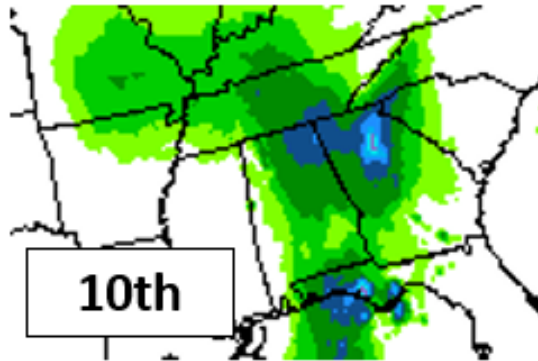
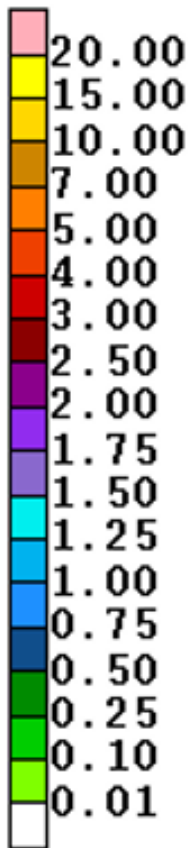


Lead Time	Avg. Error
12 hours	55 miles
36 hours	71 miles
60 hours	98 miles
84 hours	137 miles
108 hours	170 miles

*2016-2021 Displacement Error
of 2" Rainfall Forecast Contour*

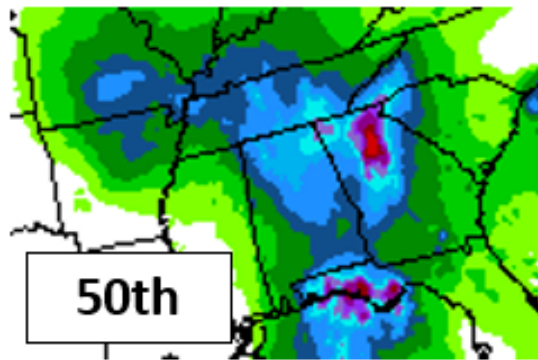
Probabilistic Rainfall Forecasts

In Percentiles



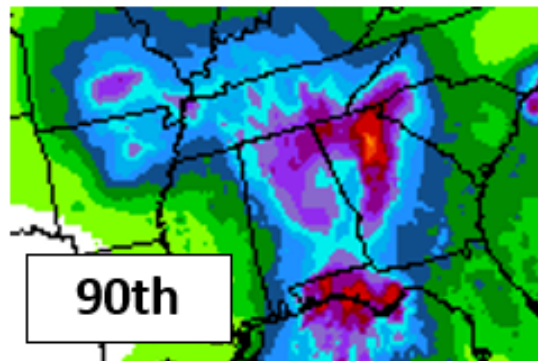
10th Percentile

Expect at least this much rainfall



50th Percentile

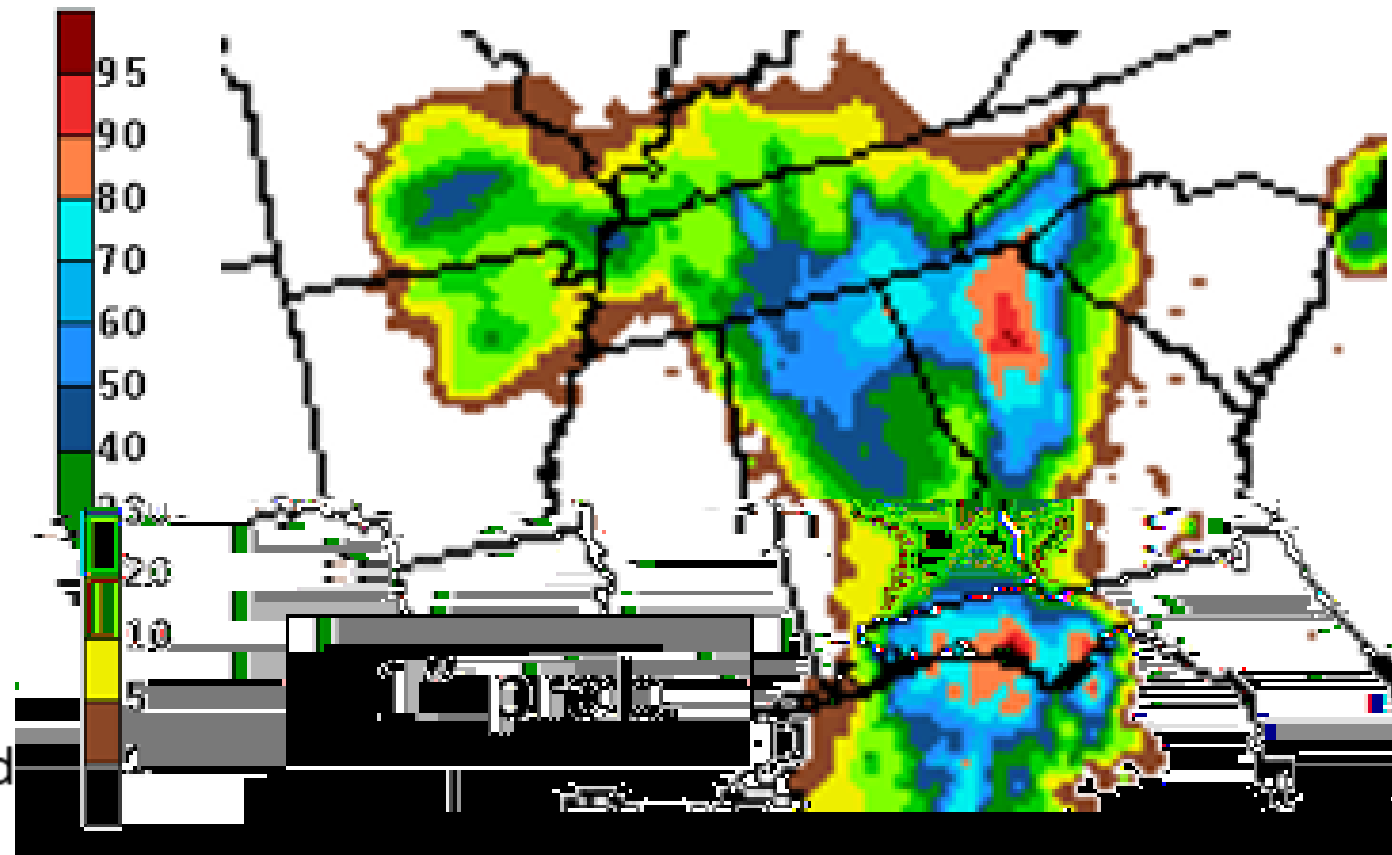
Best guess, or most likely, rainfall



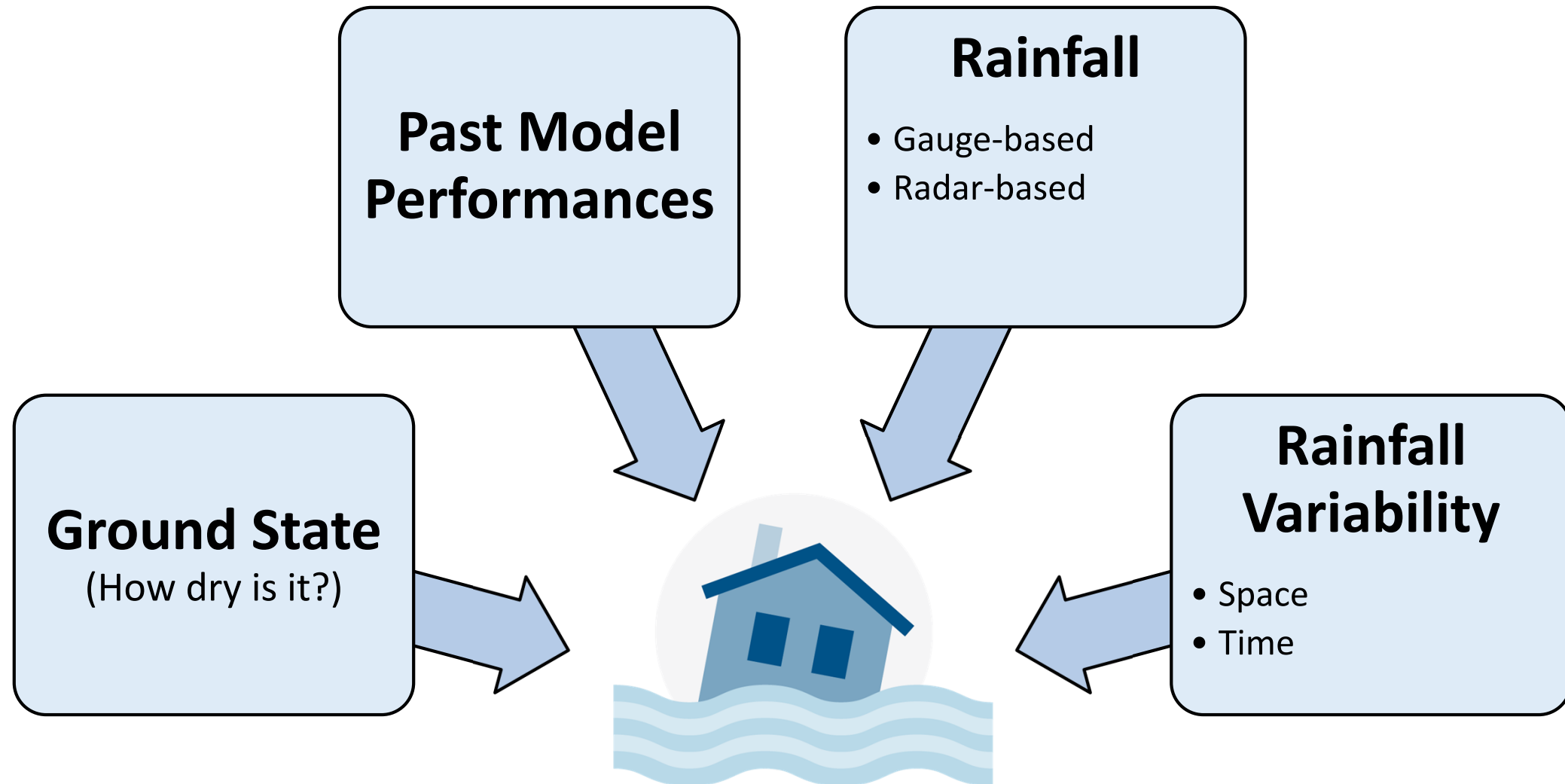
90th Percentile

Reasonable high-end scenario

Rainfall Probability



Flooding Forecast Considerations



Ensemble Forecasting

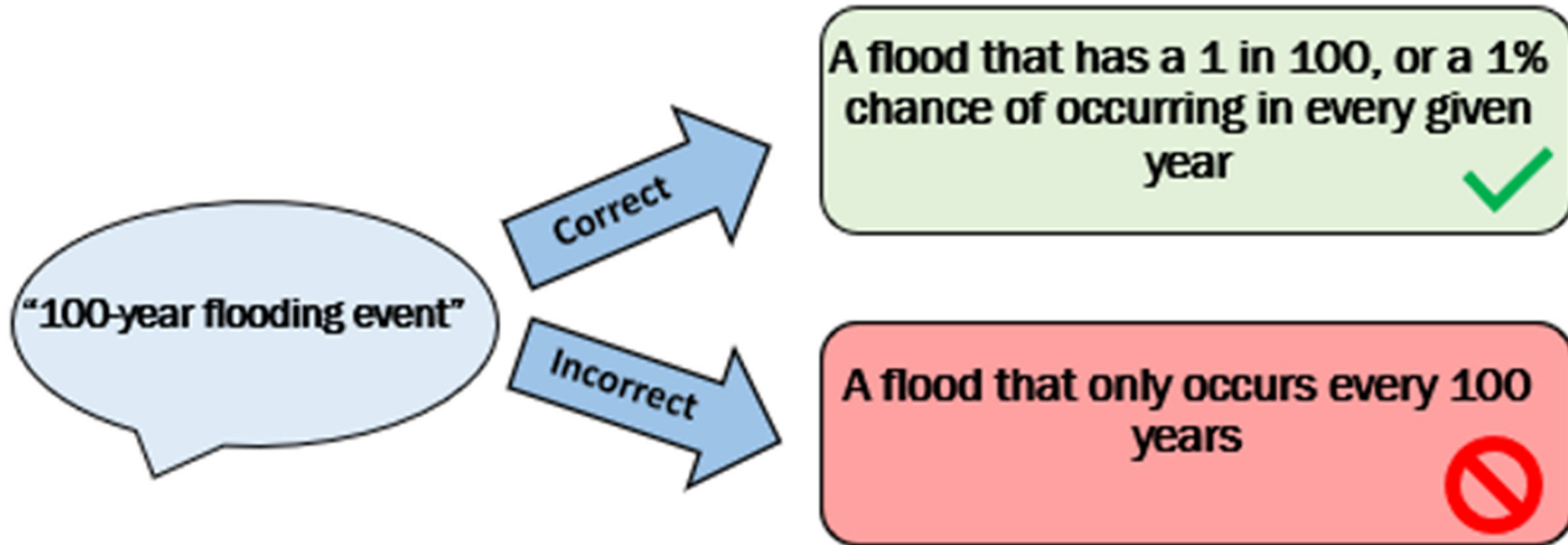


NAEFS River Ensemble Forecast on Sat. Aug 28, 2021; 4-5 days before Hurricane Ida's remnants arrived

(Recreated from the official product)

River	City, ST	10%	30%	50%	70%	90%
Lehigh River	Lehighton, PA	12.2	8.7	6.6	5.2	5.1
Delaware River	Tocks Island, NJ	25.2	15.1	11.3	7.8	7.7
Delaware River	Riegelsville, PA	28.1	21.4	13.6	8.4	8.2
Delaware River	Washington Xing, NJ	19.1	13.8	8.7	3.6	3.1
Schuylkill River	Pottstown, PA	18.1	11.7	7.7	4.3	3.8
Schuylkill River	Philadelphia, PA	13.1	10.3	8.7	7.3	6.6
Brandywine Creek	Chadds Ford, PA	13.0	7.6	5.2	3.9	2.7
Neshaminy Creek	Langhorne, PA	16.2	8.3	5.6	3.7	2.6
Conococheauge Creek	Fairview, MD	15.3	10.0	6.2	3.6	2.5
Potomac River	Shepherdstown, WV	24.1	14.7	9.6	5.7	3.9
Monocacy River	Frederick, MD	21.1	9.3	6.9	4.8	2.7

Recurrence Intervals



Technical term: Annual Exceedance Probability (AEP)
A 100-year rainfall event \neq 100-year flood

Note:
500-year flooding event = 2% chance every year
1000-year flooding event = .1% chance every year

Questions/Comments?



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The image is a composite of three elements. On the left is a satellite view of a large hurricane with a distinct eye. In the center is a screenshot of the National Weather Service National Hurricane Center website. The website header includes the title 'National Weather Service National Hurricane Center' and navigation links for 'Home', 'News', 'Organization', and 'Search'. A news section titled 'Top News of the Day...' lists several items, including 'NHC issuing advisories on Hurricane ARTHUR and TD DOUGLAS'. Below the news is a map titled 'Atlantic Tropical Cyclone Activity' showing the Atlantic Ocean and the eastern United States, with a red dot labeled 'ARTHUR' off the coast. On the right is a blue circular sign with a hurricane icon and the text 'EVACUATION ROUTE', with a rectangular sign below it showing a white arrow pointing to the right.