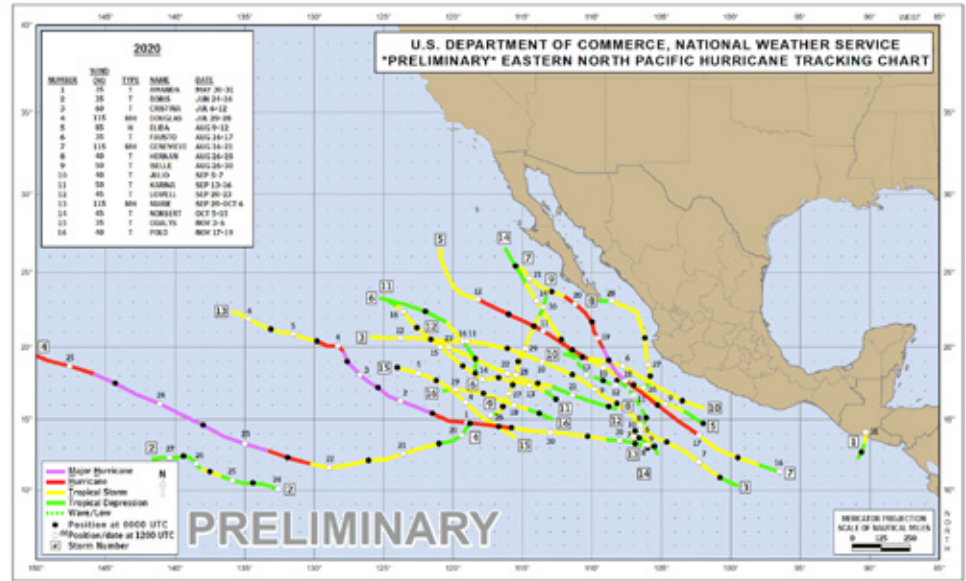
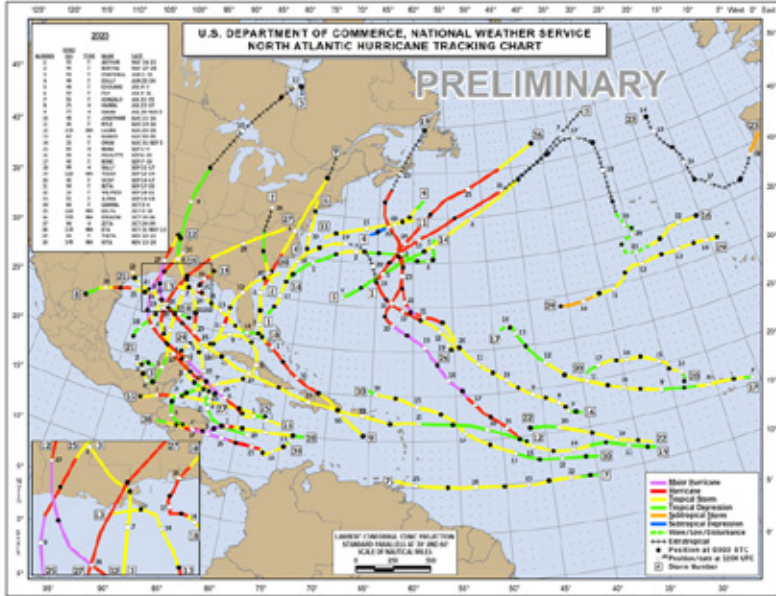




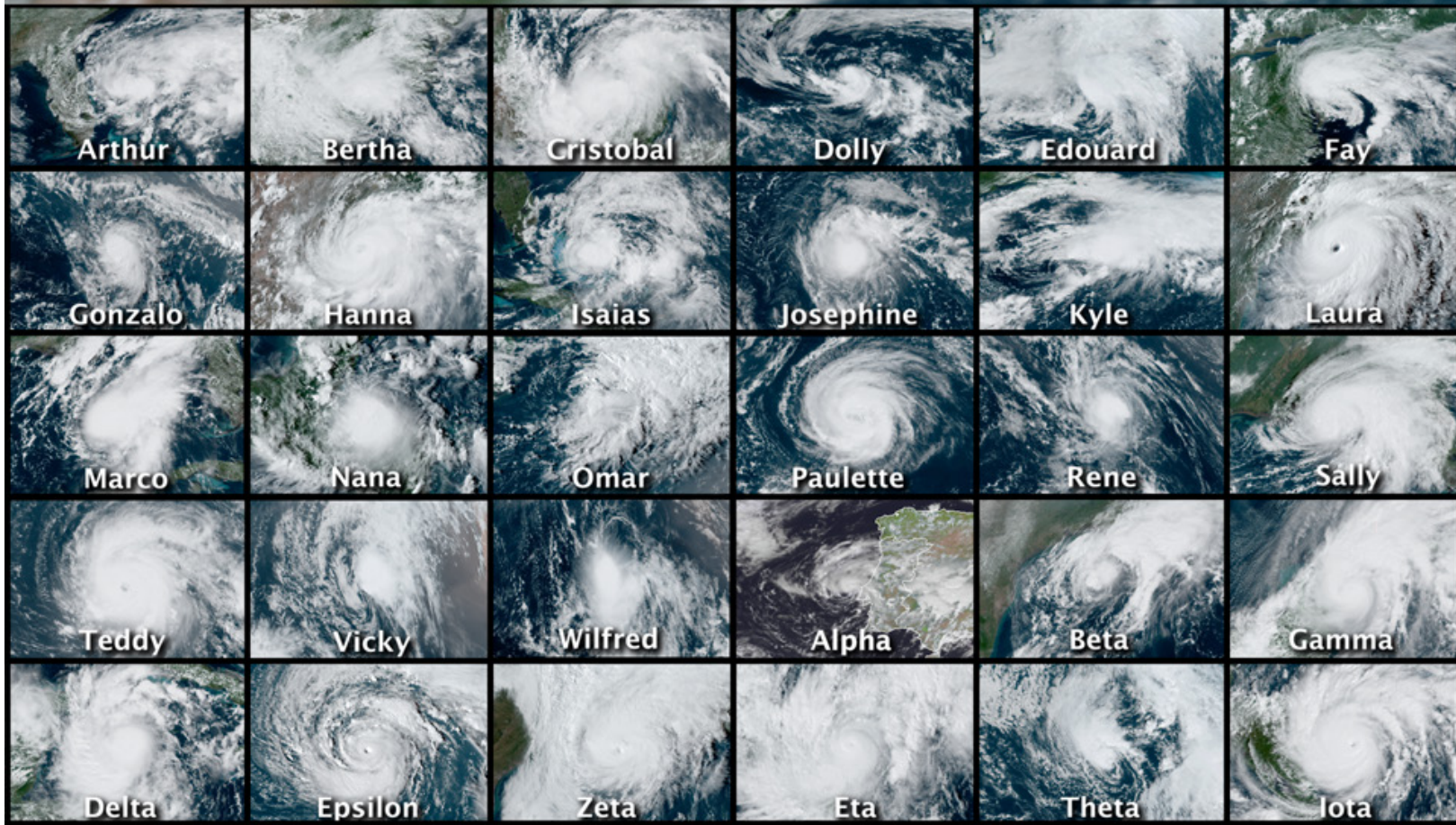
2020 Season Summary



Michael J. Brennan, HSU Branch Chief, NHC
 2021 Tropical Cyclone Operations and Research Forum
 75th Interdepartmental Hurricane Conference
 3 March 2021

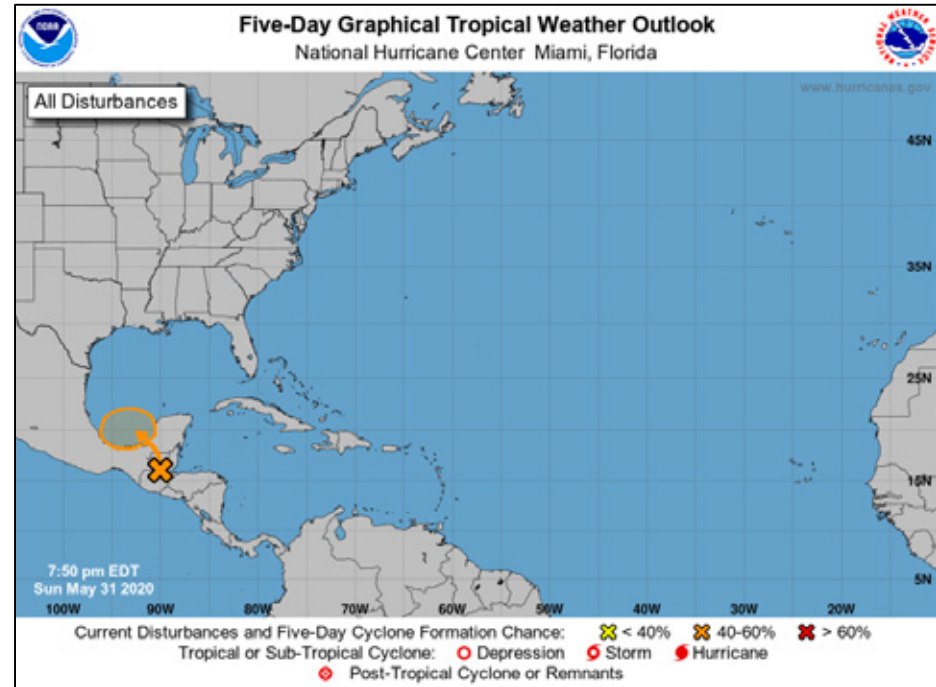


The 2020 Atlantic Hurricane Season



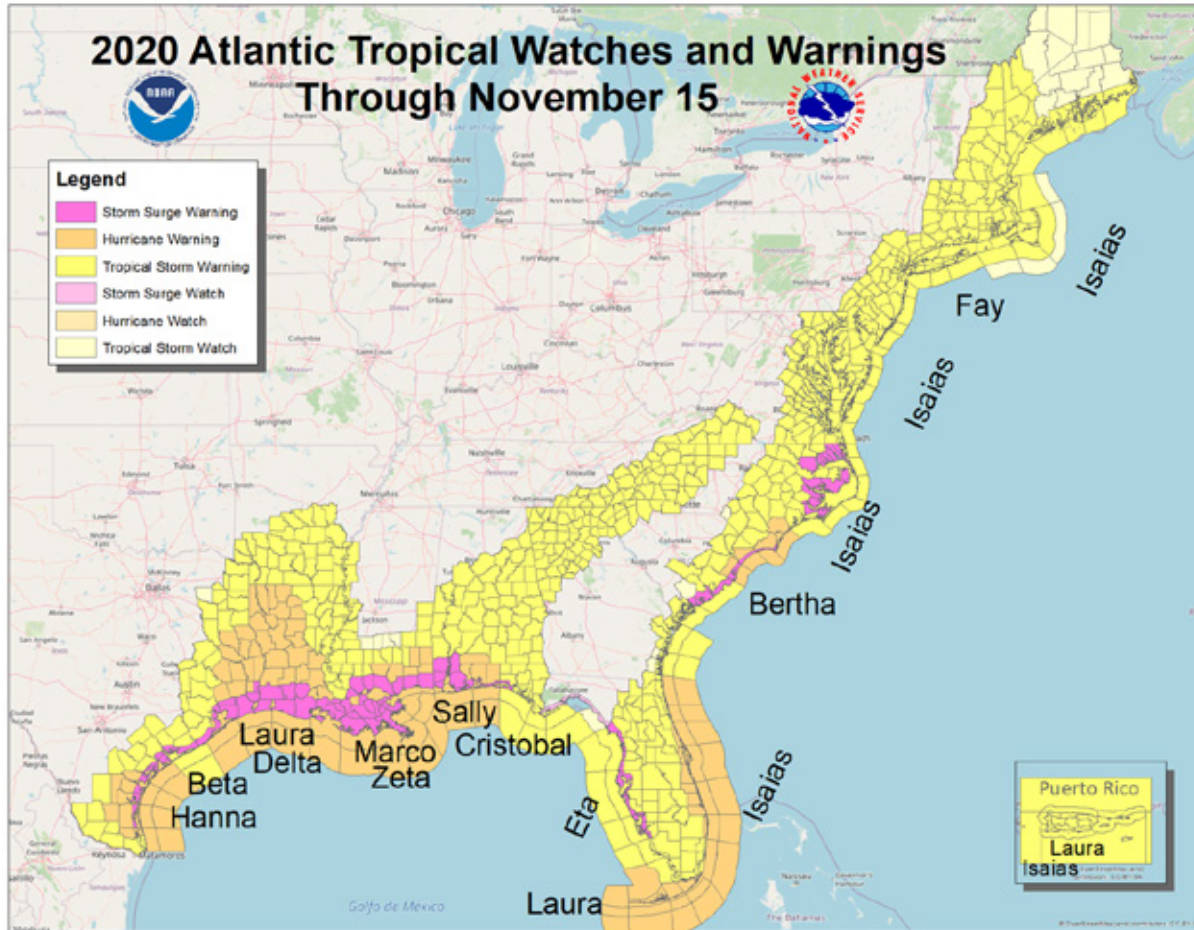
2020 – A Record-Breaking Atlantic Season

- 30 named storms
- 13 hurricanes (6 major)
- 1 depression that did not reach tropical storm strength
- ACE: 181.5
- 639 advisories issued (average is 322)
- Busiest year since 2005 and second busiest since 1990
- 22 of the 30 storms had watches or warnings for land areas or made landfall
- 62 systems mentioned in the TWO and 40 invests



2020 – A Record-Breaking Atlantic Season

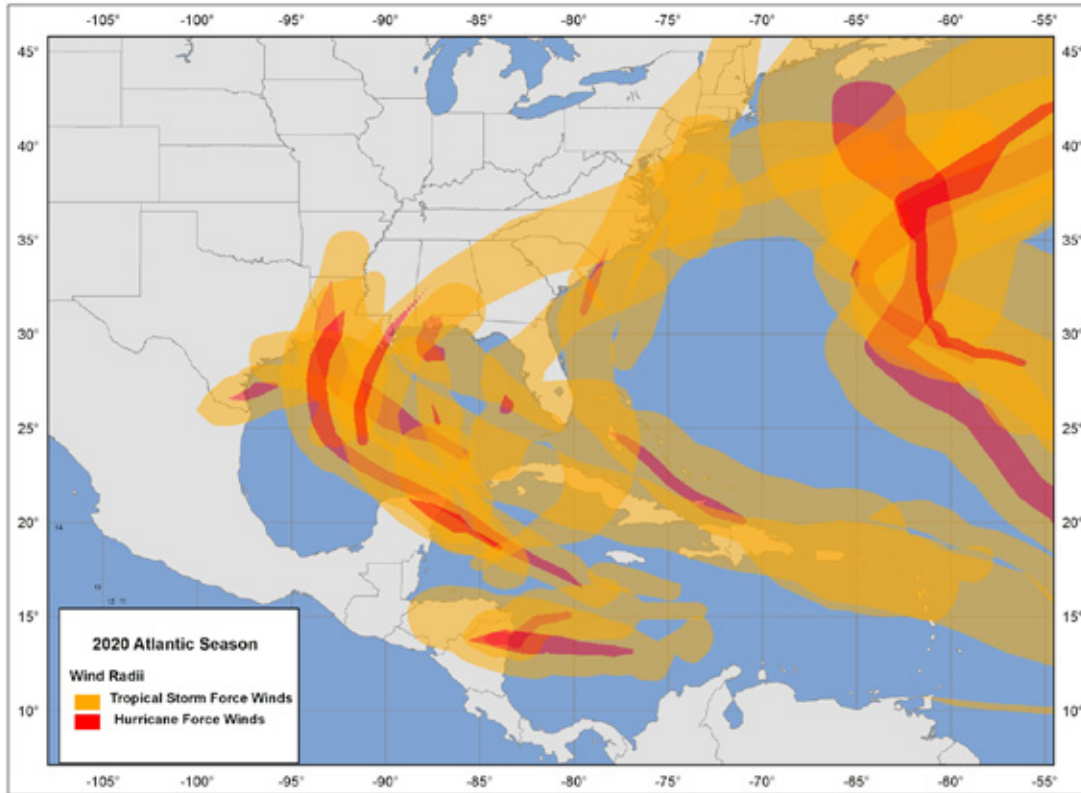
- 12 U.S. landfalls
 - 6 tropical storms (Bertha, Cristobal, Fay, Marco, Beta, Eta [2])
 - 6 hurricane landfalls (Hanna, Isaias, **Laura**, Sally, Delta, Zeta)
 - 1 tropical storm “strike” (Arthur)
- 5 Louisiana landfalls
 - TS Cristobal, H Laura, TS Marco, H Delta, H Zeta
- 9 Gulf Coast landfalls
 - Cristobal, Hanna, Laura, Marco, Sally, Beta, Delta, Zeta, Eta
- 13 International landfalls
 - Two Category 4 landfalls in Nicaragua 2 weeks and 15 miles apart (**Eta, Iota**)
 - Subtropical storm landfall in Portugal (Alpha)
 - Direct impacts in nearly every country in the Atlantic basin



- Atlantic U.S. coastal hurricane warnings in effect: **378 hours (15.75 days)**
- Coastal watches and warnings in effect for Louisiana: **474 hours (19.75 days)**
- 14 systems required issuance of watches or warnings on first advisory

Image courtesy Penny (Zabel) Harness, WFO Corpus Christi

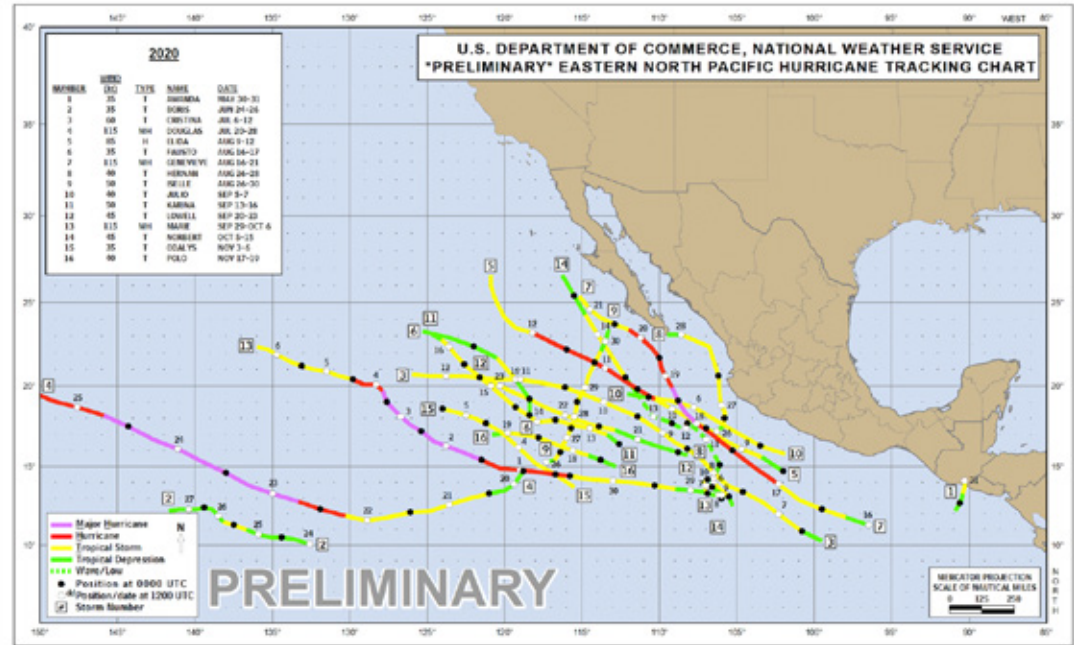
2020 – A Record-Breaking Atlantic Season



Swaths of Tropical Storm and Hurricane Force winds from 2020 TCs

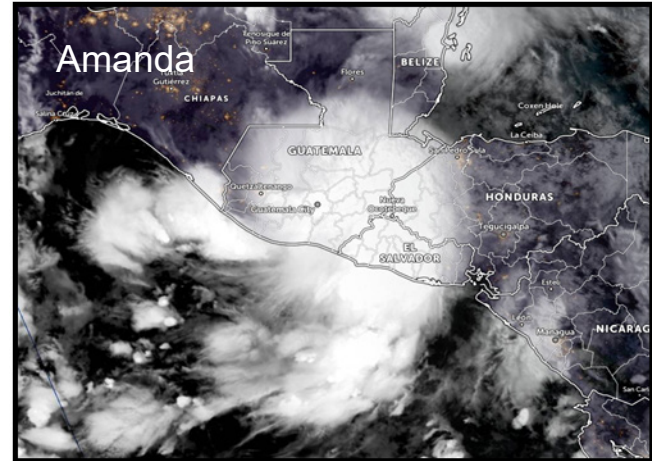
2020 – Eastern Pacific Season Summary

- 17 named storms
 - 10 had peak intensity < 50 kt
- 4 hurricanes (3 major, all peaked at 115 kt)
- 4 depressions that didn't reach TS intensity
- ACE: 66.02
- Advisories issued: 283 (average season is 331)
- Fewest forecasts since 2010

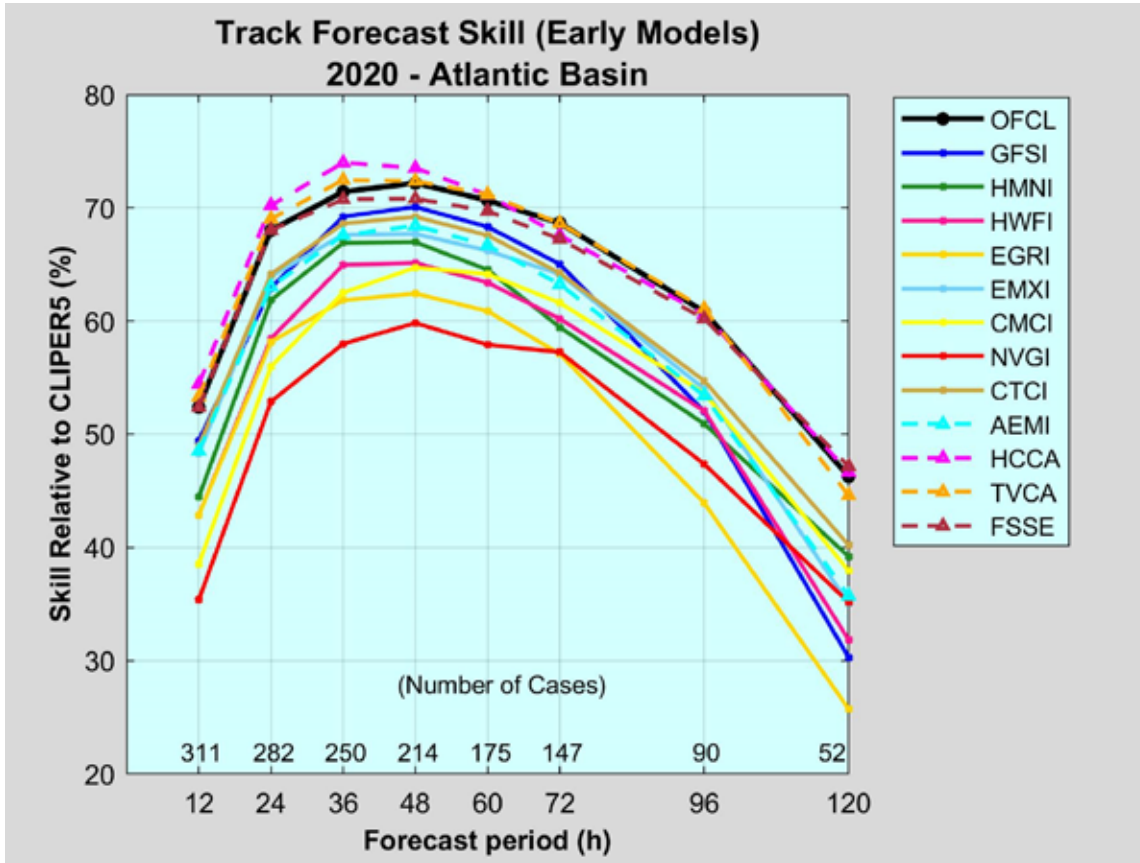


2020 – Eastern Pacific Season Summary

- TS Amanda made landfall (second on record along Pacific coast of Guatemala)
 - 40 fatalities due to rainfall flooding
 - Was precursor to Cristobal in the Gulf of Mexico
- TS Hernan brought heavy rain and flooding to portions of southwestern Mexico
- H Genevieve caused heavy rainfall to portions of mainland Mexico and TS conditions to southern Baja California, but the center remained just offshore
- Boris and Douglas moved into the central Pacific, with Douglas having impacts in Hawaii



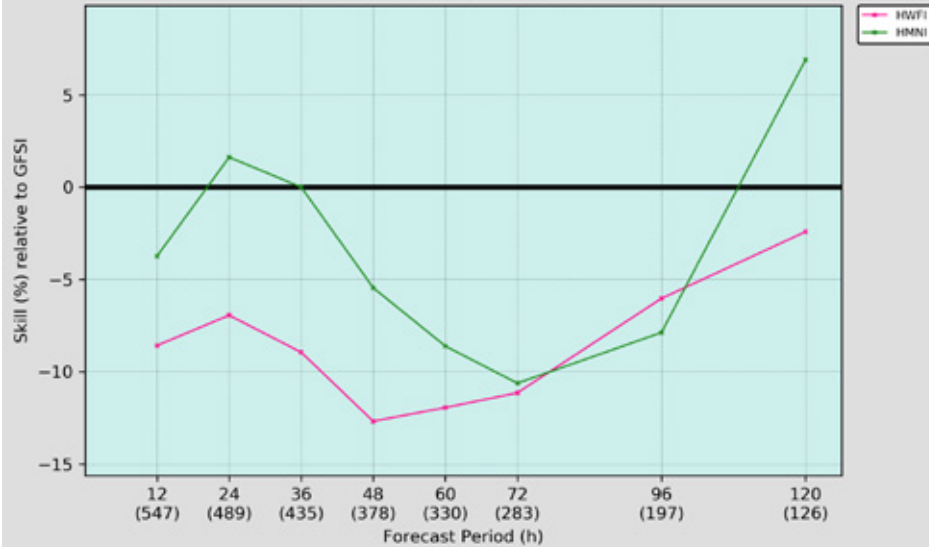
Preliminary 2020 Verification - Atlantic Track



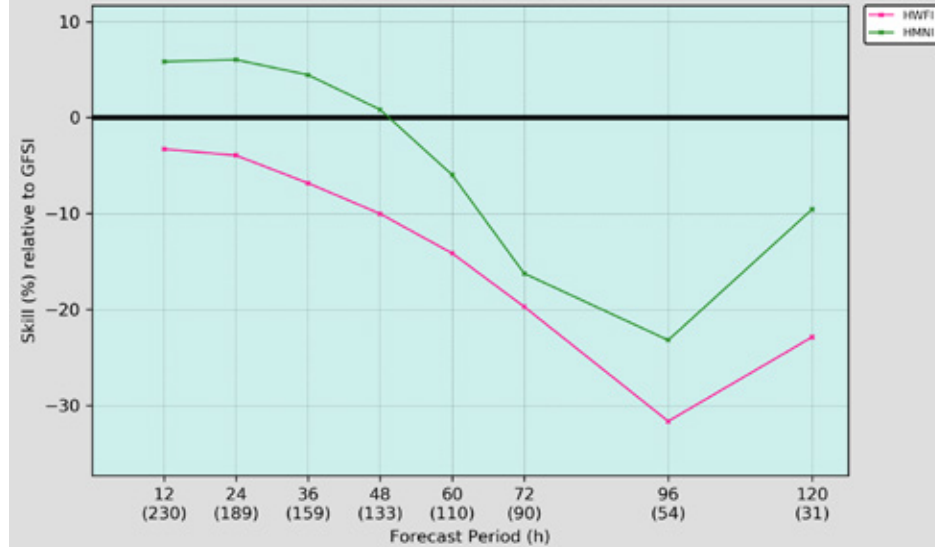
NHC track forecasts were very skillful - near the best performing models (consensus aids), and were much more skillful than individual deterministic models

Regional Model Track Skill Relative to GFS

Atlantic 2020 Track Forecast Skill



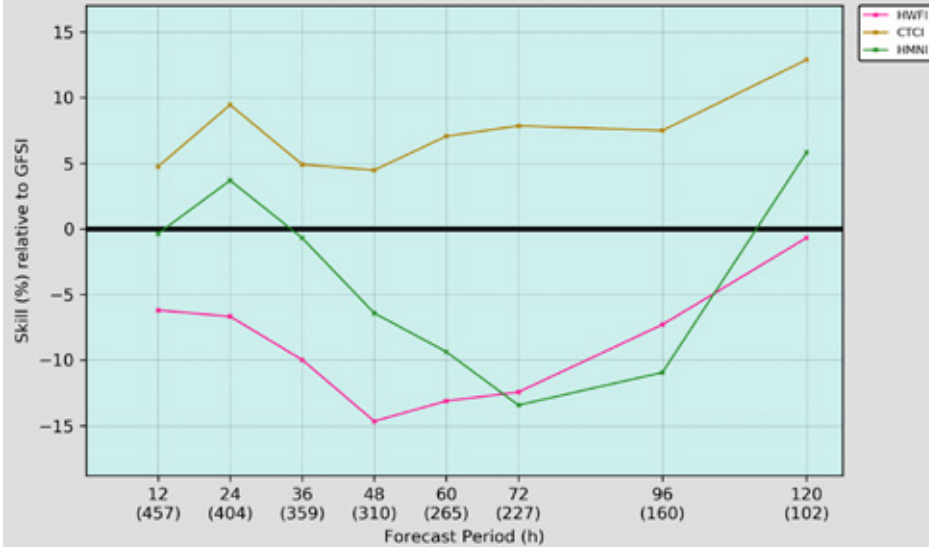
East Pacific Track Forecast Skill



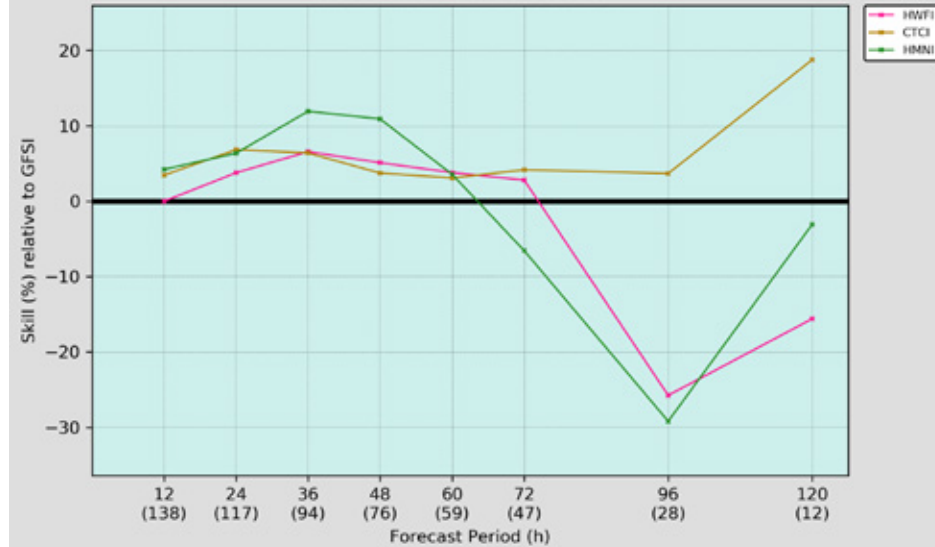
- HWR1 track skill lagged the GFS by 5-15% in the Atlantic and as much as 30% in the east Pacific
- HMON performed slightly better, but overall still had little/negative skill compared to GFS

Regional Model Track Skill Relative to GFS

Atlantic 2020 Track Forecast Skill

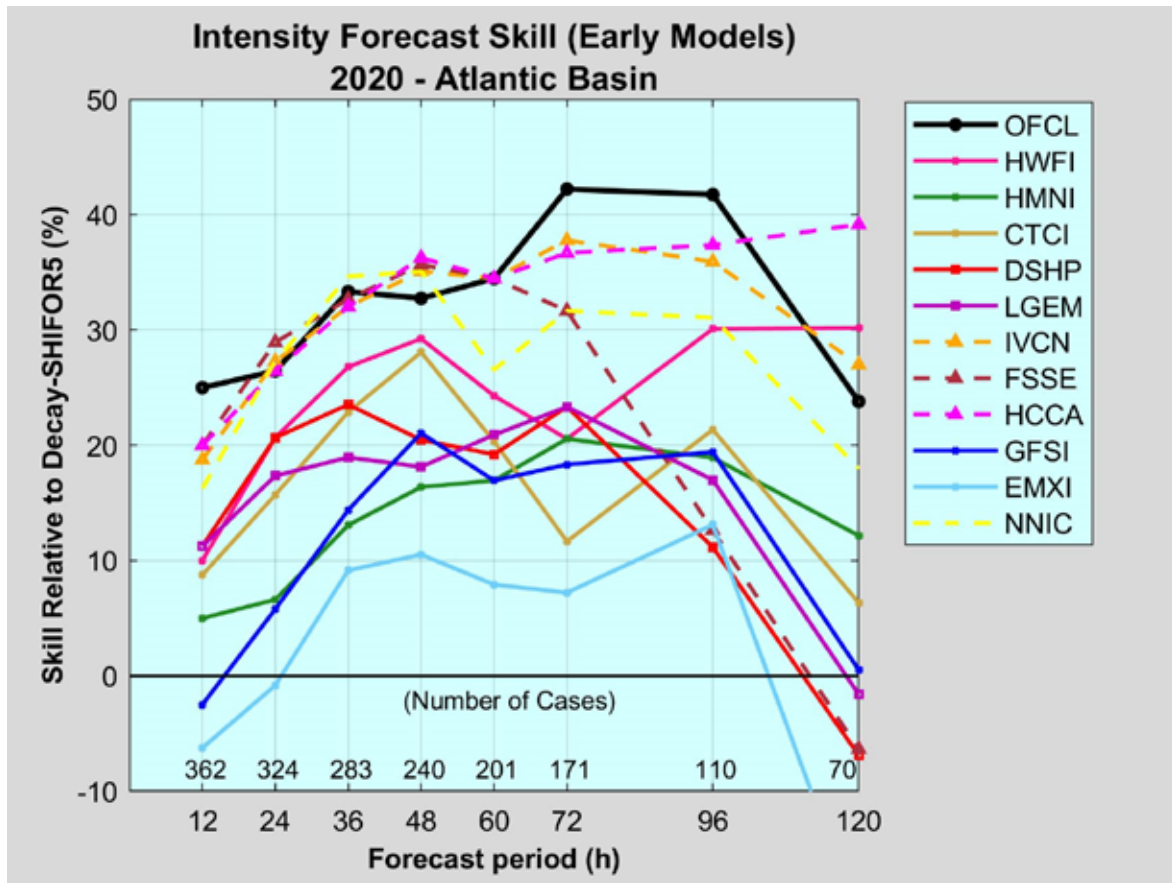


East Pacific Track Forecast Skill



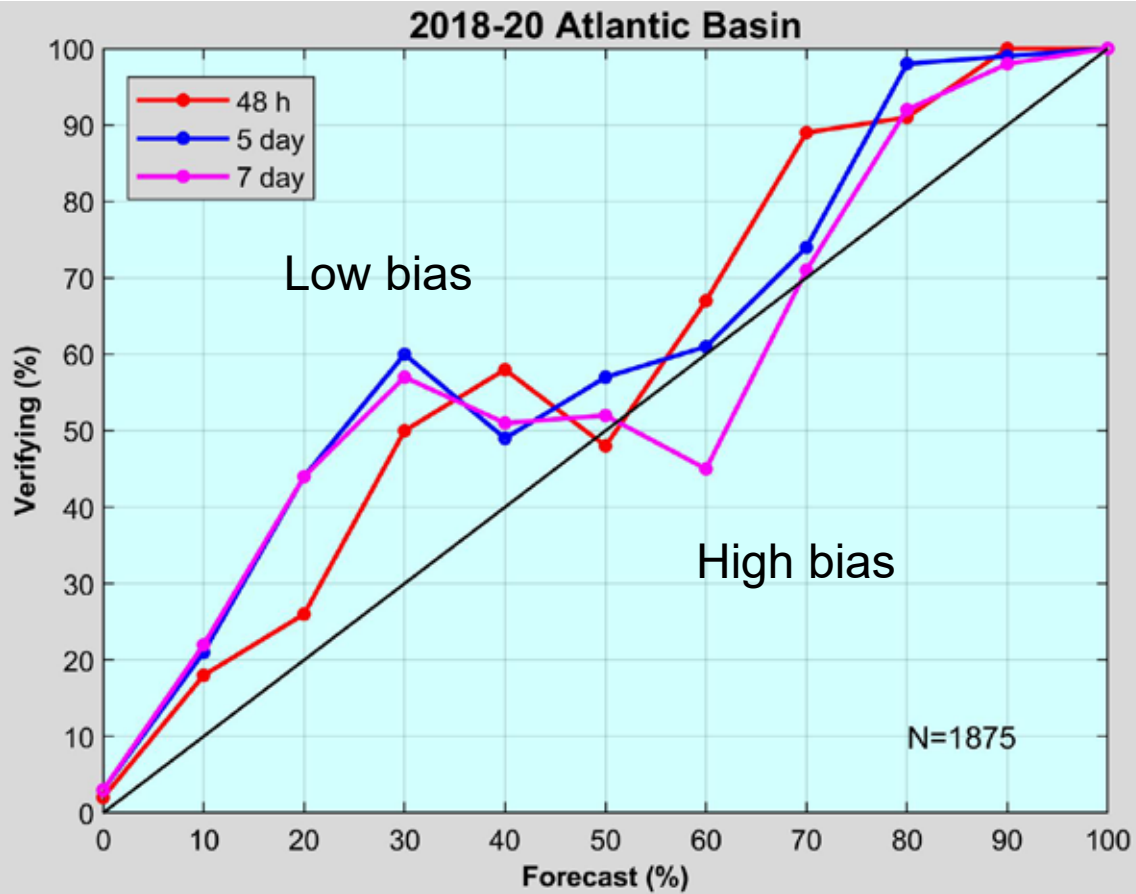
- HWRf track skill lagged the GFS by 5-15% in the Atlantic and as much as 30% in the east Pacific
- HMON performed slightly better, but overall still had little/negative skill compared to GFS
- CTCL, however, had skill at all times over GFS in the Atlantic with marginal skill improvement in the east Pacific (but for smaller sample)

Preliminary 2020 Verification - Atlantic Intensity



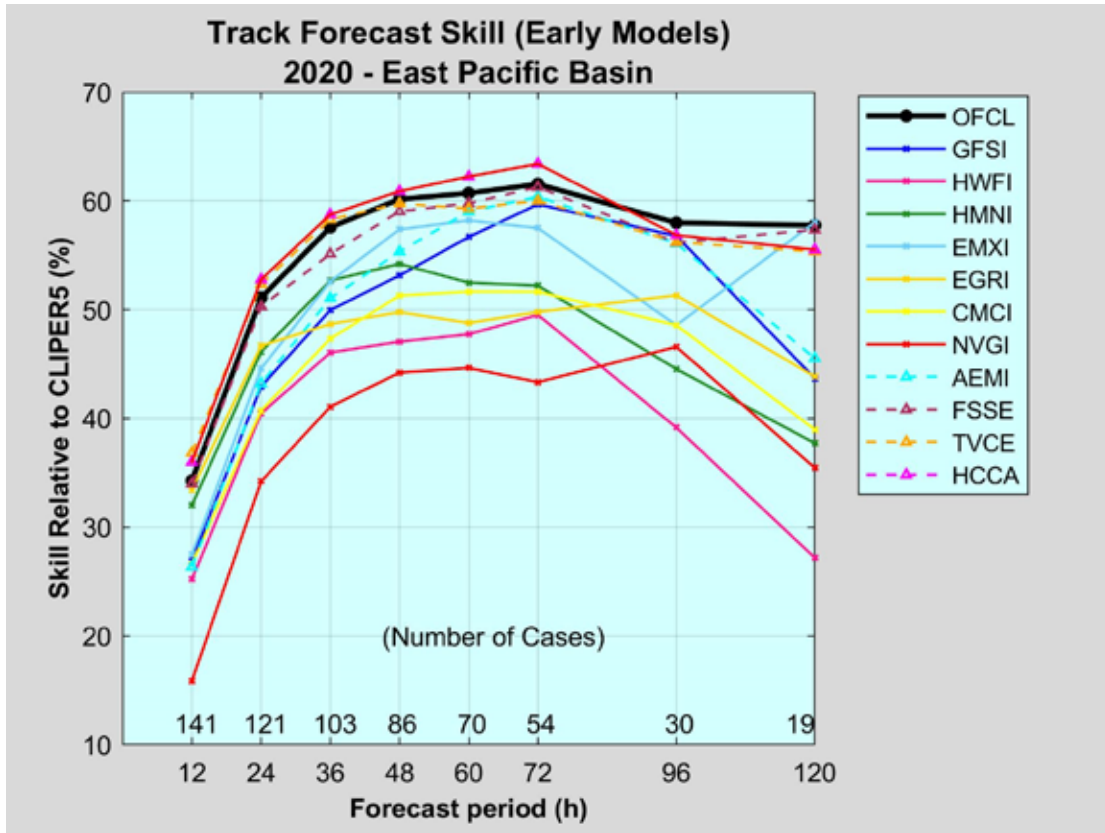
NHC intensity forecasts were very skillful, as good as or better than the consensus aids

Preliminary 2020 Verification - Atlantic Genesis



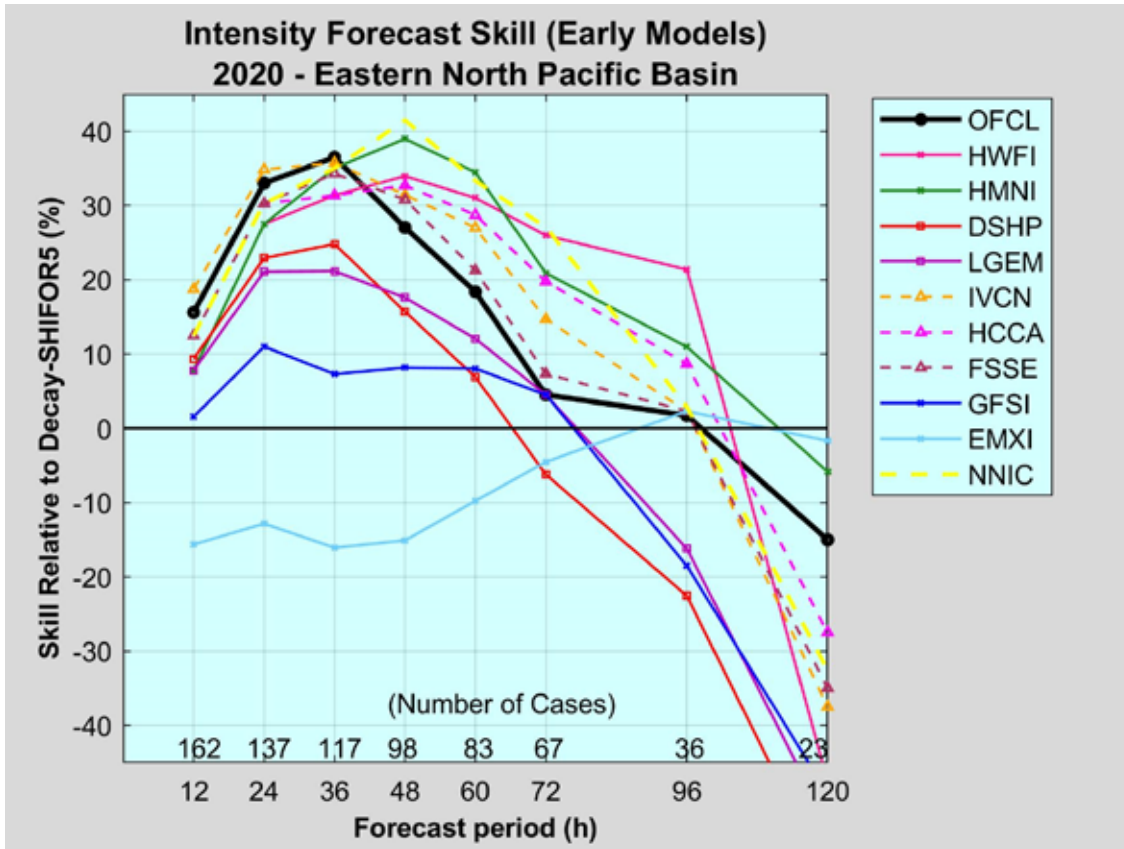
NHC genesis forecasts from 2018-2020 show a small low bias across most probability thresholds

Preliminary 2020 Verification - East Pacific Track



NHC track forecasts were very skillful - near the best performing models (consensus aids), and were generally more skillful than individual deterministic models

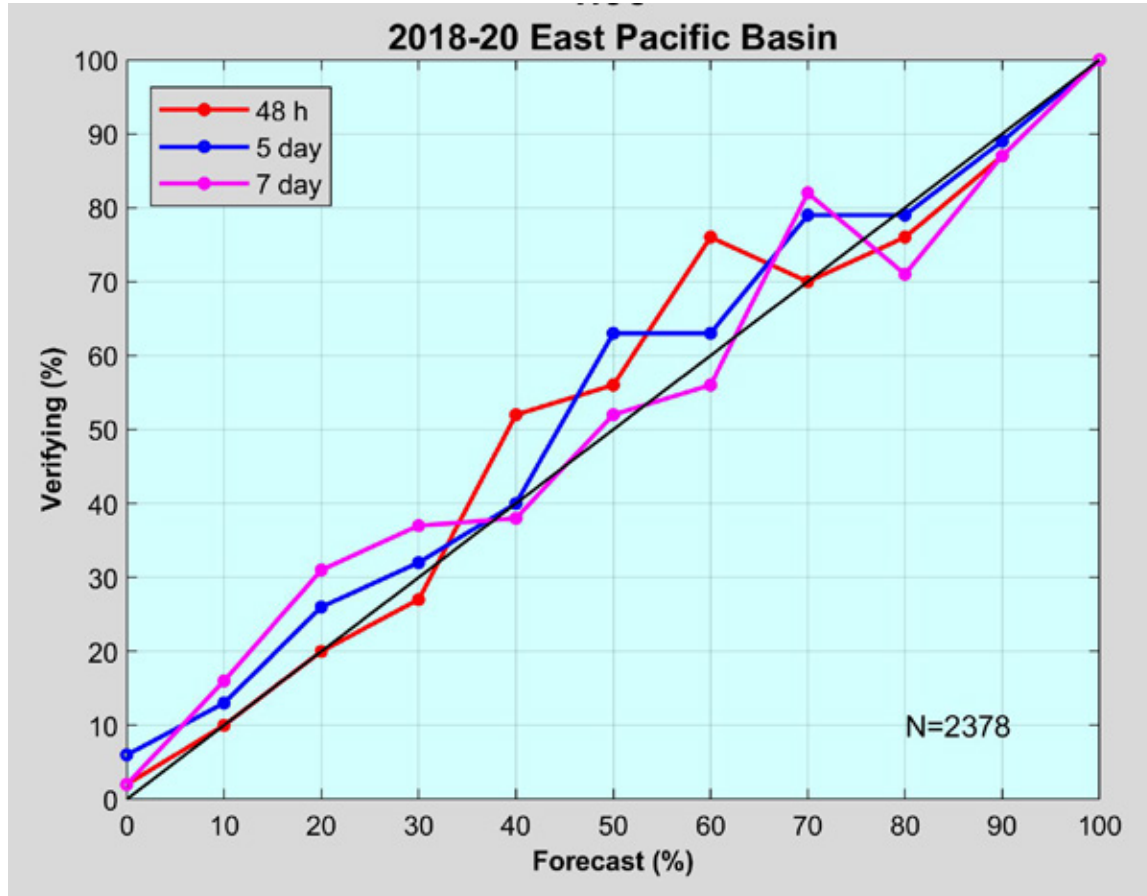
Preliminary 2020 Verification - East Pacific Intensity



NHC intensity forecasts were skillful through 60 h, but had little skill beyond that time

Most guidance lost still beyond 2 days, with all models showing negative skill by day 5, albeit for a small sample

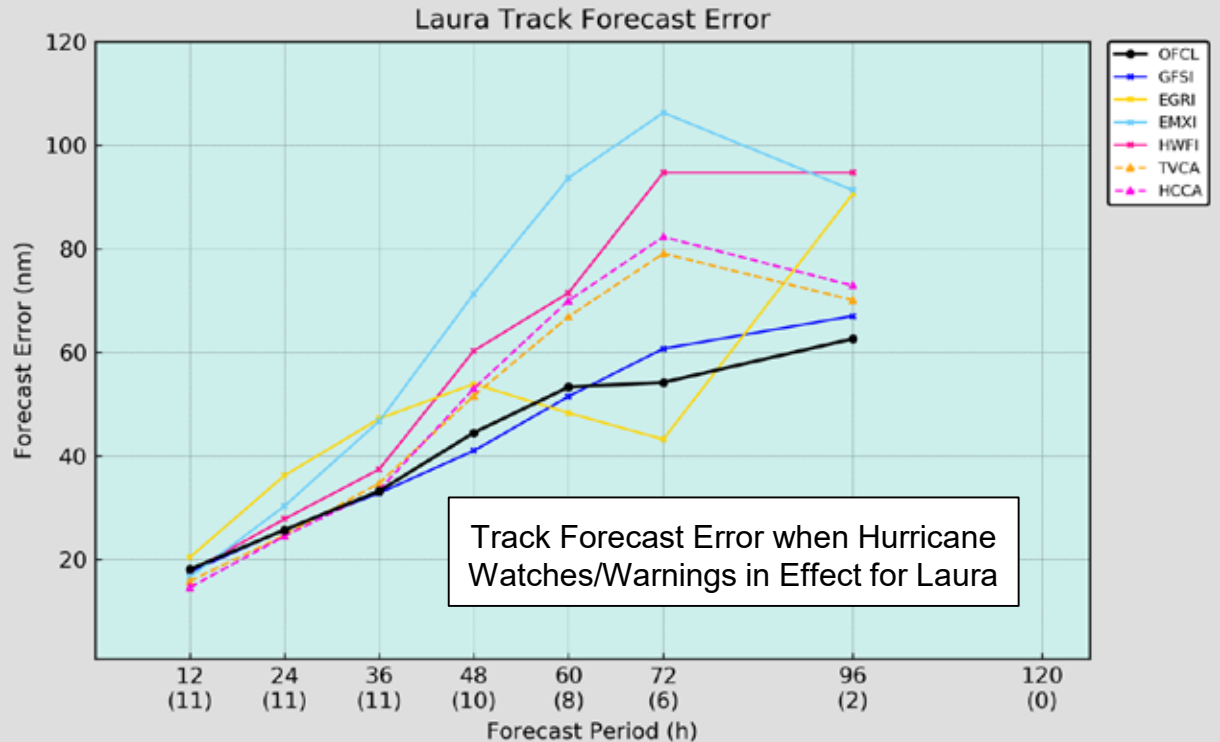
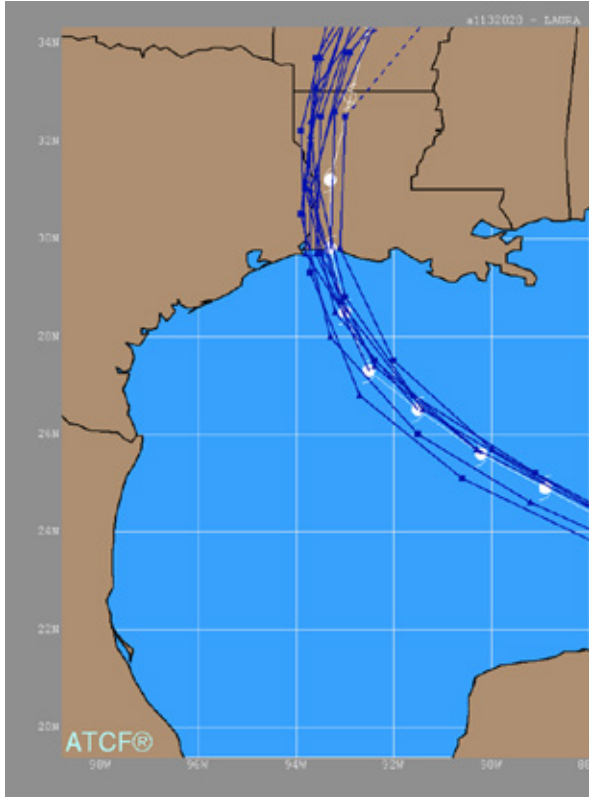
Preliminary 2020 Verification - East Pacific Genesis



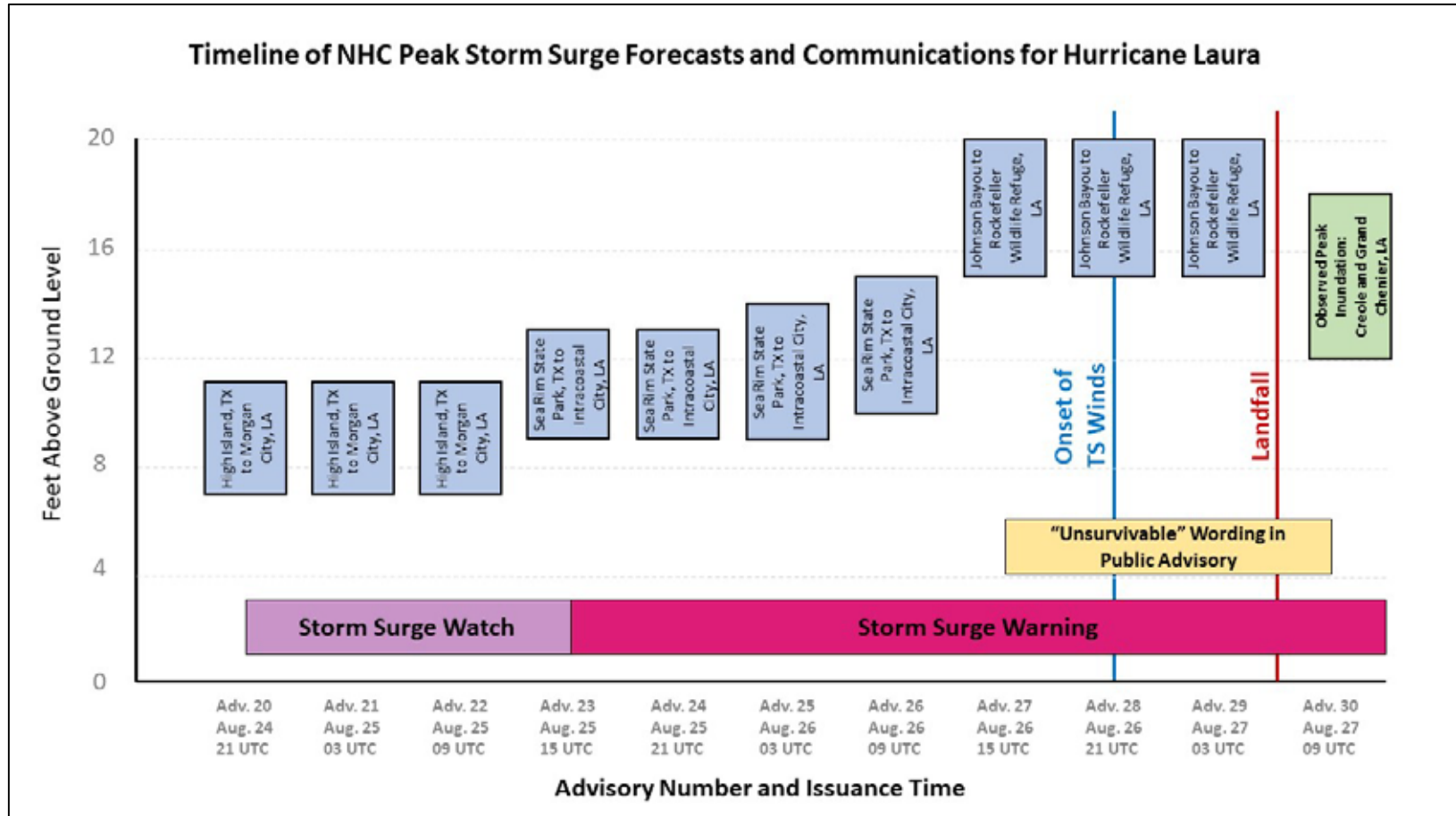
NHC genesis forecasts from 2018-2020 are very well calibrated for all time periods and probability thresholds

Top Positives from 2020


- Consistency of NHC track forecasts during Laura



Positives from 2020 – Consistent Messaging



Positives from 2020 – Consistent Messaging



Key Messages for Hurricane Laura

Advisory 27: 10:00 AM CDT Wed Aug 26, 2020

1. Unsurvivable storm surge with large and destructive waves will cause catastrophic damage from Sea Rim State Park, Texas, to Intracoastal City, Louisiana, including Calcasieu and Sabine Lakes. This surge could penetrate up to 30 miles inland from the immediate coastline. Only a few hours remain to protect life and property and all actions should be rushed to completion.
2. Hurricane-force winds are expected tonight in portions of the hurricane warning area from San Luis Pass, Texas, to west of Morgan City, Louisiana, with catastrophic wind damage expected where Laura's eyewall makes landfall. Hurricane-force winds and widespread damaging wind gusts will spread well inland across portions of eastern Texas and western Louisiana early Thursday.
3. Widespread flash flooding along small streams, urban areas, and roadways is expected to begin this afternoon into Thursday from far eastern Texas, across Louisiana and Arkansas. This will also lead to minor to isolated moderate freshwater river flooding. The heavy rainfall threat and localized flash and urban flooding potential will spread northeastward into the middle-Mississippi, lower Ohio and Tennessee Valleys Friday night and Saturday.



For more information go to hurricanes.gov

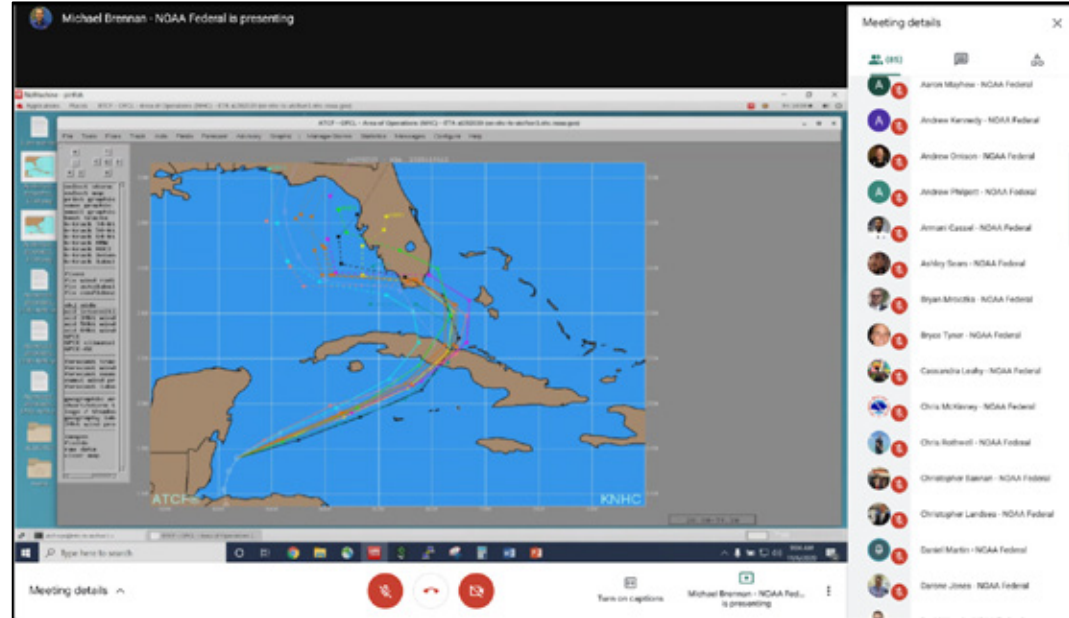
Laura produced storm surge inundation of 12-18 feet above ground level in Creole and Grand Chenier, Louisiana

While catastrophic damage occurred, evacuation compliance in the hardest-hit areas is estimated to be at or near 100%

Zero storm surge fatalities

Positives from 2020 - Coordination and Collaboration

- Maneuvered through complex Marco/Laura watch/warning situation along the Gulf Coast
- Excellent collaboration with ER WFOs during Isaias
- Successful international coordination despite COVID factors and remote ops at NHC and other met services



Positives from 2020 – Backup and COOP

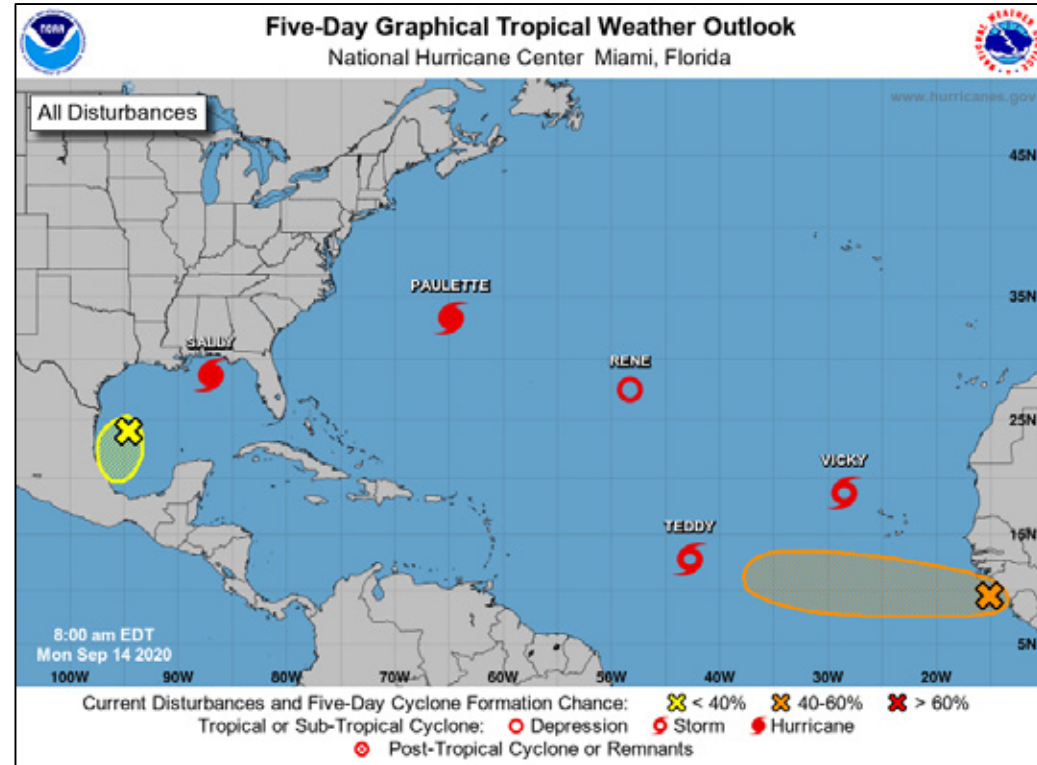
- HSU utilized cohort staffing during the peak of the season to minimize possible COVID exposure
- John Cangialosi deployed to WPC from mid-August to mid-October to be pre-positioned for backup/COOP
- CPHC provided backup in the eastern Pacific while NHC had 4-5 active Atlantic TCs in mid-September
- NHC was on standby to back up CPHC due to potential impacts from Douglas on Oahu
- Remote operations capability opens new options for backup/COOP going forward locally or at a drivable location such as AOC in Lakeland



HSU Setup in WPC Conference Room during 2020

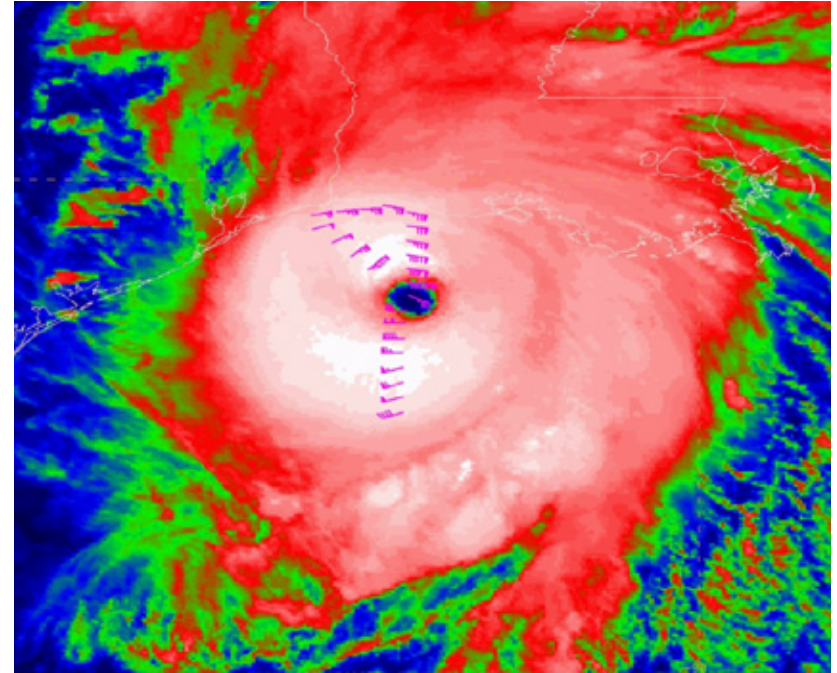
Challenges in 2020 – High Levels of TC Activity

- 10 named storms formed in September
- 5 active Atlantic TCs on 14-15 September (Paulette, Rene, Sally, Teddy, Vicky)
- Reached limit of storm bins (5) in the Atlantic
- Several model cycles where HWRF slots were maxed out between NHC, CPHC, and JTWC



Challenges in 2020 – Aircraft Reconnaissance

- Huge workload with systems near land and numerous simultaneous systems
- Forward deployment limitations, staffing shortages and maintenance issues due to COVID limited capacity and capability
- Multiple evacuations of Keesler AFB by 53RD WRS complicated their operations
- Challenges obtaining Cuban and Mexican overflight clearances



Infrared image of Hurricane Laura at 0000 UTC
27 August 2020 with flight-level wind
barbs (kt) shown

Challenges in 2020 – Rapid Intensification

9 Atlantic TCs underwent RI,
several just before landfall

Largest 24-h intensity change:

Hanna: 30 kt (50 -> 80 kt)

Laura: 40 kt (90 -> 130 kt)

Sally: 20 kt in 12 h (70 -> 90 kt)

Teddy: 35 kt (85 -> 120 kt)

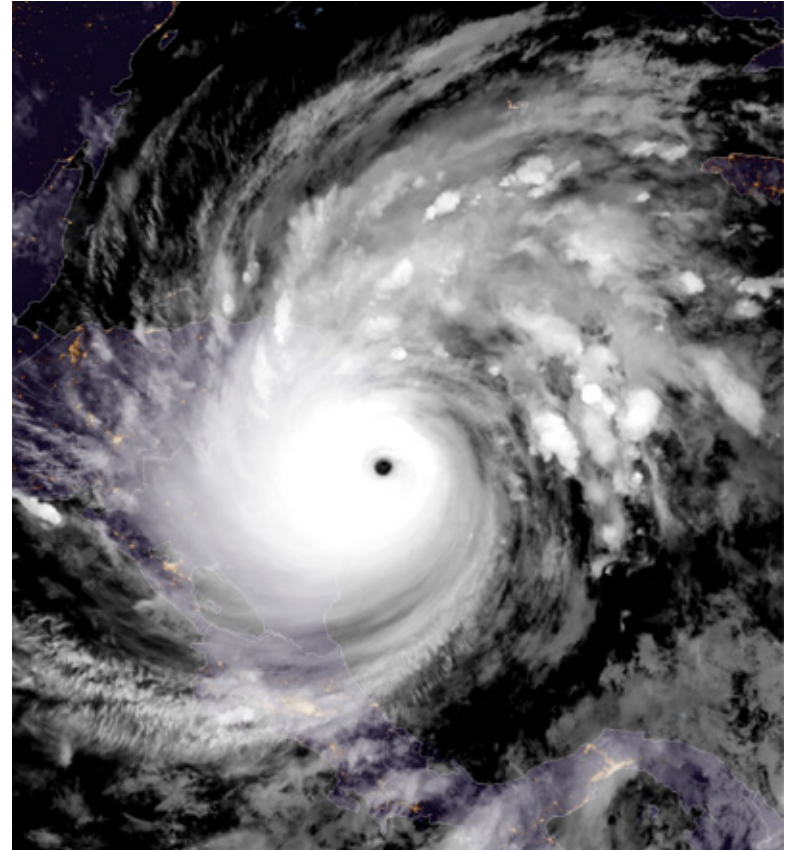
Delta: 65 kt (55 -> 120 kt)

Epsilon: 45 kt (55 -> 100 kt)

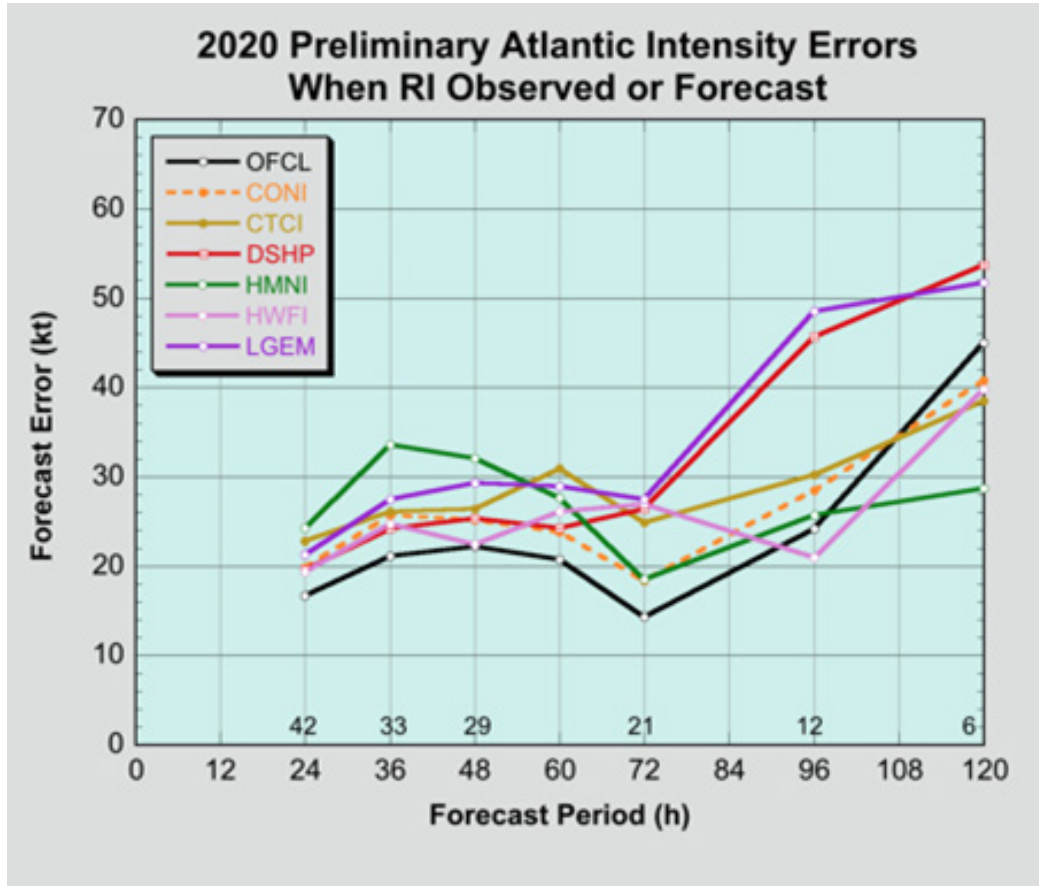
Zeta: 40 kt (55 -> 95 kt)

Eta: 70 kt (60 -> 130 kt)

Iota: 70 kt (70 -> 140 kt)

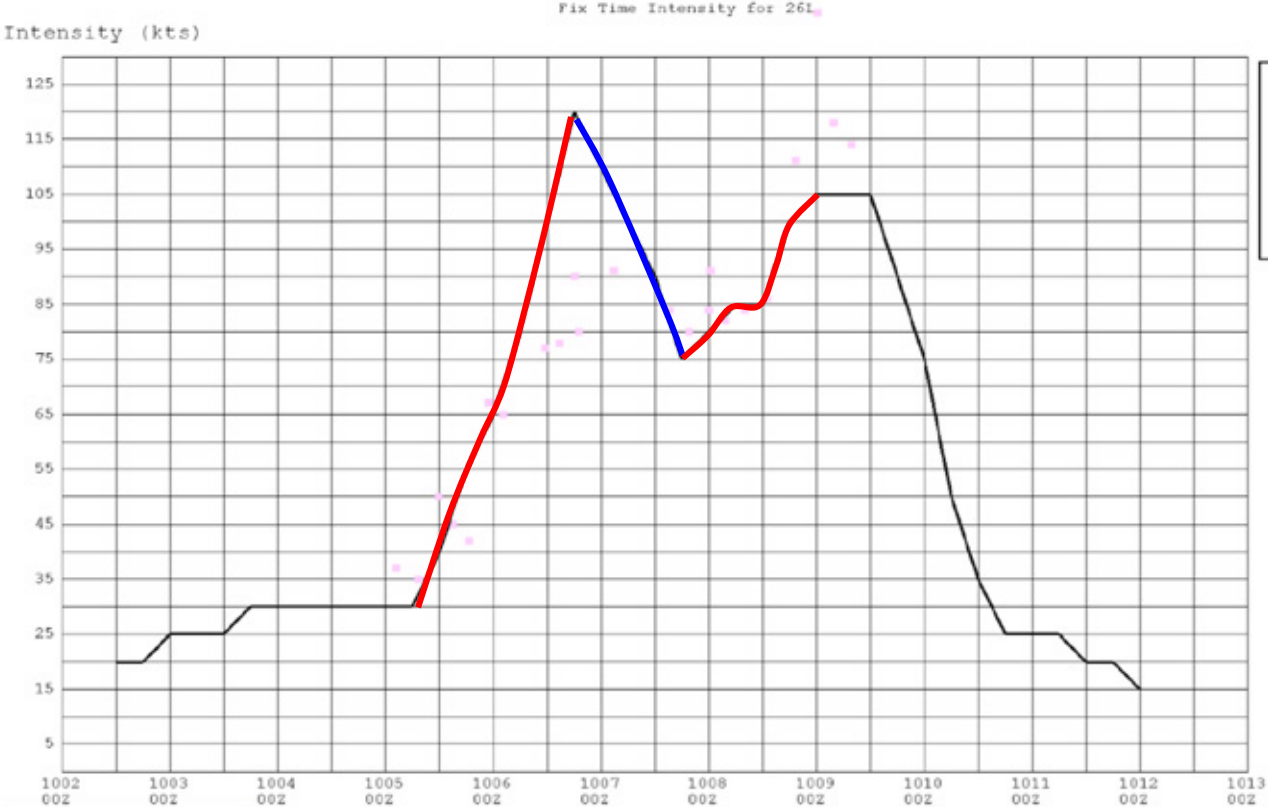


Challenges in 2020 – Rapid Intensification

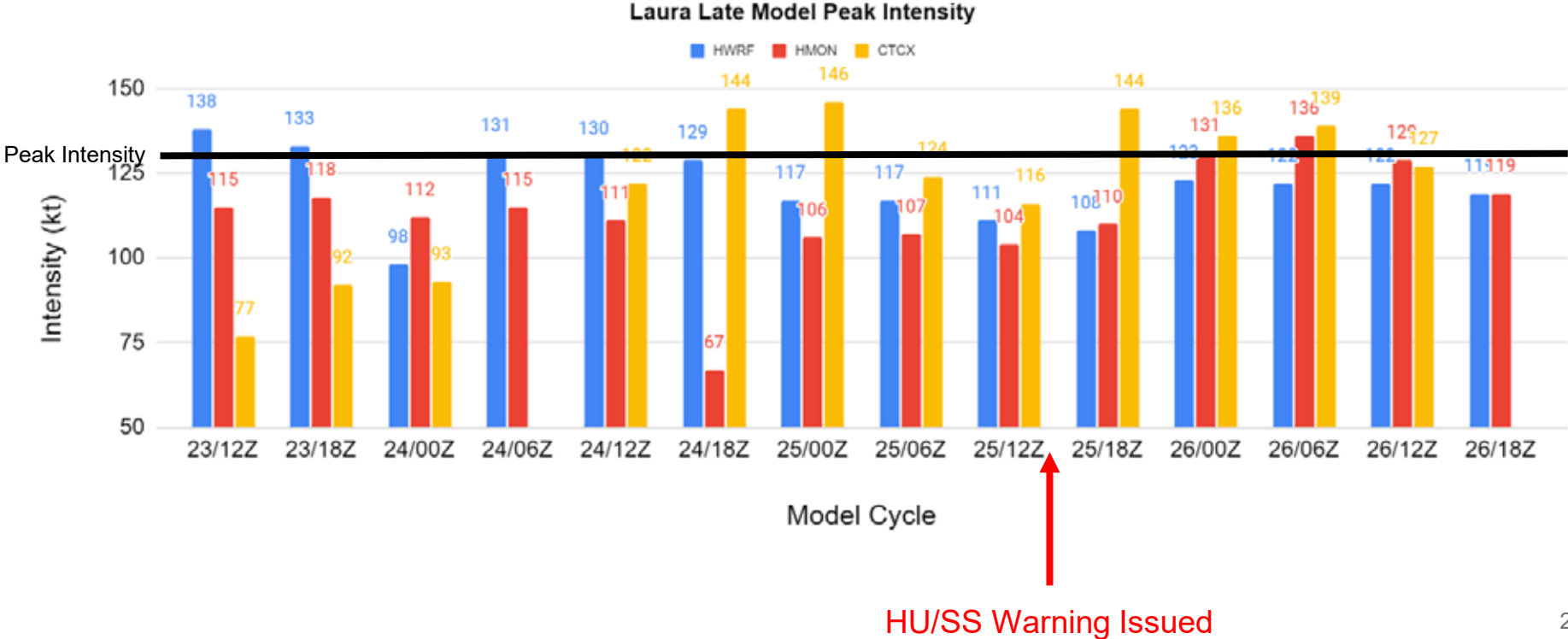


NHC forecasts
outperformed
consensus and other
deterministic models
when RI was observed
or forecast through 96 h

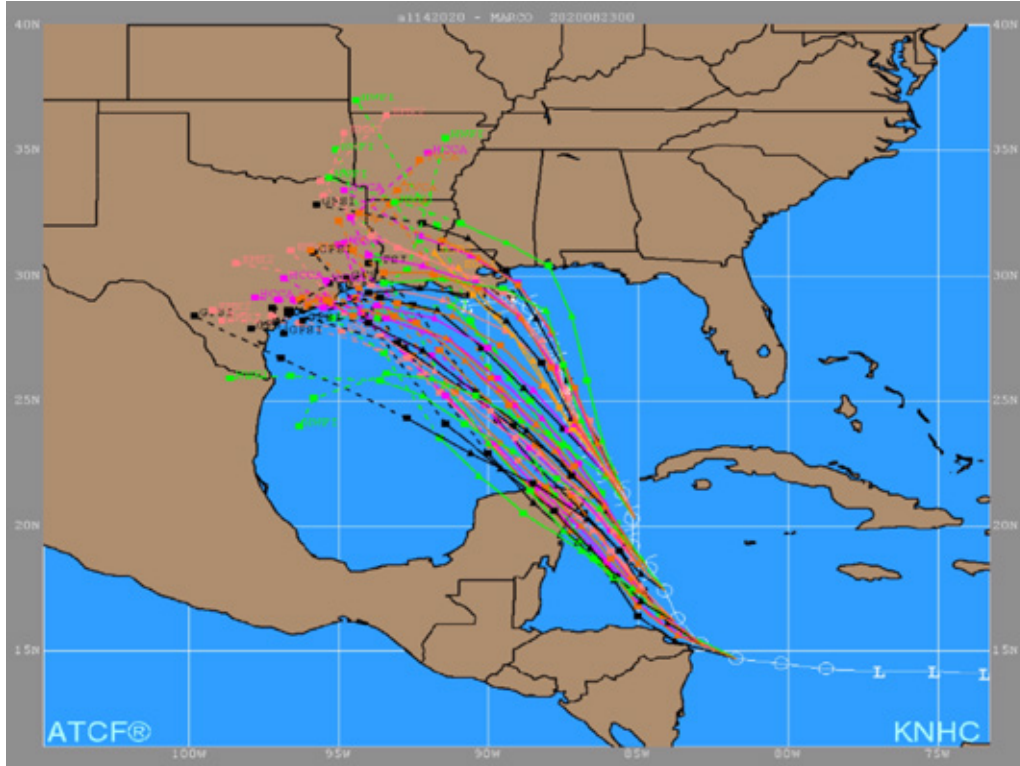
Challenges in 2020 – Rapid Intensity Changes



Challenges in 2020 – Laura Intensity Guidance



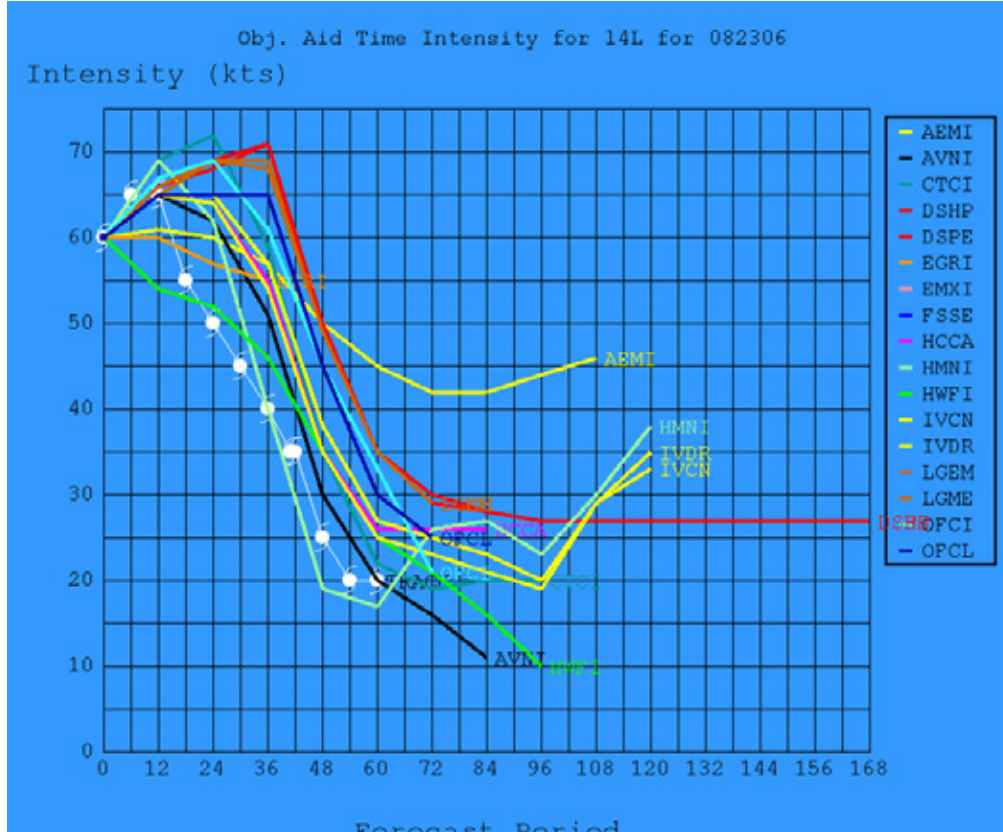
Track Forecast Challenges – Marco



Potential interaction between Marco and Laura as well as uncertainty about Marco's intensity led to huge variability in track guidance for Marco and poor forecasts

Marco track guidance 21-23 August 2020

Intensity Forecast Challenges – Marco

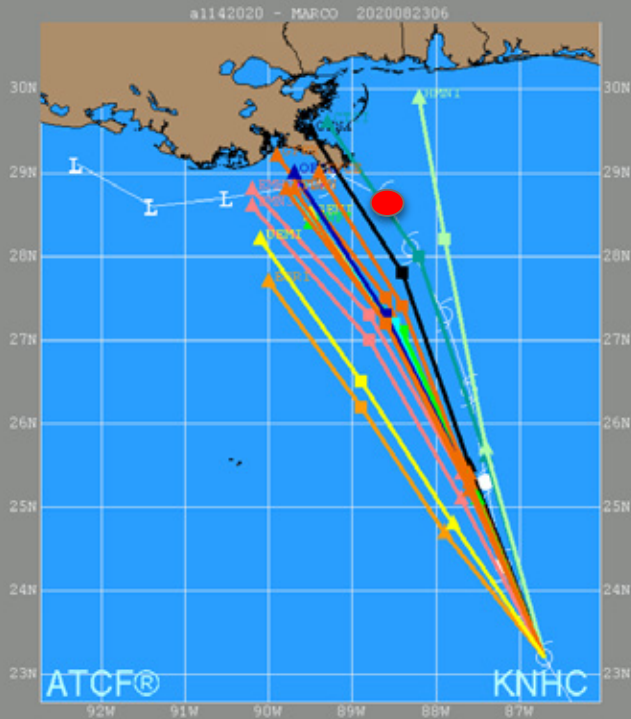


Intensity guidance 0600 UTC 23 August 2020

Many models showed landfall as a hurricane (36h)

Actual intensity was well below all of the guidance save the HMON

Warning Challenges – Marco



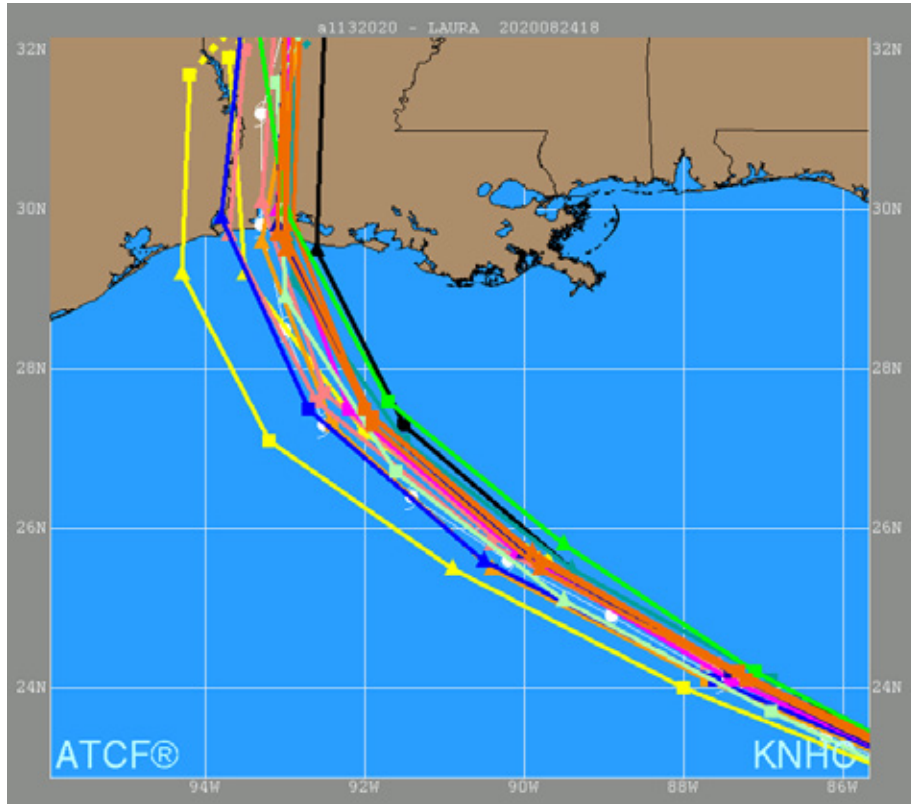
Models too far left and fast.

Best intensity model, HMNI, had a poor track forecast that had a NE bias.

Right intensity forecast for wrong reason?

36 h Marco track guidance 0600 UTC 23 August 2020

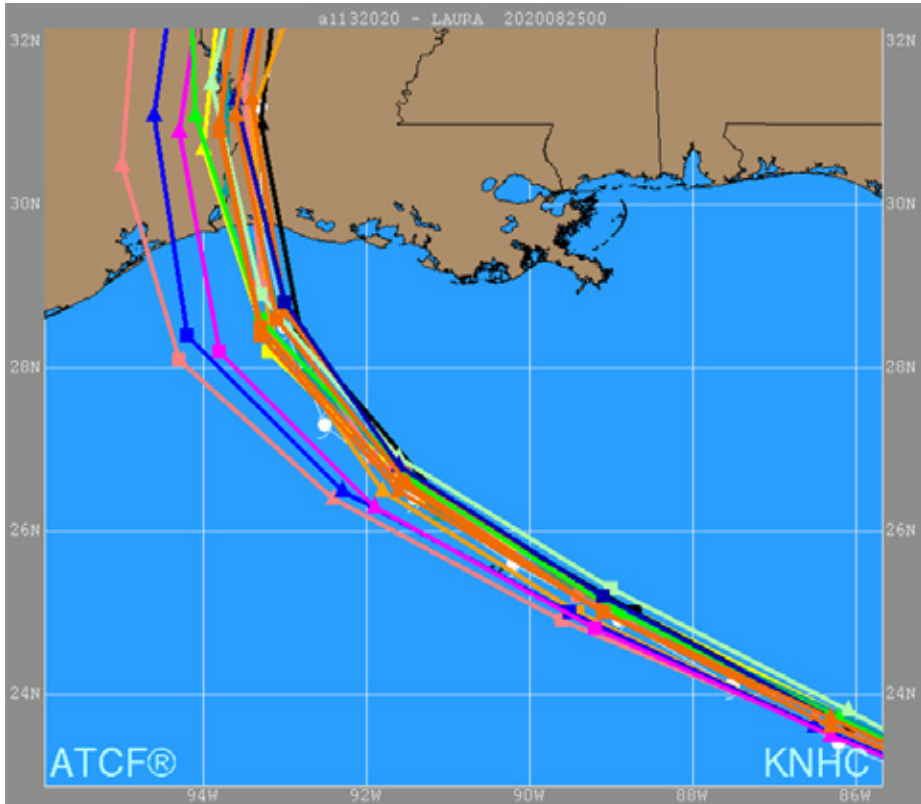
Incorrect Model Trends Near Landfall – Laura



Guidance almost perfectly centered around the Louisiana landfall

Laura guidance 1800 UTC Aug 24

Incorrect Model Trends Near Landfall - Laura

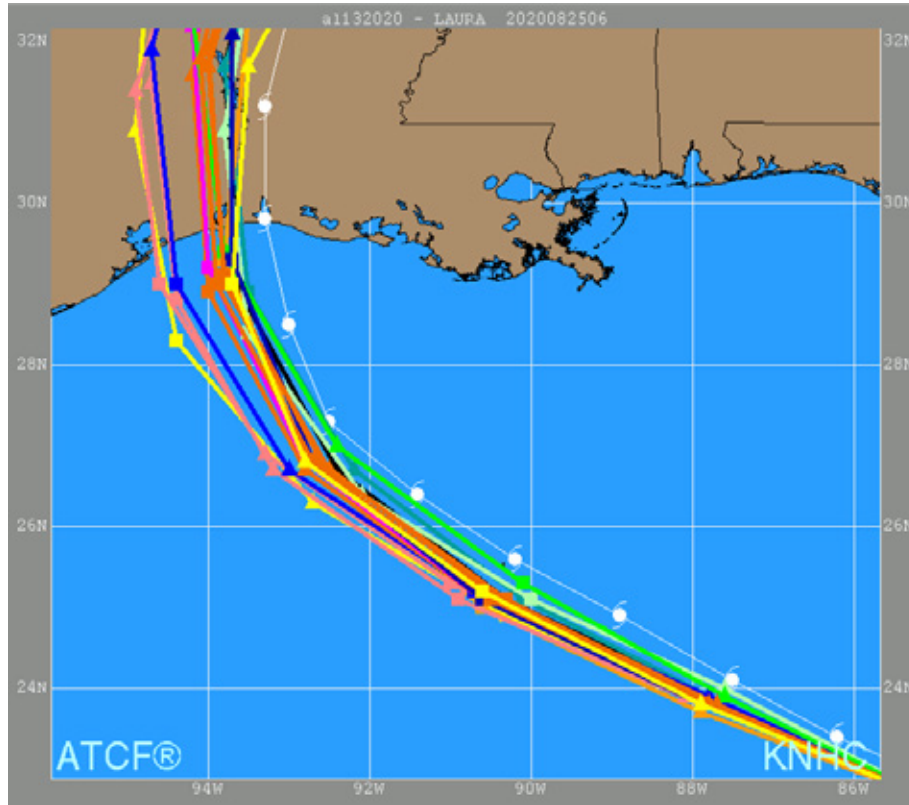


Laura guidance 0000 UTC Aug 25

6 hours later- trouble.

Notable westward shifts of
ECMWF ensemble and
corrected-consensus aids

Incorrect Model Trends Near Landfall – Laura



Laura guidance 0600 UTC Aug 25

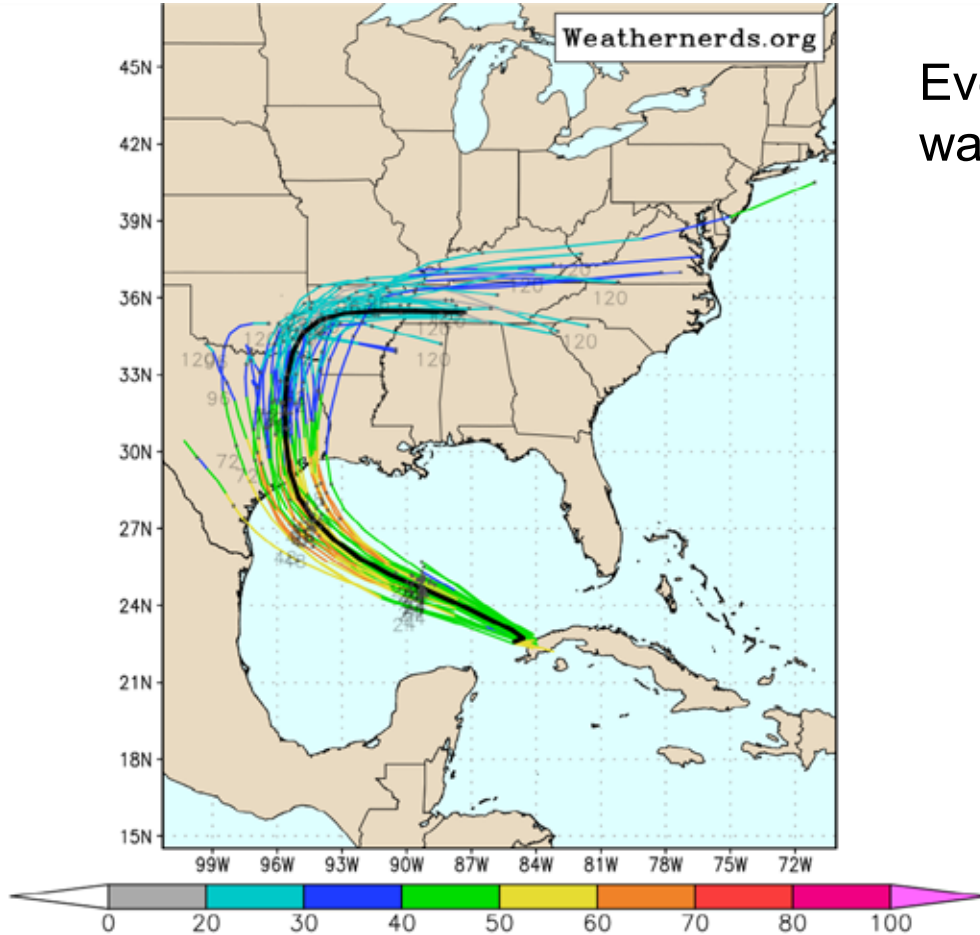
Lots of models shifted west

NHC fcst did not leave LA

Expectation of a deep hurricane/SW winds in high-levels led NHC to stay on the E side of the guidance

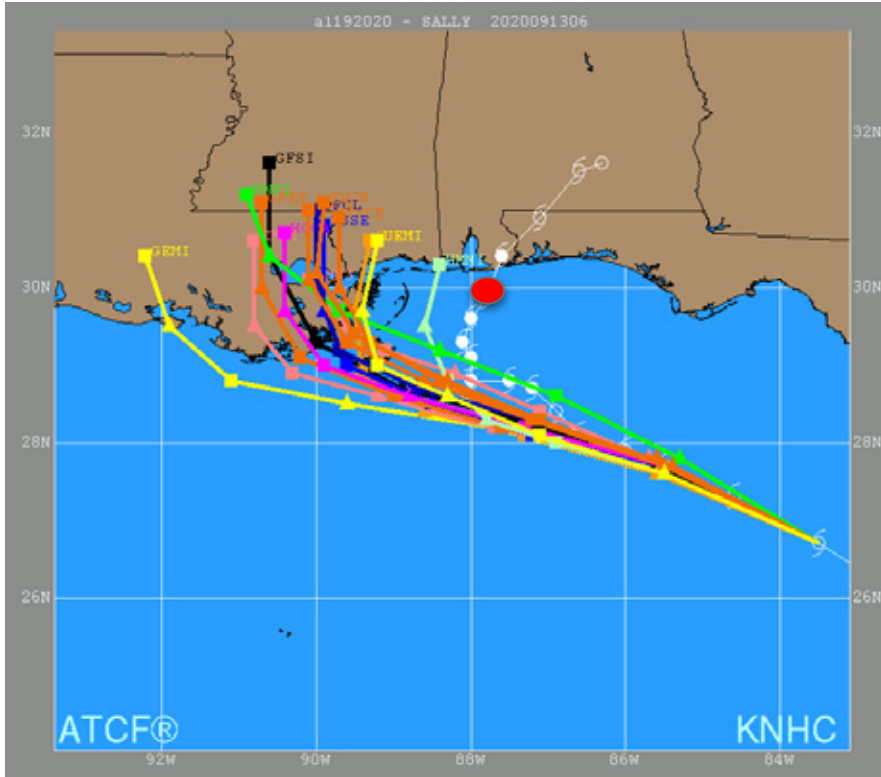
Huge Houston evacuation implications

ECMWF Ensemble Tracks - 25 Aug 0000 UTC



Every ECMWF ensemble member was too far west

Track/Warning Forecast Challenges – Sally



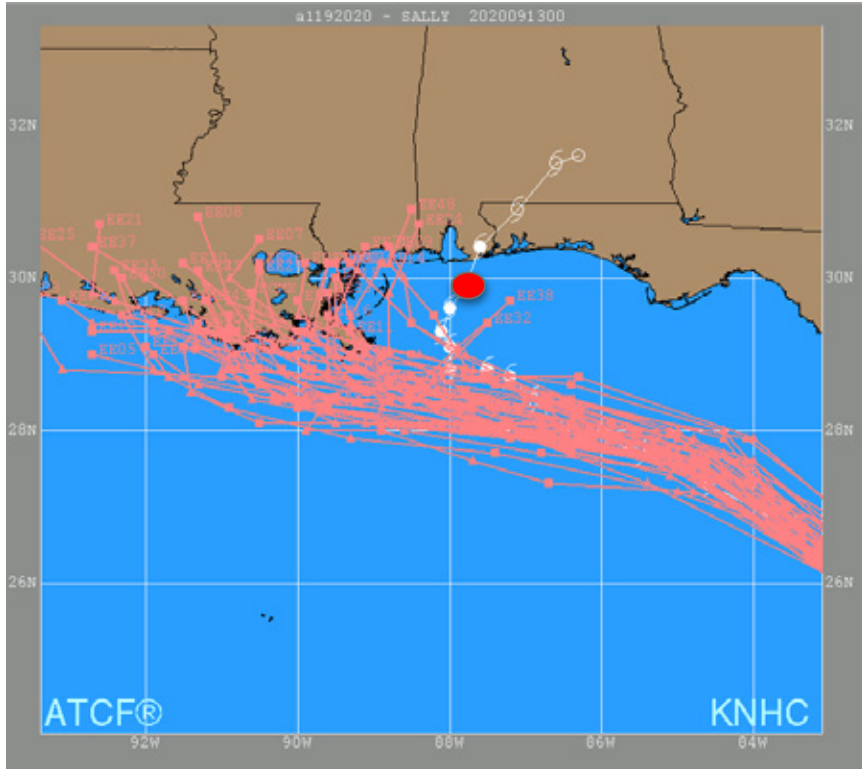
Track guidance 0600 UTC 13 September 2020

Sally's track moved completely outside the track guidance envelope for the forecast cycle where the Hurricane Warning was issued

Resulted in a clear-sky bust for Louisiana

Note HMNI closest - yet it had a NE bias for Marco. Recent past affects forecaster perceptions!

Track/Warning Forecast Challenges – Sally



ECMWF Ens 0600 UTC 13 September 2020

No help from the best ensemble system either

If anything you might suspect the forecast would bust left, not right

Some stronger members on right side, but intensity skill lags

Summary

- 2020 presented a potent mix of challenges: record-breaking TC activity and landfalling systems, staffing shortages, COVID, and other factors that severely stressed the system
- We have a lot to be proud of for the level of service the U.S. hurricane program provided to our customers and partners this season, saving potentially thousands of lives
- Moving forward from this season will take time
 - NHC is still working through a huge post-analysis workload
 - TSB is short-staffed with numerous high priority projects including AWIPS2 migration, WCOS transitions, AWIPS upgrades, etc., limiting development opportunities
 - Outreach and training for 2021 again greatly reduced/affected by COVID