
# The Spread of Tropical Storm Tracks in NCEP's Global Ensemble Model

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**UMass Lowell**

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# Acknowledgements


- Many thanks to Yuejian Zhu and Kate Zhou for providing me with data from the preliminary version of GEFSv12.

- And appreciation to Andy Penny from NHC for insightful collaboration

# Outline

- Method of Evaluating Ensemble Model Performance
- Review of Past Performance of GEFS
- Spread in Preliminary GEFSv12:  2018-08-30 to 2018-09-30
- Examples of Individual Storms
- Conclusions

# Evaluating Ensemble Model Performance

- Spread-Error Relationship
  - Larger spread *should correlate to* larger error
- Continuous Ranked Probability Skill Scores
  - Increased skill implies a better forecast

Good metrics for evaluating an ensemble prediction system

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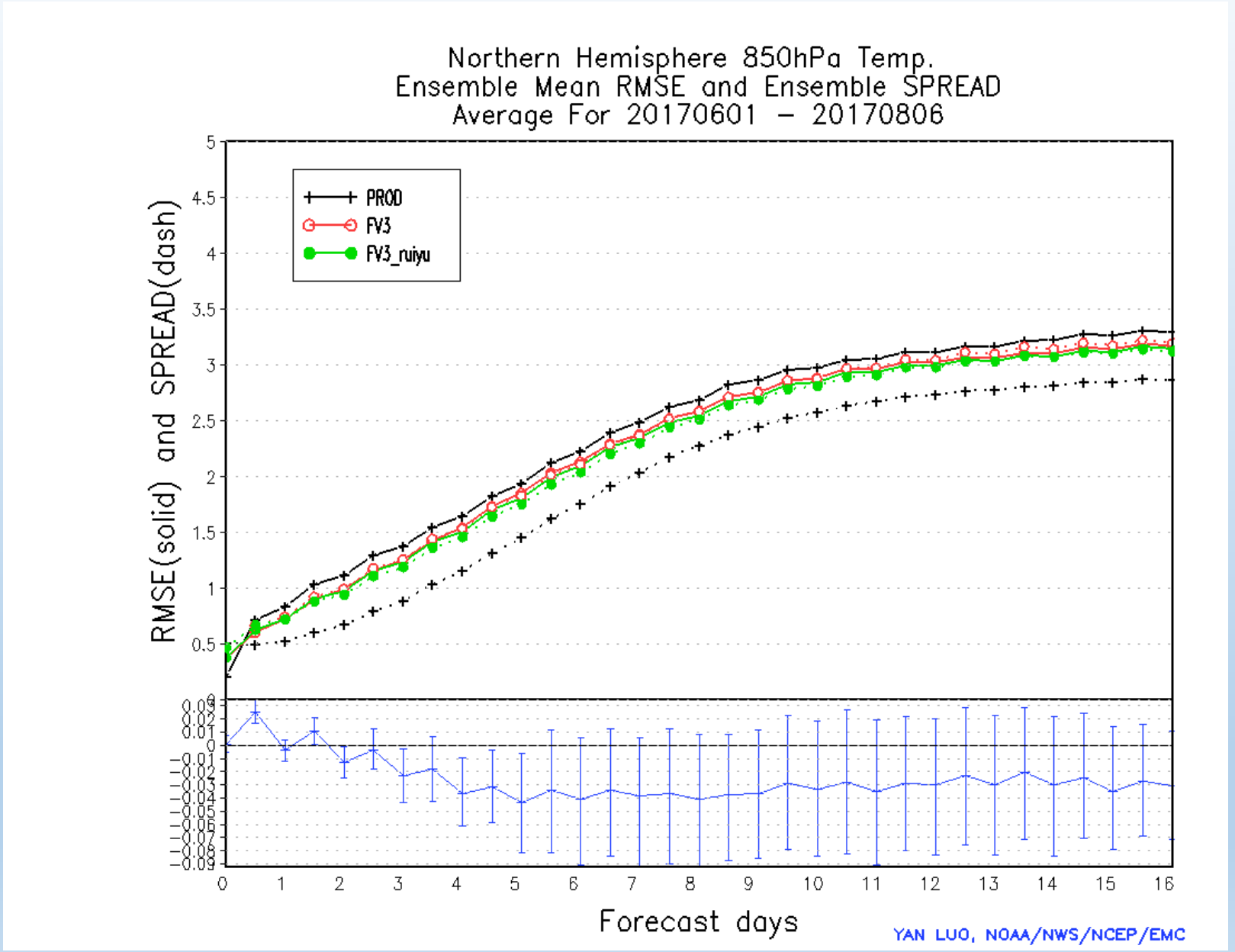
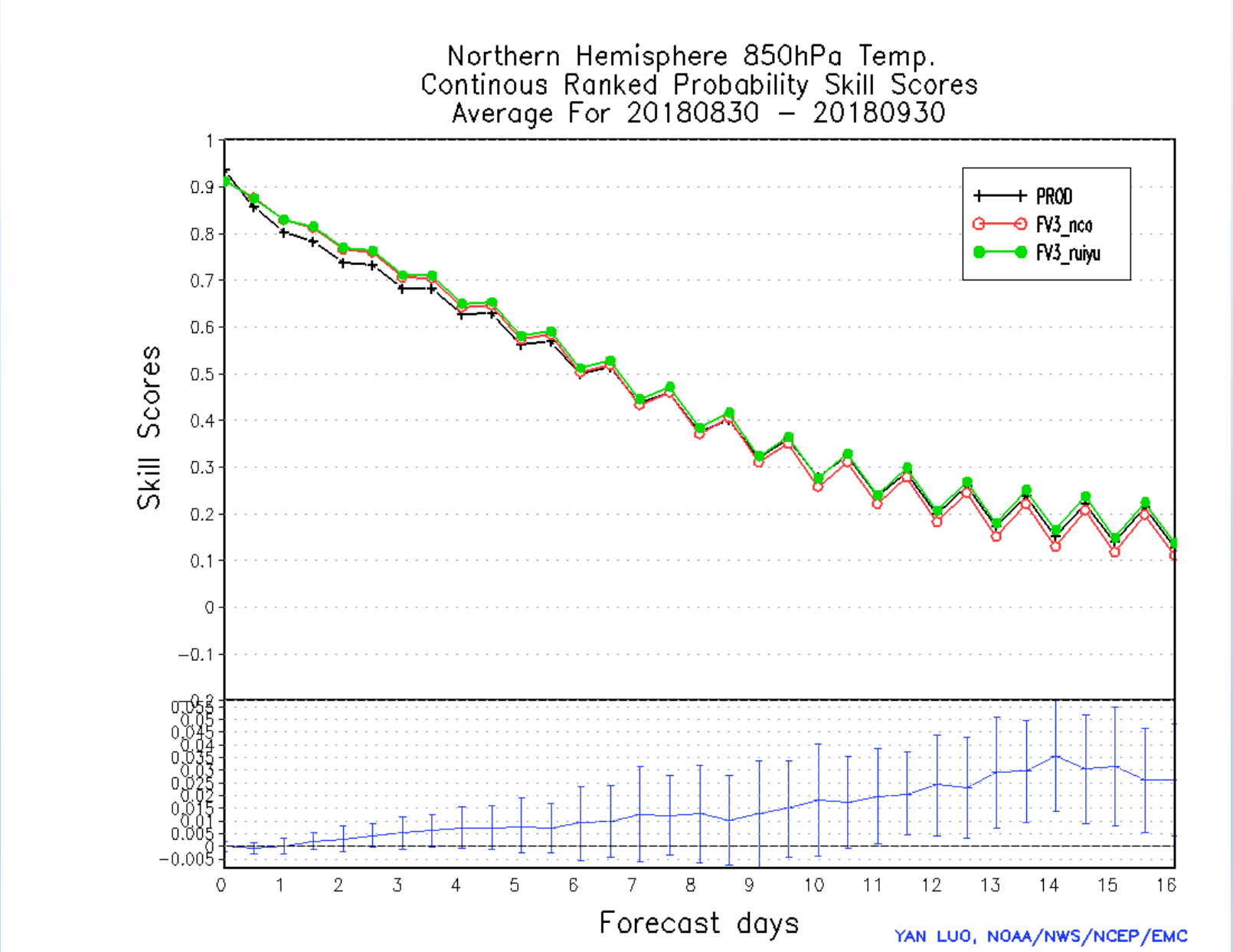
EXAMPLE:
Error-Spread

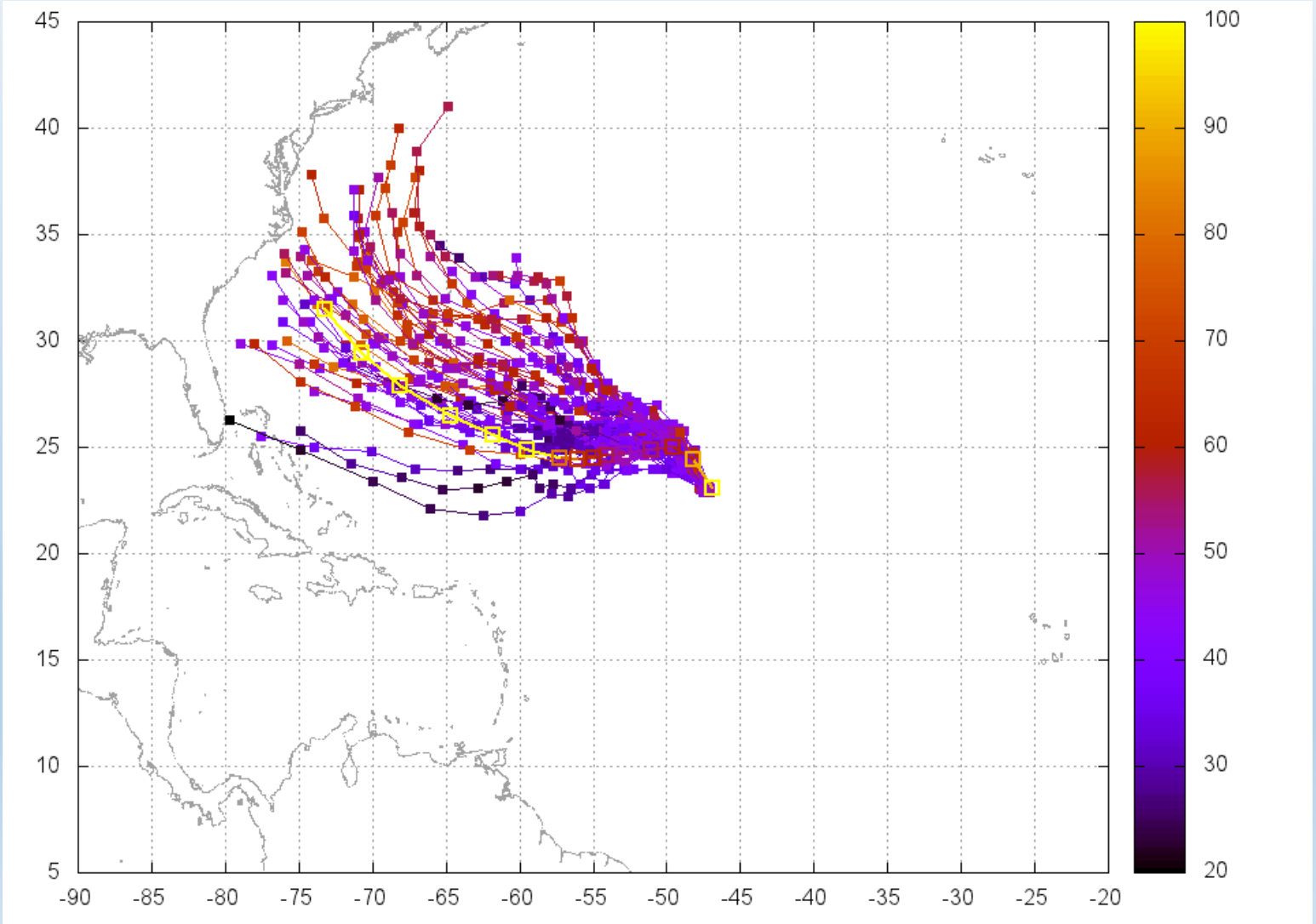


EXAMPLE:
CRPSS



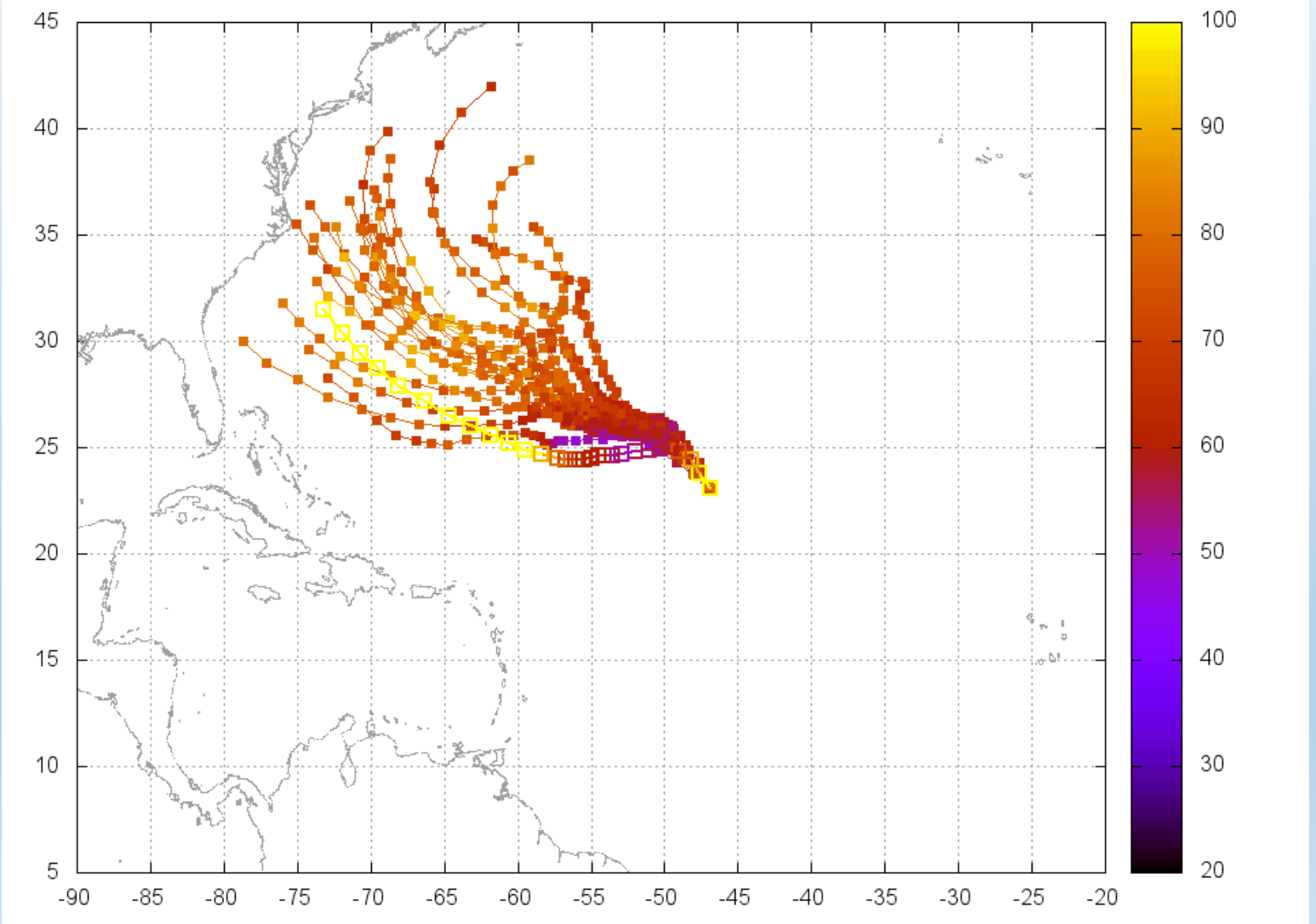
# Evaluating Ensemble Performance: Spread in Tropical Storm Tracks

- Suppose you are working at NHC, looking at forecast tracks for Hurricane Florence.
- You see this.



# Evaluating Ensemble Performance: Spread in Tropical Storm Tracks

- Or you see this from the GEFS.
- How likely is it that Florence will be in the envelope of ensemble members?



# Evaluating Ensemble Performance: Spread in Tropical Storm Tracks

- You would look at other models, certainly.
- For a forecaster, it would be helpful to use the envelope to see the possibilities.

# Evaluating Ensemble Performance: Spread in Tropical Storm Tracks

- To measure the likelihood of a tropical storm

  to be in the envelope, we:

  compare the area of a **Forecast Box** and compute the **Success Rate**.

- A Forecast Box is a rectangle that includes all ensemble member locations
- The Success Rate is % of forecasts when *the actual location* is in Forecast Box

This is a good way for forecasters to evaluate the helpfulness of an ensemble system

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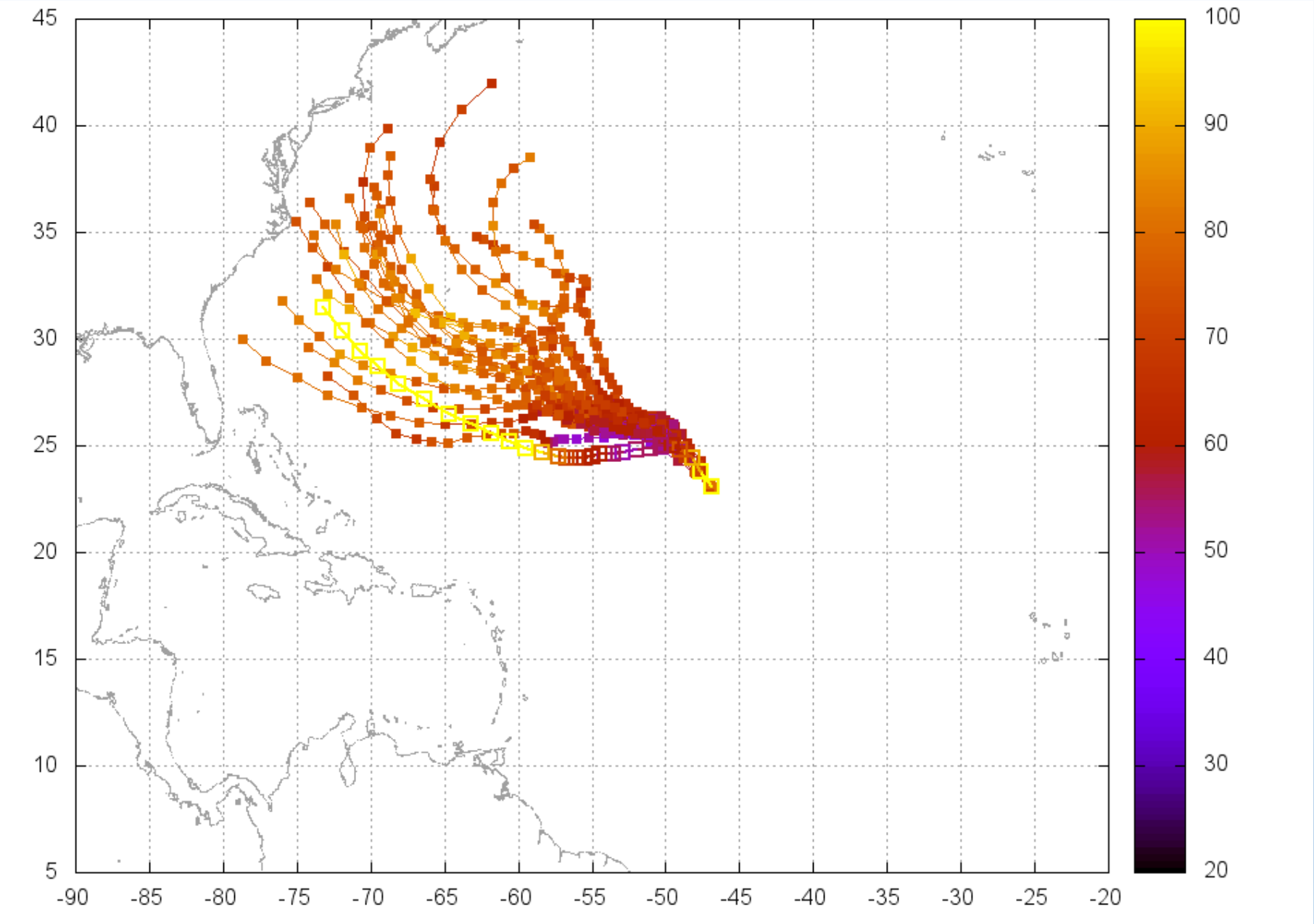
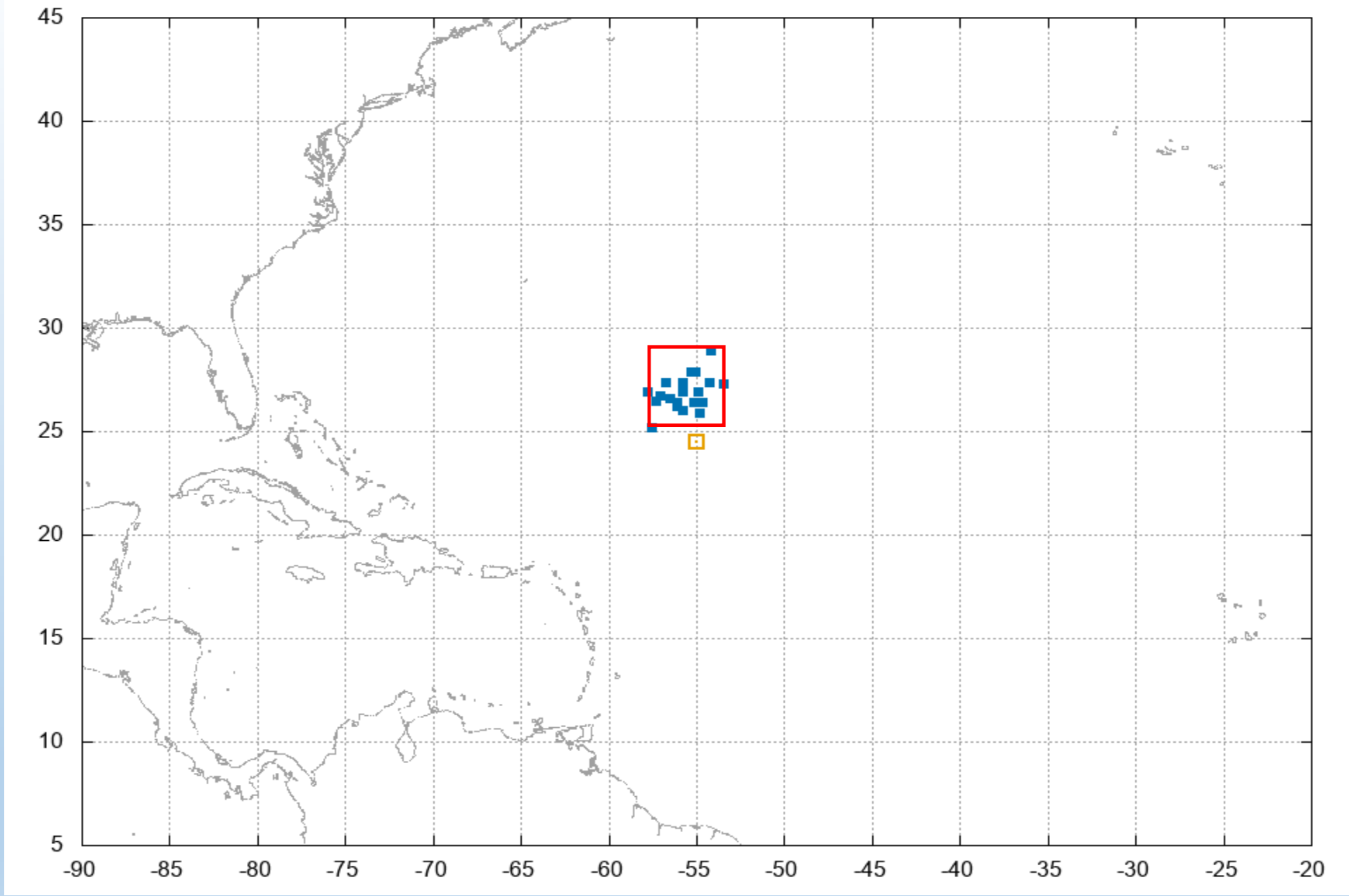



Forecast tracks for 20 members of GEFSv12 for Hurricane Florence. Large squares are NHC best track. Color coding for 10 m wind speed in knots. Forecast initialized 2018 September 6 at 0000 UTC.

Forecast Box for 72-hour forecast locations for GEFSv12 members from model run initialized 2018 September 6 at 0000 UTC for Hurricane Florence

This is an example of a miss.

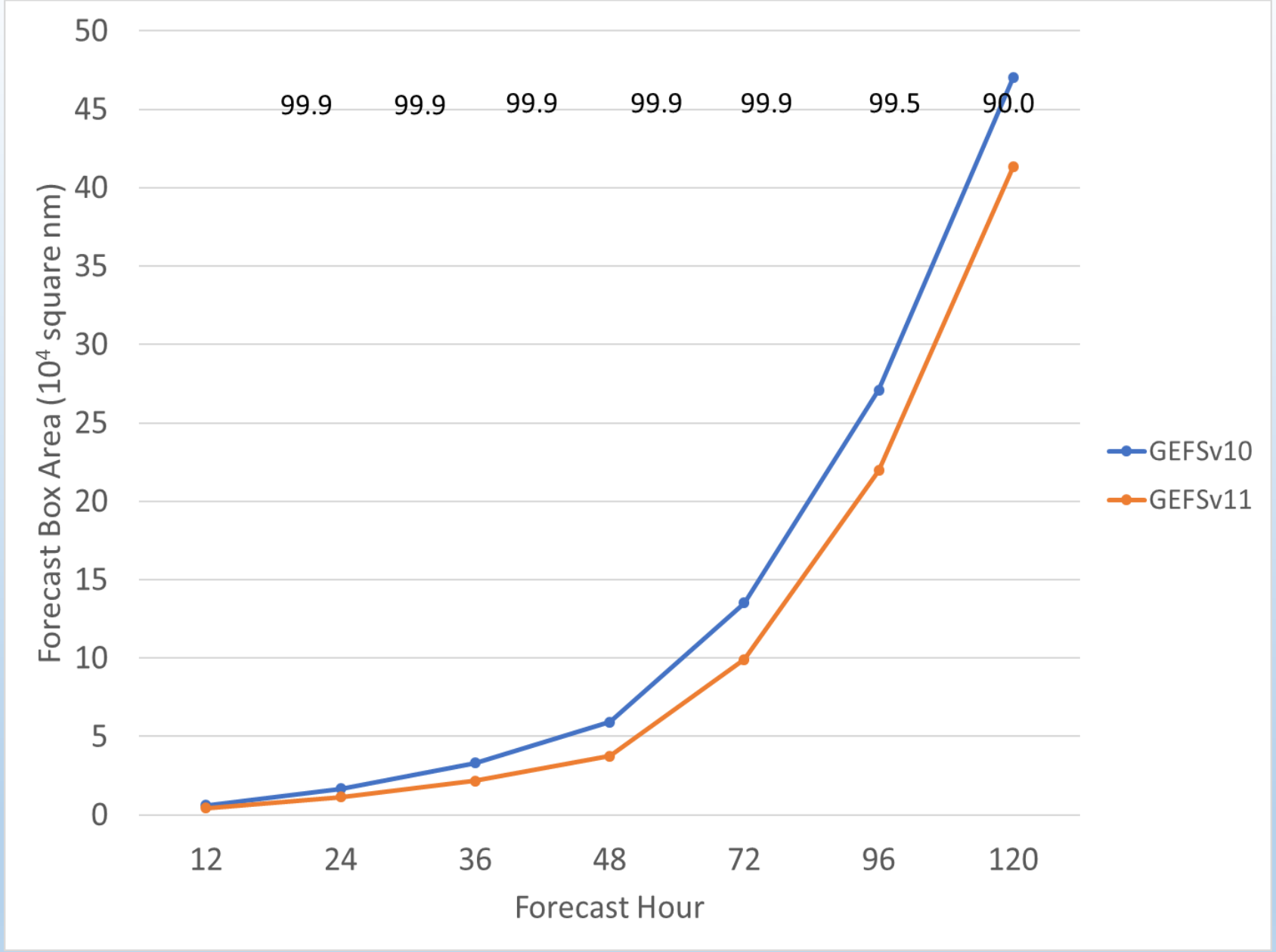


# Review of Past Performance of GEFS

- Parallel runs with GEFSv10 and GEFSv11
  - Areas of Forecast Boxes shrank with upgrade
  - Success Rates decreased slightly

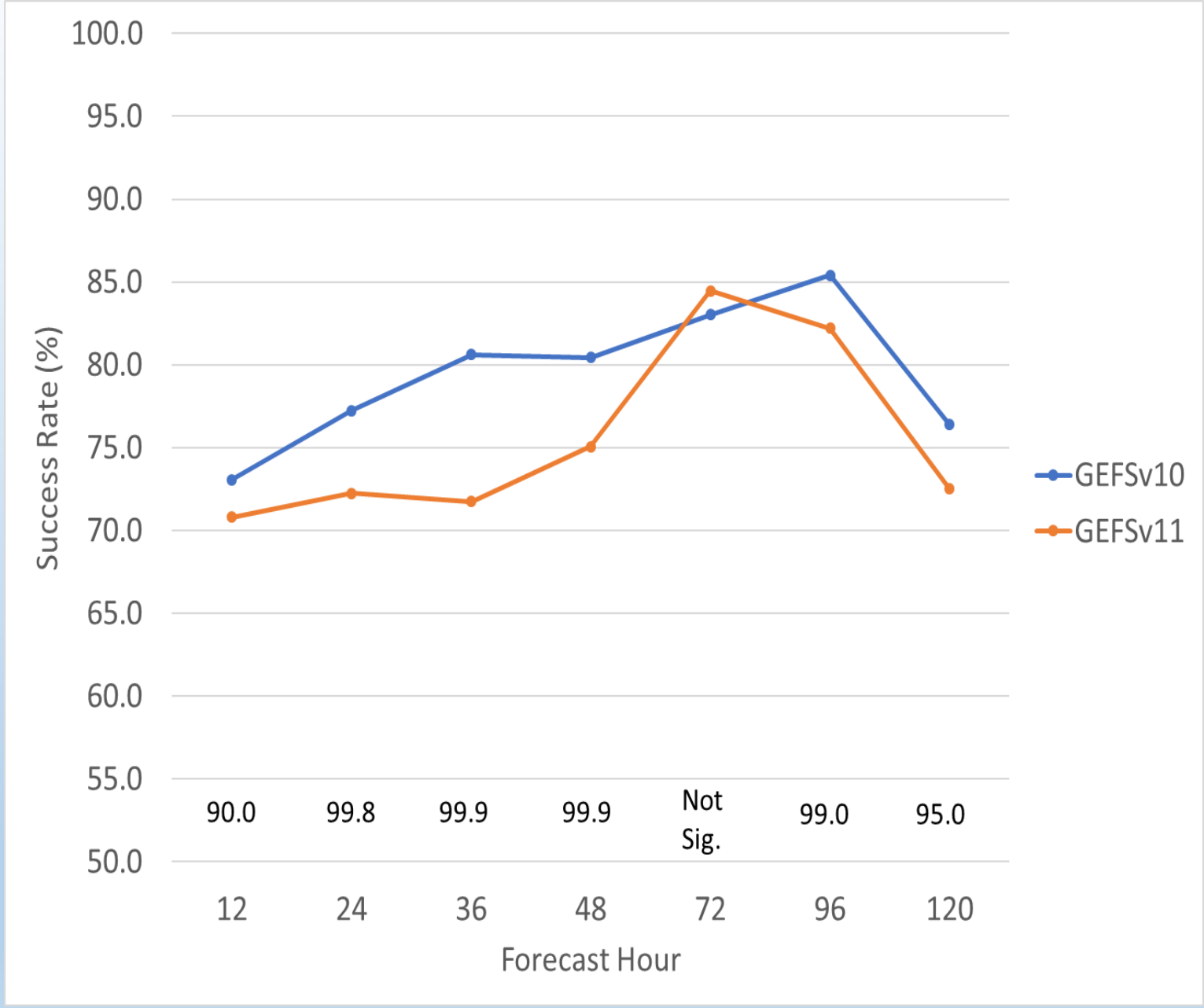
Past performance from Colby (2019) in WAF.

Areas of Forecast Boxes shrank with upgrade




Area of forecast box for parallel runs of two versions of the GEFS as a function of forecast hour for the 2014 and 2015 hurricane seasons. Student's t-test used for significance testing.

Success Rates decreased slightly




Success rate for parallel runs of two versions of the GEFS as a function of forecast hour.

# Review of Past Performance of GEFS

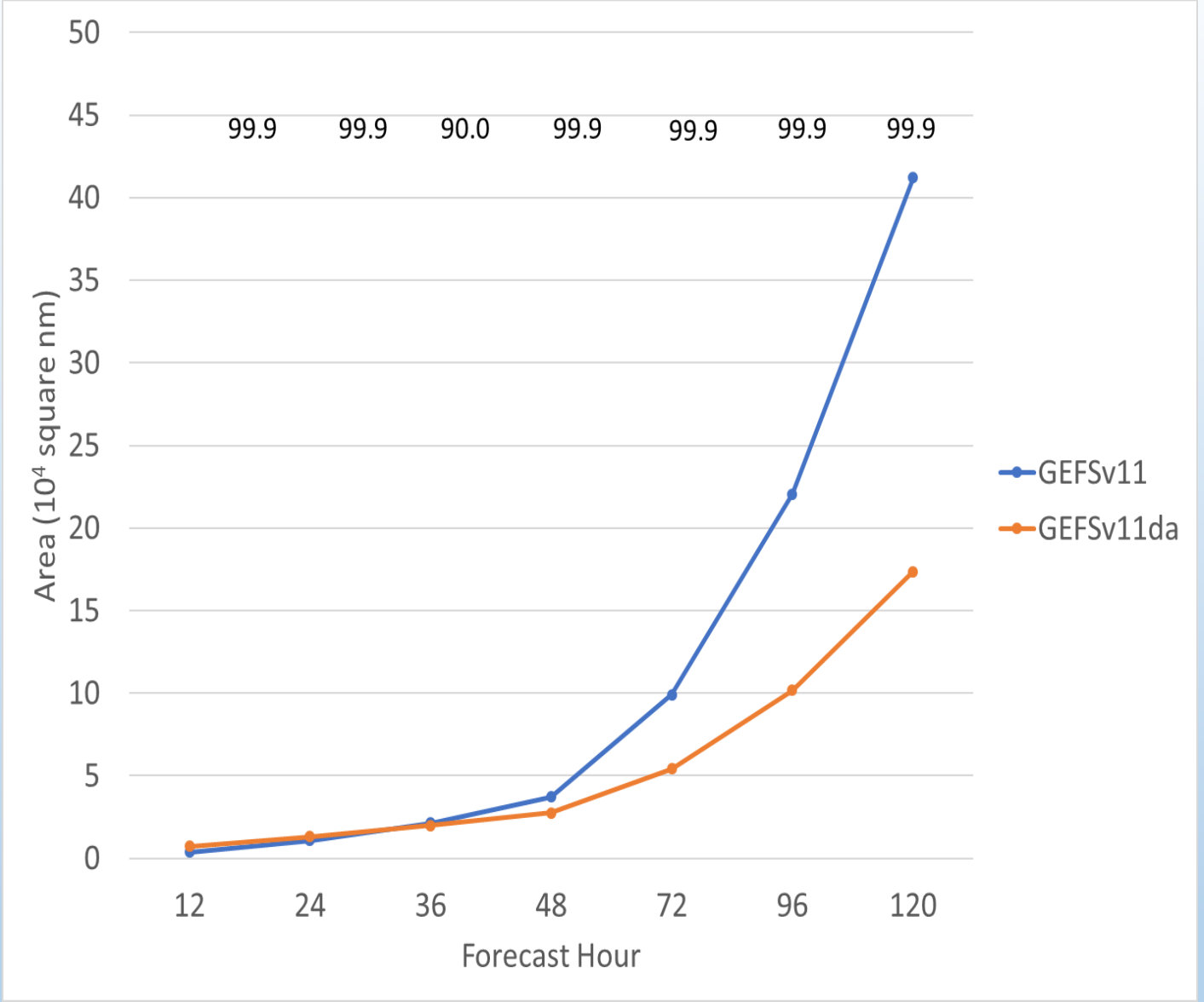
- Seasonal performance of GEFSv11 and GEFSv11(DA)
  - Parallel runs not available for 2016 – 2017 season

  Comparison is between 2014 – 2015 seasons with GEFSv11
  and with 2016 – 2017 seasons with GEFSv11 with new Data Assimilation

  - Areas of Forecast Boxes shrank with upgrade
    - **Statistically less variability in steering currents**

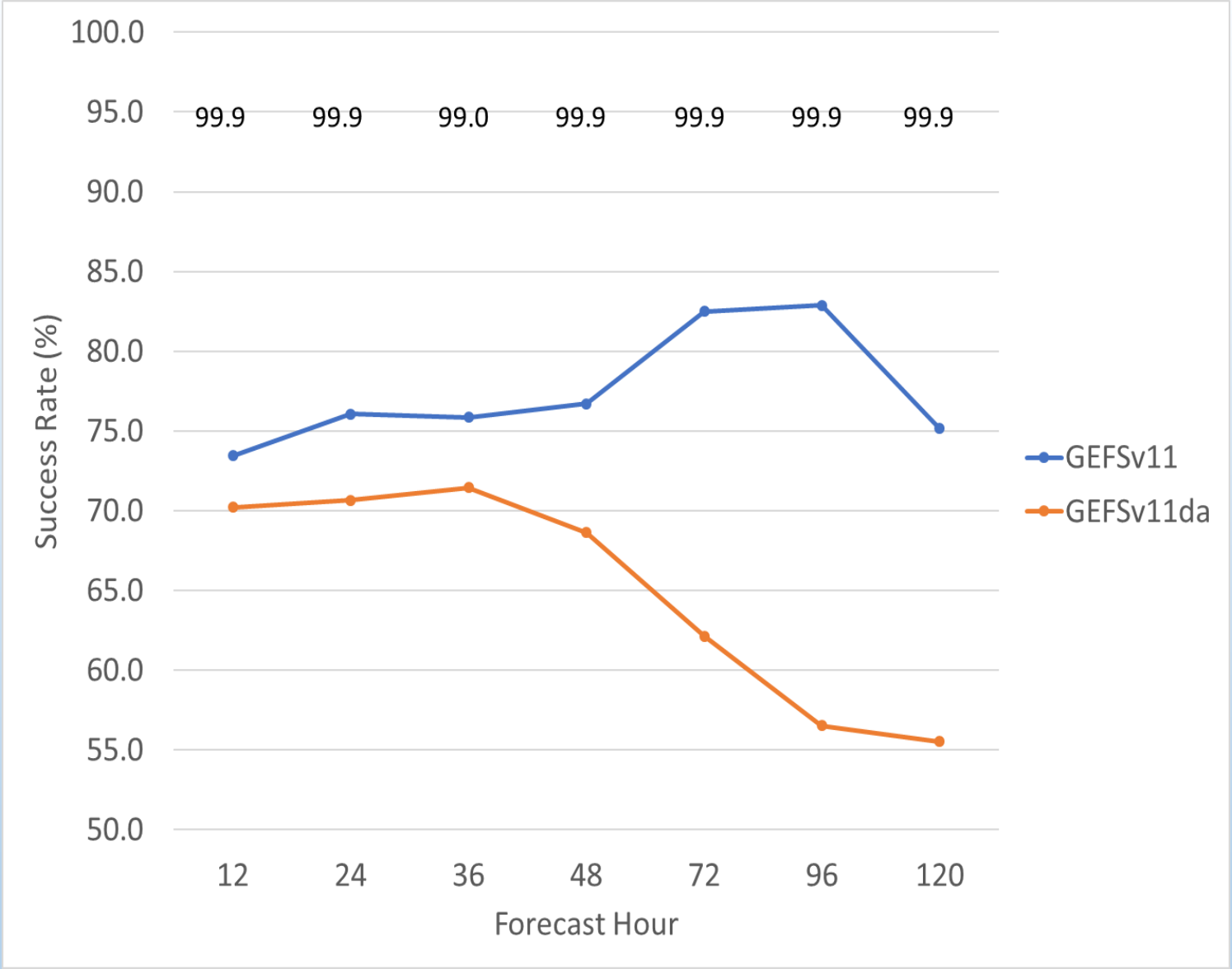
  - Success Rates decreased

Areas of Forecast Boxes shrank with upgrade

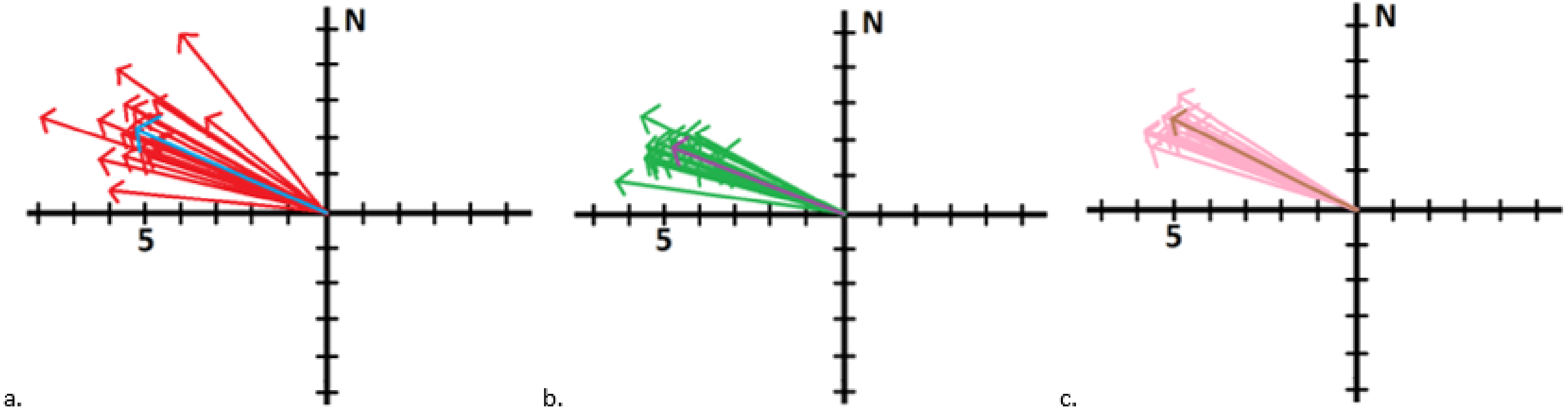



Area of forecast box for seasonal runs of two versions of the GEFS as a function of forecast hour for 2015-2016 seasons for GEFSv11 and 2016-2017 for GEFSv11 with new Data Assimilation. Welch's t-test used for significance testing.

Success Rates decreased




Success rate for seasonal runs of two versions of the GEFS as a function of forecast hour for 2015-2016 seasons for GEFSv11 and 2016-2017 for GEFSv11 with new Data Assimilation.



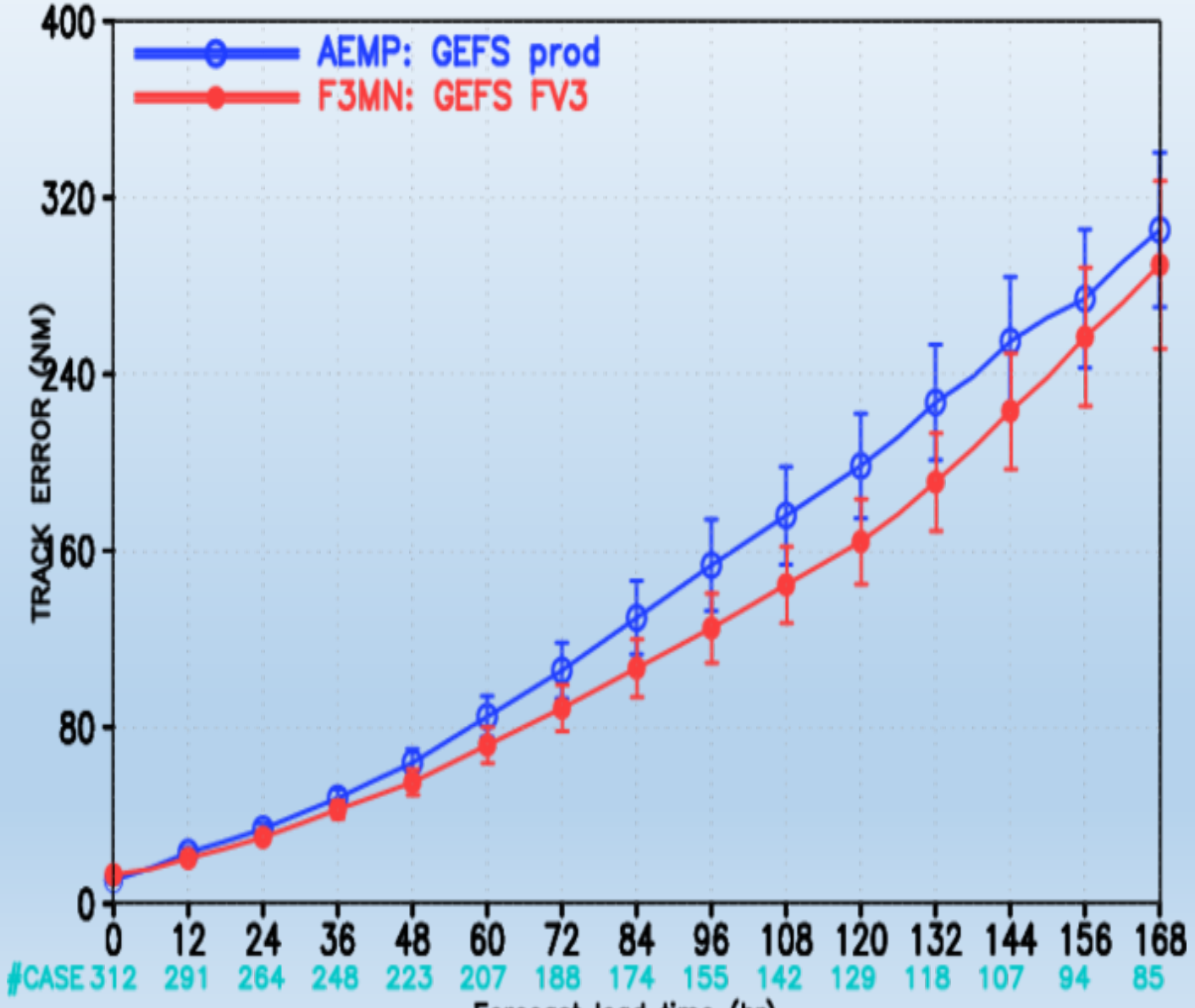

Vector plots of steering currents valid for the layer from 1000 hPa to 250 hPa for 0000 UTC 12 September a) GEFSv10, b) GEFSv11, and c) GEFSv11da model runs. Tick marks are at 1 m/s intervals.

# Spread in GEFSv12

2017 – 2018 tropical storm forecasts

Ensemble mean has smaller errors than GEFSv11(DA)

(courtesy of Kate Zhou)



# Spread in Preliminary GEFSv12: 2018-08-30 to 2018-09-30

- Parallel runs made available for analysis for 1 month.
- Florence, Gordon, Helene, Isaac, Joyce, Kirk and Leslie (part)
- Areas of Forecast Boxes grew with upgrade
  - Increases of more than 50% for hours 96 – 168
- Success Rates slightly higher at longer lead times

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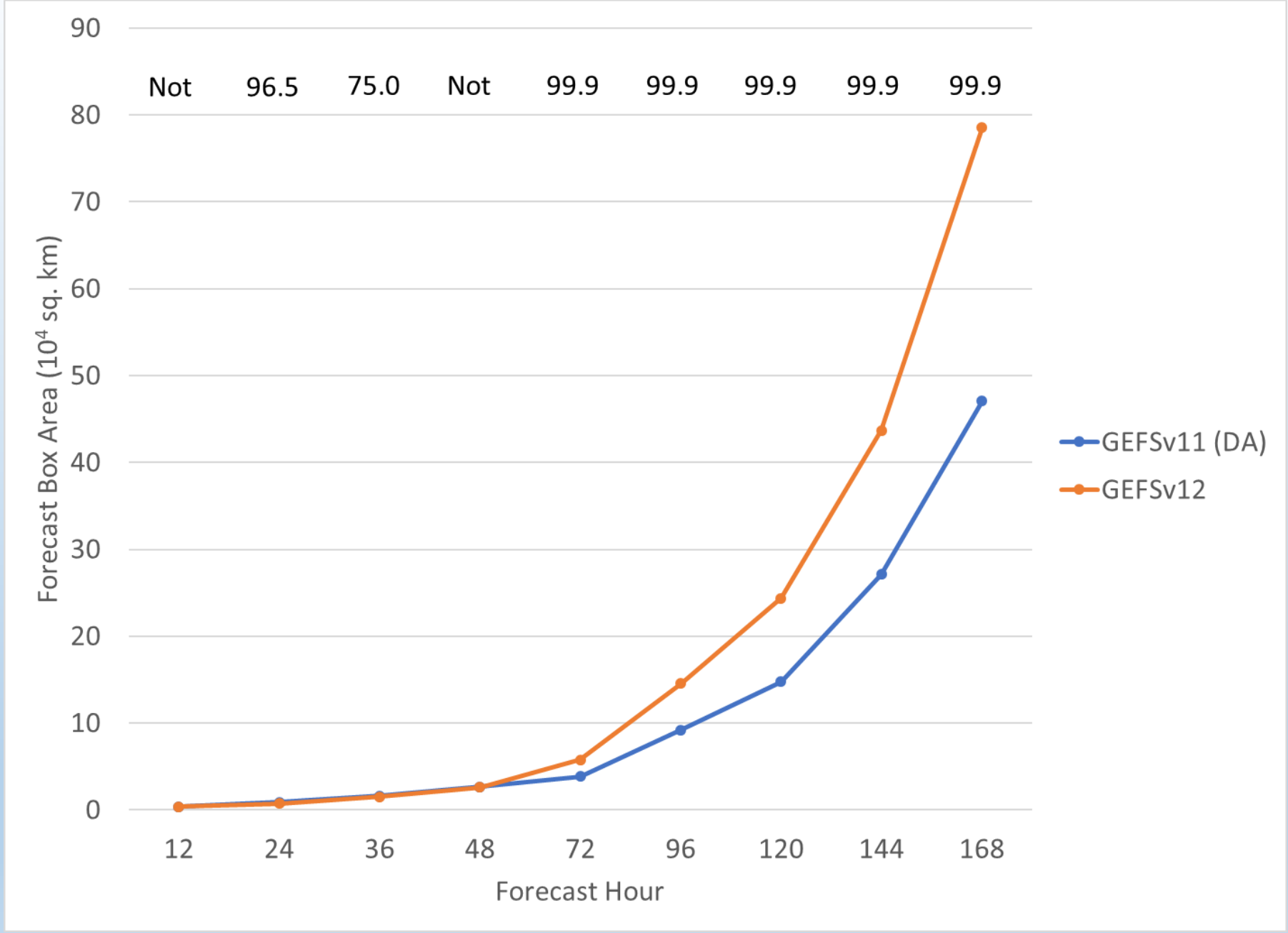
Areas of Forecast Boxes grew with upgrade

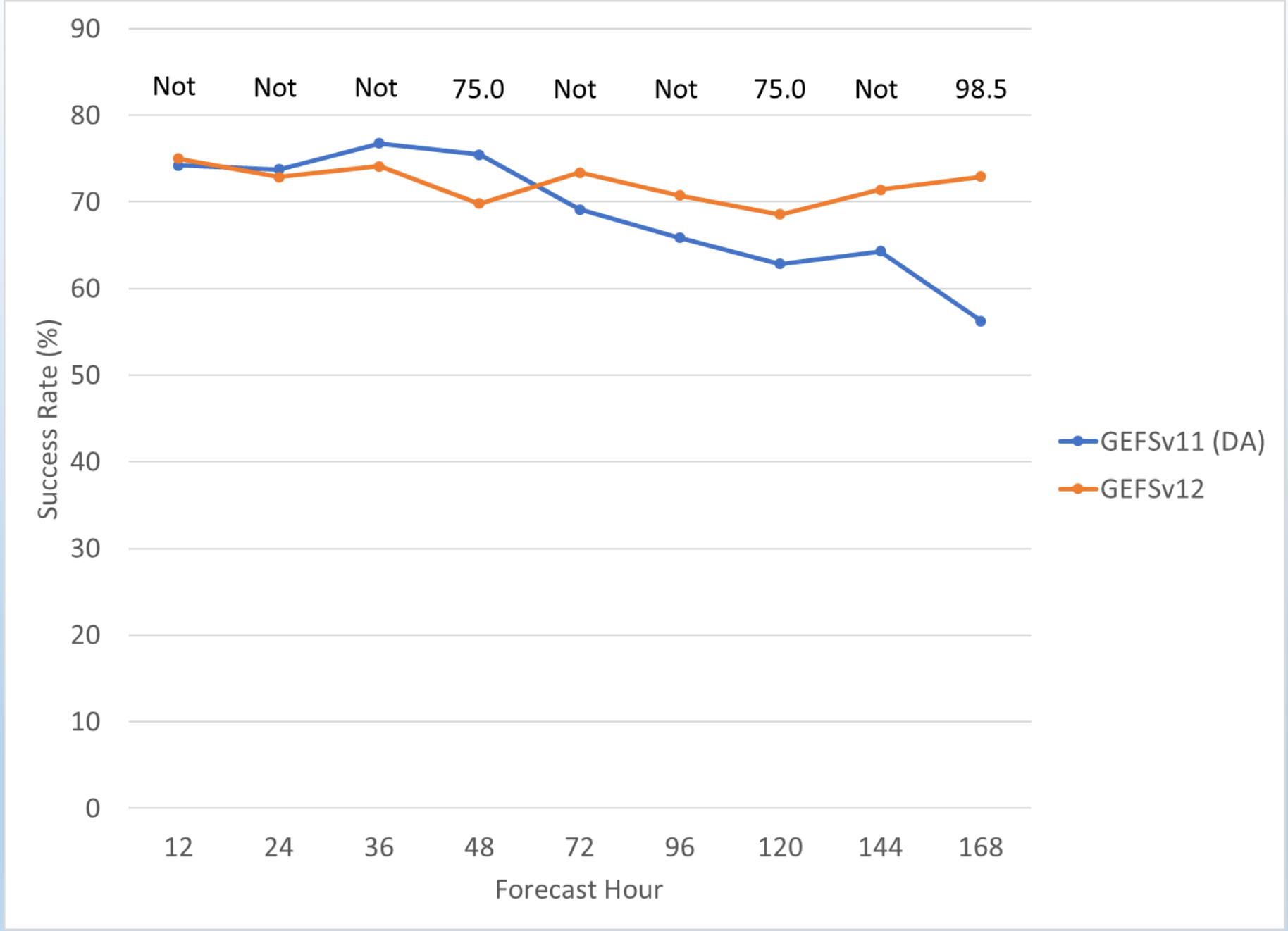
72- to 168-hour differences especially significant




Area of forecast box for parallel runs of two versions of the GEFS as a function of forecast hour for part of the 2018 hurricane season.

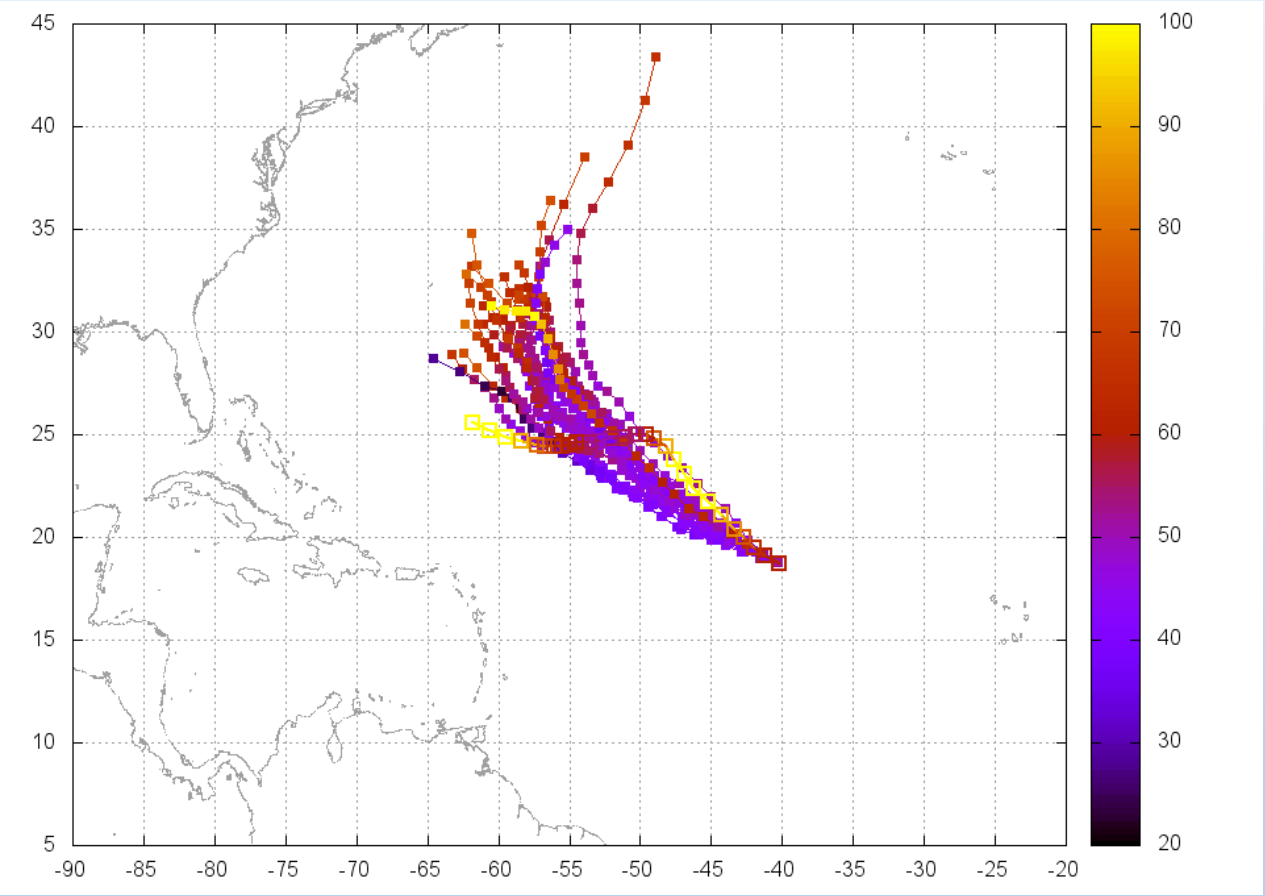
Success Rates slightly higher at longer lead times

Most differences not statistically significant – too little data.

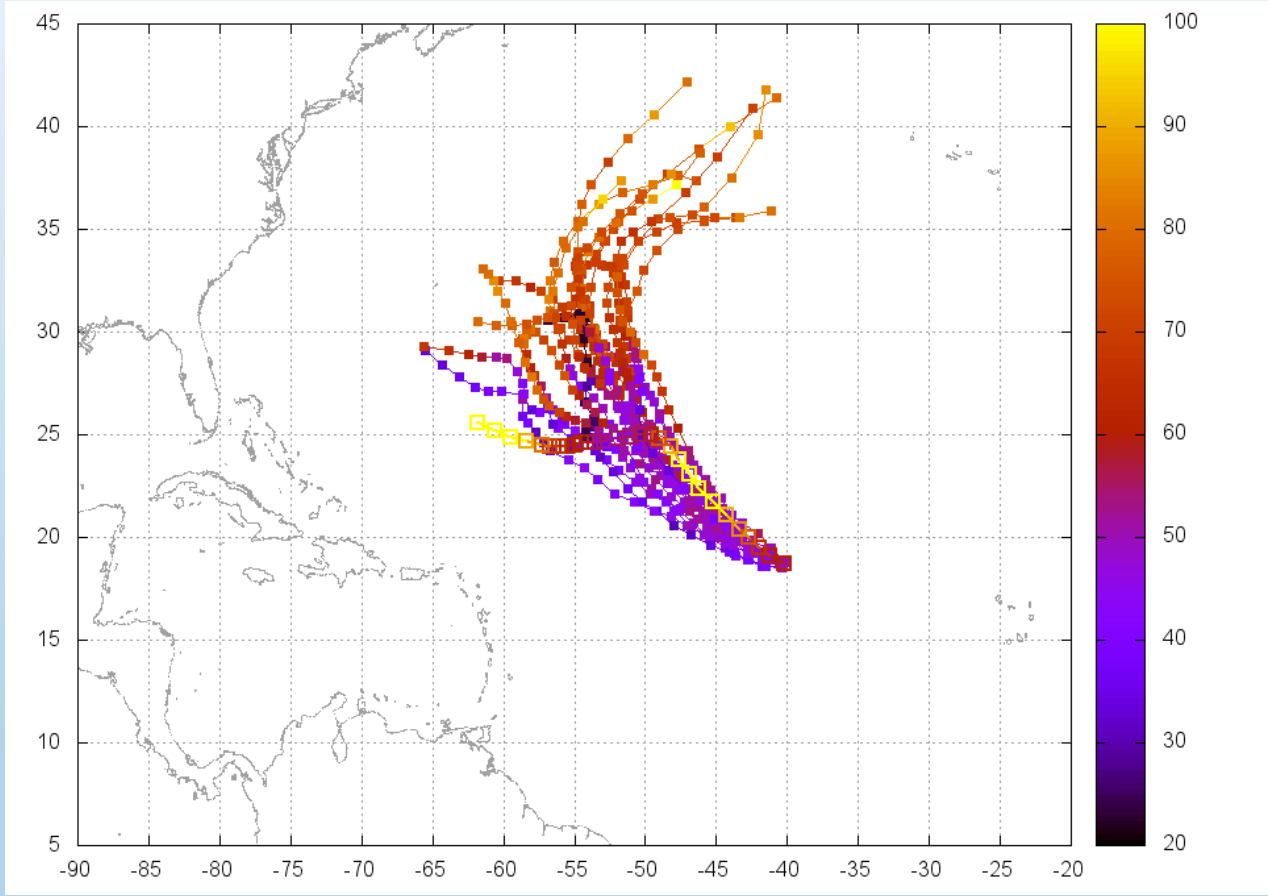



Success Rate for parallel runs of two versions of the GEFS as a function of forecast hour for part of the 2018 hurricane season.

# Examples of Individual Storms - Florence

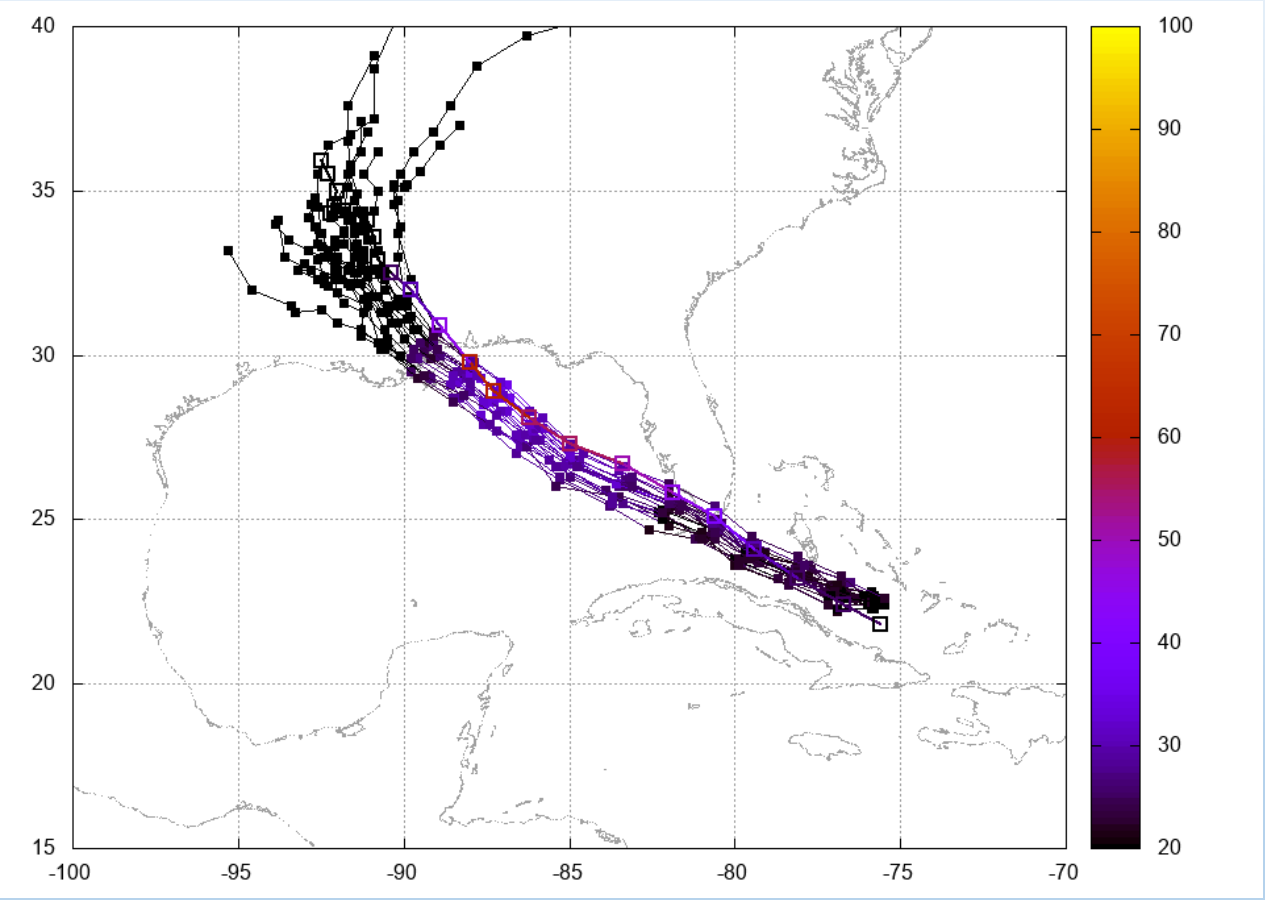



Forecast tracks of 20 GEFSv11(DA) members from 2018 September 4 0000 UTC model run

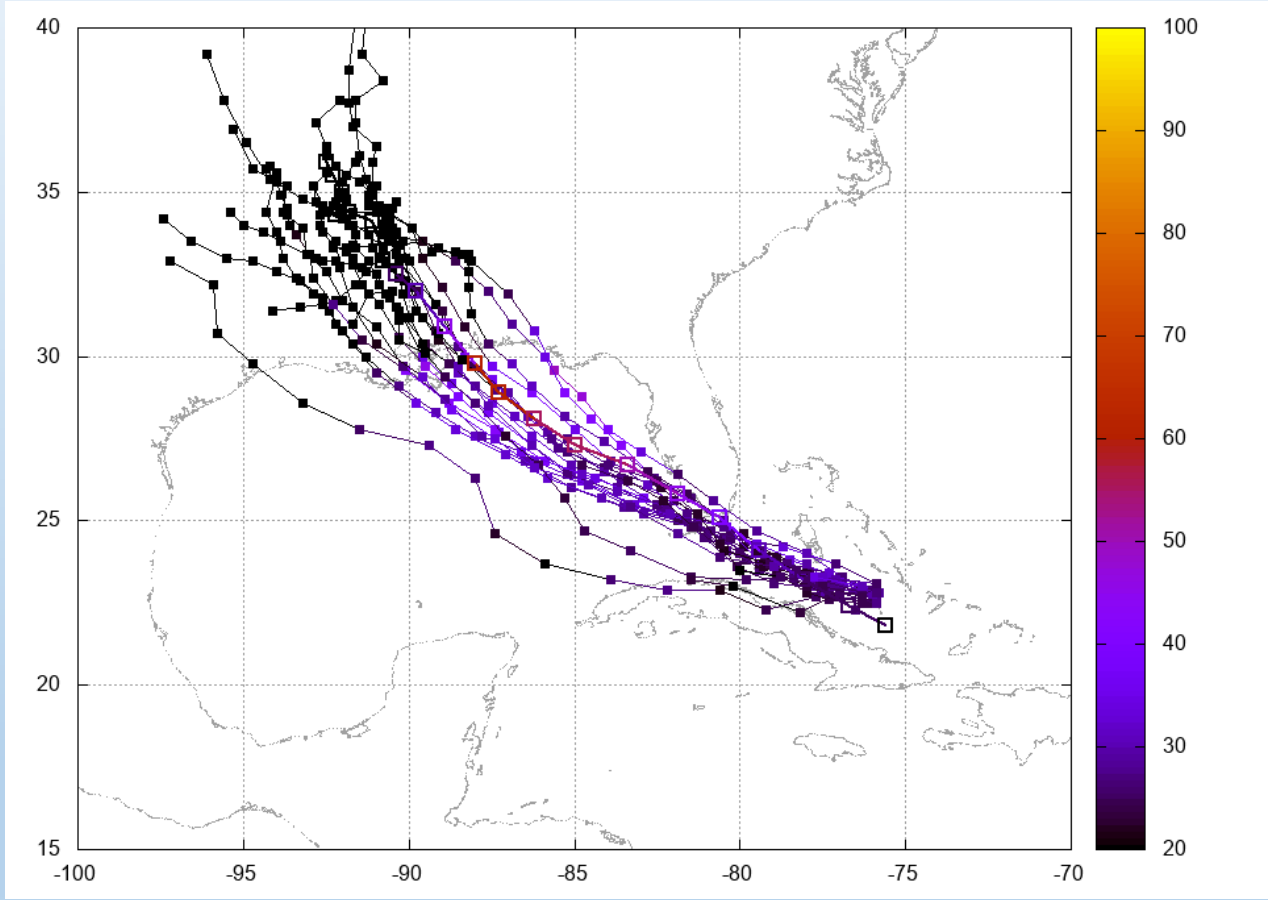



Forecast tracks of 20 GEFSv12 members from 2018 September 4 0000 UTC model run

# Examples of Individual Storms - Gordon

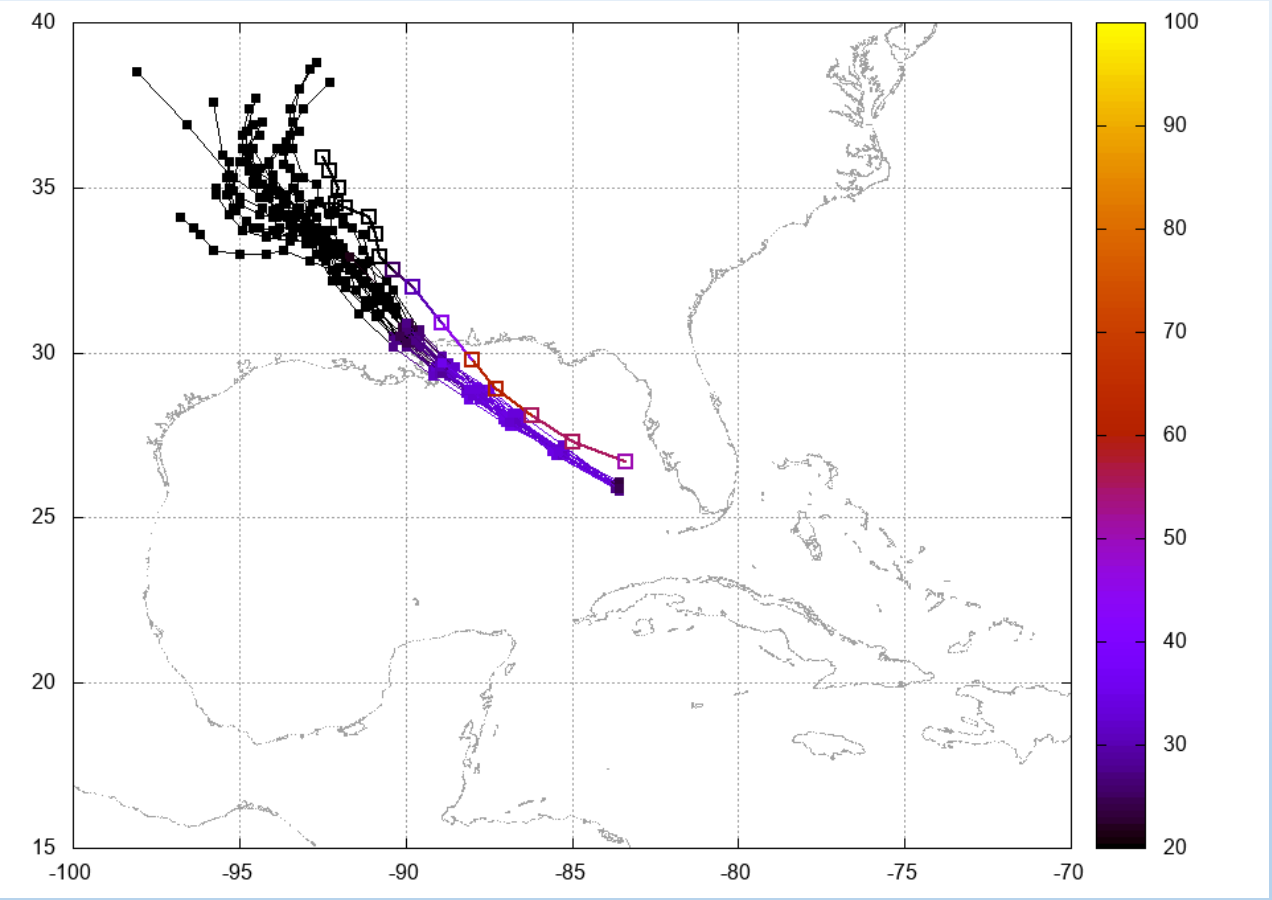



Forecast tracks of 20 GEFSv11(DA) members from 2018 September 2 1200 UTC model run

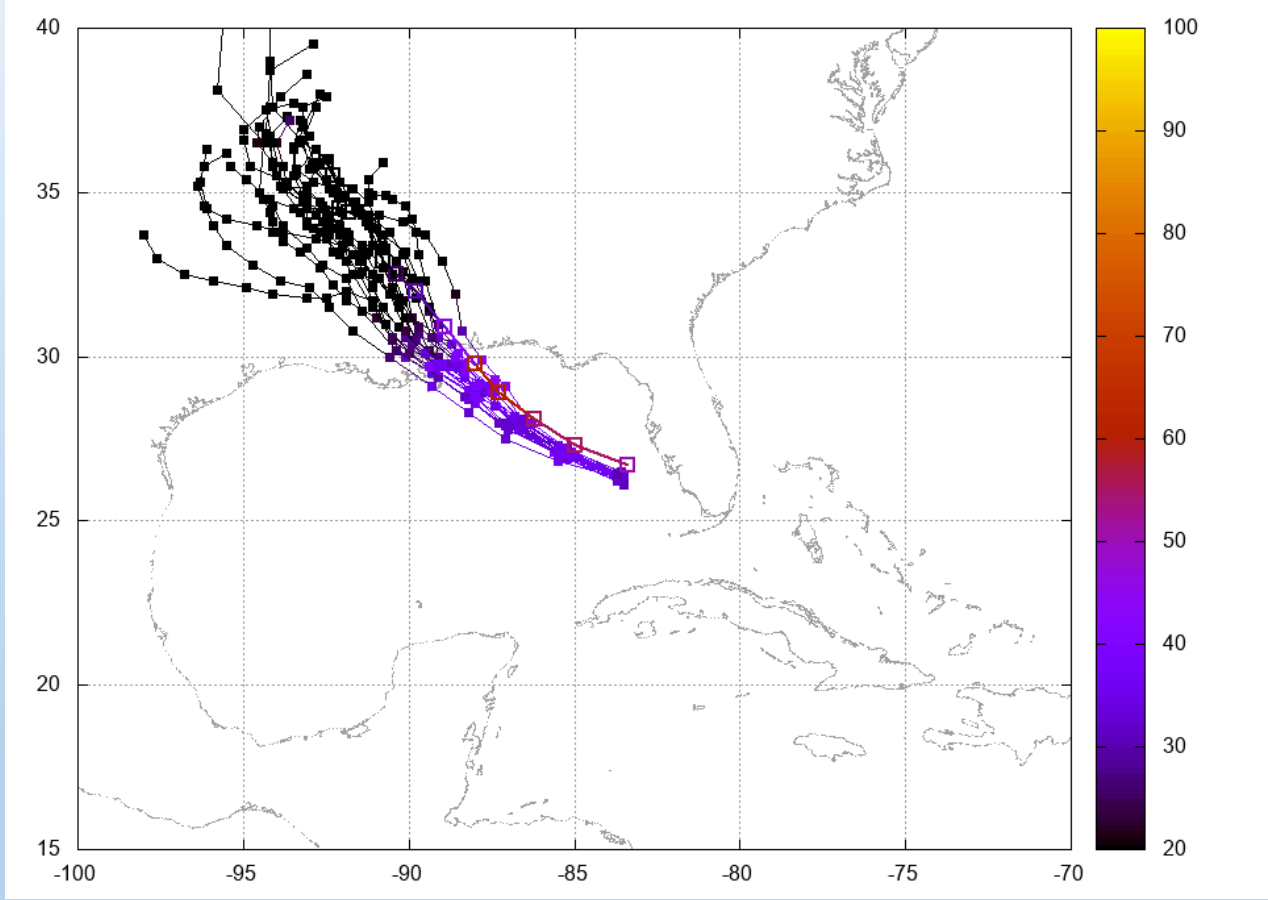



Forecast tracks of 20 GEFSv12 members from 2018 September 2 1200 UTC model run

# Examples of Individual Storms - Gordon

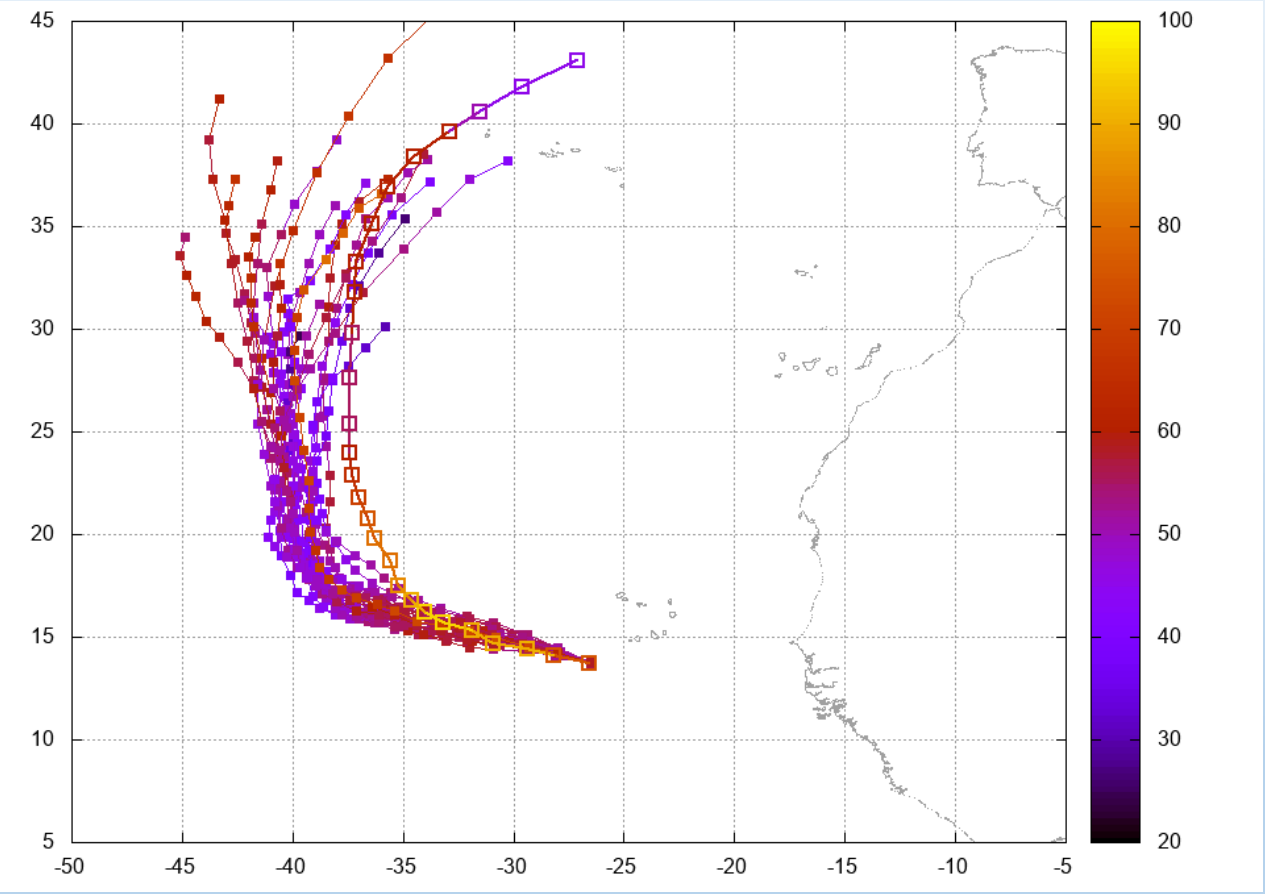



Forecast tracks of 20 GEFSv11(DA) members from 2018 September 4 0000 UTC model run

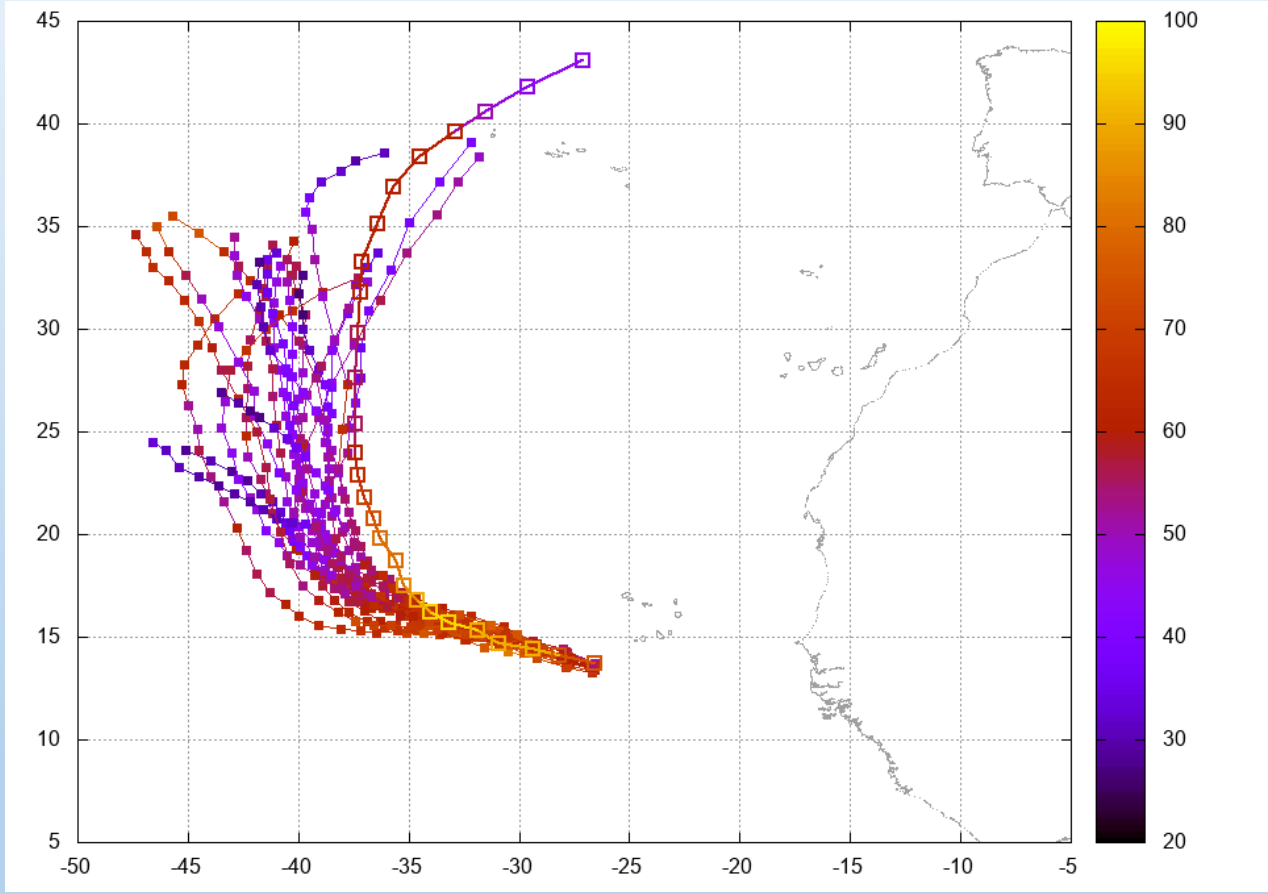



Forecast tracks of 20 GEFSv12 members from 2018 September 4 0000 UTC model run

# Examples of Individual Storms - Helene

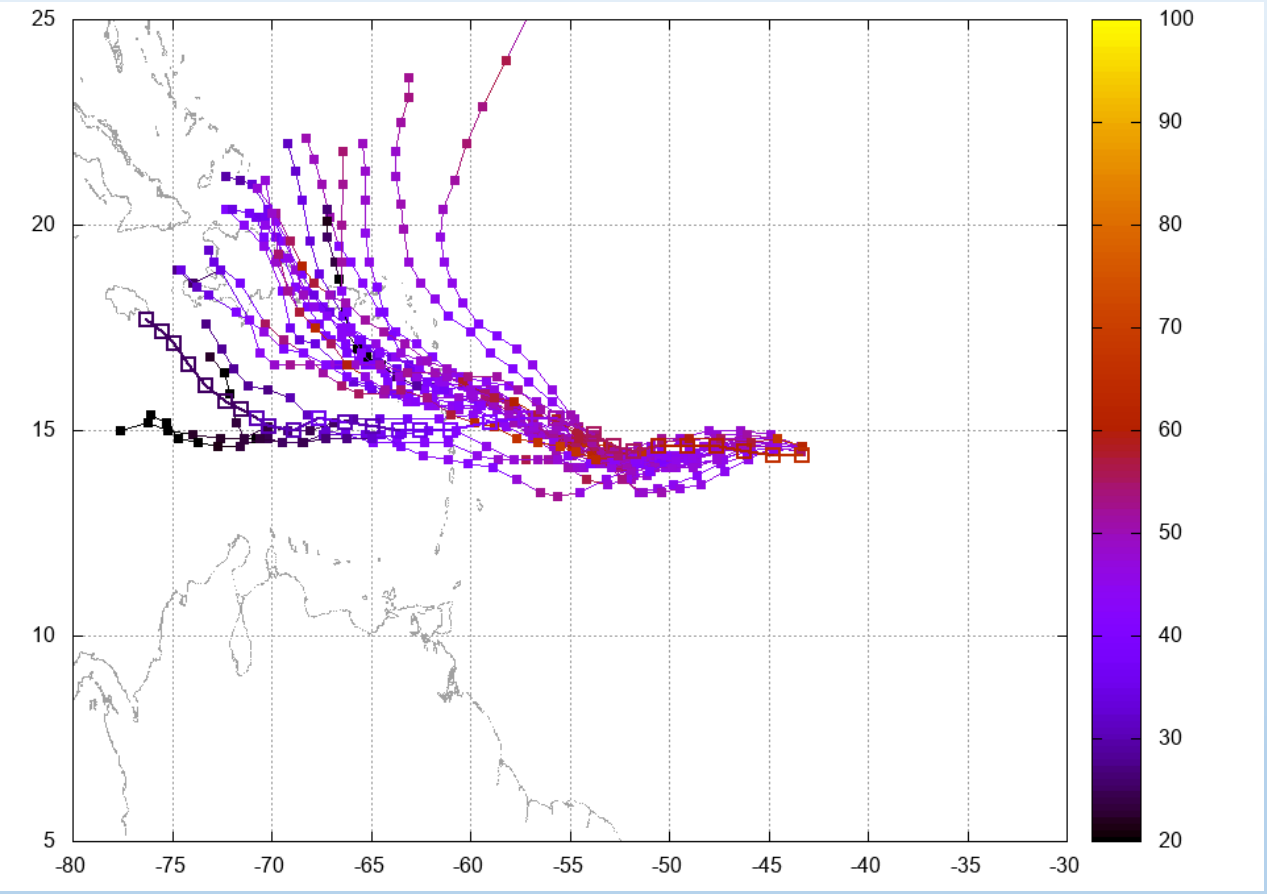



Forecast tracks of 20 GEFSv11(DA) members from 2018 September 10 0000 UTC model run

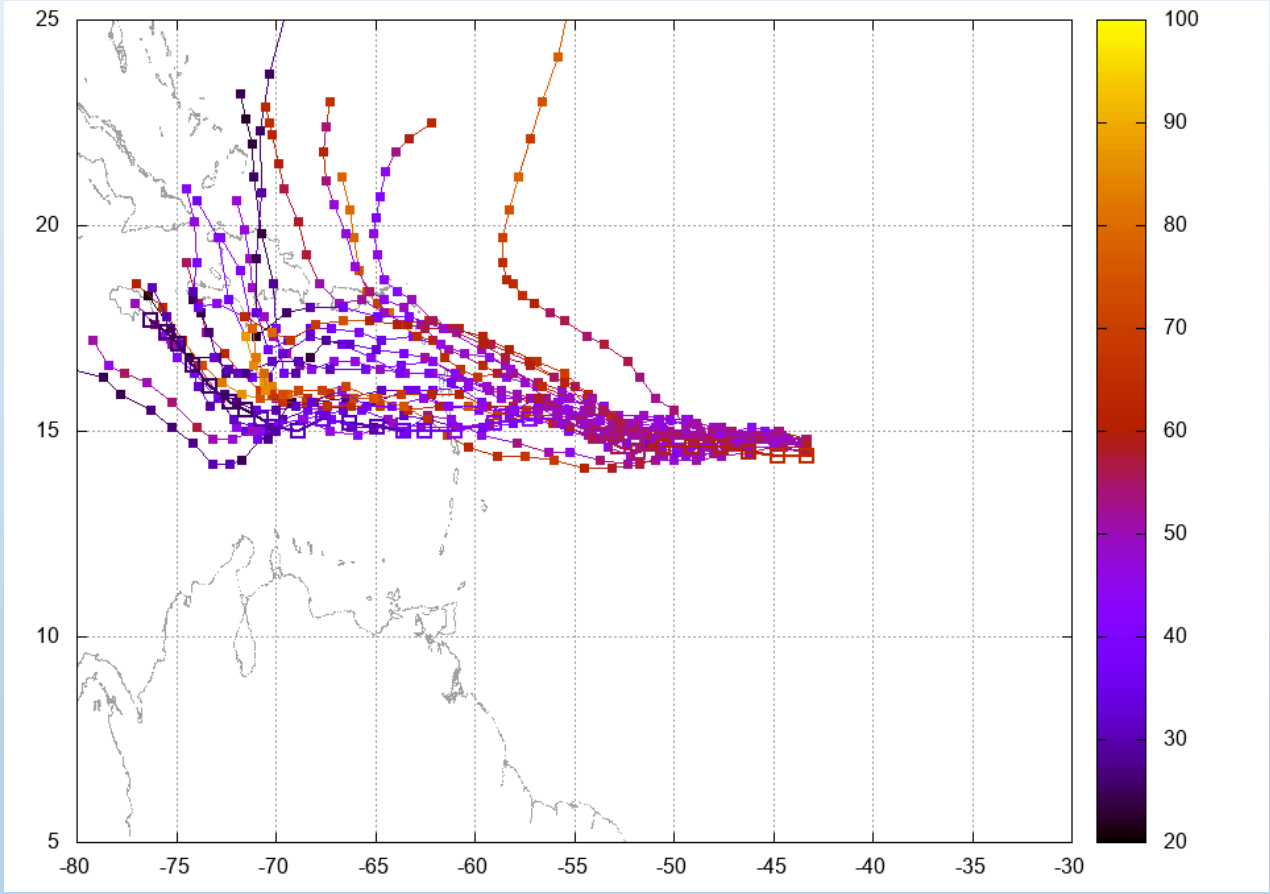



Forecast tracks of 20 GEFSv12 members from 2018 September 10 0000 UTC model run

# Examples of Individual Storms - Isaac




Forecast tracks of 20 GEFSv11(DA) members from 2018 September 10 1200 UTC model run




Forecast tracks of 20 GEFSv12 members from 2018 September 10 1200 UTC model run

# Conclusions: GEFSv12 vs. GEFSv11(DA)

- Tropical Storm forecast tracks show significantly more spread
  - Forecast box areas are statistically larger
  > than 50% larger at 72- to 168-hour lead times

- Success rates are slightly larger
  - Too few cases for statistical significance

- The change with GEFSv12 is positive for the forecast envelope

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# Spread in Preliminary GEFSv12

| | Forecast Box Area ($10^4$ square km) | | Success Rate (%) | |
|---|---|---|---|---|
| | GEFSv12 | ECMWF | GEFSv12 | ECMWF |
| 12 | 4.7 | 7.4 | 71.8 | 88.9 |
| 24 | 7.3 | 12.0 | 71.4 | 85.7 |
| 36 | 14.4 | 17.8 | 76.5 | 76.5 |
| 48 | 22.5 | 25.1 | 75.8 | 72.7 |
| 72 | 57.6 | 50.3 | 77.4 | 80.6 |
| 96 | 106.8 | 99.4 | 72.4 | 82.8 |
| 120 | 211.3 | 176.1 | 77.8 | 74.1 |
| 144 | 391.3 | 331.9 | 80.0 | 64.0 |
| 168 | 688.7 | 597.6 | 73.9 | 82.6 |