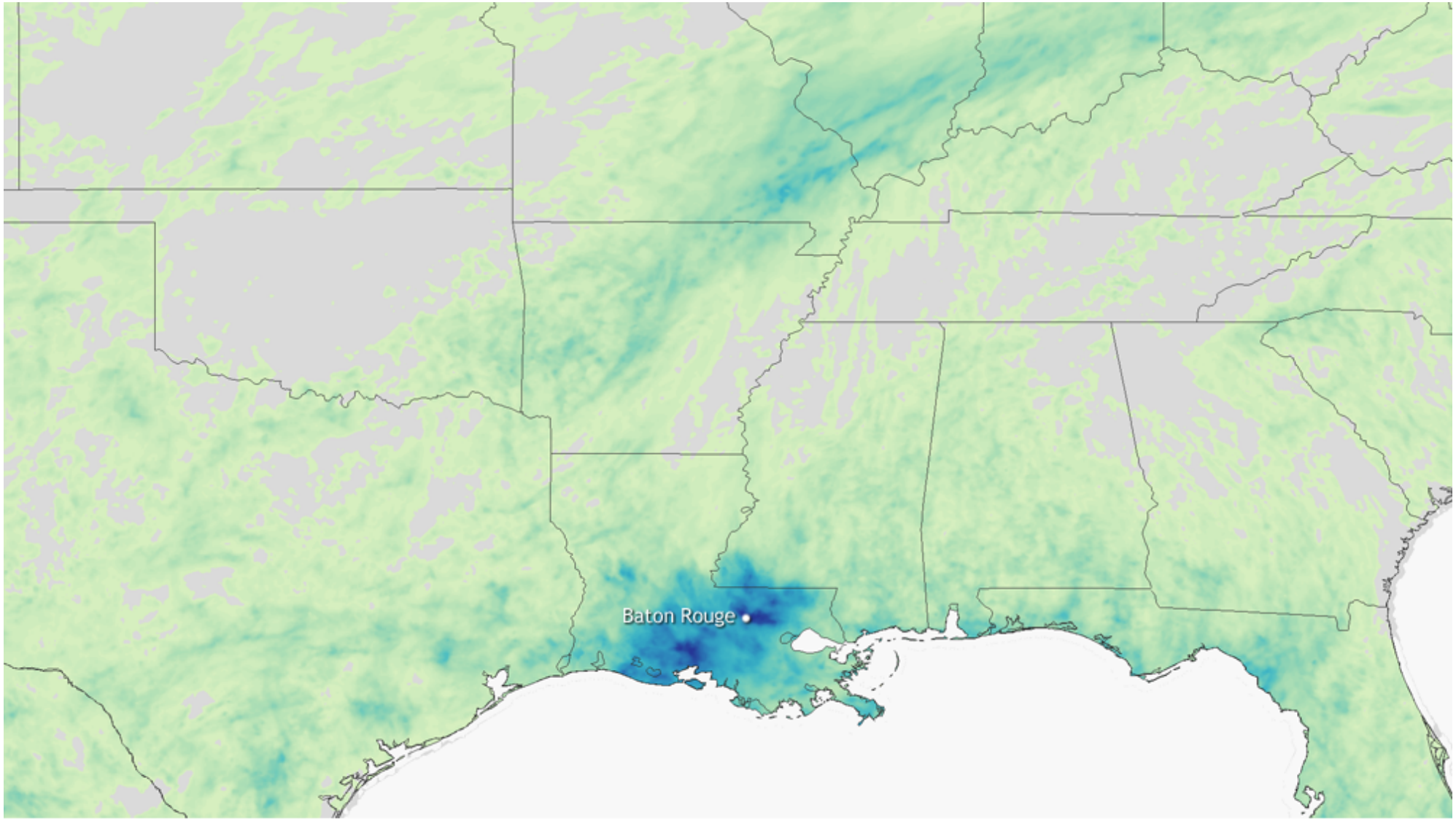
Louisiana Flooding Case: 12 -15 August 2016

Lindsay Blank and Tracy Hertneky

Synoptic Discussion

August 8-15 2016 Rain Totals



August 8-15, 2016

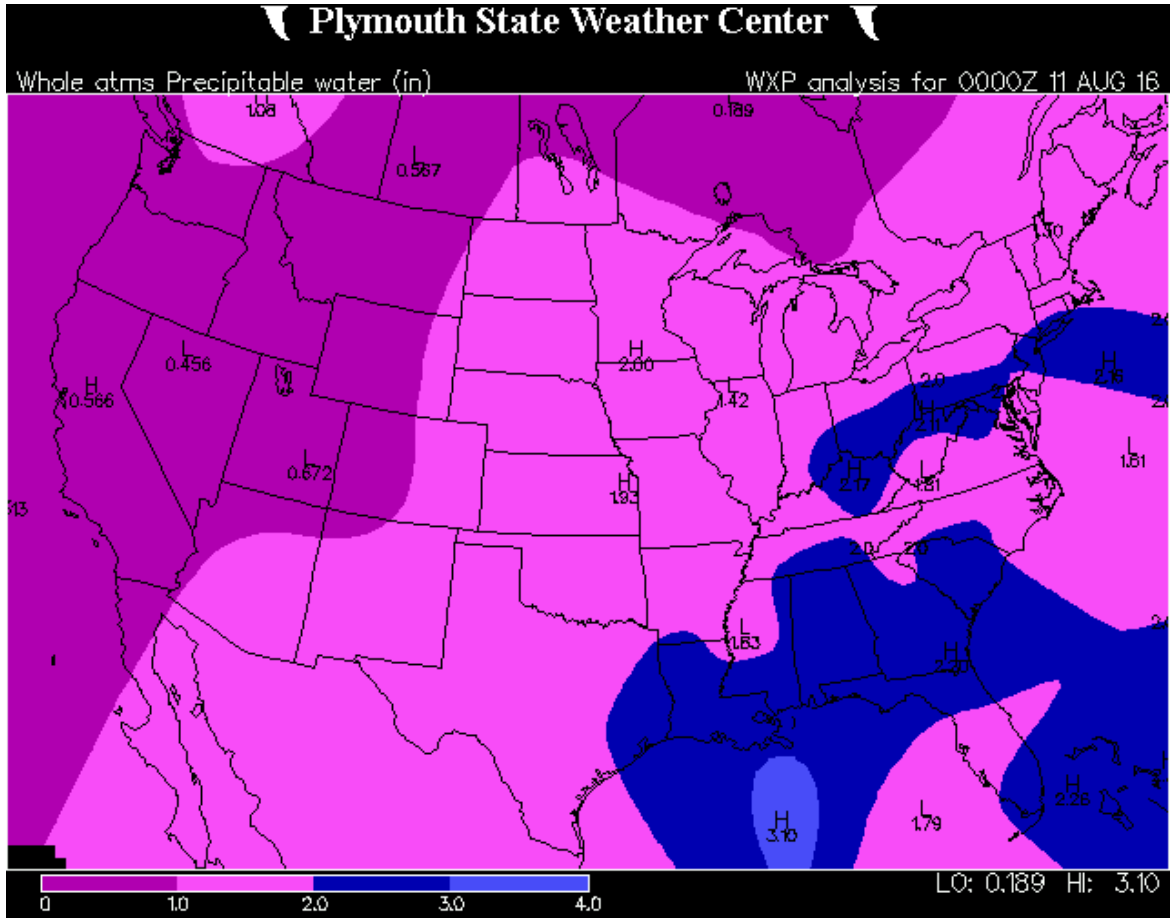
Precipitation (inches)

0 25

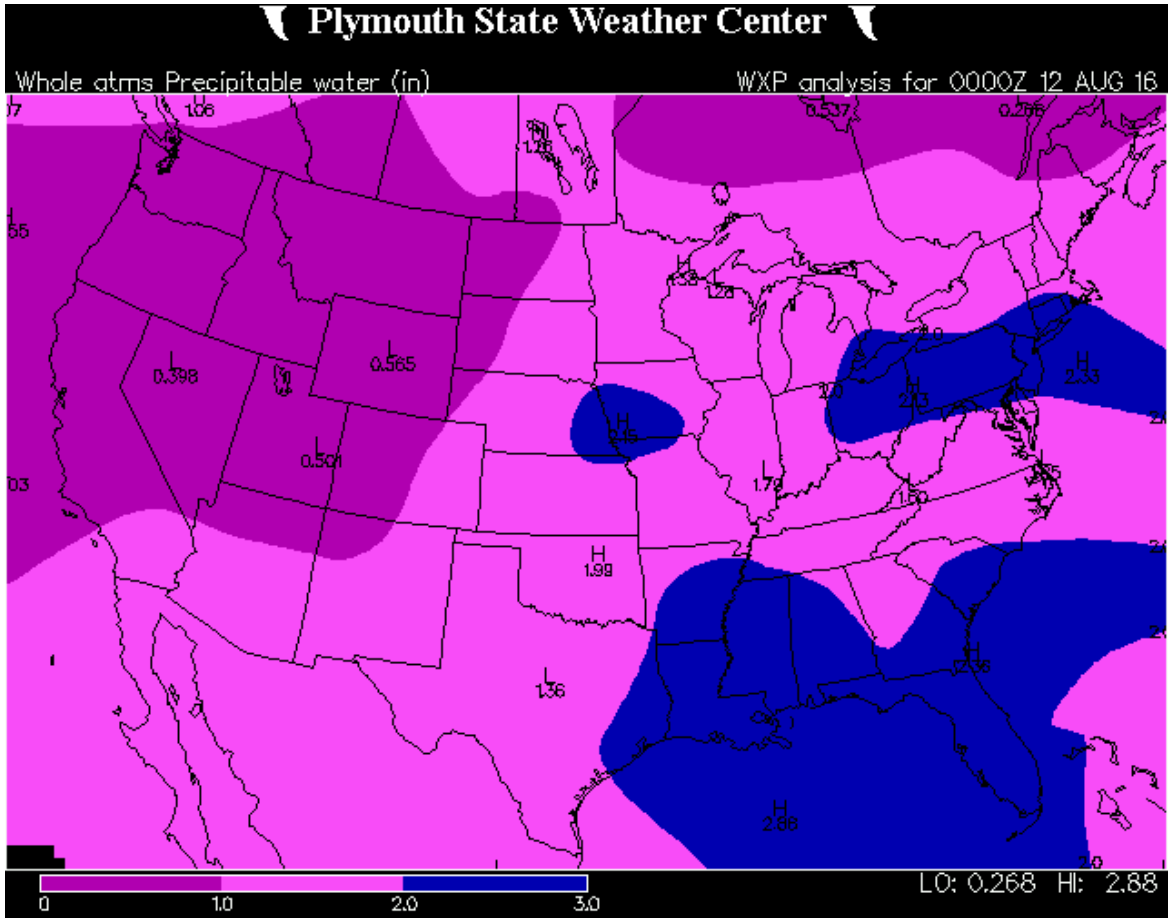
Climate.gov
Source: AHPS (PRISM)

Precipitable Water – Entire Atmosphere

11 August 00 UTC



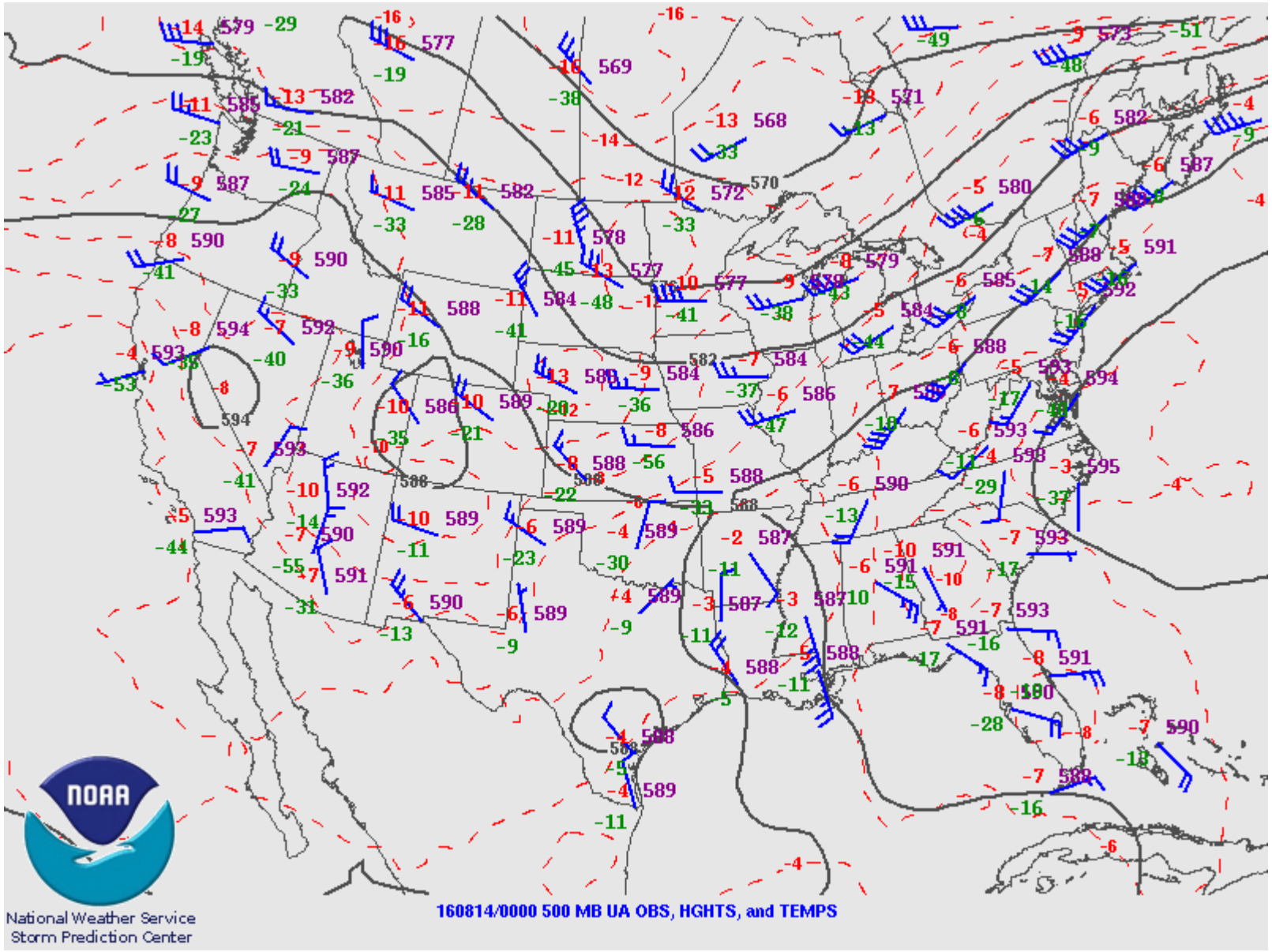
12 August 00 UTC



Near record precipitable water values in the range of 2.5-2.75 inches.

500 mb Heights

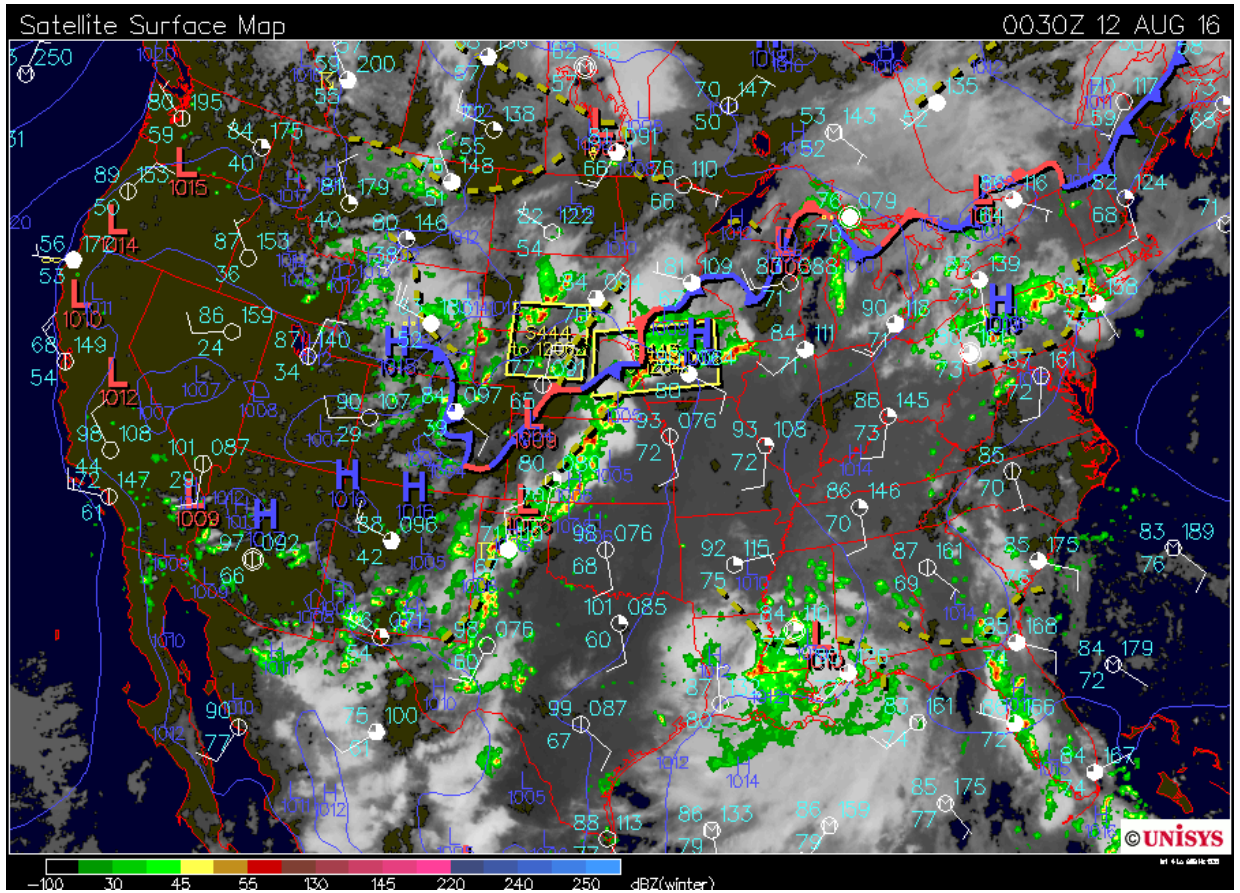
14 August 00 UTC



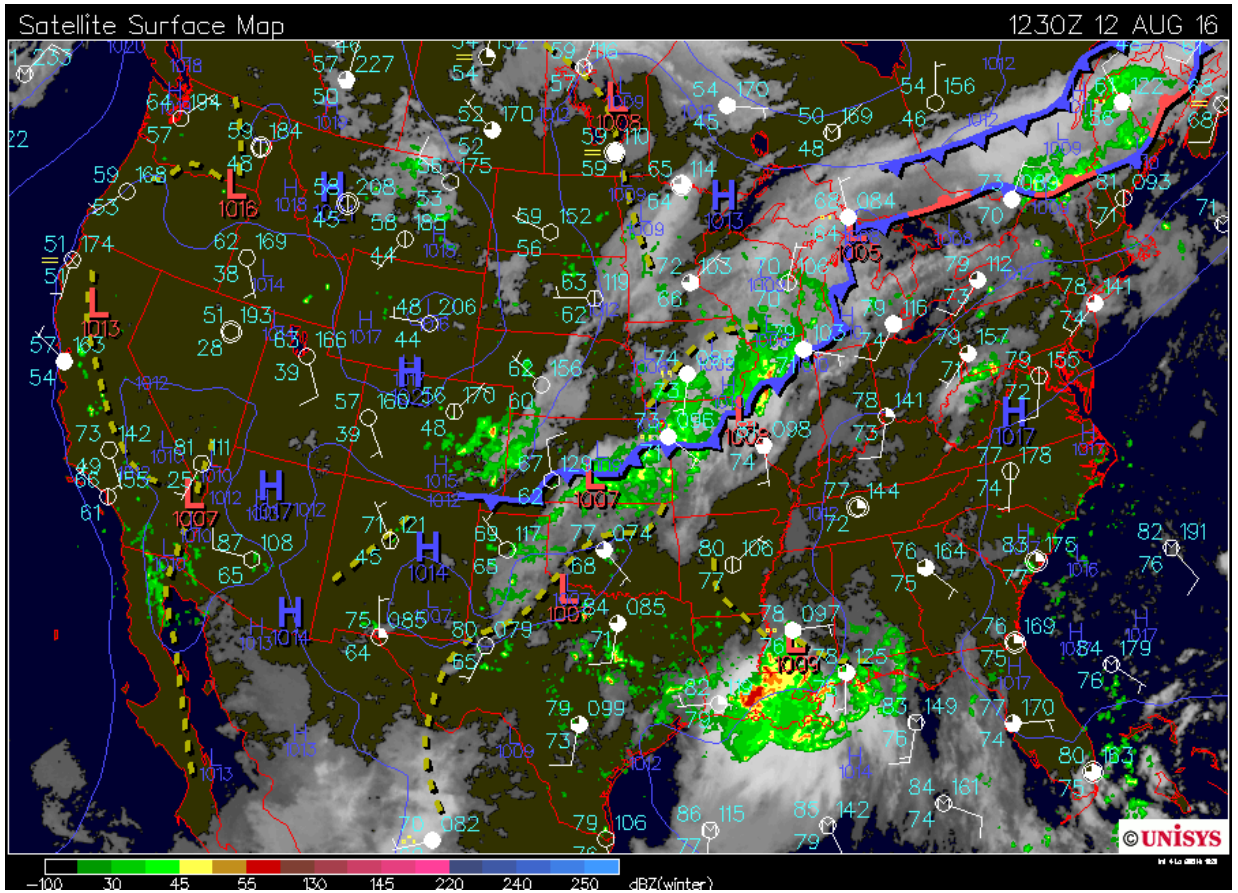
Eastward propagating baroclinic through

Surface

12 August 00 UTC

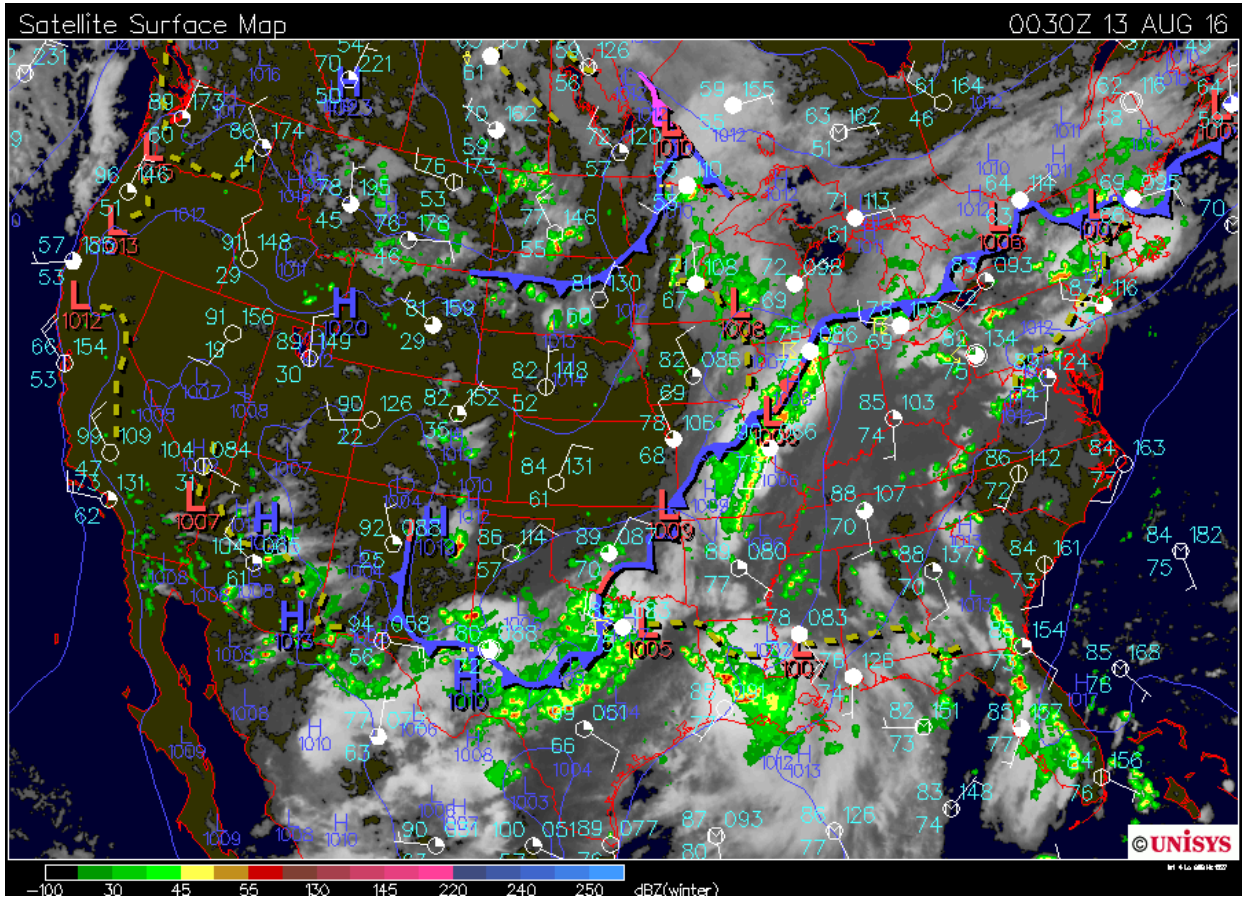


12 August 12 UTC

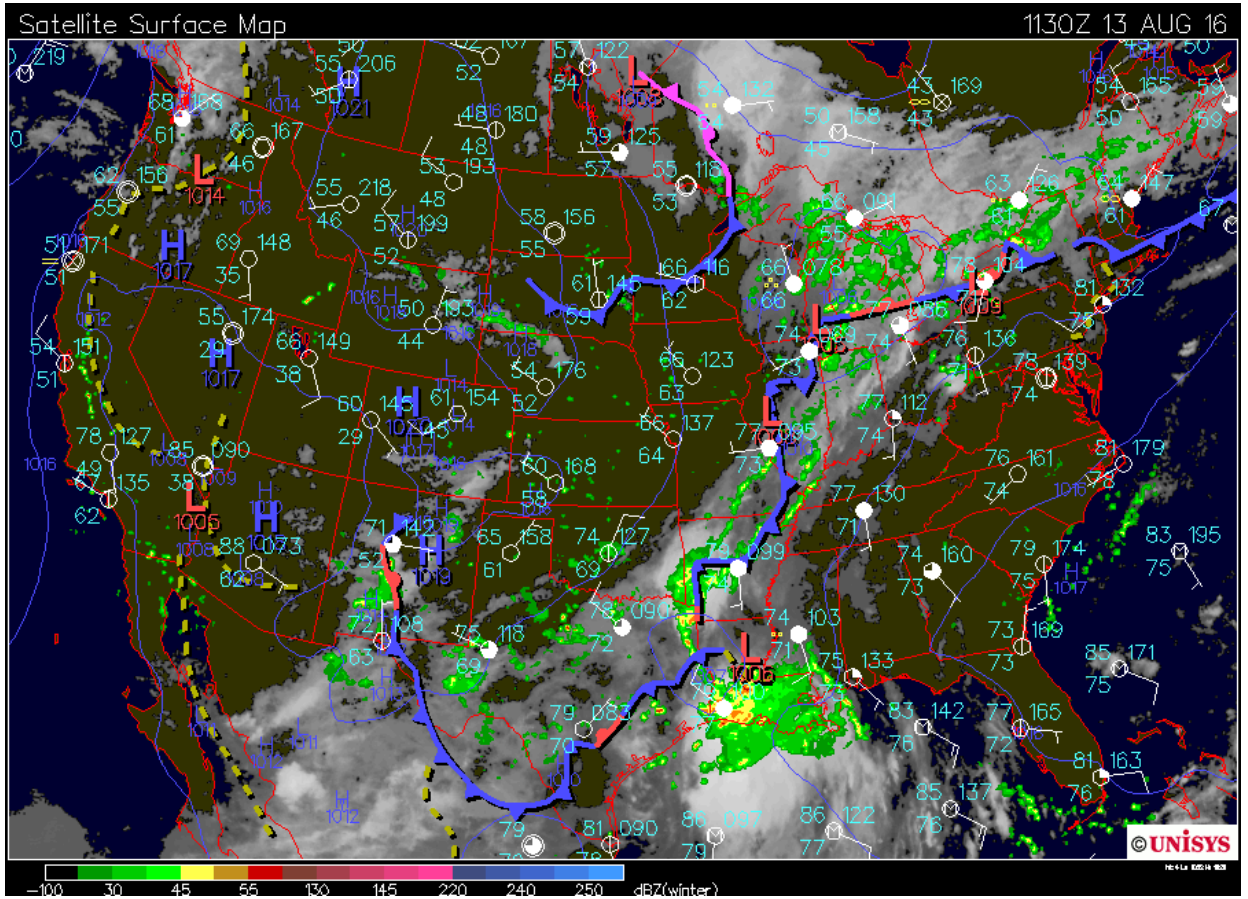


Surface

13 August 00 UTC

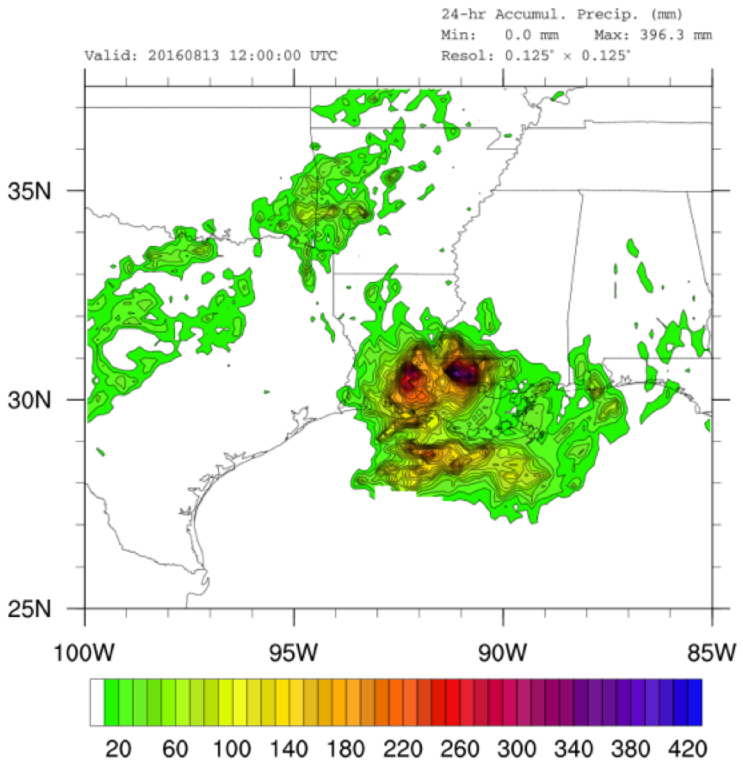


13 August 12 UTC

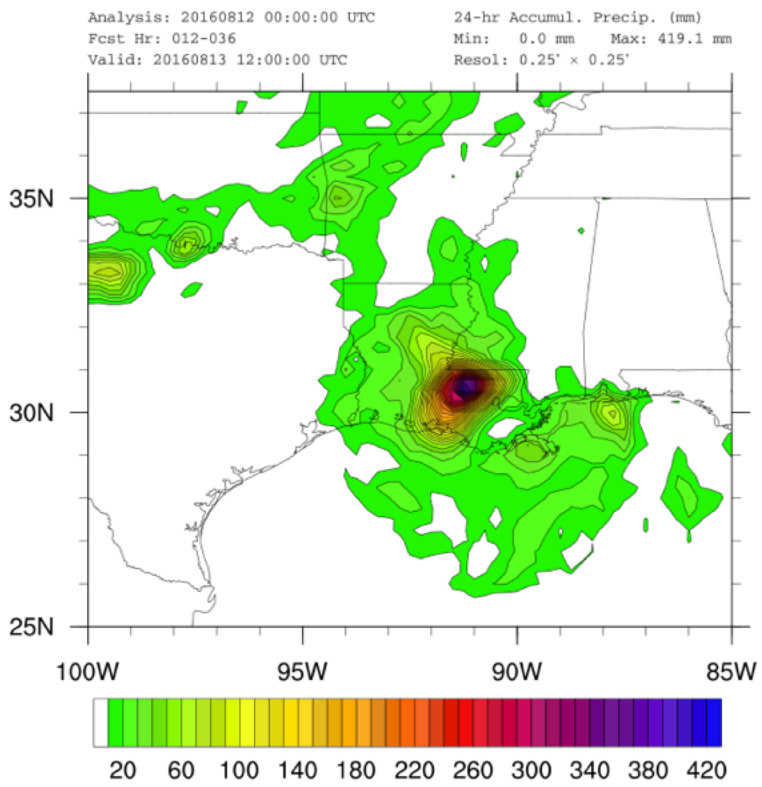


Louisiana Flooding Precipitation Accumulation (24-hr accumulations ending at 1200 UTC on 13 October 2016)

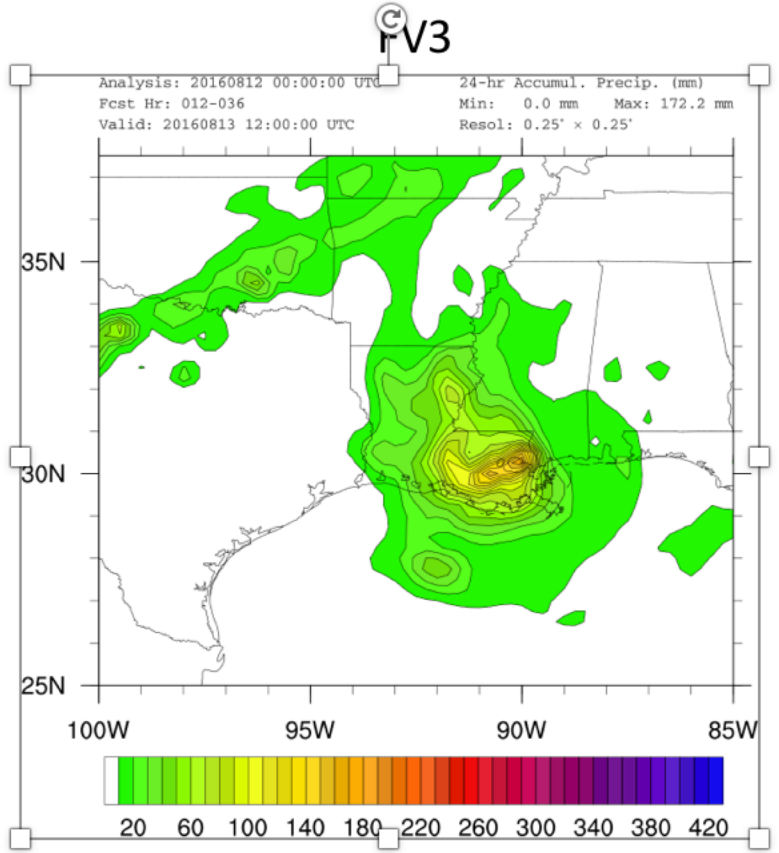
CCPA



GFS



FV3

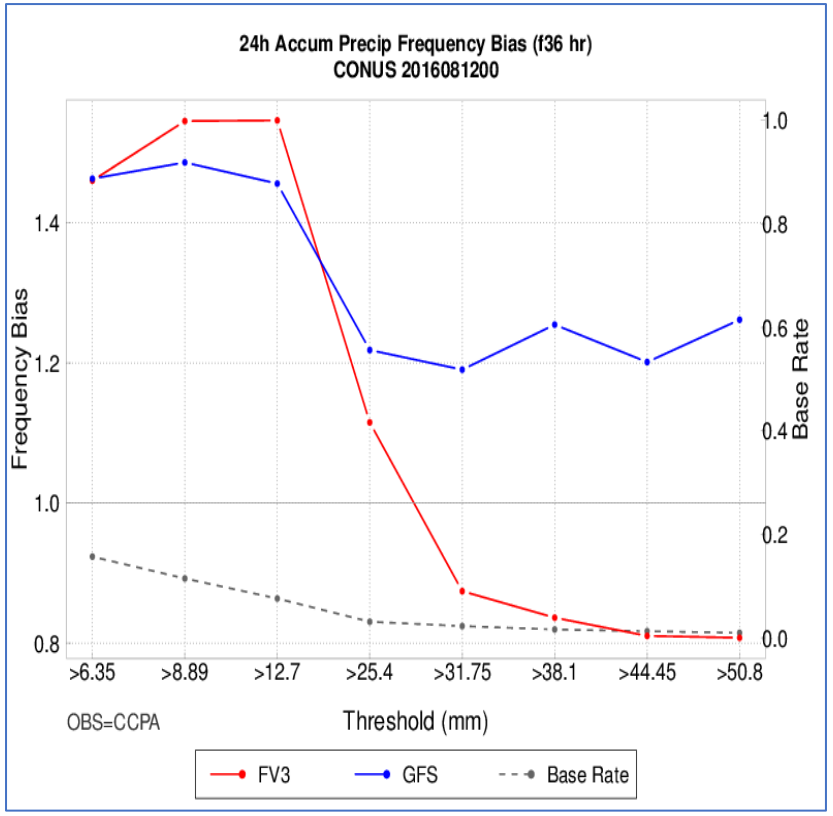


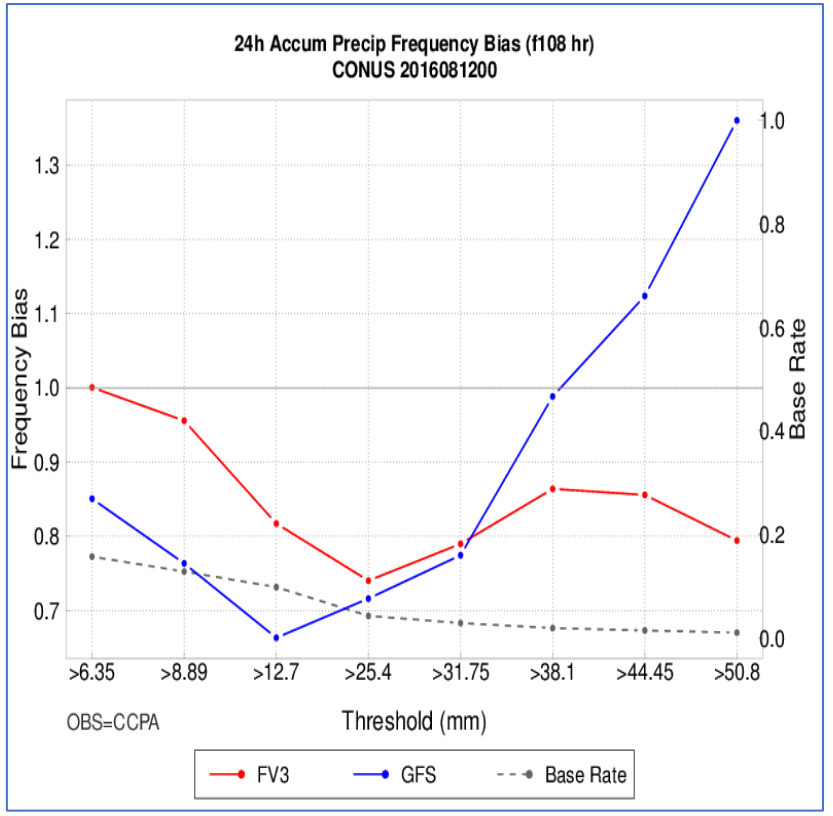
- GFS captures the eastern extreme in precipitation, but misses areas to the west and south
- FV3 also captures the eastern extreme and correctly expands that maximum west, but too far north as well
- GFS correctly estimates rainfall totals for this period, while FV3 severely underestimates

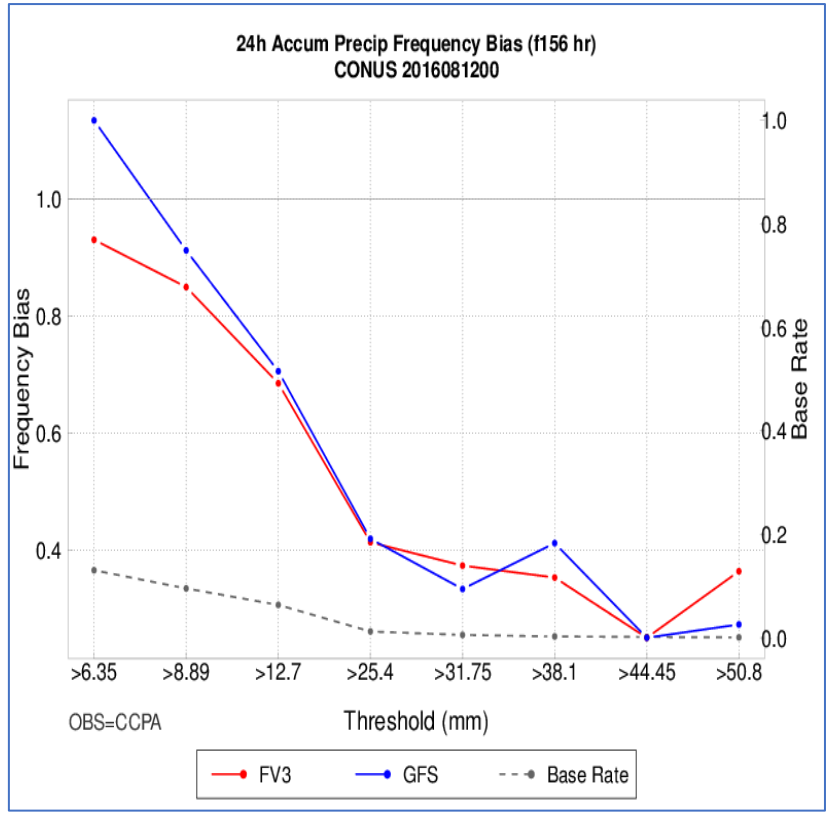
Courtesy of Gerard Ketefian and Jeff Beck.

Metric Analysis by Precipitation Threshold

24 hour Accum. Precipitation Frequency Bias



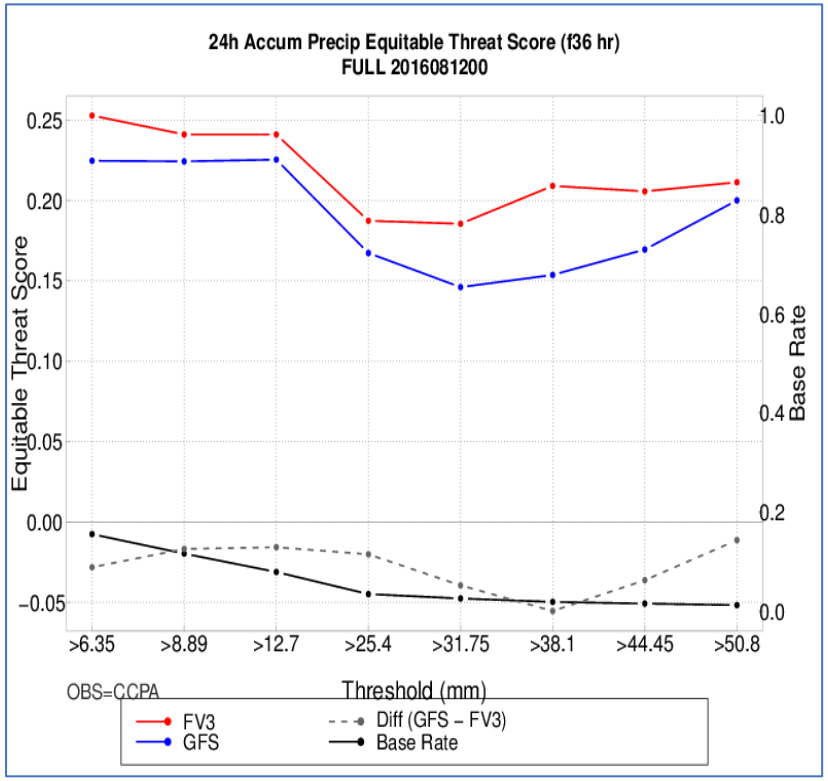


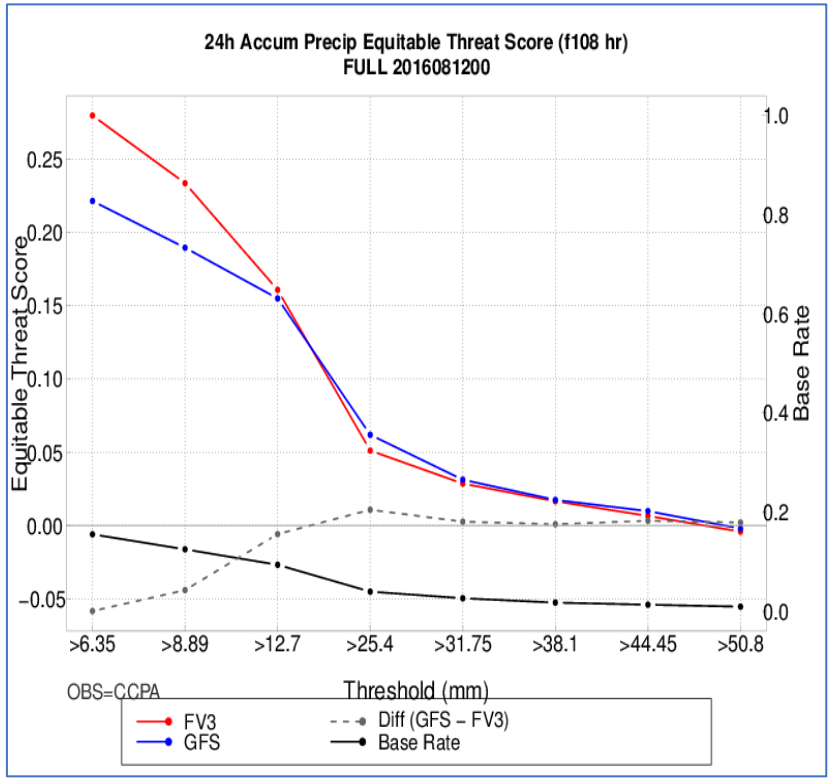


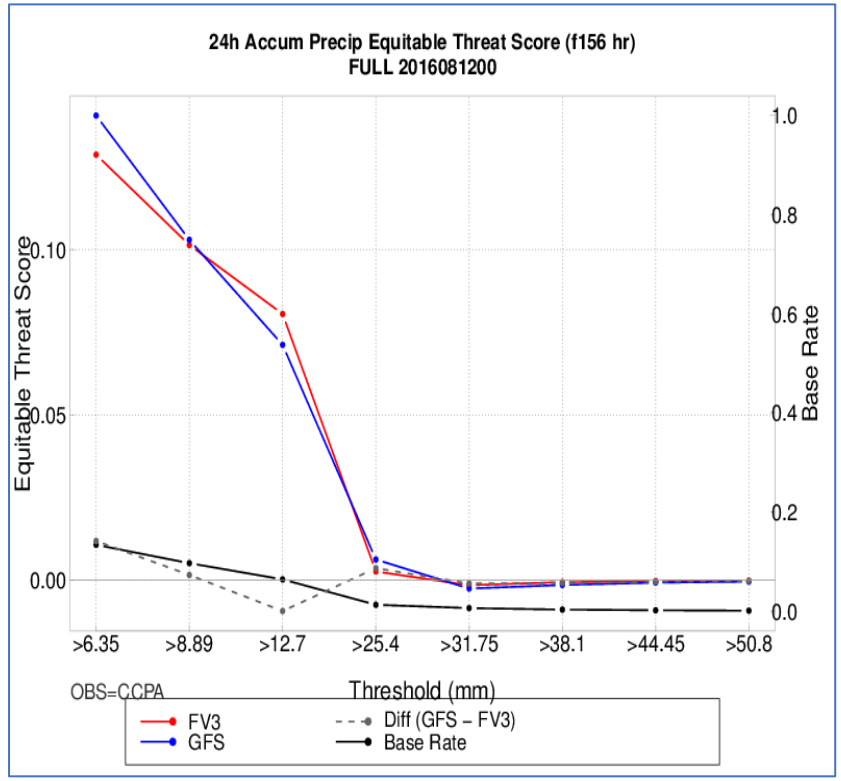
24 hour Accum. Precipitation Frequency Bias

- As lead time increases, the overall value of the FV3 frequency bias decreases for all thresholds.
- FV3 consistently under forecasts mid-high precipitation thresholds (>31.7mm and above) at all lead times.
- GFS does not display a similarly consistent frequency bias trend with time.
- GFS behaves similarly to FV3 for the first 3 precipitation thresholds across all lead times.
- As lead time increases, the more thresholds the GFS under forecasts

24 hour Accum. Precipitation Equitable Threat Score





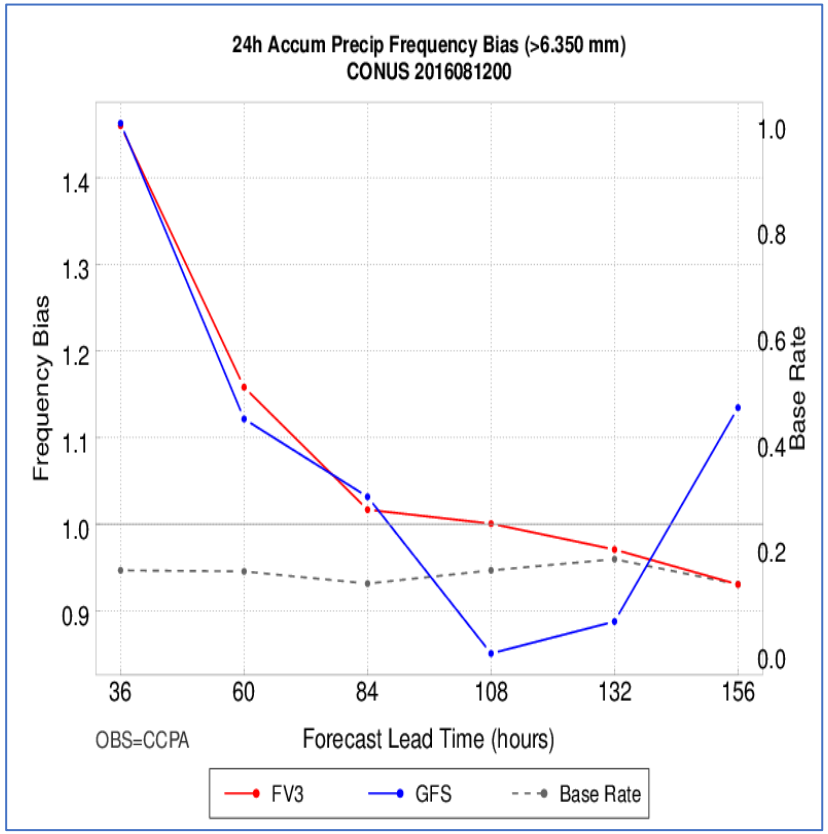


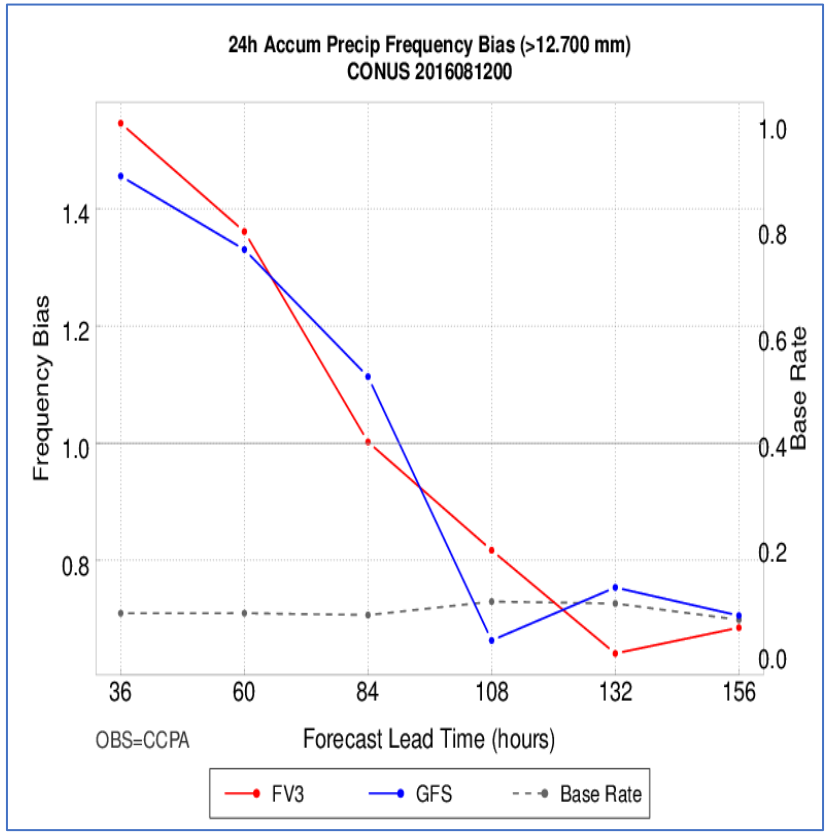
24 hour Accum. Precipitation Equitable Threat Score

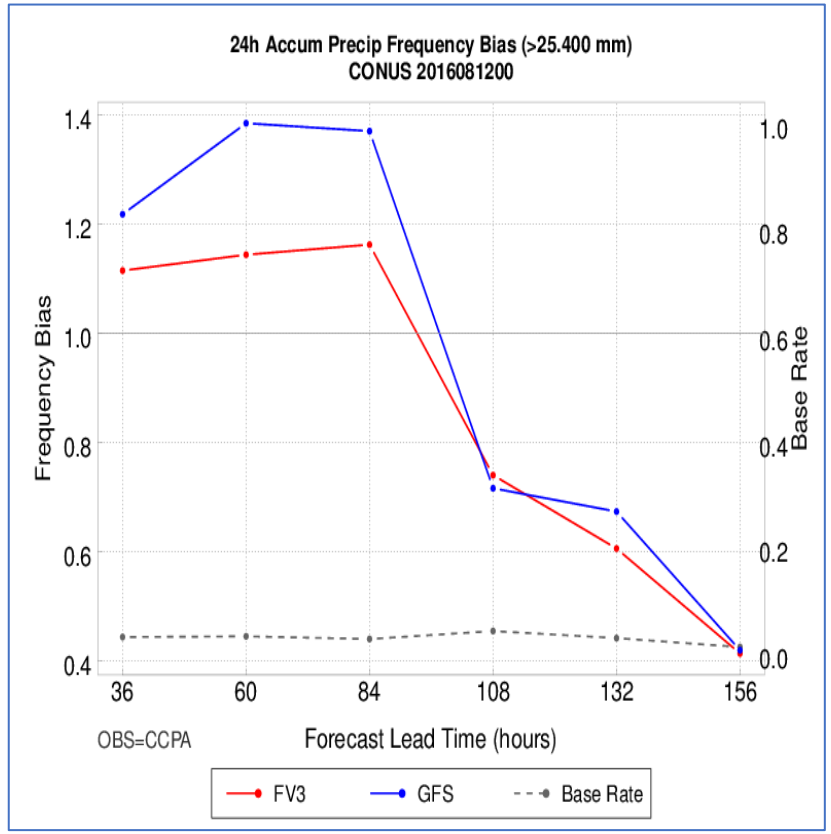
- Both the GFS and FV3 has approximately equal skill across thresholds and forecast lead times.
- Both models exhibit an overall decrease in skill, eventually converging with no skill for precipitation thresholds >31.75mm and up at 156 hours.
- Both models perform better with lower thresholds (>12.7 and lower), with FV3 showing slightly better skill at early and medium forecast lead times.

Metric Analysis by Lead Time

24 hour Accum. Precip. Threshold Frequency Bias

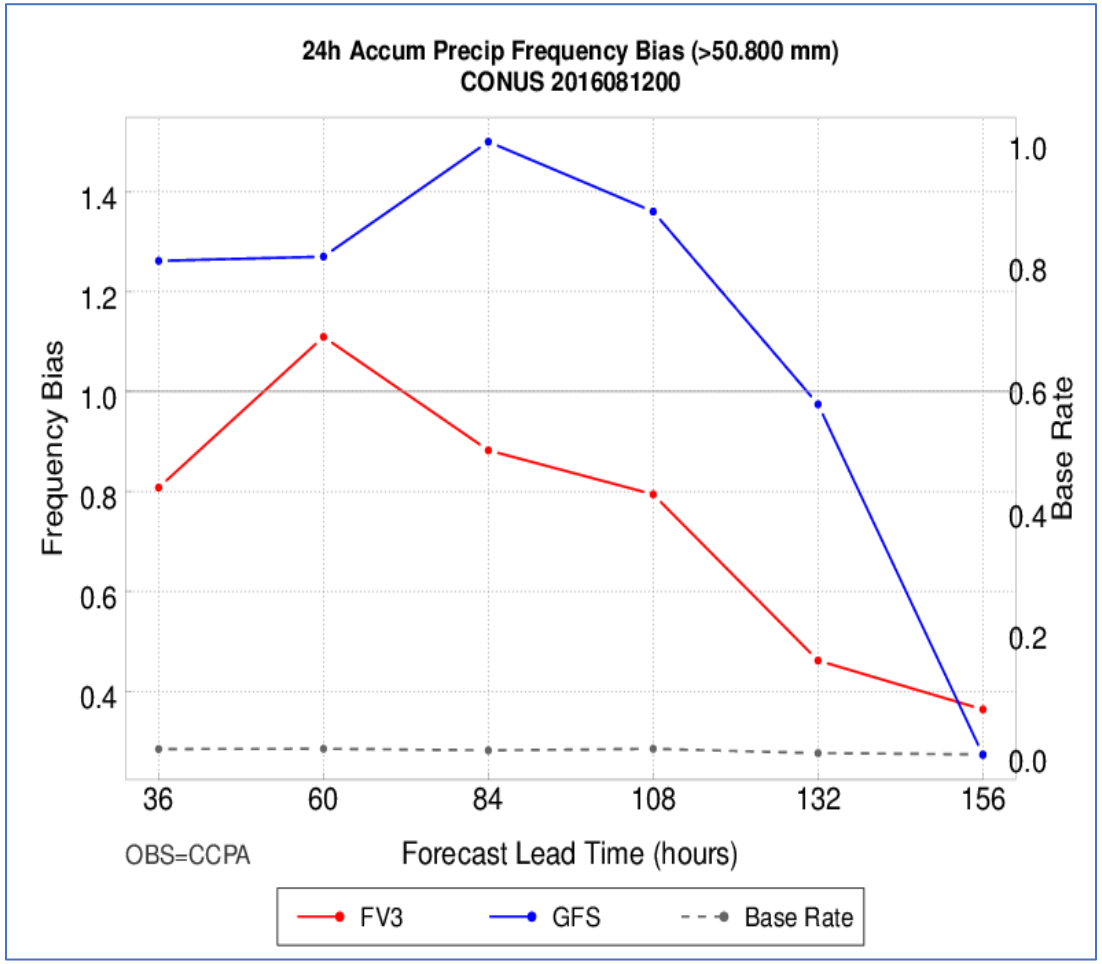




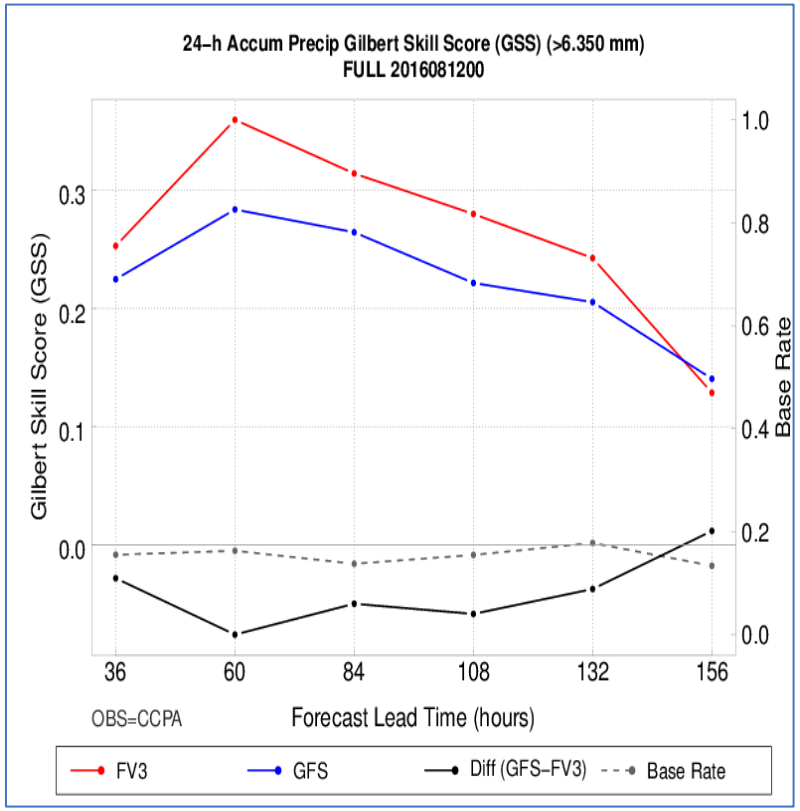


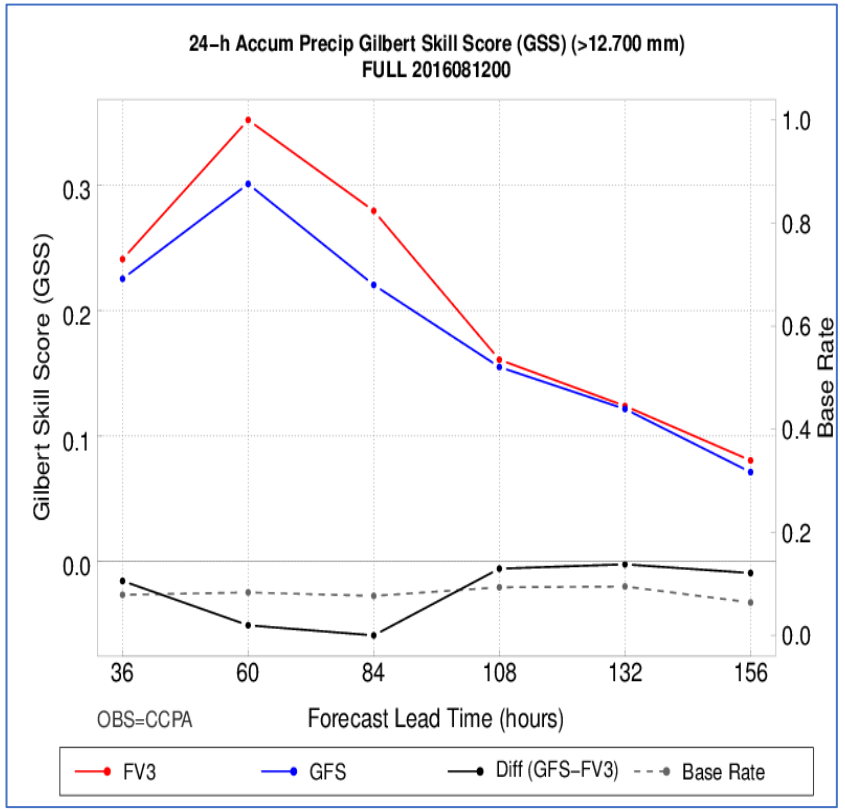
24 hour Accum. Precip. Threshold Frequency Bias

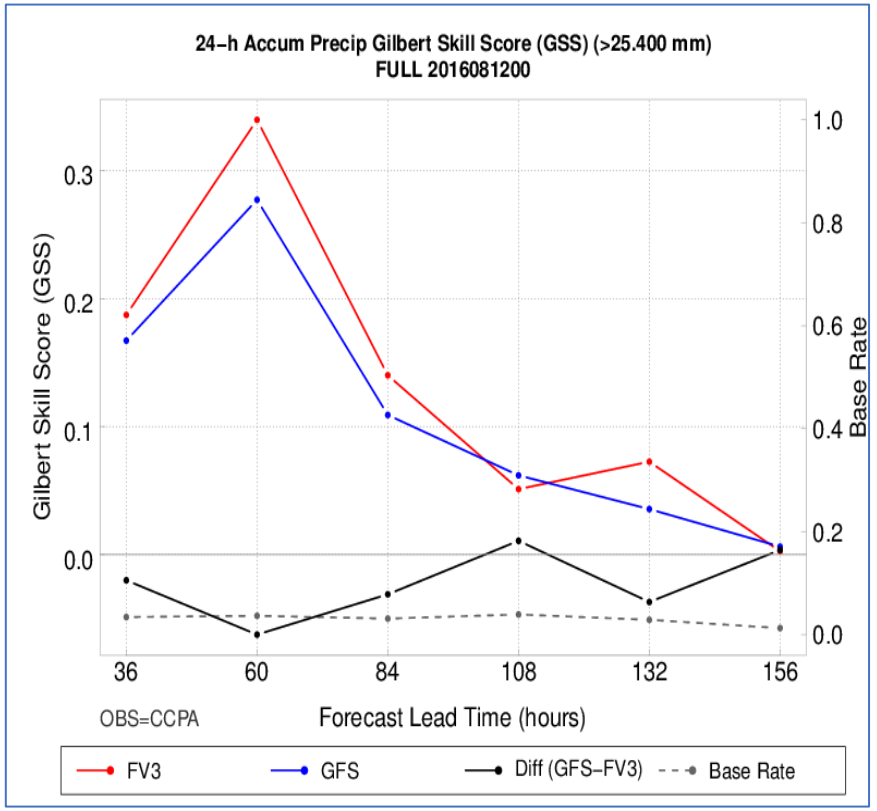
- Across all 4 analyzed thresholds (>6.35, >12.7, >25.4, and >50.8mm) both model frequency biases generally decrease with forecast lead time.
- Both models perform their best forecasting the >6.35mm threshold. FV3 performs better with increasing lead time while the GFS displays no such trend in skill.
- FV3 and the GFS display the greatest differences in frequency bias for >50.8mm threshold. The GFS always has a higher value of frequency bias than FV3 until hour 156. Until hour 132, FV3 is generally under forecasting while GFS is always over forecasting.



24 hour Accum. Precip. Threshold Equitable Threat Score

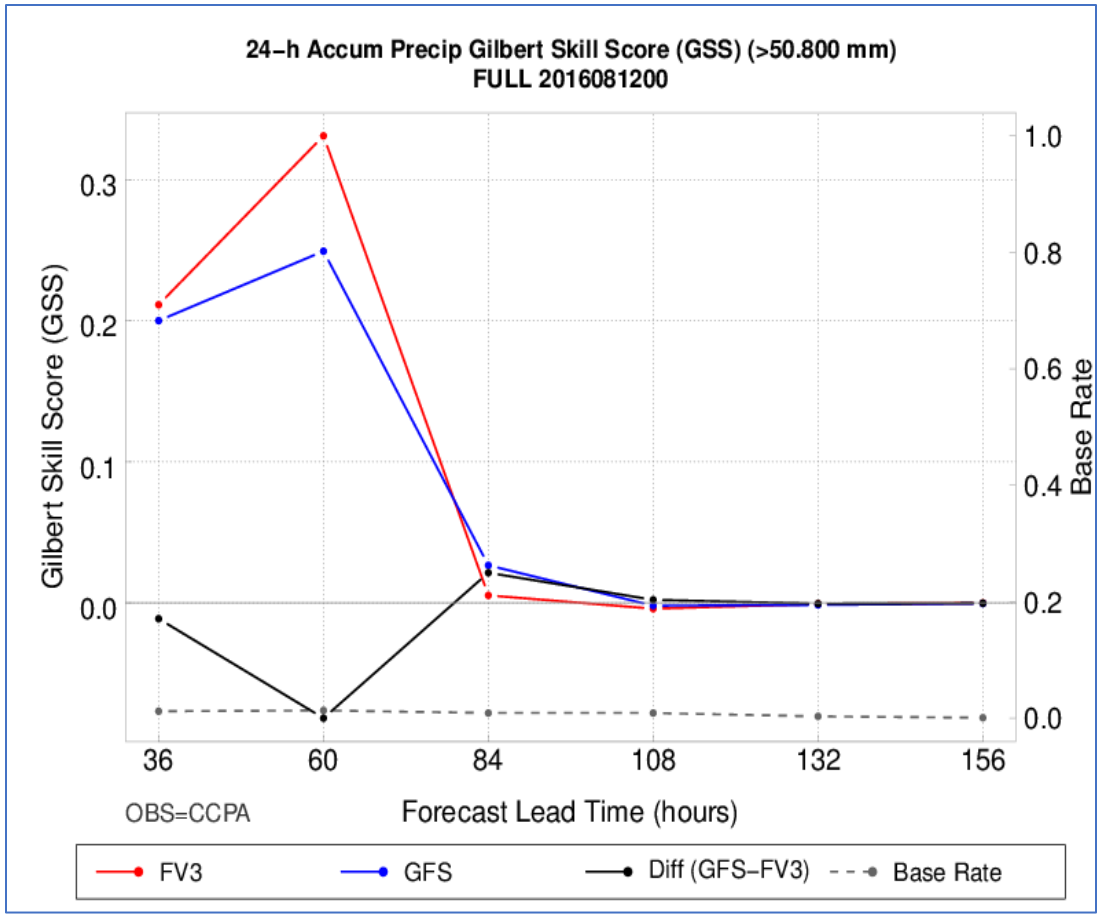




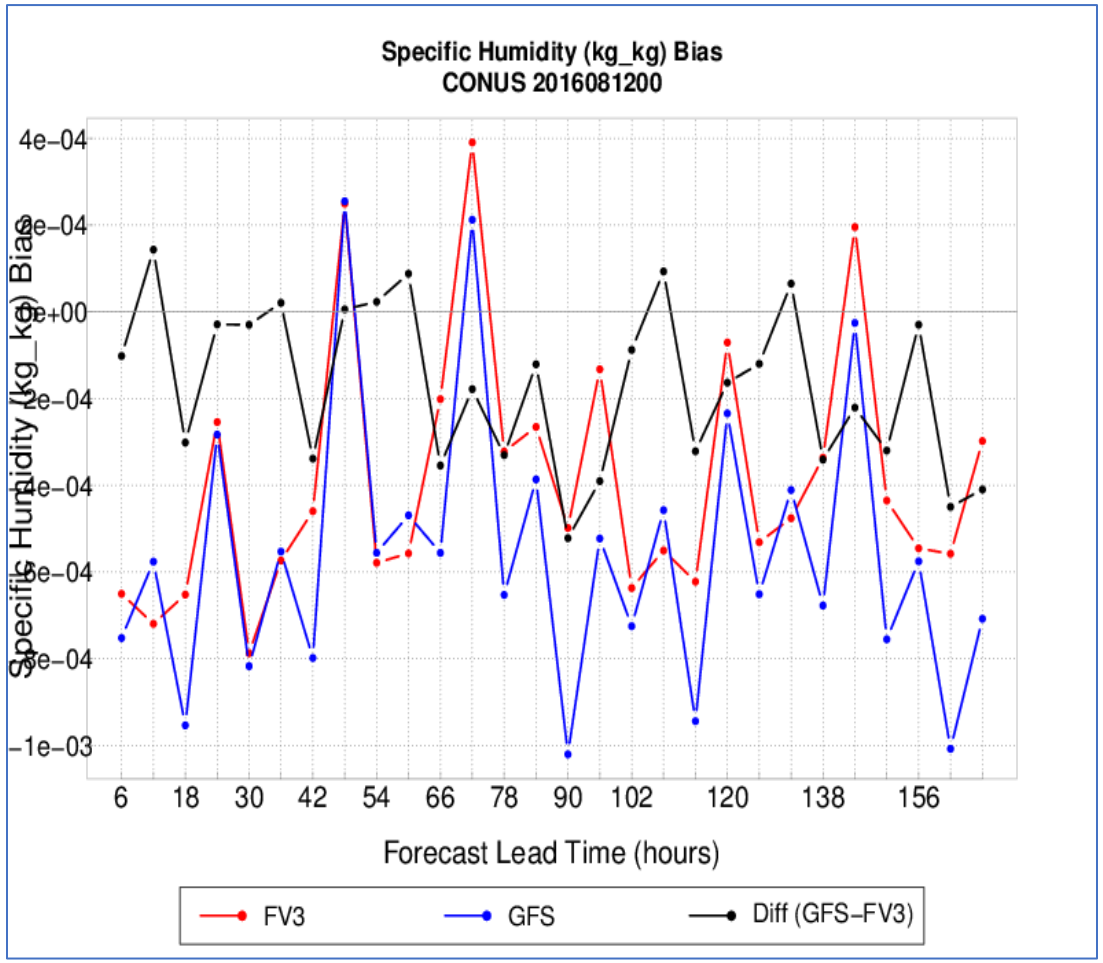


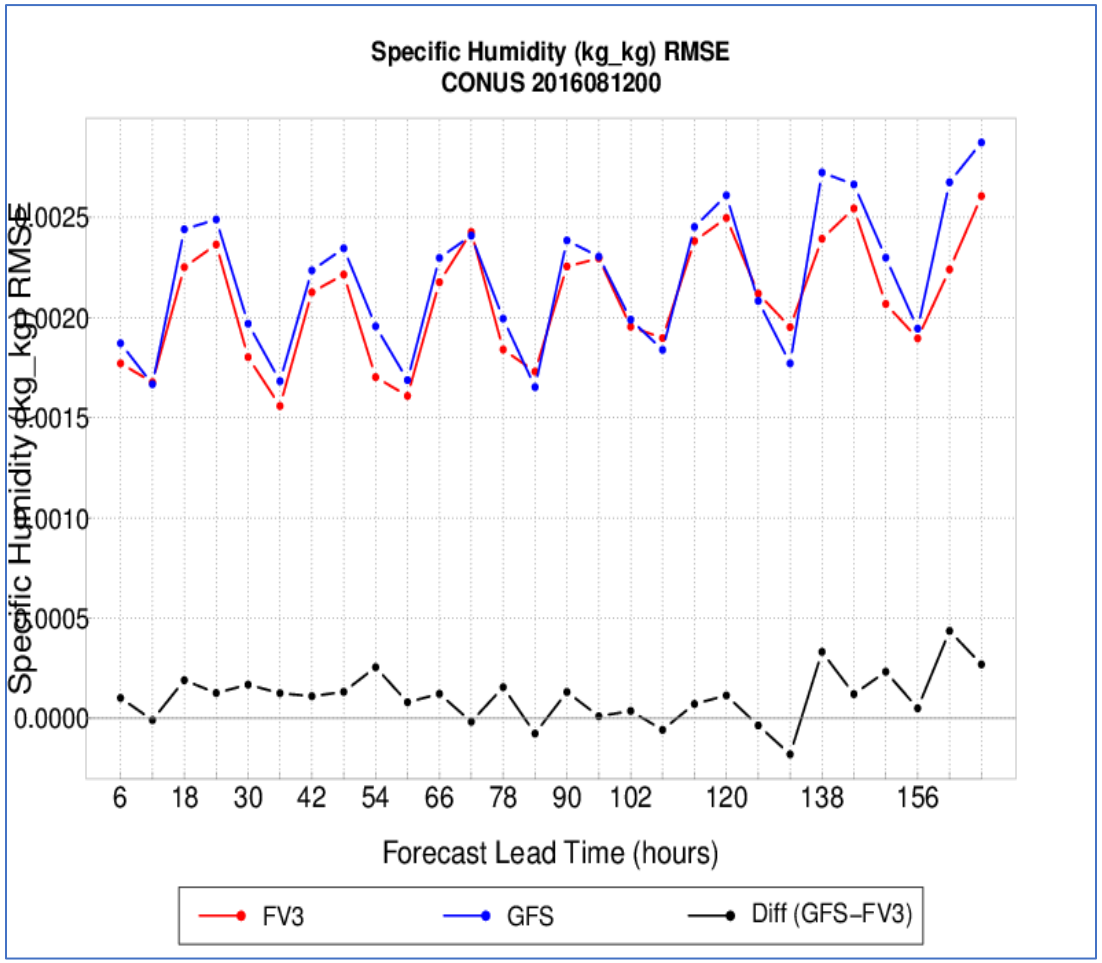
24 hour Accum. Precip. Threshold Equitable Threat Score

- FV3 has slightly more skill than GFS across all lead times for >6.35, >12.7, and >25.4mm thresholds.
- FV3 and GFS have the greatest skill across all thresholds at 60 hours, with FV3 displaying slightly more skill.
- As forecast lead time increases, the skill decreases for both FV3 and GFS.



Surface Specific Humidity

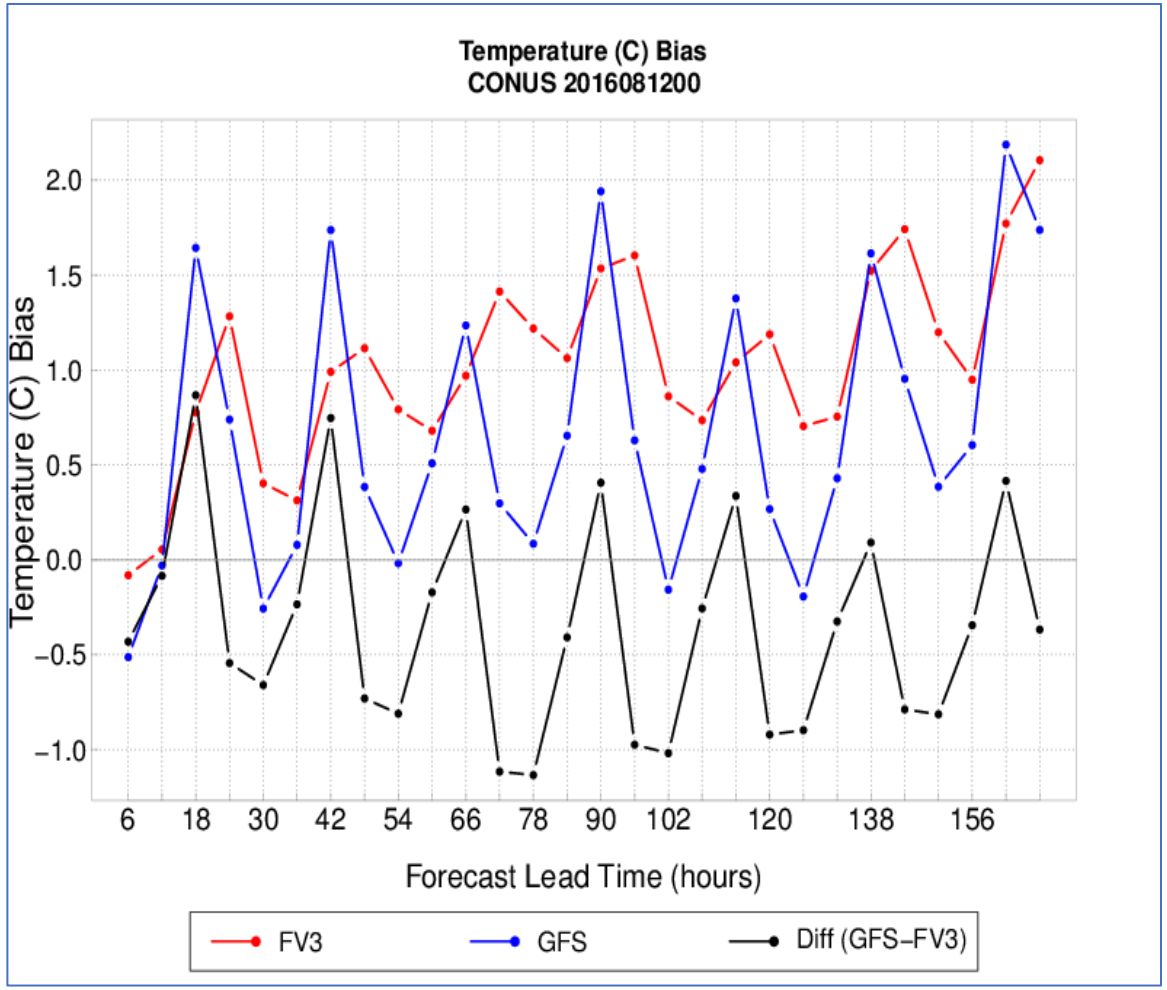


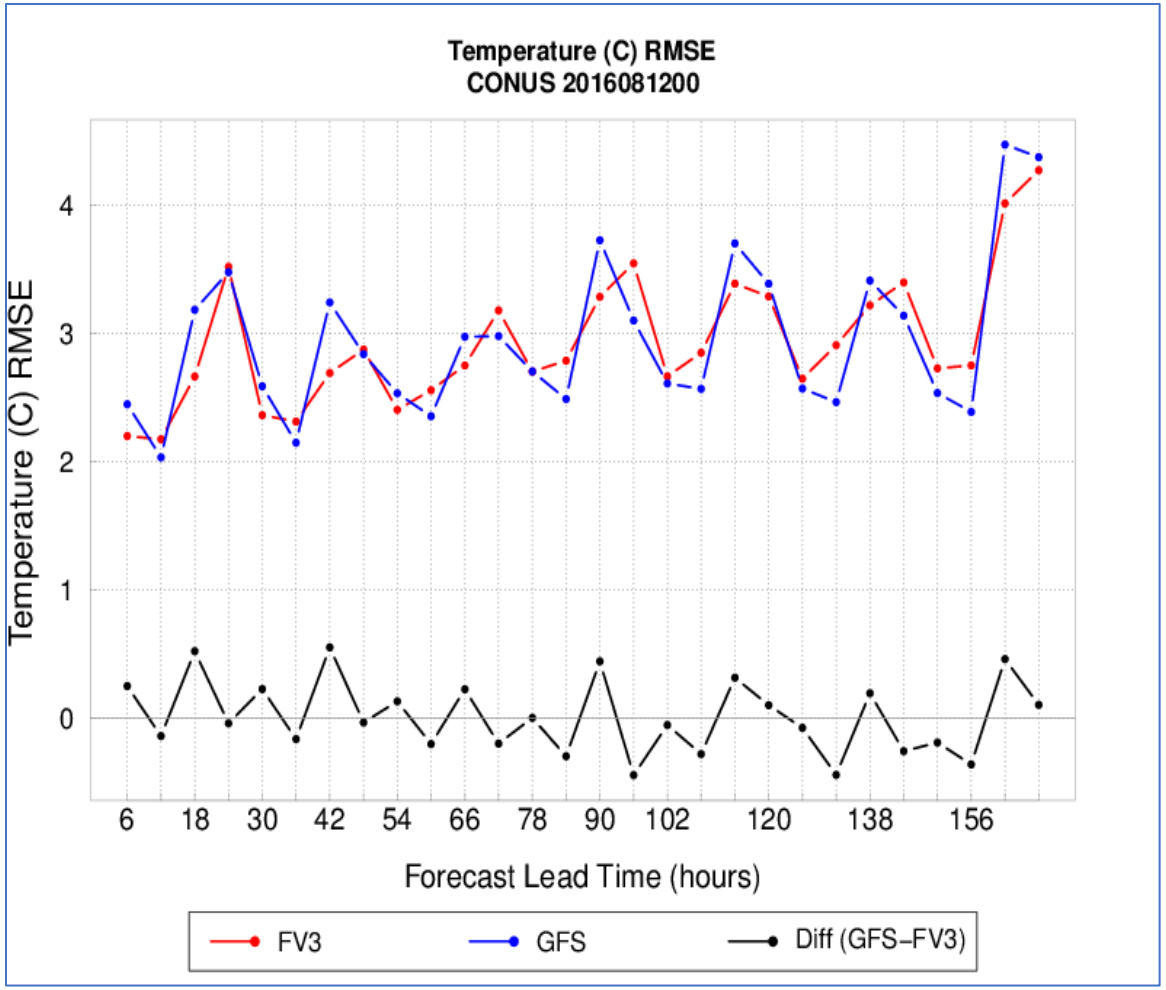


Surface Specific Humidity

- Bias:
  - Dry bias is noted at most lead times, however; values are small on the order of 10^{-4} kg/kg.
  - Differences between the models are small, with FV3 generally showing less of a dry bias.
  - A diurnal signal is less apparent, however; larger peaks in bias are often observed at 00 UTC. A few diurnal peaks transition to a slight moist bias.
- RMSE:
  - A similar RMSE is observed for both models with small differences on the order of 10^{-4} kg/kg.
  - GFS sees a slightly higher RMSE for most lead times, especially for the first 72 hours as well as the final 30 hours of the forecast.
  - A diurnal signal in RMSE is noted, with peaks, in the afternoon (18-24 UTC) and minimums at 12 UTC.
  - A gradual increase in RMSE is observed over forecast lead time, with values confined to 1.5E-03 and 3E-03.

Surface Temperature

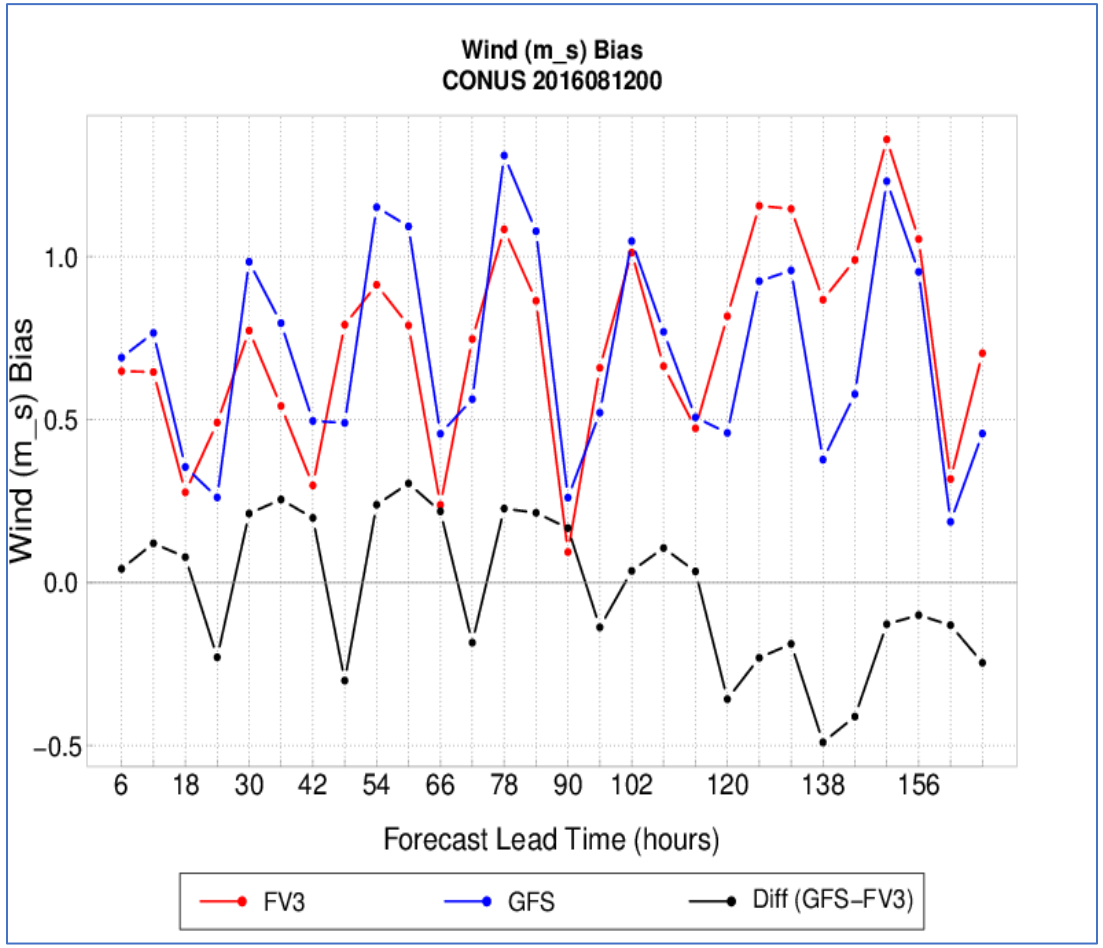


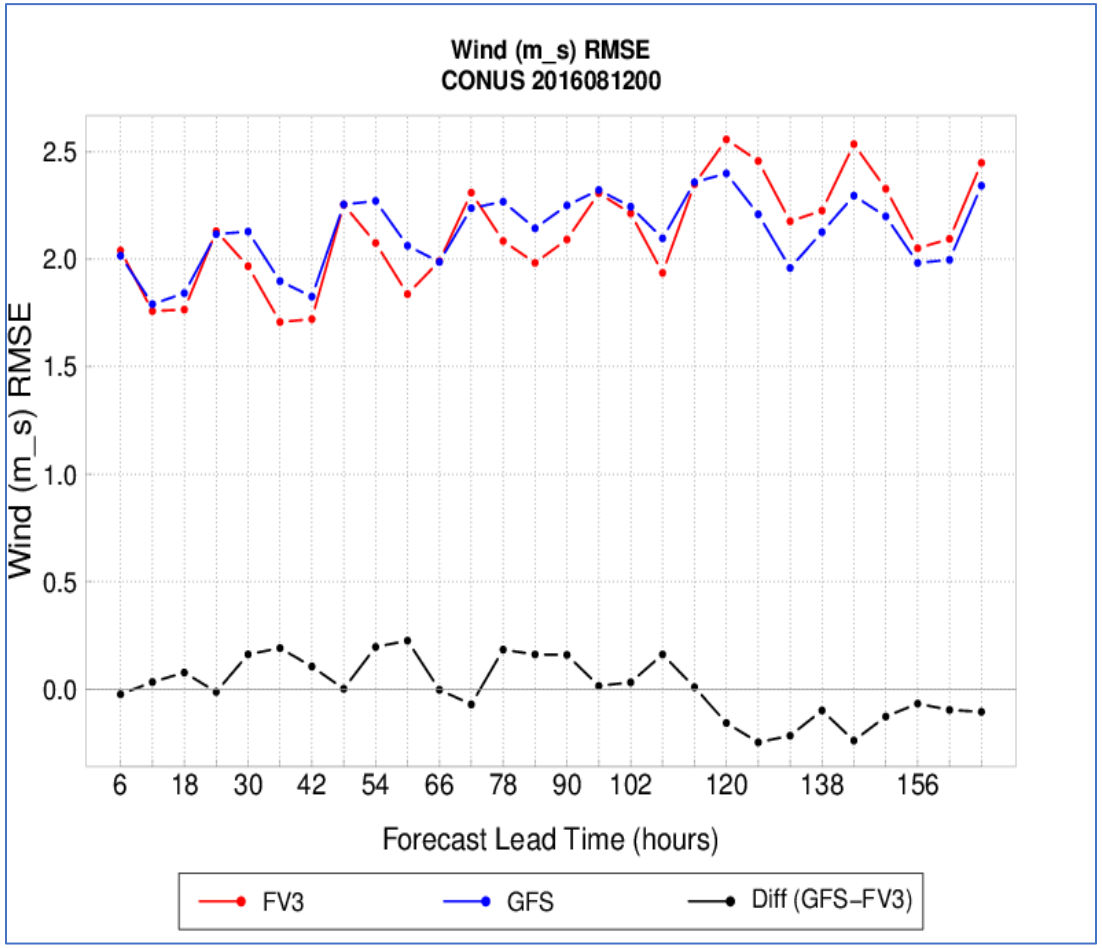


Surface Temperature

- Bias:
  - Warm bias at most lead times for both models, especially FV3, which only sees a slight cold bias at the 6-hr lead time.
  - A gradual increase in strength of the warm bias with a longer lead time is mainly noted for FV3.
  - Diurnal signature noted for both models with GFS having a much larger amplitude.
  - FV3 has its main peak in late afternoon (~0 UTC), while GFS consistently peaks 6 hours earlier.
  - Minimums for FV3 are generally observed around 12 UTC with GFS again 6 hours earlier and often transitioning to a slight cool bias at that time.
- RMSE:
  - A similar RMSE is observed for both models with a diurnal signal observed with peaks around 18-00 UTC and minimums around 6-12 UTC.
  - A small gradual increase in RMSE is observed with increased lead time with values ranging between 2-4 C, with an exception to the last two lead times where an increase to ~ 4.5C is observed.
  - In general, neither model performs better when consulting RMSE

Surface Wind Speed





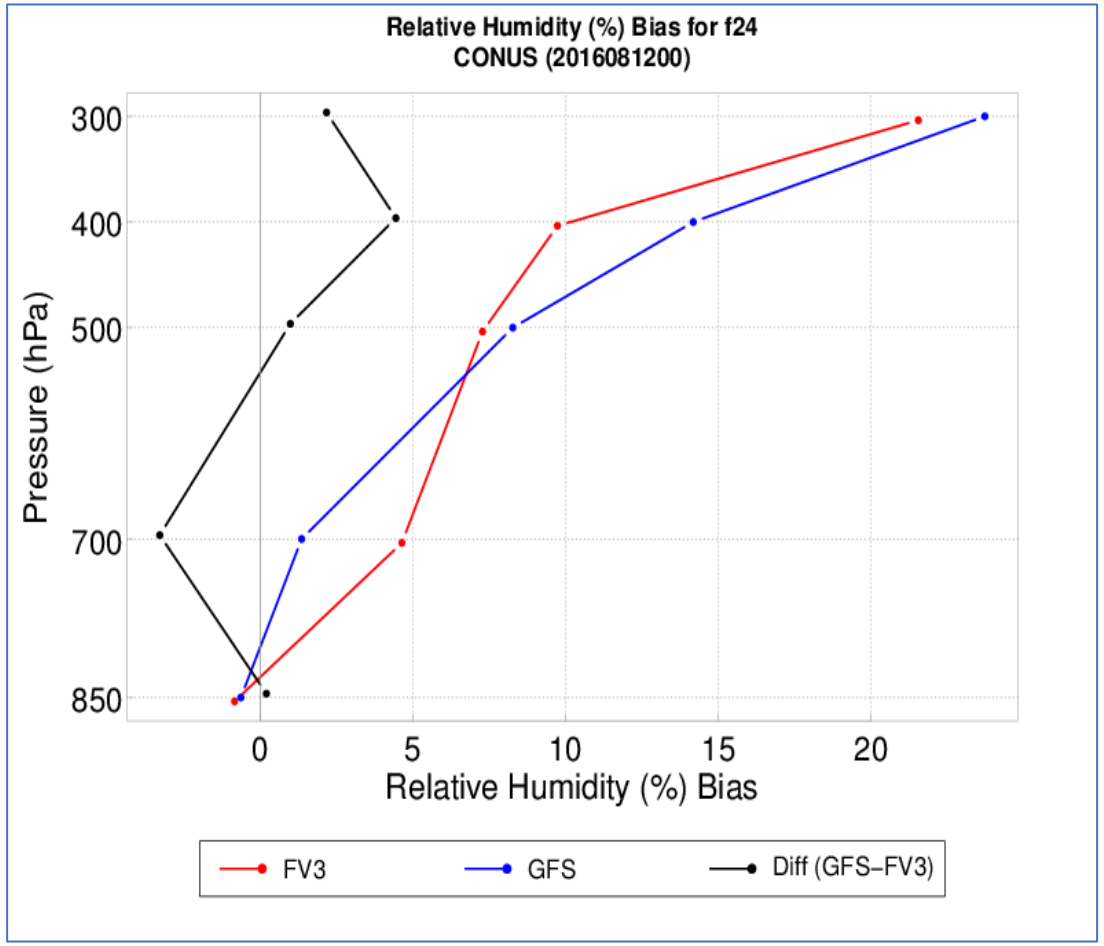
Surface Wind Speed

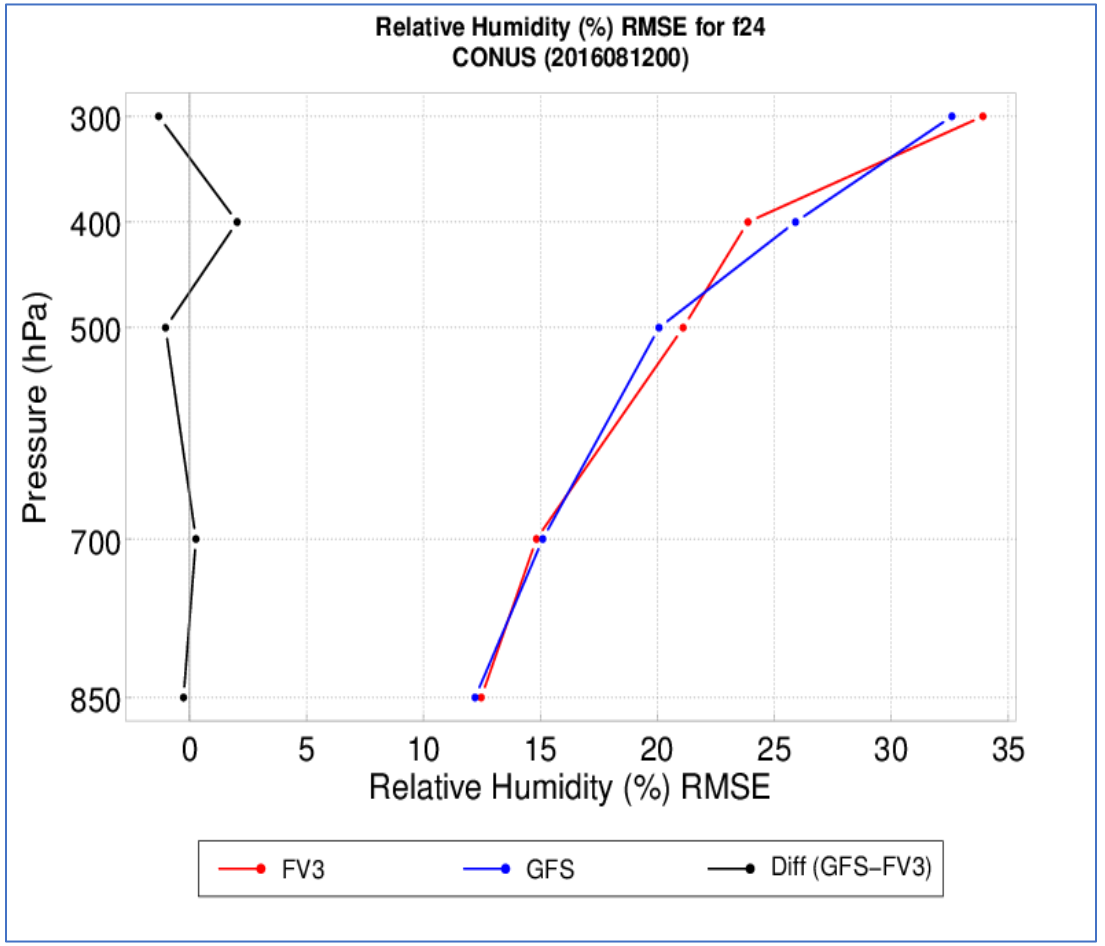
- Bias:
  - A high wind speed bias is observed at all forecast lead times for both models, with differences between the models smaller than ±0.5 m/s.
  - Both models show a distinct diurnal signal in bias, peaking at ~6 UTC with values around 1-1.5 m/s and minimums in wind speed bias during the day.
  - For about the first 114 hours of the forecast, FV3 has a lower bias, with exception to 00 UTC, where an offset between the two models results in it having a higher bias at those forecast hours.
  - For the remainder of the forecast period, GFS has the lower wind speed bias when compared to FV3
- RMSE:
  - A similar diurnal signal is observed in RMSE with differences between the models small (± 0.25 m/s) and a gradual increase in RMSE with increasing lead time.
  - Peaks occur during the night hours, while minimums occur during the day.
  - Similar to bias, the first 114 hours of the forecast have FV3 with a slightly lower RMSE, transitioning to the GFS slightly lower thereafter.
  - RMSE values are generally between 1.7—2.5 m/s.

Metric Analysis by Vertical Level

Forecast Hour 24 (valid 20160813 00UTC)

Relative Humidity: CONUS

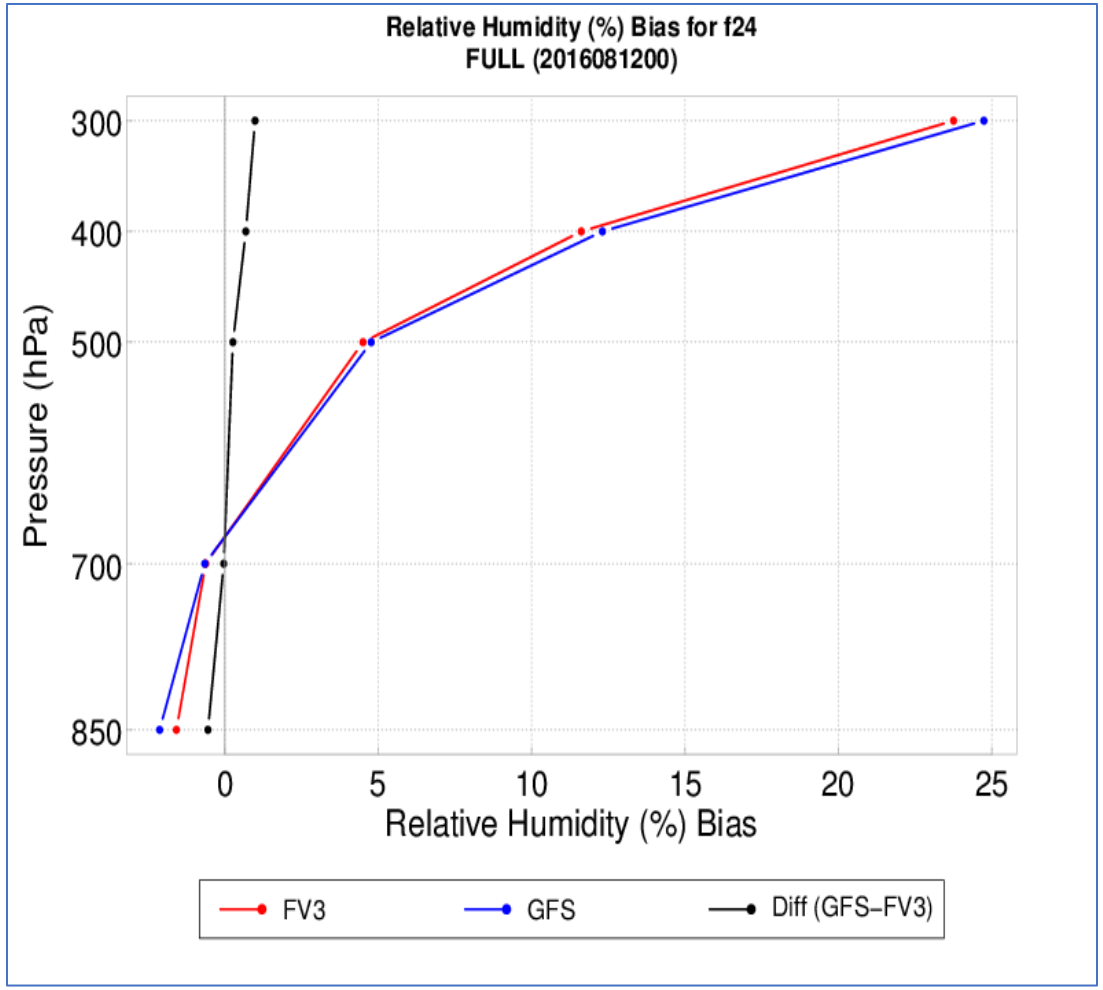


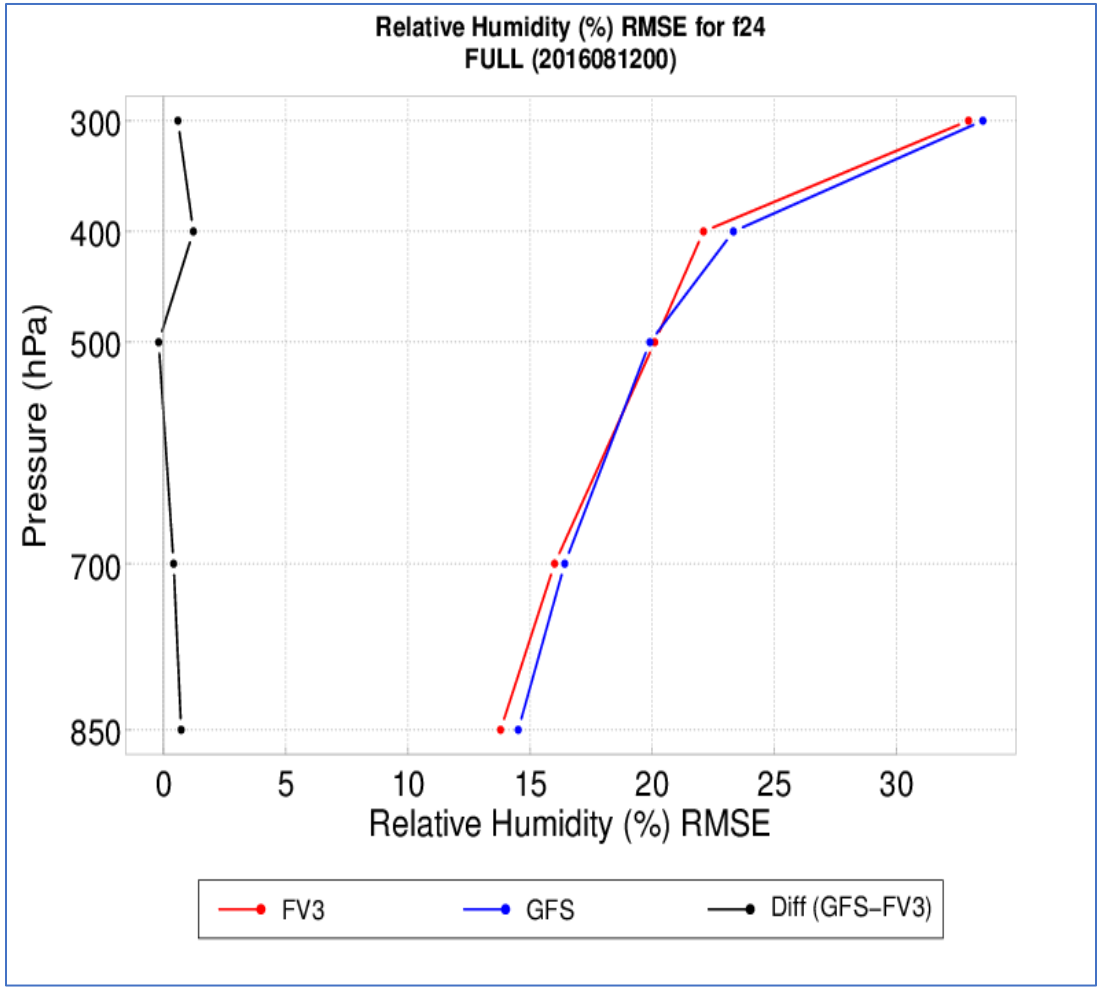


Relative Humidity: CONUS

- Bias:
  - Both models have a very slight dry bias (< 5%) at 850 hPa.
  - This bias becomes moist and increases in magnitude with increasing height.
  - FV3 has a more moist bias than GFS after 700 hPa.
- RMSE:
  - Both models exhibit an extremely similar behavior across the vertical profile: increasing error with height.
  - Neither model clearly outperforms the other when looking at RMSE.

Relative Humidity: Global

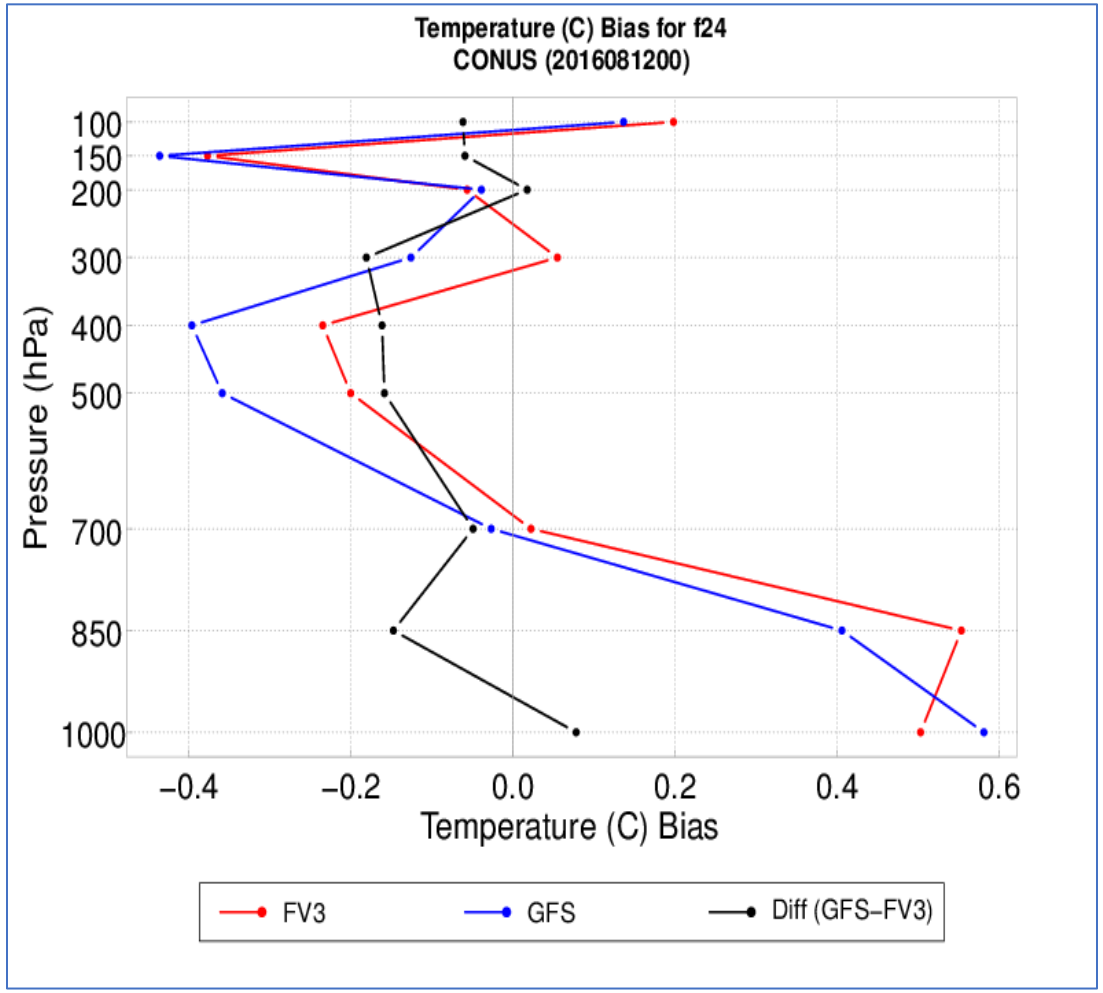


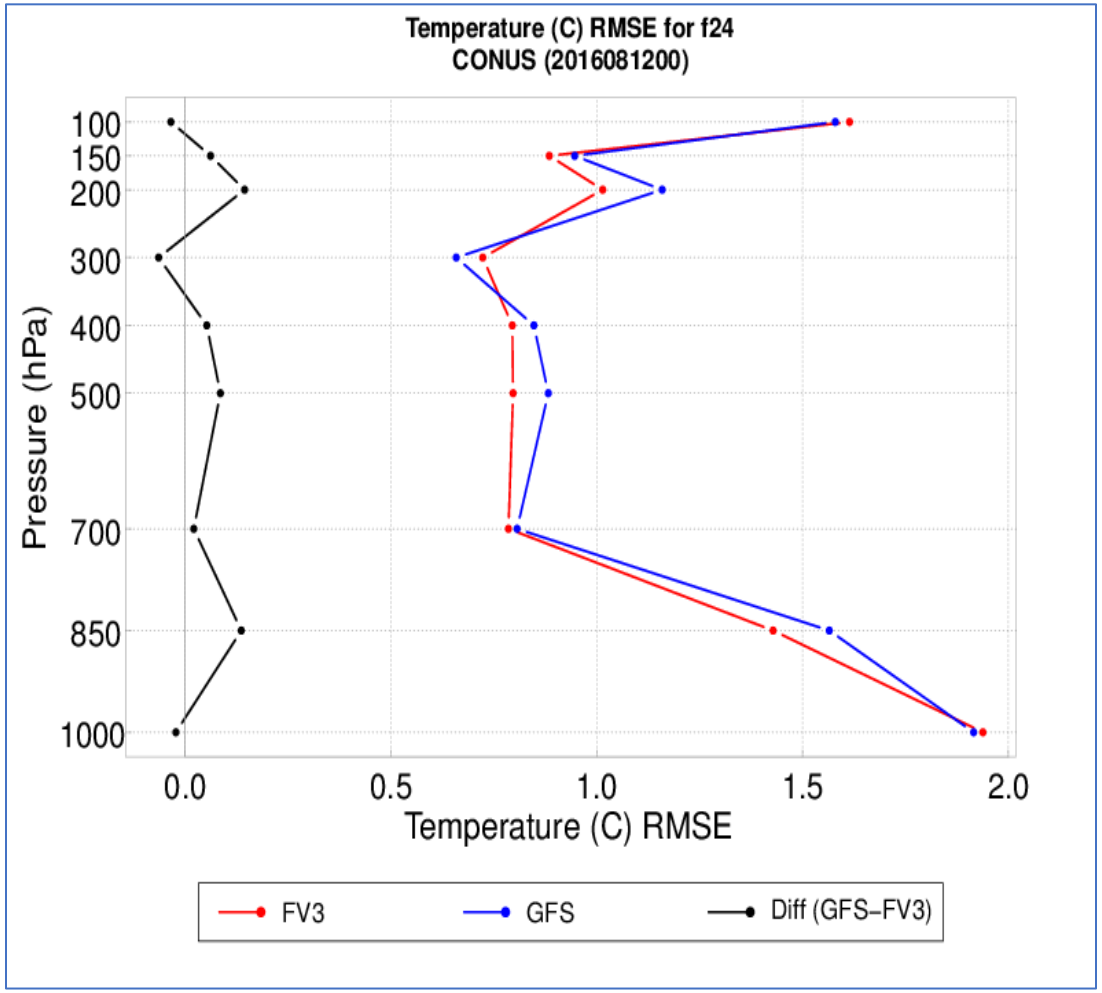


Relative Humidity: Global

- Bias:
  - Both models exhibit a near identical moist bias with height, with the GFS being very slightly more moist.
  - This bias increases with height, eventually reaching approximately +25% at 300mb.
- RMSE:
  - Both models exhibit a very similar performance across the vertical profile, with the GFS performing very slightly worse.
  - Both models predicted a more moist atmosphere than was observed with errors ranging from approximately +15 – 35%.

Temperature: CONUS

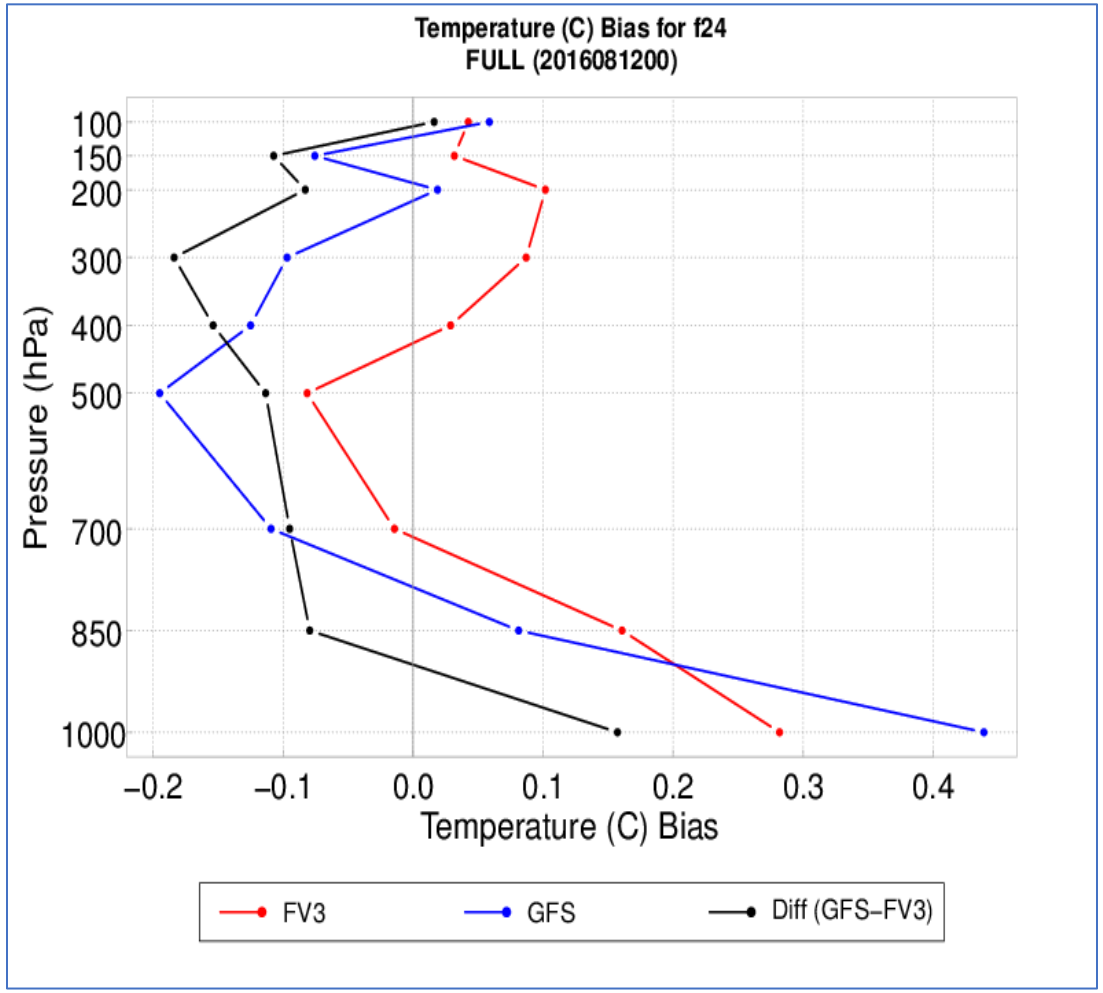


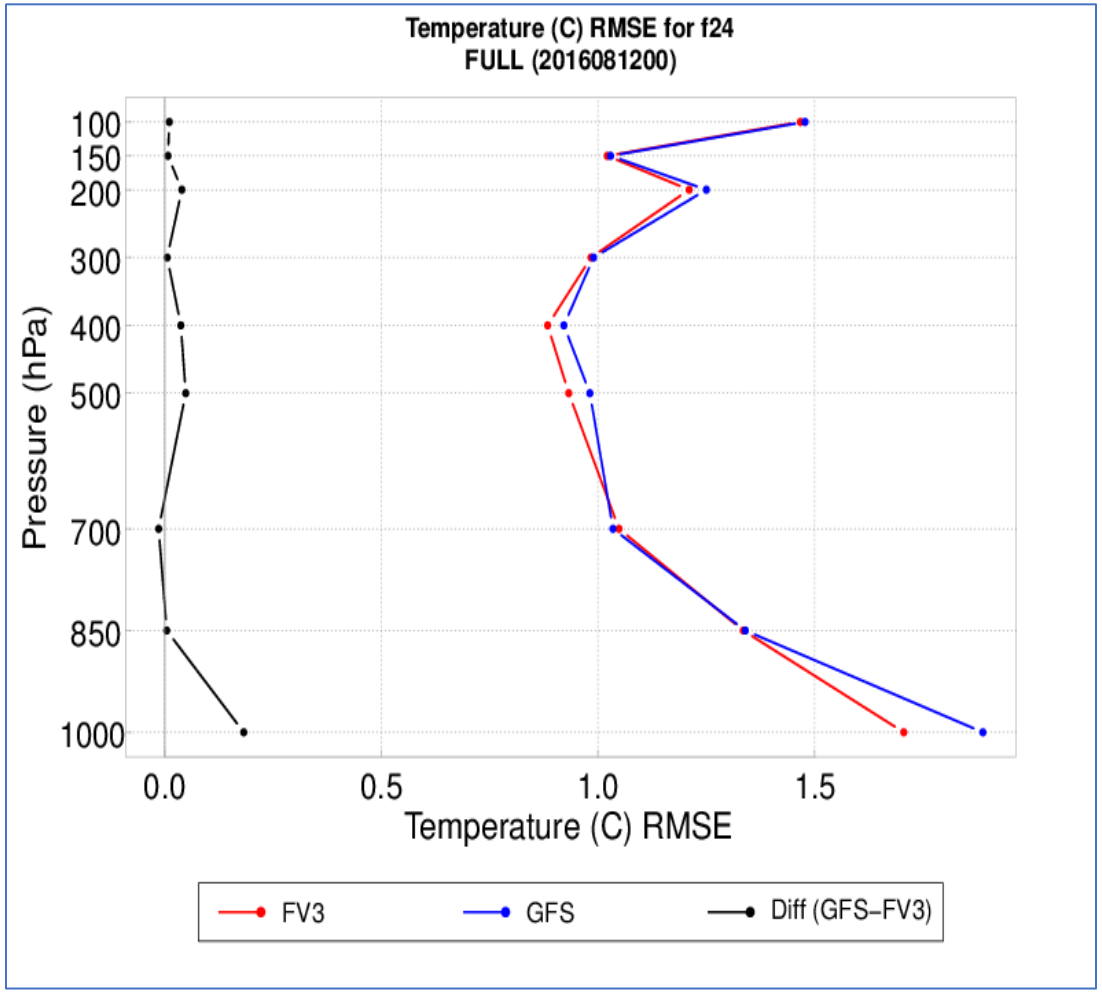


Temperature: CONUS

- Bias:
  - Both the GFS and FV3 exhibit a similar vertical bias profile.
  - These biases are small, on the order of ± 0.5 C.
  - Overall, GFS has a cooler bias than FV3.
- RMSE:
  - Both models exhibited near identical RMSE vertical profiles with errors ranging from approximately 0.75 – 2.0 C warmer.
  - Overall, FV3 is slightly more accurate than GFS.
  - The differences between the two models is less than ± 0.5 C.

Temperature: Global

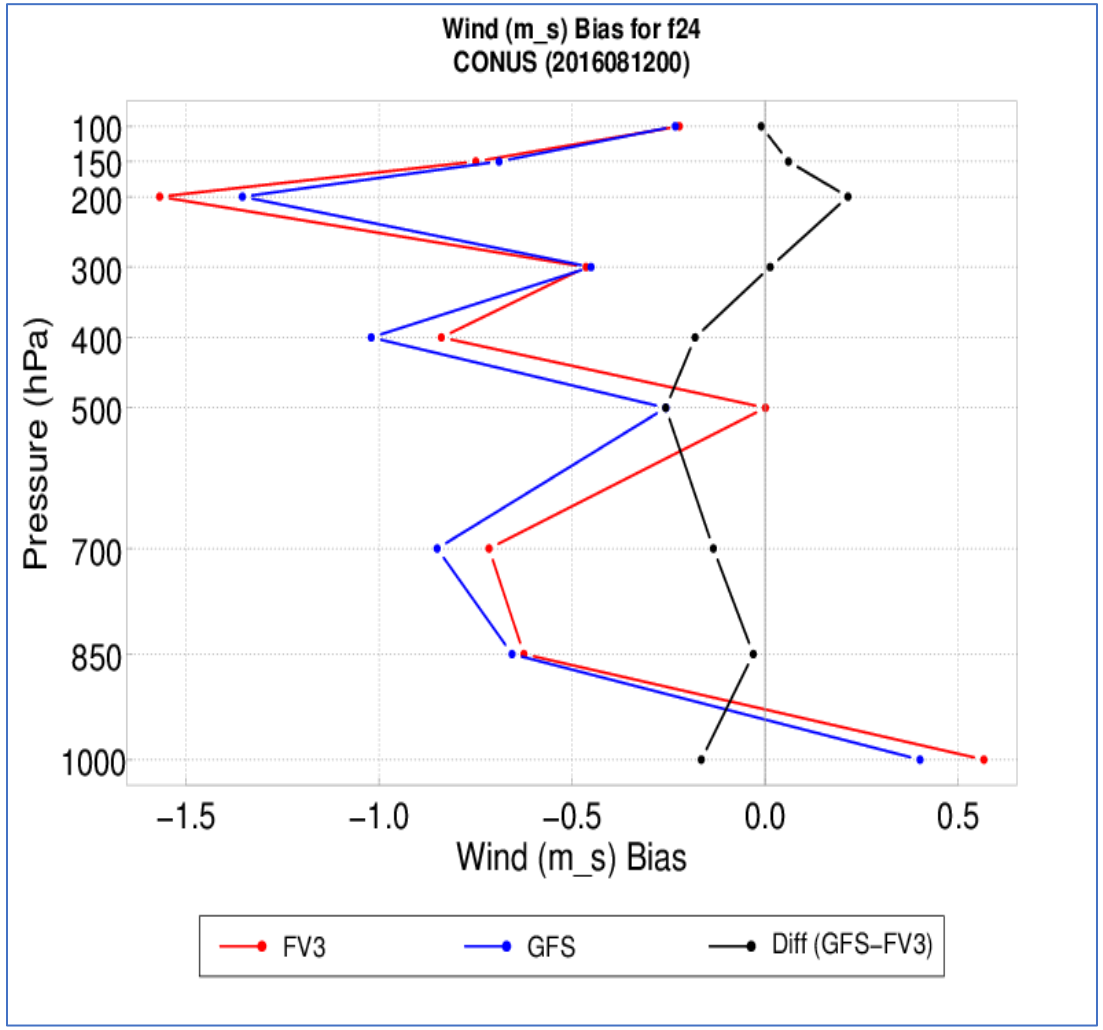


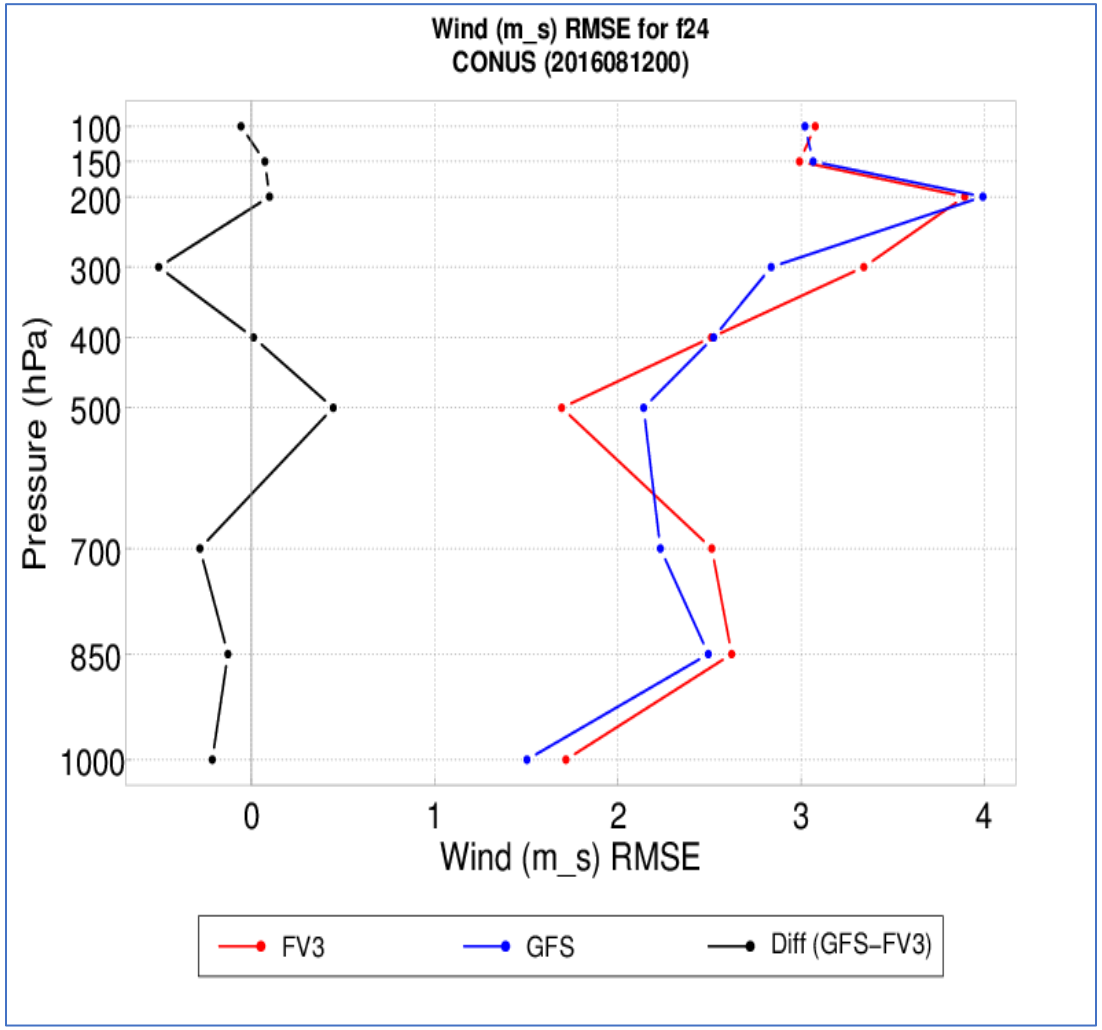


Temperature: Global

- Bias:
  - Both GFS and FV3 display a similar bias trend across the vertical profile.
  - There is a warm bias from 1000 – 850 hPa that decreases with height and increases slightly in the upper atmosphere (200 – 100 hPa).
  - This temperature bias is slight with most values ranging between $\pm$0.2 C.
- RMSE:
  - Both models exhibit near identical RMSE vertical profiles, displaying the most accuracy from 700 – 300hPa.
  - FV3 performs very slightly better (on the order of 0.1 C) across the 500-400hPa level.

Wind Speed: CONUS

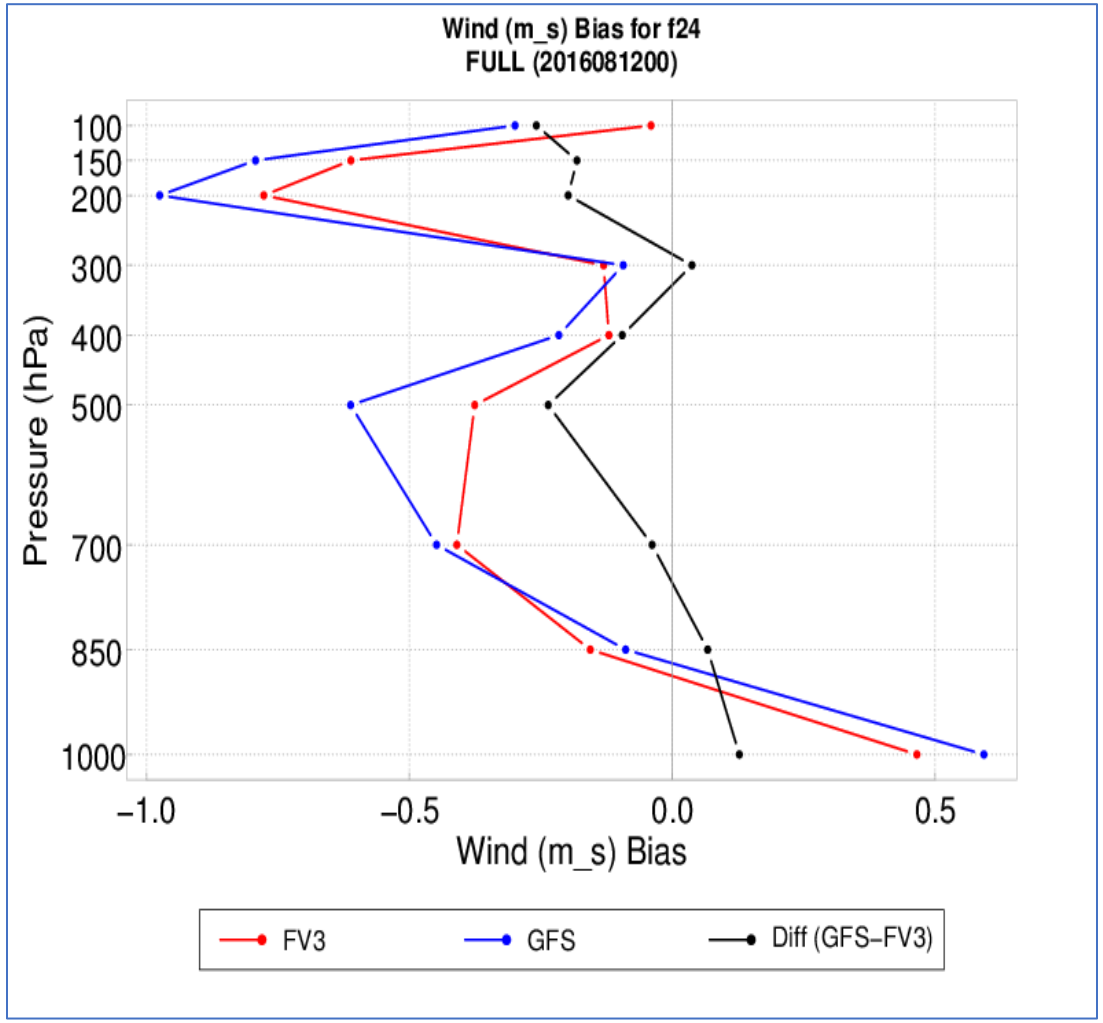


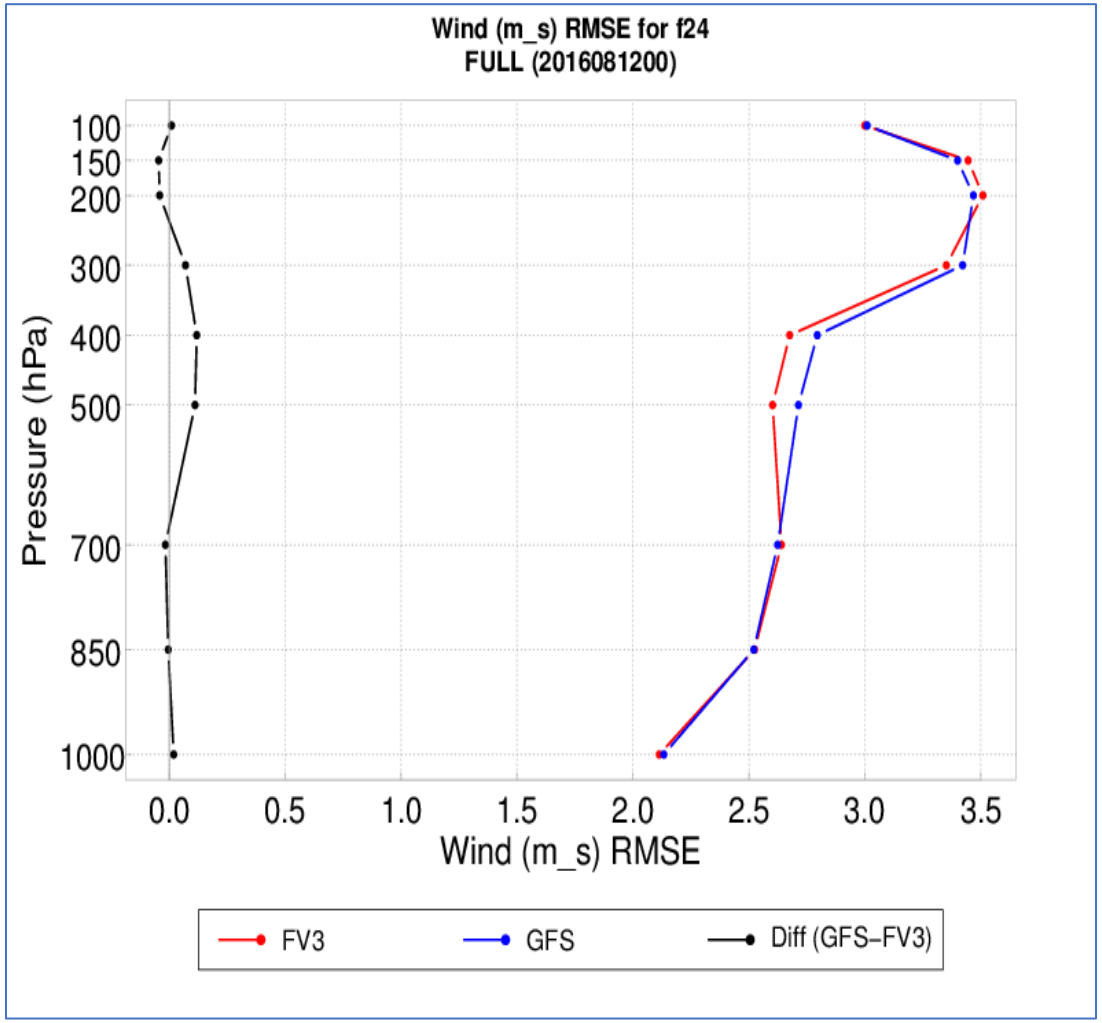


Wind Speed: CONUS

- Bias:
  - Both models exhibit a similar slow bias trend with height, generally increasing in magnitude with height until 150 mb.
  - This slow bias ranges from approximately -0.25 – -1.5 m/s.
  - Notably, FV3 exhibits no bias at 500mb.
- RMSE:
  - GFS and FV3 display a similar and generally increasing error trend across the vertical profile.
  - Overall, GFS performed slightly better than FV3 when consulting the RMSE.

Wind Speed: Global





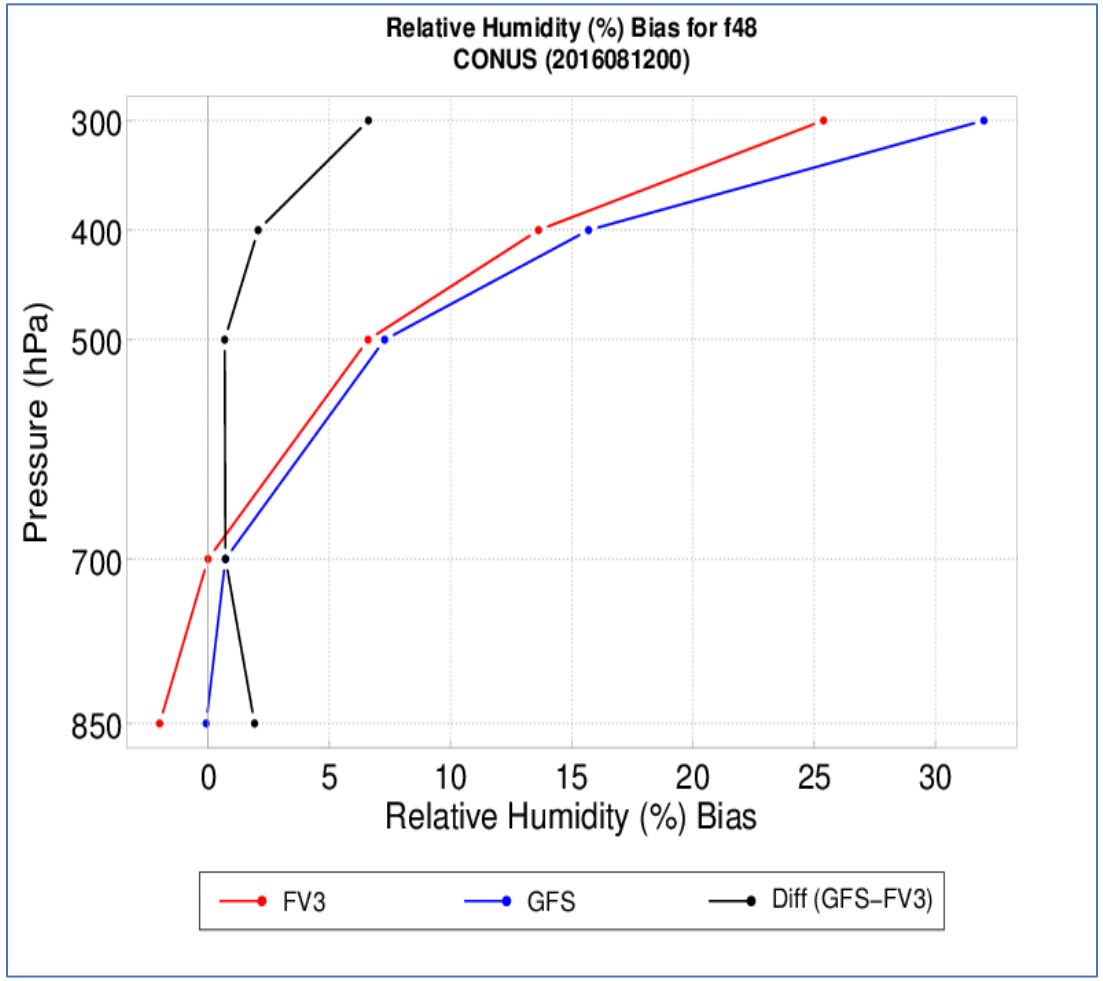
Wind Speed: Global

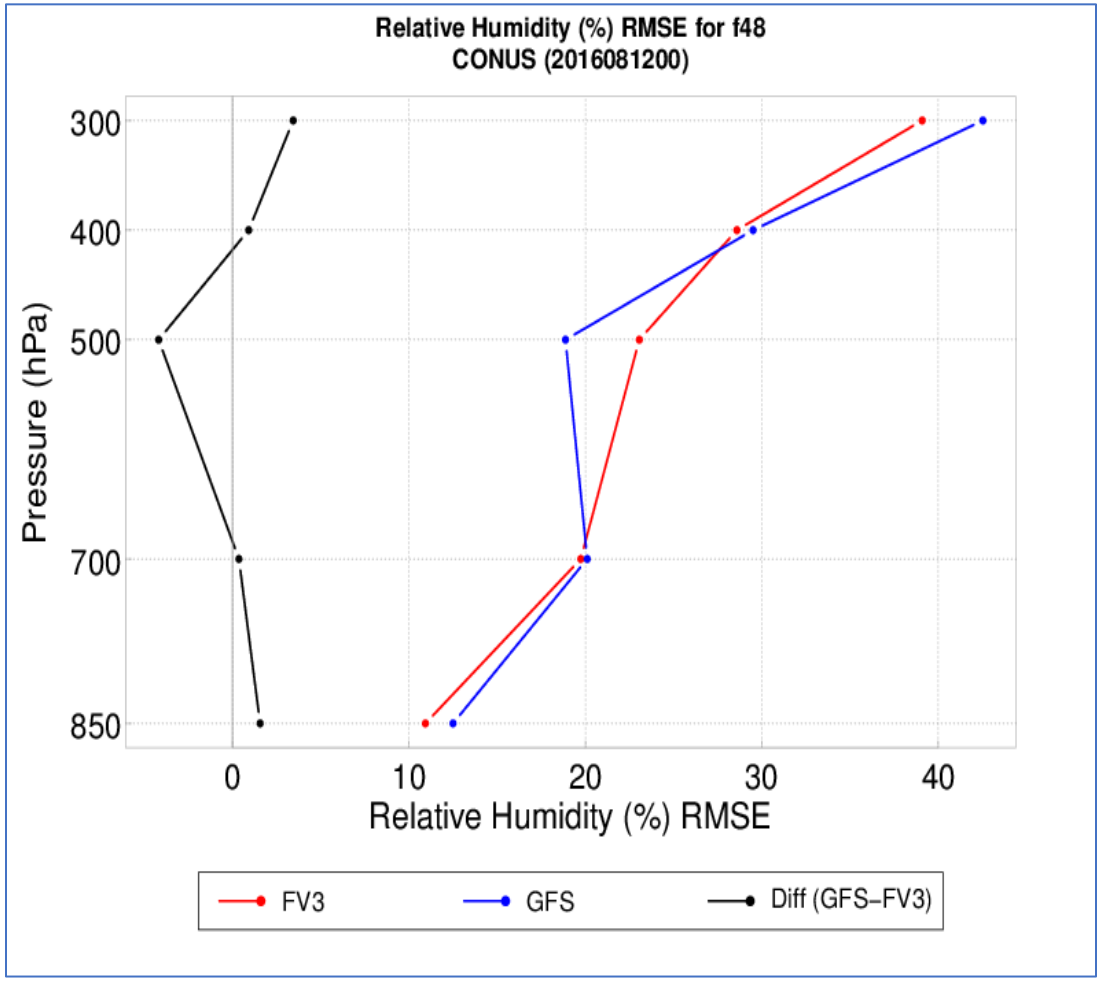
- Bias:
  - Both models exhibit an overall slow bias that ranges from approximately -0.2 -
    -1.0 m/s.
  - Overall, FV3 has less bias than GFS across the vertical profile.
- RMSE:
  - GFS and FV3 have a near identical RMSE vertical profile with values ranging from approximately 2.0 – 3.5 m/s.
  - FV3 performs slightly better from 500 – 300 hPa and then the GFS performs slightly better from 300 – 150 hPa.

Metric Analysis by Vertical Level

Forecast Hour 48 (valid 20160814 00UTC)

Relative Humidity: CONUS

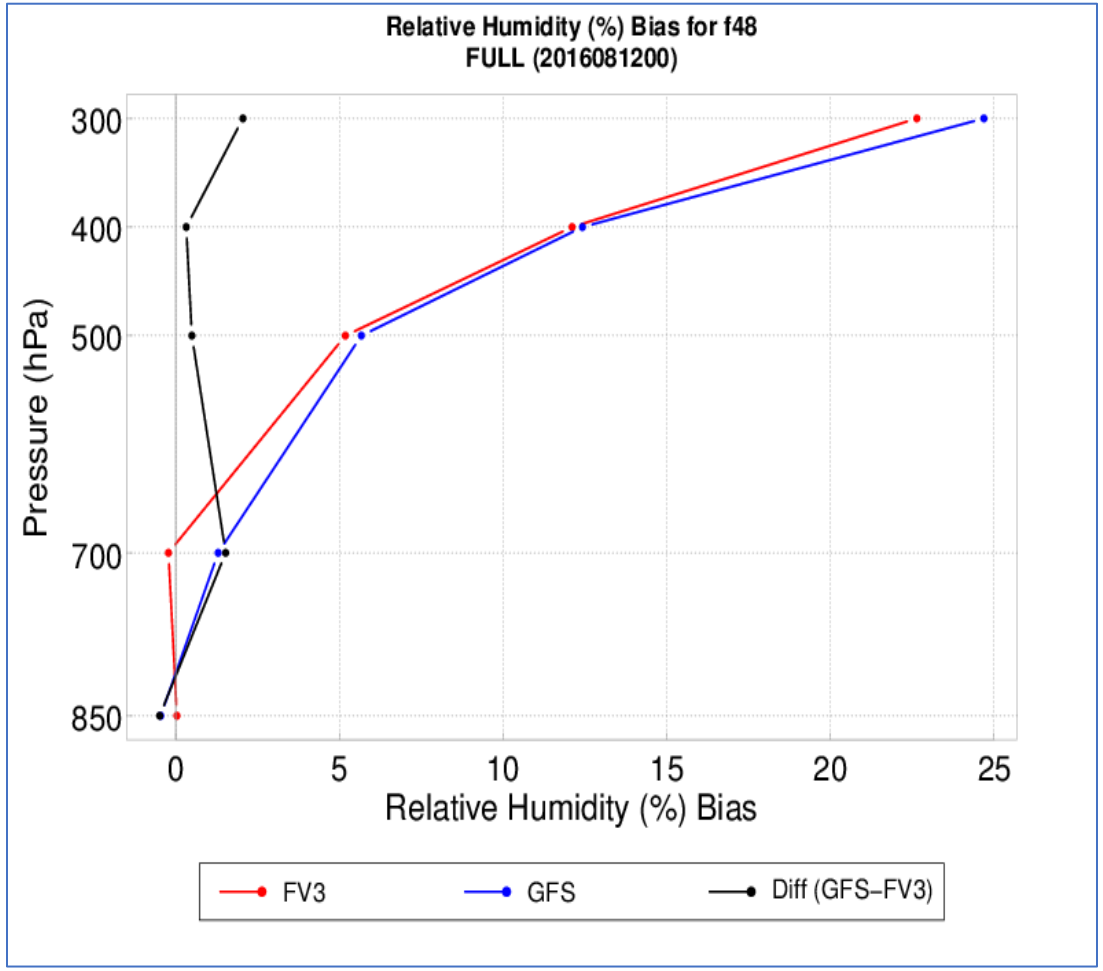


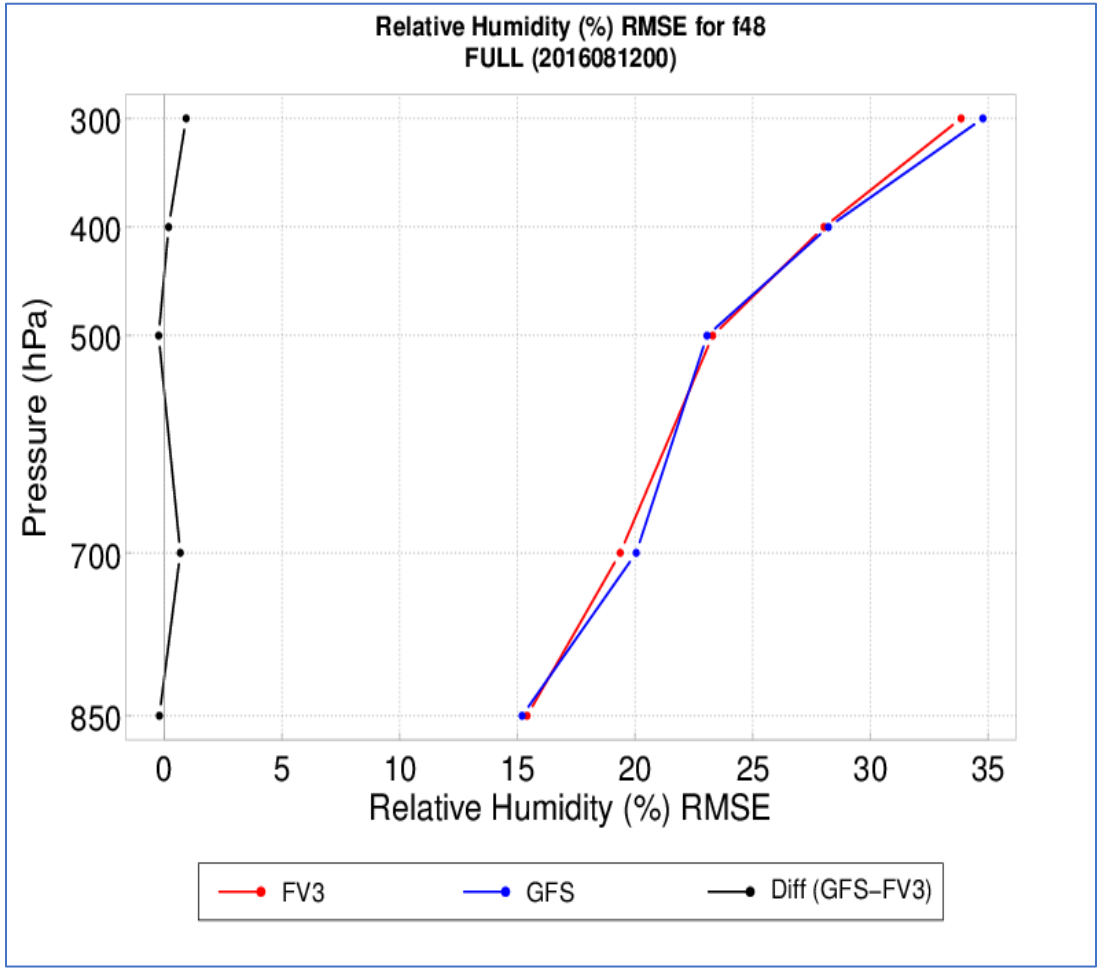


Relative Humidity: CONUS

- Bias:
  - Both the GFS and FV3 display a moist bias, similarly increasing across the vertical profile.
  - FV3 exhibits slightly less bias than GFS across the entire profile.
- RMSE:
  - Both models over predicted relative humidity and that error increases with height.
  - FV3 performs slightly better than GFS at all levels except for 500 hPa.
  - The error values range from approximately 10 – 40 %.

Relative Humidity: Global

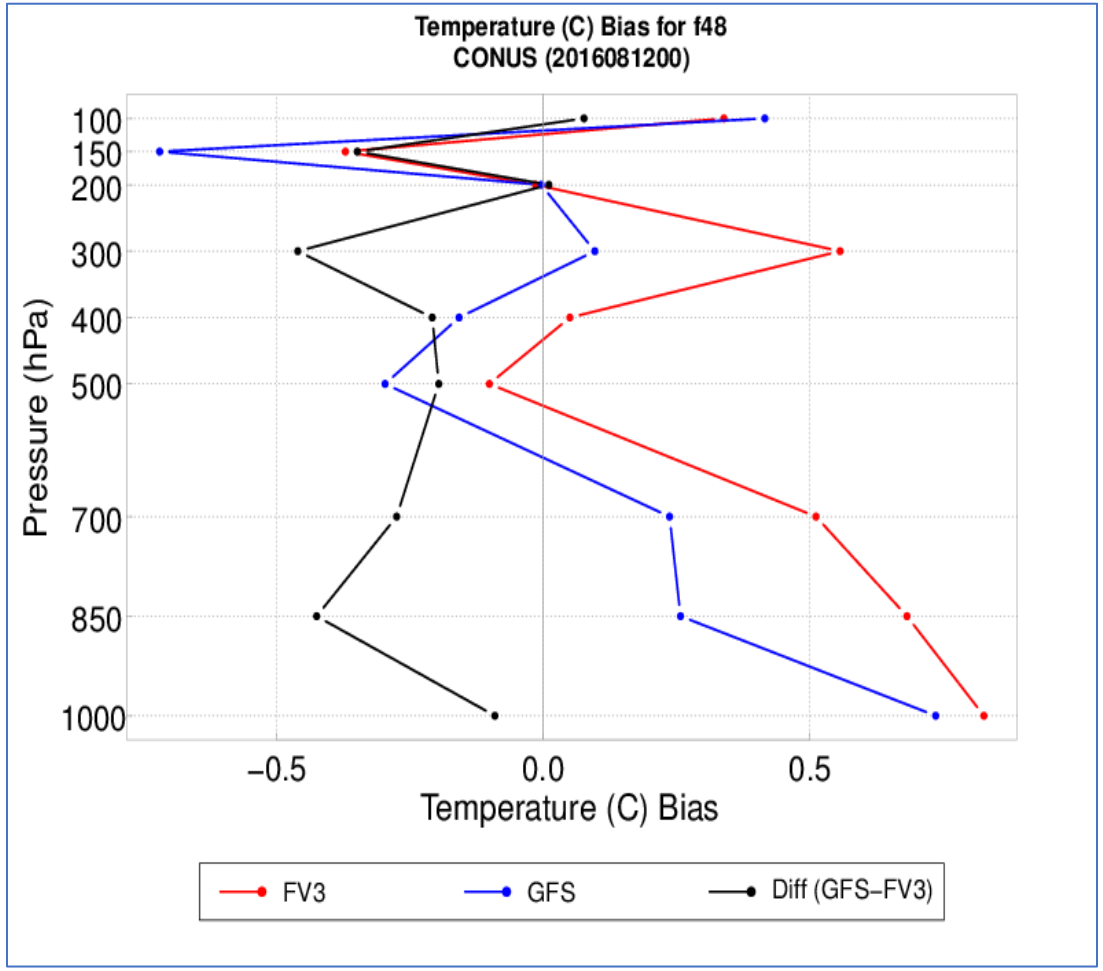


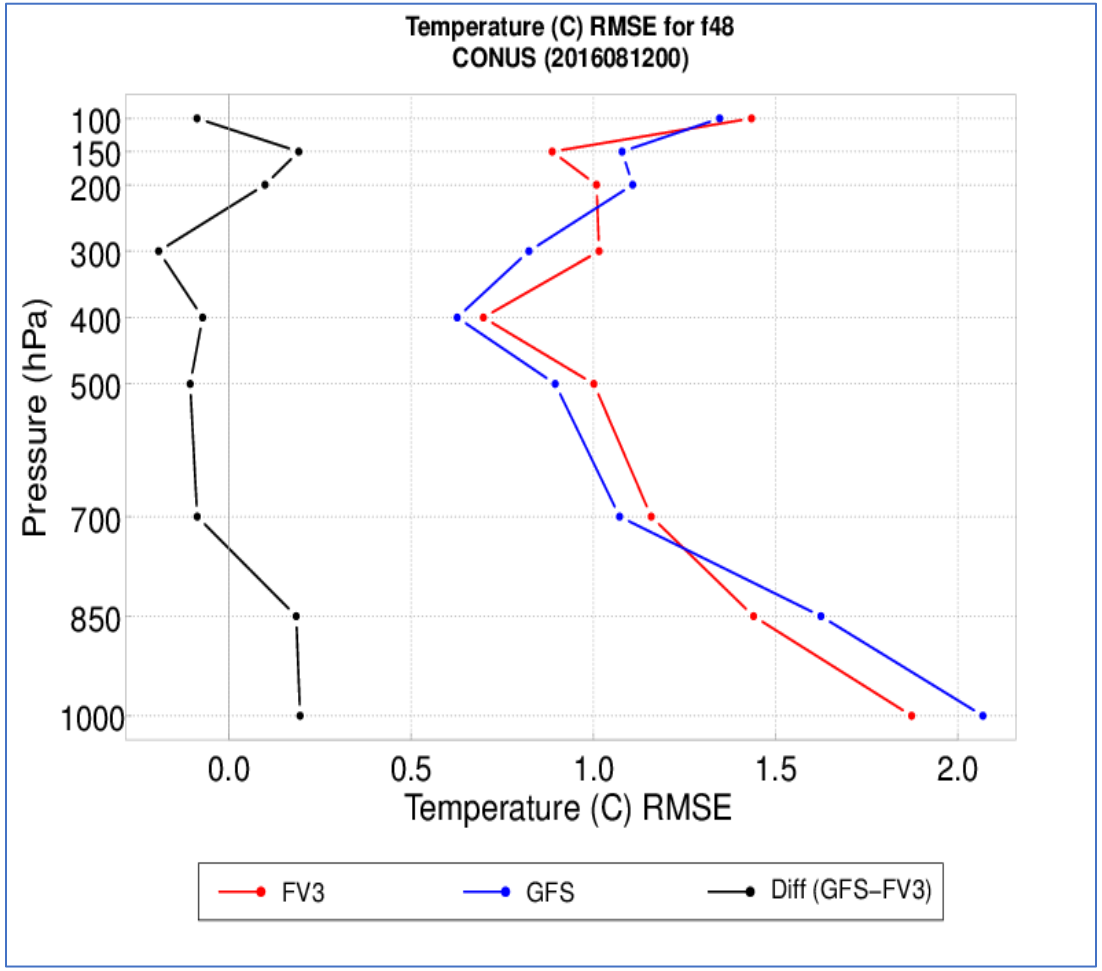


Relative Humidity: Global

- Bias:
  - Both models feature an overall increase with relative humidity bias with increasing height.
  - These biases range in value from near 0% at 850 hPa increasing to 20 – 25% at 300 hPa.
  - FV3 has a clearly better performance than GFS from 850 – 700 hPa and then only a slightly better performance across the rest of the vertical profile.
- RMSE:
  - Both FV3 and GFS display almost identical RMSE behavior across the vertical profile.
  - The errors range in value from approximately 15% at 850 hPa and steadily increase with height to approximately 35% at 300 hPa.
  - Neither model clearly outperforms the other when consulting this RMSE profile.

Temperature: CONUS

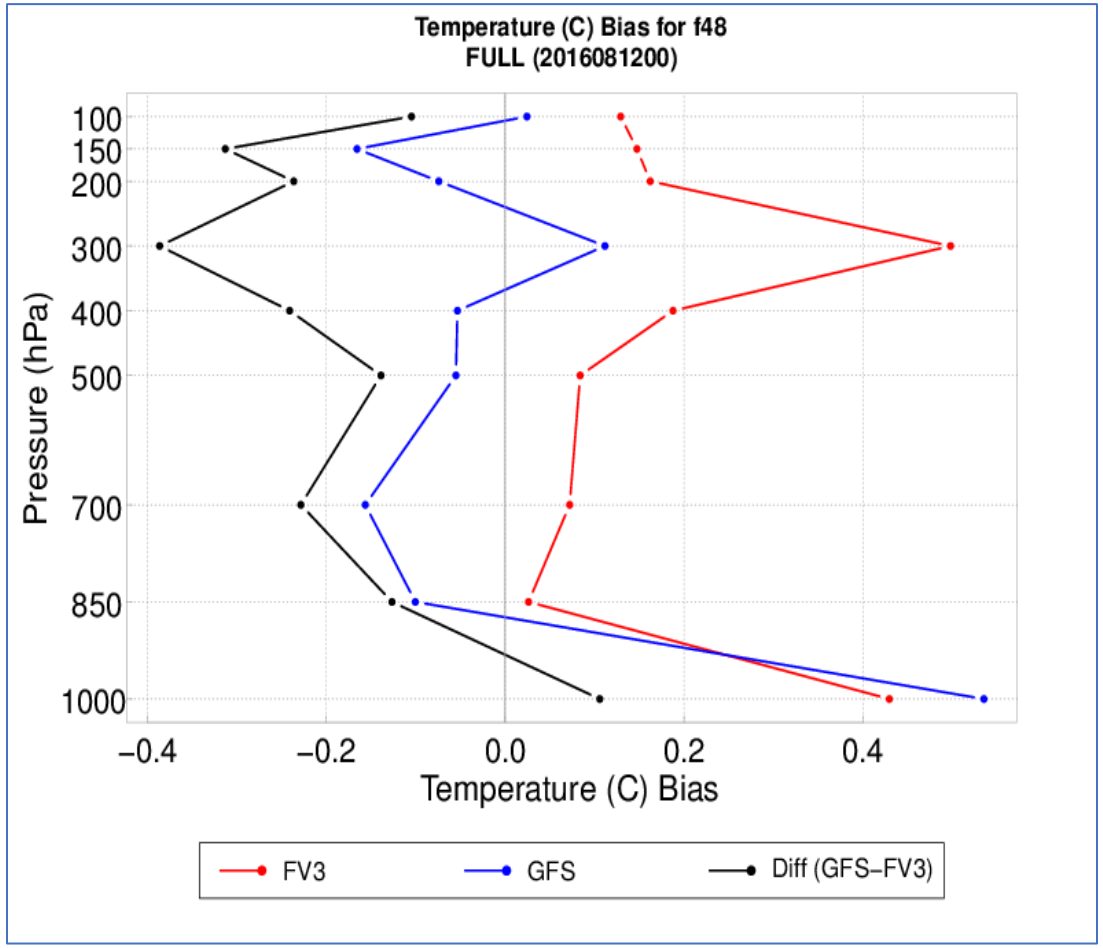


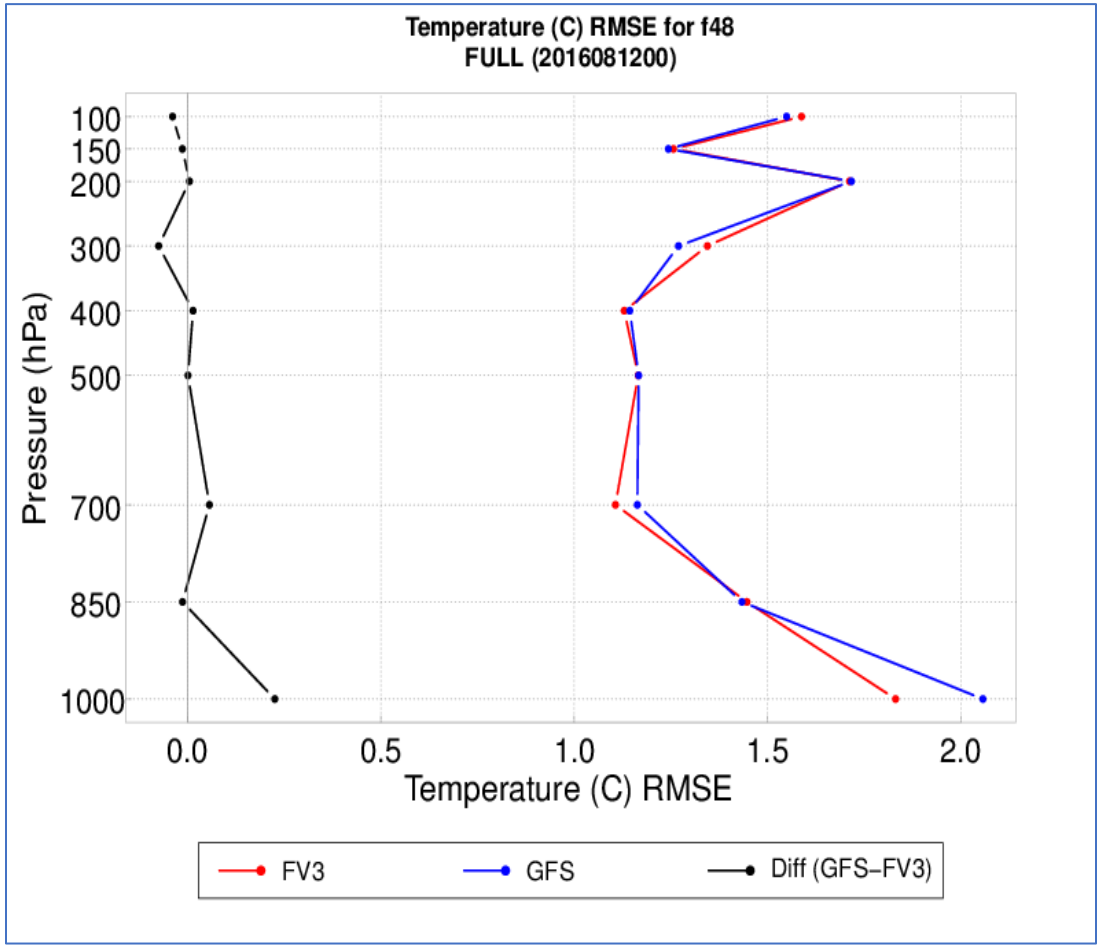


Temperature: CONUS

- Bias:
  - Both GFS and FV3 exhibit a similar trend in temperature bias across the vertical profile: the bias value decreases from the surface to 500 mb where it then begins to increase until 150 mb.
  - GFS has a cooler overall bias than FV3.
  - The bias values are small, approximately $\pm$ 1.0 C.
- RMSE:
  - Both models display very similar RMSE behavior across the profile and that profile follows the same pattern as the bias trend.
  - Neither model clearly outperforms overall the other when consulting RMSE.
  - FV3 performs better at the surface to mid-levels while GFS performs better from the mid-levels to the upper troposphere.
  - The errors range from 0.5 – 2.0 C.

Temperature: Global

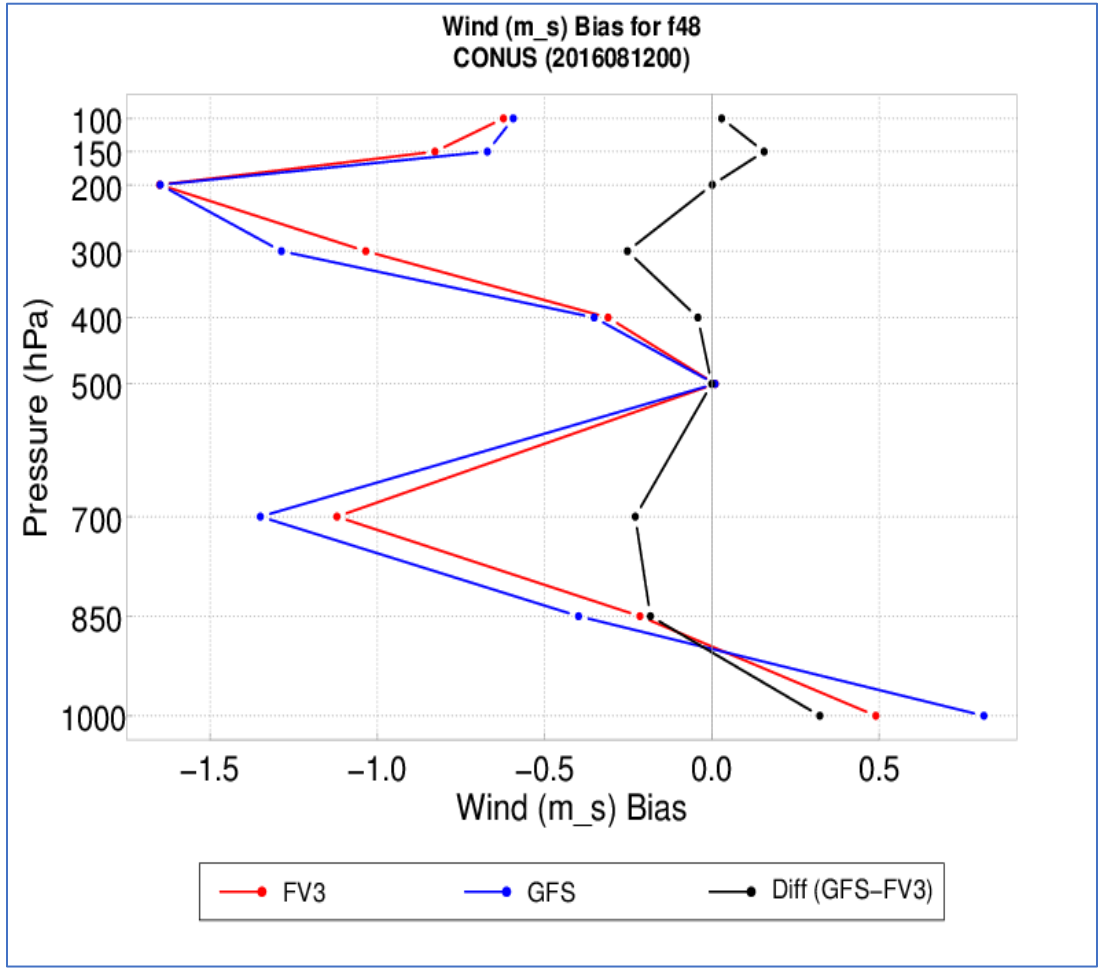


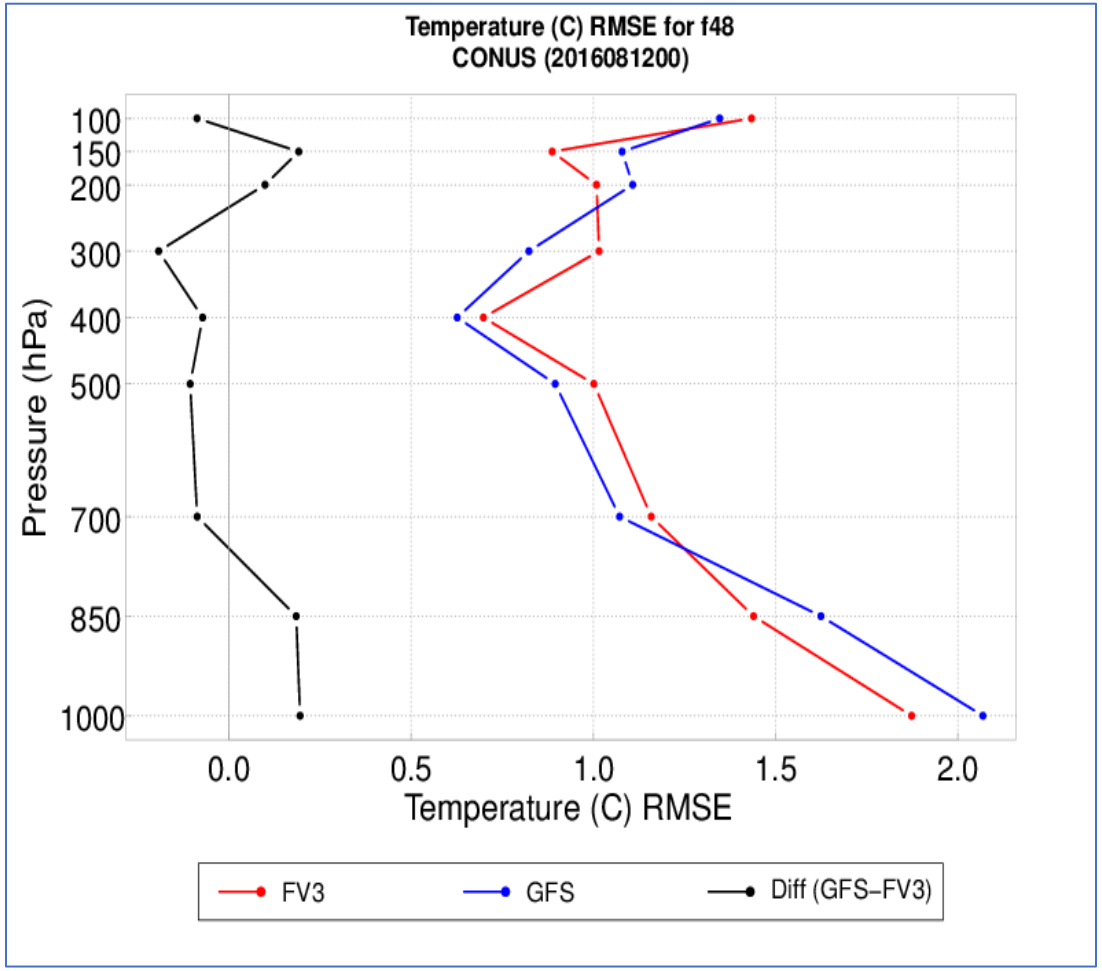


Temperature: Global

- Bias:
  - Both models follow the same general trend with height, but GFS generally exhibits a cold bias while FV3 always exhibits a warm bias.
  - These biases are small, ranging from approximately -0.2 – 0.5 C.
  - Overall, the GFS has slightly less bias than FV3.
- RMSE:
  - FV3 and the GFS exhibit very similar RMSE with height.
  - GFS performs very slightly better than FV3 at all but 4 pressure levels.
  - The errors range in magnitude from approximately 1.25 – 2.0 C.

Wind Speed: CONUS

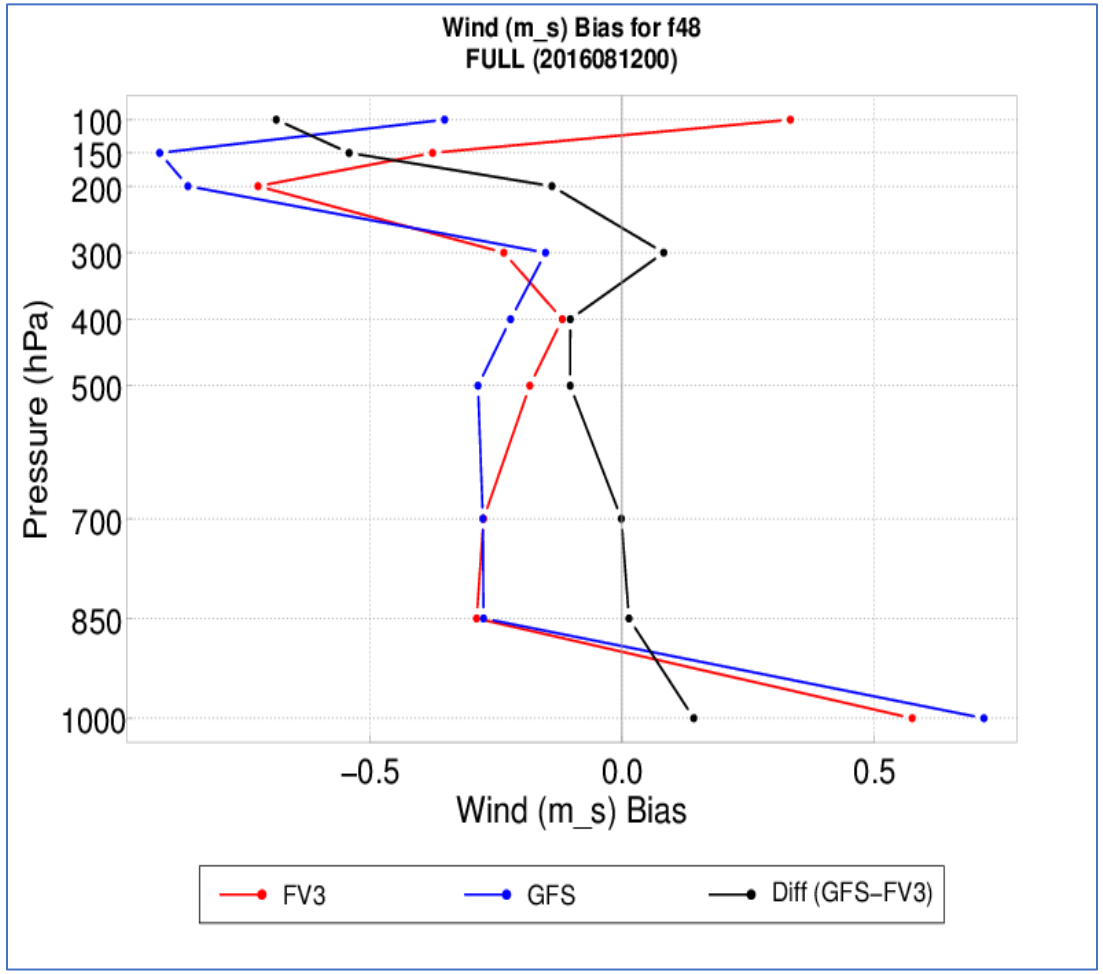


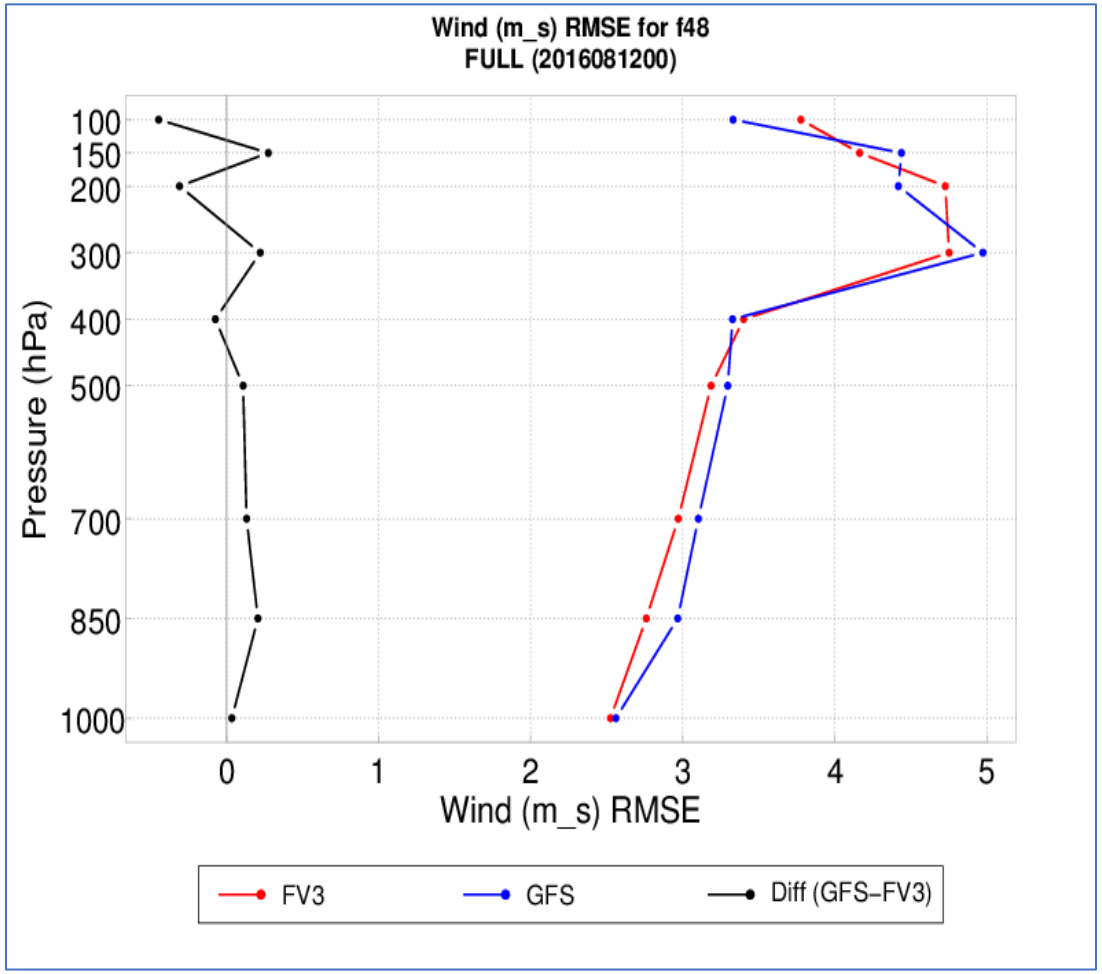


Wind Speed: CONUS

- Bias:
  - Both FV3 and GFS exhibit a similar vertical bias profile: slightly faster at the surface, then decreasing to be a slow bias across the rest of the troposphere.
  - Overall, FV3 performs slightly better than GFS at this forecast hour.
  - Notably, both FV3 and GFS have 0 bias at 500 hPa.
- RMSE:
  - Both models have a similar RMSE vertical profile.
  - GFS overall slightly outperforms FV3.
  - FV3 slightly outperforms GFS from the surface to 850 mb.

Wind Speed: Global





Wind Speed: Global

- Bias:
  - Both models exhibit a similar bias trend across the vertical profile: there is an overall slow bias except at the surface.
  - The bias is slight ranging from approximately ±1.0 m/s.
  - FV3 has slightly less overall bias than GFS.
- RMSE:
  - FV3 and GFS display a very similar RMSE vertical profile, with values ranging from approximately 2.5 – 5 m/s.
  - Overall, FV3 produced slightly less prediction error than GFS over the vertical profile.

Summary

- FV3 performed slightly better for the majority of the metric comparisons for this case (FV3= 25/44; GFS = 5/44; Neither = 10/44; Mixed = 4/44)
- GFS outperformed FV3 in terms of the intensity of the extreme precipitation.
- Both models tended to behave the most similarly for global RMSE vertical profiles
  - This is potentially due to the number of points which smooths out small differences.
- Both models exhibit a diurnal error pattern for surface variables across forecast.