# Testing and Evaluation of Regional EnKF Radiance Data Assimilation: Impact of MHS assimilation

**Kathryn M. Newman**[1,2]

Z. Liu[2], C. Schwartz[2], H. Shao[1,2], and X.Y. Huang[2]

[1] Developmental Testbed Center (DTC)

[2] National Center for Atmospheric Research (NCAR)

Special Acknowledgement to AFWA and NSF

# Background/Objectives

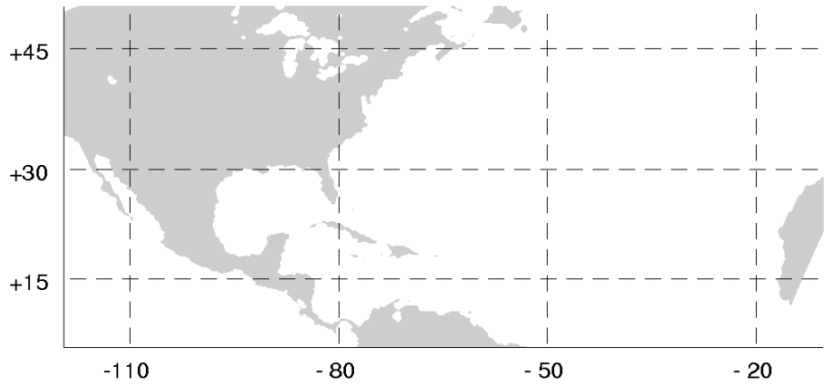
- Recent studies *(Liu et al. 2012, Schwartz et al. 2012)* have shown positive impacts when assimilating microwave radiances with a limited-area EnKF.
  - Focused on the impact of assimilating AMSU-A radiances
- This study will evaluate the impact of assimilating MHS radiances in addition to AMSU-A
  - Determine if there is added benefit from assimilating MHS
- Provide rational basis for operational centers and the research community for advancements of NWP systems
  - Core mission of the DTC (R2O)

# Experimental Design

*Experimental Design and Assimilation Strategy follows Liu et. al 2012

- Limited-Area EnKF using Data Assimilation Research Testbed (DART) with WRF-ARW v3.2.1
- Time Period: 2008081100 – 2008090212^
- 36 km horizontal resolution, 45 vertical levels, 20 hPa model top
- 96 ensemble members
- 6-hr cycling using ensemble LBCs from perturbed GFS means
- Deterministic 72-hr ARW fcsts initialized from 00/12 ensemble mean analyses
- Verification:

Model Evaluation Tools (MET) v3.0.1



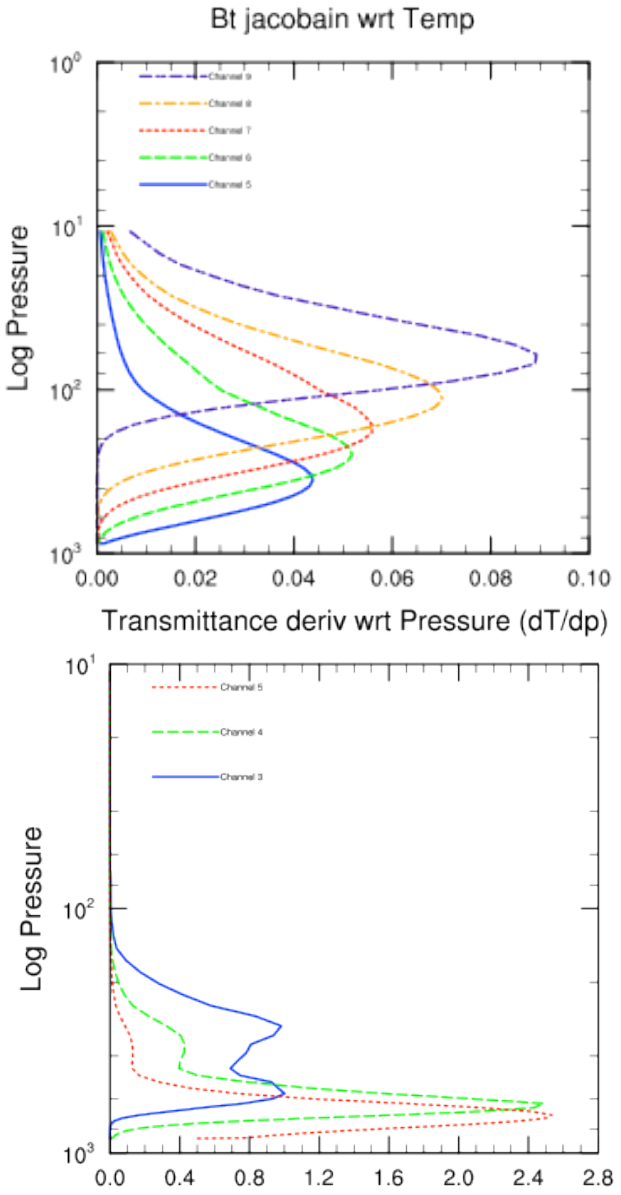

^ shorter time period than Liu et al. 2012

# Assimilation Methodology

- Assimilated observations for experiments:
  - ASMU-A radiance (AMSA): conventional obs from radiosondes, aircraft, sat-derived winds, land/ocean sfc stations, GPS dropsondes (NOAA G-IV aircraft), COSMIC GPSRO, AMSU-A radiances from NOAA-18/METOP-2
  - AMSU-A + MHS radiance (AMHS): same as AMSA + MHS radiances from NOAA-18/METOP-2
- Radiance data were thinned on a 72-km grid
- +/- 1.5 hr observation assimilation window
- Bias Correction Coefficients from 3-mo offline statistics (spun-up)
- AMSU-A channels 5-7 and MHS channels 3-4 NOAA-18/METOP-2 assimilated

# Assimilation Methodology cont'

- Radiances were assimilated into DART using the CRTM built into WRFDA as the radiance forward operator for computing radiance prior ensembles
  - Following strategy adopted by previous investigators*
- Only radiance prior ensembles came from WRFDA, all other obs from DART
- The vertical localization of each radiance observation was taken as the level the channels' weighting function peaked
- For MHS: dTr/dp was calculated in WRFDA from the CRTM and used as the weighting function



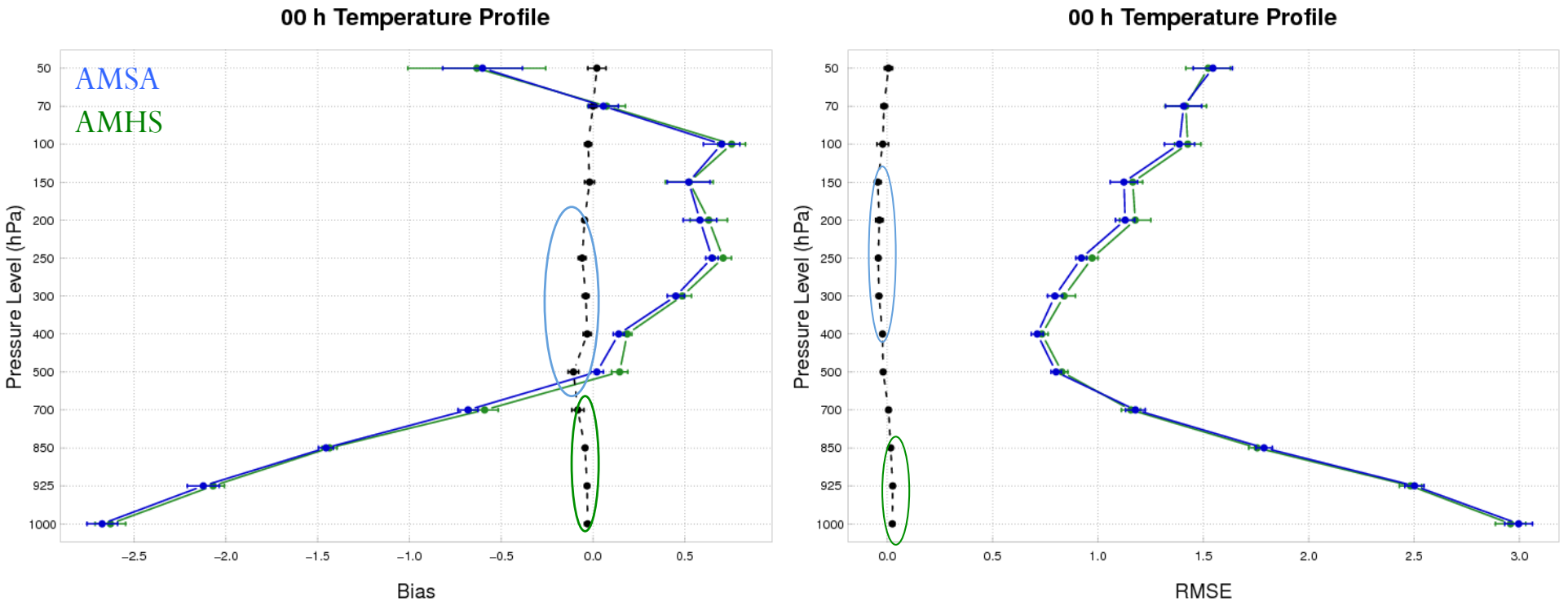

* Liu et al. 2012, Schwartz et al. 2012, Hamill et al. 2011, Houtekamer et al. 2005

# Verification Results*

- ✓ **Point verification against sounding (dropsonde) observations**
- ✓ TC case studies

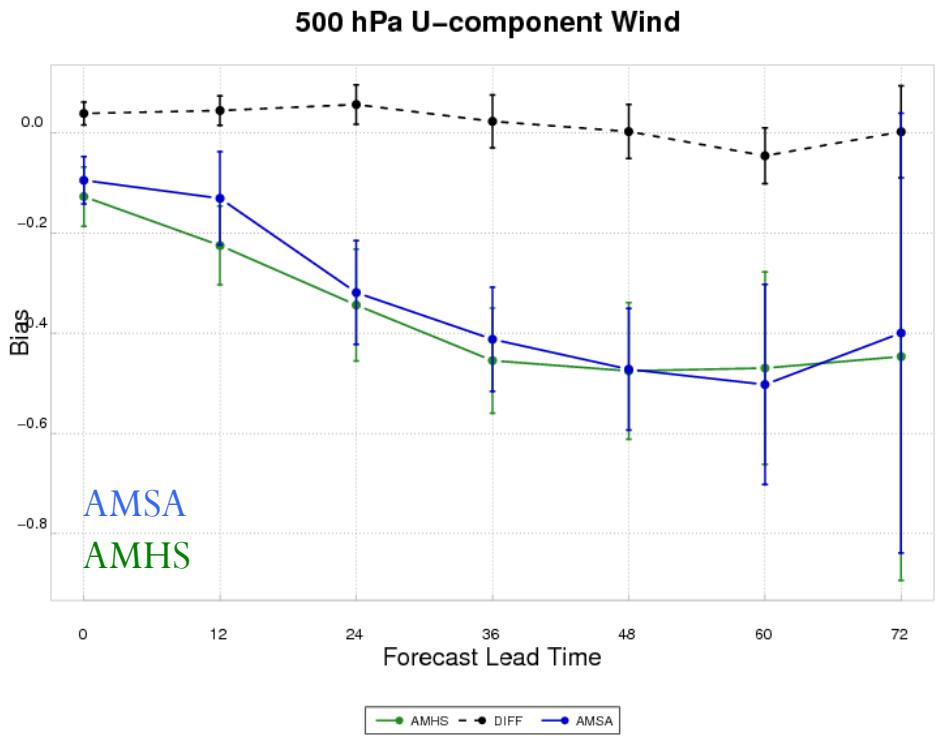
* Verification focus on AMSA-AMHS

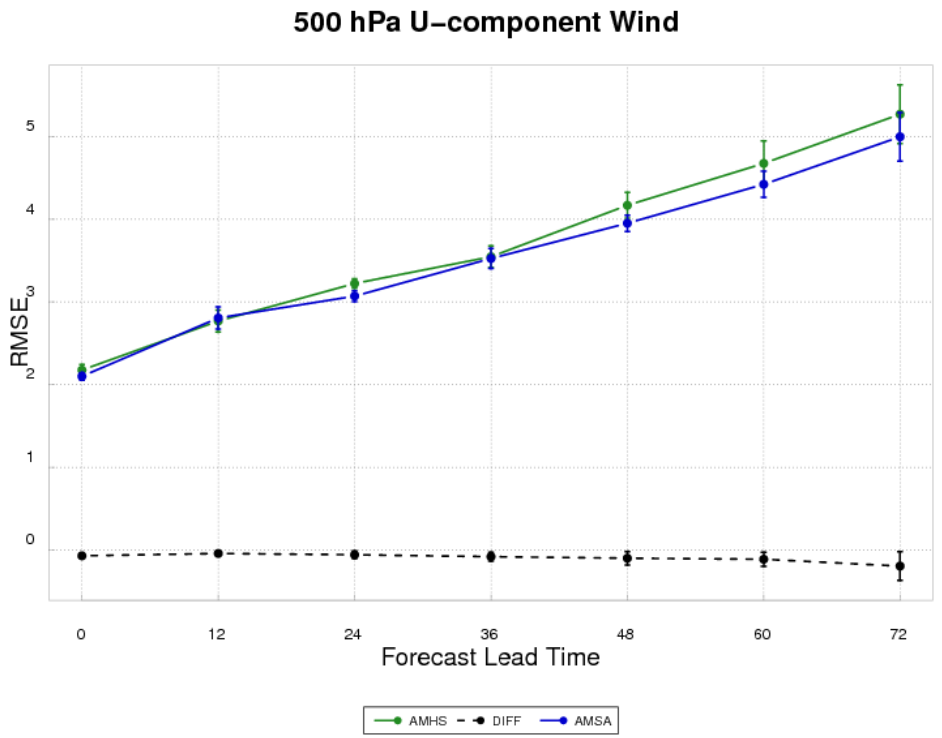
# Verification Against Sounding Data




- Pairwise statistical significance (AMSA-AMHS) is determined when the CIs of the difference do not encompass 0
- Pairwise SS differences favor AMHS slightly at the lowest levels, and favor AMSA for mid-levels

# Verification Against Sounding Data




- Pairwise differences for bias favor AMSA for lead times out to 1 day; neutral for all remaining lead times
- RMSE pairwise SS differences indicate AMSA is better for all lead times

# Verification Against Sounding Data: Summary Table

- RMSE for all aggregations favor AMSA, except low level early lead times (T) for AMHS
- Biases show more neutral and slight favor for AMHS
- Indication of larger variability in AMHS forecasts… stemming from MHS data?

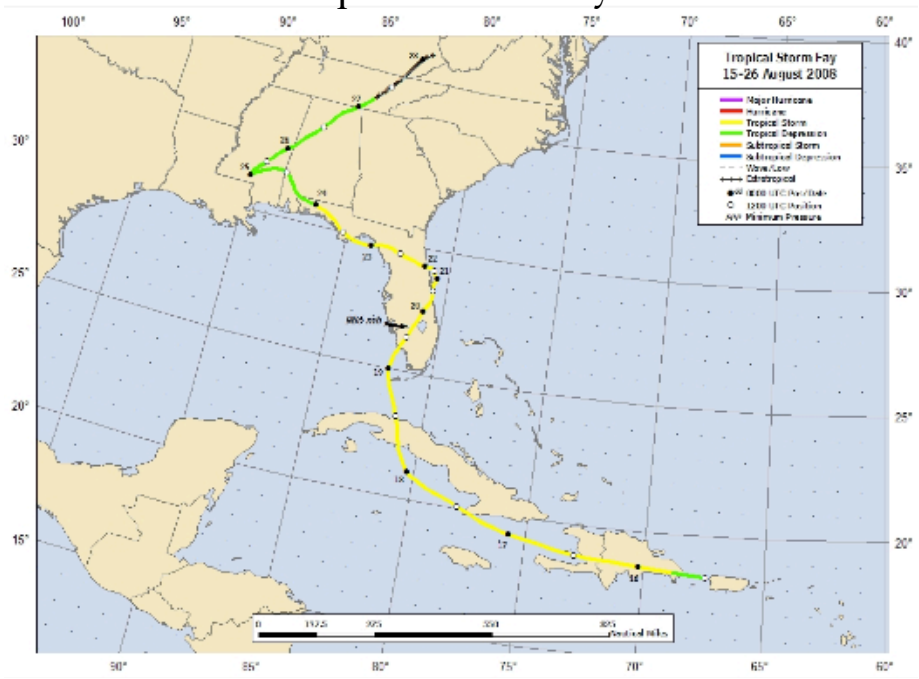
| | | BIAS | | | | | RMSE | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 925 | 850 | 700 | 500 | 200 | 925 | 850 | 700 | 500 | 200 |
| T | 0 | AMHS | AMHS | AMHS | AMSA | AMSA | AMHS | AMHS | | AMSA | AMSA |
| | 12 | AMHS | AMHS | AMHS | AMSA | AMSA | AMHS | | | AMSA | AMSA |
| | 24 | | | | AMSA | AMSA | | | | | AMSA |
| | 36 | | | | AMSA | AMSA | | | | AMSA | AMSA |
| | 48 | | | | AMSA | AMSA | | | | | AMSA |
| | 60 | | | | AMSA | AMSA | | | | | AMSA |
| | 72 | AMHS | | | | AMSA | | | | AMSA | AMSA |
| U | 0 | AMSA | | | AMSA | | AMSA | AMSA | AMSA | AMSA | AMSA |
| | 12 | AMSA | AMSA | AMSA | AMSA | AMHS | AMSA | AMSA | | AMSA | AMSA |
| | 24 | | | | AMSA | | AMSA | | AMSA | AMSA | AMSA |
| | 36 | AMSA | | | | AMHS | AMSA | AMSA | AMSA | AMSA | AMSA |
| | 48 | | | | | | | AMSA | AMSA | AMSA | AMSA |
| | 60 | | | | | AMHS | AMSA | AMSA | AMSA | AMSA | |
| | 72 | | | | | | | | AMSA | AMSA | |
| V | 0 | | | AMSA | | AMHS | AMSA | AMSA | AMSA | AMSA | AMSA |
| | 12 | | AMSA | | | AMSA | AMSA | AMSA | | AMSA | AMSA |
| | 24 | | AMSA | | | | AMSA | AMSA | AMSA | AMSA | AMSA |
| | 36 | AMHS | | | AMHS | | | AMSA | | AMSA | |
| | 48 | | | | | | AMSA | AMSA | | AMSA | AMSA |
| | 60 | | | | AMSA | | | | | | |
| | 72 | AMHS | | | AMHS | | | | | | AMSA |
| Q | 0 | | AMSA | | AMHS | - | AMSA | AMSA | AMSA | | - |
| | 12 | | | | AMHS | - | AMSA | | | | - |
| | 24 | | | | AMHS | - | AMSA | AMSA | AMSA | AMSA | - |
| | 36 | | | | AMHS | - | AMSA | | | AMSA | - |
| | 48 | | | AMSA | AMHS | - | AMSA | | | AMSA | - |
| | 60 | AMHS | | | AMHS | - | | | | AMSA | - |
| | 72 | AMHS | | | AMHS | - | | AMSA | AMSA | AMSA | - |

# Verification Results

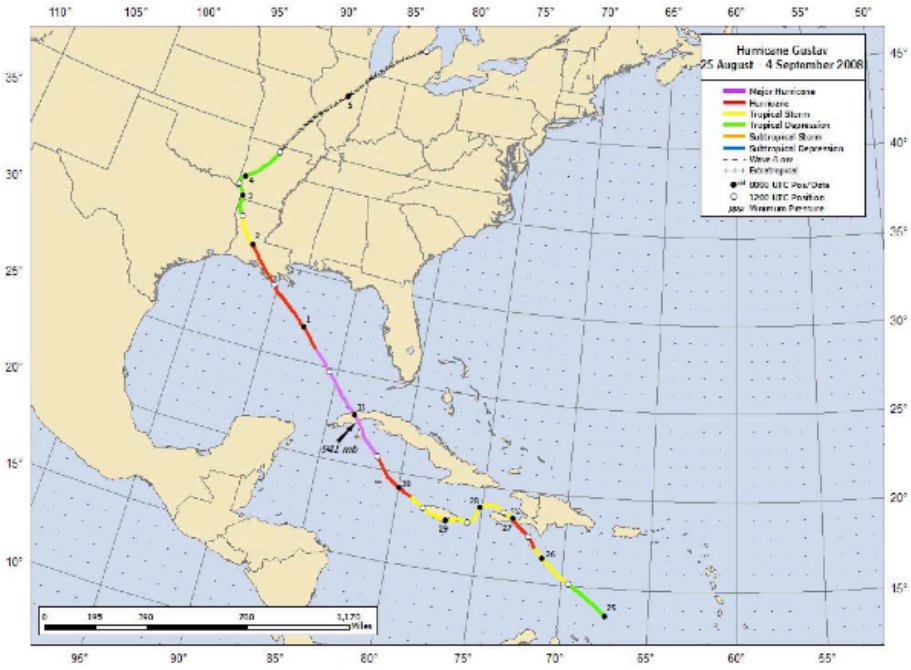
- ✓ Point verification against sounding (dropsonde) observations
- ✓ **Tropical Cyclone case studies**

# Overview of Tropical Storms

Tropical Storm Fay



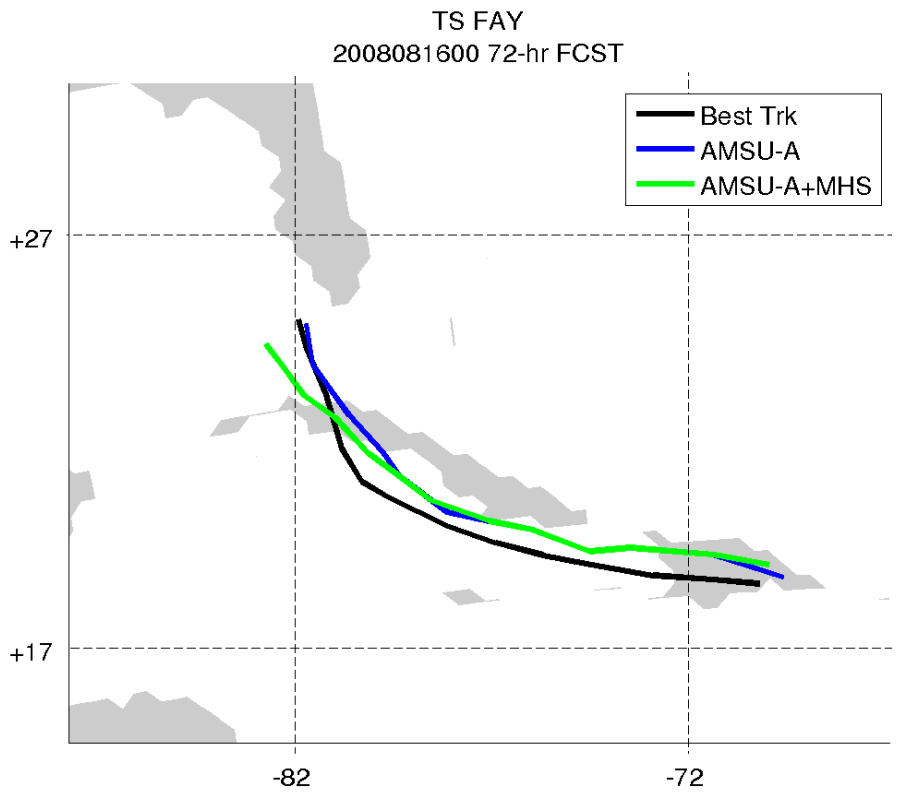

Hurricane Gustav

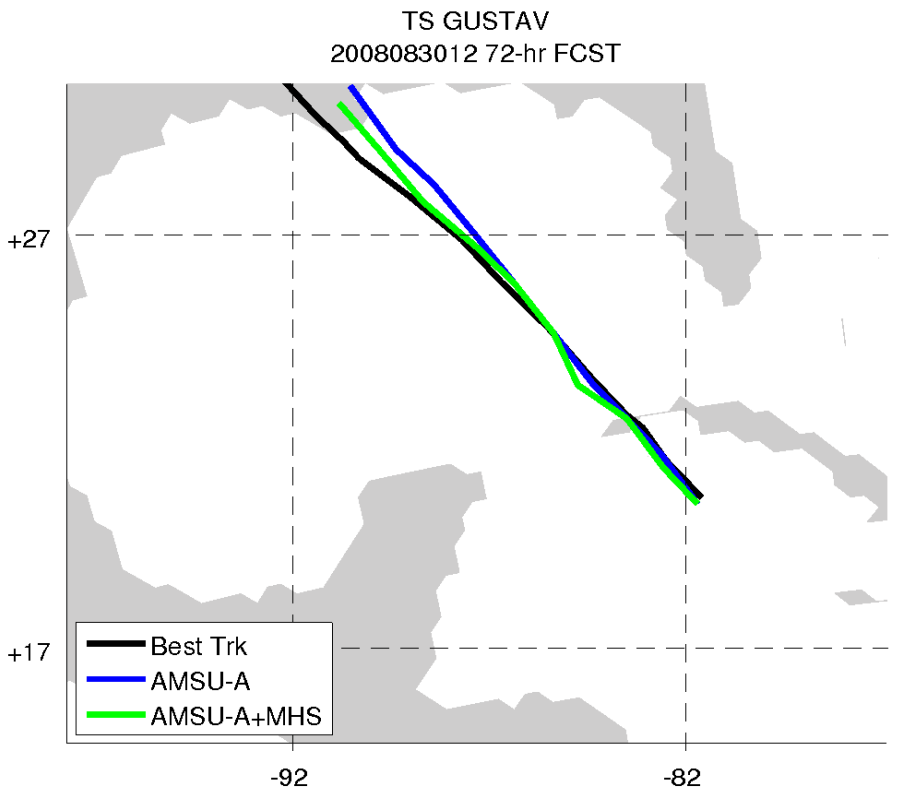



*Best Track Images from National Hurricane Center (NHC)*

- Tropical Storm Fay
  - Long lived tropical storm
  - 8 landfalls
  - Produced flooding in DR, Cuba, Haiti, FL
- Hurricane Gustav
  - Reached Cat. 4 hurricane
  - Landfall in LA
  - Significant damage to Cuba, Haiti, LA

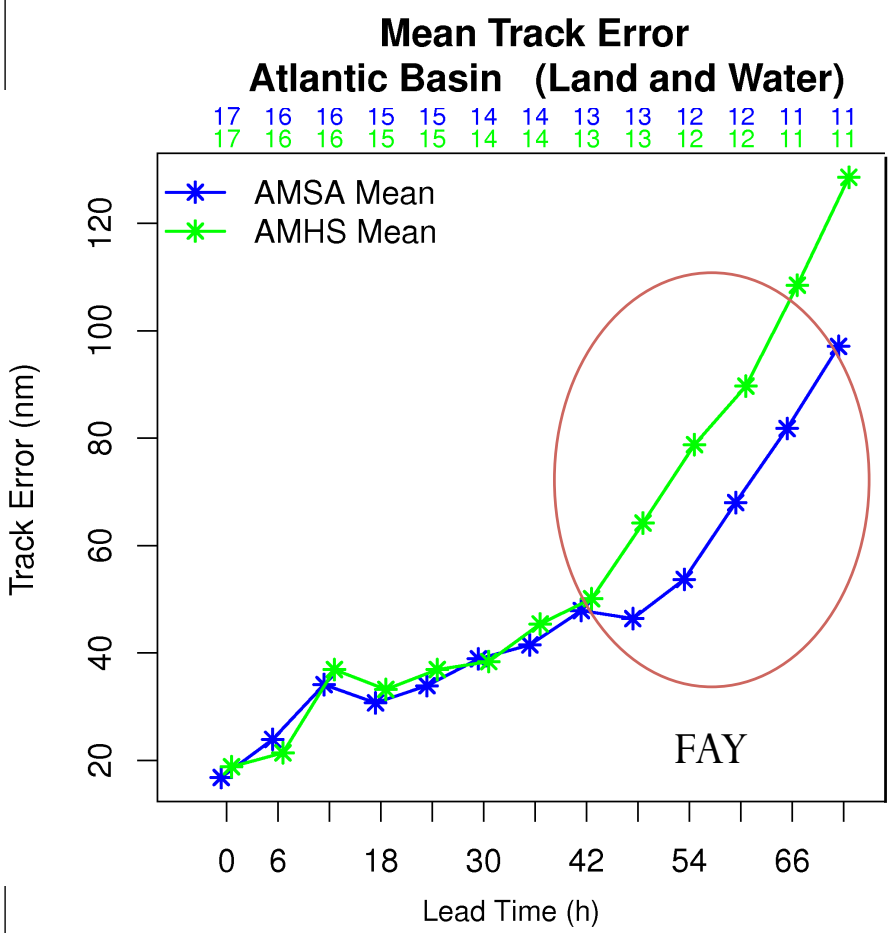
# Fay & Gustav Tracks

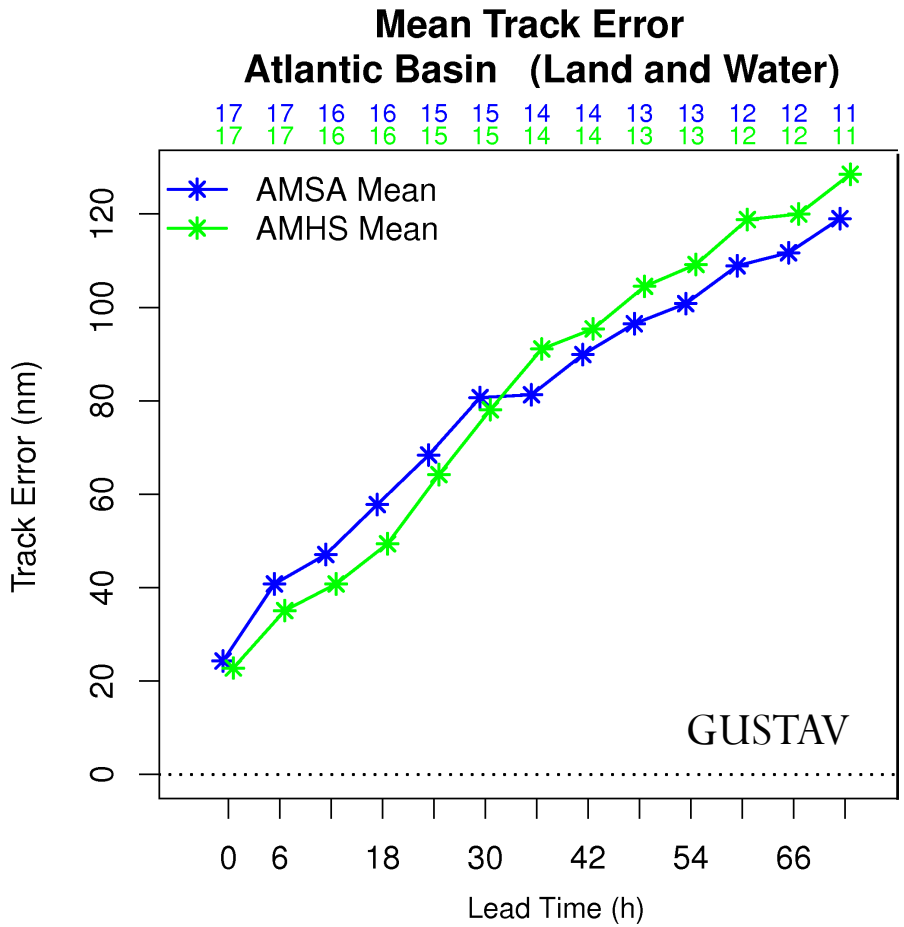



- Fay
  - AMSA/AMHS tracks N of NHC Best Track
  - AMHS misses Northward curvature
- Gustav
  - AMSA/AMHS tracks NE of NHC Best Track toward end of fcst
  - AMHS track closer to NHC Best Track at longer lead times

# Track Errors

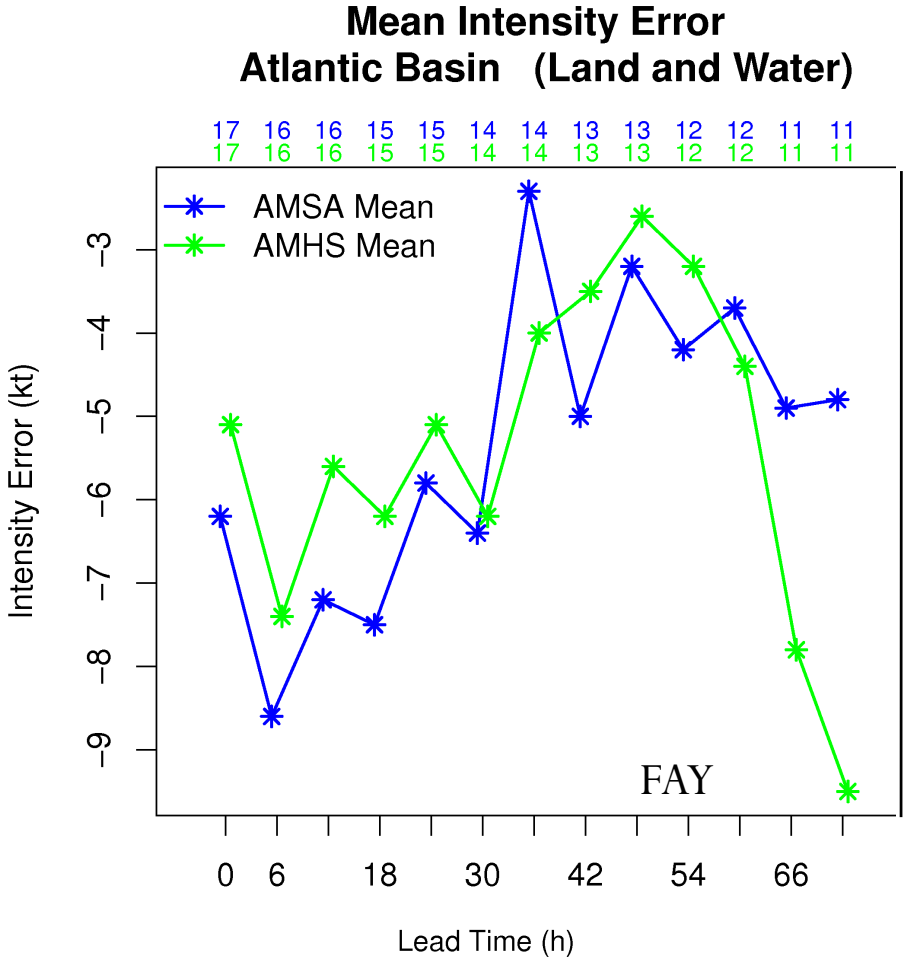


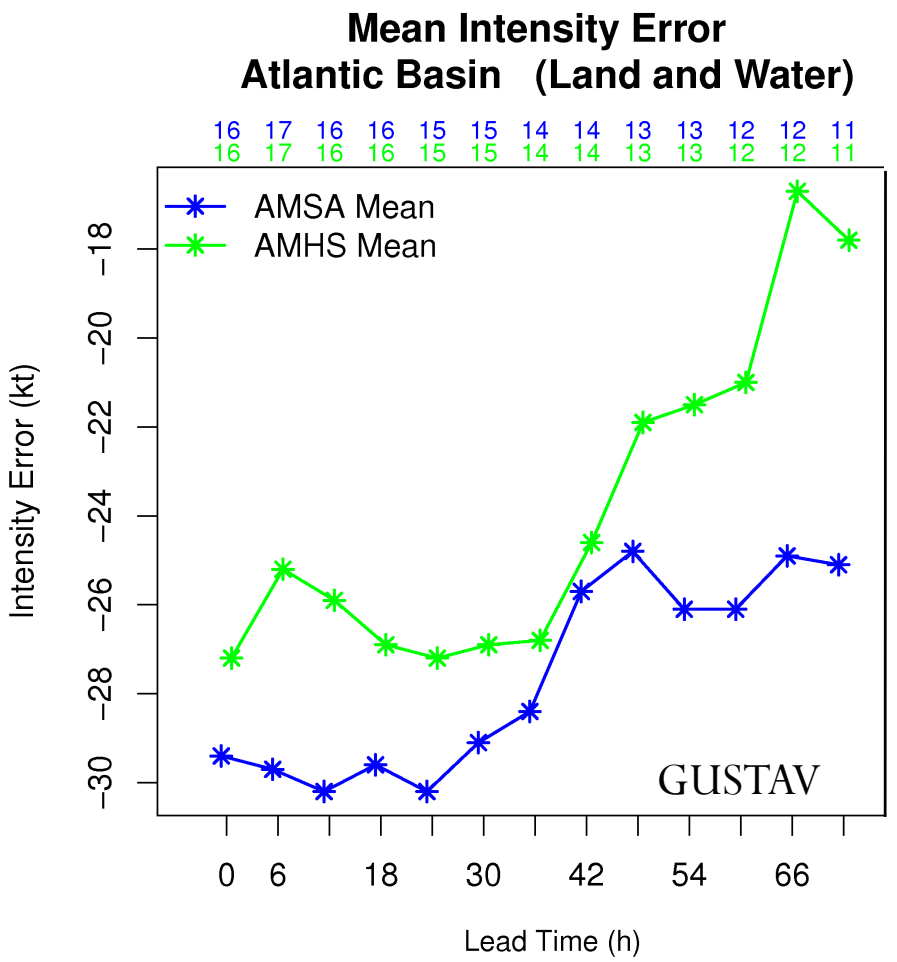




- Fay AMHS mean track error deviates from AMSA quickly after 42 hrs
  - Most contribution from Along Track (AMHS moves storm too fast)
- Gustav mean track errors close between AMSA and AMHS - AMHS slightly lower out to 30 hr

✓ Statistical Significance is not assessed for individual storms due to small sample sizes

# Wind Errors




- Fay intensity errors for AMHS slightly smaller out to 1 day, drop off quickly after 60 hrs
- Gustav intensity errors for AMHS smaller than AMSA for all lead times

# Conclusions

- When aggregating over the full time period, point verification against sounding data indicates neutral to a slight degradation in fcsts for the AMHS assimilation run.
  - Bias statistics show more SS differences favoring AMHS over AMSA than RMSE statistics
- Track and intensity errors show mixed results favoring the AMSA configuration for Fay, and the AMSUA+MHS configuration more often for Gustav.
  - Fay results show AMHS moves too quickly, does not curve the track properly, and has a sharp increase in intensity error for longer lead times
  - Gustav results indicate AMHS has lower track errors for early lead times, and lower intensity errors for all lead times