Improving SFMR Surface Wind Measurements in Intense Rain Conditions

Eric Uhlhorn (NOAA/HRD) – Principal Investigator

Brad Klotz (University of Miami/CIMAS/HRD) – Co-investigator

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Project coordination (NHC):

Dan Brown, Eric Christensen, Eric Blake, and Chris Landsea

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Background

- The airborne stepped frequency microwave radiometer (SFMR) measures surface wind speed and rain rate in tropical cyclones

- Observations are obtained in all-weather conditions -- highest winds are most accurately measured

- In extreme precipitation and weak-to-moderate wind conditions, SFMR winds tend to be biased high relative to in situ ground-truth data

Year 1 Recap

- Quantified the SFMR wind speed errors by developing and expanding a database of SFMR and GPS dropsonde pairs (2005 – 2011)

- Developed a wind speed bias statistical correction
  - This model applies a larger correction to lower wind speeds in heavy rain
  - $$\Delta U = 2.853 - 0.070 U_{SFMR} + 0.120 R - 1.019 \times 10^{-3} (U_{SFMR} \cdot R)$$

- Validated the correction through an independent sample of the database
  - RMSE and mean bias both improved by > 50% for heavy rain and weak wind conditions

JHT Year 2 Objectives

- Apply correction in real-time at the National Hurricane Center
  - Available to forecasters when aircraft data were being transmitted
- Evaluate the bias correction of the 2012 data
  - Similarly to the previous data (2005-2011), the 2012 bias corrected winds are paired with surface-adjusted winds from the GPS sondes
  - Statistical tests and comparisons are completed
- Develop an updated wind-emissivity relationship from additional data
  - Includes data from 2012 and removes data that have less than 10 mm hr^{-1} SFMR rain rate
- Develop a new rain-absorption model based on independent rain data
  - Using coincident Tail Doppler and Precipitation Imaging Probe (PIP) rain data, a new Z-R relationship is developed.
  - This new Z-R is used for determining the relationship between the R and absorption

Evaluation of 2012 bias correction

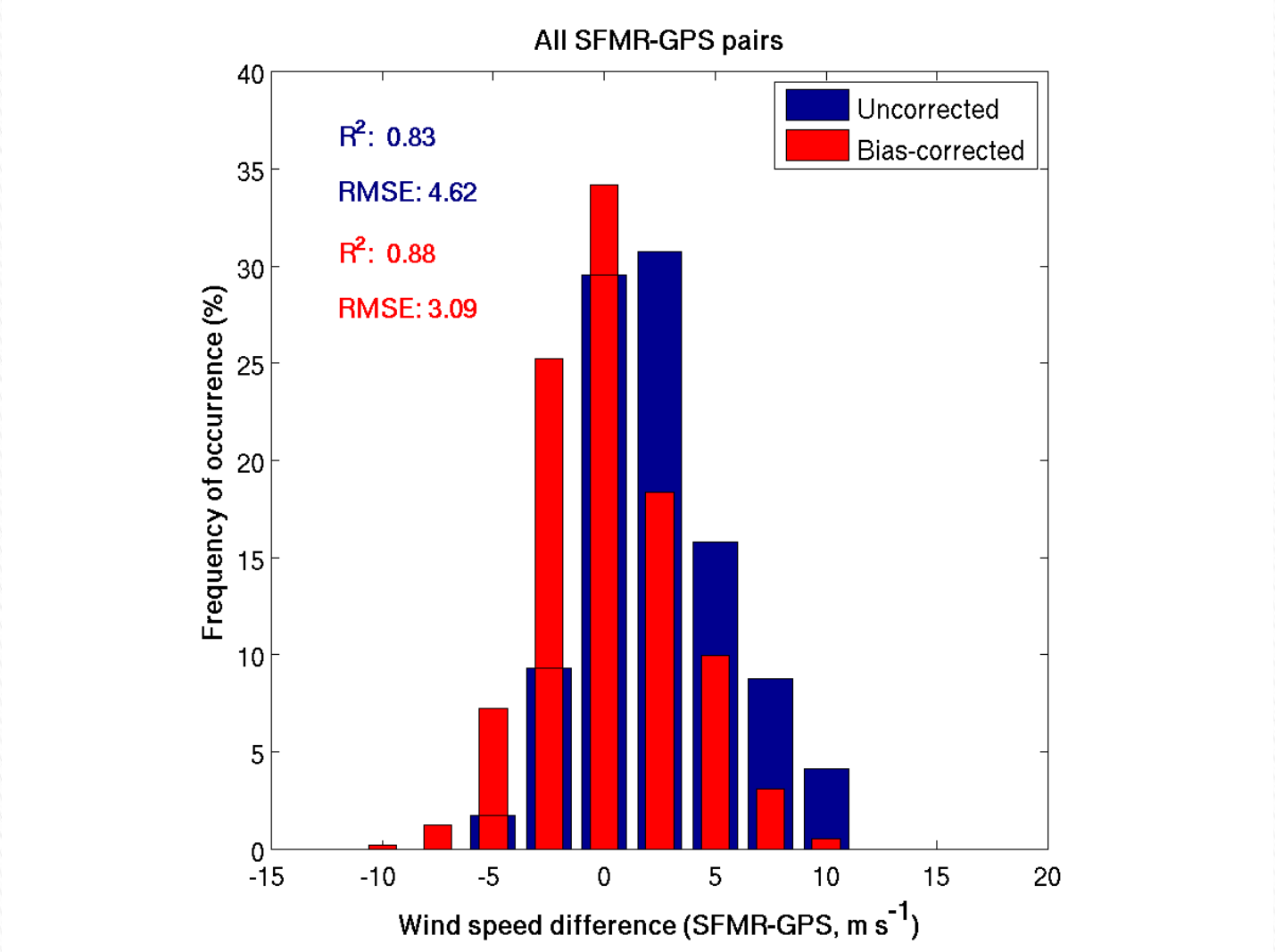
- All data for NOAA and AFRC missions were processed and paired with GPS dropsondes

- A total of 582 pairs were collected, 89% of which were in rain less than 10 mm hr^{-1}

	$U_{SFMR} < 17$	$17 \leq U_{SFMR} < 25$	$25 \leq U_{SFMR} < 33$	$33 \leq U_{SFMR} < 50$	$U_{SFMR} \geq 50$
RR < 10	**2.74 (0.22)** **281 (322)**	**1.44 (-0.39)** **186 (155)**	**1.32 (0.41)** **37 (32)**	**2.24 (1.49)** **14 (9)**	**-- (--)** **0 (0)**
10 ≤ RR < 20	**7.91 (3.64)** **5 (10)**	**4.03 (0.59)** **17 (17)**	**2.42 (-0.39)** **16 (14)**	**0.45 (--)** **4 (1)**	**-- (--)** **0 (0)**
20 ≤ RR < 30	**-- (--)** **0 (1)**	**-- (--)** **1 (1)**	**3.33 (0.64)** **6 (7)**	**2.49 (-1.11)** **5 (3)**	**-- (--)** **0 (0)**
RR ≥ 30	**-- (--)** **0 (1)**	**-- (1.96)** **1 (4)**	**4.67 (-1.00)** **7 (4)**	**-- (--)** **2 (1)**	**-- (--)** **0 (0)**

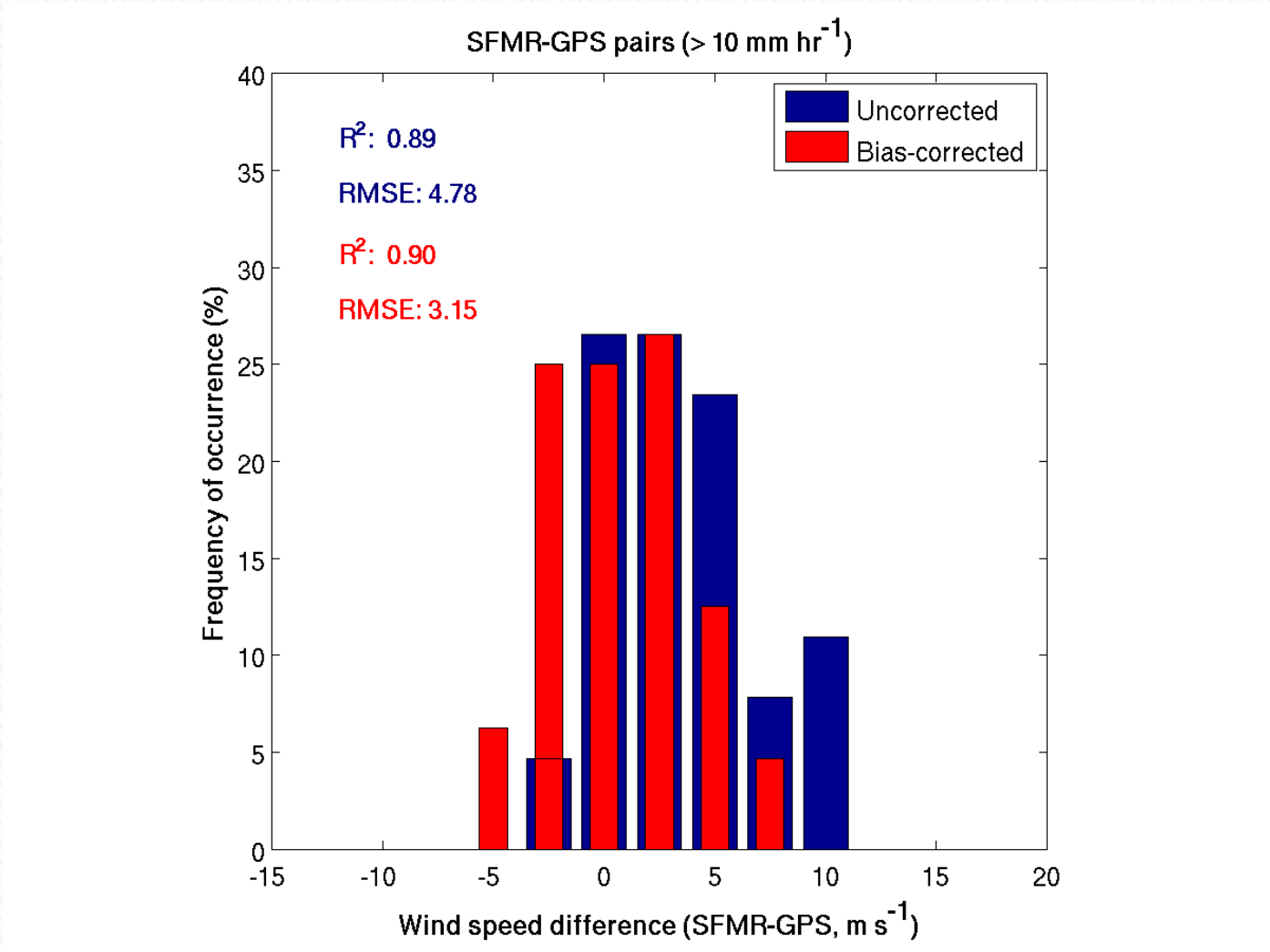
Evaluation of 2012 correction (cont.)

- Histogram of all pairs indicates that the bias-corrected winds compare better to the GPS dropsonde winds
- The difference between the two samples is statistically significant at 95% confidence



Evaluation of 2012 correction (cont.)

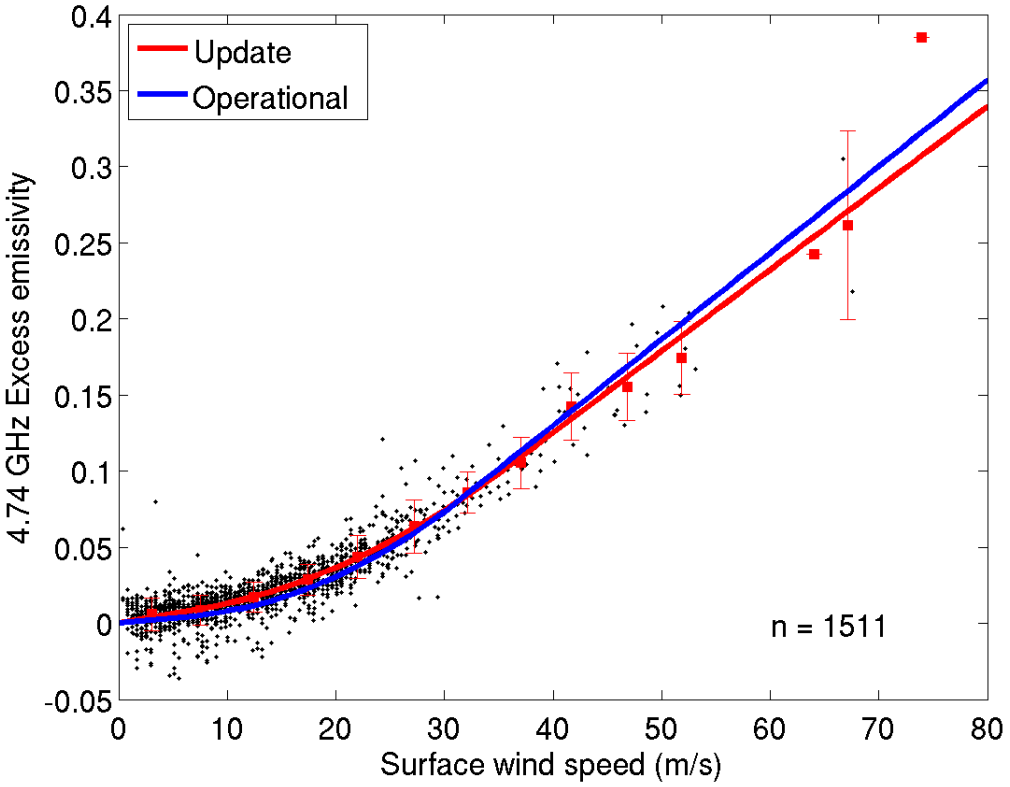
- For heavier rain conditions (> 10 mm hr^{-1}), the difference between the two wind measurements shifts closer to zero.
- The difference in sample means is also statistically significant at 95% confidence



Updated Wind-Emissivity

- As part of the year 2 goals, we updated the wind-emissivity function in the GMF
  - Used the expanded SFMR-GPS dropsonde database and excluded values with rain rate < 10 mm hr^{-1} for wind speeds < 40 m s^{-1}

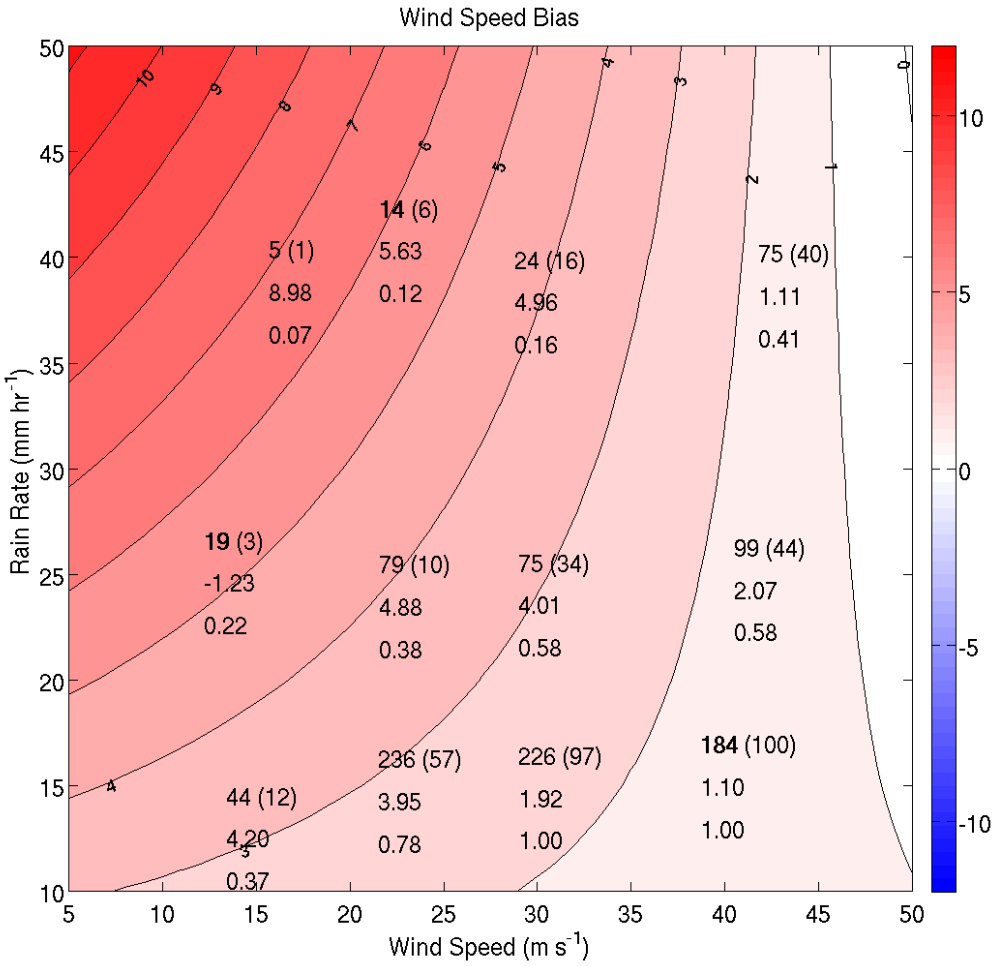
- Changes are shown at the lower wind speeds, but overall, the changes are minimal



SFMR bias correction (high rain rate)

- Bias correction model updated with new data for RR > 10 mm hr^{-1} and wind speeds < 50 m s^{-1}

- Higher weights are applied to weaker winds and higher rain rates



$$\Delta U = 1.054 + 0.0051 U_{SFMR} + 0.229 R - 5.147 \times 10^{-3} (U_{SFMR} \cdot R)$$

Summary and remaining work for year 2

- To correct the overestimation of SFMR wind speeds in the presence of moderate to heavy rain:
  - Applied the bias-correction in real-time during the 2012 hurricane season
  - Statistically evaluated the performance of the bias-correction
  - Developed a new wind-emissivity model function based on the expanded database and for rain conditions only
  - Developing a new rain-absorption model to complete the new algorithm.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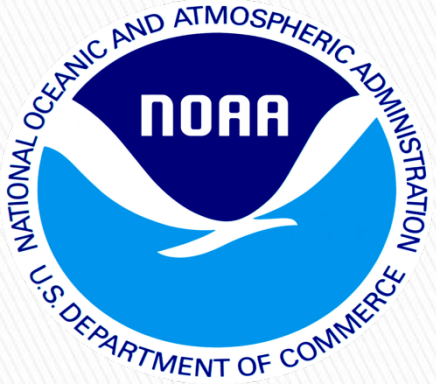
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Questions?