

# Rain Impact on SFMR Measurements

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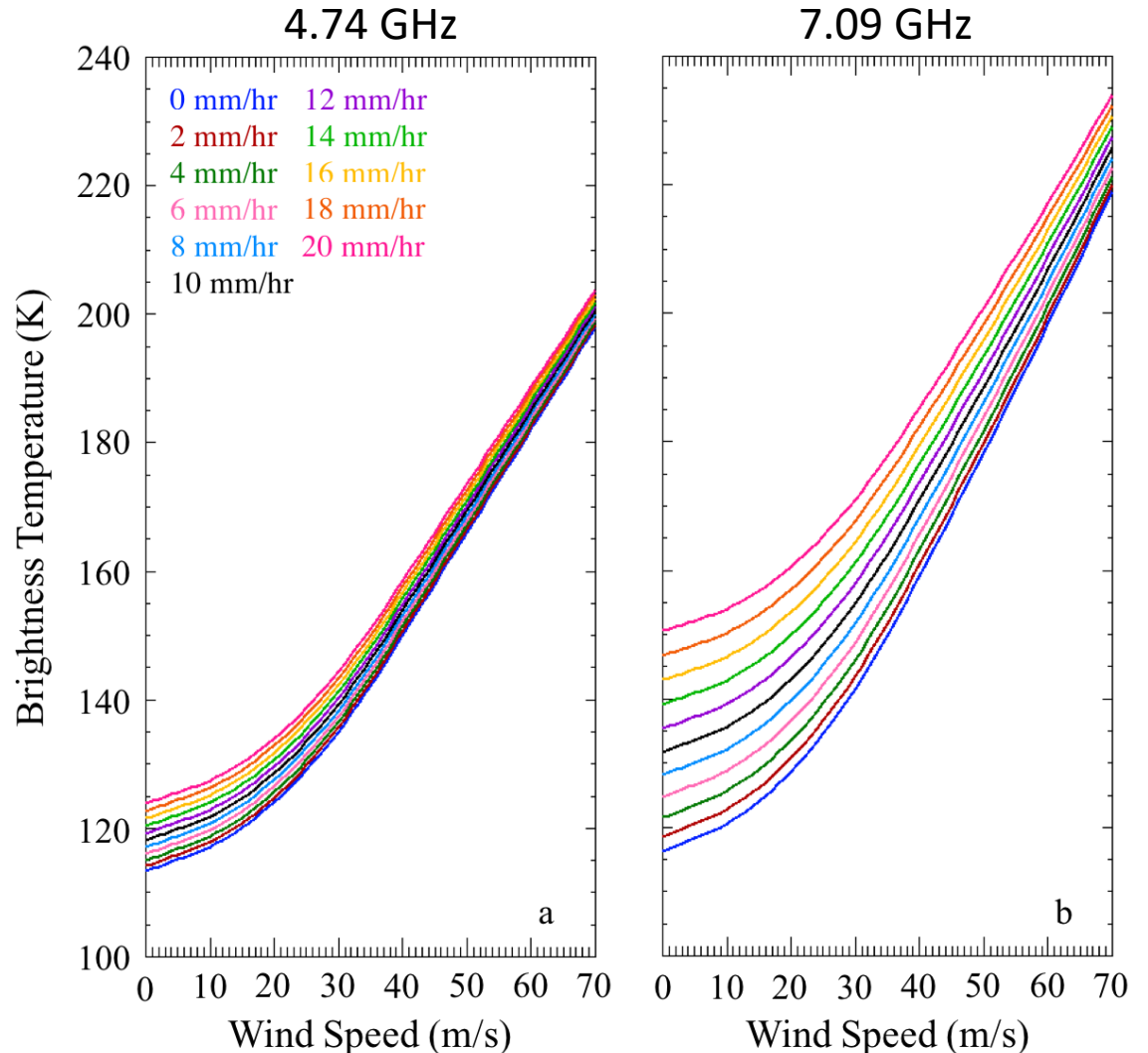
Heather M. Holbach<sup>1,2,3</sup>,  
B. W. Klotz<sup>3,4</sup>, and M. A. Bourassa<sup>1</sup>

<sup>1</sup>Florida State University, <sup>2</sup>Northern Gulf Institute,  
<sup>3</sup>NOAA/AOML/HRD, <sup>4</sup>University Of Miami/CIMAS



# Stepped-Frequency Microwave Radiometer (SFMR)

- Airborne C-band microwave radiometer
  - NOAA P-3 and Air Force C-130
- Designed to obtain surface wind speed and rain rate measurements in tropical cyclones
- Stepped-frequency design allows for rain rate retrievals
  - Larger differences with increasing rain rate at lower wind speeds



# Rain Bias in Previous Algorithm (Uhlhorn et al. 2007)

- Comparison to radar-derived rain rates indicated overestimate of weak rain rates and underestimate of strong rain rates (Jiang et al. 2006)
- Klotz and Uhlhorn (2014) found that SFMR wind speeds were overestimated in weaker wind speeds coupled with heavy precipitation

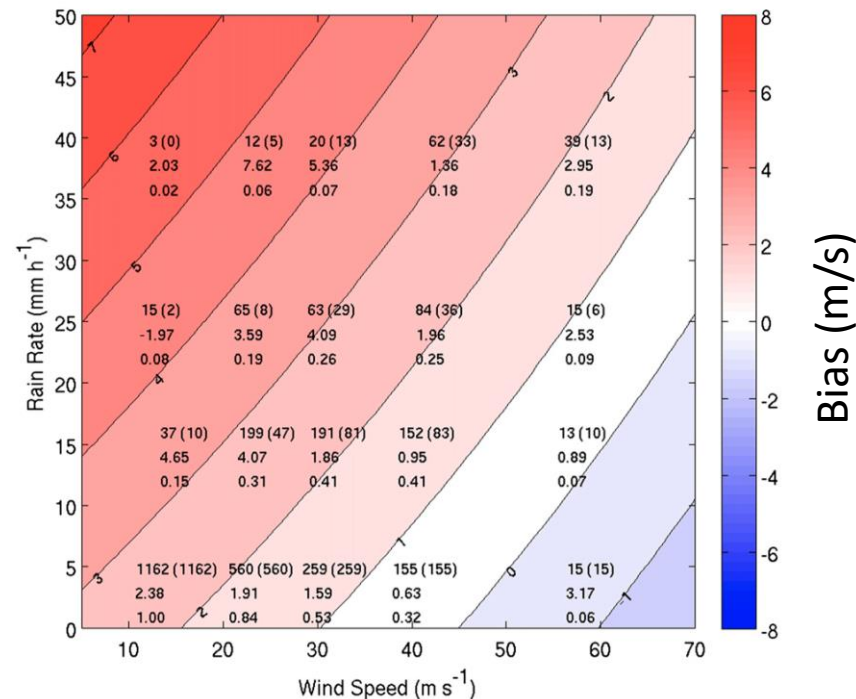


Figure 2 in Klotz and Uhlhorn (2014)

# Rain Column Height

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- Prior algorithm used a constant height of 4 km above the surface for rain column height
- Freezing level height ( $H$ ) is now estimated using flight level temperature ( $T_{amb}$ ) and altitude ( $h$ ) assuming a typical hurricane temperature profile (mean lapse rate,  $\gamma = 5.22 \times 10^{-3} \text{ K m}^{-1}$  from Zhang and Uhlhorn 2012)

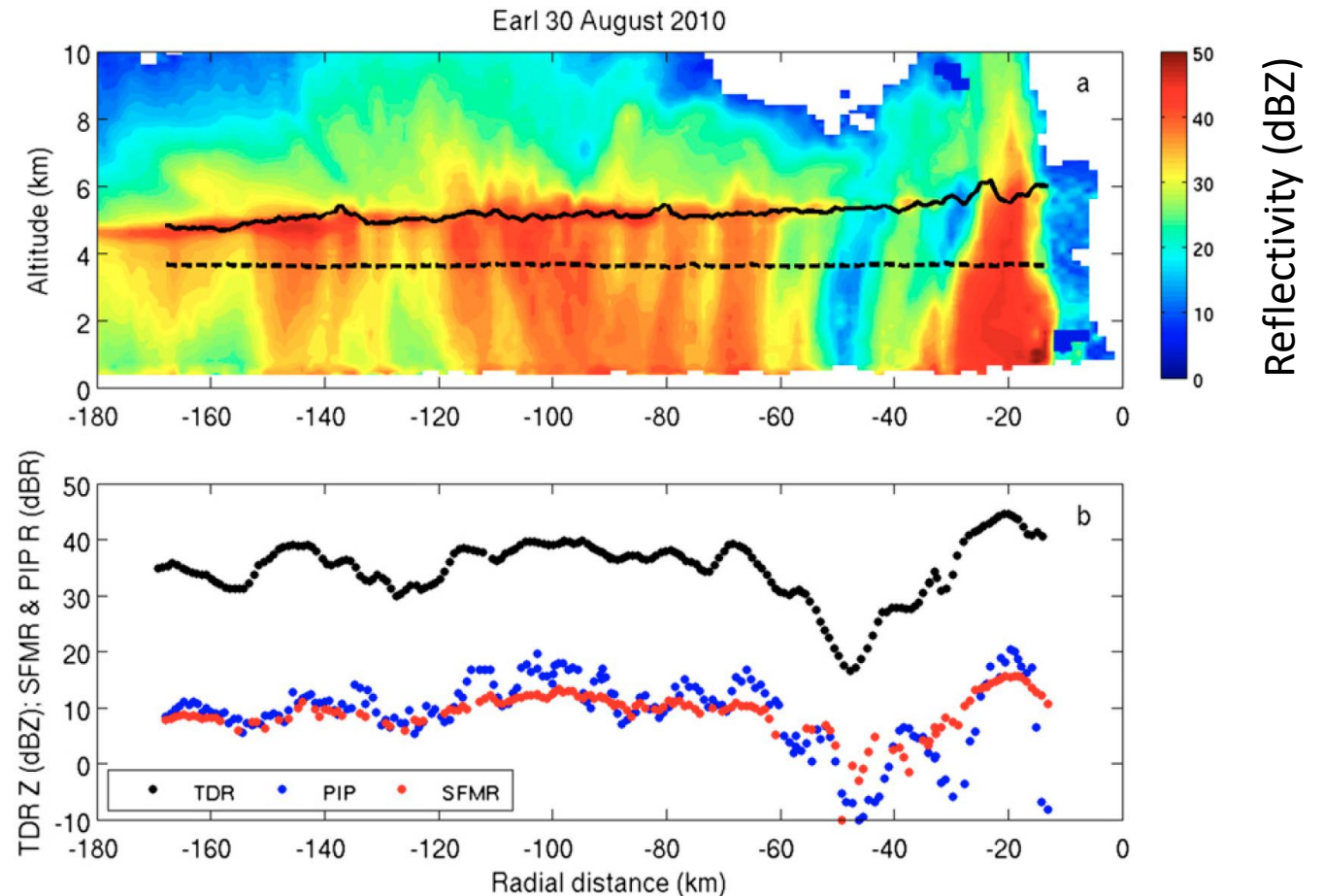
$$H = h + \gamma^{-1}T_{amb}$$

# Radar Reflectivity and Rain Rate Comparison

- PIP: Droplet Measurement Technologies Precipitation Imaging Probe
- TDR: Tail Doppler Radar
- Resulted in updated Z-R relationship:

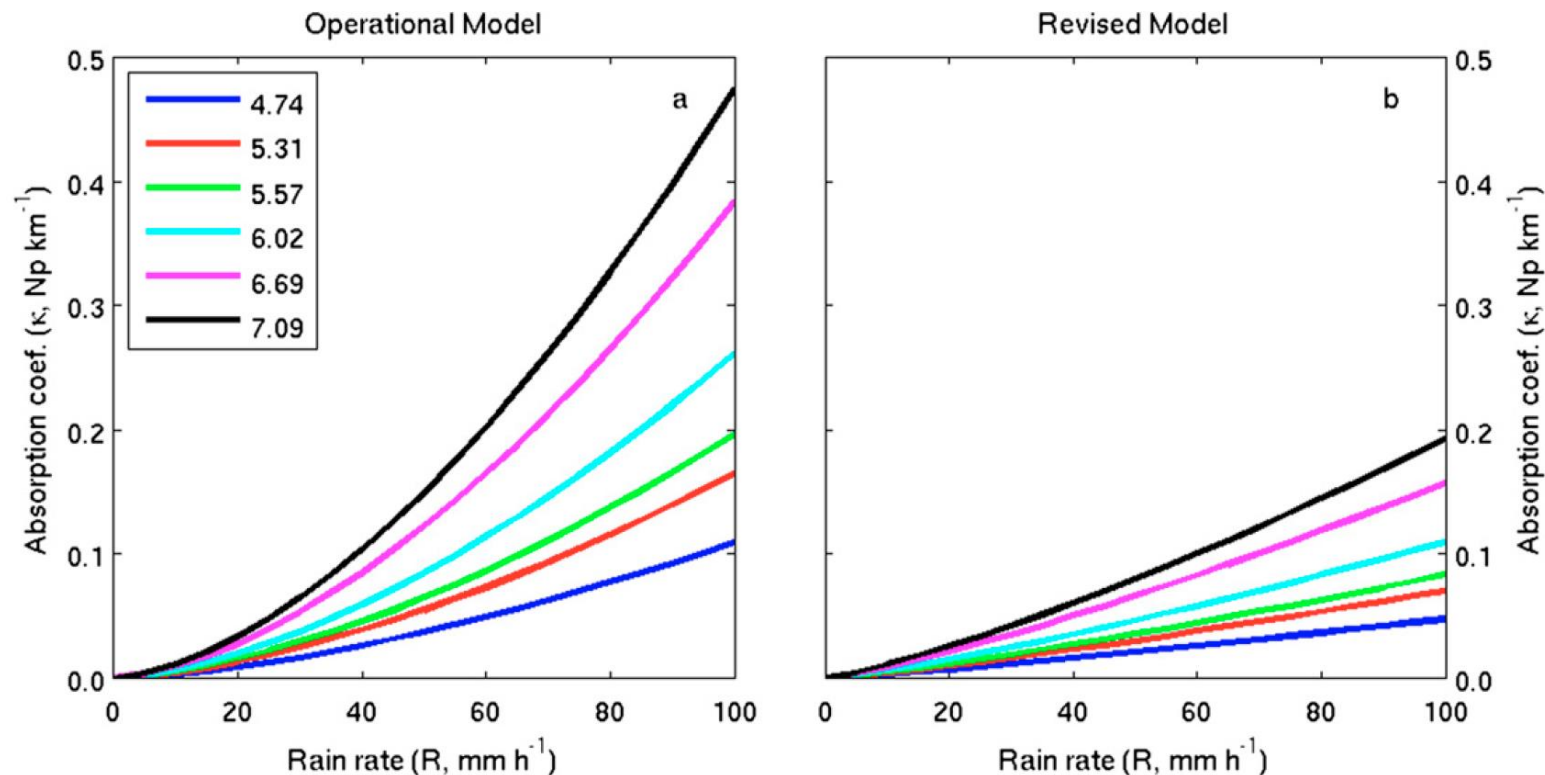
$$Z = 456R_{pip}^{1.07}$$

Figure 5 in Klotz and Uhlhorn (2014)

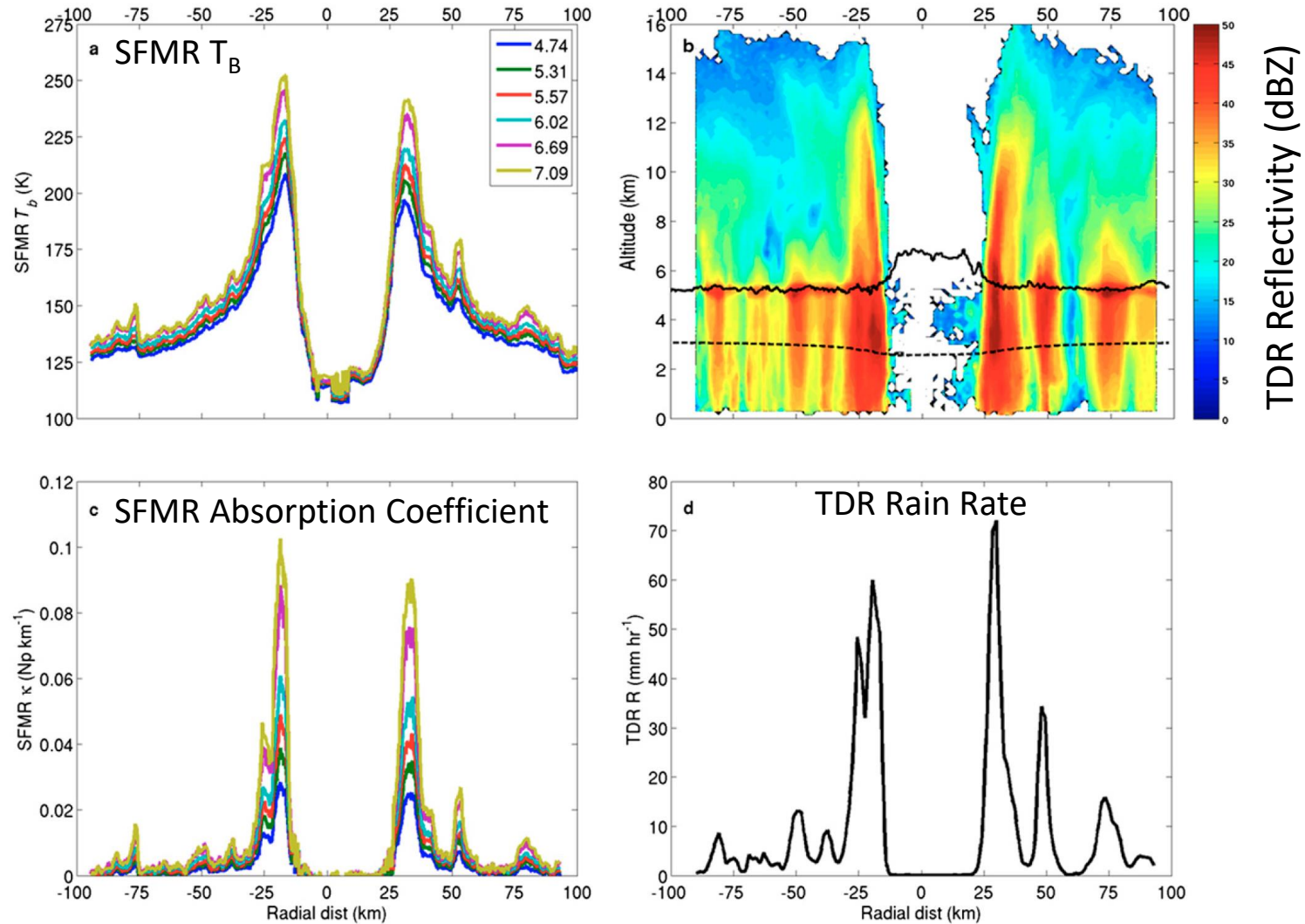


# Updated Rain Absorption Coefficient

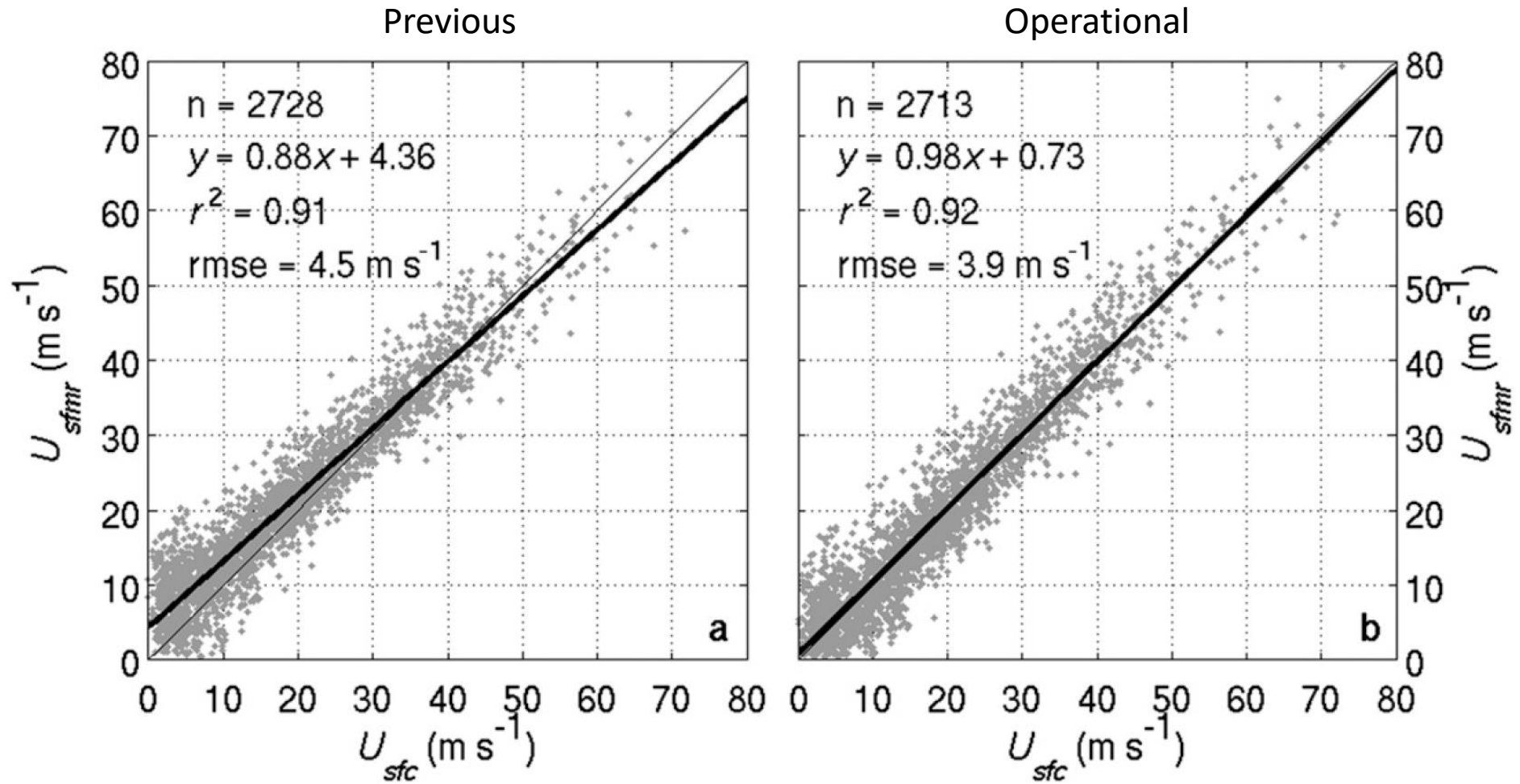
- Developed by computing rain rates from the TDR and comparing to absorption coefficients computed from updated SFMR wind-induced emissivity measurements



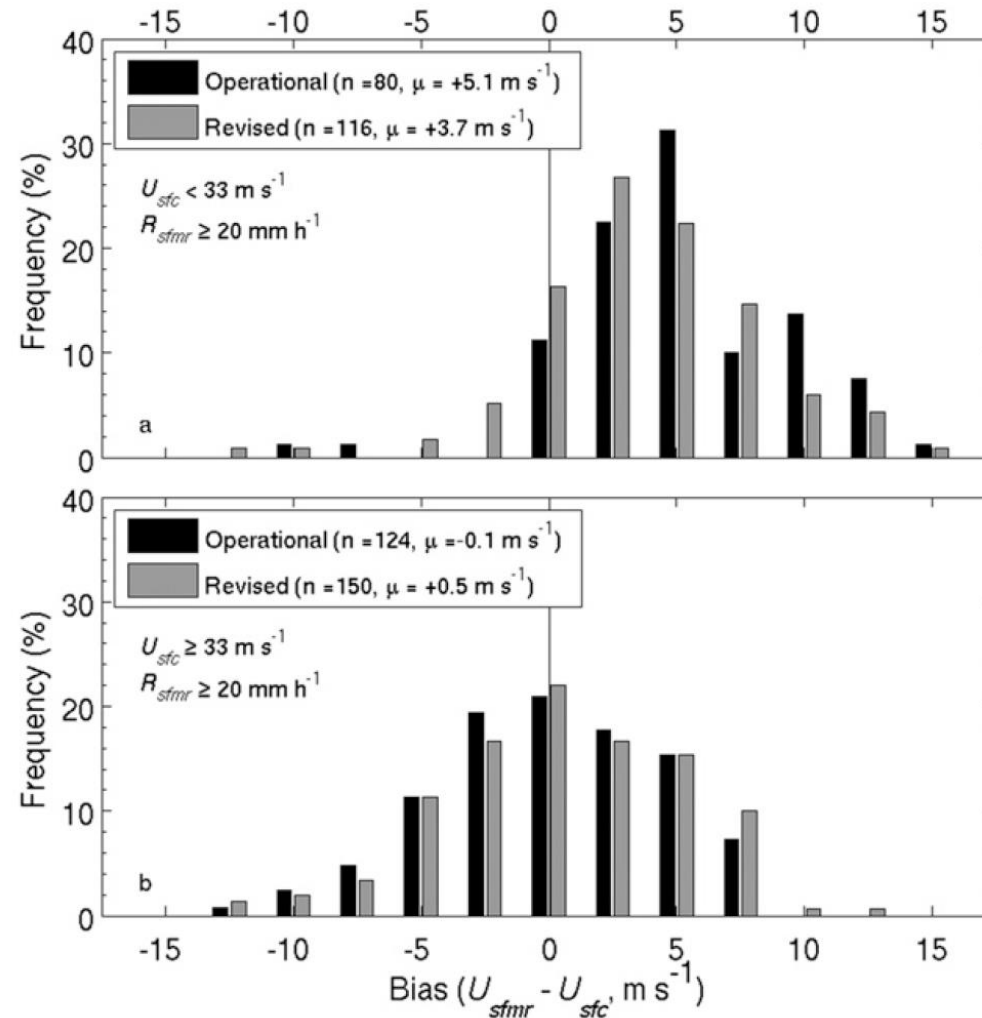
# Frequency Sensitivity to Rain



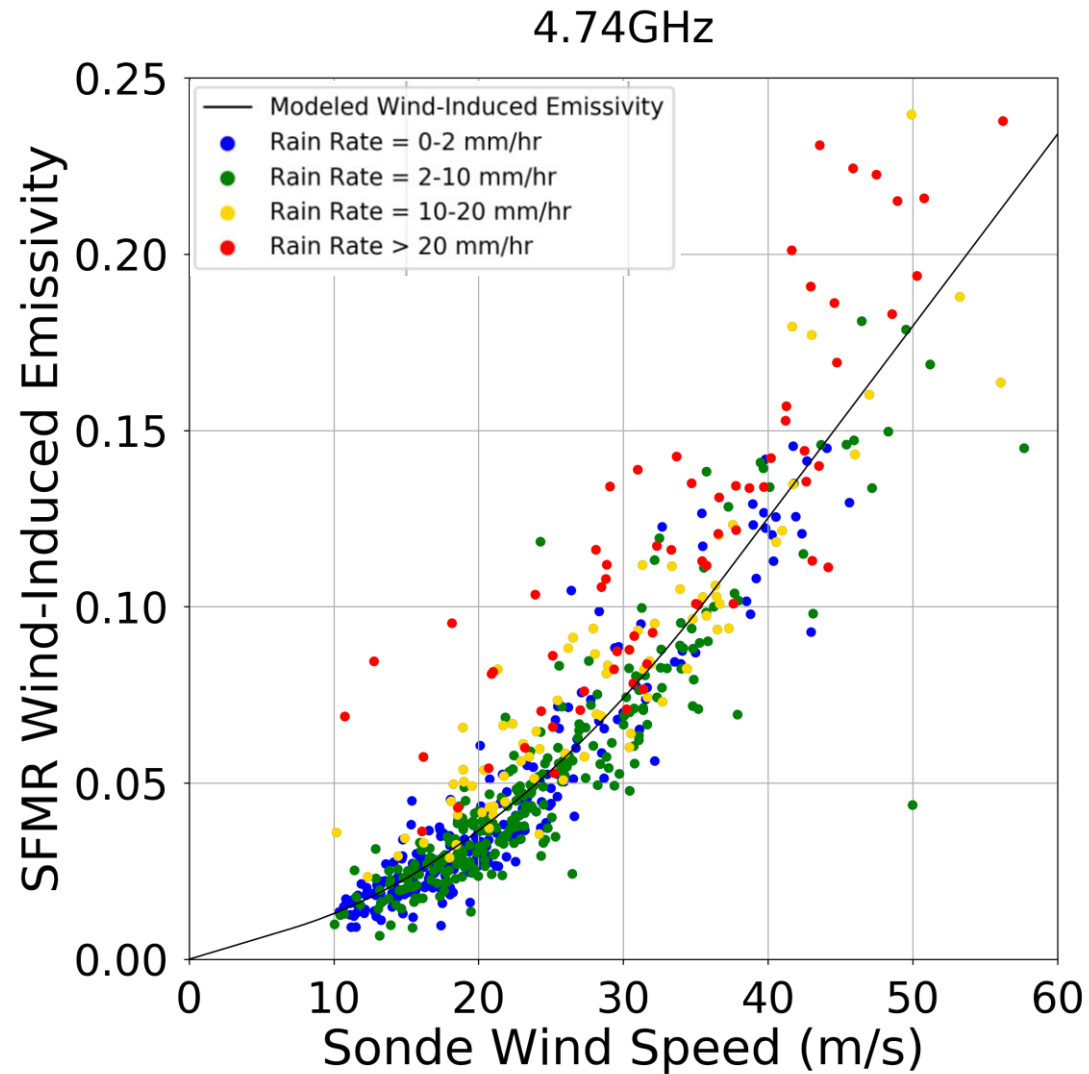
# Wind Speed Improvements



# Improved Bias



# Further Room For Improvement



# Summary

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- Klotz and Uhlhorn (2014) greatly improved the rain-related biases in the previous SFMR algorithm
  - Largest impact at low wind speeds coupled with high rain rates
  - All data from 1998-present has been re-processed using this new algorithm.
  - Data can be found here: <ftp://ftp.aoml.noaa.gov/hrd/pub/data/sfmr/>
- Future work:
  - Identify source of remaining high rain-rate error
  - Investigate impact of rain-related surface water freshening
  - How does rain impact whitewater/foam/spray at very high wind speeds?
- I am new HRD SFMR contact: heather.holbach@noaa.gov