

VALIDATION OF RAIN RATE RETRIEVALS FOR THE AIRBORNE HURRICANE IMAGING RADIOMETER (HIRAD)

Maria Marta Jacob¹, Student Member, IEEE, Matin Salemirad², Student Member, IEEE and W. Linwood Jones², Life Fellow, IEEE, Sayak Biswas³, member IEEE and Daniel Cecil³

¹Comision Nacional de Actividades Espaciales
Argentina

²Central Florida Remote Sensing Lab
University of Central Florida
Orlando, FL 32816-2362

³NASA Marshall Space Flight Center
Huntsville, AL

march.jacob@gmail.com

ABSTRACT

The NASA Hurricane and Severe Storm Sentinel (HS3) mission is an aircraft field measurements program using NASA's unmanned Global Hawk aircraft system for remote sensing and in situ observations of Atlantic and Caribbean Sea hurricanes. One of the principal microwave instruments is the Hurricane Imaging Radiometer (HIRAD), which measures surface wind speeds and rain rates. For validation of the HIRAD wind speed measurement in hurricanes, there exists a comprehensive set of comparisons with the Stepped Frequency Microwave Radiometer (SFMR) with in situ GPS dropwindsondes [1]. However, for rain rate measurements, there are only indirect correlations with rain imagery from other HS3 remote sensors (e.g., the dual-frequency Ka- & Ku-band doppler radar, HIWRAP), which is only qualitative in nature.

However, this paper presents results from an unplanned rain rate measurement validation opportunity that occurred in 2013, when HIRAD flew over an intense tropical squall line that was simultaneously observed by the Tampa NEXRAD meteorological radar (Fig. 1). During this experiment, Global Hawk flying at an altitude of 18 km made 3 passes over the rapidly propagating thunderstorm, while the TAMPA NEXRAD perform volume scans on a 5-minute interval. Using the well-documented NEXRAD Z-R relationship, 2D images of rain rate (mm/hr) were obtained at two altitudes (3 km & 6 km), which serve as surface truth for the HIRAD rain rate retrievals. A preliminary comparison of HIRAD rain rate retrievals (image) for the first pass and the corresponding closest NEXRAD rain image is presented in Fig. 2 & 3.

This paper describes the HIRAD instrument, which 1D synthetic-aperture thinned array radiometer (STAR) developed by NASA Marshall Space Flight Center [2]. The rain rate retrieval algorithm, developed by Amarin et al. [3], is based on the maximum likelihood estimation (MLE) technique, which compares the observed T_b 's at the HIRAD operating frequencies of 4, 5, 6 and 6.6 GHz with corresponding theoretical T_b values from a forward radiative transfer model (RTM). The optimum solution is the integrated rain rate that minimizes the difference between RTM and observed values. Because the excess T_b from rain comes from the direct upwelling and the indirect reflected downwelling paths through the atmosphere, there are several assumptions made for the 2D rain distribution in the antenna incident plane (cross-track to flight direction). The opportunity to knowing 2D rain surface truth from NEXRAD at two different altitudes will enable a comprehensive evaluation to be preformed and reported in this paper.



Fig. 1 HIRAD overpass of an intense tropical squall line in the Gulf of Mexico near Tampa, FL with an overlay of one simultaneous rain reflectivity (dBZ) image taken by the Tampa NEXRAD. Over a 40 minute time period, HIRAD obtained three high-resolution rain images.

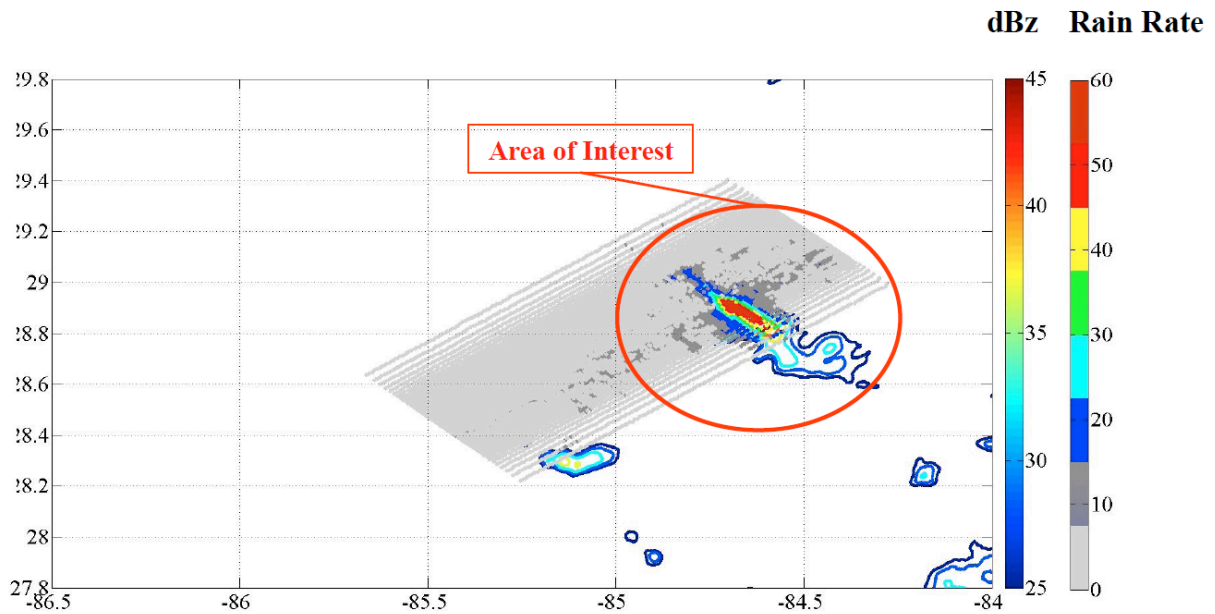


Fig. 2 Comparison of simultaneous rain rate images from HIRAD with corresponding rain rate (color contours) from NEXRAD.

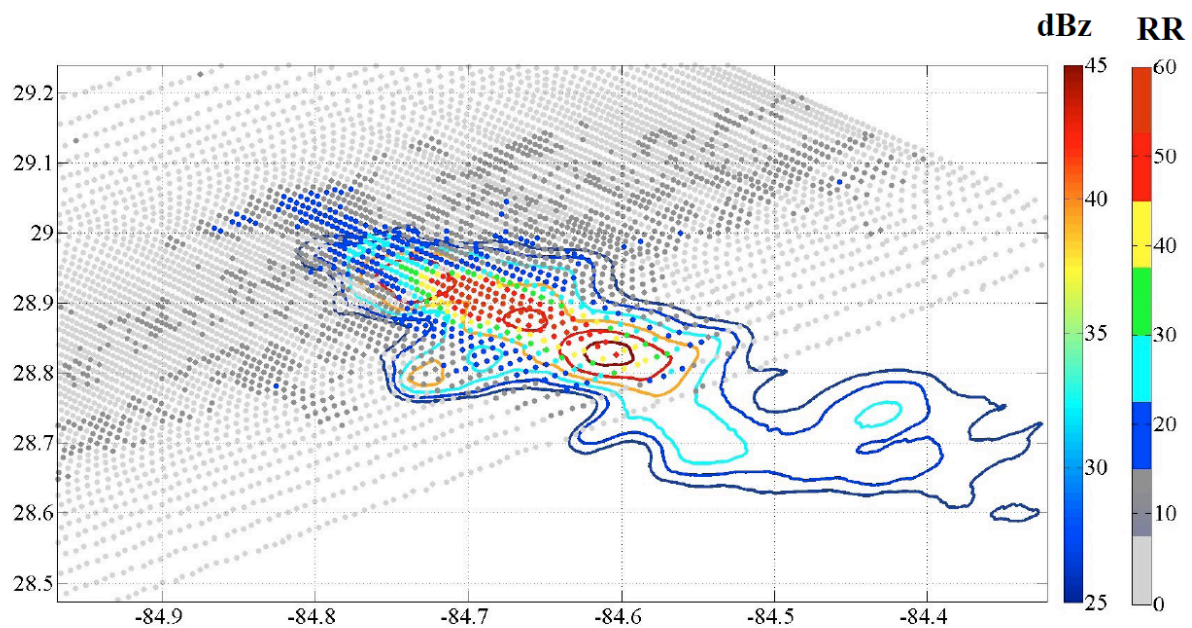


Fig. 3 Zoomed view of rain area of interest.

REFERENCES

- [1] E. W. Uhlhorn and P. G. Black, "Verification of Remotely Sensed Sea Surface Winds In Hurricanes," *J. Atmos. Oceanic Technol.*, pp. 100-115, 2003.
- [2] Johnson, James W., Amarin, R. A., El-Nimri, Salem F., and W. Linwood Jones "A Wide-Swath, Hurricane Imaging Radiometer for Airborne Operational Measurements", Proc. IEEE IGARSS-06, Aug. 28 - Sept. 1, 2006, Denver, CO.
- [3] Ruba A. Amarin; **Jones, W. L.**; El-Nimri, S.F.; Johnson, J. W.; Ruf, C. S.; Miller, T. L. and E. Uhlhorn; "Hurricane Wind Speed Measurements in Rainy Conditions using the Airborne Hurricane Imaging Radiometer (HIRAD)"; *Trans. GeoSci. Remote Sens.*, vol. 50, issue: 1, pp. 180-192, Jan. 2012