THE HURRICANE IMAGING RADIOMETER WIDE SWATH SIMULATION AND WIND SPEED RETRIEVALS

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ABSTRACT

The knowledge of peak winds in hurricanes is critical to classification of hurricane intensity; therefore, there is a strong interest in the operational remote sensing of ocean surface winds for monitoring tropical storms and hurricanes, especially those which threaten landfall. Presently, the airborne Stepped Frequency Microwave Radiometer (SFMR) is the state-of-the-art remote sensor for providing this information in real-time, during hurricane surveillance flights. However, for the future, NASA and NOAA are collaborating in the development of the Hurricane Imaging Radiometer (HIRAD), which is a prototype of the next-generation high-flying airborne instrument for monitoring hurricanes. Figure 1 shows the aircraft flight hardware that was recently calibrated in a compact antenna range. This four-frequency (4 – 6.6 GHz) passive synthetic thinned array radiometer provides a wide swath image, which expands the coverage of the narrow nadir profiles from SFMR. From a 20 km altitude, the HIRAD design produces a worst-case spatial resolution at nadir of 2.5 km at 4 GHz and a cross-track measurement swath of 60 km (± 60 degrees field-of-view) at all 4 frequencies as schematically depicted in Fig. 2.

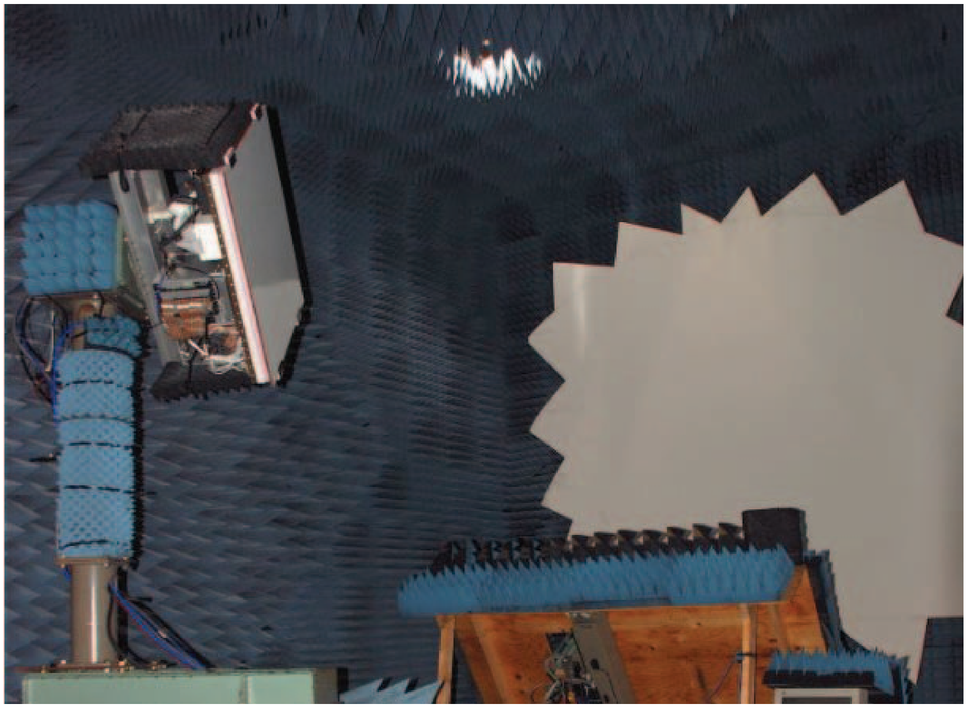

Fig.1 HIRAD flight system calibration in a compact antenna range.

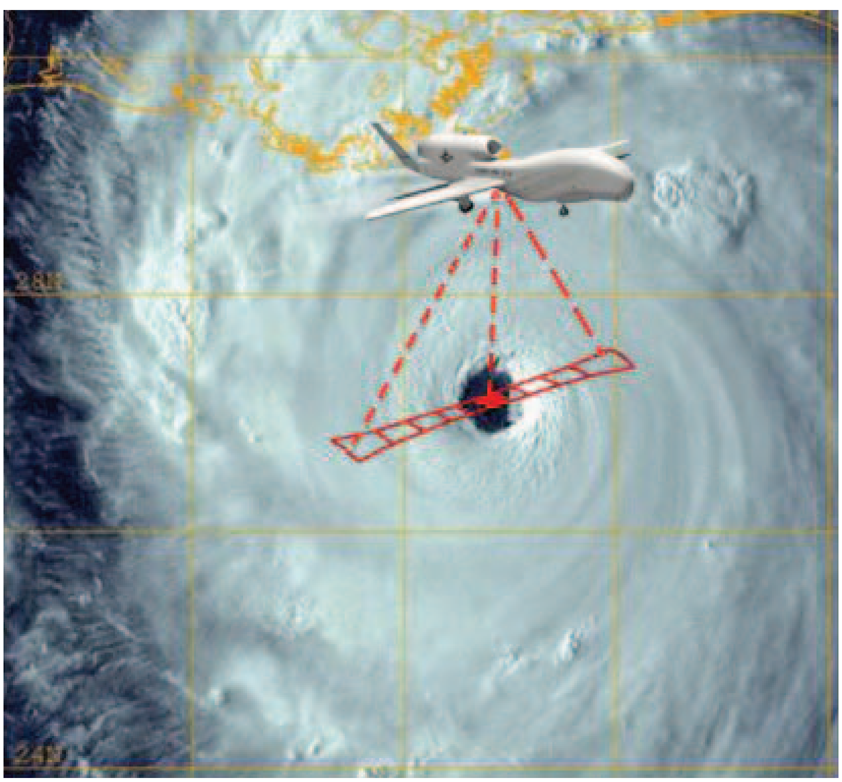

Fig. 2 HIRAD cross-track measured swath.

This paper describes a realistic end-to-end simulation of HIRAD hurricane measurements while flying on an unmanned Global Hawk aircraft. This simulation addresses a particular challenge, which is accurate hurricane wind speed measurements in the presence of intense rain rates. The objective of this research is to develop baseline retrieval algorithms and provide a wind speed measurement accuracy assessment for the upcoming NASA hurricane field program to be conducted in 2010.

Advances in radiative transfer modeling (RTM) for ocean emissivity in hurricanes at high incidence angles have been developed at the Central Florida Remote Sensing Laboratory (CFRSL) to support HIRAD. The HIRAD retrievals will be performed over long atmospheric slant path lengths that are encountered across HIRAD wide swath. Brightness temperature (T_b) simulations are presented using a forward radiative transfer model (RTM) that includes the SFMR rain model for the hurricane environment and an ocean surface emissivity model developed especially for HIRAD high incidence angle measurements [2]. Also included are realistic sources of errors which are expected in hurricane observations and include instrument NEDT and antenna pattern convolution of scene T_b. Several numerical hurricane models runs provide realistic 3D environmental parameters (rain, water vapor, clouds and surface winds) from which simulated HIRAD T_b's are derived for typical "Fig-4" flight tracks (see Fig. 3) from the Global Hawk at 20 km altitude. Using these simulated HIRAD measurements, Monte Carlo retrievals of wind speed and rain rate were performed using available databases of sea surface temperatures and climatological hurricane atmospheric parameters (excluding rain) as *a priori* information. Examples of retrieved hurricane wind speed and rain rate images are presented, and comparisons of the retrieved parameters with the numerical hurricane model data are made. Statistical results are presented over a broad range of wind and rain conditions and as a function of path length over the full swath.

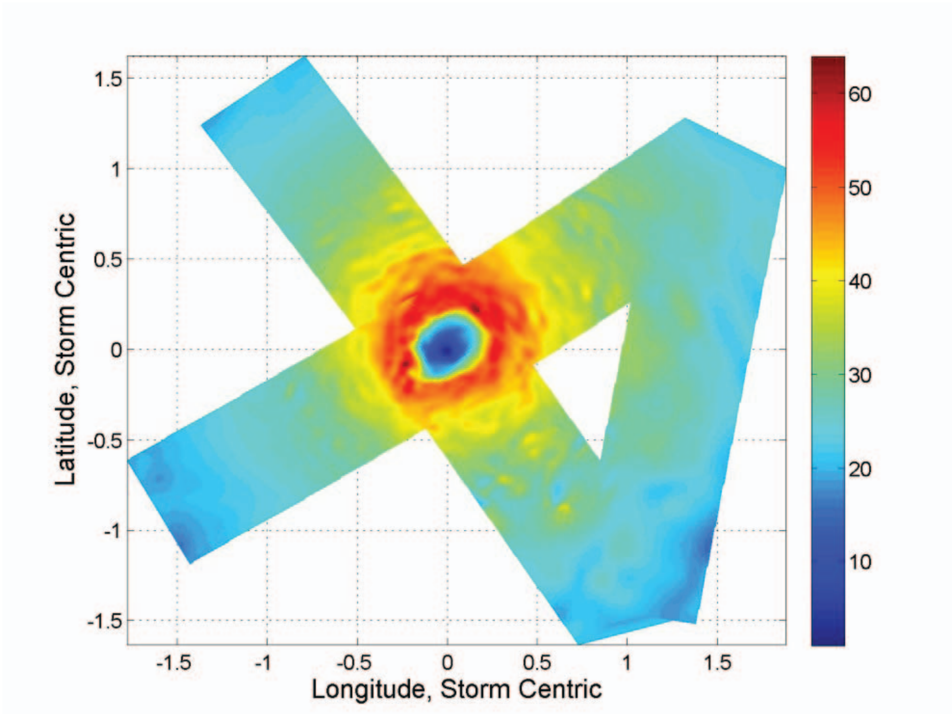

Fig.3 Example of simulated HIRAD wind speed image for Hurricane Frances with color bar in m/s. Aircraft Fig-4 flight lines from an altitude of 20 km.

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