DUAL-FREQUENCY SCATTEROMETER PERFORMANCE STUDIES

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1. INTRODUCTION

During the last decade, ocean vector wind measurements using radar scatterometers, such as the NASA QuikSCAT [1] or EUMETSAT ASCAT [2] scatterometers, have become a widely used tool for weather forecasting [3]. They have also contributed to our basic understanding of the air-sea interaction, including momentum, energy, heat and gas fluxes.

In spite of these accomplishments, prior radar scatterometers have had limitations of different kinds. Ku-band scatterometers, such as QuikSCAT or the recently launched ISRO scatterometer on OceanSat-2, suffer significant performance degradation in the presence of rain. Due to saturation of the geophysical model function (GMF) at high wind speeds, winds of strength greater than about 30 m/s are not measured accurately [3]. V-pol C-band scatterometers, on the other hand, do not suffer from the same contamination from rain. However, in current implementations, they have consistently underpredicted winds at higher wind speeds. This performance limitation is probably associated with the lower spatial resolution present in these systems, although effects due to model function saturation or training cannot be discounted. Due to a fixed beam geometry, these scatterometers have also had smaller swaths than penci-beam scatterometers, and, consequently, poorer temporal sampling.

The Dual-Frequency Scatterometer (DFS) that has been proposed by NOAA and NASA for inclusion in the forthcoming JAXA GCOM-W2 mission, to be launched in 2016, is a next-generation scatterometer design that seeks to build on the strengths of past scatterometer systems while avoiding some of their limitations.

2. THE DFS ON JAXA'S GCOM-W2 MISSION

The DFS on GCOM-W2 is a 1800 km swath pencil-beam multi-frequency, multi-polarization scatterometer. It is an adaptation of the NRC Decadal Review scatterometer recommendation, XOVWM [4], that has been modified to within the constraints of the JAXA GCOM-W2 mission. Like XOVWM, the DFS implements two Ku-band and two C-band channels and each frequency has a H and V-polarized channels. The frequency combination has the advantage of optimizing the spatial resolution (Ku-band), while minimizing the effects of rain (C-band V-pol) and measuring hurricane level winds (C-band H-pol). The C-band H-pol channel, new to spaceborne scatterometry, was chosen based on recent experimental results that indicate that this polarization's geophysical model function does not saturate at high winds.

The main change relative to the XOVWM mission required for accommodation in the GCOM-W2 mission has been the reduction of the antenna size to a 1.9 m reflector and a change from synthetic to real aperture processing. This has resulted in real aperture footprints that are a few kilometers in the range direction, and azimuth resolutions of 10 km and 35 km at Ku and C-bands, respectively.

An advantage of deploying in the GCOM-W2 mission will be coincident data collection with JAXA's third-generation Advanced Microwave Scanning Radiometer (AMSR3). These coincident data will provide significant advantages in rain corrections, wind speed estimation, and the use of the joint instruments for cryosphere and soil moisture applications.

3. DFS PERFORMANCE

Table 1 summarizes the performance requirements that have been set by the science team for the DFS performance. This table compares the ideal NOAA user requirements, the QuikSCAT performance, and the DFS requirements and goals.

Requirement	**NOAA 2006 User Goals**	**QuikSCAT**	**DFS Requirement**	**DFS Goals**
WVC Size	**<5 km**	12.5 km	10 km	<10 km
Coastal Mask	**<5 km**	20 km	10 km	<10 km
Coverage	**90% of the ocean surface every 24 hours**	90% of the ocean surface every 24 hours	90% of the ocean surface every 24 hours	90% of the ocean surface every 24 hours
Rain-free Wind Speed Accuracy (RMS)	**3-20 m/s: 2 m/s** **20-30 m/s: 10%** **30-80 m/s: 10%**	3-20 m/s: 2 m/s 20-30 m/s: 10% 30-80 m/s: no requirement	3-20 m/s: 2 m/s 20-30 m/s: 10% 30-50 m/s: 10% 50-80 m/s: no requirement	3-20 m/s: 1 m/s 20-30 m/s: 10% 30-50 m/s: 10% 50-80 m/s: 20%
Rain-free Wind Direction Accuracy (RMS)	**3-30 m/s: 10°** **30-80 m/s: 10°**	3-30 m/s: 20° 30-80 m/s: no requirement	3-30 m/s: 20° 30-50 m/s: 20° 50-80 m/s: 30°	3-30 m/s: 20° 30-50 m/s: 20° 50-80 m/s: 30°
Wind Speed Accuracy (RMS) in rain	**Same as in rain-free**	Consistent with QuikSCAT performance	5-20 m/s: 3 m/s 20-30 m/s: 10% 30-50 m/s: 10% 50-80 m/s: no requirement	5-20 m/s: 2 m/s 20-30 m/s: 10% 30-50 m/s: 10% 50-80 m/s: 10%
Wind Direction Accuracy (RMS) in rain	**Same as in rain-free**	Consistent with QuikSCAT performance	5-30 m/s: 30° 30-50 m/s: 20° 50-80 m/s: no requirement	5-30 m/s: 20° 30-50 m/s: 20° 50-80 m/s: no requirement
Product Latency	**< 180 minutes for 85% of the data**	< 180 minutes for 85% of the data	< 180 minutes for 85% of the data	
Coastal Winds				Winds retrieved closer than 10 km from the coast

Table 1: Summary of DFS performance requirements..

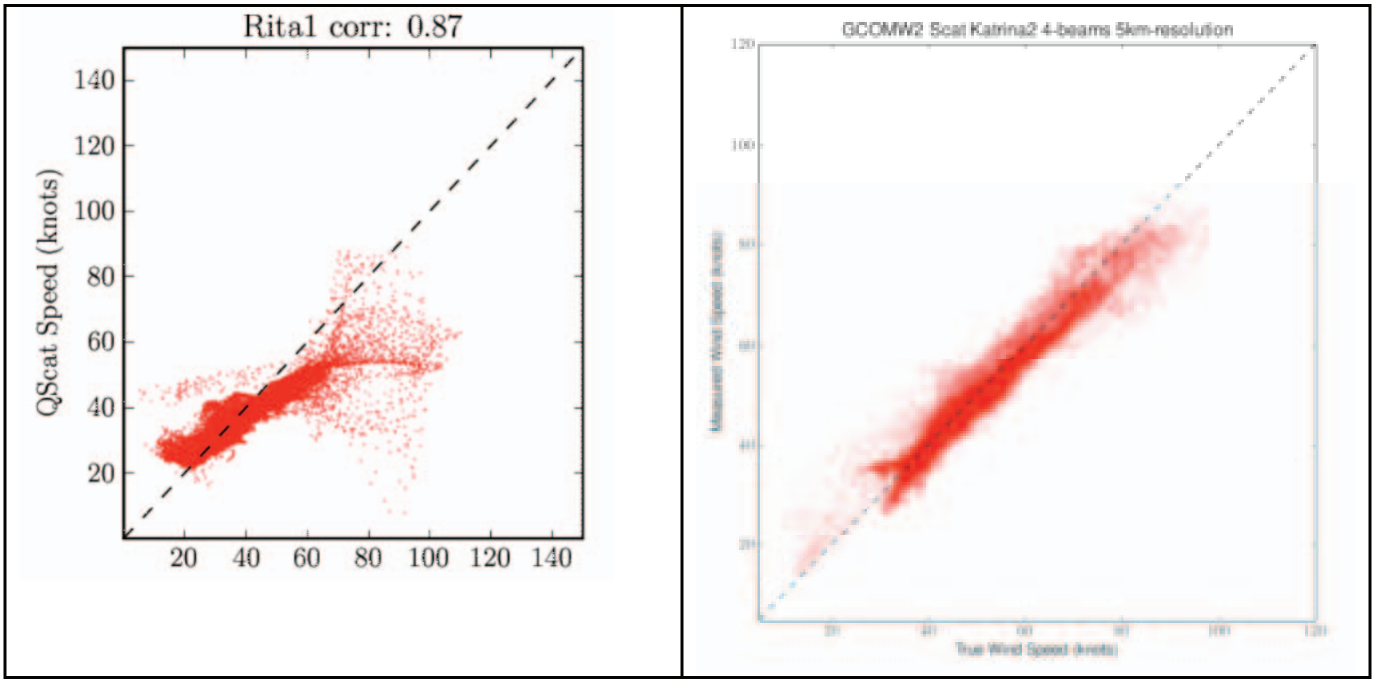

Figure 1: True winds (x-axis) vs measured winds (y-axis) for a simulated QuikSCAT (left) and DFS (right).

In order to evaluate the DFS performance, an end-to-end instrument simulator has been performed using input winds from a high-resolution WRF model to accurately simulate the wind patterns and precipitation for a variety of ocean scenes. One of the applications with highest priority for the DFS is tropical cyclones, and many instances of realistic hurricanes have been simulated. Figure 1 is a typical comparison of the expected performance of QuikSCAT and the DF for hurricanes. As can be seen from this figure, the DFS is able to measure the high winds characteristic of hurricanes, while QuikSCAT suffers significant saturation for wind speeds above 25 knots. Similar simulation studies, to be presented during the conference, show the ability of the DFS to meet and exceed the measurements requirements given in Table 1.

4. ACKNOWLEDGEMENTS

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5. REFERENCES

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