# Coincident, high resolution measurements of ocean surface rain in support of improved ascat-retrieved winds

D.E. Weissman, T. Johnson and J. Wolf
School of Engineering and Applied Science
Hofstra University, Hempstead, New York 11549, U.S.A

M. Portabella and W. Lin
Institut de Ciències del Mar – CSIC
Pg. MarítimBarceloneta 37-49, 08003
Barcelona, Spain

A. Stoffelen and A. Verhoef
Royal Netherlands Meteorological Institute (KNMI)
Postbus 201, 3730 AE De Bilt, The Netherlands

***Abstract***; Improving the quality of Advanced Scatterometer (ASCAT) derived winds in the presence of rain has been challenging due to the coarse spatial and time resolution of available rain information . A new effort is in progress that which will provide high spatial and time resolution surface rain rates coincident with ASCAT data collection off the coastlines in the Gulf of Mexico and Florida, using ground-based radar sensors. Preliminary results show that the NRCS is appreciable affected by the surface rainrate due to splash effects and also due the variation of wind speeds within and surrounding region. There are also indications that the ECMWF winds are not able to incorporate rain events and their air-sea interaction propererties.
Keywords: ASCAT, NEXRAD, ocean winds, scatterometer

## I. INTRODUCTION

Efforts towards improving the quality of Advanced Scatterometer (ASCAT) derived winds in the presence of rain are constrained due to the coarse spatial and time resolution of available rain information [Figa-Saldana, 2002; Portabella, et al, 2012]. Currently, the most suitable rain sensors are on the NASA TRMM mission spacecraft, the TMI and PR (Tropical Rain Measuring Mission; TRMM Microwave Imager, and Precipitation Radar). However, the results obtained at this time indicate that the properties of these data products are insufficient for the purposes of improving the quality control (QC) analyses of the ASCAT wind retrievals when rain is present. In particular, the resolution of these rain data-products is too coarse for an adequate correction of Normalized Radar Cross Section (NRCS). For example, the TMI rain product that was used had a resolution of 0.25 deg. While, the average of high-resolution (~5 km) PR rain fields over a certain wind vector cell (WVC) was adopted for the simple backscatter model developed by [Nie and Long, 2007], it is well known that, for C-band, the dominant effect of surface rain impacts is to increase the surface radar cross section (NRCS) as a function of wind speed and incidence angle. One other important limitation is that the referenced ECMWF winds do not well resolve the airflow under rainy conditions. The number of rain-contaminated collocations with more representative reference winds (e.g., buoy winds) is currently very small. Rain is usually markedly inhomogeneous and this property along with wind spatial variability may be contributing to limited success of the ASCAT QC efforts.

## II. APPROACH

A new effort is in progress that which will provide high spatial and time resolution surface rain rates coincident with ASCAT data collection off the coastlines in the Gulf of Mexico and Florida, using ground-based radar sensors. These are the fairly dense network of NEXRAD radar stations that lie close to the U.S. coastlines. These stations are operated by the U.S. National Weather Service and offer free and fairly easy access to numerous rain, hydrological and weather-related products. The time differential can usually be within three minutes and the spatial resolution of rain reflectivity can start at 2km.

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The usefulness of these rain measurements in association with satellite scatterometer studies has been demonstrated with QuikSCAT [Weissman and Bourassa, 2008; Weissman and Bourassa, 2011]. The focus on these previous investigations was on the comparison between the Ku-band NRCS at the surface and the average rain rate across the individual footprints, for a variety of wind speeds.

In C-band scatterometry, changes in backscatter due to rain drops (absorption, volume scattering, and rain splashing) are relatively modest for low and moderate rain rates, except for low winds. In contrast, rain induces increased wind variability, which causes increased local backscatter variability, i.e., Kp. Moreover, rain causes the consistency of the backscatter measurements to be different than that of a pure wind sea, which latter is captured by the wind GMF. The deviations from the wind GMF consistency are measured by the inversion residual or MLE. In particular, an increase in the backscatter isotropy (i.e., decrease in the wind direction signal) will increase the MLE. As such, we plan to investigate the correlation between the Kp and MLE parameters (as provided in the operational Level 2 product) and the NEXRAD rain rates for different wind conditions. Preliminary results will be presented at the conference.

## III. RESULTS

A first phase of this study will compare individual ASCAT derived wind vector estimates with collocated ECMWF wind estimates, in the presence of rain. Figure 1 shows a map of the rain intensity (in dBZ) observed by the NEXRAD station near Houston, TX. Only the data collected within 250 km of the station is useful due to the continuous increase in the elevation of the NEXRAD beam, with range. Figure 2 shows the spatial locations of and the properties of the wind vectors estimated by ASCAT during a single overpass of this region of the Gulf of Mexico. In the locations where rain was observed, the ASCAT wind estimates show erratic direction changes. These are being quantified by using the ECMWF wind estimates shown in Figure 3, for comparison, over a range of rain intensities. This will be based on a new gridded product (in matrix form) of rain intensity that was used to create Fig. 1. Additional studies are in progress to observe the combined effect of rain intensity and wind speed on multiple collocated NRCS measurements, that are at different incidence angles.

In pursuit of the objectives of this ASCAT study, a longer time span of surface rain properties, with 10 minute resolution (over +/- 2 hours) is being studied for each ASCAT overpass. In addition, in order to better understand the detailed weather and air-sea interaction conditions at the time of the overpass, the time window for rain observations will be expanded to +/- 12 hours with hourly views. As before, a gridded rain rate product (with a range of 250 km from the coast) simultaneous with the overpass will be generated. This will allow the retrieval algorithms to include information about the location as well as intensity of the high resolution rain cells within each ASCAT NRCS footprint. This will be used in conjunction with the wind retrieval algorithms to develop new wind-rain geophysical models for the user communities, with improved spatial resolution. This algorithm development effort has required an appreciable time range of processed NEXRAD results. In addition, the dependence of the NRCS on the rain intensity, ASCAT radar parameters and surface wind conditions are also being investigated. This could lead to a new generation of a “CMOD” algorithm, one that includes some rain effects.

A sample of these results is shown in Figures 4-7. There is a clear correlation between the locations of the highest rainrates measured by NEXRAD (Fig. 1) and the largest winds estimated by ECMWF, as these range from 6 to 14 m/s (Fig. 6). As expected the NCRS presented in Fig. 7 is seen to be significantly higher over those areas where rain is considerably higher, even after taking into account the increasing incidence angle seen in Fig. 6. At the same time, the wind magnitudes appear to be larger in the same locations with higher NRCS so it is not obvious how to partition the increase in NRCS, between the rain splash and wind forcing contributions.

It can also be observed that there is appreciable wind variability outside the immediate areas where rain is striking the surface. One contributor can be the downdrafts from convective cells that cause outflow across the ocean accompanied by variable wind speeds and directions.

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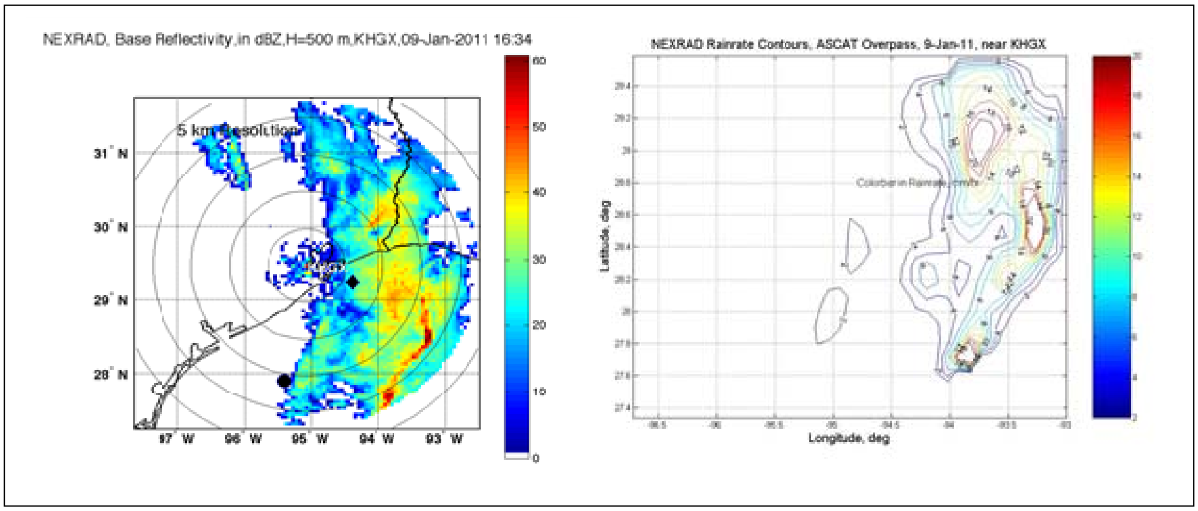


Figure 1: Radar reflectivity (in dBZ) of rain close to the surface simultaneous with an ASCAT overpass

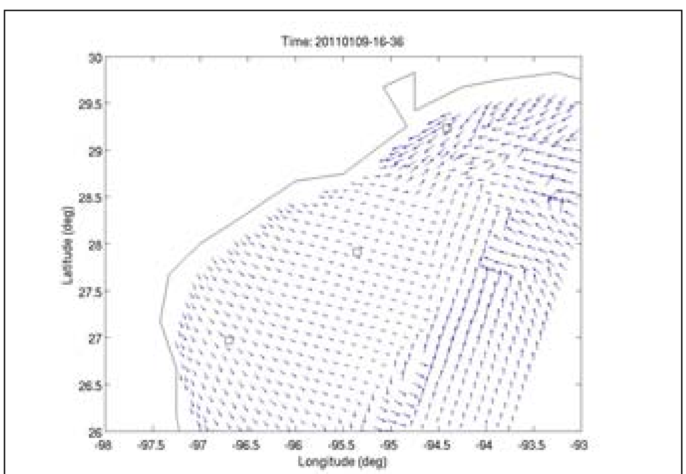


Figure 2: The wind vectors derived from the current ASCAT wind retrieval algorithm

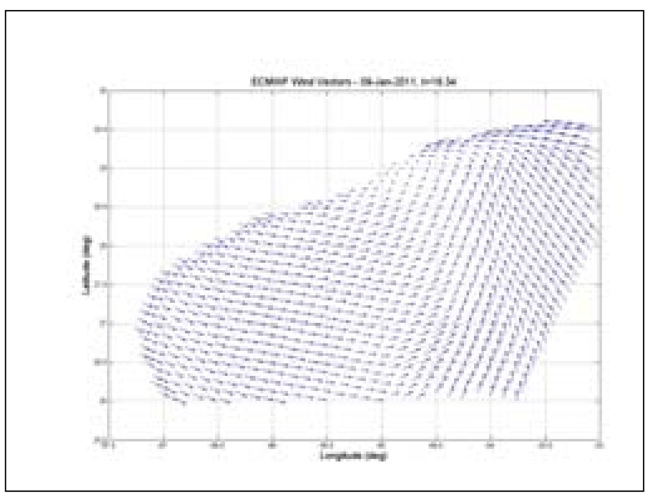

Figure 3: Collocated wind vectors estimated by ECMWF

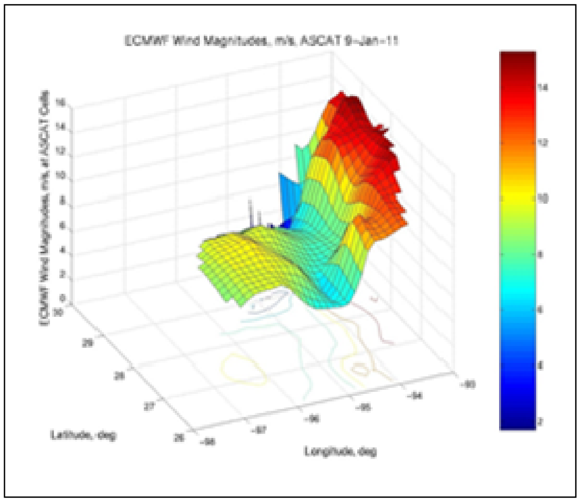


Figure 4: Wind magnitudes contour diagram; same ECMWF data shown in Fig. 3.

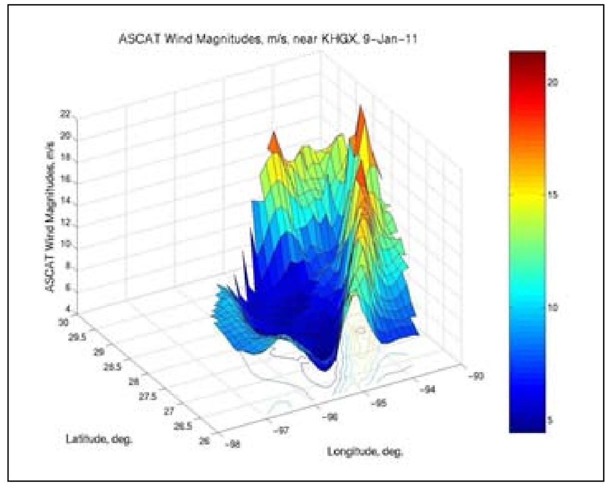


Figure 5: Wind magnitudes contour diagram; same ASCAT wind retrievals data as shown in Fig. 2

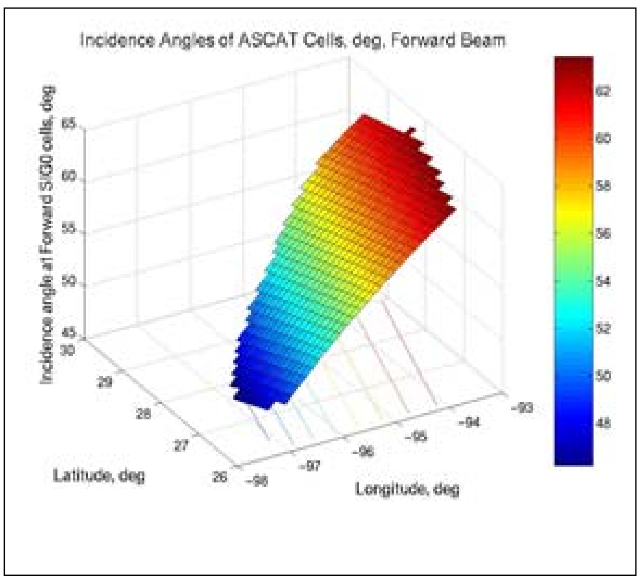


Figure 6: The incidence angle variation over the measurement area shown in Figs. 2-5

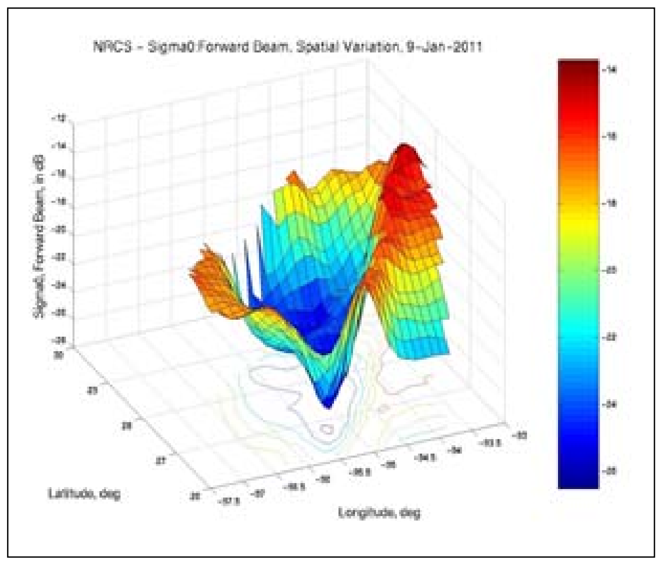


Figure 7: The Normalized Radar Cross Section measured at each of the ASCAT cells, with incidence angles shown in Fig. 6.