Towards a Correction of ASCAT Ocean Measurements for Rain Effects

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1. Introduction
Rain is known to both attenuate and scatter the microwave signal. In addition, the roughness of the sea surface is increased because of splashing due to raindrops. This increases the radar backscatter (σ0) measured, which, in turn, will affect the quality of scatterometer wind retrievals. For C-band radar systems such as the AMI scatterometer and ASCAT, the rain-induced backscatter is dominated by rain perturbation on the sea surface [1][2]. Thus, a simplified model for the ASCAT backscatter under rainy conditions is presented as a summation of the wind-induced backscatter and the rain-splashing-induced backscatter (namely bias) in this paper. The backscatter bias varies with incidence angle (or wind vector cell), rain rate and wind speed. Then, provided radiometer rain data, the rain-contributed bias is subtracted from the total backscatter measurements to improve the scatterometer wind retrieval under rainy conditions.

The performance of this simple model is evaluated by running the ASCAT Wind Data Processor (AWDP) for six months of ASCAT with and without the rain correction model, and using Tropical Rainfall Measuring Mission’s (TRMM) Microwave Imager (TMI) and European Centre for Medium-range Weather Forecasts (ECMWF) collocations for validation purposes.

2. Rain/Wind model
The rain-splashing-induced bias is estimated from one year (2008) of ASCAT 25-km data collocated with ECMWF winds and TRMM/TMI rain data. The TMI data have been obtained from the Remote Sensing Systems Web site (http://www.ssmi.com). The collocation criteria for TMI rain data are less than 30-min time and 0.25° spatial distance from the ASCAT measurement.

Figure 1 illustrates the mean ASCAT backscatter as a function of wind speed for WVC number 11. The bias is estimated for each WVC number in log space.

3. Experimental results
The proposed model is applied to 6 months (January 2013–June 2013) of collocated ASCAT 25-km measurements and TMI/ECMWF data. Due to the lack of heavy rain data, the correction is only applied to the categories with TMI-RR [0.1, 1] mm/hr, [1, 3] mm/hr, and [3, 6] mm/hr.

Figure 2 presents the ASCAT wind speed quality w.r.t. ECMWF under the three mentioned rain conditions. The upper row shows the statistics without correction, while the lower row shows those with rain correction. Figure 3 presents the same statistics as Fig. 2 but for wind direction.

4. Conclusions and Outlook
The results indicate that the proposed rain correction method increases the consistency between the corrected backscatter triplets and the forward model or Geophysical Model Function (see Fig. 4), and thus, reduces the VRMS difference between ASCAT and ECMWF winds. It improves the retrieval of wind speed significantly. However, it does not have much impact on the retrieval of wind direction. Meanwhile, the VRMS scores of the rain free and heavy rain conditions categories slightly improve although no correction is performed over such WVCs. This indicates that the rain correction applied in neighboring WVCs (contaminated by RR in the range [0.1, 1.6] mm/hr) has a positive impact on the ambiguity removal of rain-free and heavy-rain-contaminated WVCs.

Since ECMWF wind is not well resolved under rainy conditions, it is not optimal for the study. An independent wind source, such as buoy wind information, is required to improve the model. Future model improvements should also account for the backscatter impact of the wind variability increase with increasing rain rate, i.e., heavy rain conditions. Further investigation using high-resolution ASCAT and rain data will be carried out. We are currently using high-resolution rain measurements from the Next Generation Weather Radar data (NEXRAD) to improve the model. Rain-induced wind variability will be also considered in the future model improvement.

Table 1. The mean Vector-Root-Mean-Square (VRMS, m/s) difference between ASCAT and ECMWF winds for the studies with and without rain correction.

<table>
<thead>
<tr>
<th>Rain free</th>
<th>[0.1] mm/hr</th>
<th>[1] mm/hr</th>
<th>[3] mm/hr</th>
<th>[6] mm/hr</th>
<th>&gt;=6 mm/hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-correction</td>
<td>1.5958</td>
<td>2.52</td>
<td>3.24</td>
<td>3.97</td>
<td>5.30</td>
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<td>Correction</td>
<td>1.5949</td>
<td>2.30</td>
<td>2.74</td>
<td>2.97</td>
<td>5.24</td>
</tr>
</tbody>
</table>

Reference