Quality Control of WindRAD Scatterometer

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Introduction

WindRAD is a dual-frequency (**C-band** and **Ku-band**) rotating fan-beam scatterometer onboard FY-3E satellite as shown in **Fig. 1**.
The rotating fan-beam design leads to a diverse geometry of view azimuth and incidence angles across the swath, and because of the dual frequency feature, the number of views in each WVC (Wind Vector Cell) increases significantly in comparison with other scatterometers (**Fig. 2**).
Ku-band is significantly influenced by rain, but C-band is not. Therefore, the dual-frequency design is interesting to investigate the impact on the Quality Control (QC).

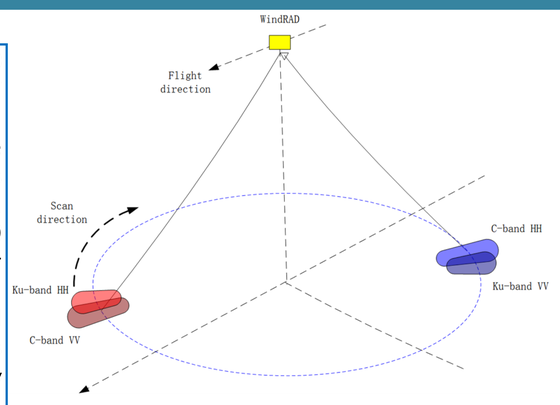
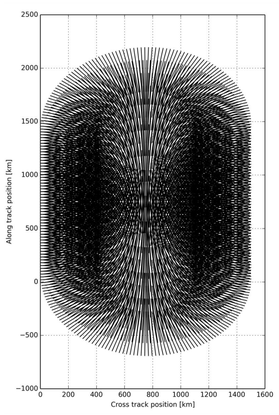


Figure 1. WindRAD scattereometer illustration plot.



What is Quality Control?

Ku-band is sensitive to rain. The retrieved winds in rainy areas are usually not reliable, which is contrary to C-band scatterometers. Spurious winds with wind speeds between 15 and 20 m/s are obtained in case of heavy rain, therefore a QC procedure is needed to filter out these winds and the false alarm rate should be kept as low as possible.

Figure 2. Illustration of pulses on the swath.

Results

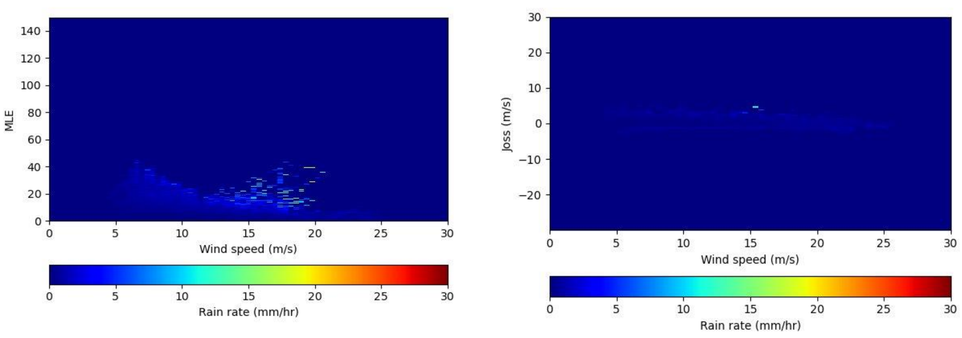


Figure 5. Accepted winds (Ku-band), Left: MLE collocation with rain as a function of wind speed; Right: Joss collocation with rain as a function of wind speed.

Fig. 6 is the QC flagged distribution of MLE (left) and Joss (right). The corresponding wind speed scatter plot against NWP model winds are also shown in Fig. 6. The ridges of the scatter plots are deviated from the diagonal and the distribution of flagged data is corresponding to the rainy areas (e.g., tropical regions).

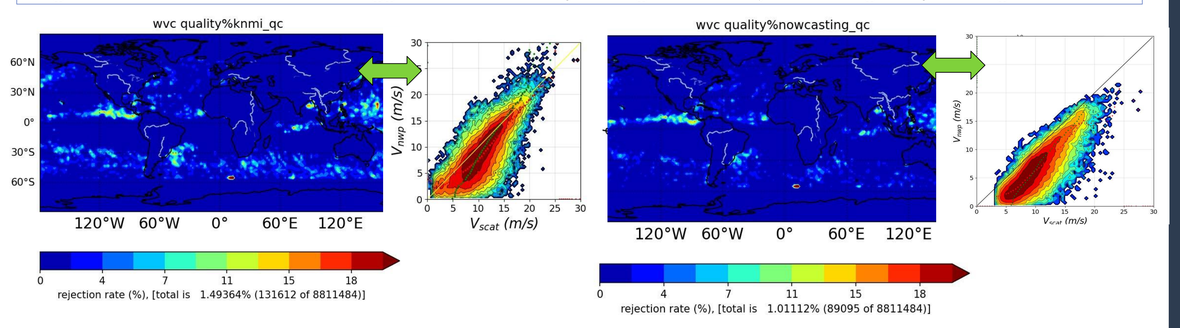


Figure 6. Flagged data distribution and wind speed scatter plot against model winds. Left: MLE QC; right: Joss QC.

Adding C-band data:
C-band wind retrieval is not influenced by wind, therefore, by adding C-band in the retrieval, the rain contamination is already penalized in the wind retrieval without any QC, which is shown in **Fig. 7** that the blob between 10 and 20 m/s is much smaller for C&Ku. To achieve the same wind retrieval quality as Ku-band only, C&Ku rejects less than Ku-band only (not shown). Further study is in progress.

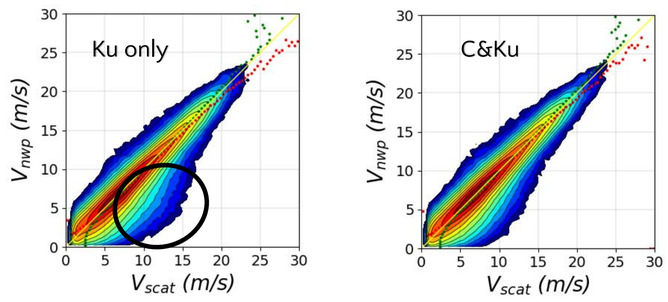


Figure 7. Wind retrieval result without QC for Ku only (left) and C&Ku (right).

How to do the Quality Control?

The classic QC method is based on the **MLE** (Maximum Likelihood Estimator). MLE is the distance between measured backscatter values and the GMF (Geophysical Model Function). The better the wind retrieval is, the shorter the distance between the backscatter values and the GMF. Rain-contaminated WVCs lead to a large MLE, therefore the WVCs are flagged. Another method is **Joss**, using the speed component of the observation cost function (Jo) in 2DVAR ambiguity removal step to accept extra WVCs rejected by the MLE QC [1]. In ambiguity removal, a wind field is constructed from the scatterometer wind ambiguities and model winds by minimizing a cost function with constraints on meteorological consistency, it is called the analysis wind field. Joss is defined as the analysis wind speed minus the selected scatterometer wind. The WVCs with a Joss value lower than certain threshold are excluded. Joss method might be too optimistic that a much lower percentage of winds are filtered out compared to MLE method, therefore the **combination of Joss and MLE** is proposed for taking both local information (MLE) and spatial consistency (Joss) into account. The QC flag is set whenever either the MLE exceeds the threshold or Joss is lower than the threshold.

Fig. 3 shows the **MLE (Ku-band)** collocated with rain at different rain rate. The higher the rain rate, the higher the MLE is. A red threshold line is determined by fitting to one of the contour lines and it is kept as constant at the wind speed above 20 m/s.

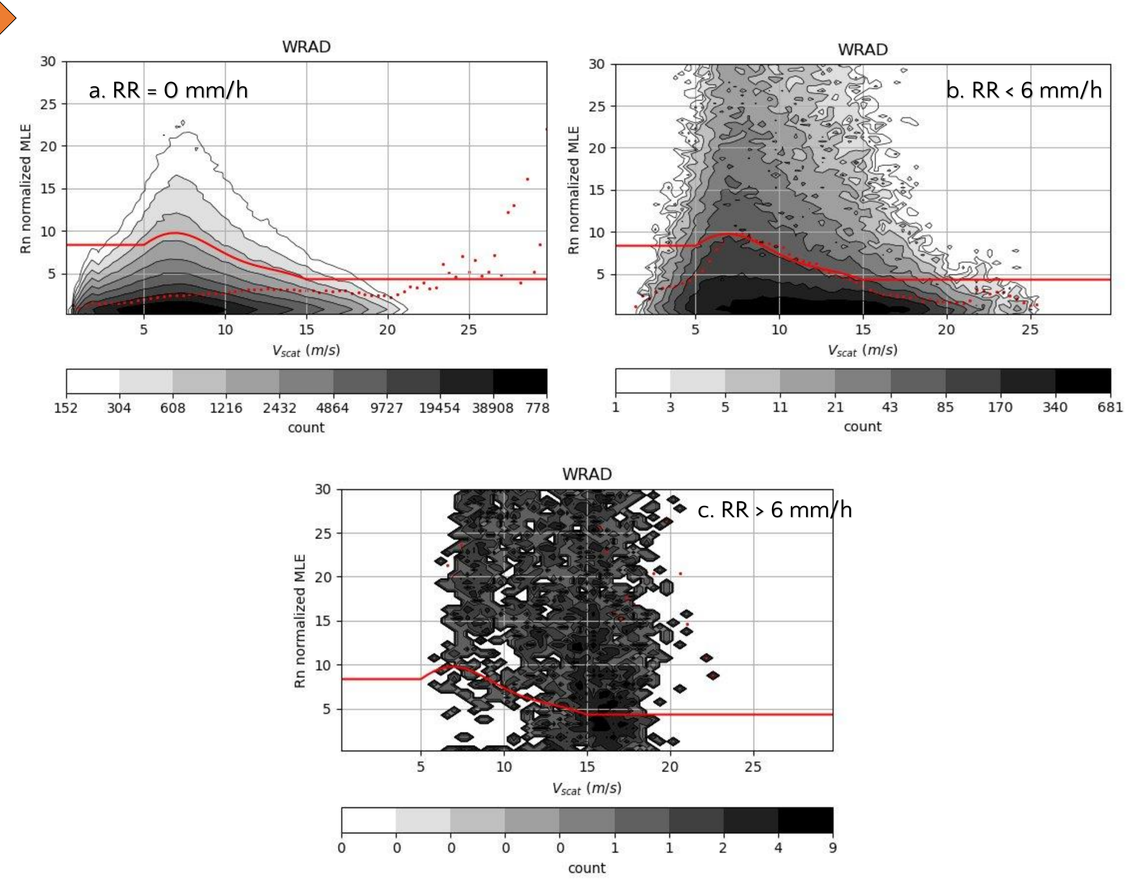


Figure 3. MLE collocated with various rain rate (Ku-band):
a. rain rate = 0 mm/h, b. rain rate < 6 mm/h, c. rain rate > 6 mm/h.

Joss threshold is defined as [1]:
Joss = 0.3 × v −4.2 for v < 9 m/s
−1.5 for 9 ≤ v < 18 m/s
−0.4 × v + 5.7 for v ≥ 18 m/s
The WVCs with Joss value lower than the threshold are flagged. **Fig. 4** shows all the winds (Ku-band) the MLE (left) and Joss (right) collocated with rain as a function of wind speed. **Fig. 5** gives the MLE and Joss of accepted winds collocated with rain. It shows that the winds collocated with high rain rate are filtered out after QC.

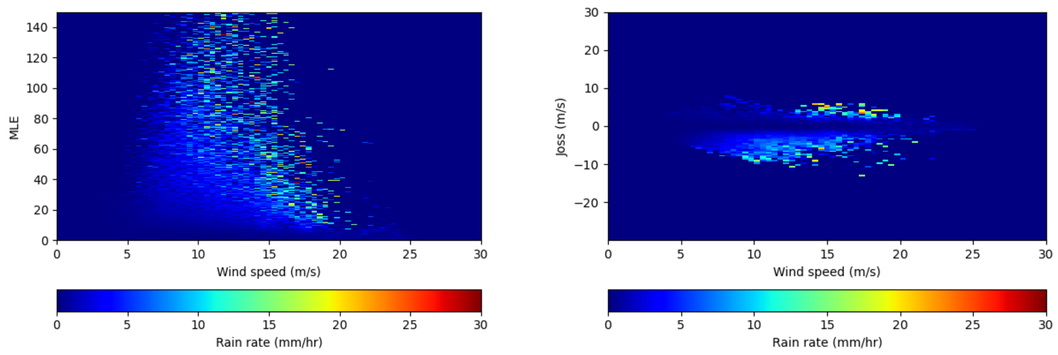


Figure 4. All the winds (Ku-band), Left: MLE collocation with rain as a function of wind speed; Right: Joss collocation with rain as a function of wind speed.

References

[1] X. Xu and A. Stoffelen, "Improved Rain Screening for Ku-Band Wind Scatterometry," in *IEEE Transactions on Geoscience and Remote Sensing*, vol. 58, no. 4, pp. 2494-2503, April 2020, doi: 10.1109/TGRS.2019.2951726.