Towards ASCAT Backscatter Correction in Rain

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1. Introduction

An important source of the scatterometer measurement uncertainty is the geophysical noise (Kp_{geoph}). For C-band scatterometer systems such as the one onboard the European Remote Sensing (ERS) satellite and the Advanced Scatterometer (ASCAT) onboard the Metop series, Kp_{geoph} is mainly caused by the sub-cell wind variability [1]. In the presence of rain, increased wind variability associated with convergence (fronts) and divergence (downbursts) is expected to increase Kp_{geoph}. In addition, the physical interaction between the radar signals and the atmosphere (increased path attenuation, and volume scattering due to raindrops) and sea surface scattering (increased roughness due to the rain splashing) may also contribute to Kp_{geoph}. In particular, the latter is thought to impact the backscatter under light wind and heavy rain conditions for C-band scatterometers. Assessment of the sub-cell wind variability impact on ASCAT data quality is crucial for a successful wind retrieval and quality control, and also helps to better understand the direct impact of rain on ASCAT backscatter.

2. Rain Effects

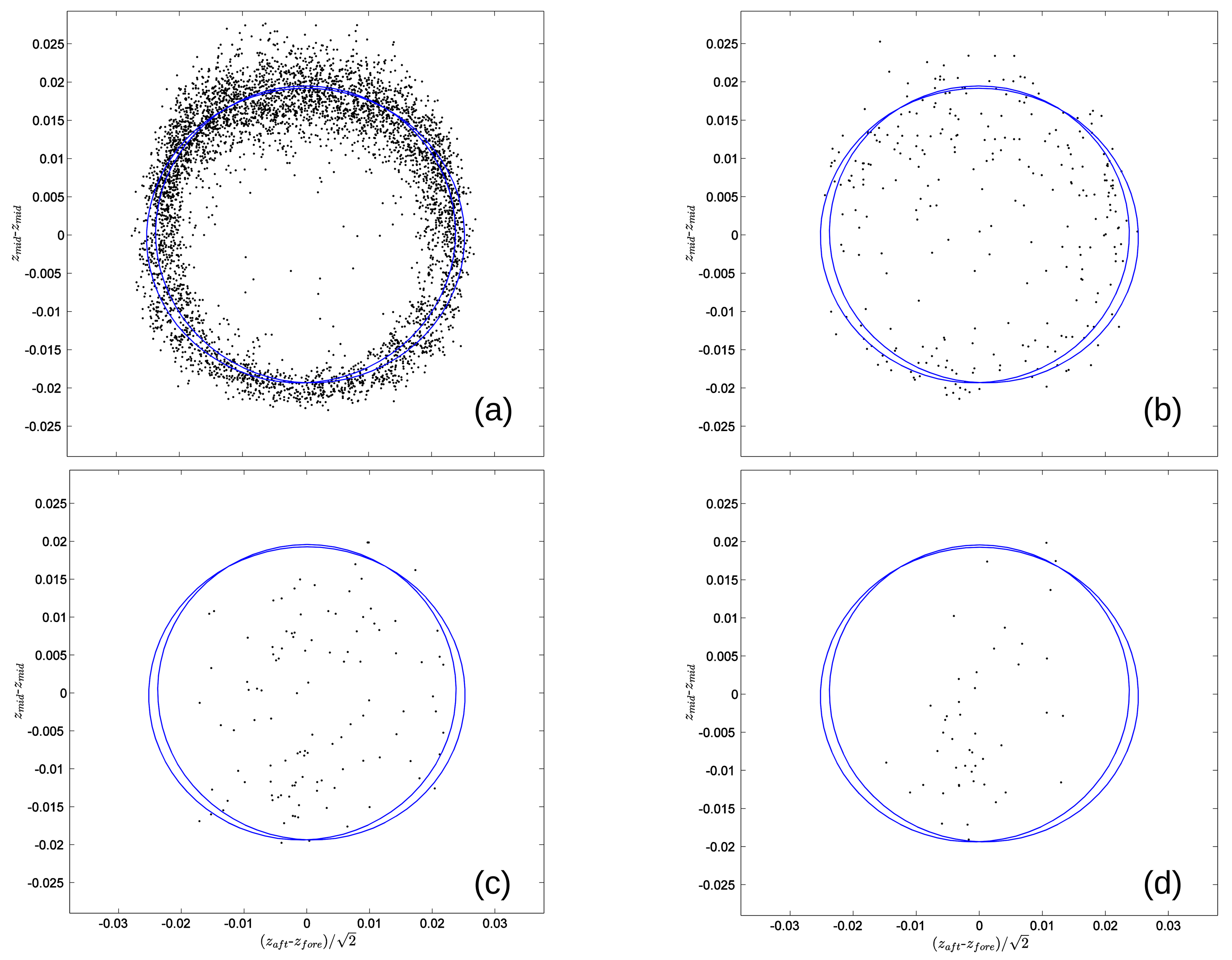


Fig. 1 Intersection of the Geophysical Model Function (GMF) cone surface with plane $z_{fore}+z_{aft}=2z_{ref}$ for a value of z_{ref} corresponding approximately to a speed of 8 m/s at ASCAT WVC #1 for: (a) TMI rain rate (RR) = 0 mm/h; (b) TMI-RR= [0.1 1) mm/h; (c) TMI-RR= [1 3) mm/h and (d) TMI-RR>= 3 mm/h

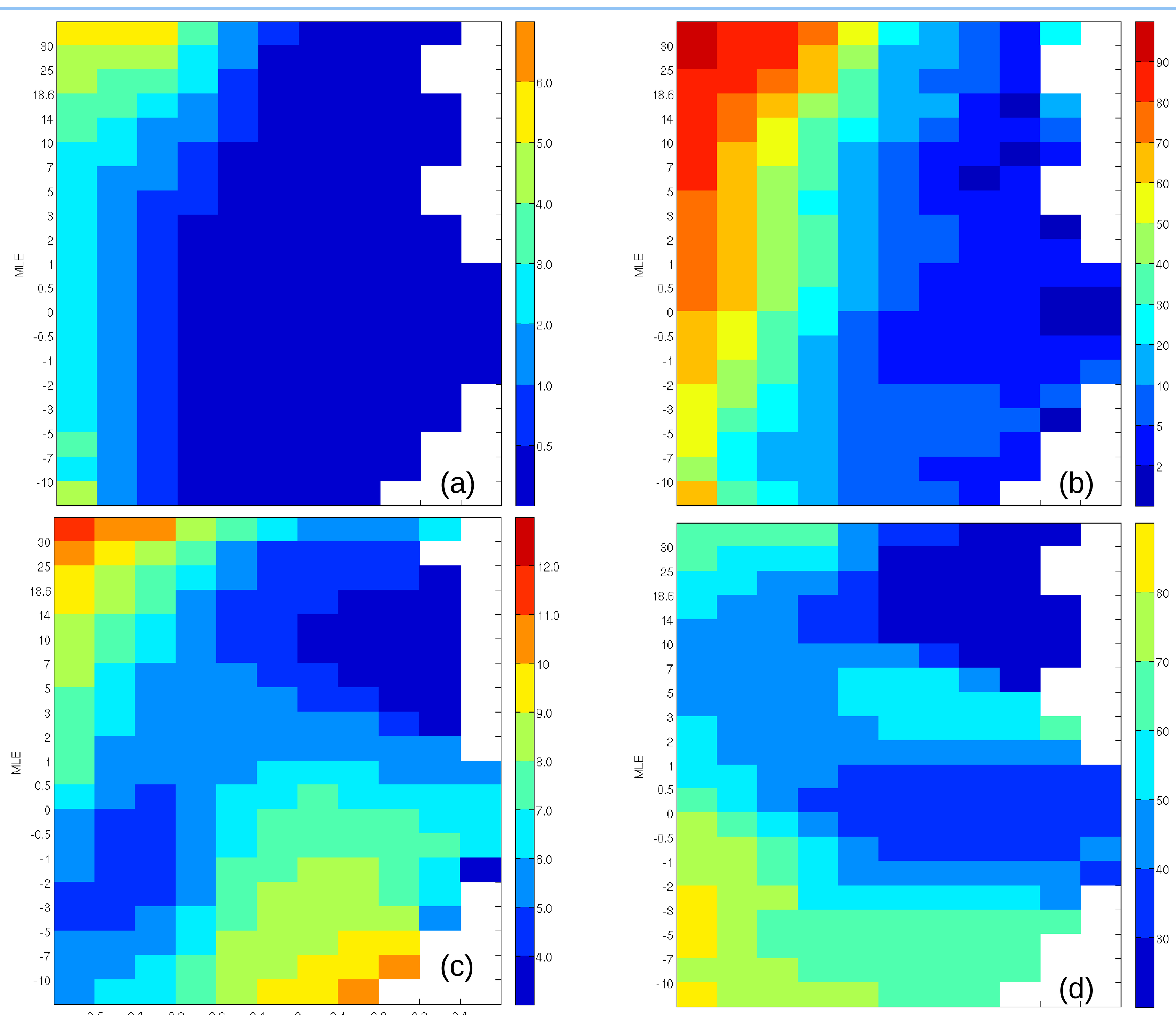


Fig. 2 Illustrations of (a) the mean TMI RR; (b) the percentage of WVCs with TMI-RR>0 mm/h; (c) the mean first-rank ASCAT wind speed and (d) the mean first-rank ASCAT wind direction (0° and 90° correspond to along-track and across-track directions, respectively) as a function of MLE [2] and singularity exponent [1] [3].

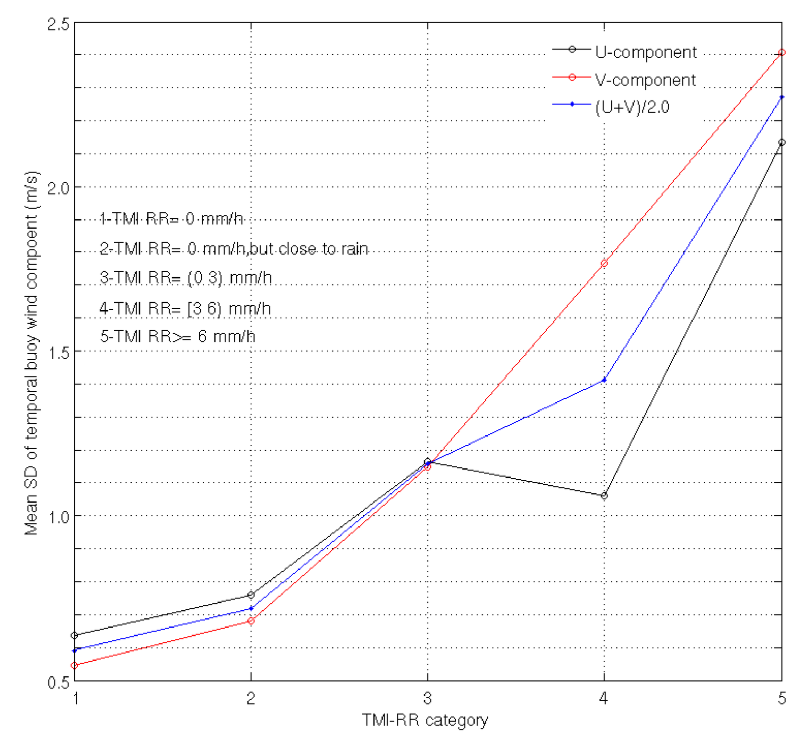


Fig. 3 The mean Standard Deviation (SD) of buoy 10-min temporal wind components (equivalent to a spatial scale of 25 km) as a function of TMI RR.

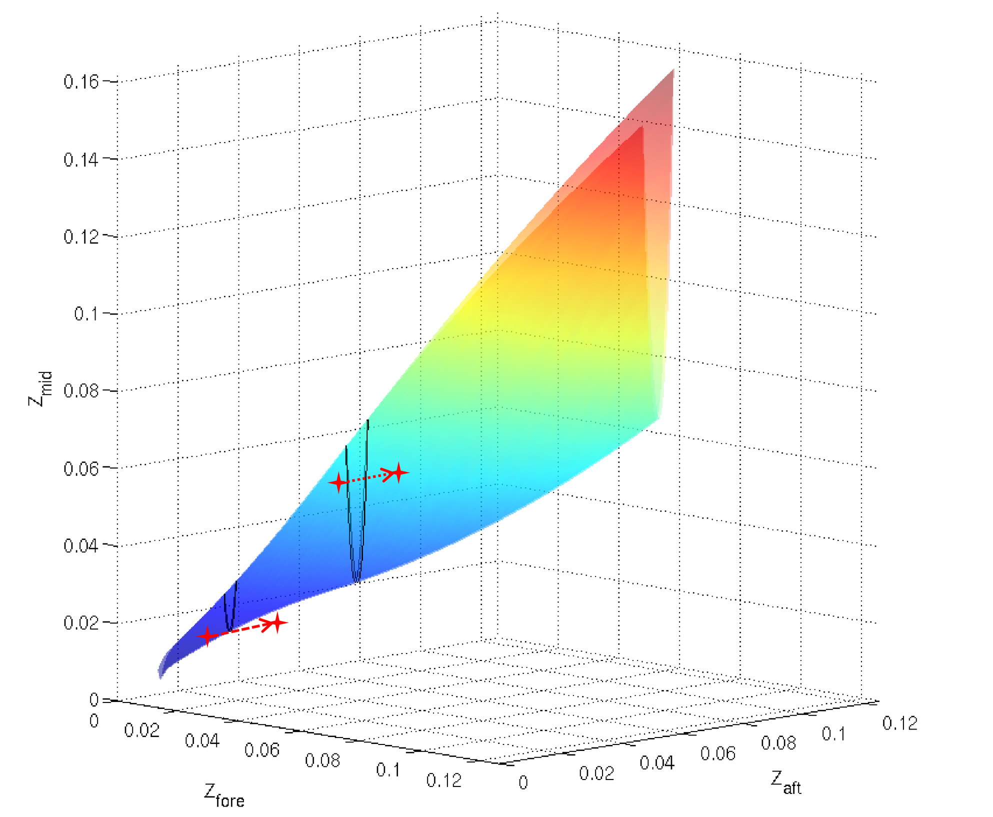


Fig. 4 3D visualization of CMOD5n GMF for WVC number 1 (0 m/s<V<=15 m/s). The black ellipses define the GMF for V= 4 m/s and 8 m/s respectively.

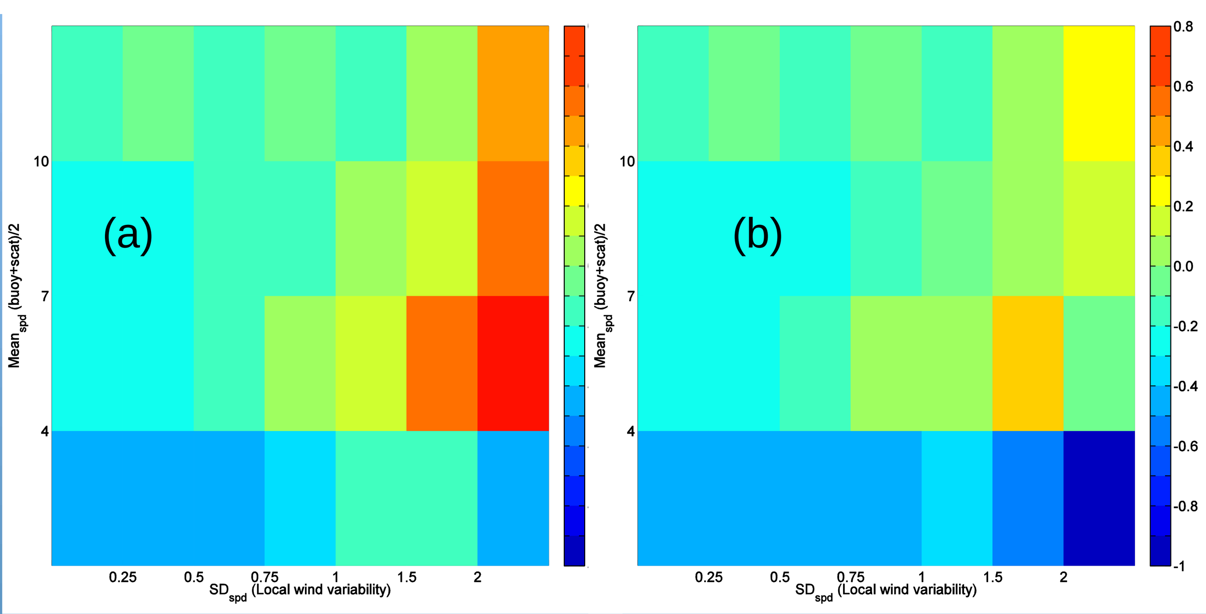
In summary:

- Fig.1 shows in general increasing anisotropy (decreasing wind direction skill), i.e., triplets tend to accumulate close to the cone centre, at increasing rain rate;
- Fig. 2 shows increasing rain concentration at decreasing SE and increasing |MLE|;
- Fig. 3 shows that local wind variability increases with rain rate;
- As illustrated by Fig. 4 and shown in Fig. 2: at low winds, the presence of rain projects triplets towards crosswind and outside the cone surface; whereas at high winds, it projects triplets towards crosswind but these stay inside the cone surface.

3. Outlook

In the absence of rain, it is assumed that Kp_{geoph} is mainly due to the spatial distribution of the backscatter footprints (often called Integrated Field of View, IFoV) and the sub-cell wind variability. The latter is calculated from the collocated ASCAT data with buoy wind time series (see Fig. 3), while the former, known as the IFoV parameter, is derived from the methodology in [4], in which **the simulated triplets** with different IFoV values are compared with the real rain-free data in the three-dimensional measurement space. [Note that alternatively one can use the L1b full resolution IFoV information] Then, Kp_{geoph} due to the characteristic sub-cell wind variance values found under rainy conditions can be modeled using the derived IFoV parameter values. Given the modeled Kp_{geoph} due to wind variability and the instrument noise Kp_{instr}, the measurement errors directly caused by rain (i.e., attenuation, volume scattering and rain splashing on sea surface), named as Kp_{rain}, can be further evaluated. This method opens the grounds for the correction of potential systematic effects caused by, e.g., rain splashing at low and moderate winds (see Fig. 5). Moreover, the characterization of the different backscatter uncertainties is of great importance for scatterometer wind retrieval in general. In particular, the estimated backscatter uncertainty is used for ASCAT QC and ambiguity removal purposes.

Fig. 5 The bias of ASCAT retrieved wind speed w.r.t. (a) the mean buoy winds; and (b) the simulated ASCAT winds using temporal buoy winds. All the ASCAT solutions which are closest to the mean buoy winds are taken into account. The simulation only takes wind variability into account. As such, the residual of (a)-(b) mainly indicates rain impact.



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References

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