NWP Ocean Calibration And Validation Of Ku-Band Scatterometers

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Introduction

The absolute calibration of the backscatter signal of a scatterometer is essential for the retrieval of optimum-quality geophysical products. Transponders, sea ice and rain forest are generally being adopted as complementary sources for scatterometer calibration. It is hard for transponders to construct an earth-based radar pulse with a stability of 0.1 dB. The radar cross section is further known to be very stable and time independent over frozen sea ice and rain forest, but these calibrations pose geographical and time limitations.

The NWP ocean calibration (NOC) technique is used to quantitatively assess the difference between measured backscatter data and NWP-simulated backscatter data using the Geophysical Model Function (GMF). This method is based on the analysis of a large collocated measurement and NWP data set. Calibration procedures over the ocean have the advantage that they may be applied over a large portion of the globe and consequently may provide accurate results over a relatively short period. Ocean calibration has been applied successfully for the European Remote-Sensing Satellite (ERS) and Advanced SCATterometer (ASCAT) C-band fan-beam scatterometer wind products at KNMI.

The QuikScat scatterometer and OceanSat-2 scatterometer (OSCAT) use a Ku-band radar wavelength, which is strongly affected by the presence of rain within a scatterometer WVC. Rain significantly modifies the radar cross section and hence alters the wind vector retrieval. The atmosphere is not transparent at Ku band wavelengths and rain leads in particular to attenuation and volume scattering. The rain effect on the QuikScat/OSCAT NOC should be minimized, since the wind GMF does not take into account effects of rain.

Here we assess the difference between the backscatter of QuikScat/OSCAT data and the backscatter simulated with the NSCAT2 GMF, using the short-range-forecast ECMWF NWP equivalent-neutral winds as input. Due to the conical scanning, a WVC is generally viewed when looking forward (fore) and a second time when looking aft. As such, up to four measurement classes (called "beam" here) emerge: HH fore, HH aft, VV fore, and VV aft, in each WVC. More in particular, in order to determine the effect of rain on QuikScat/OSCAT ocean calibration, we compute the ocean calibration results with (QC-ed) and without (QC-free) using the KNMI QC flag, which is commonly used in the KNMI scatterometer wind products and shows excellent performance in screening rainy WVCs.

Results

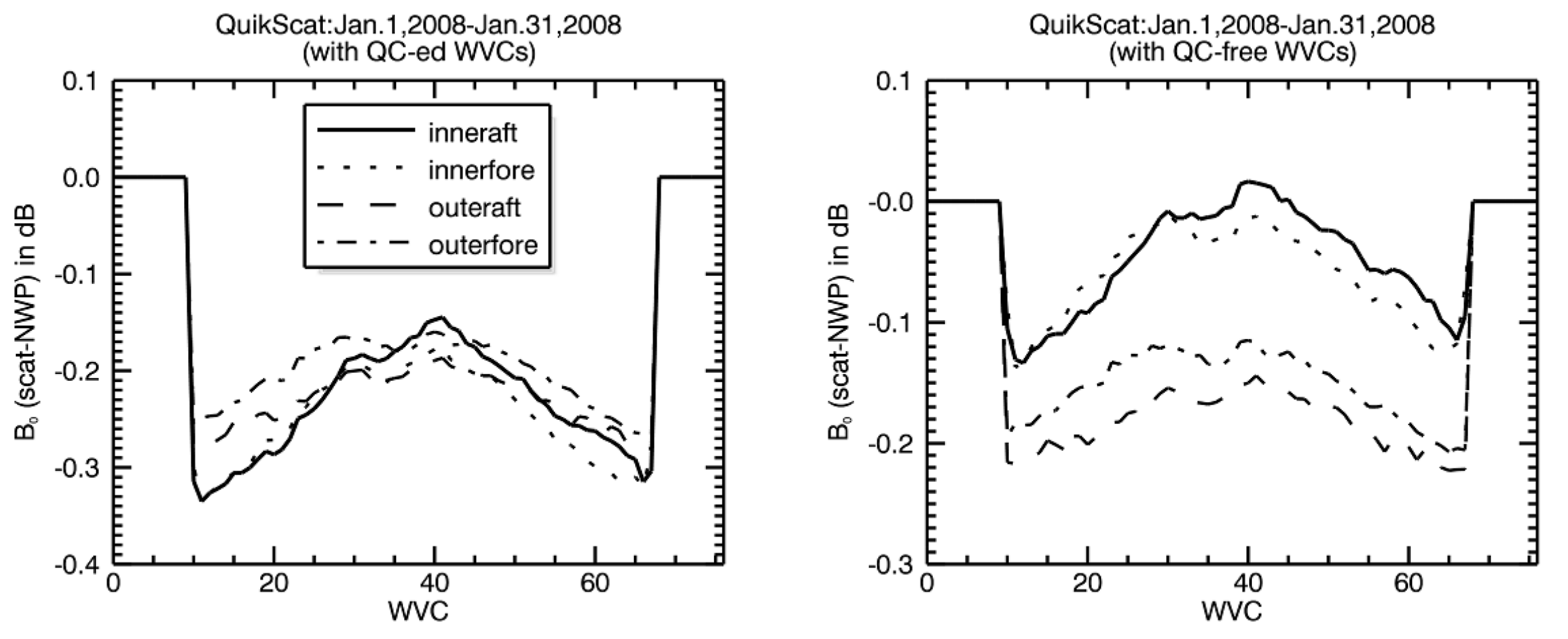

Figure 1: The average of the QuikScat ocean calibration residuals over January 2008. (left) with QC-ed WVCs and (right) with QC-free WVCs.

The 25km (50km) resolution L2A data and L2B data processed by SDP (OWDP) software which is being developed by the KNMI scatterometer group are used in the QuikScat (OSCAT) NOC. Figure 1 (Figure 3) is the average of the QuikScat (OSCAT) ocean calibration residuals over January 2008 (March 2010). For the outer beams we can find the differences in the left and right data sets in figure 1 (figure 3) are about 0.1dB, but for inner beams the differences are about 0.2dB for all WVCs. Figure 4 is the average of the OSCAT NOC residuals after correction. The corrected backscatter is underestimated when NWP ocean calibration is carried out including all WVCs. Figure 2 (Figure 5) is NWP wind validation of QuikScat (OSCAT). The wind statistics show that the ocean calibration procedure works well on QuikScat (OSCAT) data. The maximum likelihood estimator (MLE) is a measure of how well a measurement fits the GMF. Figure 6 shows the MLE as a function of WVC for OSCAT. Table 1 is Quikscat/OSCAT QC-ed NOC buoy validation.

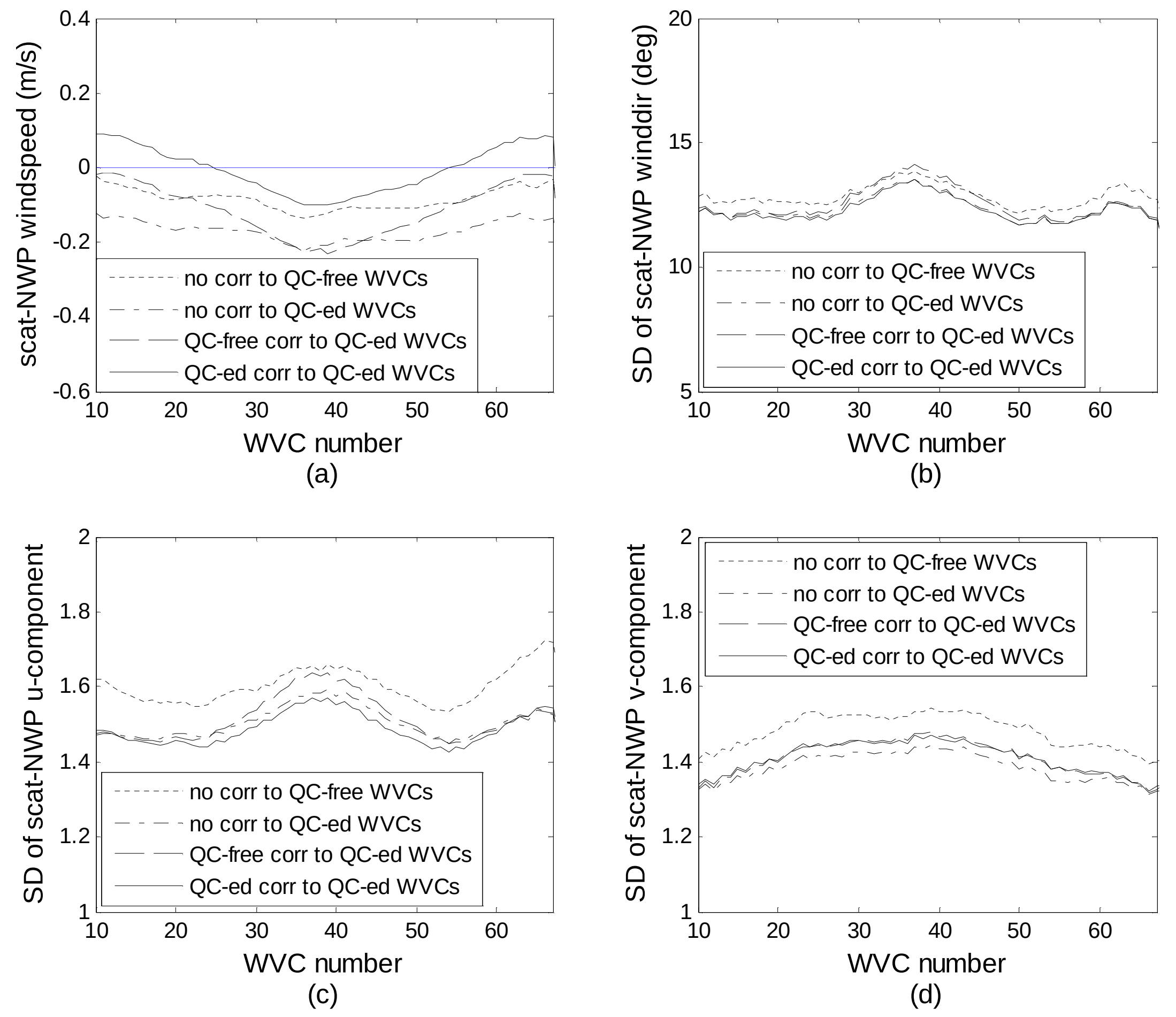

Figure 2: (a) Wind-speed bias of QuikScat versus ECMWF winds for the period January 6, 2008 to January 12, 2008 as a function of WVC. (b) Wind-direction SD. Wind-direction statistics are for the 2-D variational ambiguity removal wind solutions for ECMWF winds larger than 4 ms^{-1} (c) *u* wind component SD. (d) *v* wind component SD. Both the QC-ed and QC-free NOC corrections are applied on the QC-ed WVCs.

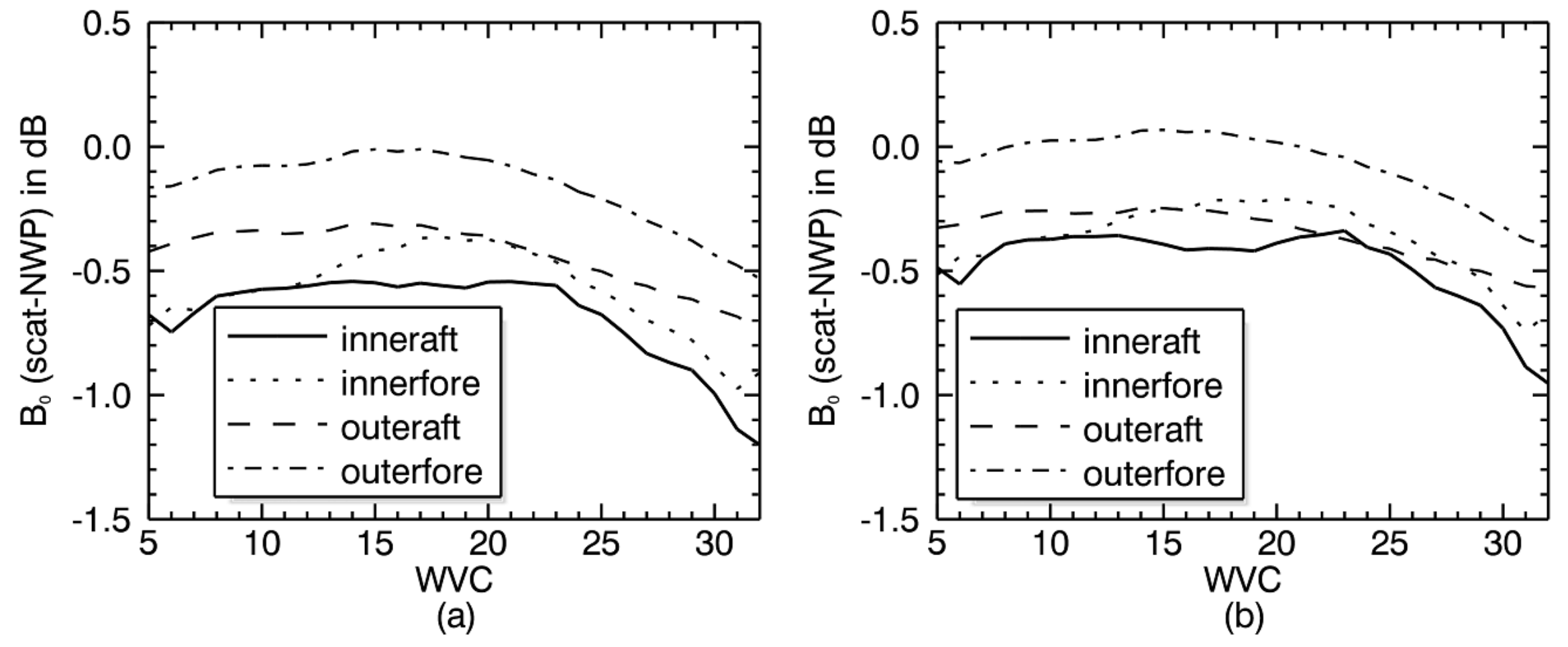

Figure 3: The average of the OSCAT ocean calibration residuals over March 2010. (a) with QC-ed WVCs and (b) with QC-free WVCs.

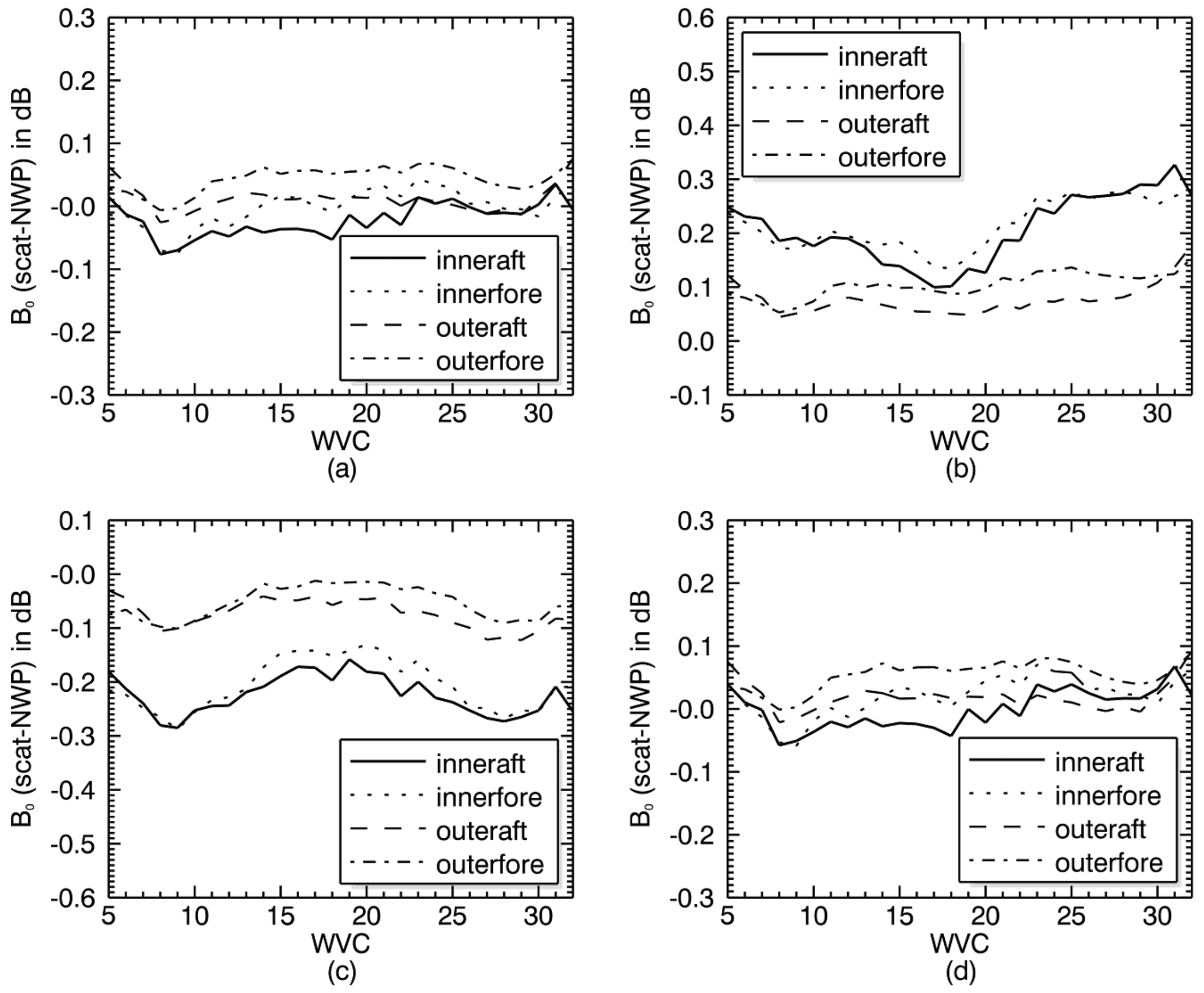

Figure 4: The average of the OSCAT ocean calibration residuals over March 7th, to March 13th, 2010 after correction. (a) applying the correction coefficients extracted from QC-ed WVCs on QC-ed WVCs; (b) applying the correction coefficients extracted from QC-ed WVCs on QC-free WVCs; (c) applying the correction coefficients extracted from QC-free WVCs on QC-ed WVCs; (d) applying the correction coefficients extracted from QC-free WVCs on QC-free WVCs;

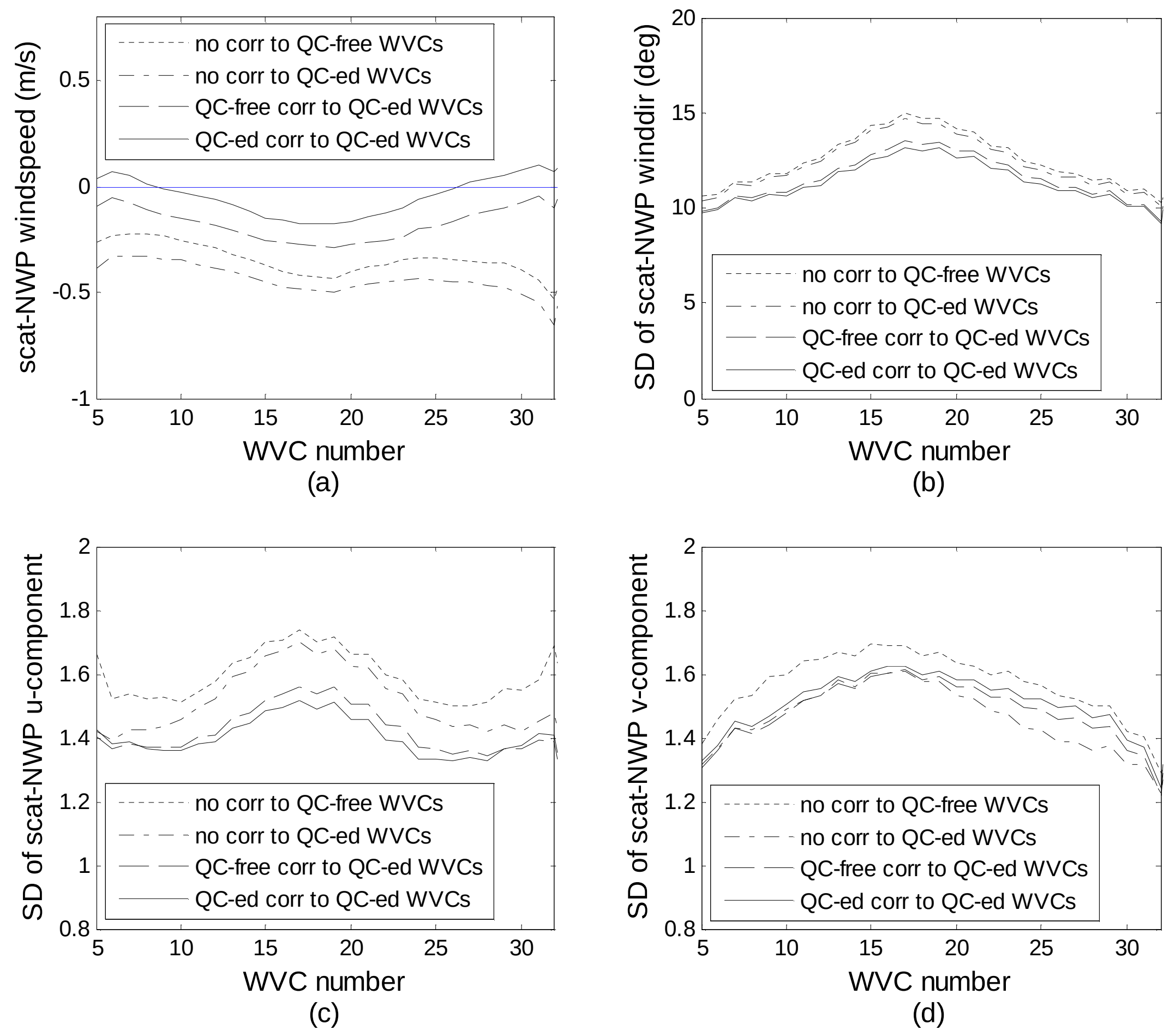

Figure 5: (a) Wind speed bias of OSCAT versus ECMWF winds for the period January 6, 2008 to January 12, 2008 as a function of WVC. (b) Wind direction SD. Wind direction statistics are for the 2-D variational ambiguity removal wind solutions for ECMWF winds larger than 4 ms^{-1} (c) *u* wind component SD. (d) *v* wind component SD. Both the QC-ed and QC-free NOC corrections are applied on the QC-ed WVCs.

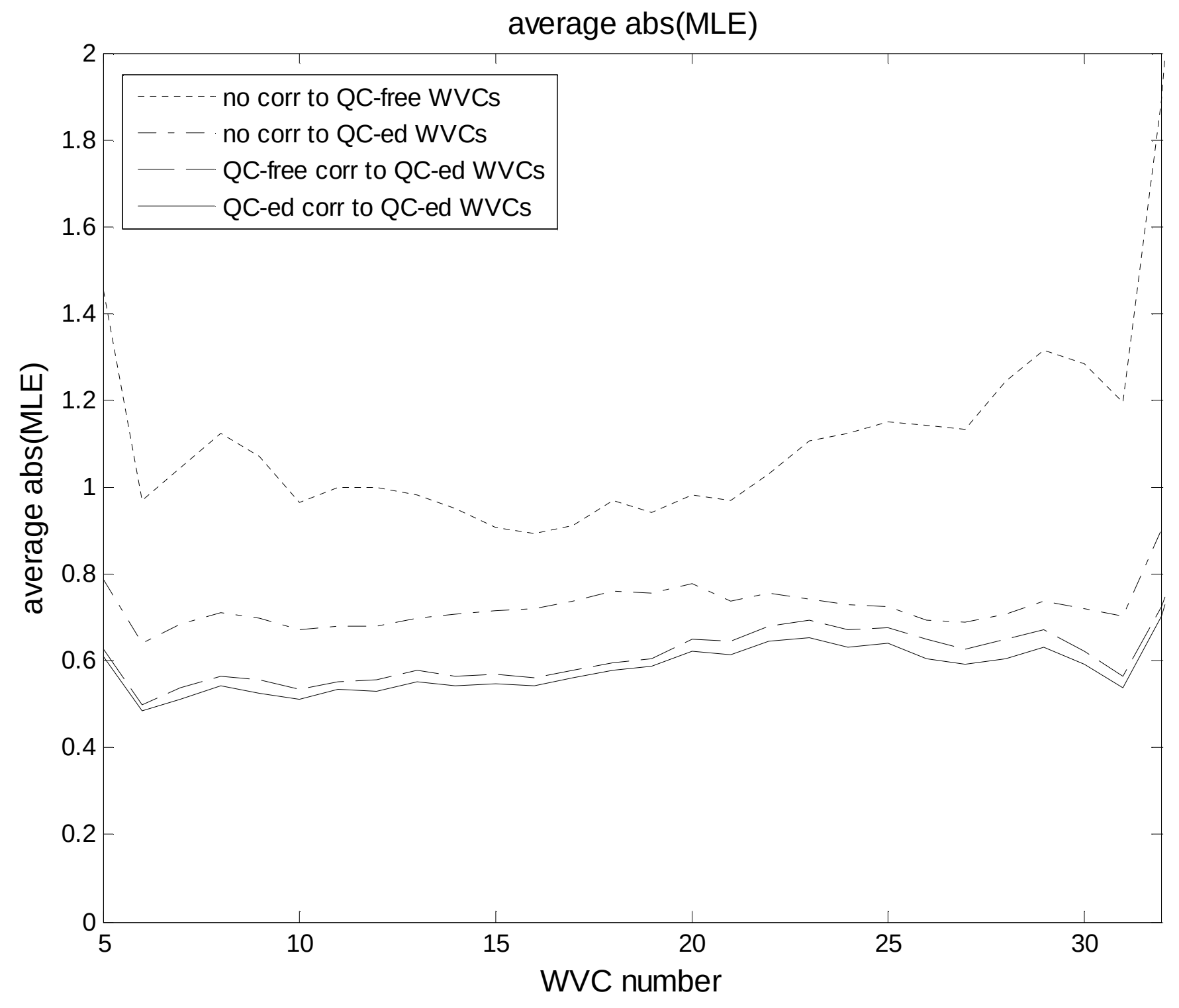

Figure 6: Absolute MLE value averaged per WVC for the corrected and uncorrected cases of OSCAT.

Table 1: Quikscat/OSCAT QC-ed NOC buoy validation

	Wind Speed (m/s): Average bias/ Average stdev	Wind Direction (deg): Average bias/ Average stdev	u component (m/s): Average bias/ Average stdev	v component (m/s): Average bias/ Average stdev
QuikSCAT (wind vector)	(3143) -0.26/1.24	(2887) 3.14/17.71	(3147) 0.34/1.86	(3147) 0.04/1.98
OSCAT (wind vector)	(2922) 0.12/1.23	(2657) 1.47/15.94	(2924) 0.26/1.74	(2924) -0.15/1.90

Conclusions

1. For conical scanning Ku-band scatterometers, the backscatter of the inner beams is much more sensitive to rain than that of the outer beams which implies a dominance of volume scattering in rain clouds.
2. The rain effects on Ku-band ocean calibration are notable. The ocean calibration including rainy WVCs will overcorrect the scatterometer winds by up to 0.1~0.2m/s.
3. The QuikScat / OSCAT NWP wind validation show that NWP ocean calibration contributes to a high quality wind product.
4. The QuikScat / OSCAT buoy wind validation show that NWP ocean calibration contributes to a high quality wind product.
5. Since MLEs are reduced, NOC provides backscatter quadruplets more consistent with the NSCAT2 GMF, and consistent with QuikSCAT.
6. OSCAT NOC shows a large fore/aft and WVC variation which needs further analysis.

References

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