An improved wind quality control for Ku-band scatterometers

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Outline

1. Suprious low winds by Pencil-beam Wind Processor (PenWP)

   - Why ?
   - How ?

2. New quality indicators

   - Spatially averaged MLE (MLE_m)
   - Singularity exponent (SE)

3. Wind quality classification

4. Validation

5. Conclusions

1. Spurious low winds

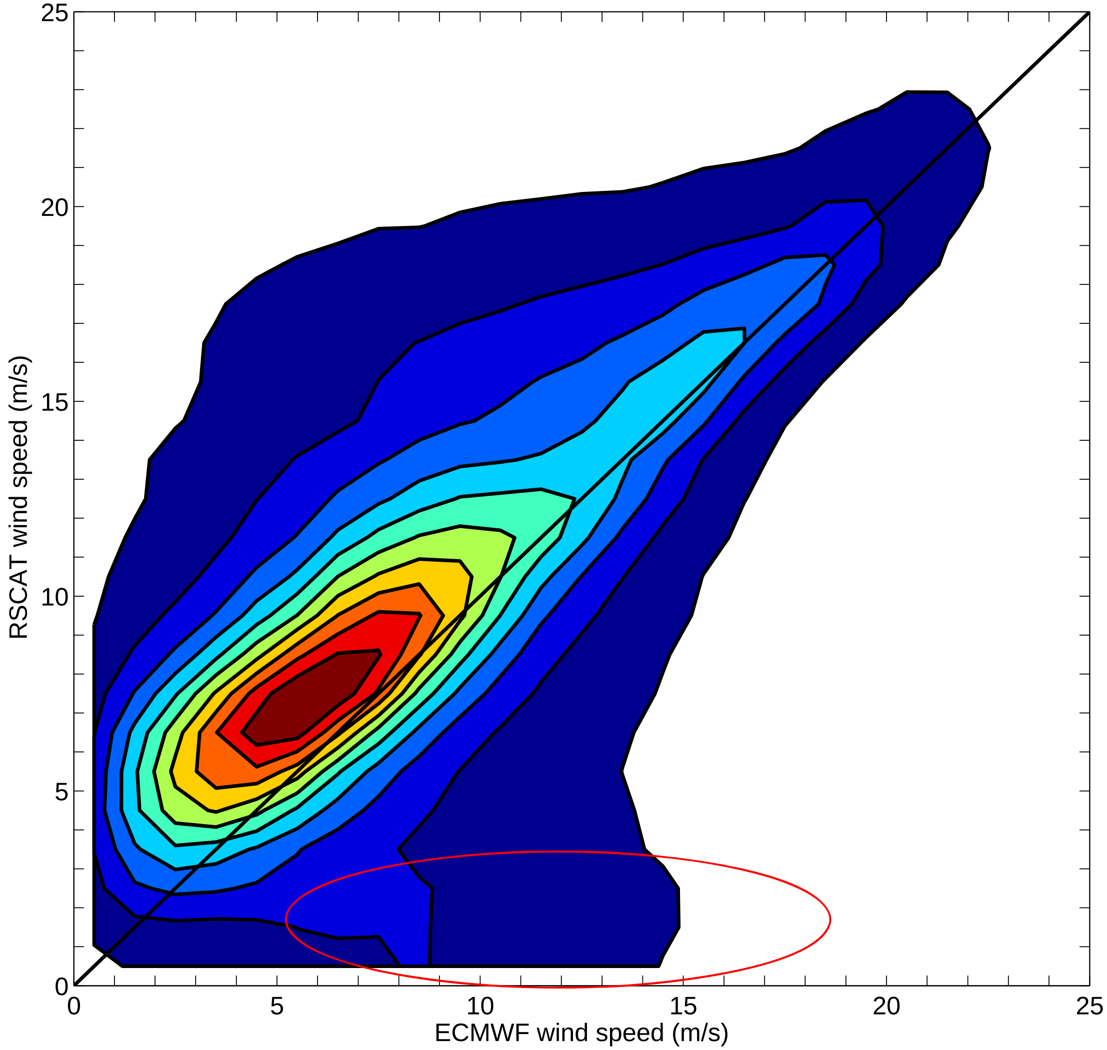
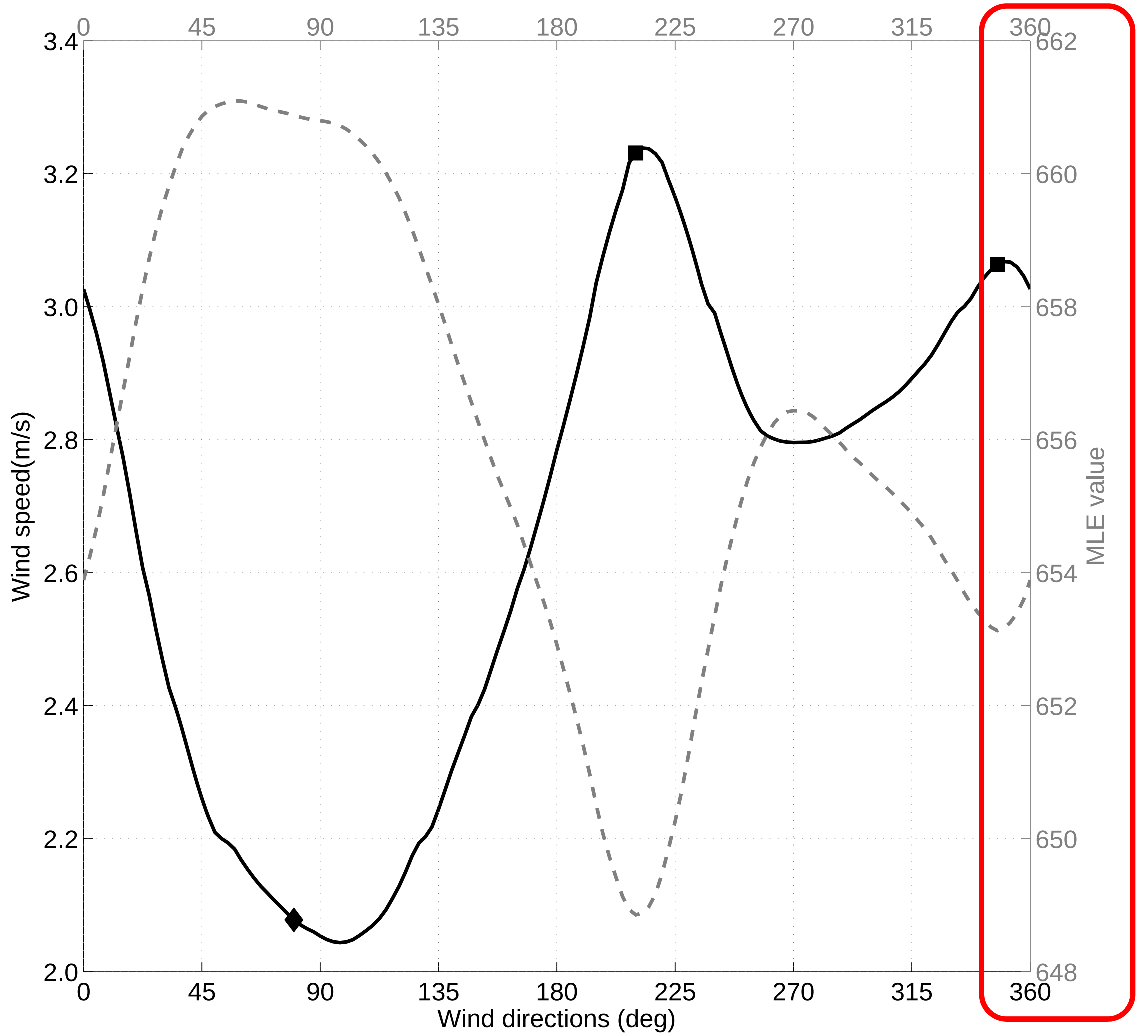


Fig. 1 Two dimensional histogram of RapidScat (RSCAT) quality control (QC-) rejected data versus ECMWF wind (bins of 1 m/s) in January 2015. The lowest level of the contour lines is 2%, and the following steps are 10%, 20%, .., and 90% of the maximum data bin.

1. Spurious low winds – WHY?



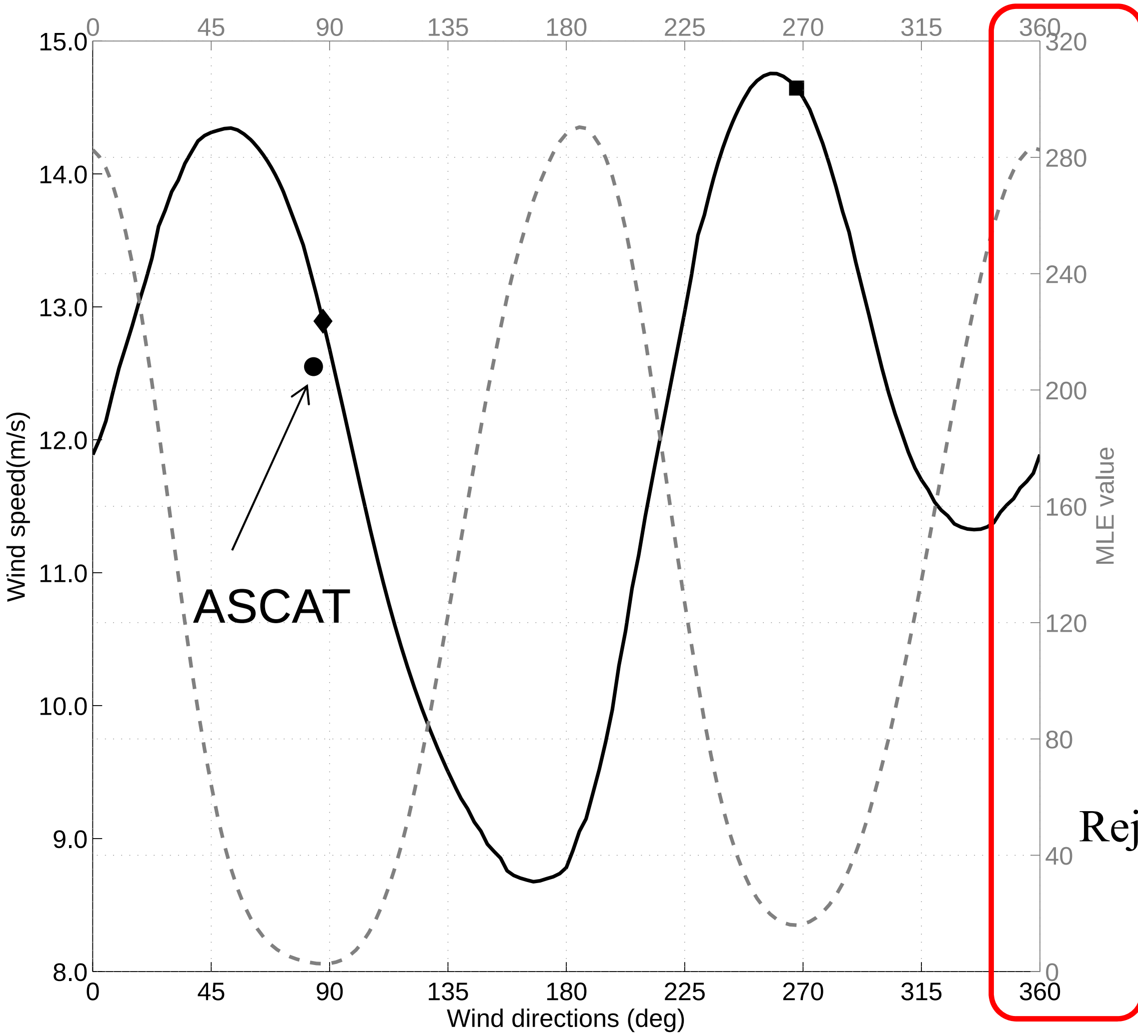
$$MLE = \sum_{i}^{N} \frac{\left(\sigma_{mi}^{0} - \sigma_{si}^{0}\right)^2}{\left(K_{pi} \cdot \sigma_{mi}^{0}\right)^2}$$

HH σ^0: -42.65, -17.88 dB

VV σ^0: -14.01, -18.49 dB

Fig. 2 (a) the wind speed that minimizes rigth-side cost function at different wind direction. And the dashed curve is the corresponding MLE value versus wind direction (see the right y-axis).

1. Spurious low winds – HOW(2)?



$$MLE = \sum_{i}^{N} \frac{\left(\sigma_{mi}^{0} - \sigma_{si}^{0}\right)^2}{\left(K_{pi} \cdot \sigma_{mi}^{0}\right)^2}$$

HH σ^0: -42.65, -17.88 dB

VV σ^0: -14.01, -18.49 dB

$$\text{RejectCriteria} \begin{cases} \max\left\{\sigma_{mi}^{0}\right\} - \sigma_{m}^{0} > 10 \quad \text{dB} \\ \max\left\{\sigma_{mi}^{0}\right\} > -30 \quad \text{dB} \\ \dfrac{\left(\sigma_{m}^{0} - \sigma_{s}^{0}\right)^2}{\left(K_{p} \cdot \sigma_{m}^{0}\right)^2} > 1000 \end{cases}$$

Fig. 2 (c) the wind speed that minimizes rigth-side cost function at different wind direction. And the dashed curve is the corresponding MLE value versus wind direction (see the right y-axis).

1. Spurious low winds – NOW?

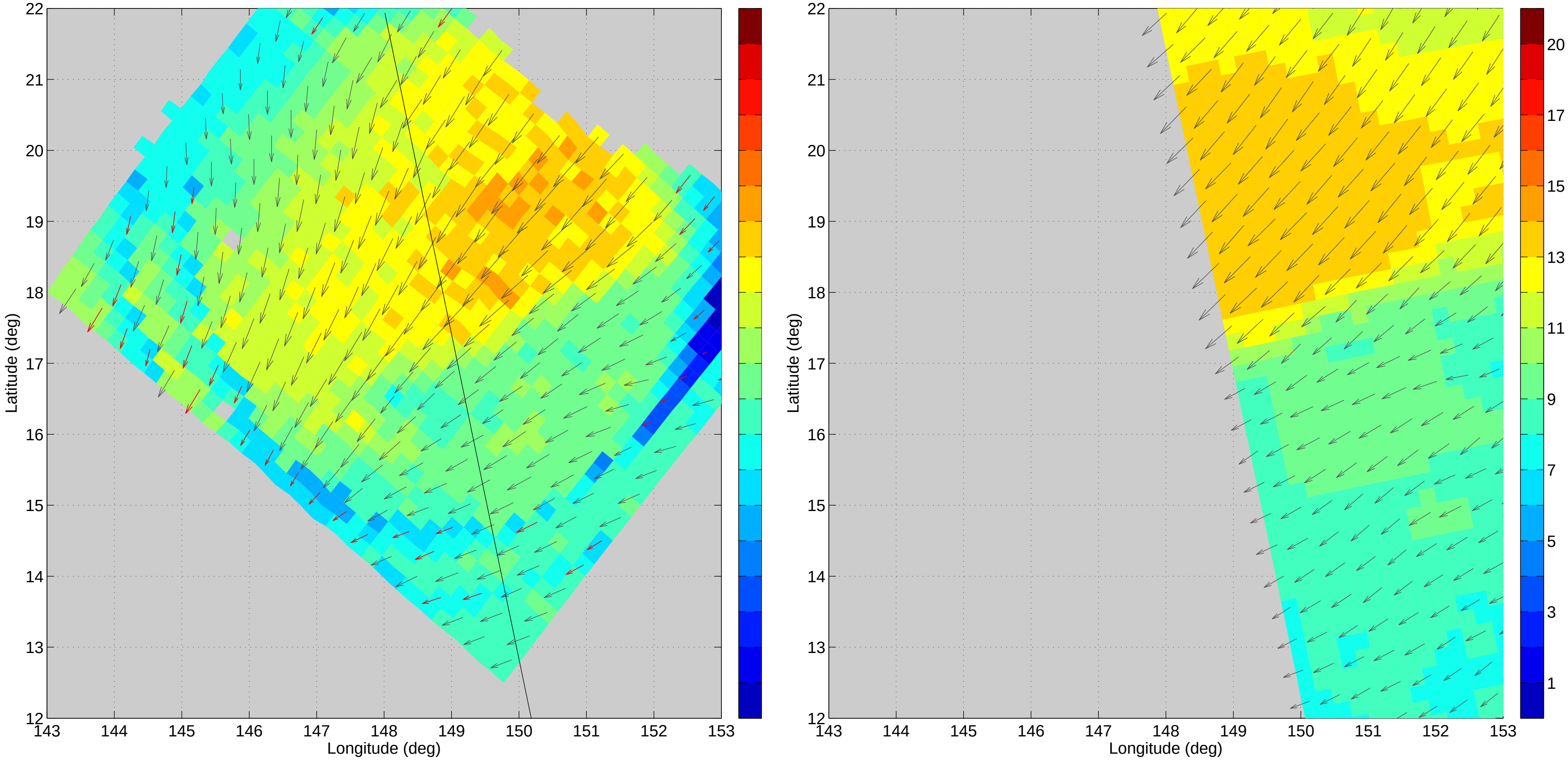
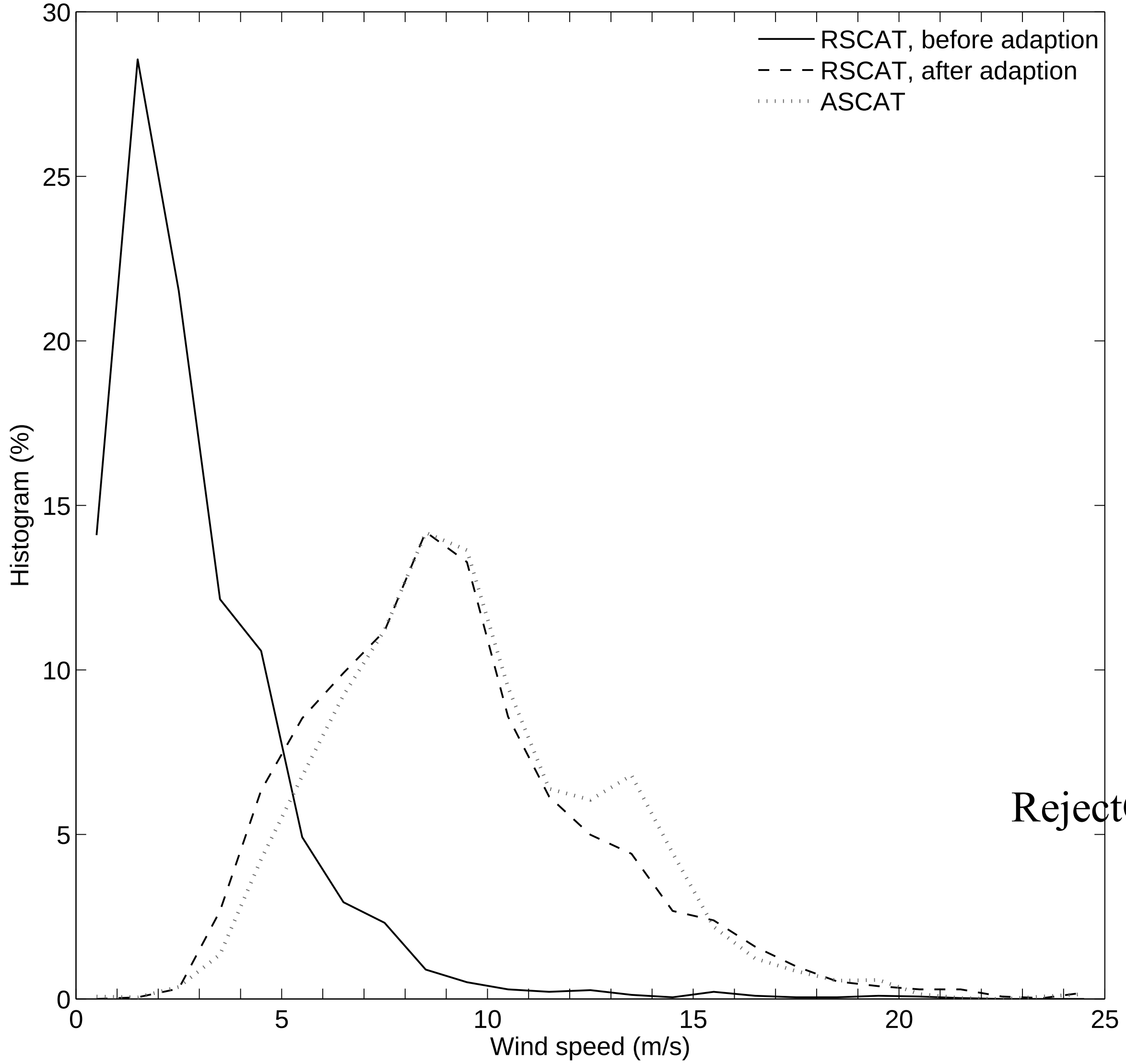


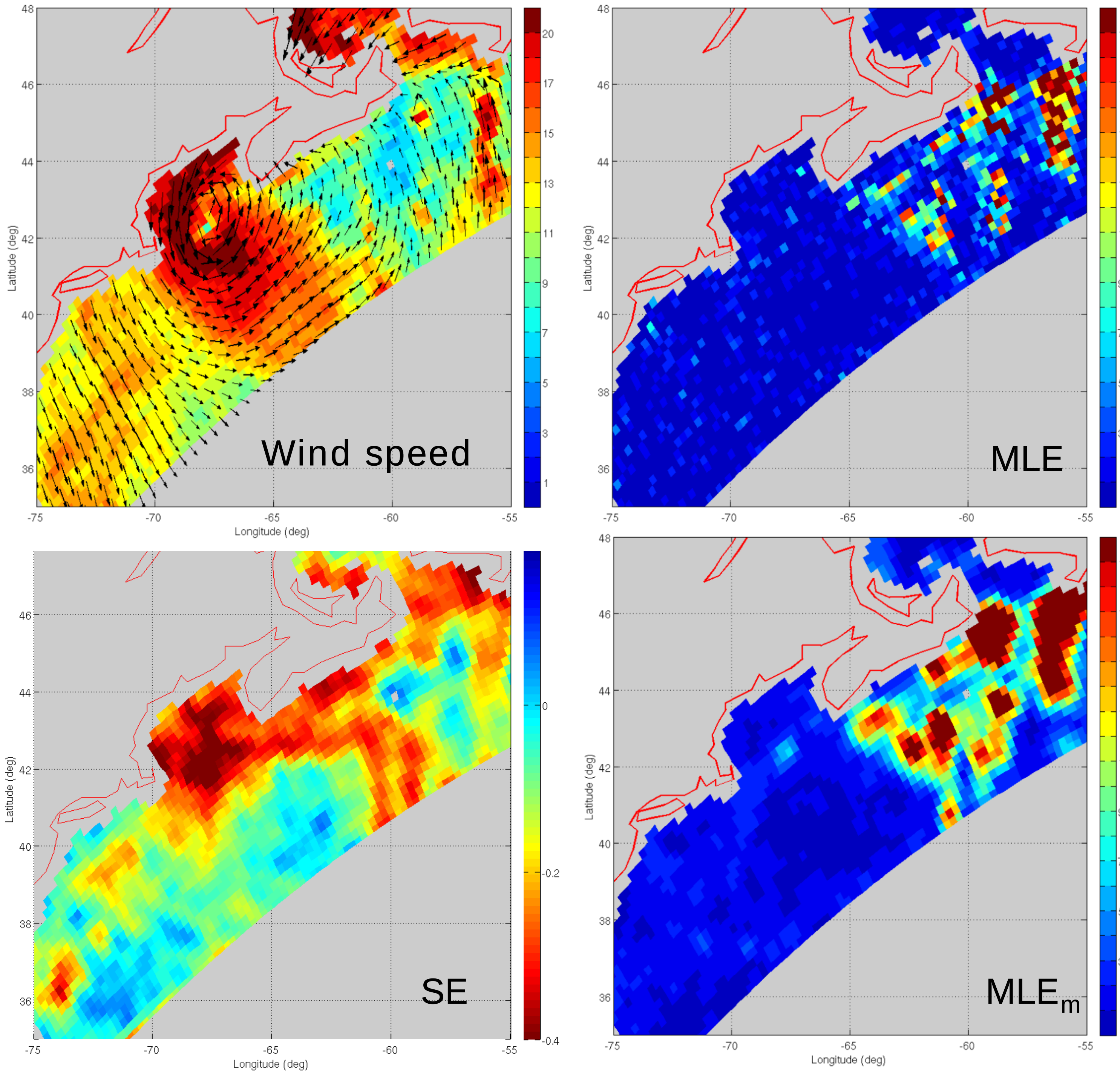
Fig. 3 (left) RSCAT wind field retrieved by PenWP setting, the acquisition time was on January 25th 2015, at 11:52 UTC; (right) The collocated ASCAT wind field observed at 11:36 UTC. Gray arrows indicate QC-accepted winds, and red arrows indicate QC-rejected winds. The colorbar shows the wind speed of each scene.

1. Spurious low winds – NOW?



$$\text{RejectCriteria}\begin{cases} \max\left\{\sigma_{mi}^{0}\right\}-\sigma_{m}^{0}>10\ \ \text{dB} \\ \max\left\{\sigma_{mi}^{0}\right\}>-30\ \ \text{dB} \\ \dfrac{\left(\sigma_{m}^{0}-\sigma_{s}^{0}\right)^{2}}{\left(K_{p}\cdot\sigma_{m}^{0}\right)^{2}}>1000 \end{cases}$$

Fig. 4Wind speed histograms of the data set rejected by the default PenWP inversion (solid curve), but accepted by the adaptive inversion (dashed curve). The dotted curve shows the speed histogram of collocated ASCAT winds (bins of 1 m/s).



3	2
4	3
3	2

$$s\|(\cdot,r)\rangle\big] + o\left(\frac{1}{\log r_0}\right)$$

2. New quality indicators (RSCAT)

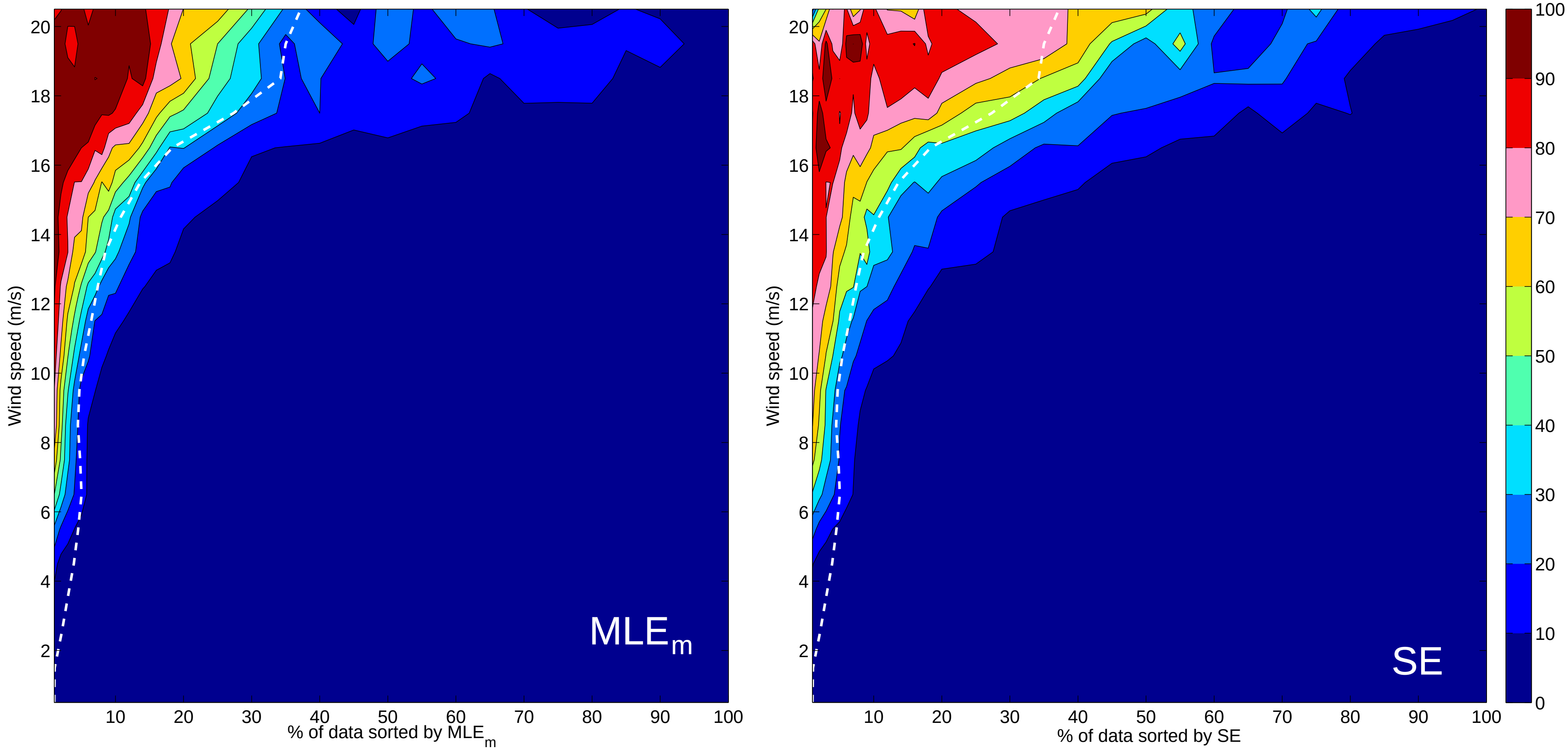


Fig. 5 The percent of **rain-contaminated data** (TMI RR > 1 mm/h) as a function RSCAT wind speed and the sort percentiles by: (left) MLE or MLE$_m$; and (right) SE. Here the inner-swath WVCs are studied. The white dashed curve indicates the rejection ratio of the operational MLE-based QC.

2. New quality indicators (RSCAT)

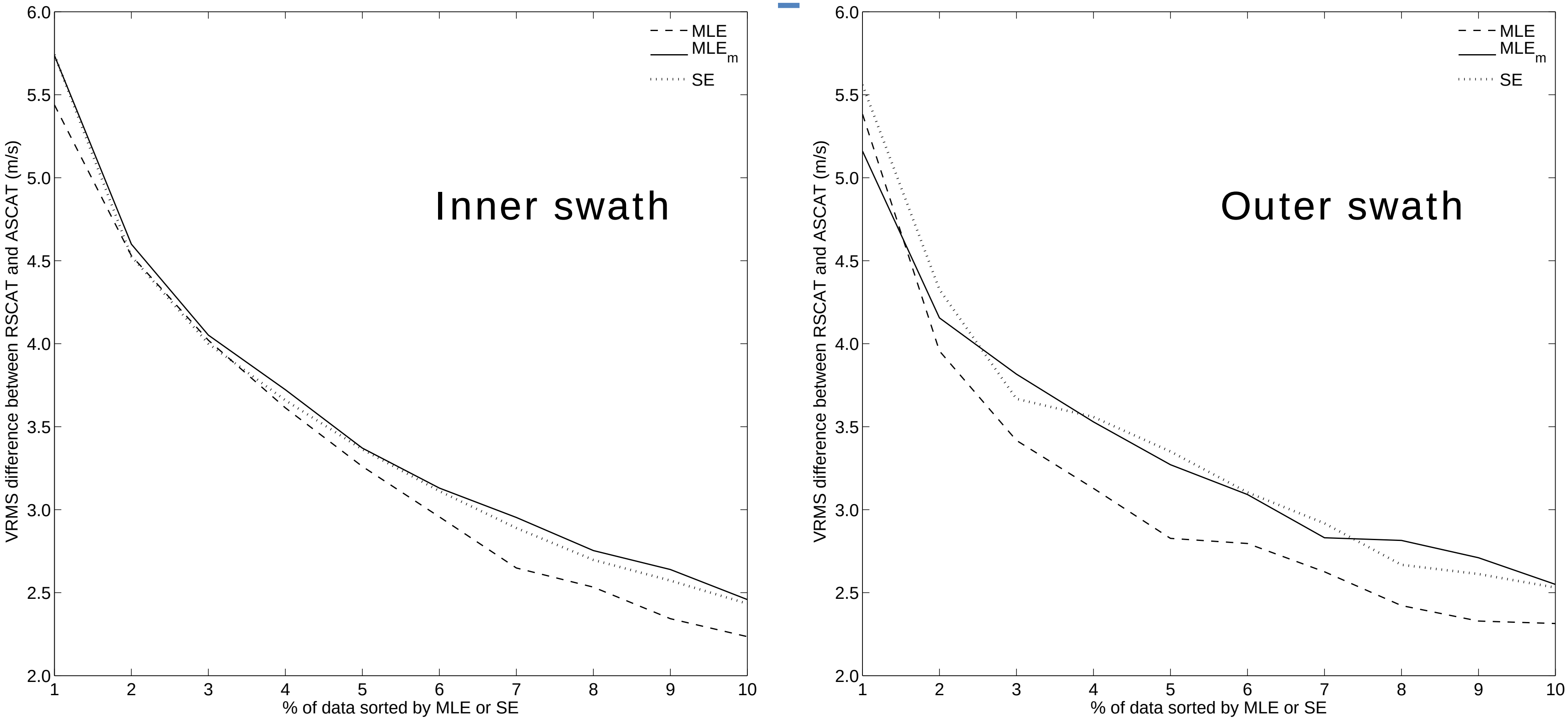


Fig. 6 The Vector Root-Mean-Square (**VRMS**) difference between **RSCAT and ASCAT** as a function of the sorted percentiles by MLE or SE (left) Inner swath; (right) Outer swath.

3. Wind quality classification

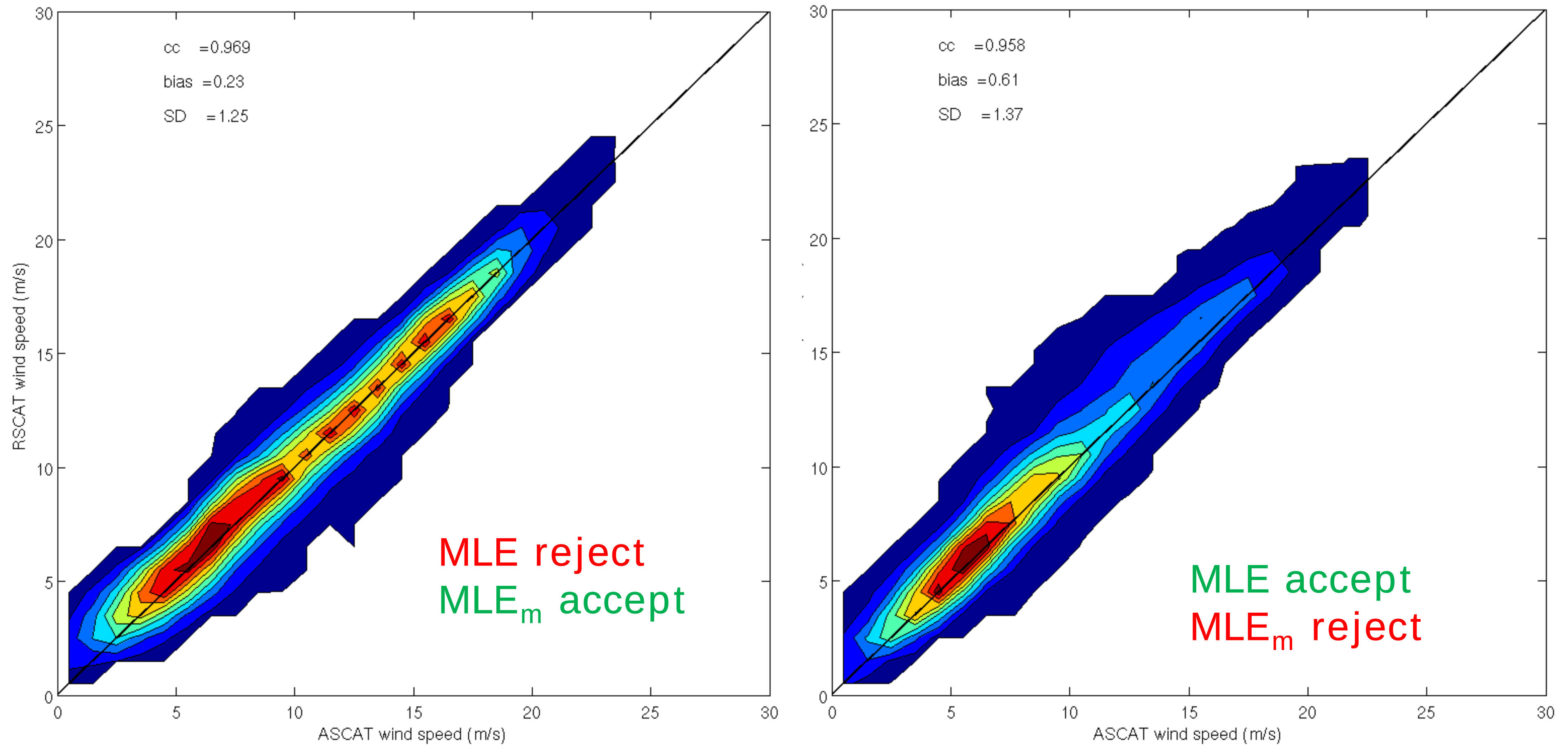


Fig. 7a The RSCAT wind speed versus ASCAT wind speed for the inner-swath data with (left) : fMLE (fSE) = 1, and $fMLE_m = 0$; (Right) fMLE = 0, and $fMLE_m = 1$; The upper left corner of each panel shows the correlation coefficient (cc), the speed bias [m/s], and the standard deviation [m/s] of RSCAT wind speed w.r.t. ASCAT winds.

3. Wind quality classification

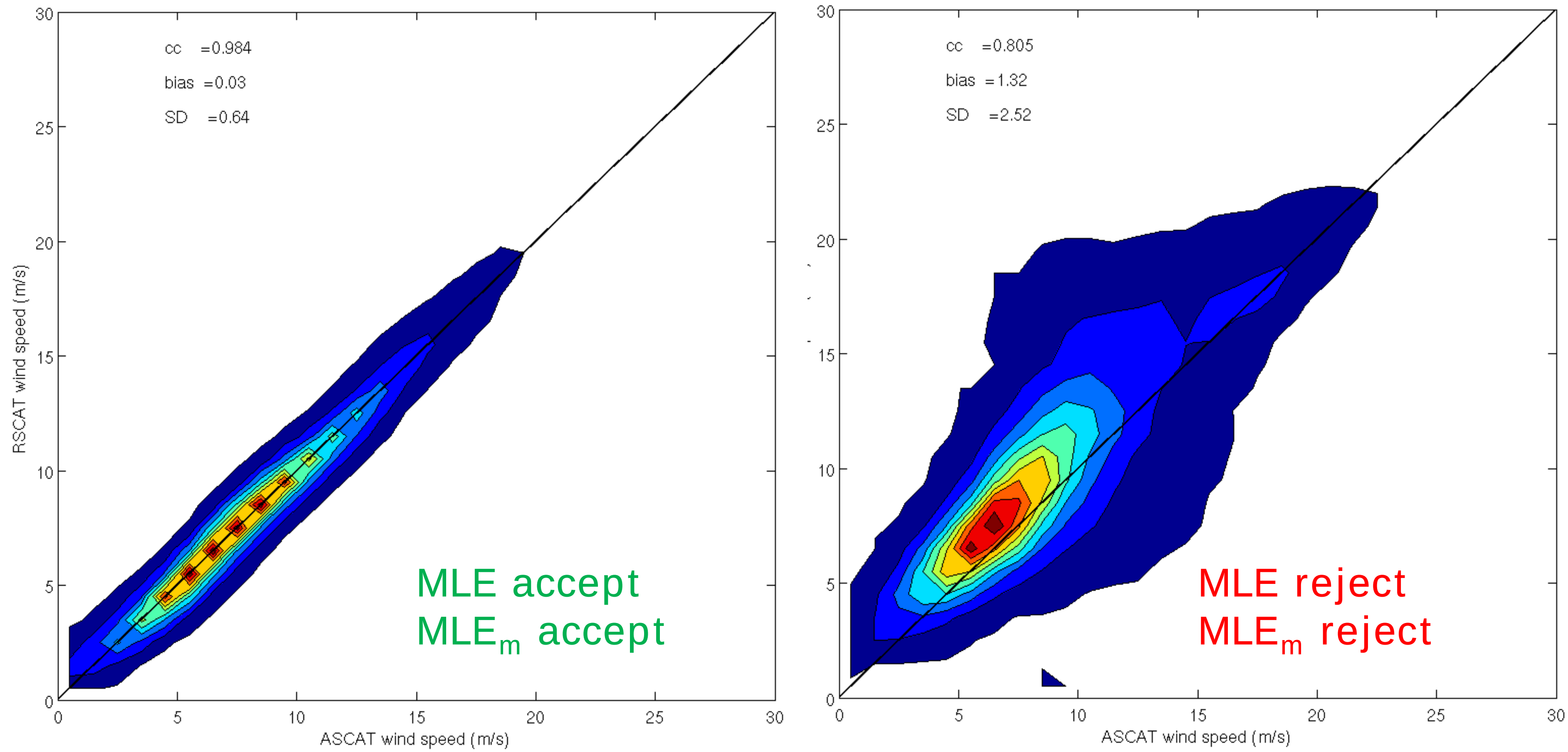


Fig. 7b The RSCAT wind speed versus ASCAT wind speed for the inner-swath data with (left) : fMLE = 0, and $fMLE_m = 0$; (Right) fMLE = 1, and $fMLE_m = 1$ (a few spurious low winds persist)

3. Wind quality classification

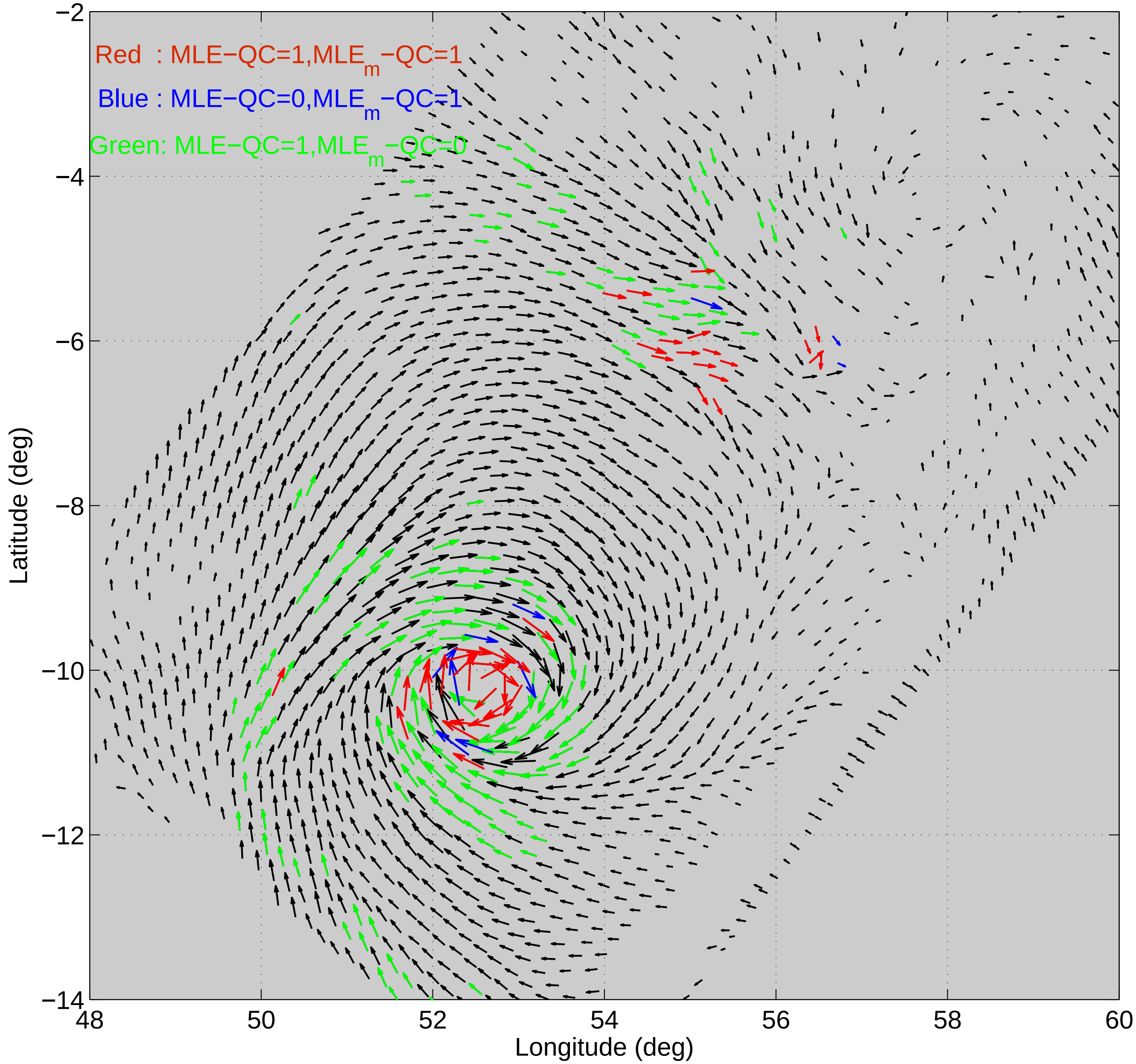


Fig. 8 The default PenWP MLE-based QC rejects too many spatially-consistent winds near the cyclone center (Green and red arrows).

The new MLE$_m$-based QC keeps the consistent winds, and rejects the variable winds (blue and red arrows)

4. Verification

Table 1. The statistics of RSCAT winds versus buoy winds at different categories defined by the PenWP MLE-based QC and the proposed QC (**denoted as fNEW, i.e., using $\mathbf{MLE_m}$ over the inner swath, and SE over the outer swath**) method constructed from $fMLE_m$ (inner swath) and fSE (outer swath). Below, wind speed bias [m/s], *abbr.* B_s; SD of wind speed [m/s], *abbr.* SD_s; SD of wind direction [degree, °], *abrr.* SD_d; and the percent of data [%].

	fNEW = 0					fNEW = 1				
	B_s	SD_s	SD_d	VRMS	%	B_s	SD_s	SD_d	VRMS	%
fMLE = 0	-0.04	1.07	18.1	2.25	90.96	0.73	1.85	33.3	4.45	2.44
fMLE = 1	0.36	1.65	26.7	3.54	2.34	2.31	3.06	40.8	6.67	4.26

5. Conclusions

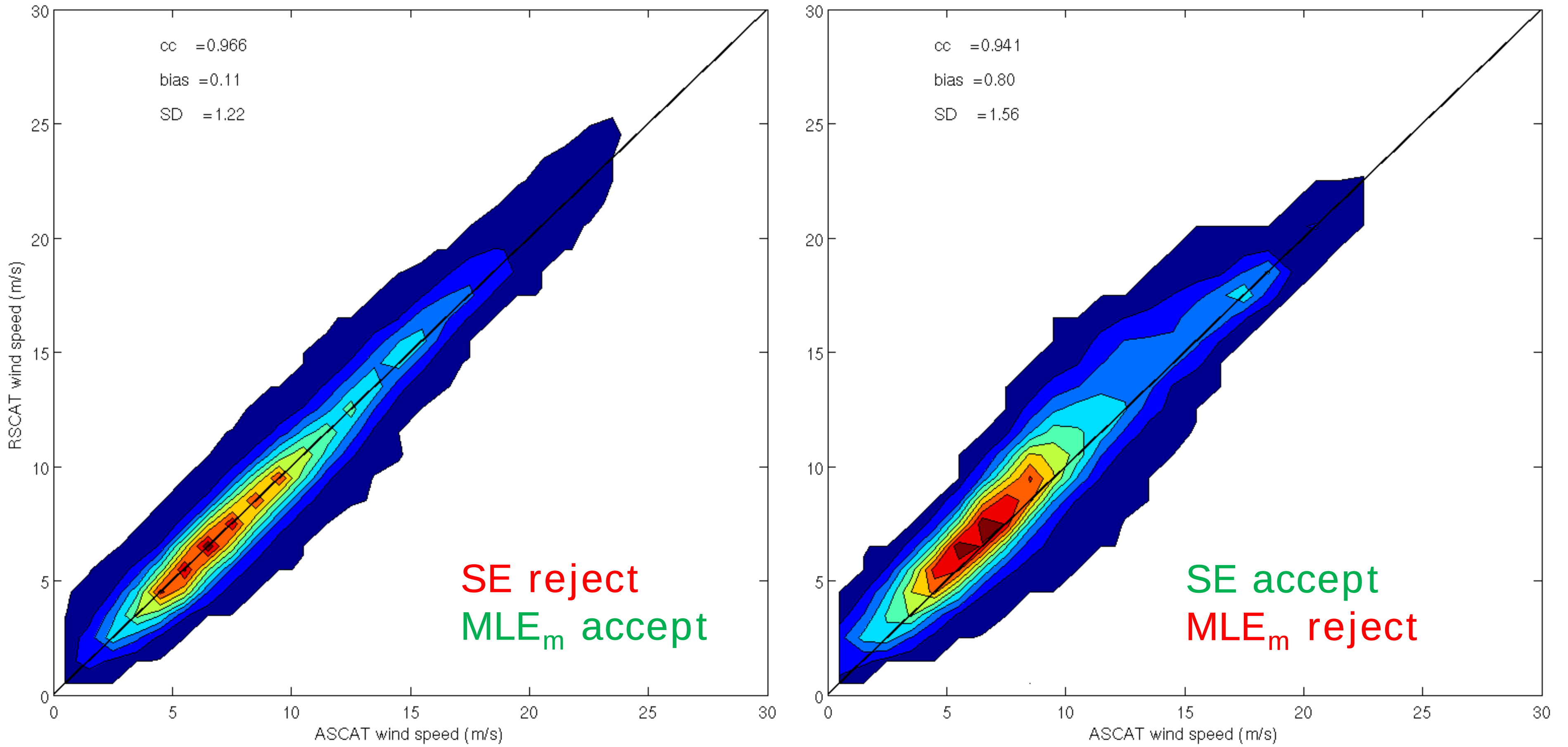
1. Spurious low winds are caused by 1) spurious low backscatter; 2) the inversion cost function. The proposed method is effective in filtering spurious low backscatter, and in turn, improves the wind inversion.

2. MLE_m is the best quality indicator over the inner swath; (Why SE is not as effective as that of C-band ASCAT? 1) the use of MSS, in which case the winds are rather spatially consistent; 2) too many missing points over the RSCAT swath, which is hazard to the image-based singularity analysis)

3. SE is the best quality indicator over the outer swath, where the inversion is an underdetermined problem due to the lack of azimuthal diversities, thus MLE and MLE_m are ineffective.

4. It is proposed to improve PenWP QC using MLE_m over the inner swath, and SE over the outer swath.

3. Wind quality classification



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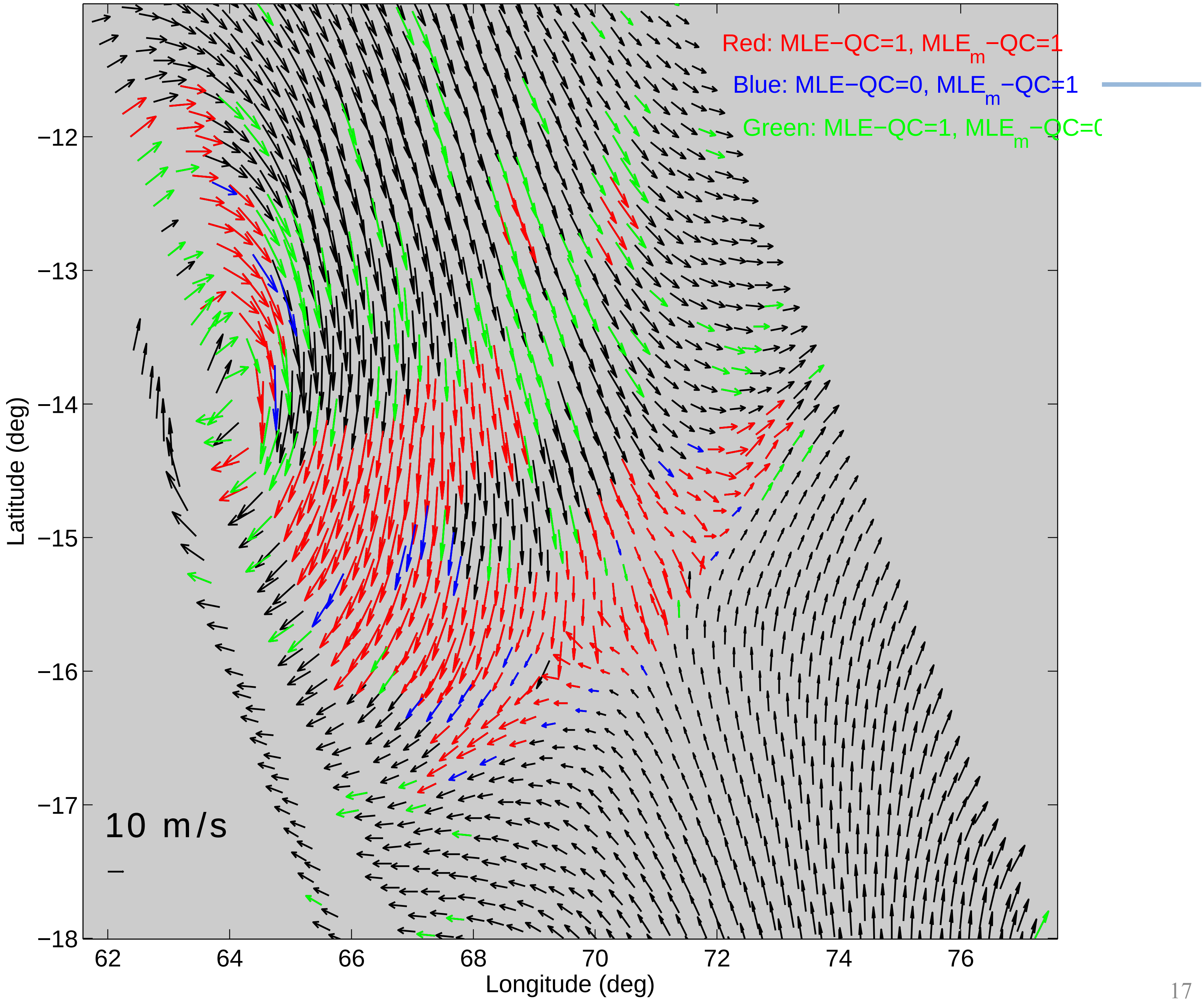
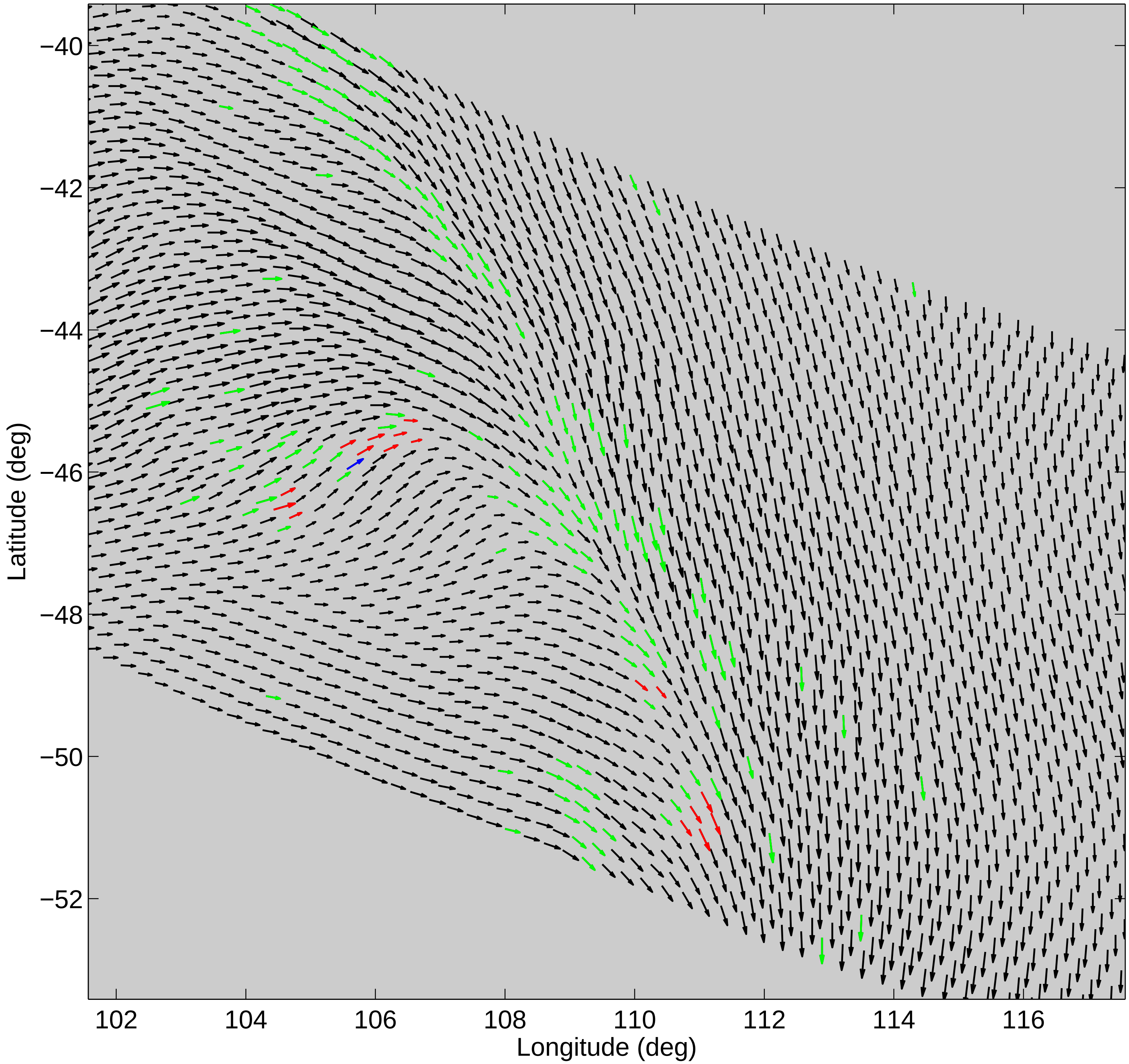
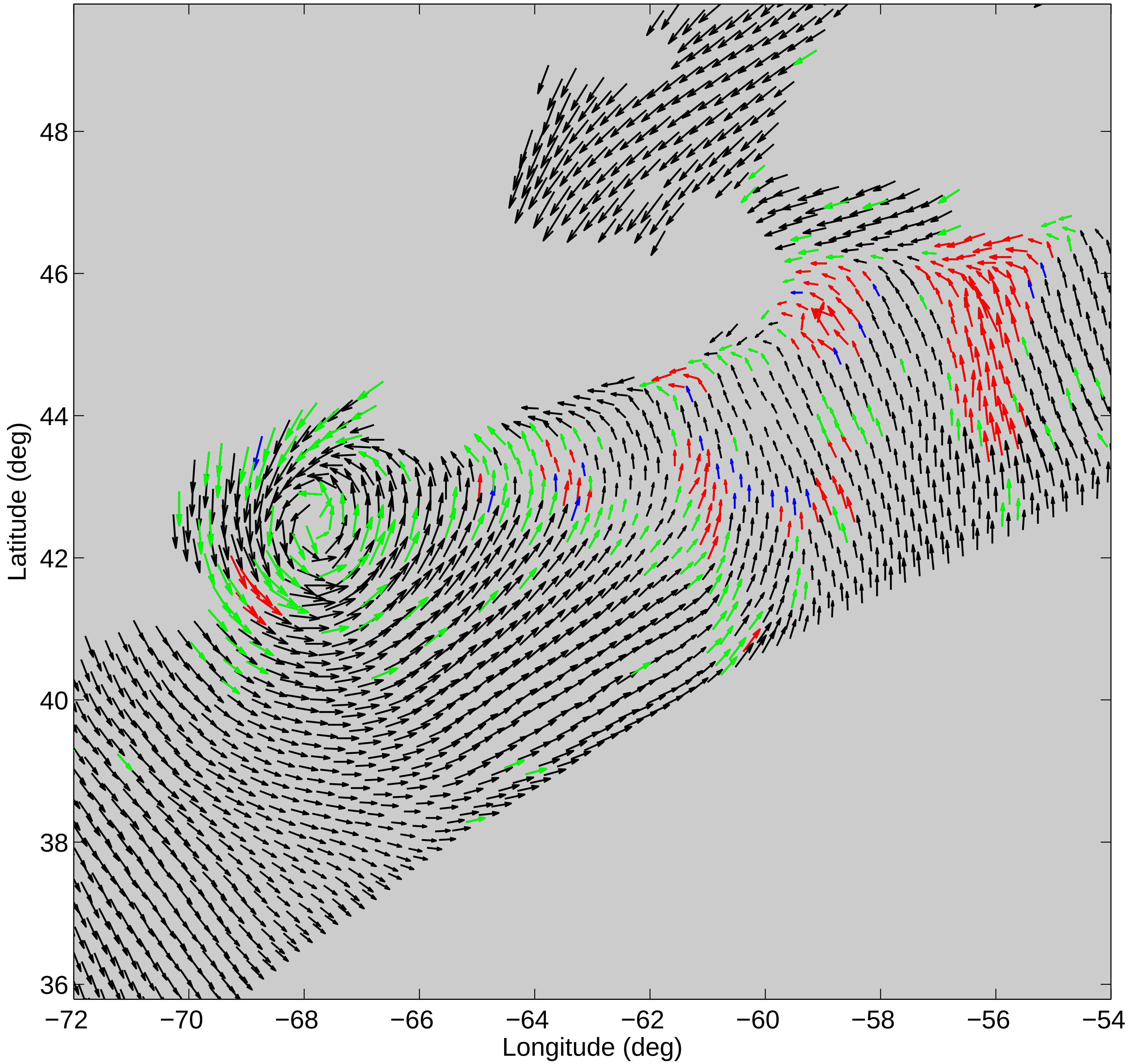

Red: MLE−QC=1, MLE_m−QC=1
Blue: MLE−QC=0, MLE_m−QC=1
Green: MLE−QC=1, MLE_m−QC=0
10 m/s
Latitude (deg)
Longitude (deg)
−12
−13
−14
−15
−16
−17
−18
62
64
66
68
70
72
74
76



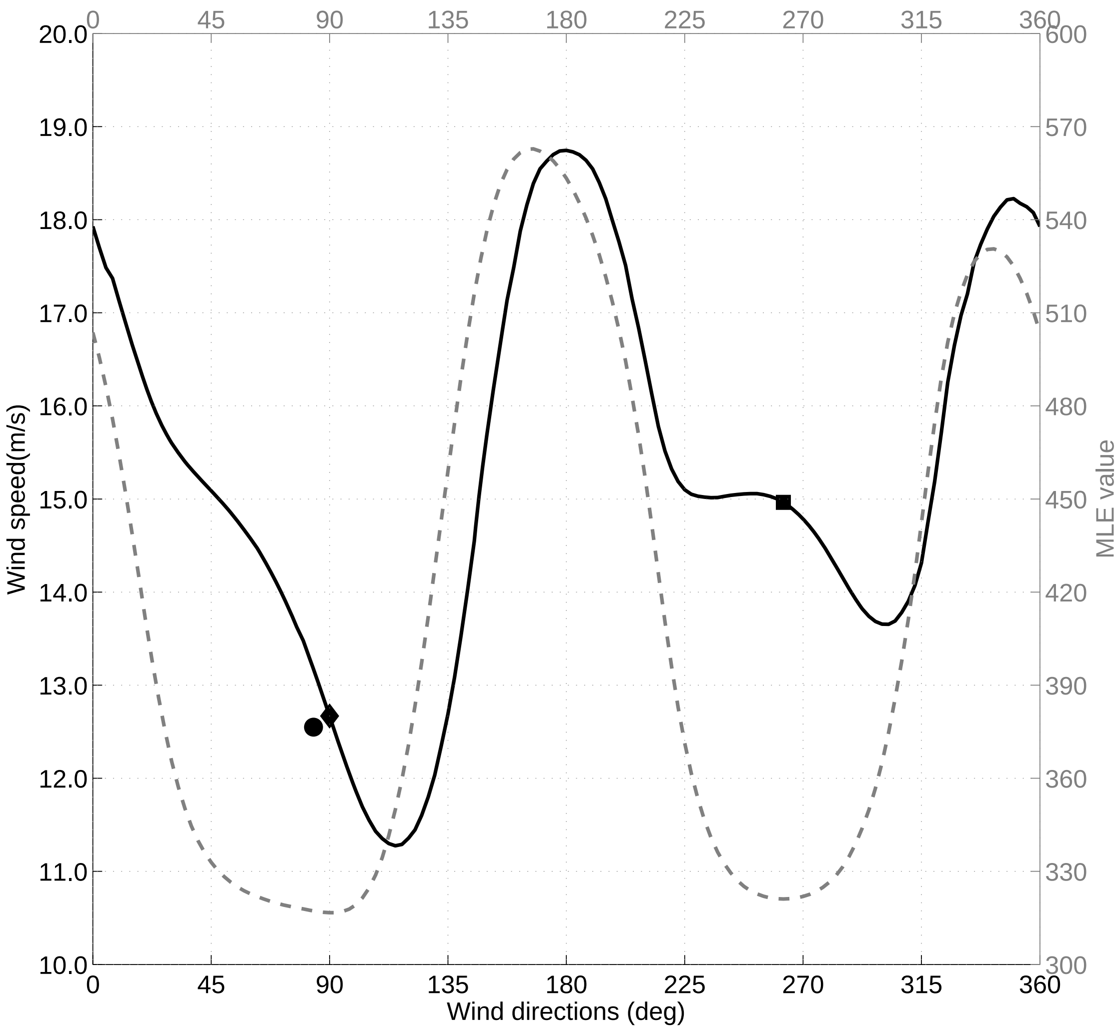
−40
−42
−44
−46
−48
−50
−52
Latitude (deg)
102
104
106
108
110
112
114
116
Longitude (deg)

S


48
46
44
42
40
38
36
Latitude (deg)
−72
−70
−68
−66
−64
−62
−60
−58
−56
−54
Longitude (deg)

S

1. Spurious low winds – HOW(1)?



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4. Verification

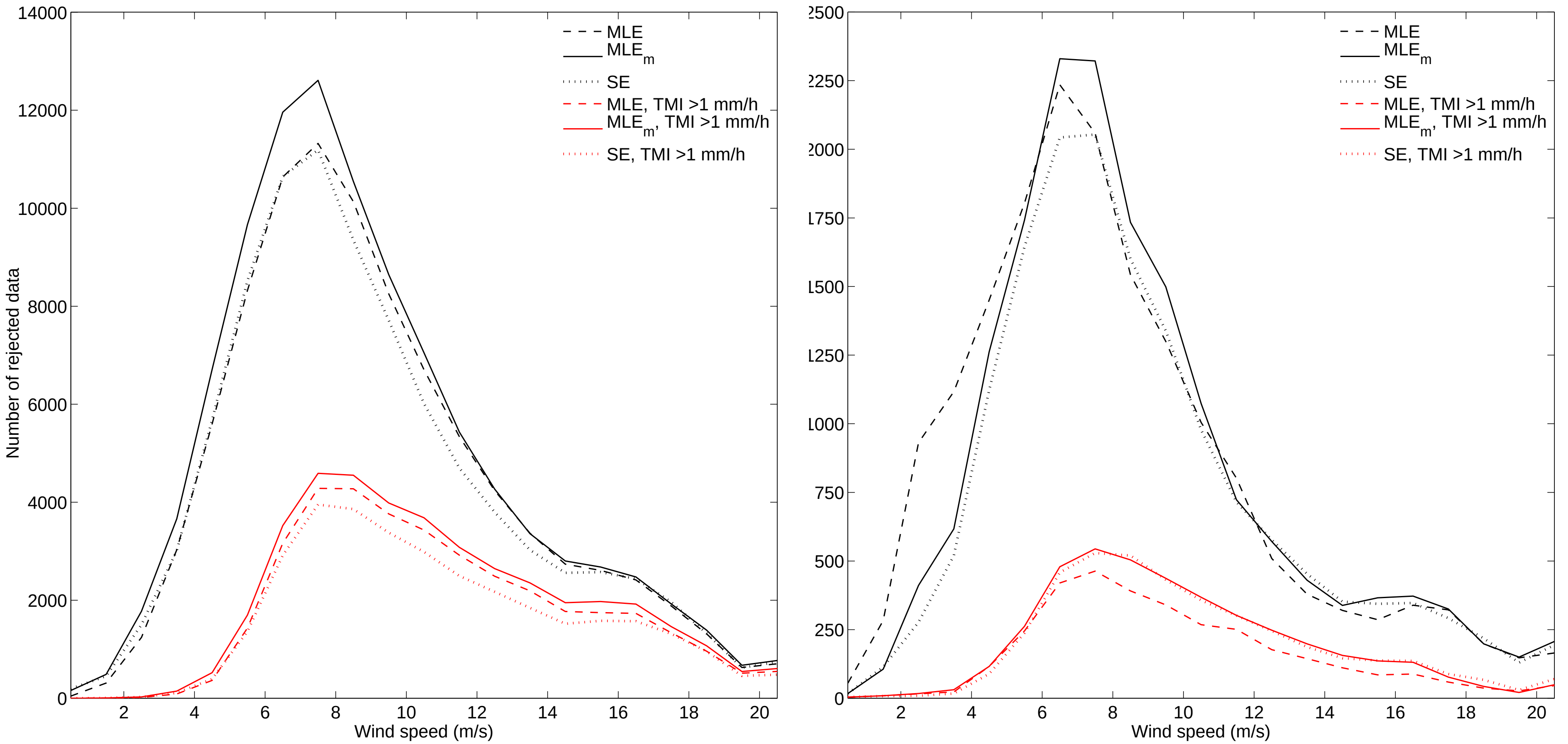

Fig. 9 (left) inner swath; (right) outer swath. The number of QC-rejected data (black curves) and QC-rejected rainy data (red curves) by MLE (dashed curve), MLEm (solid curve), and SE (dotted curve)