On the characteristics of ASCAT wind direction ambiguities

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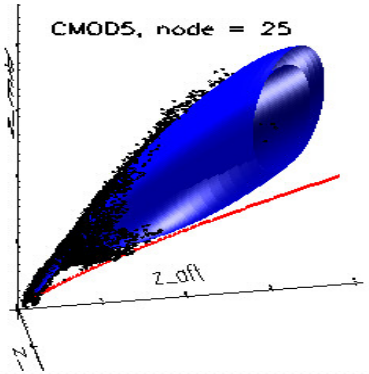
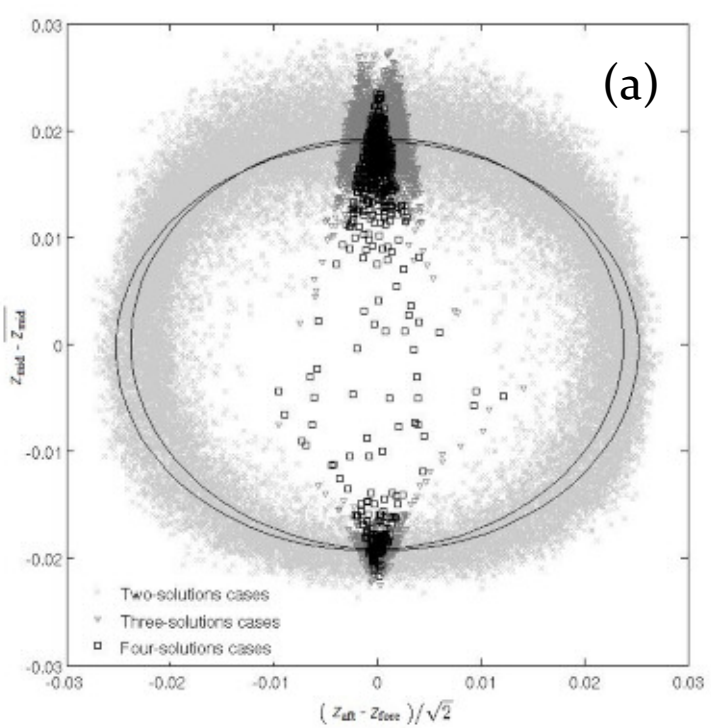
1. Motivation



- The inversion of ASCAT backscatter measurement triplets generally leads to two wind ambiguities with similar wind speed values and opposite wind directions.
- However, for up-, down- and cross-wind (with respect to the mid beam azimuth direction) cases, the inversion often leads to three or four wind solutions.
- Are these so-called "high-rank" solutions meaningful in terms of probability of being the true wind or rather artefacts of the inversion procedure?



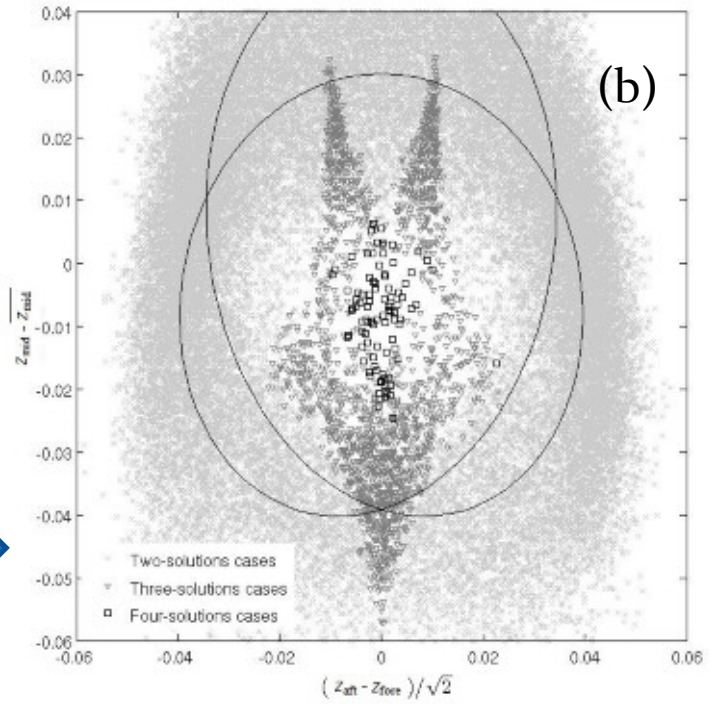


Fig.1 Intersection of the cone with plane $z_{fore} + z_{aft} = 2z_{ref}$ for (*a*) WVC number 1 and (*b*) WVC number 41, for a value of corresponding approximately to a speed of 8 m/s.

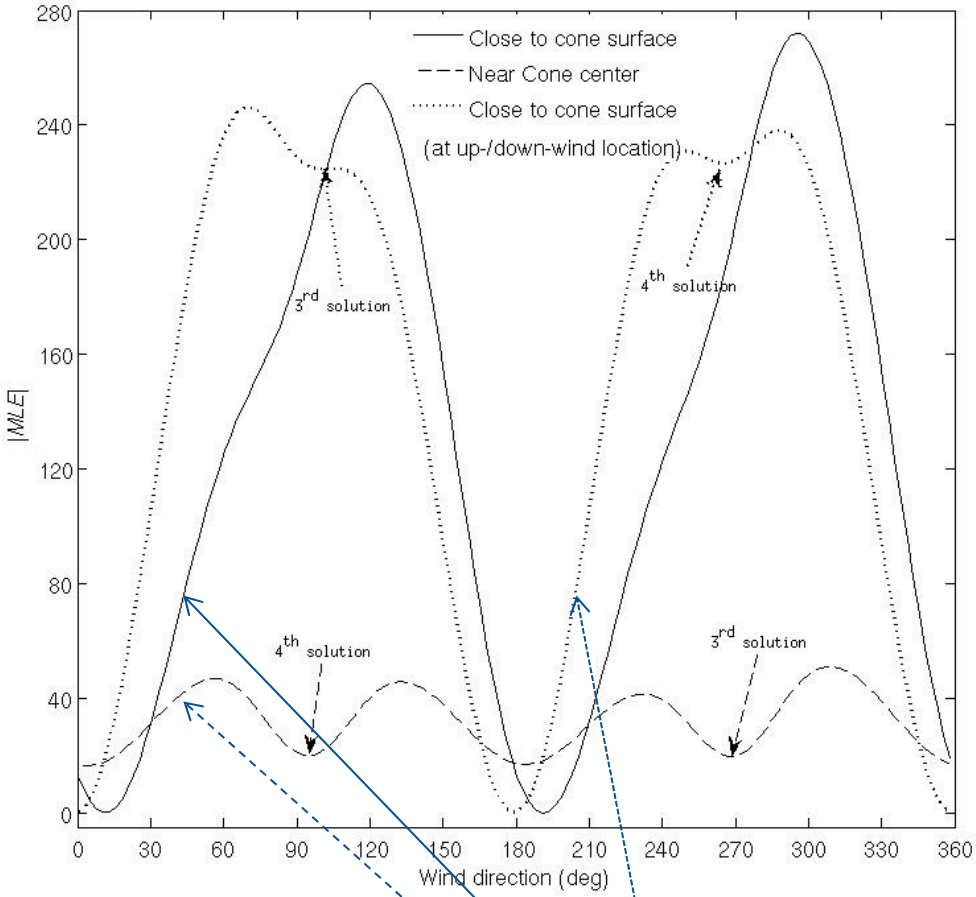
2. Wind inversion-Review

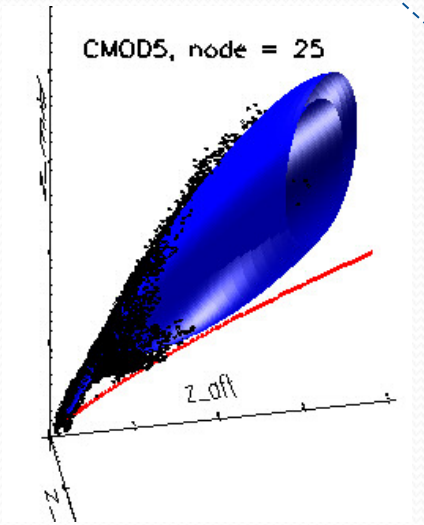
- Generally, ASCAT wind inversion includes the following **two typical situations:**

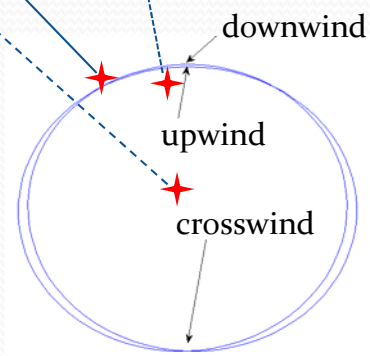
✓ When the triplets lie close to the cone surface, the inversion typically leads to two wind solutions.

✓ When triplets lie far away from the cone surface, the inversion leads to typically three or four solutions

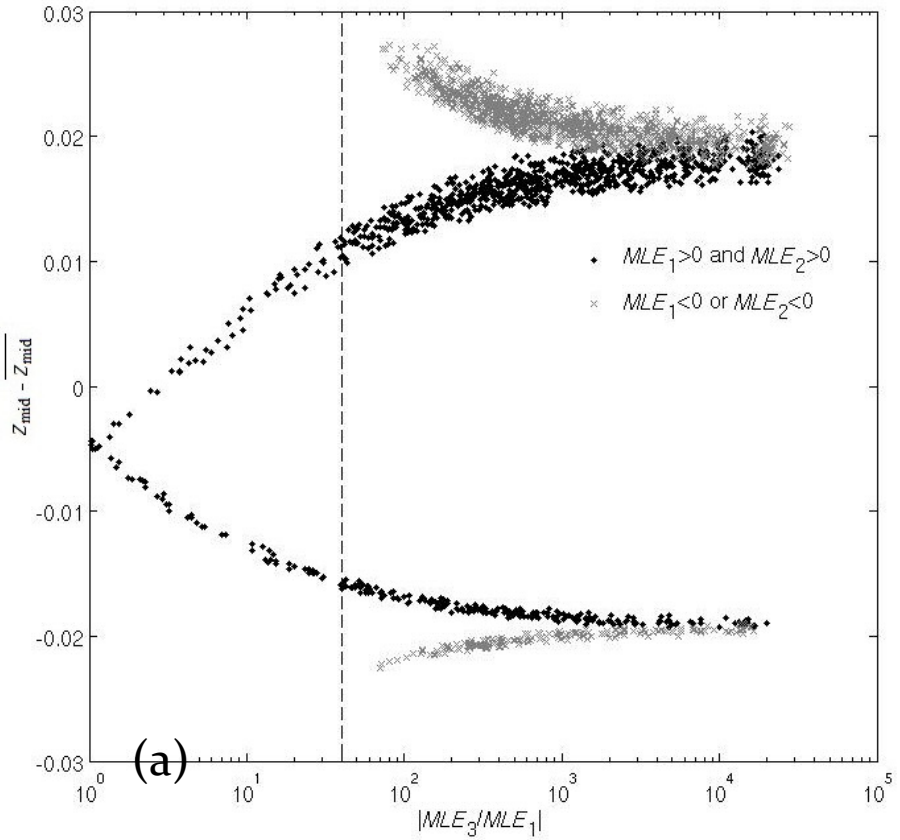
◆ **The third situation:** For a triplet close to the cone surface at an up-/down-wind location. There are two well-defined minima and two secondary minima.

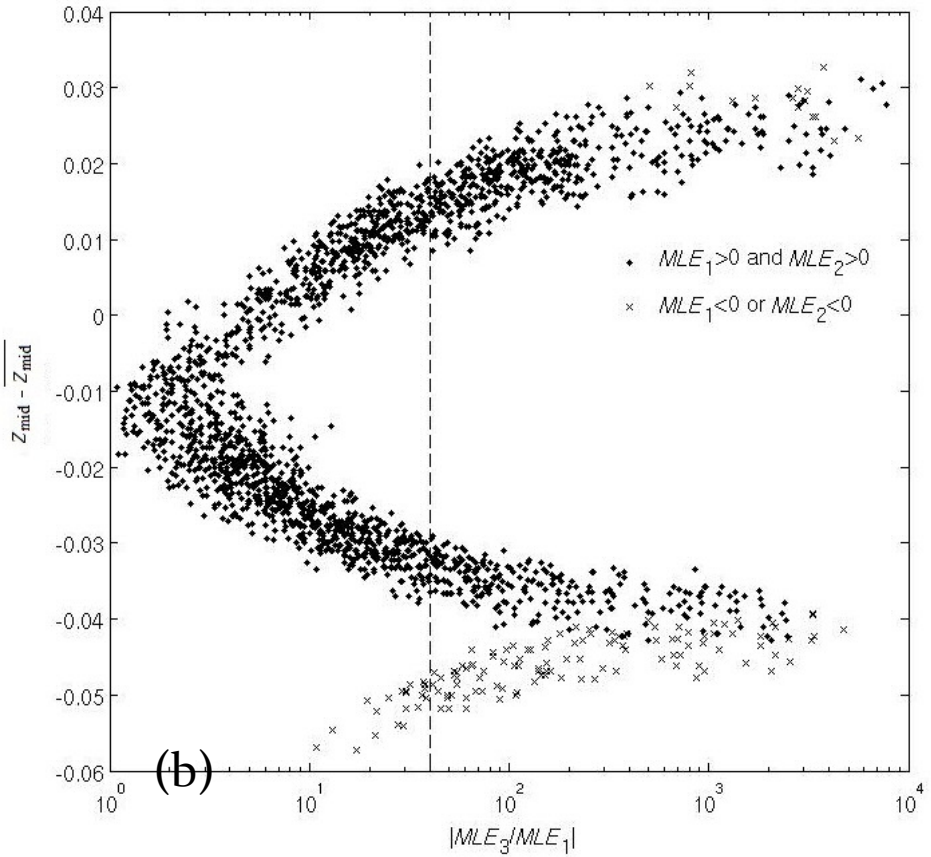


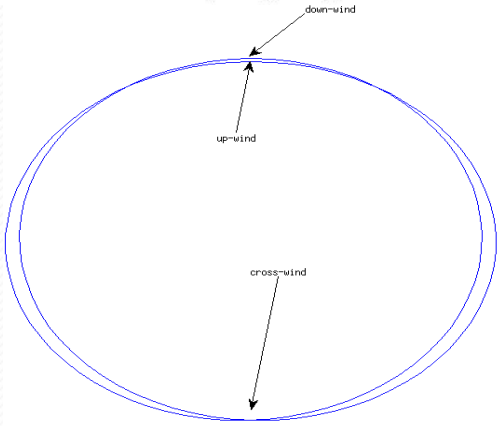


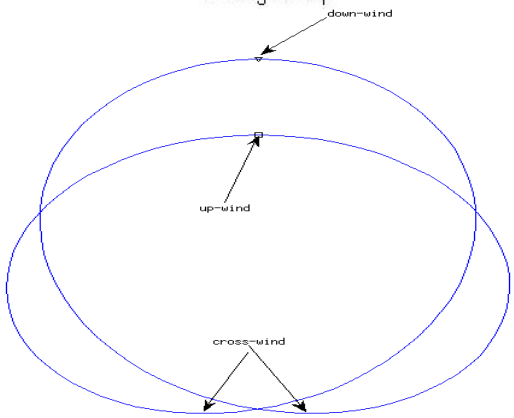


3. Criterion for rejecting high-rank solutions









3. Criterion for rejecting high-rank solutions

- In summary, the high-rank solutions are rejected for wind retrievals with first-ranked wind speed > 4 m/s for all WVCs, according to the below criterion,

$$MLE_1 < 0 \; or \; MLE_2 < 0 \; or \; \left| MLE_3 / MLE_1 \right| > T$$

The threshold T is determined by assuming that the rank-1 MLE distributions of 2-sols cases and spurious high-rank solution cases are expected to be similar.

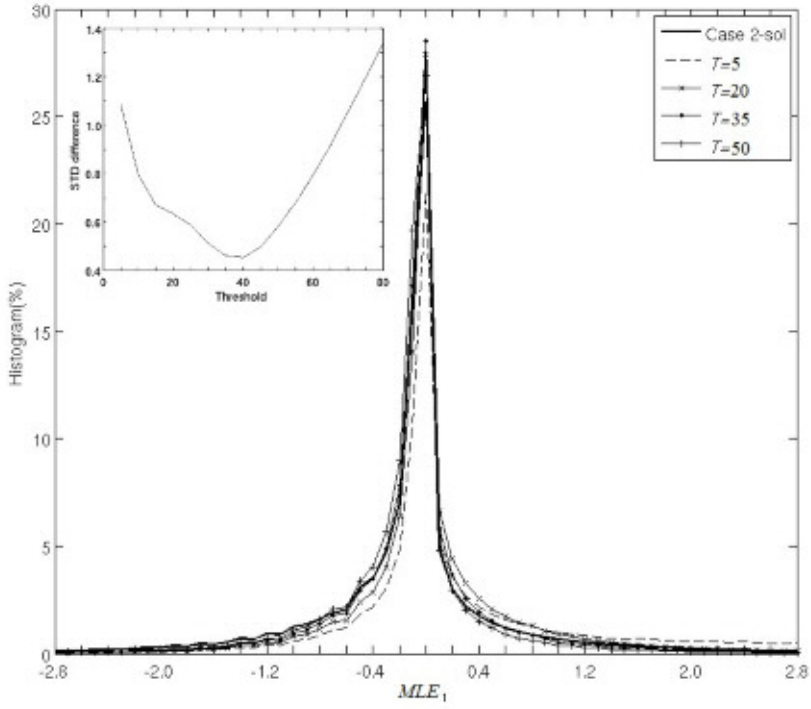


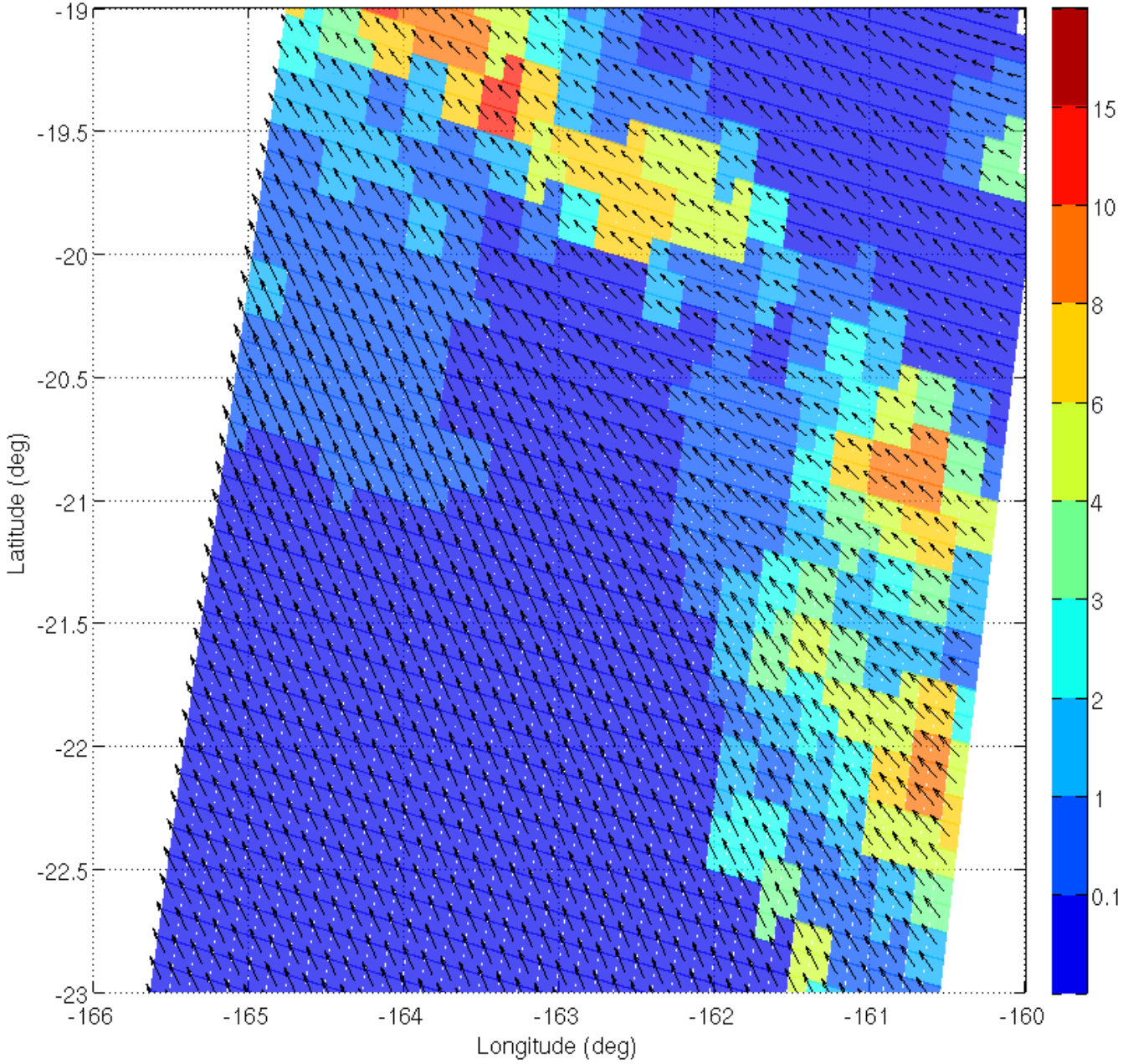
Fig.4 Probability Distribution Function of the first ranked MLE at WVC number 1, for two-solution (solid line) and rejected high-rank cases with different thresholds (see legend). The standard deviation between the PDF of the two-solution cases and that of the rejected high-rank cases is illustrated as a function of the threshold in the upper left corner of this figure.

4. Effectiveness analysis

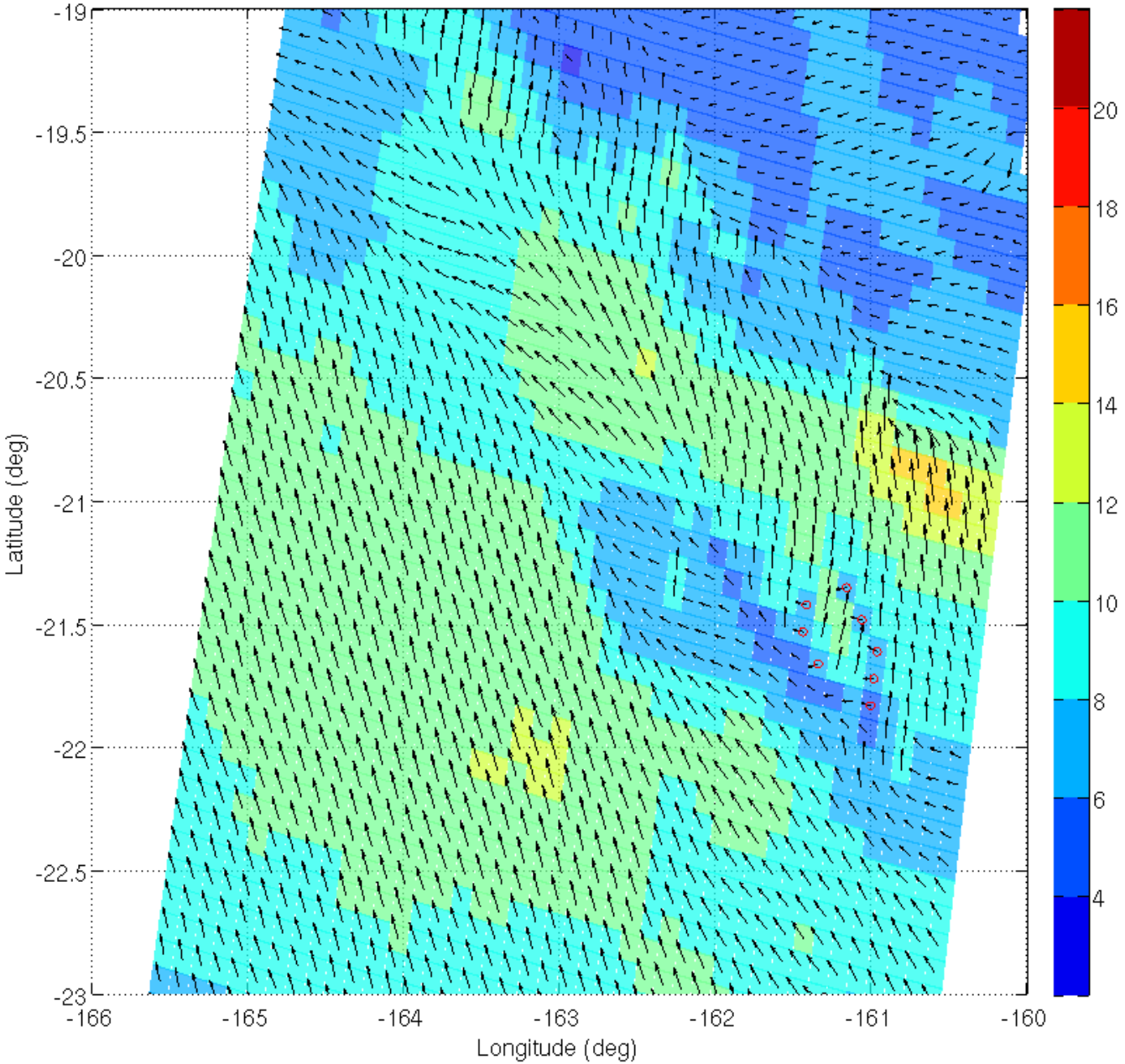
- To verify the impact of the high-rank solution rejection procedure on ASCAT wind retrievals, the number of geometry-related high-rank solutions that would be selected by the 2D-Var AR module if they were not rejected is examined. This number divided by the total number of cases with rejected high-rank solutions is denoted by R_s.

Table 1. The percentage of triplets with rejected high-rank solutions that selected by the AR module. WVC number 1 corresponds to highest incidence angle (outer-most WVC), and WVC number 41 corresponds to lowest incidence angle (inner-most WVC)

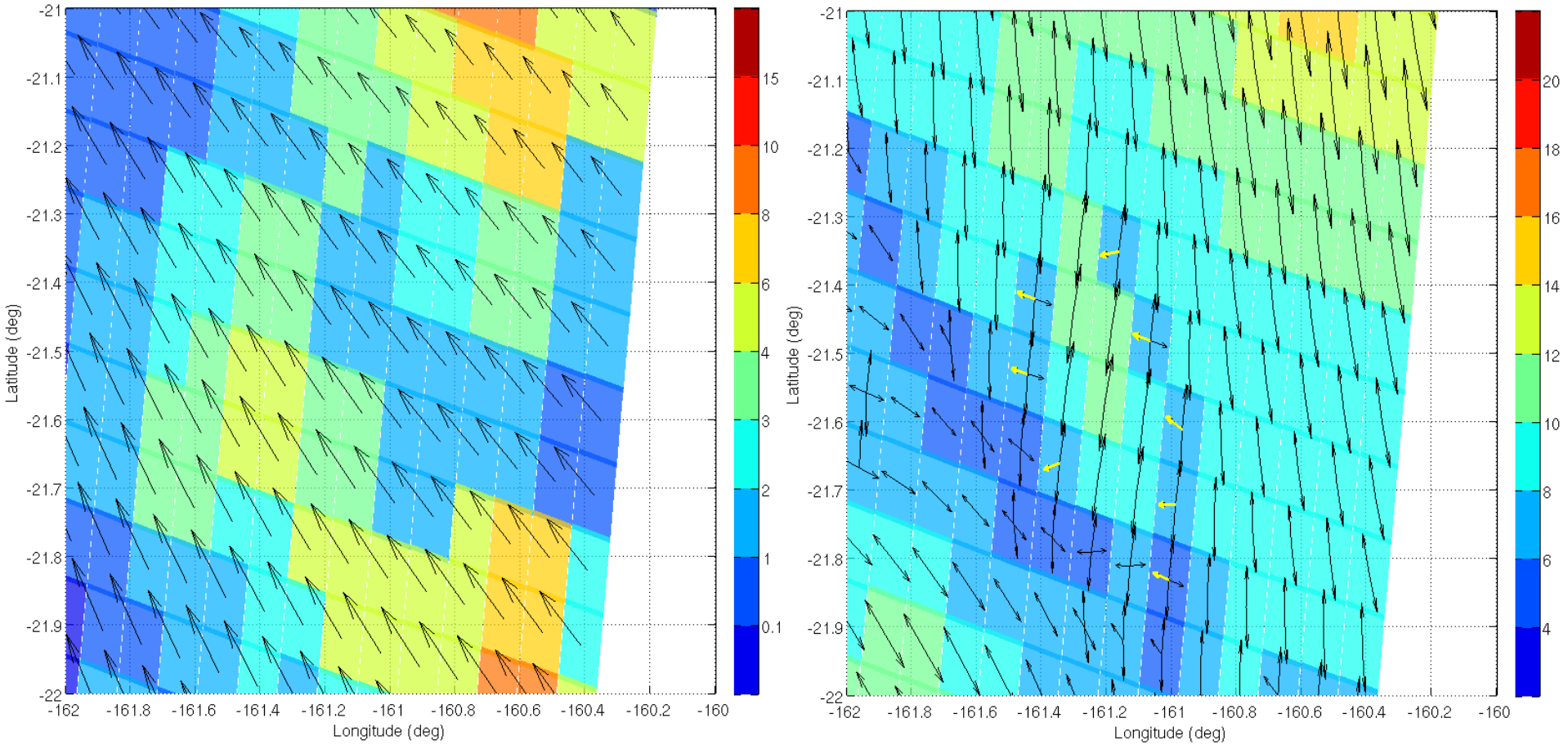
Wind speed (m/s)		4<v≤6	6<v≤10	v>10
WVC number 1	Rain free	0.3	0.07	0.07
	Rainy	5.3	3.6	3.9
WVC number 41	Rain free	2.2	0.5	0
	Rainy	11.2	6.9	3.2



TMI RR(color patches) collocated with ECMWF winds(arrows)



ASCAT wind field observed on September 24, 2008 UTC 20:32. The wind speeds are indicated by color **patches.The red circles indicate WVCs which high-rank solutions were selected by 2DVAR, but should be rejected according to the criterion in AMT paper.**



(Left-panel) ECMWF wind field collocated with TMI-RR(Color patches); (Right-panel) ASCAT ambiguities. Color patches indicate the wind speed for each WVC. Yellow arrows indicate the high-rank spurious solutions selected by 2D-VAR. **Note that this case was in the left swath of ASCAT observation.**

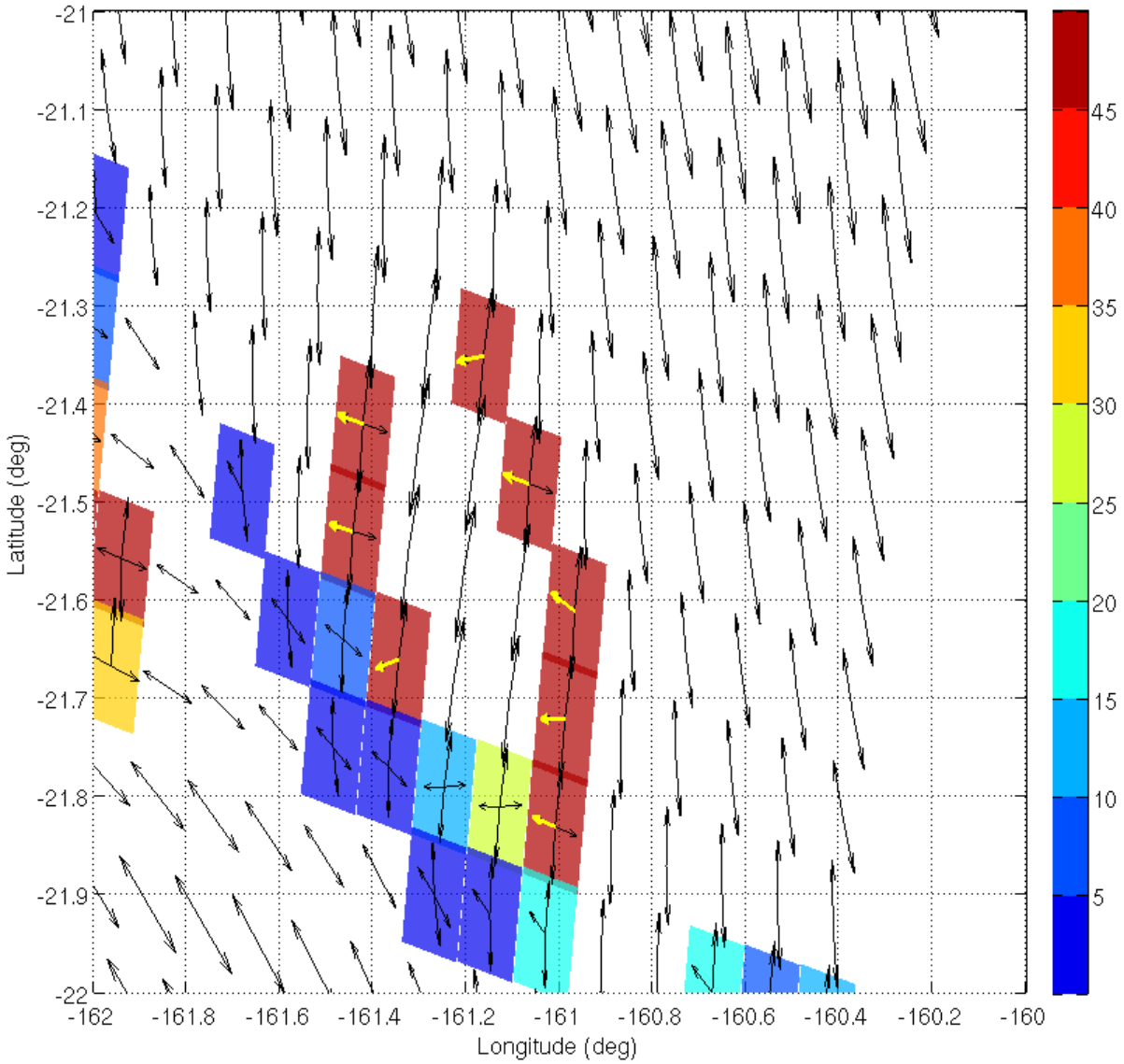


Illustration of ASCAT ambiguities and MLE ratio.

4. Effectiveness analysis

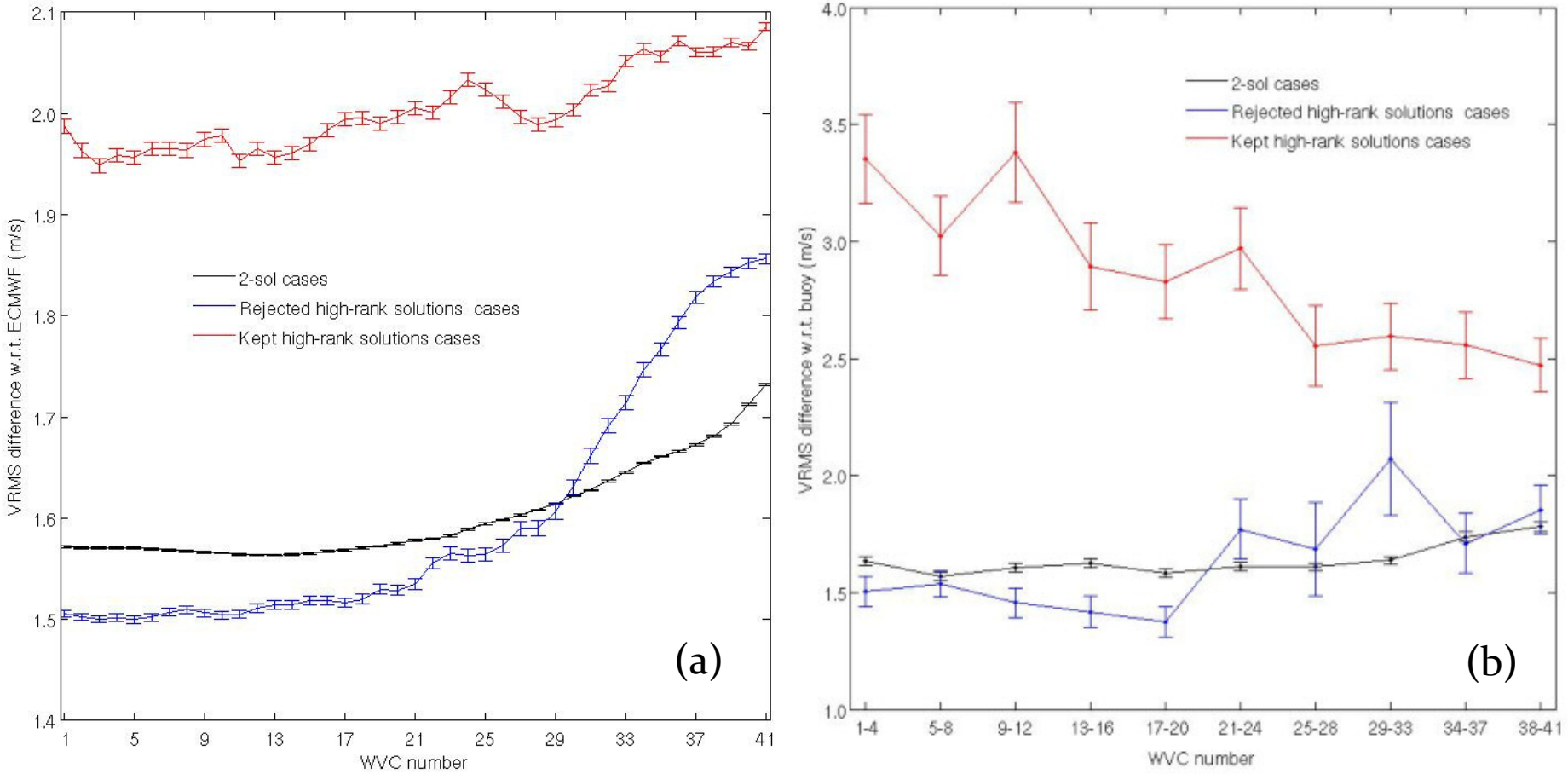


Fig 5. The mean VRMS difference w.r.t. (a) ECMWF winds and (b) buoy winds as a function of WVC number, WVCs on both left and right swaths are numbered from 1 (outermost WVC) to 41 (innermost WVC). Marker 'I' denotes the uncertainty bar of the estimated mean VRMS for each WVC bin.

5. Conclusions

- It is found that the quality (using both ECMWF and buoy winds as reference) of the less ambiguous (with rejected high-rank solutions) WVCs is similar to that of the dual-ambiguity cases;
- whereas the quality of fully ambiguous (with kept 3rd and 4th ranks) WVCs is much lower, as expected (since they correspond to poor quality cases).
- However, for inner swath WVCs, where the wind direction skill is somewhat lower, the rejection procedure is less effective, suggesting that no rejections should be performed for such WVCs below 6 m/s.
- Rejected high ranks are more likely to be selected by the AR module (denoted as R_s cases) over rainy areas than over dry areas, which suggests a more negative effect of such cases in rainy conditions when not rejected. However, a significant amount of R_s cases show high-rank solutions to be (slightly) closer to buoy data than low-rank solutions. This shows a potential ASCAT rain-contamination effect on ASCAT WVCs.

Reference:

- Lin, W., Portabella, M., Stoffelen, A., and Verhoef, A.: On the characteristics of ASCAT wind direction ambiguities, Atmos. Meas. Tech., 6, 1053-1060, doi:10.5194/amt-6-1053-2013, 2013.

Thank you for your attention!