On the characteristics of ASCAT wind direction ambiguities

Wenming Lin, Marcos Portabella
Institut de Ciències del Mar (ICM-CSIC), Barcelona, Spain
Ad Stoffelen, Anton Verhoef
Royal Netherlands Meteorological Institute (KNMI), De Bilt, The Netherlands
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 $z_{\text{true}} + z_{\text{off}} = 2z_{\text{ref}}$ 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

(a) \( MLE_1 > 0 \) and \( MLE_2 > 0 \)

(b) \( MLE_1 < 0 \) or \( MLE_2 < 0 \)
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,

\[ MLE_1 < 0 \text{ or } MLE_2 < 0 \text{ or } \left| \frac{MLE_3}{MLE_1} \right| > T \]

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>
<thead>
<tr>
<th>Wind speed (m/s)</th>
<th>$4&lt;v\leq6$</th>
<th>$6&lt;v\leq10$</th>
<th>$v&gt;10$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>WVC number 1</strong></td>
<td>Rain free</td>
<td>0.3</td>
<td>0.07</td>
</tr>
<tr>
<td></td>
<td>Rainy</td>
<td>5.3</td>
<td>3.6</td>
</tr>
<tr>
<td><strong>WVC number 41</strong></td>
<td>Rain free</td>
<td>2.2</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>Rainy</td>
<td>11.2</td>
<td>6.9</td>
</tr>
</tbody>
</table>

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).
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 Rs 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 Rs 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:

Thank you for your attention!