Assessment of the Ku-band scatterometer wind quality

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Outline

1. Introduction
   - RapidScat onboard International Space Station (Sept. 2014 - )
   - HY-2A Scatterometer (Aug. 2011 - ?)

2. Wind quality indicators
   - Inversion residual of Maximum Likelihood Estimator (MLE)
   - Spatially averaged MLE (MLE$_m$)
   - Singularity exponent (SE)

3. Wind quality classification

4. Validation (versus ASCAT, ECMWF, buoy ...)

5. Conclusions
1. Introduction – Measurement geometry

Inner beam: HH polarization
Outer beam: VV polarization

Fig. 1 Observation geometry of the current Pencil-beam scatterometers
1. Introduction – Process flow

\[ \sigma^m_0 = f(v, \phi, \theta, p, \lambda) \]

Fig. 2 Schematic illustration of PenWP wind process flow

Ref: [Portabella. 2002, Ph.D. Thesis]
1. Introduction – Problems

Fig. 3 (left) RSCAT wind field retrieved by PenWP setting, the acquisition time was on January 25\textsuperscript{th} 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.  

[\textit{Lin et al., submitted to J-STAR\textsc{s}}]
1. Introduction – Problems

Fig. 4 (left) RSCAT wind field retrieved by PenWP setting, the acquisition time was on April 27th 2015, at 20:36 UTC; (right) The collocated HSCAT wind field observed at 20:47 UTC.
1. Introduction – Problems

Fig. 5 The same as previous slide, but superimposed with MLE

- **Smooth wind field, but noisy MLE map; → challenge the MLE-based wind quality control;**
- **HSCAT seems to be noiser than RSCAT.**
2. Wind quality indicators

1. MLE

\[ MLE = \sum_i N \left( \frac{\sigma_{mi}^0 - \sigma_{si}^0}{(K_{pi} \cdot \sigma_{mi}^0)^2} \right) \]

*An metric of inter-beam (sub wind vector cell) variability*

2. Spatially averaged MLE

\[ MLE_m = \frac{\sum_i w_i MLE_i}{\sum_i w_i} \]

*An pseudo metric of inter-WVC variability*

3. Singularity exponent (SE)

\[ h(x) = \frac{\log \left[ \frac{T_{\psi} \|\nabla s\| (x, r)}{\sum_{r} \left[ T_{\psi} \|\nabla s\| (\cdot, r) \right]} \right]}{\log r_0} + o \left( \frac{1}{\log r_0} \right) \]

*An metric of inter-WVC variability*

Ref:

[Pierson 1989, JGR]
[Stoffelen and Anderson 1997, JAOT]
[Lin et al. 2014, GRSL]
[Lin et al. 2015, 2016, TGRS]
[Lin. 2016, submitted to J-STARS]
Fig. 6 Typhoon Vongfong observed by HSCAT on Oct. 11 2014, UTC 09:30
Fig. 7 The percentage of rain-contaminated data (GMI RR > 1 mm/h) as a function RSCAT wind speed (Y-axis) and the sorted percentiles (X-axis) by MLE (Left) and MLE_m(Right).

The white dashed curve indicates the rejection ratio of the operational MLE-based QC.
Fig. 7 The percentage of rain-contaminated data (GMI RR > 1 mm/h) as a function RSCAT wind speed (Y-axis) and the sorted percentiles (X-axis) by MLE (Left) and MLE_m (Right)

The white dashed curve indicates the rejection ratio of the operational MLE-based QC.
Fig. 7 The percentage of rain-contaminated data (GMI RR > 1 mm/h) as a function of the sorted percentiles (X-axis) by the mentioned three indicators [outer swath]
Fig. 8 Vector Root-Mean-Square difference between RSCAT and ASCAT as a function of the sorted percentiles by MLE, MLEm, and SE in the inner (left) and outer (right) swath.
4. Validations -- Wind spectra (RSCAT)
4. Validations -- Wind spectra (HSCAT)
## Triple collocation analysis

### Triple collocation Error Standard Deviations w.r.t. the scale resolved by ECMWF

<table>
<thead>
<tr>
<th>DataSet</th>
<th>SD errors of Buoy</th>
<th>ECMWF [m/s]</th>
<th>Scatterometer</th>
<th>$r^2$ [m$^2$/s$^2$]</th>
<th>N</th>
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<td>$v$</td>
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<td>HSCAT 25 km</td>
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<td>1.02</td>
<td>1.11</td>
<td>0.88</td>
</tr>
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</table>

Ref:

[Stoffelen 1998, JGR]
[Vogelzang et al. 2011, JGR]
[Lin et al., 2015, JGR-Oceans]
Triple collocation Error Standard Deviations w.r.t. the scale resolved by SCAT

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<td>1.10</td>
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5. Conclusions

1. $\text{MLE}_m$ 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)

2. 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 $\text{MLE}_m$ are ineffective.

3. It is proposed to improve PenWP QC using $\text{MLE}_m$ over the inner swath, and SE over the outer swath.

4. The Ku-band winds derived from PenWP or SDP seem to resolve a spatial scale closer to ECMWF than the C-band ASCAT. The HSCAT, as a noiser system, resolves a scale larger than RSCAT or SeaWinds.

5. Since RSCAT observations are limited within +/- 55 degs, RSCAT error SDs are smaller than HSCAT and SeaWinds.
Thank you for your attention!