Intercomparison of C- and Ku-band scatterometer winds

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Outline

• Physical causes of Ku- and C-band wind difference
• ‘Technical’ causes
• ASCAT vs QuikSCAT
• ERS-2 vs QuikSCAT
SST-dependence of wind retrieval

Energy balance of short wind waves

\[ \beta B(k) - B(k)[B(k)/\alpha]^n = 0 \]
\[ \beta = \beta_w - \beta_v \]
\[ \beta_w = 1.5 \frac{\rho_a}{\rho_w} \frac{u_*(W_\pi/k - c)}{c^2} |\cos(\varphi)| \cos(\varphi) \]
\[ \beta_v = \frac{4\nu k^2}{\omega} \]

Because both, wind growth rate, \( \beta_w \), and viscous dissipation, \( \beta_v \), depend on SST, the radar signal is directly impacted by SST.

\( \beta_w \) weakly depends on radar frequency

\( \beta_v \) increases with frequency
Current GMFs don’t account for SST. We assume that radar calibration, \(d\sigma^o/dW\), refers to \(T_0=19^\circ C\) (global mean SST). The temperature-related wind retrieval error becomes

\[
\frac{dW}{\rho dW} \quad \text{--- Wind error due to change in air-density} \ (\rho_a)
\]

\[
\frac{dW}{n \rho dW} \quad \text{--- Wind error due to change in water viscosity} \ (\nu)
\]

(via viscous dissipation)
SST-dependence of wind retrieval

For SST = 0°C, upwind:

- $dW_{Ku}^\rho$
- $dW_{C}^\rho$
- $dW_{Ku}^\nu$
- $dW_{C}^\nu$

Wind speed (m/s) vs. $dW$ (m/s)
SST-dependent W difference between Ku- and C-band, evaluated using a Radar Imaging Model, is stronger over cold SSS < 5°C and at moderate winds 5 m/s < W < 10 m/s.
SST-dependence of wind retrieval evaluated from the Radar Imaging Model (RIM, Kudryavtsev et al., 2005)
Collocated ASCAT and QuikSCAT

Equator crossing time ascending mode: QuikSCAT - 6:30am, ASCAT – 9.30am

<50km <4hr
Collocated ASCAT and QuikSCAT

(Left) Only rain flag is applied to QuikSCAT, and (right) rain flag and multidimensional rain probability (MPR < 0.05) are both applied.

Collocated data for 20NOV2008 - 19NOV2009. ASCAT data are based on CMOD5.n since November 20, 2008.
Collocated ASCAT and QuikSCAT wind speed difference (m/s) binned 1 m/s in wind speed and 10° in wind direction relative to the ASCAT mid-beam azimuth $\text{DIR}_{AS} - \text{AZIM}_1$.

(a) Binned data, in the latitude band 55°S 55°N, thus excluding high latitude areas of negative dW.

(b) Data fit by symmetric azimuth harmonics.
Collocated ASCAT and QuikSCAT

QS minus AS wind speed difference, rain flag and MRP<0.5

QS minus AS wind speed difference, both rain selections + GMF correction
Collocated ASCAT and QuikSCAT

$W_{QS} - W_{AS} - dW \text{ (m/s)}$

SST, degC
Collocated ERS-2 and QuikSCAT

ECT: QS - 6:30am; ERS-2 – 10:30am.

Collocation criteria: <50km, <5hr


ERS-2 data are based on CMODIFR2 GMF. CMODIFR2 has been derived by fitting ERS-1 data to in-situ NDBC buoys and used without any adjustments for ERS-2.
Collocated ERS-2 and QuikSCAT

Partial reprocessing of ERS-2 using CMOD5.n and assuming wind direction unchanged. Resulting winds (ERS/N) are available for collocated data only.

Applying GMF-related correction to ERS/N
Collocated ERS-2 and QuikSCAT

Wind speed difference is not symmetric in azimuth (versus ERS-2 mid beam) suggesting biases in ERS-2 fore- and aft-beam calibration.
Collocated ERS-2 and QuikSCAT

\[(W_{QS} - \Delta W_2) - (W_{ERS/N} + \Delta W_1)\]

QuikSCAT minus ERS/N after applying SST-related correction to QuikSCAT
Conclusions

1. Ku-band wind speed \((W)\) is higher (by 0.5 m/s) than C-band in major precipitation zones (ITCZ, storm tracks).

2. Ku-band \(W\) is lower than C-band (by 0.5 m/s) at high latitudes \((\text{SST}<5^\circ\)C\) and moderate winds 5-15 m/s.

3. Outside the two regions above, the difference between collocated Ku- and C-band winds is parameterized as a function of \(W\) and wind direction relative to the mid-beam azimuth (GMF-related correction for C-band, then applied globally).

4. Agreement between ERS-2 and QuikSCAT winds is greatly improved after applying CMOD5.n \((\text{in comparison with CMODIFR2})\). ERS-2 needs complete reprocessing. There are indirect indications of inconsistency in ERS-2 beams calibration.