Use of the azimuth wavelength cut-off to retrieve the sea surface wind speed from Sentinel 1 and COSMO-SkyMed SAR data

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Question:

• Can we say more on that?
Outline

• State of the art
• Methodology
• Results
• Conclusions and future work
State of the art

• Kerbaol et al. 1998:
  – High correlation between wind speed \( U \) and azimuth cut-off \( \lambda_c \)
  – Pay attention to the sea age
  – Pay attention to Directionality aspects

Estimation of the azimuth cut-off

\[ \lambda_C = 484.72 \text{ m} \]
\[ U = 4.23 \text{ ms}^{-1} \]
\[ H_s = 5.89 \text{ m} \]
\[ \phi = 6.86^\circ \]
• $\lambda_c$ is proportional to the variance of the azimuthal shift displacement $\text{Var}(d)$

\[
\lambda_c = \pi \sqrt{\text{Var}(d)}
\]

\[
\text{Var}(d) = \left(\frac{R(\theta)}{V}\right)^2 \int_0^\infty \omega^2 S(\omega) \left[ \sin^2(\theta) \cos^2(\phi) + \cos^2(\theta) \right] d\omega \approx
\]

\[
\left(\frac{R(\theta)}{V}\right)^2 \int_0^\infty \omega^2 S(\omega) \left[ \frac{\sin^2(\theta)}{2} + \Delta(k) \frac{\sin^2(\theta)}{4} \cos^2(2\phi_0) \right] d\omega \approx
\]

\[
\left(\frac{R(\theta)}{V}\right)^2 F(\theta, \phi_0) \int_0^\infty \omega^2 S(\omega) d\omega
\]
• In this study, a normalized value of $\lambda_C$ is used
• It takes into account the dependence on $\theta$ and on $\phi_0$

$$\lambda^*_c(\theta = 20^\circ, \phi_0 = 0^\circ) = \frac{R(\theta = 20^\circ) \sqrt{F(\theta = 20^\circ, \phi_0 = 0^\circ)} \lambda_c}{R(\theta) \sqrt{F(\theta, \phi)}}$$
Training dataset (S-1)

• Model \( \lambda_c = a + bU \)

• 355 Sentinel-1 multi look images
  – Incidence angles: 20°-45°
  – Area: East Atlantic and Hawaii
  – Period: November 2014-Aprile 2015

• \( U, H_s \) and MWD from ECMWF operational output

• 53555 samples (1065 FD)
SWH histogram
Validation dataset (S-1)

- 99 Sentinel-1 multi look images
  - Incidence angles: 20°-45°
  - Area: East Atlantic and Hawaii
  - Period: November 2014-Aprile 2015
- $U$ from scatterometer HSCAT
- $H_s$ and MWD from ECMWF operational output
- Only fully developed sea state
- 187 samples
$E[\hat{U} - U] = -0.14 \text{ ms}^{-1}$

$RMSD = 2.10 \text{ ms}^{-1}$

$H_s = 1.0 \text{ m}$

$H_s = 3.29 \text{ m}$

$H_s = 8.41 \text{ m}$
Dataset (CSK)

• 80 Cosmo-SkyMed multi look images
  – Incidence angles: 20°-45°
  – Area: Equatorial Atlantic Ocean
  – Period: July-December 2009
• $U$ from QuickScat
• $H_s$ and MWD from ECMWF operational output
• 128 samples (40 FD)
SWH histogram

Number of samples

\[ \frac{U (\text{ms}^{-1})}{U (\text{ms}^{-1})} \]

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IOVWST (Sapporo)
$r = 0.74$

$H_s = 1.2 \text{ m}$

$H_s = 2.04 \text{ m}$

$H_s = 3.77 \text{ m}$

$r = 0.91$
Preliminary conclusions

- Application of the $\lambda_C$ approach to retrieve $U$
- Linear dependency of $\lambda_C$ on $U$ in FD sea
- Agreement with HSCAT $U$
- Better agreement for high $U$
Future work

• Direction of all wave components.
• Extend the validation dataset
• Retrieval exercise with other SARs: CSK
• Optimal estimation with other GMFs