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

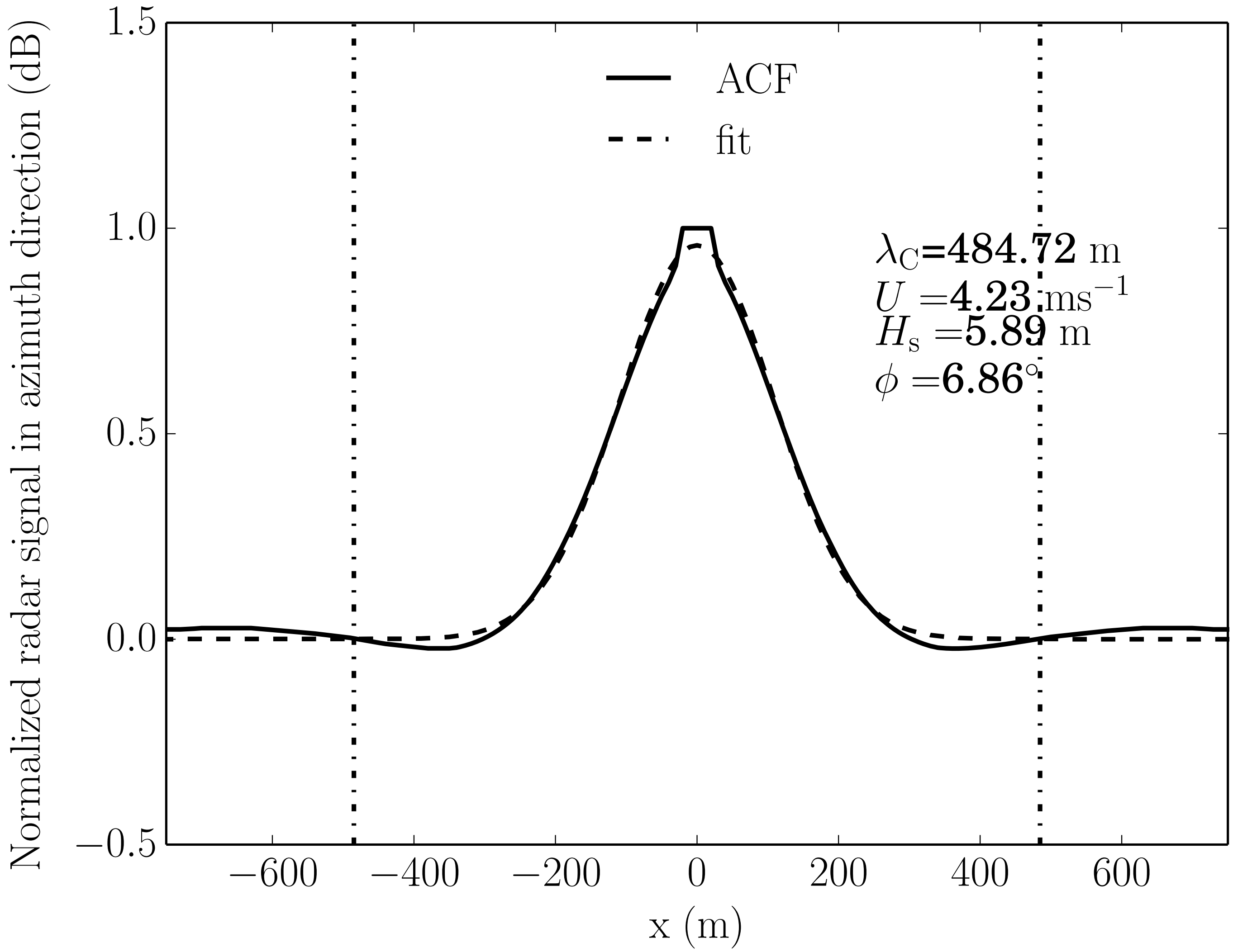
- State of the art
- Methodology
- Results
- Conclusions and future work

State of the art

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

- Kerbaol V., Chapron B., Vachon P. W., 1998, “Analysis of ERS-1/2 synthetic aperture radar wave mode imagettes”, Journal of Geophysical Reserarch, Vol. 103, No. C4, pg 7833-7846
- Krogstad H. E., Samset O. , Vachon P. W., 1994, “Generalizations of the non-linear ocea-SAR transfrom and a simplified SAR inversion algorithm”, Atmosphere-Ocean

Estimation of the azimuth cut-off



- λ_C is proportional to the variance of the azimuthal shift displacement Var(d)

$$\lambda_C = \pi\sqrt{Var(d)}$$

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

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

$$\left(\frac{R(\theta)}{V}\right)^2 F(\theta,\phi_0)\int_0^\infty \omega^2 S(\omega)d\omega$$

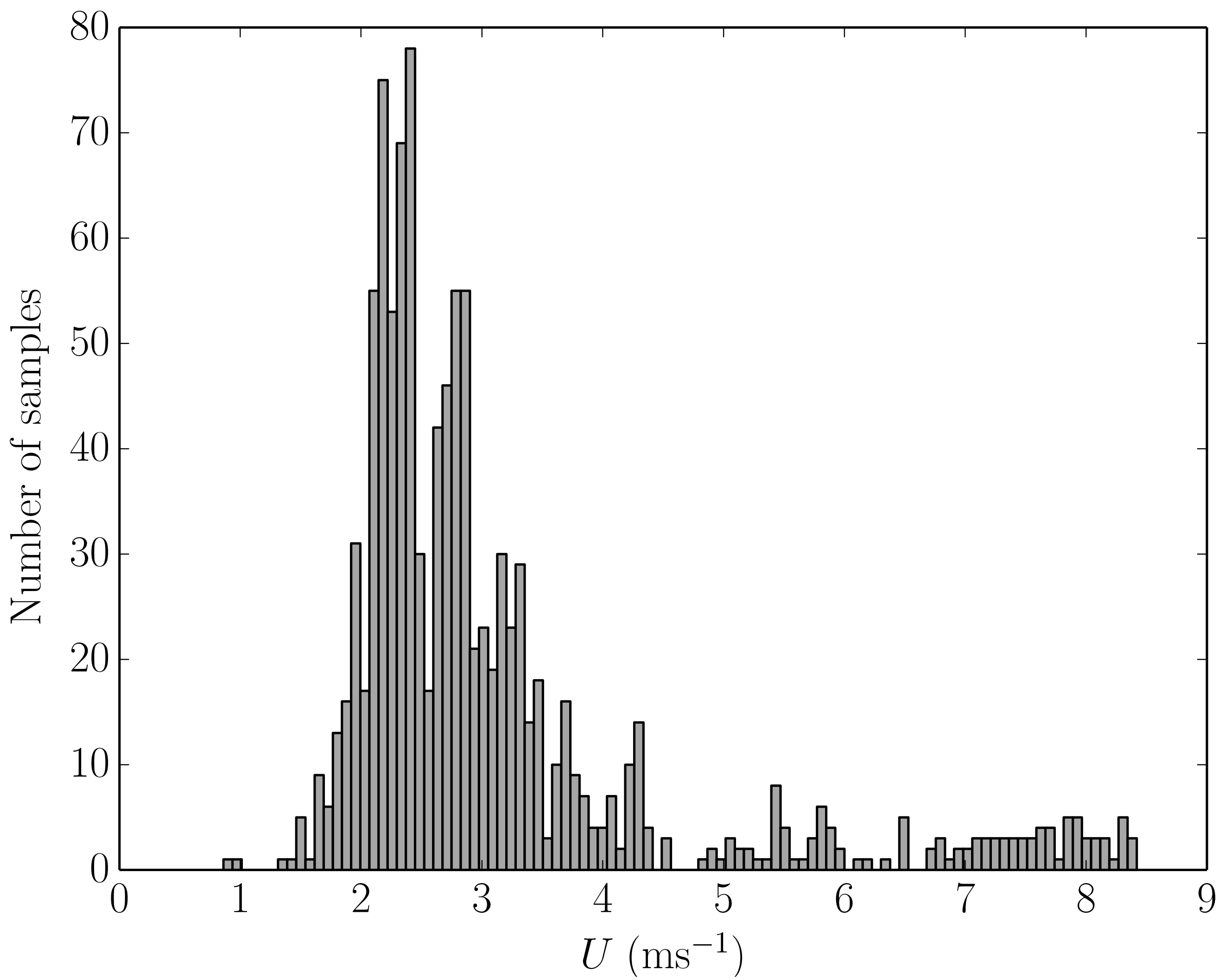
- In this study, a normalized value of λ_C is used
- It takes into account the dependence on θ and on ϕ_0

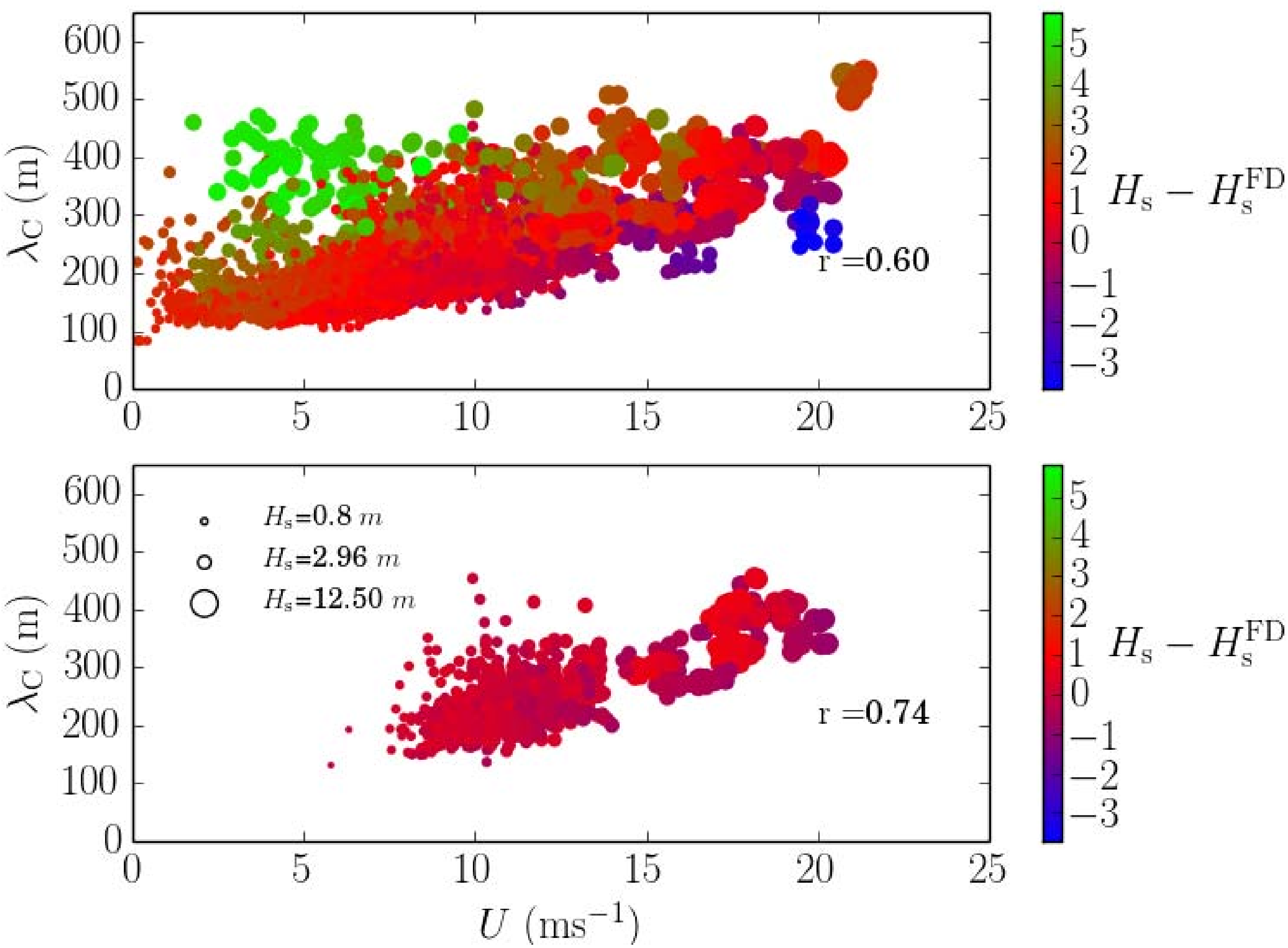
$$\lambda_C^*\left(\theta=20°,\phi_0=0°\right)=\frac{R\left(\theta=20°\right)\sqrt{F\left(\theta=20°,\phi_0=0°\right)}\lambda_C}{R\left(\theta\right)\sqrt{F\left(\theta,\phi\right)}}$$

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
- 5355 samples (1065 FD)

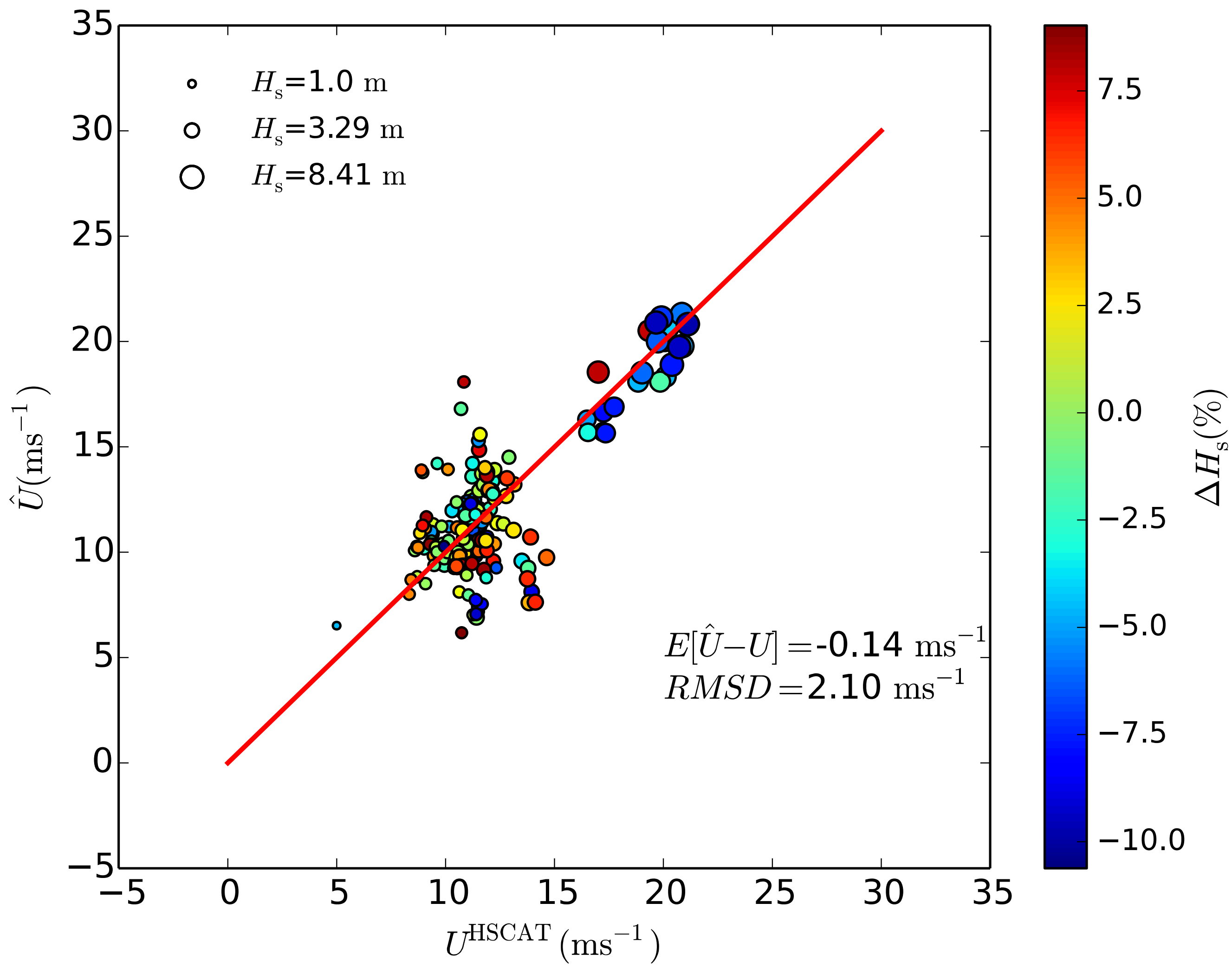
SWH histogram




600
500
400
300
200
100
0
λ_C (m)
0
5
10
15
20
25
r =0.60
5
4
3
2
1
0
−1
−2
−3
$H_s - H_s^{FD}$
H_s=0.8 m
H_s=2.96 m
H_s=12.50 m
r =0.74
U (ms^{-1})

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

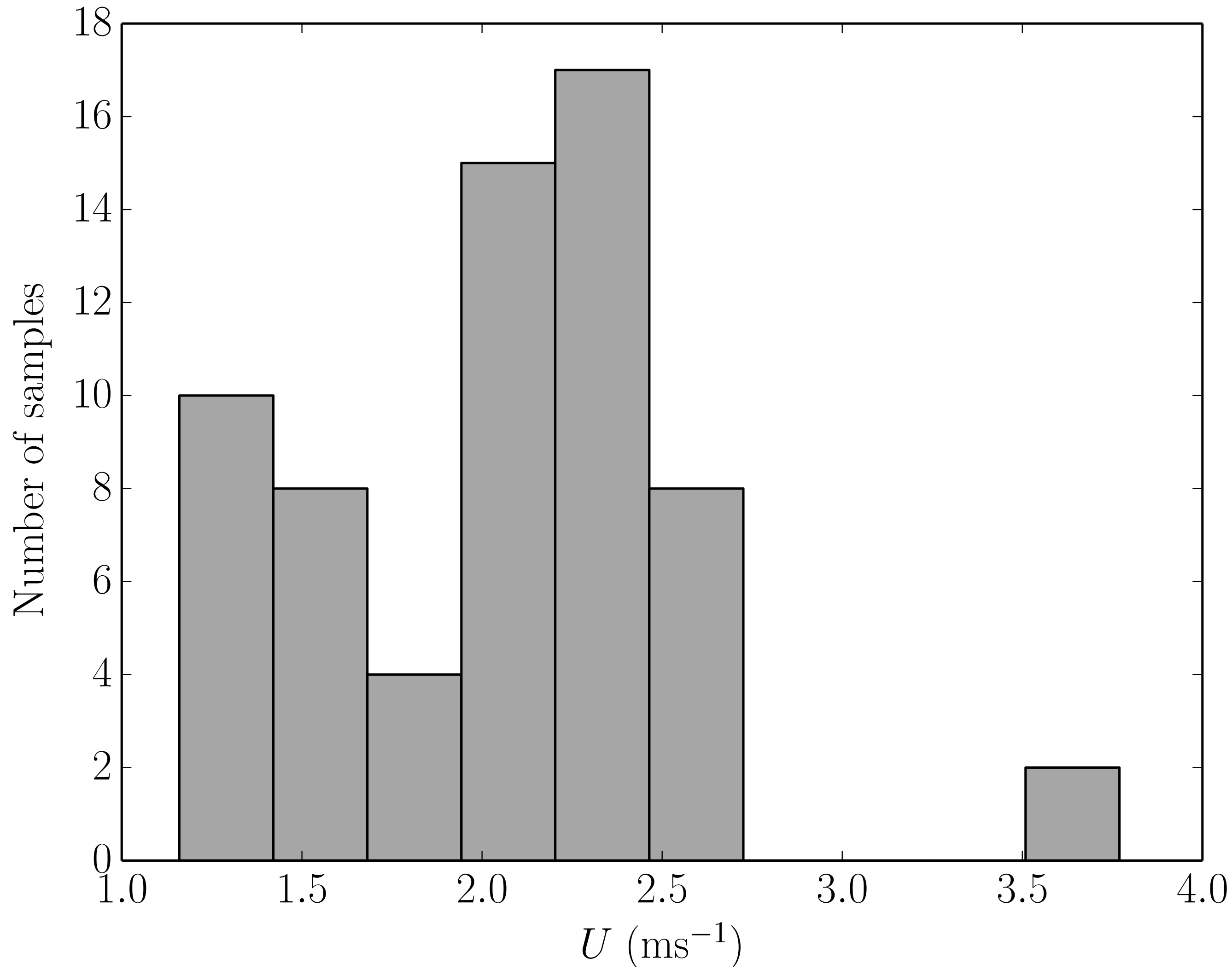


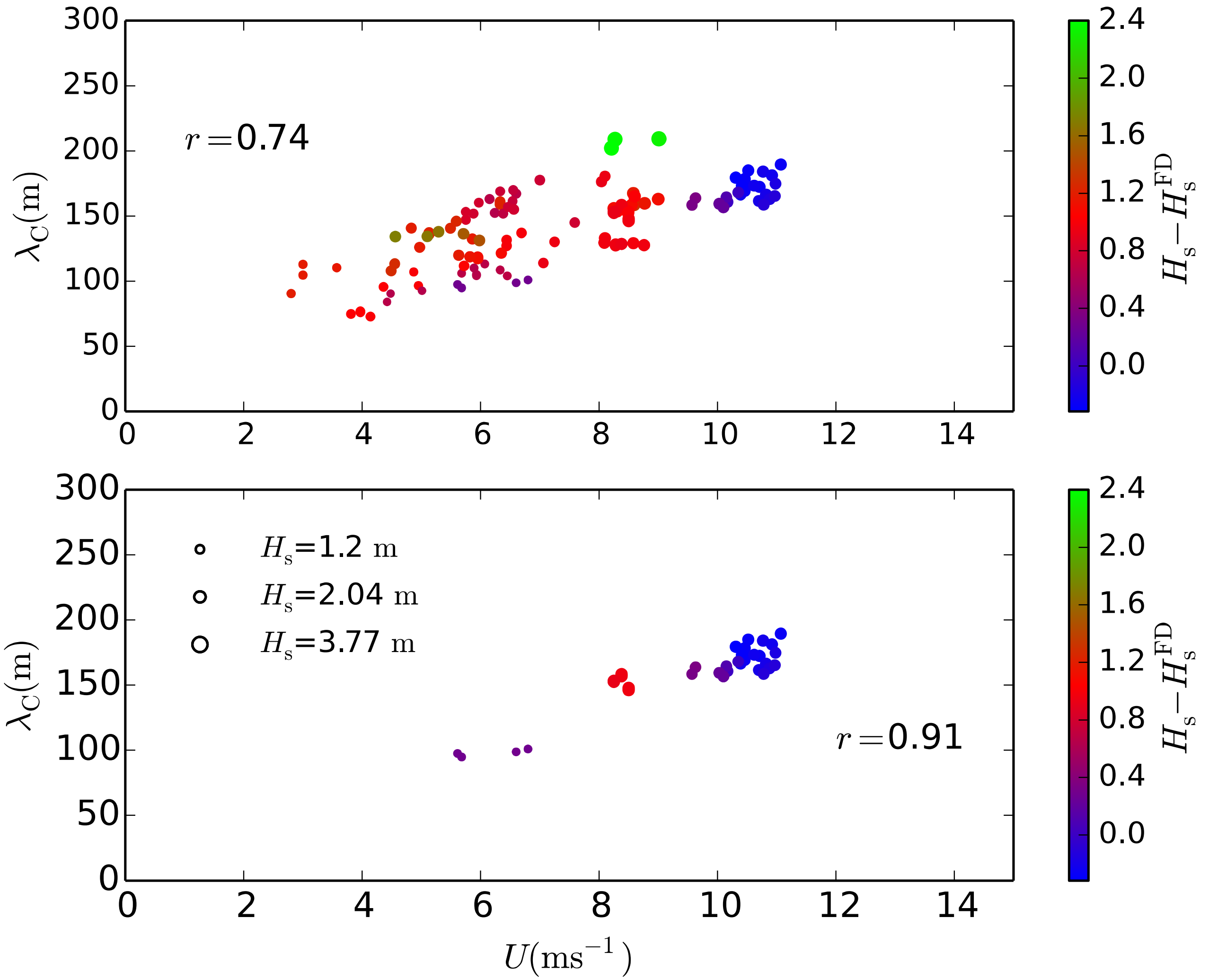
H_s=1.0 m
H_s=3.29 m
H_s=8.41 m
$E[\hat{U}-U]=$-0.14 ms^{-1}
$RMSD=$2.10 ms^{-1}
$\hat{U}(\mathrm{ms}^{-1})$
$U^{\mathrm{HSCAT}}\,(\mathrm{ms}^{-1})$
$\Delta H_s(\%)$

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





$r = 0.74$
300
250
200
150
100
50
0
$\lambda_C(\mathrm{m})$
0
2
4
6
8
10
12
14
2.4
2.0
1.6
1.2
0.8
0.4
0.0
$H_s - H_s^{FD}$
H_s=1.2 m
H_s=2.04 m
H_s=3.77 m
$r = 0.91$
$U(\mathrm{ms}^{-1})$

Preliminary conclusions

- Application of the λ_C approach to retrieve *U*
- Linear dependency of λ_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