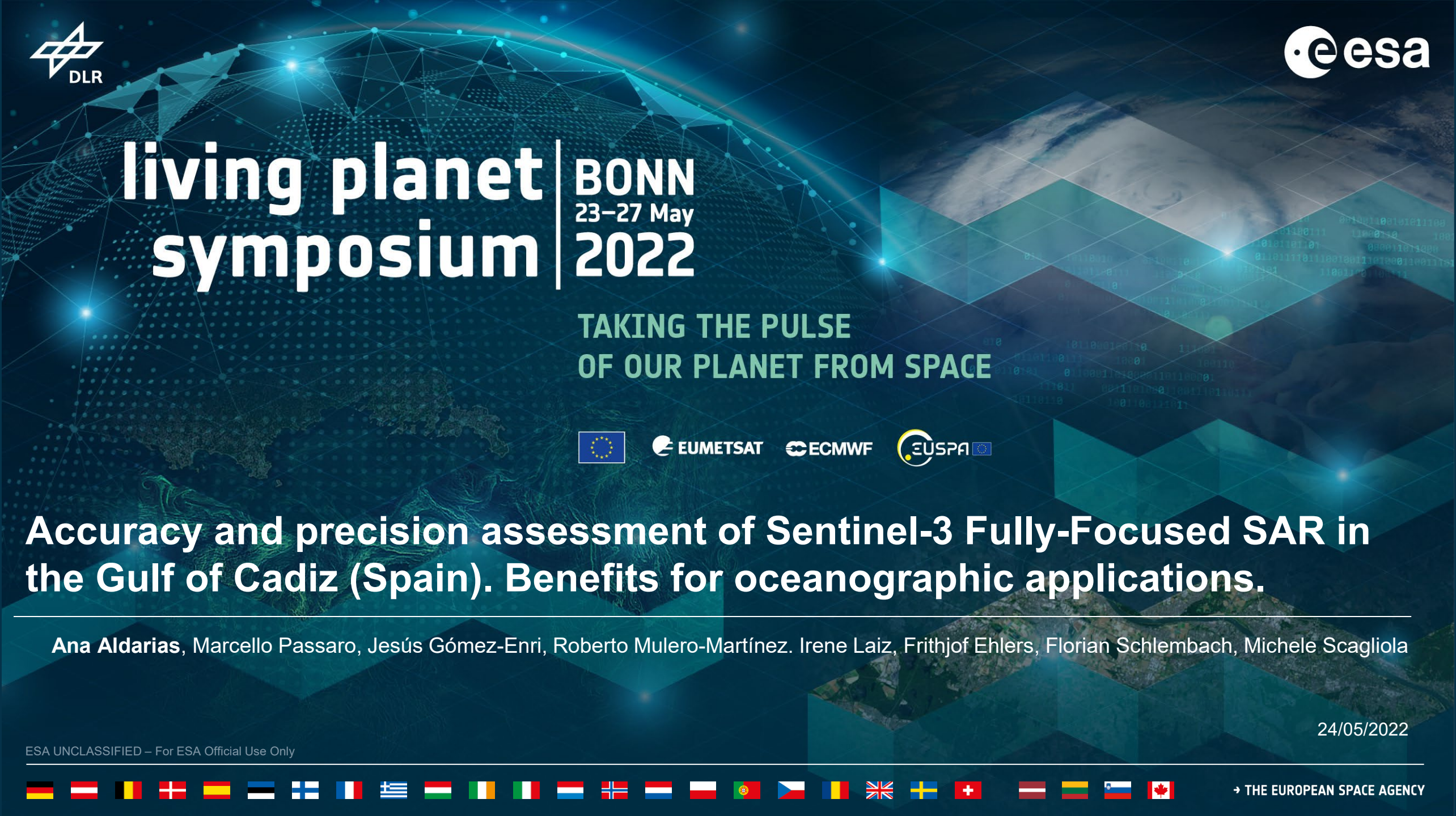

Accuracy and precision assessment of Sentinel-3 Fully-Focused SAR in the Gulf of Cadiz (Spain). Benefits for oceanographic applications.

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24/05/2022

Outline

- Introduction
- Aims
- Data and Methodology
- Results
- Discussion
- Conclusions

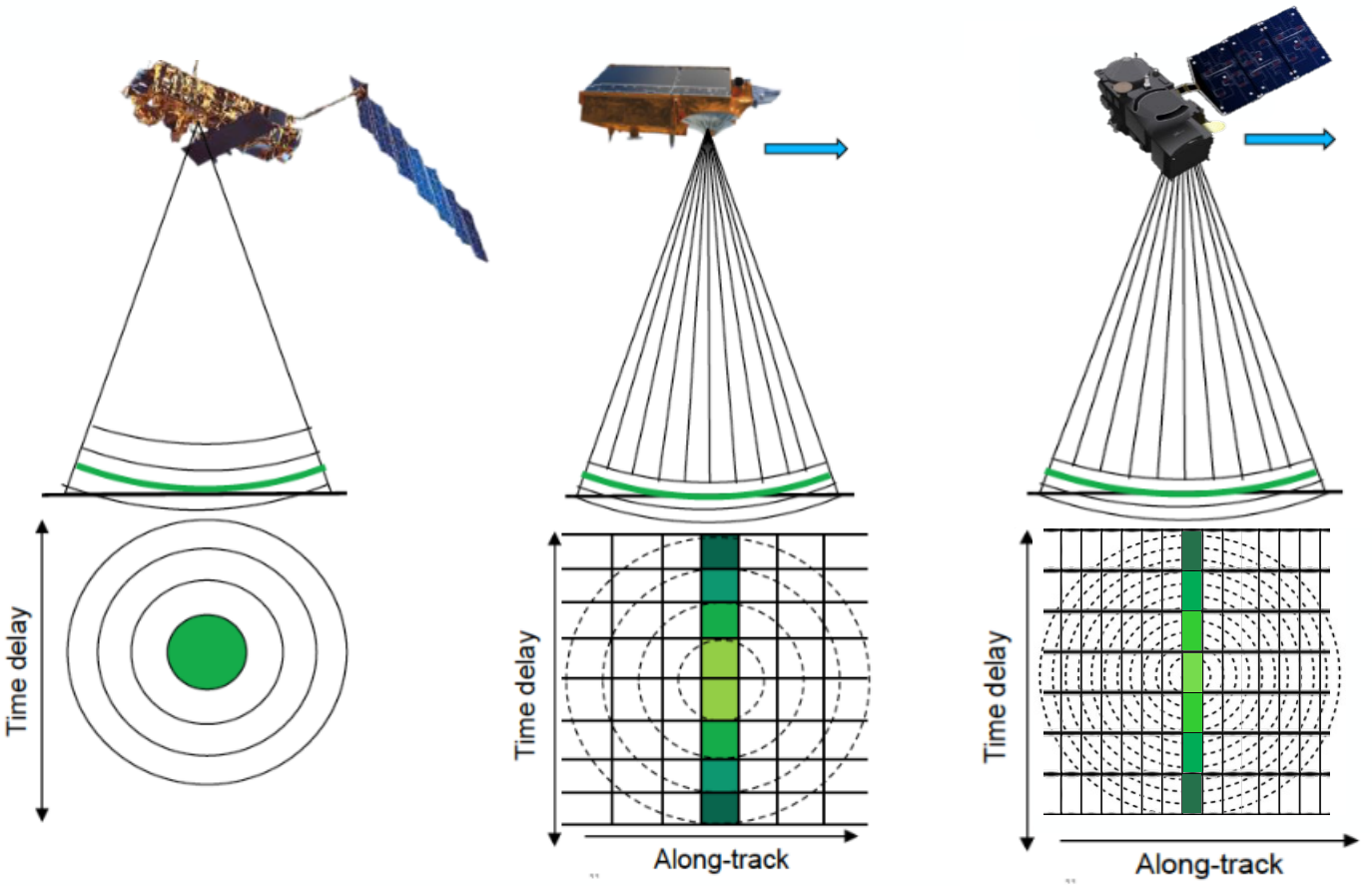
The beauty of collaboration...

Introduction

Conventional altimetry
Low resolution mode
Pulse-limited footprints

SAR altimetry (Delay/Doppler)
High Pulse Repetition Frequency
Beam-limited footprint along-track and pulse-limited across-track
High resolution along-track (~ 300 m)

Fully Focused SAR (FF)
High resolution along-track (~ 0.5 m)
FF SAR along-track and pulse-limited across-track



(Source: modificated from ESA)

Aims

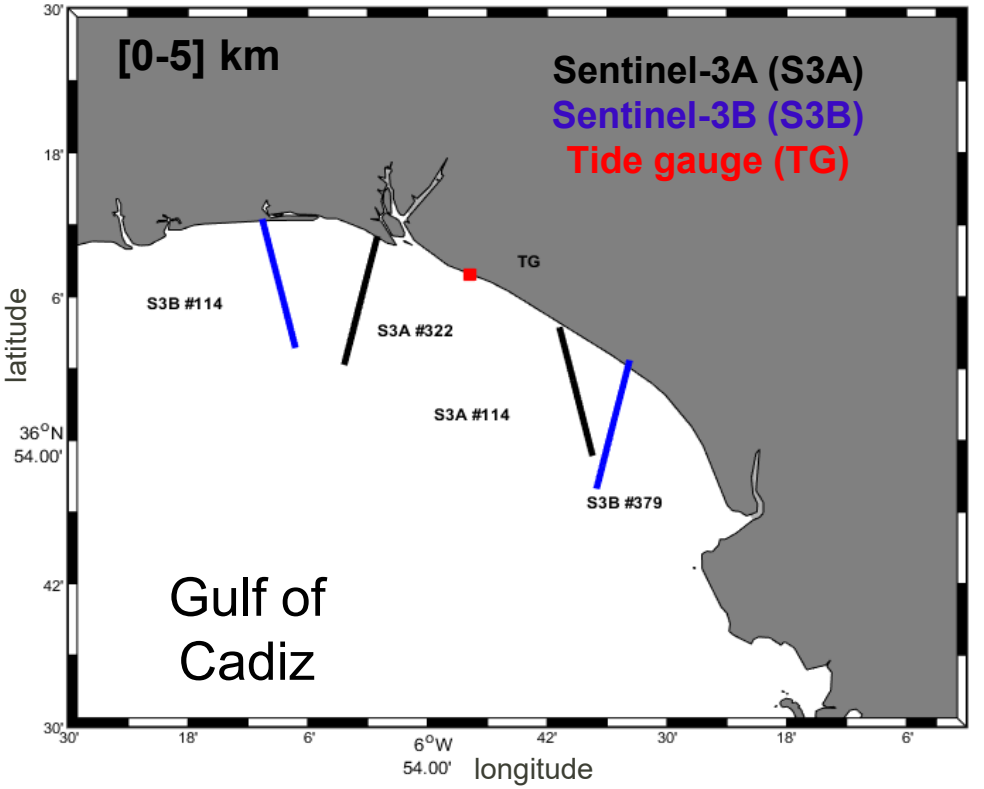
- To test Sentinel-3A and Sentinel-3B coastal altimetry data with the **FF SAR processing** and different coastal retrackers.
- To find the **best product**, in terms of accuracy and precision, to study the Gulf of Cadiz coastal sea level variations
- To analyse focus in the track segment **[0-5] km**

Data and Methodology

Two tracks of S3A and two of S3B in the Gulf of Cadiz (SW Spain) were selected. The track segment 0-5 km was selected; being zero the point where the track intersect with the coast.

Tracks	S3A #114	S3A #322	S3B #114	S3B #379
Transition	Ocean-to-Land	Land-to-Ocean	Ocean-to-Land	Land-to-Ocean
Angle	46°	75°	84°	69°
Min. Dist. TG	14 km	16 km	32 km	26 km
N° cycles	45	45	15	15

TG: tide gauge



Data and Methodology

Datasets	Retracker	Processing
SAM+ SAR **ALES+ SAR**	SAMOSA+ ALES+ SAR	Unfocused SAR (GPOD)
FF SAR BP **FF SAR BP ALES+**	SAMOSA ALES+ SAR	FF SAR Back Projection provided by Frithjof Ehlers and Florian Schlembach
FF SAR WK **FF SAR WK ALES+**	Threshold peak retracker ALES+ SAR	FF SAR Omega–Kappa provided by Aresys

FF SAR processing configuration

Calibration corrections applied	Instrument gain calibration correction applied to L1a pulses agc_ku_l1a_echo_sar_ku
Integration time	2.1 s
Along-track spectrum weighting	No along track antenna pattern compensation
Oversampling factor in range	2 (256 range bins)
Windowing in fast time	No windowing in fast time
Multilooking procedure	Multilooking single look waveform corresponding to 80 Hz posting rate

Data and Methodology

Sea Level Anomaly (SLA)

S3_SLA= Orbit − Range − Range corrections −Geophysical corrections − MSS

TG_SLA= Water Level − Tide Prediction

where the Range depends of each dataset; the Range corrections (dry and wet tropospheric correction from ECMWF, ionospheric correction from the Global Ionospheric Maps of the Jet Propulsion Laboratory), Geophysical corrections (tides from TPXO8, SSB provided by GPOD, source: Jason2 CLS 2012, and DAC not applied) and MSS (DTU15) were interpolated from GPOD files at **80 Hz**.

In the case of TG, a harmonic simple analysis of t-tide (Pawlowicz et al. 2002) were applied.

Data and Methodology

→ **Accuracy analysis** [0-5 km]

To compare datasets: Percentage of Cycles Highly Correlated (PCHC) analysis
[Threshold: 0.9, 0.8 and 0.7 with p-value<0,05]

Processing: Outlier detection ± 1.5 (mean) and ± 3· MAD · 1.4826
Remove the time average in S3 and TG time series

To validate: standard deviation of the difference (sdd)

Data and Methodology

→ **Accuracy analysis [0-5 km]**

To compare datasets: Percentage of Cycles Highly Correlated (PCHC) analysis
[Threshold: 0.9, 0.8 and 0.7 with p-value<0,05]

Processing: Outlier detection ± 1.5 (mean) and ± 3· MAD · 1.4826
Remove the time average in S3 and TG time series

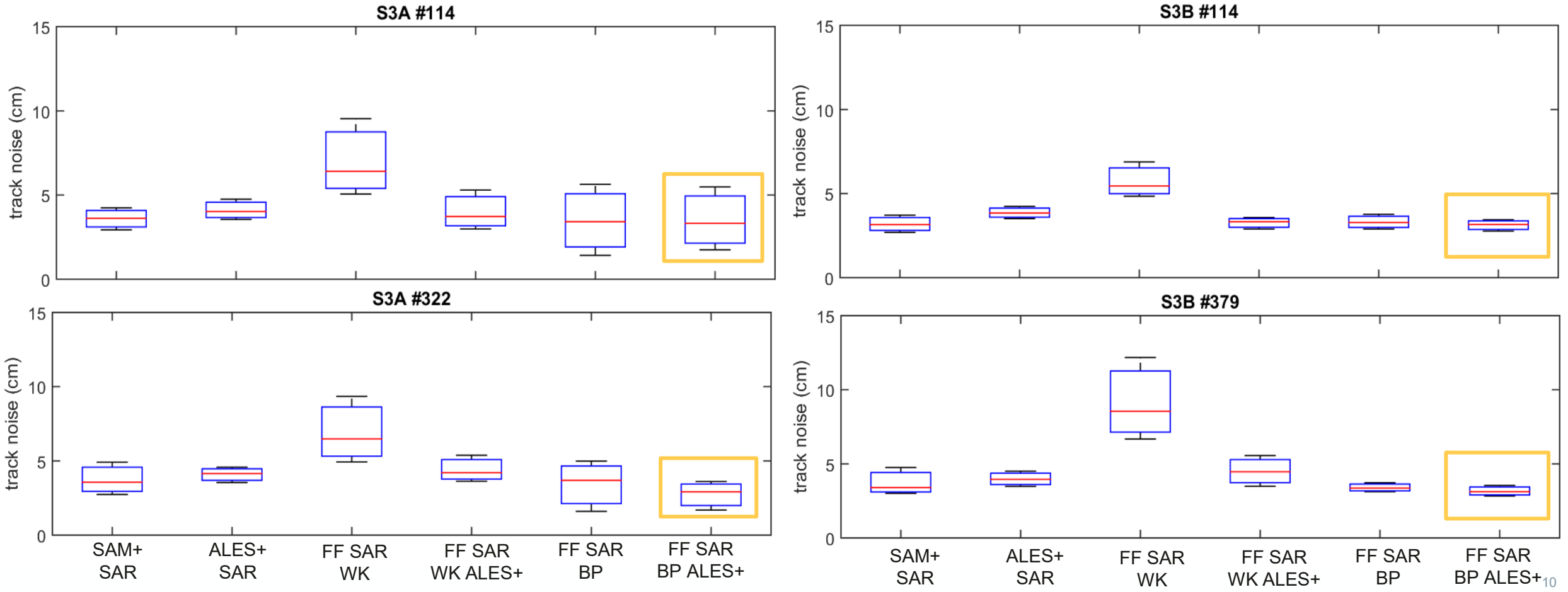
To validate: standard deviation of the difference (sdd)

→ **Precision analysis [0-20 km]**

- The difference of SLA between two consecutive points along-track, for each cycle, is calculated.
- Then the average of the cycles noise is done to obtain the noise of each track.

Results: Precision analysis

- Similar noise in unfocused SAR with both retrackers. For the FF datasets, the noise decreased in all cases using **ALES+ SAR**.
- The extra computational effort in the case of **BP**, is worthwhile → better results comparing ALES+ SAR datasets



Results: Accuracy analysis

PCHC ANALYSIS

Higher PCHC were obtained with FF SAR than with unfocused SAR.

[0-5] km	S3A #114			S3A #322			S3B #114			S3B #379		
r threshold	**0.9**	**0.8**	**0.7**	**0.9**	**0.8**	**0.7**	**0.9**	**0.8**	**0.7**	**0.9**	**0.8**	**0.7**
SAM+ SAR	35%	55%	61%	3%	5%	24%	28%	43%	59%	29%	52%	69%
ALES+ SAR	29%	41%	44%	32%	64%	70%	**31%**	46%	57%	23%	40%	58%
FF SAR WK	34%	59%	66%	30%	62%	78%	25%	43%	59%	13%	23%	34%
FF SAR WK ALES+	41%	59%	66%	34%	64%	**79%**	27%	**49%**	**67%**	18%	29%	42%
FF SAR BP	42%	**63%**	**72%**	**49%**	**71%**	77%	14%	23%	31%	**44%**	**66%**	**82%**
FF SAR BP ALES+	**48%**	60%	66%	43%	59%	60%	27%	41%	54%	17%	37%	60%

Results: Accuracy analysis

VALIDATION

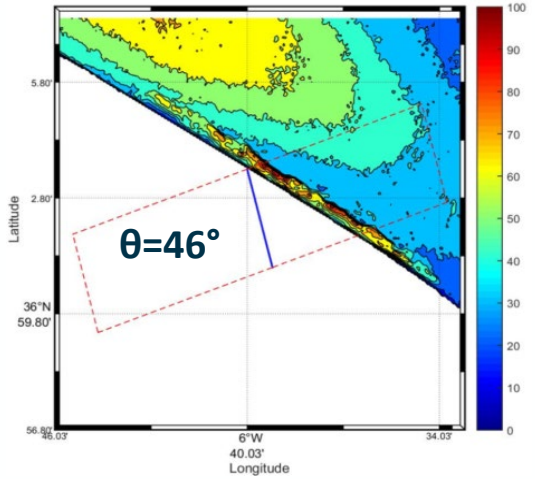
Comparing ALES+ datasets, better results were obtained in FF SAR than in unfocused SAR, and the BP product showed similar or better accuracy than the WK products.

¿Land contamination?

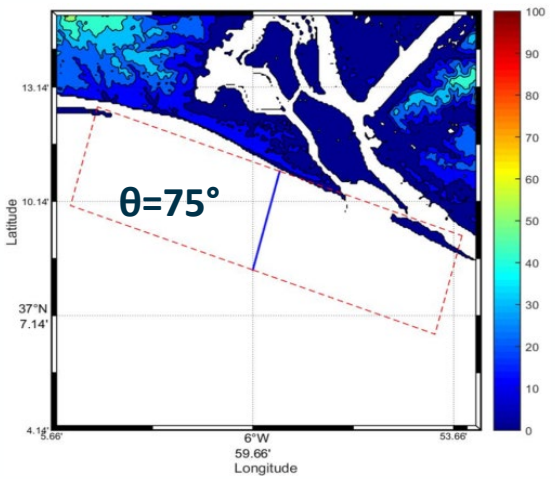
sdd ± std (cm)	S3A #114	S3A #322	S3B #114	S3B #379
ALES+ SAR	**10.0 ± 4.2 cm**	9.3 ± 5.0 cm	7.9 ± 3.3 cm	11.3 ± 9.2 cm
FF SAR WK ALES+	12.0 ± 6.2 cm	10.5 ± 8.3 cm	7.9 ± 4.5 cm	11.3 ± 4.6 cm
FF SAR BP ALES+	11.0 ± 5.8 cm	**6.6 ± 1.4 cm**	7.9 ± 5.4 cm	**9.0 ± 2.1 cm**

Results: Accuracy analysis

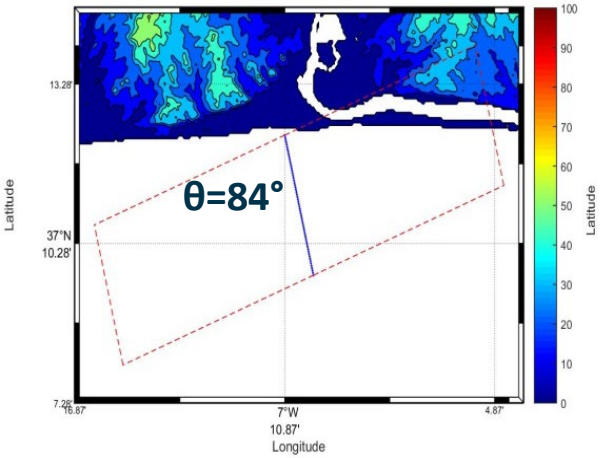
S3A #114



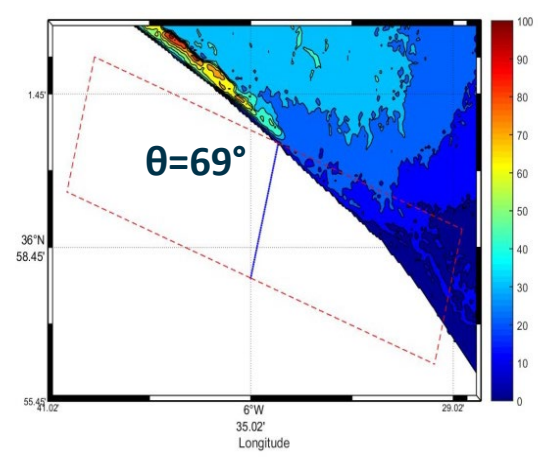
S3A #322



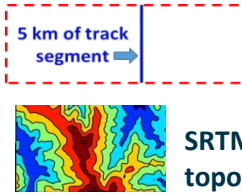
S3B #114



S3B #379

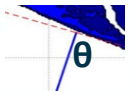


sdd ± std (cm)	S3A #114	S3A #322	S3B #114	S3B #379
ALES+ SAR	**10.0 ± 4.2 cm**	9.3 ± 5.0 cm	7.9 ± 3.3 cm	11.3 ± 9.2 cm
FF SAR WK ALES+	12.0 ± 6.2 cm	10.5 ± 8.3 cm	7.9 ± 4.5 cm	11.3 ± 4.6 cm
FF SAR BP ALES+	11.0 ± 5.8 cm	**6.6 ± 1.4 cm**	7.9 ± 5.4 cm	**9.0 ± 2.1 cm**



Envelope of the beam-limited footprint in the across-track direction (a radius of about 9.5 km perpendicular to the track)

SRTM land topography (m)



smallest angle between the track and the coastline

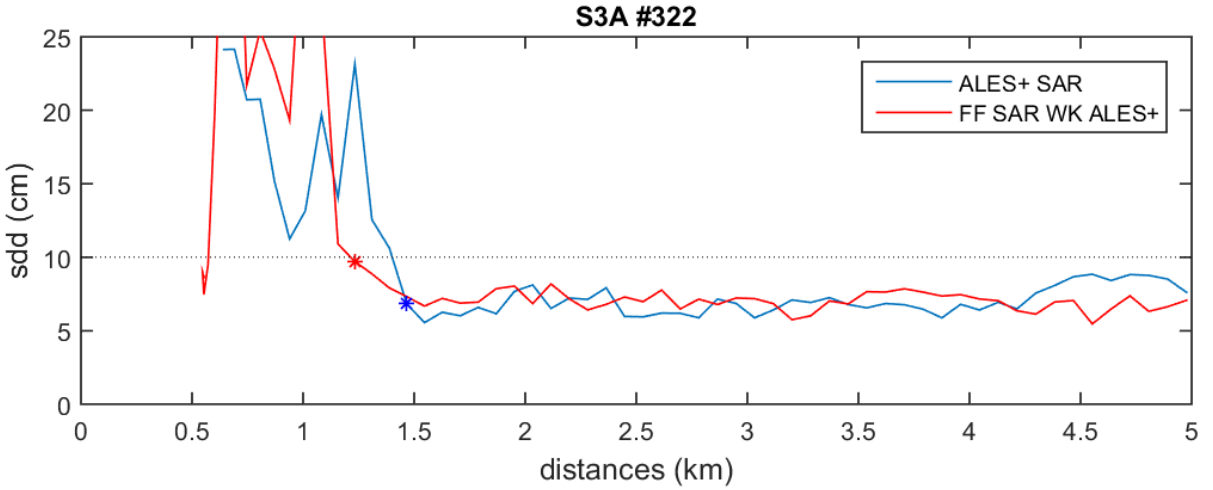
Discussion

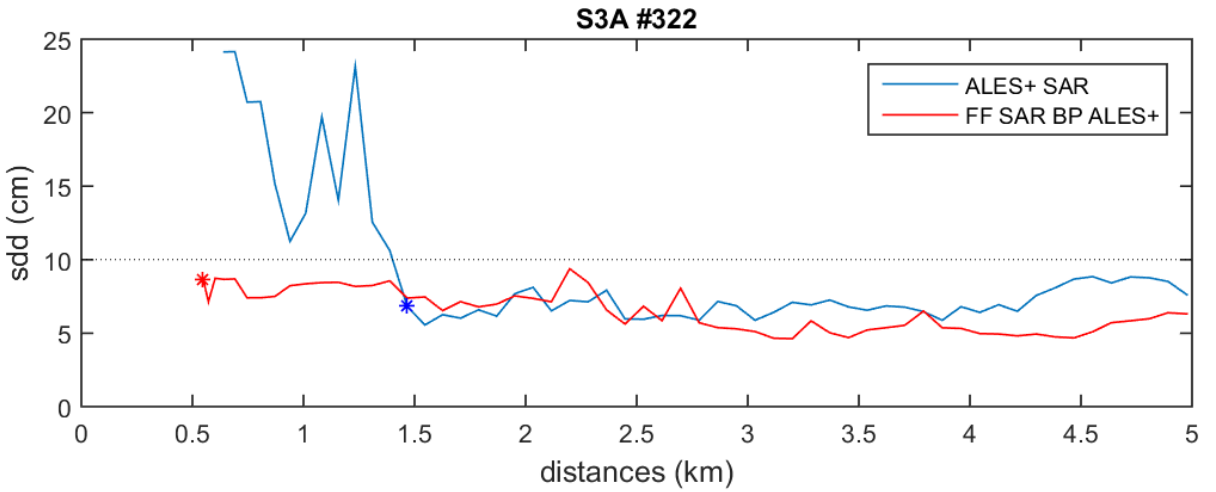
OPTIMUM TRACK SEGMENT

The optimal track segment or how close to the coast accurate data can be obtained, was calculated.

The closest point to the coast after which the sdd does **not rise above 10 cm** was detected. These points are marked with asterisks.

The results showed that the optimum km points were located closest to the zero in **FF SAR** datasets than in **unfocused SAR**.





Discussion

OPTIMUM TRACK SEGMENT

The optimum track segment and the sdd in this optimum segment **(sdd*)** were calculated.

The best accuracy were achieved with **FF SAR BP**.

Shorter optimum track segments were obtained in tracks **less perpendicular** with respect to the coast: S3A #114 and S3B #379. Therefore, the track orientation has an important influence on accuracy.

Dataset	Tracks	S3A #114	S3A #322	S3B #114	S3B #379
ALES+ SAR	km point	3.6 km	1.3 km	**0.9 km**	4.9 km
	sdd*	6.8 cm ± 0.6 cm(23)	7.0 cm ± 0.9 cm (43)	**6.4 cm ± 1.2 cm (55)**	7.2 cm ± 0.2 cm (1)
FF SAR WK ALES+	km point	3.1 km	1.1 km	3.5 km	4.4 km
	sdd*	7.1 cm ± 0.9 cm (30)	7.1 cm ± 0.8cm (46)	6.4 cm ± 1.0 cm (25)	8.6 cm ± 0.7 cm (7)
FF SAR BP ALES+	km point	**2.4 km**	**0.6 km**	1.0 km	**3.7 km**
	sdd*	**7.0 cm ± 0.9 cm** (36)	**6.6 cm ± 1.4cm** (60)	6.7 cm ± 0.9 cm (54)	**8.9 cm ± 0.8 cm** (25)

Conclusions

- The novel Fully Focused SAR processing technique used in S3A and S3B tracks provided similar or higher degree of precision and accuracy data than unfocused SAR in the Gulf of Cadiz.

- Advantages in the use of SAMOSA+ or ALES+ in S3 unfocused products were not found. However, in the case of the S3 FF SAR product, better results were obtained when applying ALES+ SAR retracker.

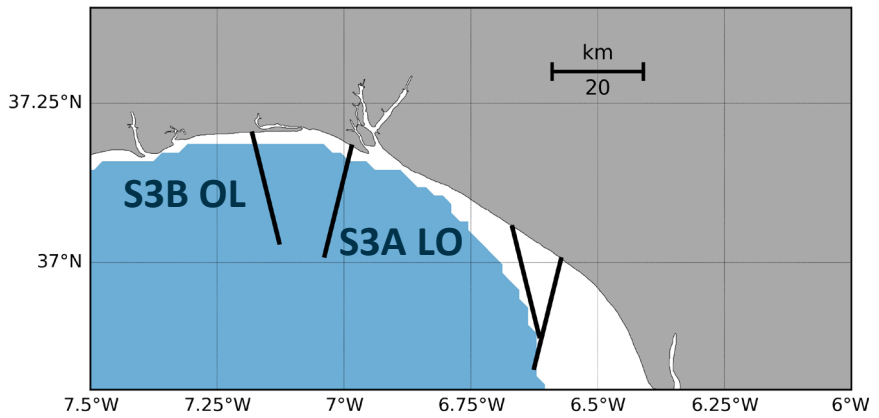
- A better approximation to the coast (0.6 – 2.3 km) was obtained with FF SAR Back Projection products when retracked with ALES+ SAR. However, a common track segment for the four tracks was not found, as occurred with the unfocused products.

- A larger number of tracks and different study areas will be necessary to prove the advantages of FF SAR for the analysis of coastal processes.

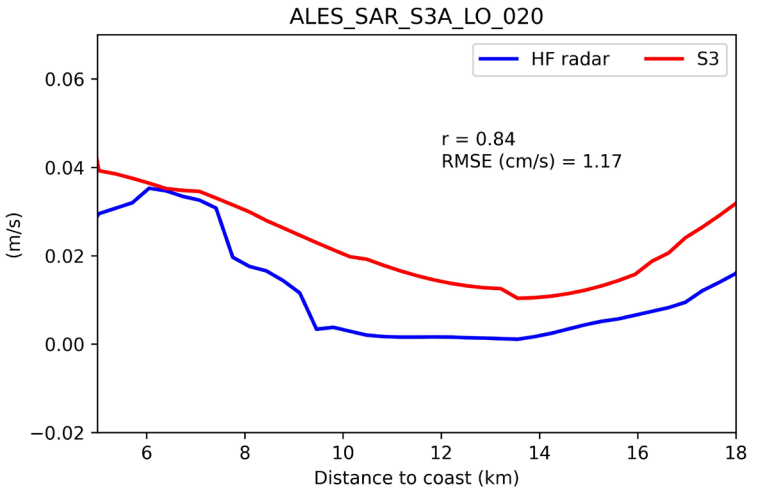
Future works

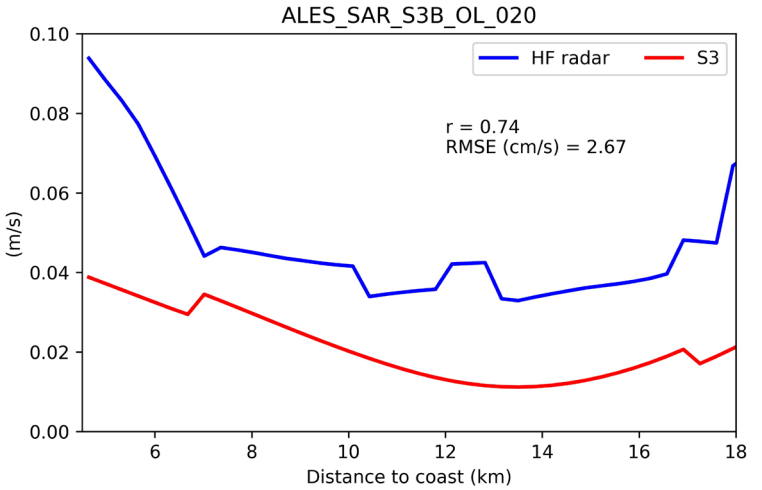
Preliminary results

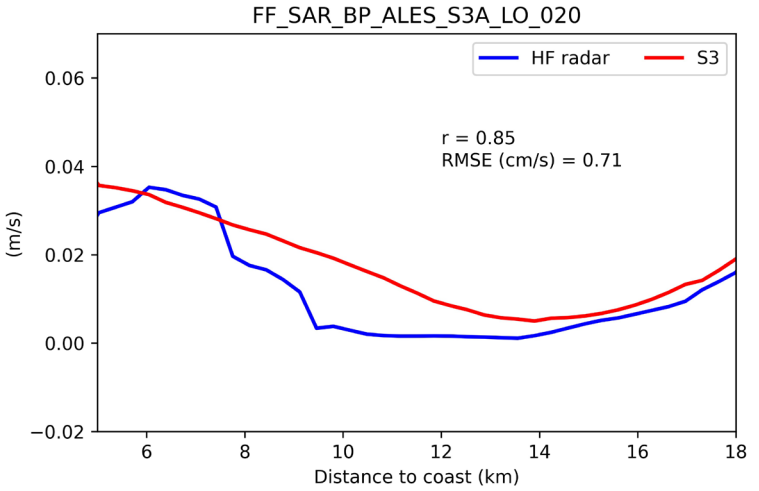
The comparison among temporal HFr average data and temporal along-track average surface absolute geostrophic current (SAGC) obtained from all the available cycles.

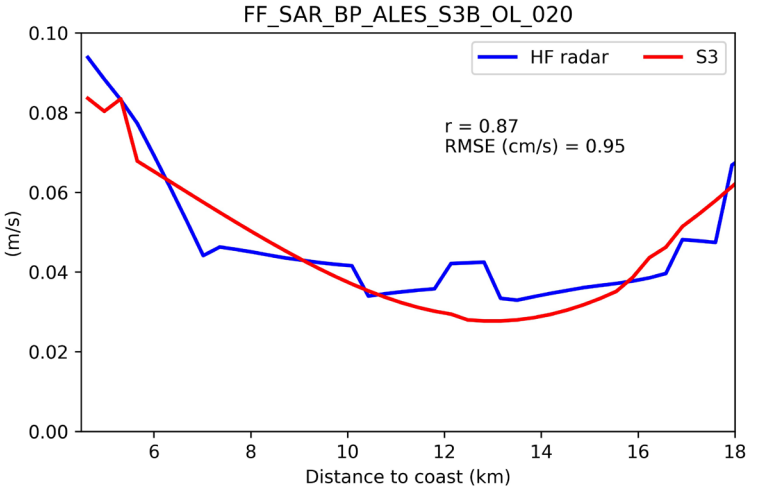


(Mulero-Martínez et al., 2021)









Thanks for your attention!

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