ANALYSIS OF FULLY FOCUSED AND UNFOCUSED SAR DATA IN THE [0-5] Km OF THE COASTAL STRIP

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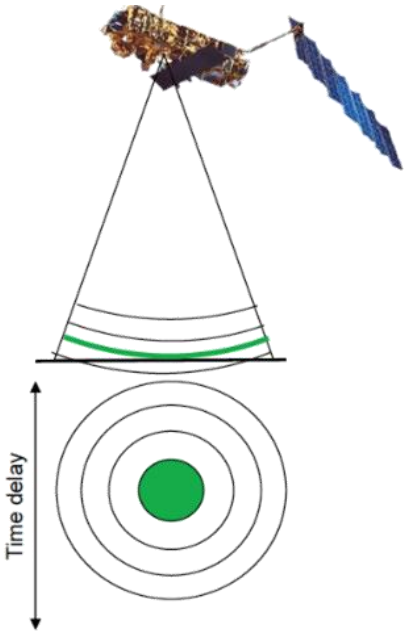
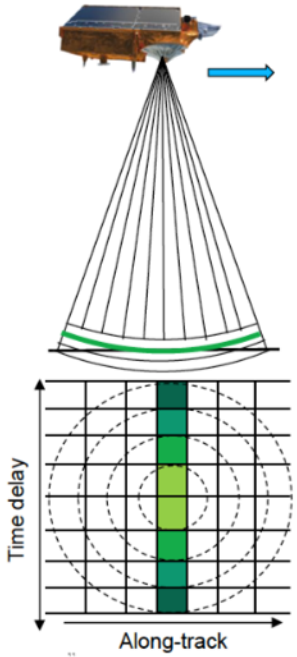
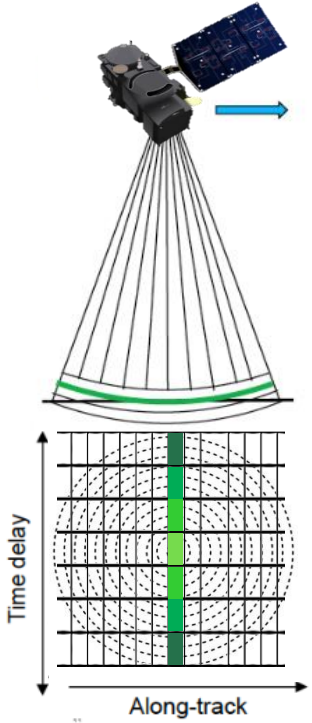


Conventional altimetry
Low resolution mode
Pulse-limited footprints

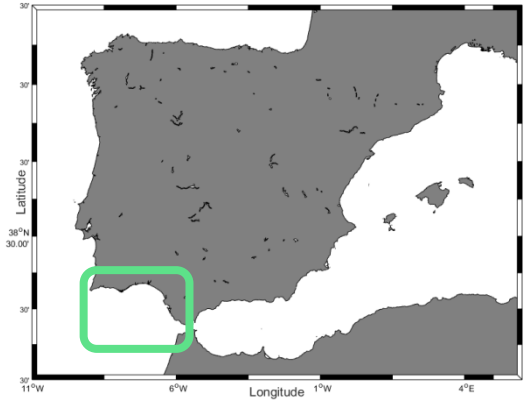


SAR altimetry (Delay/Doppler)
High Pulse Repetition Frequency
Beam-limited footprint along-track and pulse-limited across-track
High resolution along-track (~ 300 m)

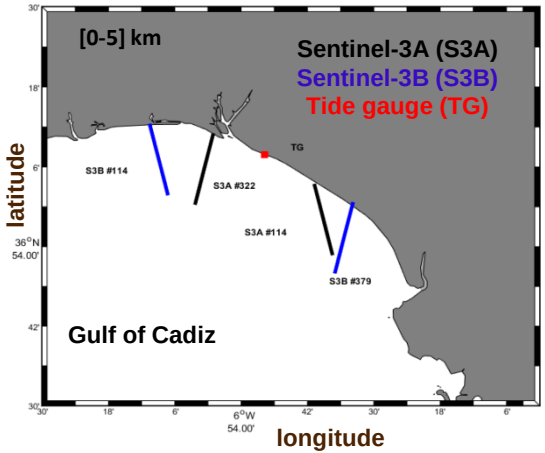


Fully Focused SAR (FF)
High resolution along-track (~ 0.5 m)
FF SAR along-track and pulse-limited across-track

(Source: modificated from ESA)



- 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**.



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

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

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

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.

→ **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]

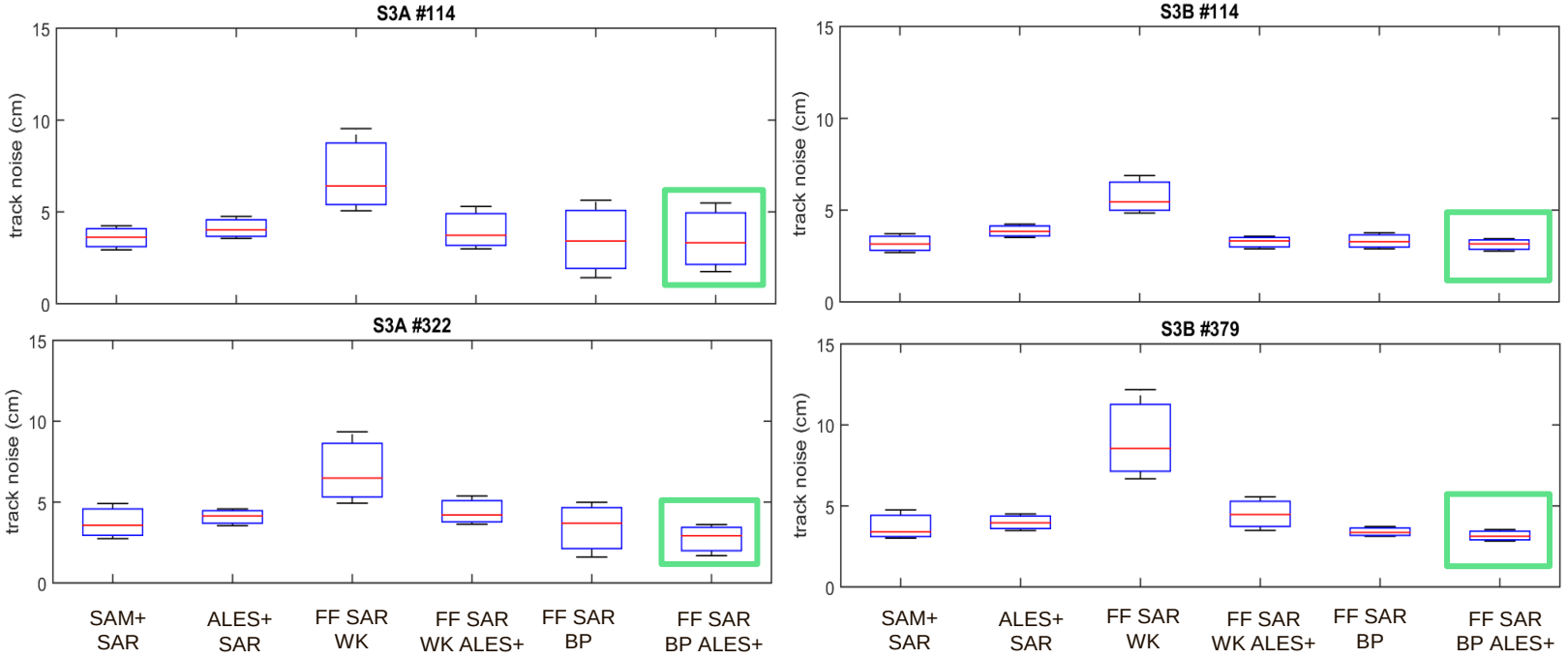
Processing: Outlier detection ± 1.5 (mean) and ± 3· MAD · 1.4826
Remove the time average in S3 and TG time series

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.

- 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



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	45%	63%	68%	50%	67%	74%	41%	56%	64%	47%	66%	75%
ALES+ SAR	37%	48%	52%	54%	70%	77%	39%	52%	64%	38%	52%	61%
FF SAR WK	52%	82%	90%	48%	57%	75%	42%	58%	68%	31%	51%	63%
FF SAR WK ALES+	62%	79%	85%	52%	66%	72%	**51%**	**68%**	**79%**	33%	45%	60%
FF SAR BP	**71%**	**84%**	**91%**	**58%**	**72%**	**77%**	37%	53%	63%	**50%**	**70%**	**77%**
FF SAR BP ALES+	64%	78%	84%	52%	59%	60%	42%	57%	66%	39%	54%	65%

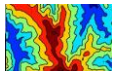
VALIDATION: Comparing ALES+ datasets, better results were obtained in FF SAR than in unfocused SAR, and the BP product showed similar or better accuracy than the WK products.

¿Land contamination?

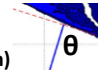
sdd ± std (cm)	S3A #114	S3A #322	S3B #114	S3B #379
ALES+ SAR	**10.0 ± 4.2 cm**	9.3 ± 5.0 cm	**7.9 ± 3.3 cm**	11.3 ± 9.2 cm
FF SAR WK ALES+	12.0 ± 6.2 cm	10.5 ± 8.3 cm	7.9 ± 4.5 cm	11.3 ± 4.6 cm
FF SAR BP ALES+	11.0 ± 5.8 cm	**6.6 ± 1.4 cm**	7.9 ± 5.4 cm	**9.0 ± 2.1 cm**

VALIDATION:

The worst results were obtained with the tracks that presented a lower angle with respect to the coast: S3A #114 and S3B #379.



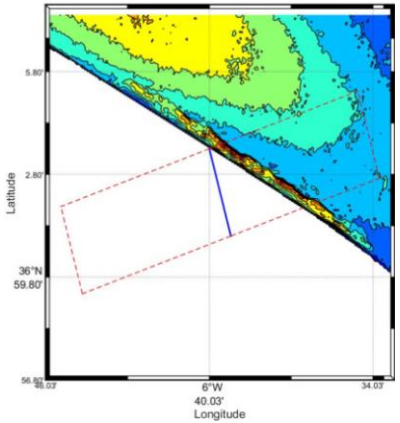
SRTM land topography (m)



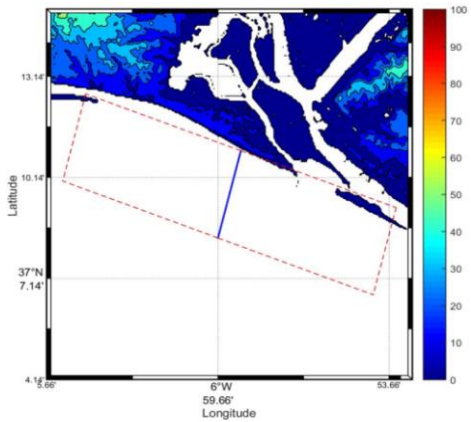
smallest angle between the track and the coastline

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

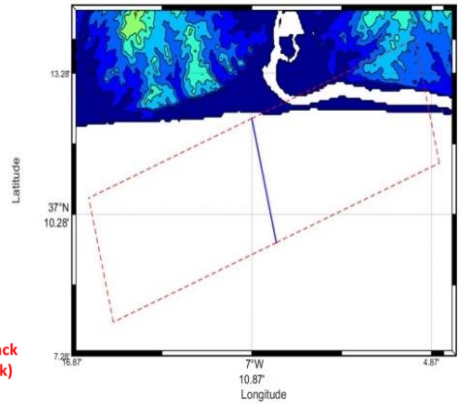
S3A #114



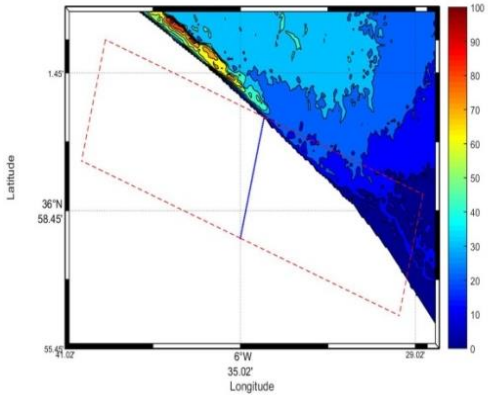
S3A #322



S3B #114



S3B #379

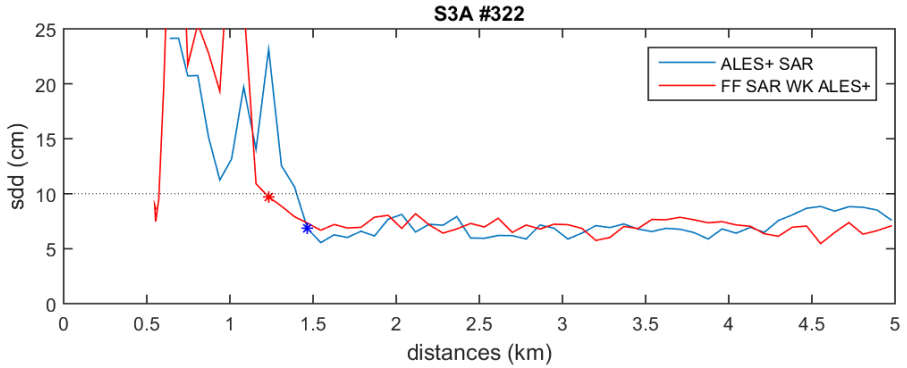


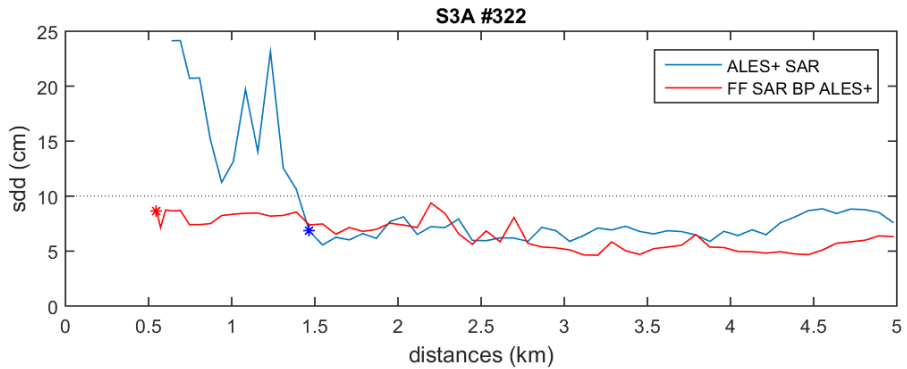
OPTIMUM TRACK SEGMENT

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**.





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**.

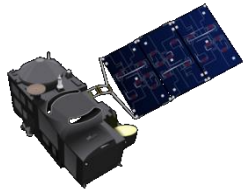
Shorter optimum track segments were obtained in tracks **less perpendicular** with respect to the coast: S3A #114 and S3B #379. Therefore, the track orientation has an important influence on accuracy.

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)

- 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.

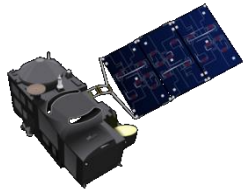
- Advantages in the use of SAMOSA+ or ALES+ in S3 unfocused products were not found. However, in the case of the S3 FF SAR product, better results were obtained when applying ALES+ SAR retracker.

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



- **The BP algorithm achieved more precise results**. Hence, in spite of the gain in computational effort given by the WK algorithm, better performance was observed in the FF SAR BP dataset. It has to be remarked that this comparison cannot be exhaustive, since it was conducted by exploiting two independent FF processing chains for S3 that differ for many processing steps other than the FF focusing algorithms. **Further analyses are needed** (including a larger number of tracks and different study areas) to assess the achievable performance of both algorithms in the coastal environment. Additionally, the **FF SAR processing chains used in this study are prototypes that can be still improved**.

- It would also be desirable **to continue** this work to Sentinel-6, since Sentinel-3 has more spurious grating lobes (every ~90m) in its PTR than Sentinel-6 (every ~300m) (Ehlers et al., 2022 under review), and so, a better performance using the processed FF SAR data from S6 would be expected.



Thanks for your attention!

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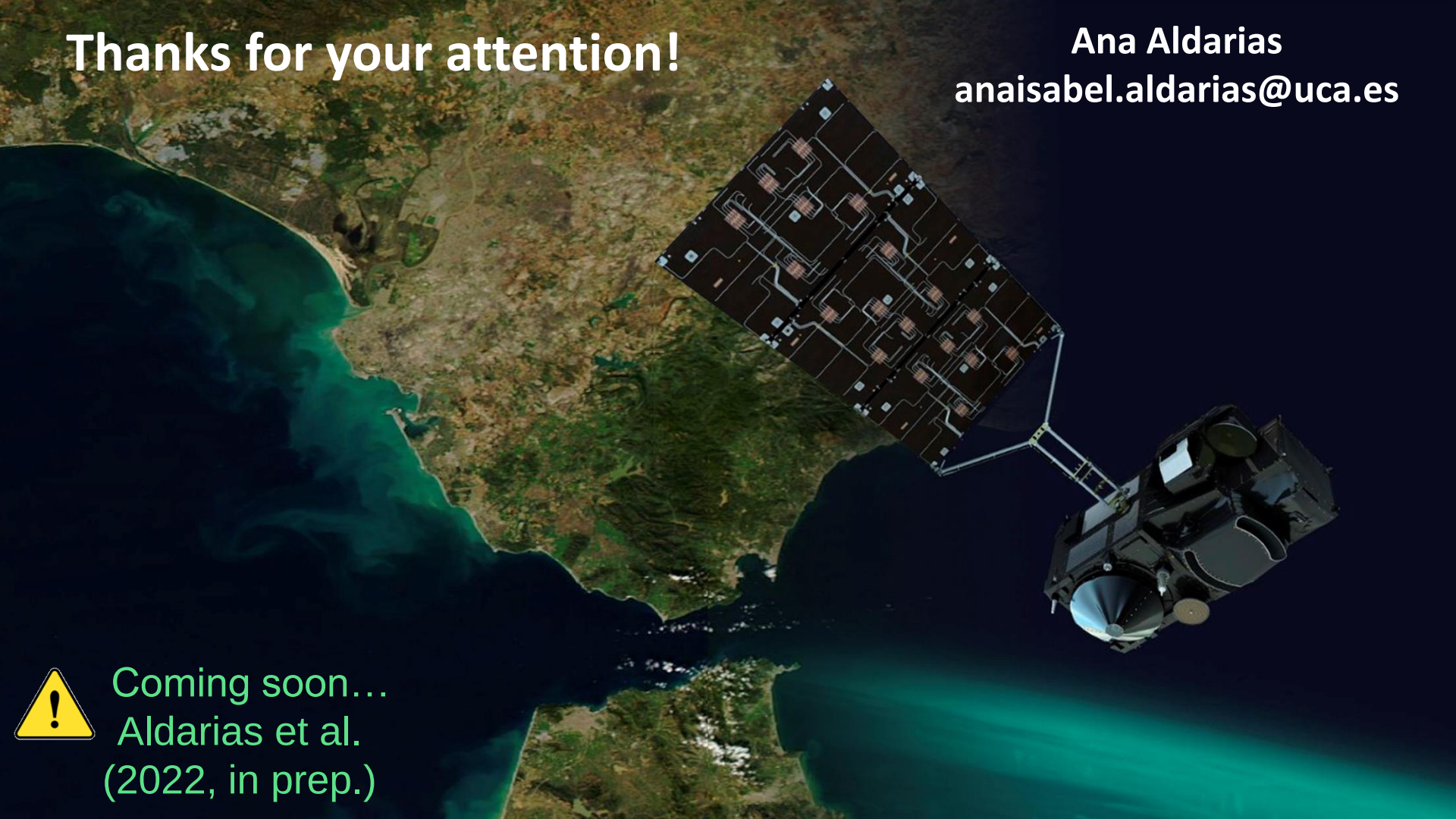

Coming soon…
Aldarias et al.
(2022, in prep.)