IMPROVING S6 ALTIMETER DATA PERFORMANCE IN COASTAL AREAS EXPLOITING FFSAR DATA RADARGRAMS

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Introduction

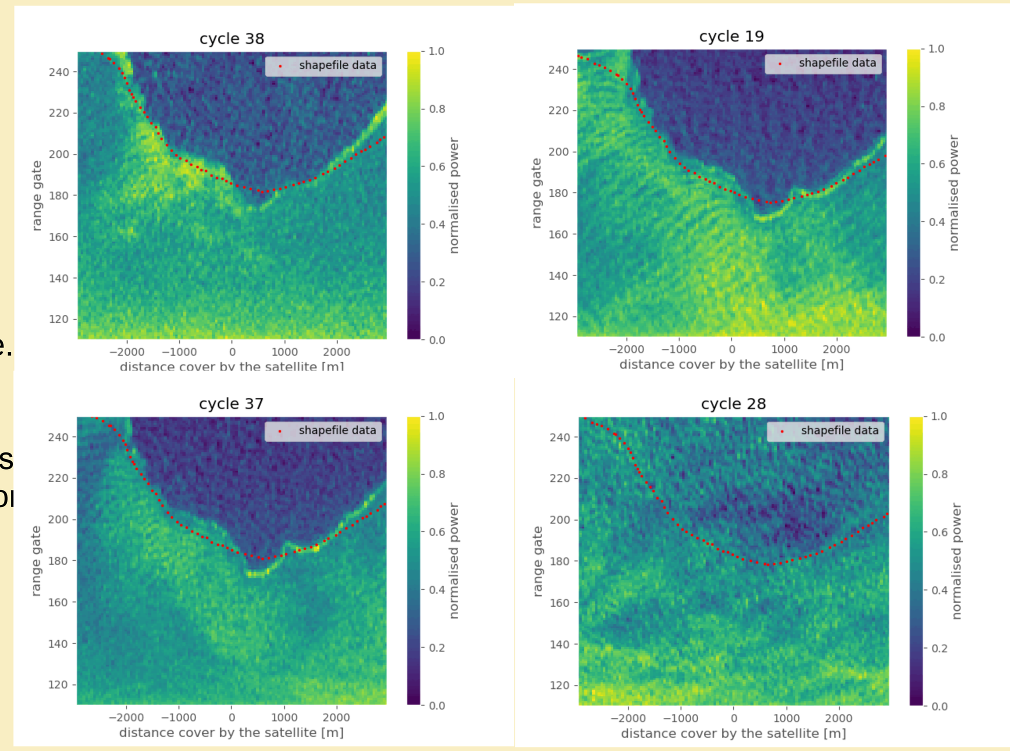
The coastal zone is of particular interest for the altimetry. However, no coastal altimeter processing is, today, able to provide highly accurate and precise measurements without removing many observations (the so-called outliers) that we would be interested in. Despite the efforts being made in the development of new solutions, those methods can still be clearly improved. An important step forward towards this objective would demand a detailed knowledge of the observed surface and the corresponding radar intensity variations to be accounted for in the waveform retracking.
With the launch of the Sentinel-6 mission, and the development of the high resolution Fully Focused SAR, we are now able to capture sharp details in complex areas, such as coastal zones.

By exploiting consecutive FF-SAR waveforms gathered in a radargram, valuable information on the coastal environment can therefore be extracted. It is possible for example to distinguish surfaces from one to another by analyzing the difference of their backscattering signatures in the radargram. This feature can help separating oceanic water from high specularity surroundings surfaces (associated to high backscattering coefficients σ0)) that are often encountered in coastal zones. We can cite shallow water, sandbanks and inland water for example. Those surfaces are responsible of major distortion on the oceanic waveform shape making them hard to retrack (resulting in significant errors in the altimeter measurements).
In this study, we developed a method to extract features from S6 FF-SAR data radargrams using a point clouds classifier (based on a statistical distribution analysis of the σ0 radar intensity values) in order to accurately locate the ocean targets within complex coastal environments. More specifically, this pre-processing algorithm allows the determination of the last useful waveform gate to retrack the useful part of the FF-SAR altimeter waveform. This method is compared with a shapefile-based method that uses a static coastline that does not include natural phenomena such as tides or storms. Advantages and drawbacks of both methods are discussed.

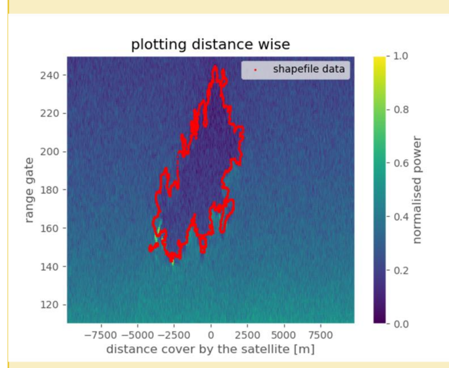
Shapefile method

This method uses the information contain in a static file that describe the theoretical coastline.
We can then compute the theoretical emplacement of each point of the shapefile on the radargram :
First, we need to compute the across track distance of each shapefile point. It is fast and easy considering the track as a straight line in the lon-lat space.

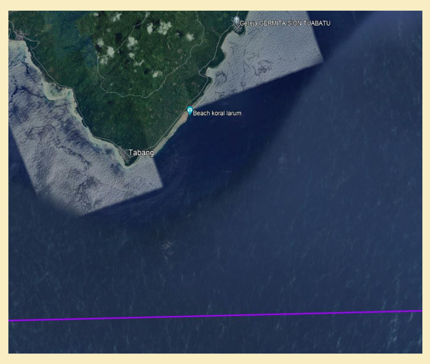
Second, we must convert this across track distance in range gate. This step needs the knowledge of the epoch point in order to be precise.
Then we can plot the point in the radargram with it's x coordinates being the position of projection over the track (either lon lat time or distance) and its y coordinates being the range gate computed before.



Pulau case



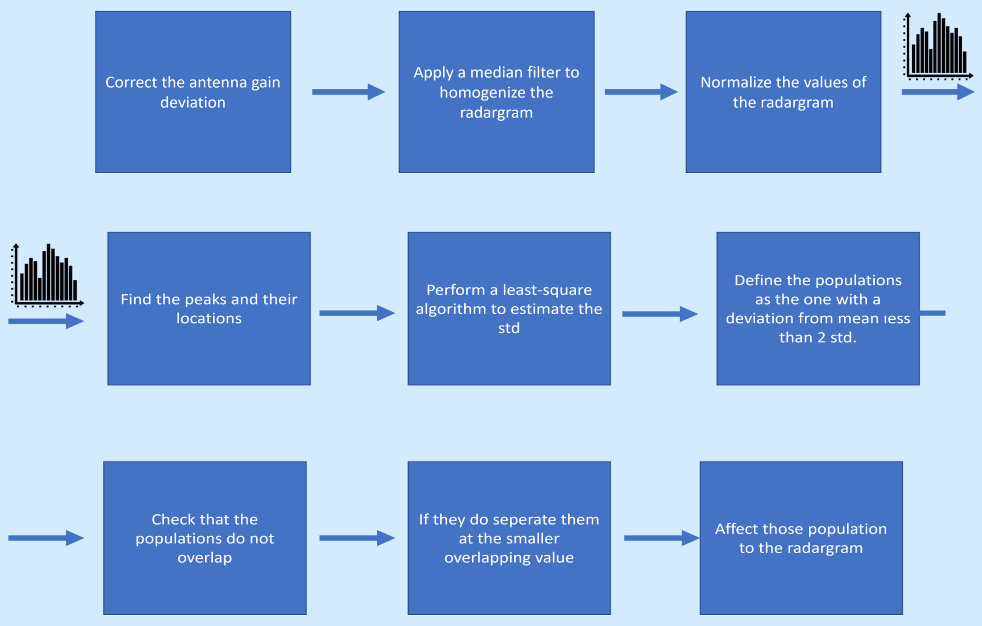
Fair island case



Pulau case

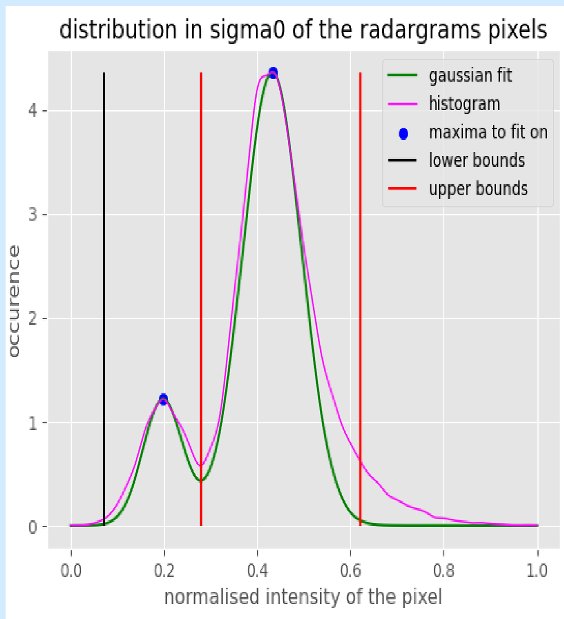
As we can observe above, the static information contain in the shapefile seems to correspond what looks like the coastline in the radargram (the part with a low reflection).
The problem is that it does not take into account the high energy zone that are the one responsible in the multiple peaks echoes. It also do not work when we are in presence of tide or storms (as in cycle 28).
We also

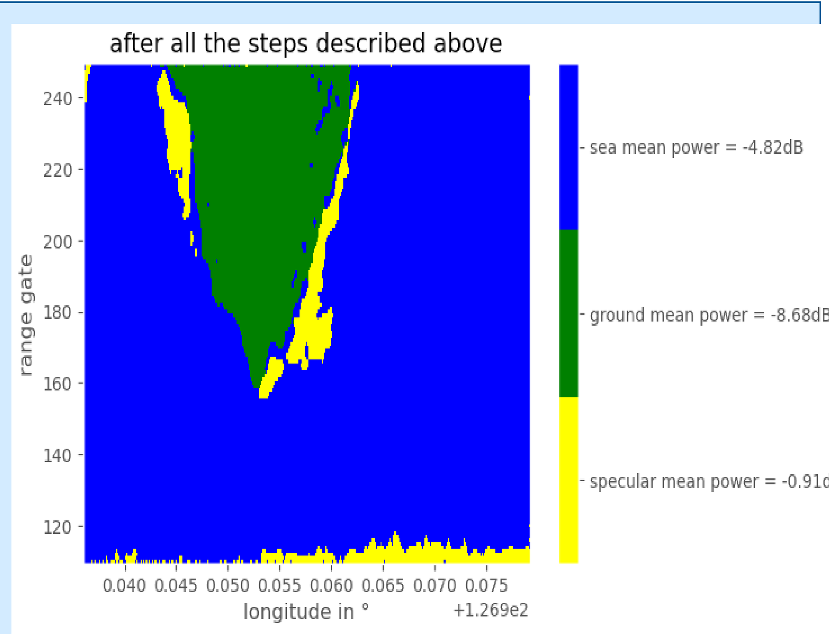
Statistical distribution method



This method use image processing treatment.
The first step is to correct the antenna gain drift over the last gates in order that a variation in 'color' on the radargram corresponf to a variation of the reflectivity/roughness of the considered surface. We then apply filter that reduce noise level (at the expense of a loss in resolution) and normalize the values of the radargram between 0 and 1.

Then we compute the histogram of the resulting radargram and fit each peak with either a gaussian or a log-normal distribution. We then define population as the one covering 95% of each peak. If the peaks overlap, we define the border between the populations as the minimum of the histogram.

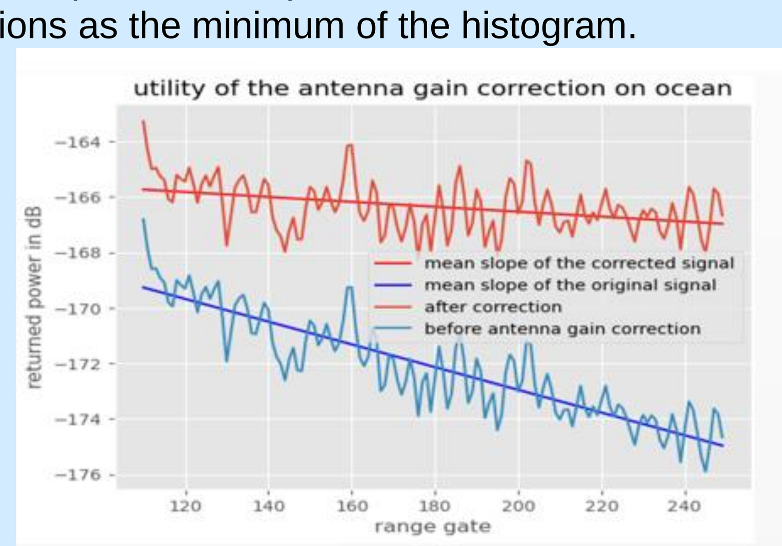


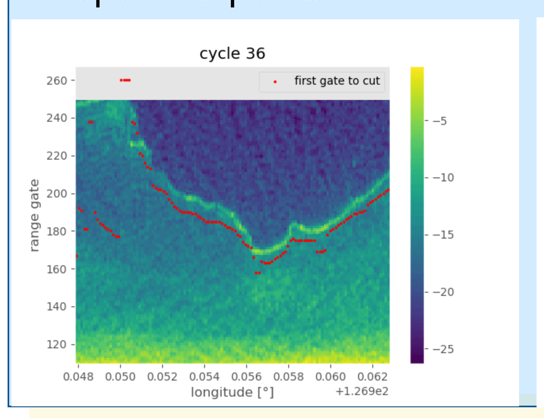


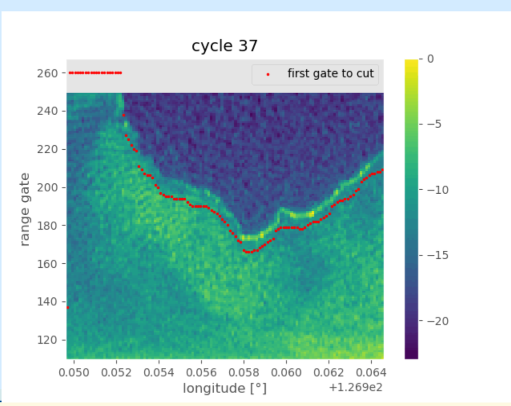
Pulau case

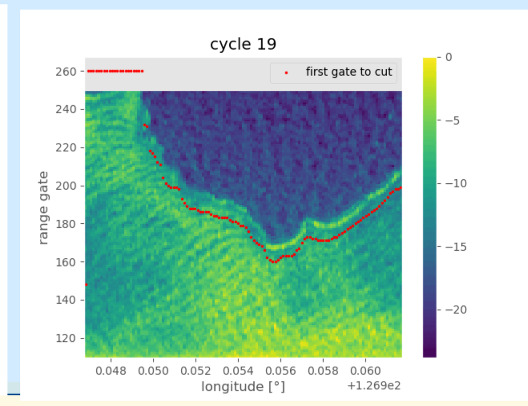
In order to understand the behavior of coastal zones, we can compute the mean power of each population . We can observe a 3dB loss between sea and ground (division by 2 in watts). This fact indicate that the ground does not backscatter signal (because we still get the oceanic signal from the other side of the track). The specular mean value is often very high and close to the max (0dB)

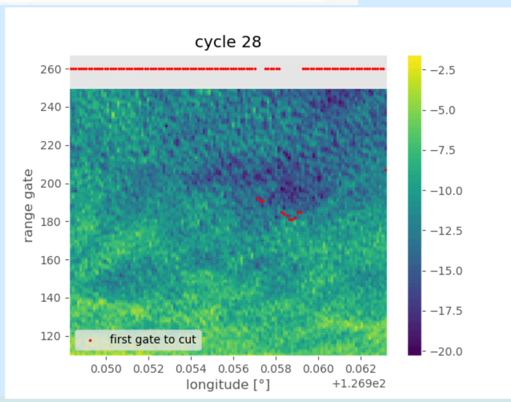
For the retracking operation we read each waveforms one by one. We cut at the first two successives 'specular point'.
In any case, we cut 90 gates (non-zero padded) after the reference gate associated to the epoch point. The sensibility analysis performed during this study showed that in case of oceanic echo we not loose that much of precision on the retracked parameters. We do this operation in order to avoid to retrack un-considered specular points





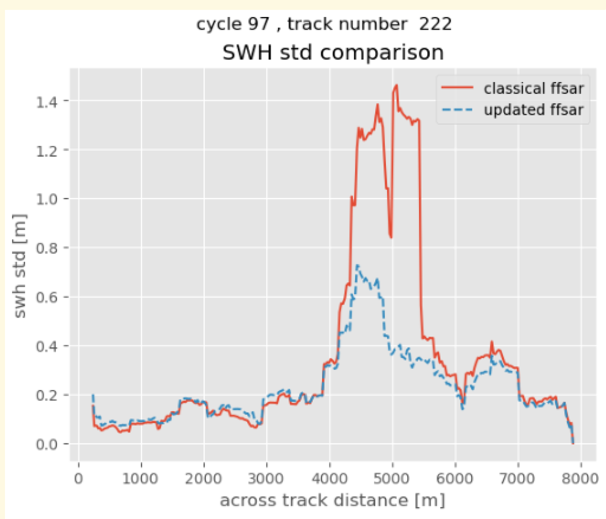


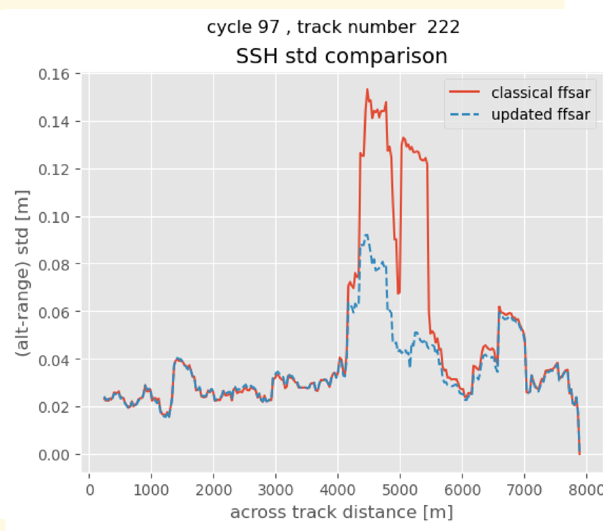




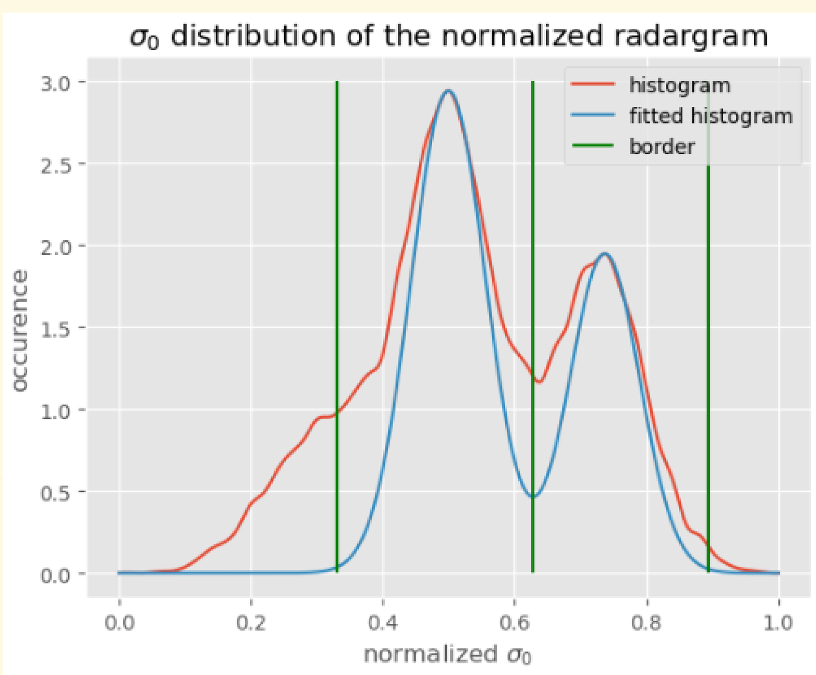
Results

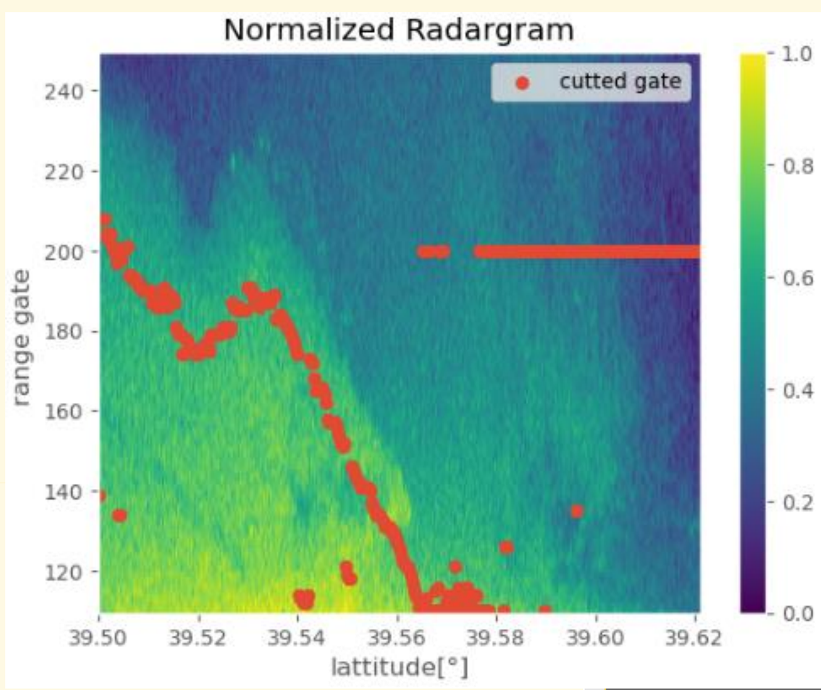
The results have been computed for the dynamic classification only. We obtain a significant reduction in noise in the 4-5 km band. Those results have to be tempered by the fact that the altimetric measure is false when we are close to the coast so it's hard to obtain a bias measure. Also, seems this method is about cutting gate contaminated by the coast we can expect to have poor result when we are to close as we will have not enough gate remaining for the retracking algorithm. Far from the coast we expect fewer contamination (those are attenuated by the antenna gain) so the difference should minimal.





Exemple of result





Configuration

All this work have been made using Sentinel 6 Fully Focus SAR[1] data. We processed this data using a version of SMAP modified for the $\omega\kappa$ FFSAR[2] (using mainly the single look). This SMAP algorithm use the C.Buchaupt retracking[3]. We used an illumination time T_i of 2.1s and a posting rate PR of 140hz.

Conclusions

The first results of this study shows an interesting reduction in both the SSH and SWH noise in the 4-5km band. It miss some data in order to obtain a better understanding on the specular points behaviour and the distribution. Also, we could implement a correspondance between the shapefile and the distribution method for a better placement of the radargram in order to get a good proportion of both ground and ocean back-scatterers wich allows us to always have a signature of them in the radargram.

References

1) Alejandro Egido and Walter Smith. Fully focused sar altimetry: Theory and applications. IEEE Transactions on Geoscience and Remote Sensing, PP:1–15, 01 2017
2)Pietro Guccione, Michele Scagliola, and Davide Giudici. 2d frequency domain fully focused sar processing for high prf radar altimeters. Remote Sensing, 10(12), 2018.
3)Buchhaupt, L. Fenoglio-Marc, S. Dinardo, R. Scharroo, and M. Becker. A fast convolution based waveform model for conventional and unfocused sar altimetry. Advances in Space Research, 62(6):1445–1463, 2018. The CryoSat Satellite Altimetry Mission: Eight Years of Scientific Exploitation.