Tuning SAR Processing to Measure Sea Ice Freeboard

S. Fleury[1] A. Laforge[1] J. Verley[1] K. Guerreiro[1]
S. Dinardo[2] J. Benveniste[3]

[1] LEGOS [2] EUMETSAT [3] ESRIN

Sea-ice strongly influences global climate through the insulation of ocean from atmosphere, the ice-albedo feedback mechanisms, and the ocean circulation modification. Its extensions have been well observed since early 80's by satellites. However, two major dimensions are still far imprecisely known for the global climate models: the variations of sea ice volumes and the sea level over Arctic ocean, both of them being identified as Essential Climate Variables (ECV) by ESA and GCOS.

The CryoSat2 altimetric mission has already demonstrated its capacity to estimate ice freeboard. Nowadays, the objectives are to better understand the uncertainties and to improve the accuracy of these estimations.

Unlike LRM altimetry, the SAR raw echoes are downloaded and processed off-line. This offers an unique opportunity to master the chain process and to adapt it according to the type of the observe surfaces.

For instance, the Doppler beams ground position can be chosen; some filtering may be added in order to avoid the secondary lob effects; or even the peaky waveforms can be re-interpolated using the raw SAR signals ...

Several products, using different signal treatment models or parameters, have been developed: ESA baselines B and C, SAMOSA2, SAMOSA+, CPPv14. Moreover, the ESA offers the unique opportunity to parameterize and compute our own SAR altimetry data on its GPOD server using the SARvatore chain: https://gpod.eo.esa.int/services/CRYOSAT_SAR/

In this study we evaluate the impact of these choices and assess the importance of different parameterization of physical radar models in different sea ice conditions.

SAR Alti Processing Options on GPOD Server

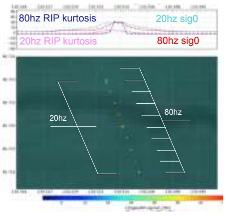
The SARvatore interface on the GPOD server allows to choose between about ten processing options. For our comparative study we have considered the following one's:

SAR processing:
- hamming filter (h)
- zero-padding (z)
- antenna pattern correction (a)
- single/multi-look (sl/ml)
- focalization rate (20hz/80hz)

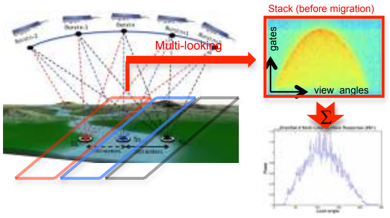
Retrakers:
- Samosa 2
- Samosa +

The '80hz' processing

The 330m ground stripe positions are artificial and they can be translated along-track. The so called '80hz' GPOD processing consists simply in computing the SAR echoes at 3 intermediate positions. Thus, on the figure at the right, the 80hz computing provides 2 measurements over the lead that was missed by the 20hz processing.



SAR Altimetry – Range Integrated Power



SAR altimetry consists of a coherent processing of 64 echoes within each burst narrowing the along track resolution to strips of 330m using Doppler principle. The stack provides distance for each view (satellite positions).

The orthogonal integration of the stack provides the RIP: the **Range Integrated Power.** It represents the power reflected by one strip for each observing satellite positions.

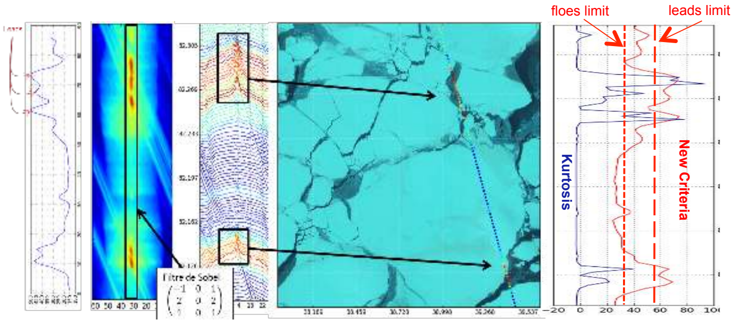
This curve is specific to SAR processing and it hasn't yet been fully exploited for sea-ice applications.

New Leads Width Estimation

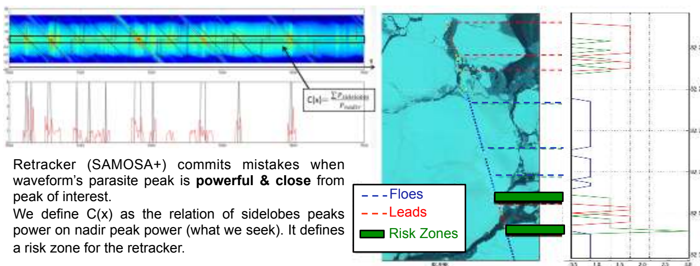
On the along-track RIPs curve, high energy peaks are observed when passing over leads. These peaks seem to correspond exactly to leads position and could inform us about leads width.

The method developed here; consist on considering the along-track RIPs as an image and extracting lines of peaks using a Sobel filter.

The convolution score for nadir positions (black square) brings us a very accurate criteria for leads detection, leads width measurement and floes.



New Leads/Floes Discrimination Criteria



Retracker (SAMOSA+) commits mistakes when waveform's parasite peak is **powerful & close** from peak of interest.

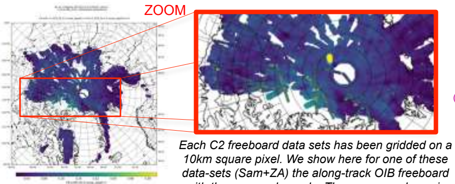
We define C(x) as the relation of sidelobes peaks power on nadir peak power (what we seek). It defines a risk zone for the retracker.

Comparison with Operation Ice Bridge (OIB)

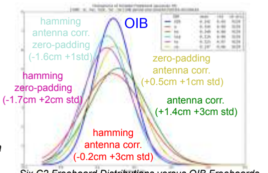
We have computed a CryoSat-2 along-track freeboard using 9 different processing combinations of the 7 options listed above: hamming (h), zero-padding (z) antenna pattern correction (a), single look (sl), 80hz focalization rate (80hz), and samosa2 (2).These 9 combinations are the following: hz2, ha, hz, hza, a za, za_sl, za_80hz, za_sl_80hz.

The data covered the period 20150319-20150423 corresponding to the 2015 OIB campaign.

For every of these combinations, the data have been gridded on a 10km square pixel map (see the example on the left). The 7 freeboard distributions (6 CryoSat-2 +1 OIB) are presented on the histograms on the right.



Each C2 freeboard data sets has been gridded on a 10km square pixel. We show here for one of these data-sets (Sam+ZA) the along-track OIB freeboard with the same color code. The correspondence is visually good.



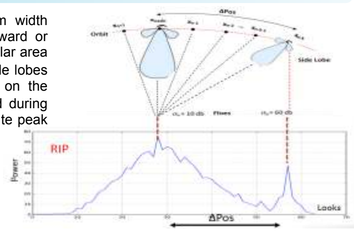
Six C2 Freeboard Distributions versus OIB Freeboards Distribution. At a first order, the Samosa+ with zero-padding and antenna correction provides the best result.

Doppler Side Lobes Effect

Doppler processing consist in focusing on a 330m width across-track stripe, but while focusing on an backward or forward stripe, a strong backscatter (caused by specular area such as leads) can be mistakenly detected by the side lobes of the synthetic antenna at this position (diagram on the right). These off-nadir impacted looks are integrated during the multi-look step and appear in the RIP as a parasite peak located at the affected position.

The impact of this phenomenon can be reduced by a hamming filtering but this filtering modified the final height measurement over the leads.

In this study we try to evaluate this impact.

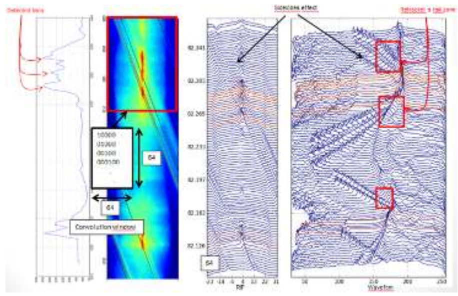


Side-Lobes Effect Detection

The side-lobe effect creates parasite peaks on the waveform responsible for retracking failures/mistakes around leads zones. These peaks are also visible on the RIP as 45° straight lines.

The detection method consists on calculating the convolution score of the along-track RIP image and the same width identity matrix. We, then, detect peak positions.

It gives us **power & position** of all RIP parasite side lobes peaks. This valuable information can be used to discriminate retracking mistakes.



Conclusions

The off-line Doppler SAR processing allows to adapt the treatment to the physics of the observed surface. In the case of the sea-ice and some hydrological configuration, the high dynamics of the backscatter signed strongly on the Range Integrated Power (RIP) curve. This RIP can be exploited to detect and localize specular surfaces like leads or similar still water surfaces.

In this study we exploit the RIP to measure the width of the leads, to localize the floes and to exclude the data that mixed up several targets.

The next step will consist in producing new sea-ice freeboard using this new criteria and evaluating the result in comparison with several in-situ data sets (OIB, IMB, CryoVex).

Cryo-SEANICE

This project is funded by ESA