SL_cci+ Kick Off

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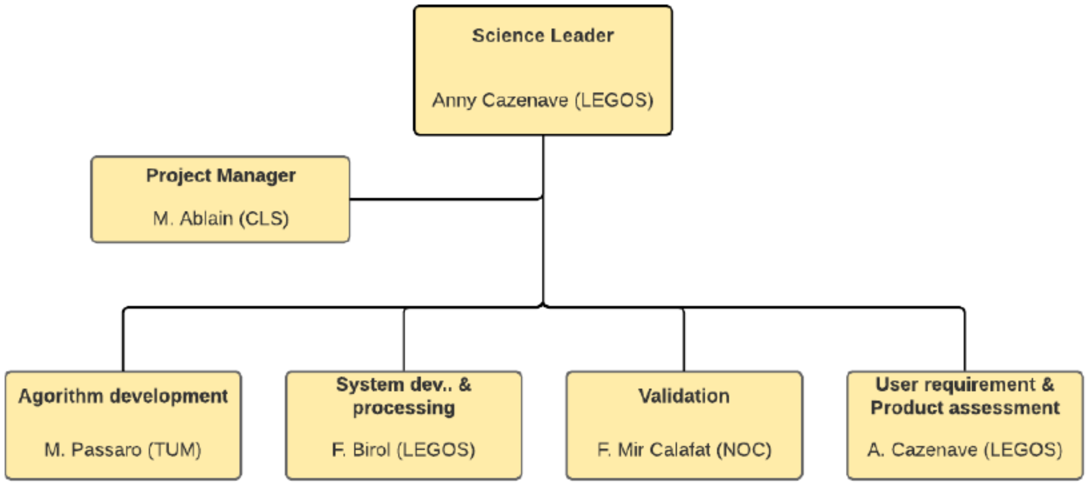
29.01.2019

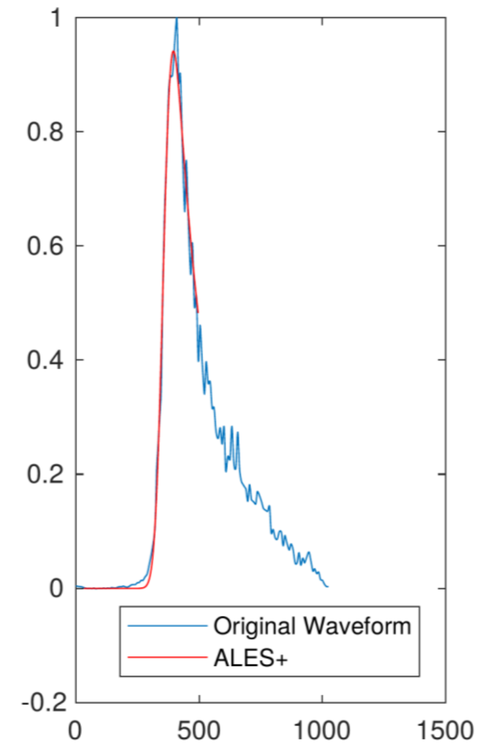
Role of TUM in SL_cci+



- Responsible for the Algorithm Development
- Provider of Range and SSB correction to System Processing (LEGOS)

Algorithm Development: Retracking

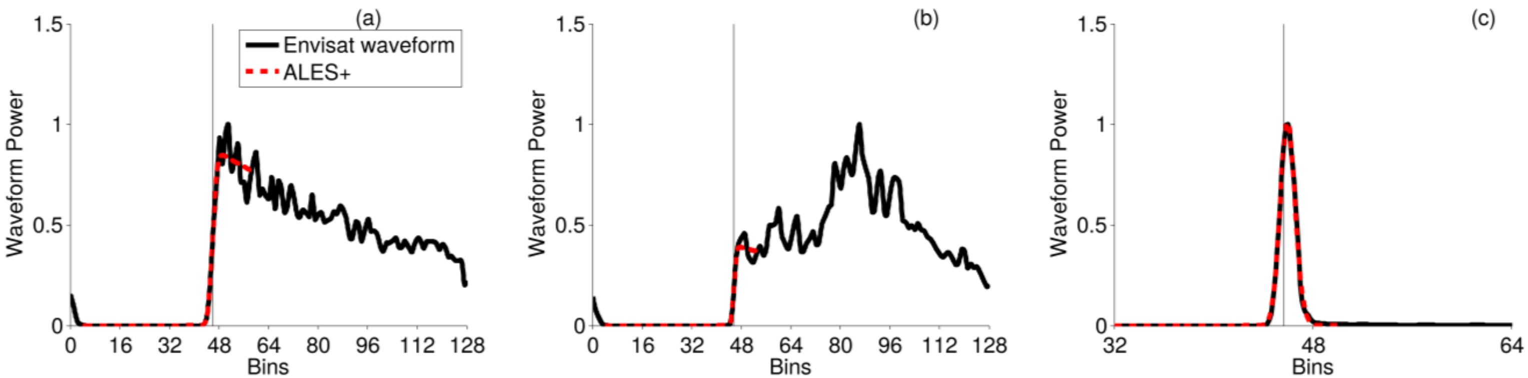
PROJECT: CCI Extension – New R&D on CCI ECVs: Sea Level	WP: 2.1
WP Title: Algorithms development – Experimental application of ALES for SAR waveforms Company: TUM WP Manager: M. Passaro Start Event: KO Planned Date: 01/01/2019 End Event: Planned Date: 30/06/2021	Sheet 1 of 1 Issue Ref: 1. 0 Issue Date 03/07/2018
Inputs: **Tasks:** • Adaptation of a subwaveform retracker based on ALES to the DD case. • Study the application of ALES+ with stable values of the parameter • Analyse adaptive vs constant size of the subwaveform • Analyse of correlated errors in the DD case • Study to perform a weighted fitting in the Nelder-Mead algorithm **Outputs:** • D2.1: Algorithm Theorical Basis Document (ATBD) • D2.3: Update Algorithm Development Plan (ADP - D1.2)	



Note that this is experimental. If validation shows it is not worth it, the official product will be used

ALES+ Retracking Concept

Open ocean | Coast | Leads/Inland Waters



$$W(t) = \frac{P_u}{2}\left\{1 + erf\left[\frac{(t-t_0) - c_\xi \sigma_c^2}{\sqrt{2}}\right]\right\} exp\left(-c_\xi\left[(t-t_0) - \frac{c_\xi \sigma_c^2}{2}\right]\right)$$

Brown-Hayne readapted from Goemmenginger et al. (2011)

Our solution: estimate trailing edge from the waveform (if peaky), use a subwaveform (if oceanic/coastal)

Passaro et al. (2018a), RSE

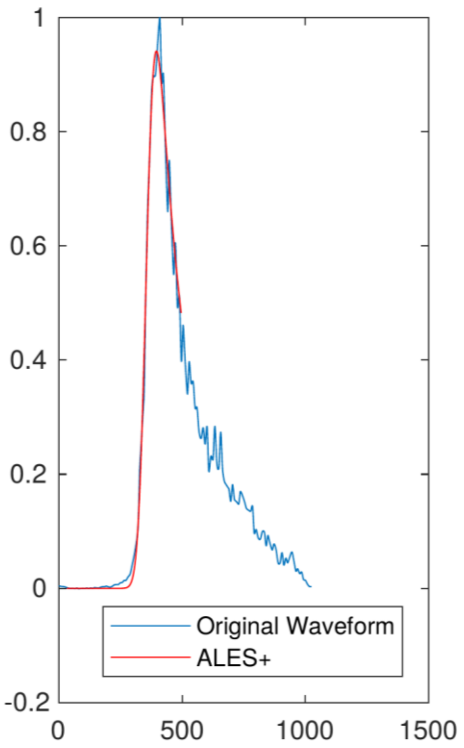
Algorithm Development: Retracking

- The objective of Range detection is to find the mid-point of the leading edge, also in SAR altimetry

- By adapting the slope of the trailing edge to the SAR case, we can fit the leading edge with an erf function as in the Brown-Hayne case

- Can we stop at some point along the trailing edge? Does this bring advantages in the coastal zone?

- Do we need the subwaveform to be adaptive, as in the LRM case?



Algorithm Development: Sea State Bias

PROJECT: CCI Extension – New R&D on CCI ECVs: Sea Level	WP: 2.2
WP Title: Algorithms development – Regional SSB Solution for ALES ranges Company: TUM WP Manager M. Passaro Start Event: KO Planned Date: 01/01/2019 End Event: Planned Date: 30/06/2021	Sheet 1 of 1 Issue Ref: 1. 0 Issue Date 03/07/2018
Inputs: **Tasks:** • Derivation of a regional SSB model for the LRM altimetry dataset based on retracked significant wave height and backscatter coefficient • Design and derivation of a SSB correction for the DD-altimetry retracked dataset used in this project **Outputs:** • D2.1: Algorithm Theorical Basis Document (ATBD) • D2.3: Update Algorithm Development Plan (ADP - D1.2)	

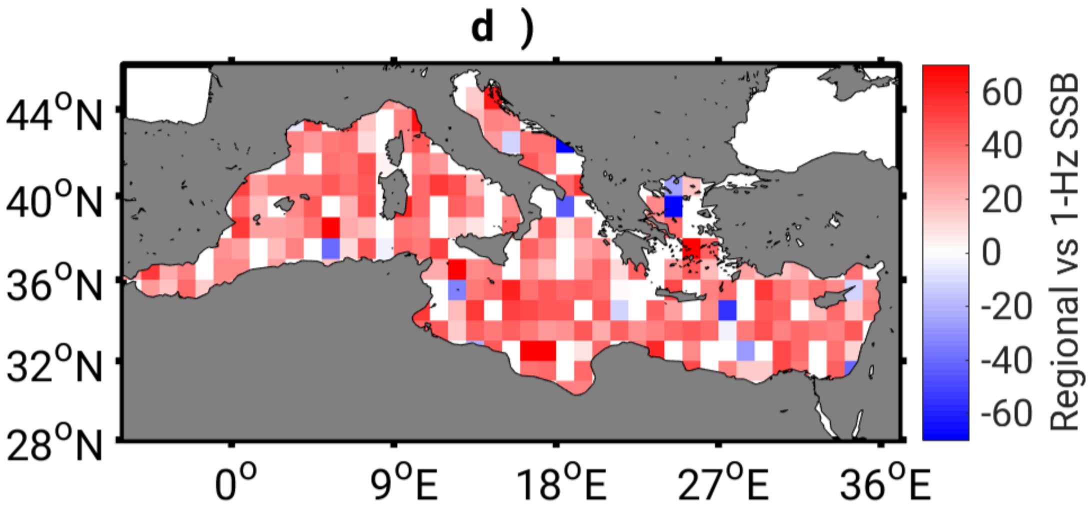
Already from first delivery in Sept 2019 (starting point):

- Application of ALES specific SSB correction at 20Hz

Planned for following years:

- Derivation of regional parametric SSB correction for all the dataset (currently only Jason in the Med)

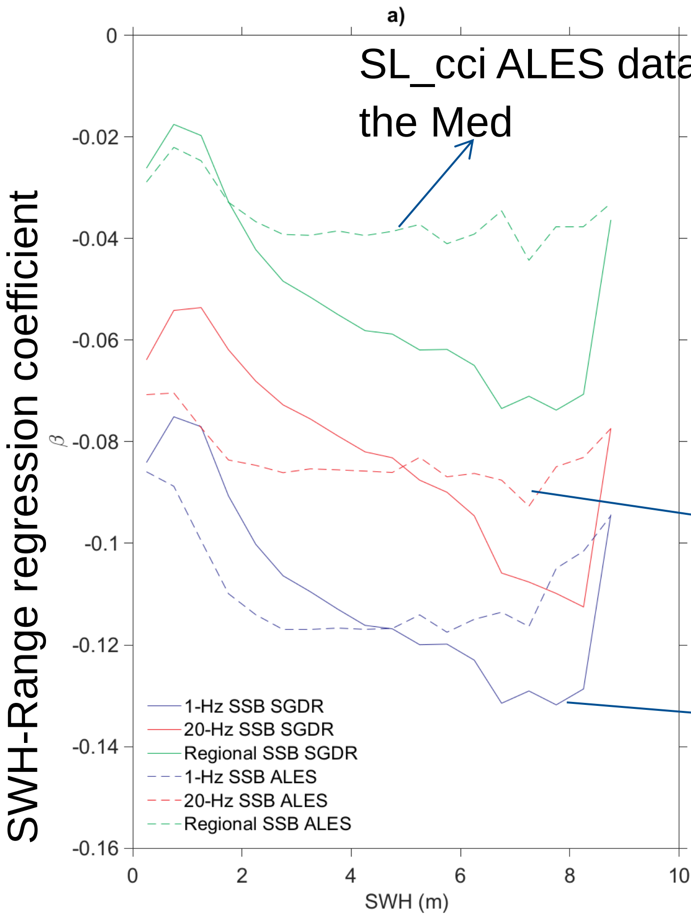
Total Variance Reduction



Dataset	20-Hz vs 1-Hz SSB [%]	Reg vs 20-Hz SSB [%]	Reg vs 1-Hz SSB [%]
ALES Med	14.05	18.77	29.34

From: *Passaro M., Zulfikar Adlan N., Quartly G.D.*: **Improving the precision of sea level data from satellite altimetry with high-frequency and regional sea state bias corrections**. Remote Sensing of Environment, 245-254, 10.1016/j.rse.2018.09.007, 2018

Removing the „retracker noise“

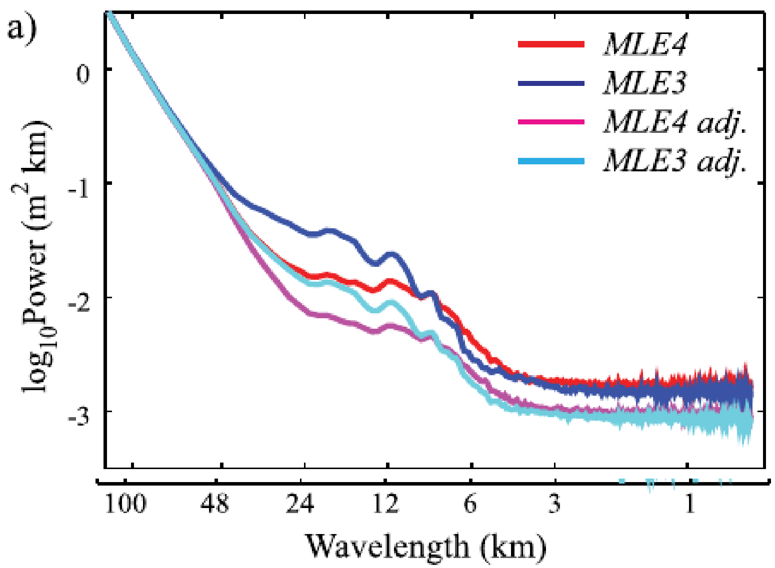


Presented also at OSTST 2018.
Message: the regional recomputation of a simple parametric model and its application at 20-Hz decreases crossover variance by 30%, by decreasing the correlation between SWH and Range estimation (alternative to Zaron&De Carvalho…we save the 20 Hz!)

SL_cci ALES dataset in the other regions

Original SGDR data

Removing the „retracker noise“



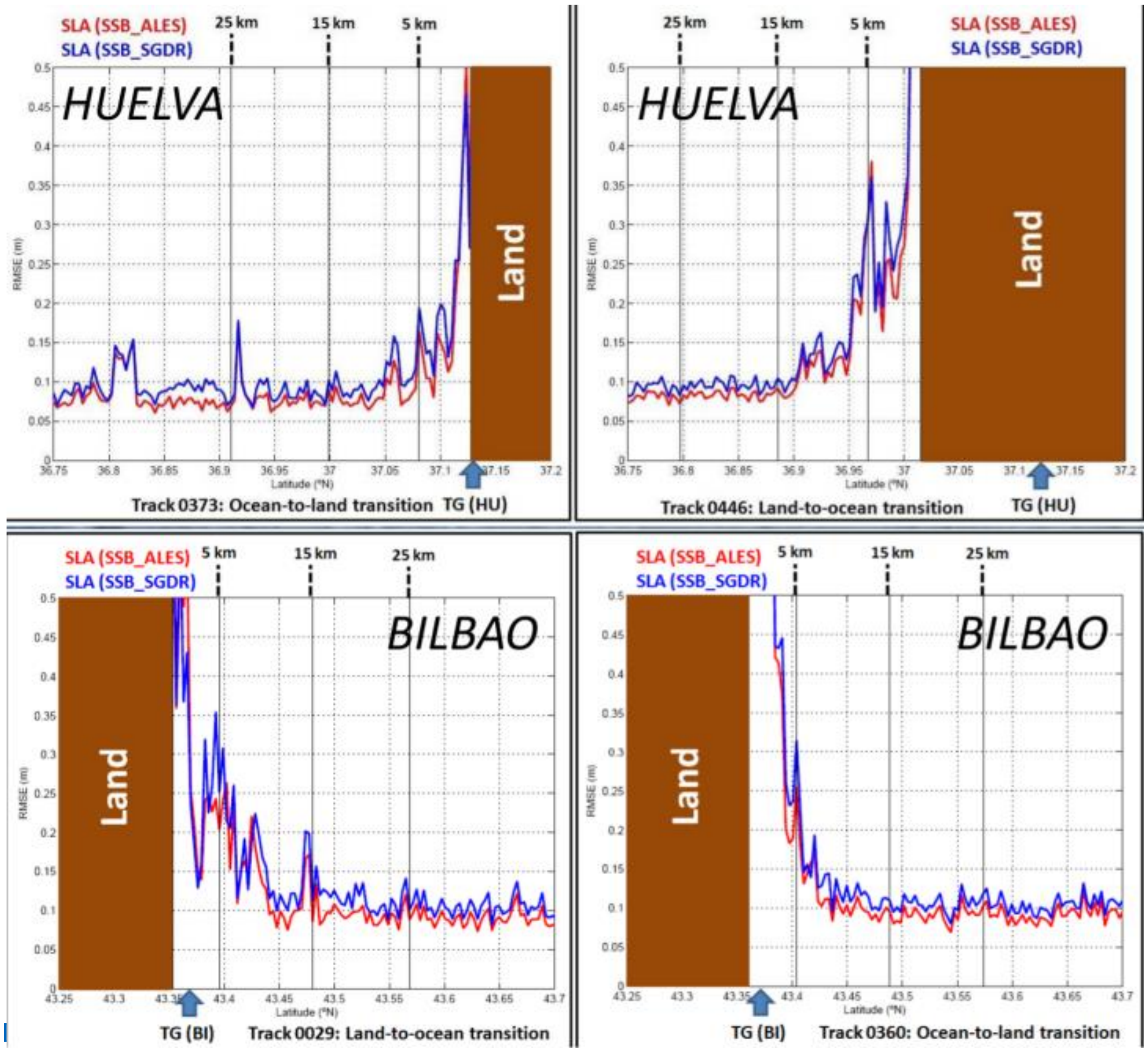
Along-track noise

Altimeter / Algorithm	Median β	% Variance explained	Resultant σ_h of h_{adj}
Jason-3/MLE-4	-0.102	38%	0.068
Jason-3/MLE-3	-0.091	35%	0.065
Jason-2/MLE-4	-0.101	38%	0.067
Jason-2/MLE-3	-0.091	35%	0.064
Jason-2/ALES	-0.117	50%	0.061
Jason-2/N-R	-0.102	19%	0.111
Jason-2/N-M	-0.252	28%	0.101
S-3A/PLRM	-0.095	40%	0.084
S-3A/SARM	-0.095	13%	0.052
Jason-3/C-band	-0.094	44%	0.137
Jason-2/C-band	-0.092	44%	0.135
AltiKa/MLE-4	-0.116	43%	0.050

Decreasing the retracker noise improves not only along-track noise, but also spectral content of sea level dataset

From: *Quartly G.D., Smith W., Passaro M.*: **Removing Intra-1-Hz Covariant Error to Improve Altimetric Profiles of σ^0 and Sea Surface Height**. IEEE Transactions on Geoscience and Remote Sensing, 1-12, 10.1109/tgrs.2018.2886998, 2019

SSB improvements: more precise and more accurate



RMSE improvement using ALES HF SSB correction instead of standard 1-Hz SSB correction,

Courtesy of Jesus Gómez-Enri J.

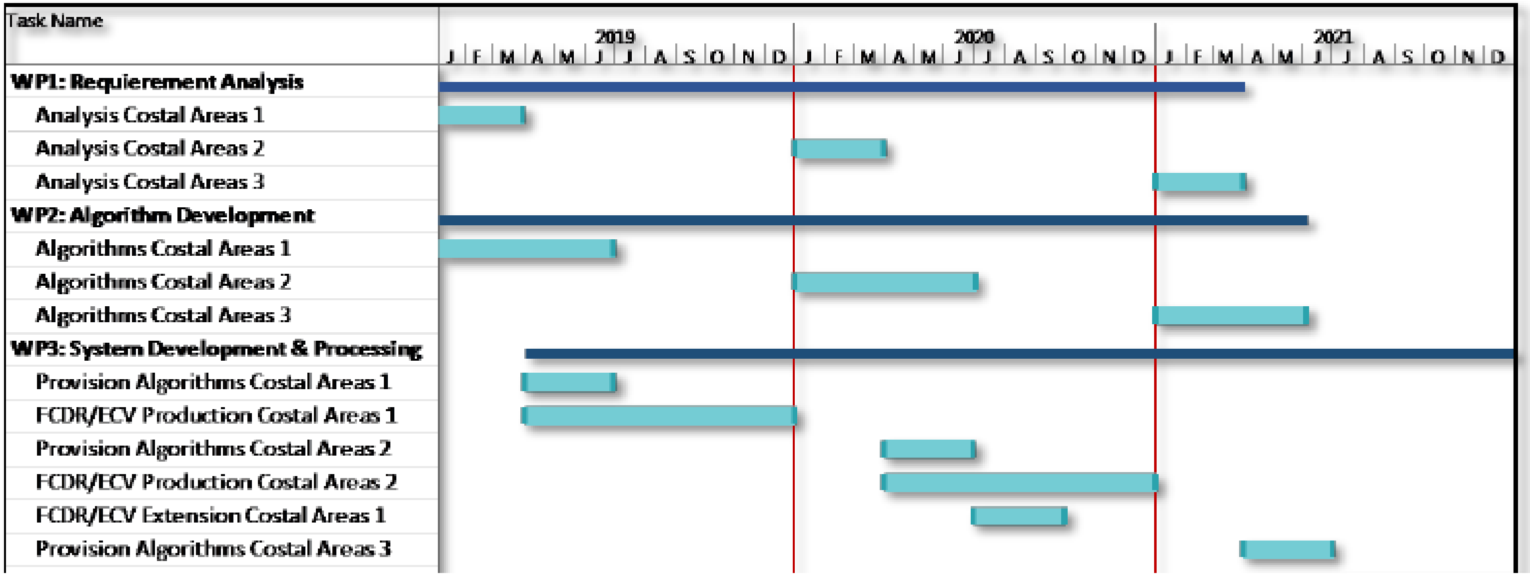
System Development: Range and SSB provision

PROJECT: CCI Extension – New R&D on CCI ECVs: Sea Level	WP: 3.1
WP Title: System Dev. & Processing – Reprocessing and provision of ALES ranges for URM missions Company: TUM WP Manager: M. Passaro Start Event: Planned Date: 01/04/2019 End Event: Planned Date: 31/12/2021	Sheet 1 of 1 Issue Ref: 1. 0 Issue Date 03/07/2018
Inputs: **Tasks:** • The adaptation of the ALES algorithm and its evolutions for the missions considered in this project • Computation, Storage and Provision of the range and SSB corrections for the selected missions and time frame, using the solutions developed in WP2.1 and 2.2 **Outputs:** • D3.1: System Specification Document (SSD) • D3.2: Climate Research Data Package (CDRP)	

To be clarified:

- TUM is not the system developer of this project. We only provide Range and SSB. Provision of content for SSD shall not be TUM responsibility
- TUM does not assemble the final dataset for climate analysis. CDRP not under TUM responsiblity

TUM‘s timeline



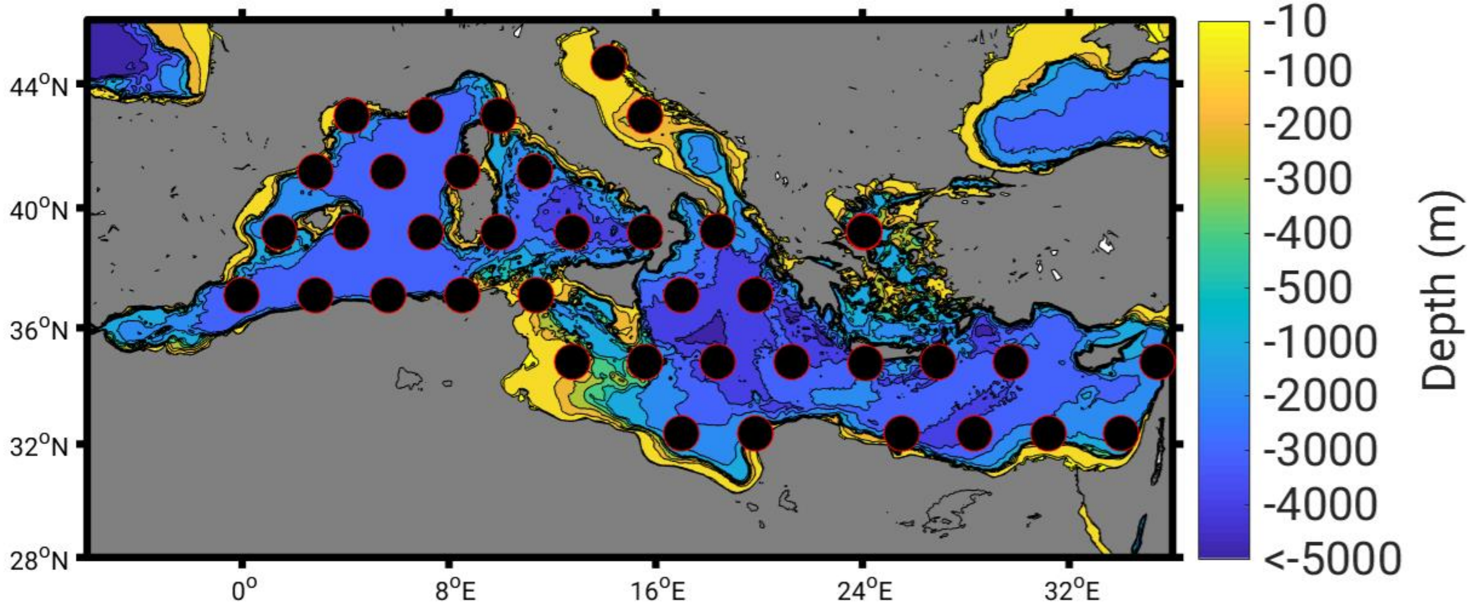
First provision of data (not algorithms) TUM to LEGOS: planned for end of September 2019

LRM Missions to be included (by the end of the project): Jason1/2/3, Envisat, AltiKa. First version doable by September 2019

SAR Missions to be included (by the end of the project): Sentinel-3 A/B. First version likely in second year.

SPARE SLIDES

Experiment: computation of a regional high-rate SSB correction



Black: crossover points of the Jason-1 mission. Full mission length used.

Use of the Fu-Glazman Model

Fu-Glazman Parametric model:

$$SSB = \hat{\alpha} SWH \left(g \frac{SWH}{U_{10}^2} \right)^{-\hat{d}}$$

At crossovers (Gaspar et al. 1994):

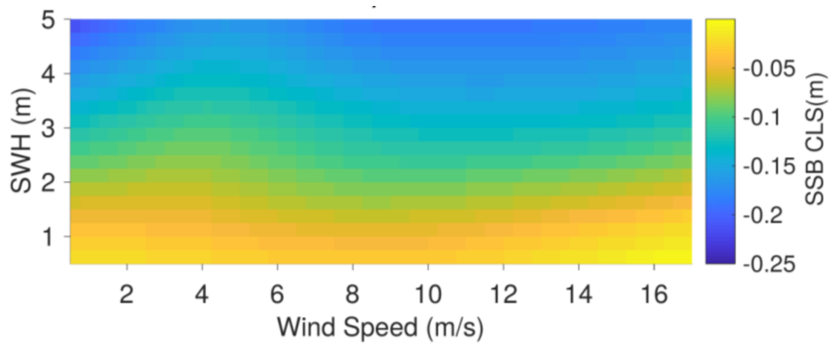
$$\Delta SLA_m = \hat{\alpha} X_o - \hat{\alpha} X_o + \epsilon \qquad (2)$$

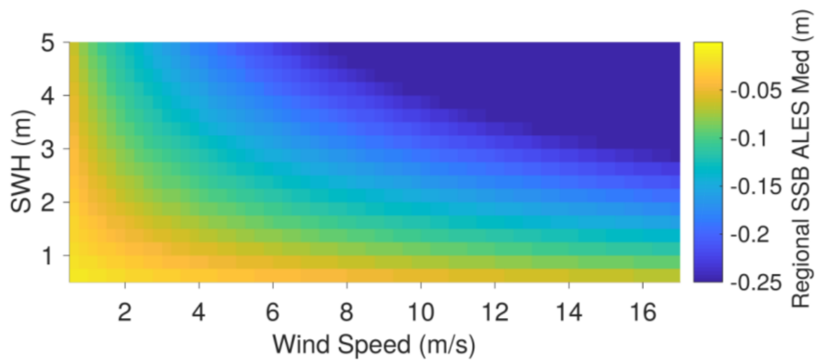
$$(3)$$

where o and e stand for odd and even tracks, ϵ accounts for residual errors that do not depend on the missing SSB correction and:

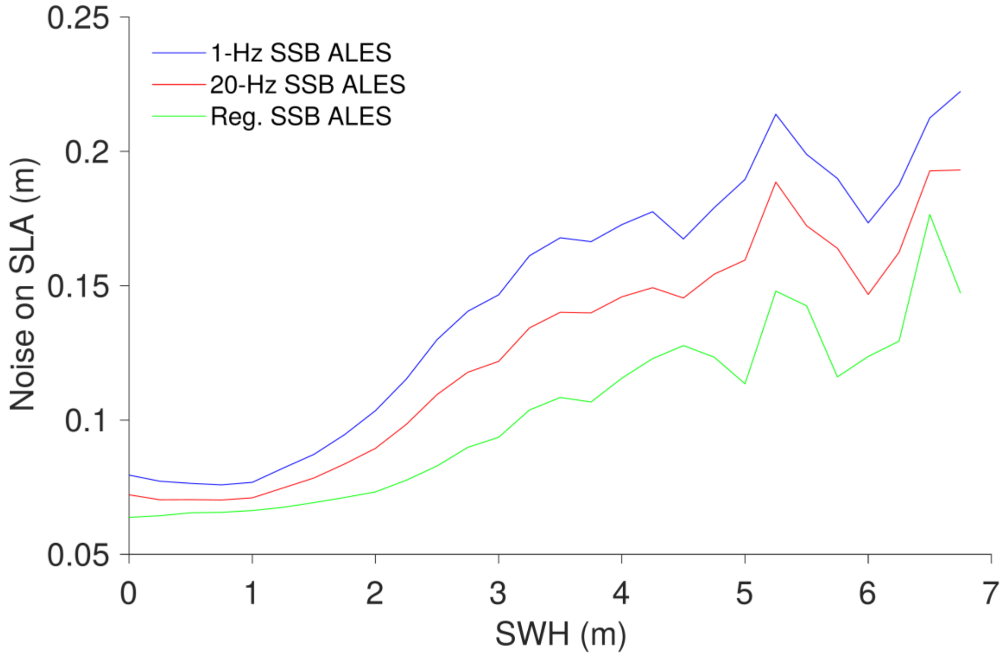
$$X_o = SWH_o \left(g \frac{SWH_o}{U_{10,o}^2} \right)^{-\hat{d}} \qquad X_e = SWH_e \left(g \frac{SWH_e}{U_{10,e}^2} \right)^{-\hat{d}} \qquad (4)$$

Comparison of SSB Tables





Noise Statistics

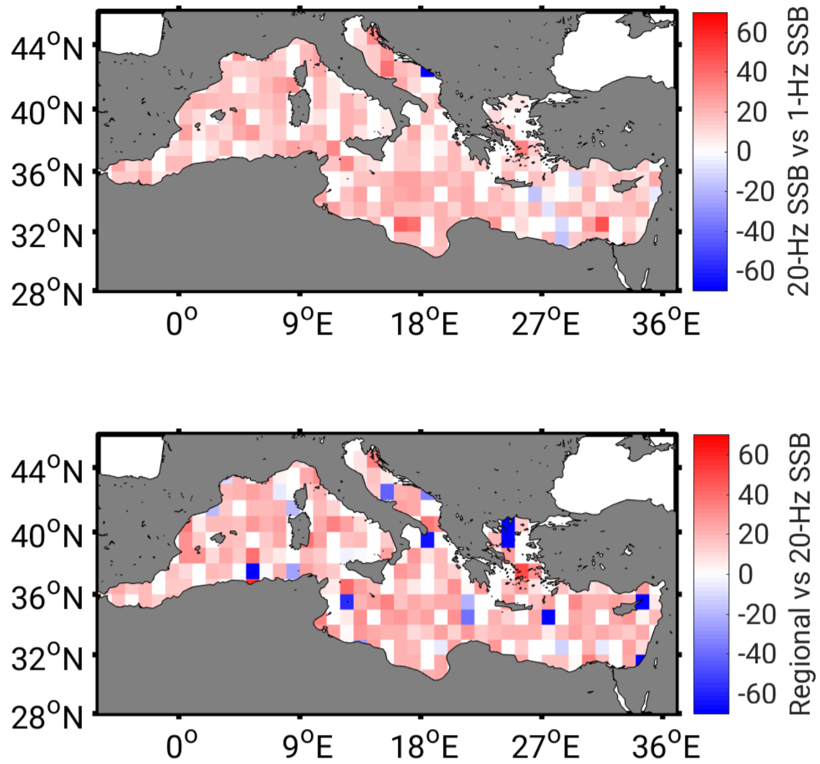


Noise computed as absolute value of the consecutive 20-Hz Sea Level Anomalies („High-Rate Noise“)

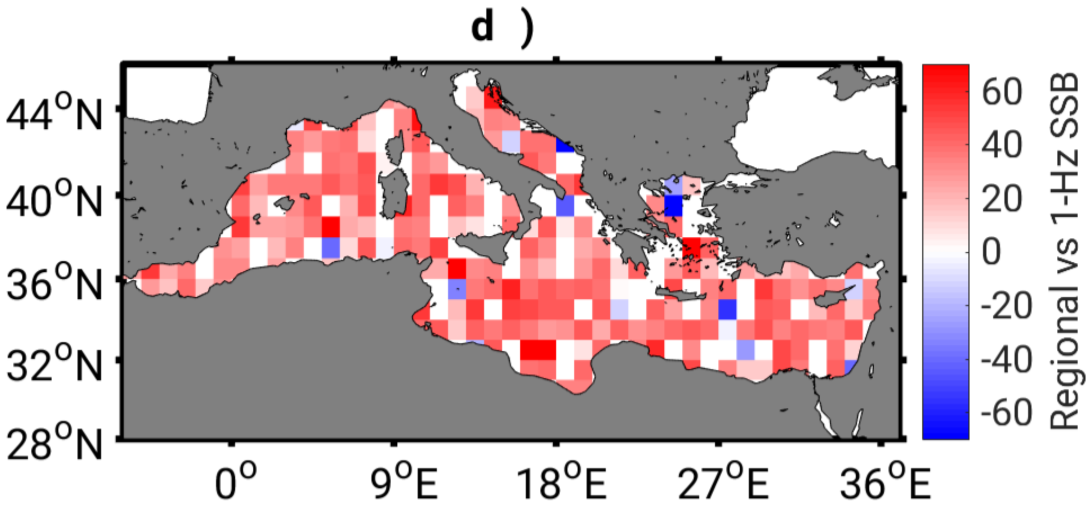
Variance Reduction

$$S = \left[\frac{(var(SLA1) - var(SLA2))}{var(SLA1)} \right] \times 100$$

Scaled SLA Variance Difference: metrics from Pires et al. (2016) based on variance reduction relative to the regional variability



Total Variance Reduction



Dataset	20-Hz vs 1-Hz SSB [%]	Reg vs 20-Hz SSB [%]	Reg vs 1-Hz SSB [%]
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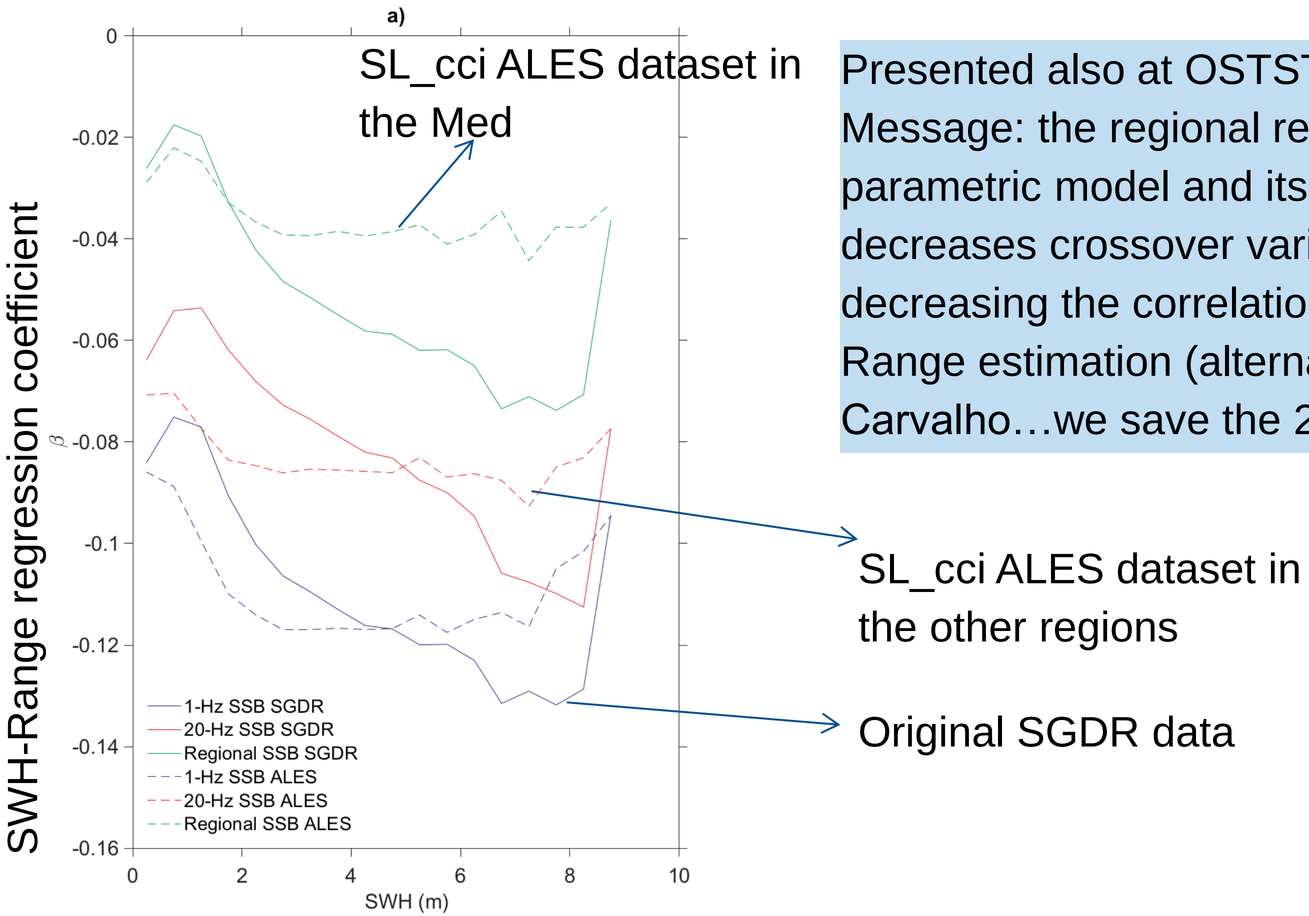
Summary of today

- Production of a recomputed SSB correction to be associated with ALES ranges using ALES SWH and Sigma0 X



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Summary of today

- Concerning TUM task:

The following activities are planned on TUM side:

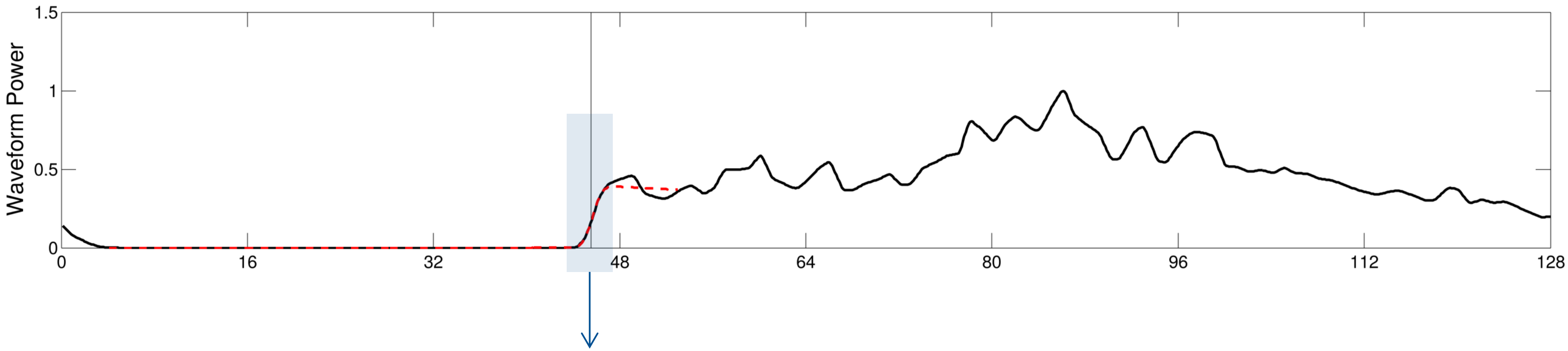
- Release of ALES products (along-track raw ranges at high frequency) in 3 pilot regions for the following missions: Jason-1, Jason-2, Envisat, SARAL/Altika X

- Production of a recomputed SSB correction to be associated with ALES ranges using ALES SWH and Sigma0 X

- Diagnostic and improvement of the editing criteria on retracked parameters through the definition of a mission-specific flag based on the fitting error

- Verification in terms of noise statistics of the retracked parameters in comparison with standard retracking in the open ocean and in the coastal zone

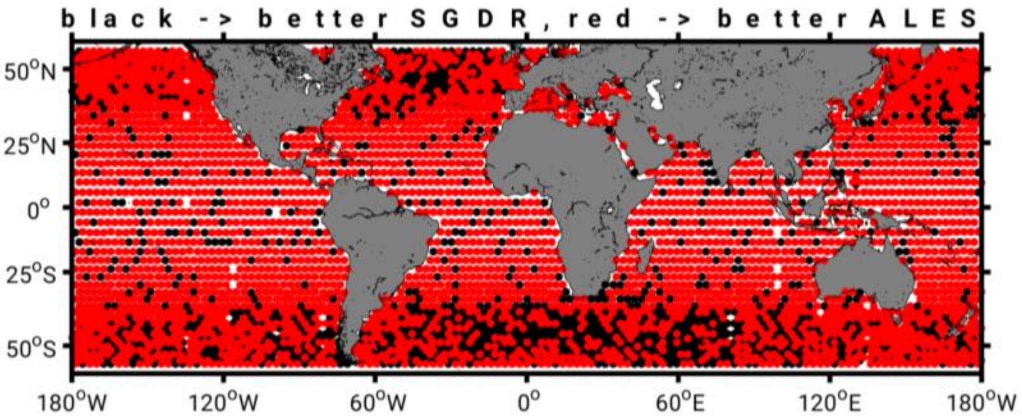
Fitting error on the leading edge as Flag



Root mean square difference (Real Waveform – Fit) in normalised power units

Crossover analysis – in space

Jason-1

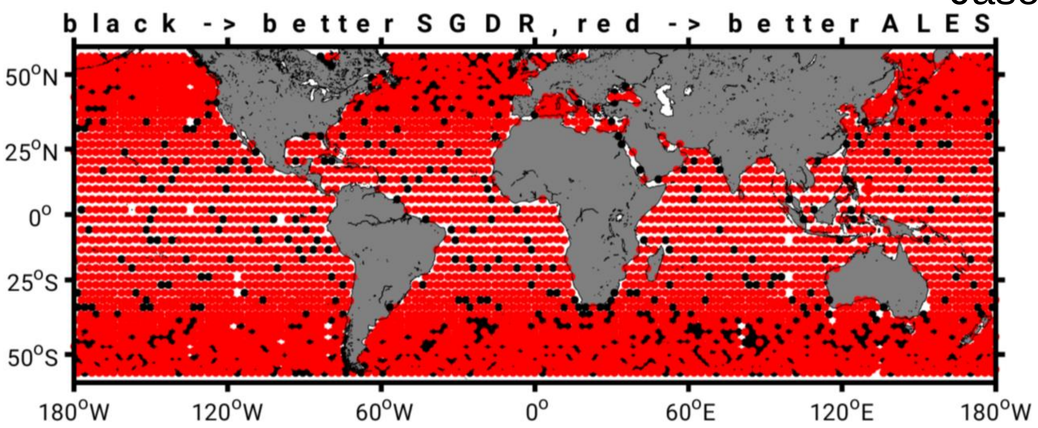


ALES is better in the 74% of the locations

Standard Deviation of the Crossovers

RED: std(ALES)<std(SGDR)

Jason-2



ALES is better in the 85% of the locations

ALES IMPROVEMENT IS NOT RESTICTED TO THE COAST