ALES for AltiKa: application of a subwaveform retracker to high frequency sea level estimation

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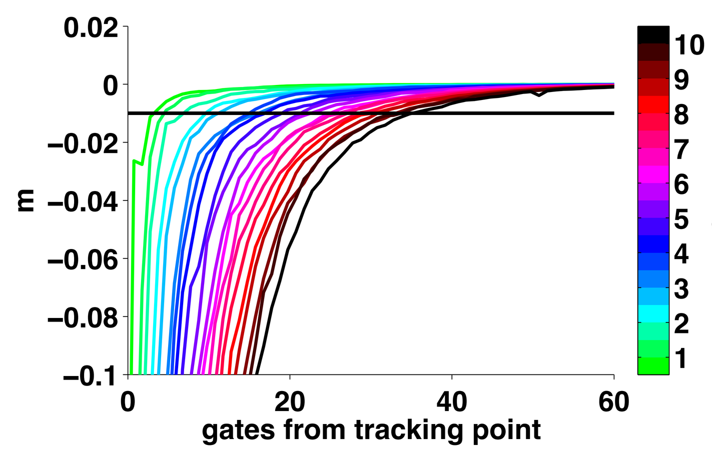
Introduction

The Adaptive Leading Edge Sub-Waveform Retracker (ALES), which has been successfully validated in conventional altimetry missions in open ocean and coastal areas, is now tuned to retrack AltiKa waveforms and tested against in-situ sea level estimations.

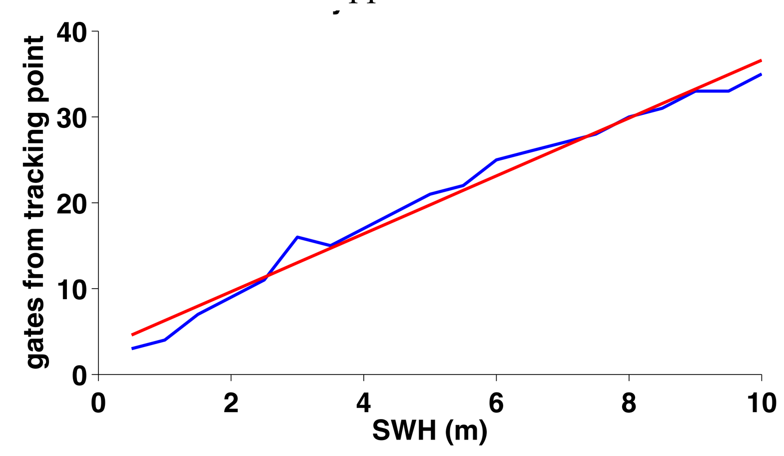
Waveforms are available at a 40-Hz rate (averages of 96 individual echoes), but a sub-waveform retracker is also the most convenient approach to retrack averages of fewer echoes, which can be particularly useful in areas such as inland waters or coasts.

ALES RETRACKER: DESIGN

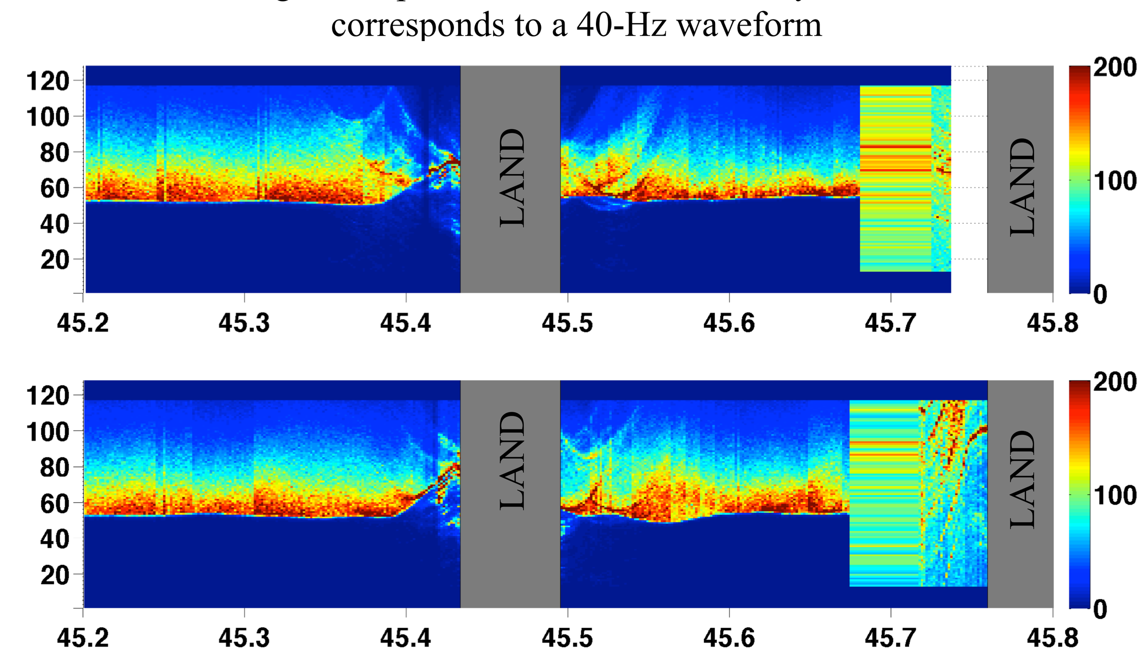
RMS Error Difference: full waveform – sub-waveform Epoch estimation



Relation between sea state an sub-waveform width for ALES applied to AltiKa



AltiKa Radargram of pass 416 for two different cycles: each column corresponds to a 40-Hz waveform



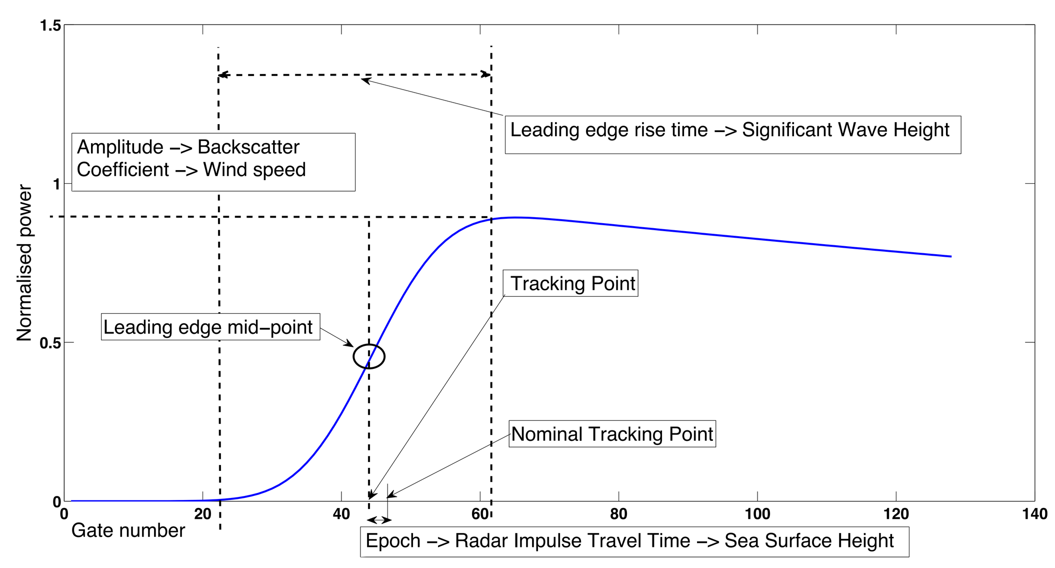
ALES algorithm is based on a linear relationship between the SWH and the sub-waveform width.

Noisy 40 Hz Brown waveforms were simulated and retracked by a sub-waveform retracker with varying width. The relationship was found setting a 1 cm tolerance on Epoch retrieval between full waveform and ALES [1].

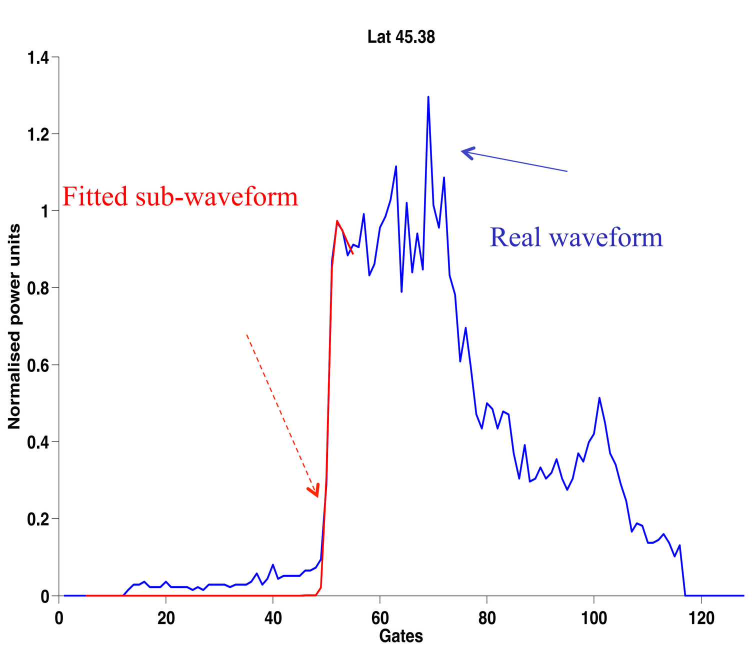
Coastal waveforms are corrupted by patches of calm water and land within the satellite footprint. (hyperbolic shapes in the radargram).

AltiKa is less affected by these spurious reflections compared to previous missions, thanks to the reduced footprint size and the higher radar frequency (fast decaying trailing edge).

Nevertheless, ALES can still be useful when "bright targets" are close to the leading edge.



Idealized radar altimeter return and parameters of interest that are estimated by retracking

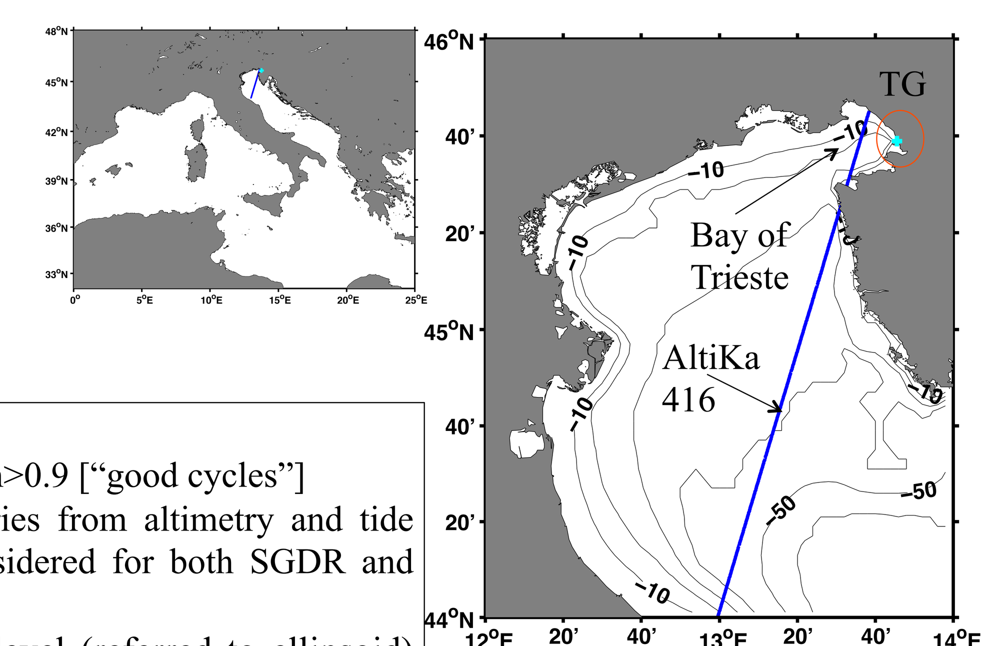


Example of ALES fit of a real AltiKa 40-Hz waveform

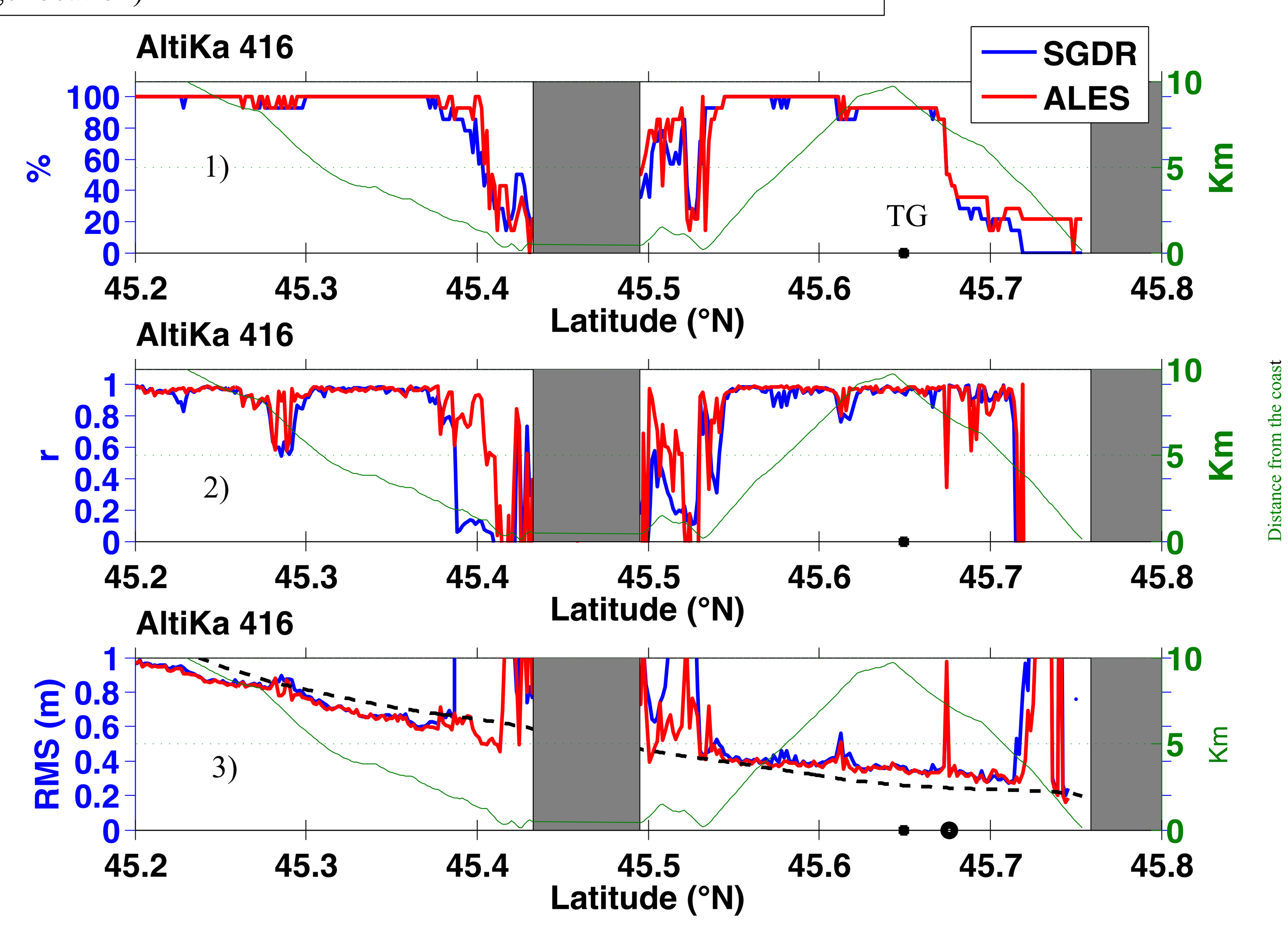
COAST

TWLE (sea level including tides) estimations from 14 ALES cycles were validated against Tide Gauge sea level in the Bay of Trieste.

As shown below, ALES was able to improve the performances, particularly within 5 km of the coast.

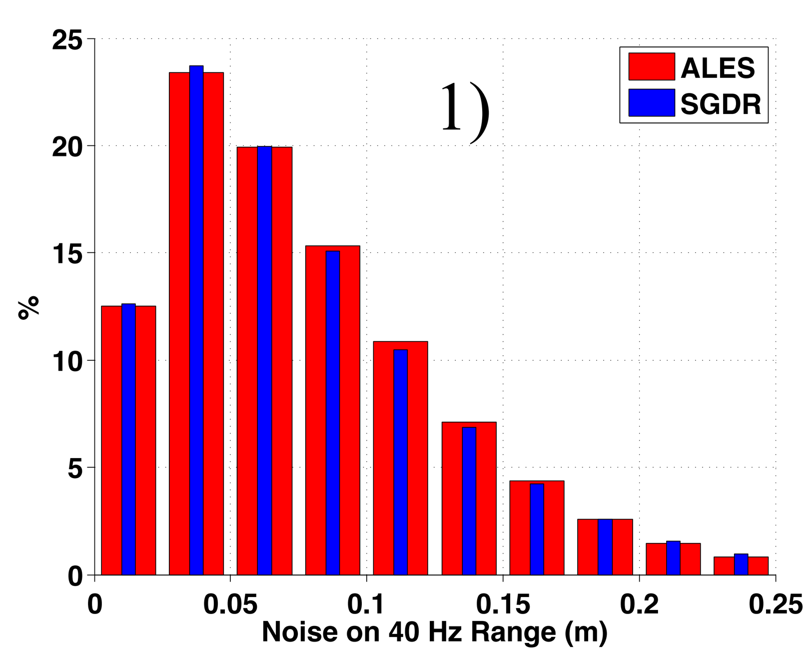


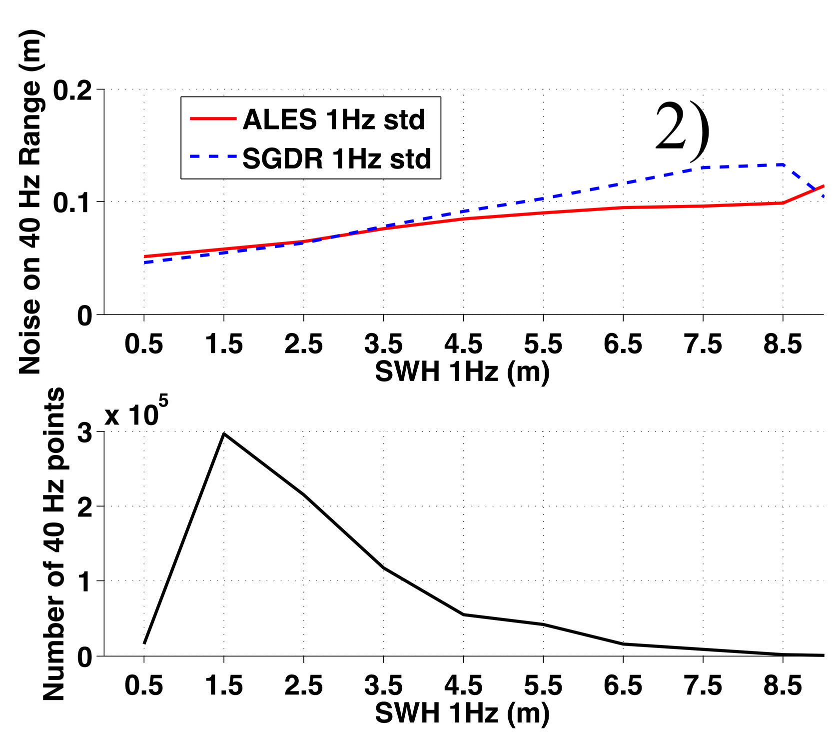
VALIDATION CRITERIA:
1) % of cycles to be kept to obtain correlation>0.9 ["good cycles"]
2) Correlation coefficient between time series from altimetry and tide gauges (outliers removed, same points considered for both SGDR and ALES)
3) RMS difference between absolute sea level (referred to ellipsoid) from tide gauges and absolute sea level from altimetry (dashed line is the geoid height difference between the ground track and the tide gauge location)



40-Hz RETRACKING OPEN OCEAN

To evaluate the performances in the open ocean, AltiKa pass 471 was retracked all along the Pacific Ocean. Noise is measured in two ways:
1) Considering the differences of consecutive sea level retrievals (a sea level change within ~165m is unrealistic)
2) Computing the std of 40-Hz retrievals within a 1Hz burst (~7 km)





FINE SCALE RETRACKING: EXPERIMENTS WITH INDIVIDUAL ECHOES (further details in [3])

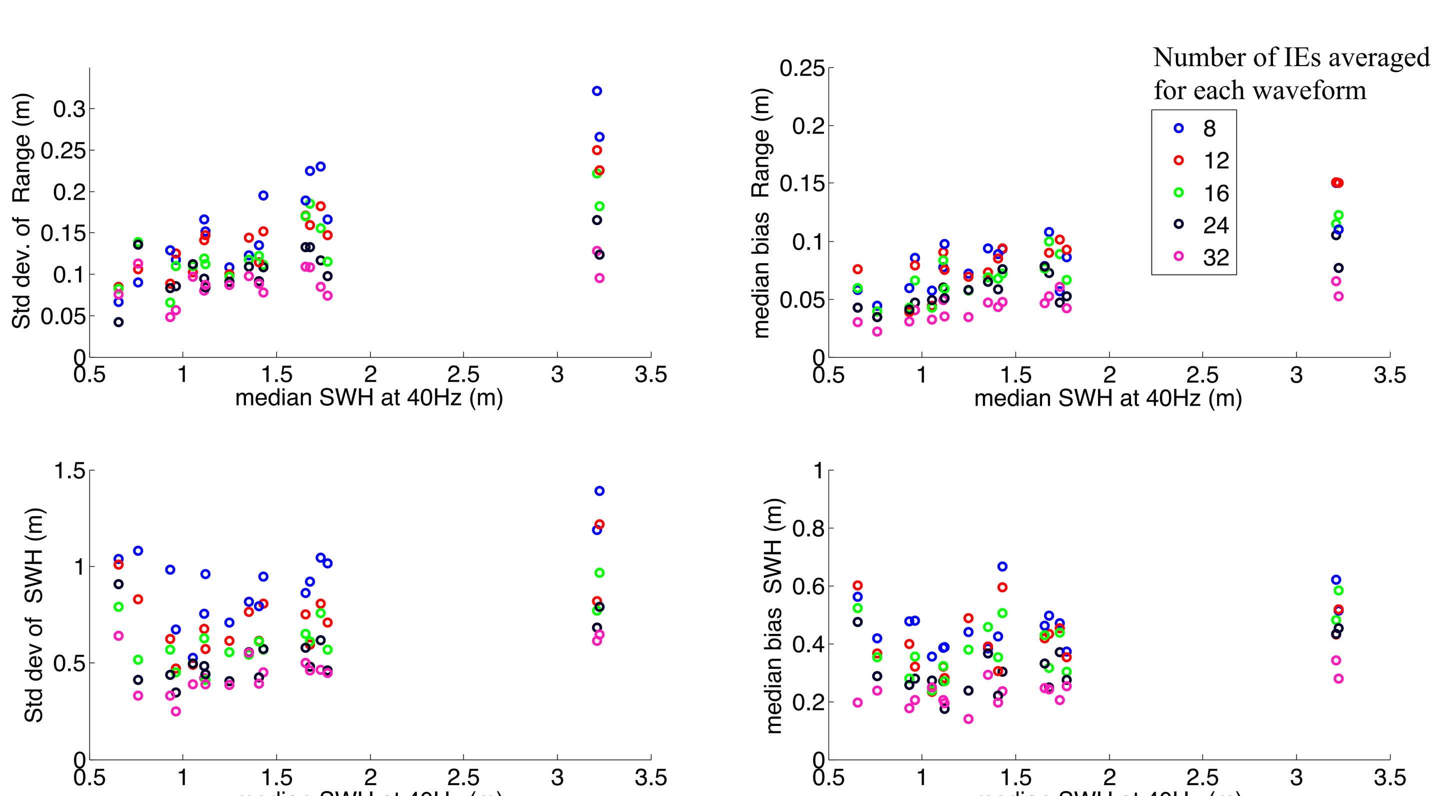
Normal high-rate retracked waveforms are an average of 96 individual echoes (IEs). In the framework of the KaNUTE project, 17 bursts of 1 seconds were collected in open sea and downlinked providing all the IEs.

Higher-frequency averages of 8, 12, 16, 24 and 32 IEs have been retracked with ALES to test the performances of a finer scale retracker.

A sub-waveform approach is more suitable for these waveforms, because their trailing edge is extremely noisy, but the leading edge is still very distinguishable.

Noise estimation: std of Range and SWH within a 1-Hz burst

Median absolute bias w.r.t. the estimation from the 40 Hz waveform

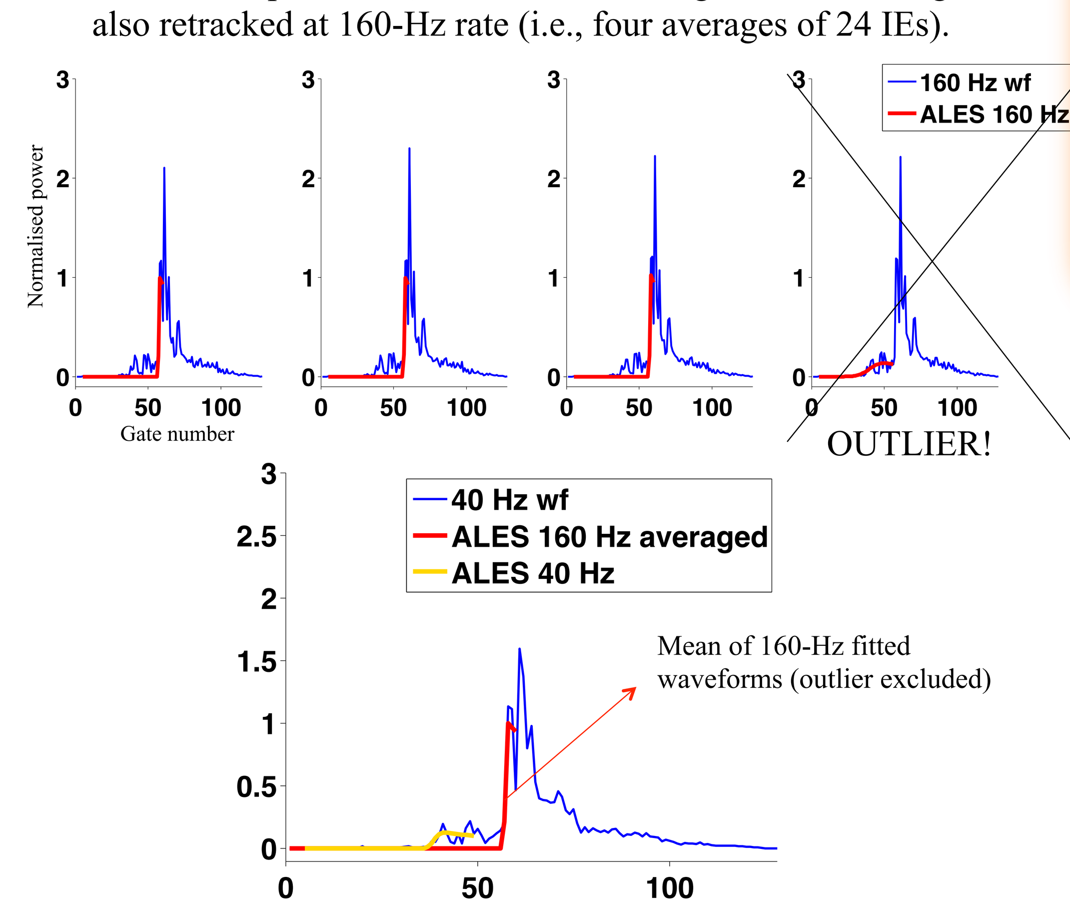


- The error decays with decreasing SWH. It also decreases as number of averaged echoes increases, at a rate of M^(-0.5) (where M is the number of IEs averaged).
- The ALES retracking of sums of 32 IEs (120 Hz) adds a lower noise level to Range estimation than was estimated for 10 Hz AEs for Jason-1 (Zanife et al. 2003, [2]).

In coastal areas and inland waters, averaging less waveforms can improve the detection of the leading edge.

By using a reference (such as the median Epoch in a 1-Hz burst), it is possible to spot incorrect estimations and provide a more reliable high-rate estimation.

In the example below, the 96 IEs forming a 40-Hz average are also retracked at 160-Hz rate (i.e., four averages of 24 IEs).



Conclusions

Sea level estimations from ALES retracking of high-rate (40 Hz) AltiKa waveforms improve in the last 5 km from the coast and have similar noise performances in the open ocean w.r.t. the standard product.

ALES is able to retrack waveforms at higher frequencies (>40 Hz). Noise performances of finer scale retracking are encouraging and suggest possible applications to improve the estimates in challenging areas, such as coasts and inland waters.

References

[1] Passaro, M., Cipollini, P., Vignudelli, S., Quartly, G., Snaith, H. (2014) ALES: a multi-mission adaptive sub-waveform retracker for coastal and open ocean altimetry. *Remote Sensing of Environment*, 145, 173-189.

[2] Zanife, O.-Z., P. Vincent, L. Amarouche, J.P. Dumont, P. Thibaut, S. Labroue (2003) Comparison of the Ku-band range noise level and the relative sea-state bias of the Jason-1, TOPEX, and Poseidon-1 radar altimeters, *Marine Geodesy.* **26**: 201-238.

[3] Quartly, G.D. and Passaro M. Initial Examination of AltiKa's Individual Echoes , submitted to *Marine Geodesy* (under review)

Acknowledgments

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