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Estimating Significant Wave Heights from SAR waveforms with a Leading Edge Retracker

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Motivation:

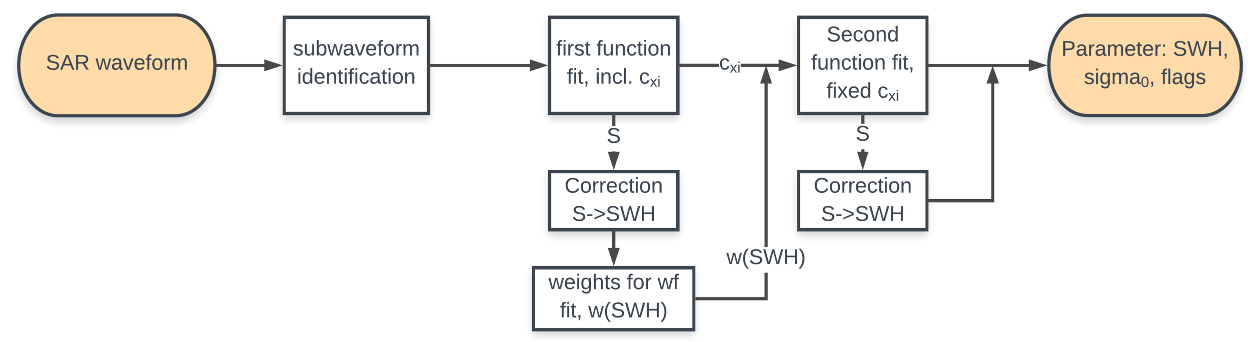
Conventional fitting methods used to retrieve sea surface heights from altimetry waveforms provide the by-product of significant wave heights (SWH). Together with the back scatter coefficient, SWH describes the sea state. However, these algorithms, called retrackers, are not tuned for precise SWH estimation, which leaves them unable to quantify extremes and prone to high noise. In the Sea State Climate Change Initiative Project of the European Space Agency a new improved sea state record is sought with new or improved methods.

For 25 years pulse limited altimeters have observed the ocean, but with the launch of CryoSat-2 in 2010 and the pair of Sentinel-3A (2016) and 3B (2018) the technique of Delay-Doppler or SAR altimetry has been established. SAR waveforms differ from LRM waveforms in the way they are generated, therefore dedicated algorithms are needed for SAR altimetry.

This study proposes a new retracker for the estimation of SWH from SAR waveforms based only on the leading edge of the waveform.

Method Subwaveform Retracker SAR-WHALES

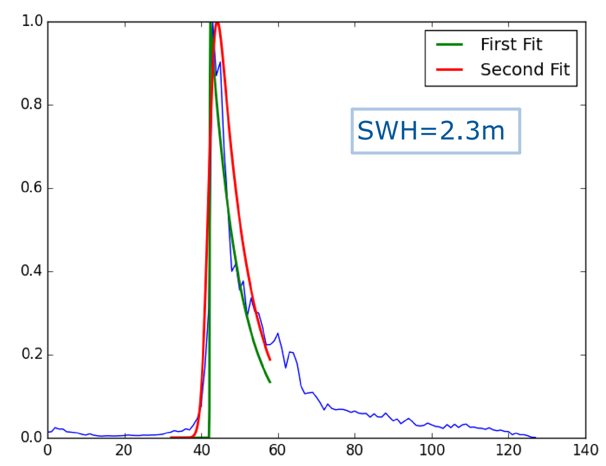
- Slope of the leading edge is relative to the significant wave height (SWH)
- This slope is estimated with a subwaveform retracker
- Inheriting of ALES+ retracker (Passaro et al. 2018) the subwaveform detection
- Relationship between the rising time of the leading edge (S) and SWH is determined in a Monte Carlo simulation with a SAR waveform simulation



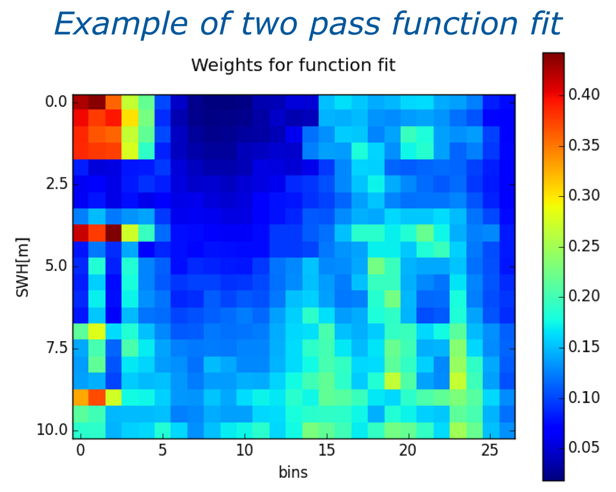
Flowchart of algorithm

Two pass function fit

- To the subwaveform a Brown-Haynes model is fitted
- First run: Slope of the trailing edge c_{xi} is estimated and all gates are equally weightes
- Second run: Fixed c_{xi} is used and weights according to the estimated SWH of the first run



Example of two pass function fit



Weights used in second fit

Analytical Correction

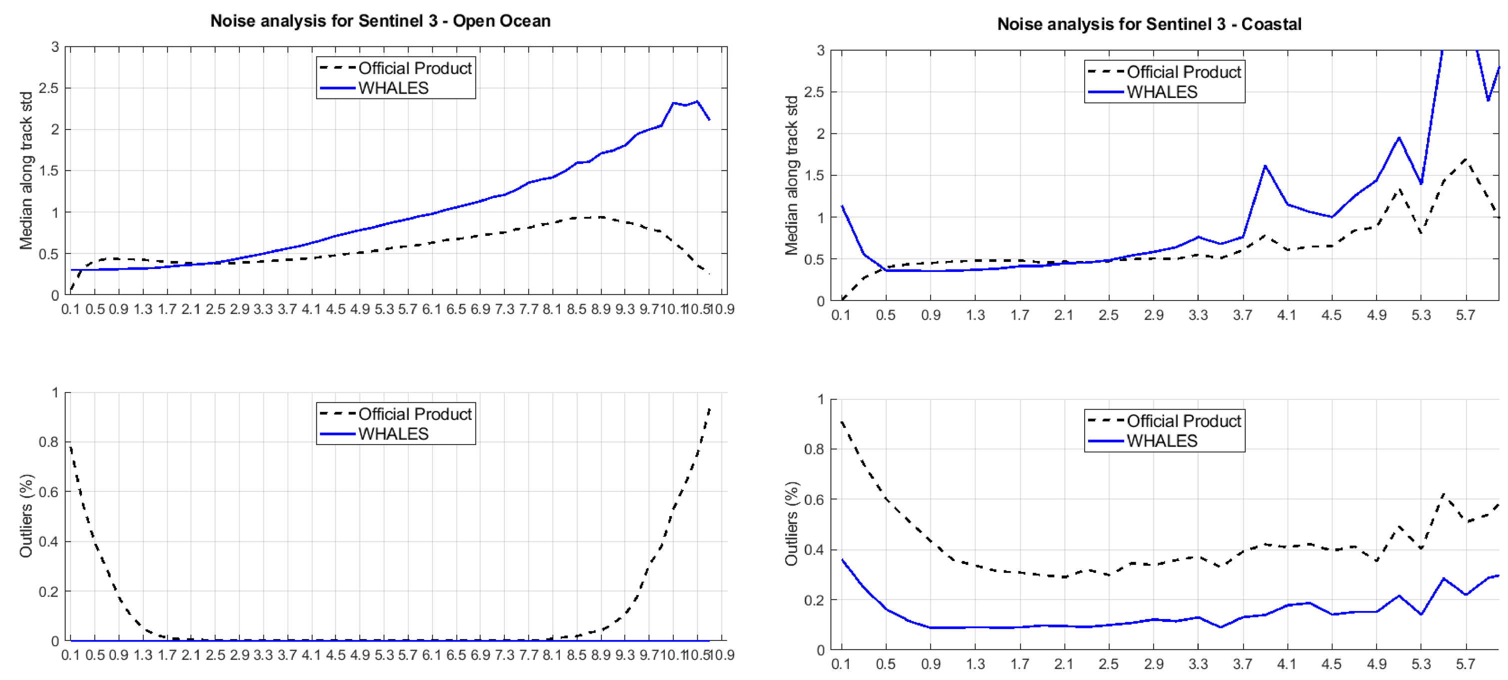
- Simulation of SAR waveforms according to formulas provided for the SAMOSA retracker (Gommenginger et al. 2017)
- Monte Carlo simulation of waveforms with SWH between 0 and 15 m
- Each simulated waveform is retracked to establish S-SWH relationship
- SWH depends on S with a square root function

$$SWH = \sqrt{28.6 \cdot S + 29.5} - 8.2$$

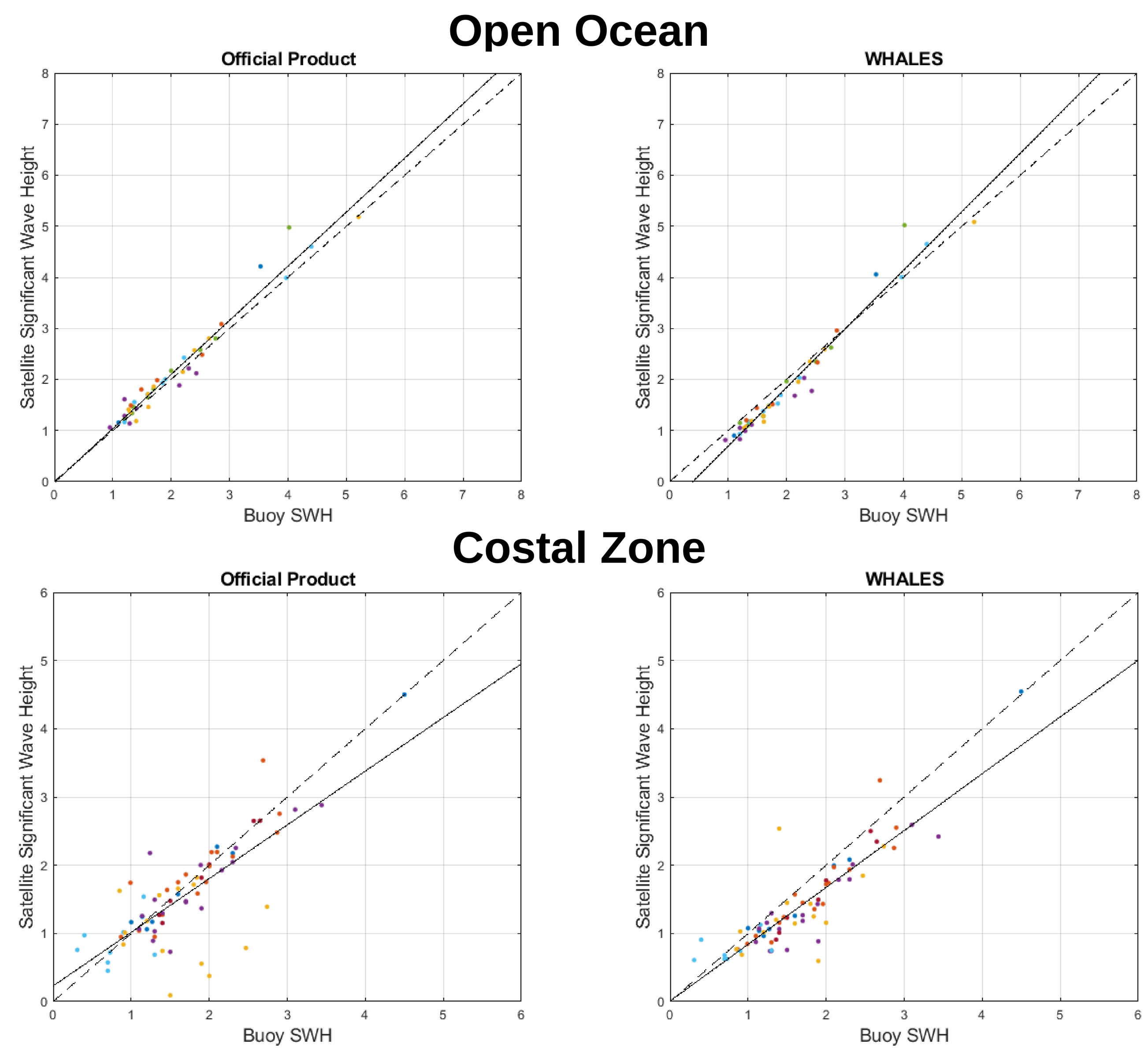
Results and Validation

Test area: US West Coast

Internal Validation



Buoys Validation



	WHALES	Standard Product
	Open Ocean	
Correlation	0.98	0.97
Standard deviation	0.26	0.22
	Costal Zone	
Correlation	0.91	0.83
Standard deviation	0.36	0.50

Conclusion:

- Application of a subwaveform retracking strategy with a simple Brown-Hayne model improves the detection of low sea states and strongly improves the performance in the coastal zone with significantly less outliers
- Lower precision for SWH>2.5 m in the open ocean could be due to range alignment in the stack
- Accuracy in the open ocean of similar quality, strongly improved at the coast

Literature:

Passaro, M., Rose, S. K., Andersen, O. B., Boergens, E., Calafat, F. M., Dettmering, D., & Benveniste, J. (2018). ALES+: Adapting a homogenous ocean retracker for satellite altimetry to sea ice leads, coastal and inland waters. *Remote sensing of environment*, *211*, 456-471.

Gommenginger, C., Martin-Puig, C., Srokosz, M., Caparrini, M., Dinardo, S., Lucas, B., Restano, M., Ambrózio, A., & Benveniste, J. (2017). Development of SAR Altimetry Mode Studies and Applications over Ocean, Coastal Zones and Inland Water (SAMOSA). Technical Report