Imrovement of Inland Water Areas Altimeter Height Estimation Using New Retracking Techniques

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Introduction

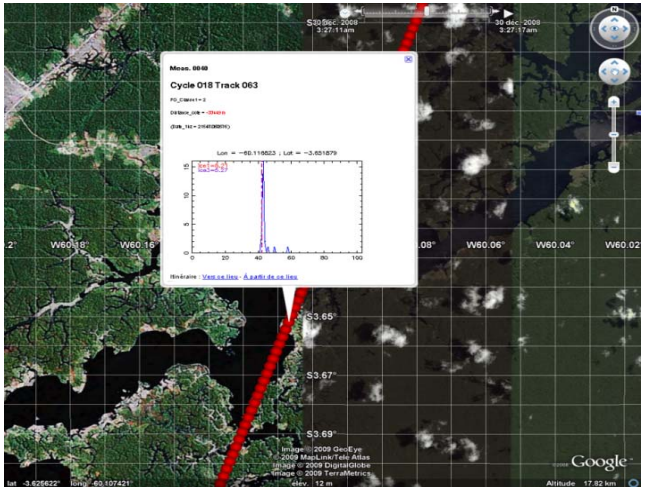
Over open ocean, the geophysical parameters are estimated using retracking algorithms that uses analytical physical model developed thanks to a statistical description of the ocean surface. Over heterogeneous areas like coastal and inland water, the altimeter waveform contains contributions from different surfaces depending on the content of the altimeter footprint. Moreover, the non water surfaces present very high height and roughness variations that are very difficult to describe.

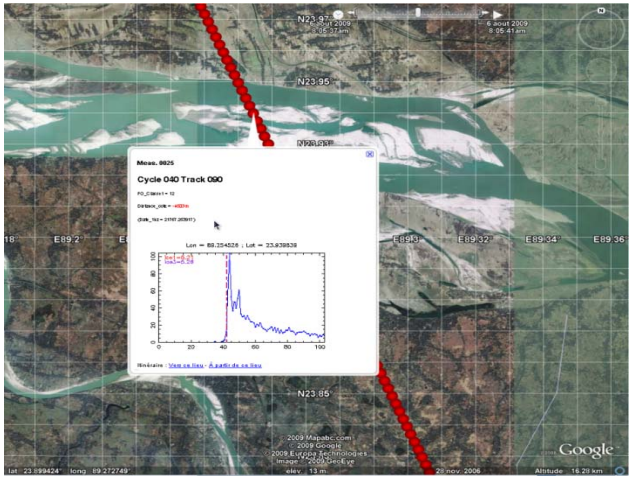
We analysed Jason-2 waveforms acquired over coastal and inland water areas and we developed new retracking techniques for those waveforms. The first one is based on a new waveform analytical model and the second one based on the waveform deconvolution. Both of them used an automatic fitting of some parameters. Those two methods showed a improved ability to fit the varying waveforms shapes over inland water.

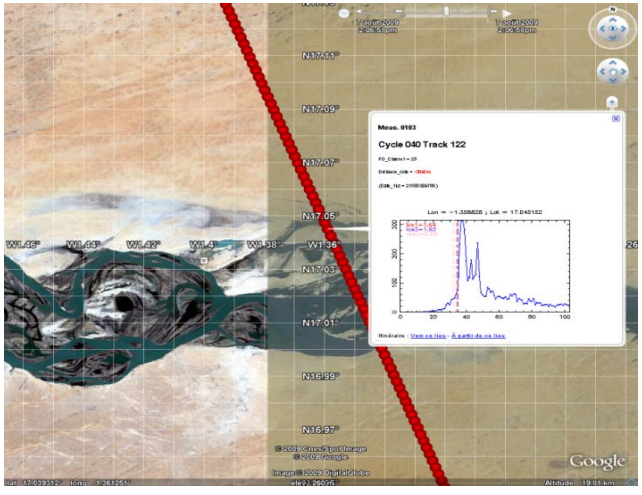
The obtained results have been compared to in-situ data over more than 50 areas and more than one year of data. Those retrackings showed high improvements on the height estimation errors.

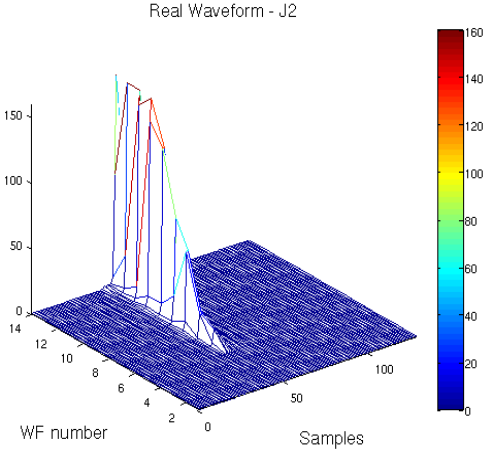
Analysis of the waveforms

We analyzed several cycles of Jason-2 waveforms acquired over different hydrological basins.
Some examples of the waveforms shapes are provided below.









New Retracking based on an analytical empirical model

- This model has been first developed for the retracking of altimeter waveforms over ice surfaces.
- This model is based on the radar equation as for Brown model but with a different sigma0 model

$$S(t) = \frac{\lambda^2}{(4\pi)^3} \int_{Surface} \frac{\delta(t - 2r/c) G^2(\theta) \sigma_0(\theta)}{R^4} dA$$

- On the contrary of Brown model, the sigma0 function used is varying with the incidence angle

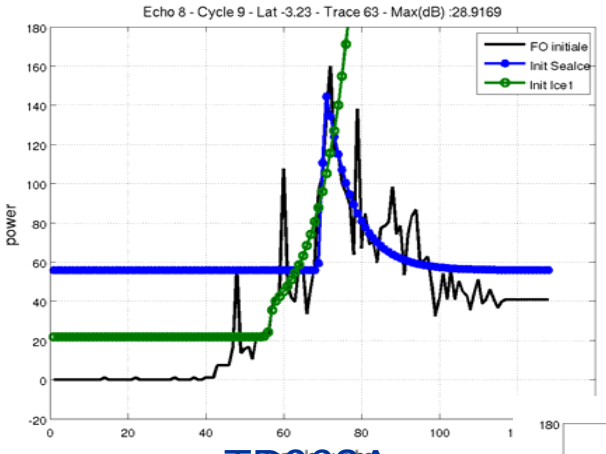
$$\sigma_0(\theta) = \sigma_0(0) \exp(-\sin^2(\theta)/mss)$$

- The model can write as an integral:

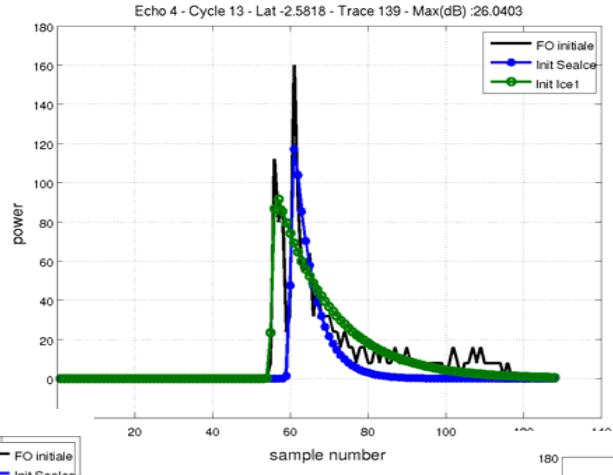
$$S(t) = \frac{\lambda^2 \sigma_0(0) G^2(0)}{(4\pi)^3} \int_{Surface} \frac{\delta(t - 2r/c) \exp\left(-\frac{2}{\Gamma}\sin^2\theta\right)}{R^4} dA \qquad \Gamma = \frac{4\gamma * mss}{4 * mss + \gamma}$$

- The integral can be solved in a maner very close to the solution of the Brown model.
- This model allows fitting waveforms that present variations of the trailing edge related to a change in the surface properties
- Two different retrackings with the same model have been selected, both based on a MLE and an analysis window centered on the initial epoch estimate:
  - Ice_New_1: the epoch is initiated with the Ice 1 or OCOG.
  - Ice_New_2: use of Sea Ice algorithm to initiate the epoch

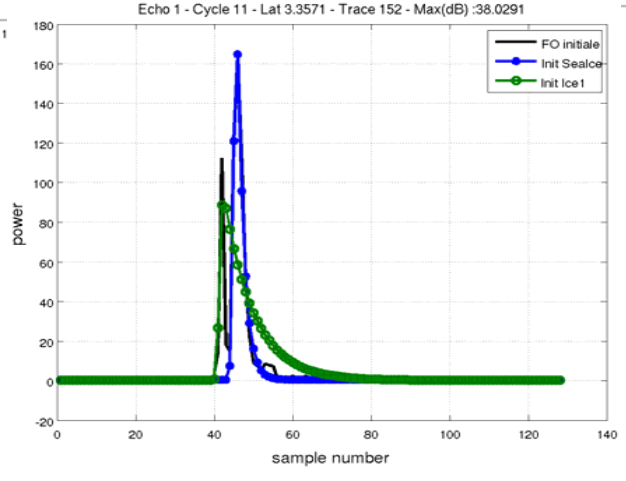
Some examples with the analytical model retracking



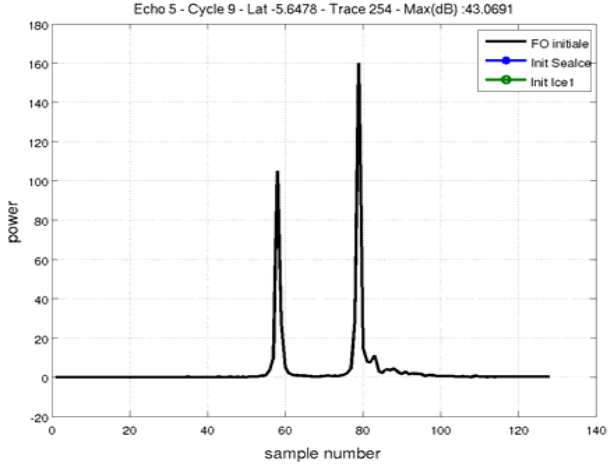
TP063A - Solimoes



TP139A - Amazone



TP152B- Branco



TP254A - Purus

In general very good fitting with the new model is obtained. Nevertheless (see the above examples), the algorithms used to initiate the epoch is of high importance in case of multi-peaked waveforms.

Deconvolution techniques

- This method is based on the Brown convolution describing the waveform model

$$P(t) = FSSR(t) * RI(t) * SP(t)$$

- The deconvolution consists in isolating the term describing the surface probability density function using the following formulas
  - « classical method » :

$$SP(t) = FFT^{-1}\left(\frac{FFT(P(t))}{FFT(RI(t)).FFT(FSSR(t))}\right)$$

  - « Derivatives method »:

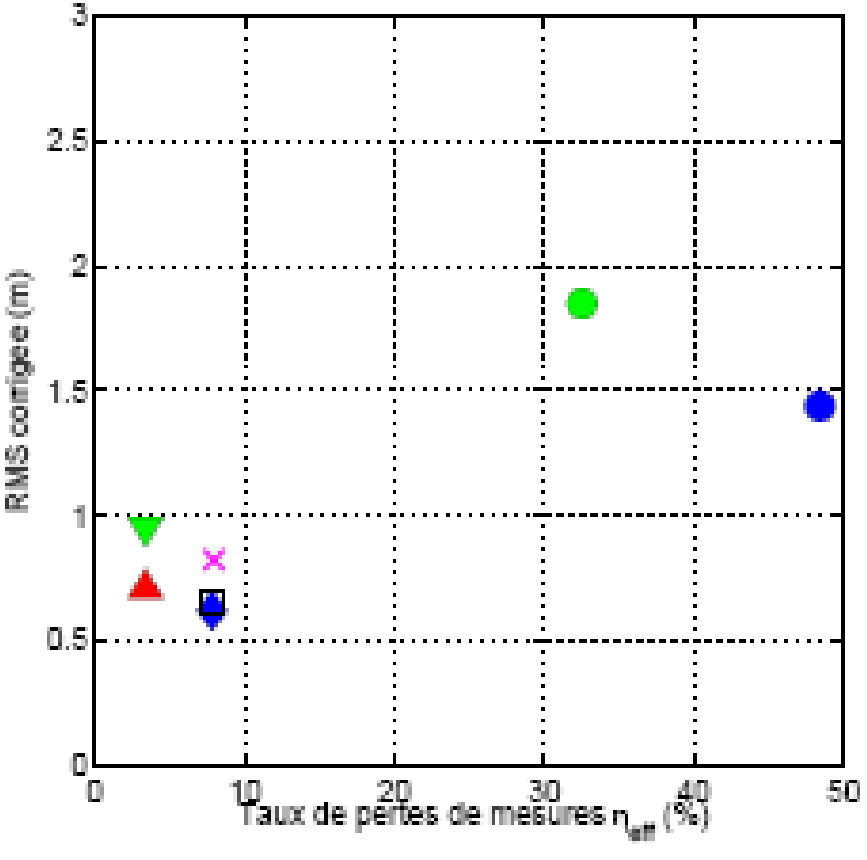
$$SP(t) = FFT^{-1}\left(\frac{FFT(P'(t))}{FFT(RI(t))}\right)$$

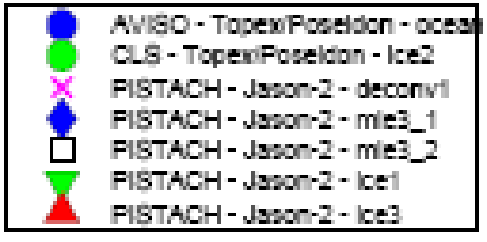
- These methods have been used in the past (see Rodriguez et al. 1989) for the ocean surface. The performance were lower than for the MLE algorithms.
- To extract the surface parameters a fit of the probability density function is used.

Performance comparison

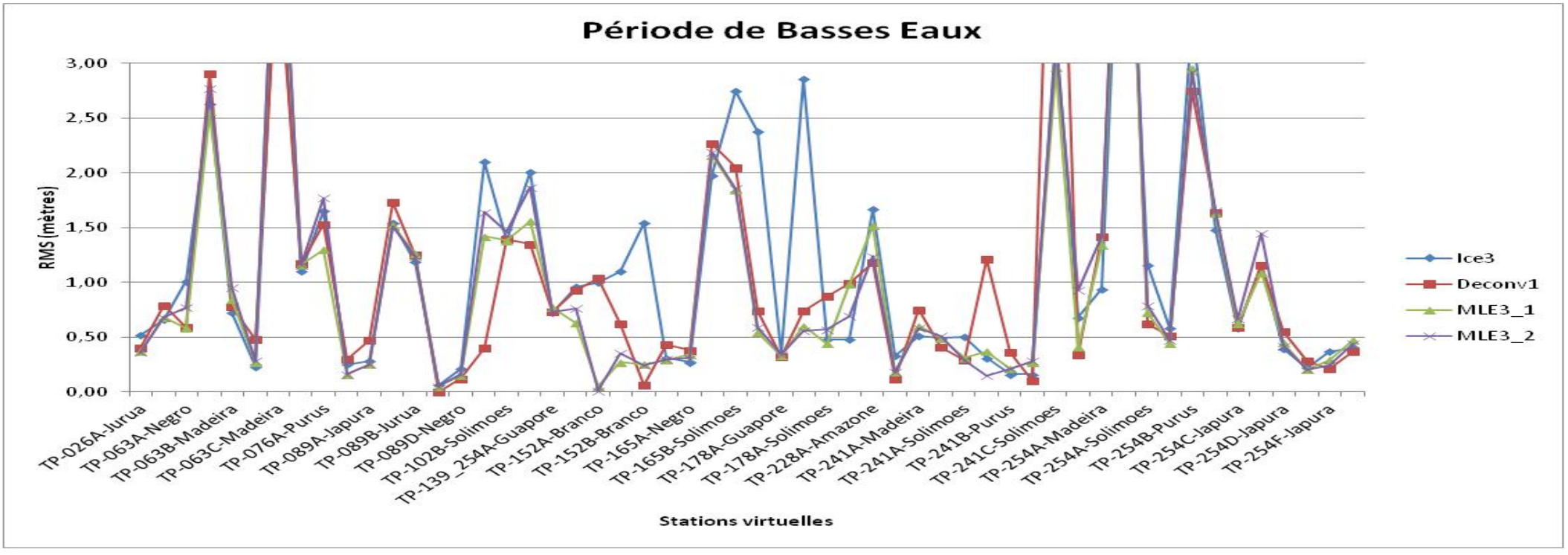
A collaboration activity with CEMAGREF laboratory (N. Bercher, P. Kosuth, CEMAGREF, Montpellier) provided a global assessment of the retracking methods developed.

This quality assessment used satellite derived river water level time series from the different retrackers over 53 virtual stations over the Amazon and 40 cycles of Jason-2 data.





	Ice3		Devonvolution		MLE3_1		MLE3_2	
	RMS (m)	Taux de perte (%)	RMS (m)	Taux de perte (%)	RMS (m)	Taux de perte (%)	RMS (m)	Taux de perte (%)
Série temporelle globale	**0.72**	3.3	**0.82**	7.9	**0.62**	7.8	**0.66**	7.8
Hautes eaux	0.19	2.0	0.41	7.7	0.21	7.8	0.19	7.7
Moyennes eaux	0.50	2.4	0.66	8.1	0.45	8.2	0.46	8.2
Basses eaux	1.17	1.6	1.10	10.7	0.99	10.6	1.04	10.6



Conclusions and perspectives

- The developed methods are very promising since they improved the performance of height estimation
- Nevertheless, we think that we still have a margin for further improvements by a correct combination of all the analysed retracking techniques
- The methods we developed for the conventional altimetry could be analyzed and adapted to the Ka band and SAR mode waveforms.