Processing of AltiKa waveforms: New retracking algorithms implemented in the PEACHI project

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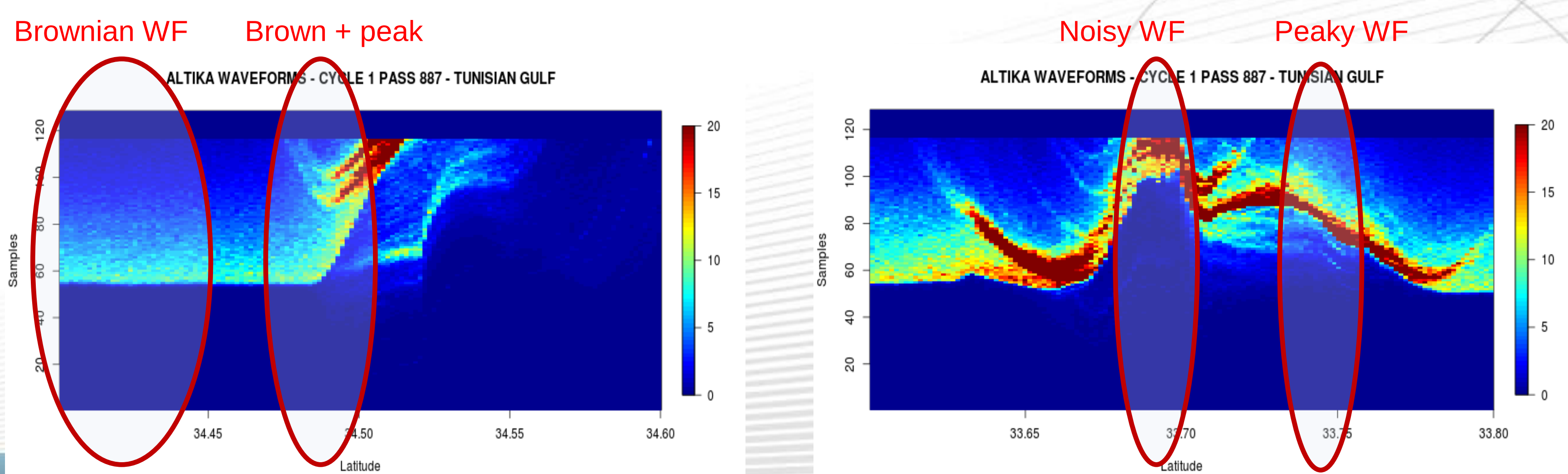
Retrackings in PEACHI

- As AltiKa is working at 40 Hz and provides high quality measurements, it is interesting to perform new retracking algorithms to improve the estimates accuracy. This is one of the goals of the PEACHI project (cf G. Valladeau's talk).

- Many different retrackers exist and have already been implemented on previous altimetry missions. In the AltiKa ground processing, 4 retrackers are implemented : MLE-4, Ice-1, Ice-2 and SeaIce. In the frame of the PEACHI project, we studied:
  - the possibility to improve existing algorithms
  - new retrackers : IceNew, BAGP3, Red-3 and 2-steps retracking approach, numerical solutions …



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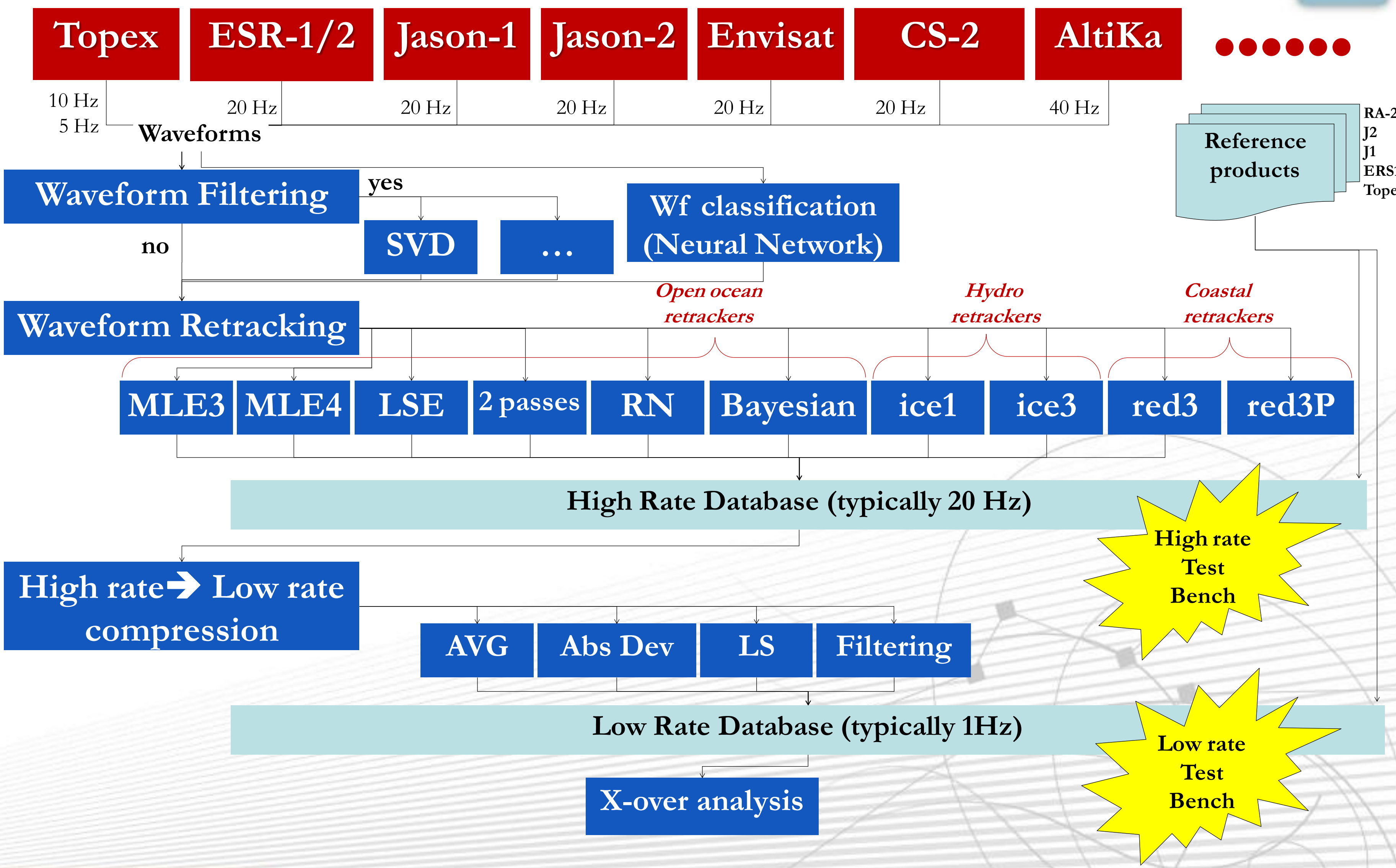
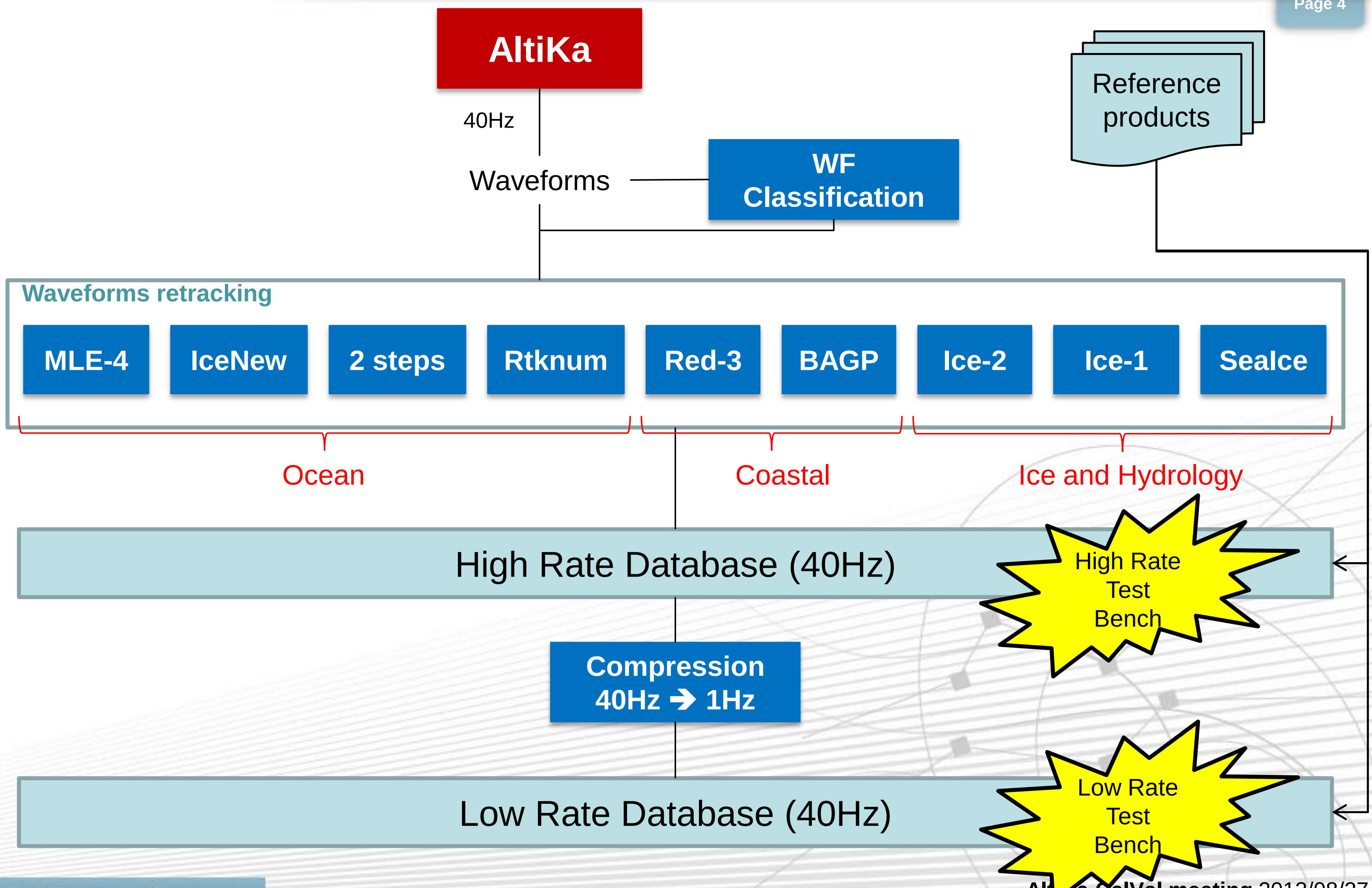
The existing retracking test bench

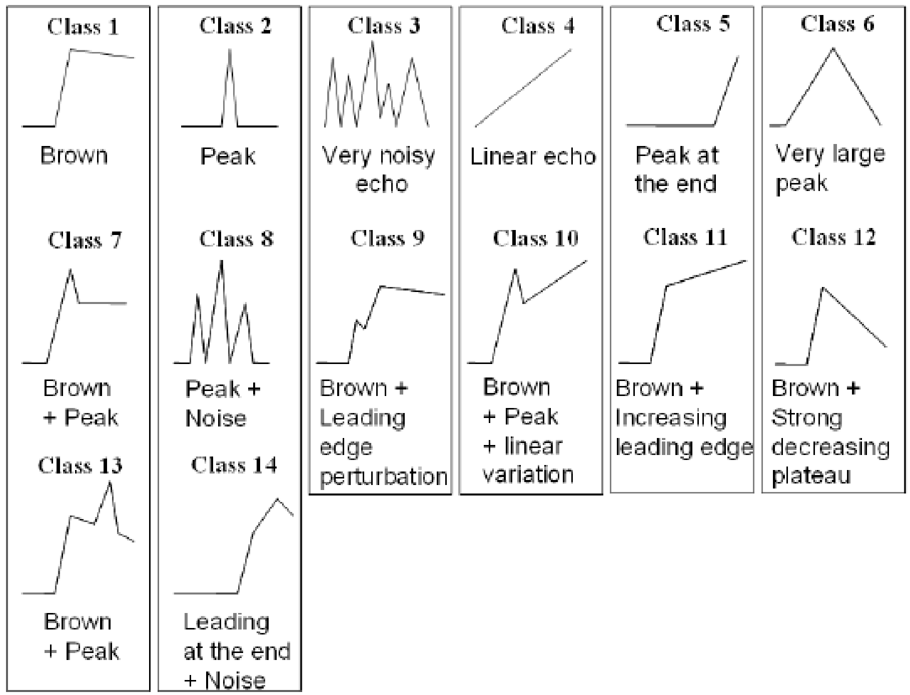


The PEACHI retracking process



Waveform classification

- A geometrical classification of altimetric waveforms is implemented in the PEACHI processing, based on a neural network algorithm (as in the CNES PISTACH project) .



Geometrical classification of altimetric waveforms
CNES/PISTACH project

Ocean retracker : IceNew

- The IceNew algorithm was designed to process sea ice data but can be helpful on Sigma0 blooms or rain cells.
- IceNew is based on a classical Brown model :

S(t) = FSSR(t)*RI(t)*PDF(t)

but in the FSSR the Sigma0 is formulated to take into account of the incidence angle:

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

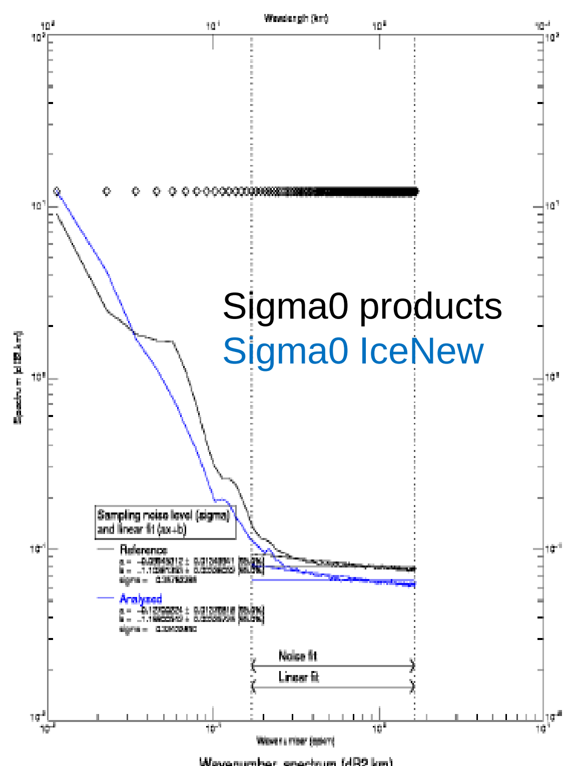
where mss = mean square slope.

- The resulting model is similar to the Brown model formulation but with the gamma parameter replaced by $\Gamma = 4\gamma mss/(4mss+\gamma)$
- The estimation process is the same as in a MLE-4 but Γ is estimated instead of the mispointing (which is always set to 0)

Ocean retracker : IceNew

- Advantages:
  - ➢ Ensures the continuity with the MLE-4 at transition areas (sea ice, Sigma0 blooms, rain cells, …)
  - ➢ Performances close to the MLE-4 ones
  - ➢ Provides a Sigma0 estimate not affected by the mispointing estimation (on well pointed missions)

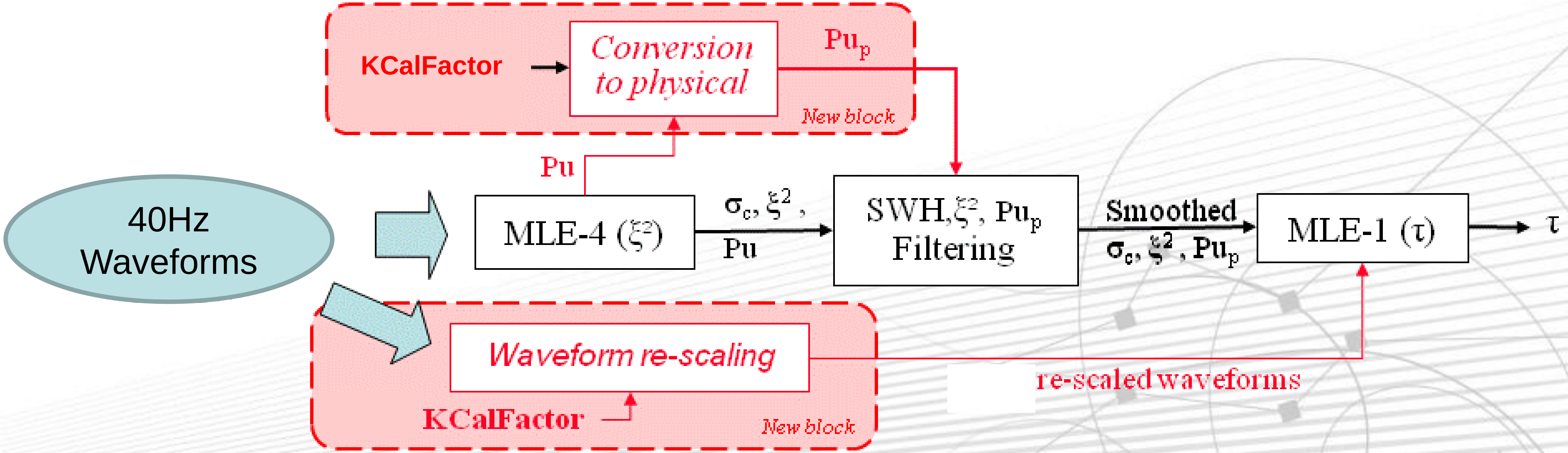
Example on Jason-1 data



Ocean retracker : 2 steps retracker

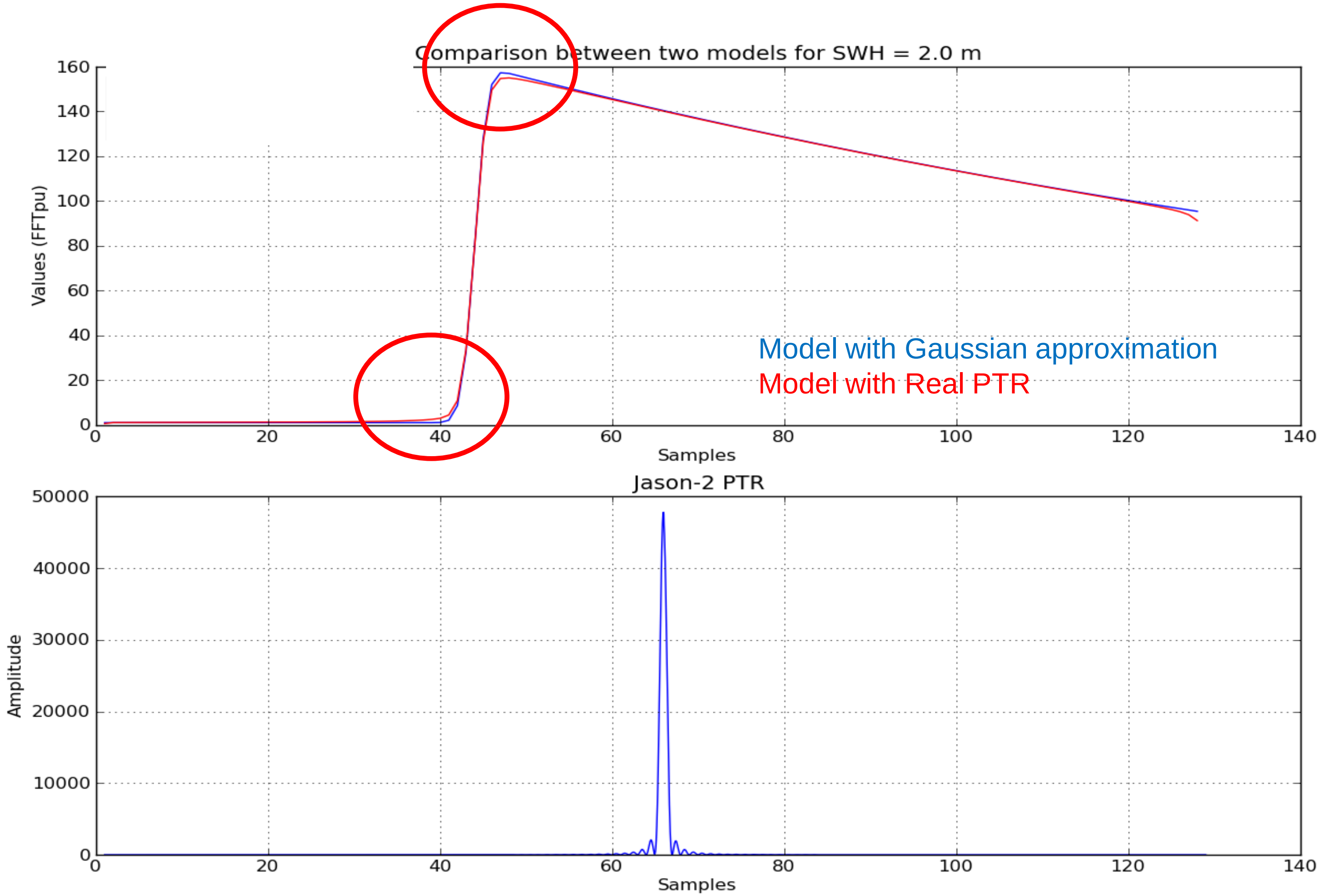
- This algorithm was designed by NOAA (Sandwell & Smith 2005) in order to improve the accuracy of the range estimate (for marine gravity applications)

- The main processing steps are :
  1. MLE-3/4 ➔ (Pu, σ_c, τ and ξ^2)
  2. Low Pass Filtering of Pu, σ_c and ξ^2
  3. The smoothed Pu, σ_c and ξ^2 are injected in a MLE-1 to only estimate τ.



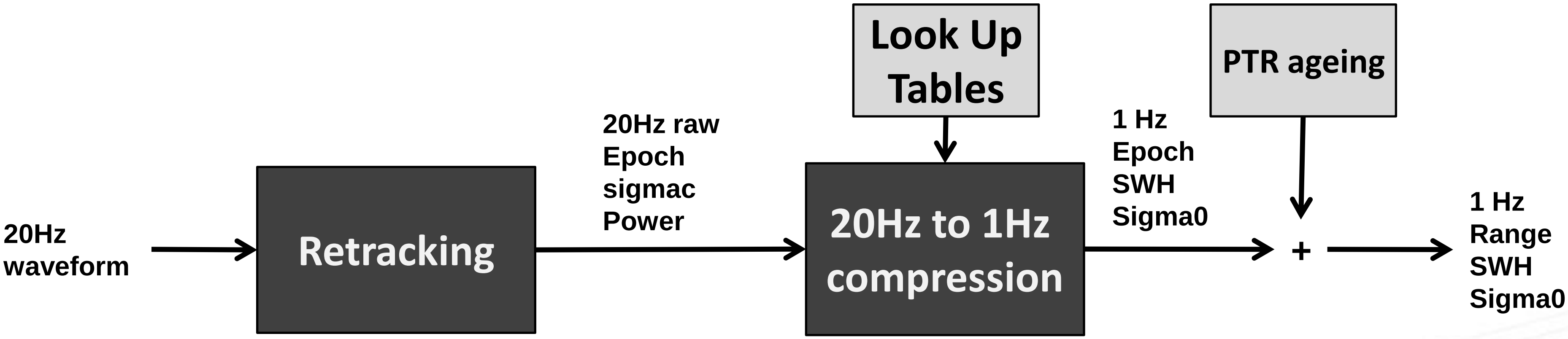
Ocean retracker : Numerical approach

- Introduce the real Point Target Response in the Brown model instead of a Gaussian approximation for the waveform retracking.
- The estimation step is similar to the one of classical MLE-4

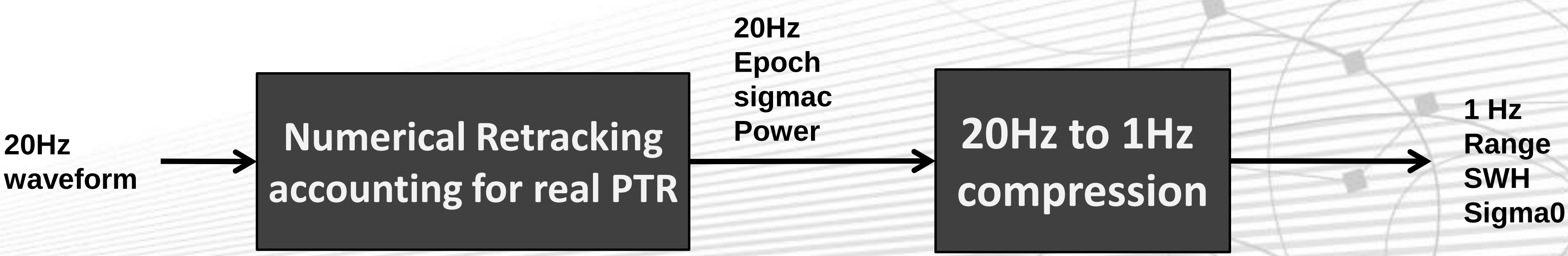


Ocean retracker : Numerical approach

Current waveform processing for Jason

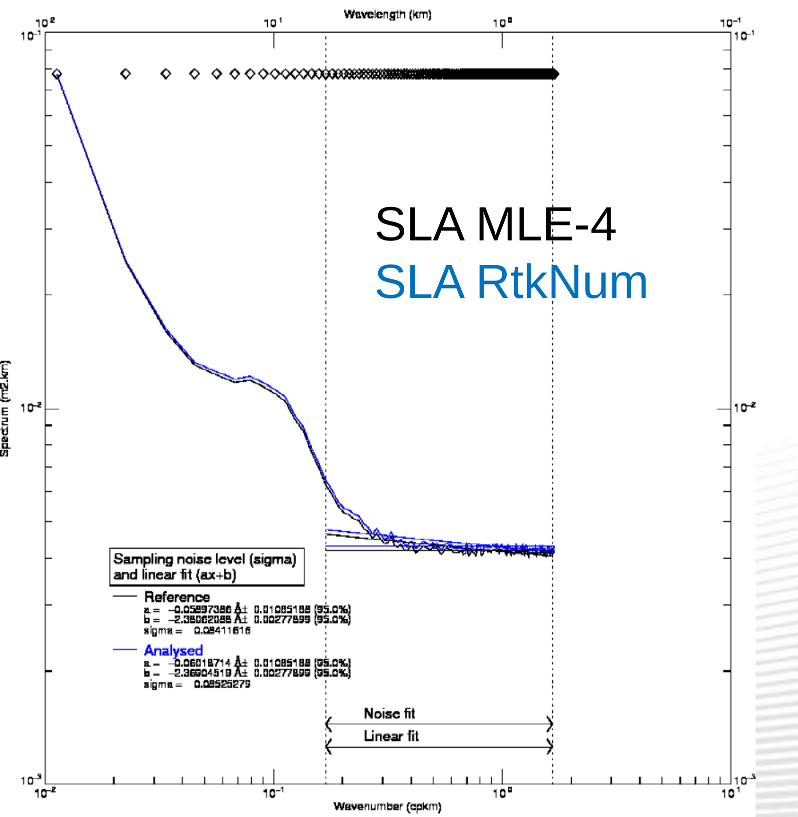


Numerical retracker



Ocean retracker : Numerical approach

- Advantages:
  - No instrumental LUT correction are required because real PTR is included
  - Improved estimates in weak SWH areas
  - Variation of the instrumental behavior is considered (thermal, ageing, …).
  - Better estimates **provided at 20Hz**
- Drawbacks:
  - Increased computation time

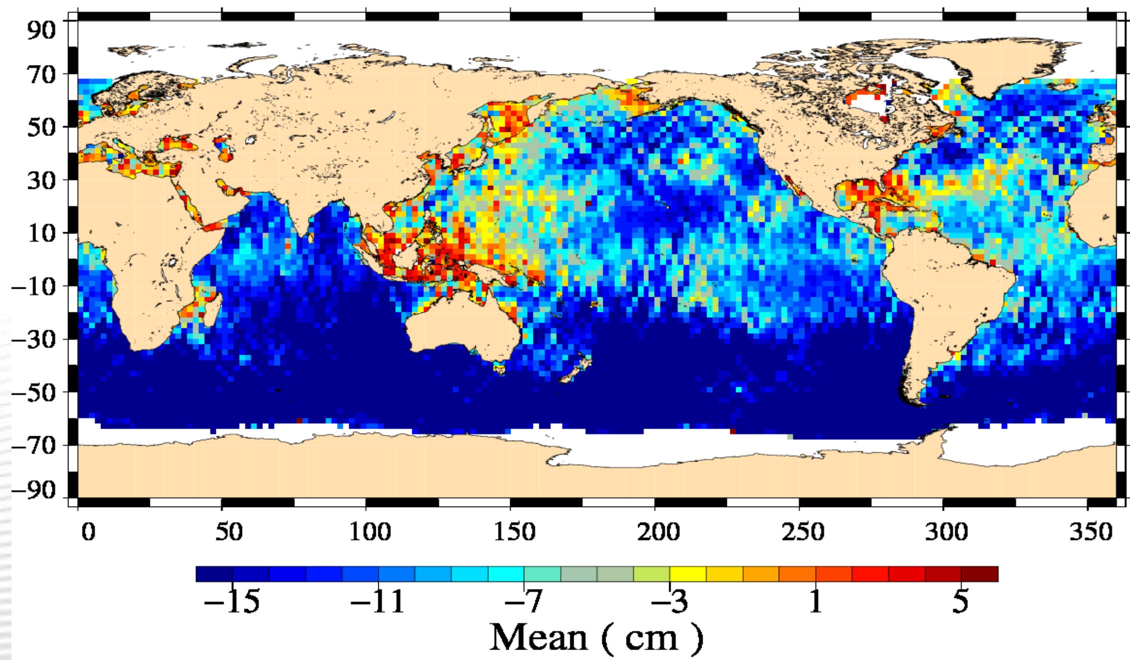


Wavenumber spectrum (m2.km)

Jason-2

Differences of waves (Ku−band)

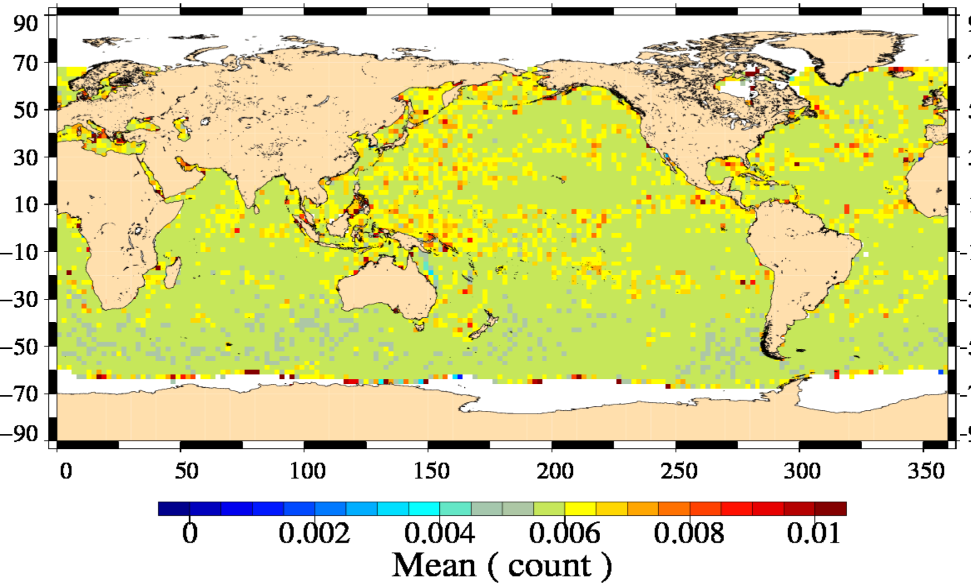
Etude_Ocean3Conv_20Hz_Cycle35



Nb of data	:	8828	St. Dev	:	6.03846	Skewness	:	0.82674	Minimum	:	−42.19342
Mean	:	−11.33476	Rms	:	12.84289	Kurtosis	:	2.04862	Maximum	:	58.35302

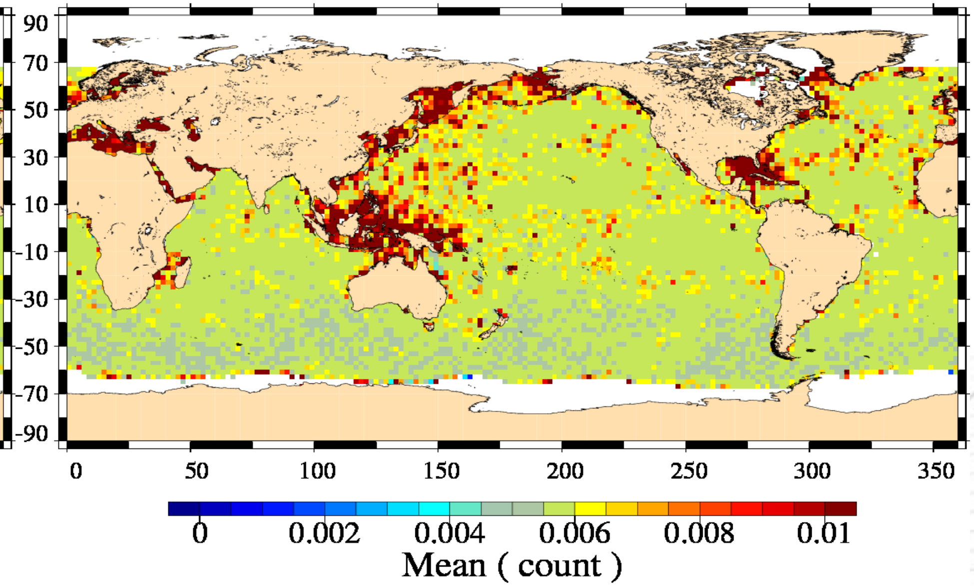
Ocean retracker : Numerical approach

MQE – Numerical retracking



Nb of data	:	8830	St. Dev	:	0.004004	Skewness	:	78.562518	Minimum	:	0.001270
Mean	:	0,006043	Rms	:	0,007249	Kurtosis	:	6876,946198	Maximum	:	0,359422

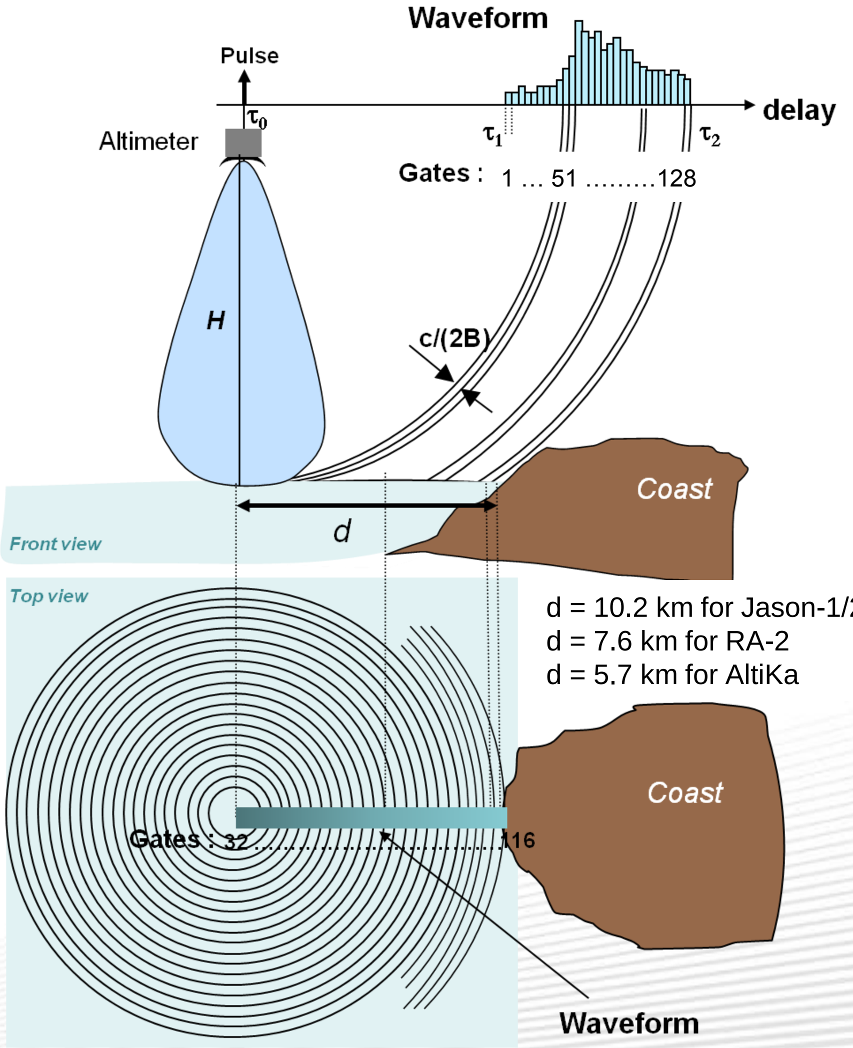
MQE – MLE4 retracking



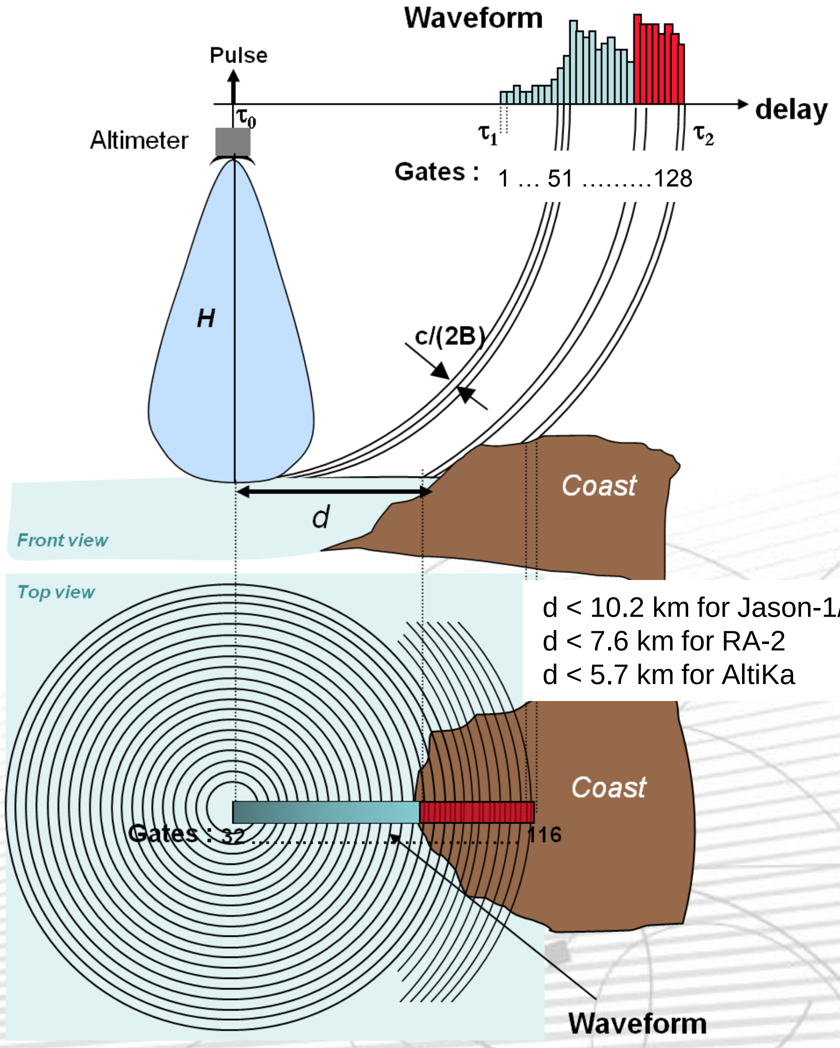
Nb of data	:	8830	St. Dev	:	0.008568	Skewness	:	19.843474	Minimum	:	0.001420
Mean	:	0,007223	Rms	:	0,011207	Kurtosis	:	580,458233	Maximum	:	0,353282

The numerical retracking has already been studied on Jason-2 data and will be implemented in the Jason-3 ground processing. It is currently evaluated on Envisat/RA-2 waveforms.

Coastal waveforms



d = 10.2 km for Jason-1/2
d = 7.6 km for RA-2
d = 5.7 km for AltiKa



d < 10.2 km for Jason-1/2
d < 7.6 km for RA-2
d < 5.7 km for AltiKa

Coastal retracker : BAGP3

- The altimetric signal is modeled using a Brown model and a sum of Gaussian peaks

$$\tilde{s}_k = s_k + p_k$$

with

$$p_k = A \exp\left[\frac{-1}{2\sigma^2}(kT_s - T)^2\right]\left\{1 + \mathrm{erf}\left[\gamma \frac{(kT_s - T)}{\sqrt{2}}\right]\right\}$$

where γ is the asymmetry coefficient of the peak

Generalization of the Brown and BGP models

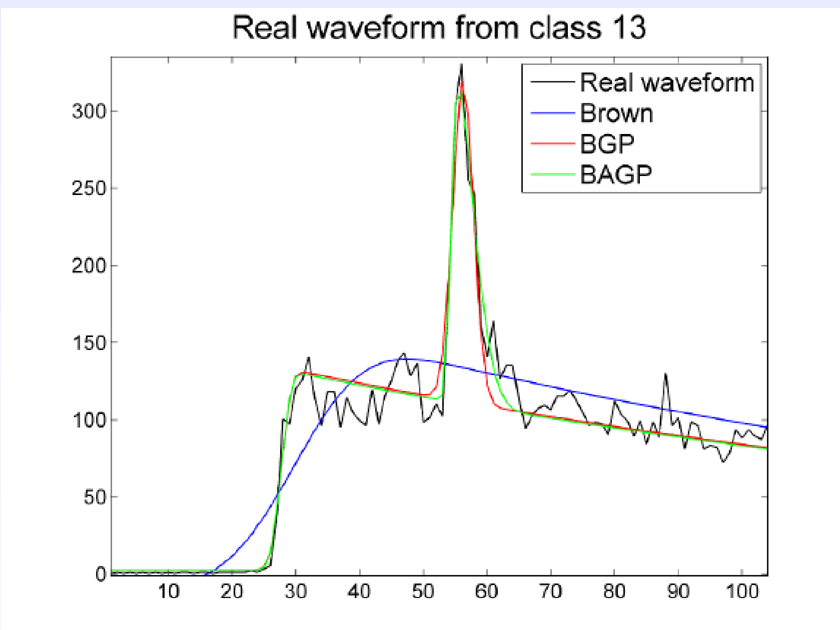
- BAGP reduces to the Brown model for $A = 0$
- BAGP reduces to the BGP model for $\gamma = 0$

- The estimation step is close to the MLE-4 ➔ Newton-Raphson (MLE)
- Estimated parameters are : Pu, σ_c, τ (like in MLE-3) and amplitude (A), standard deviation (σ), position (T) and asymmetry coefficient of the peak

Coastal retracker : BAGP3

- Advantages:
  - Allows to retrack waveforms closer to the coast
  - Mathematical formulation very close to the classical MLE-4 formulation used for deep ocean signals
  - Possibility to use the same formulation on non-Gaussian signals
  - Ensures the continuity with the MLE-4 in coastal zones (works with Brownian waveforms too)

class 13



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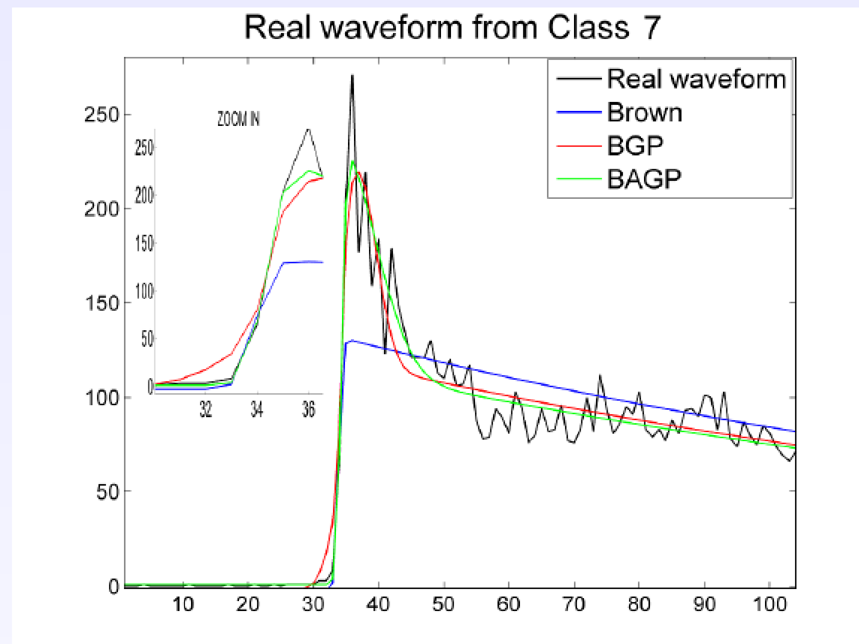
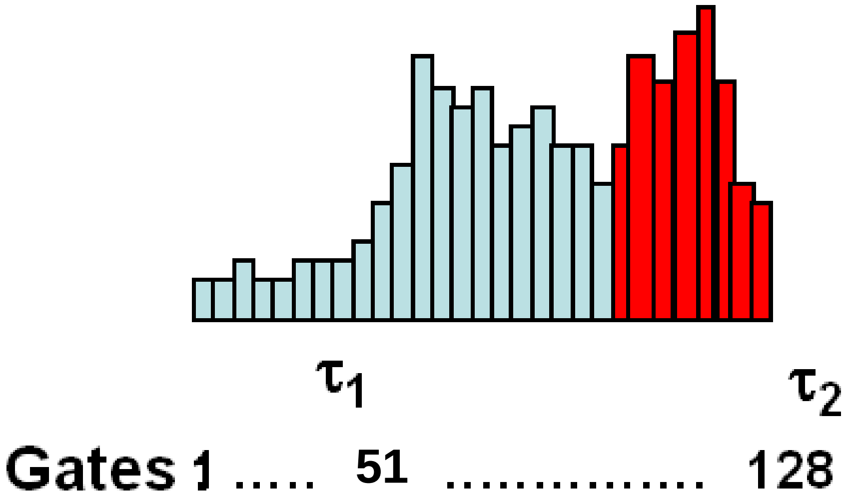
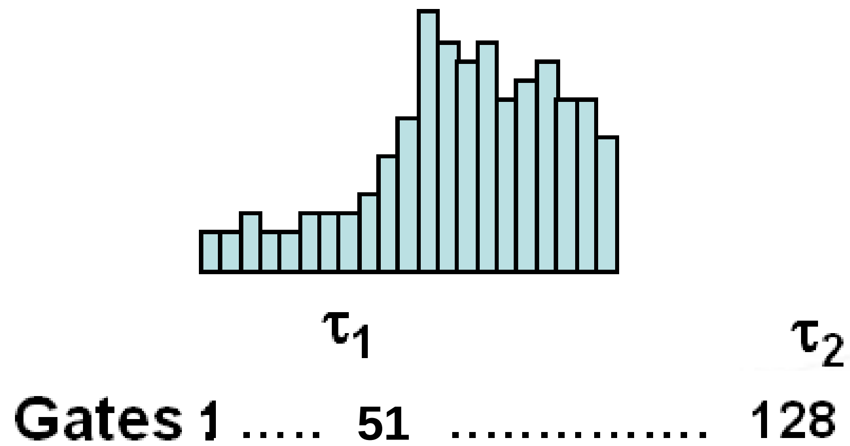


Coastal retracker : Red-3

- The Red-3 algorithm is a simple MLE-3 performed on a reduced estimation window



Corrupted waveform



Truncated waveform

- A leading edge detection is performed with the waveform classification to position the truncated analysis window.
- Advantages:
  - Allows to retrack waveforms closer to the coast.
  - Ensures the continuity in coastal zones.

Conclusions

- Thanks to the PEACHI project and the high performances of the AltiKa altimeter, many retracking algorithms can be studied to improve the quality of the waveform processing on various areas and/or for different applications.

- Many settings can be tested for each algorithm (even those already in the ground segment) in order to enhanced the AltiKa ground processing.

- The implemented test bench is a set of evolving diagnosis used to evaluate the performances of a retracker. This is helpful to evaluate the performances of a new retracking setting or a new algorithm.

Thank you for your attention !