

ENVISAT Radar Altimeter Individual Echoes

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ABSTRACT

A unique feature of the ENVISAT RA-2 is to provide bursts of individual, unaveraged Ku band echo sample data in phase (I) and quadrature (Q), at the full rate 1800 Hz. This data offers a unique possibility to assess the full capabilities of altimeter measurements. Both technically and scientifically, much can be expected from these bursts of individual echoes, e.g., speckle characteristics over different altimeter scenes, ocean, ice, land, but also, potential blurring effects associated with range window changes during the 100 echoes on-board averaging. Moreover, for the first time in altimetry from space, investigations can be carried on the direct use of phase information from backscatter signals. ENVISAT RA-2 also features a second frequency in S band. The combination between absolutely calibrated Ku and S band data can yield interesting improvement for wind speed, wave period, gas exchange estimates, etc. ESA has launched a study on this topic to seed the use of individual echoes by scientists. This study is reaching completion and reconstructed echoes will be made available for the first time

to the scientific community. Results from the technical and scientific application of individual echoes will be presented.

1. INDIVIDUAL ECHOES (IE) PROTOTYPE

Pildo and CLS have undertaken the development of an IE prototype for ESA. This prototype will provide to the users the IE acquired by the RA-2 instrument, in a form of an additional Measurement Data Set (MDS) to the current SGDR product. This new product is called the IE SGDR. The main feature of this product is to provide for the first time in altimetry, the amplitude and the phase of the IE together with the associated on-board tracker parameters at a rate of 1800 Hz.

Below (fig. 1) is shown one IE in the frequential domain and how they match their 18Hz averaged waveforms counterpart when they are reconstructed.

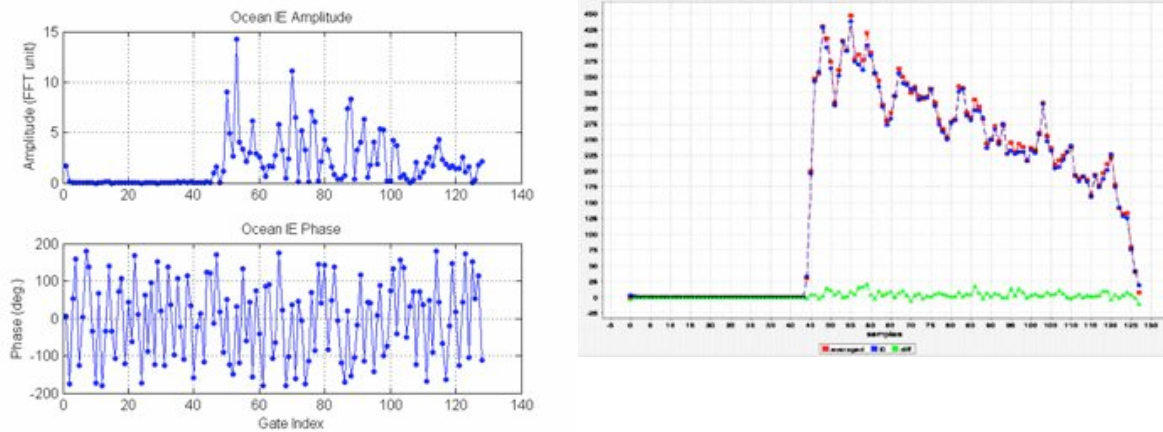


Figure 1 : IE Amplitude and Phase (left); Reconstructed averaged waveform from IE (right)

2. SPECKLE THEORY VALIDATION OVER OCEAN

Thanks to the IE, it has been possible to validate the speckle theory over ocean. Indeed

as expected, the samples within each IE are uncorrelated as well as the samples from one IE to the other. This is shown by the two graphs below (right side : sample to sample correlation, pulse to pulse correlation).

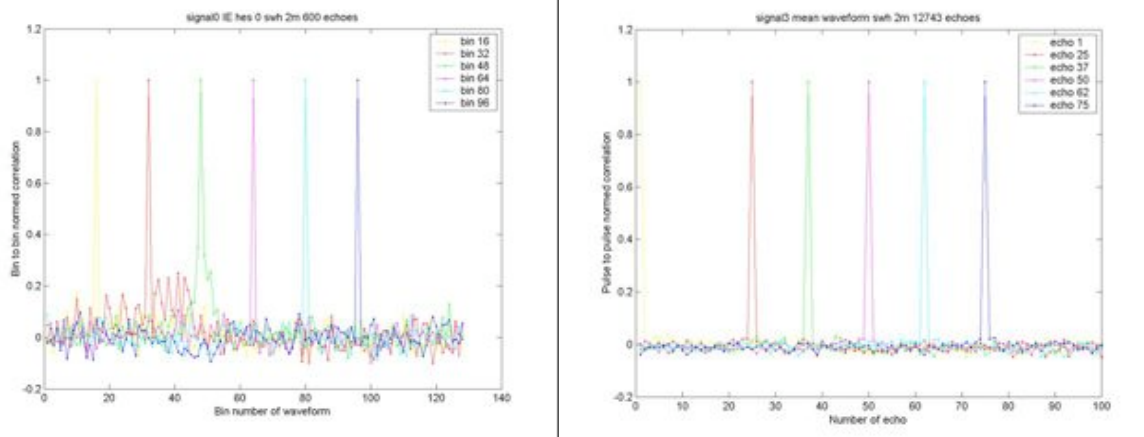


Figure 2 : IE bin to bin and pulse to pulse correlation

3. INDIVIDUAL ECHOES OVER THE SALAR D'UYUNI

IE of pass 139 over the Salar d'Uyuni (a 9600 km² salt lake acting as a specular reflector for radar altimeter, see left figure below) have been retracking using a gaussian retracker. The deduced elevations

have been compared to the ones using the 18Hz averaged waveforms (see right figure below). As it can be seen, the agreement between the two is very good and the standard deviation obtained on the IE elevation is equal to 2cm.

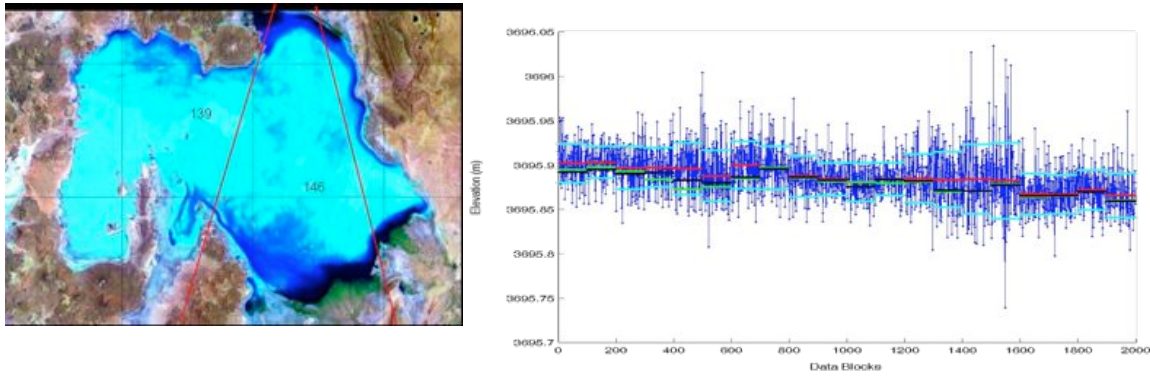


Figure 3 : ENVISAT ground track over the Salar d'Uyuni; Elevations comparison between IE and average waveforms

4. INDIVIDUAL ECHOES COMPARISON BETWEEN THE SALAR D'UYUNI AND THE ARTIC ICE

Gaussian retracking has been performed on IE acquired over the Salar d'Uyuni and over the Artic Ice. While the elevations found on the Salar d'Uyuni did fit very well to in situ measurements, the ones obtained over the Artic Ice did not perform that well. Thus a comparison of the IE has been carried out and

the results are shown below in terms of Pdf of the maximum power of groups of 100 IE (left is Salar d'Uyuni and right is Artic Ice). As one can notice, the distributions are not equivalent. While the Salar ones exhibit a gaussian distribution which can be related to coherent echo returns, the one from the Artic ice shows an exponential distribution that can be associated with an incoherent echo returns

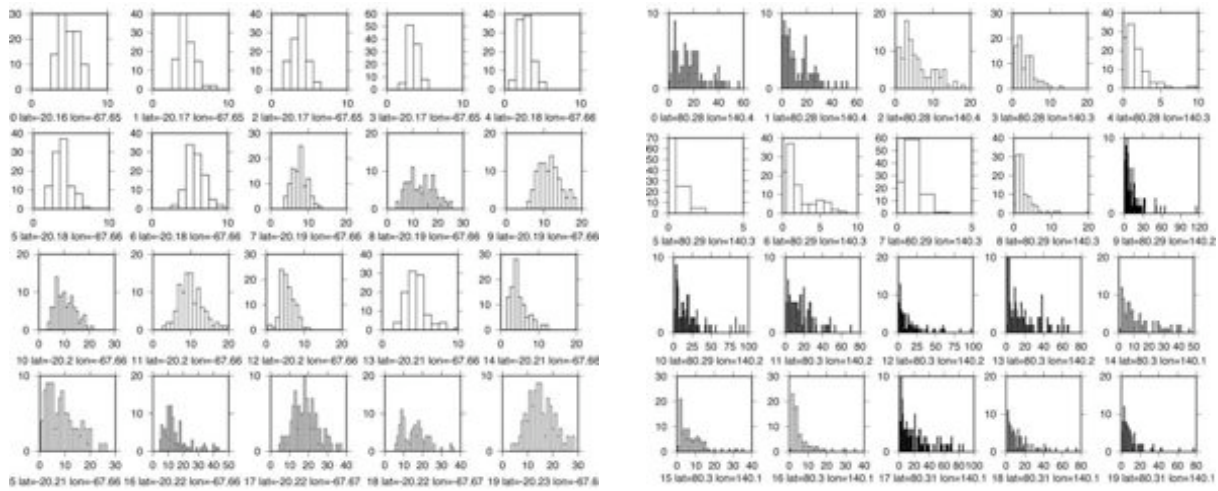


Figure 4 : PDF of maximum power of group of 100 IE : over the Salar d'Uyuni (left) and the Artic ice (right)

5. SPECKLE ANALYSIS OVER ICE CAP

In order to increase the resolution of the data, speckle analysis has been carried out out with IE over the Ice cap. First of all, the speckle variance as a function of mean amplitude (first

row, left figure below) shows that the behaviour is the same for both ocean and ice cap and follow the theory (variance = amplitude²). Then (figure in the center) a sensitivity analysis has been conducted to identify the minimum number of IE to be

averaged. The value deduced is equal to 20. The qualitative comparison (figure on the right) between the 18Hz averaged waveforms (100 IE) and the 90 Hz averaged one (20 IE) is quite excellent. This is further confirmed by the quantitative comparisons related to the

elevation (second row and left figure) and the backscatter coefficient (second row and right figure).

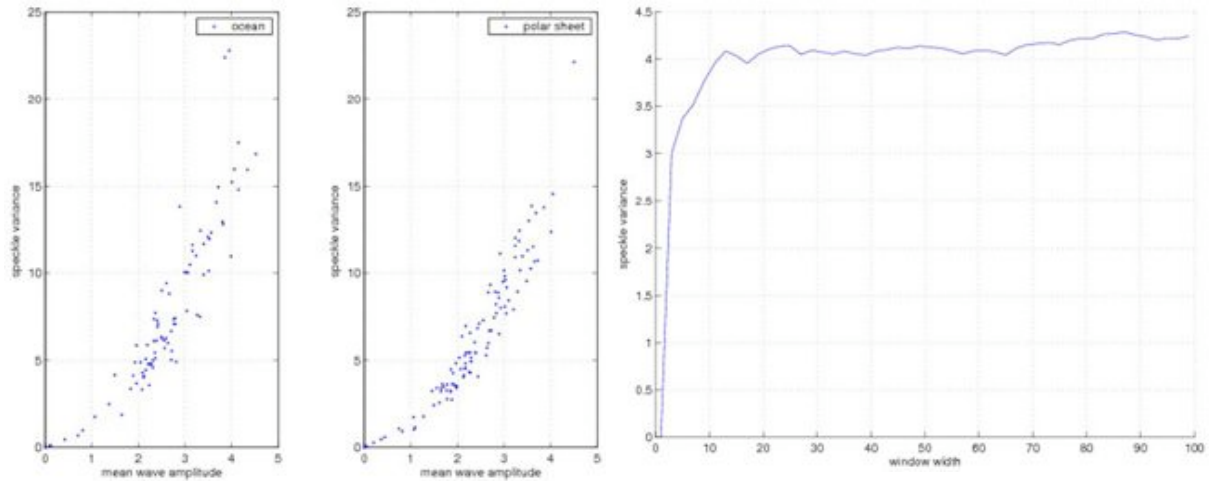


Figure 5 : Speckle variance as function of mean amplitude (left) and as function of IE (right)

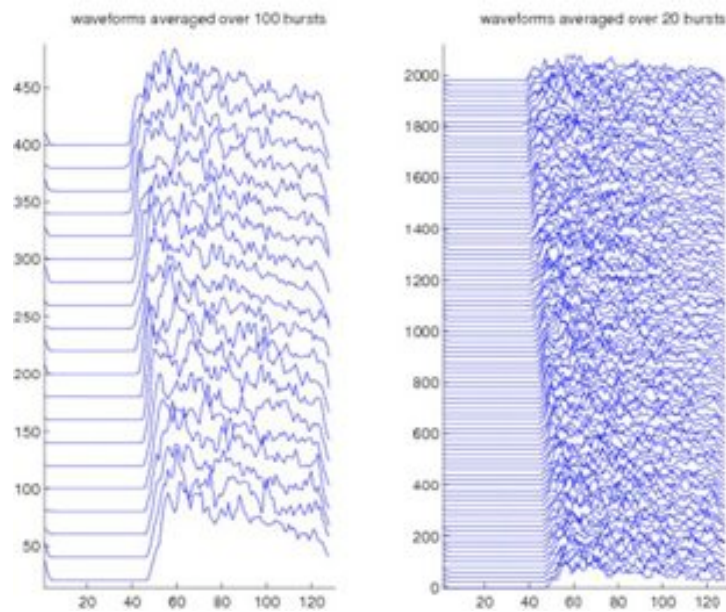


Figure 6 : Qualitative comparison between 100 averaged waveforms (left) and 20 averaged waveforms (right)

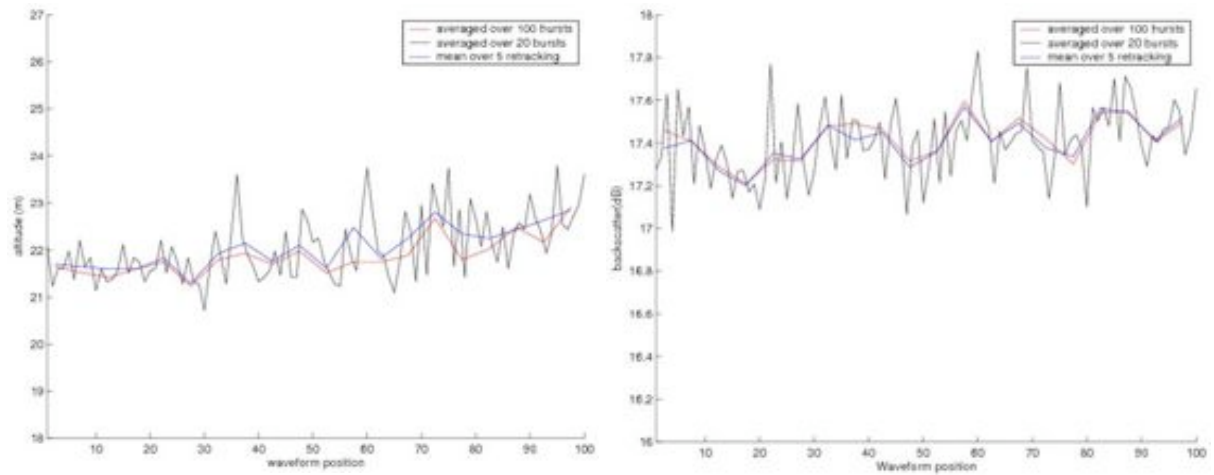


Figure 7 : Quantitative comparison(elevation) between 100 averaged waveforms(left) and 20 averaged waveforms (right)

6. CONCLUSIONS AND PERSPECTIVES

A product (IE SGDR) has been generated which helps analysing the ENVISAT Individual Echoes. Indeed, these IE are the means to verify the theory of the speckle of radar altimeter. Furthermore, they have also been used to perform high resolution precise determination of altimetric parameters. Estimates which then can be used for research.

Finally as shown, the ENVISAT IE have a great potentiel and more studies should be carried out to assess their potential.