Global Analysis of EnviSat Burst Echoes over Inland Water
Berry, P.A.M.(1), Freeman, J.A.(1)

(1) E.A.P.R.S Laboratory, De Montfort University, The Gateway, Leicester, LE1 9BH, UK
Email: pamb@dmu.ac.uk, jaf@dmu.ac.uk

ABSTRACT

The unique ability of the EnviSat RA-2 to transmit a small proportion of the full 1800Hz raw waveforms gathered on board to ground has allowed an investigation of the characteristics of inland water echoes at an unparalleled level of detail. Considerable reprocessing is required to transform the raw echoes into useable form: they must then be merged with the EnviSat SGDR dataset for inclusion of atmospheric and instrument corrections, and, crucially, inclusion of precise orbit data. For the work presented in this paper, the echoes were then retracked using an expert system approach, with retrackers specifically configured for these unique waveforms. The results show in detail the complex and intricate response of inland water to Ku band altimetry, and confirm that averaging these echoes significantly degrades the information content.

To optimise the measurement and monitoring of inland water using pulse limited altimetry, these results confirm that far higher along-track sampling is required than is permitted by the current generation of altimeters. It should be noted that the detailed analysis presented in this paper is made possible because of the superb characteristics of the RA-2, specifically, the extremely low instrument noise.

BACKGROUND

Satellite radar altimeters have now been flying for several decades, sending low energy microwave pulses down to the earth’s surface and collecting the returned echoes. Traditionally altimeters have averaged a certain number of these individual echoes (IEs) together to both reduce the noise and limit the bandwidth needed for data transmission [1].

For the EnviSat RA-2, 100 sequential individual echoes are averaged to produce each output waveform and these averaged waveforms (AEs) are available at 18Hz [2]. However, the RA-2 has an additional facility: every 180 seconds EnviSat can send to ground 1.141 seconds of individual echoes (equivalent to 20 AE waveforms). The first 16 IEs from each burst cannot be retrieved, resulting in 1984 IEs per burst available for use.

ANALYSIS

Fig. 1 shows typical burst echo locations from cycle 33. Because the burst echoes are obtained using an onboard macro command and the bursts start at the same relative time within each pass, they tend to be obtained at approximately the same latitude within each pass, which causes the horizontal ‘stripes’ in the locations. Successive cycles also collect bursts at almost the same geographical position each time, unless acquisition is interrupted by a specific command to obtain a burst over a user specified target. In this case, the locations of all subsequent bursts within the pass are altered.
Visualisation of the burst sequences illustrates the information content. Fig. 2a shows the 'normal' 18Hz data over Lake Superior and the surrounding area, with each waveform plotted vertically. The two vertical white lines in the plot show the position of the burst sequence, which is shown in Fig. 2b. It is evident that there is significant noise in these burst echoes, which appear similar to bursts analysed over the ocean [3,4]. Some evidence of features migrating through successive echoes can be seen, but the ‘speckle’ on the IEs is the dominant characteristic. This agrees with findings from analysis of ocean data and demonstrates well why the design of previous altimeters has allowed for on-board averaging of echoes before telemetering to ground.
In contrast, Fig. 3 shows a waveform sequence from the Congo basin. Here, the 18Hz sequence of waveforms is again shown in Fig. 3a, and the quasi-specular nature of many of the dominant targets is evident. The burst location is marked by vertical lines. In Fig. 3b, the burst sequence is visualised. The great increase in information content is immediately apparent. Visual inspection leads to the identification of multiple separate quasi-specular echo components migrating through the echo sequence. To examine the information content further, these echoes were retracked using a version of the Expert System [5] configured for burst echoes. The resulting height plot is shown in Fig. 4, which confirms that the expert system is responding to the presence of multiple bright targets in the individual waveforms, changing the retrack point according to the relative power of the echo components within each IE. The curved shape of many of these indicates that they are not at the nadir point; the instrument is off-ranging to the bright quasi-specular targets. This is a generic finding over inland water; it is unusual to find a burst with as few as two quasi-specular components over river networks.

Figure 3 Waveform sequence over Congo river basin (a) with burst (b); location of burst sequence is shown by vertical lines

Figure 4 Retracked burst from Figure 3: 18Hz retracked values shown in black with lines
To illustrate the temporal information content, Fig. 5 shows 10 cycles of burst echoes obtained at the same location (approximately) in the Hudson bay, Canada. Here, the changing nature of the reflecting surface is very clearly demonstrated, with the freeze-thaw cycle clearly shown by comparison with the bursts shown in previous figures. These echo sequences over time give a unique insight into the inland water target response to the RA-2.

DISCUSSION

The unique burst echo datasets give a valuable insight into both the operation of the RA-2 over inland water, and the complexity and variety of the surface response in the presence of inland water. Multiple quasi-specular reflectors are seen to move through the sequences, particularly over rivers, confirming that the averaging to 18/20/10Hz of current and past altimeters is causing a significant loss of information over inland water surfaces. One clear requirement for future altimeter missions is thus to recover information at a far higher rate along track: at 1800 Hz, as clearly illustrated by the RA-2 sequences, the surface signal components can easily be identified. The current IE sampling of inland water is non-optimal; whilst it is not possible to find a single solution for the sampling that optimises acquisition over all targets of interest (short of issuing multiple commands to the instrument to acquire specific targets, a strategy made less likely to succeed by the uncertainties in the precise timing of the commands) the fact that the current background acquisition misses almost all the Canadian lakes and gets very little data over the rivers of the Amazon basin is certainly unfortunate. Conversely, however, the Congo basin is sampled extremely well. This valuable resource is now being made available by ESA at a dedicated website; data over targets of interest can be obtained by contacting ESA [6].

REFERENCES


