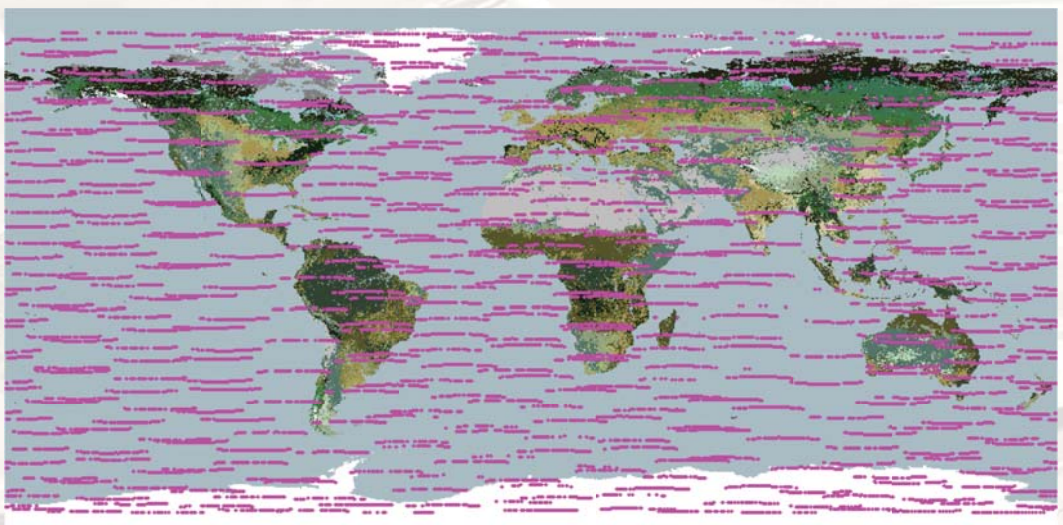
The EnviSat Individual Echoes - A Glimpse into the Future of Inland Water Monitoring

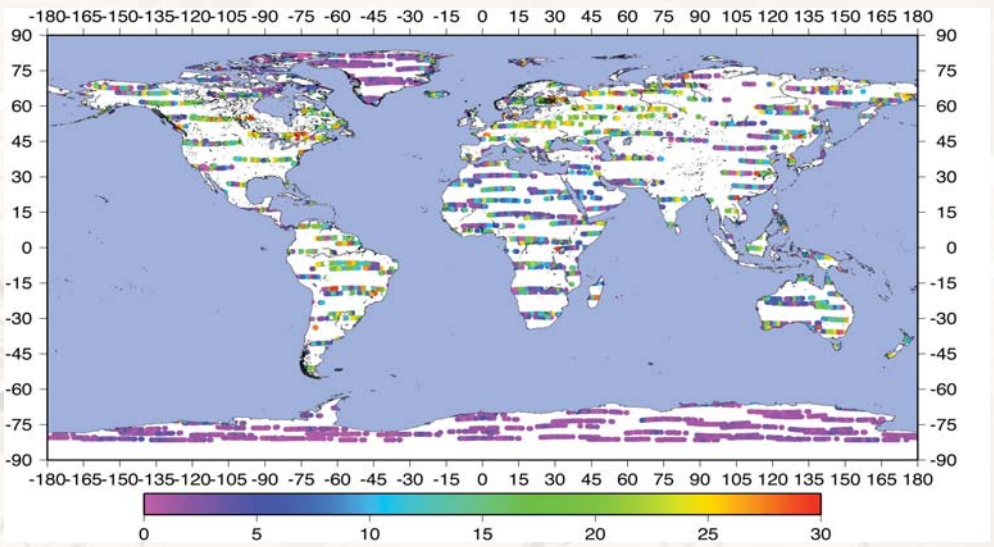
Philippa A.M. Berry [1], Simon Witheridge[1], Richard G. Smith[1], Jérôme Benveniste[2]
(1) De Montfort University, EAPRS Lab, Faculty of Technology, Leicester LE1 9BH, United Kingdom (pamb@dmu.ac.uk, 0044 116 2078159), (2) ESA ESRIN, via Galileo Galilei, Frascati (Roma), I-00044, Italy

Abstract

The EnviSat altimeter offers a unique insight into the interaction of Ku band altimeter pulses with terrain. This is due to the capability of EnviSat to return a tiny percentage of echoes at full 1800Hz sampling rate instead of the 18Hz averaged echoes. Some of these bursts are returned from inland water surfaces, and give a unique insight into the influence of the complex and intricate distribution of bright reflectors (mostly from pools of still water) on the altimeter echoes; this information can be lost in the on-board averaging process. Analysis reveals that even water surfaces as small as a few tens of metres across can be measured using the Individual Echoes (IEs). This paper presents results from a global analysis of these Individual Echoes (IEs) over inland water, and shows that time series of height variation can be successfully retrieved utilising a small numbers of IEs. The paper also presents results from SAR altimetry, with scenarios from the CRYMPS simulator for CryoSat2.

EnviSat Individual Echoes





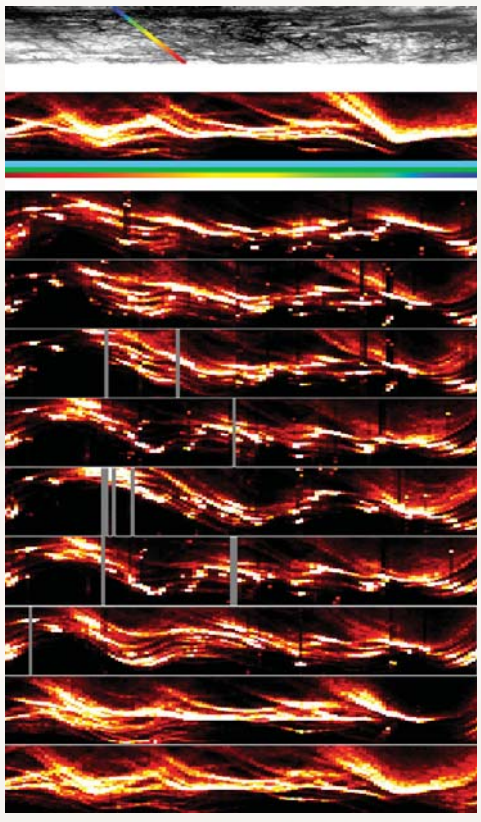
Label	No of rejected echoes	Flat surface	Still Water echoes type 1+2+3	Google Earth comparison
A	0	1353	480 + 0 +50	Not river
B	123	806	97+15+36	River
C	33	681	419+16+207	Not river
D	0	920	457+5+159	Not river
E	8	797	590+20+182	Not river
F	44	999	624+18 + 14	Canopy
G	32	436	237 +17+219	Canopy
H	1	1057	169+17+201	Canopy
I	2	739	181+0 +218	Canopy

The EnviSat Individual Echoes (IEs) exist for 1.1 seconds of data (1800Hz instead of 18Hz) with near-global distribution (shown above left). The RAIES processor is required to turn the telemetred data into useable form.

Analysing one complete cycle globally for inland water signatures produces the result above right, which shows the percentage of waveforms in each burst identified as inland water responses. Here, ephemeral water is captured as well as river data.

Analysis of a sequence of echoes which happen to lie roughly along the course of a river in the Amazon basin is shown below. Here, many of the bursts miss the river itself, but capture water returns from adjacent flooded regions under the rainforest canopy (see table left).

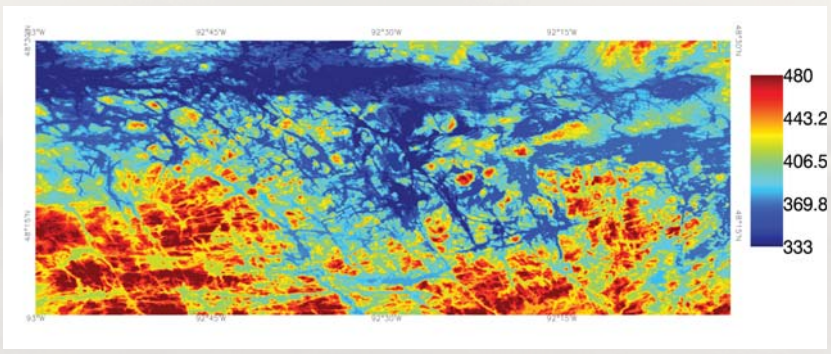
CryoSat-2 Analysis

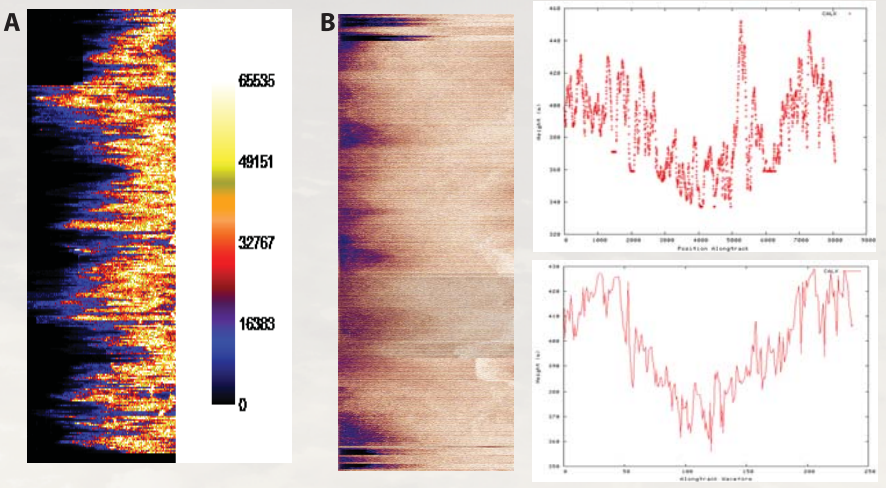


In order to assess the capability of the next generation SAR altimeter flown onboard CryoSat-2 a number of scenarios were processed by the CryoSat simulator – CRYMPS. One such scenario was that of "Inland Lakes", the DEM (right top) was selected to ensure that the terrain coupled areas of rough hilly topography along with a large number of small lakes and is derived from the SRTM 1" dataset chosen for its high frequency information content.

A sequence of ERS-2 profiles over the DEM region is shown on the left, in order to demonstrate the complexity of the waveforms returned as seen by a current generation altimeter.

The output from the CRYMPS simulator for the SAR L1B data (20Hz) is shown to the right in A and the SAR full bit-rate (FBR) data are shown in B .
Finally retracking the SAR L1B echoes has allowed for the successful retrieval of the input DEM including the inland water targets (Far right upper profile input DEM , lower profile retracked heights).





Discussion

The EnviSat Individual Echoes provide a tantalising insight into the expanded capability of the next generation of altimeters enabled by their much higher Pulse Repetition Frequency. Even small pools of still water are successfully captured and their heights can be derived by advanced retracking methods.
Over complex topography including many small lake targets, ERS-2 20Hz waveforms display fascanating characteristics. The CRYMPS simulator struggled with the rapidly varying topographic relief but was still able to produce viable waveforms across much of the underlying terrain. The successful retracking of these SAR L1B echoes by a next generation BES (Berry Expert System) in this complex scenario indicates that inland water heights can be successfully retrieved from the SAR L1B CryoSat-2 data.
Analysis of the SAR FBR data is ongoing; the IE results indicate that retracking at a far higher PRF is possible over inland water targets and demonstrates that the next generation of Satellite Radar Altimeters will dramatically increase the inland water measurement capability.

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