Global Monitoring of Inland Surface Water using Multi-mission Satellite Radar Altimetry

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Abstract

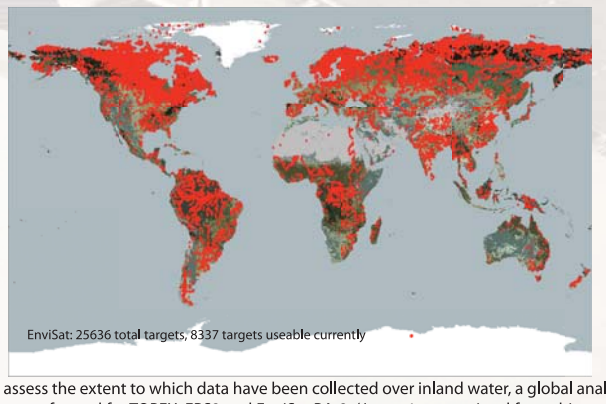
The current generation of satellite radar altimeters have gathered a huge database of echoes from the Earth's land surfaces. This unique resource now enables decadal timeseries of changing river and lake heights to be derived, and the availability of Near-Real-Time (NRT) data from EnviSat and Jason-2 has allowed this capability to be extended to disseminate the results to the global community within 3 days of measurement.

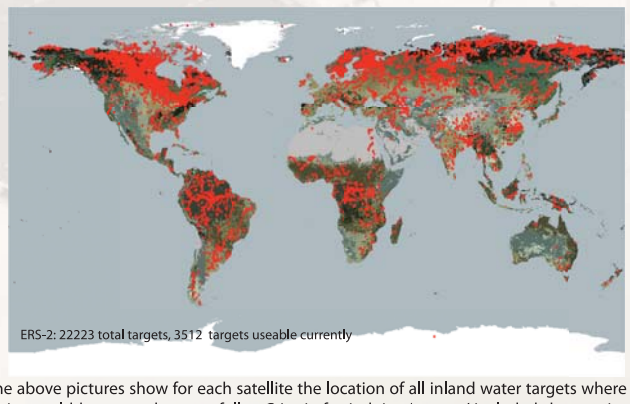
This paper presents a quantitative assessment of the global monitoring capability of the ERS-2, TOPEX, Jason-1, Jason-2 and EnviSat altimeters, and also of the ESA River and Lake NRT system, and shows that heights are successfully measured for more than 1290 targets worldwide in near-real-time. Further enhancements in waveform selection and retracking are expected to increase this capability substantially. The retrieval capability is ultimately constrained by the along-track sampling rate of the current generation of instruments, and the availability of far higher sampling rates from the next generation of altimeters will facilitate a further substantial enhancement in both precision of measurement and retrieval of smaller targets, as demonstrated using the Envisat Individual 1800Hz echoes.

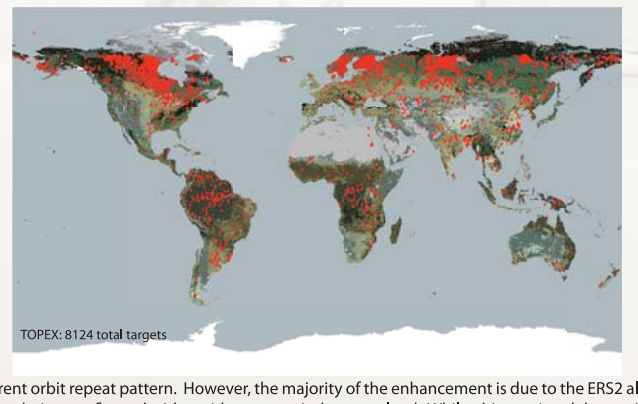
Introduction

Measuring inland water heights using satellite radar altimetry is an established technique. Whilst utilising the pre-processed data from the Space Agencies restricts the application to major lakes and the largest rivers, if the waveforms returned from the surface are 'retracked' to obtain accurate heights, there is the potential to monitor thousands of targets globally. The first step in evaluating the real scope of this technique is to determine how many potential targets are available (below). Note that Jason-2 data have been omitted from part of this analysis as a long enough time-series has not yet been accumulated.

EnviSat, ERS-2 and Topex global targets



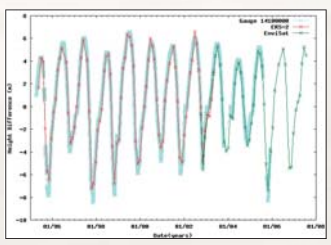


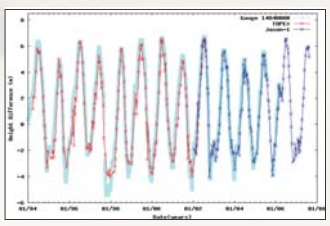


To assess the extent to which data have been collected over inland water, a global analysis has been performed for TOPEX, ERS2 and EnviSat RA-2. (Jason-1 was omitted from this poster due to generally poor performance). A mask was created to select only those waveforms likely to have returned from an inland water target. Each waveform was analysed and, if valid (i.e. contained significant signal and the leading edge was successfully captured) was retracked. Time series of successfully captured waveforms and their retracked heights were then generated.

The above pictures show for each satellite the location of all inland water targets where time series could be created successfully. Criteria for judging 'success' included the requirement that valid waveforms be present for at least 90% of crossings. Whilst only about 10-30% of these targets currently produce good time series, enhanced retracking is expected to increase this percentage to 40-60%. From left to right the images show EnviSat , ERS2 and TOPEX . The increase in the number of targets from TOPEX to ERS2 is evident, and is partly the effect of the different orbit repeat pattern. However, the majority of the enhancement is due to the ERS2 altimeter being configured with a wider range window over land. Whilst this restricted the vertical precision of measurement, it greatly increases the number of targets successfully acquired. For EnviSat, even more targets are acquired, although the skewing of the instrument logic to favour ocean mode operation degrades the waveform capture over some inland water targets.

Validation over Amazon Basin





A huge validation exercise has been undertaken in the Amazon basin, to assess the current accuracy of altimeter derived height time series using the network of available river gauge measurements. Typical examples are shown here for an ERS2/EnviSat crossing (upper image) and a TOPEX/Jason-1 crossing (lower image). Results confirm that outliers in TOPEX and Jason-1 timeseries contribute to the RMS: EnviSat timeseries consistently present the lowest RMS against the gauges.

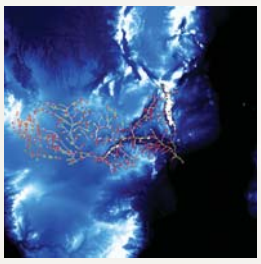
ESA River and Lake System

For some applications, data are required in Near-Real-Time. The ESA River and Lake system currently uses information from the EnviSat and Jason2 satellites to derive heights of inland water targets within 3 days of measurement. The figure (above left) shows the locations and numbers of the current NRT targets, with EnviSat in pink and Jason2 in cyan.

The ESA River and Lake site is updated daily with new results. Access is either through the website or via automated product delivery. Currently, there are ~120 registered users with ~160 subscriptions (above right).

http://earth.esa.int/riverandlake/

How can we make the next leap?



The mask used to pre-select echoes for analysis as possible inland water targets is no longer adequate. Using a detailed map of the Zambesi (courtesy P. Bauer-Gottwein, DTU) ERS2 and EnviSat data were re-analysed over this river system and classed by quality of derived time series. The locations and assessed quality are shown in the left-hand figure (green good, amber moderate, red poor) and the statistics are given in the table below.

This detailed mask is now being developed globally.

A more advanced mask highlights the limitation of the along-track-sampling of current altimeters: many of these tributaries are too small to return one waveform at nadir.

What would happen if the sampling rate were higher? We can use the EnviSat burst echoes to find out, see Berry et al. 'The EnviSat Individual Burst Echoes' poster.

	Good	Moderate	Poor	Total
ERS2 standard	18	10	31	59
ERS2 enhanced	25	102	381	508
EnviSat standard	22	16	33	71
EnviSat enhanced	53	155	337	545

Discussion

This remote monitoring technique already successfully measures heights at many thousands of locations globally but this is only a small percentage of targets for which waveforms are retrieved. There is thus a very considerable additional dataset that can be retrieved by further augmenting the processing system. For targets less than 300m wide, the along track sampling frequency limits data acquisition. However, the EnviSat burst echoes analysis (see other Berry et al. poster) shows that for the next generation of 'SAR mode' satellite radar altimeters far smaller targets can be successfully measured, greatly increasing the global monitoring capability.

Acknowledgements:
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