Near-Real-Time Monitoring of Global Rivers and Lake Heights using EnviSat and Jason-1 Altimeter data

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ABSTRACT

The ESA River and Lake Pilot project has now been running for some time, generating river and lake heights for targets globally. This paper presents a synopsis of the current system for generating river and lake heights from EnviSat Near Real Time (NRT) data and outlines a series of proposed enhancements, including extension of the NRT capability to ingest Jason-1 data. Results from a global analysis of system outputs is given, together with validation results against gauge data. The results demonstrate that very good time series are being recovered from the EnviSat NRT system, and that the current severe filtering of waveform shapes might be relaxed to some extent without significant loss of quality in the output, permitting many more river and lake measurements to be generated.

INTRODUCTION

The EnviSat RA-2 has been very successful in recovering echoes over inland water, both from lakes and from river systems. With its dynamic mode-changing capability, it is able to maintain lock in varying terrain, which allows retrieval of echoes from rivers and lakes in more complex topography than for other altimeter missions. Because the altimeter data from EnviSat are processed in Near-Real-Time (NRT), it has been possible to implement a pilot system to process the echo data through to estimates of orthometric height over many targets globally ([1,2]). This paper presents a brief summary of the existing system and outlines the enhancements planned over the next 12 months to extend significantly the scope of the inland water monitoring, and to include data from the Jason-1 satellite.

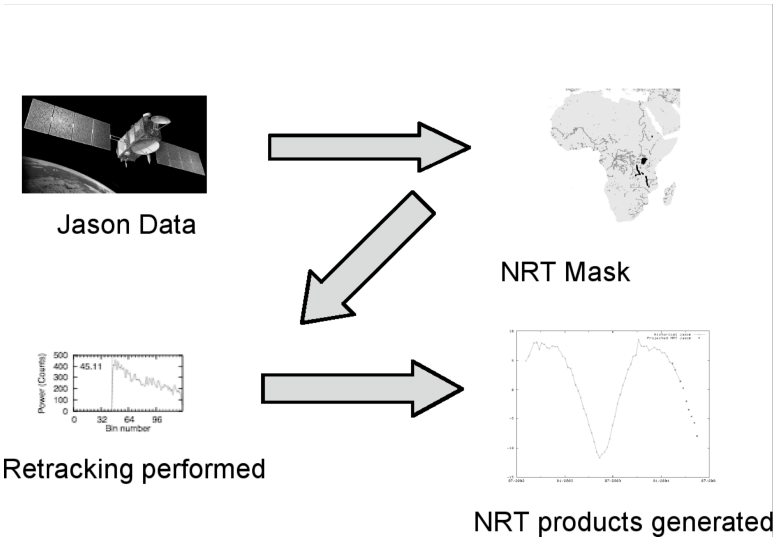

Figure 1 Schematic of the Jason-1 processing chain for derivation of inland water heights

NRT SYSTEM

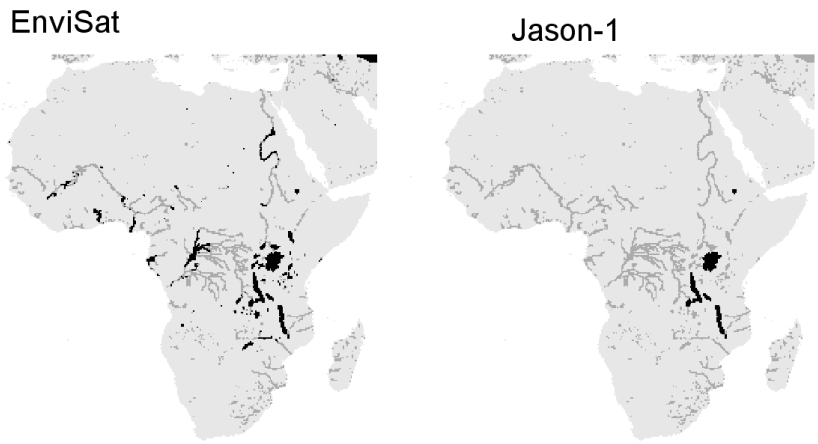

Figure 2: EnviSat (left) and Jason-1(right) masks for African lakes and rivers: targets flagged for measurement are shown in black

The EnviSat Near-Real-Time (NRT) system works by ingesting Level 1B data [3], which contain the echoes from the surface and are available within 1-2 days of measurement, and fusing these data with the IGDR product (ibid), which provides accurate orbit data, and the series of atmospheric corrections required to compute the range from the satellite to the surface. Data over inland water are then selected using a mask which is set conservatively so that only those targets known to give reliable height estimates are included. The echoes are then analysed and those with simple shapes known to be associated with inland water are retained. These echoes are then 'retracked' using one of a set of algorithms configured for each echo shape, which determines which part of the returned echo corresponds to the 'mean surface' directly below the altimeter. The range to surface is then adjusted to use this value, and the data are combined with Geoid model EGM96 [4] to calculate a height above mean sea level [5].

AUGMENTATION FOR JASON-1

Because a global assessment of the performance of Jason-1 over inland water [6] has shown that Jason-1 in fact collects viable time series of echoes over many inland water bodies, it was decided to augment the existing system to include data from this mission, since the Jason-1 data are also available in near-real-time. A conceptual diagram of the processing chain proposed for Jason-1 is given in Fig. 1. As with the existing EnviSat NRT system, the first step is to select data over inland water using a mask: derivation of this mask is discussed in the following section. The waveforms are then retracked using a suite of algorithms configures for the different echo shapes, in the same way as for the currently running EnviSat NRT system. This is vital to optimise recovery of inland water heights from Jason-1 because the position of the echoes within the altimeter 'range window' is often non-optimal; where the altimeter does successfully retrieve an echo from the inland water surface, it is often not well centred within the range window, which leads to very substantial errors if the range given is not corrected for this effect. Finally, the measurements will be converted to estimates of orthometric height, and NRT products will be generated.

JASON-1 MASK

Because, as is widely reported, the operation of Jason-1 over inland water is not optimal, it has been found necessary to limit quite severely the targets from which NRT data will be produced during the initial operation of this augmented system;

this is done by editing the mask. An initial very conservative mask has already been designed for Jason-1 over Africa, using 18 months of data to create time series. The quality of these time series has then been assessed, and a mask designed which will retrieve heights only over those targets likely to return consistently good values. For illustration, the masks for both the current EnviSat NRT system and the proposed Jason-1 NRT system for Africa are shown in Fig. 2. Here, the possible targets are shown in pale grey; the subset of these targets included in the EnviSat NRT and initial Jason-1 NRT system are shown in black. It is immediately clear that the EnviSat mask contains many more targets. This is a combination of two factors; the already discussed difficulty of Jason-1 in consistently retrieving viable echoes over many inland water targets, and the different repeat periods of the two missions. The 10 day repeat pattern of Jason-1 necessarily means that the number of crossings over inland water is substantially less than that obtained from the EnviSat mission, with the 35 day orbit repeat pattern permitting overflights of many more inland water bodies.

ENVISAT NRT OPERATION

The NRT system is currently operational for the EnviSat RA-2, successfully retrieving time series over many locations worldwide. For illustration, a few sample timeseries are included here, merged with heights retrieved by reprocessing the historical EnviSat SGDR data to yield multi-year time series. Fig. 3 shows a time series from Lake Nasser, with the NRT data at the end of the timeseries shown in dark grey. In Fig. 4, the results for the Amur River in Russia are shown, again with data obtained through the NRT pilot system shown in dark grey. Finally, a further river timeseries is given in Fig. 5, for the Brahmaputra. These are typical examples from the hundreds of time series already being generated by the NRT system. However, there is the possibility of significant enhancement of this system, both to increase the number of targets by augmenting the processing chain and to increase the information passed to the end users. To illustrate this, Fig. 6 shows statistics for Lake Kariba, graphing the along-track RMS of the measurements from each overpass, and the number of points that make up the average value. This typical example shows an average along-track RMS of about 20cms derived from about 40 points per overpass. In contrast, Fig. 7 shows the statistics derived for the Kainje reservoir on the river Niger. Here, a much more variable number of points are included, and the along track RMS values fluctuate significantly. This is one of the targets where enhancements to the initial data selection process are planned to improve the height recovery: a proportion of the waveforms being retracked show significantly different heights from the majority, indicating that they may have originated from neighbouring inland water rather than the reservoir itself. This is a generic problem affecting precision of retrieval of lake heights in the current system.

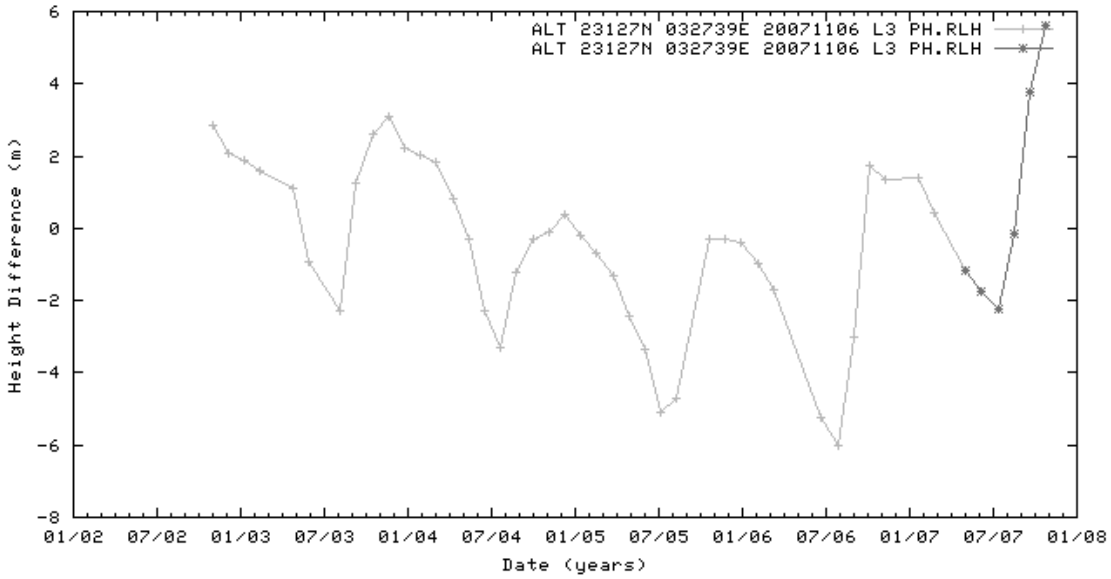

Figure 3 Lake Nasser timeseries showing EnviSat historical SGDR derived heights (pale grey) and data from the NRT system (dark grey)

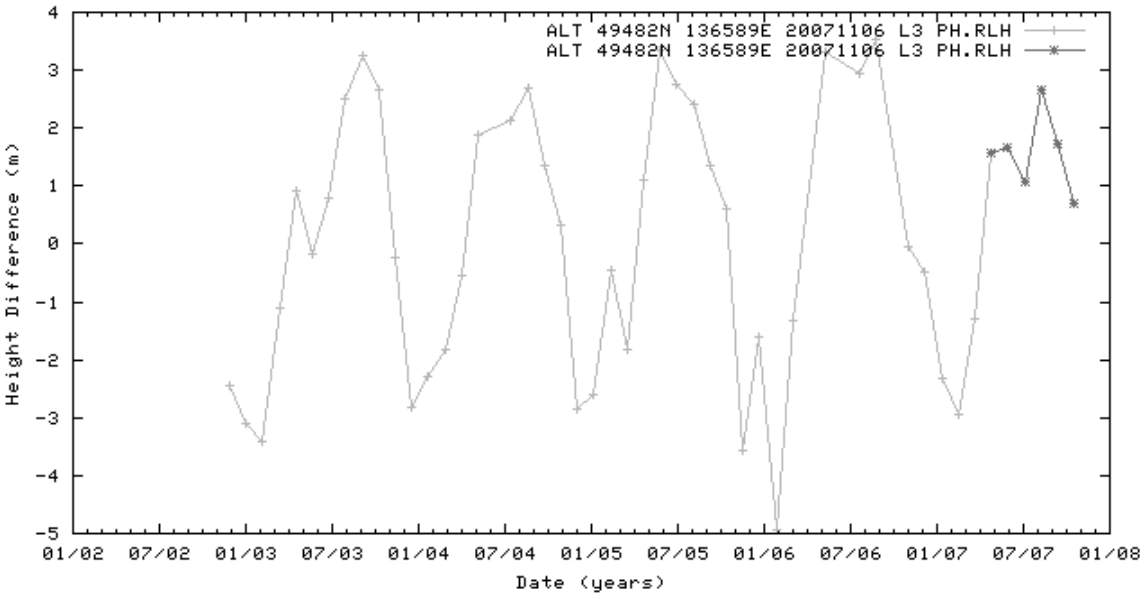

Figure 4 Amur River timeseries showing EnviSat historical SGDR derived heights (pale grey) and data from the NRT system (dark grey)

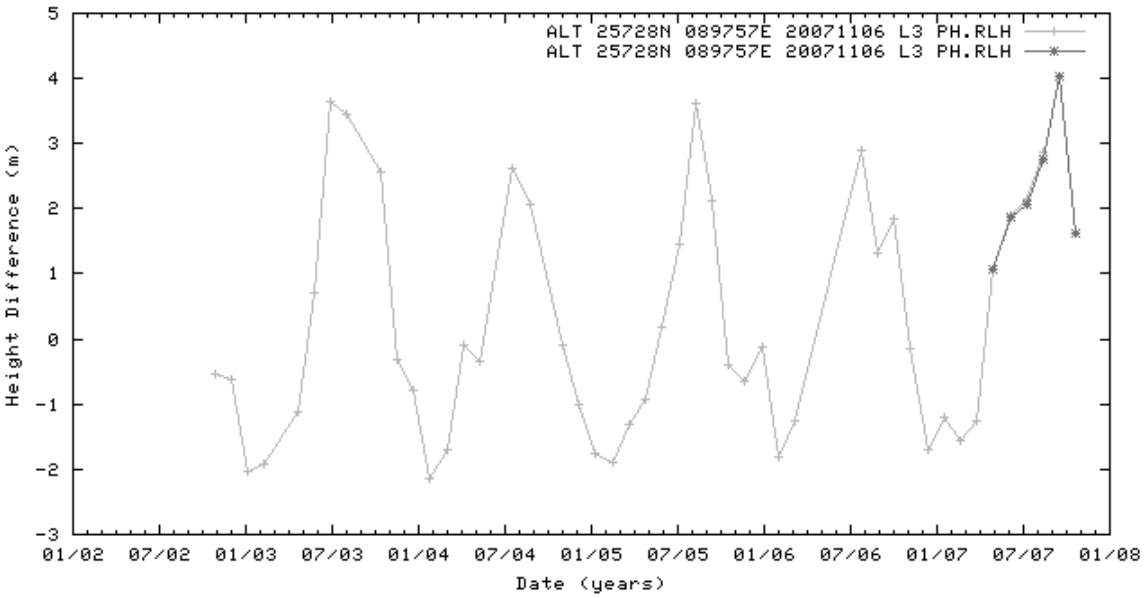

Figure 5 Brahmaputra river timeseries showing EnviSat historical SGDR derived heights (pale grey) and data from the NRT system (dark grey)

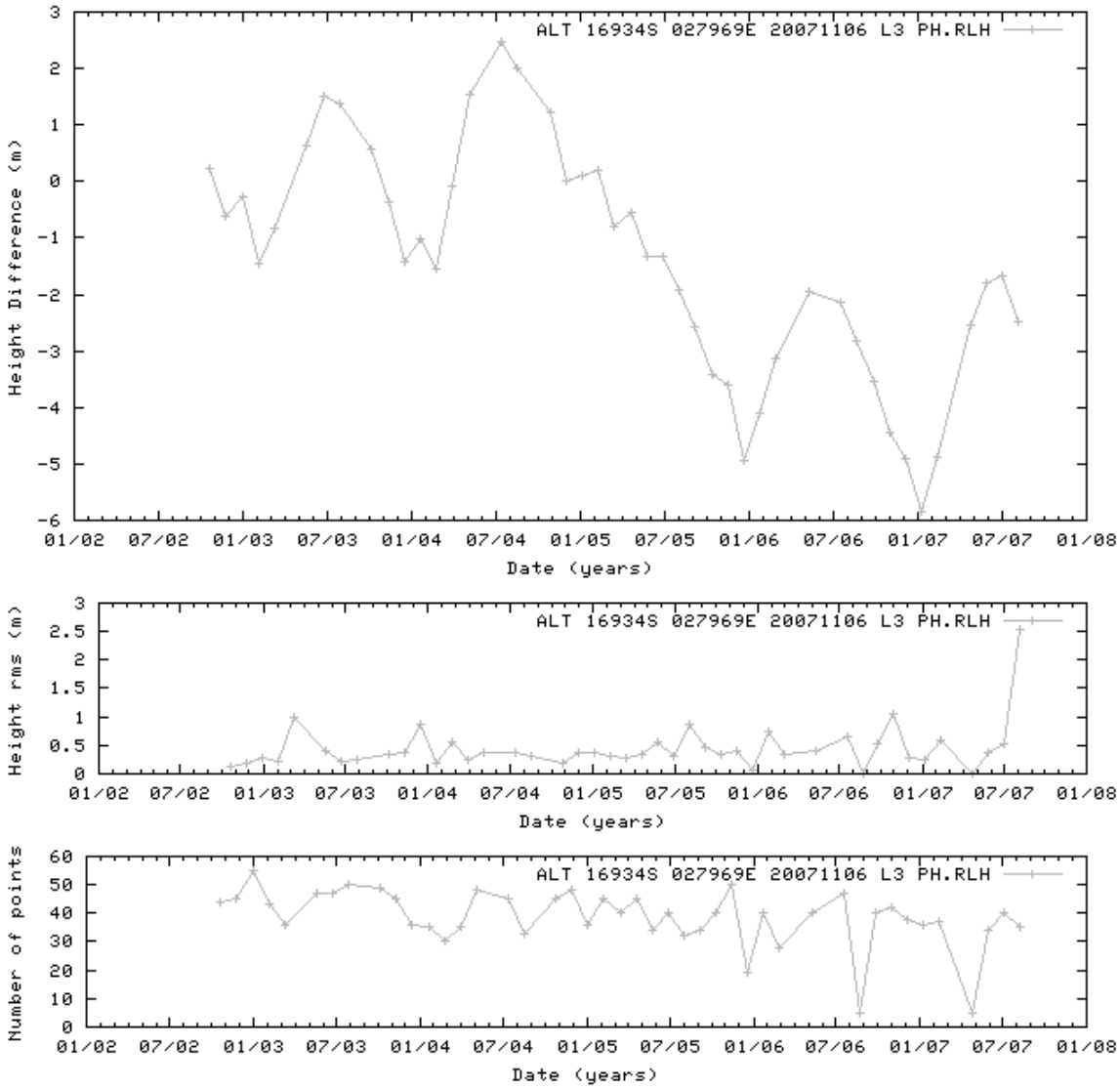

Figure 6 Lake Kariba time series from EnviSat SGDR data with statistics

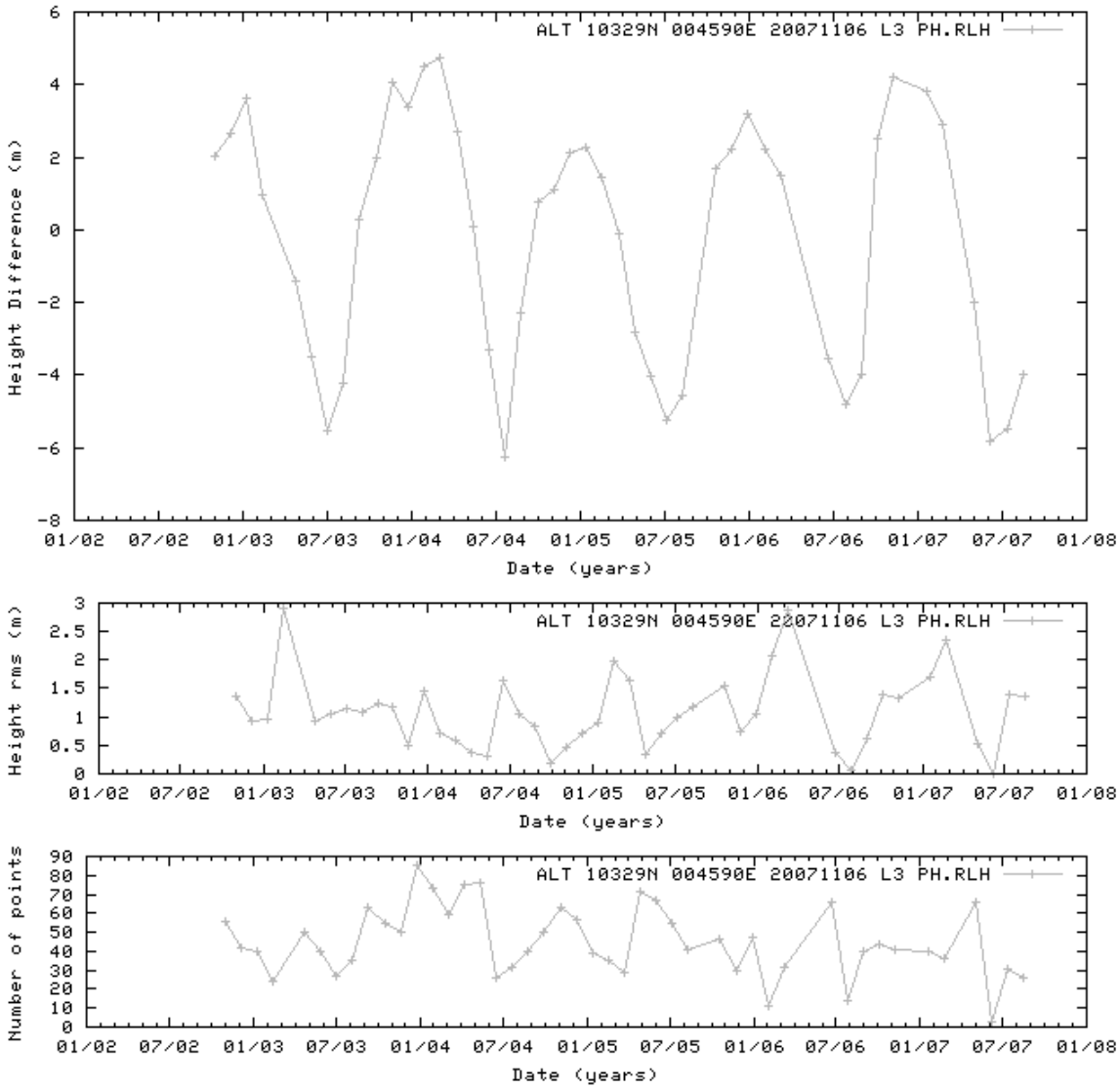

Figure 7 Kainji reservoir, Niger river timeseries from EnviSat SGDR data with statistics

DISCUSSION

The existing Near-Real-Time system for recovery of inland water heights from the EnviSat RA-2 [7] has been very successful in producing time series of heights over hundreds of river and lake locations globally, far exceeding the original expectation. However, the extremely conservative mask initially designed prevented recovery over many more targets. A series of planned enhancements to the processing chain will be implemented to both increase the accuracy of existing targets, and allow the mask to be augmented for new targets. This enhanced capability will result in recovery of many more timeseries of inland water heights. Statistical information will also be provided to the end users, to allow the accuracy of the retracking to be evaluated. Finally, in order to enhance the temporal resolution of NRT data, information for the Jason-1 satellite will be added to the system, permitting generation of data at 10 day temporal sampling over those targets where retracking the Jason-1 waveforms gives consistent and reliable height estimates. In parallel with this development, it is planned to reprocess many more of the historical datasets from ERS2 (where possible) and EnviSat SGDR datasets over the NRT locations to generate long running time series of historical data to complement the Near Real Time capability.

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