A DECADE OF GLOBAL RIVER AND LAKE HEIGHTS FROM ESA ALTIMETER MISSIONS

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ABSTRACT

The ESA missions ERS-1, ERS-2 and Envisat have gathered a unique dataset over the Earth's land surfaces, including inland water. Key to this success is the mode-switching capability, which has allowed the RA-1 and RA-2 to maintain lock over rapidly varying topography. To exploit this unique dataset, a processing scheme has been developed to derive lake and river heights on a global scale. This paper presents an overview of this work, discusses the global distribution of measurements available from both the near-real-time and historical time series, and demonstrates the unique capabilities of ESA radar altimeters to retrieve inland water heights

1 INTRODUCTION

The unique database of echoes gathered over land by the RA-1 flown on ERS-1 and ERS-2 is now augmented by the even greater land coverage of the RA-2 on Envisat. These instruments are very successful at capturing data over inland water; the static mask on the RA-1, which forces the instrument into 'ice mode' over land, has enabled the acquisition of echoes from thousands of inland water targets world wide. The RA-2 has further extended this capability, with dynamic mode switching permitting the altimeter to maintain lock even over mountainous terrain (although the loss of vertical precision in the 20Mhz mode renders data over the most extreme terrain too imprecise for useable inland water measurements).

2 ESA MISSIONS

The complex orbit repeat patterns of the ERS-1 satellite constrain the extent to which time series can be constructed over inland water targets. Whilst the 3-day repeats give good temporal sampling, the number of targets is very limited (Fig. 1a) and the alternate ice mode and ocean mode sampling introduces an additional complication. The primary time series for inland water monitoring is that of the long-running ERS-2 mission (Fig 1b). The hard wired mask forces the instrument into the lower precision 'ice mode' over land; limiting the vertical precision of measurement. This is offset by the superb acquisition of inland water targets; the wider range window allows the instrument to capture both off-ranging quasi-specular components and the nadir return within the range window. In turn this enables the instrument to maintain lock when the off-ranged target moves out of the pulse-limited footprint.

Envisat continues these time series; additionally, the dynamic mode switching facilitates collection of 'ocean mode' echoes over large lakes (although the performance of the mode-switching algorithm is non-optimal over inland water). The additional 20Mhz mode allows terrain to be sampled even over mountains, widening the scope of inland water data capture; even within the Amazon basin more data are returned (Fig. 1c). However, this capability of recovering data over inland water, although impressive, is only the first step in deriving meaningful information.

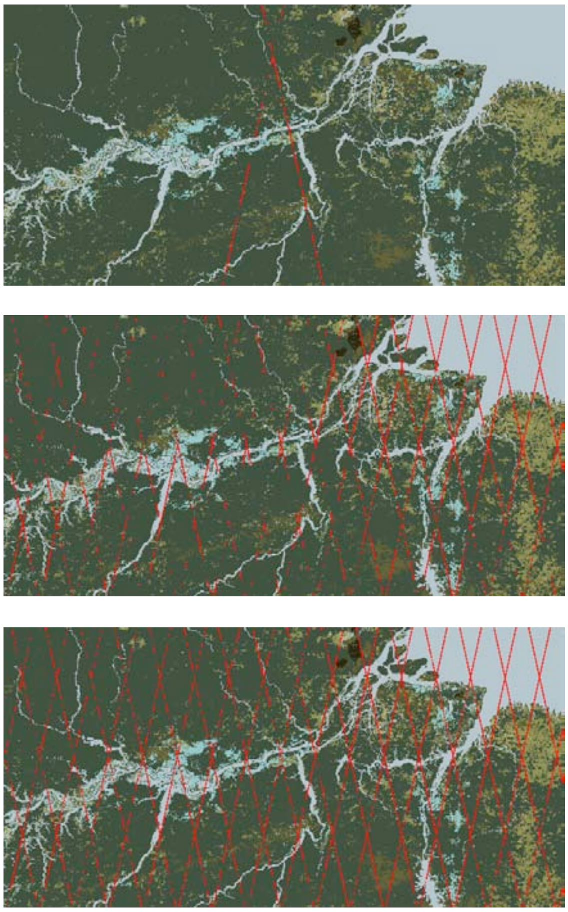

Figure 1. Echo recovery for typical repeat cycle over the Amazon basin: a) for ERS-1 3- day, b) for ERS-2 35-day, c) for Envisat 35-day data.

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3 PROCESSING

Data for ERS-1 and ERS-2 are available as WAP (Altimeter Waveform Product) [1]. For Envisat the corresponding product is SGDR [2]; for NRT applications Level 1B is merged with the IGDR dataset [ibid]

To exploit these unique data fully, and to derive information in near-real-time, an automated processing scheme was required. The first step in this processing was to derive a very detailed mask, to select out only signals from water targets.

Accordingly, for this work, a rivers mask was developed at 30”. The rivers mask was derived from the Global Land Cover Characterization (GLCC) database version 2.0. This dataset consists of a global 30” resolution classification of land cover type derived primarily from AVHRR data [3]

Echoes were then classified into several categories according to shape, and those shapes identified as returning from water were retracked to obtain a range to surface. This range was then converted into an orthometric height relative to the EGM 96 geoid [4] and time series of height differences were constructed. The results were extensively validated; example time series over the Amazon basin compared with gauge data [5] are given in Fig. 2 for ERS-2 and Fig. 3 for Envisat.

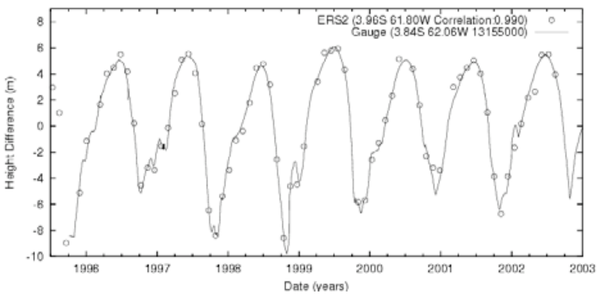

Figure 2. Sample time series against gauge measurement for ERS-2

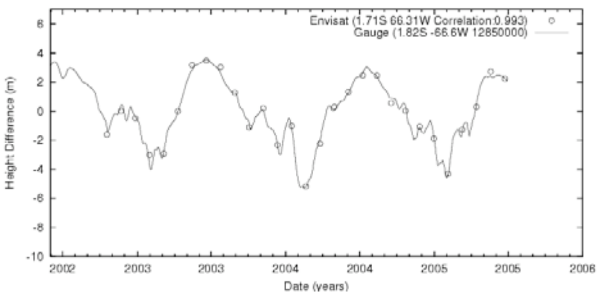

Figure 3. Sample time series against gauge measurement for Envisat

4 NEAR-REAL-TIME CAPABILITY

The capability of the RA-2 processing chain to produce Level 1b and IGDR products within 3-5 days of measurement allows the generation of near-real-time heights over inland water. As a pilot project, inland water heights are being produced for a large sample of targets on a global scale. Fig. 4 shows the current NRT mask for Africa; plotted is red are the targets currently within the pilot system. Data may be downloaded from the ESA website [6].

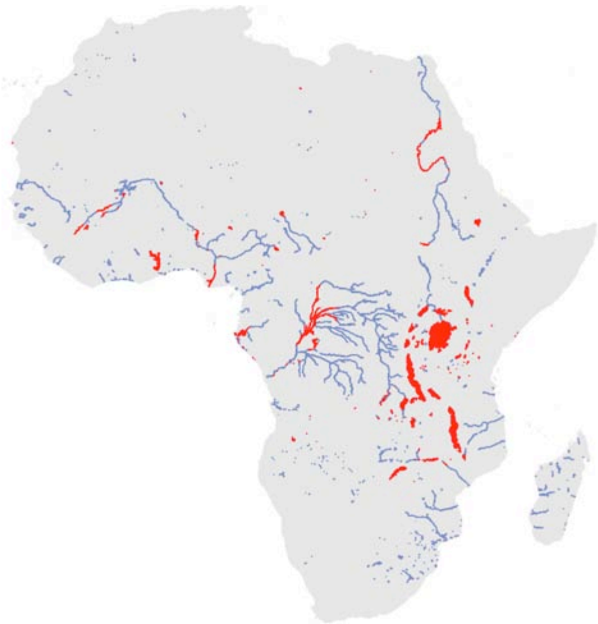

Figure 4. Near Real Time mask for Africa (red areas indicate where data are currently produced in NRT)

5 DISCUSSION

The potential to derive inland water heights from satellite radar altimetry has been greatly enhanced by the ESA RA-1 and RA-2, which have gathered data over thousands of inland water targets globally. As ERS-2 and Envisat maintain the same orbit configuration, continuous measurements over more than a decade already exist. To exploit fully this unique database of decadal measurements will take continued scientific effort. Key to the success of these missions is the mode-switching capability, which allows the instruments to maintain lock over rapidly varying topography and thus gather data from lakes and rivers even in mountainous terrain. The near-real-time capability of the RA-2 gives the possibility of obtaining river and lake heights quickly, at present within 5 days of measurement, which means that these data have the potential to inform water management decisions.

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