NEAR REAL TIME MONITORING OF RIVER AND LAKE LEVEL FROM SATELLITE RADAR ALTIMETRY OVER AFRICA

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THE RIVER AND LAKE PROJECT

This objective of this research and development project is:

• To build and validate a system that retrieves inland water heights from ERS and ENVISAT, globally.

• To drastically increase the number of measured inland water bodies, by improving the data processing.

• To Provide Near Real Time Data
  – Without time for a posteriori verification: A Challenge!!
  – For many lakes and rivers over Africa
  – Extend to South America, Asia, Oceania, N.America
THE RIVER AND LAKE PROJECT

• This research and development project is aimed at improving the river and lake level estimation and demonstrating the accuracy and robustness through a demonstration pilot.
• When it is demonstrated mature it may become operational.
• An important aspect for this, is local verification of the accuracy of the radar altimeter data.
• Gather feedback from Users on accuracy, timeliness, location, usefulness
How many virtual limnographs?
THE RIVER AND LAKE PROJECT

• How many virtual limnographs?
  – Order of 300 over central Africa
  – Not all go through quality threshold tests all the time (due to environmental variations perturbing the radar echoes)

• Accuracy
  – 10~20 cm for the best measurements, depends on the water body environment
• Potential!
   “bright targets”
THE RIVER AND LAKE PROJECT

VALIDATION

Gauge Station

TOPEX

ERS2

Height Difference (m)

Date (years)


Rio Negro
THE RIVER AND LAKE PROJECT

VALIDATION

Rio Amazonas
1. **PROJECT PRESENTATION**

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**NEW PRODUCT RELEASE**

During the first phase of the project, a first series of samples over various river systems (Amazon and Congo), lakes (Tana, Mar-Ndombe, and Victoria) and reservoirs (Aswan and Owen FallsDams) has been produced. Hydrologists provided their opinion on the first generation of River and Lake sample products and, from their feedback and requirements, the RLH product format was adapted.

Moreover, the locations of the second generation of RLH and RLA products were selected regarding the users' requests. Thus, the second release of products is composed of more samples over rivers (Rhine and Senegal), lakes (Ontario, Balchas, Volta, Dongting and Lagos es Patos) and reservoirs (La Grande Rivière reservoirs in Canada) and all products from the first generation were reprocessed in the modified RLH format.

**OBJECTIVE**

The main objective of the ESA River and Lake project is to provide the scientific community with easy-to-use, effective and accurate river and lake level height measurements from both ERS and Envisat satellite altimeters. The hydrologists' requirements present a very interesting challenge because the products produced by ESA are radically different from one based on ground based data with both vertical precision and temporal sampling more limited.

The first ambition is to obtain around 10 years of data processed on specific targets, then to propose the world-wide coverage of large rivers and lakes over 10 years and finally to make
PRODUCTS - DESCRIPTION

Technical details on the Product Handbook

Descriptions for both RLH and RLA products

River Lake Hydrology Product (RLH)

This product, designed for hydrologists with no pre-requisite knowledge of radar altimetry, consists of a single file for each river crossing with a processing header record containing processing information, a crossing header record containing information about the river crossing and a series of crossing height difference records, one for each cycle in which a height to a cross section was available. The product is distributed in XML format. The processing header record contains the name of the product, the name of the file the product was produced and the version of the software used to create the product. The crossing header record contains the mean latitude and longitude of the river crossing, the starting and ending mean height and the number of data records. The mean orthometric height is calculated at each of the crossing point heights for an integer number of years. Each crossing height difference record contains the date on which the record was measured and the height difference for this date. The date is stored as day, month and year. This date format was chosen for simplicity and to allow for the generation of an XML version of this product. The height difference is given to eliminate the effect of any good errors on the dataset.

River Lake Altimetry Product (RLA)

This product, designed for radar altimetry experts, consists of a file for each altimeter orbit over a specific inland water location. Each file contains a single processing header record containing processing information, a single region header record containing information about the region covered by the file, and a series of altimeter return records. There is one altimeter return record for each altimeter return detected by the processing chain as being over a large water body. Each record consists of time, location and height along with a number of the corrections used to generate the height. The processing header record contains the time in UTC that the product was produced and the version of the software used to create the product. The region header record contains the...
General description of the River and Lake products.

RLH LOCATION MAP

DOWNLOAD ALL PRODUCTS
RLA products are only in binary format. They can be also explored as simple ascii and html (both obtained converting from XML).

RLH products are in XML format. They can be also explored as simple ascii and html (both obtained converting from XML).

All the samples available for download.

Links to the samples individual pages.

Geographical location of each sample.
THE NEAR REAL TIME AND HISTORICAL DATA IS MADE AVAILABLE VIA THIS WEB SITE
Each sample page has the same layout:

Info

Time series

A typical Time Series

The Aswan High Dam, completed in 1960, is a rockfill dam made of granite rocks and sands, with a vertical cutoff wall consisting of impermeable clay. It stands 113 m higher than the original river bed, behind which stretches a reservoir extending for 500 km along the Nile river and covering an area of approximately 6000 km². The total capacity of the reservoir consists of the permanent storage of 35.6 km³, the active storage of 20.7 km³, and emergency flood management storage of 41 km³. The dam supplies irrigation water for Egypt, hydroelectricity, and crucially, flood protection for the lower parts of the Nile basin. However, significant ecological problems have resulted from the impact of this huge water management near the head of the reservoir, increased river erosion in the lower course of the Nile, and increased soil salinity caused by the cessation of the annual outflow of water in the Nile River.
PRODUCTS TOOLS

- RLA read/write C library
- RLA/RLH read/write/plot library
- RLH Viewer (demo)
- C Library
- IDL Library
- Java Executable
PRODUCT - RLH VIEWER TOOL

- Platform independent (JAVA)
- More than one RLH product plots
- Interactive plots (i.e. zoom feature)
- PNG export

RLH Viewer Screenshot
RLH Viewer allows three kinds of plots: scatter, line, area.

Zoom feature.
RLH Viewer allows three kind of plots: scatter, line, area

Zoom feature
PRODUCTS - IDL Tool:

File selection

Plot RLH product:

Plot RLA product:
PROJECT USERS

The major objective for the River and Lake project is to convince the scientific community, particularly hydrologists, that the new River and Lake products from the radar altimetry measurements are a valuable source of data. Hydrological requirements present a challenge because the proposed products are radically different from the ground-based data, with both vertical precision and temporal sampling more limited but with a more extensive (global) spatial coverage.

A part of the project is dedicated to contacting users and the compilation of their feedback and requirements. With the help of a hydrologist team from Lancaster University, a community of River and Lake product users has been constituted. This community is encouraged to contact, at any time, the RL team to express their observations, analyses and criticisms about the RLH and RLA products. The feedback from users is very important for the RL project because it facilitates fitting the products to the needs and the wishes of the user community.

Please contact diane.defriese@esa.int for further information.

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<thead>
<tr>
<th>Users List</th>
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<td><a href="http://www.mto.gov.cn">http://www.mto.gov.cn</a></td>
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<td>GIS Center - Louisiana Dep. of Environmental Quality</td>
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</table>
INFORMATION - HISTORICAL REVIEW

Water bodies represent important economic and cultural resources but also much economic activity and development that take place close to the shorelines of lakes and can be adversely affected by flooding [Krausler & al., 1997]. Moreover, lake volumes respond to changes in precipitation integrated over their catchment. Lakes are not as important, though, as direct indicators of climate change on both regional and global scales. Major river systems are important targets of research covering a wide range of applications such as transport, flooding hazard, water and food resource management, studies of the hydrological cycle, and addressing the impact of land use and climate change [Leopold & al., 1985].

For certain major rivers and wetlands, hydrological information can often be difficult to obtain due to the inaccessibility of the region, the sparse distribution of gauge stations, or the slow dissemination of data. Satellite radar altimeters have the potential to monitor height variation over inland waters [Birkett, 1993]. Hydrological products from satellites avoid political and logistical problems and can give an accurate height measurement not only for lakes but also for large rivers such as the Amazon, which has been a primary target of study over the last 10 years.

Since 1992, research into the application of altimeter for monitoring river and lake levels has been carried out. The highlights of the advantages of using data derived from satellites due to the global coverage and regular temporal sampling of the processed data, but also identified the difficulties in interpreting radar altimeter measurements made over inland water.

The first reason for studying altimetry over lakes was in fact to validate altimeter measurements. Evaluating an altimeter system over lakes has a number of advantages. Lakes have minimal tidal and long-term dynamic variability in contrast to the oceans, thus the spatial change in lake level closely follows the geoid. Many lakes are monitored so that changes in lake levels can be accounted for in the elevation [Morris & Gill, 1994]. The first zone of application of this new method to validate instruments was over the American Great Lakes with the Seasat [Brooks, 1982] and TOPEX/POSEIDON [Morris & Gill, 1994] altimeters. From the results of these studies the great potential of altimetry to monitor inland water levels rapidly became apparent. This has been applied several times not only over the American Great Lakes [Morris & al., 1994] but also over the Caspian Sea [Casagrande & al., 1999], over East African lakes [Birkett & al., 1999] and the largest rivers including the Amazon [Kociński & al., 1993, Mercier & al., 2001, De Oliveira Campos & al., 2002]. Recently, the potential for generating river and lake heights on a global scale by representing the individual altimeter echoes was demonstrated [Barr, 2002].

In general, the great improvement of altimeter measurement accuracy over the last decade has
25/30 April 2004
Second release of River and Lake Sample Products for Hydrologists distributed at the 1st General Assembly of the European Geosciences Union (EGU2004) held at the Acropolis Congress Centre and Exhibition Hall in Nice, France, from 25 - 30 April 2004.

Click here for the River Lake Abstract.

25 April 2004
Sample products Second Release.

26 January 2004
Hydrologists pooled for feedback on product samples.

Thanks to all for your interest on River and Lake Project. The project is on going and during the second phase of the project, the River and Lake Team really welcomes the feedback from the scientific community. The observations, the analyses and the critica from hydrologists and others, are appreciated because they permit to improve the quality of the RL and RLA products.

There are several points the Team is interested in having an assessment. Regarding the products already available on-line, we would like to know if the formats of both products are satisfactory. Whereas, in relation to the tools available on-line, we would like to know if the users find them useful as is in terms of functionality and feature or would like to submit requirements for improvment.

For the progression of the project, it is important to deliver to users some products that will be used to provide additional information for a particular river or lake study or to give an assessment of the products themselves comparing them with in situ measurements. Therefore, we really need to know what river, lake or catchment basin the users are monitoring. A great advantage of the RL samples is their time coverage due to the continity of the satellite measurement. In the phase 2, the processor will be adapted to generate products in near-real time, which will give the possibility to all users to monitor the variation of water resources. For improving the RL products, it will be very useful to know the coordinates and the frequency of the measurements made by hydrologists. Moreover, it permits to estimate the accuracy of RL products comparing the ground measurements with a crossing point from satellite.

Feel Free to contact us for any feedback and requirement.
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<tr>
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<td>Height Retrieval Over Inland Water Targets by Retracking Satellite Altimeter Data</td>
<td>P.A.M. Berry, R.A. Pinnock</td>
<td>May 2003</td>
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<td>Global Assessment of Envisat RA-2, Performance Over non-Ocean Surfaces</td>
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<td>New River-Lake Data Product</td>
<td>D. Di Cola, J. Beveniste</td>
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<td>River and Lake from Radar Altimetry, Sample Products for Hydrologists</td>
<td>J. Beveniste, D. Defrance</td>
<td>April 2004</td>
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REFERENCES

This section contains bibliography references for the project. For the sake of simplicity they are divided into DMU Publication and OTHER Publications.

Click here to download the following references list in Microsoft Word format.


1995


INFORMATION - PROJECT MEMBERS

Contact us: rl.info@plod.esrin.esa.it
http://earth.esa.int/riverandlake

PROJECT PRESENTATION

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The first ambition is to obtain around 15 years of data processed on specific targets, then to propose the world-wide coverage of large rivers and lakes over 10 years and finally to make available to hydrologists all RLH and RLA products in real time, i.e. in less than 3 hours after the measurement.

ORGANISATION

In order to design high quality products that respond to the hydrologists’ requirements, the team has been composed of altimetry specialists from De Montfort University (DMU) and hydrologists from Lancaster University (LJ). The project, proposed by the European Space Agency (ESA) draws on the extensive prior knowledge and experience of the DMU team in the analysis and interpretation of satellite radar altimeter echoes over non-ocean surfaces. Together with DMU, a team of specialists composed of hydrologists and experienced users of altimeter data for lake level studies serves the dual purpose of producing requirements and initiating user awareness of the new products.
THE RIVER AND LAKE PROJECT

NEAR REAL TIME DEMONSTRATION PILOT

- Radar Altimeter waveforms and geophysical corrections are fetched directly from the Envisat ground segment
- The near real time River&Lake processor is run as soon as the data is received
- The “River&Lake for Hydrology” (RLH) output product is stored in the web site
- The longest lag is the availability of the DORIS orbit (3~4 days)
  - This will improve to 3 hours when the DORIS Navigator orbit is processed in real time
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NEAR REAL TIME DEMONSTRATION PILOT
THE RIVER AND LAKE PROJECT

NEAR REAL TIME DEMONSTRATION PILOT

River Niger, Nigeria

Height Difference (m)

Date (years)

2003 2004 2005 2006

Envisat Historical
Envisat NRT
THE RIVER AND LAKE PROJECT

NEAR REAL TIME DEMONSTRATION PILOT

River Niger, Nigeria

[Graph showing water level changes over time with date labels from 2003 to 2006.]
THE RIVER AND LAKE PROJECT
NEAR REAL TIME DEMONSTRATION PILOT

River Niger, Nigeria

Date (years)

Height Difference (m)

Envisat Historical
Envisat NRT
THE RIVER AND LAKE PROJECT

OUTLOOK

• Processing the DORIS Navigator data in real time will reduce the River and Lake level product latency to less than six hours (more development needed)

• Improving the river identification and systematic accuracy control algorithms will make it possible to expand the research into smaller rivers.

• The demonstration pilot has goal to analyse usefulness of the River&Lake product in the User community. Feedback from a Core User Group will be gathered and published on the web site.

• On-going research on lake volume variation and wetlands.
THE RIVER AND LAKE PROJECT

CD-ROM or WEB?

• Can everyone download tools and products from the Web or are some CD-ROMs needed?
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