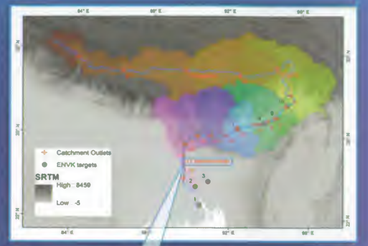
The Technical University of Denmark has conducted studies into utilising altimetry data for river models in several areas including: Bangledesh, Zambezi and Syr-Darya. Initial work showed that altimetry targets displayed high correlations with in-situ gauging stations and water levels simulated by hydrological models. Work was carried out to determine whether altimetry could be used to inform existing models. The studies demonstrated that the predictive capabilities of hydrological river basin models could be significantly improved if radar altimetry data are assimilated into the model and lake and reservoir levels are updated in real time. A real-time modelling system for the Syr Darya River Basin has been developed and was successfully operated with EnviSat near real time products.

Figure 10: Base map of the Brahmaputra River Basin (BRB).



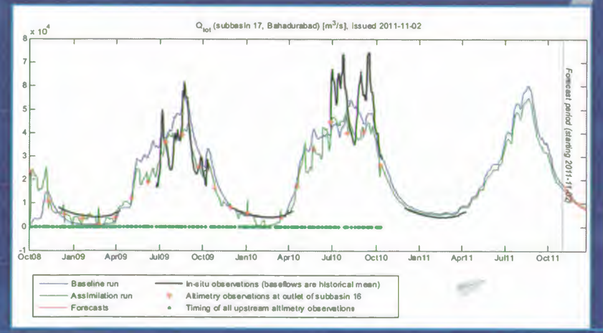


Figure 11: Model performance at Bahadurabad with and without data assimilation.
The gain factor was G = 1, the correction was distributed linearly over the upstream reaches and the discount factor for a daily time step was 0.975

For more information see:

Pereira-Cardenal, S. J., Riegels, N. D., Berry, P. A. M., Smith, R. G., Yakovlev, A., Siegfried, T. U., and Bauer-Gottwein, P.: **Real-time remote sensing driven river basin modeling using radar altimetry,** Hydrol. Earth Syst. Sci., 15, 241-254, doi:10.5194/hess-15-241-2011, 2011.

Michailovsky, C. I., McEnnis, S., Berry, P. A. M., Smith, R., and Bauer-Gottwein, P.: **River monitoring from satellite radar altimetry in the Zambezi River basin**, Hydrol. Earth Syst. Sci., 16, 2181-2192, doi:10.5194/hess-16-2181-2012, 2012

ESA (DI)

Research into the applications of spaceborne altimetry for monitoring river and lake levels highlighted the key advantages of using satellite data to augment available ground truth.

The European Space Agency launched the "River & Lake" project to provide the scientific community with easy-to-use, effective and accurate river and lake height measurements from the ERS-2, TOPEX/Poseidon, Envisat, Jason-1 and Jason-2 radar altimeters. Near-real-time measurements have been generated from Envisat and Jason-2.

Some time-series of the "River & Lake" Hydrology product (RLH) and "River & Lake" (RLA) on a representative selection of rivers and lakes are available as samples on a CD-ROM. It also contains a demo interactive website along with the product handbook and other documentation.

For more information regarding "River & Lake" please visit the website:
http://earth.esa.int/riverandlake

For any queries please write an email to:
rl-info@plod.esrin.esa.it

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GEN211

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→ RIVER & LAKE

Satellite altimetry for measuring river and lake heights

European Space Agency

The effective management of the Earth's inland water is a major challenge facing scientists and governments worldwide. Research into the applications of spaceborne altimetry for monitoring river and lake levels highlighted the key advantages of using satellite data to augment available ground data. The ability to obtain altimeter measurements remotely, regardless of human proximity, provides water resource planners with additional sources of information. This is of particular benefit in areas such as Africa, where the availability of "in- situ" data is limited.

The European Space Agency launched the "River & Lake" project to provide the scientific community with easy-to-use, effective and accurate river and lake height measurements from the ERS-2, TOPEX/Poseidon, Envisat, Jason-1 and Jason-2 radar altimeters.

A Near-Real-Time automated system has been developed and maintained by De Montfort University (DMU,UK) producing two types of products: "River & Lake" Hydrology (RLH) and "River & Lake" Altimetry (RLA). The former contains only those values required by hydrologists whilst the latter contains the individual altimeter measurements and associated orbit and corrections data.

The RLH products are text-based files, containing the altimeter derived water height differences from a given mean value. Plots of two target timeseries are shown in Figure 6 *(location A in the map of Africa in Figure 4)* and Figure 7 *(location B in the map of Africa in Figure 4)*.

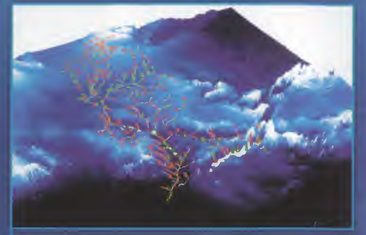


Figure 3: Potential targets with the new acquisition mask for NRT system over the Zambezi and Okavango Rivers *(located on rectangular overlay in Figure 4)*. The targets have been graded red yellow and green based upon how well the target is currently monitored.

The system currently derives river and lake heights on a global scale *(see Figure 1)* in Near-Real-Time (NRT) using the capabilities of the space borne Radar Altimeters present in the Envisat (before the orbit drift) and Jason-2 satellites. All NRT crossing height measurements have statistical data associated with them, comprising the RMS of the height measurement about the mean value, and the number of individual measurements that were combined to give the final height value.

Figure 1:
R&L NRT Mask in Red | 2011 Land GLCC water mask dark blue.

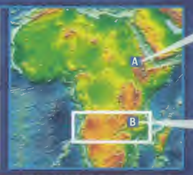
Figure 2:
Worldwide website hits provided by Google Analytics

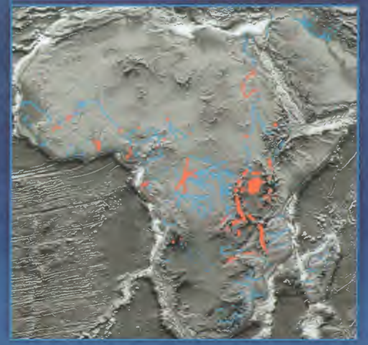
Users can easily obtain new products (RLH) by subscribing to the desired target(s) in the "River & Lake" website **(http://earth.esa.int/riverandlake)**, these products can be delivered via e-mail (push mail) or downloaded directly from the website. Locations of these targets, for Africa, are shown in Figure 5. This allows users to receive in passive way all the latest updates of their zones of interest.

The "River & Lake" system has enhanced its global measurement capability over time. It now has a significant global userbase, as shown in Figure 2. There are currently over 1350 registered users, with over 200 users, mostly in the developing world, receiving the direct e-mail service which requires much reduced bandwidth over 50 new ones in the last 12 months.

Figure 4: ACE2 GDEM of Africa. Location A is Lake Tana; Location B is Lake Malawi; Rectangular overlay contains the rivers Zambezi and Okavango.

Figure 5: The red represents the locations where currently data is available in near real time, and in blue potential locations expected to be made available in the future.





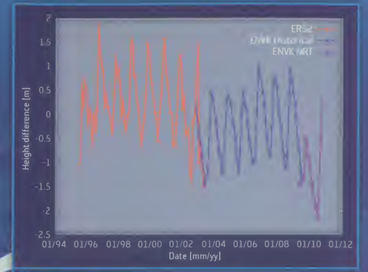
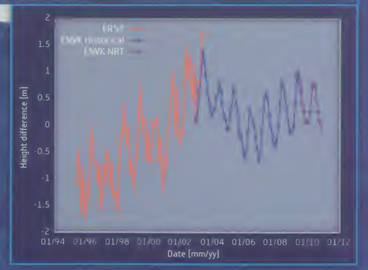


Figure 6: Example of RLH timeseries over Lake Tana (*Location A in Figure 4*), with data coming from ERS 2, from the Envisat historical series and from recent near real time processing of Envisat data on Ku-band.

Figure 7: Example of RLH timeseries over Lake Malawi (*Location B in Figure 4*), same data sources as Figure 6

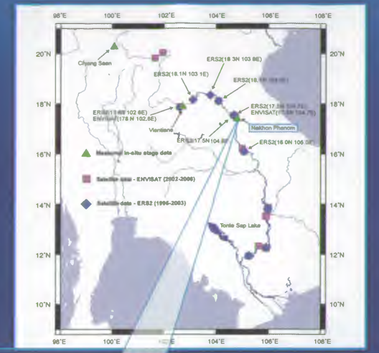


The acquisition mask *(Figure 1)* is currently being enhanced to enable better target monitoring. A preview of the enhanced mask for the Zambezi and Okavango River basins *(rectangular overlay in Figure 4)*, is shown in Figure 3. It is expected that the enhanced mask will improve the number of targets successfully retrieved by several orders of magnitude, improving the overall global monitoring capability of this service.

Modeling

As a contribution to the ESA "River and Lake" project Newcastle University is investigating the potential of altimetric stage heights and its conversion to discharge. The Mekong River has been selected as a test-bed, with gauge data supplied by the Mekong River Commission compared to a number of altimeter measurements. Investigations were undertaken to estimate discharges at a downstream site, Nakhon Phanom, assuming that in situ data are available at a site 400 km upstream, Vientiane. The use of altimetric stage data is shown to improve estimated discharges.

Figure 8: Measured in situ stage and satellite altimetry data. In this study daily discharge is estimated at Nakhon Phanom and Vientiane using satellite altimetry data and Landsat images. The is validated against the measured in situ data at these locations. The observed in situ data at Chiang Saen is used to estimate the unknown bathymetric depth at Nakhon Phanom and Vientiane. All the satellite data shown is used in the estimation of daily stage data at Nakhon Phanom and Vientiane.



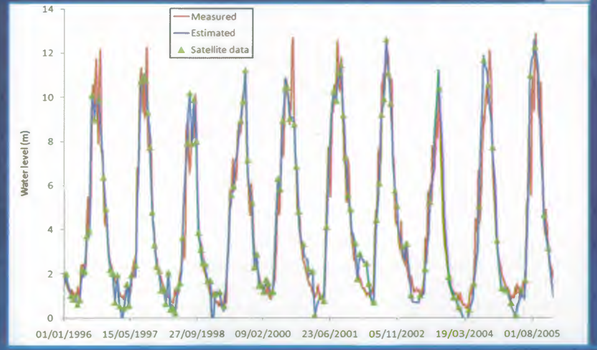


Figure 9: Channel stage at Nakhon Phanom between 1996 and 2005.

For more information see: Birkinshaw, S. J., O'Donnell, G. M., Moore, P., Kilsby, C. G., Fowler, H. J. and Berry, P. A. M. (2010), **Using satellite altimetry data to augment flow estimation techniques on the Mekong River.** Hydrol. Process., 24: 3811–3825. doi:10.1002/hyp.7811