Exploration of Multi-satellite Altimetric Data over Inland Water

A multi-interdisciplinary program utilizing radar and laser altimetry
from the NASA/CNES Jason-1 and TOPEX/POSEIDON,
NRL GFO, ESA ERS and ENVISAT, and the ICESat satellite missions.

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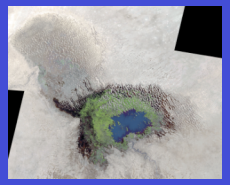
ABSTRACT: Satellite radar altimetry is a valuable tool in providing surface height (stage) measurements of inland water targets and the technique has been utilized in many interdisciplinary projects. This Jason-1 SWT project seeks to explore several investigations using data from the TOPEX/POSEIDON, Jason-1, Topex/Jason tandem period, GFO, ERS, and ENVISAT missions. With the unique opportunity to combine datasets to improve both spatial and temporal resolution, the project seeks to enhance one technical and two science-related programs. The technical program is linked to an ongoing, semi-operational, near-real time reservoir-monitoring project that has evaluation of regional drought and irrigation potential as part of its overall goal (see separate abstract). The science programs are I. Evaluating the response of lakes and reservoirs to variations in climate and II. Exploring the dynamics of the Amazon River. This presentation gives an overall review of ongoing work, and then focus is on aspects of I with investigations looking into the response of inland reservoirs to fluctuations in precipitation and temperature via observation of both altimetric stage and radar backscatter. Stage variations over large lakes are correlated with freshwater anomalies in the Beaufort Gyre (1997) and the identification and variation of freeze- thaw periods are investigated.

1. General Applications

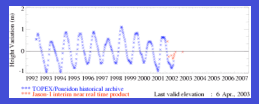
There are a number of advantages in using satellite radar altimetry for inland water applications. The stage measurements form a consistent data set that can enhance or in some regions, replace traditional gauge monitoring systems. The success of the radar altimeters on board the TOPEX/POSEIDON, Jason-1, ERS and ENVISAT satellites has contributed to many science projects and operational programs. (Birkett, Coe, Doorn, Reynolds, Beckley).

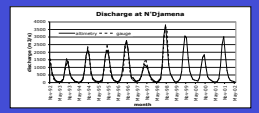
Case Study - Lake Chad

Variation in arrival time and amplitude of the seasonal inundation of the inflowing River Chari waters have major impacts on livelihood choices. Fisheries and water resources are affected with additional drought and flood concerns.

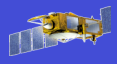


Synergy between altimetric-derived elevation, imaging-derived areal extent, satellite and ground-based precipitation, together with knowledge of how up-river observations are correlated with down-stream flows, are allowing seasonal prediction of inundation extent, magnitude and flood duration

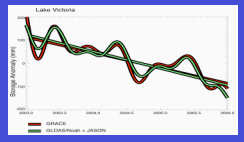




Altimetric lake level variations (taken from the CropExplorer Website) revealing seasonal and inter annual variations and the inherent inland water problem with the Jason-1 GDR data set (above-top).
Comparison of derived river discharge at N'Djamena. Gauge discharge is via from the ground-based rating equation. Altimetric discharge (with a 10-day phase lag)is inferred using the rating equation and altimetric height correlations (above).



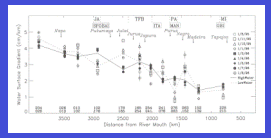
Altimetric measurements from the Topex/Poseidon and Jason-1 missions appended to historical gauge data for Lake Victoria. Results are used to prove non-compliance of the Owens Falls Dam Treaty.

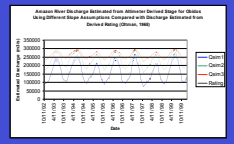


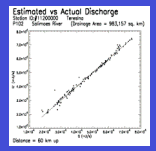
The USDA/NASA funded lake and reservoir Operational Monitoring Program (part of CropExplorer) for estimating irrigation potential and observing long-term drought. Lake level products are also being utilized by the GRACE community for validation exercises.

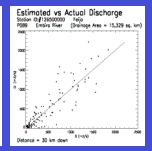
2A Product Limitations

For the majority of projects, ideally it is the volume of stored water in reservoirs and wetlands, and an estimate of river discharge, more 'higher-level' products, that is required. Through collaborative efforts, theoretical studies are underway, investigating how to determine discharge, Q via a combination of satellite-observed parameters such as river width, surface slope or river gradient, surface extent and stage. (Fekete, Bjerklie, Birkett, Coe)









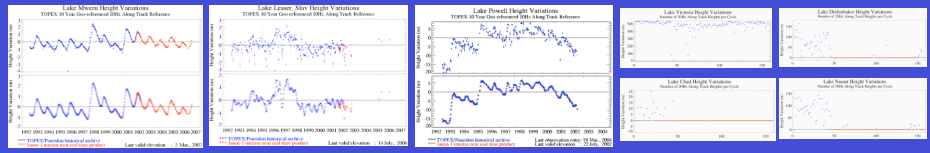
While synergistic radar and lidar altimetric-derived elevation measurements help improve observations of the spatial and temporal variations of the hydraulic gradients along the main stem of the Amazon river (top left), theoretical (above) and correlation studies (right) aim to utilize the altmetric-derived stage and gradients to infer river discharge. Ultimately both discharge and lake and wetland storage volume (higher level products) are desired for a variety of interdisciplinary applications. Science requirements demand more sophisticated type of wide-swath altimetric measurements. *(Examples by Chin, Jasinski, Birkett, Bjerklie)*

2B Instrument Limitations

Regarding elevation (stage), there are a number of instrument limitations, not the least being nadir-pointing, restricting the number of observed targets. Footprint size and along-track data rate (minimum target size), and instrument tracking logic, also restrict the quantity and quality of the measurements. Standard data (GDR) techniques are now being replaced by more intensive echo analysis examining the complexity of the returned echo shape and the variation in radar backscatter. Assembling a combined GDR/SDR data set maximizes the use of the existing Topex/Poseidon and Jason-1 data archives (Preaux, Birkett, Beckley) .

2C Jason-1 data problems

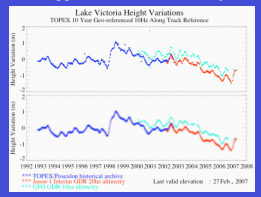
Extra echo-shape filtering by the ground data processing system is rejecting the majority of narrow-peaked radar echoes out of the Jason-1 data set. This means a major loss of data for the main river systems, wetlands and small (sheltered) lakes. This has had a detrimental effect on several science programs and the operational reservoir program, affecting 50% of the routinely monitored lakes. (Birkett, Beckley).

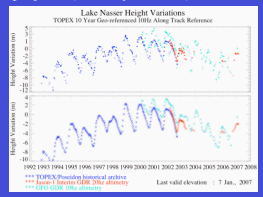


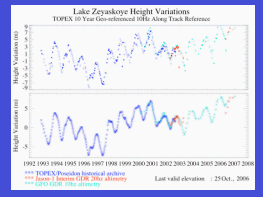
Results taken from the CropExplorer database showing the paucity of Jason-1 data over small, sheltered lakes.
The number of valid 20Hz elevation measurements severely declines after cycle 42.

3. Mission Synergy

While investigations probe the 'missing Jason-1' data problem, the various projects are turning to the data acquired during the Topex/Jason Tandem phase (2002-2005) and to data acquired by the NRL's GFO satellite (post 2000) prioritizing the use of US-based satellite missions fist and recognizing the need for continued, uninterrupted data by the USDA-funded reservoir operations program. For detailed echo analysis however, GFO SDR data is sparse, being only recorded in limited quantities over Africa. The fact that the GFO satellite overpasses the lake targets at different locations, and the fact that only 6yrs of data are available (cf 10yrs) to form a GFO mean reference datum, poses problems when the Topex/Poseidon, Jason-1 and GFO data are combined. Datum offsets, elevation bias etc need to be further investigated and results validated, before the new operations products (below) can be released or the GFO data applied to various river dynamic projects (Beckley, Birkett).







Preliminary GFO lake results plotted alongside those from T/P and Jason-1. Results for Zeyaskoye have been adjusted based on the mean residual between synergistic Topex/Poseidon/GFO measurements (2000-2002).

4. References

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5. Acknowledgements

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