

## ***Interactive comment on “Combining high-resolution satellite images and altimetry to estimate the volume of small lakes” by F. Baup et al.***

### **Anonymous Referee #1**

Received and published: 8 January 2014

**OVERALL:** An interesting paper outlining techniques for the determination of lake volume or volume changes - a much needed hydrological parameter, and a research area that is currently being addressed by the community in the light of improvements in satellite radar altimetry and imagery.

**GENERAL COMMENTS:** Is radar altimetry marginally better than imagery for the lake La Bure case because a) it's more accurate, or b) the level variation is greater? In such a shallow lake, I would expect the areal extent to vary greatly, and the altimeter to have the greater error due to little variation and few data points across the ground track. If the imagery has greater error – is this due to lake size, or failure to detect

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water in the coastline “edge” pixels, perhaps due to vegetation? How applicable are these techniques to global lake studies? In the light of little in situ data and/or unknown bathymetry for example, or, for those lakes with some in situ data, will radar altimetry be expected to be the best method? What could cause the methods to be temporally unstable? Can the authors outline what types of research will benefit from having direct lake volume estimates, and those that will benefit from having only changes in volume? Are your derived error estimates acceptable? Where some in situ data is available, what advantage is there to combining the in situ/area and in situ/elevation results to remove their individual disadvantages?

**SPECIFIC COMMENTS:** Abstract: The abstract should state what bathymetry (lake shape) is being assumed for the 3rd remote sensing only method. State the % error in derived lake volume.

Introduction: The space agencies which operated each altimetry/imagery mission should be stated. Previously published research estimating lake volume determination should be cited with their error estimates. Why have historical studies not included very small lakes?

Study Area: Are there any other (e.g., 10-day) altimeter ground tracks across Lake La Bure? Would the ICESat-1 data set been of (sporadic) use in the 2003-2009 period for such a small lake?

SAR images: Provide/define the backscatter symbol. For absolute novices why are equations 1) and 2) relevant to the determination of areal extent? What is the difference between “full quad” and “Fine Quad”?

SAR+Optical Images: What are the theoretical estimates on areal estimation? Is there a method of determining this? Optical (cloud detection, atmospheric correction, resolution), SAR (backscatter, geo-referencing, speckle filtering, resolution).

Altimetry Data: State the along-track resolution of the ENVISAT GDR data. How many

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valid elevation data points were acquire with each pass? With the lake being only a maximum of 52ha ( $\sim 0.52\text{km}^2$ ), and the reference ground track looking as though it passes to the East of the lake (Fig.6), and an along track sampling of  $\sim 300\text{m}$  it is surprising that any elevation measurements could be acquired. Could Fig.6 be re-drawn to show the actual pass locations and their spatial variation?

In Situ Data: How was the 1987 volume estimated? What are the estimated errors on the in situ volumes? What frequency are the in situ volume estimates of altimetry or imagery?

Altimetry-based water levels: The altimeter range precision can vary from cm to tens of cm over lakes/reservoirs. “Hooking effects” is really the more technical term of “off-ranging”. Were all hooked elevations rejected, and what is the difference in elevation accuracy between direct and off-ranging elevations? How were the “hooked” measurements corrected for? Could these hooked measurements been responsible for the  $>1\text{m}$  differences between instrument and in situ measurements?

Lake Volume Estimates: What simple geometric shape was the lake modeled as? Provide references for equations 4+5 (e.g., based on C.M. Taube, chapter 12 “Three Methods for Computing the Volume of a Lake”. Annual of Fisheries Survey Methods II, 2000 ??) What can the readers deduce from the horizontal spread of data points in Figure 13?

Combined use: The research also needs an assumed lake bathymetry which the authors are not highlighting sufficiently. What variations in estimated volume arise by assuming various lake bed geometries?

Conclusions: The 3rd method still requires bathymetry – how can this be achieved?

TECHNICAL CORRECTIONS:

References: Frappart et al., 2012 or 2013? Wang et al., 2011 missing Baup et al in the reference list has the date as “201” and not “2012” Frappart et al., 2008 reference not

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used in the main text.

Figures: Figure 3 could indicate typical errors on the curve Figure 6 could indicate the real track locations and their variation across this small lake Figure 12, ground measurements are displayed as “a solid grey line”? Figure 13, define symbols All figures showing altimetry levels or imagery extents should have error bars.

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 15731, 2013.

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