Anonymous Referee #3
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The authors present an interesting approach for deriving water heights over inland water bodies utilizing the Kalman filter method and increasing the temporal resolution of inland water time series by combining multiple altimeter missions that cover a target of interest. The resulting time series for various inland water bodies are made available in the Database for Hydrological Time Series over Inland Water (DAHITI), maintained by the Deutsches Geodätisches Forschungsinstitut (DGFI). Generally, I like the idea to employ a Kalman filter technique in the processing of inland water heights and the increase in temporal coverage by combining different missions. However, I think that the proposed Kalman filter approach is quite simple and some details of the methodology should be made clearer, especially why a detailed hexagonal grid is needed for the whole water body instead of just utilizing the measurement positions (or some fixed bins along the groundtrack) of the altimeter itself. Therefore, I generally recommend the paper for publication since the DAHITI database is an interesting addition to the available range of databases, but after addressing the major issues below.

Thanks a lot for your very valuable comments. Based on this, we did some important changes – not only of the manuscript but also of our approach and software. Thus, your review really helped to improve the results of our work.
For detailed answers to your comments and the updates planned for the revised manuscript see the green parts (and especially the bullets) below.

GENERAL COMMENTS

The focus of the manuscript is unclear. The title suggests that the Kalman filter approach is new and the core topic of the paper, but in fact the authors describe their own database and its features all quite wordy while the core of the KF method is described relatively sketchy (apart from the general Kalman filter equations, which can also be found in a textbook). If the authors feel their method is innovative, they should put a stronger focus on it and provide more details on the method, motivations for choosing certain parameters and validations (and maybe shorten some other topics). See also below.

Since the focus of our paper is the whole processing strategy and not only the Kalman filter we will change the title of the paper accordingly, probable to “DAHITI – an innovative approach for estimating water level time series over inland water using multi-mission satellite altimetry”.
Indeed, detailed investigations show that the main improvement of our approach is not due to the Kalman Filter approach but mainly from the preprocessing step with outlier detection.

- We will describe this in more detail in order to make the focus of the paper more clear.

The core of every Kalman filter is the dynamic model, the propagation of which is merged with the data in a least squares sense. The authors assume an identity matrix for their dynamic model and introduce an a-priori error of 5cm. This basically reduces the Kalman filter to a recursive least squares method. The choices for the model and the a-priori error, but also for the (optional) retracking procedure should be properly motivated in the text. Additionally, it could be validated whether the result is sensitive against e.g. the choice for the a-priori error or the choice of retracking algorithm, or the grid spacing, etc. . This would make the choices, which might also vary with respect to the target water body, more plausible.

It is true that the current implementation of the Kalman Filter is simple but it has a big potential in the future if a dynamic model is applied. We will try to make this more clear in the text and motivate and describe the chosen parameters in more detail. A sensitive analysis was made in the evaluation step of our approach by testing different grid sizes, a-priori values, etc. Based on this analysis the setting parameters were fixed.

- We will describe the choices for the model, the a-priori error, and the retracking procedure in more detail
- We will provide more information about the applied outlier criteria and thresholds

The authors introduce their Kalman filter method utilizing a precomputed, hexagonal grid while assuming a constant lake level. I do like the idea of employing a Kalman filter, but I do not really see the necessity of the grid when all the grid points are assumed to be the same height (P4828, line 1). In the end all grid points over the lake are averaged into one final height output. I suppose, utilizing the actual altimeter locations (with the same assumption for constant heights and averaging) would yield nearly the same result? The authors state on P4825, line 8-10 that the observations are linked by A_k only to the nearest grid points. When computing the average, only the “best water levels” of all grid points of each epoch are selected (P4828, line 3-4). I assume, these should in general be the grid points very close to the actual altimeter groundtrack since only these will be influenced by the observations?

We changed our approach and do not use a grid for the standard computation anymore. This is no longer necessary due to improved “errors” of the altimeter measurements which are now more realistic. Now, a more reliable weighting of the input observations in the Kalman Filter is realized and makes the usage of a grid obsolete. However, we will keep the option for calculations on a grid because it is very useful for investigations regarding the surface variability of larger lakes.

- We will remove the grid for our standard computations

Furthermore, when using the grid, the individual grid points would be correlated, yet the authors assume uncorrelated system noise (P4826, line 5) and initialize their co-variance matrix E_xx,k using an identity matrix (P4825, line 12). On P4824, line 10-11 the authors say that the grid is used to account for river slopes, but I think referencing the individual heights to a fixed point (e.g. by correcting for the differences in geoid height between the measurement point and the reference point) might also do the trick.The authors should better motivate these choices to make it more comprehensible.

- As described in the point before, the grid will be removed.

Another point would be the applied retacking. Why are not all the lakes (rivers) retracked. This would be more consistent. Additionally, why use 1 Hz heights instead of 20Hz (or 18Hz or 40Hz) heights all the time over inland water bodies? Furthermore, the small threshold of the applied Improved Threshold Retracker of 10% might lead to the detection of small bumps in front of the desired leading edge in a sub-waveform, depending on the number of additional range gates considered before and after the detected sub-waveform.

Over large lakes the ocean product of the different altimeter mission provides better water heights than any retracking algorithm which is not optimized for ocean applications. Moreover, using the ocean product enable us to provide absolute water heights since we can apply the range corrections from global ocean analysis and can neglect retracking biases. Therefore, we apply only an additional retracking when it is really necessary: over smaller lakes and rivers.
In future, we will switch now completely to high-frequent altimeter data for consistency in our DAHITI approach even if 1Hz data are sufficient for lager lakes.
We agree that a 10% Improved Threshold Retracker is not always optimal, but we don't want to mix retrackers and tests show that smaller thresholds in most cases (especially over rivers) lead to better results in the resulting water heights.

Maybe the biggest problem is that no systematic analysis of the many choices is made in which the results differ. It is difficult for the reader to find out which of the choices actually leads to improvements and which is not really required. What I mean is something like, first, testing the effect of the SVR outlier detection (see also “specific comments” on this). Then investigate the effect of the additional threshold outlier correction, the Kalman filter, etc.

We agree with your statement that it is not really clear what part of the processing leads to the improved results. Therefore, the following updates will be made in the revised version.

- We will add information in Table 3 and 4 which outlier criteria are applied for the different inland water bodies.
- Detailed information about applied outlier criteria and thresholds will be added for the three study cases
- Furthermore, we will demonstrate the impact of the preprocessing and the Kalman filtering. Hereby, we replace the Kalman filter step by an Median filter to demonstrate the impact of both parts. This will be done for the three investigated water bodies. Investigations show that the major improvements are due to the preprocessing and not to the Kalman Filter. Therefore, we will updated the title of the paper (see above)

As mentioned, parts of the manuscript are quite wordy, e.g. the description of the possible choices in the openADB database in the beginning of 3.1 (P4822). Additionally, some information is provided several times throughout the manuscript (see also the “specific comments” part). These could be shortened and more focused.

- We will update/shorten certain parts (see specific comments, below)

Command of language is a problem. I am not a native English speaker, but there are, e.g., a lot of commas missing in some parts of the text. Someone with better knowledge of this than me should proofread the manuscript later.

- We will try to further improve the use of English language.

Why are there two sections containing pre-processing? (Sect. 2 and Sect 3.1)

I agree that this is a bit confusing.

- Therefore, the title of Sect. 2 will be changed from “Altimeter Data and preprocessing” to “Altimeter Data and Height Estimation”.

I like the selection of the investigated water bodies, as they cover large lakes, smaller lakes, as well as rivers. However, some additional information on the chosen criteria for outlier detection etc. would be helpful.

Additional columns of the applied outlier criteria will be added in Table 3 and 4.

- Furthermore, additional information such as used outlier thresholds will be shown in detail for the three selected study cases in ‘4.3 Selected results’

For the results, the DAHITI time series are corrected for possible outliers while time series from other groups which might still contain outliers (e.g. GRLM) are not corrected. I think, it would be more consistent when the same outlier detection procedure is applied to the other time series, too. Additionally in my opinion, the correlation with an in-situ time series is more meaningful in combination with mentioning the number (or percentage) of removed outliers from the total number of points; after removing a lot of outliers, the correlation will always become better.

We do not modify the external time series before the validation process and also do not use the in-situ data for an outlier detection of the DAHITI time series since we want to document the quality of the time series without further modification. We agree that doing so would lead to a decrease of RMS but each altimeter database has the possibility to add own outlier rejection before releasing the time series.

- We will add additional information such as number of days when altimeter data was available as input data and the resulting number of days of the final time series (thus: number of outliers)
- We will add a link to Ricko et al. in which outlier rejection was applied with respect to in-situ data

In the introduction, the authors mention that the determination of the accuracies will be covered in another paper. Why is this not included here, since the outlier detection and Kalman filtering are depending on the derived accuracies? Generally, I think this is an interesting and important part of the time series provided by DAHITI.

In general, the whole method of error propagation is already implemented and explained in this paper.
However, in the present state, the provided “accuracies” are only formal errors strongly depending on the errors of the input heights which are not perfect. In addition, detailed investigations on the resulting errors are necessary covering uncertainties of the applied geophysical corrections or geoid model. And the most difficult part is the determination of an realistic error from the applied retracking. All these points will be highlighted in another paper.

SPECIFIC COMMENTS

DAHITI The name of the database is introduced several times. At first in the abstract and again on page 4817, line 15, which is fine. But also on page 4821, line 26 or page 4837, line 2 or page 4838, line 8-9. I think one (or two) time(s) is fine.

- DAHITI will be introduced once

DGFI Similar to “DAHITI“, I think that introducing it once on page 4817, line 16 is sufficient.

- DGFI will be introduced once

— Abstract

P4814, line 7-9: I think both sentences basically providing the same information. I would suggest writing something like “... approach incorporating cross-calibrated altimeter data from Envisat ...”

- Phrasing will be updated

— Introduction

P4815, line 18: The definition of “footprint” is not precise. The pulse limited footprint (which the authors talk about) is much smaller than the beam-limited footprint defined by the antenna beam-width.

- For clarification we will change “footprint” to “pulse-limited footprint”.

P4815, line 24: How are the hooking effects treated? This is important, especially when small lakes or rivers are investigated.

In the current processing strategy, the hooking effect is not corrected but the affected measurements are excluded from further processing. The restriction of measurement latitude within the preprocessing step limits the usage of off-nadir observations. Furthermore, the additional computed input uncertainty for each altimeter measurement will increase for off-nadir observations. Thus, only few off-nadir measurements will be used within the approach and these will have larger uncertainties. In addition, we are about to publish an advanced approach for correcting the hooking effect. We plan to integrate this approach in the DAHITI software in the future.

- An explanation on the handling of the hooking effect will be added

P4815, line 27-28: I think this sentence might be misunderstood in the way that the curves are fitted to the final heights instead of the heights of one overpass over the target of interest.

- The statement will be explained in more detail for clarity

P4816, line 1: When talking about ocean-like waveforms, one might refer to the Brown model (Brown, 1977). Similar on P4819, line 16.

- Reference will be added

P4816, line 4: Generally, all threshold retrackers are sensitive to the geometrical waveform shape, e.g. large peaks will lead to a larger amplitude etc. Therefore, I think “robust” should be rephrased. Same for P4819, line 20.

The statement that we indicate retackers such as OCOG, Improved Threshold as robust means that every waveform can be retracked compared to retracking algorithms such as MLE, Beta5, etc. which try to fit form function to the waveform.

- Phrasing will be updated

P4816, line 7-11: The first two sentences of this paragraph basically provide the same information.

Phrasing was updated from *“Despite of the aforementioned challenges, satellite altimetry has been successfully used for the estimation of water levels of lakes and rivers by different groups during the last years. The potential of using satellite altimetry for the estimation of water level time series and for understanding the terrestrial water cycle was already shown e.g. in Birkett (1995), Crétaux and Birkett (2006), and Crétaux et al. (2011).” to “*The potential of using satellite altimetry for the estimation of water level time series of lakes and rivers and for understanding the terrestrial water cycle was already shown e.g. in Birkett (1995), Crétaux and Birkett (2006), and Crétaux et al. (2011).”

P4817, line 22: “optional retracking”. Why is the retracking optional and not mandatory for all inland water targets. See also general comments.
See answer in general comments

— Altimeter data and preprocessing

P4818, line 12-13: The first sentence repeats information already provided in the introduction. I’d suggest to simply remove this sentence.

- Sentence will be removed

P4819, line 3: “about 80km” → “about 80km at the equator”

- Phrasing will be updated

P4819, line 3-5: Since Envisat stopped working in April 2012 and SARAL was launched in March 2013, there is a gap in the coverage.

That is true, but in line 3-5 we are talking about the time series using the same orbit as ERS-2 and SARAL/AltiKa to achieve a time series of about two decades. In 10/2010 the Envisat mission was shifted to an interleaved orbit which means that these measurements are no longer on the same ERS-2/SARAL/AltiKa orbit. This will lead to a gap between 10/2010 and 03/2013 exist.

Envisat : 05/2002 - 10/2010
Envisat extended : 10/2010 - 04/2012
SARAL/AltiKa : 03/2013 – active

- We will update this part from "The orbit of these missions is defined by a repeat cycle of 35 days and a track separation of about 80 km. The data is available for almost two decades with a data gap between 2010 and 2013 due to the shift of Envisat to a drifting orbit that lasted until the launch of SARAL/AltiKa." to "The orbit of these missions is defined by a repeat cycle of 35 days and a track separation of about 80 km at the equator. The data is available for almost two decades with a data gap between 2010 (end of Envisat core mission) and 2013 (launch of SARAL/AltiKa). The data of Envisat on its drifting orbit (10/2010-04/2012) is not used."

P4819, line 18-20: Why use a threshold of 10%? Additionally, the algorithm might provide more than one sub-waveform and corresponding water height. Is the "correct" height selected by utilizing a reference height like in Hwang et al, 2006 or Guo et al., 2009?

We tested different values of thresholds but in our opinion the 10% threshold leads in the most cases to better results as using a 50% threshold. But the the difference are not quite large. Furthermore, we are using only the first sub-waveform for our retracking. We don't use a reference height such as last SSH over ocean (Hwang et al.) since this is difficult over small lakes and rivers.

- We will explain the used version of the Improved Threshold Retracker in more detail

P4819, line 20: How is it decided whether retracking is necessary or not? Is there a reference for the statement, that ranges from the 10% Improved Threshold Retracker are more reliable?

There is no certain criteria for applying an additional retracking. In general, all altimeter measurements of smaller lakes and rivers are retracked if the ocean product does not lead to reliable time series due to land contamination. There is no reference for selecting the 10% Improved Threshold Retracker but we have implemented several retracking algorithm and found out that this leads to the best results for our application.

P4820, line 1: Suggestion: "altimeter range" could be renamed to "retracked altimeter range" to make it clear that the ranges are always retracked and not tracker ranges.

We keep "altimeter range" because not all altimeter measurements are retracked. It can also happen that the original ocean product is used.

P4820, line 22: It would be nice if the authors could give more detail on the "certain thresholds" that were used.

- The different applied outlier criteria for the different inland water targets will be added in Table 3 and 4.
- Furthermore, detailed information about "certain thresholds" will be added for three selected results

P4820, line 25: "... and do allow to predict where ...". I think "... and do not allow to predict where ..." was intended.

- Phrasing will be updated

P4821, line 1-4: Remaining uncertainties in the geoid might lead to significant height differences depending on the location over the lake, especially for larger lakes. So the assumption of a constant height level of the derived heights might not be satisfied.

We agree that in reality the resulting surface of larger lakes are not constant because geoid errors or wind and waves lead to height differences. Our statement was based on the assumptions without that errors (geoid error, retracking error) and hydrodynamics (wind, waves) are neglected. But remaining height difference is no problem for our approach.

- We will explain our assumption in more detail

— Kalman filter approach

P4821, line 22: Rephrase “hexagonal computation”.

- Phrasing will be updated

P4822, line 14: Accuracy is not the same as precision.
Yes, of course. But since we have no information on the accuracy we use the precision as an alternative.

- Phrasing will be updated

P4822, line 15: The abbreviation SD for presumably “standard deviation” has not been introduced at this point.

- SD will be removed due to the new approach described in the next comment

P4822, line 16: The authors should elaborate why they use a “floating” box (and maybe rephrase it to “sliding”) with the size of 5 instead of just all the valid heights over the target of interest. Especially, since deriving the standard deviation reduces the degrees of freedom (dof) by two, leaving only 5-2=3 dof, which is quite a small number.

The reason for using a sliding box and not all “valid” heights is that we do not know which values are valid, and which are invalid due to topography or outliers.

We improved our “error” estimation for each measurement. Now, we are using sliding boxes along the satellite track of +-3.5 km for large lakes, +-1.5 km small lakes/large rivers and +-0.5 km for small rivers. The definition of the box in km instead of number of points makes the results more comparable between different missions measuring with 10Hz, 20Hz, or 40Hz. Moreover, instead of calculating standard deviations within each box, we use the “absolute deviation around the median” (ADM) as “error” of the measurement. For that purpose, in each box, we are estimating a median of the water heights. Then the absolute difference between the median height and the current water height is computed. This method leads especially near shores to more reliable errors than the former approach..

- The new error estimation method will be explained

P4822, line 19: “without significant slopes”. As mentioned before, there might be a significant slope from uncertainties in the geoid correction. Therefore, what will happen in case there is a significant slope and the assumption is not satisfied?

- This sentence will be removed due to the new approach of estimating “errors”

P4822, line 21- P4823, line 4: I think it is not necessary to explain all possible choices for outlier detection in the software package, but rather focus on what was chosen for the water height derivation in DAHITI.

- The different applied outlier criteria for the different inland water targets will be added in Table 3 and 4.
- Furthermore, detailed information about certain thresholds will be added for three selected results

P4823, line 6-7: “ the SVR on […] is applied.” → “SVR is applied to ...”

- Phrasing will be updated

P4823, line 9: “a lake” → Which lake?

It is Lake Erie which is crossed by Pass 80 of SARAL/AltiKa

- Information will be updated

P4823, line 11-12: How have these thresholds been selected? Are there different thresholds for different targets (large lakes, smaller rivers, etc.)? When looking at Fig. 2, only a small number of points (green) are actually rejected by the outlier detection which would probably be also rejected by the selected threshold criterion. Maybe the authors could elaborate on why they need both stages of outlier detection?

In general, a threshold of 0.05 m is selected for lakes when this outlier criteria is applied. This threshold was selected because high-frequent data have a noise within +-5cm which can be seen in Figure 2. It is often not necessary to apply all introduced outlier criteria.
Planned updates in revised version:

- Table 3 and 4 will be updated by adding additional information about applied outlier criteria

P4823, line 14-16: The authors should mention this a little bit earlier in the before the example with the lake. Additionally, it is not mentioned in the results section which criteria for outlier detection were chosen for the different inland water bodies.

- This information will be moved before the example of the lake
- Table 3 and 4 will be updated with additional information about applied outlier criteria

P4823, line 19: Suggestion: Maybe rephrase “heart of DAHITI”.

- The role of the Kalman Filter in DAHITI will be rephrased

P4823, line 24-25: The Kalman filter only gives an optimal estimate for linear models and Gaussian distributed model states and observations.

We agree!

P4824, line 23-24: I think the sentence might be a bit unclear. Suggestion: “Time intervals shorter than one day are precluded by assigning the individual measurements to full days”

- Phrasing will be updated

P4825, Eq 2: I think the x_k vector is missing a minus sign in the exponent

In this part the basic equation especially the observation model is introduced which is not time dependent itself. Therefore, the x_k vector has no minus sign.

P4826, line 5-6: Why 5cmˆ2? Why are the grid nodes uncorrelated (see also general comments)?

The 5cm² was selected based on personal experience.
We did not apply correlations because they are unknown (see before)

P4827, line 7-8: I suggest to rephrase it to “ … accuracies will become smaller within the updating step” since “reduced accuracies” implies that the accuracy becomes worse.

- Phrasing will be updated

P4827, line 15-20: The information on the transition matrix and the assumed variances has already been provided on P4826, line 2-6.

Yes, in P4827, line 15-20 the general Kalman Filter is explained. But P4826, line 2-6 in we focus on our implementation in DAHITI.

- Phrasing in P4827, line 15-20 will be updated

P4828, line 6: Why 5-10cm? Is this value larger for smaller lakes or rivers? How is it chosen?

The resulting errors depend on the input errors of the altimeter measurement. By using the standard deviation which was implemented before the errors were quite small and increase for small lakes and rivers. Our new error estimation leads to more realistic and larger errors which increases also the resulting errors of the Kalman Filter approach. Therefore we choose an error limit for larger lakes which is selected manually depending on the resulting errors. For rivers and small lakes we are using the height which has the lowest error.

- We will explain in more detail how the error limit is selected

P4828, line 17-21 (Figure 5): How is the confidence interval “manually defined”? Is it different for each target? The dashed lines in Figure 5 are not described in the caption of the figure. Which lake is used for the example in Figure 5?

The confidence interval is defined manually because it depends on the scatter of the different water bodies
Lake Erie is used in Figure 5 which is already mentioned in P4828, line 18

- Dashed lines in Figure 5 will be described
- Name of the lake will be added to the description of Figure 5
- Selection of confidence interval will be explained in more detail

— Results and validation

P4829, line 14-15: The different target types have already been mentioned in the beginning of Sect. 4.

- We will remove this sentence

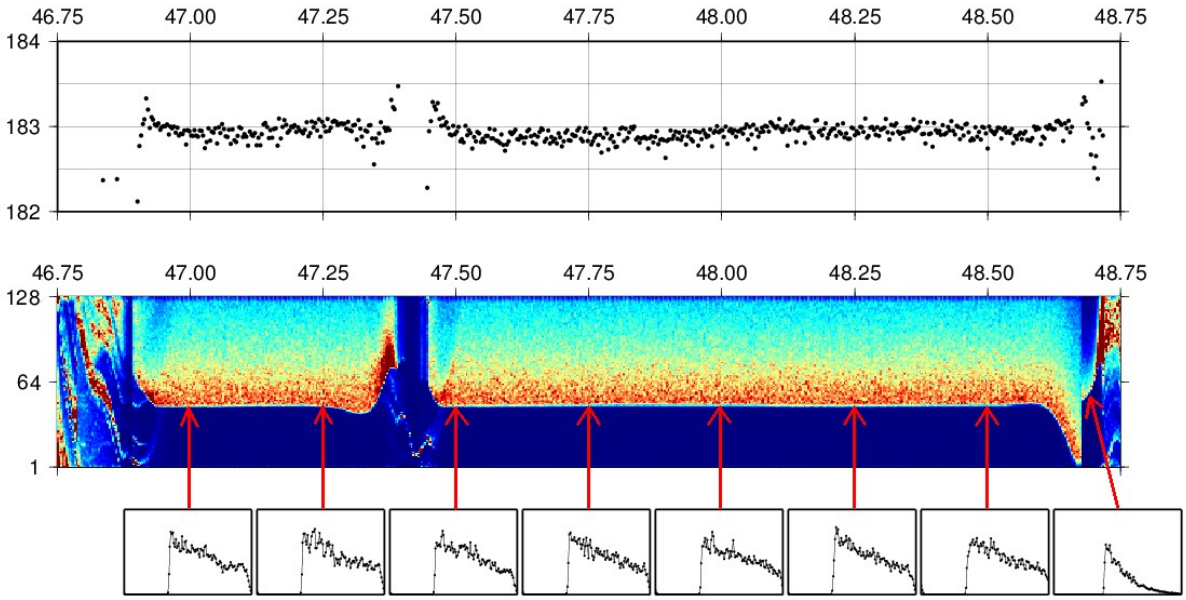
P4829, line 19-20: Suggestion: Remove that sentence, as it provides no new information.

- The sentence was removed

P4829, line 23-25: This may be correct for the central parts of the lake but closer to the land influences will impact the waveform shape.

Yes, that is true, but there is only a small band of few kilometers along the lake shore which is affected by land contamination. For the Great Lakes, the waveforms have almost always ocean-like shapes which is shown in the image below for a crossing track over Lake Superior. For those lakes the corrupted waveforms near the lake shore will be rejected by the different outlier criteria.

- We will add information about corrupted waveforms near the lake shore



P4830, line 16: “several lakes are frozen for several month” Which ones? Are all measurements during these month treated as outliers?

Sentence was updated from “Several lakes are frozen for several months which makes the water level computation challenging” to “Several lakes (indicated in Table 3) are frozen for several months which makes the water level computation challenging” .

- We will explain the usage of the backscatter coefficient as additional outlier criteria to reject measurements affected by ice coverage

P4831, line 20-21: I’d suggest to remove the first sentence, as it repeats information that has been mentioned before.

- Sentence will be removed

P4832, line 5-6: Computing the relative height changes does not avoid all the uncertainties in in-situ gauge data. E.g. there could still be gross reading errors in manually operated gauges.

That is true. The objective of the comparing relative heights is that the different altimeter time series have different absolute heights. These offsets are now removed. Other uncertainties in in-situ data will show up as increased RMS within the validation process. In our case, only clear outliers of several meters are rejected for few stations in the Amazon Basin.

P4832, line 28 (Figure 7) Why is the year 2004 highlighted?

There is no certain reason why year 2004 was highlighted. The objective is to show the data distribution of the different time series in detail. Especially the increased number of points of the DAHITI time series.

P4833, line 2: How have the time series been shifted? With respect to the mean or one (or more) selected cycles?
All external time series from altimetry and in-situ stations are shifted with respect to the DAHITI time series. Hereby, differences at all common epochs are computed and averaged.

- The method about estimating the applied offset will be explained in more detail

P4833, line 4: After applying two outlier corrections during the processing, one should in general not expect any more outliers.

That`s true. So, this result proofs the efficiency of our outlier rejection.

P4833, line 5: Why use the 1Hz ranges instead of consistent 20Hz (or 18Hz or 40Hz) ranges for all targets? Small land influences on the trailing edge of the waveforms might still influence the results of the standard ocean retracker ranges, available in the GDRs. (See also general comments).

In general, 1Hz altimeter data are sufficient for large lakes. But we changed our approach in DAHITI and we are now using only high-frequent data for all investigated water bodies.

- 1Hz altimeter data will not longer be used in the DAHITI approach

P4833, line 8-9: From Table 1, one can see that other stations showed larger RMS compared to Ontonagon and Grand Marais. Is this connected to the distance of the in-situ stations to the altimeter ground tracks?

Probably, there is a small impact of the distance to the gauging station. However, the in-situ time series of Duluth and Point Iroqouis look more noisy than the station Ontonagon and Grand Marais.
This is probably caused by wind and waves because the station Duluth and Point Iroqouis are located in brights in the most west and south-east. Thus, effects due to the quality of these stations are more likely. The distances between in-situ station and nearest altimeter track for Ontonagon and Point Iroqouis vary between 5-10 km. We think that the distance has not a major impact on the RMS differences.

P4833, line 9: In my opinion the correlation coefficient alone is not a good measure for the quality, since removing a large number of “outliers” automatically improves the correlation drastically. So additional information on the total number of measurements and the number of removed outliers from the final time series might be helpful here.

- We will add an information on the number of outliers (number of days when altimeter data was available as input data and the resulting number of days of the final time series.)

P4833, line 16-17: Have the results from the other databases also been corrected for possible outliers? E.g. the unsmoothed GRLM results which, judging from Figure 7, are used here might still contain large outliers in some cycles, which will have a significant effect on the computed RMS. (see also general comments).

We do not modify the external time series before the validation process and also do not use the in-situ data for a outlier detection of the DAHITI time series (as done in Ricko et al) since we want to document the quality of the time series without further modification. We agree that the RMS will decrease after outlier removal but each altimeter database has the possibility to add own outlier rejection before releasing the time series.

P4833, line 22: Figure 8 deals with a different lake so it does not show the "same time series" like Figure 7.

- Phrasing will be updated

P4833, line 24: The GRLM time series for Lake Athabasca is no longer available on the GRLM website.

The time series is still available. The following archive which is available via the GRLM website http://www.pecad.fas.usda.gov/lakes/images/envisat_lakes.txt.zip contains Lake Athabasca in file lake0348.N.1.4.txt

P4833, line 24-25: Figure 8 highlights the year 2004 (like Figure 7) and not 2010. Again, what makes this year special?

There is no certain reason for the selection of the year. But, it must be a year in which all investigated time series and in-situ data are available. The reason for zooming into a single year is to show the temporal resolution of the different time series.

P4834, line 1: "very good" The results for the Topex/Poseidon era seem to be more noisy compared to LEGOS.

Maybe it looks more noisy because there was only one mission used compared to the period starting in 2002. Furthermore, the time series are rarely affected by ice coverage compared to the LEGOS time series.

P4834, line 2: Since "outliers" should have been removed during the processing, I'd suggest to maybe rephrase this.

- We will rephrase the sentence

P4834, line 2-7: Generally, the same concerns regarding mentioning the number of outliers and also applying the same outlier removal to the time series of the other groups.

We do not want to modify time series of other groups as mentioned above.

P4834, line 9: Suggestion: Maybe remove the first sentence.

- The sentence will be removed

P4834, line 13: "only one mission" → Figure 9 includes results based on Envisat and SARAL. These are two different missions.

Both mission are not flying at the same time.

- Therefore we will update the following sentence: "All altimeter time series reach a temporal resolution of about 1~month since they are based purely on missions with 35-day temporal resolution (Envisat and SARAL)."

P4834, line 14-15: Similar to P4819, line 3-5, Envisat stopped working in April 2012 and SARAL was launched in March 2013, so there is a gap in the coverage.

This point was already commented in P4819, line 3-5:

P4834, line 9-24: What pre-processing criteria (mentioned in Sect. 3.1, e.g. SD thresholds) have been used? Why is the year 2010 highlighted?

There is no certain reason why we selected 2010. There requirement was to select a year in which in-situ and all other altimeter time series are available.

- We add information about the applied outlier criteria in Table 3 and 4 and especially for the 3 selected examples
- Figure 7,8,9 will be updated to be more understandable for the user
- We will explain why we select certain highlighted year

P4835, line 7: “used points (No)” →Are the number of removed outliers included? (Same for Table 4).

The number of used points is defined by the number of days for which a water level height was computed and used for the validation. This is not the complete number of days of the whole time series.

- We will explain in more detail what is meant by used points

P4835, line 9-10: The smallest and largest RMS are not marked in color in Table 3.

- Table 3 and Table 4 the smallest RMS will be highlighted in bold and the largest RMS in italic. A highlighting in red and green is technically not possible in this journal.

P4835, line 15-18: Wind effects or other local influences might have an impact on the gauge station measurements. Again this raises the question whether stations closer to the track show better agreement.

This was already answered before in P4833, line 8-9

P4835, line 19-27: In case the other products still contain outliers, the comparisons might need to be improved before a general better performance of DAHITI can be validated.

This was already answered before in P4833, line 16-17

P4836, line 1-4 (Table 4): I think it would be helpful if the authors would include information on the utilized satellite data in each row (Maybe, e.g.: Station Name (J2) …).

- The used altimeter satellites will be added to Table 3 and Table 4

P4836, line 15-16: Is there a reference for that statement? Especially for rivers, the quality of the reprocessed water heights is quite depending on the surrounding terrain (in this case mainly rain forest?), etc. I think it would be nice to rephrase this statement to make it more clear.

- We will rephrase this statement in more detail

— Conclusions

P4837, line 15: Related to the previous point, the authors could elaborate (either here or in the previous section) what is meant by “surrounding conditions”.

- We will rephrase this statement in more detail

— References

- Well presented, except for a few missed “{}” (see “technical comments”).

- {} will be removed from references

TECHNICAL COMMENTS

I will only list a few things here, since the manuscript will probably be reworked anyway.

— Abstract

P 4814, line 2: “However, since some years” → “However, for some years”.

- Phrasing will be updated

P 4814, line 16: “from available other altimeter ...” → “from other available altimeter ...”

- Phrasing will be updated

— Introduction

P 4814, line 26: “However, in the last years … “ → “However, over the last years ...”

- Phrasing will be updated

P4815, line 27: “... fitting curves on the resulting ...” →“... fitting curves to the resulting ...” Altimeter data and preprocessing

- Phrasing will be updated

P4820, line 14: Missing words. → “Finally, each single altimeter measurement is corrected for its ...”

- Phrasing will be updated

— Kalman filter approach

P4822, line 5: “data base” → “database”

- Phrasing will be updated

P4822, line 14: “Due to lacking absolute ...” → “Due to the lack of absolute ...”

- Phrasing will be updated

P4823, line 19-21: Just a suggestion: “... input heights by combining of the […] at different locations (Kalman, 1960).”

- Phrasing will be updated

P4824, line 15: “At the beginning an initialization ...” → “In the beginning, an initialization ...”

- Phrasing will be updated

P4824, line 18: “contant” → “constant”

- Phrasing will be updated

P4824, line 18-19: Rephrase: “That means that our system each time is updated if a new ...” → “That means that our system is updated each time a new ...”

- Phrasing will be updated

P4826, line 15: “actual” → “current”

- Phrasing will be updated

— Results and validation

P4830, line 21: To be consistent with the other times it is mentioned, write “Lago Argentino”

- All Spanish lake and river names were translate into English

P4831, line 5-6: Maybe merge the two sentences to one.

- Both sentences will be merged into one

P4831, line 7: Suggestion: replace “wet” with “humid”

- Phrasing will be updated

P4831, line 8: Suggestion: replace “show” with “reach”

- Phrasing will be updated

P4831, line 10: Suggestion: replace “diversification” with “variety”

- Phrasing will be updated

P4832, line 10-14: Suggestion: These 3 sentences contain the word “differences” five times. Maybe rephrasing some of it will make it more easy to read.

- Phrasing will be updated to “These results are based on various altimeter missions and diverse approaches were performed to compute the water level time series. As a consequence, these external time series cover different time periods with temporal resolutions between 10 and 35 days. This has to be kept in mind when comparing the time series of the four databases.”

P4832, line 18: “disparate” → “divers”

- Phrasing will be updated

P4833, line 21: “reaching” → “providing”

- Phrasing will be updated

P4834, line 19-20: “... when taking the […] into account” → “... when taking into account the ...”

- Phrasing will be updated

— Conclusions
-
— References

P4839, line 31: The names “ERS” and “ENVISAT” are in curly brackets

- Phrasing will be updated

P4840, line 33: The name “SARAL” is in curly brackets.

- Phrasing will be updated

P4841, line 15: “Shum, C.” → “Shum, C. K.”

- Phrasing will be updated