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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Evaluation of Historic and Operational Satellite Radar Altimetry Missions for Constructing Consistent Long-term Lake Water Level Records" *by* Song Shu et al.

Song Shu et al.

shus@appstate.edu

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Our Response to Anonymous Referee 1

The paper provides a detailed analysis of past present altimetry mission data for lake water level retrieval. The paper is well written organised and results are correctly presented and discussed. Official retrackers are discussed in detail underlining pros cons. A strategy for constructing for a consistent long-term lake water level is presented. If implemented, it would have added a significant contribution to the paper. Hopefully this is something that authors will present in a future paper. I recommend to accept the paper implementing the minor changes reported below. Some points could be discussed

with more detail but this is essentially a very good paper deserving to be published.

Response: We thank the reviewer for the thorough review and very helpful comments/suggestions. The positive comments encourage us to continue working on this subject, particularly the construction of consistent long-term lake water levels at regional or global scale in the future.

General comments: - SAMOSA3 is cited everywhere as the official S3 ocean retracker. This is not correct as it has been updated a long time ago to SAMOSA2 (https://sentinel.esa.int/documents/247904/2802412/Sentinel-3-Mission-Status-Report-06-December-2017.pdf). In table 3, authors indicated Baseline 2.45, this confirms that the SAMOSA 2.5 model (SAMOSA2) has been used as it was introduced in Processing Baseline 2.24 according to the Labroue et al. talk at the 2018 S3VT meeting in Darmstadt. Please correct from "SAMOSA3" to SAMOSA2" everywhere in the manuscript.

Response: We really appreciate the reviewer's valuable information. We have corrected "SAMOSA3" to SAMOSA2" throughout the manuscript, including the text, tables and figures.

- Please correct from ENVIsat to ENVISAT everywhere.

Response: revised as the reviewer suggested.

- In this work official retrackers have been considered, however, many non-official efficient retrackers have been developed for the inland water domain (SAMOSA+, DTU MWaPP, please see and cite the following as well: https://doi.org/10.1016/j.rse.2019.111546) performing better than OCOG. Therefore, for a possible future paper, we suggest the authors to test these alternative retrackers against the OCOG for S3 and also report the results at the Sentinel-3 Validation Team Meeting in order to eventually stimulate the adoption of retrackers alternative to OCOG. The same should be done by citing GPD+ Tropo corrections which many

papers indicate as a valid alternative for the inland water domain.

Response: Thanks for the reviewer's suggestion and information. The suggested papers and sources are cited in the revised manuscript. We will surely include the evaluation of these non-official retrackers in our future study.

- The discussion on input datasets is very good whereas the complexity of the scenario is not discussed with the same level of detail in relation to the surrounding topography (with respect to lake size), tracking modes (open loop/closed loop) size of the receiving window. This is an important point considered in the majority of papers investigating the performance of altimetry systems in the inland water domain.

Response: We appreciate the reviewer's insightful comments. These factors are indeed very important for retrieving water level over small lakes (width less than 1 or 2 km) or over rivers. Particularly, the tracking modes (open/closed loops) and the receiving window could have considerable influences on the accuracy of water level estimates when the surrounding topography is complex. In response to the reviewer's comments, we added that the surrounding topography could have nonnegligible influences on elevation measurements in Section 4.2. The smallest case study lake in our evaluation is Reservoir Lokka in Finland with a surface area of about 500 km2. For each mission, the ground track over the lake is at least 10 kilometers long. To eliminate the possible influence of surrounding topography and land contamination. We have removed the observations within 2 km buffer distance from the shoreline. In addition, for each lake surface elevation profile, we used robust MAD statistical method to exclude the spurious elevation measurements, possibly induced by land contamination So, in our evaluation, the influence of surrounding topography has been minimized. Considering the current length of this manuscript, in this revision we referred the reader to the following two papers for a more detailed discussion of the influence of surrounding topography:

Jiang, L., Nielsen, K., Dinardo, S., Andersen, O.B., Bauer-Gottwein, P. (2020). Eval-

uation of Sentinel-3 SRAL SAR altimetry over Chinese rivers. Remote Sensing of Environment, 237, 111546 Biancamaria, S., Schaedele, T., Blumstein, D., Frappart, F., Boy, F., Desjonqueres, J.D., Pottier, C., Blarel, F., Nino, F. (2018). Validation of Jason-3 tracking modes over French rivers. Remote Sensing of Environment, 209, 77-89

- In the conclusions, the FF-SAR could be cited for future investigations (see https://doi.org/10.1016/j.rse.2019.111589) as services will be providing FF-SAR Sentinel-3 and Cryosat-2 data shortly (Scagliola et al. 2020 in OSTST2020, Moreau et al. in the 2020 Coastal Altimetry Workshop final report available at http://doi.org/10.5270/esa.caw12$_2020.final_report.).Sentinel-6 data can also be processed in Fully Focused mode when available.$

Response: As the reviewer suggested, we have cited the paper in the conclusion section and remarked that it would be a worthy direction for future investigation.

Specific comments Abstract section: For Sentinel-3, Tables 9 and 8 indicate that the mean results are equivalent for the OCOG and SAMOSA, this should be underlined in the discussion. The bias (Table 7) is way lower for Sentinel-3. Therefore, the statement in the abstract ("The results show that the model-free retrackers (e.g. OCOG/Ice- 1/Ice) outperform the model-based retrackers for all missions, particularly over small lakes.") shall be revised.

Response: Following the reviewer's suggestion, we have underlined the equivalent performances of these two retrackers in discussion. We have also revised the sentence in the abstract to "The results show that the model-free retrackers (e.g. OCOG/Ice-1/Ice) outperform the model-based retrackers for most of the missions, particularly over small lakes"

Introduction: - In citing each mission, a reference paper should be added.

Response: Following the reviewer's suggestion, we have added the reference for the general information of each satellite mission.

- Please indicate that Cryosat-2 is able operating the SARin mode in: “Most of the radar altimeters operate in a conventional low-resolution mode (LRM), whereas Sentinel-3 and Cryosat-2 operate in Synthetic Aperture Radar (SAR) mode.”

Response: Revised as the reviewer suggested.

- Please support the following with a reference: “the River and Lake database (http://www.cse.dmu.ac.uk/EAPRS/products,$iverlake.html)builtbytheESAandDeMontfortl DMU),''asmadefortheotherdatabases.$

Response: As the reviewer suggested, the most relevant paper has been cited in the revised manuscript for this database.

- The position of this reference: “Jarihani et al. (2013) compared five different satellite [. . .]” shall be revised in the references list as the name is reported before the surname: Asadzadeh Jarihani, A., Callow, J. N., Johansen, K., and Gouweleeuw, B.: Evaluation of multiple satellite altimetry data for studying inland water bodies and river floods, Journal of Hydrology, 505, 78-90, 10.1016/j.jhydrol.2013.09.010, 2013.

Response: Revised. Thanks for the careful reading.

- Please evaluate revising from “self-developed retrackers” to “non-official retrackers” when citing Villadsen et al. (2016). Please cite also this paper in the sentence: https://doi.org/10.1016/j.rse.2019.111546.

Response: The sentence has been changed following the reviewer’s suggestion. And the paper has been cited in the revised manuscript.

- The following could be a bit more detailed: “HY-2A was excluded from this study because of the difficulty in obtaining its data product.”

Response: As the reviewer suggested, we revised the sentence as " HY-2A was excluded from this study because of the difficulty in obtaining its data product (The data is not available for the public)"

Section 2.1 - The overall discussion on ice cover and presence of small islands is fine. Can something more be said about the complexity of the topography surrounding each of the investigated lake? This should be related to the tracking modes (open loop/closed loop) size of the receiving window of the specific altimetry system to enhance the discussion. This is a very important point which is not discussed in detail in the paper (e.g. ENVISAT operated with 3 possible bandwidths/receiving window sizes allowing the instrument to correctly operate on various surfaces). This could be related to the data loss rate discussed in Table 6.

Response: We appreciate the reviewer’s insightful comments. In response to the reviewer’s comments, we added that the surrounding topography could have nonnegligible influences on elevation measurements in Section 4.2. Since the smallest case study lake in our evaluation is Reservoir Lokka in Finland with a surface area of about 500 km2. For each mission, the ground track over the lake is at least 10 kilometers long. To eliminate the possible influence of surrounding topography and land contamination. We have removed the observations within 2 km buffer distance from the shoreline. In addition, for each lake surface elevation profile, we used robust MAD statistical method to exclude the spurious elevation measurements, possibly induced by land contamination. So, we are confident that our evaluation results are minimally influenced by the surrounding topography.

We also include some information about Jason-3 and Sentinel-3 that have open-loop mode. ENVISAT operated with 3 different receiving window size. Considering the length of this manuscript, we did not include an in-depth discussion on these issues.

In this study, the "data loss rate" refers to the data loss rate of lake level estimates, instead of data loss rate of original elevation measurements. We have added two sentences in the result section to clarify this confusion and modified the abstract and conclusion accordingly.

Section 3 - Table 2 is introduced with the following sentence: “We used the most up-

to-date version of data product of each mission for the evaluation. The geographical coverage, operational time period, repeat cycle, footprint size and retrackers of these radar altimetry missions are summarized in Table 2.'. Please correct from "footprint size" to posting rate:

Response: Thanks for the careful reading. we changed the "footprint size" to "sampling rate".

- Please improve including 'empirical' 'physical' in the following sentence: "These retrackers can be divided into two general categories: the empirical/model-free retrackers and the physical/model-based retrackers." - Typo, plural in "retrackers": "and the Sentinel-3 Ice-Sheet retrackers is based on a 5-part piecewise analytical function (MSSL/UCL/CLS, 2019)."

Response: Revised as the reviewer suggested.

- Regarding "Jason-3 now operates on the nominal orbit and will continue until the planned launch of Jason-CS/Sentinel-6 in 2020." Please replace "Jason-CS/Sentinel-6" with "Sentinel-6 Michael Freilich"

Response: Changed as the reviewer suggested.

Section 4 - Typo "e" in : "and the most recent release e of the altimetry"

Response: Corrected.

- Regarding "Third, the ice-cover condition is examined using the simultaneous TB measurements from the MWR instruments, and those lake water level estimates during the ice-covered period are excluded in the subsequent accuracy evaluations." Did author consider the possibility of comparing TB measurements results to ice charts?

Response: We thank the reviewer's comments and suggestion. It would be helpful if the reviewer can let us know where we can find the ice charts.

Section 4.1 - Please indicate "orthometric height" in "Geoid converts the reference

surface from 330 ellipsoid to geoid(orthometric height)".

Response: Added as the reviewer suggested.

Section 6 - Regarding "Our evaluation result is contrary to Sulistioadi (2015), who found comparable performances between Sea Ice and OCOG retrackers over a couple of small lakes using ENVISat data." Please do not be generic and clearly name the lakes studied in Sulistioadi et. al (2015). As previously indicated, one cannot exclude that other factors (e.g. topography) filtering criteria played a role in justifying the results obtained by Sulistioadi et. al (2015). To confirm that the OCOG is better, your analysis should be done over the same lakes and the methodologies adopted compared in discussing the results.

Response: Following the reviewer's suggestion, we added the names of the lakes (Lake Matano and Lake Towuti in Indonesia) in order to clarify the confusion.

- A possible strategy to create a multi mission time series is discussed. If implemented, it would have added a significant contribution to the paper. - Regarding: "When a lake was visited by more than one satellite missions on the same day, the best water level estimate among the overlapping missions should be selected to form a long-term series of records, in terms of the performance (r and RMSE) of the missions", which criteria would authors suggest to select the "the best water level estimate among the overlapping missions"?

Response: We added the criteria as the reviewer suggested. The water level estimates from the satellite mission with higher r value and lower RMSE will be used.

- Typo (double full stop)in: "[. . .] in terms of the performance (r and RMSE) of the missions.."

Response: Deleted

- Please modify, according to table 9, from "6.47" to "6.08" in "The mean RMSE decreases from 35.17 cm of the early ERS-1 mission to 6.47 cm of the current Sentinel-3

mission."

Response: We thank the reviewer for the careful reading. We have revised the number.

On Tables Figures Table 2 - Sentinel-3 is indicated with a single launch date. Please consider including 2 entries for both Sentinel-3A Sentinel-3B.

Response: As the reviewer suggested, the launch dates of these two satellites have been added in Table 2.

Table 4 - Please explain how (see Sentinel-3 for example) for 18 Cycles you have 272 ground tracks selected for the first lake in the table.

Response: Table 4 lists the index of the ground track (ground track number) selected for the evaluation, not the total number of ground tracks. We have revised the caption of Table 4 to clarify the confusion.

Please also note the supplement to this comment:
https://hess.copernicus.org/preprints/hess-2020-510/hess-2020-510-AC1-supplement.pdf

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