Replies to the comments by anonymous referee #2:

We would like to thank the reviewer for their interest and comments on the manuscript. Below the reviewer's comments are in italic and the replies in normal font.

The paper describes the computation and exploitation of satellite altimetry water level time series in the Zambezi basin. According to the authors, the aim of the study is "to assess the potential of the Sentinel-3 mission in hydrological applications". For that purpose, they compare different satellite altimetry pre-processing options (from two different databases) and they analyze the impact of open loop processing. Moreover, a validation by comparison with (few) in-situ ground stations is performed. For three different wetlands within the study basin, the potential of Sentinel-3 for monitoring the interaction of river and floodplain is shown.

General comments: This is an interesting topic worth publishing. However, some aspects of the paper are not innovative and had been published before by some of the same authors (e.g. OLTC impact by Jiang et al., 2020). Moreover, some parts of the manuscript are quite technically without providing the (less experienced) readers a recommendation on which processing option to use. In my opinion, the most interesting and innovative part of the study is the approach of automatically processing all possible VS of both satellites in the entire basin with the aim to use these time series for assessment of wetland-river interactions. Thus, my recommendation would be to focus on this part of the study by adding a bit more statistics (how many potential VS, how many valid VS, how many VS gained by OLTC,. . .) and some citations of existing work on wetlands based on satellite altimetry (e.g. Zakharova et al., 2014; Dettmering et al., 2016; Park, 2020). In addition, a (at least theoretical) comparison to classical missions can be added discussing the benefit of the dual satellite constellation (with respect to spatial and temporal coverage) and the measurement mode (SAR/OLTC).

> We thank the reviewer for the interest in the manuscript and the comments. We agree on the analysis of the major contribution and propose to better highlight this in the introduction. We also propose to add a flowchart to the methods section, allowing a better overview of the different processing steps for reproduction. Finally, we plan to publish the Zambezi network and generic processing tools together with the final manuscript.
>
> In terms of the statistics requested, we will develop the text a bit more to better highlight Table 2 (which contains the requested numbers) and include basin-scale summaries where these are missing.
>
> The suggestions for additional citations will be added in text. We thank the reviewer also for the suggestions for the discussion, which we will incorporate in the discussion.

Specific comments:

Line 5: If the objective of the study is to "evaluate the density of valuable observations", you should add some more statistics on the number of VS (see general comment).

The objective is to show the value of processing Sentinel-3 at catchment scale, illustrating the performance for the Zambezi basin. We will add the requested statistics from the general comment.

Line 18: In my opinion, the paper is not showing the benefits of SAR (with respect to what? LRM?). The denser track network is due to the orbit configuration not the measurement mode, and there is not comparison to LRM data. The RMSD values are similar to those from LRM missions. So, how is the benefit demonstrated?

The results support the progress in results observed in past papers as well, where the RMSD is lower with SAR missions than LRM (e.g. in comparison to Michailovsky's results with Envisat). Direct comparison is difficult due to the lack of overlap in space and time.

We propose to instead highlight the benefit of the spatio-temporal sampling achieved by the dual-satellite constellation and orbit.

Line 44: Sentinel-3 is not only an ESA mission => Copernicus

Thank you for pointing this out – indeed, Sentinel-3 is part of the Copernicus program and the mission is developed by ESA in this context.

Section 2.2: What about adding additional information on in-situ validation observations and OLTC targets?

We will add two separate sections for the in-situ stations (taken from 2.3.6) and the OLTC table, thank you for pointing this out.

Line 104/105: Please add some more information on the stream burning. I'm not sure what is meant here.

This is part of the data processing for the river network database, as detailed in the cited paper.

We selected the dataset from Yan et al. (2019) because they defined the river networks globally (thus the same dataset can be used for other study cases) and because in addition to a river delineation algorithm, they burnt in a river line to the DEM, increasing the accuracy of the river location, particularly in flat areas.

Section 2.3.3: Some detailed info on the corrections is missing (e.g. which models).

This will be added. In the Scihub dataset, the files contain the already "corrected altimeter elevation from OCOG (ice-1) retracker" and only the geoid needs to be subtracted. In GPOD the instrumental corrections are applied already and only the geophysical corrections need to be handled and they are already aggregated. The corrections include:

- Instrumental corrections: USO drift correction, internal path correction, distance antenna-COG and Doppler-slope correction
- Geophysical corrections: GIM-derived ionospheric correction, model dry tropospheric correction, model wet tropospheric correction, solid earth tide height, geocentric pole tide height and and ocean loading tide.

Line 171: Sigma0==backscatter?

Yes, it is the backscatter coefficient

Section 2.3: I recommend to provide also the web addresses of GPOD and SciHub (in the text or alternatively in Refs or Acknowledgements.

Good point.

Line 174/175: Are these DEMs good enough to be used in this context. My personal experience is that at least ACE2 includes really large outliers in some regions.

ACE-2 has an accuracy of 5-10 m at most VS in the basin (and almost always less than 16 m). Indeed the choice of DEM might bias the selection. The +/- 30 m window should not be a problem.

Line 200: "are processed" => how? Median/mean

Reformulated: "All observations retained at a given virtual station are processed by taking the along-track mean to produce a WSE time series."

Line 204: "six". Where are these stations located. Maybe you can reference to a figure.

Indeed the locations are not presented until Figure 5 – we can add the stations to the catchment basemap.

Line 210: RMSD or D_{RMS}? Please make consistent

D_{RMS} is used in accordance with HESS guidelines for equations – we can streamline this in text – we do think that RMSD is a frequently used acronym justifying using RMSD elsewhere in the text.

Line 231: "two the" => "the" or "the two"

"the two"

Figure 2: I can't find any black cycle in the plot. On the other hand blue lines (which I assume to be rivers) not covered by data. The black lines are a bit confusing here. I guess these are sub-basin borders. Please indicate or remove. The additional maps seems to be in the Annex, not in the supplementary material.

The reference to the additional maps should indeed be the Annex. We agree that the subbasin borders do not carry significant information in this case.

Thank you for pointing out that the circles were missing. The map below shows where the stations with no data are located. There are parts of the river, which fall between tracks and are thus not sensed by either satellite.

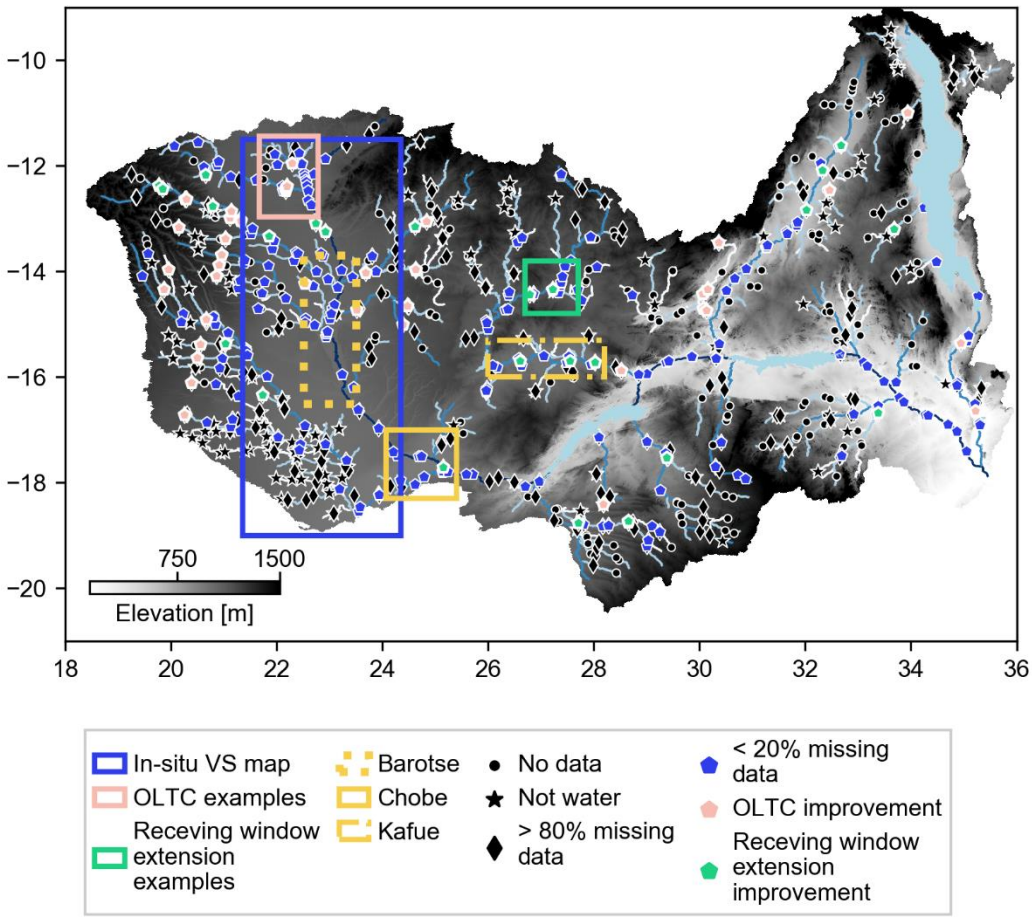

Figure 1 Zambezi Sentinel-3A and 3B VS after outlier filtering. Stations which improved by modifying processing steps (either on board through the OLTC update or on-ground by extending the receiving window on GPOD) are highlighted separately. The frames indicate examples highlighted in the next sections of this study. Additional maps are included in the supplementary material (Fig. A1, A2 and A3).

Title of 3.1: This is quite technically. What about using a title indicating the aim of this section, e.g. comparison of different L1b pre-processing

We propose to change the title to "Evaluation of VS at Level-1b level" – the section does not compare the L1b pre-processing but rather evaluates whether the L1b data supports that the VS are good inland hydrology targets.

Figure 3: What does OLTC stands for here (black and orange)? Before/after OLTC update? Please clarify.

In legend: OLTC indicates Sentinel-3A stations where observations are only available after the OLTC update in March 2019.

Table 3: Please provide the sum over the entire basin. Include description of GPOD/SciHub version for VS no (I guess it should be 2x, 3x?)

We propose adding column titles in the table to avoid confusion so the different versions are clear for the two databases and so that the information is available at basin scale as well.

Section 3.3.1. What about adding a discussion on the impact of low number and distribution of the validation sites. Are the validation numbers representative for the entire basin?

Of course the validation is limited by the low number of validation sites. However, section 3.3.2 confirms that the hydrological patterns are reliable in other parts of the basin as well. This pattern of data availability is also why S3 holds high value in a catchment with low gauging density.

We propose to mention in the text that the validation is mainly focused on the Upper Zambezi where data was made available and thus the full dataset cannot by extension be considered valid. However, the stations are located on rivers of very varying width (quite representative of the basin in general), which is encouraging in spite of the stations being close to each other.

Figure 5: in-situ (black) lines are not visible. Are they always available for the whole period? Are there more than one observation available per epoch (=> single alongtrack measurements instead of mean/median?) Can you add RMSD here?

We will try stippling the S3 lines to make the underlying black lines visible. The in-situ observations are available until April 2019 (we will add the time of observation to Table 4).

In some cases, there are more than one observation – indicated by the points – whereas the line indicates the mean WSE, which is compared to the in-situ observations. The RMSD is given in Table 4.

Line 288: OGOC => OCOG

Thank you for pointing this out.

Table 4: is the difference only due to the retracker? Might the pre-processing play a role? Is the Relative RMSD == WRMSD?

Indeed the pre-processing might also play a role, although both are intrinsically linked to the processing platform and to each other. For more clarity, we will refer to the datasets by the platform rather than the retracker here.

Yes it should be WRMSD.

Figure 6: I can not find any orange lines here. . .

There are indeed no observations from those decades – we will remove the orange lines from the legend.

3.3.3: What about adding some more information and interpretation here.

We propose to add a discussion linking back to the in-situ stations discussed in the two previous sections, which indicate annual amplitudes in the order of 5-10 m. Furthermore, Figure 7 provides a summary of the Sentinel-3 observations, suggesting that in some cases further manual validation might be necessary, i.e. to remove large outliers or confirm that the patterns are hydrologically consistent.

Line 323-324 (and in some other parts of the manuscript): I'm not sure whether it is fair to compare with global WSE databases. Since these databases aim in providing input for hydrological research, the focus is on long time-series. For sure, they are also able to process these VS - however, this has no priority given the short time series of less than 2 years.

> The comparison should be seen as an encouragement to explore the public processing platforms, which provide access to the full Sentinel-3 dataset, beyond what is available on the databases. The databases provide an excellent starting point, however, at catchment scale (including for smaller rivers) or where short time series would have useful applications there may be more information available. This paper illustrates how much additional data can be obtained through automatic extraction from the full dataset.

Line 342: Is there any statistics available on the percentage of improvement/degradation by OLTC in this region?

> We are not sure we understand the question – to obtain statistics a simultaneous closed-loop mission would be necessary. What we do see is cases where the time series stops after the update and a loss of data due to the time lag between mission launch and table update. This is quite significant as large amounts of data are potentially useless when the OLTC is not up to date.

Line 349ff: "mamsl": all other heights are provided with respect to a geoid. Why not these ones? At least you should explain the abbreviation.

> The elevation is from the OLTC database (altimetry-hydro.eu) and thus actually relative to a geoid. We will correct the unit to avoid confusion.

Line 369: options to mitigate: Do you have any recommendation for the users? What preprocessing should I use?

> This is a tricky question with no clear single answer. In some cases, the dedicated inland water options outperform the standard processing (as would be expected), in others they appear to actually worsen the results. The take-home message is that the choice of preprocessing does indeed matter and based on the virtual station and its location it might be worthwhile to consider several.

Figure 12: Is there any color change in c) and d) depending on waveform misfit?

> Indeed – in this particular case, the misfit is generally quite low with no significant change, making the misfit information superfluous.

Line 385/386: Are there no unique track numbers?

> The given track numbers are the relative track numbers – and all data will belong to those same tracks. Alternatively, there are absolute track numbers, however the point made here is that the dataset will contain two data groups.

Figure 13: What are the vertical blue lines in crossing tracks 741 and 498? Where are the VS located for tracks 498 and 085? What are the stars and cycles in the left hand plot?

The vertical blue lines are the water occurrence (we will add this to the figure caption) as seen in the basemap on the left. The VS are the cycles and stars in the left hand plot and are indeed missing from the legend.

Figure 15: left and right?

Left and right are erroneous in this case and will be removed.

4.4 This is more a summery than perspective. . . Moreover, perspective should be placed after conclusions. . . Line 409: "first" => where is second?

We propose to rewrite this section and the conclusion, in order to ensure perspectives are placed after the conclusion.

Line 429-434: Please reformulate this paragraph: SWOT will provide much more information than S3, especially in cross-track direction. Also CS2 can already extract similar information in selected locations.

Agreed – we will reformulate to better highlight the point.

Line 441: "should"? => is or is not improving!

We suggest reformulating to "is expected to improve" – the point addressed here is the expectation to OLTC vs. closed-loop rather than the conclusion of this study.

Line 446: I don't think that you should name that a "validation"

We propose to refer to the selection process as an evaluation of the data at multiple levels.

Line 447: Again: My feeling is, that this is not a fair comparison. Hydroweb is a global database not aiming in complete coverage of entire basins.

We completely agree that a comparison would not be fair – our intent with the comparison of the number of VS is to highlight the benefit of extracting data beyond what is already available on such databases, when looking at altimetry data at catchment scale. This is important for regional to local hydrological studies. Furthermore, we ease the WSE data retrieval for hydrologists. By showing the numbers together, we hope to encourage interested users to also consider the full dataset on publically available processing platforms.

Line 452-458: I suggest shifting this paragraph to line 443 (as second paragraph of this section). This would make the paper end with the application, which is the overall focus of your paper according to line 69.

Thank you for the suggestion – we will shift the paragraph.