<u>Point-to-point replies to the review report</u>

We would like to thank the editorial team and the referees for the attention given to our manuscript and for providing an evaluation of our work. Our responses to their comments are provided below.

For clarity, Referee's comments are shown in bold font and the authors' replies in *italic*.

Referee's comments: *Our reply*

<u>Referee #2:</u>

This manuscript presents a long-term monthly surface water storage dataset for the Congo Basin that was derived from multi-satellite data and/or DEM data. This is an unprecedented long SWS dataset with very high temporal resolution, which can be useful for hydrological studies in this basin. While the results look convincing, and the manuscript is well structured and nice presented, I have several comments that might be helpful for the authors to further improve the manuscript.

Our Reply: We would like to thank the Reviewer for carefully assessing our work. We are pleased that you highlighted the fact that this dataset will be useful for hydrological studies in the Congo Basin. Your comments are very useful and we have considered all the corrections you suggested. It results in an improved manuscript.

1. **Figure 3, there is no 4.2.1, 4..2.2..in the main text.**

Our Reply: You are right, thank you for your observation that helps us to add these sections title in the main text. We have added sub-section 4.2.1, 4.2.2, 4.2.3, and 4.2.4 in the Section 4.2 Hypsometric Curve Approach Using Digital Elevation Models.

The structure is now as follow (only the name of the Section and sub-sections are reported here):

4.2 Hypsometric Curve Approach Using Digital Elevation Models

4.2.1 Establishment of the hypsometric curve (area – elevation relationship)

4.2.2 Correction of the hypsometric curve

4.2.3 Establishment of the area – surface water storage relationship

4.2.4 Monthly time series of surface water storage variations

2. **Line 291, Is the hypsometric approach the same with the hypsometric curve approach in Line 310? These terms are confusing. If they are not the same, and some descriptions about the hypsometric approach here so that the readers may roughly understand how it works.**

Our Reply: Thank you for the comment that helps us to clarify the statement about the two terms. Yes, the principle of the two terms is the same but with different variables involved. To avoid any confusion, we have added the term "curve" and some details have been added.

The sentence "...with reference to a map of minimum surface water levels estimated over 1995–2015 using the hypsometric approach (Frappart et al., 2012)." has been changed into "...with reference to a map of minimum surface water levels estimated over 1995–2015 using the principle of the hypsometric curve approach between SWH from radar altimetry and SWE from GIEMS-2 to take into account the difference of altitude in each cell area of GIEMS-2. (See Frappart et al., 2012 for more details)."

3. Line 323, what does the average minimum mean? Annual average? Please clarify.

Our Reply: Thank you for the comment. The average minimum mean stands for the average of the minimum of each year over the considered period and the annual average stands for the average of the mean of each year over the considered period. To make it clear, the sentence is now "...from the corresponding average minimum and maximum of SWE." has changed in "... from the corresponding difference between the average annual minimum and the average annual maximum of SWE over the period 1992-2015."

4. Figure 4, black line and grey line are not easy to distinguish. Maybe use another color to update one of them.

Our Reply: Following your comment, we have changed the color of the lines and the figure caption. Figure 4 and its caption are now as follow:

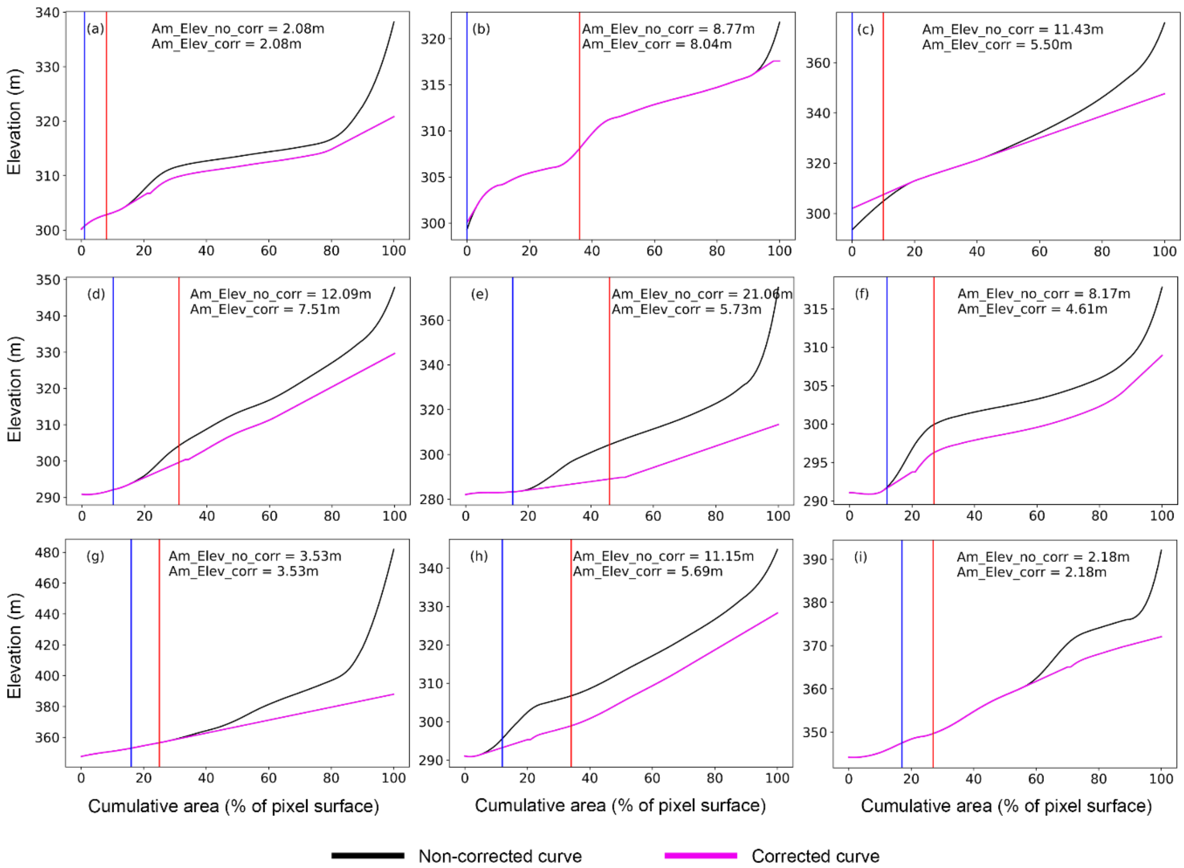


Figure 4: Correction of hypsometric curve from FABDEM by calculating the STD (m) of elevation over 5% flood coverage windows (see details of the procedure in section 4.2.2). Black and magenta curves stand respectively for non-corrected and corrected hypsometric curve. Am_Elev_no_corr (from non-corrected curve) and Am_Elev_corr (from corrected curve) are the elevation amplitude derived from the average minimum (blue line) and maximum (red line) coverage of surface water extent observed by GIEMS-2 over 1992-2015. (a) to (i) represent different pixel of GIEMS-2 in which the hypsometric curve is derived.

5. **Line 375, what does the lowest level of storage refers to? Was it determined by the GIEMS-2 observations or by the DEM data? As most of the DEMs do not have terrain information under the water, therefore, it may be important to know how much water were there when the DEM was acquiring. I guess this may also affect the lowest level of storage? Therefore, I suggest the authors to add some discussion about this issue in Section 8 or somewhere.**

Our Reply: Thank you for the comment. Indeed, it is a very important point to be discussed. The lowest level of storage refers to the level zero of storage from which the variation of the storage is started to be accounted for. It is determined by the minimum of SWE from GIEMS-2 observations for each pixel. Following your advice, we add some discussions related to the lowest level of storage (in 4.2.4 Monthly time series of surface water storage variations):

"Finally, the hypsometric curve of the area-SWS relationship is combined with the monthly variations of SWE from GIEMS-2. This enables thus the estimation of SWS for each month by intersecting the hypsometric curve value with the GIEMS-2 estimates of pixel coverage for that month (Fig. 5). Note that with such method, the lowest level of storage refers to the level zero, determined by the minimum of SWE from GIEMS-2 observations for each pixel, from which the variation of the storage is started to be accounted for. Thus, the estimated SWS represents the increment above the minimum storage.

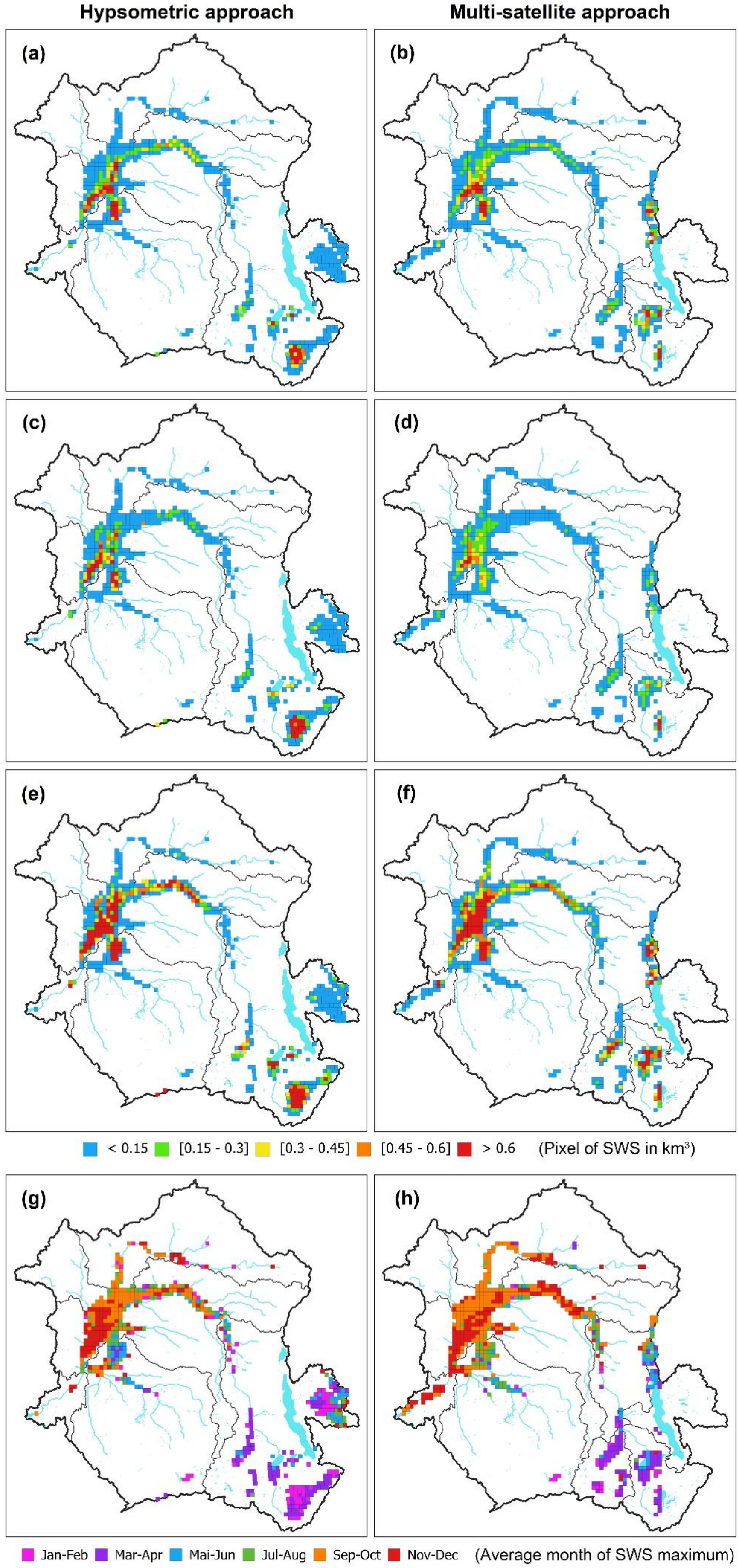
It is worth noting that, in the attempt of determining the extreme low storage values of exceptional drought years, it can be a potential source of uncertainties in a sense that DEM's values should have produced credible elevation data for those periods at the lower part of the hypsometric curve. Such information is unfortunately difficult to assess."

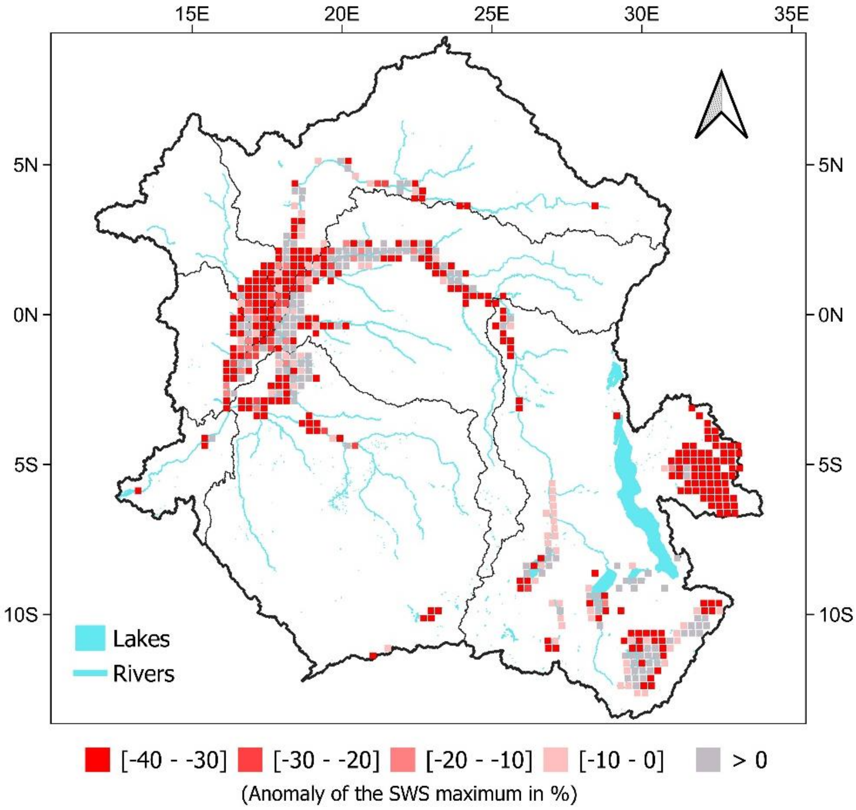
6. **Line 675, SWOT has already been launched. Therefore, Delete "to be".**

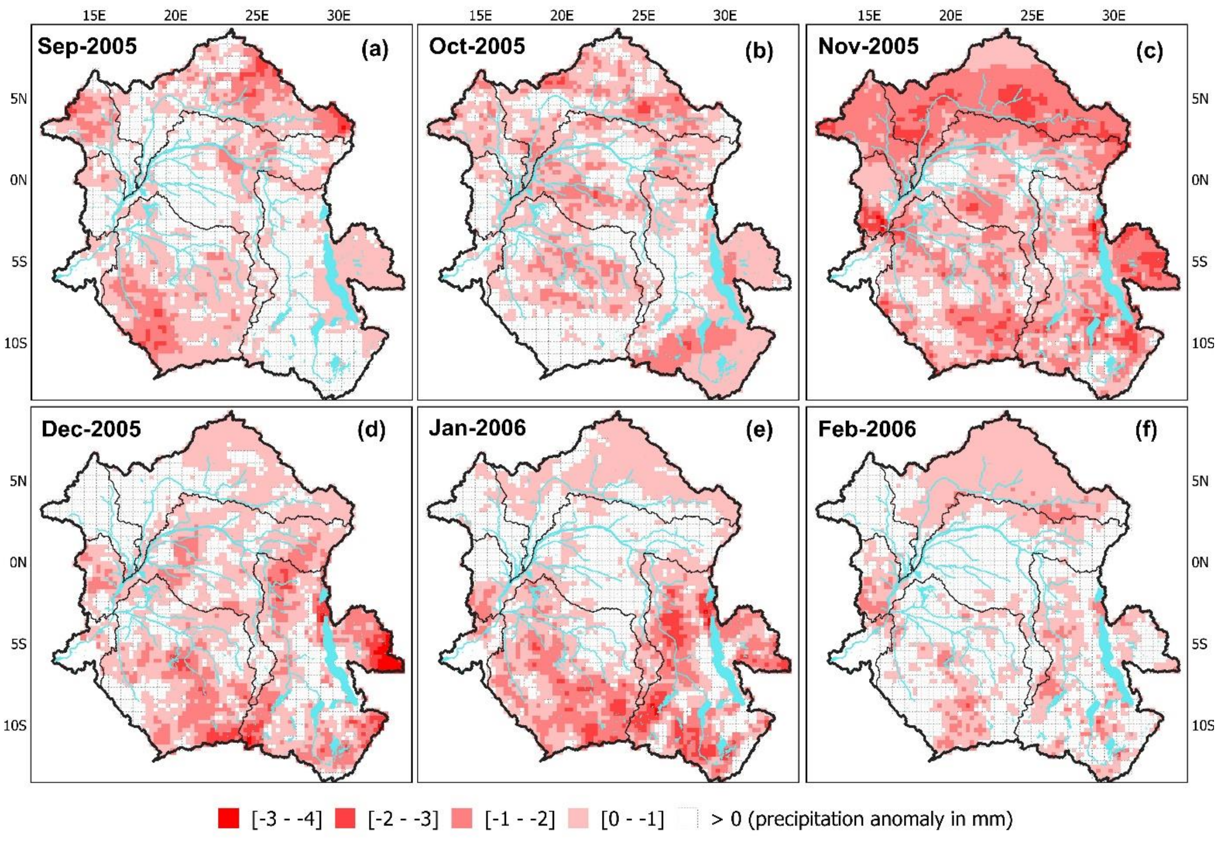
Our Reply: Regarding your suggestion, we have deleted "to be" and added "on the 16th of December". The sentence is now as follow: " ...Surface Water and Ocean Topography (SWOT) satellite mission, launched on the 16th of December 2022,..."

7. **Figure 7, 10 and 11, the legend should be more standardized. The legend should have a name so that the readers can understand the maps clearly and directly.**

Our Reply: Following your comment, we have standardized the legend. Figure 7, figure 10 (now figure 11 due the insertion of the new figure 9 on TWSA comparison with SWS), and figure 11 (now figure 12) are now as follow:

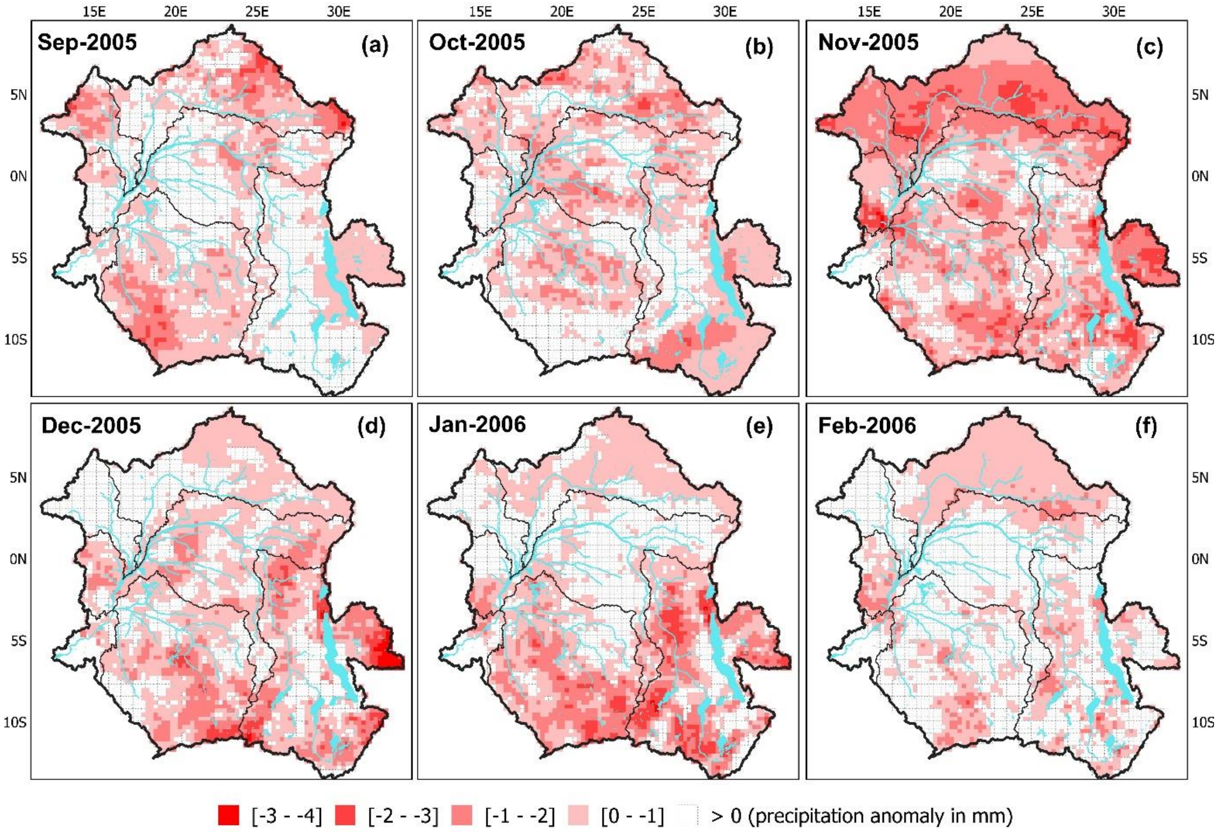

Hypsometric approach
Multi-satellite approach
(a)
(b)
(c)
(d)
(e)
(f)
< 0.15
[0.15 - 0.3]
[0.3 - 0.45]
[0.45 - 0.6]
> 0.6
(Pixel of SWS in km³)
(g)
(h)
Jan-Feb
Mar-Apr
Mai-Jun
Jul-Aug
Sep-Oct
Nov-Dec
(Average month of SWS maximum)





8. Figure 11f, Feb-2006.

Our Reply: Following your comment, we have changed in figure 11f "Fev-2006" in "Feb-2006". Figure 11 (now figure 12) is now as follow:



9. **For Figure 4 and Figure 5, what does the subfigure number (a-i) mean? Please clarify in the figure captions.**

Our Reply: Thank you for your comment. We have added in the figure captions 4 and 5 a sentence to clarify the meaning of the subfigure number (a-i). Figure captions 4 and 5 are now as follow:

Figure 4: Correction of hypsometric curve from FABDEM by calculating the STD (m) of elevation over 5% flood coverage windows (see details of the procedure in section 4.2.2). Black and magenta curves stand respectively for non-corrected and corrected hypsometric curve. Am_Elev_no_corr (from non-corrected curve) and Am_Elev_corr (from corrected curve) are the elevation amplitude derived from the average minimum (blue line) and maximum (red line) coverage of surface water extent observed by GIEMS-2 over 1992-2015. (a) to (i) show different pixels of GIEMS-2 in which the hypsometric curve is derived.

Figure 5: For the same GIEMS-2 pixel as in Fig. 3, the Surface Water Storage profile, i.e., the relationship between SWS within each GIEMS-2 pixel and the fractional inundated area of 773 km2 in percentage (abscissa – right ordinate) obtained from the area-elevation relationship (abscissa – left ordinate). Magenta, green, orange colors are respectively the curve of SWS from the formulas (3), (4), and (5). The grey curve stands for the corrected FABDEM

hypsometric curve. The blue (red) line is the average minimum (maximum) coverage of surface water extent observed by GIEMS-2 over 1992-2015. (a) to (i) represent different pixels of GIEMS-2 in which the hypsometric curve is derived.

10. It is good to see that there is evaluation against independent datasets in Section 5.2. However, I think a time series comparison or correlation analysis with the precipitation and discharge is not convincing enough to showcase the reliability of this dataset, especially in the perspective of spatial information. Is it possible to compare the SWS with the GRACE products? Or maybe validate some of the SWE results with Landsat observations at least?

Our Reply: Thank you for your valuable comment. We note that the GIEMS-2 SWE dataset we use has been already compared with others existing SWE dataset, including SAR data and other passive microwave and visible/IR observations (Prigent et al., 2007; Pham-Duc et al., 2017; Aires et al., 2018; Prigent et al., 2021; Fleischmann et al., 2022).

Prigent, C., F. Papa, F. Aires, W.B. Rossow, and E. Matthews (2007), Global inundation dynamics inferred from multiple satellite observations, 1993-2000, *J. Geophys. Res.*, 112, D12107, doi:10.1029/2006JD007847.

Pham-Duc B., C. Prigent, F. Aires and F. Papa (2017), Comparisons of global terrestrial surface water datasets over 15 years, *J. Hydrometeor.*, 18, 993–1007, doi:10.1175/JHM-D-16-0206.1.

Aires F., C. Prigent, E. Fluet-Chouinard, D. Yamazaki, F. Papa and B. Lehner (2018), Comparison of visible (G3WBM and GSWO) and multi-satellite (GIEMS-D3) global inundation datasets at high-spatial resolution, *Remote Sens. of Environ.*, 216, 427-441, doi.org:10.1016/j.rse.2018.06.015

Prigent, C., Jimenez, C., Bousquet, P. Satellite-derived global surface water extent and dynamics over the last 25 years (GIEMS-2). J. Geophys. Res. Atmos., 125, e2019JD030711. https://doi.org/10.1029/2019JD030711, 2020.

Fleischmann A.S., F. Papa, A. Fassoni-Andrade, J.M. Melack, S. Wongchuig, R. C. D. de Paiva, S.K. Hamilton, E. Fluet-Chouinard, R. Barbedo, F. Aires, A. Al Bitar, M.P. Bonnet, M. Coe, J. Ferreira-Ferreira, L. Hess, K. Jensen, K. McDonald, A. Ovando, E. Park, M. Parrens, S. Pinel, C. Prigent, F. Resende, M. Revel, A. Rosenqvist, J. Rosenqvist, C. Rudorff, T.S.F. Silva, D. Yamazaki and W. Collischonn (2022), How much inundation occurs in the Amazon River Basin? *Remote Sens. of Environ*, 278,113099, https://doi.org/10.1016/j.rse.2022.113099.

Following your advice, we have decided to perform the comparison of our SWS dataset with GRACE data. Firstly, we have added a new part in section 3.6 that describes the GRACE data we use. The comparison is shown in a new Figure 9 and discussion are presented in section 5.2. All the new material related to GRACE data are as follow:

3.6.3 Total Water Storage Anomaly from the Gravity Recovery and Climate Experiment mission

The Gravity Recovery and Climate Experiment (GRACE) is a joint NASA and German Aerospace Center (DLR) mission launched in March 2002 (Tapley et al., 2004) and, together with its successor GRACE Follow-On (GRACE-FO) launched in 2018 (Tapley et al., 2019), provides estimates of changes in water storage at the basin scale. For the analysis in this study, we used data from GRACE/GRACE-FO Mascon data available at http://grace.jpl.nasa.gov (Wiese et al., 2016,2018). The mascon data provides surface mass changes with a spatial sampling of 0.5 degrees in both latitude and longitude (Watkins et al., 2015). From this dataset, we obtained time series of Terrestrial Water Storage Anomaly (TWSA) over the CRB through area weighted aggregation of those grid cells in basins.

In the section 5.2 on ***Evaluation against independent datasets****, we have added the following comments: "Figure 9 displays the comparison at the basin level between the aggregated normalized SWS anomaly and TWSA from GRACE. Both variables, show a similar interannual variability during the common period of availability of data (i.e., 2002 to 2015) presenting a fair correlation of r = 0.84 (lag = 1; p value < 0.01; Fig. 9a). It is worth to mention as well that both datasets capture the bi-modal patterns. Figure 9b presents the deseasonalized normalized anomaly for the two variables (r = 0.4; lag = 0; p value < 0.01), showing quite similar variations, especially in the long-term variability. We also notice the higher magnitude of the normalized SWS anomaly as compared to the normalized TWSA. At the seasonal time-scale, Fig. 9c reveals a similar behavior, with the two peaks depicted in the two variables, one in November-December and one in April. The lowest level of the SWS happens in July that is one month ahead of TWSA minimum."*

We also inserted the figure 9 and its related caption as shown below.

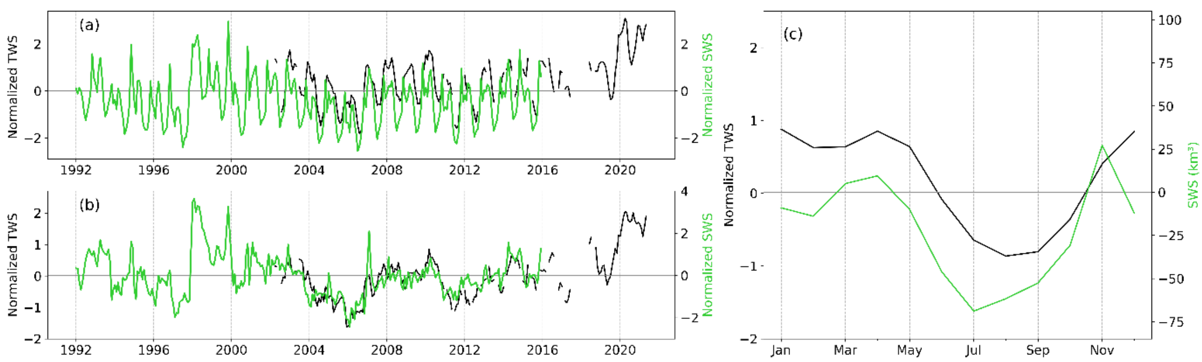


Figure 9. Comparison between the monthly aggregated normalized surface water storage anomaly and the normalized Terrestrial Water Storage Anomaly over the basin (for comparison purposes, SWS and TWSA were normalized by dividing their time series of anomalies by the standard deviation of the raw series). (a) For the entire Congo basin, the green and black line represent respectively the SWS anomaly variations from hypsometric curve (over 1992-2015, from FABDEM) and TWSA. (b) Deseasonalized normalized anomaly for SWS (green) and

TWSA (black). (c) Normalized mean annual cycle for TWSA (black) (except for SWS, in green) calculated over the same period of data availability of the two variables, SWS and TWSA.

11. I understand that it may not be mandatory, but I believe the readers would be happy to see that the related programming codes (e.g. the hypsometric curve approach) could also be publicly available.

Our Reply: Thank you for your suggestion, it is right. This is also our goal, and we are working toward that purpose. However, we have started developing the surface water storage dataset at the global scale and for that, the code is being modified in order to enable the easy computation elsewhere and taking into account certain particularity of different regions. At this stage, we will not be able to make it available due to the ongoing work and surely, later on, after being sure of the capability of the code to run properly for other regions, we will make it available to the public on a repository. However, we would like to remind that all datasets we have created for this study are available and all results are therefore reproducible.