1.1. Recommendation

Minor Revision

1.2. Overview

This technical note explores methods to make Water Storage Compartments (WSCs) data compatible with Terrestrial Water Storage Anomaly (TWSA) data derived from GRACE satellite missions, specifically for isolating groundwater storage. Because GRACE data inherently have spatial smoothing and noise, other WSC datasets must be filtered similarly for accurate comparisons and subtractions. The study found that anisotropic decorrelation filters, like DDK, introduce artefacts in WSC data, suggesting that an isotropic Gaussian filter is more suitable. By analysing spatial autocorrelation and minimising differences between WSC and TWSA autocorrelation functions, an optimal Gaussian filter width of 250 km was identified for a combined WSC dataset to align with GRACE-based TWSA data characteristics.

This technical note is well written, and the overall quality of the manuscript is excellent. The research question is clearly defined and addressed in a scientifically sound manner. However, to enhance the scientific rigour of the work, I have a few specific comments regarding certain aspects of the study.

- Thank you very much for your positive overall assessment of our manuscript and for your constructive comments. We carefully considered each of your suggestions and have revised the manuscript accordingly, addressing all points one by one to improve both clarity and scientific rigor.

1.3 Minor comments

Abstract (line 20): Please include the RMSD results corresponding to the optimal filter width, as this will help emphasise the most significant findings for the reader.

- Done.

Abstract: The time period of the data is not mentioned in the abstract. Please include it to provide readers with an immediate contextual understanding of the study.

- Done.

Line 155: I would have appreciated more information regarding the choice of bilinear interpolation. Kindly consider including a specific reference and a clear justification for its use, particularly in relation to the data characteristics and the goals of the analysis.

We have clarified the interpolation choice in the revised manuscript. In our workflow, bilinear interpolation was applied to resample and harmonize the original WSC datasets (RZSM and SWE from 0.25° to 0.5°, and SWS from 0.1° to 0.5°) to the target resolution of 0.5° before applying the Gaussian filter. We tested the alternative sequence (filtering first at the native resolution and interpolating afterwards) and found that the results were virtually identical in terms of spatial autocorrelation. Since interpolation before filtering was computationally much more efficient, we adopted this order. Bilinear interpolation was also selected because it preserves coastal grid cells, which would be lost with conservative remapping, and provides a smooth resampling that avoids artificial discontinuities. At the target resolution of 0.5°, these anomalies vary smoothly in space, making bilinear interpolation an appropriate choice. Similar bilinear resampling approaches have also been adopted in previous GRACE–hydrology studies (e.g., Ali et al., 2022).

The revised text in the manuscript now reads:

"Bilinear interpolation ensures coverage of coastal grid cells, while conservative remapping would have led to the loss some of these pixels. Similar bilinear resampling approaches have also been adopted in previous GRACE–hydrology studies (e.g., Ali et al., 2022)."

Ali, Shoaib; Wang, Qiumei; Liu, Dong; Fu, Qiang; Mafuzur Rahaman, Md.; Abrar Faiz, Muhammad; Jehanzeb Masud Cheema, Muhammad (2022): Estimation of spatio-temporal groundwater storage variations in the Lower Transboundary Indus Basin using GRACE satellite. In *Journal of Hydrology* 605 (2), p. 127315. DOI: 10.1016/j.jhydrol.2021.127315

Line 194: The manuscript mentions the time period as 2002 to 2023 in one instance, while the data preprocessing section refers to 2002 to 2020. Please ensure consistency throughout the manuscript regarding the time period to avoid confusion and maintain clarity.

- Thank you for pointing out this. We have clarified the text to distinguish between the reference period used for anomaly generation (2002-04 to 2020-12) and the analysis period (2002-04 to 2023-09). The former was selected to remain consistent with GRACE conventions for anomaly definition, while the latter reflects the full time span of available data used in our analyses. The revised manuscript now makes this distinction explicit to avoid confusion, as follow:

  "The reference period used to calculate the mean values for anomaly generation was April 2002 to December 2020, which is the standard baseline in our data sets. In contrast, the subsequent analyses of spatial autocorrelation and filtering were carried out for the full available period, April 2002 to September 2023. This distinction ensures consistency with GRACE conventions for anomaly definition while making full use of the extended observational record for analysis."

Line 195: I would have liked to have more information on the spatial autocorrelation method employed in the study. It is not clearly described in the text, nor is a reference provided. Please

consider elaborating on the approach used—such as whether it is based on Global Moran's I or another technique—and include an appropriate citation to support the methodology.

- Our analysis does not rely on a single-value global index such as Moran's I, but instead on the empirical spatial autocorrelation function, as described in previous GRACE–hydrology studies (e.g., Güntner et al., 2007; Boergens et al., 2020). The method involves calculating correlations of storage anomalies between all grid cell pairs as a function of their spatial separation distance, and then averaging the correlations into distance bins. This yields an empirical function describing how correlation decays with distance, from which the characteristic correlation length can be derived. The method is already described in the original manuscript in Chapter 3.3, specified by Equation (2). We added a sentence with the qualitative description of the autocorrelation function to this paragraph, and, following a comment by Reviewer 2, a description of the choice of the decay function.

Line 196: I would have liked to see equation numbers included throughout the manuscript, as currently the equations are only referred to in the text without numbering. Including equation numbers would improve clarity and allow for more precise referencing within the manuscript.

- Done, equation numbers have been added throughout the manuscript.

Line 242: For the sake of consistency, I would suggest using "RMSD" in Equation 4, as it aligns with the terminology used throughout the manuscript. This will help maintain uniformity and avoid potential confusion for the reader.

- Done.

Line 250: I would have liked to see the Fig. 4 flowchart improved through a clearer colour scheme and more concise text to enhance readability and understanding.

- Thank you for this suggestion. We have revised Figure 4 using a clearer color scheme and updated shapes/formatting to make the flowchart more visually appealing and to improve readability and understanding.

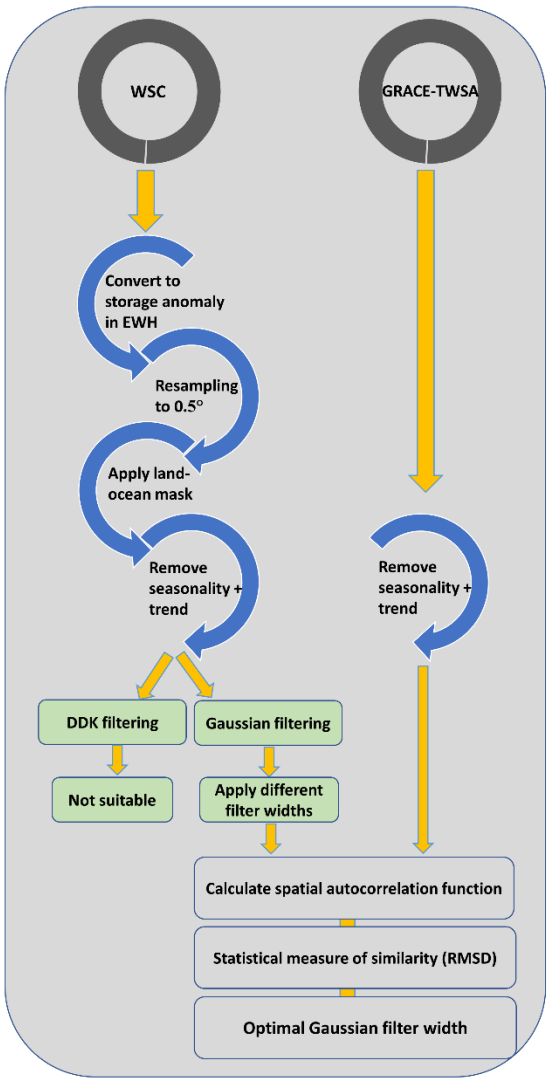

Figure 4. Schematic overview of the processing chain of the study towards a GRACE-like filter for WSC data.

Line 330: I would have liked to see the projection system specified for the global maps presented in Figure 8. Including this information would enhance the reproducibility and clarity of the spatial analysis.

- Thank you for this comment. For the global maps in Figure 8 we used the Robinson projection (ccrs.Robinson() from the Cartopy package for python). This is a widely applied standard projection for global-scale visualization, and for that reason we had not explicitly specified it in the manuscript.

Line 390: I would have liked to see proper basemap credits included in Figure 11. Acknowledging the source of the basemap is important for transparency and adherence to data usage guidelines.

- Thank you for pointing this out. The basemap features in Figure 11 (coastlines, land polygons, borders) are taken from the Natural Earth dataset, which is provided through the Cartopy package. While this is a standard open-source dataset and we did not explicitly acknowledge it in the manuscript, we agree that acknowledging the source improves transparency. We are pleased to confirm here that Natural Earth was the data source for the basemap.

I would recommend a thorough grammatical review of the manuscript, with particular attention to sentence structure and overall presentation. Enhancing linguistic clarity and coherence will significantly improve the readability and professional quality of the work. A few examples of:

(i) have been suggested change to “has been suggested” (line 56)

(ii) to change to “with” etc.. (line 70)

- Done.

I would suggest including an abbreviation table at the end of the manuscript, as numerous technical terms and abbreviations are used throughout. This will enhance clarity and assist readers in understanding the content more easily.

- Thank you very much for this helpful suggestion. We agree that clarity is essential given the large number of abbreviations used in the manuscript. According to the HESS author guidelines, dedicated abbreviation table in the end is not the standard format. Instead, abbreviations should be introduced and defined upon their first appearance in the text. We have carefully revised the manuscript to ensure that all abbreviations are clearly defined at first use, so that readers can follow the terminology consistently throughout.

In conclusion, I recommend that the study be accepted, subject to the minor corrections outlined above, to enhance its scientific rigour and clarity.