Response to the Referee #3

Following the long struggle to finish the review phase and acknowledging the very positive prior reviews, I undertook the final review of this manuscript. To acknowledge my expertise (and its lack): I am familiar with GRACE and global gravity measurements, and have done some work in developing fast/simplified global hydrological models. I am not an expert in the model at hand and have little/no direct experience in data assimilation (though I am familiar with it on a conceptual and operational level).

The manuscript is very well written, represents a significant advance in our modeling toolkit, and is in my opinion worthy of publication. Additionally, I think that the authors have done a good job of incorporating prior referee comments. I note here a few (largely minor) changes and suggestions:

Line 229: I was concerned initially about information leakage (especially using gravity for DA) across these boundaries. Lines 247-253 reassured me that this was being considered. No need to make changes, but consider whether it could be useful to address possible reader concerns around Line 229.

Response: We appreciate your great efforts for the evaluation of our paper. Regarding the leakage issue, we have followed your suggestion and added a notice there, in line 228:

"The assumption of independency is indeed too ideal but will be addressed in the next section"

Line 408. If I divide this through, I get 1.6 years model time per day of wall time. But was much of this wall time spent in the setup phase? If so, it could be interesting for readers to know the post-setup speed of the GLDA. It might also be more fair to your approach and highlight your advances.

Response: Yes, actually over half of the wall time goes to the setup process, i.e., the data preparation, as evidenced from the Table 3 (time required for a patch) of the main text. Once the GLDA is fully set up, the implementation of DA is fairly fast. In line 407, we also gave an example that it took less than 15 minutes to perform a regional DA for Danube river basin. In the revised manuscript (see line 408), we add: 'but be aware that more than half of the time goes to the data preparation'.

425-426. The heightened sensitivity on GRACE seems something to discuss, here or elsewhere. Does this mean that, once we include DA, it matters quite a bit less which base model we are using? I imagine this is a follow-up question for a later paper.

Response: Thank you for sharing the insight. In fact, DA generally adopts the spatial details of the base model, but the magnitude is tuned towards the gravity measurements/observations. In addition, be aware that the comparison of main text is based on the upscaled model and DA output

(from 0.1 degree to 0.5 degree to be compatible with GRACE), so that the spatial details <0.5 degree are invisible, which underestimate the contribution of base model. Our view is that the base model is still fairly relevant for DA, particularly in determining the spatial details of the water variability.

478-479. Because we cannot tell the future, I wonder about a good way to note next steps without necessarily promising that they will be done.

Response: Thank you very much for the suggestion. In the revision (see line 472-477), we have tuned the tone and indicated that these are potential future extension instead of actions that must be done.

480. Under the MIT license

Response: Corrected as suggested.

484-485. The policies of GMD would promote use of a permanent repository for model results rather than a Dropbox folder, which could be changed / removed over time. Could you publish the model implementation in a permanent repository? If space is a problem, then please be in contact.

Response: In fact, our code and data have been collected together and uploaded to a permanent data repository with a DOI (Zenodo, https://zenodo.org/records/12206756), instead of a Dropbox folder. Please have a check and this should be complying with the GMD policy.

The Dropbox mentioned in the Data Availability section is indeed where the original model (in Matlab) is available. However, our PyGLDA uses a latest Python version of the model, which has already been uploaded to Zenodo repository.

498. Could you define "f" closer to this and/or remove it from "Theta" if not needed?

Response: Thank you for the careful review. To improve the manuscript, we had a further proofreading of the main text including the Appendix section. Some minor changes related to the language use and formulas have been made in the revised manuscript.