Author Response

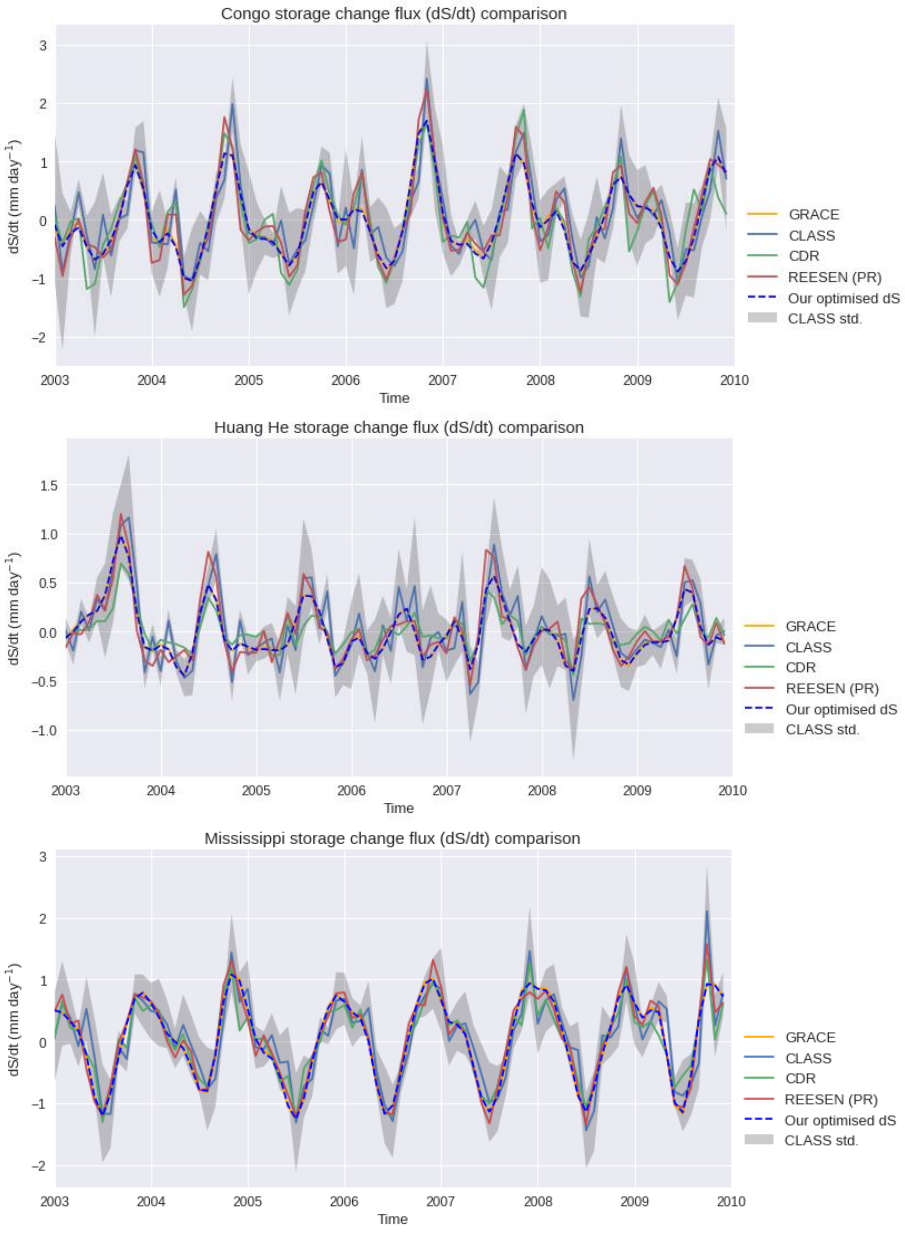
Editor comment:

I can see that you have done a lot to reply to the concerns of the referees. The referees concur with that, but one issue remains. Referee #1 raised the issue of circularity: If you force the model on GRACE, then it is to be expected that the model also fits GRACE data well. In other words, it looks as if you have calibrated on GRACE and also validated on GRACE. For final acceptance you have to make clear that this is not (entirely) the case. Only if you can explain this issue well in your final submission I shall accept the paper for publication.

We apologise for any confusion caused with regard to the point about validation. We are not using GRACE here to validate our model results. GRACE provides a valuable dataset which the other fluxes should be consistent with. Several previous papers have sought to develop a GRACE-consistent set of fluxes but do so incompletely. Our figures demonstrate clearly that previous products do not match long term GRACE variability within uncertainties, whereas our flux products do.

We have now added a sentence to the end of Sect. 4.1 describing how we are not attempting to validate our monthly fluxes.

Any “validation” of our products would require comparison with independent data that could be regarded as less uncertain that the datasets we have used. However monthly uncertainties are too large to distinguish between available products. We can see this in the figures below, which show the total water flux imbalance compared to GRACE from our and several other similar products. The shaded regions are the uncertainties taken from the CLASS product, although ours would look similar. These are the monthly values used to produce the total water storage anomalies in manuscript figure 6. Our additional constraint focuses on long timescale consistency, and so the benefits cannot be seen when looking at monthly timescales. But figure 6 still shows how the other products are inconsistent with GRACE over longer timescales, despite the monthly agreement within uncertainties shown here.



Reviewer comments:

Part of the added text reads: "Overall, Fig. 5 highlights the initial large imbalances from combining different products and shows how these are removed and made consistent with GRACE on all timescales. On monthly timescales consistency is established through monthly budget closure, similar to other studies. The improvement compared to other optimisation methods however is seen over longer interannual timescales."

If I understand clearly there is still indeed some circularity in the reasoning, and I didn't get a real answer about why no validation to precipitation or river flow data was applied.

In any case the authors claim that their method and their 'our optimised storage' would outperform 'other methods'. Other methods are not applied, so there is no way for me to verify that claim.

See response to point 1 above, including the comments about validation. Consistency with GRACE is a requirement which previous products do not properly satisfy whereas our approach does. We demonstrate this through Figure 6, where over longer timescales other products show inconsistencies with GRACE. We have altered text in section 4.2 and 4.3 to give clearer explanations.

Moreover, the variable 'our optimised storage' is still not described in the methods section.

We have now explained 'our optimised storage' in methods section 3.2.1.

The point is that the water balance is not a physical law and now it's even somewhat worse by saying the volume is constant, which is even less true due to phase and density changes.
If the authors would just write: we assume water balance by:
dS/dt = P - E - Q
I would not argue with the authors as we all make that assumption, but it is what it is: an assumption to neglect the chemical reactions of water.

We have changed this to say 'We assume water balance by: .. '