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comment

Interactive comment on "Global joint assimilation of GRACE and SMOS for improved estimation of root-zone soil moisture and vegetation response" *by* Siyuan Tian et al.

Anonymous Referee #1

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This manuscript presents the results of assimilating SMOS and GRACE data, jointly and independently, into an eco-hydrological model at the global scale. Model results were evaluated using in situ soil moisture and MODIS NDVI estimates. The assimilation method seems sound and the results are reasonable and should be of great interest to researchers in the community. My comments are mainly on how the assimilation impacts are assessed using NDVI. The authors employed MODIS NDVI to assess the impact of data assimilation on model estimates and suggested that increased correlation between soil moisture and NDVI is an indication of improved water storage estimates. This assumption may only be valid in arid and semi-arid regions; in other regions where ET is limited by available energy, changes in NDVI and water storage may

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not be correlated at all. I think the correlation presented in the paper may have been affected by the seasonality in the data which is easy to see in Fig.5 where increase in correlation is associated with increased seasonal amplitudes in model estimates. If the intention is to report on increased seasonality, it may be better to compute the changes in seasonality; otherwise, I would suggest the authors compute the correlation based on anomalies relative to monthly mean to eliminate the influence of seasonal variation. In either case, physical-based evidence and reasoning needs to be provided for justifying the use of NDVI in this purpose. In fact, the authors may look into the correlation between in situ root zone soil moisture and MODIS NDVI to see if and when this assumption is correct. In addition, if NDVI is truly correlated with water storage, wouldn't comparing model estimated ET with NDVI make more sense? The manuscript can also be improved with more details on the model and the rationale behind pre-processing satellite data. For instance, the ecological aspect of the model is never described and no results were provided on how vegetation responded to data assimilation. And there is no discussion on why SMOS data needed to be scaled before assimilation while GRACE data were not. What are the adverse impacts of assimilating SMOS without scaling and how are they related to any model behaviors?

Additional comments: Page 1 Line 12: Increased correlation between vegetation greenness and soil water storage does not necessarily mean improvement on water storage estimates, unless you back this up with in situ observations. Line 21: root depths do not unilaterally determine whether plants can access deeper water stores. The capillary force can also lift water up from deeper water stores to near surface soils.

Page 2 Line 23-25: Vegetation water content only constitutes a very small part of GRACE derived TWS and thus the lag may not be related to vegetation greenness at all.

Page 3 Section 2.1. Does groundwater interact with soil moisture?

Page 4 Line 18: a 0.25 grid or 0.5? Line 25: Is absolute value the total error of

SMOS and GRACE? What is the purpose for calculating relative errors base on land cover types (i.e., Fig. 1)? Given the coarser scale of GRACE data and the fact that vegetation water content is only a small part of total water storage, I don't think GRACE errors are related to vegetation types.

Page 5 Line 9-10: Using the 2nd and 98th percentiles as wilting point and field capacity can be a problem if the sites are located in very drier or wet climate where soil moisture is often restricted to one side of its full range. Line 23: Were the field capacity and wilting point here derived from SMOS measurements or from the model? After the adjustment, would you convert relative wetness back to soil moisture content for assimilation?

Page 6 Line 1: Adjusting temporal variance of SMOS data is not bias correction. Why did you need to do that? And why didn't you adjust the temporal variance of GRACE data to match that of W3 estimates? Line 13: equation (2). How does this update work? SMOS and GRACE have different spatial and temporal resolutions? Line 20: why do you need field capacity and wilting point to convert soil moisture content to equivalent water heights?

Page 7 Line 14: Do the two "correlation" words mean the same thing? Line 17: The API needs to be introduced in the data section. Line 20: This sentence does not sound right. In fact, I find this whole paragraph difficult to understand.

Page 8 Line 4: It looks to me that Fig. 3(b) has more points below the 1-1 line. Can you provide average r for DA and open loop, respectively? Line 9-11: joint assimilation improves SMOS soil moisture retrievals? Line 13: Fig. 4. Why are there fewer data points for the GRACE-alone plot? Line 16: This further improvement is not obvious to me. You probably should provide averaged statistics in numbers to back this up. Line 20: "less affected" is not obvious to me. Line 23: Listing uncertainties of SMOS and GRACE in Table 1 can be mis-leading as they are not relative to the same set of in situ data and have nothing to do with improvements made by data assimilation. Besides,

they are not referred to throughout the paper.

Page 9 Section 4.2. I don't think increased correlation with NDVI can be counted as improvements. In many cases, it is due to increased seasonality such as in Savannas, eastern Brazil and hence increased correlation with NDVI which has strong seasonal changes. correlation in Figs. 6 and 7 should be calculated based on anomalies relative to monthly mean; otherwise, it reflects mostly the seasonality.

Page 10 Line 8: what is exactly plant-available soil moisture storage? Root zone soil moisture? Section 4.3. Trend should be calculated using anomalies relative to monthly mean. Line 4: Can you include the correlation between soil water storage from the open loop with NDVI in Fig. 7?

Page 11 Line 27. You stated earlier that "greenness can serve as a surrogate for water availability in water-limited regions". But NDVI was used to evaluate changes in water storage across the globe, regardless of climate conditions.

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