Response to Reviewer #1's comments on the manuscript HESS-2023-33

The authors thank the Reviewer #1 for her/his constructive and insightful comments that help us improve the quality of the manuscript. The original comments from Reviewer #1 are in black font, and our responses are in blue font.

RC1: 'Comment on hess-2023-33', Anonymous Referee #1, 06 Mar 2023

I thought it was an interesting study. I have one main comment: SMOS L4 is based on SMOS L3. From what I understand (Wigneron et al., 2021) ECMWF soil moisture data is used in the SMOS L3 retrieval algorithm.

Wigneron 2021, https://doi.org/10.1016/j.rse.2020.112238

Response: Yes, we agree with the comment that ECMWF soil moisture data is used in the SMOS L3 retrieval algorithm (Wigneron et al., 2021). We will consider the effect of ECMWF soil moisture on SMOS L3 soil moisture and add the following discussion in the revised manuscript.

"Besides, the ERA-Interim soil moisture from ECMWF is also used in the operational SMOS L3 SM retrieval algorithm. For a given pixel, the total TB is simulated as the sum of several fractions contribution (F_{NO}: nominal (bare soil, low vegetation), F_{FO}: forest, and others as urban, water, etc.), i.e. $TB_{total} = TB_{FNO} + TB_{FFO} + TB_{others}$ (Fernandez-Moran et al., 2017). SMOS L3 retrievals are computed only over a fraction of the pixel (the "dominant" fraction where SM retrieval is meaningful over certain surface types) (Fernandez-Moran et al., 2017; Wigneron et al., 2021). For the remaining fraction of the pixel, only the contributions of that to the total signal need to be estimated based on ECMWF ERA-Interim SM (0-7 cm) as auxiliary input but no SM retrievals are performed. Previous studies have evaluated ERA-Interim soil moisture over China and pointed that ERA-Interim soil moisture shows an overestimation (Yang et al., 2020; Ling et al., 2021). Therefore, the overestimated ECMWF ERA-Interim SM (0-7 cm) leads to the underestimation of forest TB_{FFO} contribution, which further leads to the overestimation of TB_{FNO} and to a dry bias in the retrieved SMOS L3 SM (as there is a negative correlation between brightness temperature and soil moisture (Rao et al., 2007))."

References

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retrieval algorithm, Int. J. Appl. Earth Obs., 62, 27-38, https://doi.org/10.1016/j.jag.2017.05.013, 2017.

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K. S. RAO, GIRISH CHANDRA & P. V. NARASIMHA RAO (1987) The relationship between brightness temperature and soil moisture Selection of frequency range for microwave remote sensing, International Journal of Remote Sensing, 8:10, 1531-1545, http://dx.doi.org/10.1080/01431168708954795.

So should SMOS L4 be considered a remote sensing product or a modeled product? Please adapt the discussion according to my comment

Response: Root zone soil moisture can't be measured by remote sensing techniques directly due to the limited penetration depth. SMOS L4 is derived from a modified exponential filter method applied to SMOS L3 surface soil moisture. Though the exponential filter is a statistics-based method, we think SMOS L4 should be considered as a modeled product.

Other comments

Please discuss results considering a similar study made in China by Fan et al., RSE 2022 DOI: 10.1016/j.rse.2022.113283

Response: We will add the following discussion in the revised manuscript.

"In the study by Fan et al., (2022), three root-zone soil moisture (RZSM) products (SMAP-L4 V6, ERA5-land V2, GLDAS-Noah V2.1) are evaluated over croplands of the Jiangsu province, which is close to the Huaibei plain. A fourth RZSM dataset is derived from the ESA CCI SSM using an exponential filter, as for SMOS L4. Overall, the four RZSM products underestimate the in situ observations with median bias values ranging from -0.04 for ERA5-Land to -0.08 $m^3 m^{-3}$ for SMAP L4. SMAP L4 also presents the lowest ubRMSE value. Regarding the correlation coefficient (R), ERA5-Land obtains the highest R, followed by SMAP L4, ESA CCI RZSM, and GLDAS_Noah. SMAP L4 has overall better performance than GLDAS_Noah in terms of all evaluation metrics except for the bias. These results contrast with those we obtained over the Huaibei plain. In this study, SMAP L4 and GLDAS_Noah both overestimate the in situ RZSM with a median bias of 0.033 $m^3 m^{-3}$. On the other hand, SMAP L4 has a larger R value and a smaller ubRMSE value (R=0.37, ubRMSE= 0.039 $m^3 m^{-3}$) than GLDAS_Noah (R = 0.35, ubRMSE = 0.043 $m^3 m^{-3}$), which is consistent with results drawn by Fan et al. (2022). In both studies, the in situ stations are mainly located in croplands. The changes in the sign of the bias could be attributed to differences in soil properties. In the Huaibei plain, the main soil type is lime concretion black

soil, the main characteristic of which is (1) soil stratification, (2) poor soil permeability and water retention capacity due to high clay content, (3) clay swell in wet period due to water absorption and shrinkage in dry period due to water loss. During drought, the cracks in the soil column increase and deepen, resulting in capillary water breakage and more water evaporation. During rainy periods or during irrigation, the soil absorbs water and swells, closing the cracks and preventing water infiltration of rainfall. Water is then mainly lost in the form of surface runoff. This could explain the small RZSM values ranging from 0.2 to 0.3 m^3 m^{-3} observed in the Huaibei plain and the larger RZSM values ranging from 0.3 to 0.4 m^3 m^{-3} observed in the Jiangsu. The larger precipitation amount in the Jiangsu province could be another reason."

References

Fan, L., Xing, Z., Lannoy, G. D., Frappart, F., Peng, J., Zeng, J., Li, X., Yang, K., Zhao, T., Shi, J., Ma, H., Wang, M., Liu, X., Yi, C., Ma, M., Tang, X., Wen, J., Chen, X., Wang, C., Wang, L., Wang, G. and Wigneron, J.-P.: Evaluation of satellite and reanalysis estimates of surface and root-zone soil moisture in croplands of Jiangsu Province, China, Remote Sensing of Environment, 282, https://doi.org/10.1016/j.rse.2022.113283, 2022.

Sentence: "Previous studies have illustrated that the VOD retrievals from SMOS may be noisy" is not objective. All VOD products can be considered as noisy, not only SMOS ones. It depends on location and product version (L2, L3 or SMOS-IC). Some SMAP, ASCAT, AMSR2 versions of VOD can be considered as much more noisy than SMOS VOD.
Usually **a sliding window smoothing technique** (T = 7 -30 days) should be used for all VOD products.

Li et al., 2020 https://doi.org/10.1016/j.rse.2020.112208

Response: Yes, we agree with the comment and we will delete the sentence in the revised manuscript.