Authors' response letter (hess-2023-304)
The following is a point-to-point response to report #2 by reviewer #1

Dear Reviewer #1,
We thank you very much for taking out time to read and provide your very useful comments and suggestions. All questions and comments are addressed accordingly. Please find below your comments and our responses. Note that the authors' responses are highlighted in red

Two Questions:
Unit Consistency Between ASCAT and ESA CCI SM Data:
The ASCAT data provides relative humidity values, while the ESA CCI SM product reports absolute soil moisture values. Could you clarify how you rescaled these datasets to ensure unit consistency for comparison with the observational data?

Thank you for your question. The ESA CCI SM product reports absolute soil moisture values, expressed as a ratio of water to soil volume ($m^3\ m^{-3}$), which aligns with the observational data, also presented in $m^3\ m^{-3}$. In contrast, the ASCAT SWI product represents the degree of soil wetness or dryness, expressed as a degree of saturation (0–100%).

To harmonize the ASCAT SWI with the ESA CCI SM and observational data in terms of units, we applied a variance matching approach (see equation below). This method involves linearly transforming the SWI values using the mean (μ) and standard deviation (σ) of the observational data (VWC). This is a well-established technique for rescaling the SWI values to match observational data or other products expressed in $m^3\ m^{-3}$ (e.g., Paulik et al., 2014; Bauer-Marschallinger et al., 2018).

$$SWI_* = \frac{SWI(t) - \mu_{SWI}}{\sigma_{SWI}} \sigma_{VWC} + \mu_{VWC}$$

We have provided this information in the Appendix P47L13 of the revised manuscript.

References

Bauer-Marschallinger, B., Paulik, C., Hochstöger, S., Mistelbauer, T.,; Modanesi, S., Ciabatta, L., Massari, C., Brocca, L., Wagner, W. Soil Moisture from Fusion of Scatterometer and SAR: Closing the Scale Gap with Temporal Filtering. Remote Sensing 2018, 10, 1030, https://doi.org/10.3390/rs10071030

Paulik, C., Dorigo, W., Wagner, W., and Kidd, R.: Validation of the ASCAT Soil Water Index using in situ data from the International Soil Moisture Network, *Int. J. Appl. Earth Obs.*, 30, 1–8, https://doi.org/10.1016/j.jag.2014.01.007, 2014

Hydraulic Effects of Soil Organic Matter in PTF:
Did you account for the hydraulic effects of soil organic matter when using the PTF (Pedotransfer Function) with the SOILGRIDS dataset? Soil organic matter is particularly important for high porosity in surface layers, especially in alpine and cold regions. Its inclusion could significantly impact the accuracy of soil moisture simulations.

Thank you for your question. The reviewer raises a valid point. We did not account for the hydraulic effects of soil organic matter (SOM) in the pedotransfer function (PTF) for the following reasons.

1. Although the Saxton and Rawls (2006) PTF can use SOM data, the input SOM content in the NOAH-MP model is hard-coded as 0.0. Therefore, accounting for the effects of SOM would require adjustments to this portion of the model code or the development of a new soil hydraulic parameterization scheme to incorporate available SOM data, as has been done in other similar applications using the NOAH-MP model (e.g., Sun et al., 2021).

2. The necessary SOM data is not readily available in our case. As noted in the manuscript (P7L11-13), only sand and clay soil proportions at four depth layers are currently available as part of the WRF geographical data fields used in the PTF.

We view the incorporation of SOM as a potential avenue for future research, especially considering the differing opinions on its hydraulic effects on soil moisture. While many studies suggest it is significant, others consider it less important (Sun et al., 2021).

References

Sun, J., Chen, Y., Yang, K., Lu, H., Zhao, L., Zheng, D. Influence of Organic Matter on Soil Hydrothermal Processes in the Tibetan Plateau: Observation and Parameterization, J. Hydrometeorology, 22, 2659-2674, https://doi.org/10.1175/JHM-D-21-0059.1 2021

One Comment:
I agree with the authors' statement: "the need to develop detailed regionally-derived soil texture characteristics and for better representations of soil properties in LSMs." However, it is important to note that the corresponding model parameterizations (e.g., PTF functions) should also be optimized. For instance, the maximum porosity estimated by current PTF functions is typically below 0.4–0.5 $m^3\ m^{-3}$, which limits the model's ability to simulate soil moisture values exceeding this threshold, even when the soil texture is accurately represented. Therefore, I suggest revising the sentence in the abstract to emphasize the need for collaborative improvements in both soil texture data and localized PTF parameterizations.

Thanks very much for the comment. This has been incorporated accordingly.