Reviewer 2

This paper clearly and neatly shows a study on optimizing constants in the underlying Cosby pedotransfer functions used by JULES model via assimilating daily-averaged COSMOS-UK soil moisture data through LaVEnDAR data assimilation approach. With calibrated values for PTFs constants, the paper shows updated soil hydraulic parameters representing on field scale and comparison results to those on small (~cm) scale. With 'vsat' updated being large and 'satcon' and 'sathh' being small, underestimations of soil moisture shown as prior are corrected and simulated soil moisture as posterior shows consistency to in situ measurements. The proposed method in this paper is an alternative attractive way to contribute to improving soil water flow and heat transport simulations by land surface models. I have four major comments and few mirror comments on the manuscript. I would suggest the consideration of accepting this paper after the author addresses major comments.

The authors thank the reviewer for their useful comments. We respond to the reviewer's comments here; each of these is repeated in black text. Our responses are given in blue text and planned changes to the manuscript are given in green.

Major comments

1. At line 157-162, "The daily soil moisture measurements we use are averaged from 30 minute soil moisture measurements. . .. . .uncertainty in the daily values is approximately 20%. We have inflated this here to 50% observation error. . .. . .in fact there will likely be intra-site correlations between observation errors due to site-specific instrument calibration." Here "uncertainty in the daily values is approximately 20%", what does uncertainty mean? Is it the standard deviation of soil moisture at a daily scale or 20% is an estimate accounting for the conversion from neutron counts to soil moisture? Is inflated 50% observation error as a result of an optimized one, how? How can it be proved that inflated error accounts for intra-site correlations between observation errors due to site-specific instrument calibration?

We will make this clearer. The quoted 20% error refers just to observed variance in the half hourly soil moisture values used to calculate the daily mean. The subsequent inflation of observation error is due the fact that results of using smaller values lead to a degradation of the results at all sites. We only speculate that observation error inflation is necessary due to intra-site correlations between observation errors due to site-specific instrument calibration, but as the reviewer notes, errors in the conversion to neutron counts to soil moisture will also be important here. We will change the text at line 157 to clarify:

The daily soil moisture measurements we use are averaged from hourly soil moisture measurements; analysis of the data shows that the standard deviation of the hourly data around the hourly mean is approximately 20%. We have inflated this here to 50% observation error; we note that similar observation error covariance inflation techniques have been used in e.g. assimilation of satellite observations in numerical weather prediction (Fowler (2018), Hilton(2009)). The reason for inflating the observation error is essentially because we found that smaller observation error values impacted negatively on the posterior soil moisture results. We suggest that inflation of the observation error is necessary here to compensate for otherwise neglected sources of error (e.g. the error in converting neutron counts to soul moisture) and for the assumption of uncorrelated observation error; in fact there will likely be intra-site correlations between observation errors due to site-specific instrument calibration.

2. In Fig. 3, posterior shows matching to in situ measurements except for the underestimation of soil moisture during the soil wetting period (around 2018-04 and 2018-11), why? Is it related to PTFs structure itself? Compared to Fig. 3, please in Fig. 4, it is better to give numbers such as the correlation coefficient and RMSE.

Across the 16 sites there are variations in how well the posterior JULES estimates match the data; we see a 'global' improvement (i.e. across all 16 sites) across the two years but there are some parts of the data which fit better than others. We have not examined possible physical causes for each case. We will provide prior and posterior RMSE values and correlation coefficients in the captions of figures 4 and 6. Correlation coefficients are also given for each site in figure 7.

3. At line 148, it is mentioned that soil texture information for each site was taken from the Harmonised World Soil Database (HWSD) (Fischer et al., 2008). As soil texture information is a base for obtaining optimized constants for pedotransfer functions, how about the quality of HWSD compared to in situ measurements? Fig. 8 and Fig. 9 show almost the same values for topsoil and subsoil, soil profile in the site is homogenous or because of used HWSD product? How do the optimized constants for pedotransfer functions and associated soil moisture change with different soil texture inputs? Additionally, please if available, add (measured) soil constituents for each site in Table 3.

Other reviewers also questioned our use of the HWSD. Unfortunately, we do not have access to local sand, silt, clay fractions so we can't add those to table 3. Additionally, we wanted to make sure our method would work when only global dataset information such as from the HWSD was available. The similarity of the results in figs 8 and 9 is indeed due to the fact that the HWSD textures were very similar but we cannot comment on how well this matches the real situation. We plan to add text to clarify out choice to use the HWSD:

We assume that the soil texture values from the HWSD are correct; they are not changed during the data assimilation process. We used a global soil dataset rather than locally available soil texture observations to ensure that our method has the potential for extension to areas without local measurements. Other open source global soil texture products are also available (e.g. SoilGrids Hengl et al (2017)). We acknowledge that there may be discrepancies between the HWSD and local measurements (e.g. Zhao at al (2018)), but our choice to use the HWSD here follows recent successful integration of soil texture data from the HWSD with JULES in studies such as Martinez de la Torre (2019), Ritchie et al (2019) and Ehsan Bhuiyan et al (2019)

4. At line 245, "The new distributions allow the model to access higher soil moisture values, potentially correcting for a deficiency in supporting datasets, parameter values or process representation in JULES", please clarify supporting datasets, do you mean the deficiency of soil properties dataset?

We will clarify this statement to read:

The new distributions allow the model to access higher soil moisture values, potentially correcting for a deficiency in supporting datasets (such as soil texture information or driving meteorological data), parameter values or process representation in JULES

Minor comments

1. In Table 1, the unit of satcon, Ks shall be kg m-2 s-1. Please check.
   We will correct this.
2. In Table 3, for the last cell, please complete the phrase “mineral (soil) with very high organic content”. Please explain the difference between Grassland/heath and Grassland.
   Where we have indicated grassland/heath there are a few shrubs present at the site. We will clarify this in the table caption.
3. In Fig. 10, what does the blue line mean?
   The blue line shows the original value of the constant as in table 2, we will add this to the caption of fig 10.
4. Please keep the citation consistent, for example, (Best et al. (2011),Brooks and Corey (1964)), (Cosby et al., 1984; Marthews et al., 2014). At line 168, Gupta et al. (2009); Knoben et al. (2019)
   Thanks for flagging this - we will make this consistent.
5. Please replace "in-situ" by "in situ", which follows the convention that Latin phrases should not be hyphenated (e.g. "in situ", not "in-situ").
   We will correct this.

References:

Ehsan Bhuiyan, M. A., Nikolopoulos, E. I., Anagnostou, E. N., Polcher, J., Albergel, C., Dutra, E., Fink, G., Martínez-de la Torre, A., and355Munier, S.: Assessment of precipitation error propagation in multi-model global water resource reanalysis, Hydrology and Earth SystemSciences, 23, 1973–1994, https://doi.org/10.5194/hess-23-1973-2019, https://hess.copernicus.org/articles/23/1973/2019/, 2019.

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Martínez-de la Torre, A., Blyth, E. M., and Weedon, G. P.: Using observed river flow data to improve the hydrological functioning of theJULES land surface model (vn4.3) used for regional coupled modelling in Great Britain (UKC2), Geoscientific Model Development, 12,765–784, https://doi.org/10.5194/gmd-12-765-2019, https://gmd.copernicus.org/articles/12/765/2019/, 2019

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