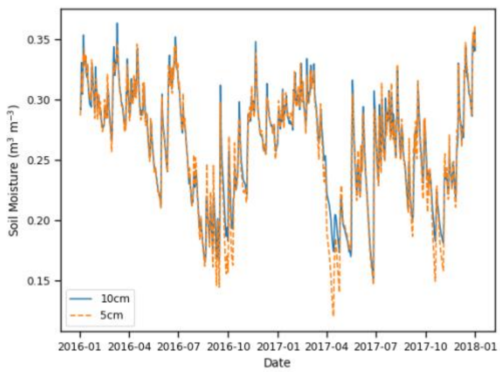
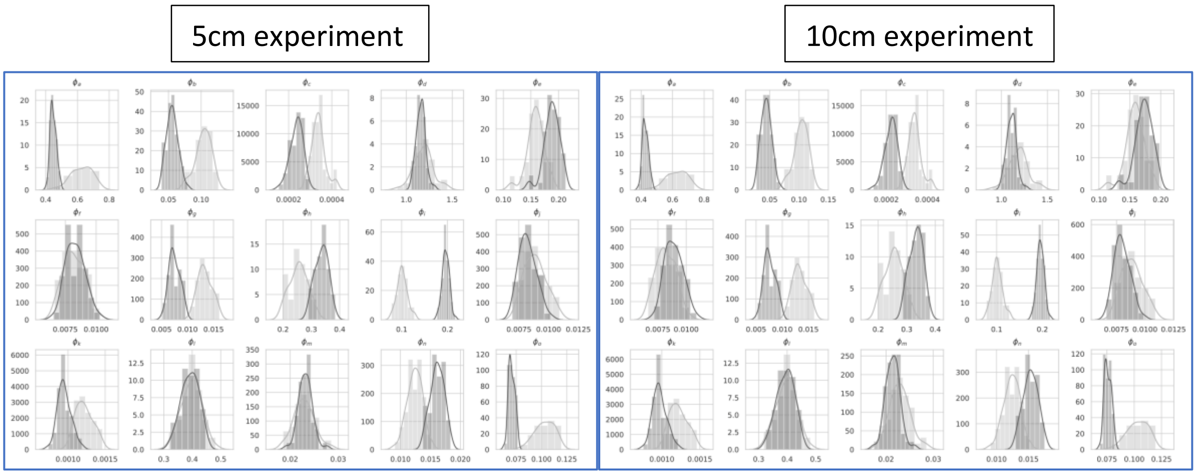
Reviewer 2 (R#2)

Accurate soil moisture simulation has always been a tough issue due to various sources of errors, including biased forcing, unrealistic model parameters, defect model structure and/or parameterizations. Focusing on uncertainties in pedotransfer functions, this study calibrates some of the key pedotransfer parameters through the assimilation of SMAP soil moisture product, and have obtained lower RMSD and higher correlation coefficients in posteriors. Independent evaluation against COSMOS observations also suggests promising results.
In general, this work presents a good example of utilizing satellite data to improve land surface models. The current layout and interpretation within the manuscript are mostly valid to me, except some remained concerns on the detailed DA implementations and soil moisture evaluations, as depicted below.
We thank the reviewer for their comments which will help us to improve this manuscript. We outline our responses and proposed changes below.

1. My biggest concern is on the comparison of modelled soil moisture from a relatively 'thick' layer of 0-0.1 m with SMAP retrievals, which in most conditions corresponds to only a few centimeters of the topsoil (_2.5 cm, according to Zheng et al. 2019). Under some circumstances, soil moisture may vary a lot with depth. Is soil moisture mostly consistent and exhibits less vertical gradient within the 0-0.1m layer across the study domain? Otherwise the evaluation and the subsequent conclusions presented in this study maybe questioned. Please elaborate. Reference: Zheng, D., Li, X., Wang, X.,Wang, Z., Wen, J., van der Velde, R., Schwank, M., & Su, Z. (2019). Sampling depth of L-band radiometer measurements of soil moisture and freeze-thaw dynamics on the Tibetan Plateau. Remote Sensing of Environment, 226, 16-25
We agree the comparison between SMAP and the model top 10cm could present issues due to the representative depths. However, as stated in your comment the model soil moisture does not exhibit a great deal of variability in the top 10cm as shown in the below plot where we have run JULES with a 5cm soil depth. We made that choice to use 10cm as this is the default JULES top layer soil depth and we wanted the optimized soil parameter ancillary files to be useful to the wider JULES community. To ensure the effects of this choice were minimal on the results we have re-run the experiments using a 5cm top layer in JULES. We attach plots for the retrieved parameters in both cases and can see that the optimised distributions are very similar whether a 10cm or 5cm top layer is used. We will ensure we highlight this choice as a potential source of error and discuss the referenced paper.





2. Looks typo in the third equation of Eq(1): should â´LE˘ _e f_clay be â´LE˘ _f f_clay ?
Noted, will correct.

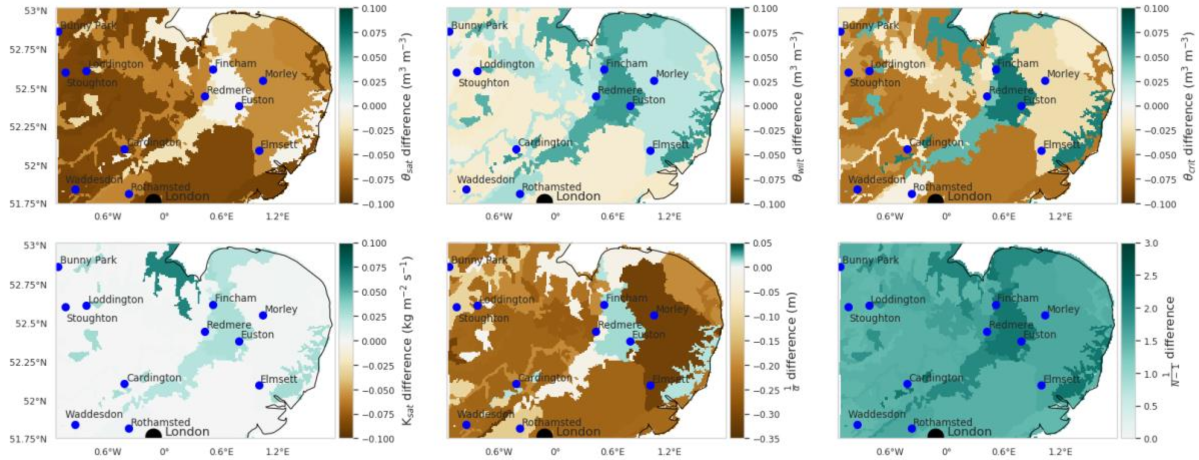
3. For the pedotransfer parameters shown in Table 1, are they independently calibrated grid by grid, or they share the same values across the whole domain?
These share the same values across the whole domain. We will clarify this within the text and also strengthen description around the data assimilation technique.

4. L138-140: it is interesting to know to which depth each COSMOS monitors soil wetness. Together with results shown in section 3, it can help understand to what extend the innovation introduced into the surface layer can propagate into deep soils. That being said, I also expect the authors to spend a short paragraph to discuss this issue.
Noted, we will discuss this and include information of the COSMOS observation depth at the sites.

5. L149-150: how is the observation operator like? Do you simply spatially average estimates from all the 1 km grids, and how do you project increments from the 9 km grid back to the 1 km grids? Please clarify. In addition, which variables are exactly included in the joint state-parameters?
Yes, we spatially average the 1km model estimates to the 9km SMAP grid. The variables included in the joint state-parameter vector are just the 15 pedotransfer function (PTF) parameters, with 50 realisations of these making up the ensemble. Each realisation will also uniquely define a model trajectory of soil moisture. Unlike sequential DA techniques we solve the problem for all observations over the whole domain at once by minimising a cost function. For this method it is not necessary to project any increments back to the 1km grid as the increments we find correspond to which parameter sets allow us to best fit the data given all relevant uncertainties.

6. L153: ": : :by a factor a four: : :"–not sure how this is done, may need to provide more details on the implementation of inflation.
This is also noted by Reviewer 1 (comment number 8). We will make sure to provide more details on this and why it is necessary for the implemented DA technique.

7. Fig. 3: if possible, better to show prior and posterior distributions of some of the soil hydraulic parameters (e.g. _sat,Ksat) in Eq(1) as well, as they directly regulate soil water within the land model.
It will be difficult to show distributions of the hydraulic parameters as they vary across the domain dependent on the underlaying soil texture map. Instead we propose to show maps of the resultant soil hydraulic parameters and how these have changed after DA (see below).



8. L192: urban areas are known to have problems in both remote sensing and land surface modeled soil moisture. I would suggest excluding urban areas in all the plots in Figs.(2, 4-5). Meanwhile, the authors may want to show some of the COSMOS sites in these plots to help better interpret results in Figs. 8-11.

We agree including the COSMOS stations on the plots may help interpretation and will do so (see above). We may leave urban areas just as a point of discussion on current limitations.