General Comments

This paper proposes fine-resolution surface soil moisture (SSM) data over China. The significance and potential impact are clear, and the novelty and results are promising. However, a major revision is needed to address my concerns. Please see the comments below.

Specific Comments

1) Line 236: About the LST validation:

Aqua nighttime passing time can be 1-hour away from 1:30 am LT. Even nighttime LST does have small variations than daytime LST, can you find some sites with minute-level observations in China to prove that using ground observations at 2:00 am introduces little uncertainty to the validation results?

Besides, the 0-cm ground temperature is different from LST physically, especially over vegetated areas, where SSM estimation by LST may have considerable uncertainty. Over these places, LST is closer to vegetation canopy temperature (air temperature).

To address my two concerns above, I would recommend including a brief test in the discussion by using site-measured LSTs that are computed by surface upward longwave radiation and BBE, and it would be convincing to include sites over various land cover types.

2) is there any evidence to prove the rationality of '7x7' and '-5th to 5th'?

3) Fig 3: Clear bias is still shown in filled LST results (Fig 3b) compared to the clear-sky validation (Fig 3a). Will it affect the SSM estimation when clear-sky (unbiased) and filled LSTs (biased) simultaneously exist in a spatial window using the 'universal triangle feature' or in SEE calculation?

4) Fig 5: After readers notice the clear differences between two data at some locations (Fig 5a&b), they may want to know which data is more accurate.

In order to address this concern, you may need to focus on the sites over these regions, where the proposed data have considerable differences with SMAP-Sentinel (e.g. far northeastern, northern west, southern provinces near the sea), specifically and separately, rather than just over entire China (Line 499).

Besides, SMAP shows a very good accuracy (Fig A1a) while the downscaled SMAP-Sentinel (Fig 5c) has large (nearly doubled) ubRMSD. Can you explain why the accuracy is considerably decreased after downscaling?

5) Appendix B:

It's strange that filled LST with considerable bias (-1.7 K) can achieve better SSM accuracy (0.058 vol/vol) than the SSM (0.064 vol/vol) from more accurate/realistic cloudy-sky LST in Fig. A3, and such accuracy difference is even larger than its difference with the clear-sky SSM (0.053 vol/vol, LST is unbiased). If that is the case, the logic behind it is that SSM is not sensitive to the LST, which is not right.

Besides, the LST bias explanation in Lines 309-311 is not convincing: if the filled LST has clear bias compared to site observations, it only means it cannot reflect the realistic surface condition.

Technical Corrections

Lines 50-56: references are necessary for the background knowledge introduction, especially for the potential application examples

Line 87: "universal triangle feature (UTF)" or "triangle feature space (TFS)"?

Line 91: please define the acronym UCLA

Line 109: ',' should be removed

Lines 78-80, 112-113: references, please.

Line 117: 'whilst .. even inferior' is not appropriate here. There is no such logic in the context unless you mean 'UTF-based methods are found even inferior to the DISPATCH in a typical humid region'

Lines 124: the objectives you mentioned here are more like broad impacts or potential significance while the objective of a study should be specific.

Line 144: 'after' or 'in the'?

Lines 179, 360: 'high resolution' -> 'fine-resolution'

Table 1: url -> URL

Line 196: 'be' -> 'being'

Line 205: ~~'the'~~

Lines 217-232: Please also include some literature to prove that these involved sites are spatially representative at km scales or have been widely used in SSM validation.

Line 224: '2014)'

Line 262: is the '10-cm-depth' different from the '0-10 cm' like you mentioned in Line 229?

Line 285: Do you mean that one set of coefficients a-d will be used for all pixels of the whole country on t1?

Lines 309-311: I agree that STDF is enough for the accuracy requirement of soil moisture estimation. However, this explanation here is weird because the atmosphere does have interactions with the surface at cloudy-sky: cloudy conditions may also indicate it is raining or the atmosphere is wet. Such LST and ET disturbance signals, which can be captured by PM-based LST but not by STDF, will impact the

soil moisture. In other words, the atmospheric condition cannot be simply separated by using such an explanation.

Line 326: One or two sentences for briefly summarizing the downscaling methodology in Song et al. 2021 are necessary.

Line 329: SEE, “soil evaporative efficiency”

Line 346: “All pixels were utilized within … centered at … ” would be better

Line 369: can you explain what “spatial averaging disaggregation” is

Line 417: why the bias caused by heterogeneity is negative?

Line 431: why RMSD_diff is important and focused? Maybe both clear-sky and cloudy-sky LSTs have higher uncertainty at some locations but the difference is small.

Fig 3: the absolute accuracy numbers of Fig 3(a) and (b) are better to be listed in the figure

Line 436: I feel 1.9 K is not small, and the RMSD difference can be ~70% of the clear-sky LST absolute accuracy [*Xu and Cheng*, 2021; *Zhang et al.*, 2021], especially for the nighttime LST. The word ‘only’ is too strong.

Fig 5, Line 663: please unify the ubRMSD or ubRMSE in the context.

Citations

Xu, S., and J. Cheng (2021), A new land surface temperature fusion strategy based on cumulative distribution function matching and multiresolution Kalman filtering, *Remote Sensing of Environment*, *254*, 112256.
Zhang, X., J. Zhou, S. Liang, and D. Wang (2021), A practical reanalysis data and thermal infrared remote sensing data merging (RTM) method for reconstruction of a 1-km all-weather land surface temperature, *Remote Sensing of Environment*, *260*, 112437.