Reply to Referee #1 interactive comment

The paper was improved. Listed are four main suggestions.

We sincerely thank the Reviewer for his/her constructive comments to improve our manuscript.

1. I think the descriptions of the reason of choosing these factors are not good/clear enough. It seems that the reason is because they are components of this DA system. Although it is true that there are many stuff in the DA system, please try to explain the reason in a more consistent/informative way.

Thank you for your suggestion. In the revised manuscript, we added the following text in the second-to-last paragraph of the Introduction Section:

"Specifically, precipitation and LAI are selected since they have been proven important for SMAP L4 SSM accuracy in a previous study (Dong et al., 2019a). The presence of errors in the vertical variability of soil properties and SSM-RZSM coupling strength are selected because both factors control the propagation of soil moisture error from the surface soil layer to deeper layers, and we focus on both the SSM and RZSM retrieval accuracy. Error in CLSM LE output is selected because of its connection between the water and energy balance. Error in Tb innovation is selected because of its direct impact on the size of the DA update. Error in microwave soil roughness is selected owing to its high sensitivity to RTM accuracy".

We also added a figure (new Figure 1) that shows a schematic of the DA framework and the connections between the eight selected factors in the analysis.

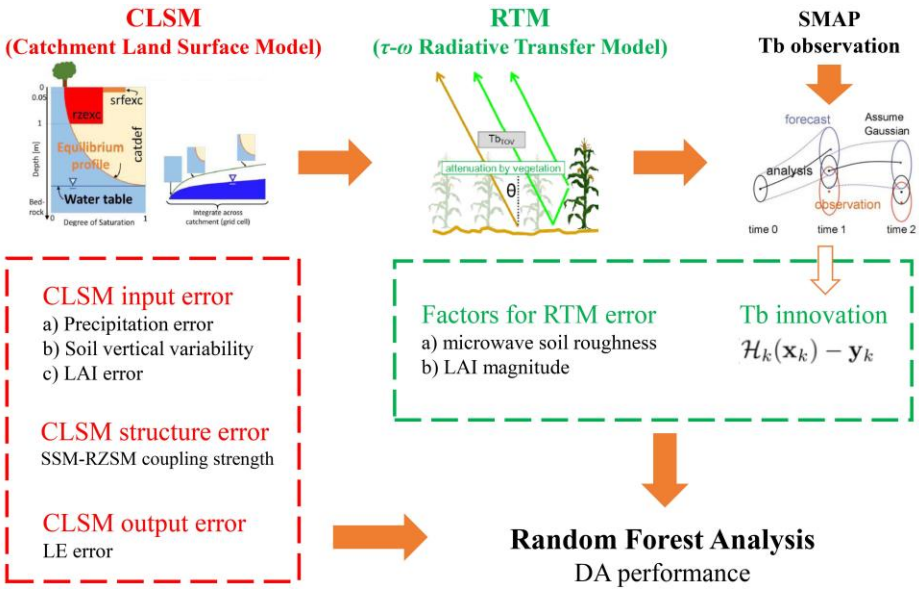

Figure 1: Systematic connection in the DA framework, and the association between the eight selected factors in the analysis.

2. Please clarify if findings described in the conclusion are the new/or similar compared to those

from evaluations based on using sparse station observations as you mentioned in section 1. This may highlight the significance of this paper.

In the Conclusion Section of the revised manuscript, we state more explicitly the similar/new findings compared to results from previous studies:

"Some of our RF analysis results fall squarely within expectation; for instance, the OL skill is predominately determined by precipitation error, which is in line with the previous studies using core validation site, sparse network sites and other microwave soil moisture datasets (Reichle et al., 2017a, 2021; Dong et al., 2019a)".

"More specifically, L4 DA contributes the most benefit for cases where CLSM underestimates SSM-RZSM vertical coupling strength. This is the first quantification of the impact of different DA aspects (including background model structure error and model input error) on DA performance".

3. In line 83, I doubt about it. The presence of vertical variability in your case depends on the used soil map. Using different soil maps will not alter the coded parameterizations (model structure). I guess this one also belongs to error in model input, similar as LAI you mentioned. Please check to avoid possible ambiguity.

Thank you for pointing this out. In the revised manuscript, we classify the presence of vertical variability in soil properties into the category of error in model input. Please see the second-to-last paragraph of the revised manuscript:

"…the errors can be attributed to potential factors including: 1) model input forcing errors of a) precipitation, and b) leaf area index (LAI) and c) the presence of vertical variability in soil properties…"

4. Please also try to make code (comparisons, plotting) available. I can see the code to better understand author's some expressions in the paper. On the other hand, it may also provide conveniences to audiences who want to do similar assessments for other regions.

The source codes are provided at https://drive.google.com/drive/folders/1IlyV6XgufDqfAmk6dTgxaT8hm4gX9lZ0?usp=sharing (last access: 22 January 2021).

Re. the comments in the annotated manuscript pdf file:

We revised the manuscript accordingly.