Reply to Referee #3 interactive comment

In this study, Qiu et al assess the performance of SMAP L4 DA system using 2 years of in-situ soil moisture profile observations at 2474 sites across mainland China. They then apply a random forest (RF) regression to identify the dominant factors (preselected by the authors) that control the spatial distribution of the data assimilation efficiency. This is an interesting study that could potentially lead to improvement in the SMAP L4 data assimilation system. I have annotated a pdf document with some suggestions as an attempt to help. In particular it would be interesting to try to justify more the choice of the studied dominant factors and then to discuss perspectives, what can be built upon this study? Without such proper discussion I have the feeling that the conclusion of the study is a bit weak (but you may want to prove me wrong!) with outcomes we could have guessed beforehand (e.g. precipitation is the dominant factor for explaining the skill of the OL results).

Please also note the supplement to this comment: https://hess.copernicus.org/preprints/hess-2020-407/hess-2020-407-RC3-supplement.pdf

We sincerely thank Dr. Albergel for his constructive comments.

Re. the comment about the choice of the control factors: We provide the same response to Major comment #5 by Reviewer #1 and Major comment #1 by Reviewer #2. For easy reference, please see below:

As mentioned in the abstract, the modeling portion of the SMAP L4 system consists of two components: land surface modelling (LSM) and radiative transfer modeling (RTM). Therefore, we select control factors from each of the two components.

For the LSM component, the errors can be attributed to: 1) model input forcing errors of a) precipitation and b) LAI; 2) model structure errors in a) characterizing SSM-RZSM coupling strength and b) the presence of vertical variability in soil properties; 3) model output error of LE.

For the RTM component, errors are characterized by: 1) DA innovation, i.e., SMAP Tb observations minus RTM Tb simulations; 2) the environmental factors that complicate the DA analysis when assimilating Tb observations, which include the magnitude of a) microwave soil roughness and b) LAI.

These 8 control factors from the above-mentioned 5 aspects determine the crucial aspects of both the LSM and RTM components in the L4 system, and are readily quantifiable using remote sensing products in the study. Therefore, they are selected to investigate the mechanism underlying the L4 improvement in this study. We will further clarify this in the corresponding paragraph of Section 2.3 in the revised manuscript.

The above response also apply to the Major comment #5 by Reviewer #1 and Major comment #1 by Reviewer #2.

Re. the comment about discussing the possible application of this study's conclusion: It should be noted that, among the RF analysis results of this study, there are conclusions that fall within our expectation, for instance, the OL skill is predominately determined by precipitation error, and L4 skill improvement (i.e., R_{L4} - R_{OL}) is mostly determined by Tb error. On the other hand, there are also noteworthy conclusions that are brought to our attention for the first time. For instance, we found that SSM-RZSM coupling error and precipitation error have a comparable impact on OL. For L4 skill, however, the impact of SSM-RZSM coupling error exceeds that of precipitation error. More specifically, L4 DA contributes the most benefit for cases where CLSM underestimates SSM-RZSM vertical coupling strength. These findings could be used for L4 product development. In addition, this study pinpoints that the L4 skill improvement is not heavily impacted by LAI magnitude, which gives confidence for using the L4 product in densely vegetated areas. We will further clarify this in the Discussion Section in the revised manuscript.

Re. the comments in the annotated manuscript pdf file: We will make corresponding revisions in the manuscript.

Specifically, regarding the comment of adding one time series in Section 3.1, please see the time series in figure below.

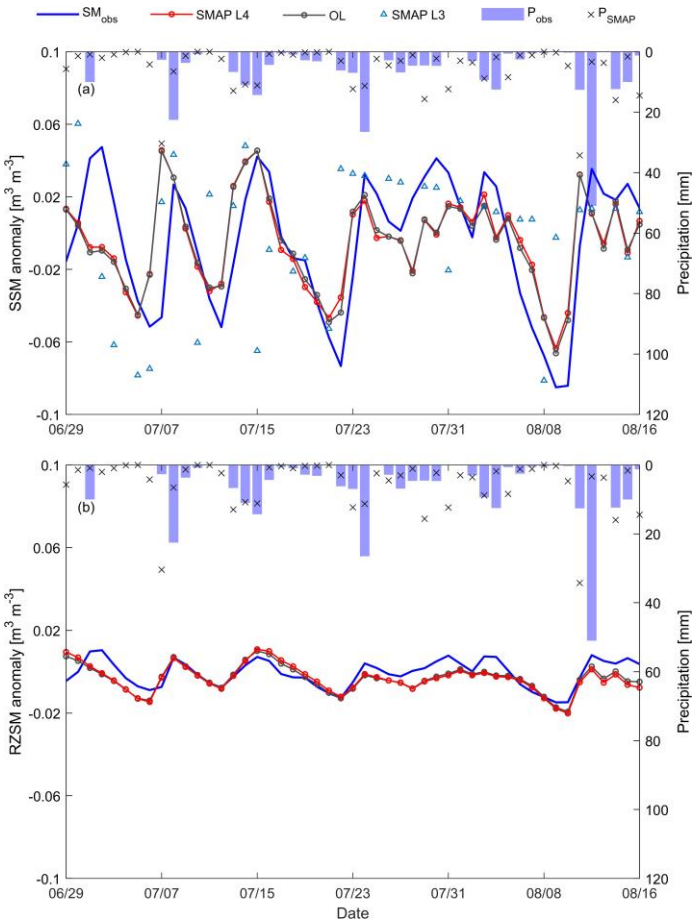

Fig. 1 The time series of gauge-based precipitation CGDPA (P_{obs}), SMAP L4 forcing

precipitation (P_{SMAP}), and anomaly time series of in-situ soil moisture measurements (SM_{obs}), SMAP L4, OL, and SMAP L3 at site-collocated grid cell for: (a) SSM, (b) RZSM.