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Reply on RC2

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Author comment on "Covariance-based selection of parameters for particle filter data assimilation in soil hydrology" by Alaa Jamal and Raphael Linker, Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2021-295-AC2, 2021

1/ While testing the proposed procedure with a real field test should certainly be the next step, we believe such a test should be conducted only after the soundness of the approach has been established, which was the purpose of the present study. For this first step, working only with synthetic data has the main advantage that ground-truth values are available for both parameters and state variables (at all depths), so that convergence of the ensemble can be fully analyzed. It would not be possible to quantify the procedure performance in an objective fashion using a real measurements since (1) measurements are not perfect, (2) measurements would be available only at specific depths and (3) the "true" characteristics of the soil would of course not be known.

2/ The constitutive law was indeed the Mualem–van Genunchten model. This information will be added.

3/ This regretfully mistake will be corrected

4/ The parameters n and alpha were regretfully mistakenly substituted in Table 1. In addition, the parameters in Figure 3 should be n instead of alpha. This mistake will be corrected throughout the manuscript.

5/ None of the parameters was fixed a priori. All parameters were allowed to change, if the correlation analysis showed that such a change was "justified". In the specific case studies reported in the manuscript, the parameter n was never selected for adjustment.

6/ In specific situations the uncertainty in Ksat could indeed be very large. However, particle filters such as used in the study tend to perform poorly when the uncertainty is very large, since it causes particle weights to become extremely small. This is most certainly a limitation of the approach (related to particle filter and not parameter selection) that should have been emphasized in the manuscript and we will correct this omission.

7/ The measurements were located close to the interface between top and middle layer, and middle and bottom layer, which explains why these measurements indeed conveyed some information about the properties of the middle layer. The fact that some of the parameters of the middle layer were indeed adjusted is a direct result of the fact that

some correlation between the parameters of this layer and the measured states indeed existed during specific periods. We will add a Figure showing such correlation and expend the explanation.

8/ C-GPFM is more consistent, or provides more robust estimations, than GPFM because it prevents changes in parameters that are currently not influential but will become influential under other circumstance. To illustrate this, consider a period during which the water content remains close to field capacity. Clearly during this period the value of the residual water content is not important, but when applying GPFM (or any other particle filter) there is nothing that prevents the value of this (currently non-influential) parameter from being changed to values that are in fact worse than the current ones. If the adjusted model is then used on a dry period (where of course the value of residual water content influences the results), the performance of the adjusted model will be worse than the performance of the initial model. The proposed C-GPFM approach prevents this by applying a "don't touch if not necessary" approach.

9/ We will add the uncertainties of the current states errors and current states to Figures 4 and 5, respectively. As mentioned in the paper (L162) parameters estimation is directly related to the state estimation so that states uncertainties provide information about parameters uncertainties as well.