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Interactive Comment

Interactive comment on "TerrSysMP-PDAF (version 1.0): a modular high-performance data assimilation framework for an integrated land surface–subsurface model" *by* W. Kurtz et al.

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General Comments

The paper of the "TerrSysMP-PDAF (version 1.0): a modular high-performance data assimilation framework for an integrated land surface–subsurface model" by W. Kurtz et al. present the work of coupling the model to the assimilation system. The manuscript focuses on the introductions of the technical implementation, computational efficiency of the parallel framework, and also examines the performance of the data assimilation. Overall, the manuscript provides proper information and description of the new system, and could be a important reference for upcoming studies in the future. In the introduc-

tion, it would be nice to mention other similar system such as "The Canadian Land Data Assimilation System (CaLDAS)". In addition, authors may want to point out the uniqueness of their compared to others. Once authors revise the manuscript based on the comments/suggestions here, I believe that the paper is worth to publish.

Reply: We thank the reviewer for recognizing the contribution of this work. We also agree that it would be good to provide a short review on other already established data assimilation systems in the introduction. We will add this in the revision of the manuscript. Additionally, we will point out the differences between TerrSysMP-PDAF and other data assimilation systems (like CaLDAS) in an additional paragraph in the introduction.

Specific Comments
P9642, line 27-28: "Assimilation of soil moisture data leads to a reduction of . . ..." In Fig.9, you show the soil water content for each member compared to the reference value. This only demonstrates the reduction of the ensemble spread after data assimilation. However, we do not see the reduction of the bias. In data assimilation, it is common to show the root mean square error (RMSE) and the bias of the control variable(s). I suggest authors examine the performance of DA/without DA in this way.

Reply: We agree that the bias reduction for some of the observation points cannot clearly be seen from Fig. 9. Therefore, we will add also a line for the ensemble mean to Fig. 9 which makes the improvement of the ensemble mean by data assimilation readily visible. We will additionally provide summary statistics for soil moisture. The absolute average error (AAE) of soil moisture averaged over all time steps and the uppermost ten layers is 0.0135 for the open-loop simulation and 0.0096 for the assimilation experiment. For calculating these values we excluded the 10 lower layers because these are constantly saturated during the whole simulation period.

P9643, line 6-7: "This can again be related to the lower observation density at the model borders." I agree with authors' explanation. However, why it does not occur in other boundaries? The results present in Fig 9 are based on four points from north to south at x=2000m. Based on my previous comments and suggestions, it would be nice if you can select different points other than x=2000m and examine the results. This could also verify your explanation of the boundary issue.

Reply: In fact, this phenomenon can also be observed for the boundary grid cells of the western and the eastern face of the model domain. The only difference is that the magnitude of AAE is larger at the southern and northern boundary. Please note, that there were problems in the calculation of the AAE fields in Fig. 10 (see below). However, the spatial patterns of AAE still remain, only the magnitude changed slightly. For Fig. 9, we also checked four independent points for verification which are in between the observation points (x=2500m, y=1500/2500/3500/4500m). However, the conclusions for these different verification points are quite similar to the ones from the previous figure (see Fig. 1 below). We will show the results from the independent verification points (see Fig. 1 below) in the revised manuscript.

In section 5.4, you performed the results of higher resolution. Are there any different setups of the EnKF between 25-m and 5-m resolutions?

Reply: The basic setup is the same for both model resolutions. For the 5m-resolution model, the input data were re-gridded from the 25m-resolution model input. The re-gridded log(K)-fields of the reference and the ensemble members were additionally perturbed with small-scale noise, which is the only difference between both models. The setup for the 5m-resolution model is described in paragraph p.9644 line 20 – p.9645 line 4.

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Interactive Discussion

Discussion Paper

In addition, P9627, line 24, authors state that there is no need for localization by global filter algorithms like EnKF. Please clarify this statement. As my understanding, as long as you have limited members for ensemble, localization is necessary and could perform better result.

Reply: Sorry, our formulation was a bit misleading here. We wanted to express that this special routine (determination of distances between state vector elements) is not used by the EnKF formulation in PDAF. The reason is that localization for EnKF is currently not implemented in the release version of PDAF. We certainly agree that localization could be a very important factor for the data assimilation results. However, this is currently not possible with EnKF in PDAF. Alternatively, PDAF provides local variants of several other filters (e.g., ETKF/LETKF). This functionality is not yet available in TerrSysMP-PDAF but will be provided in the near future. In order to avoid confusion, we will rephrase this sentence and remove the misleading formulation *"...which is not needed by global filter algorithms like EnKF."*.

Fig. 10 a) There is a discontinuity at y=1500 m, and the values of the AAE is also Discontinuous. Is this caused by MPI? b) How to explain the values of AAE in the south boundary (x=1000-2000, y=0) is larger in the EnKF (with DA) than in the open loop (no DA)?

Reply: Unfortunately, we found that there was a problem in the calculation of the AAE fields (time shift between the reference and the ensemble mean of soil moisture). Based on the new calculations, the discontinuity at y=1500m vanished and the background AAE value of 0.03 was decreased to zero (see Fig. 2 below). Other results were not affected by this calculation error. Although there is an overall decrease of AAE values for soil moisture within the model domain, there is indeed a slight increase with data assimilation around x=1000-2000m, y=

0-200m. If one compares the reference field of hydraulic conductivity (Fig. 11), one can see that the reference values are relatively low especially for this region. Additionally, one can see that this patch of low conductivity values is outside of the observation network. So, in fact, there is no information in the observations that indicates low permeability values for that region. So this is essentially a sampling problem. If one looks at the updated hydraulic conductivity field for this region, the filter even slightly increased the average parameter value for this part of the model domain which leads to the slightly higher soil moisture errors after the update.

Technical Corrections

P9624, Line 10: "i.e. the is no lateral" should be "i.e. there is no lateral"

Reply: Will be changed.

The captions in Fig. 5 are not complete. Only sub-figure in the left is traduced.

Reply: We will add an explanation of the right hand figure to the caption of Fig. 5.

The captions in Fig. 9 are not complete. What is red line and what is grey line?

Reply: A legend will be added to Fig. 9.

Fig. 11 versus Fig. 12: For inter-comparison of these two figures, please use the same maximum and minimum for the color bar.

Reply: The colour bars of both figures will be adjusted to the same range of values.

Interactive comment on Geosci. Model Dev. Discuss., 8, 9617, 2015.

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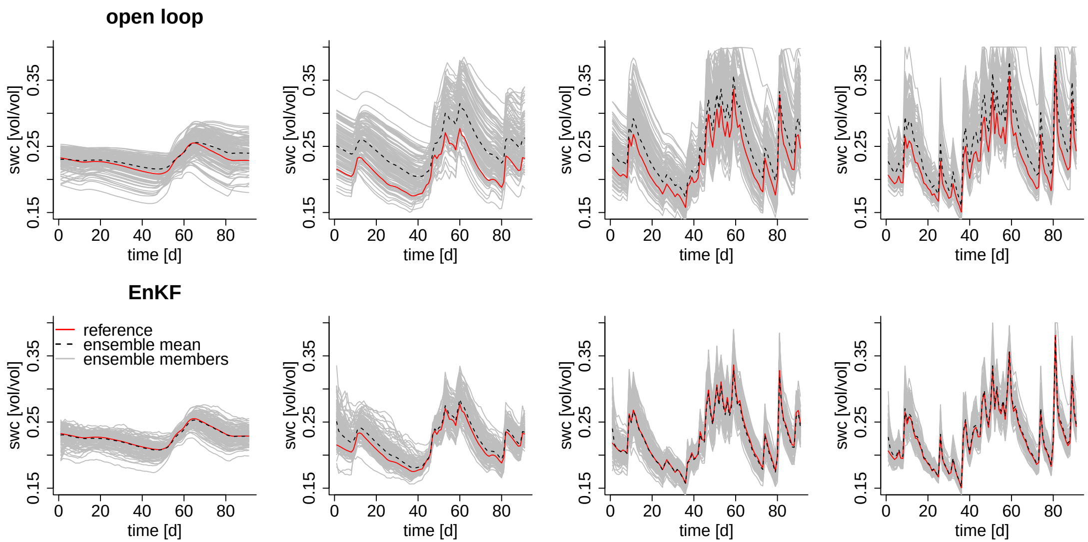

Fig. 1. Simulated soil water content at four verification nodes (x=2500m, y=1500/2500/3500/4500m, from north to south) for April–June 2013. Upper row: open-loop simulations; lower row: assimilation.

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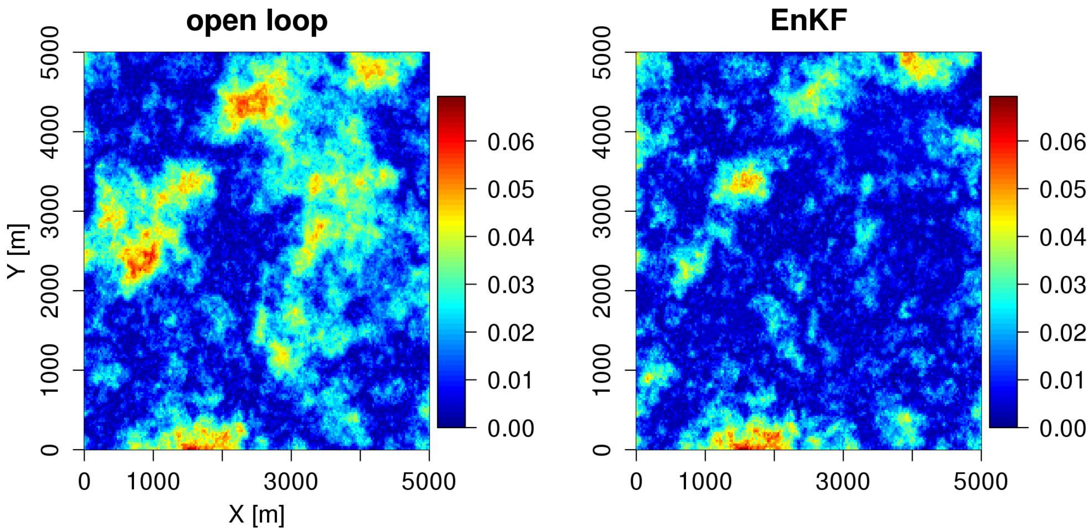

Fig. 2. Absolute average error of soil water content for open-loop (left) and assimilation (right) at a depth of −65 cm from April–June 2013.