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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Joint State and Parameter Estimation of Two Land Surface Models Using the Ensemble Kalman Filter and Particle Filter" *by* H. Zhang et al.

Anonymous Referee #2

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The manuscript presents different data assimilation methods for a joint estimation of soil moisture states and model parameters for the VIC hydraulic model and the Community Land Model. The models were tuned and evaluated at a single site and the main objectives include the advantages of the joint state and parameter estimation incorporating real data from the field, performance of the DA methods as well as the different land surface schemes.

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Discussion paper

General comments

The topic is interesting for the scientific community and the paper is clearly structured and well written. I agree for the most part with referee #1, who emphasizes shortcomings with respect to the presentation and discussion of the given objectives, to which I will add only a few more comments.

Furthermore, I have a comment regarding the usefulness of the presented data assimilation techniques for land surface modeller. In my opinion, the merits of a joint state and parameter estimation should not only be discussed with respect to DA schemes updating states only, but also with respect to alternative methods like conventional bayesian interference, e.g. (Yang et al., 2008), as well as the issue of optimizing time-invariant parameter vs. time-variant parameter, which has been intensely studied in the group of the authors (Vrugt et al., 2005, 2013). Therefore a discussion of the following (which might be too obvious for the authors to mention) can help to increase the significance for a broader community: What are the advantages of the joint parameter estimation versus optimizing time-invariant parameter? There seem to be shortcomings as time-variant parameter may be highly dependent on the end of the training sequence, especially when it ended shortly after a large precipitation event, like in this study. Will the parameter converge in the given training data set of 5 months? Vrugt et al. (2013) show that time-variant parameter can exhibit considerable non-stationarity, which is caused by changing sensitivity of the target variable on the parameters. Is there a difference/advantage of the joint estimation with time-variant parameter in terms of equifinality/identifiability of the parameter?

Specific comments

- p.10, ll.28ff: For me there seems to be no need to show the spin-up time series (Figure 2). Precipitation and temperature of the assimilation and verification period seem to be enough.
- p.11: What is the reason of choosing July 31 as the date to switch from assimilation to verification period? This choice seems to be critical for me, as the parameter of the final time step are chosen for the verification period. What would be the impact, if e.g. July 20 would have been chosen, as Figure 5 suggests, that some parameter for the MCMCPF method were significantly different?
- p.11: state updating only: How does the model then learn for the verification period? How are the parameter chosen in this case? Please describe this more clearly.
- p.11, ll.34ff, Table 1: soil moisture observation errors and parameter perturbations are given by normal and uniform distributions and corresponding ranges, means and standard deviations are given with numbers without further reasoning. As a comprehensive set of soil moisture measurements and soil core data is available, I would assume, the range of perturbation is related to the measured distributions, but I did not see a hint in the text. Referee #1 already addressed this issue related to measurement uncertainty and spatial heterogeneity, and the authors gave detailed reply, but I still miss, how the prior distributions and measurement uncertainties are related to the measured pdfs. It is surprising for me, that the uncertainty of the soil moisture measurements related to spatial heterogeneity is smaller than the given instrument uncertainty of $\pm 0.02 m^3 m^{-3}$.
- p 13. ll3-5: You state: *"Even although the soil moisture time series for the state augmentation and dual estimation method are very similar, the temporal evolution of their parameter values are different"*. This hints at the issue of equifinality and

identifiability of the parameters with respect to the time series to be predicted. Please discuss this problem.

Technical corrections

- Figures 3,7,9,12: Legend: "OBS" were coded with 2 dots. Please make use of different line types for a better discrimination between the displayed series. Especially red and green will be indistinguishable for many readers

References

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