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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Assimilation of surface soil moisture into a multilayer soil model: design and evaluation at local scale" *by* M. Parrens et al.

Anonymous Referee #1

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Overview

The study investigates the assimilation, through a Simplified Extended Kalman Filter (SEKF), of surface soil moisture observations in a multilayer soil moisture model and its effect in the simulation of the root-zone soil moisture. Specifically, a multilayer version of the ISBA model was applied to 3-year soil moisture observations collected at a bare soil field in southwestern France, the SMOSREX experimental site. Different experiments are carried out for testing different configurations of the data assimilation approach. Moreover, the comparison with the classical 2-layer version of the ISBA model is carried out.

General Comments

The paper is well written, well structured and clear; the language is fluent and precise. The content of the paper is surely of interest for the readers of HESS. In fact, with the recent availability of more and more accurate satellite surface soil moisture products, there is a need to maximize the impact of the assimilation of these datasets for improving the estimation of soil moisture, especially in the root-zone (required by many applications). This study exactly addresses this aspect by using a multilayer soil moisture model that is found to improve, with respect to a two-layer model, not only the simulation of soil moisture (open loop) but also the assimilation impact on surface and root-zone soil moisture simulation. This result is significant not only for the application of the ISBA multilayer model but also for other modelling applications. In fact, recent hydrological studies by *Chen et al. (2011)* and *Brocca et al. (2012)*, that investigated the assimilation of soil moisture data into hydrological models for improving runoff predictions, underlined that one of the main reasons for the low impact of the data assimilation that they found can be related to the simplified modelling structure (only 2 soil layers). A more detailed vertical discretization was suggested for enhancing the results exactly as it was done in the current paper.

Anyhow, I have some issues that should be addressed before the publication.

1) The application of the ISBA-DF model is only briefly described. I expect that a number of parameters should be set for the simulation of the different processes simulated by the model. However, no mention to the value of these parameters and how they are obtained is given. At the beginning, I expected that the ISBA models (2L and DF) were calibrated against in situ observations at the SMOSREX site, but this should be not the case. I expect that the model parameters are all fixed a priori based on soil texture and vegetation. Isn't it? Can the authors give more details on these aspects?

2) I believe that the rationale for the application of the bias correction (i.e., the CDF matching) should be detailed better. Usually, the bias correction is done for assimilating

satellite observations into a model that simulates ground data. In fact, the assimilation impact is evaluated in terms of the simulation of ground data. In this study, ground observations are bias corrected and, then, assimilated for simulating the same ground observations. Therefore, I expect that a bias correction should not be made (likely the model parameters should be corrected). However, I believe the authors have in mind the ISBA-DF application at a regional and global scale with the assimilation of satellite data and with the model parameters fixed a priori. In this case the bias-correction is strictly needed. Can the authors give more explanations for their choice to apply the bias-correction for this specific case study?

3) I would also suggest showing the results in term of soil moisture anomalies (with respect to a long-term mean value or by considering an N-day sliding window). By removing the seasonal cycle, it can give further insights on the assimilation impact and on the experiment that better reproduces root-zone soil moisture observations.

4) Sometimes I found that the number or the sentences reported in the text are not in accordance with those reported in Table 2 and Figure 5. For instance, at page 9568, lines 1-3 it reads that the assimilation increases the correlation coefficient and decreases the RMSE. However, if I am not wrong, from Figure 5 the assimilation provides an increase of the RMSE, not a decrease. Similarly, at page 9658, lines 23-24 it reads that the assimilation provides a decrease of 20% and 25% of the RMSE (for the w_1 simulation) for the open loop and the analysis. However, I obtain different values, i.e., (0.055-0.066)/0.066=-17% and (0.032-0.052)/0.052=-38%. See also numbers at page 9663, lines 19-20. Therefore, I suggest carefully checking all the number reported in the text (or in the Table/Figure). Moreover, I suggest not reporting a lot of numbers in the text that makes the paper hard to read.

On this basis, I feel that the paper might deserve to be published after a minor/moderate revision.

Specific Comments/ Technical Corrections (P: page, L: line or lines)

P9647, L26-27: I suggest mentioning here the very recent and interesting paper by *Pipunic et al. (2013)* that performed a similar experiment in Australia.

P9649, L18-24: I suggest specifying here, among the paper objectives (and also in the Abstract), that you are going to assimilate surface soil moisture observations obtained from ground data (at the beginning I supposed you are using satellite data).

P9649, L21: IBSA-2L, spelling error.

P9659, L26-29: It reads that in dry periods "the information provided at the surface does not penetrate very deeply into the soil". Then, that in summer the maximum values of the Jacobian and Kalman gain are obtained. This seems to me counterintuitive.

P9664, L9: I would change "flexible" with "suitable".

P9665, L3: It reads that in the ISBA-2L model the impact of the data assimilation is stronger for the first layer. Actually, the mean Jacobian value is higher for the second layer than for the first layer also in the 2L model (see P9658, L12). Please check.

Figure 5: This figure is hard to read and also the symbols given in the legend are not consistent with the text. I would suggest reporting the results of this figure in a table as in Table 2. By doing this, the reading of the results should be clearer (at least for me).

Figure 13: In the caption the meaning of the x- and y-axis is inverted.

Additional references

Brocca, L., Moramarco, T., Melone, F., Wagner, W., Hasenauer, S., Hahn, S. (2012). Assimilation of surface and root-zone ASCAT soil moisture products into rainfall-runoff modelling. *IEEE Transactions on Geoscience and Remote Sensing*, 50(7), 2542-2555, doi:10.1109/TGRS.2011.2177468.

Chen, F., Crow, W.T., Starks, P.J., Moriasi, D.N. (2011). Improving hydrologic predic-

tions of a catchment model via assimilation of surface soil moisture. *Advances in Water Resources*, 34(4), 526-536, doi:10.1016/j.advwatres.2011.01.011.

Pipunic, R.C., Walker, J.P., Western, A.W., Trudinger, C.M. (2013). Assimilation of multiple data types for improved heat flux prediction: A one-dimensional field study. *Remote Sensing of Environment*, 136, 315-329, doi:10.1016/j.rse.2013.05.015.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 9645, 2013.