

## ***Interactive comment on “Simultaneous estimation of land surface scheme states and parameters using the ensemble Kalman filter: idealized twin experiments” by S. Nie et al.***

### **Anonymous Referee #1**

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### **General Comments**

The authors apply the augmented ensemble Kalman filter to a 3-layer land surface model, called AVIM, to update both the soil moisture states and soil parameters simultaneously. The authors show that while the unconstrained 3-parameter estimation scheme improved the soil moisture prediction moderately with the parameters failing to converge to the true values, the constrained estimation scheme succeeded both in improving soil moisture prediction and in estimating soil parameters. This work nicely exhibits the values of combining parameter estimation with the model state update using the augmented Kalman filter technique in hydrological modeling and

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introduces a novel way to constrain parameter perturbation errors. The suggested constrained perturbation scheme has reduced the degree of freedom of the Kalman update scheme facilitating the convergence of the update. The topic of the research is relevant to the scope of HESS and the idea of constraining the parameter perturbation scheme is novel. This reviewer however has several comments on some technical parts of the method used in this work. I recommend the publication of this work after resolving the comments summarized below. Also, the manuscript contains noticeably many typos and grammar errors. I have listed some of them in the Specific Comments below (they do not include all the typos and errors, though).

The AVIM model was perturbed by adding zero-mean Gaussian errors to 1) soil parameters; 2) soil moisture initial conditions; 3) model forcing data (precipitation and short-wave). With given figures and tables, it is very difficult to tell if the perturbation scheme has created enough ensemble spread of soil moisture, which basically represents the model prediction error of soil moisture. Inferring from the comparison between “True”, “Prior”, and “Obs” soil moisture values in Figure 1, the perturbed model prediction of soil moisture seems to have smaller error than the observation until July, which implies insufficient model perturbation. Unlike the atmospheric models, most hydrologic models tend to suppress the large errors in soil moisture, which leads to substantially decreased *initial* soil moisture errors after several rainfall events. Consequently, soil moisture contents need to be perturbed continually in order to maintain the targeted level of mode prediction error. In relation to this comment, please clarify if the “Prior” soil moisture values in Figure 1 are the averages of ensemble soil moisture or a sample ensemble member from 100 ensembles.

It is stated that the precipitation was perturbed using zero-mean Gaussian noise with 20% of standard deviation. Due to the bounded nature of the precipitation (i.e., precipitation cannot have negative values), negative precipitation after perturbation would have been trimmed to zero. This can cause positively biased soil moisture. Is

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this part of the reason Prior\_sm1 and Prior\_sm2 in Figure 1 are positively biased in the drying down periods? Judging from the saturated hydraulic conductivity for the “Prior” run, which is about an order of magnitude greater than the “True” run, the significant positive bias is not readily understandable.

According to the description of AVIM in the section 2.1, the model has three soil layers of 0.1, 0.9, and 3.6 m, respectively. However, it says in the deepest layer of 3.6 m, *“both soil water flux and heat flux are assumed to be zero with constant soil moisture and temperature”*. I request the authors to check this boundary condition carefully again. If the bottom layer has the no-flow boundary, the upper layers of 1 m in total would be quickly saturated after a few sizeable rainfall events. Most land surface models have a “free-drainage boundary condition” in the bottom layer.

Due to the way how the RRE (Relative Root Mean Squared Error), it is not possible to directly compare the errors between the cases with different update frequencies (i.e., 1-day, 10-day, . . . , 40-day updates). It seems to me that the relatively high RRE of the 10-day case originates from the degraded soil moisture updates by assimilating the observed soil moisture not because the enhanced performance of the parameter estimation. The overall improvements in term of RMSE (not of RRE) by 10-day updates should be summarized with the 1-day-update RMSE, so that the reader can compare their improvements directly.

I recommend the authors to replace the term ‘idealized twin experiment’ with the ‘identical twin experiment’, and ‘constraint-based’/‘post-constraint’ with simply ‘constrained’ (e.g., ‘constraint-based simultaneous state-parameter estimation’ → ‘constrained state-parameter estimation’).

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## Specific Comments

**Page 1434, lines 14-17** This sentence is very difficult to understand, even after reading through the entire manuscript. Please rewrite it with more plain terms. Also, significant → significantly.

**Page 1434, line 19** temporal-sparse → temporally sparse.

**Page 1434, line 22** ranging from 1-day to 40-days → ranging from 1 day to 40 days.

**Page 1435, line 6** instrument → tool.

**Page 1435, line 18** increasing amount of research attention → increasing attention.

**Page 1435, line 22** clarify what “flow-dependent” means.

**Page 1436, line 5** There are two main weaknesses exist → There exist two main weaknesses.

**Page 1440, line 10** Actually → In fact

**Page 1440, line 18** the parameters which do not contained → the parameters, which are not contained.

**Page 1440, line 19** post-constrained update → constrained update.

**Page 1442, line 9** 2-yr spinup → 2-year spinup. Did you run the model twice for the period of 1 Jan. 1998 – 31 Dec. 1998?

**Page 1444, line 2** chose → chosen

**Page 1444, line 3** Cosby’s paper → Cosby et al. (1984).

**Page 1444, line 18** one-daily → once daily or once-a-day

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**Page 1446, line 6** been → being (or just leave it out).

**Page 1446, line 18** It is shows → It shows.

**Page 1447, line 8** can not converge → do not converge.

**Page 1447, line 10** Different from → Unlike.

**Page 1447, line 16** added on → added to. Clarify what “inherent balance relationships” means.

**Page 1447, line 20** (figures are not shown) → this result should be presented in the revised manuscript.

**Page 1448, line 3** remove “been”.

**Page 1448, line 13** potentialities → the potentials.

**Page 1448, line 21** remove “been”.

**Page 1448, line 29** guess → hypothesis.

**Page 1449, line 9** what does “*concerned*” idealized twin experiments mean?

**Page 1450, line 1** 40-days → 40-day.

**Page 1450, line 15** different → difficult?

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