Review of Plaza et al. (hess-2011-181)

This manuscript explores the important issue of assimilating surface soil moisture data into a land surface model to improve soil moisture and discharge predictions, via ensemble Kalman filtering and particle filtering methods. I have two main concerns (as discussed below) and would recommend the authors to consider them when revising the paper.

My first concern is related to the methodology. The EnKF and SIR particle filter described in this paper represent, in some sense, an inappropriate use of the two techniques; hence, all discussion on the improvement obtained by the SIR+PR filter relative to the first two techniques is not meaningful. In this synthetic study, the error in model prediction was introduced primarily by bias in the model parameters, as determined by the way the synthetic observation was generated. In such a situation, proper assimilation experiments should always consider join state-parameter estimation (as in Moradkhani et al. 2005a and 2005b), regardless of the algorithm chosen. It is not surprising that SIR+PR performs better than the first two techniques (i.e., EnKF and SIR), where parameter updating was not considered (even though parameter perturbation was used to generate the state ensemble). One possible solution would be to introduce biases in all major uncertainty sources including forcing, model initial condition, and model parameters when generating the synthetic observation and compare EnKF and PF on joint state-parameter estimation. This would mimic a more realistic situation, unless the synthetic study is specifically designed to investigate the impact of parameter bias on filter performance. I would also like to point out that the SIR+PR approach presented in this paper is very similar to the join state-parameter estimation approach introduced in Moradkhani et al. (2005b), which should be properly acknowledged.

My second concern is related to the overall presentation and clarification of the experimental design, result interpretation etc. The overall presentation needs to be improved for better flow and clarity. A few examples are given below.

- It would be better if the assimilation algorithm section is presented before the experimental design section.
- Some details on the experimental design (e.g., number of ensemble members, error covariance), the algorithms, and the results are somewhat interweaved together here and there. For example, in Section 4 (experimental design), some of the evaluation results are also presented, along with the definition of the measures. It would be much easier for a reader to follow if these details were presented in their own respective sections.
- It is unclear how the model forcing and parameters were perturbed. What were the standard deviations of these perturbations?
- Did the state vector only include soil moisture of the top 10cm soil layer in this study? Was base flow generation only related to the soil moisture in the top soil layer according to the model parameterization, while having no relation to the other soil layers? All these need to be clarified in order to determine whether the methodology used is reasonable or not.
- It is unclear what was learned from the sensitivity analysis of the initial parameter values. How were the three chosen parameter sets different from one another, in a physical sense? And what were the implications of these differences for the filter performance? The parameter set

used for generating the synthetic soil moisture observation should also be listed in Table 1, for comparison to the three optimal parameter sets.

- In Table 5 and Table 6, it would be better to use something like "every week, every 2 weeks, every 4 weeks" (instead of "16 DA events, 8 DA events, 4 DA events") to indicate the frequency of DA.

Other Minor issues:

P5857, line 25: it should be the posterior (instead of 'prior') pdf at time t-1.

P5858, Line 24: Although commonly used to provide an estimate, the ensemble mean is not necessarily the best estimate.

P5866, Line 14-17: "The reference model integration without data assimilation is performed with parameter set 2, while the assimilation integrations are performed with a slightly different configuration (parameter sets 1-2-3)". What does this mean? Shouldn't each assimilation integration with a given parameter set be compared to a reference model integration produced with the same parameter set?

References:

Moradkhani, H., Hsu, K.-L., Gupta, H. and Sorooshian, S.: Uncertainty assessment of hydrologic model states and parameters: Sequential data assimilation using the particle filter, Water Resour. Res., 41, W05012, doi:10.1029/2004WR003604, 2005a.

Moradkhani, H., Sorooshian,S., Gupta, H.V. and Houser, P.R.: Dual state-parameter estimation of hydrological models using ensemble Kalman filter, Adv. Water Resour., 28, 135–147, doi:10.1016/j.advwatres. 2004.09.002, 2005b.