Review for manuscript hess-8-3383-2011, entitled "Applying sequential Monte Carlo methods into a distributed hydrologic model: lagged particle filtering approach with regularization", authored by S.J. Noh, Y. Tachikawa, M. Shiiba, and S. Kim.

Summary:

The authors use a particle filter approach to estimate streamflow and soil moisture via implementation of a temporal lag in order to account for uncertainty within different hydrologic processes which operate on different temporal scales. In addition, a regularization step is implemented in order to prevent ensemble degeneration. Investigation of model-derived volumetric soil moisture and river discharge was investigated, including a series of statistical analyses to evaluate particle filter performance with and without the introduction of the temporal lag or regularization. In general, this manuscript would be of interest to the hydrologic data assimilation community, but could benefit (in terms of readability) by addressing the comments and concerns outlined below.

General Recommendation:
Publish with major revisions.

Manuscript Evaluation:

Principal Criteria:
      Scientific Significance: Good (2)
      Scientific Quality: Good (2)
      Presentation Quality: Fair (3)

General Criteria:
1. Does the paper address relevant scientific questions within the scope of HESS?
   Definitely.
2. Does the paper present novel concepts, ideas, tools, or data?
   Yes.
3. Are substantial conclusions reached?
   Yes, more or less. The authors' technique shows promise, but the presentation of the results could use a bit of clarification.
4. Are the scientific methods and assumptions valid and clearly outlined?
   Yes, more or less.
5. Are the results sufficient to support the interpretations and conclusions?
   Yes, but a bit of elaboration by the authors would be beneficial for the reader.
6. Is the description of experiments and calculations sufficiently complete and precise to allow their reproduction by fellow scientists (traceability of results)?

Yes.

7.   Do the authors give proper credit to related work and clearly indicate their own new/original contribution?
     Yes.

8.   Does the title clearly reflect the contents of the paper?
     Yes.

9.   Does the abstract provide a concise and complete summary?
     This could use some work. The abstract is too general without an explicit discussion of the quantitative results (see comments below).

10. Is the overall presentation well structured and clear?
     Yes.

11. Is the language fluent and precise?
     Yes, more or less. The manuscript could certainly benefit from a trained copy editor, though.

12. Are mathematical formulae, symbols, abbreviations, and units correctly defined and used?
     Yes.

13. Should any parts of the paper (text, formulae, figures, tables) be clarified, reduced, combined, or eliminated?
     Some small restructuring could likely pare down the size of the paper a bit (see comments below), but overall the authors did a good job.

14. Are the number and quality of references appropriate?
     Yes.

15. Is the amount and quality of supplementary material appropriate?
     N/A.

Major Changes/Questions/Concerns:

1.   Abstract: Please mention the measurements assimilated. Also, please include some descriptive statistics/results so that the reader has a relative idea of the improvement when using your technique.

2.   P.3385, l.23-26: Kalman-type filters do use a "linear correction step" but they are also "applicable to non-linear … state-space models" (e.g., ensemble Kalman filters). Please modify this sentence to state that SMC methods have the advantage of non-Gaussian state-space model, but remove the part about non-linear state-space models.

3.   Last two paragraphs in Section 1: Is there any way to merge/reduce the size of these paragraphs (e.g. remove redundancies)? For instance, P.3386, l.29-30 is essentially equivalent to P.3387, l. 13-15. Please pare down these paragraphs where possible for economy.

4.   P. 3394, l.16-25: Does this mean the same measurements are assimilated more than once? I don't believe so, but I could not tell from Figure 2. Please clarify.

5.   P. 3396, l.11-12: What is the remaining 8% of land characterized as?

6.   P. 3397, l.9-13: How are the fields generated (e.g., Kriging, nearest-neighbor interpolation, etc.)? Please elaborate as to how the meteorological values are defined between the 13 observation stations.

7. P. 3397, l.15-24: What are the boundary conditions for the groundwater? Constant head? Constant flux? Please elaborate with a sentence or two.
8. Equation (20): Why the use of additive error as opposed to multiplicative error (e.g.)? How might the selection of measurement error impact your results? Please elaborate with a sentence.
9. P. 3402, l.14-16: "Narrow confidence intervals" are interpreted as an "enhancement of the probabilistic forecast." Is it possible that this is a result of too little *a priori* errors? Is there additional evidence you can provide that would strengthen your argument regarding an enhanced probabilistic forecast?
10. P. 3403, l. 19-20: Did you conduct any sensitivity analyses of "two step" versus "three step" versus "four step" ahead prediction? If so, did the number of steps influence the prediction capability? Please elaborate with a sentence or two.
11. P. 3409, Table 1: Which station(s) are used in this comparison? Were the streamflow measurements used here the same ones that were assimilated? What about the other three (3) stations besides Katsura? Where these ever used in the experiments? Please clarify with a few sentences.
12. P. 3409, Table 1: How similar (e.g. total rainfall amount) was the rainfall during the calibration and verification periods? How might that impact the model performance? What is the calibration period was "dry" and the validation period was "wet." Please elaborate.
13. P. 3414, Figure 5: All of the stream gauges are near the basin outlet. Where any upland stations available? Since these gauges essentially represent the same integrated hydrologic response, the information content in one gauge could be comparable to another gauge. How might the availability (or lack thereof) of upland gauge information impact the results? Please elaborate with a sentence or two.
14. P. 3416, Figure 7: The rainfall record indicates precipitation events more or less every day. How might this strategy perform during drought periods when antecedent soil moisture conditions could have a significantly different effect on the hydrologic runoff response? Please elaborate with a sentence or two.
15. P. 3417, Figure 8: Again, are you comparing against the same gauge measurements that you assimilated? If so, then the results should always look better than the deterministic case. Any comparison that can show the efficacy of your technique should use **independent** observations for analysis. I found this to be the most confusing part in your paper, which could greatly benefit by a clarifying sentence or two.
16. P. 3418, Figures 9b and 9c: Which one is closer to the "truth"? Are there any ground-based soil moisture observations that can be used to answer this question? If not, then what is the value of this figure? Please explain.

Minor Changes/Questions/Concerns:

1. There are dozens of missing articles (i.e., "the", "an", and "a") throughout the manuscript. I am not going to comment on these particular grammatical mistakes because they are too large in number and not important to the merits of your technique. However, it may be worthwhile having an English-speaking technical editor briefly review your revised manuscript.
2. P.3384, l.13-15: Remove the sentence regarding MPI. It is a nice technical feature (as noted in the main text), but it is unnecessary for the abstract.
3. P.3386, l.15-19: This is a good point. I recommend you reiterate this statement (to some effect) within the Conclusions as it is strong reminder as to the merits of your approach.
4. Equation (1): Add space between the two "w_k" values in a similar manner as done with the two "v_k" values in Equation (2). This will make it easier for the reader.
5. P.3390, l.5: "particles" instead of "paraticles"
6. P. 3391, l7: "posterior" (i.e., one word) instead of "posteri or"