Response to the Editor for article hess-2013-463

Editor Initial Decision: Publish subject to minor revisions (Editor review) (18 Aug 2014) by Prof. Giuliano Di Baldassarre

Comments to the Author:

Most of the Referee's comments were properly addressed. However, the Referee's main concern was that the "methodology is incorrect and statistically invalid". This point is not sufficiently considered in the revised manuscript. While the authors tend to agree with this point in the rebuttal letter, this issue is not not properly discussed in the revised paper. Stating that these methods were already applied by others, does not address the criticism that the method is wrong and statistically inconsistent. Thus, I would suggest an additional revision of the paper to include a scientifically sounded discussion about this critical point.

Best regards,

Giuliano Di Baldassarre

Reply: We greatly thank Prof. Giuliano Di Baldassarre for kind encouragement in revising this paper and useful comments to make substantial improvement. In this revision, we included a brief and scientific discussion in the paper (marked in blue at Line 2-15, Page 9 and Line 8-10, Page 8).

In the previous response (reply to comment 3), we did not only state that the methods (i.e., the state augmentation and the kernel smoothing technique) have already been applied by others, but also provide the other two arguments to illustrate that the methods are ***correct and valid***. According to the reviewer's comments, moreover, we presented the results from a simple case to verify the methods (reply to comment 10).

Specifically, for the state augmentation technique, model parameters are assumed as an extension of state variables and they can travel slowly with time, in response to changes in environmental forcing inputs (Liu and Gupta, 2007). Like the model state forecasting, the parameters are perturbed/evolved using the kernel smoothing technique. In this way, the

evolution of model parameters is consistent with the forecasting of model state variables. Thus the model parameters can be appended to the state vector (Moradkhani et al., 2005; Xie and Zhang, 2010, 2013). When observations are available, the parameters are updated along with state variables by assimilating these observations. Therefore, their estimates can converge to the "correct" posterior target distribution (Xie and Zhang, 2013).

The reviewer has shown the concern that the method would fail to trace the travel of parameters because of small uncertainties in the convergence (i.e., the ensemble shrinkage). This is true if the parameters are not reasonably evolved. In this study, we employed the kernel smoothing technique to perturb the paremters, thereby relieving the ensemble shrinkage and mainting a reasonable ensemble spread (Moradkhani et al., 2005; Liu, 2000). So the estimates of parameters can converge to their appropriate values which guarantee acceptable streamflow predictions.

We added these points in this revised version of the paper, not the response alone.

References

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Liu, Y., and Gupta, H. V.: Uncertainty in hydrologic modeling: Toward an integrated data assimilation framework, Water Resources Research, 43, W07401, 10.1029/2006WR005756, 2007.

Moradkhani, H., Sorooshian, S., Gupta, H. V., and Houser, P. R.: Dual state-parameter estimation of hydrological models using ensemble Kalman filter, Advances in Water Resources, 28, 135-147, 2005.

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