

Interactive comment on “State updating of a distributed hydrological model with Ensemble Kalman Filtering: effects of updating frequency and observation network density on forecast accuracy” by O. Rakovec et al.

Anonymous Referee #2

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Overall evaluation: Minor revision

Major comments: This paper presents an application of distributed modeling data assimilation (DA) using ensemble Kalman filter (EnKF), and investigates the effect of updating frequency as well as the density of streamflow gauge on the performance of the EnKF. The authors carried out synthetic as well as real-world experiments for the basin with multiple stream gauges available, and nicely summarized research findings and discussions. This paper discusses an important topic on developing automated

C1675

data assimilation procedures for distributed models and testing with real-world data in order to improve operational streamflow forecasts. The study presented in this paper should be interesting to a broader readership, including operational forecasters, academics, etc. The only major concern I have is the validation method that the authors used. The validation of the DA results has been mostly based on the outlet flow simulation results (Figs. 5, 6, 8, 9, 10) where flow observations are assimilated in four out of five assimilation cases, as presented in Fig. 4. The validation results should be more meaningful if the validation is done at the stream gauge location where the discharge data is not assimilated. The authors may consider presenting and discussing interior flow results generated from both base model simulation and the assimilation procedure. In addition, the reviewer recommends improving clarity by adding more discussions or explanations, or rephrasing, wherever necessary or indicated by the reviewer; please, see specific comments for this. Overall, the reviewer thinks this paper merits publication in this journal.

Specific comments: 1. l11, p3962: pdf's -> pdfs (?) 2. l16, p3962: (DA), by -> (DA) by 3. l3, p3964: Lee et al. (2012) -> I do not think this paper deals with soil moisture assimilation; please check again. 4. l16-17, p3964: Unfortunately -> this word doesn't seem proper in the science paper; please, consider using a different word. 5. l4-6, p3965: Hence it is . . . forecast. -> this sentence does not read smoothly; please, consider improving readability. 6. l7,p3965: DA framework -> it appears in various places in the text, the authors are using DA “framework”, DA “scheme”, DA “machinery” but they all denote the same thing, I think; the reviewer suggests using the same word, e.g., DA procedure, throughout the paper to be consistent or not to create any confusion. 7. l6,p3969: NS's -> NSs 8. l8,p3969: root mean square error (rmse) -> Root Mean Square Error (RMSE) 9. Eqs. (8) and (9): What is different between H in Eq. (8) and H in Eq. (9)? Please, describe it in the text. 10. l16,p3972: synthetic observation Qobs,k -> How is this different from Qobs in Eq. (14)? Is Qobs in Eq. (14) synthetic observation or actual streamflow data? If they are different, then Qobs in Eq. (14) should be described separately below Eq. (14). 11. Qfor in Eq.

C1676

(14) -> It is not clear if Qfor is an ensemble mean or ensemble member? So, it is also not clear if RMSE presented in Figs. 5, 8, and 9 are based on an ensemble mean or all ensemble members. 12. l20, p3973: a variance of $(0.1Q_{obs,k})^2$ -> Where does 0.1 come from? Is it based on a sensitivity run, or based on a data analysis, or based on the literature? I think Clark et al. (2008), which is cited in this paper, used 0.1 as well. The authors may describe a little bit detail on this or may simply add a reference. 13. Subheading of the subsection 3.1.1 -> the current subheading doesn't seem good because of RMSE used in the title. Please consider renaming it, e.g., discharge forecast, as similar to the title of the subsection 3.1.2, or model performance on discharge forecast. 14. l11-13, p3974: "the benchmark case A ... to the catchment outlet" seems inconsistent with what is written in lines 17 to 20 in the same page "Additionally, ... to the outlet." 15. l23-25, p3974: "Slightly ... frequency." This finding seems counter-intuitive. Please, consider adding a description in the text on why this is happened. 16. l3, p3975: "In other words to check" Please, rewrite these words. 17. l22, p3977: "which is contradicting" Please, add an explanation in the text on what caused the contradictory result. 18. l7, p3978: "explicit routing" I do not know what the authors mean "explicit" here. 19. l5-6, p3979: "mainly. ... EnKF scheme." In the reviewer's opinion, one of main reasons for the routing states to be more sensitive than the rest model states is that the EnKF, as formulated in this study, does not explicitly consider the high correlation between soil moisture states in the immediate past and streamflow at the time of forecast. As in Eq. (4), the model state vector is composed of water balance and routing states at the concurrent time step; in this case, it may be difficult to build a covariance matrix among water balance model states (i.e., SM, UZ, LZ) via assimilating discharge observations. This seems briefly mentioned in lines 24 to 29 at page 3980, but not exactly discussing the issue described above. Please, consider discussing this in the text. 20. l2-3, p3981: A reference may be necessary to support this sentence. 21. Fig. 3: consider presenting time series of interior flows. 22. Caption of Fig. 5: "EnKF assimilation ... (right.)" Make this a complete sentence. 23. Fig. 5: As to the RMSE results for cases A and B in the left plot, I am not sure if A and

C1677

B results are considered significantly or noticeably different, given the small difference in their RMSE values as well as high NS value in the case of base model simulation. If their difference is marginal, please make it clear at the text.

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C1678