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Comment on hess-2020-668

Anonymous Referee #1

Referee comment on "Technical Note: Sequential ensemble data assimilation in convergent and divergent systems" by Hannes Helmut Bauser et al., Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2020-668-RC1, 2021

In this paper, the authors investigate the difference in the impact of data assimilation for convergent and divergent systems. They conclude that a different approach is needed for these two types of systems.

I have a dual opinion of the paper after having read it. On the one hand, this is an issue that has been under-investigated in hydrology, and could use some more research. On the other hand, there are a number of issues with the paper that really need to be addressed before the paper can be published.

Introduction Line 32: In ensemble data assimilation methods, ..., this leads to decreasing uncertainties over time, which favors filter degeneration. If the filter degenerates, that means that the ensemble is not generated correctly. An adequate generation of the ensemble should prevent this.
Line 37: You are forgetting uncertainties in the meteorological forcings!
Line 40: The Kalman filter has been developed to estimate states. In system theory, a parameter is defined as a variable that does not change. I know it is common practice to also update parameters, but it is worth noting that this violates the theoretical basis of the Kalman filter.
Line 43: A random walk is also often used as parameter model.
Line 47: Inflation methods are a complete violation of the theoretical foundation of the Kalman filter. The update equations are derived by minimizing the posterior state error. Adding this inflation will, by default, lead to suboptimal results. A correct ensemble generation will solve the need to do this.
Line 51: If the parameter uncertainty is kept constant, the Kalman filter is effectively reduced to optimal interpolation. This should be clarified.
Line 53: Same comment as for line 47. Using this damping factor is a complete contradiction of the theoretical foundation of the Kalman filter. The author of that paper is Hendricks Franssen, by the way.
Line 107-111: This is very unclear. Please think about reformulating in a manner to make this easier to digest.
Figure 1: Does "forecast" mean the open loop (forward) run?
Line 150: Do you mean Fig. 1c?

Line 189: Usually, in soil moisture data assimilation studies, only the surface layer soil moisture is assimilated. Please justify this strategy. Also, an observation error of 0.007 seems quite low.
Line 192: This is very important. It is stated: To generate the initial ensemble, the ensemble mean is perturbed by a correlated multivariate Gaussian distribution. This is very unclear. Please provide a better explanation on how the ensemble is generated, as this is very important, and could help interpret the results later in the paper.
Immediately below figure 2: This case shows that the predictability for a perfect convergent system is infinite. I do not agree. It shows that the ensemble is not adequately generated.
Line 230: I would argue that disturbing the n values leads to an ensemble that is well generated, which explains the better results.
Line 268: A model is never perfect, so a better word than "perfect" should be used.
Line 283: Again, you are forgetting meteorological forcings.
Line 290, 291 and 296: Again, inflation, and using a constant ensemble spread, are tricks that are used to compensate for a poorly generated ensemble.

As stated above, I am in favor of the idea of the study, as this is important. But the issues I mentioned should be resolved before the paper can be published.