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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Inflation Method for Ensemble Kalman Filter in Soil Hydrology" *by* Hannes H. Bauser et al.

Anonymous Referee #1

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Summary

The manuscript presents a new approach to handling inflation during Ensemble Kalman filtering, specifically developed for state and parameter estimation in the unsaturated zone. The authors suggests to calculate a dynamic inflation factor that is estimated with a separate Kalman filter within the main EnKF. Apart from theoretical development, the authors also show a test case with good performance.

General comment

I much enjoyed reading the manuscript, which provides an important contribution to the community. The manuscript is well written and well structured, although I think some things should be a bit clearer explained (which is addressed below).

Specific comments Derivations (page 5-6): I find the derivations of the internal Kalman filter sometimes tricky to follow. Primarily I am a bit confused with the second part of eq. 13, which should come from mean inflated forcast vector (Hu-overbar-f-inf), where the mean of the inflated vector u in turn is the same as the non-inflated mean u-vector (since the inflation, if I get it right, does not alter the mean). Therefore I am not 100% clear on how the lambdas come into the equation (although the equation itself makes sense). Perhaps it would be a good idea to add a more detailed version of the full derivation process in an appendix, where also smaller steps can be shown without creating a too long and tedious paper.

Damping factor: as the authors states in the introduction (page 2, line 31), damping factors are often used instead of inflation, e.g. in lack of better ideas, since it is a rather ad-hoc method. However, despite of now having an advanced and seemingly well-functioning inflation method, the authors still apply a rather strong damping factor to the parameter updates and lambda updates (page 8). Is this still needed?

Inflation factor uncertainty tuning: The authors points out that a higher value is needed for a good performance. The question that arises is whether one can also set it too high (all within reason of course), or if e.g. 1 would, in general, be good enough? Or/similarly, can the authors stress cases where a small inflation factor uncertainty could be clearly beneficial? A short discussion (if possible with some more general recommendation) would clearly increase the transition for other users to use the author's method! (the current discussion discusses more the impact of too low numbers)

In figure 3c one sees an ensemble member with Ksat values around -7, which is clearly far away from the truth and something like an outlier. To me it looks as if the inflation is maintaining this position, as in the corresponding figure with less inflation (figure 4) it is slowly reduced, and with no inflation it is removed (although the full ensemble moves towards it, rather). In a parameter estimation problem, would this really be a wanted behavior? A related question is whether the application of the inflation factor on the parameters or on the states are more influential, hence, if you need really need both

(especially in combination with damping)? Reason for asking is, partly, that in Figure 5 we can see a drifting off of the Ksat already before the rain event which is not visible in Figure 3c, despite the inflation of the parameter in is roughly 1 here. However, a rather substantial inflation is applied to the states (figure 1) during this time, suggesting that there are also effects of state inflation on the parameter estimation.

If I get it right, the inflation is applied before the analysis. Wouldn't this, at least in principle, risk altering the sought correlations between states and parameters, (especially since the inflation is applied to both and the system at hand is nonlinear)? Is this an issue that one should keep in mind or is it, in the opinion of the authors, likely negligible?

Technical stuff

Page 4, line 10: reformulate, reads funny

All figures: the inflated ensemble is almost invisible (I didn't realize until the third read-through that there were also light blue lines), change the color to something better/darker!

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