Hydrol. Earth Syst. Sci. Discuss., 12, C3241–C3244, 2015
www.hydrol-earth-syst-sci-discuss.net/12/C3241/2015/

Hydrology and Earth System Sciences
Open Access
Discussions

Interactive comment on "Data assimilation in integrated hydrological modelling in the presence of observation bias" *by* J. Rasmussen et al.

Anonymous Referee #1

Received and published: 24 August 2015

In this paper, the authors are comparing a number of methods to deal with observation biases when assimilating data into a hydrologic model. I am in favor of the idea, but a number of issues must be resolved before the paper can be published.

- The introduction does not have enough depth. Significantly more work has been done on bias estimation through data assimilation in hydrology, and hardly any of this work has been discussed. At least a good effort is needed to improve this.

- A number of issues regarding the data assimilation algorithm are very unclear. On page 8137, the authors state that a linear operator H is used when assimilating data. But the authors assimilate discharge, and the relationship between discharge and ground water levels and soil moisture is nonlinear. We need more detail on how the

data assimilation system is set up. Clearly define which variables are in the state vector, and which in the observation vector.

- Also on page 8137, what is the "observation covariance"? Is this the observation error covariance?

- On page 8139, it is explained how the localization weight is calculated. But it is still not clear to me how exactly this is used. Please provide some more explanation.

- Also on page 8139, make it more clear how H is extended. It is stated that H is extended accordingly, but that is not enough detail. Please also see my earlier comment on the linearity of H.

- I have a serious problem with using covariance inflation. A number of papers have shown that when the ensemble is adequately generated, this is not necessary. Moreover, this inflation will make the algorithm inconsistent with its theoretical derivation, and therefore will make it work suboptimal. This needs to be at least mentioned and discussed.

- I also have a question with using damping (page 8140). This is (the way I understand it) not consistent with covariance inflation. First, this inflation is applied to make sure the updates are sufficiently large, but then the damping is applied to reduce the updates. This needs a much stronger justification. Again, this is inconsistent with the theoretical derivation of the filter, and will thus make the results suboptimal. And I really think that both these tricks (inflation and damping) could be avoided through a better ensemble generation.

- Below equation 15, please again provide more details on the augmentation of H.

- Equation 21: The updated bias is calculated as the old one minus the gain multiplied by the innovation. I have a question about this minus. In all papers on observation bias estimation there is a plus here. Assume that there is a large bias between observations and results. From equation 21 this bias will reduce. Plugging this reduced bias into

HESSD

12, C3241–C3244, 2015

equation 22 the unbiased states will increase while they shouldn't. Perhaps it is a typing error but please double check this. If it is correct, I would suggest to explain why the minus is there, as opposed to the other papers on observation bias estimation.

- Section 2.3.7.: why not update the states each time a discharge observation is available? This would or at least should lead to better results.

- Section 2.4.1.: This is a mistake that is made in a large number of papers in hydrology on discharge assimilation. Discharge is NOT a state variable, it is a diagnostic variable. State variables have to be seen as initial conditions, to which you apply the model equations, and then you get the results that you update with the Kalman filter. Discharge is simply NOT a state variable, it is a model output. If you enter the discharge in the state vector, and you check the requirements of observability and controllability, they would not be fulfilled.

If one wants to assimilate discharge into a hydrologic model, the discharge has to be entered in the observation vector, and the soil moisture and water table levels in the state vector. The observation system is in this case NONLINEAR. There are a number of papers on this, that the authors really should read. Please note that this is the same principle as for example assimilating radar backscatter values or surface brightness temperatures into a hydrologic model.

- The last sentence before section 3.1.2. is a little bizarre: "Test have shown that the length of the assimilation window is of little importance and therefore no other assimilation window was tested." Doesn't this sound a bit contradictional?

- Section 3.1.2.: I do not agree with the statement that updating every observation is too often, I actually think the opposite is true. This may be the result of issues in the setup of the filter, as I explained in my earlier comments.

- Last sentence before section 3.3.: If you plug an ensemble of forcings and parameters into a nonlinear model, and even if these ensembles are unbiased, it is very likely that

HESSD

12, C3241–C3244, 2015

the resulting ensemble of model results will be biased, because of the nonlinearity. Please add this explanation.

- Just a detail: section 3.4.: why are data this old being used?

- Section 3.4.2.: are the RMSEs biased or unbiased?

- Page 8155: It is true that both methods were tested in Drecourt et al, but they looked at model biases, not observation biases. This should be clarified.

- End of page 8156 and top of page 8157: you could actually calibrate this gamma parameter. Why not try this?

These are the comments that come to mind regarding this paper. Given that they are quite substantial I would recommend a major revision to the paper.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 12, 8131, 2015.