Hydrol. Earth Syst. Sci. Discuss.,
https://doi.org/10.5194/hess-2017-760-AC2, 2018

Hydrology and Earth System Sciences Discussions

Interactive comment on "Joint assimilation of soil moisture retrieved from multiple passive microwave frequencies increases robustness and quality of soil moisture state estimation" *by* A. I. Gevaert et al.

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Received and published: 26 June 2018

Comment #1

My first question concerns the inflation factor. This inflation factor (let's call it gamma) was applied increase the ensemble spread to avoid having a disproportionate ratio of model and observation errors, which would lead to observations having no impact on the model analysis. From my understanding of the text (p.7, l.15-16), the actual value of this inflation factor is not specified, but is chosen in such a manner as to avoid the

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Discussion paper

model error (for both top layer and root zone?) from ever falling below 2%. Is this correct? In this case, what is the value of gamma?

Response #1

The inflation factor ensures that the model error does not fall below 2%. The model error is based on the model error variance $H_t P_t H_t^T$, which is based on the top layer of the model since this is the layer that is most representative of the shallow depth of the soil moisture observations. If we would have chosen a fixed inflation factor the 2% error would only be ensured with a (very) large value. Therefore, we used a variable inflation factor. This inflation factor was calculated at each timestep where the model error was calculated as being smaller than 2% by the equation:

$$\gamma=\sqrt{(0.02^2)/(H_t P_t H_t^T)}$$

In the revised manuscript, we will explain how the inflation factor was calculated and make it clearer that the value varies in both time and space.

Comment #2

My second question relates to variables boundaries. The inflation factor works well for unbounded variables, but problems may arise when an ensemble member approaches a boundary. Ensuring physical realism (e.g. by adjusting negative values to zero) may introduce a bias. How are boundaries handled for modelled variables?

Response #2

It is true that using an inflation factor on a bounded variable will introduce bias when the values are adjusted to its boundaries. However, to avoid using unphysical values, we adjusted negative values to zero and values above the storage capacity of a soil layer to its maximum value immediately after applying the inflation factor. This adjustment, being one-sided, will introduce bias in the modeled time series. However, as discussed in response to the previous comment, the inflation factor was only applied when the model error fell below 2% and its magnitude was set to ensure a model error of 2%.

Therefore, even in the worst case scenario, when the moisture store is predicted to be at capacity or empty, the magnitude of the bias is limited.

A summary of this response will be included in the revised manuscript, explaining the consequences of the inflation factor on model time series when the values approach the physical boundaries of the soil moisture layers.

Comment #3

On a similar note, how do you perturb the observations? The errors attributed to the C-band retrievals is said to be 0.24 in AWRA-L wetness units and 0.18 for the other retrievals (p.16, l.29-30). I am assuming these are standard deviations? Either way, in the original EnKF procedure, the observations are perturbed to reach these errors. What type of distribution is used and how are observation boundaries handled? Using a Gaussian distribution on a bounded variable leads to values falling outside the boundaries. Also, observation values of 0% or 100% cannot be perturbed without introducing a bias. If this is the case, I believe a discussion on the matter would be beneficial.

Response #3

The observations were perturbed using a normal distribution, with the error values representing the standard deviation. As you mentioned, this can indeed lead to values falling outside the range of possible values in bounded variables such as soil moisture. Therefore, the values were adjusted to fall within the physical range: negative values were set to zero, values larger than one to one. This adjustment can indeed lead to bias.

In the revised manuscript, we will explain how the observations were perturbed and what the consequences of our approach are.

Comment #4

As for suggestions, the first concerns the title, which I believe is misleading. The manuscript showed there was little added value to the joint assimilation schemes compared with assimilating individual bands. While the possibility of added value was mentioned where individual soil moisture retrievals are more informative in different locations.

Response #4

Thank you for your suggestion. We will modify the title to “Joint assimilation of soil moisture retrieved from multiple passive microwave frequencies increases robustness of soil moisture state estimation”

Comment #5

I would also recommend mentioning the ensemble Kalman filter somewhere in the abstract as it is an important part of the method and would facilitate the search for relevant information for readers.

Response #5

Agreed, we will add the fact we used an ensemble Kalman filter to the abstract.

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