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Hydrology and Earth System Sciences Discussions

Interactive comment on "Towards the sequential assimilation of SAR-derived water stages into hydraulic models using the Particle Filter: proof of concept" *by* P. Matgen et al.

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This paper tackles the interesting problem of improving forecasts of flood inundation by hydraulic models with SAR derived water level data. A novel method is proposed for combining the SAR data with the hydraulic model using an advanced sequential data assimilation algorithm, the particle filter. For these reasons the paper has the potential to be an excellent addition to HESS and the research in this area. However, there are a number of technical issues and the study conducted does not justify the wide range of conclusion made, especially as no real data are presented. Below is a list of issues the authors should address:

P1786, L4-5: What evidence is there that the temporal frequency of these SAR constellations is compatible with real time forecasting requirements and is this scale dependent? To my knowledge the repeat frequency used in this study is not about to become available.

P1788, L19-23: "As a matter of fact, in order to be of relevance to flood forecasting systems, uncertainties associated with remote sensing data should be smaller than simulation uncertainties." I don't see why this is the case unless you are saying the measurement bias is larger than the simulation model, surely this is one of the main reasons for using a data assimilation approach. Perhaps this section on accuracy is less clear cut given that the reference (Arya et al., 1983) pre dates all the assimilation methods discussed in this section.

P1792, L7-8: I think this section needs more care if you have a non-Gaussian distribution from an ensemble and assimilate data with an EnKF you get a non-Gaussian posterior pdf. The clarification on this section seems to describe the Kalman Filter.

L11: "for a full representation of the probability distributions" What does this mean? This might be correct but I don't understand; obviously as an ensemble method it must be an approximation of the pdf.

P1793, L13-31: Is it necessary to assume all errors in measurement data are Gaussian and normally distributed? If the weighting method is based on Gaussian likelihood and the measurements assimilated have Gaussian errors it appears this method makes lots of assumptions about the pdf that are not obvious from the introduction.

P1797, L9-11: Were there big differences in the error characteristics at high flows and what are the implications for the ensemble generation?

P1800, L2: Roughly how many particles are retained after assimilation and what was distribution of weights used... a typical example should suffice. From the figures it looks like very few particles are retained and it is not clear what the weights are for the forecast ensemble members that are subsequently simulated. How are the weightings considered in the calculation of the ensemble mean?

L14-17: Are the image repeat frequencies considered realistic?

P1801, L1-5: Is this correct? Surely each ensemble member should have its own Qerror and not be updated using an average? Also, as most of the ensemble members are re-sampled using sequential importance re-sampling how are the Qerrors related to the ensemble members in any sensible way? Should the flows not be updated individually and allowed to relax back towards the open loop values over a period of time?

L 20: I'm not convinced by the use of "best estimate" here as there is no justification for the method of propagating model errors except that it is simple.

P1802, L1-5: I think you should have a non-normal test case.

L6- : So the proposed approach has updated the states to represent current conditions then forces those conditions with the same ensemble of flows used before the assimilation, but shifted by the average difference between the prior and posterior ensemble mean. Meaning the ensemble spread rapidly returns to the original variance but with different mean? This is OK for the theoretical test case but is this likely in reality?

L26: This is rather obvious. The main question is how assimilating the measurements impacts on forecasts of the near future?

P1803, L8: This is true but you have not assessed the temporal correlation in model errors, instead you have applied a persistent shift in the mean to the boundary.

L10: Again obvious, but what about the forecasts?

L12 Discussion: "Our study demonstrates that the information contained in radar flood images can lead to improved flood inundation modeling". This is already reasonably well established in the published literature, whilst the study cannot be used as addi-

tional evidence to confirm this point because the data are simulated using an error model that is not typical of SAR imagery.

This also apples to the first conclusion (line 15-20) no attempt has been made to simulate realistic errors, the assimilation algorithm has not been demonstrated for non-normal or spatially correlated errors (both of which seem likely from an image). It seems to me the application of the Particle filter to the hydraulic model is the novel aspect here and should be the focus of the discussion and conclusions. A discussion of the limitations and assumptions of the approach implemented would be more appropriate as these can be demonstrated without real data.

P1804, L7: digestion?

L8-11: Your error model doesn't do this, the boundary flows are only adjusted to change the mean and as far as I can work out (so clarification may avoid this problem) the flows have little relation to the water levels. I don't see how the proposed error forecast model is particularly well suited to prediction in ungaged basins because it implies a scalar shift in discharge is appropriate at all forecast times. To make this conclusion you must demonstrate that it is appropriate; obviously in this case where a constant bias is added to the boundary the proposed method will do alright in terms of forecasting the mean. This and conclusion 1 are rather large overstatements and need to be toned down.

L21: "closes the overall water balance" what does this mean? It seems unlikely that you have closed the catchment water balance. Do you actually mean that the hydraulic model update conserves mass for each ensemble member?

L22:25: It is a bit difficult to understand what the message of this sentence is. The Andreadis example also estimates boundary discharge (but uses a well established auto-regressive model for the boundary errors). It also reduces uncertainty in the boundary discharge which is not the case here, although the PF can do this I assume? As for parameter estimation this is not implemented and no discussion of how this would be done is included.

In summary this is a very interesting topic which requires a great deal of skill to set up. I hope the authors find my comments useful in moving the discussion forward.

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