Hydrology and Earth System Sciences Discussions

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Comment on hess-2021-125

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Referee comment on "Simultaneous assimilation of water levels from river gauges and satellite flood maps for near-real time flood mapping" by Antonio Annis et al., Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2021-125-RC2, 2021

This study aims at simultaneously assimilating water level observations from static sensors and EO-derived flood extent for improving real-time flood modeling. I have really enjoyed reading this paper, which deals with a timely and important issue. The authors showed the potential of the joint assimilation of water level observations from both static sensors and satellite images. I think this study fits the overall focus of HESS. However, I do have a number of major comments that hopefully will help the authors in strengthening their manuscript.

- My first comment concerns the overall objective of this study. Personally, I would put more emphasis on the issue of the joint assimilation of water level observations in the 1-D and 2-D model rather than highlighting the innovation behind the proposed DA approach (line 57). Besides equations 5 and 6, and the definition of hko,t in equation 9 there is no much difference between a standard EnKF and the proposed DA method, which would not justify a publication on a high impact journal like HESS. To the best of my knowledge, this is the first study that assimilates heterogeneous observations in both 1D and 2D models and this must be better highlighted in the introduction (as novelty and the main objective of the paper) and throughout the paper.

- The proposed DA approach should be better described in the paper. What I think is still missing is the information about the size of each DA variable/matrix (e.g. the size of the model covariance matrix P) and how the merging between hydraulic model and DA is performed. Observations from static sensors are used to update the channel water level (1-D model), while satellite images are used for updating the floodplain water level (2-D model). The assimilation of one observation at a given time step allows updating not only the water level at that specific point along the channel but also upstream and downstream. This is partially solved by introducing the distributed gain (initially proposed in Madsen and Skotner, 2005), but how then the updated upstream flow will numerically influence the downstream water levels? It would be nice to show the covariance matrix P at different time steps in case of assimilation of only static sensor, only SI, and joint assimilation. This will allow visualizing the distributed effect of assimilating heterogenous observations at once.

- The abstracts read well but I would include a couple of brief sentences summarizing (quantitatively) the benefits of the joint assimilation (e.g. "Our findings reveal that assimilating observations from static sensors and satellite led to an overall reduction of the Bias and RMSE of about ---"). In addition, at the beginning and at the end of the abstract you referred to the issue of data scarcity. However, your approach is based on the case in which you have observations from static sensors, which may be not available in data-scarce regions.

- In line 143 the authors state that "In case the observation is a stage gauge measurement, the state variable position is determined by identifying the closest channel cell". However, after a few lines (153) they stated "The updating of the water levels from Static Sensors (SH) […] aims to correct both the channel and the floodplain water level". Are the static water level observations used to update only channel water levels of also the ones in the floodplains?

- I like the way the different experiments are structured and described. However, I think that a more critical analysis of the results is needed. I would like to see more discussion on results achieved with the assimilation of SI observations. The description of the results is there but what is lacking is the "why" you got these results. For example, assimilating SG observations we see that the ensemble with DA is similar to the one of OL in the downstream area of Figure 6 (see lines in lines 385-388). However, this is not the case when assimilating SI observations (figure 9). Figure 6 is barely discussed in the paper, so figure 9. Including the spatial values of P and K may help in understanding this behavior and better describe the results.

- Could you elaborate more on the impact of the low retrieval frequency of SI observations on the DA performances?

- Is your DA approach efficient when dealing with high-dimensionality issues of the covariance matrix P?

- What is the computational time required to run the DA approach in the selected case study?

- What is the difference between SH and SG? Try to avoid unnecessary acronyms if not used.

- Why do you get such an abrupt change in Figure 13?

- Where is the text of sections 2.2.1 and 2.2.5?

- Why are the results of OL in tables 1, 2, and 3 different? I would expect the same values if the sensor location and flood events are the same.

- Line 388: "The adopted updating procedure allows to increase the flood extent of 4 km2 a the time of the SI acquisition". Is this increment leading to better prediction or more false alarms?