Hydrol. Earth Syst. Sci. Discuss., 12, C3603–C3605, 2015
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Hydrology and Earth System Sciences
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Discussions



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

**Anonymous Referee #2**

Received and published: 10 September 2015

The manuscript summarizes a study aimed at assessing the performance of data assimilation while considering observation bias. System response variables (stream discharge, stream level, groundwater head), system parameters (hydraulic conductivity, stream loss coefficient), and observation biases (for groundwater head) are jointly updated using measurements of stream discharge and groundwater head. A synthetic case is presented, followed by scenarios with data from the actual watershed. Overall, the manuscript is well written and well organized, with a clear explanation of data assimilation methodology. It seems that most of the information regarding model set-up and data assimilation are contained in a companion article, which is a little concerning (e.g. the text repeatedly informs the reader that much of the information is contained in the article). Other issues are summarized as follows: 1. Page 8131, Lines 12-20.



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There have been other data assimilation studies that have focused on updating system state variables and system parameters in an integrated hydrological (groundwater-surface water) framework. These probably should be mentioned. They include:

Kurtz, W., H.-J. Hendricks Franssen, P. Brunner, and H. Vereecken (2013), Is High-Resolution Inverse Characterization of Heterogeneous River Bed Hydraulic Conductivities Needed and Possible? Hydrol. Earth Syst. Sci. 17 (10): 3795–3813. doi:10.5194/hess-17-3795-2013.

Bailey, R.T., and Baù, D. (2012), Estimating geostatistical parameters and spatially-variable hydraulic conductivity within a catchment system using an ensemble smoother. Hydrology and Earth System Sciences, 16, 287-304.

2. Section 2.2.2 – what is the discretization of the stream network? Is it the same that is used for the aquifer? Are the groundwater and surface water processes coupled, or just linked? (linked = no iteration during the time step, just passing values between the stream model and the aquifer flow model)?

3. Section 2.2.3 – spatial variability of streambed parameters (i.e. "leakage coefficient controls") has been a focus of research during the past few years, particularly in integrated hydrological modeling. How does using spatially-uniform stream model parameters influence the model results? Could this have an impact on the data assimilation results, particularly since some of the observation wells are close to the stream network and hence could be influenced by spatially-variable groundwater-surface water interactions?

4. Page 8142, Line 18. Why choose a standard deviation of 0.6 m? Is this based on field data? Were other values tested?

5. Page 8145, Lines 20-21. I am confused by this. Isn't the point of the DA methodology to estimate the parameters? (i.e. "calibrate" the model?) So then why is the model calibrated using AutoCal? I am not sure how this fits into the general aims of the study.



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6. Section 2.4.2 – Is Hydraulic conductivity spatially-uniform throughout the catchment? Is this realistic? It seems that K should be specified as spatially-variable (according to geostatistics), and the K field should be updated using the system-response measurements.

7. Section 2.3.7 - Please provide more information regarding the “Asynchronous assimilation”. Are the daily discharge measurements averaged over the 28 days, and then the average discharge is assimilated at the update time?

8. Page 8140, Line 21. Change “hereby” to “thereby”

9. Section 3.4. A 1-year warm-up period does not seem long enough to provide a significant spread in the ensemble, given the slow travel time of groundwater. Could you please quantify the spread of the ensemble at the end of 1969, to demonstrate that enough spread occurred?

10. In the Results section, please provide a 1:1 plot (simulated vs. observed) of groundwater head for some of the scenarios. Perhaps show a “before” and “after” plot (without and with data assimilation) to demonstrate the improvement of the hydrologic system when DA is used. Also, a plot to compare the results of the different scenarios, with the ensemble mean used for the simulated results.

11. Section 5: please provide conclusions, rather than just a summary of the study and discussion of results. What are the implications of the results? How can results be used in future studies, particularly in applications to real-world watershed systems?

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