

# ***Interactive comment on “Data assimilation with multiple types of observation boreholes via ensemble Kalman filter embedded within stochastic moment equations” by Chuan-An Xia et al.***

## **Anonymous Referee #3**

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General comments: The authors evaluate the accuracy of hydraulic conductivity (K) and head (h) estimates in a three dimensional, randomly heterogenous K field, when considering point (from multi-node monitoring wells) and depth averaged (from partially and fully screened monitoring wells) h measurements. The estimation of the K field is conducted via stochastic moment equations coupled with ensemble Kalman filter (ME-EnKF).

The authors first establish that, to solve this three-dimensional problem, the ME-EnKF approach is as accurate and computationally more efficient than EnKF relying on

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10,000 Monte Carlo realizations/simulations. This result supports and extends previous findings from two-dimensional cases.

Then they use the ME-EnKF approach to investigate the importance of including point measurements in the assimilation process, leading to more accurate estimates of  $K$  and  $h$  fields, as opposed to employing depth averaged measurements. They also show that the accuracy of the results of the latter approach can be improved by using an inflation factor imposed to the observation error covariance matrix.

The manuscript is well written, logically structured and the conclusions are soundly supported by the results.

Specific comments: Second order approximations to moment equations are formally limited to  $\sigma^2_Y < 1$  or to well-conditioned, highly heterogeneous media. Can the authors comment on their decision to place the observation wells at  $x$ - $y$  distances close or equal to the value of the integral scale of  $Y$ ?

Results for test cases in group 3 ( $\sigma^2_Y$  equal 0.2 and 1.7) are presented in Figure 8 but not discussed to the same level of detail than the rest of the cases. For example, it would be interesting to verify if the estimation errors in  $K$  and  $h$  increase with the variance of  $\ln K$  ( $\sigma^2_Y$ ).

Line 476, is “duration of the assimilation period” the appropriate term to refer to data collected at different depths (as in cases TC1\*1, TC1\*2, TC1\*3)?

References cited in the text need to be checked (for example, line 86, Winter et al. (2003) is missing from the list of references, line 167, “Konikow . . .”).

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