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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Multivariate hydrological data assimilation of soil moisture and groundwater head" *by* D. Zhang et al.

Anonymous Referee #1

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General evaluation:

This paper presents a novel contribution which is the joint assimilation of soil moisture and piezometric head data in integrated hydrological models. The paper investigates different scenarios for univariate and bivariate assimilation, and the role of ensemble size and localization. Especially the role of localization is important and the paper reaches the conclusion that a combination of distance localization and variable localization gives the best results. This is an important conclusion in the context of data assimilation for integrated models. It can be questioned whether for a larger ensemble size the importance of localization would be reduced and variable localization would not be needed. It is however also clear that for many applications a large ensemble size cannot be afforded.

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Discussion paper

I recommend minor revision for the paper.

Detailed points:

P2, L17-L29: Kurtz et al. (2014), WRR assimilated piezometric heads and groundwater temperatures.

P4, L22-L23: How is the irrigation handled then?

P6, L5-L9: Is this a realistic perturbation of the forcings? Spatial correlation is excluded and therefore the perturbations have less influence than in case larger grouped areas would get either a positive or negative perturbation of the precipitation.

P11, L1: If this would be the case, it would be better not to use localization at all. Was the optimal localization length used, and how was it determined? Was the correlation length of hydraulic conductivity taken into account?

P11, L24-L27: Can this be related to Non-Gaussian distributions as soil moisture is Non-Gaussian distributed? At this point, it would be good to know whether soil moisture or pressure is updated in the data assimilation. MIKE-SHE calculates internally with pressure, so probably pressure was updated in/after the data assimilation procedure. This implies that soil moisture data have to be transformed to pressure for which soil hydraulic properties are needed. In addition, pressure shows in general strongly non-Gaussian distributions, especially under drought conditions. If instead the data assimilation is done in terms of soil moisture, and soil moisture is updated, I wonder how piezometric head is assimilated. For those cases, and the grid cells affected (the grid cell with the groundwater level and the grid cells below the groundwater level), soil moisture could be set equal to porosity. Was this done? It would be good to have some more detail here as this also affects non-linearity/non-Gaussianity in the DA and therefore affects the results.

Section 4.3: Further increase of ensemble size could improve results further. In my opinion, the ensemble size is an unresolved issue.

P13, L14-L15: Is pressure perturbations also transferred to the surface water domain? This could generate the observed stronger perturbations in one of the simulation experiments in the discharge.

P17, L7-L8: Would a coarser model but a much larger ensemble size not be better? The number of grid cells could for example be reduced by a factor of 4 (half of current resolution) and increase the number of ensemble members by a factor of 4.

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