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Re: hess-2020-252 (Editor: Harrie-Jan Hendricks Franssen) - Editor Decision

Dear Prof. Hendricks-Franssen,

Please find attached the manuscript **"Unsaturated zone model complexity for the assimilation of evapotranspiration rates in groundwater modeling**", which includes the minor revision requested by one Referee**.** We appreciate the valuable comments made by the referee and have applied these in the revised manuscript. The annotated manuscript is attached to this letter. We have also attached the three comments made by the referee and our answers to these.

If any questions regarding this manuscript or our responses should arise, please feel free to contact me at any of the above coordinates. We wish to thank the referee and the editorial team for the efforts made to improve our manuscript.

Yours sincerely,

Dr. Simone Gelsinari

Response to Anonymous Referee #3

1. Could you please explain the reasoning behind using a global optimization scheme before data assimilation, rather than updating the parameters during data assimilation?

During the previous review step, we answered a similar comment acknowledging that in some groundwater studies, model parameters are updated along with the state variables. We argued that in system theory, from our point of view, a parameter is defined as a system property that remains unchanged. For this reason, and also for the dimensionality of the state vector, we did not update the parameters.

As a consequence of this, there is a need to apply a calibration algorithm to the model before the data assimilation procedure. The assimilation of observations in an uncalibrated system (for example one that does not represent the dynamic between ET and GW levels) does not guarantee an improvement of the modelled states. This concept becomes even more relevant when the quantity assimilated is not a model state itself (i.e. ET fluxes).

An effect of performing this study with an uncalibrated model could be that updating the states to improve the modeled evapotranspiration rates could lead to degraded water table and soil moisture simulations, instead of an improvement.

2. Initial conditions uncertainty will vanish if you undergo a spinup phase before doing DA, which should actually be done.

We agree with this comment. For our experiment, a simulation spin-up period is performed before starting the data assimilation phase. This was particularly effective to determine the initial values of soil moisture and soil water potential. However, in line 293-294 we refer to the perturbation of the initial condition of WT level, which helps to induce a good spread of the ensemble. In other words, every ensemble member starts from a slightly different WT level. This produces a wider and more representative ensemble spread in fewer time steps compared to the case where WT level initial conditions are not perturbed.

3. The Referee asks why we perturbed the first time-steps if we do not include them in the calculation of the ensemble skills and ensemble spread. Then why were they perturbed?

We thank the Referee for noticing this, which is closely related to the previous comment. By perturbing the WT level initial conditions, together with parameters and forcing inputs, a more representative ensemble spread is reached in a few (roughly 10) time steps. These initial time steps still need to be perturbed. They can be seen as part of the (ensemble) warm-up phase. For this last reason, as explained in the manuscript, we did not consider them for the calculation of the ensemble statistics.