Review of the paper « Kalman filters for assimilating near-surface observations in the Richards equation – Part 3 : Retrieving states and parameters from laboratory evaporation experiments » by H. Medina, N. Romano and G.B. Chirico

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This paper presents results from data assimilation experiments at local scale using a dual Kalman filter procedure for the retrieval of soil hydraulic parameters and of soil moisture profiles. The originality of the paper lies in the retrieval of soil hydraulic properties and on the use of in-situ laboratory measurements for the validation. Indeed, many studies have been performed in the past regarding the assimilation of superficial soil moisture for retrieving soil moisture profiles (preparation of satellite missions on soil moisture such as SMOS or SMAP). The results are convincing since they compare well with in-situ measurements and with estimates from a previous study (Romano and Santini, 1999). Sound explanations are given when results depart from expected ones. The authors have used a rather new flavour of the Kalman filter : the Unscented Kalman Filter that allows to account for the non linearities of the hydraulic parameters without performing linearization. They also propose a technique in order to rescale the increments so that they can maintain the analysis states produced by the filter within physical bounds. **My conclusion is that the paper should be published in HESS once some minor corrections are taken into account**.

Comments :

1) I would like the authors to explain more clearly why the fact of considering a Crank-Nicolson numerical scheme makes the Richards equation more linear and therefore avoids the need for an Extended Kalman Filter. An explanation has probably been given in the previous parts of this paper but it would be useful to have it here as well.

2) I found that too many results are presented, in particular the fact of having chosen a set of 6 initial parameters (S1 to S6) makes Table 4 and Figures 2 to 12 (except Figure 11) difficult to read and does not bring a lot of additional information (slower convergence when initial parameters are farther from the optimal solution). I suggest to simply keep one set of initial parameters and maybe to have a paragraph discussing the sensitivity of the results to the choice of initial parameters.

3) Similarly, considering 3 observation depths is not very useful : indeed the 1 cm layer is shown to be less informative about the deeper layers than the 2 cm layer. Even though the 12 cm depth is providing some kind of upper bound for the behaviour of the assimilation, it is an unrealistic set-up in the context of remote sensing information. Results shown with OD=2cm are convincing enough.

4) Can the authors provide an explanation about the negative Kalman gain coefficient $K_{12,1}$? Is there a decoupling in terms of behaviour between the first layer and the soil column below ? At least such negative value explains why using an observations at OD=1cm is not so useful.

5) Would there be an interest for a combined assimilation for state and parameter retrievals, instead of the parallel assimilations proposed in the paper ?