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Interactive comment on "Assimilation of SMOS soil moisture into a distributed hydrological model and impacts on the water cycle variables over the Ouémé catchment in Benin" *by* D. J. Leroux et al.

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We would like first to thank Anonymous Reviewer #2 (AR#2) for her/his comments and remarks. Some changes have already been made according to comments from other reviewers. The focus of the study was not well defined and some of the reviewers already highlighted the lack of purpose. We have worked on that aspect and put this study in an operational context with possible real-time applications.

As AR#2 mentioned, the calibration of the model is realized using in situ precipitations, which is then used with satellite precipitations. This can be confusing because if the in situ precipitations are available, why would someone use the satellite products. In our case, (and it has not been clearly mentioned in the text), the in situ precipitations have

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been produced for this study using Lagrangian kriging at very high resolution (Vischel et al., 2011). This product is not an operational product and is generated on demand. The reprocessed satellite precipitation products (post-adjusted observations using in situ networks) are only available several weeks after the observations and cannot be used operationally. These post-adjusted satellite precipitation products are very close to the in situ measurements. Using either product would lead to the same calibration. Here, in an operational context, only real-time satellite precipitations are available and these products should not be used for calibration (as advised in Bitew et al., 2011) as they are not accurate enough: not enough or too much water, and often not at the right time of the year. What has been done here and what makes more sense to us, is to use the in situ precipitations generated for 2010 for calibration and use this calibration for the following years. This calibration is supposed to be good if the right amount of water is given in. Of course, this is not the case when the real-time satellite precipitations are used and by assimilating SMOS soil moisture products in the model, we hope to achieve that. By assimilating SMOS soil moisture products, we go back to the case where the appropriate amount of water is in the model, and the previous calibration, after assimilation, is then appropriate.

The main purpose of the study is to be able to run the model operationally in quasi real time (a few days delay) using real time precipitation forcing and soil moisture assimilation.

In order to illustrate that, simulations using post-adjusted satellite products have been added to the manuscript showing that they perform as good as the in situ precipitations. After assimilation, the performances are almost as good (similar using near real-time PERSIANN+SMOS, a bit lower for the other two).

Regarding the assimilation methodology, we agree that the one used here is a rather gross simplification of what should be ideally done. By choosing an optimal interpolation, implementation simplicity has been preferred as it was our first attempt of data assimilation using this model. Ensemble methods need computer resources and skills that were not available at the time of this study. With the experience of this first exercise, it would make no doubt that ensemble or extended Kalman filtering methods would provide much more reliable results. However, the question of the optimal perturbation to be applied for the ensemble generation or for the Jacobian matrix is still an open question to the data assimilation community, and is for now up to the user.

As a first attempt of R and B estimations, the variances and the covariance of the variables have been used. We totally agree with AR#2, this is not the correct way to compute the errors. However, we were more looking at the ratio between the model and the observations and were looking for "fair" trade between these two quantities, i.e. K around 0.5 for the assimilation layer giving as much weight to the model and to the observations. This is the case here, for the 2nd soil layer, where B is 0.019 m3/m3 and R is 0.017 m3/m3. We are aware this is a huge simplification, and so is the assumption that R is diagonal. With a large satellite footprint, this is not true to assume that there is no covariance between the observations. In general we agree that big improvements can be realized by using more sophisticated methods in the assimilation process. Here, we just implemented everything from scratch and wanted to see the impact of a surface variable (soil moisture) on a more integrated variable (such as the streamflow at the outlet). In future developments, ensemble Kalman filter will be used to avoid this kind of assumptions.

Regarding the CDF matching, it has been done using open-loop simulations and not the in situ soil moisture measurements. The reason why SMOS appears closer to in situ on Figure 6 is only a coincidence in this case. CDF matching is actually performed at SMOS scale, i.e. at 25 km, which requires to upscale the model simulation from its finer resolution (1 km) to SMOS resolution. In order to achieve the upscale, a simple average of the model pixels contained in the SMOS pixel is performed. However, the adjustment of the soil moisture is realized at the model scale. So, for each model pixel, all the SMOS observations contained in a so called 'influence radius' (set here at 40 km, corresponding to the SMOS instrument resolution) and weighted according to their distance to the considered model pixel. On Figure 6, the SMOS yellow squares represent the closest SMOS observations but not the assimilated soil moisture. This methodology is the same as the one defined in deLannoy et al., 2010 (called "3DCm").

****** * Bitew M.M., and Gebremichael M.. Assessment of satellite rainfall products for streamflow simulation in medium watersheds of the Ethiopian highlands. Hydrology and Earth Science Systems, vol. 15, pp. 1147-1155, 2011. * De Lannoy G., Reichle, R., Houser, P., Arsenault, K., Verhoest, N., and Pauwels, V.. Satellite-scale snow water equivalent assimilation into a high-resolution land surface model, Journal of Hydrometeorology, vol. 11, pp. 352–369, 2010. * Vischel T., Quantin G., Lebel T., Viarre J., Gosset M., Cazenave F., and Panthou G.. Generation of high-resolution rain fields in West Africa: evaluation of dynamic interpolation methods. Journal of Hydrometeorology, vol. 12, pp. 1465-1482, 2011. (this last reference will be added to the manuscript bibliography) ******

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