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Interactive Comment

# Interactive comment on "Monitoring of water and carbon fluxes using a land data assimilation system: a case study for southwestern France" by C. Albergel et al.

#### C. Albergel et al.

CALVET@METEO.FR

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The authors thank Alexander Loew for his review of the manuscript and for the fruitful comments. For an easier comprehension, general comments of the referee are also reported (1.XX).

1.1 [section 2.3,3.3: the authors use the dimensionless SWI as an additional proxy for root zone soil moisture. They argue that the simple exponential filter approach might be used as an alternative to an LDAS where the needed meteorological forcing is missing and where applications mainly focus on soil moisture dynamics. However, I doubt if these conclusions can be easily drawn from the analysis presented in the





paper. A critical aspect of the exponential filter is the choice of the characteristic time scale parameter T. The authors used a value of T = 11 days from a previous study. This value was obtained by minimizing the differences between the filter results and measured profile soil moisture for the same site (SMOSREX) as used for the present study. Thus it is best calibrated for the conditions of that particular site. Other authors suggest different characteristic lengths (e.g. 20 days Wagner et al., 1999). As the T parameter was already calibrated to the local conditions, it is clear that it provides good results for the soil moisture profile in the present study. However, one can not argue that one will obtain similar predictive skills in other (even close nearby) sites. The authors therefore need to further elaborate if the approach is really transferable and could really be used as an alternative to LDAS for certain (limited) kind of applications].

Response 1.1 - Using a pre-calibrated T value from Albergel et al. (2008) could impact the result. However, Albergel et al. (2008) showed that to some extent, the exponential filter method is not much sensitive to the T value. While an inter-annual variability of the yearly optimum T estimates was found for the SMOSREX in situ observations of soil moisture during the 2001-2007 period, the use of a unique value corresponding to the optimum value for the whole period did not significantly impact the Nash score. It must be noted that T=11d was found to optimize the retrieval of the SMOSREX integrated soil moisture observations (SWI) down to 0.95m, based on surface (0-6cm) soil moisture observations. Because a thinner upper layer (0.5-2 cm) of the soil is observed at C-band, T values higher than 11d are expected in the context of, e.g., ASCAT data, consistent with Wagner et al. (1999). We would also like to emphasize that the simple exponential filter produces a proxy of the root-zone soil moisture, but has not the LDAS capacity of monitoring the surface fluxes and the vegetation biomass. The two techniques may be complementary as both surface soil moisture (SSM) and SWI will be soon operationally available. The assimilation of SWI by the LDAS, instead of SSM, is being investigated by the authors. Additionally, the SWI calculated with a calibrated T-value at SMOSREX is compared to the best case no-precipitation LDAS, which can also be seen as a calibrated experiment (observed atmospheric forcing and

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site-specific parameters, specific background errors).

1.2 [section 2.5.: the authors set the errors for the model and observations based on a priori assumptions of the error statistics which are mainly based on findings from previous studies. An appropriate selection of the error (co)variances is crucial for the performance of the Kalman filter. The Kalman filter allows to analyze if these assumptions are in general valid by analyzing the filter innovation statistics. The innovations of the filter should be serially uncorrelated with zero mean if the assumptions for B and R are correct. The authors are asked to provide additional information about the innovation statistics and discuss if the assumed errors are correct.]

Response 1.2 - Indeed, an appropriate selection of the error (co)variances is crucial to achieve a good performance of the Kalman filter. In this study, they were set using information from previous studies. The pdf of the innovations is Gaussian, with a variance of about 0.0066 (m3m-3)\*\*2 and a mean of 0.04 m3m-3. Moreover, the value of 0.0036 (m3m-3)\*\*2 used for R (observational errors) is similar to the estimated errors, 0.06 m3m-3, found for ASCAT remotely sensed estimates (Albergel et al., 2009).

1.3 [section 3.1: CDF matching: The authors apply a CDF matching prior to the assimilation of the surface soil moisture observations. The application of CDF matching is an important step to ensure that the general assumptions of the Kalman filter (unbiased zero mean differences) are matched. However, from an application point of view, one might want to calibrate the CDF polynomial using data which is independent from the observations assimilated into a model. Typically a monitoring of the relationships between the observations and model predictions will be used for that purpose for a training period. The estimated polynomial might then be applied for the data assimilation. We wonder, if the authors did apply such an independent CDF calibration. If not, what would be the impact if the CDF function would be estimated from a subset of the available data. We expect that additional bias might be introduced in the analysis if the CDF calibration is based on a subset that does not represent the full variability of the data. Could the authors comment on this issue and it's impact to their results?.] HESSD

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Response 1.3 - Yes, the implementation of the CDF matching technique is a critical issue. The use of a training period to calibrate the CDF polynomial was tested (using the first year, 2001, only). However, 2001 was not representative of the longer time series (2001-2007) and the resulting CDF matching failed to remove the systematic differences between observations and simulations. Most of previous studies using this technique have applied it in a similar way. In satellite applications, data may be scarce for the first months/years and it may be impossible to use independent data.

1.4 [section 3.3/Table 4: While the analysis of the different assimilation experiments results in absolute error estimates [m3 /m3 ], the error of the exponential filter (SWI) results are given as relative values. This is a bit confusing and makes it different to compare the different results. We therefore recommend to convert the relative error in absolute errors of the model by rescaling the errors using the wilting point and field capacity of the model respectively. It is suggested to provide these rescaled errors in addition to the relative errors for the SWI.]

Response 1.4 - When these errors are rescaled using the wilting point and field capacity values used in the model, the following scores are obtained, bias = -0.001 m3m-3 and RMSE = 0.015 m3m-3. This will be added in Table 4 for a better understanding, as advised by reviewer #1.

1.5 [section 3.4.2: The section on the assimilation of TB derived soil moisture is rather short. The main rationale of the paper is the investigation of the general sensitivities and potentials in assimilating multivariate observations (sm and lai) to improve the predictive skills of the model. However using real brightness temperature data is very important for the practical application of the methodology. We suggest to investigate a few more aspects in the TB assimilation scheme: a) the optical depth is a very critical parameter in the inversion of SM from brightness temperatures. Typically, the optical depth is parameterized using information on the vegetation water content or multiangular measurements (which are available in the case of the LEWIS radiometer). The optical depth is correlated with LAI. It is recommended that authors comment if and

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how they did include the relation between LAI and optical depth in their analysis, which leads to a more consistent assimilation setup. Further, it has been shown in recent studies, also taking the SMOSREX data set, that a litter layer can have considerable impact on the microwave emission and might deteriorate the soil moisture retrievals (e.g. recent papers from Saleh et al). Have authors taken into account litter the effect? How will this change the results of the TB assimilation, if this is done?]

Response 1.5 - Yes. In section 3.4.2, it was not explained clearly enough that we did not assimilate brightness temperatures but, instead, SSM estimates derived from the brightness temperatures thanks to an inversion algorithm.

1.6 [eq. 1,3: what does the superscript '0' mean (e.g. x0). We guess it's the beginning of the assimilation window, but this should be clarified. The difference between xt and x0 is therefore not clear. Please clarify.]

Response 1.6 - The t and 0 superscripts stand for time (t) and for the initial time (t=0). This will be added in the text.

1.7 [p. 1712, l. 8: how large is N ?]

Response 1.7 - Here, "Nx" refers to the size of the control variable, the number of prognostic variables of the land surface scheme (two, w2 and LAI). This sentence could be reworded as: 'the elements of the Jacobian matrix are estimated by finite differences, by individually perturbing each component xj of the control vector x by a small amount  $\delta xj$ '

1.8 [p.1714, l.27: a rooting depth of 95 cm seems to be rather high for grassland. Can authors provide a reference for that value?]

Response 1.8 - The root biomass was not measured at SMOSREX. Over the grassland of the MUREX site, located in the same region as SMOSREX, most roots were found in the 0.25 m surface soil layer and few roots were observed in deeper layers, down to 0.70m (Calvet et al. 1999). It must be noted that, in this study, a simple force-

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restore version of the model hydrology is used. In fact, w2 represents the volumetric soil moisture of a single soil layer (0-0.95m) including the root-zone and deeper layers contributing to the evapotranspiration flux through capillarity rises. As at SMOSREX, soil moisture is observed from the surface (0-6 cm) and each 0.1m until almost one meter, using a d2 value of 0.95m in the ISBA-A-gs model permits to compare the modeled w2 with the observed w2 values.

Calvet, J.-C., Bessemoulin, P., Noilhan, J., and 19 coauthors: MUREX: a land-surface field experiment to study the annual cycle of the energy and water budgets, Ann. Geophys., 17, 838-854, 1999.

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