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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Integrating ASCAT surface soil moisture and GEOV1 leaf area index into the SURFEX modelling platform: a land data assimilation application over France" *by* A. L. Barbu et al.

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The authors thank the anonymous referee #2 for his/her comments that will help to improve the quality of the manuscript.

Minor comment #1

Why not mentioning at all the Ensemble DA techniques and Ensemble applications of the current study? There is large evidence in literature and also in operational applica-

tions that the Numerical Weather Prediction, dealing with chaotic complex systems, is best addressed by systems that generates an ensemble of states, therefore enabling to account for uncertainties in the modelling (ancillary, parameters and parametrisations) and observations (systematic and random errors) in the predictions. I believe that adding a few sentences and relevant publications with comments on the possible extension of the present study to EnKF or Particle Filters might be beneficial.

RESPONSE 1:

The characterisation of errors associated with model dynamics and parameters is a rather challenging area for land data assimilation as mentioned by Reichle (2008). Even though model errors and parameter adjustment can be described by an EKF (Carrassi et al., 2012), ensemble approaches (EnKF), that are becoming extensively used in Numerical Weather Prediction, offer a more flexible framework for addressing these questions in the case of a LSM as shown by Reichle et al. (2002). The EnKF approach should be examined in the future for land data assimilation together with the Particle Filtering technique. The latter is well suited for non-linear problems of small dimension (van Leeuwen, 2009).

Additional references:

Carrassi, A., R. Hamdi, P. Termonia, and S. Vannitsem, 2012: Short term augmented extended Kalman filter for soil analysis : a feasibility study. Atmos. Sci. Lett. , 13, 268-274.

Reichle, Rolf H., Jeffrey P. Walker, Randal D. Koster, Paul R. Houser, 2002: Extended versus Ensemble Kalman Filtering for Land Data Assimilation, J. Hydrometeor, 3, 728–740.

Reichle, R. H.: Data assimilation methods in the Earth sciences,2008: Adv. Water Resour., 31, 11, 1411-1418, doi:10.1016/j.advwatres.2008.01001.

van Leeuwen, P. J., 2009: Particle filtering in geophysical systems. Mon. Wea. Rev.,

137, 4089-4114.

Minor comment #2

The patch-aggregation observation operator is a necessity for the application of a simplified EKF to complex multi-patch LSMs such as in SURFEX platform. However the multi-patch aggregated grid-boxes could contemplate cases where inner grid inconsistencies are present (e.g. a field being harvested while another kept growing, or similarly for soil moisture, a field being irrigated next to a field that kept drying out), this information cannot be disentangled from the grid-wise satellite data but an estimation of such an effect can be obtained in a simulated experiment. Has this being tried? Obviously inner-grid inconsistency are very likely attributed to human intervention. How big a limitation of the validity of this method can come from such cases? Is it worth mentioning this as a limitation of current observational and/or products resolution? I would invite the authors to consider those questions.

RESPONSE 2:

The question of taking into account the grid heterogeneity is central to this work and has been the main justification for including vegetation patches in the model and in the assimilation scheme. In the absence of a priori knowledge about anthropogenic interventions at the landscape scale, the assimilation approach employed in our study uses the hypothesis that the distribution of innovations is proportional to the cover area. Additional sub-grid information coming from other sources could be included in our assimilation system. This could be done more easily in a multi-patch model than in an average-grid model. The impact of inner grid inconsistencies on the assimilation scheme was not tested. As mentioned by the referee, this could be possible by considering observing system simulation experiments. This would have required further studies that are beyond the scope of the present paper.

Differences in amplitude or phase of seasonal vegetation cycle when comparing model simulations with observations could be to some extent attributed to the missing anthro-

pogenic processes. The assimilation may partly compensate for a missing anthropogenic component in the model, especially in the case of homogeneous pixels. In the case of highly heterogeneous pixels, this compensation may be not adequately distributed among patches, especially in grid boxes covering complex crop rotation systems. One has to be aware that the “patch” concept implies already the definition of a mean land use type. The patch is not representative of the land use complexity at the landscape scale. The LAI observations used in this study have an original resolution of 1 km and have been aggregated to the grid cell resolution (8 km). This means that up to 64 pixels have been used to compute the LAI observation for each model grid cell. Assimilating higher resolution LAI data (at 1 km) may help decreasing the occurrence of inconsistencies. However, at this resolution, there is still a high degree of landscape heterogeneity over France.

Nevertheless, the patch fraction, the Jacobian behaviour and the prescribed uncertainties in the model and in the observations, offer the possibility to adapt the analysis to each plant functional type. In future developments, the LSM multi-patch structure may be used to account for additional information about the land use and management practices. For example, when an important reduction in LAI is observed over a short period of time in relation to a harvest, a specific distribution of the analysis increments could represent this additional information. The multi-patch assimilation may be viewed as an opportunity to include valuable additional information for improving the analysis among patches. This will have to be addressed in future studies.

Minor comment #3

It is a pity that no river discharge data is being used to further validate and to convince the reader that the LDAS is indeed improving the water partitioning between evapotranspiration, soil storage and soil drainage. It is true that the soil moisture in-situ validation provide such a supplement, but this lacks the regional-scale validity that considering French major rivers would have provided (after all the results are presented on the whole of France and SMOSMANIA represent only a transect in the southern part). I

hope this can be considered in future studies and if so be explicitly mentioned in the concluding sentences.

RESPONSE 3:

We agree with the referee's remark on the utility of using independent discharge data for validation. Draper et al. (2011a) already showed that the assimilation of the satellite-derived ASCAT soil moisture can improve runoff and river discharge simulations when assimilated in the operational hydro-meteorological model SIM (Habets et al., 2008). The coupling between the ISBA-A-gs LSM and a hydrological model was investigated (results not shown), but several preliminary results obtained were not conclusive, especially at wintertime. A dedicated study is needed to further analyse the seasonal impact of the assimilation, using a more refined description of the soil hydrology. Current developments concerning the soil hydrology, namely a vertical distribution of the root profile in the soil are expected to improve the excessive drainage rate of the force-restore approach (Decharme et al., 2011) used in this study. This will facilitate the coupling between the ISBA-A-gs LSM and river discharge models.

Minor comment #4

Figure 10-12 adopt shadows of greens and reds colours that made difficult to appreciate the quantitative aspects of the maps shown. When colours figures are adopted why not using a legend that would enable appreciating also the values, using different colours?

RESPONSE 4:

The proposed modifications regarding the quantitative aspects of the maps have been done and the new figures are included in the revised manuscript.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 9057, 2013.