

Interactive comment on “A dual-pass data assimilation scheme for estimating turbulent fluxes with FY3A data”

by T. R. Xu et al.

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Response to reviewer #1 comments on “A dual-pass data assimilation scheme for estimating turbulent fluxes with FY3A data”

Thanks for your comments and recommendations to help us improving our manuscript. Please find below our responses to your inquiries (in blue):

Major Comments:

Comment: As clearly stated by the authors in the Introduction section, a large number of studies employing different land surface models, satellite-derived land surface products and data assimilation techniques have been already published in the scientific literature. I am aware that the topic incorporates several issues and a lot of work has to be done to improve our knowledge of the mass and energy balance between the land and the atmosphere. However, the same authors published a similar paper on Journal of Geophysical Research (Xu et al., 2011b) by using the same land surface model (CoLM), a similar data assimilation algorithm but different remote sensing and ground experimental observations. I believe that the paper shows enough new material to be published on HESS but I also would like to understand clearly which is the added-value of this paper with respect to the papers already published (not only by the authors).

Specifically, the main novelty of this paper seems to be related to the specific data assimilation scheme that optimizes model vegetation parameters and soil moisture at different temporal scales according to their expected time variability. Theoretically, this scheme seems to improve the data assimilation performance but it should be confirmed through model simulations. I suggest to compare the joint data assimilation scheme as proposed in Xu et al. (2011a; 2011b) with the procedure developed in this paper to effectively understand the benefit (if present) of this new scheme for the prediction of turbulent fluxes and soil moisture. Moreover, the paper employs for the first time LSTs derived from the FY3A satellite. It would be also interesting to compare different LST products (e.g. by using MODIS) again in terms of CoLM performance.

Response: Thanks for your suggestion. This manuscript looks similar with Xu (2011b) “Estimating turbulent fluxes through assimilation of geostationary operational environmental satellites data using ensemble Kalman filter, Journal of Geophysical Research, 05/12/2011”. But they are different actually. The main novelty is the data assimilation technique. In Xu (2011b), the model states and parameters are simultaneously optimized by using GOES data. But in this manuscript, we optimize the model states and parameters separately using a dual-pass data assimilation technique at the different temporal scales. Since the model states and parameters vary at different temporal scales, it’s more reasonable to optimize the model states and parameters with two loops than optimize them simultaneously. That’s why we develop the dual-pass data assimilation technique in this study. Actually, both the data assimilation schemes, in Xu (2011b) and in this study, can improve significant turbulent flux simulations, and both of them are

excellent schemes. However, we can compare the results produced by them in this study. In this study, we assimilate FY3A LST data for the first time into a land surface model to improve model predictions. The revisit time (around 11:00 Am) and spatial resolution (1 KM) of FY3A is similar to MODIS. However, it's hard to match the pixel of FY3A with MODIS one by one, since there is a pixel drift phenomena for the two sensors. Therefore, it's difficult to compare and assess the performances by assimilating MODIS and FY3A LST data, separately.

Comment: In my opinion, the description of the dual-pass data assimilation scheme should be improved. Seeing the scheme in Figure 1 it seems that the optimization of vegetation parameters and soil moisture is done separately but at each time step for which satellite-LST data are available. However, the optimization of vegetation parameters should be done once per week; for that the scheme in Figure 1 is not clear to me. Moreover, I do not understand how the EnKF can be applied once per week by using the LST observations for the whole week (i.e., seven LSTs if daily data are available). Likely I'm wrong and only one LST per week is assimilated discarding the other observations that are only used to update the model states (i.e., soil moisture). Summarizing, by reading the text it is not clear (at least for me) and it should be revised.

Response: We agree with your comments. The dual-pass data assimilation scheme is developed to optimize vegetation parameters and soil moisture. The first pass will optimize vegetation parameter once per week, and the second pass will optimize soil moisture once the FY3A LST is available. In one week, all the LSTs will be used to optimize the vegetation parameters. We will revise the description of the dual-pass data assimilation scheme and will make the technique more clearly.

Comment: The improvement in the prediction of turbulent fluxes and soil moisture seems to be related to the significant model bias. In particular, land surface temperatures and sensible heat fluxes are overestimated and the latent heat fluxes are underestimated by the model (the same happens in Xu et al., 2011b). A bias in the forecast model (or assimilated observations) invalidates key assumptions of (bias blind) data assimilation, leading to sub-optimal filter performance (Dee, 2005). In general, it is better to address the cause of a model bias, rather than rely on an assimilation to correct it (Draper et al., 2011). Data assimilation techniques are designed to correct random errors in the model and rely on the assumption of unbiased background and observations (Barbu et al., 2012). Which is the bias between modelled and satellite-derived LST? If the bias (if present) is removed, which is the effect of the assimilation of LST on model predictions? I suggest addressing these aspects in the paper to correctly evaluate the performance of data assimilation.

Response: Thanks for your advice. The turbulent fluxes are affected by many factors such as model parameter, soil temperature, soil moisture, and uncertainties from all these factors will add errors to turbulent fluxes. Thus the model errors of turbulent fluxes and land surface temperature are very complicated. In this study, the ground-measured meteorology data are used for the forcing data, so we did not consider errors from forcing data. Then the model errors will be produced by the model states (soil moisture) and model parameters (vegetation parameters). The model errors are composed by biases and random errors, and we think the model biases mainly caused by model parameters and the random errors mainly caused by

model states (soil moisture). Thus, we develop the dual-pass data assimilation scheme to optimize vegetation parameters and soil moisture. The first pass is a procedure like to calibrate model parameters to reduce the model bias, and the second pass is a procedure to update soil moisture to reduce the model random errors. The calibrated model parameters are also applied in model simulations section 5.3. We will discuss these in the last section of our manuscript.

Comment: Finally, I was very interested to see the impact of data assimilation on the modeled soil moisture. In the paper, only one figure is dedicated to this aspect while in situ observations should be available for all the investigated sites. Why are the results for the other sites not shown? A significant bias was also observed in the simulation of soil moisture. Therefore, the same issue as before is valid also for soil moisture. Furthermore, some additional information on how soil moisture is simulated in the CoLM model would be beneficial to better understand the results. For instance, how many are the soil layers simulated by the model? Which depths? Which equations? ...

Response: Thank you for your suggestions. We will add the method used to simulate soil moisture of the CoLM, including the number of soil layers, the depth of each layer, the equations, and etc. The soil moisture simulation results of all the experiment sites will be shown in the revised manuscript.

Minor Comments:

Comments: P8511, L1-5: Why are the results only shown in term of RMSE? Please, add also in terms of correlation as it was done for the comparison with LAS measures sensible heat fluxes. The same also applies for soil moisture.

Response: Thanks, we will add correlation to assess the results.

Comments: P8512, L22: Why is the evaporation fraction computed from 10:00 to 15:00 and not for the whole day?

Response: Thanks, the evaporation fraction for the whole day will be calculated.

Comments: P8512, L4: Change "surfer" with "suffer".

Response: Thanks, we will change it.

Comments: P8516, L1-6: These conclusions are too general and should be revised to better delineate the specific issues to be solved in the context of assimilating satellite products in land surface models.

Response: Thanks, we will revise these conclusions.