Hydrol. Earth Syst. Sci. Discuss., 10, C1884–C1889, 2013
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Hydrology and Earth System Sciences
Discussions
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Interactive comment on "A dual-pass data assimilation scheme for estimating surface energy fluxes with FY3A-VIRR land surface temperature" *by* T. R. Xu et al.

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Received and published: 22 May 2013

Dear Editor and anonymous Referee #1,

We thank the anonymous reviewer and editor very much for your valuable comments on our paper. Our responses to referee #1 are as follows:

General Comments: The paper by Xu et al. proposes a new data assimilation approach applied to the CoLM land surface model. Remotely sensed Land Surface Temperature (LST) data from the Chinese meteorology satellite FY3A-VIRR are assimilated into the model. The modeled energy fluxes (and soil moisture) without and with the assimilation are compared and analysed. I believe the paper is well-written, well structure and clear. Moreover, the topic of the paper is of interest for the HESS readership as the improvement of modelling predictions through the assimilation of satellite data represents an important issue for scientific and operational applications. However, this is not the first time I am reviewing the paper and I am disappointed that the authors did not address the main issue that was revealed, at least in my opinion, in the paper. In fact, it is clear from reading the paper that the assimilation provides a significant improvement in the estimation of surface energy fluxes and this is good. Unfortunately, it is not clear why these results were obtained. Specifically, the added value of the assimilation of satellite derived LST data seems to be only related to a BIAS between modelled data and observations that is corrected through the assimilation (see page 3959, line 7: "The errors in surface energy in flux predictions are mainly model biases (Figs. 3 and 4) and the dual-pass data assimilation can cut down model biases significantly (Table 4)"). As I already wrote in the previous review, a bias in the forecast model (or assimilated observations) invalidates key assumptions of (bias blind) data assimilation, leading to sub-optimal performance (Dee, 2005). 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). Looking at Figure 3, it is clear that the model significantly overestimates observed LST and that satellite data are closer to the observations with respect to the model (if daily values were shown this overestimation would be clearer). Therefore, it is highly expected that any assimilation technique will provide an improvement in the modeled energy fluxes. Therefore, if the paper wants to propose a new data assimilation approach for improving predictions, I am not sure that improvements are related to the proposed technique. Moreover, it would be interesting to know why the BIAS exists. Is it due to the model parameterization? To the model structure? To input data? This issue should be addressed. In summary, I believe that if the BIAS between modelled and observed LST data was removed, the improvements related to the assimilation will be much smaller. In my opinion, if the authors do not address this issue, the paper does not deserve to be published (as I already suggested).

Response: Thanks for your advice, and your comments are very important to improve our manuscript.

The surface energy fluxes (sensible and latent heat fluxes) are diagnostic variables, and they are affected by vegetation parameters, model states such as soil temperature, soil moisture, and so on. Uncertainties from these factors will add errors or biases to surface energy fluxes.

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 or biases will be produced by the model states (soil moisture) and model parameters (vegetation parameters). As we all know, soil moisture and vegetation can influence the surface energy more than one day. When soil moisture increased, the latent heat flux will increase and the sensible heat flux will decrease with a diurnal changes at least. Thus, the dual-pass data assimilation scheme was developed to optimize vegetation parameters and soil moisture. Pass 1 is used to optimize the vegetation parameters at the weekly temporal scales, and the pass 2 is a procedure to update soil moisture at the daily temporal scale. As from Fig. 10, the dual-pass data assimilation scheme can cut down the model biases significantly.

From Fig. 10, the model biases are mainly from vegetation parameters and soil moisture. The uncertainties from the vegetation parameters can cause biases in surface energy flux predictions. That why pass 1 was built to optimize vegetation parameters. The inaccurate simulation of soil moisture is another reason for the surface energy flux biases. There are some reasons for the inaccurate simulation of soil moisture at the four experiment sites in this study. The uncertainty of soil texture (percentage of sand and clay) is one reason. As the soil texture is source from the dataset of CoLM, the uncertainty is inevitable. We will recalculate the results with the soil texture in-situ measurements which can decrease the biases at the four sites.

There are some specific reasons for underestimation of soil moisture at Arou and

Guantao site. At Arou site, the cold condition leads to slow decomposition of soil organic carbon, and therefore makes it easy to accumulate dense roots and high soil organic carbon contents in the top soils layer (Chen et al., 2012). The high soil organic carbon contents can cause high soil porosity at about 0.67 at Arou site. However, the soil porosity in CoLM can be calculated using $\Theta sat=0.489-0.00126\times(\%sand)$ with maximum value of 0.489 which is much lower than 0.67. Thus, this parameterization scheme is not appropriate in this site. On one hand, we will use 0.67 as the soil porosity to recalculate the results of Arou site. On the other hand, the new parameterization scheme should be developed for soil porosity with high soil organic carbon contents.

At Guantao site, the irrigation occurred in May and June. The no input of the irrigation caused the big biases in model simulations in May and June (Fig.10). Thus, we will input irrigation data to cut down the model biases at this site.

Thus, model biases of the four sites are complicated and are caused by the uncertainty of parameters (vegetation parameters and soil parameters from the model data set), caused by the inappropriate parameterization of soil porosity with high soil organic carbon contents (Arou site), and also caused by uncertainty of input data (no irrigation input at Guantao site in May and June). 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). Bias in the land surface model or observations will lead to sub-optimal performance (Dee, 2005). Thus, bias correction is necessary for better model performances (Draper et al., 2011). It is necessary to know why the model biases exists, and the study on model biases should be enhanced.

Barbu, A. L., Calvet, J.-C., Mahfouf, J.-F., Albergel, C., and Lafont, S.: Assimilation of Soil Wetness Index and Leaf Area Index into the ISBA-A-gs land surface model: grassland case study, Biogeosciences, 8, 1971-1986, 2011. Dee, D.: Bias and data assimilation, Q. J. Roy. Meteorol. Soc., 131, 3323–3343, 2005. Draper, C., Mahfouf, J. F., Calvet, J. C., Martin, E., and Wagner, W.: Assimilation of ASCAT near-surface soil moisture into the SIM hydrological model over France, Hydrol. Earth Syst. Sci.,

15, 3829-3841, 2011. Chen, Y. Y., K. Yang, W. J. Tang, J. Qin and L. Zhao, 2012: Parameterizing soil organic carbon's impacts on soil porosity and thermal parameters for Eastern Tibet grasslands, Sci China Earth Sci, 2012, 55: 1001–1011, doi: 10.1007/s11430-012-4433-0

Specific Comments At page 3950, lines 14-20 the dual pass contributions for reducing the model BIAS are analysed. It is underlined that Pass 2 performs better than Pass 1. I believe that it can be due to the higher temporal density of the Pass 2 assimilation (daily) with respect to the Pass 1 (weekly). Can the authors elaborate better on this aspect?

Response: Thanks for your suggestion. We have done the experiment of Pass 1 with daily and weekly temporal scale. The results are shown in Figure 1. From this figure, the effects of pass 1 are very similar with weekly and daily temporal scales.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 3927, 2013.

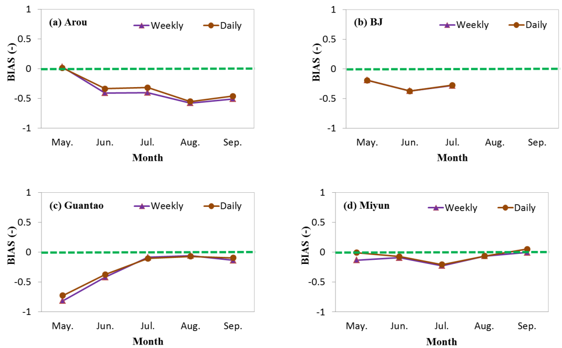

Fig. 1.

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