

Interactive comment on “Spatial horizontal correlation characteristics in the land data assimilation of soil moisture and surface temperature” by X. Han et al.

X. Han et al.

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Response to reviewer #2 comments on “Spatial Horizontal Correlation Characteristics in the Land Data Assimilation of Soil Moisture and Surface Temperature”

Thanks for your comments and recommendations to help us re-designing the data assimilation experiment. Please find below our responses to your inquiries ([in blue](#)):

Major Comments:

Comment: The experiment setup is extremely selective in that the assimilation is done

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only for a single day, at a single time instance. Though the results indicate that there is value from incorporating spatial correlation information, it is not clear how these improvements translate (and grow) with time. In order for this study to be relevant, the period of assimilation should be extended to include several days (I would consider at least several months during a summer season), so that the dynamic variabilities in soil moisture (and temperature) are incorporated in the assimilation setup. Are the improvements more significant during dry/wet/drydown periods?

Response: Thanks for your suggestion. We agree that this experiment setup at a single time instance is not enough to show the value of this approach. So we have extended the experiment to three months (with an hourly time resolution) and the observations are assimilated once every day. We will update the results in the revision. The soil moisture of this study area during the summer season will be in the range of 0.3–0.5, and conditions will therefore never be very dry. The results of this study will therefore only show the wet period.

Comment: It is not clear why a single day in september is used. Isn't it better to choose a day in summer where any potential effects of winter season can be ruled out? This domain seems to be at a high latitude and the temperature fields indicate that the ground is frozen at several locations of the domain. In this case, how was soil moisture (and temperature) fields updated? From my understanding, the state variables in CLM account for both liquid and frozen part of the soil moisture storages. Which of them were updated? The article provides no mention of the details of the state vector that is updated in the assimilation scheme.

Response: Thanks for your suggestion. We will use the research period June–August in the revision. We only updated the liquid soil moisture with the observation and the synthetic observation was also the liquid soil moisture. During the update, we added a constraint to make sure that the sum of the liquid content and the ice content will not exceed the soil porosity. We will add this description in the revision.

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Comment: The experiment uses an identical twin setup in that the same model is used in assimilation and for generating synthetic observations. However, the observations are generated from a different year (2007), which is likely to introduce systematic biases. The assimilation algorithm is designed to only account for random errors. I suggest that the authors include some description of potential biases in the experiments. I would also include bias errors along with RMSE and NSE.

Response: Thanks for your advice. There should be systematic biases in the observation because of the different weather conditions in these two years. We have re-designed the experiment and used the synthetic observation from the same period as the model. This result will be updated in the revision.

Comment: Here the masking of the observations is done based on cloud masks, based on MODIS - a visible sensor. The soil moisture observations typically are measured from microwave sensors, which do not have issues observing through clouds. They, however, have difficulties with dense vegetation and such. The temperature sensors on the other hand are from visible sensors and they have difficulties with clouds. These issues are ignored in the experimental setup. To be clean and to mimic a real environment, it is better to apply different masking schemes for both types of observations and assimilate them separately.

Response: We agree with your comments. This mask is not suitable for the microwave sensors. We are also trying to use the MODIS data to retrieve the soil moisture based on the thermal inertia, in which the surface temperature will be used. Then we will have the same mask assumption for both the surface temperature and soil moisture. For this small and mountainous area, the coarse passive microwave is not suitable and the active passive microwave is easily influenced by the terrain. In addition, more than 90% of the grid cells are covered by short grass and we think that the mask used in this work is more suitable for representing the proposed idea. We will add this discussion in the revision.

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We will also analyze the use of two other masks to evaluate the results. So there will be three masks used in the revision.

Comment: Soil moisture and surface temperature have very different temporal behavior in terms of their memory. Soil moisture has more memory, whereas the skin temperature in models has no memory because the model assumes a low (close to zero) heat capacity associated with the surface layer. When assimilating skin temperature obs, the increments do not persist in the system as a result of this low memory. Unless more advanced diurnal updating schemes are used (Reichle et al. 2010), the assimilation does not yield any improvement except at the time of the assimilation. These issues require that the period of assimilation be extended temporally. Otherwise, it is not clear if the improvements seen here will translate in time.

Response: Thanks for your advice. We agree that the soil moisture can be easily transferred forward. In Reichle et al. 2010 at each model step also an observation was available, but in our study, we assumed that we only had one observation every 24 model steps. Through the sensitivity analysis of CLM surface temperature, we found that the surface temperature was very sensitive to the deep soil temperature. So we think that the deep soil temperature could provide the memory for the surface temperature during the forward steps. If we could use the surface temperature to update the deep surface temperature, then the deep surface temperature will respond to the surface temperature after each assimilation step. If there is no such feedback, the assimilation of surface temperature will not influence the system much. In the new experiment, we will extend our experiment to three months; the results for surface temperature without assimilation will be included.

Minor Comments:

Comment: Abstract: I'd modify to state that LETKF is used as the assimilation scheme and to say that the upper limit of 9 observations is in the 'spatial' sense.

Response: Thanks, we will change it.

C5325

Comment: Section 3.1: Better notation is to say “2008, 06Z” instead of “2008, 06”

Response: [We will change it.](#)

Comment: The identical twin experiment setup typically overestimates the model performance – It is in general easier for one model to simulate its own simulations (please see Kumar et al. 2009, “role of subsurface physics in the assimilation of surface soil moisture observations”, J. Hydromet. So the results in this paper may be an overestimation of the potential improvements you could get. A acknowledgement of this issue would be helpful.

Response: [Thanks, we will add this discussion and reference.](#)

Comment: A mention of the following reference may be appropriate for the background section: De Lannoy, G.J.M., Houser, P.R., Verhoest, N.E.C., Pauwels, V.R.N. (2009). Adaptive soil moisture profile filtering for horizontal information propagation in the independent column-based CLM2.0, Journal of Hydrometeorology, 10(3), 766-779.

Response: [We will add this reference.](#)

Comment: It would be instructive to provide measures of statistical significance to the values in Tables 2 and 3. Are the improvements on the order of 6-9 percent statistically significant?

Response: [We will add information on the statistical significance of our results.](#)

Comment: Labels in Figure 2, 6, and 7 are hard to read.

Response: [We will improve it.](#)