

Review on "Correction of systematic model forcing bias of CLM using assimilation of cosmic-ray neutrons and land surface temperature: a study in the Heihe catchment, China" by Han et al.

General comment

The major contribution of this work is to improve CLM performances by assimilating cosmic-ray data and LST data over irrigated site with Local Ensemble Transform Kalman Filter method. Basically, the idea is good. It is impressive to update soil moisture and temperature by jointly assimilation of cosmic-ray data and LST. Moreover, the turbulent heat fluxes are improved significantly. However, the manuscript is lacking in detail in a few areas and I'd not recommend the paper for publication unless substantial improvements are made to address the following concerns.

Major comments:

1. The introduction section needs to be carefully revised. The aim of this paper is to correct biases in CLM forcing, and improve model performances (e.g. soil moisture profile, ET) by assimilating cosmic-ray data and LST. However, the authors pay less attention on soil moisture and LST assimilation; only two sentences focus on soil moisture and temperature assimilation progresses were stated in the introduction part. The progresses should be enhanced in this part. Moreover, on page 9031, "In CLM, the surface fluxes are calculated based on the Monin–Obukhov similarity theory. The sensible heat flux is formulated as a function of temperature and leaf area index, and the latent heat flux is formulated as a function of the temperature T_0 and leaf stomatal resistances. The leaf stomatal resistance is calculated from the Ball-Berry conductance model (Collatz et al., 1991). The surface fluxes are therefore sensitive to the surface and soil temperature." this sentence looks wired, why surface fluxes are sensitive to soil temperature, the previous sentences cannot lead to this conclusion. Then why calibrate LAI? It is stated abrupt. Any other persons focus on LAI calibration to improve ET? I recommend authors rewrite the introduction part to describe more logically.
2. In section 3, LAI was updated by assimilating LST and soil moisture, I'm not certain if it is correct to do this. Does LST and soil moisture are strong correlated to LAI? Please state their relationship clearly.
3. In this study, the soil moisture related instrument, the cosmic-ray, is a ground measurement instrument. It can be used to measure soil moisture at plot scale about 600 m. it is hard and expensive to be applied at the continent scales. However, MODIS LST can be easily obtained globally. Thus, the limitation of assimilating cosmic-ray data should be discussed.

Minor comments

1. On page 9040, the augmentation method was used to update surface temperature, ground temperature, vegetation temperature and 10 layers of soil temperature by assimilating LST. However, surface temperature and vegetation temperature are diagnostic variables in CLM. To change them at the current time step may not influence model estimates in next time step. It is wasting time to add them as the updated variables. Remove them in the vectors.
2. In section 2.2, please state what meteorology parameters are used as the forcing data in CLM, and how long is the time step of CLM run?
3. The forcing data were perturbed by set of noises, what are the observation errors of cosmic-ray data and MODIS LST? How to perturb them?
4. The caption of figure 4 can be change as "Same as figure 3 but for 50 cm and 80 cm"
5. The figures 6, 7, and 8 can be combined into one figure, as they are all turbulent heat fluxes.
6. The ignorance of energy imbalance problem for eddy covariance system may cause some error in producing ET observation. This should be discussed.