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 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.

   Response: We will improve the introduction in the revision for the soil moisture and LST assimilation.

   In CLM, the sensible heat from the vegetation is formulated as:

$$H_v = -\rho_{atm} C_p (T_s - T_v) \frac{(L+S)}{\gamma_b}$$

   where ρ_{atm} is the density of atmospheric air (kg/m^3), C_p is the specific heat capacity of air (J/kg K), γ_b is the leaf boundary layer resistance (s/m), and L are S the exposed leaf and stem area indices. T_s is the surface temperature (K) and T_v vegetation temperature.

   For the latent heat flux, the leaf and stem area indices are also involved in the calculation like sensible heat flux. So we would say the sensible heat flux and latent heat flux are sensitive to the leaf area index. And our study was also based on the conclusions of Schwinger, J., et al., 2010: "results confirm that soil texture and LAI are key parameters that have a dominant influence on modeled LE under specific environmental conditions." Moreover, we used the MODIS LAI in CLM, the MODIS products usually underestimate the LAI compared with the field measurements. We will improve the introduction in the revision.

Schwinger, J., et al. (2010). "Sensitivity of Latent Heat Fluxes to Initial Values and Parameters of a Land-Surface Model." Vadose Zone Journal **9**(4): 984-1001.

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.
   Response: the LST was used to update the LAI, not soil moisture or Cosmic-ray. CLM first updates the sensible heat flux and latent heat flux, then the updated fluxes are used to update the vegetation temperature T_v. As we mentioned above, the T_v is sensitive the LAI. Yang, Z. L., et al. 1999 also showed the sensitivity of ground heat flux to LAI in two former land surface models of CLM. There both soil temperature and vegetation temperature are sensitive to LAI. We will improve the description in the revision.

Yang, Z. L., et al. (1999). "Sensitivity of ground heat flux to vegetation cover fraction and leaf area index." Journal of Geophysical Research-Atmospheres **104**(D16): 19505-19514.

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.
   Response: thanks, we will add this discussion in the revision.

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.
   Response: we calculated the surface temperature out of CLM for assimilation purpose only, because it is the right state to be assimilated. In order to calculate the Kalman gain, we need the surface temperature to compare with the MODIS LST. For the simplicity, we calculate the surface temperature out of Kalman filter and transferred the surface temperature into Kalman filter through the state vector. The vegetation temperature is the initial state of CLM, the calculation of vegetation temperature in CLM is: $\mathrm{T}_v^{n+1} = \mathrm{T}_v^n + \Delta T_v$.

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?
   Response: The incident longwave radiation, incident solar radiation, precipitation, air pressure, specific humidity, air temperature and wind speed were used in CLM. The time step of CLM was hourly.

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?
   Response: The observation data were not perturbed in LETKF and other square root Kalman filters. The variance of Cosmic-ray was the measured neutron counts value (Zreda,

M., et al., 2012) and the variance of MODIS LST was assumed to be 1 K (Wan, Z. and Z. L. Li, 2008).

Zreda, M., et al. (2012). "COSMOS: the COsmic-ray Soil Moisture Observing System." Hydrology and Earth System Sciences 16(11): 4079-4099.
Wan, Z. and Z. L. Li (2008). "Radiance‐based validation of the V5 MODIS land‐surface temperature product." International Journal of Remote Sensing 29(17-18): 5373-5395.

4. The captain of figure 4 can be change as ”Same as figure 3 but for 50 cm and 80 cm”
Response: thanks, we will change it.

5. The figures 6, 7, and 8 can be combined into one figure, as they are all turbulent heat fluxes.
Response: thanks, we will change it.

6. The ignorance of energy imbalance problem for eddy covariance system may cause some error in producing ET observation. This should be discussed.
Response: we will add the discussion in the revision.