

Interactive comment 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 X. Han et al.

Anonymous Referee #2

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General comments

The paper provides an important contribution to the research on data assimilation in land surface modelling. The paper considers assimilation of cosmic-ray soil moisture data and land surface temperature in the Community Land Model (CLM). Assimilation of the data sources individually and jointly as well as in combination with estimation of leaf area index are evaluated with respect to soil moisture, evapotranspiration, and latent and sensible heat flux. The paper is, in general, well written and technically

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sound. However, some elaborations are needed; especially on the Kalman filter setup and evaluation (see detailed comments below).

Detailed comments

1. Page 9031, line 10-13. Not clear. Inclusion of bias in the Kalman filter is usually defined either as a bias in the system equation or a bias in the observation equation. The specific source of error need not be known.
2. Page 9031, line 13. Not clear what is meant by ‘bias blind assimilation’ and why this is applied for ‘safety’.
3. Page 9031, line 17. Define ‘CLM’.
4. Page 9036, line 8-10. Are the measured data at the station in Switzerland representative for the Chinese case study?
5. Page 9036, line 24-26. Soil moisture from 10 soil layers (does this correspond to the top 10 cm of the soil?) in CLM is used as input to COSMIC. The effective measurement depth of the cosmic-ray probe depends on soil moisture, so why is a fixed depth used here? I expect this will introduce a bias in the simulated soil moisture for comparison with the measurements.
6. Page 9039, line 1. Definition of state vector not clear. Why soil moisture from 10 layers (see previous comment) and soil temperature for 15 layers?
7. Page 9040, line 17-20. How is the leaf area index represented in the augmented system equation? As a persistence model?
8. Page 9041, line 1-15. The Kalman filter settings are not sufficiently discussed. They seem rather arbitrarily chosen. It is not clear how the standard deviations, spatial and temporal correlations, and cross correlations given in Table 1 are determined. Has sensitivity analysis been applied to analyse the sensitivity of ensemble size and model error statistics on the assimilation results? You can analyse the prediction uncertainty

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provided by the Kalman filter to evaluate the Kalman filter settings by comparing measurements with predicted confidence bands or analyse the statistical properties of the model innovations. Definition of measurement uncertainty is not described.

9. Page 9043, line 4. How is measured soil moisture estimated?

10. Page 9045, line 4. Same information shown in Figs. 6-8 and Table 3. All results can be included in the table and figures omitted.

11. Page 9045, line 3-25. It is stated that the results for latent and sensible heat flux correspond to the results obtained for soil moisture. However, there are some notable differences that should be elaborated. The effect of inclusion of parameter estimation of LAI on latent and sensible heat flux depends on the type of data being assimilated. For LST assimilation an increase in RMSE is obtained when LAI estimation is included. With assimilation of both LST and CRS lower RMSE is obtained with LAI estimation. In addition, assimilation of LST provides better results than assimilation of both LST and CRS.

12. Figure 5. Explain numbers in lower-right corner in figure caption.

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