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Interactive comment on "On the factors influencing surface-layer energy balance closure and their seasonal variability over semi-arid loess plateau of Northwest China" *by* X. Xiao et al.

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We would like to thank you for attention and constructive comments to our work. The comments are addressed in the following response and the manuscript is being revised to accommodate the changes.

General comments

(1) The analysis and the results presented in this paper are almost completely site-specific and cannot be generalized to this type of ecosystem.

Response: The type of ecosystem did not been clearly indicated in the text, and this is my mistake. The vegetation type is native short grassland at SACOL site, and we have added a detailed description of this part (see Sect. 2.1). The analysis and the results is representative for the native short grassland ecosystem of semi-arid loess plateau. And there are referred to the ecological representation in these two references (Huang et al., 2008 and Xie et al., 2010).

(2) Since neither the methodology or the findings and their interpretation are new, I doubt that the paper in its present format provides new insights on the EBC problem.

Response: We apply ogive function to study the EBC effect of the low frequency and footprint analysis to understand the EBC effect of the underlying surface heterogeneity, and compare the different methods of surface soil heat flux to estimate the its influence on EBC. Perhaps, the methodologies are not new, but previous studied have focused on energy balance closure at multiple sites (i.e. space) (Li et al. 2005; Wilson et al. 2002). In this paper, we used long-term data to analyze the seasonal variations of EBC over the native grassland of semi-arid loess plateau even if the seasonal changes are not very obvious. In addition, we have analyzed the fourth factor, the relative turbulence intensity RIw (Sect. 2.6 and 3.5). The energy balance is unclosed all the same even taking into account the above three factors, so we think the EBC is relative to the atmospheric motion itself. Previously, the friction velocity had been used to characterize the EBC effect of the turbulent mixing. However, friction velocity u* could not correctly describe the atmospheric turbulence motion developed sometimes, e.g. with low u* during the daytime the turbulence have a good developed (Barr et al., 2006). So we used the relative vertical turbulent intensity to characterize the strength of atmospheric turbulence motion.

(3) Sections 4.1 (EBC effects of flux contribution from the target source zone) and 4.2 (EBC effect of low-frequency part of turbulence spectra) serve mainly as a basis for quality analysis and pre-screening of flux data before interpreting ecosystem energy- or gas-exchange characteristic at this site.

Response: Certainly, ogive and footprint analysis are very effective quality assessment approaches for evaluating the measured fluxes. Ogive analysis could obtain an average period that a majority of low frequency parts are included in the turbulent flux measured with the eddy-covariance method in the time series. As well, it could check the average period if all low frequency parts are included. The ogive analysis can evaluate the effect of low-frequency parts of turbulence spectral on EBC in a certain average time. Quality assessment tools for eddy covariance measurements have been combined with footprint modelling. Footprint analysis is especially useful for checking to what extent the measured fluxes at a site are representative of a specific type of land use (Göckede et al., 2004). We used footprint analysis to evaluate the eddy covariance measurement and the statistical results of quality levels were shown in Sect. 2.4(3). Then, the effect of underlying surface heterogeneity on EBC is illustrated by the relation between flux contribution from target area and OLSs (see Sect. 3.3).

Other comments

(1) The quality of English is rather poor, which makes parts of the text very difficult to understand. The organization of the paper is quite odd and should be greatly improved. The Results and Discussion sections are overlapping and both contain extensive parts which would rather belong to Methods.

Response: The manuscript has been proofread by native speakers; the paper structure was re-organized and had a great change. I hope it can make our results more clearly.

(2) The characteristics of the SACOL site are not sufficiently described. Without knowing details on the spatial heterogeneity of the site, the reader is without tools to understand the results presented in section 4.1 (Figure 2 and Table 2). Moreover, it is quite obvious that if there is significant heterogeneity within the footprint of EC –fluxes (as in this site?), the source areas of net radiometer and EC –setup will differ and possibly cause low EBC-ratios. The description of measurement construction, instrumentation, data-acquisition and post-processing is not complete, e.g. details on net radiation, soil

temperature and soil moisture measurements etc. are missing. The authors should significantly improve this part to convince the reader on the quality of the measurements.

Response: Following reviewer's suggestion, we have increased the description of the characteristics of the SACOL site in Sect. 2.1 and 2.3, including instrumentation, data-acquisition and post-processing.

(3) The EBC -analysis is done separately for the four seasons but this choice is not motivated. Are there distinct seasonality in climatic conditions or it this choice arbitrary?

Response: In terms of the climate of temperate zone, especially for China, we usually combine astronomy and climate season to divide a year into four seasons, i.e. spring (March-May), summer (June-August), autumn (September-November) and winter (December-February).

(4) What is the basis of neglecting the biomass energy storage term in EBC analysis? What is the neglected "additional energy source/sing Q?

Response: The biomass energy storage is neglected in EBC analysis includes heat storage in above-ground biomass (Splant), and heat storage in the canopy air space (Sair); The additional energy source/sing Q includes vertical flux divergence, horizontal advection, photosynthesis and water pumping (Oncley et al. 2007). And we have increased them in Sect. 2.2.

(5) How the values in Table 1 were calculated; sentence on p. 563 l.25- is very unclear? Majority of values given in Results and Discussion have too many significant digits.

Response: The values in Table 1 were calculated by the equation: , with the data sampling every 30 min during the daytime. So do the other parameters. And in the revised manuscript, we have deleted this part. In addition, we have revised the results and discussion.

(6) p. 566 l. 19-25. Sentence is very unclear. Response: We have revised the sen-

tences and hope them could be more clearly (please see Sect. 3.3).

(7) p. 567 l. 10-11. "In a similar way we analyzed the seasonal flux contributions in a range of z/L and wind directions in agreement, on the whole, with the above." What is meant with this sentence?

Response: It means that the seasonal and all-year characteristics of flux contribution from the target area in percent depending on the stability parameter and on wind direction are similar. In the modified manuscript, we added the concrete figures and illuminations of seasonal characteristics for the flux contribution from the target area in percent depending on the stability parameter and on wind direction (See Fig. 7 and Sect. 3.3)

(8) p. 570 l. 1-12. Motivate why you define RIw as in eq. 10 and use it as an indicator for the strength of the turbulent mixing over more conventional measures such as friction velocity? Moreover, did you classify the EBC to RIw classes or vice versa as the text implies?

Response: We have explained the reason why we choose the RIw instead of friction velocity to indicate the strength of the turbulent mixing in the response of general comment (2). In the text we didn't classify the EBC to RIw but merely divided RIw into a number of equal portions evenly from large to small, and solved the EBC-ratio and average RIw for each portion. The EBC effect of the developed of atmospheric turbulent motion is illustrated by the relation between RIw and OLSs.

(9) p. 572 l. 7-8. So? It is obvious that correct measure of G will be needed to close the energy balance.

Response: So far, there are many kinds of approaches to calculate the surface soil heat flux, but none of them can accurately calculate the SSHF without any error. Of course, we suppose that there are no other factors influencing the EBC except the surface soil heat flux, then a correct approach for calculating SSHF would close the

energy balance.

(10) p. 572 l. 14-17. This information is not relevant for broader audience. Also, the spring data quality is not optimal but only slightly better than in other seasons.

Response: Thank the reviewer's comments, I have been aware of this problem and have been carried out in the text to delete or modify.

Reference

Barr A. G., Morgenstern K., Black T. A., McCaughey J. H., Nesic Z.: Surface energy balance closure by the eddy-covariance method above three boreal forest stands and implications for the measurement of the CO2 flux. Agr. Forest Meteorol., 140, 322-337, 2006. Huang J. P., Zhang W., Zuo J. Q., et al.: An overview of the semi-arid climate and environment research observatory over the loess plateau. Adv. in Atmos. Sci., 25, 906-921, 2008. Jing X., Huang J., Wang G., et al.: The effects of clouds and aerosols on net ecosystem CO2 exchange over semi-arid Loess Plateau of Northwest China. Atoms. Chem. Phys., 10, 8205-8218, 2010. Li, Z. Q., Yu, G. R., Wen, X. F., Zhang, L. M., Ren, C. Y.: Energy Balance Closure at ChinaFLUX Sites. Sci. China Ser. D-Earth Sci., 48 Supp.âĚă, 51-62, 2005. Wilson, K., Goldstein, A., Falge, E., Aubinet, M., Baldocchi, D., Berbigier, P., Bernhofer, C., Ceulemans, R., Dolman, H., Field, C., Grelle, A., Ibrom, A., Law, B. E., Kowalski, A., Meyers, T., Moncrieff, J. Monson, R., Oechel, W., Tenhunen, J., Valentini, R., Verma, S.: Energy balance closure at FLUXNET sites. Agr. Forest Meteorol., 113, 223-243, 2002.

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