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Interactive Comment

Interactive comment on "Biophysical controls on net ecosystem CO_2 exchange over a semiarid shrubland in northwest China" *by* X. Jia et al.

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Thank you for providing helpful comments. The authors have made revisions and clarifications to the manuscript in light of your suggestions. The response to each of your comments is detailed below.

1. It will be much better to list all the abbreviations and parameters in an appendix so that readers could easily lookup those terms and better understand the article.

RE: We have added a table of nomenclature in Appendix A to list all the abbreviations and parameters in the revised manuscript.

2. The gross ecosystem productivity (GEP) and net carbon sink were presented with standard deviation, i.e. 456 ± 8 g C m-2 yr-1 and 77 ± 7 g C m-2 yr-2. No interpreta-

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Interactive Discussion

Discussion Paper

tion was ever described in the text, except the authors used bootstrap to analyze the uncertainty in gap-filled data. If it is from spatial variation, the vegetation in semiarid areas usually has extensive spatial and temporal heterogeneity, and the variation seems small to my understanding. The uncertainty analysis needs to be clarified.

RE: In the revised manuscript, we evaluated the cumulative effect of random measurement uncertainty on annual estimates of net ecosystem exchange (NEE) with the "successive days approach" (Hollinger and Richardson, 2005; Dragoni et al., 2007). This approach infers the statistical properties of the random error from the difference between half-hourly NEE measurements made exactly 24 h apart. A Monte Carlo approach was then used to generate a random error for each measured half-hourly NEE. The simulation was repeated 2000 times and the uncertainty of the measured annual NEE was estimated by calculating the 90% prediction limits of all simulated annual NEE values. The random measurement errors derived from the "successive days approach" have several sources, primarily including (1) random instrumental errors, (2) flux footprint heterogeneity and (3) the stochastic nature of turbulent transport. In addition, the random errors could be contaminated by the mismatch of environmental conditions between the successive days. Therefore, the effects of imperfect environmental similarity between the successive days were controlled for following Dragoni et al. (2007).

We evaluated the random uncertainty for annual sums of gross ecosystem productivity (GEP) and ecosystem respiration (Re) following a Monte Carlo algorithm detailed by Hagen et al. (2006). The algorithm infers the statistical properties of the random error from the residuals of the model for gap-filling and flux partitioning. Again, the 90% prediction limits of all (N = 2000) simulated annual GEP and Re values were calculated. The resulting GEP and Re uncertainties encompass sources from both measurement error and model parameterization (Hagen et al., 2006).

The cumulative annual uncertainties (the 90% prediction interval) calculated using the abovementioned methods was 68-87 g C m-2 yr-1 for NEE, 370-389 g C m-2 yr-1 for Re and 449-463 g C m-2 yr-1 for GEP. The degrees of uncertainty were comparable to those reported by previous studies (Hollinger and Richardson, 2005; Hagen et al., 2006; Dragoni et al., 2007). Intuitively, the uncertainties seemed relatively small considering the heterogeneous vegetation in semiarid areas. However, previous analyses indicated that over long time periods, random uncertainty of eddy-covariance-based carbon fluxes is small compared to other potential sources of systematic bias (e.g., incomplete surface energy balance closure, choice of model type, and choice of a friction velocity threshold). Hagen et al. (2006) concluded that random uncertainty of eddy-covariance-derived GEP estimates at the half-hourly timescale is generally on the order of the observations themselves (i.e., ∼100%), but is much less at annual timescales (∼10%). In other words, the relative random uncertainty of eddy-flux decreases with increasing timescale (Hagen et al., 2006). The underlying explanation is probably that positive and negative errors tend to cancel out each other over long periods of time (Dragoni et al., 2007).

We clarified the method for uncertainty analysis in the revised manuscript.

3. Should the uncertainty generated by bootstrap be standard deviation or standard error?

RE: In the revised manuscript, we used the 90% prediction interval to quantify uncertainty following Hagen et al. (2006). Many other studies (e.g., Dragoni et al., 2007; Savage et al., 2008; Yu et al., 2011) used standard deviation instead. We also calculated uncertainties in terms of standard deviation, and their relative magnitudes were comparable to previous studies.

4. Table 1 and figure 2: as the authors described in the text that October in 2012 is an exception when study the correlation between NEE and PAR. However, there is no further explanation about the causes of the exceptions.

RE: We clarified this in the revised manuscript. This exception was partially a result of senescent leaves and reduced LAI at the end of the growing season. Temperature and radiation also decreased at the late season, contributing to reduced CO2 uptake

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by the vegetation.

5. This work analyzed the relationship between NEE and environmental variables. Is it possible to generate comprehensive models to predict the NEEday, NEEnight, and GEP using related environmental variables together?

RE: We agree that it is important to develop comprehensive models to predict ecophysiological processes in arid and semiarid ecosystems. The objective of this study was to examine how biophysical factors regulate CO2 fluxes at multiple timescales. Gaining such an understanding is needed to develop mechanistic models suitable for arid and semiarid ecosystems. The authors feel that comprehensive modeling efforts are beyond the scope of the present study. However, process-based ecosystem modeling is one of our ongoing research focuses. We clarified this point in the revised manuscript. Our results could provide some implications for modeling. For example, our result that the Ts-REW model over-performed the Ts-only model (Fig. 7) indicated the need to take water availability into account when modeling short-term (e.g., hourly) changes of respiration in dryland ecosystems.

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