Biogeosciences Discussions

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Comment on bg-2022-171

Anonymous Referee #1

Referee comment on "Variations of carbon flux at different time scales in a semi-fixed sandy land ecosystem in Horqin Sandy Land, China" by Yayi Niu et al., Biogeosciences Discuss., https://doi.org/10.5194/bg-2022-171-RC1, 2022

I have carefully reviewed the manuscript of Niu et al on sandy land carbon fluxes and climate variability. The manuscript presents a five-year time series of standard eddy covariance carbon flux data (measured NEE with GPP and Reco estimated by accepted methods) and associated weather and soil profile data. The main novelty of the paper is the sandy land ecosystem, a degraded state of the Inner Mongolian grasslands produced by a combination of climate and land use factors. The manuscript presents a generalized exploration of the data and does not test any specific hypotheses. The key conclusions of the paper, summarized in the latter half of the abstract, mostly repeat ideas that are well-established in semiarid ecosystem flux literature, such as the idea that many dryland ecosystems have mean annual NEE~0 but pivot between carbon sinks/sources in wet/dry years. Or that precipitation, temperature and soil water content are "dominant controls." In the end, I find myself unable to clearly answer the important referee question: "Do the results support the key points/conclusions?" because the results are relatively unstructured, and the key points are overly general. The presentation of the manuscript follows accepted guidelines for organization and formatting. The writing contains numerous faults in English language usage, although I was able to follow the meaning in nearly all cases. Figures are of medium to poor quality, both in terms of visual presentation (especially readability of high-frequency data) and of conceptual representation.

Overall, my impression is that this manuscript is not suitable for publication due to a lack of clear, testable hypotheses (or clear goals). This deficit leads to other "downstream" problems including poorly-conceived figures. The literature cited is missing many major bodies of work from several other continents. I encourage the coauthors to examine the literature more extensively, identify key knowledge gaps that could be addressed with this dataset, and write a manuscript that leverages these valuable data to advance understanding. Given the large number of single-site, multi year eddy covariance studies published over the last 25 years, some suggested avenues for enhancing novelty include 1) comparing/contrasting the sandy land flux behavior with other dryland sites. For example, it appears that the mean annual precipitation and seasonal distribution of this site are quite similar to grassland sites in New Mexico and possibly Arizona, USA, but with

very different temperatures; 2) Showing how these flux data change the (or do not change) what is presently assumed about fluxes from such regions using currently available tools (often ecosystem models and/or remote sensing).

Below are some specific comments included in the hope that they may be useful for advancing this work

21: What is semi-fixed sandy land?

25-29: This part would be stronger if it were framed around hypothesis testing. Instead, the writing focuses us on a few statistical techniques for assessing variable importance. What new knowledge is produced by this study that is transferable to other times and places?

29-32: This is all well-known from many other dryland studies.

Since the mean annual NEE = zero (within the uncertainties of the method), there could be more interest in evaluating the magnitude of the deviations from the mean (e.g. source and sink function in dry and wet years).

45: As a result of what? The prior sentence talks about how NEE is mathematically related to GPP and Reco, but it does not logically follow that these relationships establish a reason that understanding NEE is crucial.

62:: This is a potentially promising topic for development of new knowledge, if the manuscript focuses on testing controlling mechanisms for sandy lands, especially if there are different controls in sandy lands than for other semiarid ecosystems.

72; please define semi-fixed sands.

74: was a carbon source

113: I am trying to determine what to expect that is new and different in this study as compared to the extensive body of literature in other semiarid ecosytems and as compared to the works cited here of Niu (2020, 2021) in sandy lands. Can this be made more clear?

169: I find these paragraphs very difficult to read, since they are packed with numbers and generally lacking any narrative thread to tie them together. It could be more effective to report means and ranges in a table and then use the text to illustrate key features of the data (features related to testing the study hypotheses, such as extreme seasons/years).

170: to my understanding, describing a solar-cycle time series as a unimodal distribution is not appropriate, because a time series (which may be unimodal) is a sequence, not a distribution of (random) samples from a population.

190: VPD is an example of a mechanistic control with potential to be explored. Is there a hypothesis related to VPD? See, for example, recent papers by Kim Novick on this topic and specifically the inferences related to drylands with respect to canopy flux controls by VPD vs. SWC.

194: this paragraph is mostly generalizations, such as "showed obvious seasonal changes." It would be better to describe what these dynamics are. Better yet, refer to Figure 3 for the dynamics and use the text to point out key features related to the study questions.

216: it would be more compelling to lead with the study hypotheses and then use the statistical techniques to test the hypotheses.

Figure 2 and Figure 3: While the figures contain valuable information, the high frequency nature, many time series, many panels, and 5-year coverage period makes it difficult to discern anything meaningful beyond what we could learn from a table of climate variables. If there key study hypotheses being tested that depend upon these variables (e.g. wet vs. dry years, or SWC variability at differing depths), the figures should highlight the key aspects of these datasets.

Figure 4: This figure with monthly values could potentially provide some interesting ideas for hypotheses to test. For example, the large GPP and carbon sink NEE in summer 2021 might inspire a figure or other analysis relating monthly fluxes to key hypothesized controls.

Figure 6 strikes me as rather oversimplified, and I struggle to learn anything new from this figure. The fits are generally poor, and the time scales might not even make sense. For example, a scatterplot of high-frequency data like this does not account for the Birch Effect, in which the largest respiration values in dryland ecosytems often follow (lag) by several days, pulses in SWC. Graphical tests of key drivers (e.g. GPP vs. SWC at 3

depths) might be more tractable at the monthly scale, as suggested by the interesting results for summer 2021 in Figure 4.

Figure 7-9: This shows some potentially interesting results, but there are problems with this figure. First, it does not follow from any hypotheses posed in the introduction about the key controls. Second, lines are fit to data that are apparently nonlinear. For example, panel a shows a flat response of NEE to Ts50 between -8C and +8C, and then a declining relationship, and there is likely ecological meaning in that nonlinear patterns. Second, these simple scatter plots to not seem to account for the seasonality of the ecosystem. In other words, we are presented the relationship between SWC and NEE in all months of the year, when we have major reasons to expect different relationships within the growing season or outside it. One suggestion for improving this analysis would be to present a bivariate relationship (like these ones) that is screened for a given range of values in other variables. For example, plot GPP vs. SWC for Ts50 between 5-10 C (or whatever might make sense). Or plot GPP vs. SWC for summer growing season only. Etc.

Table 1: this is a valuable table. Please express significant digits such that they represent the true uncertainty. For example, Uncertainty in precipitation measurements with a tipping bucket gauge can range from 5-15% or more. Therefore, P = 312.80 mm, which communicates precision to 1x10-5 m, is not reasonable. Perhaps 312 or 310 or 300 would be more representative. Please consider this for each variable shown.

Suggested reading:

In addition to the valuable works cited herein, mainly focused on China sites, there exists extensive literature on semiarid fluxes by the eddy covariance method across multiple other continents. Please see for example the following short list and the references in these papers:

Novick, Kimberly A., et al. "The increasing importance of atmospheric demand for ecosystem water and carbon fluxes." *Nature climate change* 6.11 (2016): 1023-1027.

Haverd, Vanessa, et al. "Carbon cycle responses of semiâ□□arid ecosystems to positive asymmetry in rainfall." Global change biology 23.2 (2017): 793-800.

Scott, Russell L., et al. "The carbon balance pivot point of southwestern US semiarid ecosystems: Insights from the 21st century drought." Journal of Geophysical Research: Biogeosciences 120.12 (2015): 2612-2624.

Biederman, Joel A., et al. "Terrestrial carbon balance in a drier world: the effects of water

availability in southwestern North America." Global change biology 22.5 (2016): 1867-1879.

Biederman, J. A., Scott, R. L., Arnone III, J. A., Jasoni, R. L., Litvak, M. E., Moreo, M. T., ... & Vivoni, E. R. (2018). Shrubland carbon sink depends upon winter water availability in the warm deserts of North America. Agricultural and Forest Meteorology, 249, 407-419.

Dannenberg, Matthew P., et al. "Exceptional heat and atmospheric dryness amplified losses of primary production during the 2020 US Southwest hot drought." Global change biology (2022).

Scott, Russell L., et al. "Commonalities of carbon dioxide exchange in semiarid regions with monsoon and Mediterranean climates." Journal of arid environments 84 (2012): 71-79.

Castellanos, Alejandro E., et al. "Plant functional diversity influences water and carbon fluxes and their use efficiencies in native and disturbed dryland ecosystems." Ecohydrology: e2415.