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Interactive comment on "Field-based observations of regional-scale, temporal variation in net primary production in Tibetan alpine grasslands" *by* Y. Shi et al.

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We thank Referee #1 for reviewing this paper. We have seriously considered the constructive comments and suggestions. The point-to-point responses have been listed in the following context. Revisions have been made accordingly in the revised version.

Comment 1:

1. I wondered about whether the authors may have considered analyzing their data sets with the aim of detecting potential interannual, or even longer, lagged effects (e.g., Reichstein et al. 2013 Nature for broader discussion). I think the authors should evaluate quantitatively the possibility of delayed or prolonged ANPP responses to a

particularly warm, cold, dry, or wet year (or years). A study-duration of four years may make this difficult (but perhaps not if an "extreme" year occurred in the first or second year of the observation period). Use of "calibrated" satellite imagery and data from the 49 existing weather stations in the Tibetan Plateau might enable such an analysis.

Response:

As the Referee #1 pointed out, combining the transect data with the calibrated remotely sensed data such as NOAA NDVI or MODIS EVI could provide broader and more detailed information to explore the spatio-temporal dynamics of vegetation production. However, as the handling editor noted, linking the satellite data to the transect data, and analysing the even longer lagged effects further, might go beyond the scope of our present paper. Thus, we think it might be appropriate for another paper to address the issues, but not in this one.

Comment 2:

2. Also, the means by which study sites were selected must be clarified in more detail, especially with respect to grazing history and intensity.

Response:

Thanks for this comment. It is necessary that providing the detailed information about sites, especially grazing history and intensity, in ANPP studies in the grasslands, if possible. However, grazing patterns and grazing intensities are supposed to vary greatly in such diverse regions, while reliable ofïňĄcial data cannot be used to reïňĆect the details since they are bound to county and provincial boundaries. Therefore, the estimations of this information must be very inaccurate.

Owing to above reasons, we have tended to minimize the impact of herbivores on grasslands through experiential method when we chosen our sampling sites. All of our plots are located either in deferred grazing areas (described as "non-grazed areas" in the paper), which have no domestic animals, or on the winter pastures that are free

from livestock in the growing seasons. Through this approach we exclude the affect of livestock as much as possible. Of course, even though no domestic animals exist, there are still wild animals. Although we chosen the sites with visual inspection, it is very difficult to exclude herbivorous behaviour from wild animals.

For clarifying the contents that are unclear, we modified the corresponding sentence in the "Methods and Materials" section and added a short paragraph in the section 4.5. The detailed revisions are given in the response to specific comments.

Comment 3:

3. The novelty of the study really is the examination of possible plant community species richness effects in combination with climate variability. I don't believe that there is enough power in the data set to extrapolate to talking about vulnerability to anthropogenic climate change.

Response:

Exactly the same as the referee's comment, one scope of this study is to quantify the effects of climate fluctuations and species richness on the temporal variation of ANPP in Tibetan alpine grasslands. Therefore, our expression in the "Introduction" is not very accurate, we corrected the corresponding sentence as following:

"Thus, the objectives of this study were to: (1) explore the interannual variability of ANPP of the Tibetan alpine grasslands and compare its sensitivity to climatic fluctuation with other grassland types, (2) detect the year-to-year variation in observed spatial pattern of ANPP across all 40 sites and discuss if it is necessary to make repeated survey in large-scale studies, and (3) quantify the effects of climatic fluctuations and species diversity on the interannual variation of ANPP in the Tibetan alpine grasslands."

Other ambiguous expressions are also corrected in the revised version.

Specific comment 1:

Abstract:

4. Lines 31 (Abstract): Delete "the" and insert "ANPP in" before "Tibetan". Since you originally hypothesized that temperature would be the primary factor modulating NPP in these alpine grasslands, you could insert the word "surprising" or "surprisingly" somewhere in this sentence to indicate this unexpected result from your study.

Response:

Revised as suggested.

Specific comment 2:

Abstract:

5. Line 32: Consider rewording to explain in this result in a direct way. For example: "Finally, we found a reduction in year-to-year variation (i.e., CV) in ANPP with increasing species richness of plant communities suggesting that diversity can ...". It is very important to specify what type of variation you are talking about (i.e., interannual).

Response:

Thanks for the comment. We have modified the corresponding sentence as following:

"Finally, we found a reduction in interannual variation (i.e., CV) in ANPP with increasing species richness of plant communities, suggesting that diversity can stabilize community production in high-altitude grasslands."

Specific comment 3:

Introduction: 6. Lines 60-62: Are there really no earlier references that have quantitatively show that grasslands cover 25% of Earth's land surface area??? At least insert an "e.g." before the list of references included in the parentheses.

Response:

We have cited the following two references in the paper:

Lauenroth, W.: Grassland primary production: North American grasslands in Perspective, in: Perspectives in Grassland Ecology, edited by: French, N., Ecological Studies, Springer New York, 3-24, 1979.

Parton, W. J., Scurlock, J. M. O., Ojima, D. S., Schimel, D. S., Hall, D. O., and Scopegram Group, M.: Impact of climate change on grassland production and soil carbon worldwide, Global Change Biology, 1, 13-22, 1995.

And the citations in the main text are revised accordingly:

(e.g., Lauenroth, 1979; Parton et al., 1995; Scurlock and Hall, 1998; Hui and Jackson, 2006)

Specific comment 4:

Introduction:

7. Lines 70-71: To make sentence accurate, please modify to read something like: "...because temperature should be the primary environmental factor constraining vegetation growth ...".

Response:

We have revised the corresponding sentence as following:

"Because the extremely environmental condition they face, alpine grasslands are often considered more sensitive to environmental variation than other ecosystems (Theurillat and Guisan, 2001; Cui and Graf, 2009; Gao et al., 2009). Particularly, temperature variation should be the main driver for the temporal variation in alpine vegetation because low temperature is believed to be the primary environmental factor constraining vegetation growth (Shaver and Jonasson, 1999; Wielgolaski and Karlsen, 2007; Cui and Graf, 2009)."

Specific comment 5:

Introduction:

8. Line 78: After "... anthropogenic activities" please insert ", such as ..." and list the activities you are referring to. Certainly, rising atmospheric CO2 is impinging on these grasslands, as well!

Response:

We have specified the "anthropogenic activities" in the corresponding sentences as follow:

"Moreover, a large part of the plateau has not been strongly disturbed by many anthropogenic activities such as mineral exploration, industrial pollution, and farmland reclamation."

Specific comment 6:

Introduction:

9. Line 83 to end of paragraph: The authors must state these as objectives! Otherwise, there is no way to know whether the study meets any concrete objectives (e.g., "Thus the objectives of this study were to quantify: (1) ..., (2), and (3) ...").

Response:

We have revised the corresponding sentence as following:

"Thus, the objectives of this study were to: (1) explore the interannual variability of ANPP of the Tibetan alpine grasslands and compare its sensitivity to climatic fluctuation with other grassland types, (2) detect the year-to-year variation in observed spatial pattern of ANPP across all 40 sites and discuss if it is necessary to make repeated survey in large-scale studies, and (3) quantify the effects of climatic fluctuations and species diversity on the interannual variation of ANPP in the Tibetan alpine grasslands."

Specific comment 7:

Methods:

10. Lines 96-99: The site selection process needs to be described in more detail. Were these sites selected to accurately represent the alpine grasslands of the Tibetan plateau? Line 97 states that sites were minimally grazed. Line 98 states that "non-grazed" sites were also included and even sites that were inside fenced areas. I understand the practical reason for choosing sites that were either ungrazed (do you mean by domesticated animals?; please specify) or where grazers (both domesticated and wild animals?) were excluded. However, grasslands are notorious for almost always having grazers present during snow-free periods (and even during periods with snow cover). So, it seems that arguments for studying grassland ANPP responses under atypical conditions should be strengthened. Could grazing level be used as a covariate in the analysisâAËŸTmaybeËĞ not even separating into wild vs. domesticated grazingâAËŸTjustËĞ "grazing".

Response:

Thanks for the comments. We have responded this comment in the response to Comment 2. Because our descriptions in the "Methods and Materials" is not very accurate, we modified the corresponding sentence as following:

"All of the sites were selected by visual inspection of the vegetation with the aim to sample sites subjected to minimize grazing and other anthropogenic disturbances. Further, for this purpose, sites were established either in deferred grazing areas or on winter pastures inside fences to minimize livestock-induced disturbances."

We also added a short paragraph in the section 4.5 "Limitations of the research" about the grazing impacts:

"Another potential limitation in our study could stem from excluding the influences of grazing incompletely. Due to herbivorous behavior has major effect on the measurement of ANPP, we located our survey sites either in deferred grazing areas, or on

the winter pastures which are free from grazing in growing seasons. However, even if no domestic animals exist, there are still wild animals such as Mongolian gazelle (Procapra gutturosa) and Tibetan antelope (Pantholops hodgsonii) which appear in a number of study sites. Because of the absence of the data, it is very difficult to exclude herbivorous behaviour from wild animals. To what extent grazing may affect the interannual variation of ANPP in our study region is still difficult to quantify."

Specific comment 8:

Methods:

11. Lines 124-127: I'm wondering about the appropriateness of using a presumably coarse spatial scale (cokriging) modeling of climate data that is so critical to the outcome of the study. Does the cokriging procedure include slope and aspect? Why weren't air T/RH dataloggers, or gauges, used to measure actual climatic conditions at each 10 x 10 m site? It has been long known that microclimatic conditions on spatial scales used in this study can play as large a role as general larger-scale whether/climatic conditions (e.g., Larcher 2003 book; Körner 2003 book). Was slope aspect considered in the estimation of microsite climate? Can any modeled climate vs. measured climate comparisons be pointed to in order to convince the reader that climatic conditions at each of the 40 sites were reliable? If some data are available that would demonstrate reliability, they should be shown as a figure either in the paper or in the supplementary section (e.g., regression scatter plot; better in the paper itself).

Response:

Thanks for this comment.

We did not install air T/RH dataloggers in our study region due to some reasons (the most important one is they might be stolen). However, we buried automatic soil thermal probes (Hobo U12, Onset Computer Corp., MA, USA) at 10 cm soil depth at 33 sites from 2007-2008. The measured soil temperature was highly related to our inter-

polated atmosphere temperature, with a R2 of 0.76 (Fig. 1). Considering the difference between soil temperature and atmosphere temperature produced by time-lag, soil texture, and freezing/thawing process (Zhang et al., 2005; Harris et al., 2003), this result suggests that the interpolated atmosphere temperature data are appropriate for analysis.

On the other hand, many previous studies focused on the Tibetan Plateau (e.g. Piao et al., 2003; Yang et al., 2008; He et al., 2009) used the same method to interpolate the climate data, as we cited in the present paper. Moreover, the spatial resolution of our data is much higher than those studies (most with a resolution of $0.1^\circ \times 0.1^\circ$, about 10 $\times$ 10 km). Because we cannot access the actual climatic conditions at each sites (we only have soil temperature records), we think that using the modelled climate data is appropriate before we can get the very fine spatial resolution data.

Considering these reasons and the fact that there are 6 figures in the paper, we think it is better to put the above scatter plot in the Author Comment. Specific comment 9:

Methods: 12. I did not see a reference to Figure 1 in the text.

Response:

Thanks for the comments. We have added the reference.

Specific comment 10:

Results:

13. Lines 170-172 belong in the Methods section.

Response:

We have moved this part to the “Methods and Materials” section.

Specific comment 11:

Results:

14. Line 170: I am uncertain about the meaning of the first part of this sentence (“To detect temporal changes in the spatial pattern ...”). I did not see an objective that sought to quantify this, or anything about spatial pattern. Do you mean, “To detect temporal changes in ANPP [temporal, or year-to-year variation in ANPP] across all 39 sites, ...” ? Please clarify to make sentence unambiguous.

Response:

Thanks for the comments. In this part, we focused on whether the spatial pattern of ANPP across all 40 sites underwent significant change during the four years. Combining with the last suggestion, we removed this sentence and added the objective in the “Introduction” section. Meanwhile, we revised the next sentence to make the phrasing clear as following:

“The type-II regression indicated that annual ANPP across all 40 sites from different years was highly correlated ($P < 0.001$, Table 3).”

The subtitle of the section is also revised.

Specific comment 12:

Results:

15. Line 176 is also unclear in the same way “... spatial sequence ...”.

16. Line 177: Do you mean “... corresponding changes in ANPP”? In other words, did ANPP change in correspondence with changes in climate?

Response:

We have modified the corresponding sentence as following:

“These results demonstrate that the sites with relatively high productivity in one year maintained relatively high productivity in other years. Despite climatic fluctuations and corresponding changes in average ANPP in our study region, the pattern of annual

ANPP across all 40 sites was consistent from 2006 to 2009."

Specific comment 13:

Results:

17. Lines 186-187: It would be much easier to actually "see" this result if Figure 4 were converted into two-dimensional graphsâAËŸTratherËĞ than 3D. It is very difficult to determine where points and best-fit lines lie in the three dimensions. A two-way scatter of (a) CVANPP on CV-AT (b) CV-ANPP on CV-AP, (c) CV-ANPP on CV-GST, and (d) CV-ANPP on CV-GSP .

Response:

Revised as suggested.

Specific comment 14:

Results:

18. Line 190: To be consistent and unambiguous, please replace "temperature" with "AT" and "aboveground NPP" with "ANPP".

Response:

Revised as suggested.

Specific comment 15:

Results:

19. Line 193: In line 191, you state that you entered rainfall factors first into GLMs, but in this line it looks like CV-AT was entered first. I am confused.

Response:

This is an error. We have corrected it in the Biogeosciences Discussion.

Specific comment 16:

Results: 20. Line 201: Replace "temporal" with "interannual".

Response:

Revised.

Specific comment 17:

Discussion:

21. Repetition of results in the Discussion should be minimized. For example, lines 207-208 and 214 in the Discussion are nearly identical and repeat line 163 in the Results. Other occasions follow.

Response:

Revised as suggested.

Specific comment 18:

Discussion:

22. I also do not think the subheadings are needed in the DiscussionâAËŸTatËĞ least not in such grandiose style. The data are worth publishing without grandstanding; especially since there is an entire subsection dedicated to "limitations" (which I think need to be incorporated in the main part of the discussion where needed).

Response:

Thanks for the very constructive suggestion. We have revised the subtitles into simple styles.

Specific comment 19:

Discussion:

23. Line 212: I am not completely comfortable with the use of the term “vulnerable” or “vulnerability”. It seems that you can/should talk mainly about ANPP responses to year-to-year climate variability – focusing on precipitation and specifying precipitation as the dominant controlling climate variable rather than continuing to talk in general terms about “climate”, when your data indicate that annual temperature had little explanatory power. And extrapolation to “ecosystems” seems a bit of a stretch. There is no harm in using the term “productivity” in the heading (even if this is already an extrapolation since the present study did not include BNPP). Vulnerability also implies loss of species from an ecosystem or community, and your study did not look at this.

Response:

Thanks for the comment. We have revised the term “vulnerable” and “vulnerability” into “sensitive” and “sensitivity”, respectively. Meanwhile, we modified the subtitle and corresponding sentences as the referee suggested.

Specific comment 20:

Discussion:

24. Line 230: Same comment as in 21.

25. Line 244: Please replace “NPP” with “ANPP”.

Response:

Done

Specific comment 21:

Discussion:

26. Line 245. Lines 266-270: This header in the text reminds me once again that it would be good to show a simple time-course figure in the paper covering the 4 years of your study, with three lines: mean$\pm$SE of ANPP (n=39); (b) mean$\pm$SE of AT; and

(c) mean$\pm$SE of AP. On this graph, you could also show some measure of monsoon intensity for each year of your study.

Response:

Thanks. We have taken seriously for the suggestion. The aim of this study focused on the temporal variation at regional scale, while the mean values of ANPP, temperature and precipitation of the whole study region would ignore the huge variations among sites in appearance due to the large spatial scale of our transect. Meanwhile we lack the measure of monsoon intensity because of the absence of the data. Thus, we think it may not be appropriate to present the figure here.

Specific comment 22:

Discussion:

27. Lines 266-270: If AT and AP moved synchronously, wouldn’t this suggest that AT could be playing as much a role as AP?

Response:

This might be misinterpretations due to our ambiguous expressions. The sentences mean that due to the monsoon climate system, the interannual variations of temperature (or precipitation) in different locations keep synchronous to each other across the plateau. To avoid further misunderstanding, we revised the corresponding sentences as following:

“This monsoon climate system would induce synchronous temporal variation in temperature and precipitation at different locations across the plateau. Meteorological records also show that over the past several decades, temperature variations have been spatially consistent across the plateau (Lin and Zhao, 1996), and the rainfall has the similar temporal trends and fluctuations in most regions (Xu et al., 2008). In addition, by using climate data from 66 meteorological stations from 2006 to 2009 in our study region, we found that climatic variables (AT, AP, GST and GSP) all exhibited parallel spatial

inter-annual variation (Fig. 6)."

Specific comment 23:

Discussion:

28. Line 271+: This is not stated as an objective of the study, so it seems strange to see this discussed here (see comments on this above). Please state as an objective. It is also implied by the separation of results into alpine steppe and alpine meadow (which seem puzzling without a "need" to know this).

Response:

We have stated the objective in the "Introduction" section as mentioned above.

Specific comment 23:

Discussion:

29. Lines 340-356: I would eliminate this section and build these ideas into the previous parts of the Discussion. Another option is to state the findings in more of a moderate way using words like "suggest" or "may indicate" rather than definitive wording.

30. Lines 352-356: Delete! This does not belong in a paper.

Response:

Thanks for the constructive suggestion. We have modified the findings in a moderate style. The last paragraph is also deleted as the referee suggested. However, we think it is still necessary to discuss the limitations of the current study separately. The uncertainties, especially those from short study period and herbivorous behaviour, are relevant to all previous parts of the "Discussions" section, thus it may be appropriated to present the limitations in a new section.

Please also note the supplement to this comment:

http://www.biogeosciences-discuss.net/10/C8786/2014/bgd-10-C8786-2014-supplement.pdf

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Interactive comment on Biogeosciences Discuss., 10, 16843, 2013.

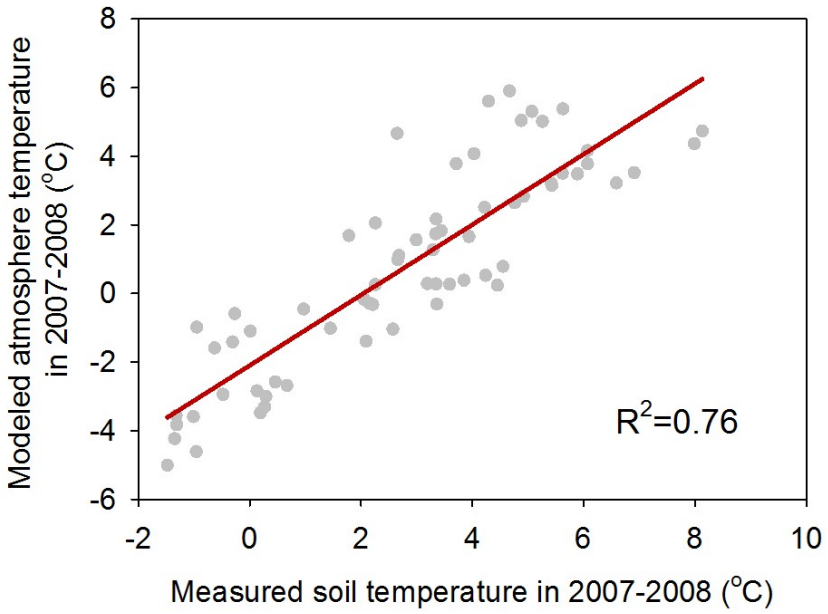

Fig. 1. Comparisons between the measured annual soil temperature at 10 cm and modeled annual atmosphere temperature in 2007 and 2008.