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Interactive comment on "Patterns and controls of soil respiration and its temperature sensitivity in grassland ecosystems across China" *by* Jiguang Feng et al.

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General comments This manuscript made a contribution by compiling published data of soil respiration and temperature sensitivity related to soil respiration from five types of Chinese grasslands. The spatial extend of the dataset covers a large region. The temporal extend of the dataset is at the annual scale. It seems that the majority of the data points in this dataset have not been integrated into any published synthesis yet. Some aspects of the manuscript deserve attention. The authors carried out some basic correlation analyses on this dataset, and found some inconsistencies as compared with results in some published reports. One inconsistency was the correlation between

annual soil respiration rate (Rs) and total soil nitrogen content (or total soil carbon content, because soil C and N tend to go together). As normally expected, most published reports showed highly significant correlation between Rs and soil C & N, but not this manuscript. The actual causes of this inconsistency were unclear. Another inconsistency was that the manuscript did not find any significant correlations between climatic variable (e.g., temperature and precipitation) and Q10 values measured at 5 cm or 10 cm depth, which is in contrast to published results. Again, clear causes of this inconsistency were not offered. Response: Thanks for the constructive comments. We show our response to the three main comments on the inconsistency between our results and previous studies.

The first inconsistency was the correlation between annual soil respiration rate (Rs) and total soil nitrogen. In this study, we found that annual soil respiration did not significantly correlate with soil total nitrogen ($p = 0.10$, Fig. 2f), which was not consistent with previous results at the regional and global scale. Not surprisingly, we found that soil organic carbon was closely associated with soil total nitrogen ($p < 0.01$, Table S3). But, annual soil respiration increased closely with soil organic carbon ($p < 0.001$, Fig. 2e). The non-significant correlation between soil total nitrogen and annual soil respiration might be due to the limited sample size in soil total nitrogen compared to soil organic carbon (24 vs. 40), and/or due to the fact that soil total nitrogen might not well represent nitrogen availability for plants and microbes.

The second inconsistency was that this study did not find any significant correlations between climatic variables (i.e. mean annul temperature (MAT) and mean annual precipitation (MAP)) and Q10 values measured at 5 or 10 cm depth. This was not consistent with previously published results. But, we found Q10 measured at 5 or 10 cm soil depth was significantly decreased with increasing soil temperature, partly supporting the previous statement that Q10 tends to be higher in colder regions. Additionally, although the single factor of precipitation or temperature only explained a small proportion of the spatial variation of Q10, the combined factors of MAT and MAP, or soil temperature and soil moisture, explained a significant proportion of the spatial variation of Q10 across Chinese grasslands at regional scale (Table S4). Please see the discussion in section 4.2.3 Controls of environmental factors on Q10.

As the authors stated in the manuscript, the soil respiration in this context has two main components: autotrophic respiration of plant roots, and heterotrophic respiration of soil microbes. Therefore, the soil respiration should be controlled by both plant-related variables and soil-related variables. But unfortunately, there were only 7 data points that have autotrophic and heterotrophic respiration measured separately (and probably using questionable methods). Consequently, Rs and Q10 data could not be discussed in relations to plant-related variables and soil-related variables. Furthermore, these Q10 values were calculated using the seasonally changing temperature data which often highly co-vary with plant growth (therefore, the seasonal increase of root respiration). As a result, the seasonal increase of root respiration would contribute to abnormally high Q10 values. This key aspect definitely needs authors' attention. Changes in the Introduction, Materials and Methods, and Discussion sections are required accordingly. Response: Thanks for the constructive comments. When discussing annual soil respiration among grassland types, we analyzed autotrophic (root) respiration and heterotrophic (microbial) respiration, respectively, for example, section 4.1.1 Annual soil respiration among grassland types. In addition, as the substrate of microbial decomposition, soil organic carbon (SOC) affects soil respiration. In addition, soil pH mainly controls heterotrophic respiration via regulating soil microbial activities. Therefore, the discussions related to SOC and pH were associated with plant-related variables and soil-related variables. But, the few samples (n = 7) from heterotrophic respiration and autotrophic respiration measured separately limited the in-depth discussions.

As you stated, the seasonal dynamics of plant growth affect root respiration and thereby seasonal Q10. At large scale, the seasonal amplitude of plant activity among different sites varied largely, which could affect the calculated seasonal Q10. Indeed, a previous global synthesis study found that seasonal amplitude of plant activity fundamentally

dominates seasonal Q10 among different study sites compared with other environmental factors (Wang et al. 2010). But, in this study, we could not analyze the effects of seasonal variation of root respiration on Q10 due to the limited samples (n = 7) from autotrophic (root) respiration. In addition, the seasonal dynamics of plant growth at a given site might also affect the calculated Q10. In this study, our dataset included Q10 estimated at different time scale for measuring soil respiration. We categorized them into three types according to plant growth stage, including growing season Q10, non-growing season Q10, and annual Q10. In this case, we also conducted a one-way ANOVA analysis to examine the effects of measurement period (including growing season, non-growing season and annual scale) on Q10 derived by soil temperature at the depth of 5 and 10 cm, and found that measurement period did not significantly affect Q10 derived by soil temperature at the depth of 10 cm, but significantly affected Q10 derived by soil temperature at the depth of 5 cm. (Fig. S7). We have discussed this result in section 4.4 Uncertainties. Following your suggestions, we have revised the related content in the sections of Introduction, Materials and Methods (Section 2.2 Data analysis), and Discussion (section 4.2.3 Controls of environmental factors on Q10 and Section 4.4 Uncertainties).

Specific/Minor comments Line 25: 'latitude and' should be removed here. These geographic features (e.g., latitude, longitude, altitude or elevation) may be used as proxies for temperature or precipitation in data analysis only when temperature or precipitation data were not available. So authors should consider eliminate all parts of the manuscript that use these geographic features in statistical analyses and any related discussion. Response: Thanks for your good suggestion! We have eliminated all parts of the manuscript that use these geographic features in statistical analyses and any related discussion. In the revised manuscript, we added statistical analyses and discussion of soil temperature and soil moisture.

Line 28: The % heterotrophic respiration was only based on 7 data points, therefore, should not be in the abstract. Similarly, if the authors really want to make the "key" point of growing season vs. non-growing season, they should have given clear descriptions about how the separation was done accurately and reliably. Response: Thanks for your good suggestions! We have eliminated the contents related to % heterotrophic respiration and % growing season in the abstract. In addition, we described how the growing season and non-growing season were defined. The growing season was from May to October, and the non-growing season was from November to April in the second year.

Lines 29-31: This sentence needs a re-write so that the meaning becomes clear. Response: Thanks for your good suggestion. We have re-written the sentence in the revised manuscript.

Line 33: Remove the sentence about latitude and longitude here (the reason is given at line 25). Response: Thanks for your good suggestions. We have removed all the sentences related to latitude and longitude in the revised manuscript.

Lines 35-38: Authors need to substantiate about 'how have they advanced the understanding' here. Response: Thanks for your good suggestion. We have revised the abstract and substantiated which understandings were advanced (line 41-45).

Line 53: "on the large scale"? Do you really want to 'step' on the large scale by the wall? My guess is that you really want to state: 'at a large scale' here. This correction should be made throughout the entire manuscript. Response: Thanks for your good suggestions. We have changed "on the large scale" to "at a large scale" throughout the entire manuscript.

Lines 67-68: Move the "and" to the place before the last part of the sentence, before "leaf area index". Response: Thank you. We have moved the "and" before "leaf area index".

Line 83: "As known to all . . ." The sentence is awkward. Response: Thank you. We have re-written the sentence.

Line 133 and line 137: How could equations (1) and (2) have the same right sides? Also, what is the time factor for the T here? Is it measured at hourly, daily, weekly or annually time period? Response: Thanks for your good suggestion. The equation (2) in the original manuscript was not correct. We have corrected equation (2). Here, the T represents the soil temperature recorded when measuring soil respiration. In this study, we only selected Q10 data when soil respiration measurement time was not less than four months (see section 2.1. Data collection). Here, the time period among case studies was not consistent with each other. Some studies provided the weekly time period, and some studies provided the monthly time period.

Line 155: Please define the "R-square and the model" here. Response: Thanks for your suggestion. We have defined the "R-square and the model" in the section 2.1. Data collection when the R2 first appeared in the manuscript.

Line 174: Why using "a constant of 0.58" here? I think it should be 0.5 now (see Pribyl 2010, Geoderma 156: 75–83). Response: Thanks for your good suggestion. We have carefully read the article you provided (Pribyl 2010), in which the author suggested that the constant of 0.50 is more accurate than the conventional factor of 0.58. At present, the conversion factor of 0.50 was widely used. We have converted soil organic matter to soil organic carbon by the constant of 0.50. Meanwhile, we re-analyzed the content related to soil organic carbon, and revised the corresponding text throughout the entire manuscript and the supplementary information.

Line 263: "Q10-ST10" is not shown by Figure 5. Did you mean Q10-ST5? Response: Thanks for your comment. Here, the Q10-ST5 was correct. In the original manuscript, the caption of Figure 5 missed the information of Q10-ST10, but the figures in Figure 5 were right. Now, we have added the missing information of Q10-ST10 in the caption of Figure 5.

Line 267: Not "Table S3", should be Table S4. Response: Thanks for your correction. We have changed Table S3 to Table S4.

Line 302: “untimely” should be ‘ultimately’ Response: Thanks for your correction. We have corrected the word.

Lines 308-315: The discussion here is unclear. Response: Thanks for your good suggestion. We have re-written this part of discussion (line 356-362).

Line 320: “n=20” here, but there were only 6 dots in the figure? Response: Thanks for your corrections. Here, we miswrote the sample size. Indeed, there only 6 dots for the relationships of Rs and belowground biomass. We have changed n = 20 to n = 6.

Lines 331-352: These low R-square values could be a serious problem for this manuscript. How did you deal with this issue? Response: Thank you for the comment. In this study, we obtained Q10 and its R2 calculated using the equation (1) and (2). We only selected the R2 values when the exponential fitting between soil respiration (Rs) and soil temperature were statistically significant ($p < 0.05$). If the p values were larger than 0.05 in case study, we did not select the Q10 and its R2 value. In spite of this, the R2 in some case studies were very low. As presented in this study, only 37.3% of R2 for Q10 was larger than 0.7, indicating that most of the seasonal variation of Rs rate cannot be well explained by soil temperature using the van’t Hoff equation. In section 4.2.1 R2 for Q10 in Chinese grasslands, we discussed the R2 for Q10 in detail, and pointed out that for ecosystems (e.g., grassland and desert) in arid and semi-arid regions, Rs could be better estimated by the combined factors of soil temperature and moisture.

Lines 405-425: This section is really rough. The quality of the discussion needs improvement. Response: Thanks for your good suggestion. We have revised this part (line 470-500).

Lines 453-457: To me, Fig. 7 actually showed huge differences between those three methods. Response: Thanks for your comment. Here, we guess you mean Figure S7. The differences might be not only due to the measurement methods, but also be due to the differences among grassland types. To eliminate the influences of grassland

type, we also compared the measurement method effects within each grassland type. As presented in the new Figure S7, the ANOVA analyses showed that there were generally no significant differences for Q10 (at the soil depth of 5 and 10 cm) among measurement methods, whether the data was pooled across all grasslands or within each grassland type. For Rs, there was only one sample from alkali absorption (AA, Rs = 202.5), which seems to be much lower than dynamic closed chamber (DCC, Rs = 589.2) and static closed chamber (SCC, Rs = 459.9). Considering this AA data for Rs was from temperate typical steppe (TTS), we also compared this value (202.5) measured by AA to those measured by DCC and SCC within TTS. We found that the value of 202.5 (AA) was lower than 548.3 (DCC), but close to 193.0 (SCC). Therefore, including the single data measured by the alkali absorption method in our synthesis does not meaningfully change the results of Rs and Q10.

Lines 471-473: The sentence structure is problematic. Response: Thanks for your comment. We have re-written the sentence.

Lines 468-481: The Conclusion really needs lots of improvement. Response: Thanks for your good suggestion. We have revised this part.

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