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Interactive comment on "Effect of plateau pikas disturbance and patchiness on ecosystem carbon emission of alpine meadow on the northeastern part of Qinghai-Tibetan Plateau" *by* Yu Qin et al.

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Introduction: This section has not clarified clearly why we should study the effect of plateau pika disturbance and patchiness on ecosystem carbon emission at the plot scale, but not at other scales? What are the exact differences between this study and so many previous studies? Thank you for your careful review. We have revised the whole manuscript to eliminate the reader's confusion. In fact, we mainly focused on the effect of plateau pika disturbance and patchiness on ecosystem carbon emission of alpine meadow and we did not refer to any scales in this work. We have clarified clearly why we should study the effect of plateau pika disturbance and patchiness on alpine grassland at plot scale in our previous study (Yi et al., 2016). Typically, most of the previous studies compared carbon fluxes under intact vegetation at plots with different number of pika burrows. However, ecosystem carbon emissions from the homogeneous land surface induced by pika piles and patchiness have yet to be quantified. These are the exact differences between this study and so many previous studies. Yi, S., Chen, J., Qin, Y., Xu, G.: The burying and grazing effects of plateau pika on alpine grassland are small: a pilot study in a semiarid basin on the Qinghai-Tibet Plateau, Biogeosciences, 13(22), 6273-6284, 2016. Materials and methods: Line 114-118: Is there any standard to distinguish the six representative underlying surfaces? Especially how to determine the threshold area for the division of large, medium and small bald patches (i.e. 9 m2 and 1 m2)? Thank you for your careful review. Six representative underlying surfaces were selected according to the previous work in our study site (Yi et al., 2016; Qin et al., 2018). They were distinguished easily in aerial photographs. Large bald patches had less vegetation cover and the smallest side was larger than 3 m. Medium patches also covered by less vegetation cover and the larger side was in a range of 1 to 3 m and small bald patches were characteristic by less vegetation cover and the larger side was less than 1 m. Intact grassland was characteristic by high vegetation cover and no large and medium bare land was found. Pika tunnel and pika pile usually co-exited. Pika tunnel is approximately 6 cm in diameter and pika pile is in the front of pika tunnel, 60 cm in diameter and less vegetation cover. We calculated the threshold area of large, medium and small patches by aerial photograph. Each aerial photograph has 12 million pixels. At a height of 20 m, the resolution of each pixel is ∼1 cm and each photograph covers ∼26 m × 35 m of ground. Pixels in each aerial image were first classified into two groups, i.e. vegetated or bare patches (Yi, 2016). Then patches with different sizes were created using OpenCv Library. And finally, fractions of vegetation and bare patches (large, medium and small patches) were calculated. We revised this part as follow (Line 114-118). “At early June 2016, three 100 m × 100 m plots were established as replicates. In each plot, six representative land surfaces were selected: (1) large bald patch with size larger than 9.0 m2 (LP),

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(2) medium bald patch with size of 1.0-9.0 m2 (MP), (3) small bald patch with size of less than 1.0 m2 (SP), (4) intact grassland patch (IG), (5) above pika tunnel (PT), (6) old pika pile (PP) (Figure 1) (Yi et al., 2016; Qin et al., 2018)." Yi, S.H., 2016. FragMAP: a tool for long-term and cooperative monitoring and analysis of small-scale habitat fragmentation using an unmanned aerial vehicle. Int. J. Remote Sens. 1-12. http://dx.doi.org/10.1080/01431161.2016.1253898. Yi, S., Chen, J., Qin, Y., Xu, G.: The burying and grazing effects of plateau pika on alpine grassland are small: a pilot study in a semiarid basin on the Qinghai-Tibet Plateau, Biogeosciences, 13(22), 6273-6284, 2016. Qin, Y., Yi, S., Ding, Y., Xu, G., Chen, J., Wang, Z.: Effects of small-scale patchiness of alpine grassland on ecosystem carbon and nitrogen accumulation and estimation in northeastern qinghai-tibetan plateau, Geoderma, 318, 52-63, 2018. Line 124-136: Were the soil temperature and moisture measured at all three 100 m $\times$ 100 m plots or only one 100 m $\times$ 100 m plots? Thank you for your question. Soil temperature and moisture were measured in one 100 m $\times$ 100 m plot where ecosystem respiration was measured. Both soil temperature and moisture were measured with three replicates under each underlying surface type. We revised this part to eliminate the confusion (Line 124-127). "Soil temperature and moisture at 10 cm were measured in a 100 m $\times$ 100 m plot where ecosystem respiration was measured by using an auto-measurement system (Decagon Inc., USA) from early June to the late August. The system consisted of an EM50 logger and five 5TM sensors. The data were logged automatically every 30 min" Were the soil saturated hydraulic conductivity, soil hardness and ecosystem respiration rates measured for only one time or many times during the study periods? These key questions should be clarified. Thanks for your suggestion. Soil saturated hydraulic conductivity and soil hardness under each surface type were measured one time every month from June to August. Ecosystem respiration was measured every 7-10 days from June 16 to August 20 depending on weather conditions. We therefore revised this part as follow (Line 124-155). "Soil temperature and moisture at 10 cm were measured in a 100 m $\times$ 100 m plot where ecosystem respiration was measured by using an auto-measurement system (Decagon Inc., USA)

from early June to the late August. The system consisted of an EM50 logger and five 5TM sensors. The data were logged automatically every 30 min. Soil saturated hydraulic conductivity and compactness were measured once each month from June to August. Soil saturated hydraulic conductivity was measured by Dual Head infiltrometer (Decagon Inc., USA). The measurement process included 15 min soak time, 20 min hold time at low pressure head (5 cm) and high pressure head (15 cm) with 2 cycles. Each measurement takes 95 min altogether. Soil compactness was measured with TJSD-750 (Hangzhou Top Instrument co., LTD, Hangzhou, China) from the soil surface to 10 cm depth. Ecosystem respiration rates were measured using the LICOR-8150 Automated Soil CO2 Flux System, which was an accessory for the LI-8100A with at most 8 individual chambers at one time. Ecosystem CO2 emission was sampled and controlled by the LI-8100A Analyzer Control Unit. The air temperature inside of the chamber was measured using the internal thermistor of the chamber. The ecosystem CO2 fluxes were calculated by the equation as follow.

where Fc is the soil CO2 efflux rate (μmol m-2 s-1), V is volume (cm3), P0 is the initial pressure (kPa), W0 is the initial water vapor mole fraction (mmol mol-1), S is soil surface area (cm2), T0 is initial air temperature (°C), and ∂C'/∂t is the initial rate of change in water-corrected CO2 mole fraction (μmol-1 mol s-1). Six LICOR-8100-104 long-term opaque chambers (20cm in diameter LICOR, Inc., Lincoln, NE, USA) were used to measure alternately between three replicates for six land surface types. Therefore, 3 days at least were required to complete one rotation measurements of ecosystem respiration. To measure ecosystem respiration, eighteen polyvinyl chloride collars with a 20 cm inner diameter and a 12 cm height were inserted into the soil with 3-4 cm exposed to the air (Qin et al., 2013). All of the collars were installed at least 24 h before the first measurement to reduce disturbance-induced ecosystem CO2 effluxes. Ecosystem respiration rates were measured every 7-10 days from June 16 to August 20 in 2016 depending on weather conditions. A round-the-clock measurement protocol was carried out and ecosystem respiration rates were measured every 30 minutes. Each measurement takes 1 minute and 45 seconds, including pre-purge

10 seconds, dead band 15 seconds, observation length 1 minute and post-purge 20 seconds." Line 138-141: How depth was the pika tunnel? Did this depth limit the collection of soil core to 40 cm? Thanks for your question. We investigated pika tunnel by digging soil pole and the depth of pika tunnel was about 40cm. Therefore, it wasn't difficulty to collect soil core at depth of 40cm. We have revised this part as follow (Line 157-164). "Soil samples were collected during the periods of late July to early August 2016. In each surface type of each plot, five soil cores were collected using a stainless-steel auger (5 cm in diameter) at depths of 0-10, 10-20, 20-30 and 30-40 cm, and bulked as one composite sample for each depth in each quadrat. Another five soil cores were sampled by cylindrical cutting ring (7 cm in diameter and 5.2 cm in depth) to determine soil bulk density from each land surface type. Pika tunnel was approximate 6 cm in diameter and 40 cm in depth. Therefore, soil samples were available to collect at depth of 40cm. Totally, 512 soil samples were collected." Discussion: Line 216-217: "Nevertheless, the increased water infiltration was unable to increase soil moisture under pika pile." Why? The potential reasons should be discussed. Thanks for your suggestion. We discussed the reason why the increased water infiltration was unable to increase soil moisture under pika pile as follow (Line 263-271). "Nevertheless, the increased water infiltration was unable to increase soil moisture under pika piles. For example, soil moisture under pika piles was approximate 5 % lower than intact grassland (Figure 4). Our result was discrepant with previous studies which reported old pika mound had the highest soil moisture during the summer (Ma et al., 2018) and moderate pika burrowing activities increased surface soil moisture (Li and Zhang, 2006). This difference may be contributed to the high pika density in alpine meadow (Guo et al, 2017). Moreover, pika piles were loose (Figure 6) with less vegetation cover (Figure 8), which was not beneficial for soil moisture storage." Line 227-229: The explanation for the low soil moisture under bald patches was not convincing, because the vegetation transpiration at intact grassland may be higher than the corresponding soil evaporation under bald patches at the same periods. Thanks for your comment. In fact, we have measured evaporation

under different surfaces of the intact grassland, isolate grassland, large patches, medium patches and small patches since the early June 2016. It is difficult to measure evaporation from pika tunnle and pika pile due to their small sizes. Therefore, these data were not presented in this manuscript. We found that the evaporation under bald patches were higher than the intact grassland in our study sites through three years observation. We have revised this part as follow (Line 288-297). "Our results showed that soil moisture under large and medium patches decreased 10 % than intact grassland (Figure 4). Previous studies had reported that the soil compaction of bald patches decreased the rate of water infiltration (Wuest et al., 2006; Wilson and Smith, 2015), which was similar with our results showed that bald patches had less saturated soil hydraulic conductivity (Figure 5). Low vegetation cover under bald patches was not beneficial for water retention and utilization, where most of soil water was mainly lost as a way of evaporation (Yi et al., 2014). We have measured evaporation of the intact grassland, isolate grassland, large patches, medium patches and small patches since the early June 2016. Three years results indicated that evaporation under bald patches were higher than the intact grassland (data were not shown here)." Line 230-233: More details about the reason for the different soil temperature patterns should be added. Thank you for your suggestion. We have added more detailed information about the difference of soil temperature between intact grassland and pika pile and bald patches. This part has been revised as follow (Line 301-309). "Our results indicated that soil temperature under pika piles and bald patches was approximate 1 to 3 °C higher than intact grassland (Figure 4), which mainly resulted from the heterogeneity of surface albedo, surface soil water retention, heat conduction properties and radiation (Beringer et al., 2005; Pielke, 2005; Yi et al., 2013; You et al., 2017). It was suggested that pikas disturbance create a better soil temperature buffer for them to avoid the extreme cold in winter (Ma et al., 2018), whereas high soil temperature under bald patch was a disadvantage for the recovery of vegetation because patch surface had the smallest soil moisture content (Figure 4) and the largest daily range of soil temperature (Ma et al., 2018)." Line 234-235:

What is the reason for the description of “high soil temperature under bald patch was a disadvantage for the recovery of vegetation”? Thank you for your question. Our study site belongs to semi-arid region, where water was one of dominant limit factors for vegetation growth. Patch surface had the smallest soil moisture content and the largest daily range of soil temperature, which was not beneficial for soil water retention. We have changed this part as follow (Line 305-309). “It was suggested that pikas disturbance create a better soil temperature buffer for them to avoid the extreme cold in winter (Ma et al., 2018), whereas high soil temperature under bald patch was a disadvantage for the recovery of vegetation because patch surface had the smallest soil moisture content (Figure 4) and the largest daily range of soil temperature (Ma et al., 2018).” Ma, Y.J., Wu, Y.N., Liu, W.L., Li, X.Y., Lin, H.S.: Microclimate response of soil to plateau pika’s disturbance in the northeast qinghai-tibet plateau, European Journal of Soil Science, 69(2), 232-244, 2018. Technical corrections: Line 33: Delete “under”. Thank you for your suggestion. We have deleted “under” according to your suggestion. Line 88-90: This sentence is not exact, because lots of previous researches have studied the heterogeneous underground vegetation and belowground soil properties. Thank you for your suggestion. We totally agree with your comment that lots of previous researches have studied the heterogeneous underground vegetation and belowground soil properties. However, few studies have investigated the difference of ecosystem respiration under the heterogeneous underlying surface. Therefore, we have changed this sentence to “Nevertheless, most of these studies have mainly focused on ecosystem carbon emission rate under the homogeneous land surface rather than heterogeneous land surfaces.” (Line 88-90) Line 188-189: This sentence has the same mean with the sentence in line 185-186. Thank you for your suggestion. We have deleted this sentence according to your suggestion. Line 197-198: According to the description in line 172, the growing season in the study is from May to September. Please add the data about ecosystem respiration in May and September. Thank you for your suggestion. Actually, our field observation started at the early June and finished at the late August in 2016. It’s pity we can’t add the data of ecosystem respiration in May and September. Line 214: Change "Figure 3" to "Figure 4". Thank you for your suggestion. We have changed "Figure 3" to "Figure 4" according to your suggestion. Line 311: Some references cited in the text were not listed in the "Reference" section. Thank you for your suggestion. The references have been checked carefully through manuscript according to your suggestion. And now all the references cited in the manuscript are also included in the "Reference" section. Line 518-520: Six small photos below the aerial photo are not clear. Moreover, add "MP" after "2". Thank you for your suggestion. We have redrawn Figure 1 according to your suggestion. We also add "MP" after "2". We believe that the photos are clear now. Line 539: The regression analysis was used to analyze the relationships of ecosystem respiration with biotic and abiotic factors (line 168-169). However, the result in figure 9 was only the correlation coefficient between them. Thank you for your suggestion. We have redrawn Figure 9 according to your suggestion and now it contained both the correlation coefficients and P value in one figure. The title of Figure 9 was changed to "Figure 9. The correlation coefficient charts between ecosystem respiration (Re) and biotic and abiotic factors for all six land surfaces. The diagonal line in the figure shows the distributions of the variables themselves. The lower triangle (the left bottom of the diagonal) in the figure shows scatter plots of the two properties. The upper triangle (the upper right of the diagonal) in the figure indicates the correlation values of the two parameters; the asterisk indicates the degree of significance (*** indicates significant differences at $P < 0.001$, * indicates significant differences at $P < 0.01$, * indicates significant differences at $P < 0.05$.). The bold bigger numbers mean the higher correlation."

Please also note the supplement to this comment:
https://www.biogeosciences-discuss.net/bg-2018-296/bg-2018-296-AC1-supplement.pdf

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