Reply comments on reviewer 1#:

Specific comments

1. Experimental warming is widely used in ecological research to help to understand changes in carbon stocks and fractions, and the related processes resulting from climate change. However, experimental research in the open field on the response of freeze-thaw processes and the active layer of permafrost-affected soils are rare, at least to my knowledge. In this respect, the paper is a valuable contribution to the scientific discussion on the consequences of global warming. The overall quality of the paper is good and I appreciate the large number of citations in the introduction which gives a very good overview of permafrost research on the Tibet plateau.

Reply: Thank you very much for such a highly positive evaluation of our research. Up to now, *in-situ* experimental research using OTCs warming in the field on quantitatively systematic response of freeze-thaw processes and permafrost is extremely rare in the Qinghai-Tibet Plateau. The main objectives of this manuscript with regard to the permafrost regions of the central the Qinghai-Tibet Plateau were to quantitatively assess the response characteristics of freeze-thaw processes including air freezing/thawing index and soil freeze-thaw processes, and permafrost represented by active layer thickness in the alpine swamp meadow and the alpine steppe ecosystems to OTCs experimental warming based on the monitoring data of air temperature and soil hydrothermal condition during 2009-2011.

2. I would be happy if some more findings from ecology and soil science could be added (e.g. Baumann et al. Global Change Biology 15, 3001-3017 (2009), doi: 10.1111/j.1365-2486.2009.01953.x, He J-S et al. New Phytologist, 170, 835–848 (2006), Geng Y et al. PLoS ONE 7 (4): e34968. (2012), doi:10.1371/journal.pone.0034968).

Reply: Thanks for your suggestions. We have added these findings (He et al., 2006; Baumann et al., 2009; Geng et al., 2012) into our revised manuscript. Three references are as following:

Baumann, F., He, J., Schmidt, K., Kühn, P., and Scholten, T.: Pedogenesis, permafrost, and soil moisture as controlling factors for soil nitrogen and carbon contents across the Tibetan Plateau, Glob. Change Biol., 15, 3001–3017, doi: 10.1111/j.1365-2486.2009.01953.x, 2009.

Geng, Y., Wang, Y., Yang, K., Wang, S., Zeng, H., Baumann, F., Kuehn, P., Scholten, T., and He, J.: Soil respiration in Tibetan alpine grasslands: belowground biomass and soil moisture, but not soil temperature, best explain the large-scale patterns, PLoS ONE, 7, e34968, doi:10.1371/journal.pone.0034968, 2012.

He, J., Wang, Z., Wang, X., Schmid, B., Zuo, W., Zhou, M., Zheng, C., Wang, M., and Fang, J.: A test of the generality of leaf trait relationships on the Tibetan Plateau, New Phytol., 170, 835–848, doi: 10.1111/j.1469-8137.2006.01704.x, 2006.

3. The results section has many sentences that consist of data rows. I suggest to shorten the text and present the data in tables.

Reply: Thank you for your suggestions. We have omitted some sentences that consist of data in the Results section. However, it is still unclear that diurnal to annual variations of some variables (e.g., soil temperature) owing to OTCs experimental warming are quantitatively exhibited by Figures (e.g., Fig.4, Fig. 7). Therefore, we need to retain some sentences that include data based on Figures. Moreover, these data are difficult to be further presented clearly by Table.

4. The introduction to the discussion (p7, l37 to p8, l8) could better be integrated into the introduction section. This holds true for quite some parts of the following paragraphs of the discussion section.

Reply: Thanks for your opinions. We have integrated the part (p7, l37 to p8, l5) in the Discussion section into the part (p2, l7 to l13) in the Introduction section in the revised manuscript. However, the part (p8, l6 to l8) in the Discussion section is still retained as a guidance of OTCs experimental warming. Thus, the Introduction section is revised into:

The fifth assessment report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) indicated that the global average surface temperature had increased by 0.85 (0.65 ~ 1.06) ^{o}C over

the period of 1880 to 2012, and the change for the end of the 21st century would be likely to exceed 1.5 ºC than the average from 1850 to 1900 (IPCC, 2013). Likewise, the Qinghai-Tibet Plateau (QTP) has experienced a universal and significant warming (Wu and Zhang, 2008; Li et al., 2010; Wu et al., 2013), the recent warming rate has been greater than those for the northern hemisphere, the southern hemisphere and the world as a whole (Trenberth et al., 2007). Mean annual temperature in the QTP has increased by 0.2 ºC per decade over the past 50 years, and is expected to increase 2.6-5.2 ºC by 2100 under the A2 and B1 scenarios (Chen et al., 2013).

5. As mentioned in the title of the manuscript, processes of freeze-thaw cycling would play a central role. I would suggest to extend the discussion of such processes. Instead, I would leave out the objectives to estimate the release of old carbon and to evaluate the stability of Qinghai-Tibet Railway/Highway since I couldn't find any own results on this issue in the manuscript.

Reply: Thanks for your suggestions. In this study, we used the monitoring data of air temperature and shallow soil hydrothermal condition within and without OTCs during 2009-2011, to quantitatively assess response of freeze-thaw processes including air freezing/thawing index and soil freeze-thaw processes, and permafrost figured by active layer thickness in two typical alpine grassland ecosystems to OTCs experimental warming in the permafrost regions of the central Qinghai-Tibet Plateau. Until now, a quantitatively systematic research on the response of these variables to climate warming is extremely rare in the permafrost regions of the Qinghai-Tibet Plateau. As mentioned in the title of the manuscript, freeze-thaw processes (include freezing/thawing index and soil freeze-thaw processes) and permafrost (implied by permafrost regions) would really play the central roles. Therefore, these above variables were mainly discussed in this manuscript. In addition, we also discussed moderately the method of OTCs warming, variations of air temperature and shallow soil hydrothermal condition under the OTCs experimental warming. However, it is our hope that this work could greatly provide the scientific references on further assessing the infrastructure stability (e.g., the Qinghai-Tibet Railway/Highway), soil carbon release and alpine ecosystem health in the permafrost regions of the Qinghai-Tibet Plateau under the future climate warming. It just highlight the importance of our

research at present, and need to be intensively studied in the future. We have added some studies of soil freeze-thaw processes in the Discussion section as following:

The near-surface soil freeze-thaw processes is an important indicator of climate change, which is primarily controlled by air temperature (Wang et al., 2015). Using data from 636 meteorological stations across China, Wang et al. (2015) found that the onset date of near-surface soil freezing was delayed by about 5 days, and the frozen days decreased by about 10 days over the period 1956-2006.

In addition, we have also merged the part (p10, l33 to l36) and the part (p11, l18 to l23) in the Discussion section, and revised into:

However, numerous studies have showed that changes in not only freeze-thaw processes but also permafrost triggered by climate warming, strong affected vegetation productivity, soil physicochemical properties, carbon feedback and engineering infrastructure, etc. (e.g., Grogan et al., 2004; Qi et al., 2006; Zimov et al., 2006; Kreyling et al., 2008; Wang et al., 2009; Chen et al., 2012a; Hicks Pries et al., 2016). Therefore, it is very necessary for us to further conduct the systematic monitoring research that extremely limited in the permafrost regions of the QTP in the future.