Dear Professor Beer,

We are grateful to you for the helpful and constructive suggestions and comments. We have made a major revision to address all issues raised by you, which we believe improved the manuscript substantially. The revised contents were marked with red fonts in the text. We highlight here how we have addressed your suggestions.

1) Fig 3. Please discuss further the overestimation in spring and underestimation in autumn by the (temperature-driven) model.

We acknowledged that our models have limitation due to low sampling frequency and the limited sampling time of a day due to harsh field conditions and logistic restriction. However, the RMSE values and the similar variation trends between modelled and measured Rs suggest that our model is still valid with the information we gather. We discuss this in the text as:

At AF stage, exponential regression analysis was carried out with fewer measured R_s values because the duration was shorter than other stages. The modeled R_s fluxes was generally lower than that measured during this stage (Fig.3). These biases between the measured and modeled R_s fluxes were likely to be caused by sampling scheme. The low sampling frequency (two occasions for daily average data) in the period of AF could increase the variance of aggregated estimates (Ryan and Law, 2005). In addition, measurements during this stage were usually restricted to daytime and dry days, and the sampling would inevitably miss the pulse of microbial or root activity immediately following occasional precipitation (Sotta et al., 2004). Thus, the cumulative R_s (143.74 to 157.34 gCO_2/m^2) calculated by an exponential model only accounted for about 8.89% of the total R_s emission in a complete freeze-thaw cycle, which probably underestimated the R_s emission during this stage. Although the active layer gradually became a closed system in this stage, it is noteworthy that a proportion of respired soil CO_2 can still be transported via vascular plants, which may function as a conduit for CO_2 from deeper soil layers (Ström et al., 2005). Furthermore, the diurnal freezing and thawing actions occurring in this stage also played an important role on the R_s emissions (Contosta et al., 2013). Therefore, more frequent observations with automated chambers incorporating vegetation function are warranted to refine the estimated R_s at AF stage in this study.

At SW stage, the modeled R_s fluxes showed a rising trend in the ranges from 0.42 to 0.72 $\mu mol/m^2s$, and were generally higher than those measured in 2017 (Fig.3). These biases may also be caused by low sampling frequency and simple averaging for daily average data in regression analysis (Ryan and Law, 2005). The diurnal freezing-thawing process during this stage also stimulated the activities of soil microorganisms and promoted the R_s emissions, but the low sampling frequency and the restricted sampling time (between 9:00 and 11:30 a.m. local time) probably missed the peaks and pulses of R_s fluxes of a day. Therefore, the measured R_s flux may underestimate the actual emission rate in this stage. However, it is also reported that biases of chamber-based estimates of R_s can be reduced by using a regression model which is extrapolated with soil temperature and moisture (Ryan and Law, 2005). In addition, the smaller value of *RMSE* at this stage also testified the temperature-driven model was preferable for the R_s prediction (Fig.5). Thus, the cumulative R_s (181.43–198.37 gCO_2/m^2) calculated by the exponential model was estimated to be 11.29±0.11% of the total R_s emission in a complete freeze-thaw cycle. Despite of the possible biases between the modeled and measured R_s fluxes, our model is still a reliable estimate for R_s emission during this stage, which is further supported by the same trends in the variations between the two values. The increasing trend in R_s fluxes can be caused by the following mechanisms: First, the activation of soil respiration was mediated by increased soil microbial activities as soil temperature and water content increased. Furthermore, as spring proceeds with warming of soil, the mobilization of stored carbohydrates enhanced soil respiration (Davidson et al., 2006). Finally, daily freeze-thaw actions in late April may have further enhanced the soil respiration quickly.

2) Fig. 4: I assume the data are observations? Please, clarify in the caption.
Yes, and we clarified it in the caption.
Fig. 4. Relationship between soil temperature and moisture at 5cm depth and measured R_s flux for the summer thawing stage (ST), autumn freezing stage (AF), winter cooling stage (WC), and spring warming stage (SW)

3) Fig 6 and discussion 4.1.: Please, justify why these model results are important for our understanding of the processes. In Fig 4 we see that the model results are biased in spring and autumn, why are these results now used for understanding the processes and not the observations. For example, in Fig 6, AF stage, observations decrease and are not stable over the time. What do we learn here from the model results that are also only driven by temperature?

Soil respiration (R_s) is the major pathway for carbon exiting terrestrial ecosystems and it has been treated as strictly a heterotrophic process in many models and syntheses with responding to temperature or moisture (Kicklighter et al.1994; Raich and Potter 1995). For the heterotrophic process, soil temperature and moisture are the two important factors to influence the enzyme activities and amount of substrate pool and hence microbial respiration (Pendall et al. 2004). However, for the active layer in permafrost regions, the biggest characteristic of the freeze-thaw process was its complex variations in soil temperature and moisture and the changes of soil temperature and moisture content at different freeze-thaw stages again affected the soil microbial activities, aeration status, and biochemical properties, which regulated the R_s. According to the characteristics of soil temperature and water change, the freezing-thawing cycle of active layer can be divided into processes of cooling, start freezing to fully freezing, dropping in temperature, rising in temperature but still in frozen state, start thawing to fully thawing, and rising in temperature but in thawed state (Jiao and Li, 2014). So, we determined the R_s, the soil temperature and moisture of the different freezing-thawing processes and used a regression model with soil temperature or moisture to reduce the variance of aggregated estimates under the conditions of harsh environmental conditions and lack of manpower with low sampling frequency. In addition, although biases existed between the modeled and measured R_s fluxes especially in the AF (autumn freezing) and SW (spring warming) processes in the present study, *RMSE* analysis showed that the exponential models of R_s were preferable for R_s prediction at different freeze-thaw process (*RMSE*<0.67). Hence, we think these model results are important for our understanding of the processes. For

the problem of low sampling frequency, resulting in greater biases between the modeled and measurement R_s fluxes, especially in the AF and SW stages, we will take more frequent observations with automated chambers to refine the estimated R_s in the follow-up work.

In Fig.4, we made a regression analysis basing on the measured R_s fluxes and soil temperatures at 5cm depth and have clarified its caption. The reasons why the model results were used for understanding the processes and not the observations, especially when the model results were biased in spring and autumn are: First, due to harsh environmental conditions and lack of manpower especially in winter seasons on the Qinghai-Tibet Plateau, measurements with low sampling frequency were just undertaken, the peaks and pulses of R_s fluxes could have been missed; Second, low sampling frequencies easily increased the variance of aggregated estimates but using a regression model with soil temperature is a preferable method to reduce the variance of aggregated estimates (Ryan and Law, 2005).

In the present study, from the model results that are also only driven by temperature, we learn that although the rates of soil respiration are usually positively correlated to soil temperature, soil moisture can easily become a limiting factor when the soil moisture content is high (for example at the ST stage) during the freezing-thawing processes of active layer. In fact, multiple factors usually interactively affected the soil respiration but we cannot separate their interactions completely. In addition, we also find that the soil respiration is not sensitive to moisture under low temperatures. For example, when the soil temperatures were below 2°C at the SW stage, R_s fluxes didn't have big ups and downs as the soil moisture fluctuated greatly (Fig.6d). This result is well consistent with the study by Luo et al (Luo and Zhou, 2006). Similarly, soil respiration is not very sensitive to temperature under low moisture (below 7%). Among all the different freezing-thawing processes, the AF process maybe is special due to the active layer gradually developing from an open system into a closed one as the surface soil became frozen. The free exchanges of gas between the active layer and atmosphere were blocked. As a result, the soil respiration fluxes were not well correlated with soil temperatures or moistures. So, much more effort is needed to find an indicator to strongly link the soil respiration and the freezing-thawing process of active layer.

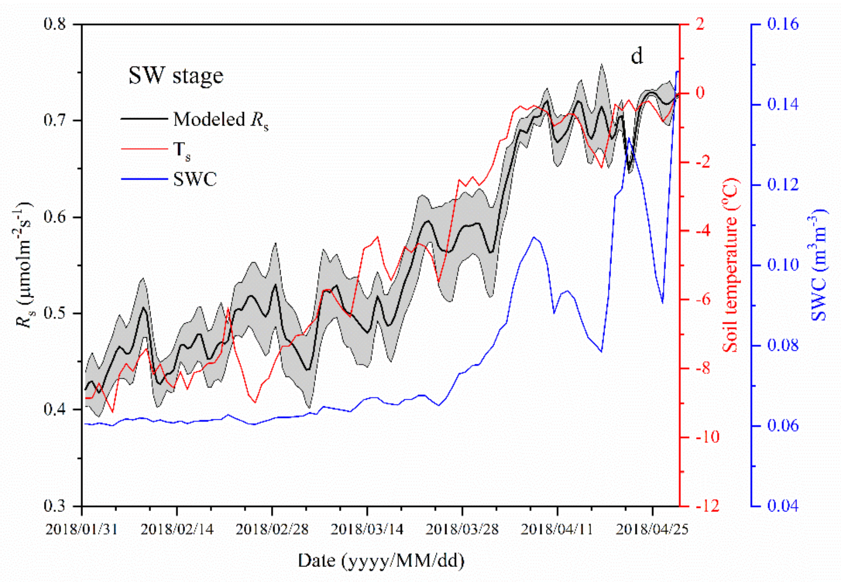

Fig.6d. Variations in modeled soil respiration (R_s), soil temperature (T_s) and soil water content (SWC) for the SW stage. The SWC unit stands for water volume per total soil volume. The error band of modeled R_s stands for 95% confidence interval.

Minor: Please, add figure captions a,b,c etc. for clarity.

We have added a, b, c etc. in the figure captions.

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