Reply comments on reviewer 2#:

The manuscript" Thermal impacts of engineering activities on permafrost in different alpine ecosystems in Qinghai-Tibet Plateau, China" presents measurements of the ground thermal regime in a range of settings impacted by construction activities. Although the manuscript contains a number of interesting data sets and findings, I do not recommend the manuscript for publication in TC, unless serious revisions are conducted by the authors. In particular, the authors present a number of interpretations for their measurements which are not well enough supported. This could be done by a) a statistical analysis of a sufficient number of samples (= boreholes in this case which is most likely difficult to achieve), or b) a careful, at least semi-quantitative argumentation involving the physics of the system, in particular the heat fluxes related to the thermal properties of the different parts/layers of the system and possibly the radiative forcing at the surface, or c) a study with a 2-dimensional ground thermal model considering the points raised under b).

Reply: We are very thankful for the comments of our manuscript and good suggestion. We try to add data measurement of three boreholes to further support our findings.

Major points:
The manuscript presents and discusses a lot of measurements in great detail (which is OK). However, some of the conclusions on the underlying processes, although not implausible, are not directly supported by the measurements. Although a number of boreholes exist, their number is too small for a statistical analysis that could secure the interpretations given by the authors. On the other hand, no data on the processes themselves are presented. In the following, I comment on the different results and conclusions as given in the abstract (l. 12 ff): "The results show that alpine meadows on the Qinghai–Tibet Plateau can have a controlling role within engineering construction effects on permafrost beneath embankments. "Why not also alpine steppes? Their controlling role would be different, but they would still have a controlling role?

Reply: When railway embankment constructed, the vegetation layer can be remained. The vegetation in alpine meadow can prevent heat conducting, because the vegetation layer in an alpine meadow in Qinghai-Tibet Plateau has thicker humus soils with a small thermal conductivity. Although a vegetation layer of alpine steppe were remained, there is not any humus soil with sparse vegetation. So, soil with sparse vegetation layer has pressed, heat insulation can be found. We adds some interpretation in discussion as follows:

This is because the vegetation layer in an alpine meadow has thicker humus soils with a small thermal conductivity, reducing heat amount conduct down.

“The artificial permafrost table (APT) beneath embankments is predominantly controlled by alpine ecosystems, : : :” Is this not a direct consequence of different ALTs before construction?

Reply: Thank you. It is my fault. I have not clearly show my mean. We revised as following:

As before railway constructed, the artificial permafrost table (APT) beneath embankments is predominantly affected by alpine ecosystems, but the change rate of APT is not closely related with those ecosystems, but dominantly affected by climate change and engineering activities.

“: : : but the change rate of APT is not closely related with those ecosystems. “ Is it possible to draw this conclusion from the few boreholes, considering that the spatial variability could be quite high?

Reply: Thank you for your comments. We add some data measurement of four boreholes to explain this view. These data newly adding show the same result, seeing in Table 3.

“it is mainly related with cooling effects of railway ballast and heat absorption effects of asphalt pavement.” No evidence for this is presented, although it is a plausible conclusion.

Reply: Thank you for your comments. Except the effect of climate change, APT change is contributed to engineering activities. ALT in Qinghai-Tibet Plateau show a continuously increased trend, this result can be documented in many literature (Wu et al., 2012, The Cryosphere; Li, et al., 2012, Chinese Sciences Bulletin; Wu et al., 2015, Global and Planetary Change, listing in the reference). So, the trend of APT decreasing beneath railway embankment and increasing beneath highway can certainly contributed to the cooling effect of railway ballast and heat absorption heat of asphalt pavement because these data from general embankment without any measures of keeping cooling. So, this conclusion is plausible.

“Variation of soil temperature beneath embankments is independent of alpine ecosystems, but variation of mean annual soil temperature with depth is closely related to those ecosystems.” It is not clear to me what the authors mean with that and how this could be explained in terms of changing energy content of the soil.

Reply: Thank you for your comments. We may explain unclearly. Variation of soil temperature beneath embankment seems to be difficult to show the difference between alpine meadow and steppe, but we can easily see the difference of mean annual soil temperature with depth. So, we revised it as follows:

Variation of soil temperature beneath embankments is difficult to identify the difference between alpine meadow and alpine steppe, but variation of mean annual soil temperature with depth can be easily found out the difference between alpine meadow and steppe.

“The vegetation layer in alpine meadows can have an insulation role within engineering activity effects on permafrost beneath embankments. “ The problem is that the data set does not allow differentiating between the effects of road pavement/railroad grade vs. vegetation removal/no vegetation removal. It is at least possible that the described effects are entirely due to the different heat transfer processes in the roadbed and railroad grade.

Reply: Thank for your comments. We infer that the vegetation layer in alpine meadow can play an insulation role on underlying permafrost based on the mean annual soil temperature with depth. The data set cannot be differentiating this effect of road/railroad vs. vegetation, we need special research design to study this problems. On the different heat transfer processes in the roadbed and railroad grade, we simply explain that ballast pavement of railway has a strong air convection effect, it may have a cooling effects by many literatures, and asphalt pavement has a strong heat absorbed effect by many literatures. We specially study the physical mechanics of asphalt pavement by energy balance, but ballast pavement not. Except pavement has a difference with different heat transfer, the heat transfer of roadbed and railroad grade is same because filled soil is same.

“This insulation role is an advantage for alleviating permafrost temperature rise in the short term,” I agree with this finding, the around ten-year time series supports this. “but a disadvantage in the long term because of climate warming, suggesting that vegetation layer in alpine meadow should be removed upon initiating engineering construction” No evidence for this conclusion is presented.

Reply: Thank you for your comments. We cancel this conclusion.

-What happens to the insulating vegetation layer when it is buried under the railroad grade? How thick is this vegetation layer, and how would the heat transfer through this layer interact with the heat transfer through the railroad grade/road bed during different times of the year? How would lateral heat transfer play a role? Could the different geometries of the roadbed/the railroad grade play a role? Is it certain that winter snow cover can entirely be neglected in the discussion (the authors state that there is no steady or winter-long snow cover)? Is there snow accumulation at the shoulders of the road/railroad? What causes the significant offset between MAAT and MAGT (Table 2) if it is not snow? Is this related to radiative heating of the surface and thereby caused difference between MAAT and MAGST?

Reply: Thank you for your comments. You propose many problems being worth to study. Indeed, we cannot answer your problems now, because we may require special study design to study these problems. On the different geometries of the roadbed/the railroad grade, it have strong different heat effect of sunny-shadow slope, there are many paper to study this problems. In Qinghai-Tibet Plateau, no stable snow cover will accumulate at the shoulder of the road/railroad. MAGT is the temperature in the depth of 12 to 15 m beneath ground surface, heat transfer cause the offset between MAAT and MAGT. The offset between MAAT and AMGST is significant as the radiative heating of the surface.

Please revise the English language!

Reply: English language of our manuscript was revised by scientist of native English.

Minor point：
L. 32: How do you define alpine meadow and alpine steppe?

Reply: we define alpine meadow and steppe based on dominant species and vegetation cover.

L. 38: Please explain what is meant with “increasing permafrost table”?

Reply: L. 38, increasing of permafrost table means that permafrost table is deepening.

L. 54: How are the conclusions of the study influenced by the fact that the boreholes in alpine meadow are at the centerline of the QTR, but at the shoulder for alpine steppe?

Reply: Thank you for your comments. Because soil temperature at the centerline of the QTR has not been set from railway pavement to 20m for alpine steppe, we substitute soil temperature at the centerline of the QTR by using data from two shoulder of the QTR. This may have some heat effect of embankment slope, but it cannot change our understanding.

Fig. 1: What is meant by “Country” in the figure legends?

Reply: Sorry, it should be “country”.

l. 107: I don‘t understand this sentence. What is meant by “cool energy” and why should this be the case?

Reply: Thank you for your comments. “cool energy” means the amount of heat release in winter. So, we revised:

“cool energy” is revised into the amount of heat release.

l. 124: What is meant by “contributed”? Wouldn’t it rather be “caused by”?

Reply: Thank you. We revised “contributed” into “attributed to”

l. 126: What is meant exactly by “engineering activity increase of APT”?

Reply: Sorry, this sentence seems to be repeated. We cancel it.

l. 175: But this vegetation layer will decay and compress over time, thus changing its thermal properties? Is there any evidence how the “vegetation layer” under the railway looks today and how fast this process of decay/compression has occurred/is occurring?

Reply: Thank you for your comments. I absolutely agree with your opinion. From the view of Fig. 8, the temperature gradient from vegetation layer to a depth beneath embankment is gradually decreasing and trend of permafrost warming is gradually weakening, indicating the heat insulation effect of vegetation will decay. We add some explanation. At the same times, we revised the conclusions by adding the mentioned explanation. Thank you, you give us a right conclusion.

From the view of Fig. 8, the temperature gradient from vegetation layer to a depth beneath embankment is gradually decreasing and trend of permafrost warming is gradually weakening, indicating the heat insulation effect of vegetation will decay.

This suggests that vegetation layer of alpine meadow has an insulation role within the effects of engineering activities on permafrost beneath embankment, but insulation role is gradually disappeared because this vegetation layer will decay and compress over time. On the whole, this vegetation layer is an advantage for alleviating permafrost temperature rise in the short term, but this role is gradually weakened in the long-term.

l. 183: I don’t think that QTH and QTR are really comparable – one is a road, the other one a railroad grade, with completely different thermal properties. It is thus not necessarily clear that the described effect on ground temperatures is due to the vegetation layer.

Reply: Thank you for your comments. Although embankment pavement is different, filled soil of embankment is same,

l. 217: Why is it a disadvantage? I don’t think this follows from this study; at least no evidence for this is presented.

Reply: Thank you. According to your comments, we re-revise our conclusion. On the whole, vegetation layer is advantage.