Interactive comment on “Controls on the distribution of the soil organic matter in mountain permafrost regions on the north Qinghai-Tibet Plateau” by C. Mu et al.

Anonymous Referee #2

1. This manuscript tried to clarify the main factors for affecting the SOC densities in the Tibetan Plateau based on dataset from the far north corner of the Tibetan Plateau, source region of Heihe River, Qilian Mountains. The dataset was valuable in such a data-absent region, specially, the dataset from deeper layer of soils. But the conclusions were general knowledge, which could be found in most related literatures.

Response: Thanks for your acknowledgment of the merits of the data. The general knowledge usually confined to the upper soil layers and it seldom involved the SOC with depth deeper than 2 or 3 m. Moreover, little is concerned about the effects of vegetation and soil texture on deep carbon in mountain permafrost regions.

Since the deep frozen carbon pools in permafrost regions are important to global carbon budget under global warming scenarios, this finding would be helpful to improve our knowledge in the carbon pools in mountain permafrost areas, where with great heterogeneities. In the revised version, we clarified these points. Detailed information was included in the responses of questions 2-7.

2. The concerns and suggestions include:

It could be seen from Figure 1 that all the boreholes are located on the bottom of valley and the lower part (gentle) of the slopes. The sites even could not cover all the surface ecological and geological conditions of the study region. The dataset is so limited, just 10 boreholes to be considered as representatives of 3 types of ground surface conditions (AS, AM and ASM). Furthermore, the sampling sites are located in the far northeast boundary of the Plateau, and the area of the study region accounts for less than ten thousandth of Tibetan Plateau. All the geologic, geomorphologic, geographical and climatic backgrounds are great different from the real plateau. I do think that the dataset collected in this region just can be representative of the local condition, even not as representative of Qilian Mountain Ranges, because the climatic conditions is also great different to the western part of the mountain range. It would be better if the title of the manuscripts revised as "Controls on the distribution of the soil organic matter in the Upper Reach of Heihe River, Qilian Mountains.

Response: Thanks very much for your suggestions. We changed the tile into "Close relationships between deep organic carbon and soil texture with vegetation types in permafrost regions over Heihe River basin, Qilian Mountains, China".

We proposed a schematic diagram (Figure 7) in the revised version, and we explained in the discussion that the result potentially is applicable for the other areas of Qinghai-Tibetan Plateau as below:

"The QTP is a young plateau that was uplifted since Palaeogene epoch, and the parent materials for soils distributed in the vast areas on the plateau were mainly alluvium that associated mountain processes (Zheng and Yao, 2004). Therefore, the sampling area could be potentially considered as an example for the study of SOC distribution for the other areas on the QTP. Since the sampling area for PT sites is less than 100 km^2, and has same meteorological conditions, thus the great differences for SOC among these sites could be attributed to the difference of topography, which affects the SOC via the pedogenesis (Fig. 7). For the deep SOC stocks, the paleoclimatic conditions may also played important roles during the SOC accumulation (Schuur et al., 2009). However, this data is largely unavailable, which limited the further study of deep SOC in mountain permafrost. This study showed that the SOC both in upper layers and deep layers, which could be down to tens of meters, has close relationship with vegetation and soil texture. Although the accumulation process of SOC is difficult to be interpreted in this study due to the lack of chronological sequences of the soil layers, the results demonstrated that vegetation types and soil textures are useful proxies for the predictions of SOC in both upper and deep layers. Since these data are more accessible in regional scale (Li et al., 2015; Wang et al., 2016), it would be possible to upscale the SOC pools in the regional scale using vegetation types and soil texture data in the future."

3. The results in section 3.1 and 3.2 are very general description for soil organic carbon, C:N ratios and stable carbon isotopes. The highest soil organic carbon density was found in boreholes under ASM, and the lowest was at AS. Similar results were reported in great amount of literatures by Wang, et al. and Wu et al., but there is no more new.

Response: Thanks very much. The previous study confined the SOC contents and C:N ratios to the upper layers, however, little is known about their distribution in deep soils. Therefore, we performed this study. In the revised version, we clarified this and emphasized the SOC in deep layers.

In the section 3.1, we emphasized as: “From the upper layers to the deep depth, which down to 20 m, ASM sites (PT9, EB1 and EB2), the SOC densities were much higher than those of AM sites, although there was a decreasing trend along with depth at EB2. The mean SOC densities for the sites ranged from 0.4 to 22.4 kg m^{-3} at different depth….”

We also added the SOC stocks for the different depths, this result may be of interest potential readers since carbon stocks below 2 m depth are rare.

“As shown in Table 2, the SOC stocks for the upper 2 m were highest for ASM sites (varied from 38.39 to 58.20 kg m^{-2}), followed by AM sites (varied from 8.62 to 21.73 kg m^{-2}). The lowest values appeared in AS sites (lower than 5.0 kg m^{-2}). For all the sites, the most SOC was distributed in the upper 6 m. The upper 6 m SOC stocks showed similar trends with those of upper 2 m. The highest SOC was recorded at EB1 site, while the PT9 had higher SOC stocks than that of EB2 since the later had a shallower soil thickness. The SOC stocks for the upper 6 m layers at AM sites varied from 29.7 to 48.5 kg m^{-2}. The SOC stocks were lowest at AS sites.”

Table 2 SOC stocks (SOCC, kg m^{-2}) for different layers for the sampling sites

Site	**0-1 m**	**0-2 m**	**0-3 m**	**0-6 m**	**Active layer**
PT4	9.74±0.62	10.81±1.35	18.17±1.67	38.04±2.09	3.63±0.44
PT5	8.94±0.65	16.05±1.21	20.37±1.87	29.72±3.01	3.42±0.38
PT6	11.84±0.88	21.73±2.04	29.47±3.08	48.51±4.33	2.40±0.14
PT7	5.20±0.48	8.62±0.75	13.20±1.43	29.89±3.05	2.41±0.17
PT9	22.76±2.14	38.39±3.66	57.46±6.35	104.17±7.76	1.63±0.09
EB1	39.62±3.17	58.20±4.43	81.88±7.77	134.46±9.94	1.20±0.05
EB2	34.49±2.43	52.89±3.20	64.24±4.31	69.47±5.66	1.30±0.04
PT10	3.85±0.11	3.91±0.18	4.07±0.32	4.66±0.38	4.85±0.31
PT11	3.91±0.22	4.70±0.27	5.24±0.37	7.25±0.67	6.00±0.60
PT12	0.55±0.04	1.10±0.08	2.36±0.14	7.59±0.51	5.75±0.43

Data were presented as Mean ± SD from measurements of three triplicate samples.

For the 3.2 section, we emphasized as below:

"For samples at different depths including below 2 m depth, the C/N ratio and SOC content had a weak positive relationship for ASM sites (r^2=0.028, p<0.05, Fig. 3a), whereas they had a higher correlation for AS and AM sites (r^2=0.522, p<0.001, Fig. 3b)….."

We hope these revisions would be helpful to highlight the merits of the data for the deep SOC in the permafrost regions.

4. SOC in deeper soil layers should be affected more by paleo-climatic, ecological and geological background of the soil formation. The authors simply correlated SOC with the moisture content and texture (gravel and clay) of the soils. It would be better to add more *information about soil formation history and discuss the controlling factors of SOC for different soil layers separately.*

Response: Thanks for the review. The paleo-climatic, ecological and geological background of the soil formation should be the fundamental mechanisms for the SOC formation and preservation in deep layers. We tried to add such information in the data analysis, however, these data were either largely unavailable or could not be presented quantitatively for statistically analysis. Therefore, we changed the title into "Close relationships between deep organic carbon and soil texture with vegetation types in permafrost regions over Heihe River basin, Qilian Mountains, China"

According to your suggestions, we discussed these in the revised version as below:

"From the basic theory of SOC in permafrost carbon and results from this study, a conceptual framework was proposed as Figure 7. Topography has been long recognized as an important factor in the distribution of permafrost and soil water content (Noetzli et al., 2007), and consequently has important effects on the vegetation types (Wang et al., 2006). The landform determined sediment processes and even soil textures during pedogenesis (Yoo and Mudd, 2008). In this study, the PT9, EB1 and EB2 sites have north facing aspects with poor drainage conditions, and thus belong to swamp meadow types. The distribution of PT sites follows a pattern from mountain hills to mountain foot along with elevation gradients: (PT9, PT6) > PT7 > PT4 > PT5 > (PT10, PT11, PT12). It could be seen that drainage conditions, which usually were greatly affected by microrelief conditions (Schoeneberger, 2002), are extremely important to vegetation types (Tab 1). In QTP, previous studies showed that soil texture, vegetation, and soil water content are of great importance for the existence of permafrost (Wang et al., 2012; Wu et al., 2015). This framework was consistent with the basic theory of SOC accumulation and preservation (Wang et al., 2012; Wu et al., 2015). It has been also known that the fine particles can protect the SOM from decomposition by the adsorption effects (Jardine et al., 1989), and soil water could be a controlling factor in microbial decomposition through limit the microbial growth and oxygen availability (Mu et al., 2016). In addition, soil water content interacts with texture and vegetation (Mohanty and Skaggs, 2001). This study showed close relationships between soil texture, water content, vegetation and SOC. Therefore, the effects of these factors on the SOC could be both direct and indirect, which via the permafrost (Fig. 7). From this schematic diagram, it is obvious that geomorphology is the fundamental factors in the determination of SOC by the mechanisms of pedogenesis."

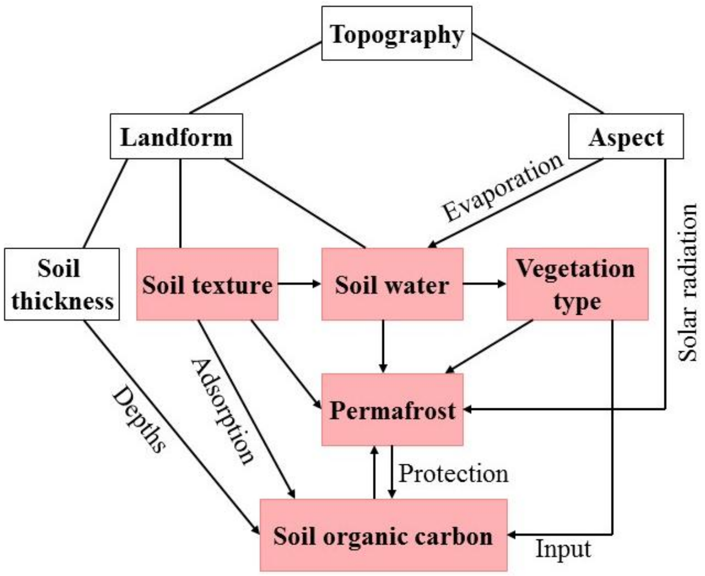

Figure 7 A schematic diagram for the relationship between environmental factors and soil organic carbon (SOC) in mountain permafrost area. The solid lines show the components of environmental conditions, arrows show the direct effect of one factor on the other. There is also another possible effect of

soil water content on the soil organic carbon via affecting the microbial growth and oxygen availability (Mu et al., 2016).

"The QTP is a young plateau that was uplifted since Palaeogene epoch, and the parent materials for soils distributed in the vast areas on the plateau were mainly alluvium associated mountain processes (Zheng and Yao, 2004). Therefore, the sampling area could be potentially considered as example for the study of SOC distribution for the other areas on the QTP. Since the sampling area for PT sites is less than 100 km^2, and has similar meteorological conditions, thus the great differences for SOC among these sites could be attributed to the difference of topography, which affects the SOC via the pedogenesis (Fig.7). For the deep SOC stocks, the paleoclimatic conditions may also played important roles during the SOC accumulation (Schuur et al., 2009). However, this data is largely unavailable, which limited the further study of deep SOC in mountain permafrost. This study showed that the SOC both in upper layers and deep layers, which could be down to tens of meters, has close relationship with vegetation and soil texture. Although the accumulation process of SOC is difficult to be interpreted in this study due to the lack of chronological sequences of the soil layers, the results demonstrated that vegetation types and soil textures are useful proxies for the predictions of SOC in both upper and deep layers. Since these data are more accessible in regional scale (Li et al., 2015; Wang et al., 2016), it would be possible to upscale the SOC pools in the regional scale using vegetation types and soil texture data in the future."

We hope these revisions are helpful to the potential readers to get a clear framework of the SOC in deep soils.

5. L160-168: it is a general knowledge that SOC is produced by photosynthesis of plants. There is without exception for organic carbon deposited in deep soil layers. Therefore, generally speaking, the better in the vegetation, and the higher in SOC densities. So, I do think that is not so called "finding" of this paper.

Response: Thanks. We revised the text as the follows:

"For the upper ~3 m layers, it has been well known that vegetation types affect the SOC contents (Jobbágy and Jackson, 2000; Wu et al., 2012). Result from this study confirmed that this pattern was not only limited to the upper layers (which were usually studied in previous reports) but also extended to the deep permafrost layers, which could reach to 5 meters (PT6, PT9, EB1, EB2) and even about 20 m depth (PT4, PT5, PT7)."

We hope these sentences would be helpful to the potential readers so that they can understand the main propose of this study.

6. L91: "The collected core diameter was about 15 cm." I do think that the core diameter is not 15 cm according to the Geological drilling specification. Please check and correct.

Response: Thanks for your reminding. The diameter was 13.5 cm for the upper 20 cm and then changed to 11.7 below 20 m. Since this data only collected from upper 20 m layers, we clarified it as "13.5 cm".

7. L185, L189: the expression of "_^{13}C‰′' is right?

Response: Thanks, we deleted the "‰" in the revised version.