Thank you for your comments and suggestions. We made detailed point-by-point response to these comments and suggestions. The modified version of manuscript was uploaded as a separate file.

Interactive comment on "The characteristics of gravelly soil physical properties and their effects on permafrost dynamics: A case study on the central Qinghai-Tibetan Plateau" by Shuhua Yi et al.
Anonymous Referee #2
Received and published: 19 March 2018

In general, improvements are needed in making statements more specific and eliminate confusion. Examples include many instances of "default." It should be made clear on its first usage that "default" refers to the model default value(s).
Reply: Thank you for your comments. We made the "default" clear in Section 2.5.

"We first ran the DOS-TEM using the default porosity, soil thermal conductivity (Equation 4), hydraulic conductivity (Equation 8) and matric potential schemes of these two soil textures (Equation 7). The default parameters Φ,Ψ_{sat}, K_{sat} and B were calculated based on soil texture used in Community Land Model (Equation 7 and 8; Oleson et al., 2010). We then substituted the default values of Φ,Ψ_{sat}, K_{sat} and B based on laboratory measurements and calibration."

The major flaw of this manuscript is the Method section. The study involves only one sampling site The Site Description is very general. In addition to Lat. & Long., elevation, the site description should include landform, slope and aspect, microtopography, land cover type (alpine meadow, steppe, or others?), parent material (surficial deposit, parent rock or bedrock type), surface drainage. Then the soil pit was excavated, but there is no soil profile description. What are the genetical horizons? Without identifying diagnostic horizons, there is no ground to classify the soils. They refer to published source for the soils in the study area; Gelisols and Inceptisols. These are the terms of Soil Taxonomy. In Soil Taxonomy, Gelisols are defined as permafrost within one meter without cryoturbation or permafrost within 2 meters with cryoturbation. The same definition was adapted by the World Reference Base (WRB, UNESCO-FAO). But the active layer at the study site was measured at 3.3 meters, thus disqualify this soil as Gelisols. So probably, the next choice is Inceptisol, but there is no soil description to justify it. Bottom line: what is the classification of your soil?
Reply: Thank you for your comments. We made modifications according to your suggestions.
We mentioned "Based on the soil map of Li et al. (2015), soil of this region belongs to Gelisols and Inceptisols, which occupy 34% and 28% of the total area of permafrost region of the QTP". Li et al. (2015) is the most up to date and most accurate source of soil taxonomy on the Qinghai-Tibetan Plateau. We consulted with Dr. Li, Wangping, who is the leading author of Li et al. (2015). He mentioned that active layer thickness on the QTP is generally bigger than that of high latitude. The Gelisols classified on the QTP has all the same characteristics as that of high latitude, except the active layer thickness. They met the similar question in their paper of Li et al. (2014). Therefore, in this study, we used the Gelisols and Inceptisols as suggested by Dr. Li, Wangping. We also consulted with Prof. Chien-Lu, Ping of University of Alaska about the genetical horizons

of the soil pit. However, it seems impossible to get this information at the current stage.

In the modified version of manuscript, we first introduced the general information of Beiluhe Basin; then we provided detailed information of the permafrost and weather station.

"The site (34°49'46.2" N, 92°55'56.58" E, 4,628ma.s.l.) is located in the Beiluhe basin. This basin is in the continuous permafrost region of the central QTP (Figure 1a, Zou et al. 2017). Based on the soil map of Li et al. (2015), soil of this region belongs to Gelisols and Inceptisols, which occupy 34% and 28% of the total area of permafrost region of the QTP, respectively. Land surface types include alpine meadow, alpine steppe, barren surface and thermokarst lakes (Figure 1b; Lin et al., 2011).

The site is on top of upland plain landforms, which are formed with fluvial and deluvial sediments. The surficial sediments are dominated by fine to gravelly sands and stones (Figure 2; Yin et al., 2017). Soil of this site belongs to Inceptisols (Dr. Li, Wangping, personal communication). Mudstone is common beneath soil. The plant community type is mainly alpine meadow which is dominated by monocotyledonous species, primarily Poaceae and Cyperaceae. The dominant species are *Kobresia pygmaea*, accompanyed *Elymus nutans*, *Carex moorcroftii*, *Oxytropis pusilla, Tibetia himalaica, Leontopodium nanum* and *Androsace tapete* (Figure 2c-e)."

References

Li, W., L. Zhao, X. Wu, S. Wang, Z. Nan, H. Fang, and W. Shi (2014), Distribution of soils and landform relationships in the permafrost regions of the Western Qinghai-Xizang (Tibetan) Plateau, China, Soil Sci., 179, 348-357.

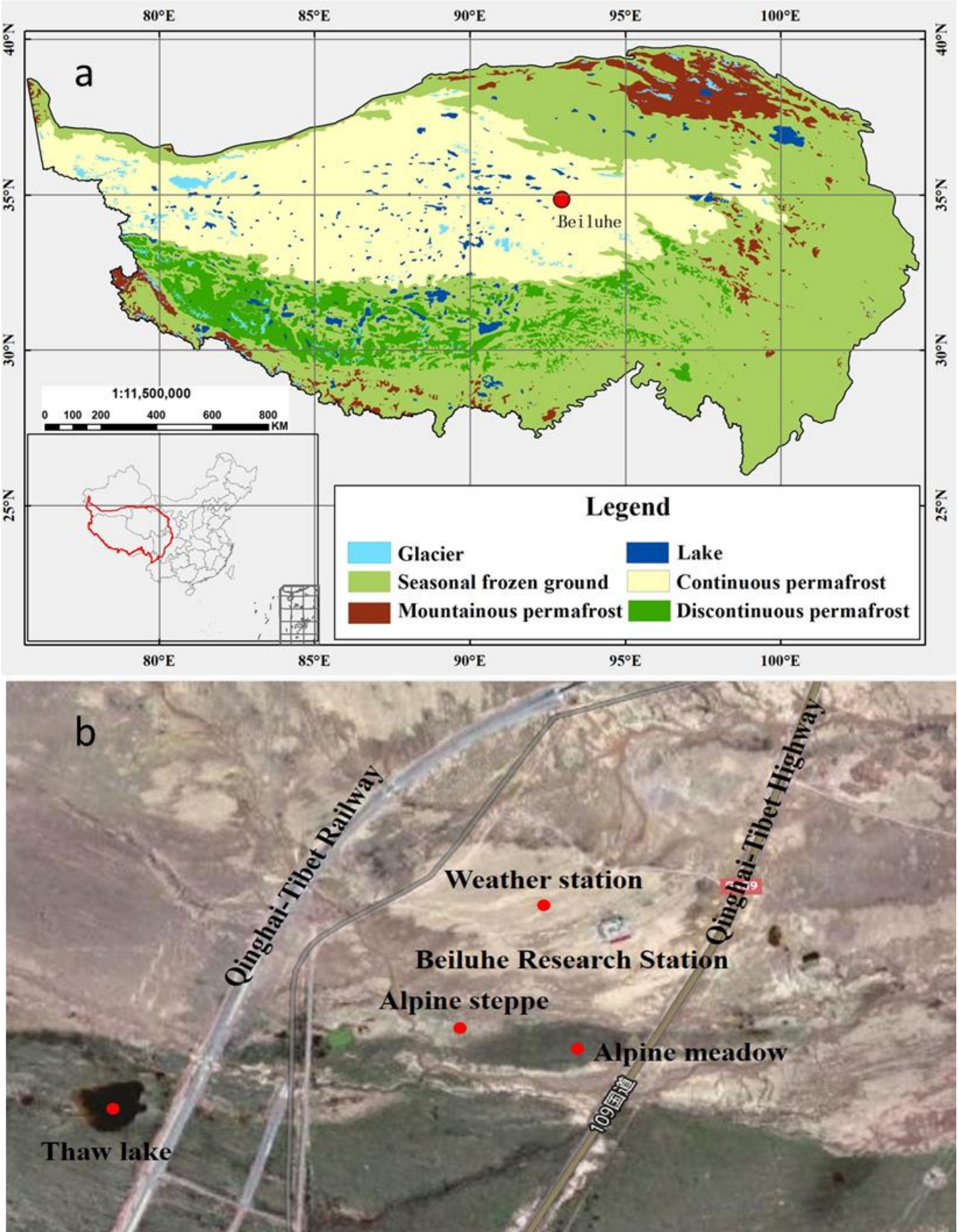


Figure 1. a) The location of Beiluhe permafrost station on the Qinghai-Tibetan Plateau (Permafrost type is from Li and Cheng, 1996); **b)** the google map of the weather station and the surrounding environment.

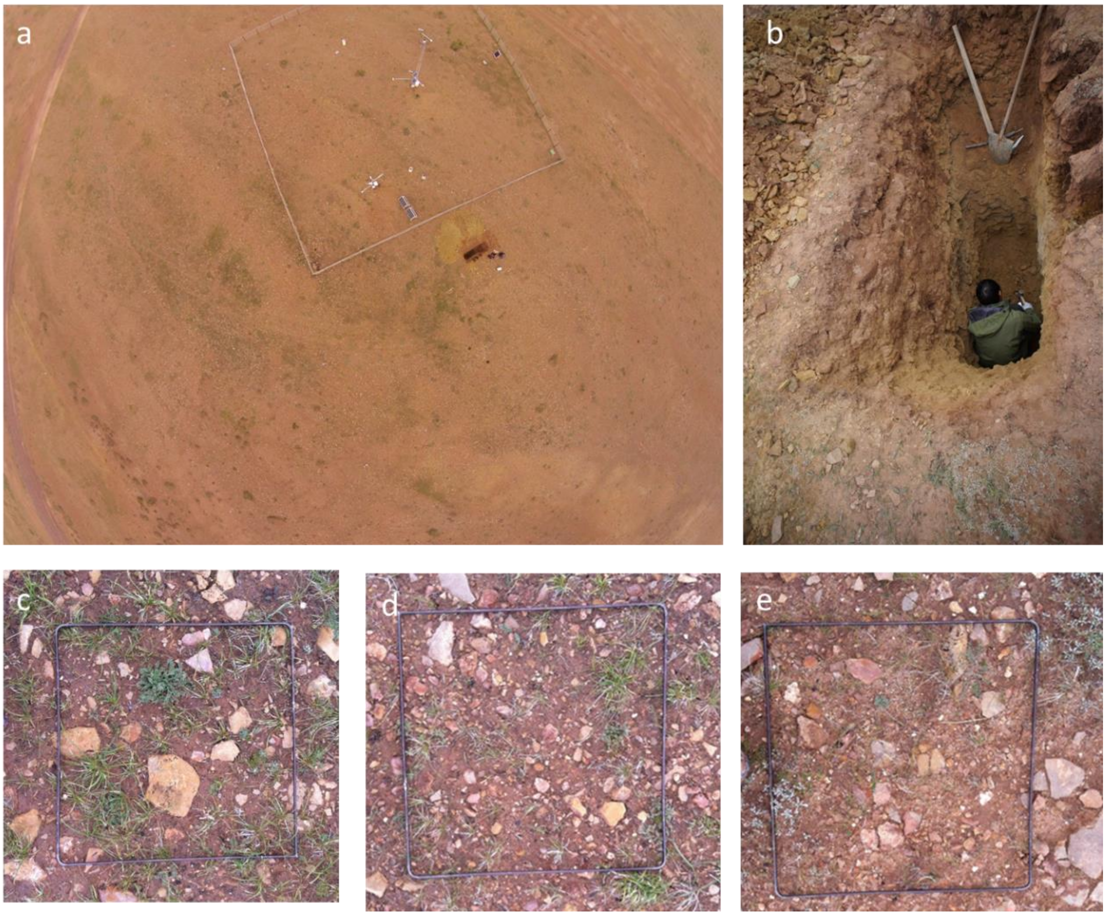


Figure 2. a) the aerial view of the weather station and the excavated soil pit; the borehole is located in the lower left corner of white fence; b) the detailed view of the excavated soil pit; and c)-e) examples of vegetation, gravel and stones (iron frame is about 0.5 m × 0.5 m).

They say soil temperature and “moisture” have been measured at the weather station since 2002, but indicate neither method nor frequency. Measurement depths are not provided. Same problem with precipitation and air temperature. At the end of the paragraph, they direct the audience to find the meteorological data from Qin et al! It is critical for the authors to list or tabulate the meteorological parameters; mean annual air temperature, mean summer and winter temperature, annual precipitation, mean annual soil temperature at 50 cm, mean summer and winter soil temperature, and permafrost temperature (borehole data). The mean annual soil temperature is used to define soil temperature regime and correctly classify the soils (at the suborder).

Reply: Thank you for your comments. We added detailed information about the measurement of weather station and borehole as suggested in the 3rd and 4th paragraphs of Section 2.1.

“A weather station was set up in 2002 (Figure 2a). Air temperature and relative humidity (2.2m, HMP45C - L11 /L36, Campbell Scientific Inc.), solar radiation (MS–102, EKO), precipitation (QMR102, Vaisala Company) were measured. Soil temperatures were measured at depths of 5, 10, 20, 40, 80 and 160 cm using PT-100 (EKO); soil moistures were measured at depths of 20, 40, 80 and 160 cm using CS616-L50 (EKO). CR3000 data logger (Campbell Scientific Inc., USA) was used to store these data at an interval of 30 minutes. These halfhour values were averaged or summed (e.g. precipitation) into monthly values for model driving and validation. Based on measurements, multi-year mean annual air temperature, precipitation, downward solar radiation and relative humidity were -3.61 °C, 365.7 mm, 206.3 W/m^2 and 51.1%, respectively (Figure 3). The multi-year mean summer (June to August)/winter (December to February) air temperature and precipitation were 5.27/-12.44 °C and 248.3/5.3 mm, respectively. The multi-year mean annual, summer, winter soil temperature at 40/80 cm were 0.17/0.11, 6.65/4.32 and -7.15/-4.86 °C, respectively.

A borehole was drilled in 2002. Temperature thermistors made by the State Key Laboratory of Frozen Soil Engineering, Chinese Academy of Sciences (ref) were installed at depths between 0.5 m and 10 m with interval of 0.5 m; at depths between 12 m and 30 m with interval of 2 m; at depths between 34 m and 50 m with interval of 4 m; and at 55 and 60 m. Temperature accuracy of this type of thermistor is 0.05 °C (Wu et al., 2016). The temperatures were recorded on the 5th and 20th days of each month using CR3000 data logger (Campbell Scientific Inc., USA). Based on measurement, active layer depth is ~3.3 m and the lower boundary of permafrost is at a depth of ~20 m. The multi-year mean ground temperature at 0.5/12/60 m is about -0.52/-0.29/1.81 °C, respectively."

New added reference:

Wu, Q., Z. Zhang, S. Gao, and W. Ma: Thermal impacts of engineering activities and vegetation layer on permafrost in different alpine ecosystems of the Qinghai-Tibet Plateau, China, The Cryosphere, 10, 1695-1706, 2016.

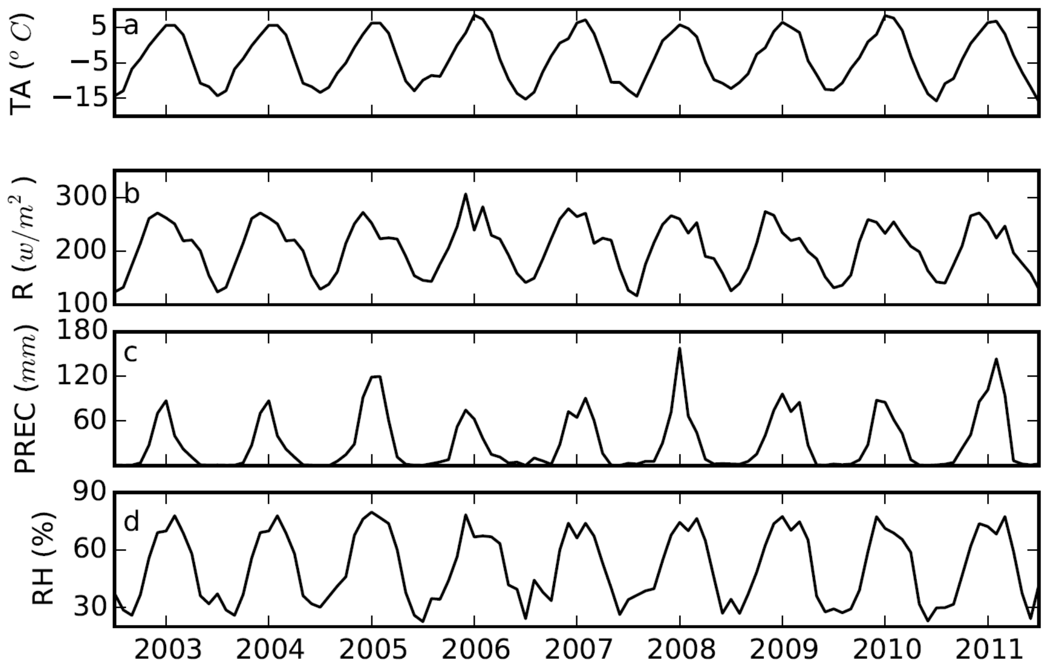


Figure 3. a) air temperature (TA, °C); b) downward solar radiation (R, w/m^2); c) precipitation (PREC, mm) and d) relative humidity (RH, %) measured on Beiluhe weather station on the Qinghai-Tibet Plateau from 2003 to 2011.

Soil Texture It is not clear what classification system of texture is being used. I'm pretty sure it's not USDA as the results don't appear to put the soil samples into either texture. In this study soil particle size distribution was simply done by sieving and the grades are 2.0, 1.0, 0.5 and 0.25 mm. These grades tells nothing about the soil texture of the soil samples of the study site. The problem is the fraction <0.25mm. According to the USDA system; clay (<0.002 mm), silt (0.002 – 0.05 mm) and sand (0.05 -2.0 mm). According to the International System (ISSS); clay (<0.002 mm), silt (0.002 – 0.02 mm) and sand (0.02 -2.0 mm). Thus, according to both systems, this <0.25 mm fraction includes fine or very fine sand, silt and clay! It would have been good if clay content had been measured as it's important to both texture and soil water characteristics. Again, soil description is needed. It appears that they consider the zone above 150 cm to be sand and that below to be silty clay (weathered mudstone), but Table 1 doesn't show a distinct difference between these two zones.

Reply: Thank you for your comments. We made additional measurements of the soil texture for soil particles smaller than 2 mm.

We updated at the end of Section 2.2.

"Finally, soil samples were sieved through meshes with diameters of 2.0 mm, and soil particle size distribution was determined with a Malvern laser diffraction analyzer (Malvern-2000, Instruments Inc. Worcestershire, UK)."

We also updated the 1st paragraph of Section 3.1.1 and Table 1.

According to the USDA classification system (clay (<2 μm), silt (2 –50 μm, in this study 2-63 μm) and sand (50μm -2.0 mm, in this study 63μm -2.0 mm)), the major soil texture of this site was loamy sand, with the exception of sandy loam at depth of 20-30 cm (Table 1).

Table 1. The mean (standard deviation) of measured soil bulk density, porosity, and particle size diameter fractions （>2 mm means the weight fraction between soil particles greater than 2 mm and total soil sample; while other fraction means the ratio between soil sample weight of a size range and the weight of particles < 2mm） and soil texture (based on USDA classification system) of different layers based on soil samples in this study.

Layer (cm)	Bulk density (g cm^{-3})	Porosity (%)	Fractions of particle in each diameter range				Texture
			>2 mm	<2 μm	2-63 μm	>63 μm	
0—10	1.74 (0.21)	28.4 (0.03)	0.38 (0.07)	0.05 (0.02)	0.18 (0.04)	0.77 (0.07)	Loamy sand
10—20	1.81 (0.11)	27.7 (0.02)	0.52 (0.14)	0.07 (0.05)	0.20 (0.05)	0.72 (0.11)	Loamy sand
20—30	1.86 (0.32)	30.2 (0.05)	0.55 (0.17)	0.07 (0.01)	0.24 (0.08)	0.69 (0.09)	Sandy loam
40—50	1.61 (0.23)	29.6 (0.02)	0.55 (0.19)	0.04 (0.02)	0.26 (0.11)	0.70 (0.13)	Loamy sand
70—80	1.62 (0.20)	20.6 (0.11)	0.65 (0.16)	0.04 (0.02)	0.25 (0.07)	0.71 (0.09)	Loamy sand
110—120	1.75 (0.09)	27.7 (0.01)	0.63 (0.05)	0.03 (0.02)	0.19 (0.08)	0.79 (0.09)	Loamy sand
150—160	1.70	26.3	0.63	0.02	0.13	0.85	Loamy

	(0.15)	(0.02)	(0.09)	(0.01)	(0.03)	(0.04)	sand
190—200	1.81 (0.09)	27.1 (0.02)	0.50 (0.19)	0.05 (0.05)	0.24 (0.14)	0.71 (0.19)	Loamy sand

The authors cited FAO/IIASA/ISRIC/ISSCAS/JRC (2009) that the dominant soil texture of the QTP is silty clay. I am very curious that why the authors ignored so many published data on soil textures of the Plateau, but rather cite a source with such gross estimate (on the world scale). Fine textured soils such as clay loam or loam formed in eastern QTP where the temperature is warmer and precipitation is higher, thus favors strong weathering. However, in the central and western QTP, most soils are sands or sandy loams. In addition, most fine textured soils are free of or containing little rock fragments. Most gravelly soils are found in the central and western part of the QTP. If you go through those literatures, you wouldn't make the statement in Line 14, page 14.

Reply: Thank you for your comments. We agree that it is not proper to cite the FAO/IIASA/ISRIC/ISSCAS/JRC (2009) in this study. In the revised version, we cited Wu and Nan (2016), which indicated that sand, loam and gravel were major soil types on the QTP. Therefore, we rerun our model using sand and loam textures. We modified Section 2.5 and Section 3.

In section 2.5

The soil textures on the QTP mainly consist of loam, sand and gravel (Wu and Nan, 2016). We used sand and loam in whole soil profile uniformly to represent coarse and fine soil textures, respectively. The parameters of gravel are not considered in most of the modeling studies (e.g. Oleson et al., 2010). Therefore, we used our measured parameters to substitute the parameters of sand and loam to investigate the effects of soil parameters on permafrost dynamics.

Added Reference

Wu, X. and Nan, Z.: A Multilayer Soil Texture Dataset for Permafrost Modeling over Qinghai–Tibetan Plateau, IGARSS, 4917-4920, 2016

Definition of gravel. In the USDA system, the fractions >2 mm are collectively called rock fragments, Gravel is defined as 2.0 – 75 mm. then cobbles (75 – 250 mm) and the rest as stones. In the International system gravel is defined as 2.0 – 20 mm and the fraction >20 mm as stones. Normally, rock fragments are referred as hard rock. But in this study, it seems the lithology of the parent rock is mudstone and that can be cut through by the bulk density sampling ring. This makes me wondering how is this "gravelly soil" representative of the rest of the hard rock gravelly soils on the QTP? If the gravel –mudstone can be cut through and included in the bulk density samples, then it is part of the soil. So how can you separate the effect of gavel on soil properties and other measured parameters, and most important, to find the correlations you suppose to find?

Reply: Thank you for your comments. We agree that it is not proper to use gravel (2.0-7.5 mm) to represent coarse content of this site. Therefore, we used "coarse fragment" throughout the text to replace "gravel".

Soil Sampling an Analysis. The rings are about 6.4 cm high (calculated from the diameter and volume), but the sample depths are in 10-cm increments. Were the samples taken at the top of the increment or the center, or somewhere within the increment? Or are the dimensions of the rings incorrect?

Reply: Thank you for your comments. We modified the sentences to make our methods clear in Section 2.2.

"We used cut rings (10 cm diameter, 6.37 cm height and 500 cm^3) to take soil samples at depth ranges of 0-10, 10-20, 20-30, 40-50, 70-80, 110-120, 150-160, and 190-200 cm. Three replicates were sampled from the top of each depth range and sealed for analysis in the laboratory."

Thermal conductivity measured at different water content levels. What levels? Assume volumetric water content, but this should be specified. If thermal conductivity was measured for oven dry water content, why was the soil saturated first and then dried out? Or was it measured after oven drying? Text says dried and bulk density calculated (how? From particle density of 2.65 g/cm3?), then saturated and then thermal conductivity measured.

Reply: Thank you for your comments. In the thermal conductivity experiment of this study, we injected a known volume of water into the soil sample, so the thermal conductivity at different water content levels refers to different volumetric water content. We made modifications to sentences of the second paragraph of Section 2.2.

"We used the KD2 Pro (Decagon, US) to measure thermal conductivity of soil samples. The steps were: 1) soil samples were dried in oven and weighed (0.001g precision) to calculate bulk density; 2) soil samples were exposed to a constant temperature (20°C) over 24 h, a certain volume of water was injected into the soil samples, and the KD2 was used to measure the thermal conductivity of the soil samples 3) samples and the KD2 probe were then put into a refrigerator (0~-26°C) at -15°C over 12 h, thermal conductivity was then measured; 4)Steps 2 and 3 were repeated at different levels of soil volumetric water content until soil samples were about to be saturated. 5) Finally, soil samples were immersed into water over 24 h and weighed to calculate porosity; and the saturated unfrozen and frozen thermal conductivity were then measured, accordingly. The bulk density (BD), porosity (PORO) and volumetric water content (VWC) were calculated with the following equations.

$$BD = \frac{W_{dry} - W_{cr}}{V_{cr}}$$

$$PORO = \frac{W_{sat} - W_{dry}}{V_{cr}} / \rho$$

$$VWC = \frac{W_{all} - W_{dry}}{V_{cr}} / \rho$$

Where W_{dry}, W_{sat}, W_{all}, W_{cr} are weight of over dried sample, saturated sample, sample with some water with cut ring, and empty cut ring (g), respectively. ρ is density of water (1 g/cm^3). "

Evidently the difference between oven dry soil sample weight and weight of the soil samples after immersion in water was used to calculate porosity. Probably not the best way unless samples placed under a vacuum. What are the differences in the porosity calculated this way and calculated from bulk density?

Reply: Thank you for your comments. Unfortunately, we cannot measure weight of soil samples under a vacuum condition. We think the method used in this study to measure porosity is direct and accurate. Based on our results, the porosity has no significant relationship with bulk density (Section 3.1.1).

We also calculated porosity based on the following equation.

Porosity =1-(BD/2.65). As shown in the following table, the measured porosity was always smaller than that calculated based on bulk density, except for the third layer. We did not add this part in the current revision.

Bulk density (g cm^{-3})	MeasuredPorosity (%)	Calculated Porosity (%)
1.74	28.4	34.33962264
1.81	27.7	31.69811321
1.86	30.2	29.81132075
1.61	29.6	39.24528302
1.62	20.6	38.86792453
1.75	27.7	33.96226415
1.7	26.3	35.8490566
1.81	27.1	31.69811321

Matric potentials were measured with 15- and 5-bar pressure chambers. Actually, water contents (volumetric or gravimetric) were probably measured when the samples were equilibrated (takes a long time for samples that thick!) under selected pressures. What were the pressures used? How long were the samples equilibrated?

Reply: Thank you for your comments. We added the following sentences to make the method of matric potential measurement clear in the last paragraph of Section 2.2.

"Pressure values were set at 0, 10, 20, 40, 60, 80, 100, 150, 200, 300, and 400 kpa. It usually took 3-4 days to finish one measurement at one pressure level."

Models I'm not going to get into the models as that what they used and they don't have control over model default inputs, algorithms, etc. However, not all of the terms in this section are defined and all should have units (e.g., assume temperature units are ◦C, but thermal conductivity temperature units are Kelvins). The parameter ke on P6, line 6; and the parameters T and Tf on line 13 need to be defined, including units. Assume Tf is the freezing point of water in soil, but soil water does not freeze at 0◦C, so it's the value used for Tf should be given.

Reply: Thank you for your comments. We do have control over model default inputs, algorithms. The model used in this study was written in C++. Algorithms have been changed since 1990s.

"Thermal conductivity is a measure of the ability of a material to transfer heat. Given two surfaces on either side of the material with a temperature difference between them, the thermal

conductivity is the heat energy transferred per unit time and per unit surface area, divided by the temperature difference. It is measured in watts per degree Kelvin". Difference of temperatures in Kelvin equals the difference of temperature in Celsius. We used Kelvin consistently in the unit of thermal conductivity in the revised manuscript.

We described ke in the revised manuscript (Section 2.3.1).
"k_e is Kersten number (Côté and Konrad, 2005)."

We described T and Tf in the revised manuscript.
"T and Tf are temperature of soil and freezing point temperature of soil (^oC), respectively."
We agree that soil freeze or thaw over a range of temperature below 0 ^oC. We used algorithm to freeze or thaw water at 0^oC, which is commonly used in land surface models (e.g. Oleson et al., 2010).

The statements on P6, lines 18-20: "Soil matric potential (ψ) determines the direction of water movement. And hydraulic conductivity determines the rate of water movement" are false. The hydraulic gradient determines the direction of water movement. If the hydraulic gradient is 0, then there will be no water movement regardless of the hydraulic conductivity. Rate of water movement is given by the hydraulic conductivity multiplied by the hydraulic gradient. See Darcy's Law.
Reply: Thank you for your comments. We modified the sentences in the revision (Please see section 2.3.2).
"Soil matric potential (Ψ) determines the direction of water movement. And hydraulic conductivity describes the ease with which water can move through soil pore."

In addition, the authors use a saturated soil matric potential (mm). I'm assuming the units mm are mm H2O, but again, this should be specified. The definition of saturation is that the soil matric potential is zero. How saturated matric potential was determined should be discussed. It would also be nice to know how B, the pore size distribution parameter, is determined. This is part of the model, but I couldn't help but address it.
Reply: Thank you for your comments. We modified the sentence in the revised manuscript.
"where Ψ_{sat} is saturated soil matric potential (mm H_2O, hereafter mm)" . Please see Section 2.3.2.

The default values of saturated matric potential and B were specified in land surface models (e.g. Oleson et al., 2010). We used these default values in our "Default" model runs (Please see Section 2.5).
We moved the corresponding sentence from Section 3.1.4 to Section 2.5 as suggested.
"Saturated matric potential and B were fitted with measured matric potential data using lsqucurvefit tools of Matlab"

Model Inputs and Initialization On P7, lines 17-18, I don't know to what "one-half of the total green leaf area per unit ground surface area" refers. It's not the definition of Leaf Area Index. Is this a default or initial model approximation to the Leaf Area Index? On line 19, it says the Leaf Area Index is "interpolated linearly in other months", which implies that the value from October to April is 0.1. I think they actually used 0 for the value between October to April. Also, are the values unchanged for the entire month? This section needs to be clarified.

Reply: Thank you for your comments.

We used "one-half of the total green leaf area", since one leaf has two sides and only one side leaf is used.

We modified 1st sentence of Section 2.4.

"We used the measured air temperature, downward radiation, precipitation and humidity (monthly) as input to drive the DOS-TEM. Leaf area index, one-sided green leaf area per unit ground surface area, was specified to be 0.6 m^2m^{-2} in July and August, 0.1 m^2m^{-2} in April and October, 0 m^2m^{-2} between November and March, and interpolated linearly in other months. It is used in the DOS-TEM to calculate ground surface temperature in combination with other meteorological variables (Yi et al., 2013). Its value is unchanged within each month."

Also, the last sentence needs to be clarified too. Spun up? Driving data from 2003-2012 for 100 years? 100 years into the future or past? Monthly averages? Only soil temperature and moisture? Moisture meaning volumetric soil water content?

Reply: Thank you for your comments. Spin up is a common modeling technology to get initial model conditions for further modeling run. We modified the sentences at the end of Section 2.4.

"Multi-year mean (2003-2012) monthly driving data were used for spun up for 100 yr. In this way, proper initial values of soil moistures, temperatures and rock temperatures at each layer can be generated for the beginning of 2003. Finally, monthly driving data were used to drive DOS-TEM over the period of 2003-2012."

Sensitivity Analyses Looks like the model was run using two soils, one with a texture of silty clay and one of sand. Uniform throughout all depths? Evidently the values measured on the soil sampled for the project were used for both soils (silty clay and sand) in the model. The model used three slopes, but doesn't address aspect. Again, this is a model characteristic and not controlled by the authors.

Reply: Thank you for your comments. We modified the sentences to make our point clear.

At the beginning of 1st paragraph of Section 2.5.

"We used sand and loam in whole soil profile uniformly to represent coarse and fine soil textures, respectively. The parameters of gravel are not considered in most of the land surface modeling (e.g. Oleson et al., 2010). Therefore, we used our measured parameters to substitute the parameters of sand and loam to investigate the effects of soil parameters on permafrost dynamics."

At the end of 1st paragraph of Section 2.5

"Since the site is on the top of upland plain landforms, we did not further test the effects of aspect on radiation on ground surface. We considered the effects of slope on surface runoff."

Results

Soil Porosity, Particle Size and Bulk Density P9, line 8, gives mean porosity of the 2-m depth, but in the methods section, the deepest measurements were 190 cm to 200 cm. I suppose these were used for the 2-m porosity, but this is rather imprecise and should be noted. It should be noted when model default and measured values are used. They seem to be intermeshed here.

Reply: Thank you for your comments.

The sentence of previous version is misleading

"The mean porosity 2 m depth ranged from 21% to 30% with a mean of 27%."

We changed it to

"The mean porosity of samples in 2 m depth ranged from 21% to 30% with a mean of 27%."(Please see section 3.1.1)

Also, line 9-10 it's stated that "No significant relationships were found among soil porosity, bulk density and the fraction of gravel. There should be a highly significant relationship between soil porosity and bulk density. I didn't do statistics on these, but I'm very surprised that there isn't a significant relationship between fraction of gravel and bulk density (and porosity). The only reason I can think of that there wouldn't be a significant relationship between these parameters, would be that there's a fairly narrow range and everything's clustered around a point with measurement errors dominating.

Reply: Thank you for your comments. We agree that it is caused by narrow ranges.

Thermal Conductivity The first thing I noticed in this section was that incorrect units for thermal conductivity were used. Thermal conductivity units should be Wm-1K-1. The units used throughout this section of Wm-2 are for heat flow or flux. The units in Table 2 are also incorrect. The units in Figure 2 are Wm-1C-1 which will work, but they are not the same as those in the model (see P6). If they used Wm-1C-1 in the model which was expecting Wm-1K-1, then this would affect the model output. This is critical and needs to be addressed!

Reply: Thank you for your comments. We corrected this mistake in the revised manuscript, including Section 3.1.2 and Table 2.

"Thermal conductivity is a measure of the ability of a material to transfer heat. Given two surfaces on either side of the material with a temperature difference between them, the thermal conductivity is the heat energy transferred per unit time and per unit surface area, divided by the temperature difference. It is measured in watts per degree Kelvin". Difference of temperatures in Kelvin equals the difference of temperature in Celsius. We used Kelvin consistently in the unit of thermal conductivity in the revised manuscript.

Matric Potential P10 line 9. This should be in the Methods section and should be detailed as how it was done. Again, saturated matric potential, by definition is zero. Why they are using the mean of the absolute value of the saturated matric potential should be discussed.

Reply: Thank you for your comments. We moved the sentence into Methods section (Section 2.5).

"Saturated matric potential and B were fitted with measured matric potential data using lsqcurvefit tools of Matlab."

Saturated matric potential should not be zero, otherwise, matric potential should be always zero according to equation 7 in Section 2.3.1. For example, saturated matric potential in the widely used Community Land Model was specified to be -47.29 and -390.66 mmH2O for sand and clay, respectively. They are close to 0 mm H2O. All matric potential values are negative, therefore it is common to use the absolute value in the text. However, negative values were used in calculation.

Soil Temperature Were the soil temperatures measured monthly? Daily? Hourly? How measured? Thermistor connected to a datalogger or with a Hg thermometer in a hole at noon on the first of each month? Assume the monthly values are averages.
Reply: Thank you for your comment. We added additional information about the measurement of soil temperature on Section 2.1.

Soil Liquid Water Same as for soil temperature – methods and instruments for measurement. What kind of sensor for soil moisture? Neutron probe, TDR, calibration, samples collected and oven dried, other?
Reply: Thank you for your comment. We added additional information about the measurement of soil moisture on Section 2.1.

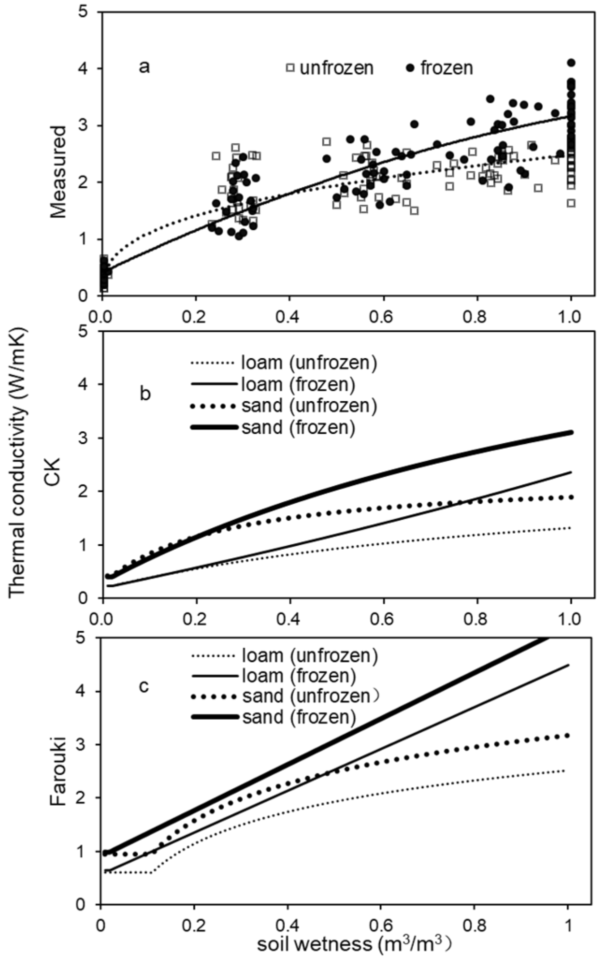
Discussion P14 line 18 should be: measured thermal conductivities of saturated soil samples. . . Note: The thermal conductivity of ice is about 4 times that of water.
Reply: Thank you for your suggestion. We changed the sentence as suggested.
"The measured thermal conductivities of saturated soil samples were relatively close to those estimated by the Côté and Konard (2005) scheme."

P16 line 7-8 states that the measured frozen thermal conductivities were smaller than the unfrozen thermal conductivity. However, Table 2 shows that the measured frozen thermal conductivities were larger than the unfrozen, except for the 4 deepest dry layers (and one of those has nearly the same thermal conductivity for both the frozen and unfrozen states). The thermal conductivities for frozen and unfrozen states of the dry samples should be very close. Only the differences in the thermal conductivities of the soil minerals, organic matter, and air at the measurement temperatures would influence the thermal conductivity of the soil.
Reply: Thank you for your comments. In the discussion part (Section 4.3.1) we mentioned our unsuccessful measurement using QL-30 instruments. We put a plate of QL-30 on the surface of soil sample during measurement. It worked fine for unfrozen soil samples, however, failed for frozen soil samples. When frozen, surface of soil samples was uneven and its touch with plate of QL-30 was not ideal, which caused smaller measured values of thermal conductivity. Therefore, we used KD2 pro instrument to measure thermal conductivity after trial of QL-30. The values in Table 2 were measured using KD2 pro, rather than QL-30. We discussed this in Section 4.3.1.

We agree with the reviewer that the thermal conductivities for frozen and unfrozen states of the dry samples are very close. We also discussed it in Section 4.3.1.

Fig 2. Use smaller symbols. Hard to see all individual points. Are units correct?
Reply: Thank you for your suggestion. The units are correct. We reduced the size of symbols as suggested. We also changed the unit of thermal conductivity from W/m^{o}C to W/mK in the revised

manuscript (Figure 4).



Based on the comments above I recommend the manuscript be released. But I'd encourage the authors to resubmit it after addressing all the shortcomings.

Reply: Thank you for your recommendation. We made changes carefully according to your suggestions.