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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

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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).

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?

They say soil temperature and "moisture" have been measured at the meteorological 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).

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.

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.

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?

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?

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.

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?

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?

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.

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.

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.

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. 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?

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.

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. 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.

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!

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.

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.

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?

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. 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.

Fig 2. Use smaller symbols. Hard to see all individual points. Are units correct?

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.

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