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Interactive comment on "Soil temperature-threshold based runoff generation processes in a permafrost catchment" *by* G. Wang et al.

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First, we like to give our heartfelt thanks to the anonymous reviewer for providing valuable suggestions to improve our manuscript. We respond to the questions as follows:

(1)Despite the fact that this process controlled by ground surface temperature thaw depth at each particular moment of time does not correlate to surface temperature. So I would recommend to authors to rename the article to "Seasonal thawing - threshold...." RES: We agree with the opinion of the reviewer; the term "soil temperature threshold" is not suitable to reflect the correlation. Considering the impact of freezing processes, we agree with the suggestion of referee 1# that "Freeze-fraction threshold" is more

suitable. Thus, we revised the article to include the "Freeze-fraction threshold. . .. . .".

(2)To revise equations 2 and 3 replacing the function f(Ts) which is not clearly explained in the text by the function of temporal dynamics of sum of positive degree hours (sum of measured of temperature values multiplied by measurements interval. RES: We revised this by adding a paragraph to describe the conversion from Equation 1 to Equation 2 more clearly. The revision paragraph is as follows: In a catchment, the area of SERG varied with T_sˆ' at different elevations and slope directions due to differences in the solar energy input on the land surface, which is defined as a variable runoff-contributing area induced by the soil temperature. If the SERG is the dominant surface runoff in the thawing period when T_sˆ'≤T_0, the runoff of this period in a catchment is the sum of the runoff generated from the area of SERG with 0ãĂŰ≤TãĂŮ_sˆ'≤T_0. Because the soil water-storage capacity curve is replaced by the soil water content at the field water capacity, which is controlled by the soil temperature curve with 0ãĂŰ≤TãĂŮ_sˆ'≤T_0, equation (1) can be expressed in terms of soil thawing processes as follows. Obviously, the application of equation (2) abides by the hypotheses: . . ..; (3) In the study catchment, the depth of the suprapermafrost groundwater level is generally below 100 cm when the frozen soil is beginning to thaw (Chang et al., 2015). Until early July, the thawed soil depth in only half of the study catchment would reach 80-90 cm (Fig. 2 b). Thus, the runoff generated from the thawed suprapermafrost groundwater discharge was ignored when the surface soil temperature ≤ T_0.

(3) In this case they can use time as a threshold parameter. Page 5958, line 18. The phrase "zero thawing isotherm" does not make sense, use zero isotherm or thawing front. RES: Yes, there is a hide time parameter in f(T_sˆ') and g(T_SD) because the ratio of areas with surface soil temperature ≤ T_0 to the total catchment area and the soil temperature at lower bound of active layer are varied with time (day or month). We agree with the opinion of the reviewer; the term "zero thawing isotherm" was replaced by "thawing front".

(4) Page 5960, lines 23-25. It is not clear what do numbers of percentage coverage of meadows and swamps mean. Is it part of the area covered by combined meadow and swamps? Why it is so variable? RES: The sentence means that alpine meadows and swamps are the two types of dominant vegetation in the study catchment, and these two types of alpine grasslands have an average total plant coverage of 60 to 97%. To revise the unclear statement, we rewrote this sentence as follows: Alpine meadows and swamps represent the most widespread types of vegetation in the experimental catchment, with an average coverage of 60 to 93% and 67 to 97%, respectively (Wang et al., 2010).

(5) Page 5962, line 16. Given value of 0.25 mm is not accuracy but resolution of this type of sensors. The accuracy is 1 cm. RES: Yes, the referee is correct. We have revised this incorrect statement.

(6) Page 5962, lines 20-21. Soil water dynamics mostly controlled not by the temperature but by the thaw depth (see comment at the beginning). RES: We agree with the opinion of the reviewer and revised this sentence by adding "by temperature and thawing depth".

(7) Page 5962, lines 23-25. Physical sense of threshold parameter (in this case temperature) must be clearly defined here. RES: We rewrote the paragraph as follows to explain the threshold parameter more clearly. The thawing depth of active soil is strictly correlative to the surface soil temperature; therefore, there is a threshold of the surface soil temperature at which the maintaining depth of the surface soil water-saturated condition reaches its extremum in a given slope of the catchment. If the threshold of the surface soil temperature is T_0, saturation excess runoff generation (SERG) can occur when the actual surface soil temperature T_sˆ' is less than or equal to T_0. In a catchment, the area of SERG varies with T_sˆ' at different elevations and directions of the slope due to different solar energy inputs on the land surface, which is defined as a variable runoff-contributing area induced by the soil temperature. If the SERG is the dominant surface runoff in the thawing period when T_sˆ'≤T_0, the runoff of

this period in a catchment is the sum of runoff generated from the area of SERG with 0ãĂŰ≤TãĂŮ_sˆ'≤T_0.

(8) Page 5963, lines 16-18. Downward freezing actually controls both surface and subsurface discharge. RES: Yes, the referee is correct. However, downward freezing directly affects the recharge of suprapermafrost groundwater and drops the level of suprapermafrost groundwater. Generally, upward ground freezing is faster than downwards freezing. We revised this paragraph, as follows: Downward ground freezing controls the surface runoff generation and recharge of suprapermafrost groundwater. In the study catchment, the depth of the suprapermafrost groundwater level decreased from 40 to 60 cm in the summer to less than 100 cm in the winter as the soil temperature declined. The depth of the meeting point of the downwards and upward ground freezing is at 50-60 cm (Chang et al., 2015; Wang et al., 2010). Considering that the effects of downward ground freezing on the recharge of suprapermafrost groundwater could directly drop the level of groundwater, but will not directly reduce the groundwater discharge, the impact of the active soil freezing process in two directions on the groundwater discharge was supposed to be dominated by upward ground freezing.

(9) Page 5963, lines 18-24. Give more explanations about dynamics of ground water discharge input in total runoff. RES: According to the opinion of the reviewer, we added two paragraphs to explain the dynamics of the groundwater discharge input to total runoff more clearly. âŚă Generally, groundwater discharge occurs in June and continues to increase through the summer months, reaching a maximum in September. Groundwater flow starts to decrease in October, as temperatures decline, and becomes dormant from November to the following April (Ge et al., 2011; Chang et al., 2015). âŚąAfter the surface soil is frozen, the surface infiltration excess runoff generated from snowmelt when frozen soils limit infiltration is also ignored because of the small amount of winter snow cover in the study catchment. Thus, the runoff production during the autumn freezing period is primarily composed of surface saturation excess runoff generation and groundwater discharge.

(10) Page 5965, lines 20-22. If authors ignore impact of winter snow what does Qs in equation 2 mean? RES: Here, we mean that the winter snow had little effect on spring seasonal runoff because the winter snow was irregular, filmy and discontinuously distributed over the ground surface. Specifically, most of the winter snow cover was blown away by strong winds in early spring. However, the snow in the spring season after March, coupled with the soil temperature rise, had important impacts on surface runoff. Thus, the snowmelt water Qs was listed in equation (2) as a water balance factor.

(11) Page 5966, line 5. How did authors defined f(Ts)? Is it empirical function based on combination of temperature and soil moisture measurements? Generally, from the text of paper is absolutely unclear what does this function means, what units it is measured in. Figure 3. Add another Yaxes for f(T'). RES: In line 195-199 in Page 9 of the revised manuscript, we defined the f(T_sˆ') more clearly as follows: f(T_sˆ') is defined as the surface soil freeze-fraction threshold curve, which refers to the ratio of areas with a surface soil temperature ≤ T_0 to the total catchment area. As described above, the thawed soil layer would maintain a water-saturated condition when the surface soil temperature ≤ T_0; f(T_sˆ') is a dimensionless function and could refer to the catchment area in a soil water-saturated condition.

According to the opinion of the reviewer, we redrew Figure 3 (Figure 4 in the revised file) by adding another Y axes for f(T').

(12) Since the concept of surface temperature direct influence on subsurface discharge does not look very good argued in the paper it is very difficult to comment results and conclusions. RES: To revise this problem and clarify the influence of the surface soil temperature on subsurface discharge more clearly, we added text in different places, as follows: âŚă In "During the thawing period" of section 2.2 Analysis Approach, we added a paragraph, as follows (3), to explain why the influence of the surface soil temperature on suprapermafrost groundwater discharge was not considered in equation (2). Obviously, the application of equation (2) abides by the hypotheses: …………; (3)

In the study catchment, the depth of the suprapermafrost groundwater level is generally below 100 cm when the frozen soil is beginning to thaw (Chang et al., 2015). Until early July, the thawed soil depth in only half of the study catchment would reach 80-90 cm (Fig. 2 b). Thus, the runoff generated from the thawed suprapermafrost groundwater discharge was ignored when the surface soil temperature ≤ T_0.

âŚą In "During the freezing period" of section 2.2 Analysis Approach, we added a paragraph, as follows, to clearly explain why the influence of downward ground freezing on groundwater discharge was ignored in autumn. In the study catchment, the depth of the suprapermafrost groundwater level decreased from 40 to 60 cm in the summer to less than 100 cm in the winter as the soil temperature declined. The depth of the meeting point of the downwards and upward ground freezing is at 50-60 cm (Chang et al., 2015; Wang et al., 2010). Considering that the effects of downward ground freezing on the recharge of suprapermafrost groundwater could directly drop the level of groundwater, but will not directly reduce the groundwater discharge, the impact of the active soil freezing process in two directions on the groundwater discharge was supposed to be dominated by upward ground freezing.

âŚć In the Result and Conclusion sections, we added text to explain why ignoring the runoff generated from the thawed suprapermafrost groundwater discharge would result in a simulation error that increases with the precipitation increment in early summer. However in spring (from May to June), the new approach accurately simulates the runoff dynamics despite the precipitation increment.

Please also note the supplement to this comment:
http://www.the-cryosphere-discuss.net/9/C2828/2016/tcd-9-C2828-2016-supplement.pdf

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Interactive comment on The Cryosphere Discuss., 9, 5957, 2015.