Reply to interactive comment on "Role of rainwater induced subsurface flow in water-level dynamics and thermoerosion of shallow thermokarst ponds on the Northeastern Qinghai–Tibet Plateau" by X. Pan et al.

Received from anonymous Referee #1

The paper "Role of rainwater induced subsurface flow in water-level dynamics and thermoerosion of shallow thermokarst ponds on the Northeastern Qinghai–Tibet Plateau" by Pan et al. deals with the hydrology of thermokarst ponds in the Qinghai–Tibet Plateau. Although the topic, methods and results are very interesting, the paper has several flaws that should be carefully addressed. In particular: 1. the paper is very difficult to read and to follow. Although the introduction is well written, the rest of the paper is too dense of information and lacks of clarity. In addition, it is hard to find a correlation between the sections, and the figures are not clearly explained in the text. More figures and tables should definitely be added to improve the understanding of the paper. 2. the English language is very poor, full of syntactical, orthographical and punctuation errors. This further complicates the paper readability. Short sentences should be preferred to long sentences. In addition, the British and the American standards should not be mixed. For example, you can write either "behaviour", "vapour" and "modelling", or "behavior", "vapor" and "modeling". An accurate revision of the text is needed.

We would like to thank the first referee for her/his valuable comments and suggestions that will help to significantly improve the original manuscript. Particularly, we appreciate the referee's specific remark and suggestion for writing. We carefully went over the mentioned problems of the manuscript, and revised the text greatly. Answers for specific comments are given in the following.

Specific comments:

Line 22, page 6121: adding a summary of section 3 would be recommended to ease Readability.

A summary of section 3 was added as follows.

A variety of measurements were implemented in this study to characterize the role of rainwater induced subsurface flow in water-level dynamics of two thermokarst ponds. Firstly, methodologies for determining the major components of water balance are introduced in the following: (1) the hydrogeological condition was characterized with drilling and borehole temperature measurements (Subsection 3.1); (2) pond evaporation, precipitation and water storage change were quantified in Subsections 3.2, 3.3 and 3.4, respectively; (3) the lateral water flux was derived from a simplified water balance

equation (Subsection 3.5). Secondly, impacts of subsurface flow on pond thermal regime were revealed with pond bottom temperature measurements (Subsection 3.4).

Line 3, page 6122: acronyms should be always explained: what is a.g.l.? I assume "above ground level", but you should write it.

The first acronym was explain at the first place. The same was done for other acronyms in the revised text. Thank you for your suggestion.

Line 10, page 6122: put the depths in a separate table. I would also recommend describing sensors, depths and sites in separate tables.

Done in following Table 1. Besides, there are two different types of soil temperature sensors. The thermistors of model 107 were used to monitor soil temperature in the soil profile, and the other type of thermistors calibrated by the State Key Laboratory of Frozen Soil Engineering, CAS were used to measure borehole temperature. A mistake in the description of these sensors was corrected in the revised text.

Table 1 Measurement setting at the soil-weather monitoring site.

Surface measurements	Probe	depth (above ground surface) m
Air temperature & relative humidity ℃ and %	MP100A	2.0
Net radiation W m^{-2}	NR-LITE	1.5
Wind speed and direction m s^{-1}, degree	WindSonic	2.0
Rainfall mm h^{-1}	RM Young 52202	0.5
Snow depth m	SR50	2.3
Subsurface measurements	**Probe**	**depth (below ground surface) m**
Soil temperature ℃	Thermistors (model 107)	0.05, 0.10, 0.15, 0.20, 0.30, 0.50, 0.70, 0.90, 1.10, 1.30, 1.50, 1.70, 1.92, 2.08, 2.18, 2.30, 2.50, 2.70, 3.00, 3.30, 3.60
Soil water content m^3 m^{-3}	CS616	0.10, 0.20, 0.40, 0.65, 0.89, 1.19, 1.535, 1.92, 2.10

Corresponding technique information of the probes can be found on the website of Campbell Scientific, Logan, UT (http://www.campbellsci.com).

Line 14, page 6123: what are the values of the constants? I mean the slope vapor pressure curve and the psychrometric (not psychometric!) constant. The same thing is also valid for the constants and parameters in equations 3 and 8.

Thank you for your reminding. The complete Penman-Monteith method was added in the text now. The values of the constants in equations 3 and 8 were added.

Line 6, page 6126: I do not understand where the "mudstone with high clay content" is and which percolation is here meant.

The imprecise words were clarified. "mudstone with high clay content" was rephrased in the text. The percolation should mean the vertical seepage of pond water to deep groundwater. It was replaced in the whole text.

Line 20, page 6126: Before starting with Section 4.1 a summary of Section 4 would be recommended.

A summary was added as follows.

The components involved in pond water dynamics were quantified with the water balance equation (12), together with a hypothesis of negligible vertical seepage. Relevant observations were demonstrated to illustrate the role of rainwater induced subsurface lateral flow in water-level dynamics and impacts on pond bottom thermal regime as follows. (1) The hypothesis of negligible groundwater seepage is verified with hydrogeological drilling and ground temperature measurements in Subsection 4.1. (2) Re-evaluated rainfall measurements were presented in Subsection 4.2. (3) The mechanism of pond water-level dynamics was described with pertinent observations in Subsection 4.3. (4) The significant role of rainwater induced subsurface lateral flow was demonstrated using the water balance equation (12) in Subsection 4.4. (5) The impacts of subsurface lateral flow on pond bottom thermal regime were revealed with pond bottom temperature measurements in Subsection 4.5. Here we note that the subsurface lateral flow in the text mainly means the lateral flow in saturated layer above thawing front, although the much slower interflow in the vadose zone can also slightly contributed to the pond water storage.

Line 25, page 6126: Why can surface runoff occur at pond 2 only in some conditions? And at pond 1?

Surface runoff by over land flow is rarely in this semi-arid region. The major runoff is stream flow linking different ponds. Since there is a track of stream flow between Pond 2 and other ponds (shown in Figure 1), surface stream runoff might occur when meeting heavy rainfall or snowmelt events. Whereas the Pond 1 is rather closed, and no surface runoff is expected. The text was rephrased in the new text.

Line 1, page 6127: Could you describe better this subsurface seepage?

Thank you for suggestion. It was clarified as vertical seepage of the pond water to deep groundwater in the next.

Line 3, page 6127: Add figures or tables where this can be better understood.

The adapted figure (Fig. 2) from the Fig. 7 in the original manuscript was moved to this Subsection. Corresponding text was also rephrased. Besides, the irrelevant borehole B4 was removed in the revised text.

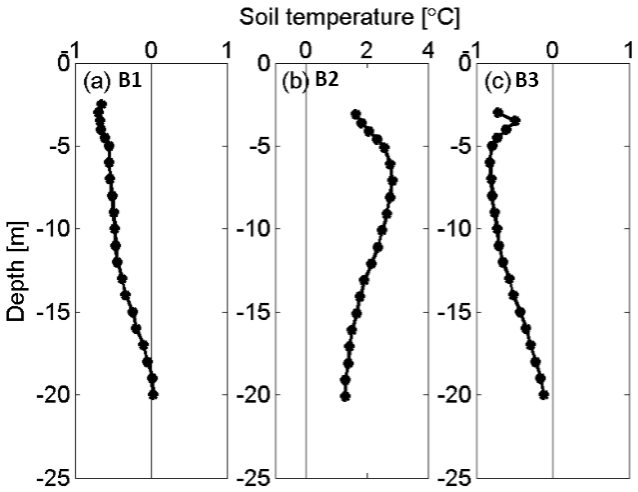

Figure 2. Ground temperatures measured in 2014 at the boreholes (B1, B2 and B3 in Fig. 1).

Line 14, page 6128: This sentence is not understandable to me, I can find no independent clause.

This sentence was removed in the new text. A new figure in the following was added to help to identify the ice-cover period. Clear changes of daily temperature amplitudes of air temperature and pond bottom temperatures between the ice-cover period and ice-free period can be distinguished. Additional explanation by analyzing the effects of water depth on pond bottom temperature was not necessary any more here, and it was removed in the new text.

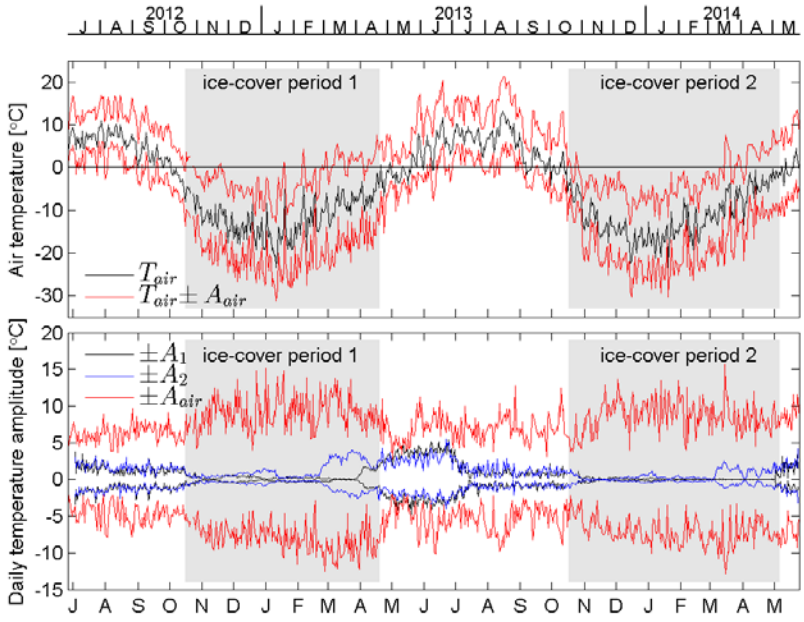

Figure 4. Identification of ice-cover periods (grey areas) from the varying daily temperature amplitudes of air temperature, Pond 1 and Pond 2 bottom temperatures. (a) The daily mean air temperature (T_{air}) plus amplitude (A_{air}). (b) Variation of the daily temperature amplitudes of air temperature, Pond 1 and Pond 2 bottom temperatures (A_1 and A_2) between ice-free periods and ice-cover periods.

Line 20, page 6128: why are these sub-periods not described in separate bullets?

Done as suggested.

Line 24, page 6128: it is improper to say "since the intensive rainfall events could quickly reach the saturated layer". It is not possible to compare inconsistent quantities.

We fixed this sentence.

Line 4, page 6129: This paragraph is particularly difficult to follow and should be reformulated. The soil above the water table is by definition unsaturated. What does it mean that the unsaturated layer is about 1.2 m thick? Also I do not understand "The wetting necks . . .. . . the water table".

The paragraph was reformulated. The soil above the water table was unsaturated, and the water table was about 1.2 m below ground surface. We call it vadose zone in the revised text.

Line 9, page 6130: Maybe it would be good to indicate the three periods in the figure. Are the same periods discussed in the previous paragraph?

Thank you for this valuable suggestion. The three periods were marked using the rainy season sub-period (gray area in the following modified figure). These three periods are consistent with the previous paragraph, as well as Fig. 4 in the revised text.

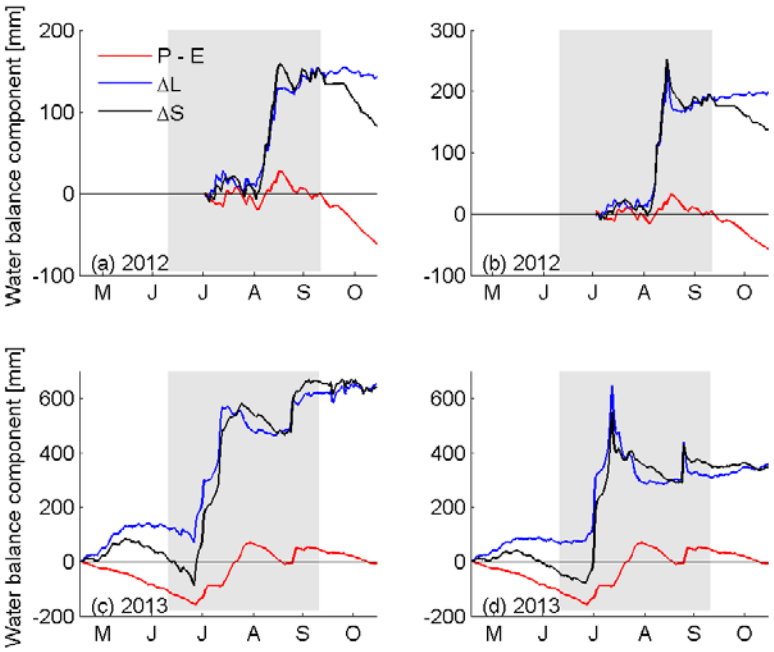

Figure 6. Significant role of lateral flow in water budget of two ponds in 2012 and 2013. Pond 1: (a) and (c; Pond 2: (b) and (d). *P - E*: accumulative net rainfall; *ΔL*: accumulative net lateral flux; *ΔS*: water level. Grey area indicates the middle sub-period of the rainy season.

Line 17, page 6131: What is the mentioned microtopography? Is it just the topography mentioned in the previous section?

Here the micro-topography means the land surface with small scale variation in topography. Thermokarst ponds can be linked by tracks at low locations, and stream flow might occur temporally. For instance, the dashed line in Fig. 1b. The sentence was rephrased in the text.

Line 5, page 6132: What does "The two bulges are consistent with the inlets of preferential flow" mean?

From our previous study (Pan et al., 2014), we identified subsurface preferential flow paths in the northwest of the pondshore, and their directions were coincident with the two bulges of pond edge (Fig. 1c). This indicates that the shape of the thermokarst pond was influenced by the subsurface lateral flow in the surrounding active layer. This sentence was rephrased and moved to the Subsection 5.2.

Line 10, page 6132: What is the freezing degree-day? This has not been defined.

We slightly changed the analysis in Subsection 4.5. In the original manuscript, the freezing degree-day was used to quantify the different thermal impacts of pond water-level during ice-cover period with different thicknesses in two years. In the revised manuscript, we simplified this subsection, and also dropped this analysis of the freezing degree-day. Instead, we only demonstrates some straightforward evidences to show the thermal impacts of water-level regime on pond bottom. (1) Sub-seasonal variation in pond bottom temperature amplitude during ice-free period, and its relationship with water-level change. (2) Variation in the pond bottom temperature during the ice-cover period, and its relationship with water level depths and heat transfer mechanism.

Thank you for your suggestion.

In addition, Figure 6 is not explained in the text. All the figures should be first of all explained in the text, not only in the caption.

Explanations for the figures were added in the revised text.