Responses to comments from anonymous referee #2

Original comments are in **black.** Our point by point responses are in **blue**. All changes in the context have been highlighted with yellow background.

The paper focused on seasonal lake ice mass and energy balance over a small lake in Tibetan Plateau with thousands of lakes. Owing to the harsh environment, the Qinghai Tibetan lakes are very sparsely covered by in situ measurements and little studied. With a case study observations and numerical simulation, the manuscript showed the interesting and useful information about the lake ice thermodynamics and heat and mass balance during ice-covered season in the Qinghai Tibetan Plateau, but the work and the manuscript should be checked carefully. Therefore, in my opinion, it should be published after moderate revisions. Specific comments as follows:

L15-16 What's the relationship between ice-covered lakes in the plateau and monsoon systems in winter?

Actually, here we meant that the lake-rich QTP, rather than lakes in QTP, has impacts on monsoon systems.

Previous studies have indicated that QTP contains the freshwater resources for 2/3 of the population in Asia, and QTP can affect the Asian monsoon system through the exchange of heat and moisture between the Earth surface (including lakes) and atmosphere, driven by the large scale atmospheric circulations (e.g. Li et al., 2016, *J. Hydrol.*).

In general, water and moisture transport and their interactions with QTP land topography under the influence of strong ABL circulation are the driving force of QTP on Asian monsoon system. In winter, QTP is cold so the water and moisture transportation is much reduced, instead evaporation and sublimation from ice-covered lakes has been observed (Huang et al., 2016; Li et al., 2016 *JGR*), but the linkage between ice-covered lakes in the plateau and monsoon systems in winter remains unclear and still need to be investigated.

L24-25 The author draws the conclusion that strong solar radiation, consistent freezing air temperature, and low air moisture were the major driving forces controlling the seasonal ice mass balance. The wind is quite strong including frequent gusts. It is quite important to the calculation of latent heat flux. How about wind effects on the seasonal ice mass balance?

Prevailing strong wind is vital factor influencing the ice mass balance because it increases the turbulent heat exchange between ice surface and near-surface atmosphere and contributes to ice surface ablation. The effect of wind on seasonal ice mass balance has been investigated before (e.g. Huang et al., 2016, *Ann. Glaciol.*) through sensitivity tests. We have concluded that both sensible and latent heat fluxes are crucial components for heat budgets for ice cover. We have added following text in the revised manuscript: "Strong solar radiation, consistent negative air temperature, low air moisture, and prevailing strong winds were the major driving forces controlling the seasonal ice mass balance."

L32 Ice surface sublimation could account 41% of lake water loss in ice season. Can we know its contribution in the annual water balance?

Yes, we can make the calculation. The inter-annual water balances of small lakes have been investigated before. According to multiyear investigations on lake water level in nearby two similar small lakes (Pan et al., 2017, *J. Hydrol.*), the water level of those small lakes decreases continuously from September to the June of the following year with a magnitude of about 0.5 m. The water loss includes subsurface seepage, evaporation, and sublimation of ice. During rest of the year: July-August, the lake water level increases rapidly due to surface and supra-permafrost recharge induced by heavy precipitation and runoff of melting glaciers with a total water level increase of about 0.5 m (Lin et al., 2017; Pan et al., 2017). So the annual water balances of those lakes remain stable. According to Pan et al.,(2017), the annual lake water loss (~ 620 mm) consists of evaporation during ice-free seasons (~340 mm, 55%), ice sublimation during ice-covered seasons (260 mm, 42%), and lateral seepage (20 mm, 3%) with negligible vertical seepage.

The contribution of ice surface sublimation on annual water balance is added in the revised manuscript section 4.3. The new text reads:

"The surface evaporation/sublimation hence accounts for 41% of lake water loss during the ice-covered period and for 42% of annual water loss (Pan et al., 2017)."

L94-95 "During years 2004-2014, the mean annual air and ground temperatures varied from -2.9 _C to -4.1 _C and from -1.8 _C to -0.5 _C, respectively". How could ground temperature increase 1.3 _C and mean annual air temperature decrease 1.2 _C during 11 years? And the warming rate is quite fast.

The original description was incorrect due to poor language formulation. The corrected description reads: "During years 2004-2014, the annual mean air temperature ranged between -4.1 ℃ and -2.9 ℃, and the annual mean ground temperature between -1.8 ℃ and -0.5 ℃".

L96-97 "precipitation ranged from 229 to 467 mm (average: 353 mm), while the annual mean potential evaporation ranged from 1588 to 1626 mm " VS L103 "The lake is perennially closed without rivers or streams flowing into and out of it." How did the lake survive with huge vaporation and less precipitation? How did the lake area and level respond to the rapid increase of precipitation?

Yes, a very minor gully flows (negligible recharge) into Lake BLH-A during summertime without outflow, and there is no surface inflow/outflow during freezing period. Although P-E-WSD (annual precipitation–evaporation–wintertime subsurface discharge) is negative, this can be compensated by the supra-permafrost inflows and slope runoff (confluence) during thaw seasons (especially summer) resulted from precipitation and glacier melting (Pan et al., 2017, J Hydrol; Lei et al., 2017, GRL). According to Pan et al (2017) field investigations in similar thermokarst lakes, a large portion of lake water storage change is because of the supra-permafrost discharge resulting from precipitation. The annual total loss can be roughly offset by the total recharge, therefore, the lake survives and stabilizes.

L110 What's the effects of plenty of gas bubbles on albedo as showed in Figure 1? Does it include in the simulation?

In general gas bubbles affect the ice interior texture, reflection and back-scattering of the light as well as roughness of ice-water interface. We would need to have incoming and reflected spectral solar radiative fluxes measurement to identify the impact of gas bubbles on surface albedo, which we were not able to carry out during 2010/2011 field campaign. We are not aware of an albedo parameterization that takes into account the effect of gas bubbles on ice surface. In other respects, the albedo scheme we applied is a sophisticated one, taking into account temperature, snow and ice thickness, solar zenith angle, and atmospheric properties, and distinguishing between visible and near-infrared albedos values (Briegleb et al., 2004).

L128 May I think the other two years' experiments failed? Why?

The other two years (ice seasons) mainly suffered, from time to time, the instrumental malfunction. Therefore, we focus on modelling experiments only for 2010/2011 season.

L142 The incident longwave radiation Ql is missed in equation (1), and the direction of the upward longwave radiation should be wrong. In this case, how about the simulated results?

The equation has been corrected accordingly.
The observed average down-welling Ql was 177 W m^{-2} during daytime (8:00-19:00, local time) and 180 W m^{-2} during nighttime (19:00-8:00), respectively. Table 3 gave the monthly mean net long-wave radiative flux (i.e. $Ql – \varepsilon\sigma T^4$) .

L162 The bulk transfer coefficient for water vapor is vital for Qle calculation. It varies with wind, stability and the type of landscape. How does it set in the calculation?

The effect of roughness lengths for momentum and heat/moisture transfer as well as the effects of ABL stratification were taken into account in the calculation of the turbulent surface fluxes of heat and moisture based on the Monin-Obukhov similarity theory (Launiainen, 1995; Launiainen and Cheng, 1995; Launiainen and Cheng,1998). Same approach has been applied to estimate sensible and latent heat fluxes between lake and atmosphere in large QTP lakes (Wang et al., 2015 *JGR*; Li et al., 2016 *Theor Appl Climatol*).

L178 Undoubtedly, the air temperature between the two sites are highly correlated. What's difference between them? Could air temperature over lake surface show the lake characterises?

Yes, the air temperatures between the two sites are highly correlated. The average difference is about 0.3 ℃. We added this number in the revised manuscript.
The air temperature over a lake surface has a strong linkage associated with freeze up and breakup of the lake ice due to its strong cooling and warm effect.
We believe the air temperature observed in the floater located near the centre of the lake well represents the general temperature characteristics over the lake. We assume that the air temperature over a lake is not as sensitive as latent/sensible heat and moisture flux to surrounding land surface changes during wind direction changes.

L264-266 The percentage of solar radiation absorbed by lake surface is main factor to decide the Qss. Could you show more information about it? How to get the percentage of Qsi and Qsw? Are they fixed?

In HIGHTSI, very sophisticated schemes were used to quantify the light transfer in air-ice column. Within ice layer, two-layer model were usually used taking into account a thin surface ice layer (coefficient i_0) that is different from the ice layer below with respect to optical properties (Maykut & Perovich, 1987).

$$q_i(z,t) = i_0(1-\alpha_i)Q_s e^{-\kappa_i(z-\bar{z})},$$

where i_0 is defined as the fraction of the wavelength-integrated incident irradiance transmitted through the top layer of the ice, and parameterized as a function of sky conditions (cloud fraction, *C*) and ice colour (Grenfell & Maykut 1977; Perovich 1996). Accordingly, the radiation Qss absorbed by the surface layer can be calculated.

In the below ice layer, simple parameterizations based on the Bouguer-Lambert law are used. And the light extinction coefficient κ_i of ice was usually regarded constant during freezing and melting stages. With integration of q_i over the whole ice depth, we can get the Qsi. So the Qsw=(1−α)Qs−Qss−Qsi can be obtained.

Therefore, coefficients involved in radiative transfer model change through the ice process, so the percentages of the Qss, Qsi, and Qsi were not constant during growth and ablation.

The analyses here are meant for the mean values during the modelling period.

In this study, the down welling solar radiative (incident solar radiation: Qs) flux was observed so the measured value has taken into account the cloud effect. The average Qs = 181W/m^2. The average surface albedo was about 0.42, so the net Qs at ice surface was 106W/m^2.

The solar radiative flux used for surface heat balance Qss was $(1-\alpha)(1-\gamma)Qs$ (Eq 1). The mean value was 47 W/m^2.

The average solar radiative flus penetrated below ice surface layer was 59W/m^2

At ice bottom the penetrating solar radiative flux exponentially decreased to 22W/m^2,

So for ice surface layer Qs = 106-60 = 46W/m^2

For the ice layer Qsi = 59 -22 = 37W/m^2

At ice bottom Qsw = 22W/m^2

So the average percentage =

Qss: 47/106 = 43%

Qsw: 36/106 = 35.8% =~36%

Qsi: 22/106 = 20.75% = ~ 21%

We have added short information on the above description to the *section 2.3*.

L395 During melting period, the lake water temperature below lake ice will increase fast owing to the strong solar radiation. The absorbed solar radiation by ice and the warm temperature should not be ignored for the ice melting. Will the model simulate the lake water temperature? If yes, how about the precision?

The absorbed solar radiation by ice and water were not ignored during ice melting.

The absorption by ice is used to increase the ice temperature and to generate internal melting, and these processes were included in our simulations.

The absorption by under-ice water is used to increase the water temperature and also partly to increase (in turn) the water-to-ice heat flux that mainly caused ice melt from the bottom.

Our model does not simulate the water temperature, but rather uses it as a boundary condition.

L335-L339 According to the manuscript, the monthly mean Ts was consistently lower than the monthly Ta from December through April, while Ts was higher than Ta in November when the ice was rapidly growing, especially when the ice thickness was less than _ 10 cm. But in Table 3, the direction of Qh may not match it?

In this study, the positive flux was defined towards the ice layer. We have clarified this in the revised manuscript.

L405-407 Make sure if the lake (ice) released heat to the atmosphere through the whole ice-covered season with a consistent stable ABL.

For most of the time, the ice surface temperature was lower than the near-surface air temperature indicating a stable atmospheric boundary layer (ABL). Therefore, the atmosphere provided heat to the ice cover through a downward turbulent sensible heat flux (positive Qh in Table 3). However, the total amount of latent heat flux and net long-wave radiative flux (cooling) was large (negative) and exceeded the total amount of net solar radiative flux and sensible heat flux Qh, resulting in heat loss from the ice surface to the atmosphere. And this heat loss resulted in ice gowth.

L424 and Table 1 Lake ice albedo is very important for the simulated results and it may be very low in the plateau as mentioned by authors. But we couldn't get the specific information about your lake ice albedo. How to treat it in the work?

We have applied a sophisticated surface albedo scheme taking into account temperature, snow and ice thickness, solar zenith angle, and atmospheric properties, and distinguishing between visible and near-infrared albedos values (Briegleb et al., 2004). The calculated surface albedo was strongly associated with observed changes in ice thickness, suggesting that the parameterization worked well.

Other changes:

(1) We improved the English readability by a native speaker, many definite/indefinite articles, singular/plural nouns, simple phrases, and sentence patterns have been modified, but are not shown in this response letter.

(2) Julian dates have been removed and replaced by calendar in the text and in all figures.

(3) All "2010/2011" have been reformed to "2010–2011".

(4) Lines 98-101 (and references therein) were removed since it is not essential to the topics.

(5) Line 105: delete "with a stable water level through the year", and "fresh" → brackish".

(6) Line 106-107: delete "Submerged plants grow abundantly in the lake sediment throughout the year.", since it is not essential to the topics.

References listed in the above responses:

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