Author's Response

We thank Adam Emmer for reviewing the manuscript and pointing out methodological aspects that require further explanation in order to clarify our ideas.

The point-by-point response to the reviewer comments are below.

General comments:

P. Iribarren Anacona et al. presented interesting study dealing with the topic of outburst floods from moraine-dammed lakes in the Baker basin of Patagonia and assessment of outburst susceptibility. From my point of view, this topic is highly actual in the frame of climate change and glacier retreat and surely fits into the scope of NHESS. Generally, paper is understandable, well-structured and language is clear. Text is accompained by five tables and fourteen illustrative figures. List of references contains 75 records.

My specific comments (see below) are connected especially to the selection and use of outburst susceptiblity factors used for assessment of susceptibility to outburst flood. I need authors to explain why they have chosen those factors and clarify their relation to the triggers and mechanisms of outburst floods recorded in this region. I also miss deeper verification of assessment scheme (prove of its ability to distinguish between lakes with different susceptibility to outburst flood). Therefore, I recommend **moderate revision** before publication.

Specific comments:
P4771L12: McKillop and Clague, 2007; please, check through the whole text. Done

P4772L8: Emmer and Vilímek, 2013 in NHESS is review article already published, not for review

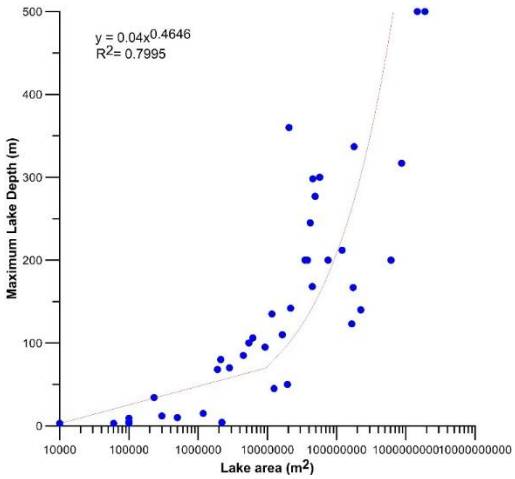
-In the sentence we are encouraging the reader to see the Emmer and Vilímek's (2013) review paper and not saying that the paper is in the review process. The text now reads as follows "(see Emmer and Vilímek's, 2013 review paper)."

P4772L19: From my point of view, lake area (or volume) is not a factor influencing susceptibility of the lake to outburst flood; larger lakes are maybe more hazardous (larger volume of potential flood), but they are not generally more susceptible to outbursts; please explain to which trigger and mechanism of lake outburst is lake area related ??

-We acknowledge that the lake area/volume has a direct influence on the hazard posed by the lake. However, we sustain also that the lake's outburst susceptibility is at least marginally influenced by the lake area/volume, as these factors can be related to the hydrostatic pressure exerted over the dam. Furthermore larger lakes have more area potentially exposed to the impact of mass movement and ice avalanches. These two points are highlighted now in the text (see response to the next comment).

P4772L22: hydrostatic pressure is not related to the lake area, but to the height of water column (lake depth); hydrostatic pressure affecting the same dams of lake with small area and large lake is Equal

-As the reviewer pointed out, the hydrostatic pressure is related to the height of the water column and hence to the lake depth. Larger lakes are generally deeper than smaller lakes (see the figure below), thus larger lakes are expected to exert higher hydrostatic pressure over the dams, increasing their outburst susceptibility.



Relationship between maximum lake depth and lake area based on data from 41 lakes of glacial origin in Patagonia. Data from various sources including Diaz, M., Pedrozo, F., Reynolds, CS., and *Temporettia, P.: Chemical composition and the nitrogen-regulated trophic state of Patagonian lakes. Limnologica 37:17–27, 2007.*

As the lake area/volume influences the lake hazard and, at least marginally, the outburstsusceptibility, we included the factor in the analysis, although with a low score. Furthermore, as the aim of this regional assessment is to identify lakes that require further detailed analysis, the inclusion of afactor related with the lake's GLOF hazard has also practical implications.

-The text was modified to address these points and now reads as follows "Furthermore, lakes with larger areas are generally deeper (see e.g. Diaz et al, 2007 database), and can exert higher hydrostatic pressures over the dams making them more susceptible to failure (Richardson and Reynolds, 2000). Larger lakes have also more surface potentially exposed to mass movement and ice avalanche impacts, increasing their outburst susceptibility."

P4773L11: "lakes that are expected to grow are more hazardous" – please, explain why ??; from my point of view, growing moraine-dammed lakes are more susceptible to failure, because they are in direct contact with retreating glacier (calving and floating of dead ice), which is overlapping characteristic

-We include the following sentence to explain this relationship "Lakes that are expected to grow are more hazardous than lakes which areas are expected to remain stable since the area exposed tomass movements or ice avalanches may increase in the future and their dams may be subject to higher hydrostatic pressures".

2.3.2 Glacier-lake contact; why not to use lake area change rather than slope of glacier terminus indicating lake area change ?? Again, please explain relation of this characteristic to the possible trigger and mechanism of outburst flood.

-We used the slope of the glacier terminus instead of the lake area change since the first may be indicative of the glacier/lake future behaviour (Frey et al., 2010), and the second, of the past glacier/lake dynamics. Lakes that grew in the last decades may not necessarily grow in the future. Furthermore, failed lakes (at least 3 events) in Patagonia presented rapid changes (infewyears)before the failure. Unfortunately, suitable satellite imagery for yearly analysis of glacier/lake changes are scarce or absent in Patagonia due to the region's cloudy conditions limiting this type of analysis.

P4773L17: steep outlets are associated with high dams ?? how ?? please, explain

-The sentence was restructured and now reads as follows "Furthermore, high dams which produce outbursts with high peak discharges (Walder and O'Connor, 1997) usually have steep outlets (check table 1).

P4773L20: yes, but it is essential to consider distance (or slope) between lake and glacier (glacier far away from the lake can not caused GLOF even if its slope is steep)

-We agree with the referee comment, the text now reads as follows "The likelihood of an ice avalanche impacting a lake depends on the distance, slope and roughness of the terrain between the glacier and the water body. Ice avalanches are…"

P4774L2: also vegetated slopes can fail; I see significant difference between stability of exposed solid bedrock slopes and non-cohesive moraine slopes; is this distinguished in presented work somehow?? I recommend to consider this; from my point of view, this is much more important, than distinguishing between vegetated and unvegetated slopes

-We stated that unvegetated slopes are common sources of mass movements and not that vegetated slopes cannot fail. We incorporated a reference (Peduzzi, P.: Landslides and vegetation cover in the 2005 North Pakistan earthquake: a GIS and statistical quantitative approach. Nat Hazards Earth Syst Sci 10:623-640, 2010) to highlight the vegetation and mass movement susceptibility relationship.

-We modified the text in the section 2.4.2 to address the points highlighted by the reviewer, the text now reads as follows "The angle of reach and the slope of the starting zone of rock falls, debris flows and other complex mass movements vary locally according to the geology, terrain roughness **and vegetation coverage. Steep unvegetated slopes may indicate high geomorphic activity and can be associated with loose, readily erodible material**. Thus, we assume potential starting zones for all mass movements are unvegetated or sparsely vegetated slopes ≥ 30°. **We have not distinguished between solid bedrock slopes and non-cohesive slopes since this task can only be accurately accomplished by photo interpretation or fieldwork, which are costly or time consuming, and consequently not suitable for a preliminary regional analysis**."

-Furthermore, we acknowledge in the Table 4 and in the Discussion that the mass movement susceptibility analysis could be improved (e.g. using data from regional mass movement inventories, which have yet to be accomplished), and consequently we assigned to this variable a low score.

P4775L24: Is the use of term "Mass movements" proper in this section ?? From my point of view, also ice avalanches are a type of mass movements, but this section is focused on slope movement of rocks, right ??

-We use here the definition of mass movement stated in Dikau, R. (2004): Mass Movement. In: Goudie, A. Encyclopedia of Geomorphology: 644-652, which does not include ice avalanches. We prefer the mass movement term to landslide as the last term implies a shear failure occurring along a well-defined shear plane.

P4778L24: "Drained lakes were dammed by both, steep moraine arcs and relatively flat ground moraines." This is casting doubt on considering dam outlet slope as the characteristic with the highest weight (Tab. 4)

-We acknowledge this point, however, as is indicated in the Table 1 and Figure 9, the majority of the failed lakes had steep dams. This point is addressed also in the Discussion.

-We modified the text in the Discussion section to highlight that these are exceptional cases. The text now reads as follows "However, **two** small failed lakes had low dams with flat and broad surfaces and superficially appeared stable."

P4779L27: All types of mass movements including ice avalanches ?? I suppose, that evidence of ice avalanche can not be visible relatively short time after the event

-As we stated earlier, we do not consider ice avalanches a type of mass movement, as we are following the Dikau's (2004) definition. We agree with the referee comment that ice avalanche evidence can rapidly disappear and we stated it in the page 4783 line 25.

P4781L2: Are those outburst floods included in analysis of 16 previous GLOFs ??

-Yes, the 7 GLOFs from moraine-dammed lakes are included in the analysis.

P4871L4: Section numbering ??

-We will include the section numbering in the next version.

P4781L7: This sentence seems to be rather a discussion than result

-We modified the sentence, it now reads as follows "However, such lakes may still produce outburst floods as are subject to ice avalanches or mass movement impacts. "

P4781L10: Discussion ?? This makes your results seem questionable

-We agree with the reviewer comment. However, here we are pointing out facts about the outburst classification results (including some references to provide context) which are further covered in the Discussion section (where advantages and disadvantages of the method are analysed). Thus, we think is worth to leave this part of the text.

P4782L19: Hydrostatic pressure is not connected to the lake growth (change of volume or area), but depth; from my point of view, lake growth itself cannot be considered as a trigger / mechanism of outburst flood; please, reformulate or avoid

-The text was modified and now reads as follows "…and the increase in the hydrostatic pressure over the dams as a result of lake **growth/deepening** may explain some of these outburst floods".

P4783L1: I'm not sure about the use of the term "potential energy" in this context; please, reformulate or avoid

-We modified the text, it now reads as follows "The **higher shear stress** in these steep slopes probably favoured the dam's erosion when overflows or an increase in the lake discharge occurred."

P4783L8: This is interesting point which would deserved more detailed elaboration (kind of verification of outburst susceptibility assessment procedure)

-We verified the "success" of the outburst susceptibility scheme classifying the failed lakes according to our weighting scheme. In the sections 2.5 and 4.2 is stated that 75% of the failed lakes had scores ≥65 and thus this threshold was selected to classify lakes with high outburst susceptibility. In other words, the verification of the classification scheme shows that it is able to correctly classify 75% of the hazardous lakes.

-The above point is discussed in the section 4.2 entitled "Outburst Classification" were is stated that "Twelve (75%) of the sixteen failed lakes in Patagonia had scores ≥ 65 (other failed lakes had scores ranging from 30 to 49) and thus we selected this score to identify lakes with high outburst susceptibility. This score does not comprise all the failed lakes in Patagonia but includes lakes with at least three characteristics that make them susceptible to failure."

P4783L10: This statement makes use of dam outlet steepness for smaller lakes as the most weighted characteristic questionable

-We modified the text to highlight that these are exceptional cases. The text now reads as follows "However, **two** small failed lakes had low dams with flat and broad surfaces and superficially appeared stable."

P4783L14: What is meant by "potential freeboard" ?? In my understanding, dam freeboard = 0 m in case of lakes with surface outflow P4783L15: Likelihood of dam overtopping is directly related also to the dam freeboard

-We modified the text to clarify the idea, the text now reads as follows "A possible factor contributing to their failure is that lower dams can be easily overtopped by waves or a rise in the lake level since they have less potential freeboard **(i.e. there is less height difference between the lake surface and the lowest point of the dam)."**

P4784L7: I do not recommend to relate lake area with dam failure

- As we included the lake area in the GLOF outburst susceptibility scheme we consider necessary to include the possible relationship between lakes area and the lakes failure in the discussion.