

Interactive comment on “Glacier lake outburst floods of the Guangxieco Lake in 1988 in Tibet, China” by J. J. Liu et al.

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GENERAL COMMENTS

The authors present a reconstruction of a glacier lake outburst that took place in 1988 at the Guangxieco (Midui) Lake in front of Gongzo (Midui) Glacier in southeastern Tibet. For the analyses, the history of glacier fluctuations and meteorological conditions are considered, interpretations of satellite imagery and topographical maps are made, and field observations of the glacier, the outburst traces and grain-size distributions of the dam and the depositions of the outburst flood are performed. Based on these investigations, the causes of the lake outburst as well as the development and the characteristics of the outburst are reconstructed.

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Although the aim and as well the findings of the study are interesting, the manuscript lacks reproducibility in many parts. For instance, none of the mentioned satellite images or the topographical map are shown, and some statements lack references. Furthermore, large parts of the event reconstructions rely on findings from other studies, which all are properly cited, but only available in Chinese, and hence not known by, and neither really available to, the scientific community outside China. For some aspects it seems doubtful, that field investigations in 2007 can be used to infer the conditions during the event in 1988, i.e. 19 years before. Finally, the language at some parts is not clearly understandable; therefore I was not able to follow some parts; in particular the suggested relation of a glacier surge and the ice avalanche which supposedly triggered the lake outburst. More details are given in the following sections.

Except a few details, the structure is in accordance with the scientific standards. Nevertheless I suggest adding a discussion section to critically reflect the applied methods and findings before the conclusions are drawn. Furthermore, this new section should contain comparisons to other GLOF reconstruction studies. The quality of figures and tables are sufficient, suggestions for changes are given at the end of the following section. However, as mentioned above, more figures would be needed to ensure independent traceability of the findings.

SPECIFIC COMMENTS

Title: The singular ('flood' instead of 'floods') should be used, as a single event is investigated.

P406L2: Is there a scientific study that proofs that GLOFs became more frequent in the course of global warming? If so, the respective study should be cited in the text (e.g., in the introduction). Otherwise I suggest avoiding this statement.

P406L3-4: 'there are few observations of the reasons ...' I agree that there are only a few observations of glacier lake outbursts in the meaning that only very few outbursts could have been monitored in real time during an actual outburst. However, the reasons

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of the outburst are known for many (maybe most?) lake outbursts (see also comment for P4607L6). I thus suggest avoiding or rewording this statement in the abstract.

P4606L6-7: The fact that Guangxi Lake is the lowest glacier lake of Tibet that burst out should also be referenced in the text. Anyway I suggest removing this statement from the abstract and only mention it in the introduction or study site description, as it is not relevant enough to be mentioned here.

P4606L20-21: For me it is confusing to list 'sediment quantity', 'flash floods', and 'large-scale down-river floods' in a row here; causes and consequences should be separated. I suggest rewriting.

P4606L24: To be in accordance with the other regions listed afterwards, the South American Andes should be mentioned instead of the Cordillera Blanca. Or – even better – would be to mention the specific mountain ranges of the other regions listed as well (in Central Asia, North America, and the Himalayas).

P4607L6: As mentioned above in the second comment, I do not agree with the statement, that only little is known about the reasons for GLOFs. It maybe applies to the specific region (the Karambar Valley) mentioned by Iturrizaga (2005), but there are many scientific studies of GLOF analyses and reconstructions from all regions in the world where triggers of the outbursts are clearly identified. I suggest removing.

P4607L12: To which region correspond the mentioned 35,000 km² if they account only for a certain fraction of the Qinghai-Tibet Plateau? Please re-write.

P4607L20: Where does the number of 30 GLOFs in Tibet from 1930-2010 come from? Please cite! (The cited studies were published in 1988 and 1999, i.e. more than 10 years before the end of this period. . .)

P4606: General comment on the structure of the background section: The description of the 1988 event (currently section 2.1) should be moved to after the description of the lake the glacier, and the valley (currently 2.2). It could be placed in the beginning of

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section 3 (i.e. before the section on the reasons for the GLOF).

P4608L5: Please give references for the statements that this region has stronger seismic activities, more rainfall, and higher temperatures than the rest of Tibet.

P4608L8: Much more details are needed about the influence of the monsoon in this region. Since strong precipitations are mentioned as one factor for this lake outburst and since all Tibetan GLOFs seem to have taken place in a certain period of the year, characteristics of the monsoon are of fundamental importance for analyses of lake outbursts in this region.

P4608L9: More details about the glacier characteristics should be given as well (e.g. the altitude of the equilibrium line (ELA)) since the cited study is in Chinese.

P4608L14/15: The wave overtopped the rock dam? According to next sentence (and the rest of the text and the figures), I assume that this lake is dammed by a moraine dam!

P4609L13: Which slope is 70–80°, the inner or the outer? This value is extremely high for morainic material.

P4609L21-22: The measured runoff is a single measurement at one day. It is doubtful how well this measurement represents the conditions for the event 19 years ago. For sure this runoff doesn't say anything about the conditions during the event, neither about the condition before the event (i.e. before the breach formed). And neither it is a mean rate of the summer runoff, as stated in the text. Please revise.

General comment on figures of the study area section: I suggest adding a figure with an overview of the study region in the beginning of this section. In the background of the figure, a satellite image or a topographical map could be shown. This would also replace Figure 2 for the description of the glacier, which is not very suitable in the current form. The current Figure 1 (photo of the lake) could either still be a stand-alone figure or part of this new overview figure as well. Locations of the sites for grain size

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distributions could be indicated as well, and furthermore the photos of Figure 3 could be integrated. Even if Figs 1 and 3 will remain, at least a minimal overview figure is required, including an inset showing the location of the lake and the valley within the larger region.

P4611L2-5: More references are needed here. There is a lot of literature on potential triggers for GLOFs, but currently only a non-scientific report is cited.

P4611L6-7: The event in question took place 25 years ago; the fact that no earthquakes were recorded in the last 20 years is thus useless in this context. Here, only seismic records from the 15 July 1988 (and maybe a few days before) are of interest. Furthermore, a source of this information should be given.

P4611L11: I suggest changing the title of this section (e.g., 'climatic observations').

P4611L12-13: Only the fact that all recorded GLOFs in Tibet took place in the same four month does not at all suggest a relation to climate change! I rather suggest a relation to the monsoon. As mentioned above, the relation to the monsoon should be further elaborated.

P4611L16 and Fig. 4a: Figure 4a rather suggest an increase in precipitation since the 1960s, predominantly from 1960 to 1980. After 1980, the increase is not obvious.

P4611L18 and Fig. 4a: In Figure 4a, the precipitation in 1983 appears to be clearly below 1000mm. I thus suggest rewriting this paragraph.

P4611L19-21: These statements are not documented in Fig 4b; to do so, the monthly averages should be plotted as well. Furthermore, it would be useful to also show the temperature and precipitation records for the week before the event in another figure (e.g., 4c).

P4611L24-25: As long as no climatic monthly average temperatures are given, the statement that July was the hottest month of 1988 is not surprising or exceptional (this applies to large parts of the northern hemisphere).

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P4611L25-26: Here as well, climatic average values are needed to show, that the 75 days period with average temperatures above 10°C are exceptional.

P4612L10-14: A figure showing the glacier terminus in the mentioned satellite images would be very illustrative. In particular it would be interesting to have an additional satellite scene shortly before the event, in order to verify the small distance of only 15m to the lake.

P4612L6-9 and L15-27: I cannot follow the explanations of the glacier surge and the supposed ice avalanche; an ice avalanche break-off from the tongue seems not be realistic to me. Ice avalanches of temperate glaciers are normally observed at slopes steeper than 25°, but the tongue of Gangxieco glacier is described to have a slope of only 2 – 5° (P4610L13). A break-off at such low slope angles is not realistic. Field investigations have been performed in 2007, i.e. 19 years after the event, so evidences for a glacier surge observed in 2007 only proof that this is a glacier that surged in 2007 and therefore potentially performed other surges in earlier years; however, it does not make a direct link to the conditions in 1988. Furthermore the observed ogives and the tensile crevasses (rather use the term crevasses instead of cracks) are not at all a proof for a surge; ogives typically form below ice falls (see Fig. 2), and crevasses are caused by the shape and geometry of the glacier bed rather than changes in velocity. The reported front variations as observed in the satellite images listed in Table 4 hint to a glacier surge, which of course would have increased the water level and the pressures an the moraine dam. However, a surge does not explain the retreat of more than 600m within only a few months as suggested in P4612L10-14. Please revise this section and add supporting figures and text.

P4614L11-16: How can perennial piping been inferred from a topographical map? Please show the topographic map of 1980 in a figure and give more details on the local interviews from 1990.

P4614L22-P4615L8 and Fig. 6: All the findings presented in this section are based

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on other studies. Since these studies (Lv et al., 1999 and Li and You, 1992) are only available in Chinese, more details should be given here, in order that all involved reconstructions can be followed without knowing the cited studies. For instance, it is not clear to me: (i) how the volume of the ice avalanche has been inferred (as mentioned above, I have strong doubts about the ice avalanche hypothesis); (ii) how the peak discharge (and its timing) was calculated; (iii) how the discharge after the peak discharge has been inferred; and (iv) how the lake volume before and after the event (and hence the outburst volume) has been reconstructed.

P4615L10-P4616L16 and Fig. 7: An figure showing not only the locations of MD1 and MD5, but also a map of the observed depositions would be helpful to interpret the evolution of the flow characteristics.

P4615L22-P4616L16: In general: I assume that these samples have been taken during the field mission in 2007. Is it certain that all observed depositions originate from the 1988 outburst? Or could it be that other (maybe smaller) outbursts happened after 1988? Or that some of the sediments were deposited after the 1988 event by the river, e.g. during periods with heavy rainfall and thus high discharge?

P4616L20-22 and Table 4: As mentioned above, a figure showing the satellite images listed in Table 4 would help to illustrate the lake evolution. How have the lake volumes been estimated? Please give the used formula and its source.

P4616L22-24: To which volume refer the numbers of 36.6% and 16.2%? Please reword.

P4617L9-10: As mentioned above (P4606L6-7), this statement needs a reference.

P4617L20-24: Again, showing the mentioned satellite imagery should support this. In particular it would be interesting to see an image from shortly before the event in 1988, to verify the glacier advance to 15m before the lake as stated by Li and You (1992). In P4607L25 it is mentioned that Yang et al. (2012) used satellite images from before and

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after the outburst. The explanation of the ice avalanche is still not convincing to me.

TECHNICAL CORRECTIONS:

P4606L14-15: Add spaces before and after the dashes (as done on P4618L7)

P4607L3: Remove one 'W' of WWantanbe.

P4607L11: To me, 'widely distributed' seems not to be an appropriate expression for describing the glacier coverage.

P4607L13: Replace 'With climate changes' (e.g., by 'with climate change' or similar)

P4607L26: Insert 'the' between 'after' and 'outburst'.

P4608L17: Replace 'mainstream' by 'main river'.

P4609L10: Rephrase sentence. (e.g., begin with 'Figure 1 shows that'; and replace 'two-grade').

P4610L4-8 and Fig. 2: I suggest using the expressions 'the western, a central, and an eastern branch' throughout the text, also in Figure 2.

P4610L24-25: I think this sentence should be written in present: 'There 'are' three Tibetan villages [...] which 'have' approximately [...]' (Or were they destroyed during the event?)

P4613L8-10: Please mention in the text that the location of the sampling sites is given in Fig. 7.

P4611L22-23: I do not understand the term 'pre-accumulation'. Do you mean 'accumulation'? Please reword.

P4612L4: Please reword the sentence; the phrase 'the necessary conditions of climatic background' has no meaning.

P4613L4: Replace 'outside' by 'external'.

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P4613L8-10: This is confusing: in the previous sentence it is stated that this is the lowest outburst lake of Tibet, but here the high altitude is mentioned. And from the context of the cited references it seems that already several studies exist that deal with the causes and involved processes of this lake outburst. Please revise.

P4615L17: Mention that locations of MD1 to MD5 are shown in Fig. 7.

P4618L2: The last sentence of point 3 is not understandable to me. Please revise.

Tables 1 and 2: I suggest merging the two tables into one, identical to Table 2 in Liu et al. (2013). Or skip Table 1 completely, the information of Table 1 (elevations and coordinates of the sampling sites) are not that important as long as the locations of the sites are indicated in a figure (currently in Fig. 7).

Figures 1-3: As mentioned above, I suggest to make a new overview figure based on a satellite image or the topographical map. Figures 1 to 3 could be replaced, or the photos could be included as insets in this new overview figure.

Figure 4: As mentioned above, climatic averages should be included into Fig 4b, and a new figure (4c) showing the temperatures and precipitation of the week before the lake outburst in 1988 would be very helpful and should be added.

Figure 6: As for the explanations in the text (P4614L22-P4615L8), it is not clear how this hydrograph has been inferred. And I assume it is taken from another study, so please mention the source in the figure caption.

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