The Cryosphere Discuss.,
https://doi.org/10.5194/tc-2018-201-RC1, 2018

The Cryosphere Discussions
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EGU

Interactive comment on "Brief communication: 4 Mm^3 collapse of a cirque glacier in the Central Andes of Argentina" *by* Daniel Falaschi et al.

Anonymous Referee #1

Received and published: 31 October 2018

General comments :

This study deals with the collapse of an unnamed glacier in the central Andes of Argentina in March 2007 (between 5 March and 14 March 2007). This glacier, named by the authors, ' Lenas glacier ', is located in the very remote area. The collapse and the avalanche have not been observed directly and it seems to remain unnoticed during several years. Very few data are available about this collapse. Most of data come from satellite images. This study aims at reconstructing the conditions of the collapse (Volume, slope, meteorological conditions, sismic events,. . ..) in order to understand the possible causes of this breaking off. The authors claim that this event, very rare, can be compared with the very large collapses of Kolka in 2002 and Aru glaciers in 2016, given that the volume size is huge and the slope of the glacier is low.

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Discussion paper

Unfortunately, the analysis and the conclusions remain qualitative and speculative due to the lack of data. This study contains vagueness, large assumptions, and lack of rigour for the following reasons :

1) First, the uncertainty relative to the collapse volume can be questioned. The volume changes have been assessed from satellite images (Spot 5 12 February 2007, Landsat 5 March 2007, Spot 5 14 March 2007, Quickbird 19 April 2007). The failed glacier area and thickness have been estimated from images 12 February 2007 and 19 April 2007. The accuracy of each DEM is not mentioned. The authors wrote that ' the average thickness at the scarp was roughly 35 m as estimated from scarp shadows and solar angles at the time of acquisitions . Thus assuming a linear decrease of the glacier thickness from the scarp to the former glacier front . . . . . a rough estimate of 4.5 106 m3 ' (l. 108-111) . No detailed information is given about the method and the uncertainty of thickness. In the following lines (l.112), the authors mentioned a ' conservative 15% error from uncertainty in detached area and thickness estimate' without providing any details about this uncertainty. Another ' independent ' estimate has been done from the difference between SRTM DEM (February 2000) and ALOS PRISM DEM AW3D obtained between 2007 and 2011. Again, the uncertainty of these DEM is not given. The uncertainty related to SRTM penetration is not mentioned. The authors mentioned only that the assumption of no radar penetration is confirmed by the comparison between C Band and X Band SRTM which show no significant difference. The authors did not provide any detail or reference. In addition, the authors used the ' average DEMS' of ALOS PRISM DEM (2007-2011) with an ' average year' of 2009. They assume that there is no change between March 2007 and 2009 (l. 125-126). It is very confusing. The uncertainties relative to this assumption are not explained. Nothing is said about the elevation differences between these 2007-2011 DEMs. The uncertainty of 2.3 m (l. 128) on elevation difference seems to be very optimistic. Moreover, from Figure 2a, one can see surprising elevation changes of 25-50 m in several areas of the upper part of the glacier between 2000 and 2009 far from the detached zone. These values are similar to the elevation changes of the collapse

area. However, no explanation is given about that. Due to the lack of information, it seems very difficult to assess the uncertainty on the volume of the collapse.

2) The discussion about the ' mean slope' is confusing. The authors make a difference between hanging glaciers with steep slopes (>30°) and glaciers with low slope (lines 26-27). They wrote that ' the detachment of large portions of low-angle glaciers is much less frequent ' (l. 34-35). The manuscript is confusing because the authors mentioned both the low angle of reach (5°) (lines 22 and 106), the average slope of glacier (24.6°) (line 97) and the slope of the detachment part to discuss the stability/instability of the glacier. These slopes are mentioned in different sections of the manuscript which creates confusion. The low angle reach is not relevant to study the stability of hanging part of the glacier. More specifically, the ' suprisingly low angle of reach (5°) ' (Abstract, l. 22) seems to be irrelevant as an indicator of stability of glacier. The slope of ' detached glacier', which seems to be the relevant value to assess the stability, is mentioned in Discussion only in line 186 (15.6°). We do not have any information about the method used to calculate this slope. Is the surface slope before the collapse ? calculated on which distance ? is the surface slope after the collapse ? Which images have been used to obtain this value ? What is the accuracy of this calculated value ? The analysis of slope change reveals also a lack of rigour. In line 142, the authors wrote : Âń the glacier slope decreased from 24 .6 to 20.4° from before to after collapse Âż. The distance on which this slope is calculated is not specified. One can assume that the slope change is mainly due to the length changes of the glacier and the size of the avalanche. In this way, is the slope change a relevant information?

3) As mentionned by the authors in Conclusions, due to the limited data, this study is not able to identify the causes of the Lenas event. Many assertions are highly speculative. For example ' the thin glacier front could have been frozen to the bed and a change in this polythermal regime may have caused changes in stability' (l. 202-204) or ' we suggest that the soft glacier bed material could have played an important role in the collapse. . . .' (l. 206-207), or ' we hypothesize a mixed origin for the debris layer

observed on the ice avalanche deposit. . .' or ' . . .may indicate that a large glacier collapse has not happened in 2007 for the first time. This speculation relies on. . .. . . '. The Discussion is a list of assumptions and questions and does not shed light on the causes of this collapse.

In summary, the authors claim that the Lenas collapse deviates from typical ice avalanches from steep glacier and can be compared to the rare low-angle glaciers collapses similar to Aru glaciers and Kolka glaciers avalanches. Given the lack of information given in this study, the uncertainty on collapse volume can be questioned. In addition, the data provided by this study are poor and do not allow to identify the possible causes of the collapse. This study points out the low detachment slope (15.6°) although the determination of the slope has not been explained and the uncertainty on this slope is unknown. 'No significant change in glacier geometry could be identified due to the lack of data' as mentioned in Conclusions (l. 267-268). The authors suggest that soft bed characteristics play a crucial role on the collapse trigger. I do not think that this study provides sufficient quantitative information for understanding complex processes in glacier instabilities and collapses. I do not think this study shed new light on the triggers and factors responsible for this event. Given the paucity of data, I am not sure that this event can be compared to Aru glaciers and Kolka glaciers avalanches as claimed by the authors.

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