

Interactive comment on “Buoyant calving and ice-contact lake evolution at Pasterze Glacier (Austria) in the period 1998–2019” by Andreas Kellerer-Pirklbauer et al.

Anonymous Referee #1

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This is a well researched observational study on the calving mechanism of a quickly retreating glacier in the European Alps. Pasterze glacier is the largest glacier in Austria, and the mechanisms described here may be pertinent to other similar alpine glaciers where strong temperature increase due to climate warming caused substantial increase in surface melting. The novel findings show new insights in a process, which to my knowledge hasn't been observed in the European Alps before. Image data from satellites and time-lapse cameras and GNSS data acquired over a period of 20 years reveal a significant glacier retreat, and the formation of supraglacial lakes and a proglacial lake; the latter increasing in size at exponential rate. The drastic retreat ('backwasting') significantly reduced once the glacier was detached from the lake (to-

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wards the end of the observation period). The interpretation of the calving events relies on time lapse photography, which are put into a geophysical context by making use of geo-electrical resistivity tomography (ERT) surveys prior to the calving (2015-2019). It is concluded that debris-covered dead-ice bodies were widespread and existed in a proglacial basin (up to 48 m deep), which disintegrated in four ice-break-up events (buoyant calving). The processes related to hydrostatic disequilibrium are clearly identified, and the authors conclude that buoyant driven calving is causing the rapid formation of the pro-glacial lake. Overall, the applied methods are suitable and scientific rigour has been applied. However, I have added major comments about the referencing below. The chain of arguments is convincing and I rate the manuscript suitable for publication in The Cryosphere after addressing a small number of major and minor comments addressed below. The figures are largely of great quality, and I have only one minor comment listed below.

Major comments:

One of my main comments is about the literature and references used. Quite a number is either not quality assured, and hard or impossible to find. Some of this literature is in German, and in that case it needs in my opinion a precise reference to a page or figure with description, in order to allow a non German speaking person to follow. Examples are Avian et al. (2007), Bernsteiner (2019), Kellerer-Pirklbauer (2017), Krisch and Kellerer-Pirklbauer (2019), and Wakonigg and Lieb (1996). I couldn't find Loke (2000). These references need in my opinion get either better referenced or replaced, or otherwise, if the information is not critical, could be removed. The latter could help to shorten the manuscript, and to give more focus on the analysis and interpretation of the geophysical survey and the time-lapse photography. It is unclear if data will be provided upon publication, but it would be great to have the time-lapse photographs of ice-break-up events as animated gifs. I am unsure what 'super-buoyant' actually means, but I was wondering how the thickness of sediments influence the buoyancy of dead ice bodies. As sedimentation is identified as an important process, is it possible

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to estimate if sedimentation, solely by its weight, would influence or delay the break-up event? Or is it a relatively thin layer of sediments on dead ice which results in what is described as 'super buoyant', as opposed to thick layers, which would prevent dead ice from buoyant calving? As a final comment, I agree that flood outbursts pose a significant hazard. I imagine that the sudden buoyant calving is also a significant risk for tourists walking in the pro-glacial area.

Minor comments:

Line 27: Use GNSS (preferably) or GPS throughout the document; Replace 'geoelectrical' with geo-electrical or, preferably, with 'electrical', in order to make the acronym ERT obvious. Line 35: ... for the fast lake expansion (add 'the'). Line 80-82: This sentence requires a reference, as it reports on 'observed instances of fast lake-bottom lowering'. Line 89: What does 'super-buoyant' mean? I doubt that there is something like this, and should be replaced by 'buoyant'. Line 94: Kellerer-Pirklbauer (2017) is not a quality assured reference and should be taken out or replaced, or the sentence rephrased. Line 120: Wakonigg and Lieb (1996); unaccessible source. Line 234-236: What method was used to measure lake level variation? Line 242: I could not find this thesis, and as it is in German, it is not suitable reference. Line 244: I suggest to provide a more descriptive heading; Line 249: Geotom, Geolog, Germany – provide more specific information or a suitable reference; Line 253: RTK-GNSS Line 258-259: 'Bad datum points were removed...' What do 'bad datum' points mean in this context? Line 266: an estimated accuracy of 10 cm is likely only the case for a flat bathymetry; how is this degraded for slopes? Line 469: Pasterzensee; this is the only time that this is used in the document; change to 'Lake Pasterzensee'? Line 506: reference; Stokes et al. (2007) Line 576: what does 'super-buoyant' mean? Line 778: Roehl (2006) Line 781: Remote Sens-Basel; typo? Line 834-835 (Figure 4): one box describes 'extent of Figs 5, 7, 9'. Is this supposed to be 'Figs 5, 7, 10, 11'? Or, more likely, is it only referring to Fig. 7?

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