

The Cryosphere Discuss., referee comment RC1  
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## **Review of Field et al. 'Topography exerts primary control on the rate of Gulf of Alaska ice-marginal lake area change over the Landsat record'.**

Jenna Sutherland (Referee)

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Referee comment on "Gulf of Alaska ice-marginal lake area change over the Landsat record and potential physical controls" by Hannah R. Field et al., The Cryosphere Discuss., <https://doi.org/10.5194/tc-2020-366-RC1>, 2021

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### **General comments**

The effects of ice-marginal lakes are a topical and emerging area of research. Due to the impacts on biophysical systems through water and sediment fluxes, the authors make a strong case for investigating physical controls on lake areal change. This is a nicely designed and detailed study which quantifies ice-marginal (both proglacial and ice-dammed) lake area changes across a representative sample over northwest North America from 1984-2018. The authors find that proglacial lakes increased in area over the last three decades whilst a large proportion of ice-dammed lakes shrunk. Specifically, large, low-elevation coastal proglacial lakes associated with wide, thick glaciers appeared to change most in absolute terms, in contrast to small, interior lakes at higher elevation that changed most relative to their initial area. Appropriate statistical analyses suggest limited correlation between climate and lake area change. Instead, the authors conclude that lake geometry and topographic setting are the dominant controls on lake area change in this region. Overall, the manuscript is well-written and clear. I suggest several very minor corrections which I expect can be addressed very easily. Although these technical corrections may look extensive, they are merely intended to help tighten up the precision of the text. I am convinced that this work presents interesting and novel results demonstrating the influence of geometry and topography as controls on ice-marginal lake evolution. Indeed, on the basis of this study I see the value of further investigations to see if similar correlations exist in other regions.

### **Specific comments**

I appreciate that lake area change was the focus of this study and I suspect that lake depth or bathymetry is unknown for many of the lakes. However, I wonder if the authors might comment on how important lake volume might be, relative to area, for a more in-depth discussion. A basin may well get deeper as it widens, and so lake volume is also likely to be influenced by the same environmental variables, specifically geometry and topography.

The statistical analyses undertaken and assumptions made are valid and clearly outlined. However, the authors infer that covariance between continentality and climatic parameters is the underlying cause for correlation with other environmental factors. Line 660 states that 'when considering climatological, glaciological and topographic controls on lake area change, it is important to note that these variables are often intertwined'. I wonder why a multivariate statistical technique such as Principal Component Analysis was not undertaken instead? In PCA, the data are easily reduced into smaller numbers of interrelated groups that can reveal underlying patterns within the dataset. Measuring the importance of each variable relative to each other in this way might help to confirm the authors' assumptions.

### **Technical corrections**

Line 23. 'These systems...' Could you clarify which systems you are referring to here. The low-elevation coastal proglacial lakes or interior lakes at high elevation? Or both?

L28. The Introduction is labelled as 1.1 but there are no subheadings within this section. Change to 1.

L37. 'may pose a serious hazard'. To downstream communities?

L56-60. Make it clear that this study (Wolf et al. 2014) refers to lakes in northwest North America (I think)

L62-63. This sentence seems to be a repeat of what is stated in the first sentence of the intro (lines 29-30). I think you can delete either one to make the text more concise.

L70. 'bys' should be 'by'

L75. 'In addition to these glaciological factors....' It seems unusual to start a new paragraph like this. This sentence should be linked to the points made above.

L79. 'below lakes.' I suggest rephrasing this because it reads as if the streams are positioned underneath the lake, I think you mean downstream?

L83-86. A bit of repetition (such GLOFs) from paragraph 1 here. I suggest paragraph 4 of the intro is either deleted or at least condensed and moved into another paragraph. I would also suggest combining the last two (short) paragraphs of the intro into one.

L94. 'how lakes change over time'. And space?

L98. I suggest clarifying here if the lakes studied in Brun et al. (2020) were ice-marginal or disconnected/distal to glacier terminus. This is quite important. I think the latter.

L100. 'shifted up in elevation'. I suggest rephrasing for clarity, e.g. shifted to higher elevations.

L101. 'may influence proglacial lake evolution...' add 'also' in-between may and influence

L106. Clarify if this 'model' is a numerical/physical/conceptual model?

L122. 'Our 107 study lakes span...' I suggest re-phrasing, so it reads more fluently e.g. 'We study 107 lakes that span...'

L163. 'We utilize the 1960s decade to consider the longest-term comparison allowed by the SNAP dataset.' Given that the lake extents were digitised from 1980s onwards, could you have utilised 1980s decade also?

L267. 'summery' should be 'summer'

L314. 'We exclude lakes that detached from their adjacent glacier (n = 18; 13 proglacial lakes and 5 ice-dammed lakes).' These numbers don't seem to match up with what is written in lines 257-259 that suggests 15 proglacial lakes detached?

L318. 'Though we omit these lakes from lake area change characterization and analysis'. I would delete this as it is repeated from the previous sentence and perhaps re-phrase this part of the paragraph, so it reads more fluently.

L358. I found the many values reported in the first two paragraphs of section 4.1 slightly confusing as to what they represented. E.g. Lines 358 'In terms of lake number, 83 % of the investigated proglacial lakes (n = 88 in total) grew, 10 % shrunk, and 7 % were relatively stable, changing by less than  $\pm 0.1$  km<sup>2</sup>.' So what then are the numbers reported for proglacial lakes in previous paragraph (Lines 349-350)? Are the 72 proglacial lakes that grew, 82 %? Do these statements need to be linked in some way?

L493. 'Though their signs are flipped'. Could there be a better way to phrase this?

L518. 'against the backdrop...' I suggest re-phrasing this e.g. 'into the context of global...' or similar

L554-556. 'The initial existence of a large lake requires a large basin, and basins generally do not end abruptly. Therefore, the simple existence of a large lake suggests that there is high potential growth in a regionally-extensive depression.' I agree with this statement to a certain extent, but the opposite could also be true – initially large lakes could be at their maximum extent with no further room for growth and therefore I would not expect large lakes to expand further.

L556. 'longer zones' – clarify whether this is spatially or temporally. I think you mean how much surface area of the glacier is in contact with the lake as 'wider' is referred to later in the sentence.

L559. 'perhaps that large lakes tend to be warmer'. Could a reference be cited here?

L560. 'submarine' change this to one of subaqueous/basal/sub-lacustrine (my preference is subaqueous)

You infer that topographic and geometric factors most strongly control ice-marginal lake area change, so perhaps in section 5.2 a discussion about how the geometry of the lake

and the topography also influence the geometry of the adjacent glacier could be made. The following study supports your conclusions about such inter-related variables:

Sutherland, J. L., Carrivick, J. L., Gandy, N., Shulmeister, J., Quincey, D. J., & Cornford, S. L. (2020). Proglacial lakes control glacier geometry and behavior during recession. *Geophysical Research Letters*, 47(19), e2020GL088865.

L556. 'Several other factors are statistically significantly linked can be explained using...' Insert 'that' after factors.

L621. 'glaciers act as low-pass filters on climate variability'. Could you elaborate upon this? Do you mean that subtle changes in climate are not detected by the glacier?

L623. 'responding to climate change in a lagged and smoothed manner' Insert 'is' before 'responding'

L637. 'lake area coming into equilibrium with the current environment' I am unsure what you mean here, equilibrium suggests a steady state so do you mean the lake will neither grow or shrink further?

L669. 'where has been more winter precipitation' should be 'where there *has* been...'

L698. There is a change of tenses within this sentence. I suggest changing 'find the majority (82 %) of proglacial lakes are growing' into the past tense.

### **Code data and availability.**

I am unable to access the data specifically linked to these webpages :  
<https://arcticdata.io/xx> and <https://github.com/armstrwa/xx> (the end of the links appear to be missing?).

'Climate reanalysis data are available at xx'. Insert the correct location instead of xx?

'The Randolph Glacier inventory is located at [link]' this link actually takes you to the SNAP climate data not RGI.

## **Figures and Tables**

Figure 1. Perhaps an insert of the wider region would be useful here for readers not familiar with the area? Could you state what the insert (photograph) is in the caption, e.g. is this glacier or lake named?

Figure 3. Lines 242. 'Ice thickness color bar and map scale are identical between panels a and b'. I don't think you need to state this in the caption because the reader can see they are identical looking at the figure. If space allows, could the lake outlines from different years also be labelled (I think I see 3 or 4 different outlines)?

Figure 4. Line 373 in the caption 'while proglacial lakes that appeared that time are unfilled' is there something missing here? The dashed line shows 1:1 (i.e., lakes with constant area), while the dashed lines show various levels of relative area change.' Do you mean dotted lines perhaps?

Figure 6a. Has this data been plotted from specific lakes? If so, could the lake/glacier be labelled or mentioned in the caption?

Table 1. Could you add the resolution (and range) of elevation data from GTOPO30 here?

## **Supplementary Information**

Line 928. Figure S1 caption, insert the word 'lake' in-between 'proglacial bounded...'

Figure S7. I can't see where this figure is referred to in the main text. Figure caption states c) is 'winter precipitation for each lake for 2009-2009 decade'. Should this be 2000-2009 instead? Line 984. 'A positive change indicates warmer temperatures' I think needs to be deleted as it is repetition of c) and d) is precipitation only

Line 990. 'lake are time series and area change' should be 'lake area time series'?

Dr Jenna Sutherland (Leeds Beckett University, UK). 05/02/2021.