Changes in Supraglacial lakes on George VI Ice Shelf, Antarctic Peninsula: 1973-2020, Thomas Barnes et al. Response to reviewers.

Thanks to the reviewers for offering their time to review our manuscript, we appreciate the posted comments, as they will aid in improving our manuscript. Each of the major comments will be addressed in turn, with responses given beneath.

Review 1

1. The paper needs to be reassessed after considering how surface topography affects where water pools. Several of the proposed mechanisms and causal relationships between climate, firn, and meltwater lake coverage need to be reconsidered, and revised if still true or removed if no longer true.

To approach this point we intend to look at a high resolution DEM to find out whether surface topography and water pools show a connection. Based on the results of this investigation, we will identify whether or not they support the above hypothesis.

2. The methods by which lake pixels are selected need to be further explained. Moussavi et al. (2020) would be a good reference if the new method is to be kept, but I would recommend using Moussavi et al.'s available code for Landsat 8 imagery and discuss the process used to select the NDWI thresholds for Landsat 1-7. I also don't understand what the scaling of lake pixels derived from non-Landsat 7 imagery includes, but the uncertainty introduced by this needs to be discussed.

This point will be approached by comparison of the results of Banwell et al., (2021) where Moussavi et al (2020)'s methods were used to compare an alternative method to the results of this study. This was done previously through correspondence with A. Banwell, but not included in the manuscript. Additionally, reasoning behind thresholding will be discussed. The final part of this comment is addressed in the response to point (8) from Reviewer 2.

3. Many of the assertions about climate effects on meltwater lake coverage presented in the discussion/conclusion need to be supported by data or citation of the literature. The choice of MAR is discussed in the supplementary materials, but the authors also seem to use MAR output as a single point rather than a spatially-varying raster dataset.

Effort will be made to improve referencing in relation to climatic effects on lake coverage. Additionally, clarification will be made for the use of MAR, as it was initially tested as a point source, however over the course of the study this evolved into a gridded use, and may not have been fully updated in writing as an oversight.

4. Some sections need to be rewritten to clear up ambiguity in what was done, what is being extrapolated, etc.

Line by line comments will be addressed to improve the manuscript and lessen any ambiguity in writing. Additionally, effort will be made to include much of the supplemental information in the main body of the manuscript so as to avoid further ambiguity with methods.

Reviewer 2

1. The abstract of the text needs to be re-written. When compared to the introduction it is of a lower standard of writing, and it doesn't convey the key findings well.

The abstract will be rewritten to cover findings more comprehensively, once all other comments are addressed.

2. When describing George VI Shelf (Lines 47-55), the authors need to do some wider reading of literature. For example, they should use past work here to describe the different glaciological settings of the north and south GVIIS. A study area figure is also required.

A study area figure will be produced and included, further efforts to discuss the differing settings of the north and south end of George VI ice shelf will be made. References such as Smith et al., (2007), Holt et al., (2013) and Hambrey et al., (2015) will be used among others to improve the quality of this discussion.

3. It makes little sense to me to use the NDWI Green and Near Infrared method over the NDWI blue and red method, given that the majority of literature would use the latter, and this has been well justified in many previous papers. I am not convinced as to why the authors chose to use this alternative thresholding method, and the text in S2 still does little to convince me. It would be interesting to see some maps showing the differences between the two thresholding approaches.

Inclusion of information from the supplement and associated MSc project will be added to this work. Comparisons between each NDWI methodology were made at the initiation of the study on a test region, where Green-NIR served to produce lake polygons which were more 'strict' towards lake shorelines, and therefore less likely to pick up slush and saturated snow surrounding lakes.

4. The lakes in some imagery were manually delineated, yet there is no mention of the error that should be considered when comparing these manually delineated lakes to lakes found using the thresholding method. Overall, the authors should consider the errors associated with all methods, and reference these where appropriate.

Consideration of error will be made for manual delineation, with the generated error being subject to discussion within the research group. This was tested again at the initiation of the project, however it was found that due to the subjectivity of manual delineation, a true value of error was hard to ascertain if multiple people carried out manual delineation, or the same person carried out the process over several days. Hence, further testing may be necessary.

5. The authors state that they use a different threshold for Landsat 1 because the bands do not correlate with the other Landsat instruments. But I question whether the Sentinel-2 bands correlate? If not, why did you not use a different threshold for that too?

Sentinel 2 and Landsat 8 bands correlate closely, and therefore the same threshold value was used for each satellite. This will be made clearer in the text. Landsat-1 was an anomaly as it includes many fewer bands of differing width to more modern instruments.

6. Is there full ice shelf coverage for every data point investigated? If not, how much of the ice shelf is 'missing'?

Full ice shelf coverage is found for all data points other than those specified. A diagram including this information was produced but not included in the text due to initial constraints on manuscript length. However this will be included with the changes made in response to comments.

7. The authors only show satellite imagery of GVIIS in maximum melt years, however they comment (Line 167) on the spatial organisation of surface meltwater in low melt years too. It would be useful to see some figures showing this, to allow the reader to see the changes that occur over time.

Included in the original MSc thesis was a series of diagrams showing the full lake coverage across GVIIS for each year during the study period. This will be included in the supplement in future submission as per this comment. However, it would not be appropriate as part of the main text due to the size of the diagram.

8. The authors suggest that they convert the areas for all data that wasn't affected by the Landsat-7 scan line failure, ultimately reducing the areas? This is a questionable decision as it broadly means the data presented is not representative of the true area of melt on GVIIS, which is an important statistic to have. I suggest the authors present both the converted and unconverted data.

We agree with the suggestion to approach Landsat-7 data in an alternative manner. Pre- and post- conversion data will be included in discussion in the updated manuscript. Another approach we have discussed would be to keep non-LS7 data as unaltered, and to convert Landsat-7 data using the 0.78 scaling factor. However, inclusion of both sets of values would show a more complete picture.

References:

Banwell, A. F. *et al.* (2021) 'The 32-year record-high surface melt in 2019/2020 on the northern George VI Ice Shelf, Antarctic Peninsula', *Cryosphere*, 15(2), pp. 909–925. doi: 10.5194/TC-15-909-2021.

Hambrey, M. J. *et al.* (2014) 'Structure and sedimentology of George VI Ice Shelf, Antarctic Peninsula: Implications for ice-sheet dynamics and landform development', *Journal of the Geological Society*, 172(5), pp. 599–613. doi: 10.1144/jgs2014-134.

Holt, T. O. *et al.* (2013) 'Speedup and fracturing of George VI Ice Shelf, Antarctic Peninsula', *Cryosphere*, 7(3), pp. 797–816. doi: 10.5194/tc-7-797-2013.

Moussavi, M. *et al.* (2020) 'Antarctic Supraglacial Lake Detection Using Landsat 8 and Sentinel-2 Imagery: Towards Continental Generation of Lake Volumes', *Remote Sensing 2020, Vol. 12, Page 134*, 12(1), p. 134. doi: 10.3390/RS12010134.

Smith, J. A. *et al.* (2007) 'George VI Ice Shelf: past history, present behaviour and potential mechanisms for future collapse', *Antarctic Science*, 19(1), pp. 131–142. doi: 10.1017/S0954102007000193.