Review of: Tides and Damage as Drivers of Lake Drainages on Shackleton Ice Shelf

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1 General

The goal of the work is very straightforward and well defined. Basically, there are three main goals: 1) map the overlap of damage and ponds; 2) find the draining ponds and identify in which conditions they occur; and 3) identify triggering events.

It is an interesting study, very important in the study of Antarctica. However, it is hard to define how impactful the findings are, since the methodology lacks more description of the metrics. Furthermore, the analysis should be deeper (see Major Comments).

I think the manuscript has 4 main issues:

1. observations do not support the claims in the manuscript
2. lack of a more robust statistical analysis
3. small number of observations
4. more descriptive methodology and how are the thresholds defined

2 Major Comments

2.1 Sample size

The authors used a time span of 3 years for the analysis performed. They found 13 events, which is a small sample size. Why do you not cover a larger time span to have more data? In addition, covering other regions would be beneficial. Furthermore, the definition of threshold values seems quite arbitrary, indicating that they fit only to these present specific conditions.

Also, the authors highlight the need for more sophisticated statistical approaches. This is a major concern for me, because not only the dataset is small, but it also lacks meaningful statistical analysis.

2.2 Not supportive data

I think the data presented do not support the conclusions drawn. In fact, the authors repeatedly make an affirmation and draw it back after a few sentences, for example:

L139-140 = "However, all of the detected lake drainage events occur in areas of the ice shelf classified as medium to highly active"

and

L151-L153 = "For example, drainages H, K, and M took place in areas with relatively low damage but high activeness, while drainages A, F, and G occurred in the least active regions, yet showed high levels of damage."

Furthermore, analysis of Figure B1 reveals that 1 of the events is in a low activeness area, undermining the claim in L139-140.

2.2.1 Activeness parameter

The authors conclude that "all of the detected lake drainage events occur in areas of the ice shelf classified as medium to highly active", but they sum up to 90% of the studied region. Taking into account that they have only 13 drainage events, their conclusion is not supported by the data since further analysis should be made.

Even if drainage events are correlated to activeness, it could be the case that activeness is actually related to damage (meaning that damage is higher when it is caused by the flow, which is very plausible) and that drainage events are mainly driven by damage (also very plausible).

2.2.2 Section "Lake Drainage Events in Periods of Increasing Tidal Heights"

As reviewer #1 said "6/11 drainage events in 2019 (more than half) started during the lowest (or even descending) phase of the tidal cycle (drainages M, L, F, H, J, E)". This simply invalidates the sentence: "Our findings unveil a compelling narrative of ice shelf dynamics, revealing an intricate interplay between tidal forces and supraglacial lake drainage events".

Furthermore, in a hypothetical case where all the drainage events occur in an ascending-amplitude phase of the tidal, it will not imply what is said: if you have thousands of lakes in a ice shelf, and each time only a small fraction of lakes drain, the likelihood of a drainage event triggered by tidal flexure would be higher in the crest of the amplitude phase.

3 Minor comments

3.1 Methodology clarification

Some clarifications are needed on the two main metrics used in the study. First, I agree with reviewer #1 about the lack of information on how damage is calculated. Usually it is inverted from

$$\mu = \frac{(1-D)B}{2\dot{\varepsilon}_e^{\frac{n-1}{n}}} \tag{1}$$

where μ is the ice viscosity, D is damage (which you want to invert), B is the ice rigidity, ε_e is the effective strain rate, and n is the flow law exponent. I think it is needed to specify how damage is calculated from remote sensing. Also, if possible, it would be interesting to relate the damage calculated in the present work (which reviewer #1 suggests changing the name to "satellite-derived damage" and I agree), and damage calculated from Equation 1.

3.2 Activeness vs. damage

I think a further analysis of the relationship between damage and activeness is required. It can be the case that the relationship between them is high, so any relationship between activeness and drainage occurrences is only due to damage.

3.3 Motivation

The first sentence of the article ("Surface lake drainage can destabilize ice shelves, occurring either slowly via supraglacial channels or rapidly through crevasses") makes me wonder if you are not studying the opposite. Instead of analyzing how damage influences lake drainage, should not you analyze how lake drainage influences damage? Otherwise, if you really want to analyze how damage influences lake drainage, you should motivate that in the introduction. I think you are putting the cart before the horse.

4 Specific comments

- L16: Is it the first time that "activeness" is used? If so, say that the manuscript introduce this concept. Otherwise, make a reference.

- L44: Do you advect the features when you merge the images in the mosaic?
- L50: This sampling frequency (once a year) is very different from the optical image that you are going to contrast later on. How do you deal with that?
- L52: It is not clear where you use the velocity field. For sure for the "activeness" calculation, but do you also use to transport the features? Make it clear near the description of the velocity field calculation.
- L61: Regarding the threshold 1800 m^2 you make a citation for this value, but what is the reasoning of using this threshold?
- L65: Why 80%? I can also imagine 50% as a massive drainage event. this looks like a random choice, that you need to pick one, but if you lower the threshold, you would have many more drainage events, increasing the data you can use to infer, since 13 drainage events are not many.
- L67: Was not the are threshold 1800? Furthermore, why do you use these threshold? Give a reason and use the citation. Only the citation is not enough.
- L72: you excluded 20 out of 25, so you have 5 drainage events. How then you have 13 drainage events in your results?
- L78: Add "resolution" after "300 m".
- L83: Missing citation. Makes sense to compare the angle of the fracture to its orientation, but quantifying it can be tricky. Is there any supporting studies for the use of that values?
- L88: If activeness is binary, how you produce an image like Figure 2 b)? It do not seems like a product of downsampling.
- L88: I don't see the reason of donwsampling it.
- L89: Why normalizing? You can say directly that damage varies between 0 and 1 and everything is already normalized.
- L89: Add "resolution" after "3000 m".
- L101: Add "total" in "with total maxima".
- L116: I think the definition of the thresholds should go to methods with a further explanation of the threshold used.
- L119-124: This is a very sounding result, supporting the hypothesis of a strong relationship between drainage events and damage. However, I would expect the same analysis regarding the activeness. The distribution of 10%, 71%, and 19% does not allow this analysis. Contrasting the area distribution and Figure B1, and do not see a strong relationship between activeness and drainage events. I would say that most of the signal of drainage events are due to damage.
- L129: Same comment as for damage.
- L139: This conclusion is not surpirse. It sums 90% of the studied area.
- L151: What do you mean by "parallel trend". Be more specific.
- L151-153: This goes against the phrase: "However, all of the detected lake drainage events occur in areas of the ice shelf classified as medium to highly active".
- L156: You previously said the opposite.
- L158: As far as I understood, it is impossible to drainage event to occur without damage. Be more precise with this statement.

- L161: I agree with reviewer #1 regarding the drainage events with respect to the ascending phase of tidal cycles.
- L187: I think you do not have drainage events that last hours. If this is the case, remove the "few hours".
- L190: Here you say that it is difficult to assign the drainage events to hydrofracturing, but in the discussion you did this.
- L197: If NeRD can not identify individual fractures, how then you measure the orientation of the fractures to calculate the activeness?
- 214-216: This sentence is another major concern for this study.

4.1 Figures and tables

I would appreciate a hexabin graph with activeness and damage in the axes. This would allow us to see the correlation between both metrics and the occurrence of drainage events.

- Table A1: Bring it to the main body of the text, it is too important. I suggest including two more columns: Classification of damage and activeness (low, medium, high).
- Figure 1: Define LIMA as an optical imagery mosaic from Landsat.
- Figure 2: Add ", respectively" at the end of the first sentence.