

# ***Interactive comment on* “Spatial and temporal variability of water-filled crevasse hydrologic states along the shear margins of Jakobshavn Isbrae, Greenland” by Casey A. Joseph and Derrick J. Lampkin**

**Casey A. Joseph and Derrick J. Lampkin**

cajoseph@terpmail.umd.edu

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Comment #1 “... the data are not fully presented. For instance, instead of plotting a time series of “full” / “drained” for each crevasse group, the authors plot histograms and box-and-whisker plots of monthly averages, which obscure the data by overly summarizing it. There is some value in histograms and statistical plots, but these should be presented alongside a full plot of the dataset, not instead of it.”

Reply #1 We are posting our dataset, along with a complete time series of the dataset

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as supplemental material.

Comment #2 “For instance, the paper might be substantially improved with the addition of a few time series of “full” / “drained”, with time series of the other variables (air temperature, strain rate, and calving front position) superimposed. This is approximately done in Figure 5, but because the data are limited to yearly totals or averages, a limited amount of information can be gleaned. Repeating the analyses in more detail and presenting them in full detail is a primary recommendation.”

Reply #2 The time series will be presented as supplemental material, along with the dataset. The time series can be difficult for the reader to interpret with 7 crevasse groups presented over 16 years. Superimposing other variables make the plot even more difficult to interpret.

Comment #3 “Another considerable shortcoming within this work is an immature treatment of event detection. . . I recommend assessing whether the apparent increase in the number of drainage events in recent years is real, following analytical techniques from any upper-level statistics text.”

Reply #3 We have performed a Spectral Decomposition along with a logit regression analysis. These sections have been appropriately added in the methods, results, and discussion.

P5 L7: 3.3 Spectral Decomposition of Unevenly Sampled Data P6 L1: 3.4 Logistic Regression Modeling P9 L10: 4.6 Hydrologic States Spectra P9 L15: 4.7 Logit Model P10 L6: 5.2 Power Spectra P10 L28-10: “This is also consistent in the logit model results as we might expect to see statistically significant trends in the probability of filled states with time commensurate with an increase in temperatures. The lack of significance in the trend on the probability of filled states regardless of the sign seems to indicate that temperature is not a control on whether a given crevasse group will be more or less likely to be filled.”

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Comment #4 “the recent paper by Everett et al (2016) is missing from this manuscript. That C2 TCD Interactive comment Printer-friendly version Discussion paper work studied a very similar phenomenon on Helheim and was able to make a conclusion about what drives the drainage of water-filled crevasses on that glacier. Consideration and comparison of Jakobshavn to that system could add some good science here, but at the very least, needs to be included as it is the only other group, to my knowledge, studying this phenomenon.”

Reply #4 I have mentioned the hypothesis for crevasse drainage outlined in Everett et al., prior to factors we investigated that may influence crevasse drainage.

P10 L13-19: Everett et al., (2016) hypothesize that drainage and filling downstream of Helheim Glacier may be the result of a high pressure wave passing down glacier following a lake drainage. We have not observed coordination in drain and fill behaviors among adjacent pond groups. There is no relationship between supraglacial lake drainage and water-filled crevasse drainage within the shear margins of Jakobshavn as the closest lake to many of our CV groups is more than 15km away in the extra-marginal ice field. Lastly, it is not feasible for drainage of crevasse groups within the northern margin to impact the filling and drainage behavior of those within the southern margin and vice versa. The margins are separated by a deep trough with no evidence for connected subglacial hydrology transverse to the main direction of ice flow.

Comment #5 “P1 L17 and elsewhere Strain rates of 1.2 /second are very high, more like a putty or a lava flow than a glacier. The correct unit is probably /year, this should be checked.”

Reply #5 The reviewer is correct, we had a unit error. The correct units were 1/annual. This has been changed throughout the paper, and in figure 5.

Comment #6 “P3 L7 Google Earth is not a satellite”

Reply #6 Deleted google earth from the list of satellites to emphasize that it is a platform

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that combines imagery from 3 satellites.

Comment #7 “P3 L8 Some elaboration on how the 7 data sources “offset the relative performance limitations” of each other is required. As far as I can tell, it just results in a denser time series.”

Reply #7 Our original wording is confusing. We have changed the wording to the reviewer’s suggestion, which better represents the benefit to using multiple satellite platforms.

P3 L8-10: “Data from Landsat-7 ETM+, Landsat-8 OLI, Quickbird-1/2, Geo-Eye, Worldview-1/2, EO-1 ALI, SPOT-5 and ASTER, are used in this analysis. The combination of data from these systems increases the frequency of sampling resulting in enhanced temporal resolution which offsets the impact of cloud cover.”

Comment #8 “P3 L20 The NSIDC velocity dataset used here has approximately 11-day temporal resolution for Jakobshavn, yet only yearly strain rates are obtained and presented. This puzzled me greatly. Certainly much more can be learned with the level of detail available in this dataset. Why was the choice to analyze only on a yearly level made? This should be explained.”

Reply #8 It is true that velocities are available at higher temporal resolution but we opted to assess strain rates from yearly data in this analysis to provide a first order assessment of changes in annual strain rates at a temporal scale where our observation data set is most robust. We have inconsistent sampling from season to season and we took a conservative approach by not attempting to attribute inter-seasonal changes in strain rates to observed drainage events could be spurious. The scope of this paper was not to attribute each drainage event to a specific process as we assess that the sampling limitations inherent and acknowledge that our current data is not sufficient at this time to warrant this level of attribution. In future efforts, we intend to seek out additional data sets to establish a more seasonally consistent sampling interval over the archive.

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Comment #9 “P4 L1 More detail is needed in the methods for identification. Is the method for detection of “filled” or “drained” automated or manual? What are the thresholds? Are any “in-between” states observed, and how would they be classified?”

Reply #9 The details addressing this question were clearly articulated in the manuscript (see page 4 L10-18). We have added additional content (page 4, line 18-19) to address your point about the inability to distinguish if a given pond was at its maximum or minimum extent when observed. We assume this is what you referring to as “in-between” state. If not, we already address that we are not able to determine any information about changes in the extent of the pond between successive images or the exact date of drainage if the pond was observed to contain water at the beginning of an observation interval and lacked water in the subsequent image.

P4 L10 “The hydrologic state of water-filled crevasse systems ( $\psi$ ) are quantified through visual interpretation of imagery. P4 L18-19 “We did not document the areal extent of ponds and do not record partial drainage events. If water is present at all regardless of pond size, we designate the pond as “filled” otherwise it is classified as “drained”.”

Comment #10 “P4 L11 These data are posted at 100 meter resolution, yet the crevassed areas appear to be considerably larger than that. How are the strain rate data interpolated and/or smoothed to account for this?”

Reply #10 The method for application of the strain data are described on P5 L2-6.

Comment #11 “‘multi-drain event’ should be defined’ Reply #11 Multi-drain event is now defined prior to first use in the paper outside of the abstract.

P6 L20-21 “Some systems were observed to fill and drain more than once during a season, this will be referred to as a ‘multi-drainage’ event for the remainder of the paper. “

Comment #12 P6 L28 How is the calving front tracked? (Data source, analysis tech-

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niques, presentation of data.) I was surprised to see a very smooth curve for calving front position Figure 6, as usually they are very jagged.

Reply #12 A data section has been added to the paper for our calving front data P4 L2-7. The data is acquired from the ESA archive without any further augmentation or processing.

Comment #13 P7 L11 The discussion section should be better organized (it is currently one 60-line paragraph!) and extent the specific results into general conclusions. The literature review on hydrofracture does not belong here. This section was very difficult to follow and needs a lot of work.

Reply #13 The literature review on hydrofracture has been moved to the motivation and prior work section on pages 1 and 2. We have also reorganized the discussion section to be easier to read.

Comment #14 “Figure 1 Adding velocity contours or elevation contours would give a better sense of where the crevasse groups are located within the glacier system. The scale bar is too small and the color is very hard to read.”

Reply #14 We have added in elevation contours to figure 1 as recommended.

P20 L1: Figure 1: Study area showing the location of water-filled crevasse systems (CV) (white) within the shear margins of Jakobshavn Isbræ, west-central Greenland. The spatial extent is a composite based on observed areal extent from cloud-free, Landsat-7 panchromatic imagery only from 2000- 2013. Contours of elevation in meters are superimposed.

Comment #15 “Figure 3 could be combined into Figure 2a, or better yet the y-axis here could be the percentage of time that a crevasse group was filled or drained.”

Reply #15 We believe figure 3 does offer some valuable information for this paper. We have opted to keep figure three the way it currently is. However, we have taken the advice and created a new figure (A2) that has the percent of filled days for the entire

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study period for each CV group.

P30: Added Figure A2

Comment #16 “Figure 4 Are the pattern groups identified here meaningful or discussed elsewhere in the manuscript?”

Reply #16 The patterns are discussed on page 7, L22-24.

Comment #17 “Figure 5 This shows that 2012 was one of the coolest years on record. I am skeptical of this because 2012 is well known as a very big melt year”

Reply #17 Although peculiar, we double checked our temperature data from Swiss Camp and Jar-1, and the average displayed on the figure for 2012 is correct.

Comment #18 “Figure 6 Why is the calving front position so smooth? This cannot be correct (see comment above) and is not explained.”

Reply #18 The calving front is plotted with the data from ESA archives as is. We have not manipulated or augmented the data in any way.

Please also note the supplement to this comment:

<https://www.the-cryosphere-discuss.net/tc-2017-86/tc-2017-86-AC1-supplement.zip>

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Interactive comment on The Cryosphere Discuss., <https://doi.org/10.5194/tc-2017-86>, 2017.

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