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Interactive comment on "A ten-year record of supraglacial lake evolution and rapid drainage in West Greenland using an automated processing algorithm for multispectral imagery" *by* B. F. Morriss et al.

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This manuscript describes an analysis of spatial and temporal patterns in the filling and draining of supraglacial lakes along a flow line in central West Greenland. The analysis is based on lake characteristics extracted from a 10-year time series of MODIS and Landsat images using an automated procedure. My principal criticism is that the analysis is fairly superficial and leads to conclusions which are not all that surprising (i.e., lots of interannual variability). With a modest amount of additional effort, the authors might be able to carry out a deeper analysis of the existing datasets (especially

in the sections relating lake evolution to surface air temperature and lake drainages to ice-flow speed-ups) and turn the manuscript into a stronger contribution more suited to publication.

In examining changes in lake coverage from year to year, the authors take too narrow a view by only considering air temperature data from a single weather station. First of all, air temperature might not be the only meteorological factor playing a role and, second, the station data were collected at an unspecified distance from the study transect. A better approach would be to extract air temperature records along the whole transect from a reanalysis model like RACMO2 or PolarMM5. Using model output would avoid the problem of using far-field temperature data, and would also allow the role of other meteorological factors to be examined. For example, snowier winters might retard lake development the next summer by retaining meltwater in a longer-lasting/deeper snowpack (and prevent it from draining downslope and ponding in depressions), regardless of the summer's air temperature forcing. In examining the annual evolution of lake coverage, the authors only consider the total number of PDDs, but it also matters how the summed PDDs are distributed throughout the season. A convex distribution implies a rapid rise in early-season PDDs which will melt snow and might lead to early peak coverage, while a linear or concave distribution implies more energy available to melt ice later in the season and perhaps a delayed peak lake coverage. You might also think about using the PDDs to make first order estimates of the amount of meltwater generated over your study area as each season progresses, then compare these estimates against the lake volume estimates to see what proportion of meltwater gets stored on the ice sheet surface vs routed as runoff. Exploring all these ideas would make for a very interesting manuscript.

The potential link between rapid lake drainage and ice sheet motion needs a more robust examination. To start, the authors need to establish that the GPS sites are directly in the subglacial drainage pathways of water leaving upstream lakes (i.e., compute and plot the hydraulic potential gradients for the study area). This analysis might reveal an

influence from draining lakes farther upstream than just the two closest ones. The authors also need to look at the lake drainage and ice motion records in finer temporal resolution to determine the precise of sequence of events. As currently written ("a clustering of drainage events around a...surface velocity peak"), two scenarios seem possible. In one, an increase in downstream ice speed (e.g., due to rain or enhanced melt) propagates extensional strain rates upglacier which, in turn, promote fracturing of lake bottoms and their sudden drainage. In the other, rapid lake drainage occurs by hydrofracturing and the subsequent reorganization of subglacial hydrology causes a speed-up of downstream ice motion. If the latter scenario is confirmed, it would be very useful to know what volumes of water were released from the lakes so that we can get a sense of how the velocity response scales with discharge volume (or rate...though this will be difficult to assess without closely-spaced repeat observation of lakes during drainage).

A few minor comments are listed below. As an aside, the line- and page-numbering scheme for TCD manuscripts is ridiculous from a reviewer's perspective (not the fault of the authors, I know). It would be much simpler to use consecutive line numbering throughout the whole manuscript, number each line, and make the first page of the manuscript page 1 instead of page three thousand and something. In my comments below, P1 = P3543, etc.

P2 L7: suggest rewriting this sentence for readability, "We developed...78 large perennial lakes, and applied it to a 10-year time series of ETM+ and MODIS imagery of an outlet glacier flow band in West Greenland."

P2 L11: "low" and "middle" are vague. Please specify elevations.

P3 L4: delete the latitudinal info. Moulins, streams, supraglacial lakes, etc., are just as common in the far northeastern sector of the ice sheet.

P3 L4: shorten sentence by deleting "drain individual watersheds...(field observation) and"

P3 L7: here you define large lakes as having diameters > 250 m. On L17 you use a different definition (0.125 kmˆ2) and on P4 L7 you choose a different value (0.14 kmˆ2) and add a depth component (> 2 m)! Choose one definition and be consistent!!!

P4 L4: I don't understand the meaning of "maps of the study area-output density"

P4 L7-13: the last two sentences of the paragraph are awkwardly written and sort of don't mean very much. Suggest deleting them, or replacing them with something clearer.

P4 L16: Too much info in this sentence! Either break it into pieces or simply delete ", just north of Jakobshavn...70 N"

P5 L6: delete "The"

L5 L8: state that you are using MODIS bands 1 and 2 (i.e., the 250 m resolution bands).

P5 L10: change "identification" to "detection"

P5 L12: change "imagery" to "images"

P5 L13: the statement "1 May to 30 September in 2002-2011" is ambiguous. Does it mean May to September each year, or May 2002 to September 2011??

P6 L13: is "separability" a real word???

P6 L19: delete "respectively"

P6 L24: when you write "by inspection", do you mean inspection of the images? Or field observations?

P7 L9: I suggest reading Sneed and Hamilton (2011; Ann. Glaciol. V52, n59) in which we re-examined the issue of R_inf and concluded that using a generic value (as long as it was derived using the same sensor being used for the lake-depth mapping) is perfectly acceptable. In other words, the requirement for the image with lakes to also include optically-deep water is no longer necessary.

P7 L19: using K_d from Smith and Baker (1981) is okay but, strictly speaking, I think it refers to pure sea water. For “pure freshwater”, see Pope and Fry (1997, Appl. Opt.).

P7 L22: did you also collect lake water samples for analysis of spectral properties (e.g., chlorophyll content)?

P8 L7: Not sure I follow the point of creating the “buffer”. Can you please rewrite L7-13 to make it clear.

P8 L15: sentence seems tautological (“rapid”, “catastrophic”, “short period”)!!

P8 L18: what exactly is your data density (i.e., temporal resolution)? MODIS images are collected multiple times per day but allowing for clouds, optimal viewing geometry, etc., what is the average time separation between scenes (e.g., an image every x.xx days)?

P8 L21: can you cite any studies/observations that might support your assumption for the timescale of slow drainages?

P8 L24: change “maximums” to “maxima”

P8 L25: please choose a different symbol for the area terms (A_p, A_n) to avoid confusion with the albedo term (A_d) in eq. 2.

P8 L26: I would prefer a definition that involves the loss of a critical volume of water. Large area loss can occur without much change in volume, because area change happens quickly at the relatively flat, shallow margins of lakes while most of the volume is contained in the deep basins.

P9 L1: not sure how the six day criterion helps detect false positives. A lake could drain catastrophically, and still be subsequently replenished quite quickly by overland flow from another lake or the surface stream network.

P9 L5: what is A_max? Is it the same term as A_p (defined as maximum lake area on P8 L24)? (Also see the comment for P8 L25.)

P9 L10: “Rapid drainage events are listed in the Supplement”

P9 L14: “...ranging IN ELEVATION from...” for clarity.

P9 L15: delete “of these” and change “those nearest” to “close to”

P9 L21: what exactly are the “difficulties” and “uncertainties” in remote sensing of lake depth (volume)?? A series of papers has established that it works quite well for supraglacial lakes, with well-constrained uncertainties (see Box and Ski, 2007 J. Glac.; Sneed and Hamilton, 2007 GRL; Sneed and Hamilton, 2011 Ann. Glaciol.; Tedesco and Steiner, 2011 TC; etc.). And there is an extensive ocean optics literature applying essentially the same principals to coastal bathymetric mapping. So I think you’re writing off the volume analysis too quickly here. You will be able to do much more analysis with a quantitative parameter like lake volume, compared to lake area (e.g., see my general comment on lake drainage and ice motion at the start of this review).

P10 L1: by “diameter”, do you really mean the long axis of a lake? Very few supraglacial lakes are perfectly spherical.

P10 L7: I agree the correlation looks quite good, but reassure us that n = a relatively big number.

P10 L8: is z = 1.06 m an average lake depth? Average maximum lake depth?? Something else? And why report a depth when your correlation is between area and volume??

P10 L17: “Our water inventory includes...and identifies 238 rapid drainage...”

P10 L21: “...and incidence of rapid drainage...”

P10 L22: the attribution of reduced incidence of lake drainage with elevation to ice thickness seems to be contradicted by your follow-on sentences!

P10 L26: why does thicker ice produce larger surface basins?

P11 L6: “similarly” to what??

P11 L6: what do you mean by rapid turnover? Surely nothing to do with circulation within the lake, right?

P11 L26: “overland drainage through moulins” doesn’t make sense. Do you mean overland drainage in streams?

P12 L1: this section needs an overhaul; see my general comment at the start of the review (so the next few comments pertaining to this paragraph may become irrelevant).

P12 L2: “To explore relationships...” is a weak paragraph intro.

P12 L6: refer to Figure 1 for the location of Swiss Camp within the study area.

P12 L7-9: I think what you’re saying in a roundabout way is that Swiss Camp sees the same synoptic forcing as the rest of the study transect.

P12 L16: not sure what you mean by “lake area fades”. Decreases??

P13 L1: this section also needs an overhaul per my comment at the start of the review.

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