The Cryosphere Discuss.,
doi:10.5194/tc-2016-213-RC2, 2016

The Cryosphere Discussions
Open Access
EGU

Interactive comment on "Frontal destabilisation of Stonebreen, Edgeøya, Svalbard" *by* Tazio Strozzi et al.

Anonymous Referee #2

Received and published: 31 October 2016

General Description:

Strozzi et al., [2016] use optical and SAR datasets to observe the dynamic evolution of the Stonebreen Glacier of Edgeøyjøkulen Ice Cap (Svalbard) in 1994, and more frequently from 2011-2016. They combine the observed pattern of velocity fluctuation with glacier geometry evolution (determined from DEM differencing) and terminus position change, in order to speculate at the mechanisms causing the observed fluctuations in surface motion. A secondary stated goal is to evaluate the potential of frequent standard coverage acquisitions from recent earth observation missions (such as Landsat-8 and Sentinel-1) in order to analyze temporal variability in ice motion. The authors draw upon well used methods, and although there is little novel with regard to the methodology, they are nevertheless suitable for this type of work and reasonable uncertainty levels are provided. For the most part, the paper is well written and easy to follow,

Printer-friendly version

Discussion paper

although in some places small typos need to be corrected and some modified work choice would help improve clarity. The tables are generally well done and complete, although some of the figures may be combined to improve clarity.

At present, the discussion section of the paper is a bit too brief. I suggest that the section begin with a short paragraph which outlines how the velocity variability observed here differs significantly from glacier surging (which is observed in other basins of Edgeøyjøkulen Ice Cap), once the distinction from surging is made clear, then the other mechanisms that may be causing the variability in ice motion and the reasons for and against each of these mechanisms from the observations, can be described. I suggest that the authors also look at the "pulse" mechanism described by Van Wychen et al., [2016] for the Canadian Arctic as another mechanism that may be inducing fluctuations in ice motion. Finally, given that a major goal of this work is to assess the importance of frequent standard coverages of earth observation data for glacier velocity monitoring, there needs to a portion of the discussion devoted to this topic and more than a single sentence regarding this topic in the concluding remarks. Despite these comments, the authors now provide a much more comprehensive record of ice velocities for Stonebreen than was previously available and the dynamic behaviour observed here may apply to other glaciers in Svalbard (and other Arctic regions). I have provided a number of points below for the authors to address.

Specific Comments

Minor Changes

PAGE 1

L6: Please provide a reference for the warming trend observed since the 1990s.

L7: "ice mass loss" -> "mass loss"

L11: "glacier's" -> "glacier"

L12: suggest changing "speed increases" to "velocity increases"

L13: Please provide references.

L14-15: “from 1971 until 2011 followed since 2012 by a strong increase in ice surface velocity along with a decrease of volume and an advance in frontal extension” -> “from 1971 until 2011, followed by (since 2012), a strong increase in ice surface velocity along with a decrease of volume and frontal extension”.

PAGE 2

L3: “The total calving flux of Svalbard is dominated by a few large and fast-flowing glaciers” please provide a reference.

L4: “So, far” -> “So far,”

L5: “A few glaciers” -> “A few glaciers,” add comma

L9: “overdeepenings in the glacier bad” -> “overdeepenings of the glacier bed”

L10: “reduced buttressing” and “changes in the back-stressing sea ice cover in front of the glaciers” are these differing mechanisms? If so, please clarify the distinction.

L11-12: Please provide a reference or example to back up the statement.

L14: “of Svalbard” -> “of the ice masses of the Svalbard Archipelago”

L22: “seem possible” -> “seems possible”

L24: “data a” -> “data, a” (add comma)

PAGE 3:

L4: Please provide a lat/long coordinate for Stonebreen.

L6-7: “new missions” -> “new earth observation missions” such as Sentinel-1 (SAR) and Landsat 8 (optical) to detect. . .”

L10: “5,073 km2” -> “5,073 km2” change to superscript.

L11: “The eastern side of Edgeøya is covered by the Edgeøyjøkulen Ice Cap, which had an area of 1365 km2 in 1985”. . . (also note the superscript) –> please modify text.

L12-13: “is among the least well” -> “are among the least well”, also please add the (Dowdeswell and Bamber, 1995) reference to this statement.

L19: “extension” -> “area”

L20: Mark the northern lobe of Stonebreen with an “*” and the southern lobe of Stonebreen with an “#” on Figure 1 to make it clear to the reader exactly where you are referring to. Also suggest making all the glaciers previously identified as surge-type (e.g. from Liestøl, 1993 and Dowdeswell and Bamber, 1995) with an “*”.

PAGE 4:

L7-11: Please provide an indication of the relatively uncertainty between glacier delineations versus pixel size between sensors. Have all the images been georeferenced to a common image?

L15: Please provide an uncertainty value for the NPI DEM.

L23: “Digerfonna Kääb (2008)” -> “Digerfonna Ice Cap, Kääb (2008)”

PAGE 6:

L1-9: Please provide a description of the window sizes used for the SAR offset matching algorithm.

L12: “Landscape 8” -> “Landsat 8”

L13: “For good visual contrast such as given for our study site and data due to the crevassed and snow-free glacier” -> “For areas of good visual contrast, such as those in our study site due to crevassed and snow-free glacier surfaces, displacement accuracies. . .” also please provide a reference for these values.

L1-16: For both the SAR offset tracking and the optical feature tracking, please de-

scribe how mis-matches or blunders are removed from the dataset. Was this completed manually? Was the strength of the cross-correlation value used to flag poor matches? Please describe in more detail.

L20: “on a Landsat image of 14/07/2014” this can be removed as it appears in the figure caption.

PAGE 7:

L2: “NPI DEM of 1990” -> “NPI DEM of 1970”

L3: “From 1990” -> Please check here and throughout the manuscript and figures. You note that the NPI DEM is derived from aerial photography in 1970 (Page 4, L16), however at other times in the manuscript (see section 4.2 you describe it as being from 1990). Please correct.

L2-4: This section is somewhat awkwardly phased and could be clarified and would benefit from further description. Please describe more fully what “height losses of up to 150 m over current sea level and up to 100 m over current ice” really means. Suggest changing “current” to the last year when DEM data is available. It is noted that height changes of 100-150 m are observed, however the Figure scaling only shows elevation changes +/- 50 m, please adjust the scale bar so that the description in texts describes what can fully be seen in the figure.

L13: “The velocity is lower towards south” -> “The velocity is lower towards the south”

L14: “The northern sector is decorrelated, i.e. flowing faster” -> Yes, this can cause decorrelcation, but what about change in the glacier surface that could cause decorrelation? Provide further evidence why you attribute it to faster flow speeds rather than changes in surface characteristics.

L17: “are indicating” -> “indicate”

L19: “in summer of 2014 (a) respectively 2015 (b)” -> awkwardly phrased, should be

re-written.

L20: “with a migration of the front of increased speeds towards inland” -> “due to an inland migration of a front of elevated velocities”

L20: “1’500” -> “1,500” or just “1 500”

L24: “12-days” -> “12-day”

PAGE 8:

L5-6: “dynamically active sector is increasing again inland” -> does this mean that the dynamically active sector is again migrating inland?

L13: “2’500” -> “2,500” or “2 500”

L14: “The different SAR and optical satellite sensors complement each other very well”. In principal I agree with this statement, however I would like to see the authors develop this idea further, especially because evaluating the potential of frequent standard acquisitions is stated as a secondary goal of this paper (Page 3, lines 6-8).

To further illustrate this statement, I suggest creating a timeline figure that shows all the image acquisition broken down (colour coded) by sensor for the period from ∼2010-2016. For an example, see bottom panel of Figure 2 in Burgess et al., [2012] of how this can be accomplished. I recognize that this information is available in Table 2, however the visual timeline would show the ready more easily how much of the time during the study period that the site was under observation, and further highlight the point that frequent observations improve our understanding of the temporal evolution of glacier velocities. This newly created figure may have the potential to replace Table 2, or at least move that table to supplementary materials.

L20: “increase in slope” -> “increase in surface slope”

L22: “increment” -> “increase”

PAGE 9:

L7-8: “The increased elevation loss towards the front lead to an increase” -> “The elevation loss at the glacier front between the NPI DEM and the IDEM led to an increase in surface slope of $\sim 2^{\circ}$...”

L18-20: This sentence is somewhat awkward to me and should be rewritten to improve clarity.

PAGE 10

L10-12: The method for extracting and comparing backscatter intensity needs to be more fully described, and this should be provided in the methods section. Have all the backscatter intensity values been corrected to sigma nought values to account for various incident angles to enable comparison from different acquisitions and incidence angles? Or can this be neglected because all of the images are interferometric pairs with the same viewing geometry? This is not clearly described in text and should be. In addition to only using the backscatter values to determine melt rates, is it possible to use nearby meteorological station data or NCEP reanalysis to strengthen your claims?

PAGE 11

L13-17: This portion of the paragraph is somewhat unclear and could be tidied to improve clarity.

PAGE 12:

L1-5: These sentences can be modified to improve clarity.

L10: suggest changing “(surge-type?) instability” to just “instability”

L15-L19: Comparisons with unpublished data for Basin-2 should be presented at the end of the discussion section rather than being introduced within the conclusions.

L21: “at high temporal sampling”, suggest quantifying this remark. How often will

Svalbard be covered with standard acquisitions in the future? Every 12 days going forward? Or does it change seasonally? Provide a bit more information here.

PAGE 13:

L4: “The Reearch Council of Norway” -> “The Research Council of Norway”

PAGES 13-16:

Check all references, in some cases DOI numbers are missing.

Substantive Comments:

Methods/Results Sections

Please further discuss the comparison of Sentinel-1 backscatter values over the melt season. Currently, this topic only appears in the discussion section, but should also be described in the methods and results sections.

Discussion Section

I would like to see the discussion section begin with a brief description of why the observed velocity pattern does/does not conform to traditional surge theory, which then narrows down to introduce the alternate processes provided by the authors that could explain the velocity variability.

One potential mechanism that is not described by the authors, but may be relevant, is “pulsing” which has been observed in other Arctic regions (see Van Wychen et al., 2016). This mechanism involves geometry changes, glacier advance and glacier speed-up, and the authors may want to include this as another potential mechanism in their discussion.

Given that the stated secondary goal of the paper is to evaluate the potential of frequent standard coverages of earth observation data to analyse glacier dynamics there needs to be a portion of the discussion section devoted to this topic. Currently, the

discussion section does not provide any reason why the authors believe that frequent standard coverages are beneficial beyond a very brief statement. Although this may seem somewhat obvious, it needs to be discussed fully if the authors intend on it being a major outcome of the paper.

Conclusion Section

Again, given that the secondary goal of the paper is to show how beneficial it is to have frequent coverage of earth observation datasets for glacier monitoring, the conclusions should devote more than one sentence to this topic. Specifically, the authors should note that with the data they had available, that they were able to monitor the dynamic evolution of this glacier nearly continuously from ∼2011-2016, and that this likely would not have been possible in the recent past. The authors may also want to speculate as to how recently launched (Sentinel 1b) or future sensor (Radarsat Constellation Mission) will even further increase the amount of data available for this type of monitoring.

FIGURES:

Figure 1: needs to be modified and clearly indicate that the ice cap is named "Edgeøyjøkulen" and that "Stonebreen" is a glacier basin within the Edgeøyjøkulen Ice Cap. Suggest adding the glacier basin delineations from the GLIMS Randolph Glacier Inventory and provide an arrow to the Stonebreen Glacier Basin. Suggest also adding a notation, such as "*" to the basins that have previously been identified as "surge type" in the literature. Increase the size of the north arrows as well as the font of the scale bars (particularly on (b), (c), (d)) to improve readability.

Figure 2: Please provide the background image as a panchromatic image rather than a multi-spectral image, right now the image appears washed out and for clarity would appear better as a grayscale background image. Suggest changing the colour scheme of the glacier outlines and use a graded colour scheme (blue to red with time) rather than a mixture of colour and gray outlines. Please add a scale bar to this figure as it will aid the reader to determine the scale of terminus position change along the calving

front. Suggest adding an inset map to show the frontal advance of the southern lobe of Stonebreen between 2011 and 2015, at the current scale it is difficult to see.

Figure 4: It would be more beneficial if these figures were projected to velocities rather than presented as interferomgrams. This would enable comparison of glacier velocities shown in Figures 5-8 and may be beneficial to readers that are not familiar with interpreting interferometric fringes.

Figures 4-8: The authors should consider combining Figures 4-8 into a single figure with multiple panes and with a common glacier velocities scaled colour bar. By combining these figures together it would help the reader understand the dynamic evolution of the glacier more clearly. Also note, in figures 5-8, that the glacier velocity colour bar and the velocities provided on the map are fully saturated at the high end of the velocity bar, please consider increasing the colour bar scale to provide more distinction between velocity bands.

Figure 10: It may be beneficial to add a trend line for both data series which shows that RADAR backscatter values decrease as glacier velocities increase (albeit with some temporal lag) to indicate that melt may be modulating ice flow. Also, the figure caption needs to be more description, e.g. it needs to say that the blue marking indicate backscatter values and that red markings indicate ice surface velocities.

REFERENCES:

Burgess, E.W., Forster, R.R., Larsen, C.F., Braun, M. [2012], Surge Dynamics on Bering Glacier, Alaska, in 2008-2011. The Cryosphere, 6, 1251-1262, doi: 10.5194/tc-6-1251-2012.

Van Wychen, W., Davis, J., Burgess, D.O., Copland, L., Gray, L., Sharp, M., and Mortimer, C. [2016], Characterizing interannual variability of glacier dynamics and dynamic discharge (1999-2015) for the ice masses of Ellesmere and Axel Heiberg Islands, Nunavut, Canada. Journal of Geophysical Research: Earth Surface, 121, doi:

10.1002/2013JF003839.

Interactive comment on The Cryosphere Discuss., doi:10.5194/tc-2016-213, 2016.