Dear Anonymous Referee #1

Thank you so much for your time in carefully reviewing our manuscript. This is our response to your comments. The blue sentences in italics indicate *your comments*.

*GENERAL COMMENTS This paper provides a summary of the recent changes in area and velocity of Donjek Glacier, with the main finding that the glacier has had a 12-year surge periodicity for its past 3 surges. This information is useful and interesting, but it does not provide the novel information that the authors claim it does. The main problem is that the authors provide poor referencing to previous studies, and miss out many important papers that describe previous surges of this glacier and others nearby. If the results from this previous work are properly incorporated into this study, then the authors could reconstruct the past 6 surges of Donjek Glacier and therefore make much more useful comments about the surge periodicity of this glacier and whether it has been changing over time. Better information is also needed about the potential impacts of differences in the acquisition time of Landsat imagery on the reported velocity patterns (e.g., whether image pairs capture summer speed up events).*

Thank you for your valuable comments. Although we had known the paper by Johnson (*JG*, 1972), and the suggestions are quite intriguing, no equally quantitative data (e.g., velocity, terminus position…) were presented that allowed us to reconstruct the history of past surges. Moreover, the number of references is limited to less than 20 references in the *Brief Communication* manuscript, and thus we did not refer to them. However, we should have more clearly stated the research history on Donjek Glacier within the introduction. We will comment the previous literatures on surges at Donjek Glacier, clarifying the data sources. Moreover, the detailed list of Landsat images will be added in the supplementary material. We will also mention the seasonal changes in ice speed.

*Finally, the English language needs to be improved as explanations are difficult to follow in places. I have made some suggestions below to improve the language, but the text needs to be thoroughly read and corrected by a native English speaker prior to publication.*

We will re-write the language according your suggestion, and the revised manuscript will be checked by English editing services.

*SPECIFIC COMMENTS (by page and line #) P5944, L7: change 'narrows than upstream' to 'narrows upstream'*

We will change it.

*P5944, L10-16: the explanation of glacier surging needs to be more clearly described, and a distinction made 'Alaskan-type' and 'Svalbard-type' surges and their respective surge and quiescent periods*

We will add more explanations of surging in the introduction to make it clear.

*P5944, L17: change 'called as build-up' to 'called the build-up*

We will change it.

*P5944, L20-21: the statement that 'detailed observations of the repeating surge cycles have been extremely limited' isn't really correct. Although there aren't large numbers of such observations, there are several key papers in the study area that reconstruct surges up to the past 100 years for Variegated Glacier: Eisen et al. 2005. Variegated Glacier, Alaska, USA: a century of surges. Journal of Glaciology, 51, 399-406*

*...and up to the past 65 years for Lowell Glacier: Bevington and Copland. 2014. Characterisics of the last five surges of Lowell Glacier, Yukon, Canada, since 1948. Journal of Glaciology, 60, 113-123.*

*. . .and similar papers for other regions. These need to be properly reviewed and assessed in the introduction.*

Thank you for your suggestion. We will re-write the statement, adding the references.

*P5945, L2: change 'allowed' to 'allows'*

We will change it.

*P5945, L9-10: I would merge these two sentences, so that they read '...derive the spatial-temporal changes in both the velocity field and the terminus area of Donjek Glacier'.*

We will re-write the last two sentences as bellow.

"To reveal the long-term evolution of surge-type glaciers in this area, we use Landsat optical images acquired between 1973 and 2014 to derive the spatial and temporal changes in ice speed (1986-2014) and the terminus areas (1973-2014). As a consequence, we here report our findings of three surging events of Donjek Glacier."

*P5945, L13: it would be useful to show the location of these other glaciers in the figure*

We will modify the Figure 1a to show the glaciers.

*P5945, L15: delete the sentence 'As shown in the result. . .' – this describes results, which should be kept in that section.*

We will delete it, and add below instead.

"Donjek Glacier is located at an elevation of 1000-3000 m, and the valley width significantly constricts toward downstream at 20 km section from the terminus."

*P5945, L19: previous studies on these outburst floods should be referenced here, such as: Clarke and Matthews. 1981. Estimates of the magnitude of glacier outburst floods from Lake Donjek, Yukon Territory, Canada. Canadian Journal of Earth Sciences, 18(9): 1452-1463.*

We will refer to Clarke and Mathews (1981).

*P5945, L20: key references that describe previous surges of Donjek Glacier (in 1935, 1961 and 1969) are missing here, such as: Johnson. 1972. The morphological effects of surges of the Donjek Glacier, St. Elias Mountains, Yukon Territory, Canada. Journal of Glaciology, 11, 227-234 Johnson. 1970. Ice Cored Moraine Formation and Degradation, Donjek Glacier, Yukon Territory, Canada. Geografiska Annaler, 53, 198 ...these previous surges, together with the 1978 surge described by Clarke and Holdsworth (2002) need to be properly described. Indeed, the incorporation of the known dates for these previous surges with the new findings from this paper can enable the reconstruction of surges of the Donjek Glacier back to at least the early 1960s. Doing this would significantly enhance the findings and conclusions of this paper, and enable more meaningful discussion of whether the surge periodicity has changed over time and how it compares to the frequency of other surge-type glaciers in this region.*

Thank you for the suggestions. As we should have written the previous literatures on the surge at Donjek Glacier, we will refer to Johnson (1972, JG), in which past "surges in 1935, 1961(1962?) and 1969" were mentioned. However, we are wondering if the three episodes before 1970 could be equally compared to our detected surges, because the data sources are entirely different from ours in terms of both quality and quantity. For instance, Johnson (*JG*, 1972) mentioned the 1969 surge in terms of morphological features (push structure and erosion forms), based on a personal communication with Post. Whereas we consider that Post's observations are comprehensive and historically very important, the details of the observations (such as observation frequency) are extremely uncertain. According to Post (1969, JG), it seems that he regarded Donjek as surge-type in view of Table 1 and Figure 1. The 1961(1962?) event might correspond to this, but there were no descriptions on the active phase of Donjek Glacier during 1960s; we could not find what evidences were provided for the 1961(1962?) surges. Regarding the 1969 episode, Johnson (JG, 1972) noted that the terminus advance was less than 500 meters, compared to the earlier surges in 1935 and 1962. It could be likely that mini-surge-like accelerations (so-called pulse) caused the slight advance of the terminus in 1969; we can point out such pulse-like events in our Fig. 1c in 1995 and 2009. Johnson (Arctic, 1972) also wrote, "The history of the glacier from 1935 to the present is well-documented photographically (Wood and Post, personal communications)". Because there were no observations before 1935, we cannot say the surge started in 1935.

*P5946, L2-3: the wording needs to be corrected here: terminus fluctuations were examined from 1973 to 2014, but the flow speed evolution was only examined from 1986 to 2014.*

OK. I will modify the sentence.

*P5946, L12: no information is currently provided in the main text or supplementary material about the exact dates of the image pairs that were used for velocity derivations. However, this information is crucial to understand whether and how image pairs have been influenced by summer speed ups or winter slow-downs. For example, an image pair from Jun-Aug in the same year would likely show higher velocities (when standardized to m/day) than an image pair from August one year to June the next year,* *irrespective of surge conditions. The dates for image acquisitions therefore need to be provided (e.g., in a Table in the supplementary material), and the potential effect of seasonal variability in velocities needs to be discussed.*

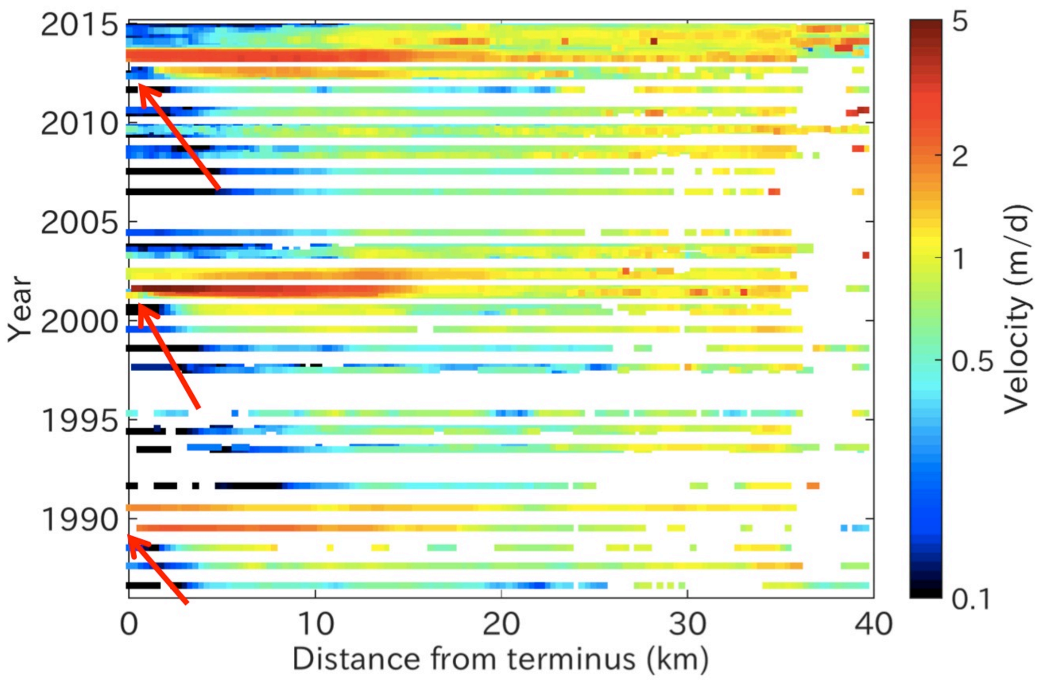
We are going to present the exact dates of images and temporal separations of image pairs used in this study as a table in the supplementary material. Temporal separations of image pairs used in this study ranged from 16 to 128 days. These temporal separations were mostly less than 4 months. Thus, some pairs could be influenced by summer speed-up. However, the seasonal amplitude is apparently smaller than that in surging episodes we discuss here.

*P5947, L2-3: the wording here is unclear: it reads as if the 2, 4.5 and 3 m/day values relate to 'other years' (i.e., quiescent years), when they actually relate to surging years.*

We will re-write the sentence as below.

"In 1989, 2001, and 2013, the speed near the terminus is apparently much greater, up to 2, 4.5 and 3 m/d, respectively. In contrast, the speed during the other years (i.e., quiescent phases) is about 0.5 m/d or less."

*P5947, L8-10: I don't follow the explanation here of what a 'velocity front' is, and how it propagates downstream. Showing these patterns in a figure would be useful, and I would like to see explanation of this point expanded as it can provide useful insight into the propagation mechanism of the surges.*




The velocity front we mention here is the boundary between the stagnant and moving part near the terminus. The red arrows indicate the front propagation toward downstream prior to the surging (The figure was updated according to the Referee#2 comments). We will add more explanations about this in the revised manuscript.

*P5947, L21-27: this paragraph is missing temporal resolution: please provide months, as well as years, for events. There are frequent repeat images available for the recent surges, so it should be possible to better define them than 'about 1 year'.*

We will add the detail of the exact image pairs in the supplementary. We basically used the pairs whose periods were not overlapped each other. Thus, we can discuss the duration of the episode. As pointed out, there are so frequent repeat images only after the 2013 episode (i.e. late 2013-2015), but less frequent before the episode. Thus, we cannot define the exact period (i.e. months) of the active phase.

*P5948, L1 (and elsewhere): secular is an unusual word to use here. Something like 'gradual' would be better.*

We will replace "secular" to "gradual".

*P5948, L3: it's a very broad, and somewhat inaccurate, statement to say that the negative trend is due to 'recent global warming'. It's more accurate to say that it's due to 'negative mass balance', and provide some references to studies from this region that indicate that.*

OK. We will change the sentence as below and cite two more references.

"the trend corresponds to negative mass balance by recent global warming (e.g., Larson et al., 2015; Luthcke et al., 2013)"

*P5948, L6-9: the connection between the surge cycle and 'wax and wane of the terminus area' needs to be better developed. This is a crucial point, as if you can clearly demonstrate that terminus area provides a proxy for surge activity, then it enables the timing of the late 1970s surge to be confirmed (as also suggested by Clarke and Holdsworth, 2002). This would enable the surge record to be extended further back in time.*

We will add more explanations about the relation between surge cycle and terminus fluctuation.

*P5948, L11: an important question is whether the velocity matching technique could actually capture velocity changes in the accumulation area due to a lack of surface features to track. For example, Bevington and Copland (2014) limited their velocity matching measurements to the lower part of nearby Lowell Glacier for this reason. It therefore needs to be clarified as to whether the observed velocity variations over the lower 20 km of the glacier are simply due to better measurements there, or whether they really reflect glacier-wide changes.*

We have confirmed that the orientations of the displacement vectors in the upstream region were identical to the flow direction of the glacier. Hence, the observed velocity variations over the lower 20 km do really indicate the glacier-wide. Moreover, we agree that it is harder to track the surface features in the accumulation area due to its low contrast. Actually, our velocity data in Fig.1c also indicate the poorer coverage in the upstream region (above 35 km from the terminus).

*P5948, L21: the recurrence interval is actually very similar to the recent surges of Lowell Glacier described by Bevington and Copland (2014), and not that different to some of the surge periods of Variegated Glacier described by Eisen et al. (2001, 2005).*

OK. Here we will change the sentence as below, making both the similarities and differences much clearer.

"The 12-year recurrent interval is as short as the latest interval at Lowell Glacier (Bevington and Copland, 2014). However, in contrast to Lowell and Variegated Glaciers whose average recurrent intervals are 15.25 years (Bevington and Copland, 2014) and 15 years (Eisen et al., 2001; 2005), respectively, the recurrent interval at Donjek Glacier is not only shorter on average but also constant and less variable over time."

*P5948, L23-25: this is a key item that needs to be updated: as discussed above, previous literature indicates that surges of Donjek Glacier also occurred in 1961, 1969 and 1978. This information needs to be incorporated with the text here to provide a better long-term record of the surges of this glacier and their variability over time.*

As we mentioned above, we will mention the past surges, and re-write the sentences. As noted above, however, we do not think that the available data would allow us to claim the changes in the recurrence interval since 1960s.

*P5949, L3-7, L15: I would remove most of the detailed references to the surges of Medvezhiy Glacier. This is a glacier that is very far away from the study site and in a different climate regime, so I don't think that it makes a good comparison to Donjek Glacier. Instead, a comparison with detailed studies of the repeat surges of glaciers nearby to the Donjek (e.g., Bevington and Copland, 2014; Eisen et al., 2001, 2005) should be the focus here.*

While we will discuss a comparison with other nearby surges in the revision, what we'd like to stress in the surge of Donjek Glacier is that the surging area initiated at ~20km point from the terminus, where it significantly narrows downstream; no previous studies on Donjek Glacier have pointed out this observation. This geometry is very similar to that in Medvezhiy Glacier; no such geometry can be found at other glaciers near Donjek Glacier. Although the climate regime at Donjek is similar to that in Variegated and Lowell, we consider that the regularity of the 12-year cycle and the limited surging portion are significant. Thus, we compared with Medvezhiy Glacier in terms of the valley constriction and the active surging area. We will add more explanations to make it clear.

*P5949, L7-9 & P5950, L11-21: if slope changes and changes in ice thickness are going to be invoked as a causal mechanism for surges, then they need to be properly described and evaluated. At the moment there is no evidence provided to back up any of the statements made here, so they are unconvincing.*

We do not consider the thickening of ice and steeper slop as the direct cause of surging. The thickened ice upstream is just a pre-condition prior to surging. The reasons why we have speculated the ice thickening here are 1) the surging initiated around here, 2) the valley significantly narrows 3) the ice speed upstream is larger than here and constant, which indicates that ice is delivered from upstream with a constant rate. Although we have no available data showing the thickening, we may speculate that the valley constriction is an important pre-condition of the surging at Donjek Glacier. We will add more explanations about this.

*P5951, L2-3: this last sentence doesn't really say anything. E.g., exactly kind of measurements should be made? Can they be made from space? Or are local field measurements necessary?*

What we would like note here is that various data both ground observations and satellite data analysis are needed to reveal the mechanism of these events.

*P5951, L8: change 'grand' to 'grant'*

We will change it.

*Fig. 1a: need to provide image date in caption. 1b & 1c: The colour scales used in these two figures need to be the same, rather than plotting one as linear and one as logarithmic.*

The image date will be added in the caption and the color scale will be set as logarithmic.

*Fig. 2a: add numbers to the secondary y axis.*

We will add the secondary y axis.

*Fig. 3: provide exact image dates, rather than just years*

We will add the exact image dates in the caption.

*Supplementary material P1, L17: the mean error is quoted in m/day, but this isn't very meaningful as the error will vary depending on the time between image acquisitions (greater time separation results in lower error in m/day). This effect therefore also needs to be discussed.*

We will add the list of data sets we used in this study. The time separations between image acquisitions were less than about 4 months, and the velocity errors ranged between 0.09 and 0.80 m/d. We also agree that the error is dependent on the time between image acquisitions, and the amplitude of seasonal change is within the error. However, the velocity during the surging is quite larger than the error.

*P2, L2: 'snapshot s' should be 'snapshots'*

We will modify it.

*P2, L32 7 L34: reference here should be to Figs. 2a, 2c and 2e*

We will modify it.

Best regards,

Takahiro Abe, Masato Furuya, and Daiki Sakakibara