

Dear Referee #1

Thank you so much for your time in carefully reviewing our manuscript. We believe the comments will greatly help revise our original manuscript.

*My primary concern is that most of the observed variations in flow speed, while interesting, aren't of great surprise and appear to be, at least as shown here, as examples of already published dynamics. As such, I think what this paper contributes, is not the mechanics, but an example of how variable velocities are in the St. Elias because of these mechanics. For example, it appears mini surges are common throughout the range.*

While we agree that “mini surges” appear to be common around the study area, there are, to our knowledge, no comprehensive observations of them in terms of both spatial and temporal coverage. We could not find any previously published velocity observations throughout wintertime in the upstream. More importantly, as we discuss below, we do not think that the observed variations in flow speed could be explained by the previous understandings on basal sliding and glacier hydrology. However, this discrepancy is probably due to our insufficient review of previous studies, and thus we will significantly modify the Introduction in the revision. Also, we will describe in more detail that the observed winter speed is nearly comparable to or even faster than the summer speed at some of the glaciers.

*I think perhaps some of the confusion here is that the seasonal minimum in flow velocity is actually in fall, and through winter gradual acceleration occurs as cavities close and water pressure increases. (Iken and Truffer, J.Glacio.1997; Truffer et al., J.Glacio., 2005; Sundal et al., Nature, 2012; Sole et al., GRL, 2013; Burgess et al., GRL, 2013).*

While we had read some of the suggested references, we examined them again. We agree that the seasonal minimum is in late summer to fall, which is referred in those papers. We explain below how our winter speed-up data are different from the previously published data.

Iken and Truffer (J. Glaciol., 1997) demonstrated gradual speed-up from fall to winter at the ~2km long downstream section of the temperate Findelengletcher in Switzerland, and the velocity continues to increase and reaches maximum in summer. In contrast, our

observed winter speed-up was taking place in the upstream, and the winter velocity does not further speed-up toward summer. For instance, the winter velocity takes nearly the seasonal maximum at Anderson glacier (Fig. 8a). Hence, the observed winter speed-up is qualitatively different from the previously known signals, and cannot be explained by standard theory.

Truffer et al. (J. Glaciol., 2005) showed the relationship between mass balance and winter velocity during 2004-2005, when there is heatwave in the summer. Mean annual velocity is lower in 2004/2005 than other years. However, they did not show any data set that indicate winter speed-up.

Sundal et al. (Nature, 2011 (probably not 2012)) examined how ice speed-up and runoff are related at land-terminating glaciers in Greenland. We agree that ice speed-up can be affected by the amount of surface runoff at each year, and can see the differences between high and low melting year. The results indicate that the ice velocity at high melting year gradually increase from fall to winter (Fig. 3a of Sundal et al.). However, the ice velocity does not accelerate in low melting year (Fig. 3b of Sundal et al.). Moreover, they did not report how the speeds evolve in space during winter, and the maximum speed is apparently observed in early spring to summer.

Sole et al. (GRL, 2013) found a negative correlation between summer melt and winter displacement at a land-terminating glacier in Greenland. The Fig. 2 in Sole et al. indicated the velocity evolution at each site from 2009-2011. While we agree with summer speed-up as cumulative PDD increases, the Fig. 2 doesn't indicate acceleration from fall to winter and the maximum is clearly in summer. Besides, there are no data from December to March. The Fig. 3d in Sole et al. indicated displacements at each site in 2009, 2010, and 2011 for early summer, late summer, and winter. This figure seems that displacements in winter are larger than those in early and late summer. However, the winter period is defined as that from September to April (as written in the Supporting Information), which is much longer than the period during early and late summer. Thus, it is unclear whether winter speed is faster than summer speed.

Burgess et al. (GRL, 2013) reported inter-annual changes in the winter velocities, with which they associated with the amount of summer melt throughout Alaska. We agree with the negative correlation between summertime PDDs and January velocities. While they showed the relationship between velocity anomaly and PDDs anomaly (Fig. 2b of Burgess et al.), we cannot find any data sets that indicate winter speed-up.

*Your observations of "summer" velocities are actually late summer to fall thus I don't see it surprising that velocities are lower in Aug-Oct than mid winter. Also, as you say, many surges begin in winter, and such is likely the case for mini-surges as well.*

We are aware that the seasonal minimum is in late summer to fall, and agree that the surge "initiation" or, initiation of winter speed-up can be explained by cavity closure and subsequent water pressure increase. However, it is still an open question why and how the water pressure increase and subsequent speed-up can be maintained without any input of meltwater from the surface; we consider that this is an important point that we should clearly address in the revision. Indeed, Kamb (JGR, 1987) stated in the Introduction of his seminal paper, "The discussion concentrates on the mechanisms of surging in spring and summer when relatively large amounts of water are available to the basal water conduit system." Kamb's theory is based on the observations of the 1982-83 surge at the Variegated Glacier. The figures in Kamb et al (Science, 1985) actually indicate that the flow velocity seems constant during January to March but reveal acceleration only after April.

*Thus the downstream propagation on Anderson for example appears to be as a excellent picture of annually recurring mini-surges.*

In order to correctly put our study in the context of glaciology, we re-examined the previous literatures on "mini-surges", which were discussed in Kamb et al. (1985) and Kamb and Engelhardt (J. Glaciol., 1987). We found, however, that the observed "mini-surges" occurred in summer prior to the 1982-83 surge at Variegated Glacier. Although Kamb et al. (1985) noted "wintertime velocities began to show an anomalous increase" after 1978, the actual measurements by Raymond and Harrison (J. Glaciol., 1988) have been performed only two times a year in September and June, and thus it could contain the spring speed-up signals (Harrison and Post, Ann. Glaciol., 2003). As such, it should be noted that not all the mini-surges in the previous literature were occurring in winter. Incidentally, the speed-up episode we detected at the upstream of Hubbard Glacier in 2009 surely occurred in winter.

*Burgess et al., GRL 2013, also identified wintertime seasonal acceleration in Alaska; it would be worth seeing how these changes compare. I encourage the authors to consider*

*their results again considering previous knowledge more carefully.*

As we understood, what Burgess et al (GRL, 2013) reported is not wintertime acceleration but inter-annual changes in the winter velocities, with which they associated the amount of summer melt. The Referee#1 might be confusing Burgess et al (GRL, 2013) with Burgess et al (Nat. Comm., 2013), because we found a phrase in Burgess et al (Nat. Comm., 2013), "... have been observed to have velocity maximums in spring, minimums in fall and intermediate speeds in mid-winter." Examining our velocity data again more carefully, we are now sure that the upstream velocities of some glaciers (e.g., Anderson, Chitina, Walsh) in winter are nearly comparable to those in early summer. We will more clearly state this point in the revision.

*If done well, I think these results would be a substantial contribution. Writing clarity in this version was also an issue, but given the substantial changes needed, I will mostly comment on more substantive points.*

*Update intro with proper literature review.*

Thank you again. It is now clear that the original manuscript failed to adequately deliver our findings, probably because the reviews of previous literatures on glacier surge dynamics were lacking in the Introduction.

*P2614 L8 How did you correct for the stereoscopic effect?*

*L11 How does your elevation-dependent correction work?*

We used ASTER DEM to correct for the effect, and confirmed that there remained few topography-correlated artifact offsets. Our approach is basically the same as described in Kobayashi et al's Wenchuan earthquake paper (GRL, 2009).

*What are your uncertainties in flow velocity?*

The uncertainties of offset tracking data have been estimated to be ~0.3–0.4 m at the rugged terrain on the basis of two data images with ALOS/PALSAR's 46-day intervals acquired at non-deforming areas (Kobayashi et al., GRL, 2009). Assuming linear temporal evolution, the errors in the velocity estimate can be inferred approximately less than 0.1 m/d. In fact, we derived the average velocity data over the 350m×350m area along the flow line and estimated the measurement error to be less than 0.1m/d from the standard deviation at each area.

*Section 3.1.3 This tributary actually has a name: Ottawa Glacier*

Thank you for the information. We will replace “the tributaries” with “Ottawa Glacier”.

*P2617 L15 This is typical of surging glaciers in quiescent phase (Burgess et al., Nat-Com 2013)*

What we would like to tell was that while the lower reaches behave like normal summer speed-up, the upper reaches exhibit winter speed-up at each glacier. Thus, the summer speed-up seems to take place every glacier at least in the downstream.

*L25 I have never heard any reason why winter speed up would be dependent on glacier size, it occurs on ice sheets as well (Zwally et al., Science 2002)*

There seems to be a confusion here probably because of our poor wording. We agree with you and consider the winter speed-up occurs regardless of a given glacier’s size.

*L28 Looks to me to be late winter to early spring, could this be the spring acceleration?*

As pointed out, the signal includes spring acceleration. However, the velocity changes are small, but the speed, especially in the black-square section, gradually increases as winter approaches.

*P2618 L2 Don’t really see this downstream propagation here. More just an acceleration.*

We think you pointed out at Fig.10. From 2008 to 2009 and from 2010 to 2011, the down propagation is clearer to us

*L11 These variations are clearly not due to snow accumulation. This test is unnecessary.*

We will remove the sentences.

*Discussion should be rewritten considering previous knowledge.*

We will substantially clarify our new findings in the discussion.

*P2620 L9-21 This all seems tangential and too speculative given your results.*

As pointed out, this part might be overly speculative. We will substantially rewrite the

Discussion section, but consider that some speculation would be helpful and necessary.

*Figure 6 Unclear it dates are by column or row, or how these maps progress in time?*

*Is there temporal overlap here?*

We apologize for the inconvenience. To derive the velocity data, we use two adjacent paths, and there are some temporal overlaps in this glacier. We will change the Figure 6 and its caption so that it will be much clearer.

*Fig 10 State what the box is in the caption.*

The box indicates the section where we can clearly observe seasonal changes. We will rewrite the caption.

Best regards,

Takahiro Abe and Masato Furuya