Anonymous Referee #2

Referees comments (RC) in grey. Our reply (AC) in black.

Dear Referee,

We are pleased that you found our contribution valuable and thank for constructive critique and useful suggestions.

RC: Somewhat lost in the fog of details is whether the whole set of behaviors observed in this new case really differ in any significant way from Sortebrae (where the surge started in the middle of the glacier, presumably in thawed-bed regions) or even from the non-tidewater Trapridge Glacier, where the surge progressed downglacier into regions with frozen bed. The authors should make a better effort to construct a succinct and cogent statement about how the current surge differs from these two previously-studied cases.

AC: We acknowledge this could have been expressed more clearly. We do not invoke there is a difference in the surges as such, but we pointed out that the (limited) spatial and temporal coverage in previous observations could have influence the interpretation of the behaviour. We have now reorganized the discussion section as well as rewritten major parts. In the last version we had compared the surge with other known and well studied surges in Svalbard as well as the surge of Variegated Glacier that in many instances has been used as a “template”. We have now included some more references and comparisons to Sortebræ and Trapridge Glacier.

Some comments on the Sortebræ surge:
As far as we have understood, the Sortebræ surge is assumed to have started in 1992. Before this a glacier surface from 1981 only, is presented (Jiskoot et al., 2001). To be able to do a more detailed comparison between Sortebræ and NGS we would have liked to see more elevation and velocity data from the period between 1981 and 1992 for the whole system. For a glacier where the assumed surge cycle period is 40-50 years only, at least one or two more surface profiles during the last 10 -20 years prior to observe surge activity would have been necessary to compare the whole dynamic with the NGS study.

“Between 1950 and 1981 Sortebræ retreated about 8 km. (...) The position and surface characteristics of Sortebræ did not change significantly between 1981 and 1992” (a Landsat image). “The surge initiation is based on crevasse pattern distribution”, while our study as well as that of Sund et al. 2009 has shown that there are not necessarily changes in crevassing in the initial stage. Furthermore, a surface which has not changed significantly does not necessarily mean unchanged velocity or surface elevation as shown in our study. Jiskoot et al also point to that “The Sortebræ observations on the 1994/95 crevasse distribution are incomplete, as only the lateral zones of the glacier are covered”.

In Murray et al. 2002 there is only one SAR image of the middle/lower section of the glacier system in 1992, which is assumed to be before surge initiation. The upper part is not covered at this stage in their study. It is therefore not possible to draw any conclusions about to what extent there would be a possible difference between Sortebræ and NGS.

In the study by Pritchard et al 2005 there are velocities shown for 1992. They write" Over summer 1992, a gradual retreat took place, which abruptly switched to a rapid and accelerating advance averaging 7 m d-1 from November 1992 to May 1993." This is comparable with the situation on NGS for autumn 2008 and spring 2009, and we have added this to the discussion. However it also shows that data both on velocities and elevation changes would have been needed in the years prior to 1992 to do a real comparison on the dynamics with NGS.

Comments on the Trapridge surge:
The studies of Trapridge Glacier (as well as those of Bakaninbreen, Svalbard, which we have chosen to use) don't cover the whole glacier. They both concentrate on the bulge area, thus neither velocities nor elevation changes are given for farther upglacier: therefore we are not able to compare the entire surge progress with these two glaciers.

Finally, we have tried to reduce the amount of details somewhat and have among other removed the paragraphs about surge/non-surge of tributaries in order to focus more on the main glaciers.

RC: The "Results" section is very hard to read. It is like a laundry list of numerical values. Such information should be summarized in graphics (tables and figures) and not repeated in the text! The reader cannot keep track of the argument and what are the significant points if he/she is buried by all these specifics.

AC: We have tried to omit all numbers which can be directly referred to figures. Some numbers, especially velocities, are still in the text. To our opinion, these points to comparisons and calculations where the numbers are useful for the reader.

RC: It is well recognized from studies of other surging glaciers that a surge often propagates along the glacier due to feedbacks in the system that expand the area undergoing surge. In Section 5.2 the authors suggest that a key ingredient in such propagation is increased melt caused by frictional dissipation of sliding. The authors should strengthen this argument with a quantitative estimate for the melt rates due to friction. Such melt rates are normally trivial compared to rates of surface melt. (Which is why they are so important in the Antarctic.) It seems more likely that the feedback involves release of englacially stored water to the bed, or transfer of stresses from the slippery bed regions to surrounding regions of the glacier.

AC: We agree with the referee that the most important factor, also in Svalbard glaciers, is release of englacially stored water from surface melt. We realize that that this could have been made clearer in our manuscript. Yet it was pointed out in P19 L7
"Some crevasses may also open during Stage 1 or a later stage, allowing more water to penetrate to the bed and thus accentuating the process."
It was also put forward in the discussion of the role of the weather event in P 22 L12.
"Yet, the weather event in September 2008 possibly enhanced the velocity acceleration and hence the timing and force of the advance. At the fast flowing Kronebreen, close to Ny-Ålesund (Fig. 1) the weather conditions in September 2008 accounted for 15% of seasonal surface melt and also resulted in greater mean velocities than during summer (Sund, 2011)."

But while this is an external factor that is probably even more important as new crevasses opens, we wanted to shed some light on the *relative changes* in this internal factor although the contribution from englacial water is larger. We hope this have become clearer in the new manuscript. If not, or if the referee still believes such calculations are useful here, we can of course add this. But since this study treats a larger system with limited data on e.g. ice thicknesses and bed topography as well as substrate, we feel that it would be rather speculative and also could exaggerate the importance of one of the elements on the cost of the others. This part in now rewritten as a part of the changes in the discussion section and we have added references on Hodgkins 1997 and Hagen 1987 for storage of water in two Svalbard glaciers.

RC: Section 5.3 talks about surface bulges. For a beautiful example of a bulge at the boundary between thawed and frozen beds, the authors should look at Clarke's pictures from Trapridge Glacier (see, for example, Fig. 12.7 in Cuffey and Paterson).

AC: We are familiar with Clarke's great picture of a bulge on Trapridge glacer (Clarke et al., 1984), as well as that of Bakaninbreen (e.g. Murray et al, 1998; 2000) and several others. Some (Kroppbreen and Bjuvbreen) are mentioned in Sund et al 2009 and references therein, although they are not as prominent as the one at Trapridge. However, to repeat an important point mentioned previously, the length covered in the longitudinal profiles of Trapridge and Bakaninbreen are only a few hundred metres and the development of the glacier surface above this area is not covered in those studies.

Of interest to the Trapridge Glacier could be that Sund et al., 2009 pointed out that in the first two stages surge activity is implied by elevation changes, but that a propagating bulge may not be apparent at this time, but could appear in late Stage 2 or in Stage 3.

We are not sure if we understand what the referee wants us to do in this comment, but have added a reference to Trapridge Glacier (Clarke et al., 1984) in addition to the existing reference for a bulge in Svalbard. We have now pointed out that the bulge is visible in a late stage of the surge development and thus that this could also be the case on Trapridge Glacier. Our main aim with mentioning the bulge were to discuss why some glaciers may display bulges during surges and others not.

RC: The figures are very informative. I suggest that more of the details described in the text be moved to some new figures. It would make it much easier for the reader to digest and remember the results.

AC: An overview figure of the progress of surge events is added on the request from referee1. If the referee still feels there are more results that should be shown in figures, we kindly ask for advice and suggestions on which parts and what kind of figures we can implement.

Sincerely,
Monica Sund and co-authors

References

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