Comments on "Triggers of the 2022 Larsen B multi-year landfast sea ice break-out and initial glacier response" (revised version)

by N.E. Ochwat et al.

I wish to thank the authors for the careful considerations of the comments on the first version of the paper and the detailed response. The revisions address a main part of the issues raised in the review. However, there are still some items to be revisited, taking into account the issues explained below.

Main issues:

Volume and mass of the floating terminus of HGE glaciers:

The volume of the floating terminus of HGE glaciers is largely overestimated, contradicting mass continuity in view of the available mass for frontal advance. In L392/393 it is stated: "Hektoria Glacier had an extended thick (> 300 m) floating tongue that persisted until 12 to 17 March 2022". The joint HGE terminus area (formed by frontal advance after 2011) covered in January 2022 an area of 250 km^2 (L243). Assuming a thickness of 300 m and density of 900 kg m^{-3} adds up to a total volume of 75 km^3 and mass of 67.5 Gt. This is about two times the mass flux (MFL) supplied through the HGE gates located close to the 2011 glacier fronts. See numbers for 2011 to 2016 in Rott et al., 2018, and 2016 to 2021 computed for the same gates accounting for reduced velocities:

- MFL 2011-2013: HG 5.73 Gt a^{-1}, Evans 0.39 Gt a^{-1}
- MFL 2013-2016: HG 3.39 Gt a^{-1}, Evans 0.30 Gt a^{-1}.
- MFL for July 2016 to Jan 2022 HG 2.24 Gt a^{-1}, Evans 0.23 Gt a^{-1}.
- Total HGE mass flux July 2011 to Jan 2022 to the frontal advance area: 36.9 Gt a^{-1}.

This implies a mean ice thickness of 148 m for an area of 250 km^2 if no frontal calving at all would have taken place between 2011 and Jan 2022. In fact, there were many small calving events, in particular during the first years of frontal advance. In view of these numbers, the statements referring to ice thickness on the order of 300 m and more need to be corrected.

Estimate of the grounding zone location:

The assumption of a partial grounding zone (GZ) within the advancing glacier terminus area and the inferred location of the grounding zones shown in Fig. 8 for HG and Crane glaciers are lacking traceability and are not in agreement with mass continuity (see point above). A much larger supply of ice mass to the frontal advance area would be needed than actually available. Fig. 8 (page 17) shows the inferred grounding zone (GZ) positions downstream (seaward) of the 2011 glacier fronts. By contrast, intensive thinning of the ice inland of the HG 2011 front, going on in subsequent years, implies further upstream shifts of the GZ after2011 (see the figure on HG elevation change below). Furthermore, the inferred GZ of Crane glacier in Fig. 8 shows a GZ seaward protrusion in the centre of the glacier which is located in a deep narrow canyon. In such a setting seaward extent of grounded ice has to be expected along the lateral slopes rather than in the centre.

Further issues:

L32: The calving of grounded ice was delayed by many months (not rapid).

L236/236: "During the 2011-2022 period of fast ice presence in the embayment, changes in the glacier extents suggests that the fast ice stabilized the Larsen B tributary glaciers" During 2011 to 2013 the losses of glacier mass were very high, and also in 2013 to 2016 the mass deficit was significant (Rott et al., 2018). This means there was no distinct stabilization signal during the first years of the fast ice period, but a rather gradual transition.

Figure 9c: Please check the Hektoria LS velocities for Nov. 2022, Dec 2022, Jan 2023. These numbers exceed the numbers derived from Sentinel-1 data and show a different trend along the flowline.

Figure 12, chronology: In the context of processes leading to frontal advance after 2011 detailed data on glacier mass balance, mass fluxes and ice flow velocities (as reported by Rott et al., 2018) are of relevance. (not mentioned in the chronology)

L592/593: “The calving regimes and dynamical changes of the Larsen B tributary glaciers are similar to their response after the 2002 Larsen B ice shelf.” This is statement is not well founded, considering that the ice shelf in 2002 was more than 200 m thick, the tributary glaciers were in balance, at least up to 1999, and the glacier tongues were several hundred metres thick, of compact ice and grounded. In contrast, in 2022 the glacier had newly formed floating glacier tongues of less than 150 m mean thickness with rugged surface topography (evident in ICESat-2 transects of Fig. S1), implying significant variations in ice thickness at small spatial scale and rheologically weak ice on account of this.

L623: High thinning rates were observed on Hektoria Glacier also in 2011 to 2013, amounting to 20 m a^{-1} on extended sections of grounded ice.

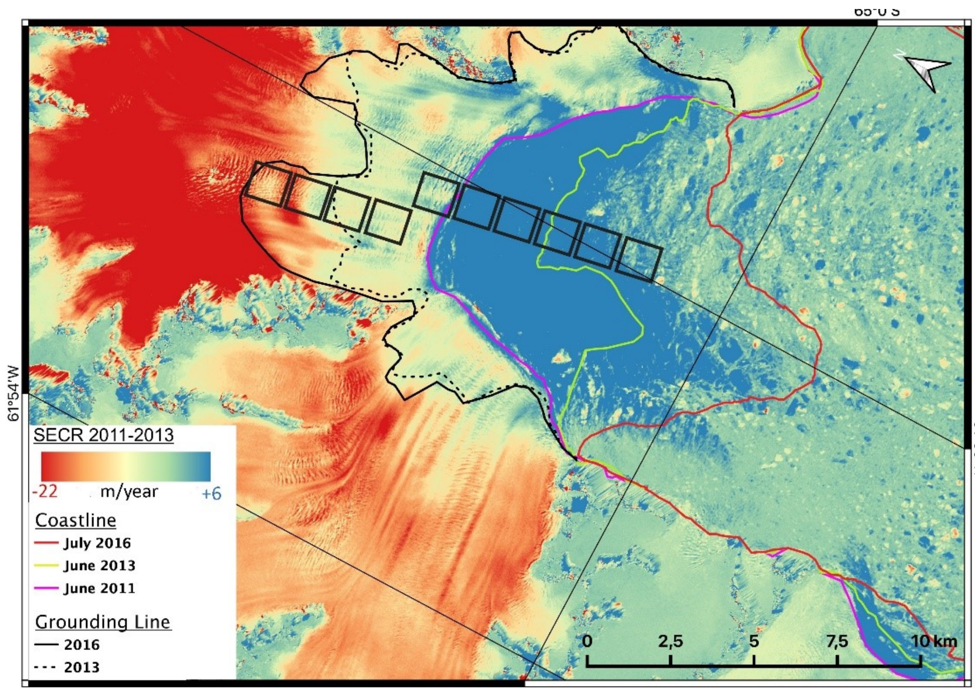

Figure 1: Map of rate of surface elevation change (dh/dt, m/year) from June 2011 to June 2013 based on the elevation difference in TanDEM-X DEMs. Background: TanDEM-X amplitude image of Hektoria and Green glacier terminus, 2011-06-25. Colour code dh/dt from ≤-22 m/yr to ≥+6 m/yr. According to mass continuity the transition from dh/dt on the order of -20m/year to much smaller numbers is a clear indication for the transition from grounded to floating ice. Further details in Rott et al., 2018 and 2020.