Comments to the author:

Dear Authors,

You considered carefully the last comments of the referee and I am happy to accept your manuscript for publication.

However, before final publication and copy-editing, I ask you to take into account carefully my comments below. There are still a few typos in the text and some statements need further clarifications. In particular, a non specialist like me has a bit of a hard time to make sense of the different values quoted for the penetration depth of the radar signal.

To facilitate and speed-up my assessment (I do not want to delay further publication), I to ask you to upload a point-by-point response, the revised manuscript both cleaned and track-changed.

Best regards,

Etienne Berthier

Thank you very much, we made some corrections according to the suggestions, did some proofreading and extended the description of the different signal penetration values in the supplement. Please find our point-by-point responses below.

Best regards,

Christian Sommer

L42: "over most of our study area" sounds better to me (the study area has already been defined just above)

***Agree, changed to "over most of our study area"**

L47 "respective" not needed

***Ok, deleted**

L66. in "beta_1", 1 should be a subscript (like done for 0)

***Ok, corrected subscript**

L67. Does "autumn" corresponds to September? Not necessarily obvious (officially “autumn” starts 21 September). Maybe stick to September (everywhere in the text), or define "autumn".

***Agree, the phrase “autumn” corresponded to September (in most cases) but it is probably less confusing to use “September” everywhere. We replaced “autumn” with “September” whenever a sentence specifically referred to September data.**

L108. I find "measured" ambiguous. I think "uncorrected" (as you defined it above) would be best.

***Agree, it should be “uncorrected” and not “measured”**

L134. I think I would rather write "the occurrence of melt or presence of fresh snow" (presence of melt does not sound right or rather “presence of meltwater”)

***Ok, changed accordingly**

L150. See my comment above about "autumn", a bit ambiguous. Check everywhere.

***Agree, replaced “autumn” in most cases**

L169. "smaller" is not clear. Do you want to say "less negative"? And then “less negative” than what? To be improved. Maybe quote the value of the mass change rate you want to compare to (the sum for the 4 glaciers you listed above, maybe?).

This sentence should compare the regional mass change rate of entire Severnaya Zemlya and Severnaya Zemlya without the (4) most changing glaciers. Our total mass change result for Severnaya Zemlya is more negative compared to other studies but most of the mass loss is confined to those 4 glaciers, e.g. the Vavilov ice cap had a large surge event within the TanDEM-X observation period. Therefore, we also wanted to provide a number for the remaining majority of glacier areas which show much smaller mass changes. Rephrased sentence to*: *“For the remaining glacierized areas of the Severnaya Zemlya Archipelago, the mass change rate is much smaller (-2.39 Gt a^{-1}, 850 kg m^{-3}) than for the entire region (-4.70 Gt a^{-1}, 850 kg m^{-3}).”

L180. A thought (not necessarily leading to changes in the MS). Can you exclude a melt/refreezing event between your two set of measurements (for example in summer 2015 or 2016) that would create an efficient scattering surface not so deep in the firn and would induce this apparent uplift ?

***No, we cannot entirely exclude this possibility but the radar metadata does not show clear indications for signal penetration at these areas. Also, the locations of glacier areas which show those small gains are very similar to the elevation change maps shown by the referenced altimetry studies.**

Figure 1a : I could not find the curve for the 2016-12 backscatter. Were these data included? Maybe I missed them, sorry of this is the case.

***The 2016-12 data is in fact difficult to find in Fig. 1a because in December 2016 only a very small area of Novaya Zemlya was covered. This is due to the irregular acquisition plan of the TanDEM-X satellites. In 2016-12 only one DEM strip was acquired which covered some parts of the northern coastline but not the interior of the Novaya Zemlya ice cap. Also, we could only show a subset of sample points in the figure. Therefore, very few datapoints of December are visible at low elevations (<100 m a.s.l.). Nevertheless, I added "In December 2016 (blue crosses), only a small glacier area at the Northeastern coast was acquired." to the caption because readers might also have difficulties to find those datapoints.**

Fig 1d: maybe I missed something but the mean difference in signal penetration in the cruve appears much larger than the ~2 m values quoted in the text (rather around 3 m here on average). See also comments below on the values in the supplement. In the end a reader would have a hard time quoting a mean penetration depth from your study.

***The different measures of signal penetration in literature can be sometimes confusing because in many cases the penetration depth is defined as the vertical bias between two surfaces. This is often the case when comparing two different elevation datasets. However, the actual length of penetration into a (glacier) volume can be obviously much higher due to the side looking geometry of the radar antennas and the surface topography (e.g. penetration into a flat surface versus a steep slope). The approx. 2 m stated in the text are the vertical difference between the September und winter surface. In detail, the 2.13 m are the vertical difference on the overlapping glacier areas, which we can measure by differencing the respective DEMs, while the ~2.3 m are the modelled vertical difference for all September DEMs (estimated by the linear regression).**

The values shown in Figure 1d are higher because those are the estimated penetration lengths and not the vertical offsets (of overlapping glacier areas). We extended the description of the different vertical and penetration length values in the supplement (see last comment).

Supplement

L132. Add space between 150 and "m"

***Ok**

L136. Can you help the non SAR specialist reader and compare these numbers with the values of the main text which are 2.13 m (L100) and 2.3 m (L108). In the end it is a bit confusing.

***Agree, we rephrased this paragraph and extended the description of vertical elevation offsets and different surface penetration estimates (see comment below).**

L140. Penetration of 5.4 m or 3.1 m (or 2.13 m in the text) seems to translate in a larger difference over a total of 6 years. Maybe clarify why the corrections are so similar.

***Both methods (supplement sections 3.1. & 3.2.) use the vertical offsets (Winter – September elevation) and topography (local incidence angle) as input variables. (For the two-way power penetration (3.2.), the local incidence angle has to be converted additionally to the refraction angle but this introduces only very small changes.) The spatial distributions of the estimated penetration lengths of both methods are rather similar but the magnitude is different (3.1 m versus 5.4 m). However, these differences in magnitude do not have much impact on the derived linear regressions as the general correlation between backscatter and surface penetration difference is the same.**

Eventually, both equations are rearranged to convert the modelled surface penetration lengths of all September areas back into vertical offsets. This is necessary to correct the elevation change rate. In the end, the actual estimated vertical offset is very similar because both linear regressions are based on almost the same input data.

The respective paragraph in the supplement was extended and summarizes now all values (L.136-146):

"Eventually, the mean signal penetration length l_p of the two-way power penetration conversion is 5.4 m while the trigonometric estimate is 3.1 m. In general, both estimates are higher than the measured vertical elevation difference of overlapping glacier areas $\Delta h_{W\text{-}A}$ (2.13 m) due to the side-looking geometry of the TanDEM-X SAR sensor. However, the spatial distribution of penetration l_p and the derived linear regressions (see 2.1) are similar because both conversions are based on the measured vertical offset and local incidence angle. Therefore, when rearranging Eq. 1 and Eq. 2, the influence on the actual spatial vertical correction of glacier areas which were acquired during September 2016 is very small. The average vertical correction values for all September 2016 glacier areas are 2.29 m and 2.30 m, respectively. Eventually, the corrected elevation change rate of Novaya Zemlya ($\Delta h/\Delta t_{corr.}$) is less than 0.01 m a^{-1} more negative when using the two-way power penetration estimate and the geodetic mass change results calculated with both values are almost identical."