A new global data set of Sentinel-1 glacier surface velocities that covers 12 major glaciated regions outside the polar ice sheets is presented. This is a very welcomed data set, congratulations to the authors for their efforts! By making all data freely accessible via the interactive web portal, your work is indeed a valuable contribution to open science. The portal with the Sentinel-1 glacier surface velocities is intuitive and data sets can be easily searched, downloaded and analysed. A comparison with velocity maps we produced within the ESA Glaciers_CCI project (https://climate.esa.int/en/projects/glaciers) revealed an outstanding quality of the data.

The manuscript is carefully written with very accurate descriptions of methods and results. I have three major comments and a series of small amendments and suggestions to be included in a minor revision of the manuscript.

1. Agreed that with your data set you are able to provide continuous glacier velocity-time series all year round independently from weather conditions and sun illumination, but the quality of results obtained from Sentinel-1 is better in winter than in summer. In particular, often during the summer the coverage with valid data is more restricted than in winter because of snow and ice melt and thus loss of coherence (or speckle). This point should be somewhere mentioned in the description of the data.

We agree with the reviewer. We added the following sentence to the Data and Methods section: *In general, the quality of tracking results is often better in winter than in summer over both accumulation areas and glacier tongues, because snow and ice melt during summer can quickly alter the surface properties of tracking features (i.e. feature tracking becomes more difficult) and cause loss of coherence (i.e. speckle tracking becomes infeasible).*

2. What is the effect of the coarse Sentinel-1 spatial resolution on small glaciers, in particular over mountainous areas? Is there a minimum size below which the Sentinel-1 results are no more accurate? Is there an underestimation of the ice velocity measured with Sentinel-1 over small glaciers? Please discuss this point in your manuscript. One way to study the performance of Sentinel-1 over small mountainous glaciers would be a comparison to Sentinel-2, e.g. over fast moving surging glaciers in the Himalayas.

We appreciate the reviewers comment. Following the suggestion by the reviewer, we carried out a comparison of Sentinel-1 results with other data at a mountain glacier. We selected Yazghil Glacier in the Karakoram Range. Compared to the many wide tide water glaciers in Svalbard, is Yazghil Glacer a rather narrow (~800 m) but fast flowing (up to 2.5 m/d) mountain glacier, allowing an analysis of the impact of the spatial resolution and the tracking window size of our products for smaller glaciers.

However, we decided to do a comparison with velocities derived from high resolution TerraSAR-X/TanDEM-X (TSX in the following) data (~3 m ground range resolution). Results, the discussion and conclusion are provided below.

We added the following statement to the manuscript.

Supplement:

Section S1: Comparison between Sentinel-1 and TerraSAR-X velocity fields at a narrow mountain glacier.

We carried out a comparison of our Sentinel-1 products with a velocity field derived from high resolution TerraSAR-X data at the glacier tongue of Yazghil Glacier in December 2015. Yazghil Glacier is a rather narrow (~800 m) but partly fast flowing (up to 2.5 m d^{-1}) mountain glacier in the Karakorum, allowing an analysis of the impact of the spatial resolution and the tracking window size on the velocity estimates.

We applied the same routine to the TerraSAR-X data as for the comparison on Svalbard (Section 2.5). The resulting velocity fields from both sensors are illustrated in Figure S1. We selected 4 profiles (one along and three cross glacier profiles) to further investigate the difference between the resulting products (Figure S2). As seen in Figure S1, the Sentinel-1 product has a lower spatial coverage on glacier. Moreover, the velocities in the lateral zones of the glaciers are often lower for Sentinel-1 as for TerraSAR-X. These findings are supported by the velocity measurements along the glacier profiles (Figure S2). In particular the plot of profile 1 indicates that there is a general trend for Sentinel-1 products to underestimate the flow velocity, in particular at the slow-moving section towards the terminus and for the small-scale high velocity section.

The larger tracking window size for Sentinel-1 (250 x 50 pixels at about 4x20 m ground resolution, see Table S1 vs. 128x128 pixels at about 3x3 m ground resolution for TerraSAR-X), explains these limitations. For Sentinel-1, more stable areas around the glacier are covered by the tracking window, affecting the offset estimation and leading to the revealed but also expected underestimation of the glacier velocities towards the margins. In a similar way, the relatively small zone with high glacier velocities (>1 m d^{-1} according to the TerraSAR-X data) are partly averaged out by the lower resolution and larger tracking window size of the Sentinel-1 data.

The tracking window sizes were carefully selected to obtain good results for the majority of the glaciers in the respective region. However, for such a global database, there are always certain limitations and not all details can be fully resolved. Considering the results from this comparison and experience from visible inspection of further Sentinel-1 products, we conclude that it is very likely, that the flow velocities at glaciers narrower 1 km are underestimated, in particular towards the margins, and that high velocity variations at scales of 1-2 km and below may be partly averaged out.

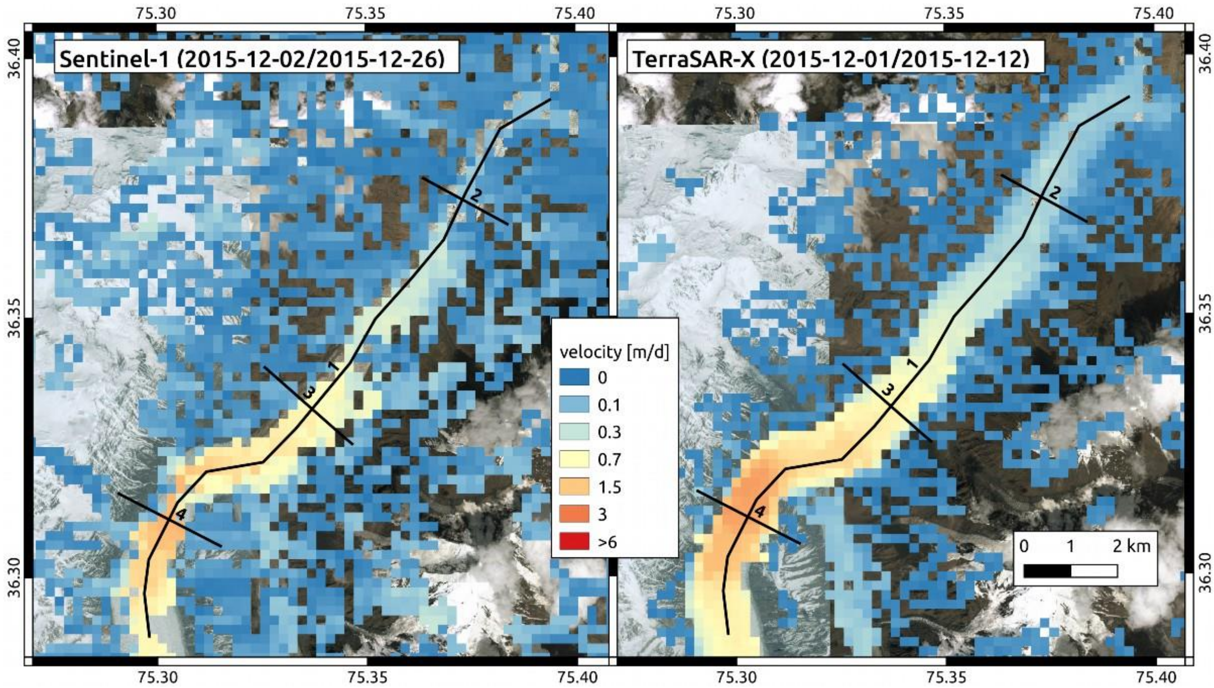

Figure S1: Surface velocity fields at Yazghil Glacier, Karakorum, derived from Sentinel-1 (left panel) and TerraSAR-X (right panel) imagery in December 2015. Black lines indicate profiles for velocity measurements, see Figure S2. Background: Bing Satellite

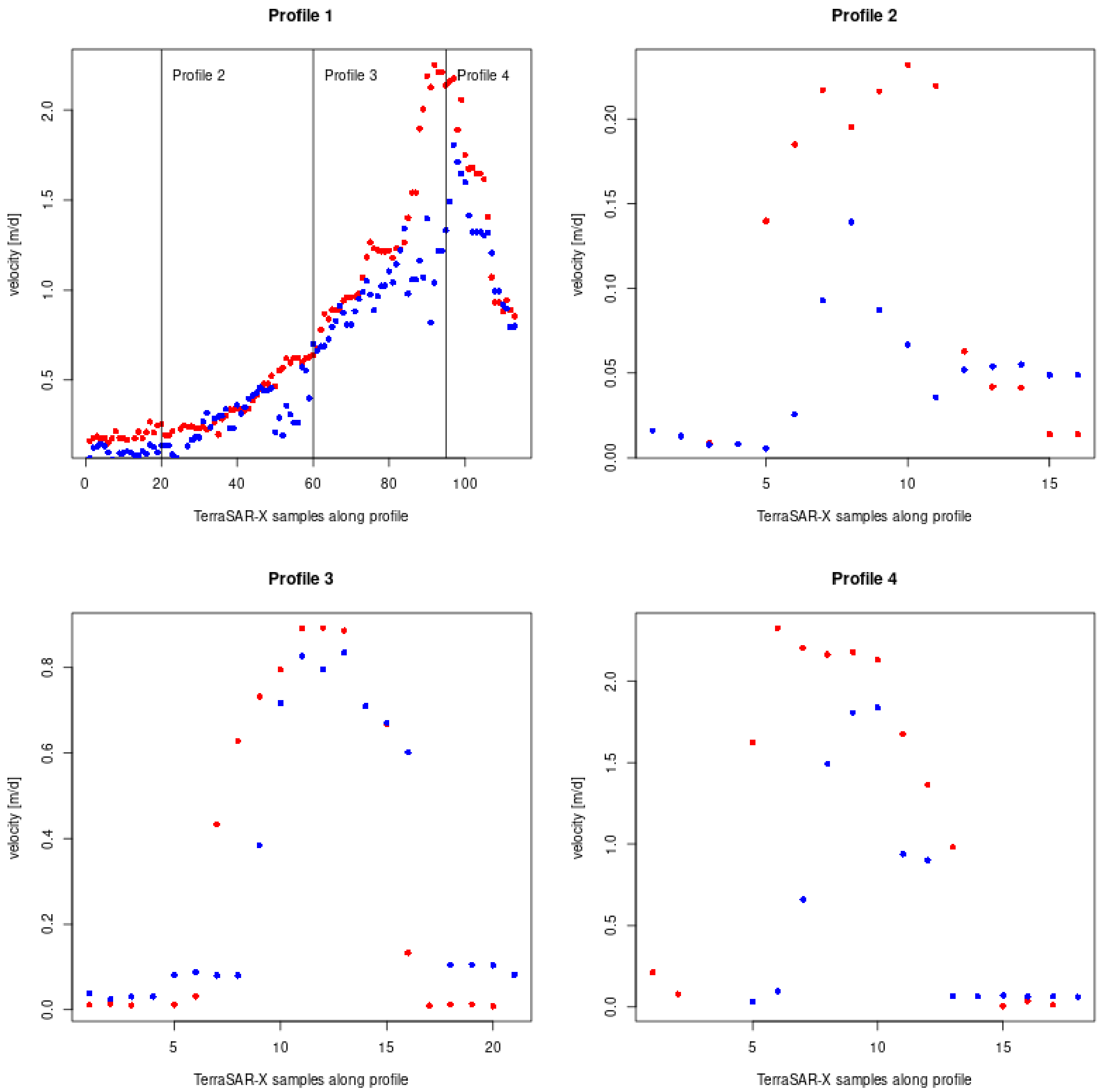

Figure S2: Velocity estimates based on Sentinel-1 (blue dots) and TerraSAR-X (red dots) along profiles on Yazghil Glacier (See Figure S1) in December 2015. Vertical lines in the top right panel indicate crossing points with other profiles.

Manuscript:

End of Section 3.2

In order to investigate the impact of the tracking window size and spatial resolution of the Sentinel-1 data on the quality of the results for narrow glaciers, we carried out a comparison between Sentinel-1 and TerraSAR-X velocity fields at the glacier tongue of Yazghil Glacier in the Karakorum. We conclude that it is very likely for glaciers narrower 1 km, that the velocity estimates are underestimated, in particular towards the margins, and that small (< 1-2 km) velocity fluctuations may be partly averaged out. We attribute both issues to the lower spatial resolution of the Sentinel-1 acquisition in combination with the used tracking window size. More details on the analysis can be found in Supplement Section S1.

3. I couldn’t find any indication in your paper about use of ascending and descending Sentinel-1 data. Are you processing both directions and combine the results? Or just of the two? Have you done any comparison, e.g. over Svalbard? And for other regions? In principle, ascending and descending Sentinel-1 data could be also employed for a 3D decomposition of the ice velocity vector.

At the moment, we do not combine ascending and descending data but use consecutive pairs of images with the same imaging geometry. However, we agree with the reviewer that combining ascending and descending passes is a promising technique to further increase the quality of the measurements and hence an interesting feature to be included into our processing chain in the future. We changed the sentence in l. 73 ff. to:
Our main input data are consecutive pairs of single or dual polarized Sentinel-1 SLC (Single Look Complex) SAR (Synthetic Aperture Radar) images with the same imaging geometry, acquired over 12 glacierized regions outside the Antarctic and Greenland ice sheets (Fig. 1). Ascending and descending orbits are handled independently.

We also added a sentence to the Conclusions and Outlook section:
In the future, the data set may be extended by more precise velocity measurements, derived by applying DInSAR (Differential Interferometric SAR) techniques in very slow moving regions and by combining acquisitions from ascending and descending satellite passes (Sánchez-Gámez and Navarro, 2017).

Here the list if minor points:

l. 11. What do you mean by “near” global? What is not covered? Certain regions? Or glaciers, e.g. small ones?

The data set is “near” global, since the polar ice sheets and surrounding glaciers and ice caps are not included. However, we removed the word “near”, as the spatial limitations of the data set are explained in l. 14 ff.

ll. 13-14. By writing that velocity is derived “by applying feature and speckle tracking“ you give the impression that two algorithms are used. Instead, the technique is based on tracking persistent patterns of intensity values in both images, which are either formed by surface features such as crevasses (feature tracking) or correlated radar speckle (speckle tracking). This point can be better explained also in the abstract. Same applies to the conclusions (l. 481).

We changed the sentence in the abstract to: *The velocity information is derived from archived and new Sentinel-1 SAR acquisitions by applying a well-established intensity offset tracking technique.* **In the conclusions we now write:** *We derived the velocity information by applying intensity offset tracking to all available Sentinel-1 radar images over 12 glacierized regions outside the large polar ice sheets.* **This leaves the exact tracking procedure somewhat open, but does not suggest anymore that two separate algorithms are used. The detailed explanation of what is tracked by the algorithm (either surface features or speckle) is contained in the text (L 121 ff.).**

ll. 38-39. Actually, Ice Velocity is a product of the ECV Ice Sheets and Ice Shelves (https://gcos.wmo.int/en/essential-climate-variables/ice-sheets-ice-shelves). For glaciers, the products are only Glacier Area, Glacier Elevation Change and Glacier Mass Change (https://gcos.wmo.int/en/essential-climate-variables/glaciers/ecv-requirements).

We thank the reviewer for this hint. We changed the corresponding sentence to: *Therefore, glacier surface velocity and its short and long-term variations should be monitored on a regular and global scale.*

l. 30. Why “only”? I would remove this adverb.

We think that the reviewer refers to l. 40 instead of l. 30. We removed the word “only” here.

l. 48. In addition to sun illumination and polar night, past coverage of optical velocity data is restricted by other constraints of historical missions (e.g. acquisition capacity, image quality, …).

We thank the reviewer for this important note. We added the following sentence to the text: *Furthermore, past coverage of optical velocity data is restricted by the general constraints of historical satellite missions such as e.g. acquisition capacity and image quality.*

l. 83. Add “slant” to the resolution of about 3 m.

Added.

l. 84. You can possibly explain why data are available at HH or VV polarization, i.e. VV polarization is the default mode over land, while HH polarization is the default mode over polar regions (see e.g. https://sentinels.copernicus.eu/web/sentinel/missions/sentinel-1/observation-scenario).

We agree with the reviewer that the coverage of the different polarization modes is worth to mention. We added the following sentence to the text: *The HH or HH-HV polarization is the standard polarization scheme for acquisitions over polar regions and the VV or VV-VH polarization is the default mode for all other observation zones.*

ll. 205-207. If you want, you can add here that by applying this procedure the possible bias introduced by strong, short-term summer speed-up events is removed from the annual means.

Good point. We added this sentence: *This procedure removes the possible bias introduced by strong, short-term summer speed-up events (Sect. 3.1) from the annual means.*

ll. 285-287. I would not consider the surges of Austfonna Basin 3 and Negribreen too similar, because the stepwise frontal acceleration of Austfonna Basin 3 lasted at least five years with winter velocities much smaller than summer ones, while that of Negribreen lasted only two years with only a slight slow-down during winter.

We agree with the reviewer. We added the following sentence, in order to more emphasize the differences between the surges of both glaciers: *In contrast to the surge of Austfonna Basin 3, the stepwise acceleration phase of Negribreen was shorter (2 instead of 5 years) and the difference between summer and winter velocities during the acceleration phase was much more pronounced on Austfonna Basin 3 (Dunse et al., 2015).*

l. 302. Tunabreen already surged in 2004, see https://doi.org/10.1016/j.quascirev.2014.11.006, that may explain the short duration of only 2 years, the relatively low maximum velocities, and the absence of a clear seasonal velocity pattern.

We thank the reviewer for this important hint. We added the following sentence to the text: *The special characteristics of the surge of Tunabreen with its short duration, the relatively low maximum velocities and the absence of a clear seasonal velocity pattern may be linked to its short temporal distance to the glacier's last surge in 2004 (Flink et al., 2015).*

l. 384. Sentinel-1 and not Setinel-1.

Changed.

l. 487. What do you mean by 6-day repeat data available for overlapping orbits? 6-day repeat is over the same orbit.

We mean that if the same point on earth is sampled by multiple overlapping orbits with a 6-day repeat cycle, the sampling interval of this point can be reduced to < 6 days due to converging orbit at higher latitudes (i.e. the same point is overflown by the satellite e.g. every 2 days). We changed the sentence, hoping that it makes the point clearer: *In contrast to existing data sets based on Landsat imagery, we are able to provide continuous glacier velocity-time series all year round independently from weather conditions and sun illumination, at very short sampling intervals of up to <6 days over regions that are covered by multiple overlapping orbits with a 6-day repeat cycle.*

l. 506. Also the archives of past JERS-1 SAR data (1992-1998) are now freely and openly available.

We have added this to the text: *Furthermore, data collected by previously operating radar satellites (e.g. ERS-1/2, 1991–2011 or JERS-1 SAR, 1992–1998), as well as new (e.g. RADARSAT Constellation, since 2019) and upcoming missions, like the joint NASA-ISRO (Indian Space Research Organisation) SAR mission (NISAR) can be integrated into our processing chain.*