General comments

This manuscript discusses the use of time series of Sentinel-1 SAR imagery to map regional melt characteristics of glacier ablation in the Hindu Kush Himalaya region. The topic is of high importance to further understand how to operationally use Sentinel-1 SAR backscatter intensity for mapping glacier characteristics. The authors are using the SAR data to investigate the duration of seasonal glacier melt, these are important inputs to surface energy models. Additionally, using time series SAR data is of high importance for further understanding of how to map glaciers using SAR backscatter signals, e.g. refreezing of liquid water in the percolation zone.

The authors give a good overview of the regional glacier melt dynamics in the HKH region and this is a very interesting study. However, the presented results are rather general in terms of the regions studied and lacks a proper error analysis. The text has some long and complex sentences here and there, but is overall relatively easy to understand.

Specific comments

The chapter about SAR processing (2.3 Computer Infrastructure) is too limited, e.g. there are many processing options in SNAP that are not described properly. To be able to reproduce the data, more information about the processing of Sentinel-1 satellite images is thus needed. The authors should also be aware of the limitations of the SRTM DEM over glaciers used here for processing the Sentinel-1 data (e.g. Kääb, A., Treichler, D., Nuth, C., and Berthier, E.: Brief Communication: Contending estimates of 2003–2008 glacier mass balance over the Pamir–Karakoram–Himalaya, The Cryosphere, 9, 557–564, https://doi.org/10.5194/tc-9-557-2015, 2015.).

Unfortunately, the authors do not give detailed error estimates in relation to the Sentinel-1 SAR time series over glacier ablation. The study lacks in situ observations for comparison with the SAR backscatter intensity, and the authors should discuss whether the results are trustworthy in the HKH-region. Even though in situ measurements might be absent, the authors might compare the melt signals retrieved from Sentinel-1 SAR data to other remote sensing sources (optical e.g. Landsat-8 and/or Sentinel-2 and SAR e.g. Radarsat-2).

The four glacier regions studied are rather large, and it would have been interesting to understand more of the local variations of backscatter intensity values within these regions. A suggestion is to pick out some glaciers from each region and compare results from these individual glaciers.

If possible, the authors should discuss the refreezing process in the percolation zone in the Hindu Kush Himalaya region in more detail. Are there more examples of the results described in Figure 8?

L 70, P 3: “This study builds on extensive research into microwave scattering from dry and wet snow and techniques for snowmelt retrieval from imaging radar sensors to present an operational monitor for spatially-resolved glacier surface melt characteristics using synthetic aperture radar (SAR) time series and up-to-date glacier outlines derived from satellite optical imagery across the HKH.” Which years are the up-to-date glacier outlines from? (Sakai, 2019)

L 85, P 3: “In areas that are seasonally snow-free, like for areas of debris-cover or bare ice, melting conditions are dominated by surface scattering that is significantly darker relative to winter conditions (Lievens et al., 2019).” What is meant by “darker”? Is this connected to roughness differences between debris-cover, bare ice and wet snow showing different backscatter intensity?

L 95, P 4: “Limited only by the frequency of observations (12-days per orbit direction)”. Are 6-days repeat orbits of Sentinel-1 available in the study region? If not, will 6-days repeat be available in the future? If so, this should be discussed.

L 155-160, P 7: Why only Sentinel-1 SAR imagery from 2017-2019? Sentinel-1A was operative since 2014.

L 160, P 7: “By combining orbit directions, we utilize observations acquired at day and night. For the purpose of this study we do not attempt to resolve diurnal-scale melt freeze processes and instead focus on retrieving annual characteristics of melt timing and duration.”. The backscatter intensity signal differs between day and night. Further explanation on how this might affect the results must be included.

L 261, P11: “Mean seasonal melt magnitude averaged over 100m elevation bins over all three calendar years of data shows strong ($z > 2$) melt signals across glacio-climatic sub-regions and across all elevation ranges of significant glaciation (Fig. 4). The occurrence of seasonal melt signals across all ranges of elevation in the HKH is both noteworthy and striking.” These statements should be placed in the Results and Discussion section.

L 315, P 14: “A summary of glacier melt timing with elevation averaged across study years is shown across 100m elevation bins in Figure 5 and tabulated across 1km elevation bins in Table 2. Due to errors in melt classification at elevations below 3,500m a.s.l., we will summarize our observations across elevations >3,500m a.s.l. and assume that the relatively small glaciated area at elevations at or below 3,500m a.s.l. is negligible for the purposes of identifying trends across regions and elevation.“ What kind of errors are referred to? And what are the assumptions based on?

Technical comments

Figure 1: Top: Glacier outlines are not that apparent in the figure. Bottom: Blue color of descending swaths would be clearer.

Figure 2: Figures are too small and dark, and are hard to interpret. A suggestion is to cut down on the amount of figures and enlarge the most important ones that indicates VH polarization which is used in this work. Consider a brighter color on glacier outlines.

Figure 3: Use same scale in the plots for VV and VH backscatter.

Figure 5: Suggestion to have elevation on the y-axis. Make the plots broader so more information can be interpreted. Include stippled lines for each 50 DOY in the figure to help the reader to interpret the results.

Figure 6: Difficult to understand and interpret the small circular insertions in the plot. Make them larger and explain more carefully, if these are of big importance.

Figure 8: Suggest to show the location on a map and include glacier outlines.

References should be in chronological order. e.g. L72, P 3.