The Cryosphere Discussions

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Comment on tc-2021-78

Anonymous Referee #1

Referee comment on "Sentinel-1 time series for mapping snow cover depletion and timing of snowmelt in Arctic periglacial environments: case study from Zackenberg and Kobbefjord, Greenland" by Sebastian Buchelt et al., The Cryosphere Discuss., https://doi.org/10.5194/tc-2021-78-RC1, 2021

General comments

The paper studies a time series of Sentinel-1 images over Zackenberg valley, Greenland for snow melting and compares with high-res terrestrial optical data over an area. They use backscatter thresholds to identify start and end snowmelt and wet/dry/perennial snow status. They find that HV-pol data outperforms VV-data.

The paper uses S1 data at an interesting site and combine with high-resolution in situ data to validate their method development. This is valuable since S1 data is a very useful at high latitudes where optical data often fails due to cloud cover/darkness.

The authors suggest a method to retrieve snow cover (SC) at 20m spatial resolution. The method is based on finding the minimum backscatter for each pixel in the time series (SOS) where snow cover is expected to be 100% and subsequently the end of the melting season (EOS) when snow cover is 0% based on a fixed threshold 4dB above minimum. This method deviates significantly from the standard approach (Nagler&Rott,2000) relying on static reference images. A main obstacle is that the whole time-series need to be considered before SC-maps are made. Hence near-real time mapping is out of the question.

It is somewhat unclear if the authors think that this approach is globally applicable, or only gives the best snow cover estimates for the current site. A discussion on the applicability of the method worldwide for various conditions (mountainous with variable local incidence angle, variable land types, forested areas etc.) would also be valuable. If the method has limited applicability outside Zackenberg, then why not only use the optical time series?

I dislike the fact that the authors only processed one satellite geometry. Unfortunately, there doesn't seem to be systematic acquisitions with S1 for more geometries (SciHub). This could have been used to confirm results and/or improve the temporal resolution for the SOS/EOS. Also, variability in incidence angles could shed some more insights. An alternative could have been to also look at EW mode data (HV) since Greenland is covered by numerous geometries, but at the cost of lower spatial resolution.

Overall, I feel that the paper looks at a somewhat limited time series (one geometry, two years) with good results. Using the minimum backscatter per pixel/year is interesting, but I believe more work should be delivered to convince readers that this can be applicable to other sites/landscapes. The paper has limited value if it is only applicable to Zackenberg.

Specific comments

20 m pixels lead to significant speckle noise. Authors should evaluate whether slightly lower resolution (e.g. 50m, 100m) could lead to better performance in general.

Although terrain-corrected gamma is used, it could be interesting to look at local incidence angles. If the variability in incidence angles is large, there may be a variability in the contrast of gamma during wet/dry-conditions as noted by e.g. Nagler et al., 2018, which could lead to a more variable result with respect to whether VV or VH is the preferred polarization. High local incidence combined with wet snow could lead to signals close to NESZ. By eye measure from fig 2 I suspect that the incidence angle for the site is around 30 deg. This is close to the range where Nagler et al. (2018) also state that VH is superior to VV, and the results are hence supported. However, perhaps some of the poor classifications could be explained if higher local incidence angles are involved somewhere in the sloping terrain?

Figure 5a: Colours/symbols used to separate between time laps based/in situ based data for 2017 and 2018 do not correspond with legend. Perhaps use different symbols for each year like fig 8?

The term perennial snow is used throughout the paper. In my view this is snow patches that persists over several years, whereas the authors redefine it as snow that does not vanish over one summer. E.g. fig 9 shows significant amounts of perennial snow in 2018 but not in 2017. I think a better term should be found. E.g. Snow does not melt for the current year. The same could also be invented about permanently snow-free pixels. These, I suspect, are in general only snow free for the current season.

Technical matters

Line 374: temporal/spatial has been switched: should be … much higher temporal (1 to 10 days) and spatial (2.5m)… Perhaps also reconsider “much higher temporal” since S1 has 6 days temporal resolution? "Much" fits better on the spatial resolution.