

The Cryosphere Discuss., author comment AC1  
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## Reply on RC1

Molly E. Tedesche et al.

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Author comment on "Brooks Range Perennial Snowfields: Extent Detection from the Field and via Satellite" by Molly E. Tedesche et al., The Cryosphere Discuss.,  
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The authors would like to thank Referee #1 for the detailed, thorough review, along with the specific and useful suggestions. We will address all the comments in detail during the revision. Below we discuss some of the improvements currently in process, based on the Referee's review.

We agree that our study could be improved with additional statistical analysis of the results and are working towards making these additions. We will provide errors of omission, errors of commission, and the statistics of precision, recall, and F-statistic, as requested. We will also add RMS error and Bias analyses for the fractional SCA (250 m or 2 km areas).

Specific comments and replies (*Reviewer comments are italicized*):

*For comparisons with S1 and S2, identification of the situations in which either, but not both, identify snow, along with situations in which they both identify snow, and (finally) areas of false identifications. The Discussion and Conclusion are hard to follow and hard to understand the vague references to S1 SCA > S2 SCA but it is not clear how they each compare to S1+S2 (Union?).*

We believe these comments both relate to the quantification of areas of convergence, abbreviated as "Conv" in the figures. For various geographical areas, we quantified and mapped where S1 NDSI derived SCA and S2 backscatter derived SCA overlap and do not overlap, as well as overlap/not overlap with field data, and overlap/not overlap with the S1+S2 union dataset in Figures 2, 3, 4, 5, and 6. We will be more specific that "Conv" is an abbreviation for convergence, or spell it out completely in the figures. We will revise the discussion to more specifically go through the numbers/values of the quantified areas.

*The description of the SAR processing leaves some details unmentioned. Why the factor of 3 added to the RVV values? How is the "dynamic threshold applied to each image" (line 174) determined?*

This is addressed in the Supplemental Material document in Section S3 – Extended Methods. It was placed there for brevity's sake for the primary document. This is mentioned on lines 127 – 128 of the primary document.

*The analysis uses NDSI to identify snow-covered areas. The NDSI is a binary classification,*

*that is, snow or not-snow. The photos and the description of the field work implicitly indicate that some of the snow fields are small, so the issue of subpixel snow arises. How is it handled?*

The Sentinel 1 and 2 data are available at a resolution of 10m pixels. This is as fine scale as we can identify and quantify NDSI areas, given the data analyzed. Figure 3 shows differences in scale between results from analysis of the Sentinel data vs. on the ground field collected data. We will reference Figure 3 and indicate the limitations of our study and potential subsequent errors that might be possible.

*Line 27: Tedesche et al. cited but no date:*

The sentence begins on Line 26 as "In 2019, Tedesche et al. considered...."

*And you delay mentioning that this paper also follows the four-year convention until Line 56. This language can be tightened.*

The introduction contains three paragraphs reviewing previous research / literature in which we do not interject details about the work done in our study. Those paragraphs are followed by introducing the objectives of our study and work to follow in the remaining sections. We believe this is one (of perhaps several) standard ways to structure the writing and believe flipping back and forth between our study and previous work in the introduction might be confusing and disorganized.

*Lines 38-49: This short summary paragraph says nothing about polarization, nor about the contributions of volume and surface scattering. Absorption by liquid water reduces the volume scattering, but surface roughness increases backscattering. Thus the statement that wet snow "reduces the backscatter coefficient" is not entirely true because of surface scattering. If the surface is smooth, then indeed most of the surface scattering is in the forward direction, but if the surface is rough, then the backscattering can be significant.*

Some of this is addressed in Section S1 – Additional Background Information in the Supplemental Material document. It was placed there for brevity's sake for the primary document. However, we will also add this information to the main document with an appropriate reference/citation.

*Line 67: Helicopter-acquired "field" data are also derived from "remote sensing," so perhaps clarify what you mean by "field observations" in Lines 52 and 54.*

For our study, the first author was physically present in the helicopter, data were acquired from first-hand visual observations in real time, and the helicopter landed at many of the almost 190 observation points where we exited the helicopter and walked around the sites. Therefore, we believe that these are field acquired data. We will add a brief, detailed description of how the helicopter points were acquired in the methods section. Our manuscript also refers to "helicopter fly-over and touch down points" in some places, while only referring to the points as "fly-over" in other places, so perhaps this is adding to the confusion. We will specify that the points are both fly-over and touch down more clearly.

*Lines 70-71: What is the zero value for aspect (i.e., north of south)? In calculating mean aspect, how do you handle the discontinuity at North?*

The aspect information was calculated using a simple command in Google Earth Engine across the 10m ABoVE DEM. It is not crucial in the study area descriptions, so we can simply remove the information to avoid confusion.

*Figure 1: The symbols and the caption do not discriminate between the on-foot surveys*

*and the helicopter data acquisitions.*

The helicopter data are magenta dots, as indicated by the magenta colored frame around the helicopter photo pointing to the dots. The on-foot survey areas are in teal, as indicated by the teal frames around the local study area photos pointing to the teal squares. We can add this description to the caption and provide a legend with the point and square symbols.

*Line 100: "are" instead of "is" to reflect that the word "data" is the plural of "datum."*  
Thank you for pointing this out, we will correct this mistake.

*Lines 115-117: Given the availability of the 10 m ABoVE DEM, why did you also use the ASTER DEM? The ABoVE DEM would likely be more accurate, especially for calculations of slope/aspect and incidence angle.*

The statement begins on line 113: "Each S1 scene was pre-processed in GEE for thermal noise removal and radiometric calibration.... GEE applied a terrain correction using the ASTER DEM..." All Sentinel-1 scenes available worldwide through GEE are pre-processed with the ASTER DEM by GEE before any user obtains them, as coverage by other DEMs vary spatially from location to location. In addition to GEE's pre-processing with the ASTER DEM, we also used the 10m ABoVE DEM for all of the terrain corrections/calculations in our study area. We will briefly clarify this in the revised draft.

*The citation to the DEM used appears in multiple places in the manuscript, so it would be useful to clarify the DEM used just once.*

We cited Burns et al. 2018 as the source of the 10m ABoVE DEM in both the Data Sources and Methods sections. We will remove the citations in the Methods section.

*Figure 2: Are the blue (S1) and cyan (S2) areas distinct? How do you identify snow that both S1 and S2 find, vs snow that only S1 finds and snow that only S2 finds?*

The cyan areas in the maps are translucent; areas of overlap show the blue underneath the cyan. However, we realize that these are not extremely easy to see and therefore, quantified the areas using the bar charts underneath the maps. In the bar chart below each map, the grey "Conv" bar stands for convergence (overlap), as stated in the caption. This is the quantified area found as snow in both S1 and S2. We will be more specific in the caption.

*Table 2 takes up a lot of space and is hard to interpret. Can this information be synthesized instead of being presented in raw form?*

We will work to create a more succinct and clear table or visual synthesis of this information.

*Lines 244-245: "Cohen suggested . . ." Is there a citation to apply here?*

The Cohen's Kappa statistic is described and referenced in Vieira et al., 2010 in the Methods Section in lines 182-184. We will reiterate the reference in lines 244-245.

*Figure 4 needs some geographic context. Moreover, does S2+S1 mean S2 Union S1 (as I interpret)? Is there a way to indicate the S2 Intersection S1 snow?*

The Figure 4 areas are the AKP Study Area (mentioned in the caption), which is shown in red within Alaska in the Figure 1 Study Area map. We will add the Alaska map with the red area to Figure 4. Yes, the third column, S2+S1 is the dataset wherein we filled the voids in S2 with S1, a process described in multiple locations throughout the text and mentioned in the caption. We will make the caption more descriptive.

The S2 intersection S1 is quantified in the following Figure 5 as "S1 & S2 Conv", and S1 intersection S2+S1 (union/void filled dataset) is quantified and shown in Figure 5 as "S1 & S2+S1 Conv", as in convergence. While it would be interesting to add maps of the convergence areas to Figure 4, this would result in 5 columns of maps, making it extremely busy and difficult to view.

*Figure 5 and Table 2 caption or accompanying text could use a definition of "Conv" in the Figure and Table.*

"Conv" stands for convergence. Convergence is mentioned in the caption, but we will make it clearer that this abbreviation stands for convergence. It was difficult to squeeze such a long word into the figures without abbreviating, however, we understand the confusion and will try to spell it out more clearly.

*Code Availability: The codes in the Earth Engine are not accessible without a GEE account. The first author will download a copy of their GEE folder, then push it to a github repo, and replace the link in the code availability section with the github link.*