

The Cryosphere Discuss., referee comment RC1  
<https://doi.org/10.5194/tc-2021-361-RC1>, 2022  
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## Comment on tc-2021-361

Anonymous Referee #1

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Referee comment on "Divergence of apparent and intrinsic snow albedo over a season at a sub-alpine site with implications for remote sensing" by Edward H. Bair et al., The Cryosphere Discuss., <https://doi.org/10.5194/tc-2021-361-RC1>, 2022

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The manuscript presents a very interesting treatment of "apparent" snow surface albedo that the authors have defined as the description of a rough snow surface as compared to an "intrinsic" snow albedo that the authors describes as an idealized smooth snow surface. The results of this work make a very compelling case that corrections for surface roughness and larger scale topography are important for a range of applications. The measurement methods used to verify the approach outlined in the manuscript, including the incorporation of a highly temporally-resolved timeseries of surface roughnesses derived from lidar data over the study plot and the use of an adjustable arm to minimize shading effects from measurement infrastructure, are novel and interesting. The manuscript describes important considerations for accounting for illumination variation caused by topography and for impurity vs. surface roughness quantification when interpreting remote sensing data over subarctic terrain, particularly multispectral, coarser resolution data. Results show that uncertainty in impurity estimates due to terrain effects can be improved especially in coarser resolution satellite data by considering both topography and shading impacts. I have mostly minor comments about the manuscript and some areas that need clarification.

The largest issue I have is concerning the description of the methodology, specifically the way the surface roughness is defined and incorporated into the apparent albedo correction. As written, it is hard to determine how the surface roughness data derived from the lidar data were incorporated into the modeled apparent albedo—with the largest confusion occurring over the description of the use of "a generic ablation hollow" to define the surface roughness within the calculation of the rough surface albedo on line 164 in the text vs. the derived distribution of slopes derived from the lidar data used to define a parameter of surface roughness (line 154). I have added specific notes below where this becomes confusing or unclear. The next issue I have is with the authors' definition of "apparent" and "intrinsic" albedo which is I believe is non-standard within the literature, i.e., apparent albedo typically describes other effects outside of surface roughness, such as slope, aspect and snowpack thickness and geometry, not just surface roughness, and intrinsic albedo typically refers to albedo due to material properties of the snowpack (i.e., effects due to snow grain size, impurities, etc.) and not just a narrow definition of "smooth

surfaces." References to the use of apparent and intrinsic albedos referring to rough vs. smooth albedo usage should be included if this is a more common use of the terminology than I am aware of. The rest of the specific comments as follows are minor/technical.

Line 54: A very minor suggestion, but the phrase "These models provide intrinsic albedos with lighting conditions controlled by snow properties and illumination angles" is confusing/imprecise as written, as lighting conditions aren't controlled by snow properties.

Line 75 also line 395: This is not a very good description of sastrugi or classification of snow surface roughness features into 3 broad examples. My biggest issue with this description is that it is not generally true sastrugi are smaller than the ablation hollows, at least in polar regions; sastrugi can be on the order of 1m-1.5m in height. Additionally, sastrugi are one form of snow bedforms that also include snow dunes, ripples, scour marks and pits, etc.—and so it might be more correct to include snow bedforms or dunes as a third type of surface roughness feature. I would recommend Filhol and Sturm (2015) as a good review of snow surface roughness features to cite.  
<https://doi.org/10.1002/2015JF003529>

Sticking to surface features commonly encountered in mid-latitudes vs. polar areas would avoid needing to delve into some of the complexities when describing sastrugi vs. snow dunes and other polar surface features.

Line 83: Not sure if the authors are aware of the reference Wright et al., 2014, <https://doi.org/10.1016/j.rse.2013.08.044> that discussed apparent albedo effects when making field spectrometer measurements in Greenland in comparison to MODIS retrievals.

Line 95: Would be good to specify how many up and down pointing radiometers of what type there are here to make it less confusing? And to add what sensors are on the fixed arm and what sensors are on the adjustable arm.

Figure 2: Is there an explanation of the offset from the PSP and SPN1 and divergence from modeled results at higher wavelengths for the PSP? Is that a known source of error at higher wavelengths for the PSP?

Line 123: For consistency, should add that this "on a computer-controlled and self-leveling arm" is the adjustable arm

Figure 3 legend: This is a very minor comment, but I suggest keeping the naming convention used in the legend consistent with Figure 2 and the text.

Line 124: This section is confusing as written. If the adjustable arm is kept at 1m, would it be better to specify the heights of the different sensors as 8m and 1m vs. fixed and adjustable? Isn't that the most germane comparison of the measurements that are made with respect to the field of view of the sensors?

Line 154: How is this value, i.e., "the root mean squared value of the distribution of slopes in the field-of-view" used in the model in the corrections? Also, suggest adding that this parameter is in degrees to help clarify why degrees are used in Figure 7.

Line 162: How is a "generic" ablation hollow defined? From the distribution of the slopes derived from lidar point data as described above in line 154? Or an arbitrary ablation hollow based on other past work? Along the same lines, how are the effects averaged over the footprint, i.e., how was the spacing between ablation hollows determined—from Lidar data or some other means? There would be a sensitivity due to spacing, size, etc. Also, how is the temporal nature of the surface roughness treated since these features will change over time?

Line 173: typo/missing word somewhere: the initial approach the model this effect uses monochromatic radiation, "is" in front of monochromatic?

Line 175: Define variable  $I$  upfront in description, it is slightly confusing here as written if  $I$  is equal to irradiance or initial irradiance (suggest rewording to the initial irradiance  $I$  is set to 1 perhaps) gets a little sloppy/messy with the definitions for irradiance and hard to follow, i.e., line 209  $I$  is defined as spectral radiation, and then  $I_{\text{reflected}}$  is used in Equation 8

Line 197: what is the term/variable "alphaI" referring to?

Line 205: Why was San Juan dust mass concentration used in the model and is that valid for this region? Was there mass concentration or other info collected in the Sterle et al., 2013 study mentioned in line 247?

Line 233: missing word (maybe "model") after SPIReS definition as it is awkward as written

Line 236: For future work, possible to do lidar surveys over the target pixel? Seems like the lidar data are under utilized for the remote sensing validation portion for this work. Is the slope and/or aspect at least similar to the CUES pixel?

Line 260: I think there is a mistake in the text as this seems to describe Figure 6, not Figure 5.

Line 270: should be "is also shown" since the subject is "an unadjusted fsca"

Line 271: Is the surface roughness the distribution calculated from the lidar data or is the "generic ablation hollow"? (see comment from section 2.2 about this)

Figure 7: Suggest using two separate scales for albedos and for the surface since 30 is an awkward divider at best for the reader to interpret, and the units are different the way the caption is written since the caption is implying the surface roughness is still in degrees after dividing by a scalar 30. Please ignore suggestion if it makes the plot too busy, but refine the caption to reflect the units. Also note the suggestion up at line 154 to include a phrase noting that the distribution of the slopes derived from the lidar data are in degrees in order to make it clearer what value is plotted here (see comment about line 271---both the surface roughness derived from the lidar data and the "generic ablation hollow" concept are described in section 2.2).

Line 276: In the caption seems like there is a typo here, "with the error bars (2.0 %) representing based on stated values from the manufacturer." And it should be "with the error bars (2.0 %) representing stated values from the manufacturer." Or "with the error bars (2.0 %) based on stated values from the manufacturer."

Line 395: As mentioned before, sastrugi can reach heights of 1-1.5m in polar areas and so this statement is not correct.