The Cryosphere Discuss.,
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The Cryosphere Discussions

Interactive comment on "Effect of small-scale snow surface roughness on snow albedo and reflectance" *by* Terhikki Manninen et al.

Anonymous Referee #2

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The authors presented a snow surface albedo model with small-scale surface roughness being considered. The model was constructed by combining the bulk volume albedo model (TARTES) with a surface scattering model based on the photon recollision probability theory. Overall, the manuscript is well written. Nevertheless, I agree with Picard that the authors should discuss their results with respect to the recent literature like Larue et al. 2020 to further improve the manuscript.

Detailed comments:

Line 131: rms -> root mean square?

Line 131-141: This section is not clear. Elaborate more about "the rms height and correlation and their distance dependence". It would be helpful if the authors can make

a schematic diagram to illustrate the parameters and variables (the distance x and the correlation length L) in equation (1) and (2). In addition, explain "The snow surface roughness is close to a Brownian fractal surface" with more details.

Line 144: "The vertical resolution was about 0.1 mm and the horizontal resolution 0.04 mm." These two resolutions, you mean precision? It is a bit confusing with the context "...calculated for the measured spatial resolution, which was on the average 0.26 mm."

Line 150-156: what is the exact data acquisition precision for your dataset? How does it compare with the plate measurement precision and resolution?

Line 158-160: Is it possible to provide a figure to show the snowmobile tracks? and one scanned profile? How was "the root mean square (rms) slopes per size of horizontal distance increment" calculated? What's the unit?

Line 209: per cent -> percent

Line 212: "complemented by set or artificial light measurements", typos?

Equation (4): please make the equation and the description of variables consistent.

Line 313-314: provide the surface height distribution histograms like figure 4.

Equation (7) and (8): give a detailed description of each variable shown in the equations.

Line 356-369: This section involves lots of statistical correlation analyses between surface roughness parameters and surface albedo measurements. Please provide the scatter plots as supplementary material to show the correlations. The authors used the rms height as the only explanatory variable to explain the variability of albedo and obtained quite high R square and therefore concluded that "This result supports the view that surface roughness affects the albedo." I don't think this is a solid statement given that the snow grain size variations from March to April could greatly affect the variability of surface albedo. Without controlling for the snow grain size, it is not plau-

sible to validate the relationship between rms slope and surface albedo. The authors should take both rms slope and snow grain size as the explanatory variables to explain the variability of surface albedo, and then compare the relative contributions of rms slope and snow grain size.

Discussion: according to the analysis, it appears that the spatial scale matters when evaluating the impact of surface roughness to snow albedo. Based on the results, can the authors discuss the implications of this study for studying the snow albedo changes using satellite data of different resolutions? Is there a rough estimate on how much surface roughness would affect the satellite albedo (such as MODIS albedo)?

Figure 3. Please label the figure to indicate the meaning of each different line.

Figure 11. For the April data, it appears that the uncertainty was dramatically increased after Julian day 112, any possible reason?

Figure 13. Shrink the Y axis scale to 0.5$\sim$0.8 instead of using 0-1, otherwise, the measured albedo seems to be constant through the time.

Figure 14. Are there three different profiles for the “rough” surface? If so, label the rough profiles differently (different parameters)?

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