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The Cryosphere Discussions

Interactive comment on "Snow albedo sensitivity to macroscopic surface roughness using a new ray tracing model" *by* Fanny Larue et al.

Anonymous Referee #1

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Authors measured spectral albedo in a flat smooth and an artificial rough surface, and developed a new ray tracing model to quantify the effects of the macroscopic surface roughness on the snow albedo. Reviewer gives a certain appreciation for the reasons; authors showed that the presence of macroscopic surface roughness significantly decreases snow albedo. Furthermore, snow albedo depends on the fraction of roughness feature, solar zenith angle and relative azimuth angle between the sun and the surface roughness orientation. However, the explanations of some results are insufficient. Particularly, reviewer cannot understand the reason why spectral albedo exceeded 1.0. It is not a realistic in nature. In addition, reviewer is wondering whether the RSRT model can represent the measurement data even in the flat smooth surface from the results of comparison between simulated spectral albedos and measured ones. Thus, it is

questionable whether all simulation including results of sensitivity analyses are true. Reviewer supposes there are new findings about this research (regarding measurement data). Thus, the manuscript would have a merit for the publication in the TC. But, simulation results would be insufficient at this moment. Authors should carefully confirm the results and then provide a detailed explanation or modify the structure of the manuscript.

(Major comments)

1. In Fig. 5, all the simulated spectral albedos exceed 1.0 in the wavelength region of < 700 nm even in the case of the flat smooth surface. Also, the measured spectral albedos exceeded 1.0 in the range of < 870 nm in Fig. 7. These results are not realistic in nature and misleading information. Reviewer recommends explaining the reason why spectral albedos exceed 1.0.

2. Simulated spectral albedos were not consistent with measured ones as a whole. There are some discrepancies between them. For example, the measured variation $Delta alpha$ shows a clear dependence on $Delta phi_r$ while the simulated one doesn't (Fig. 8). Reviewer supposes that the measurement values presented here are true. Thus, I am wondering whether the RSRT model provides certain values or not. Authors need to show the agreement between the model and the measurement to present how the proposed model works properly. Otherwise, it could be difficult to achieve the objective of this study which is to quantify the impact of surface roughness on snow albedo.

(General comments)

1. L29: Regarding the sentence "For a typical alpine snowpack ... 27 Wmˆ2).", this estimation was the value at the site C based on the artificial rough surface. Reviewer is wondering if "a typical alpine snowpack" means the natural rough surface in the mountain regions. How does the artificial rough surface represent the natural snow surface in the mountain regions?

2. L40: Snow grain shape is also one of the important factor to control the snow albedo (Tanikawa et al., 2006; Jin et al., 2008) in addition to the physical properties mentioned in the manuscript. Authors should add explanations and cite research papers.

- Jin et al. (2008): Snow optical properties for different particle shapes with application to snow grain size retrieval and MODIS/CERES radiance comparison over Antarctica, Remote Sensing of Environment, 112, 3563-3581.

- Tanikawa et al. (2006): Monte Carlo simulations of spectral albedo for artificial snowpacks composed of spherical and nonspherical particles, Applied Optics, 45, 5310-5319.

3. L199: What does LAP stand for?

4. L201: Reviewer is wondering if measured spectral albedo is relatively high at wavelength range 500–700 nm even in a contaminated snow. This comment might be related to the major one.

5. L202: It would be difficult to say a following sentence "The albedo decrease in the 400-600 nm range is a clear structure of a high LAP concentration". Only small amount of black carbon causes a drastic albedo decrease in the visible regions. Authors should add/modify the explanation properly.

6. L205: Describe the reason why authors chose 700 nm and 1000 nm for the statistical results. The reason is not clear. For example, it would be better to select wavelengths used for satellite remote sensing.

7. L210: How did authors consider the effect of atmosphere in the radiative transfer calculation?

8. L230: In general, the asymmetry factor (g) increased with increasing (decreasing) the snow grain size (SSA) in the near infrared regions. So, g should be linked with the snow grain size (or SSA). This assumption might lead to biases of spectral albedo simulation.

9. L264: It is not clear whether the roughness part (Monte Carlo algorithm) employs the single scattering properties (single scattering albedo, phase function and so on) and/or surface reflectance of snow or not. How does the photon decide “hit” or “not hit”? Random number with snow single scattering albedo or snow reflectance? How does next direction after the scattering (i.e. after the photon hits to the snow grain) decide? Detailed explanations are needed.

10. L463: In Figs. 8a and d, the results $Delta alpha$ were not symmetry at $Delta phr_r$=0. The effect of surface slope caused the asymmetry of $Delta alpha$ at $Delta phr_r$=0? Explanations are needed.

11. L635: This is a rough estimation in a net SW radiation because the validation of the proposed model would not be adequately tested in the visible and shortwave near-infrared region (> 1000 nm). In addition, the effect of snow impurity such as a black carbon and a dust was not considered in the estimation of the net SW radiation. As authors well know, the spectral snow albedo depends on the concentration of snow impurity in the visible region where solar radiation is larger in the relatively cloud free condition. Thus, there would be a large uncertainty in the estimation (there are many parameters to be considered in the estimation, e.g. snow layer (vertical) information). Reviewer supposes that this item is next step.

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