The Cryosphere Discussions

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Review of "SNICAR-ADv4: A physically based radiative transfer model to represent the spectral albedo of glacier ice" by Whicker et al.

Anonymous Referee #1

Referee comment on "SNICAR-ADv4: a physically based radiative transfer model to represent the spectral albedo of glacier ice" by Chloe A. Whicker et al., The Cryosphere Discuss., https://doi.org/10.5194/tc-2021-272-RC1, 2021

This manuscript describes a physically based radiative transfer model (RTM) to represent the spectral albedo of glacier ice, called SNICAR-ADv4. In this RTM, air bubbles in the ice were treated as a scatterer, the layer structure was considered, and the ice and the snow overlying the ice were coupled, resulting in that the RTM of coupled atmosphere-snow-ice system was completed as SNICAR-ADv4. It can be said that we have taken a step forward to understand the spectral albedo of glacier surface. This is a very important research for the climate studies using SNICAR-ADv4. Reviewer gives a certain appreciation for reasons mentioned above. However, there are some concerns regarding the explanation and technical details of the validation method of SNICAR-ADv4, which are list below. Given this, I recommend this paper for publication after minor revisions with attention to comments.

(Major comments)

1. Regarding the surface roughness, called "the surface scatter layer (SSL)" which consists of "Fresnel layer" plus "thin snow layer". Reviewer guesses that the SSL is to avoid a specular reflection in the flux calculations. This is a good representation but the SSL is the approximate one even in a physical-based method. There are some more realistic models proposed (e.g Stamnes et al., 2011, Sun et al., 2019)ï¼□In order to confirm this representation properly, reviewer recommends to depict the solar zenith angle dependence on the spectral albedo and then explain it at high solar zenith angle.

2. Authors described the effects of the air bubble and the SSL on the spectral albedo especially in the VIS and NIR regions. However, there is no mention about those at wavelength > 3 um. Authors should describe the spectral features in these regions as well.

3. In general, the glacier surface tilted so there seems to be a limitation for the application of the plane-parallel RTM. It is desirable to mention the effect of slope on the spectral albedo calculations with the scope of application of SNICAR-ADv4.

4. Regarding the model evaluation against measured spectral albedo (Figs. 8-10), (1) authors mentioned in the manuscript that for most of the comparisons, the exact conditions are unknown (L361). Thus, some of input data were determined (constrained) from the comparison between model and measurements. However, it is not clear what parameter(s) was(were) constrained in the RTM calculations. Authors should described these parameters in the manuscript to distinguish known parameters from the input data clearly. (2) It seems that input parameters including the constrained ones shown in Appendix provide good agreement between model and measurement (Figs. 8-10) . However, there are no sufficient explanations in the manuscript as to how reasonable the constrained values are. Authors should give a careful explanation here. (3) In addition, spectral albedos were seemed to be calculated under fixed conditions as follows: the mid-latitude winter profile in the atmospheric profile (even in Greenland ice sheet), the solar zenith angle of 50 degree (for all cases) and the hexagonal plate as snow grain shape (even in large grain size). Reviewer knows that similar spectral albedos can be achieved using different model parameters (L322). But, I think these conditions do not suit the validation of the SNICAR-ADv4 even though authors showed good agreement between model and measurement. At least the latter two parameters should be determined (constrained) from the measurement values to calculate the spectral albedo properly.

(Specific comments)

L152: How did you marge two refractive indices in this analysis? You need explanations more in details.

L154: Definition of thin snow layer overlying ice is not clear. How thin is it? For example, give the optical thickness of thin snow layer.

L203: I don’t know how this number oln(1.5) is valid for the size distribution of air bubble. Please give a valid explanation.

L313: “SNICAR-ADv4 simulates a wide … of snow and ice”. It seems that this sentence has been taken out of context.

Figure 1: I can’t see the shading range of spectral albedo especially for NIR regions because y-axis is so shrunk compared to x-axis. I recommend to replot (reshape) all figures (a-f) such as Fig. 3 or Fig. 6 for example.

Figures 8, 9 and 10: I recommend to replot (reshape) all figures to see the spectral features clearly such as Fig. 3 or Fig. 6 for example. In addition, please show the difference between model and measurements in order to see how differences there are .

References:

Stamnes et al., Modeling of radiation transport in coupled atmosphere-snow-ice-ocean systems, Journal of Quantitative Spectroscopy & Radiative Transfer 112 (2011) 714–726.

Sun et al., Modeling polarized solar radiation from a snow surface for correction of polarization-induced error in satellite data**,** Journal of Quantitative Spectroscopy & Radiative Transfer, 222-223 (2019) 154-169.