Comment on tc-2021-366

Anonymous Referee #2

Referee comment on "The effects of surface roughness on the calculated, spectral, conical–conical reflectance factor as an alternative to the bidirectional reflectance distribution function of bare sea ice" by Maxim L. Lamare et al., The Cryosphere Discuss., https://doi.org/10.5194/tc-2021-366-RC2, 2022

The authors present a well-defined model study that investigates the effect of sea ice surface roughness on the directional reflectance of bare ice as a function of wavelength, sea ice thickness, and solar zenith angle. The work represents a further important contribution for the understanding of radiative transfer in a polar environment, even though the study shows its limitations. But these limitations are well addressed by the authors.

General Comments

- The study is about bare ice reflection properties. Therefore, I suggest to elaborate a little bit the meaning of this specific surface type in a meteorological context. In the current version, the introduction is mostly related to technical aspects. What is the seasonal contribution of bare ice in polar regions? Introduce the three ice types which are used in Sec. 2. Also give some more background on the surface roughness. What are typical scales?
  An entire paragraph is listing snow surface studies without giving any details. However, in my opinion this part could be removed. The authors should focus on a review on bare ice studies dealing with surface reflection properties and their dependencies. A comparison with findings related to snow surfaces should be given in the discussion section.
- I'm wondering if Section 3 could be restructured. In the current version it's no easy reading. Starting with the roughness and wavelength dependence might help (Fig. 8), without showing the nadir BRF plot (Fig. 4). The main message becomes clear from the contour plots already. Then show and discuss Fig. 5 (roughness and thickness). Based on Figs. 8 and 5 I would introduce the shift and broadening of the scattering peak by presenting Fig. 6. At the end show and discuss the roughness - SZA relation (Fig. 7).

Specific Comments

- P1l12: "Different types of sea ice…" A lot of numbers quantifying the roughness effects are given at this part of the abstract. Try to reduce the information since it is a way too much.
- P2l2 and other: Omit the term "light" when you talk about solar radiation which is not within the visible wavelength range (400 – 700 nm)
- P2l10: "The BRDF is a directional description of albedo..." The relation is more complex than stated here, be more precise. Also the HDRF should be introduced better than just saying that it is a proxy of the BRDF.
- P2l33: "high sensitivity" – please elaborate
- P3l2: "13 bands" – spectral bands, p3l7: "300 and 4000 nm" add wavelength afterwards, same as on p3l19 to make sure that wavelength is meant here
- P3l17: "… is required" Because it has not been done yet is not a convincing reason. What kind of consequences do you expect to derive from this study?
- Last paragraph of the introduction could be improved to reflect the outline in a better way.
- P3l32 / Fig. 1a: Do you really need Fig. 1a?
- Eq. (2) add "=pi*BRDF"
- When I have understood correctly, the PlanarRad model was designed for aquatic radiative transfer. What justifies its use for calculating sea ice reflection properties? Is it a numerical model? Later (p5l9) Monte Carlo ray tracing is mentioned. Please explain a little more how this is related.
- P4l10: "calculation of the BRDF" Actually, the model allows rather the simulation of the biconical reflection. So it's not a real BR(D)F which is shown in the following plots.
- P4l17+Fig. 1b and P4l28+Fig. 2: You could combine both figures as Fig 1a and Fig 1b.
- P5l3: Here the roughness parameter is without unit, but later and on p4l29 sigma is given in meters. Also in Fig. 3 its given without and with unit. Further, I suggest to move the definition of the roughness parameter to section 2.1.
- P5l11: "using 10 rays per quad" Could you explain, how is this number selected?
- P5l12: A scale height between 0.1 and 10 cm is chosen here. How do these numbers relate to real roughness features?
- P5l14: The three sea ice types come somewhat out of the blue. Some more background should be already given in the introduction (see my first general comment).
- P5l19: "mass-ratio of 1 ng/g" Did you see any effect of black carbon for this low number? From Marks and King (2014), Figure 3, I don't expect any significant contribution.
- P5l25: "increases by 29.5%...up to 630.7%" I would give only integer numbers (here and elsewhere)
- P7l8: "…calculate the energy budget of the sea ice…" The sentence tries to motivate the direction of investigation. However, you should make this point already in the introduction, where the relation between satellite-based observations of the directional reflection, BRDF, BRF, ice albedo, and energy budget should be given.
- P7l32: "moves lower on the hemisphere" – maybe better say that it is shifted to higher viewing zenith angles
- P9l27: "to a larger zenith angle" – better write "viewing zenith angle" here
- P11l1: The comparison with findings for snow surfaces should be extended. Give also quantitative results.
- P11 Section 4.2: I would shift this subsection to the model setup section. Statements related to the surface in general should be part of the introduction.

Technical Corrections

- P2l8: "rwith" – with
- P2l12 and other: insert a space before references "roughness(e.g. Manninen, 1997)" – roughness (e.g. Manninen, 1997)
- P2l22: "snow kernals" – kernels
- P2l31: "isotopic" – isotropic; Do you mean a Lambertian assumption here?
- P3l1 and other: "dependance" – dependence
- P4l4: "idea" – ideal
- Figure 3: Please increase the font size of the axis labeling.
- P6l3: "thickness" – ice thickness
- Figure 4: Please increase the font size of the axis labeling.
- P6l24: "… due to the large absorption in the ice dominating the signal …" Sounds strange.
- 5: please check color bar labeling
- 7: roughness (sigma) is in wrong order, also check color bar labeling
- 8: roughness (sigma) is in wrong order, also check color bar labeling
- P7l31: "as shown in Figure 6" – wrong reference
- P8l6: "inter-dependant" – inter-dependent
- P8l20: "inter-dependant" – inter-dependent
- P10l12: Start a new paragraph with "Miao et al. (2020) …"
- P10l27: "a airborne" – an airborne