

The Cryosphere Discuss., referee comment RC1
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Comment on tc-2022-76

Anonymous Referee #1

Referee comment on "Metamorphism of Arctic marine snow during the melt season. Impact on spectral albedo and radiative fluxes through snow" by Gauthier Vérin et al., The Cryosphere Discuss., <https://doi.org/10.5194/tc-2022-76-RC1>, 2022

General comments

The study by Vérin and colleagues investigates snow metamorphism on the arctic sea ice and in particular how it impacts on spectral albedo, and how well the albedo variability can be reproduced using a RTM. I believe that this study provides great insights into the temporal variability of snow sea ice albedo during the melt season, and that the albedo dataset could be useful to parametrize or validate the evolution of snow sea ice albedo in global models. The results are clearly presented and the methods are robust - my comments are minor and mostly focused on the albedo measuring and modelling since snow metamorphism is out of my expertise.

Specific comments and technical corrections

Title:

Arctic marine snow can be confusing because it commonly refers to debris sinking in the ocean, maybe it would be clearer to indicate "Arctic snow on sea ice" or equivalent in the title?

Abstract:

Line 19-20: Maybe a minimum BBA value can be indicated here rather than the value at

1000nm? Then it makes it comparable with the number from line 18.

Line 24-25: "based on measurements" is probably unnecessary here because "measured" is already written earlier in the sentence - maybe reformulate to ".. using measured SSA, density vertical profile and impurity content"?

Line 25: "calculations" - also, "at the interface snow-ice" may be clearer than "at the top of the sea ice"?

Introduction:

Line 56-57: What about longwave radiation on overcast days – can this also have an impact on the dry snowpack?

Line 70: In Domine, F., et al. "Three examples where the specific surface area of snow increased over time." *The Cryosphere* 3.1 (2009): 31-39, the authors conclude that "SSA increases are probably not rare", including cases that are described in this paragraph like depth hoar formation. Is this reference maybe worth mentioning here? (especially as other "occasional" processes are mentioned in the introduction, such as summer snowfalls in line 86.

Line 74: "samplings" is probably incorrect, maybe "a lot of samples" or "a lot of sampling"?

Line 93: global radiative transfer "in" sea ice not "of"?

Line 101: "light absorption" may be clearer than "optical absorption"?

Line 102: instead of "and using measurements on melted snow samples", maybe "and measuring absorption coefficients of LAPs isolated from snow samples"?

Line 116: I think that the correct spelling is "set up", not "setup"?

Line 157: LAPs are often distributed in the top cms – if the top 7cm are discarded, how is

it possible to get data on the LAPs from the profiles? Or do the authors mean that the top 7cm was removed only from thin snowpacks on line 150, which is why thick snowpacks were used for retrieval of LAPs properties?

Line 180: Is it possible to indicate the reference of the electronic scale and the sensitivity?

Line 223: Is it possible to indicate at what time were the albedo measurements recorded?

Line 196: "then" instead of "them"

Line 207: "As the snowpack was already ripe, the study of spatial variability using large scale measurements was favored." What do large scale measurements mean here – UAV measurements, or transect measurements?

Line 213: short wavelengths

Line 238-240: Why were simulations performed considering diffuse radiation and not using the exact SZA values corresponding to each albedo measurement?

Line 252: "whose" to replace with "of which"?

Line 259-260: So density, SSA and irradiance profiles were not measured in 2016? Please indicate this in the methods when describing the sampling and analysis of snow physical properties (2.3 and 2.2.2)

Figure 3: How were the wavelengths of 500 and 1000 for albedo chosen? Why not calculate broadband albedo in the IR and VIS? Or an averaged value? Is it possible to indicate more clearly the different phases in the figure - eg the end of phase 3 in 2015 seems to extend to end of June on the figure but extends to mid-June in the text. Similarly, phase II starts on may 19 in the text but before may 14th in the figure. The albedo of the highly heterogeneous ponded sea ice from 2016 was calculated from the transect measurements? Is it possible to indicate in the figure legend how many measurements are included in the box plots?

Line 294: Did you mean "The transition from snow cover to bare ice"?

Line 356: Typo "junE 6"

Line 365: "wicked up the first snow layer" I don't understand the meaning of this, could it be reformulated?

Table 1: Is it possible to indicate in the methods or in the table how many samples were analysed for density and SSA to derive averages and standard deviations?

Figure 7: Why are albedo data presented only from 400nm if the spectroradiometer could measure from 300? Is it possible to indicate the number of samples used in the boxplots, or at least a range? What does "specific albedo spectra" mean, are they averages, or how were these examples of bare ice and melt pond albedos chosen?

Line 409: I am not sure I fully understand what was done here: "It was multiplied by the average density of snow (350 kg m^{-3}) in order to obtain an average absorption coefficient of the impurities in the snow". If I understand correctly, the absorption of particulates from melted snow leads to a coefficient expressed in m^{-1} of melted snow. How can this then be multiplied by the density of snow, leading to units of kg snow per m^4 of snow, and give an "average absorption coefficient"? and where are these "average coefficients" shown? Do the authors mean that they divided the coefficient in m^{-1} of melted snow by the density of water and then multiplied it by the density of the snowpack in order to get an absorption coefficient in m^{-1} of snow instead of melted snow?

If possible, would it be possible to divide the absorption coefficient in m^{-1} by the LAP concentration (in kg m^{-3}) in the solution of melted snow that was filtered to carry the spectrophotometric analysis in order to get a mass absorption cross section in $\text{m}^2 \text{ kg}^{-1}$? Then the data could be used in other widely used radiative transfer model such as SNICAR.

Line 434: "It is possible to fit each spectral albedo with optimized LAP concentrations, but without measurement in each pit, this is not very meaningful" I do not understand what the authors mean here – if it is possible to retrieve the impurity concentrations by inverting TARTES, why would it not be meaningful?

Line 438: "consistence" -> "consistency"

Line 444-447: It would be clearer to have this paragraph at the beginning of the section

3.4.2 to understand the reasoning in comparing LAPs concentrations between 2015 and 2016 in line 443.

Figure 9: typo "albedo with LAP" (h missing) and maybe write "LAPs" instead of "LAP" because both MD and BC are included in the simulations if I understood correctly. It would be beneficial to add the phases as in Figure 3.

Lines 458-462: It would be clearer to indicate only absolute values without units in this paragraph since the relative errors in % are in the table already – the error at 500nm is given in % (indicated as absolute value?) whilst the 0.04 and 0.02 are indicated without % units (are they %?).

Line 467: Why were LAPs omitted in these simulations (Figure 10) if they improve the fit between measured and modelled albedo?

Line 512-513: the link in parenthesis should come before the dot and there should be a dot and a space after the last parenthesis

557-558: According to figure 3, the albedo at 1000nm still varies a lot in phase III (similar slope than phase II?)?

Line 568: What is meant by "the coupling with the grain size"?

Line 575: What is meant by "not adjusted"?

Line 600: snow cover instead of coverS