The Cryosphere Discuss.,
https://doi.org/10.5194/tc-2019-114-RC2, 2019

The Cryosphere Discussions
Open Access
EGU

Interactive comment on "Solar radiative transfer in Antarctic blue ice: spectral considerations, subsurface enhancement, and inclusions" *by* Andrew R. D. Smedley et al.

Ruzica Dadic (Referee)

ruzica.dadic@vuw.ac.nz

Received and published: 12 July 2019

This paper validates a Monte Carlo method to track photons to calculate reflection and transmission of radiation into Antarctic blue ice. While using the MC method for tracking photons is not exactly new, the authors have made it interesting and relevant by discussing the inclusions of inclusions, such as meteorites. Here I agree with the review of S. Warren, that the study would be much more interesting and novel if the results of the downward movement of those inclusions would be quantified and discussed. As suggested by S. Warren, and considering that many meteorites are found on the surface of the blue ice areas, there either must be some sort of size/material threshold

Printer-friendly version

Discussion paper

beyond which the inclusions won't melt into the ice and experience a downward motion, or they are melting much slower than the sublimation in those areas. I would like to see these questions and the questions by S. Warren addressed in a revision, which would make this work more interesting and applicable.

General comments:

- Considering that the authors have used the morphological data from Dadic et al. 2013, it would be interesting to see how their results compare to the measured albedos from the same dataset, especially for the validation part. This is particularly relevant because we found that our SSA (bubble size and number density) differs if estimated from Micro-CT (or through the caliper measurements of density) or from the measured albedos and the model.
- P5, L12: I am not convinced that the approach of "homogenization" of our morphological measurements the best solution here. I like that the authors used the "no cracks" data for an upper bound for density, but I think to get a more representative sample, it would have been better to use the lowest density for blue ice for the lower bound, instead of taking means of the data.
- Albedo is usually not given in percent, but as a dimensionless number between 0-1. This should be adjusted, unless there is a particular reason to keep is a percent.
- Generally I found it hard to follow the conclusions from the figures. The figures are referenced, but I often couldn't see where the conclusion is coming from. That could be improved.

Printer-friendly version

Discussion paper

Detailed comments:

- P2, L23-25: The distinction between snow and firn here is vague and incorrect. Snow starts recrystallizing as soon as it falls, so this distiction is invalid. I suggest either using snow or firn.
- P2, L26: Sea ice also has brine, which has different optical properties than air bubbles.
- P2, L28, This sentence doesn't make sense. Blue ice is formed the same way as glacial ice, which is formed through compression of snow. It's blue because its surface is sublimating and not melting.
- P3, L19-20: This is entirely true. The studies by Mullen and Warren, Light 2003, and Dadic et al. 2013 (studies cited in this paper, and there are probably other studies as well) describe exactly that: spectral albedos and radiative transfer derived from the interaction of solar radiation and embedded bubbles. This sentence should be rephrased: maybe add "by direct ray tracing"?

  Maybe you could also reference Tancrez and Taine 2004 (Direct identification of absorption and scattering coefficients and phase function of a porous medium by a Monte Carlo technique), Haussener et al. 2012 (Determination of the macroscopic optical properties of snow based on exact morphology and direct poreâĂŘlevel heat transfer modeling) and Farmer and Howell 1998 (Comparison of Monte Carlo Strategies for Radiative Transfer in Participating Media). I'm sure they are others as well.
- P8-9: I can't see the enhancement in Figure 4. Please clarify.
- P8, L3: If you assume that bubble geometry is spherical, why do yo discuss the asymmetry factor? I appreciate that it is acknowledged, but it takes a whole figure

(Figure 2), which has no relevance to this manuscript.

- P10, L9-10 (also in Conclusion and Discussion): I am not sure why a change of albedo from 0.29-0.52 is referred to as "only", and that the albedo is "insensitive" to the scattering coefficient. Small changes in albedo can have a profound effect on the Earth's energy balance. E.g. Pierrehumbert et al. [2011] showed that a change of ice albedo from 0.55 to 0.65 means a factor-of-10 increase in the CO2 mixing ratio required to end the Snowball Earth state. I would like to see this rephrased in the manuscript.
- P10, L18 (also conclusions): It's not exactly a new finding that ice is most reflective in the blue wavelengths, and I'm not sure why this is one of the conclusions. E.g. See Warren et al. 2019 (Green icebergs revisited) and the references therein.
- P14, L15-20: See Haussener et al. 2012 for direct ray tracing in a real geometry.
- P14, L29-31: see comment above about the "insensitivity" of the albedo to scattering. Considering that the albedo is between 0-1, it can't be expected that even a fourfold increase in the scattering coefficient would cause a fourfold increase in albedo (which would bring the albedo to above 1). Again, this should be discussed in relative importance of the changes in albedo.
- P15, L1-3: again, not a novel conclusion and relevant papers should be referenced.
- P15, L17: Can the main results from Section three be explicitly repeated here, otherwise the reader has to go back through that seciton.
- P15, L17-19: Again, I disagree that there is only a moderate dependence of radiative properties on the zenith angle and bubble parameters. Please have a look at this again.

Printer-friendly version

Discussion paper

- Figure 2 can be removed. It doesn't really contribute more than when Mullen and Warren 1998 are referenced.
- Figure 3: I can't see how this Figure is different from Light et al. 2003. I also can't see any difference between figures a) and b). Maybe to make it relevant, you could instead plot the differences between 3a) and 3b) and then discuss the differences.
- Figure 7: Same here, I think to see what the authors are discussing, it would be more helpful to plot the difference between 7a and 7b, otherwise it's hard to draw any conclusions.

Interactive comment on The Cryosphere Discuss., https://doi.org/10.5194/tc-2019-114, 2019.