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

Anonymous Referee #2

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The manuscript is dedicated to the ray-tracing model of Antarctic blue ice with bubble inclusions. Ray-tracing models allow to obtain exact solutions of light scattering within particulate media with respect to complicated particle and inclusion shapes and size distributions, surface properties, various illumination conditions, etc and remain a valuable tool in understanding of light scattering processes within atmosphere and surface of the Earth and other planets.

In the presented manuscript, a non-polarized spectrally dependent ray tracing model of the plane parallel Antarctic blue ice with spherical air bubbles and inclusions is developed. While it certainly is an idealisation due to the mentioned assumptions, the

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manuscript provides an insight into the energy distribution in the ice within quite some range of wavelengths, which is potentially important for a number of land ice and sea ice related applications. The used assumptions e.g. about the planar upper surface of the ice or the uniform distribution of spherical bubbles within the ice, although unrealistic, do help highlight the mechanisms responsible for specific light scattering scenarios which would not be observable otherwise. The presented ray tracing code should be easy to modify to account for e.g. surface roughness and the scientific community would certainly gain if the authors decide to continue and do so as a next step; the reviewer, however, appreciates the fundamental study on the subsurface enhancement because even if not always observable in the field due to many factors, the ray scenarios responsible for this enhancement may still be important and it is crucial to understand those scenarios.

The manuscript is well-written and well-structured, nice quality of the figures.

This work is certainly relevant, fits into the scope of the journal, and is recommended for the publication in The Cryosphere subject to minor corrections which are listed below.

- although the manuscript is quite comprehensive already, the reviewer would still like to suggest a short analysis on the orders of scattering and light ray scenarios which were responsible for the subsurface enhancement and peak. The corresponding Section 3.1 currently omits this and could be extended. Conversely, the self-shadowing explanation in the Section 4, Line 7-17, could be more condensed, so that the total volume of the manuscript does not need to increase.

- please take care to specify the important details on the model already in the abstract, e.g. the size parameter range, the fact that the model does not account for polarisation, the Henyey-Greenstein approximation, spherical bubbles, and plane surface.

- please give a short overview (from the perspective of formation and optical properties) on what the Antarctic blue ice is, e.g. in the Introduction, from the top of Page 2, or near Line 31 on P2, and how it (optically) differs from snow, sea ice, lake ice, Antarctic

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firn with respect to layering and granulation.

- P6, Lines 27 - 30. Please consider making the description more self-consistent, so that referring to Light et al would be needed for additional information only.

- P7 Line 2 and Caption of Fig. 3. Albedo at which wavelength? please specify.

- Section 2.5 - here again please specify how the assumption of a continuous medium with spherical bubbles really relates to the Antarctic blue ice and other cryospheric surface types.

- P 7, Line 21-23: please reformulate the sentence or split into two, unclear what is meant here.

- please consider reformulating the title of the paper so that Monte-Carlo and Antarctic blue ice are included. They are the main scope of the manuscript and clarity is essential here, even when the results can potentially be applied in a broader context.

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