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The Cryosphere Discussions

# *Interactive comment on* "Application of asymptotic radiative transfer theory for the retrievals of snow parameters using reflection and transmission observations" *by* H. S. Negi et al.

**Anonymous Referee #2**

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This manuscript studies the applicability of an asymptotic analytical radiative transfer (AART) theory to the retrieval op snow optical properties using measurements of snowpack reflection and transmission performed by Perovich (2007). First, it reiterates the framework of the previously developed AART technique and defines a number of quantities related to this theory. Next, the field measurements by Perovich (2007) are presented, after which the AART theory is applied to these measurements. The optical parameters computed with AART are compared to field observations (density, grain size) or output from a two-stream approximation model (AFEC - asymptotic flux extinction coefficient).



To start with the latter part, I find the comparison of retrieved AFEC with two-stream model results a flawed one. The two-stream approximation, which happened to be developed already in the beginning of the 20th century in the work of Schuster (1906), is an approximation to the radiative transfer equation in which the scattering is isotropic. In principle, the two-stream approach is only valid in the regime where the radiation field is indeed isotropic - i.e. deep inside the scattering medium. So, fundamentally, the two-stream approximation is also an asymptotic RT formulation (which, incidentally, works surprisingly well outside this regime). If the single-scattering albedo is taken constant, it can even be solved analytically, and in that case, the two-stream approximation is also an AART. This is essentially why I find the comparison of two asymptotic RT theories inappropriate to test the applicability of one of them.

The authors stress that their AART theory is practical in the sense that it can be used instead of more complex solution techniques for the RT equation that "require[..] quite large computation time" (p.1241 line 6). However, this should then be proven against such solution techniques and not against the two-stream theory that is equally easily programmed in any programming language in less than an hour and takes less computation power than running an internet browser. A comment on the manuscript by Mathias Gergely points out essentially the same issue, and he notes that the only difference is that the AART of this manuscript assumes anisotropic scattering, albeit with a constant asymmetry parameter. Apparently, this assumption is not critical. On the other hand, the retrieval of AFEC seems to depend on the value assumed for the asymmetry parameter, so how can that be explained? As a side note, it is not difficult to formulate a generalized two-stream approximation that would take into account the anisotropy of the radiation field.

I don't find the match between retrieved grain size and density with observed values convincing. The number of data points is very limited, and in quite a few cases the agreement between AART results and observations is not good, or they match merely because the error margins of the AART retrievals are very large. Do not understand me wrong, I fully appreciate how exceedingly difficult it is to correctly collect data on snowpack reflection and transmission, but it is simply a fact that to show the usefulness of a theory requires a certain amount of validation, which I find limited and not unambiguous in this case.

After reading the manuscript a few times, I started wondering what its (practical) use is. The requirement for transmission measurements for this theory to give results precludes virtually all optical observations of snow. And even if transmission measurements are available, the retrieval of snow properties could be problematic, and is moreover limited to relatively homogeneous snowpacks under diffuse illumination (at least, that is the impression I get). So then, it must be that the authors aim to come up with an alternative theory for the two-stream approach to interpret the data collected by Perovich (2007). The novelty of the paper by Perovich (2007) is obvious to me in that he pioneers transmission observation, and that he uses measurements to establish typical extinction coefficients for different types of snow. In that paper, the two-stream approximation is merely a tool to process the data. This paper however presents a slightly (but not fundamentally) different tool that gives almost identical results (figs 1-3) and is far from novel. This is not substantial enough to warrant a publication in TC to my opinion.

SPECIFIC COMMENTS

- Equation (6) is not congruent with the definition of y (p. 1242, line 17).

- The labels in figure 2 are incorrect: I presume that solid lines are for Perovich (2007) and dashed lines are for AART results.

- The manuscript would benefit from some grammatical scrutiny by a native speaker, which in this case should not be a problem since one of the authors has English as a mother tongue.

- Regarding the topic of transmission observations in snow, the careful observations by



Meirold-Mautner and Lehning (2004) at Summit, Greenland should also be referenced.

REFERENCES

Perovich, D.K. (2007). Light reflection and transmission by a temperate snow cover. J. Glaciol., 53, pp 201-210.

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Interactive comment on The Cryosphere Discuss., 5, 1239, 2011.