The Cryosphere Discuss.,
https://doi.org/10.5194/tc-2018-72-RC1, 2018

The Cryosphere Discussions

Interactive comment on "On the reflectance spectroscopy of snow" *by* Alexander Kokhanovsky et al.

Anonymous Referee #1

Received and published: 14 May 2018

This study presents an impressive analytical technique for deriving snow grain size and impurity absorption coefficient from snow reflectance or albedo measurements. The technique is compared against a limited set of in-situ measurements of spectral albedo and reflectance, both of clean and highly contaminated snow, and is shown to work very well in reproducing the observed spectra and impurity contributions to absorption. Overall, this represents a nice demonstration of the analytical technique derived by Kokhanovsky and Nege (2004) and subsequent studies. My comments for improvement are relatively minor.

General comments:

1) Overall, the technique and its accuracy (against a small number of measurements) is very encouraging, but the main limitation I see with this analytical approach is its inabil-

ity to account for vertical heterogeneity in snow grain size and impurity content. This could be important in situations where grain size varies over the top several millimeters, and/or in situations where impurity content varies over the top several centimeters. In general, the sub-surface snow properties exert different relative contributions to the snow reflectance at different wavelengths. Thus in cases of substantial vertical variations in snow properties, a single grain size or impurity content will be insufficient for modeling the snow reflectance over the entire near-infrared and visible spectra, respectively. Given the nature of this study, I don't see this as a major problem, but I do think this limitation, along with the closely-related restriction of semi-infinite conditions, needs to be acknowledged more clearly, including in the abstract. A second limitation that should probably be acknowledged is the assumption that the spectral distribution of impurity absorption follows perfectly from the absorption Angstrom profile. This assumption could lead to issues in situations where the combination of impurities that are present in the snow do not abide by the Angstrom profile, as is the case with some biological constituents and types of dust.

2) The analytical derivations span 48 equations, and it is easy to become lost when going through these. To help ameliorate this, I suggest that the authors (a) include an appendix listing all of the terms in the equations, and (b) include fundamental SI units of the variables, where appropriate, both parenthetically in the text where they are introduced and also in the appendix. The latter will help readers to infer definitions of variables whose terminology varies across the radiative transfer literature. (For example, even the units of 'extinction coefficient' vary across texts).

3) Lines 194-207: This passage might be presented better as an expanded sub-section on the analytical relationships between errors in albedo/reflectance measurement and uncertainty in inferred quantities. An expanded discussion on the impacts of measurement error/uncertainty on inferred grain size and impurity absorption coefficient would be especially welcome here.

Minor comments:

line 44: Here I would explain that the technique is used to inter *near-surface* snow properties.

line 77: Here and elsewhere, please provide fundamental SI units of the quantity. (Is c the inverse of snow density?)

line 79: Please first define alpha before including this reference to it.

line 84: 'm' should be defined somewhere as the absorption Angstrom coefficient.

line 85: I don't recall sigma having been defined. I suspect this should be kappa.

lines 99-107: The asymmetry parameter (g) itself depends on particle shape, as has been shown in several studies (e.g., Yang and Liou, 1995, doi:10.1364/JOSAA.12.000162), but it appears here to be a constant that factors into the derivation of the grain shape dependent parameter (line 99). This seems confusing to me. Please devote a bit more discussion to the meaning of g in the context of its relationship to the shape parameter, and whether or not it needs to be assumed a constant in this framework.

line 143: Here it appears that kappa_0 only refers to absorption from impurities, but some of the earlier references to kappa indicate absorption by ice. This is an example where an appendix with all symbols and definitions would be helpful.

line 255 and Figure 4 mistakenly list the latitude twice without the longitude.

line 253: Over what depths of snow do these dust load measurements apply? This relates somewhat to general comment #1.

Figures: Please make the figures larger.

Interactive comment on The Cryosphere Discuss., https://doi.org/10.5194/tc-2018-72, 2018.