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Interactive comment on "Soot on snow experiment: bidirectional reflectance factor measurements of contaminated snow" *by* J. I. Peltoniemi et al.

Anonymous Referee #1

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This study reports measurements of the directional reflectance of snow that has been artificially contaminated with different impurities. The measurements are novel and some of the results are quite interesting, particularly that the impurities generally cause much more darkening from a nadir-looking perspective than at oblique viewing angles. This has important implications for the interpretation of satellite observations, which usually occur at near-nadir viewing angles. It is also an interesting observation that snow melt commences within minutes of application of the impurities, suggesting efficient energy transfer from the particles to the ice grains. I recommend publication of the manuscript after the following minor issues are addressed:

Major comments:

The technique used to remove the diffuse contribution to the bidirectional reflectance factor (BRF) is unclear and needs to be described more precisely. To accurately account for the contribution of diffuse incident light, the full BRF of the snow, with respect to all incident light angles, must be known. What is the term "M_D" in equation 3, which is currently described only as the "estimate for the diffuse part"? Please include more precise definitions and descriptions of the terms used in equation 3, including subscripts for incident/viewing angles, if necessary.

The uncertainty in BRF associated with the diffuse correction is reported as 1-5%. Please describe how this estimate was arrived at.

The impurity loads applied in this study are necessarily very high, relative to natural snow, so that the signal can be clearly discerned. An implication of studying snow with such high impurity loads, however, is that some of the conclusions drawn from this study may not apply to natural snow surfaces, or at least not apply to the same extent. In particular, the downward diffusion of impurities, which is critical for explaining the directional reflectance signal, may not occur as often or as markedly in natural snow, especially when the impurities do not actually cause snow melt to occur. Please acknowledge more clearly the potential limitations of studying snow with extreme impurity loads, perhaps even in the abstract.

If any quantitative details about the impurity optical properties can be provided, e.g., from previous studies, it would be helpful to provide them. This would potentially enable modelers to attempt to reproduce the general features of the measured impacts of the impurities.

Minor comments:

How was instrument shadowing accounted for, if at all? How important, or unimportant, is this issue likely to have been? Please address this issue in the text, even if briefly. Perhaps there is no shadowing at the incident zenith angles explored, and the issue only matters for the diffuse contribution of incident light.

3077,17 (Abstract): "albedo should be lower..." - I think the authors instead mean the "albedo perturbation should be lower" (?)

3078,23-25: Many of these studies were actually conducted on "natural snow" rather than "pure snow", and were contaminated to some (unknown) degree by impurities. I suggest changing "pure snow" to "natural snow", to the extent that this change applies to all of the listed studies.

3079,2: The reference to Flanner and Zender (2006) would be more appropriately changes to Flanner et al (2007), as the former did not study impurities but the latter did.

3080,1-3: Please use consistent symbols for the terms listed in Equation 1, shown in Figure 1, and described in the text. The in-text symbols seem consistent with the figure but inconsistent with the equation.

3080,20-21: Please add units of "nm" to the FWHM values of 3 and 10.

3081, bullet 3: What is the reflectance of the "white" Spectralon standard that was used? In practice it is likely less than 100%.

3084,12: How much was the "measured amount of soot"?

3084: Although the volumes of applied impurities (usually 10 mL) are listed, it would also be helpful to know the masses that were applied. If these are known, please report them. This is requested because most impurity-in-snow studies report mass mixing ratios of impurities, rather than volume mixing ratios.

3085,23: "bandwidht"

3086,4-11: Presumably the laboratory measurements of the pure impurities were conducted on optically semi-infinite samples, but please indicate this in the text.

Conclusions: The text in this section could be improved a bit for clarity.

3088,19: "this kind of particles" - which kind of particle? Perhaps "dark particles", in general, are being referred to here.

3090,4: "wide conclusions" -> "wide conclusions are drawn"

Figures 9-12 are too small to read on a printed copy. These are probably the most important figures of the study, so I suggest enlarging them, or breaking them into multiple figures if necessary. Enlarging the axis labels would also help.

Table 1: The meaning of "unstable data" should be explained more precisely.

Figure 7: Do "just above" and "just below" refer to the snow-air interface? Please clarify. Please also mention whether "just" implies a distance on the order of millimeters, centimeters, or something different.

Interactive comment on The Cryosphere Discuss., 9, 3075, 2015.