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Interactive comment on "The effect of snow/sea ice type on the response of albedo and light penetration depth (e-folding depth) to increasing black carbon" *by* A. A. Marks and M. D. King

Anonymous Referee #1

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Summary:

This is a well-written paper that should be accepted after minor revisions. This paper uses the TUV-snow model to investigate relationships between black carbon concentrations and the albedos and e-folding depths of various snow and sea ice types. The various types of snow and sea ice are specified using scattering coefficients and asymmetry parameters in line with observations for each surface type. Changes in black carbon influence the albedo and e-folding depths of each surface type to varying degrees. Changes in albedo due to variations in black carbon are different depending on sea ice and snow type. However, changes in e-folding depths due to variations in black carbon are not dependent on snow or sea ice type. It would be informative to

include estimates of snow grain size for each snow type if possible. Also, it would be interesting to note why snow and sea ice have distinct spectral profiles for albedos and e-folding depths. There are multiple types of snow and sea ice types considered, but it appears that there are some common patterns.

Minor comments:

Abstract: Line 11-15: It's not clear why the relative change in albedo between melting snow and cold snow is compared or why the relative change in albedo between melting sea ice and multi-year sea ice is compared. These comparisons became clearer after reading the paper, but adding a sentence before these comparisons in the abstract that puts these comparisons in context would be beneficial. Otherwise it could seem that random snow and ice types are being compared.

Body: p. 1025, line 7: Include the wavelength bands over which BC is responsible for 85% of absorption.

p. 1025, line 12: Since this statement will become dated, I wonder if there is a better way to estimate the date of the next IPCC report. If not, it's probably best to remove the sentence.

p. 1025, line 18: add "light-absorbing" before impurities for consistency.

p. 1026, top of page: It would be good to give the reader a brief reminder of why large grains lead to lower albedos. This topic comes up frequently during the paper, so it would be good to put a sentence or two in the introduction that provides a clear explanation.

p. 1029, line 9-11: There are polluted places in the world where BC values can reach these high values [Wang et al., 2013]. Please consider removing this statement.

p. 1029, 13-14: it would be helpful to mention the mass absorption efficiency values that were used in this study at some point during the paper.

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p. 1029, line 22: This sentence needs rewording, or perhaps should be split into two sentences. You could say something like “the e-folding depth and albedos were calculated using snow and sea ice of a variety of thicknesses: 0.5 m, 1 m, and 10 m. Additional simulations were performed using thicknesses of 0.25 m for sea ice and 0.1 m for snow”.

p. 1030, line 25: Why is a base case of 1 ng/g chosen?

p. 1031, line 15: Figure 2a also shows sea-ice, not just snow, but the sea ice cases aren’t talked about until later in the paper. It would be good to mention that sea ice is also shown in Figure 2a here, even if it isn’t discussed until later.

p. 1031, line 18: How exactly were these mid-range albedos and e-folding depths? By eye? Please describe the process and also provide values for each snow and sea ice type.

p. 1032, equation 3: Why S? S should be given a proper name. S in theory could be used for any BC base-case concentration (not just 1). It would be useful to note that, because this relationship is a great way to relate changes in BC to albedos/e-folding depths in different types of snow.

p. 1032, line 8: Please add a clarifying statement that better explains why the sensitivity is only a week function of mass-ratio.

p. 1032, line 11: The word “light” isn’t needed.

p. 1032, line 17: Please elaborate on the pronounced effect.

p. 1035, lines 7-10: Why is the change in albedo less pronounced for the melting sea ice compared to the melting snow?

p. 1035, line 20: How is the change in density related in magnitude to the change in snow grain size? Do changes in grain size influence the e-folding depth more than changes in density?

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p. 1036, line 5-7: This is an important result that should be highlighted in the abstract. It would be even more informative if the link between grain size and scattering coefficients were incorporated into this statement to refresh readers.

Figure 2: Adding equation 3 or the equations on 1030, line 26 somewhere in the figure would be helpful so that the reader doesn't need to flip back to the equation when trying to think about the percent change in albedo and e-folding depths. Also, specifying the mid-range albedo and e-folding depth on the figure or in the caption would be helpful.

Figure 4: In the caption, when comparing the BC sensitivity, which type of snow of semi-finite thickness are being comparing to the thin, melting snow? In some cases here, (e.g. comparing the 10 cm melting snow to the 10 m cold snow), the sensitivity of the melting snow appears larger.

Figure 9: The snow e-folding depths look realistic (Figure 8), but the sea-ice e-folding depths are really large. Are these values realistic? Also, have there been any measurements of black carbon in sea ice? If so, what are the typical values? I would assume that the main light-absorbers in sea ice are organics. If there are any measurements of these species, perhaps estimates of the equivalent black carbon values in sea ice using the technique you describe earlier in the paper could be provided.

p. 1037, line 25: spelling of 'scattering'

p. 1038, line 5: Missing a parenthesis

Section 4.4: This is a great way to link this work to the bigger picture.

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