Atmos. Chem. Phys. Discuss.,
https://doi.org/10.5194/acp-2020-985-RC1, 2020

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Enhanced light absorption and reduced snow albedo due to internally mixed mineral dust in grains of snow" *by* Tenglong Shi et al.

Anonymous Referee #1

Received and published: 23 November 2020

The authors conducted a theoretical investigation of dust-snow internal mixing and its effects on dust-induced snow albedo reduction. The dust-snow internal mixing has not been quantified by many previous studies, and the present study could potentially increase our understanding of its impact. This manuscript is suitable for this journal and is generally well structured in terms of language. However, I do have one major concern related to the method used in this study. Please see my comments below for details.

Major Comments:

1. My major concern is that the effective medium approximation used by the authors

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cannot be applied to dust in snow due to the much larger dust size than black carbon (e.g., Bohren, C. 1986: Applicability of effective-medium theories to problems of scattering and absorption by nonhomogenous atmospheric particles, J. Atmos. Sci., 43, 468–475). This has also been discussed in detail in Section 2.1 of Flanner et al. (2012, ACP doi:10.5194/acp-12-4699-2012).

Minor Comments:

1. Page 2, Line 10: “absorption coefficient”. Did the authors mean the absorption coefficient of snow-dust mixture?

2. Abstract: The authors assumed spherical snow grains and semi-infinite snowpack in their calculations. These need to be mentioned in the abstract to avoid potential confusion.

3. The authors assumed spherical snow grains in this study. But it would be good to discuss the role of snow grain shape in the introduction, because recent studies showed that snow nonsphericity can interact with LAP-snow mixing, which leads to weaker LAP-induced albedo reduction for nonspherical snow shapes than snow spheres (e.g., Dang et al., 2016 JAS: doi:10.1175/JAS-D-15-0276.1; He et al., 2018b JGR, doi:10.1002/2017JD027752). The snow shape can have nontrivial impacts on dust-snow albedo reduction.

4. The authors used the effective medium theory to handle dust-snow internal mixing. However, as mentioned in my major comment, this method has its limitation when applying to large particles (e.g., dust) in snow. Some other studies (e.g., Liou et al., 2014, JGR doi:10.1002/2014JD021665; He et al., 2019, JAMES doi:10.1029/2019MS001737) have used another geometric-optics surface-wave approach to deal with dust-snow internal mixing. These two are the pioneering studies investigating dust-snow internal mixing effects, and need to be discussed in the introduction. Particularly, the authors also need to highlight the difference or novelty of the present study compared with these recent studies (e.g., new method, new perspective,

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etc.?). In the results or discussion section, it is good to also discuss the difference in the results from the present study and the previous study (e.g., He et al., 2019 JAMES) in terms of the impact of dust-snow internal mixing. It would be interesting to see if the results are consistent or not based on two different methods.

5. Page 5, Lines 13-14: Please rephrase this sentence. Did the authors mean 20cm and 3cm of snow depths?

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