Review of
Quantifying the influence of mining dust particle deposition on the melting rate of nearby glaciers in northwestern China
By Zhiyi Zhang et al.

With interest have I read the manuscript by Zhang et al, which basically performed idealized laboratory and numerical experiments to determine the effect of mine-originating mineral dust particles on ice melt. To my regret, I assess this manuscript is not meeting the publication standards of The Cryosphere and that a significant extra amount of research and analysis is needed before publication can be considered.

The major critics focus on the 'awareness' of past research and existing knowledge; the analysis of the laboratory experiments; the numerical experiments; and the final discussion.

Added value to existing knowledge.
The usual methodology to estimate the effect of a thin layer of dust (MDPs) on melt is by calculating the surface energy balance (which would provide melt as outcome), and to derive the surface albedo with an albedo model. The field situation in mind of this study has a thin or scattered MDP layer at the surface, and is thus not like a debris covered glacier where the debris layer thickness becomes relevant as well. For this kind of surface situations, albedo models already exist, like, for example, Gardner and Sharp (2010); Libois et al. (2013); Warren and Wiscombe (1980). Even more papers investigate the effect of dust and debris on melt (for real world glaciers), like Azzoni et al. (2016). The authors must, therefore, add a better review of existing literature (which goes further than the papers I cite here), formulate in the introduction what their research add on or test of existing knowledge, and evaluate, at the end, what the laboratory and numerical experiments taught us.

Laboratory experiments
These experiments are novel and interesting. There are, as far as I can see, only in situ experiments of the effect of dust on melt, e.g. Conway et al. (1996). Nevertheless, the experiment set-up and analysis preclude - so far - a translation of the laboratory experiments to 'real-world' situation. As the experiments are carried out at 15 ℃, part of the melt is due to thermal heating and part of it by insulation. Luckily, the authors carried out experiments with different light strengths, so these two effects can be separated. Furthermore, due to the use of three insolation angles during every experiment, comparing the absorbed light energy with the total light energy 'received' on the ice cubes. That analysis allows to retrieve an ice albedo for clean and dusted ice and hence allows to evaluate (one of the) existing albedo models with your data. It would be great if the authors could add an additional experiment, namely the amount of melt when the light was kept off, but given the very smooth results they have now, I expect that the evaluation suggested above can also be carried out successfully without this extra experiment.

Numerical experiments

Where the laboratory experiments would be easier to interpret if the authors kept it even simpler, the numerical experiments are overly simple. Given the existing models of the effect of small particles on the albedo - and hence energy absorption - I don't see what the presented numerical experiments add to that or prove. Furthermore, the existing provided analysis is very shallow - the authors derive the absorbed extra energy (in Joules) per MDP grain, and that is it. I find it hard to conceive how this part of the manuscript can be improved so that it becomes novel scientific research - in all cases the numerical experiments should lead to an analysis that assess if existing albedo models are right or wrong.
Besides that, the numerical experiments are very simplistic in technical setup and very sophisticated in computational execution. However, I wonder if not the near same results were obtained if simple 0D energy balance calculations were carried out. Furthermore, the authors seem to be unaware that albedo is not a bulk quantity (but very complicated, even for rocks). In all cases, the bulk surface albedo for visual light is not related to the (bulk) emissivity for longwave radiation. And if the authors had the emissivity for short wave radiation (=visual light) in mind (which would be odd, because how do you determine short wave emissivity for objects at "normal" temperatures as the emission peak for those temperatures is still in the far infra-red?), the discussion is still irrelevant.

<u>Discussion</u>
This whole section would be interesting if no albedo / ice melt models would be there - still it would be a pity that the authors leave it to theoretical considerations without any evaluation or even exploratory numerical examples. The reality is that such models already exist, so that the whole discussion as is now, is pointless and unpublishable.

<u>Assumed knowledge level of the readers</u>
Especially the manuscript sections related to the numerical experiments hugely underestimate the knowledge level of readers of the Cryosphere. I presume that every reader understands that a higher solar zenith angle leads to less surface insulation per square meter (Figure 3, accompanying text), nor I don't see the need to write out Equations 2-4.

<u>Minor comments</u>
L28: Why is not also a more general, review like paper cited or the relevant chapter of the last IPCC report (or the SROCC)?
L34: Give a reference for this WGMS statement.
L56: Please add that this >0.9 albedo applies for clean (and fresh) snow (and not ice, for example)
L64: In this study, MDP are primarily linked to mining activities, which is presumably correct for the test sites inquired. However, in the papers cited the MDPs have likely a different origin - like in the alps mining is not the source of dust. Please formulate this (mining is the source for this study, but not for other studies) more accurate.
L68: I'm not sure this trend (more high-altitude mining) is applicable outside China, so make it specific for China.

Figure 1; The spatial gap from figure 1a to 1b is large (that is probably unavoidable if no additional panels is added) and scales and orientation are missing in panels 1b and 1d. Please add the orientation and scales in these two panels.

L97: You cannot conclude this from just two glaciers - it could be simply geometry driven that glacier #1 retreats faster of these 6 years than glacier #2. Rephrase.

L115: There is only compelling evidence that the MDPs come from the mine if the rocks and dust available around the glacier is different than the skarn-type mineral rocks, or that the collected dust arising from the mine has an identical structure. If that has been demonstrated, add this - otherwise there is no compelling evidence.

L122-134 & Figure 3 & Table A2: The effect of the axial and celestial rotation on the top-of-atmosphere radiation should be known to readers of a scientific paper, so remove this text, table and figure. [By the way, S2 is less than S1 as the atmosphere absorbs radiation]. Please specify what is incorporated in the NASA number for Q in figure 3? E.g. is it observed TOA irradiance or a mean value of insolation (so without solar intensity variations and orbital effects?)

A1: The density of ice is 920 kg/m3 if it is -20 ℃, while it is 917 for 0 ℃. Please specify why this density is used or adjust.

Give the seriousness of my concerns if this manuscript is suitable for publication, I stopped collecting minor issues after line 145.

Azzoni, R. S., Senese, A., Zerboni, A., Maugeri, M., Smiraglia, C., & Diolaiuti, G. A. (2016). Estimating ice albedo from fine debris cover quantified by a semi-automatic method: the case study of Forni Glacier, Italian Alps. *The Cryosphere*, *10*(2), 665-679. https://doi.org/10.5194/tc-10-665-2016

Conway, H., Gades, A., & Raymond, C. F. (1996). Albedo of dirty snow during conditions of melt. *Water Resources Research*, *32*(6), 1713-1718. https://doi.org/https://doi.org/10.1029/96WR00712

Gardner, A. S., & Sharp, M. J. (2010). A review of snow and ice albedo and the development of a new physically based broadband albedo parameterization. *Journal of Geophysical Research: Earth Surface*, *115*(F1). https://doi.org/https://doi.org/10.1029/2009JF001444

Libois, Q., Picard, G., France, J. L., Arnaud, L., Dumont, M., Carmagnola, C. M., & King, M. D. (2013). Influence of grain shape on light penetration in snow. *The Cryosphere*, *7*(6), 1803-1818. https://doi.org/10.5194/tc-7-1803-2013

Warren, S. G., & Wiscombe, W. J. (1980). A Model for the Spectral Albedo of Snow. II: Snow Containing Atmospheric Aerosols. *Journal of Atmospheric Sciences*, *37*(12), 2734-2745. https://doi.org/https://doi.org/10.1175/1520-0469(1980)037<2734:AMFTSA>2.0.CO;2