

Review of “Variability in individual particle structure and mixing states between the glacier snowpack and atmosphere interface in the northeast Tibetan Plateau” Dong et al., 2018.

The authors clearly show that the morphology of carbonaceous, dust, and other aerosol varieties changes between the atmosphere and the snowpack at all of their sampling locations in the Tibetan Plateau region. Their findings could significantly improve aerosol parameterizations in climate modeling environments, so I believe that this study is scientifically important and well-motivated.

I recommend this study for publication after major revisions. In my comments below, “L” means line. For example, L17 is “line 17”.

#### MINOR:

##### General:

When you state acronyms for the first time, you must also define them. Please define the following:

- SNICAR: L28, L81.
- TSP: L87
- DKL-2: L96
- JEM-2100F: L106

##### Introduction:

After L82: the organization of the paper should be relayed to the readers here.

##### Methods:

L84-L86: Are these analysis varieties for atmospheric aerosols, terrestrial aerosols, or both? It’s difficult to tell.

L86-89: Is it possible for you to describe EDX, TSP, and TEM techniques in a couple of sentences? I’m a climate modeler, so I don’t know anything about these methods.

L89-L93: Because you have listed out all of the sampling locations in Table 1, I do not think you need to list those locations here. In lieu of this list, just refer the readers to Table 1.

L95: What do you mean by “large-range”? Does this range refer to distance, or does it refer to time (taking measurements over long time spans)? The term is vague and should be changed to allow for easier interpretation.

L100-L101: When you say the sampling method is similar to the Dong et al., 2017 study, do you use the same exact methods (are they identical?), or do you make small changes to these methods? If they are the exact same methods, you should say “the same as” instead of “similar to”. If the methods are indeed “similar” but not identical, how are they different?

L113-114: What happened with samples not measured in frozen states? Did anything change about the methods? Or were all of the samples measured in frozen states? If so, make sure this is stated clearly.

L120: ug/g should be changed to  $\mu\text{g/g}$ .

Results:

L148: Use of “Meanwhile” is misleading. Please rephrase.

L152, L230: LAIs should be LAI.

L160-L162: You can delete the sentence starting with “Figure 4a-4d is representative of...” because this is mentioned in the caption for Figure 4.

L169-171: What previous work? Please cite this (these) reference (references) in this sentence.

L176-178: Since this sentence is basically the same information that is provided in Figure 5’s caption, you can delete it.

L181-185: You stated that atmospheric BC/OM have higher ratios of fresh structure particles than the snowpack (L178-181). If this is what you are trying to say, you can delete the sentence starting with “We can demonstrate...”. If you are trying to provide the readers with another result, please revise this sentence to make it clearer.

Radiative Forcing in other sections: either keep this information where it’s at and delete Section 3.4, or wait to mention the following until Section 3.4:

L188-192: You don’t need to discuss the Peng et al. article here (or the fact that BC/OM particle structure changes lead to changes in radiative forcing on cyrospheric features). If you’re keeping 3.4, move this to section 3.4.

L216-219: (starts with “...many particles without salt-coating...”) Move this to 3.4.

L226, L236-L238: This discussion should be included in Section 3.4.

L196-197: What does “...on the advantage of the transmission micro-observation of the single particle structure” mean? This is unclear, so please revise the sentence to clearly depict what you are trying to say.

L197-199: Add “(Figure 6)” to the end of the sentence, and delete the sentence starting with “Figure 6 demonstrates...”. The caption you have for Figure 6 provides the reader with this information.

L208-210: The sentence starting with “Figure 7 shows...” can be deleted since the caption for Figure 7 will provide the reader with this information. At the end of the previous sentence (L207-208), insert “(Figure 7)”.

L264: “previous modeling studies”; which ones? Please cite the relevant sources in the document.

L265: “cell” (in phrase “cell core”) is unclear. Do you mean “particle”?

L266-269: This is awkward and should be rewritten. State the studies you reference at the beginning of the sentence. Do all of the sources provide the same exact forcing values you cite? If not, provide the trends that the authors of all of the studies find between external and internal mixing. If the authors have markedly different results for internal versus external mixtures, their findings should be discussed in multiple sentences.

L269, L275: What do you mean by “heat-absorbing”? Would it be clearer to say “light-absorbing” instead?

L278-281: You’re discussing the methods you use for SNICAR in a results section. This sentence should be part of the methods, not the results. Also, see below in the MAJOR revisions section for other questions I have regarding your SNICAR work.

#### Conclusions:

L300-302: If you keep Figure 11, either mention it in this sentence or delete “A schematic model diagram” and talk about how all of your results tie together.

L308-309: (“...the model...”) you mean SNICAR, correct? If so, write SNICAR instead of “the model”.

#### Figures and Tables:

Overall, I found the table and figures to be quite illustrative of your findings. Minor fixes/comments are listed below:

Figure 1: I recommend that the font color marking each sampling location be changed from black to white since black blends in with the topographical coloring scheme.

Figure 2: Does “mineral” mean dust in your microscopic images? If so, call it “dust” for clarity.

Figure 3: Is the photo (part c) really necessary? It seems like this would be something eye-catching for a presentation, but it doesn’t really demonstrate any of your results.

Figure 4: The caption (L406) lists “Figures 3a-3d” and “Figures 3e-3h”. These should be changed to “Figures 4a-4d” and “Figures 4e-4h”, respectively.

Figure 5: Replace “Structure” with “LAI” (or something similar) in the caption (L408). “Structure” is a little ambiguous. Is part (a) the atmosphere and part (b) the snowpack? Revise your caption to show this.

Figure 8: (Caption) put a period at the end of the caption. Please label the panels.

Figure 9: (Caption) put a period at the end of the caption.

Figure 10: In the text, you refer to particle sizes on the order in MICROMETERS. In the figure, you use NANOMETERS (on the x-axis). Please be consistent; either change the figure to match to main text, or change the units you list in the main text.

Also, the secondary y-axes on the right-hand side of the plot are color-coated to match mixing state, correct? Is it possible to redo either the axes or lines in the plot so that the colors more clearly match with the corresponding axes?

Figure 11: See my notes in the “Major Revisions” section below.

Figure 12: I think it would be more readable if the “Broadband Snow Albedo” values listed in the body of each plot are rounded to two decimal places. Also, please label each panel.

## MAJOR:

### General:

There are some grammatical errors that need to be addressed in this paper. The foremost issue I have found pertains to sentence structure. There are many instances of run-on sentences that can be split into multiple sentences and restructured. Examples of run-on sentences can be found in L15-L19, L22-25, L71-L79, and L120-L124. This list is not exhaustive, though, so you should check the entire manuscript (including figure captions) to find other grammatical errors.

### Methods:

Which SNICAR configuration are you using? Are you using the online version? Or are you incorporating it into a climate model configuration? Please describe this in your methods section with 1-2 additional sentences.

### Results:

Section 3.1 (shorter title would also be preferred): Is this supposed to be a summary of all of your findings? It is difficult to follow.

Based on the title of the section, I think you should focus on the morphology of the particles. The reasons why the changes in particle morphology between the snow and atmosphere should be discussed in later sections. You could mention that these changes in morphology and structure lead to changes in radiative forcing, but that such impacts will be discussed in a later section.

L151: What does “aerosol change processes” mean? This is confusing phrasing that should be changed.

I interpret “aerosol change processes” as the changes in morphology and structure observed between aerosol species in the snow and in the atmosphere. If my interpretation is incorrect, what does “aerosol change processes” mean? Can you describe what information you are trying to relay here?

If my interpretation is correct, it seems as if you are saying that changes in morphology and structure (mostly through snow-based deposition) lead to large variability of individual LAI particle structures and morphology. This is redundant and need not be mentioned. If I am incorrect, then this sentence needs to be rewritten.

Section 3.2 (Again, the section title should be shorter) and Section 3.3

In the following instances, you are restating findings that have been previously discussed. Take one of the following steps: 1) If you are trying to say something new, rewrite the sentences, 2) If you are reiterating the point that is previously discussed, either a) delete the sentence (redundancy is not necessary) or justify why you want to restate this particular finding.

L186-188: What are you trying to say? Are you stating that dominantly fresh particles transitioned to aged particles from the atmosphere to the snow within the interface?

L212-214: Are you trying to say something new about salt coating of LAIs in the snowpack? If so, what information are you trying to provide to the reader?

Section 3.4: In the section heading, delete “Discussion of”.

L241-243; L251-253: You’ve already stated these findings in previous sections. Since both of these findings are referenced to Figure 11, do you really need to include Figure 11 in the manuscript? In my mind, Figure 11 is not necessary for reader comprehension. Please justify why you wish to keep Figure 11 or delete it.

The discussion of your SNICAR-based findings (L277-287) should be at the beginning of this section. The first two paragraphs depict how your findings from previous sections match up with the literature, and what the literature suggests about how these findings will affect radiative forcing. Instead, use this information to justify why your SNICAR radiative forcing results make sense.

L283-L287: Although albedo reduction does imply positive radiative forcing, it would be convenient for readers to have access to calculated radiative forcing values (especially since this section is dedicated to radiative forcing).

I feel like this section is more of an afterthought (as it is currently written). However, the implications of morphology on snowmelt in the Tibetan Plateau region are important and directly related to your radiative forcing calculations. To better wrap up your findings, I think that the information you provide in this section should pertain more to your own calculations and less to the calculations of other authors.

Figures:

Figure 11: As I've asked above, is this really needed? You depict morphology, aging, and mixing changes in previous figures, and you state the radiative forcing tendencies in Section 3.4. The information depicted in this image represents the information that should be written up in the conclusion section (that is, it answers the following question: how are all of your findings connected?). Since you can easily describe how these conditions are connected, I do not think the figure is necessary.