

Review of Linke et al. 'Specifying light absorbing properties of aerosol particles in fresh snow samples, collected at the Environmental Research Station Schneefernerhaus (UFS), Zugspitze.'

General comments:

This paper present results from snow samples analyzed for their aerosols content over one winter season. The authors are using an array of different instrumentation, making this an interesting study that is most certainly within the scope of ACP. In light of the instrumentation used in this study, it appears that the authors have not presented the full potential of the data that should be at hand in the current version of the manuscript. For example: absorption measurements coupled with the BC mass content have been carried out, enabling the authors to present direct MAC values for the particulates in the snow (which could then be used for comparison and additional data in the manuscript). Another issue that should be addressed more thoroughly in the manuscript, is the fact that it seems as there is only the one sample (from March 10th) where the additional analyzes are performed, and from this one sample conclusions about all of the snow samples are drawn. Please see further comments below on these topics, as well as some other questions and recommendations that should be addressed. Lastly, the manuscript's language should be checked and re-evaluated for a better read. Although I'm not a native English speaker myself, I do believe the manuscript would benefit from such a procedure. Some mistakes have been highlighted in the technical corrections below, but I'm sure there are mistakes that I have missed, and so make sure to check the whole manuscript. On the whole, this work would be a welcomed addition to the literature after it has been majorly revised.

Specific comments:

Section 1

The introduction could use some restructuring and clarifications. My opinion is that some references are missing, and the addition of these papers will change some of the claims the authors are making in the introduction. Under 'technical corrections' I have provided comments to specific line numbers on this.

Section 2

Lines 128-129: Do the authors have any idea to what degree the station is affected by the anthropogenic emissions? It would be valuable information to add in the text, if it exists? How close is UFS to the skiing area?

Line 136: As the manuscript currently reads, 10 cm of snow was collected after each snowfall. What was the procedure of collecting the snow if there was more (or less) snow in the precipitation event? If it was more than 10 cm, for example, BC particles from the beginning of that snow event would be missing in the analysis. On the opposite, if there was a small snow event, producing only a few centimeters of snow, how was that snowfall sampled? In that event, if 10 cm of snow was sampled, it would include not only the fresh snow (and its particulates), but also more aged particles in the snow, leading to possible differences in the analysis.

Also, on the topic of the snow sampling, the authors mention that the collection was from a place exposed to wind, and so how did they manage to collect the new precipitation? One would expect the wind to remove this snow (that is typically is not very dense). A table in the supplement of this manuscript could easily be added, providing valuable information about the snow samples, precipitation events, as well as other basic weather parameters during sampling.

Line 144: How do the authors know that using the ultrasonic bath to melt the snow sample did not change the structure of the BC particles? (e.g. break the particles apart into smaller sizes, which obviously will have an impact on their optical properties), or the other particles present in the snow also?

Section 3

Some sentences in the fourth paragraph are already mentioned in the second paragraph (e.g. lines 235-237 are mentioned in lines 216-219). Technically, I do not see why the information in this fourth paragraph (which ultimately contains more details) could already be incorporated into the second paragraph.

Lines 225-226: Could you present any quantitative numbers on this minor influence?

Section 4

Lines 263-266: What about adding the size distribution of the fullerene in a figure, to show that the difference in fullerene MAC's could be explained by differences in size?

Section 5

The results of the snow sample measurements could be highlighted even more. You have 33 samples from one snow season. How do they differ from one another? In Fig. 7 you show how the BC snow concentration varies over this season, what about the air concentration of BC from the station? (it is mentioned that no correlation was found between the snow and air BC concentrations. I would argue that this is shown, possibly in fig. 7 or a different figure). Is there any seasonality in the size distribution of BC particles from snow? I'm not convinced that there is such a clear decrease in the size distribution of the larger BC particles, please elaborate on this to further convince the reader that this is the case. (It is true that since you have taken relatively fresh snow samples, there would be no thawing and freezing cycles, possibly leading to larger BC particles). One example comes to mind where fresh snow BC size distributions were measured (Sinha et al., <https://doi.org/10.1002/2017JD028027>). Although in a different setting, please put your results into context by comparing with this study.

What about the dust concentrations? How did the described Saharan dust episodes influence the BC mass (and the snow samples)?

Through the measurement set-up that the authors present, they should have the data necessary to directly derive MAC values for the particles in the snow. How come this was not done? I believe one of the other referees also commented on this. Either the authors provide these MAC values also, and compare (and discuss) that in the manuscript with the data that they already have. If this is not possible, then it should be stated why, and more emphasized why the approach used currently in the manuscript is utilized. There is evidently other impurities other than the BC particles, which will influence the MAC

value for the particles in the snow, but with the other instrumentation available, it should assist in describing those particles (i.e. the OC content).

Line 313: What evidence is there to show that this one sample from March 10th is representative for all of the snow samples? (This sample contains a low amount of BC compared to the other samples and has an enhancement factor of 2.7 compared to the 2.34 presented for the others samples). Either present some evidence that this is representative for all of the samples or emphasize in the manuscript that these additional analyzes (presented in the following paragraphs) were only done to the one sample, and so it is difficult to draw conclusions for all of the snow samples. Ideally, I would argue that additional snow samples would be analyzed from different times during the season in the same way as the one sample from March 10th.

Lines 320-326: Although you discuss it further in the following paragraph, please include some sentence (or sentences) of what these specific results indicate about the snow samples?

Line 329: It would be interesting to have some information (even if it is hypothetical) on where this biological information originate from? E.g. Local or long distance?

Technical corrections:

Lines 29-30: This opening sentence is not structured well. Please revise for a better read.

Line 32: Please remove 'packs' from ice packs. Could say snowpack, but not ice packs here.

Line 32-33: You could argue that a better reference here would be Warren and Wiscombe 1980 [https://doi.org/10.1175/1520-0469\(1980\)037<2734:AMFTSA>2.0.CO;2](https://doi.org/10.1175/1520-0469(1980)037<2734:AMFTSA>2.0.CO;2), look into details of Doherty et al. 2010.

Lines 33-34: How is this sentence different than the previous sentence? I would think that it is better to have this sentence earlier.

Lines 35-36: How does 'this reduction' contribute to the snow-albedo feedback? Please include in the manuscript. What metamorphosis?

Line 41: What 'BC amounts' are you referring to? Please specify.

Lines 44-46: How are permafrost regions also affected? Unclear what you mean how they are affected? Also, after reading the rest of this paragraph, I would argue that you should remove this sentence. Since the rest of the paragraph discusses the Arctic, and these other 'areas' are not brought up again until later in the introduction, it could come then instead.

Line 50: As far as I remember Flanner et al. (2007) did not present any measurements, but based their modeling work on measurements instead.

Line 53: I would argue that you either introduce what the term 'soot' refers to, or stick with only discussing BC.

Line 56: Ice sheet instead of 'ice shield.' Please change also 'extend' to extent.

Lines 55-60: Concerning the Greenland ice sheet, there are also new papers on this topic of impurities, which could be added here (e.g. <https://doi.org/10.5194/tc-10-477-2016>; <https://doi.org/10.5194/tc-11-2491-2017>).

Line 60: Please capitalize a in 'arctic.'

Line 61: Doherty et al. (2010) is already referenced to in the beginning of the sentence.

Line 68: How high amounts of dust? Would be more informative to actually reference to some numbers on this.

Line 69: To my knowledge, Bolch et al. (2012), is incorrectly referenced to here. No studies of BC nor dust were conducted in that paper.

Line 73: Remove 'the' before light absorbing particles.

Lines 77-80: I find this sentence confusing, please rewrite. Mixing the optical method (Doherty et al., 2010), and then the thermos-optical analysis, with the previous sentence about MAC causes some of the confusion. The following paragraph (lines 81-93) dig deeper in each analysis technique and that is appropriate, but the order of this seems strange, in light of the previous paragraph. Actually, I think you could delete the sentences in lines 75-80, and jump right into line 81 and an explanation of the methods (after current sentence ending on line 75).

Lines 92-93: Either remove this sentence or add more information on other instruments and protocols out there (e.g. DRI and Improve-protocol). I would vote for removing this sentence, I do not think it is very crucial information.

Line 97: I would argue that you do not need quotation marks around Fullerene.

Lines 98-100: This sentence is basically a repeat of the first sentence of this paragraph, please remove.

Lines 102-103: I generally agree with this statement that not much have been reported on the light absorbing properties. But, there has been some publications on this topic addressing it directly and indirectly, e.g. Schwarz et al., 2013 <https://doi.org/10.1038/srep01356>; Zhang et al., 2017 <http://dx.doi.org/10.1016/j.scitotenv.2017.07.100>; Dal Farra et al., 2018 doi: 10.1017/jog.2018.29; Dong et al., <https://doi.org/10.5194/tc-12-3877-2018>. Please add and discuss these references.

Line 104: Please remove 'solar' before albedo.

Lines 103-106: Please clarify the structure by checking the structure. As it currently stands, it is not clear what the main point of the sentence is.

Lines 106-108: Please change this sentence according to the forthcoming changes made for lines 102-103.

Lines 109-110: The second half of this sentence (starting after 'but') I find problematic. Similar to the comment in lines 102-103, I do believe this topic has been addressed in the literature. For example: Kaspari et al., 2014 (that you already referenced to earlier in the manuscript); Skiles and Painter, 2016 doi: 10.1017/jog.2016.125; Schmale et al., 2017 DOI: 10.1038/srep40501; Zhang et al., 2018 <https://doi.org/10.5194/tc-12-413-2018>, 2018. Please adjust your claim by including these references on this topic.

Line 137: The fact that the snow samples were collected at 'platform 7' does not add any information to a reader unfamiliar with UFS. Please either elaborate on this, or remove.

Line 147: What does 'Enhanced' refer to? Please explain.

Line 150: I do not find the flow rate for this peristaltic pump anywhere. Please add it.

Line 184: Please remove the double reference to 'Fischer and Smith (2018).'

Lines 196-198: Do you mean that the solution was prepared in the same way as in Schwarz et al? If so, please correct. Also, I believe the reference should be Schwarz et al. (2012) and not (2010) as it currently reads.

Line 204: How did you 'drop' 30 mL of fullerene solution onto the quartz filters? Please explain more.

Line 260: What did Zhou et al. (2017) refer to with MAC_{real} ? Please clarify.

Line 276: Remove 'before' at the end of the sentence.

Line 294: The presented enhancement factors for the different wavelength appear to be averages, please clarify this.

Lines 315-319: The instruments and methodology presented here should be described in section 2.

Lines 344-345: This information should be moved to section 2.

Figure 2. I'm not sure how needed this figure is. I actually think that this figure could be integrated into fig. 1.

Figure 8. Why is there is a data gap around 280-300 nm?

Figure 9. This figure is quite busy right now. Could the data points be zoomed in on more? And could the data points be made smaller?