Comment on acp-2021-39

Anonymous Referee #2

Referee comment on "Variability in black carbon mass concentration in surface snow at Svalbard" by Michele Bertò et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-39-RC2, 2021

The manuscript '**Variability of Black Carbon mass concentration in surface snow at Svalbard**' by Michele Bertò et al. reports the cumulative processes (such as atmospheric, snowpack and meteorological conditions) in governing the refractory Black Carbon (rBC) mass concentrations in the upper snow layers at Svalbard. The database (85 days in 2014, 1 Apr-24 Jun and 3-days in 2015, 28 Apr- 1 May) in this study is useful to the characterization of aerosol-cryosphere interaction over the Arctic. However, there are many weak elements and lack of clarity in several aspects. I recommend publication of this manuscript in the Atmospheric Chemistry and Physics after my comments have been addressed.

The major concern is the main outcome of the study. Authors state that 'precipitation events were the main drivers of the BC variability (line-33)". However, the snow precipitation amount is negatively associated with the rBC mass concentration during 3-days experiment, as against the positive association during 85-days experiment. How do authors explain these contrasting effects of precipitation on BC concentration in snow? In line 353-367, authors try to connect atmospheric eBC concentration with the wet scavenging processes, which requires better investigation. Do authors want to highlight (quantify?) how effective the wash out processes in compared to various other factors considered in this study?

The interpretation of the standardized estimated coefficients derived from multiple linear regression models amongst rBC (in snow) and water conductivity, coarse mode particles number concentration, equivalent black carbon atmospheric concentration, snow precipitation episodes, solar radiation and the snow temperature during 85- and 3-days experiments lacks coherent interpretation as well as proper explanation of the physical processes involved. The positive and negative associations seen in the case of eBC, fresh snow and SWR during 85 days and 3-days experiments must be clearly described. Information about both dry and wet deposition processes are randomly put in different context, this could be avoided.

The BC in the upper snowpack affects the snow Albedo. There are multi-layer approaches to understand the effect of vertical distribution of BC in the snow pack (e.g., Dang et al., 2017). In this study, what is the criterion of selecting "upper snowpack" as 10 cm in 85-days and 3-cm in 3-days experiments?

If SZA is the primary driver of the diurnal variation of BC in snow, what about the cloud cover? SZA is important while estimating snow albedo change, but does it really influence (under the given circumstances) the BC concentration on a diurnal scale in 3 cm snow? How magnificent is snow metamorphism when the diurnal temperature remains below -6 C?

Line 35-36: "The statistical analysis suggests that the BC content in the snow is decoupled from the atmospheric BC load." This is not clear.

Line 82-85: The citation about the dry deposition parameters is not suitable in the context of present study

Line 98: seasonal > intra-seasonal variability

Line 121/ 99: Sampling period is contradicting; is it May end or till June 24?

Section 2.3.1: In general, filter loading effect is negligible at Arctic due to very low BC concentrations. Why MAC at 530 nm is used? Do aethalometer derived absorption coefficients agree well with PSAP measurements?

Why MAC = 7.25 m^2g^{-1} is considered for PSAP estimates of eBC? Virkkula (2010) is more appropriate for PSAP data correction.

Section 2.4.2: This section is very important, which explains the estimates of rBC in snow. However, the methodology using SP2 (please expand) for rBC (in snow) estimation is not clear. The following statement needs to be refined:

"The nebulization efficiency was evaluated daily by injecting Aquadag® solutions with different mass concentrations, ranging from 0.1 to 100 ng g-1, obtaining an average value of 61%, that was used to correct all the BC mass concentrations reported in this manuscript."

Line 345-347: Please include the values of R^2?

Line 381: "…. as residuals of carbon extraction mining activities", add reference to this statement

Line 432: Why average coarse mode number concentrations are significantly higher in 3-days experiment ($\sim$ 26642 $\pm$ 9261 ml^{-1}) than that in 85 days experiment ($\sim$ 4914 $\pm$ 4109 ml^{-1})?

Fig-3: Why rBC concentration is relatively higher in 3 days experiment (> 10 ppb) as compared to the values in the corresponding period of 85 days experiment (< 6 ppb)?

Fig-4: 80 or 85 days? In the regression model, how the values of SWIR are considered? Diurnal average or normal incident condition?

Lines 465-469: "… low mass concentrations when the solar radiation is high and vice versa. The BC particles are known to be non-volatile and not photo chemically active, therefore the decrease in their concentration observed when the solar radiation is higher could not be explained as a re-emission process from the snowpack into the atmosphere as observed for other aerosol species". The sentence is not clear. Please rewrite.