Nov 15, 2021

Dear Editor and the reviewers,

Thank all of you very much for taking the time and efforts to review our manuscript, titled with "APCC Data Report I: Black carbon and organic carbon dataset from atmosphere, glaciers, snow cover, precipitation, and lake sediment cores over the Third Pole", that we have submitted to "Earth System Science Data" (MS No.: essd-2021-187). We have considered all comments and suggestions carefully and tried our best to address them and revised the manuscript accordingly. We greatly appreciate all the constructive comments and suggestions that have led to an improvement of the paper, and we hope the revised manuscript is suitable for publication in the journal.

Revisions are made to address the following specific comments.

Our point-by-point responses to the comments are listed below in blue color.

Yours sincerely,

Shichang Kang and Yulan Zhang on behalf of all co-authors

Response to RC1:

Review on paper #ESSD-2021-187: The manuscript entitled "APCC Data Report I: Black carbon and organic carbon dataset from atmosphere, glaciers, snow cover, precipitation, and lake sediment cores over the Third Pole " by Kang and colleagues present a systematic data report on black carbon and organic carbon from various environmental medias including atmosphere, glaciers, snow cover, precipitation, and lake sediment cores over the Third Pole. The authors setup an observation network named atmospheric pollution and cryospheric change (APCC) covering the Tibetan Plateau (TP) and its surrounded region, noting their efforts for APCC are very commendable. The data reported in the manuscript from the APCC is valuable and crucial for understanding the atmospheric pollution and their impact on cryosphere on TP, where continually observations are scares. The topic of the paper is of great importance, and within the scope of the journal Earth System Science Data. The manuscript is logically organized, well structured, nicely written, and the figures and tables are appropriate. I suggest a minor revision, and recommend the authors address the following suggestions before

publication.

Answer: Thank you very much for all these comments.

Line 112: This paper reported data from APCC. However, the description about the network is too short. Please provide more detail information, eg. the background of the network setup, the beginning and development of the network.

Answer: APCC network namely the "Atmospheric Pollution and Cryospheric Changes" has been thoroughly introduced by Kang et al. (2019). In this paper, we have provided more information on the APCC. As shown, in 2013, we initiated a coordinated APCC monitoring network with the overarching goal of performing more integrated and in-depth investigations of the origins and distributions of atmospheric pollutants and their impacts on cryospheric changes over the Third Pole region. Meanwhile, the specific goals of APCC network are listed as flowing:

(I) Characterize the chemical compositions and levels of atmospheric pollutants and depict their spatial and seasonal variation over the Third Pole region;

(II) Identify the source regions of atmospheric pollutants and reveal the pathways and mechanisms by which atmospheric pollution is trans-boundary transported to the Third Pole region;

(III) Investigate the role of atmospheric pollutants deposited as Light Absorbing Impurities (LAPs) in the melting of glacier ice and snow cover and, further, quantify the contribution of LAIs to glacier and snowpack melting, and determine the fates of environmentally relevant pollutants within glaciers and snowpack and their scavenging processes during the melting of snow and ice.

Certainly, as development, we have also modified our goals according to the research progress. Currently, we also focused the feedbacks of cryospheric melting on carbon cycle and hydrology in the Third Pole (Gao et al., 2021). The research area is not only focused on the Third Pole, but also extended to the central Asia (Chen et al., 2021). Besides, new emergent pollutants (for example, microplastics) has been observed and sampled (Zhang et al., 2021). The monitoring prototype, observational and sampled process, measurements and quality control were all

introduced (Kang et al., 2019).

Therefore, in this study, we briefly provided the main structure and observations in the main text. According to the suggestion, we have also tried to added the related new information, which is not redundant from our already published paper (Kang et al., 2019)

References:

Chen, P., Kang, S., Abdullaev, S. F., Safarov, M. S., and Li, C.: Significant influence of carbonates on determining organic carbon and black carbon: a case study in Tajikistan, central Asia. Environ. Sci. Technol. 55, 5, 2839–2846, doi: 10.1021/acs.est.0c05876, 2021.

Gao, T., Zhang, Y., Kang, S., Abbott, B.W., Wang, X., Zhang, T., Yi, S., Gustafsson, Ö.: Accelerating permafrost collapse on the eastern Tibetan Plateau. Environ. Res. Lett., doi: 10.1088/1748-9326/abf7f0, 2021.

Kang, S., Zhang, Q., Qian, Y., Ji, Z., Li, C., Cong, Z., Zhang, Y., Guo, J., Du, W., Huang, J., You, Q., Panday, A.K., Rupakheti, M., Chen, D., Gustafsson, Ö., Thiemens, M.H., and Qin, D.: Linking Atmospheric Pollution to Cryospheric Change in the Third Pole Region: Current Progresses and Future Prospects. Nat. Sci. Rev., 6, 4, 796−809, doi: 10.1093/nsr/nwz031, 2019.

Zhang, Y., Kang, S., Gao, T., Kang, S., Shangguan, D., Luo, X.: Albedo reduction as an important driver for glacier melting in Tibetan Plateau and its surrounding areas. Earth Sci. Rev., 220, 103735, doi: 10.1016/j.earscirev.2021.103735, 2021a.

Zhang, Y., Kang, S., Wei, D., Luo, X., Wang, Z., Gao, T.: Sink or source? Methane and carbon dioxide emissions from cryoconite holds, subglacial sediments, and proglacial river runoff during intensive glacier melting on the Tibetan Plateau. Fundamental Research,1, 232-239, doi: 10.1016/j.fmre.2021.04.005, 2021b.

Zhang, Y., Gao, T., Kang, S., Allen, S., Luo, X., Allen, D.: Microplastics in glaciers of the Tibetan Plateau: evidence for long-range transport of microplastics. Sci. Total Environ., 758, 143634, doi: 10.1016/j.scitotenv.2020.143634, 2021c.

Line 126-127: Do these three domains have exact bound? Please add the longitude and latitude if have.

Answer: The three domain don’t have the exact boundary. In Yao et al. (2013)’s study, they

only show the schematic boundaries in grey lines separating the three domains (the westerlies domain, the transition domain, and the monsoon domain) (Fig. R1). The boundary lines are not in strait lines. It is difficult to add the exact longitude and latitude for each domain.

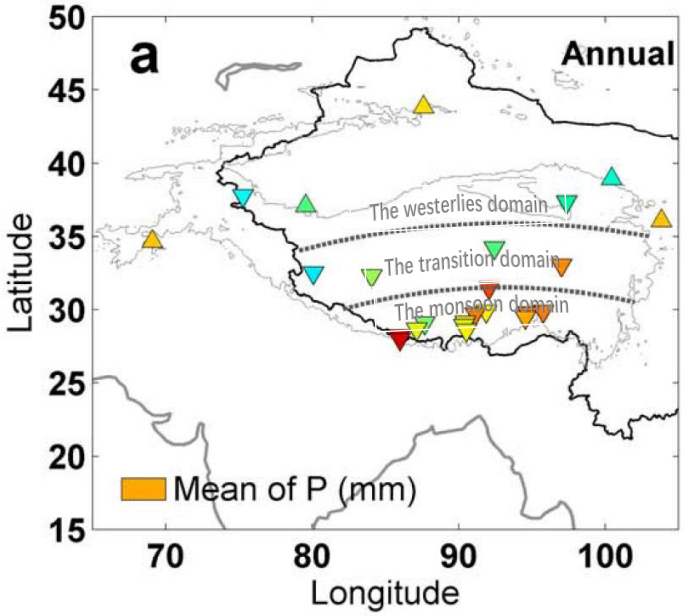

Figure R1. Schematic boundaries of three domains over the Tibetan Plateau. (Yao et al., 2013)

References:

Yao, T., Masson-Delmotte, V., Gao, J., Yu, W., Yang, X., Risi, C., Sturm, C., Werner, M., Zhao, H., He, Y., Ren, W., Tian, L., Shi, C., and Hou, S.: A review of climatic controls on δ18O in precipitation over the Tibetan Plateau: Observations and simulations. Rev. Geophys., 51, 4, 525–548, doi: 10.1002/rog.20023, 2013.

Line 142 and 145: sometimes you use ‘2 stations’ but sometimes ‘two stations’. Please use consistent expression.

Answer: Agree, we have revised to keep them in the consistent expression.

Line 166-171: you introduced some aerosol sampling sites in central Asia but didn’t provide OC and EC data of these sites.

Answer: The sites in central Asia were included in our APCC network. However, BC and OC data from these sites were not analyzed until we submitted our manuscript to the journal. Currently, Chen et al. (2021) have reported the variations of OC and EC from aerosol in Central

Asia. And we have added the related data in this study now.

References:

Chen, P., Kang, S., Abdullaev, S. F., Safarov, M. S., and Li, C.: Significant influence of carbonates on determining organic carbon and black carbon: a case study in Tajikistan, central Asia. Environ. Sci. Technol. 55, 5, 2839–2846, doi: 10.1021/acs.est.0c05876, 2021.

Line 178: why only detected rBC in the site? Why chose Mt. Everest station?

Answer: Do you mean eBC here? We only have one equipment to measure the eBC, which has been setup at the Mt. Everest station to investigate the trans-boundary transport of BC aerosols. Therefore, we can only provide the eBC data from this station currently. Meanwhile, Mt. Everest region

Line 195, 200: again use three, five glaciers. Please check the whole manuscript.

Answer: Sure, we have checked through the entire manuscript. At the beginning of the related sentences, we use the six or five, not the numbers.

Line 200: “Five glaciers studied in the Karakoram…” confused about this sentence.

Answer: Here we mean we have observed 5 glaciers in the northern Pakistan regions (part of Karakoram and western Himalayan region).

Line 240: why do you collected TSP but not PM2.5? I think fine particles are easily to transport to remote regions. Actually, I think APCC will be of great importance to scientific communities worldwide. However, by now, it seems that the APCC only observes BC, EC, OC and some other related indexes. Will you observe other important atmospheric pollutant in the future? for example, PM2.5, POPs.

Answer: Based on APCC network, we have truly studied the other pollutants, for example, mercury, PAHs, and microplastics (Huang et al., 2019; Zhang et al., 2021; Zheng et al., 2020). But in this article, we focused to report the carbonaceous aerosols rather than other chemicals. As we mentioned in the abstract, in the future, datasets of mercury, heavy metals, and POPs will be reported.

In this study, OC and EC are retrieved from TSP samples. PM2.5 samples were not collected at most of the station due to the harsh environment (limited power, cold and high-elevations). Therefore, we reported the data analyzed from TSP samples.

References:

Huang, J., Kang, S., Ma, M., Guo, J., Cong, Z., Dong, Z., Yin, R., Xu, J., Tripathee, L., Ram, K., Wang, F.: Accumulation of atmospheric mercury in glacier cryoconite over western China. Environ. Sci. Technol., 53, 6632-6639, 2019.

Zhang, Y., Gao, T., Kang, S., Allen, S., Luo, X., Allen, D.: Microplastics in glaciers of the Tibetan Plateau: evidence for long-range transport of microplastics. Sci. Total Environ., 758, 143634, doi: 10.1016/j.scitotenv.2020.143634, 2021c.

Zheng, H., Kang, S., Chen, P., Li, Q., Tripathee, L., Maharjan, L., Guo, J., Zhang, Q.: Sources and spatio-temporal distribution of aerosol polycyclic aromatic hydrocarbons throughout the Tibetan Plateau. Environ. Pollut., 261, 114144, doi: 10.1016/j.envpol.2020.114144, 2020.

Line 243: Could you give more description on the roof the TSP sampler setup? For example, how high the roof is? Is it different for the remote sites and urban sites? Do you think that the height of the roof influences the sampling?

Answer: The detailed information about height of roof where the TSP sampler setup has added in Table 1 in the main text. In urban and rural sites, most samples are set on the roof of building with height of 10 or 15m. In remote sites, most are about 2 or 3 meters, which are based on each station' infrastructure. The height can affect the sampling if set near the surface. Therefore, we set all sampler height higher than 2 m.

Line 265, 266: does the 'snowpit' and 'snowpack' represent the same meaning? If yes, use one for easy reading.

Answer: Snowpit is used for studied glaciers, and snowpack were used for snow cover.

Line 290: the eBC was measured for TSP? Why it is BC but not EC? Because for aerosol

samples, you use EC in section 4.2.

Answer: The eBC represented the equivalent black carbon, the abbreviation is generally used as eBC. The eBC was measured on-line, not off-line analysis from the TSP samples. For BC measured in TSP samples, it is also name as EC which equals to BC.

Line 302: The title of 4.2 is not clear. What is Atmospheric aerosol EC and OC methods?

Answer: The sub-section title has been revised as ***Analysis methods and data of atmospheric aerosol EC and OC***.

Line 327: please check the manuscript, some words were deleted using revision mode.

Answer: We have revised. Thank you.

Line 365: this has been described in section 3, thus the first sentence can be deleted here.

Answer: Agree, and deleted.

Line 367: what is the pore diameter of the quartz filter? Please clarify because if the pore size is big, some particles will be lost.

Answer: the pore size of quartz filters is 2.2 μm. In Li et al. (2016)' study, we have estimated the efficiency of filtration. It was reported that the ratio of the BC contents in samples with and without $NH_4H_2PO_4$ was determined to be 77±17%, which denotes a fairly high degree of recovery.

References:

Li, C., Bosch, C., Kang, S., Andersson, A., Chen, P., Zhang, Q., Cong, Z., Chen, B., Qin, D., Gustafsson, Ö.: Sources of black carbon to the Himalayan-Tibetan Plateau glaciers. Nat. Comms., 7, 124574, doi: 10.1038/ncomms12574, 2016.

Line 390, 411: again there are some words deleted using revision mode.

Answer: We have revised.

Line 394: the author introduced the blanks information for WSOC measurement, but didn't

provide information for other equipment.

Answer: We have tried to added the measurements accuracy, limits, and blanks for each equipment mentioned in the study.

Line 507: put ‘and’ before ‘samples’

Answer: Done.

Table 1: it seems the abbreviations are not used in this manuscript. In addition, can you add the location of every site in TP (eg. southern, northern). This would be useful for reading.

Answer: The abbreviations is used in the Data tables. Thus, we provided the abbreviations here. The location information of latitude, longitude, and elevations are also provided.

Figure 1: is that possible to add the boundary of three domains?

Answer: As we mentioned, there is no exact boundary of each domain, thus we didn’t put the boundary in the figure.

Caption of figure 3: please use correct reference style.

Answer: Revised.

Figure 10: put the long descriptions in the title but not in the figure.

Answer: The descriptions of sample types and locations are for each reference, which make them clear to understand.

Figure 11: add unit to the title of y-axis.

Answer: Added, and thank you for all of these comments.

Response to RC2:

The paper "APCC Data Report I: Black carbon and organic carbon dataset from atmosphere, glaciers, snow cover, precipitation, and lake sediment cores over the Third Pole" by Kang et al., presents a comprehensive summary of data report regarding the field measurements of black carbon and organic carbon in the Tibetan Plateau, known as the Third Pole. Generally, the paper is clear-written, and the dataset is important to the community for investigating the effect of anthropogenic impacts on the carbon cycle and the potential climate feedback in high elevation regions. I only have a few comments before publications:

Answer: Thank you very much for all the structured comments to improve our manuscript.

- There is a lack of descriptions about the data quality control and what methodology has been used for data processing.

Answer: The data quality for each equipment or parameter reported in this study has been added. The BC and OC data provided in our study are based on the different samples, the processes of sample collection are according to the standard protocols used. For example, in study by Zhang et al. (2017), for BC and POC in snow samples, we evaluated blank filters for total carbon <1 μg cm^{-2}. For the same filter, multiple measurements showed small relative standard deviations (RSD, <10%), indicating that the data points tended to be close to the mean value, an acceptable filtration (Fig. R1). To test if the filtered meltwater volume contributed to BC measurement error, we filtered the carbon mass concentrations using different volumes. Corresponding relative standard deviations were mostly <30% (Table 1). This implied that our filtration procedure was reasonable. The duplicate snow samples demonstrated the similar concentrations of BC and OC (Fig. R2). We also evaluated the impact of inorganic carbonates interfering with BC measurements at the Laohugou No. 12 glacier, we acidified (N37% HCl) selected filters by fumigation in open glass Petri dishes held in a desiccator for 24 h and subsequently dried at 60 °C for 1 h to remove any remaining HCl. The results from the carbonate acidification and analysis indicated acceptable data quality with a discrepancy <20% (Fig. R3).

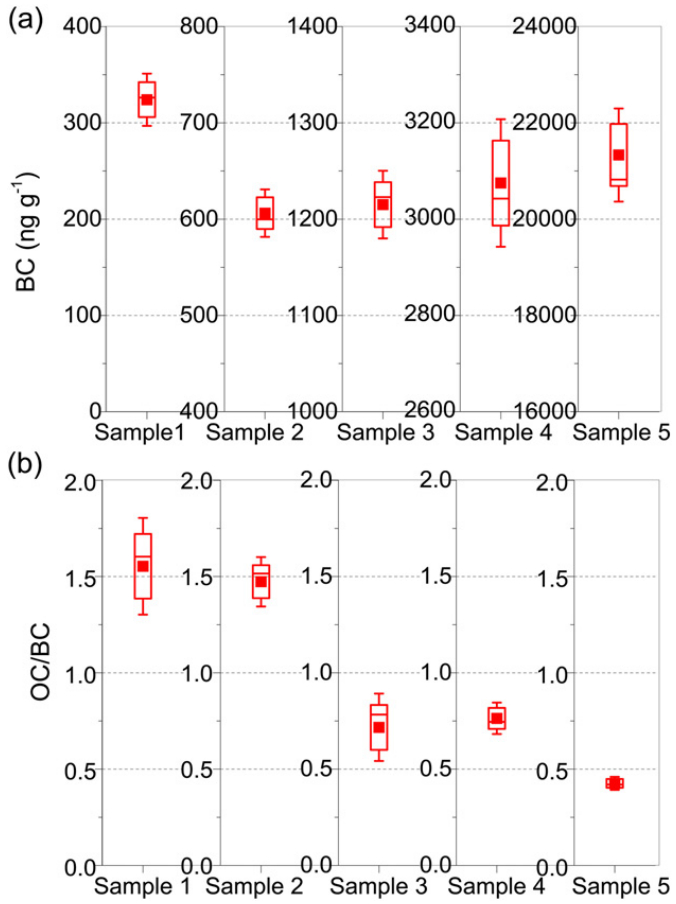

Figure R1 Multiple measurements of (a) BC concentrations and (b) ratios of OC to BC for selected samples. (Red square represents the mean value.)

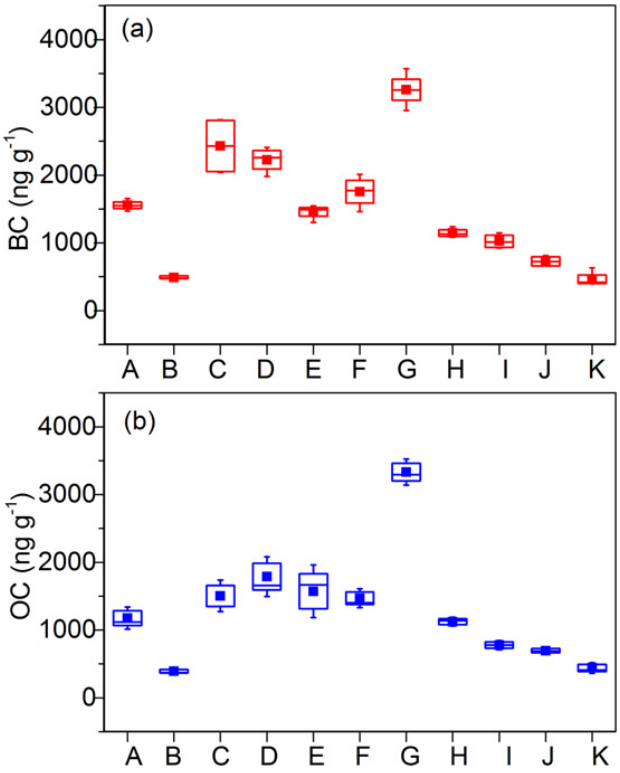

Figure R2 (a) BC and (b) OC concentrations for duplicate snow samples (collected in Aug 2015) filtered with different volumes. (A-K mean the sampling sites on the Laohugou No.12 glacier as shown in Fig. 1b.)

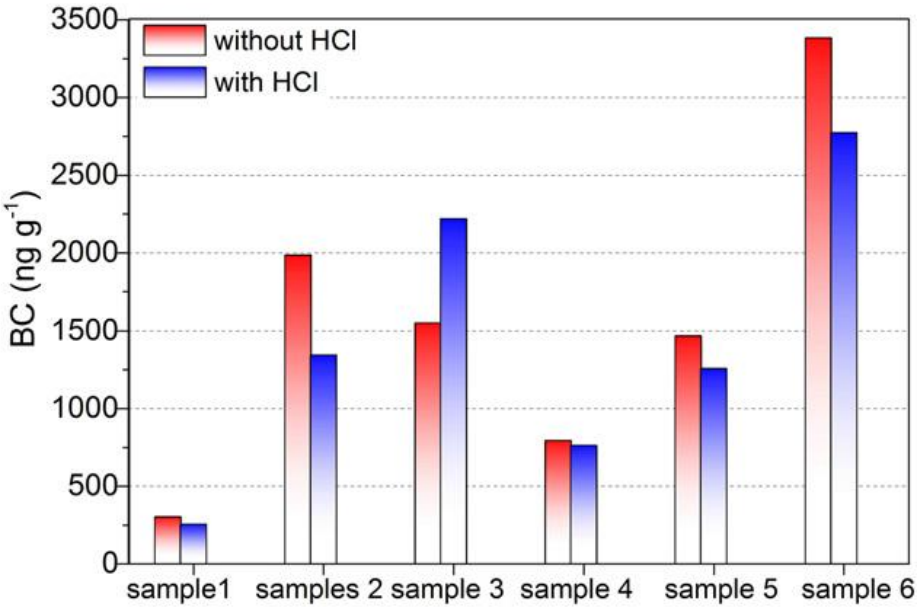

Figure R3 Comparison of BC concentrations measured with and without acidification.

Table 1
BC and OC concentrations (ng g^{-1}) for snow samples collected in August 2015 and the corresponding RSDs (%) filtered with different volumes.

Sampling site	BC Mean	BC RSD%	OC Mean	OC RSD%
A	1556	4.81	1177	18.53
B	489	4.56	391	10.99
C	2379	16.63	1504	22.96
D	2226	8.31	1787	21.97
E	1457	7.32	1571	32.88
F	1754	13.14	1470	12.62
G	3259	7.76	3332	7.79
H	1146	5.99	1123	7.69
I	1024	10.67	778	11.50
J	728	10.68	696	8.64
K	464	23.97	442	23.55

For WSOC in snow and ice, the detection limit of the analyzer was low at 4 μg L^{-1}, while the precision and average WSOC concentrations of the blanks were ± 5% and 4 ± 2 μg L^{-1}, respectively, demonstrating that contamination during the pre-treatment and analysis processing of these samples was weak (Hu et al., 2021).

For real-time eBC observations, when calculating eBC concentrations, it is therefore possible to eliminate the "loading effect" with the loading compensation parameter k, which allows extrapolation to zero loading, and the accurate ambient BC concentration is obtained (Drinovec et al., 2015). Previous studies have evaluated the real-time compensation algorithm of dual-spot Aethalometer model AE-33 and indicated that AE-33 agreed well with the post-processed loading effect compensated data obtained using earlier Aethalometer models and other filter based absorption photometer (Chen et al., 2018; Drinovec et al., 2015).

The rBC concentrations from ice cores are likely to be systematically underestimated due to the following: 1) Samples were stored in the liquid phase after melting, and prior findings indicate that storage in the liquid phase can result in as great as 80% reduction in measured BC concentrations (Wendl et al., 2014). This reduction is hypothesized to be caused by rBC particles sticking onto the container wall during storage in the liquid phase, or rBC particles agglomerating beyond the size range at which particles are nebulized (Wendl et al., 2014; Kaspari et al., 2014). 2) The nebulization efficiency is size dependent, with large (>500 nm) and small (<200-250 nm) BC particles nebulized with lower efficiency than mid-sized particles

(Wendl et al., 2014; Schwarz et al., 2012). Nevertheless, because we focus on the temporal variation of rBC from ice core for the historical records rather than on absolute concentrations, the systematic underestimation of rBC does not affect the historical change trends.

For BC in lake sediments, the repeated measurement of BC in a few lake sediments (n=5) were to ensure reproducibility of measurements, which reported as relative percentage deviation was better than 8%. Standard reference material (marine sediments, NIST SRM-1941b) was also analyzed to assess the accuracy of measurements. It indicated an average accuracy of 5.5% for the measurements of BC in lake sediments in this study (Neupane et al., 2019).

As suggested, we have added the related information for the data quality control.

References:

Chen, X., Kang, S., Cong, Z., Yang, J., and Ma, Y.: Concentration, temporal variation, and sources of black carbon in the Mt. Everest region retrieved by real-time observation and simulation, Atmos. Chem. Phys., 18, 12859–12875, doi: 10.5194/acp-18-12859-2018, 2018.

Drinovec, L., Mocnik, G., Zotter, P., Prévôt, A. S. H., Ruckstuhl, C., Coz, E., Rupakheti, M., Sciare, J., Müller, T., Wiedensohler, A., and Hansen, A. D. A.: The “dual-spot” Aethalometer: an improved measurement of aerosol black carbon with realtime loading compensation. Atmos. Meas. Tech., 8, 1965–1979, doi: 10.5194/amt-8-1965-2015, 015.

Hu, Z., Kang, S., Chen, Q., Xu, J., Zhang, C., Li, X., Yan, F., Zhang, Y., Chen, P., Li, C.: Photobleaching reduces the contribution of dissolved organic carbon to glacier melting in the Himalayas and the Tibetan Plateau. Sci. Total Environ., 797, 149178, doi:10.1016/j.scitotenv.2021.149178, 2021.

Kaspari, S., Painter, T.H., Gysel, M., Skiles, S.M., Schwikowski, M.: Seasonal and elevational variations of black carbon and dust in snow and ice in the Solu-Khumbu, Nepal and estimated radiative forcings. Atmos. Chem. Phys. 14,8089e8103, doi: 10.5194/acp-14-8089-2014, 2014

Neupane, B., Kang, S., Chen, P., Zhang, Y., Ram, K., Rupakheti, D., Tripathee, L., Sharma, C.

M., Cong, Z., Li, C., Hou, J., Xu, M., and Thapa, P.: Historical Black Carbon Reconstruction from the Lake Sediments of the Himalayan-Tibetan Plateau, Environ. Sci. Technol., 53, 5641–5651, doi: 10.1021/acs.est.8b07025, 2019.

Wendl, I.A., Menking, J.A., Farber, R., Gysel, M., Kaspari, S.D., Laborde, M.J.G., Schwikowski, M., 2014. Optimized method for black carbon analysis in ice and snow using the Single Particle Soot Photometer. Atmos. Meas. Tech. Discuss. 7(3), 3075e3111, 2014.

Zhang, Y., Kang, S., Li, C., Gao, T., Cong, Z., Sprenger, M., Liu, Y., Li, X., Guo, J., Sillanpaa, M., Wang, K., Chen, J., Li, Y., and Sun, S.: Characteristics of black carbon in snow from Laohugou No. 12 glacier on the northern Tibetan Plateau, Sci. Total Environ., 607, 1237–1249, doi: 10.1016/j.scitotenv.2017.07.100, 2017b.

- The manuscript lacks discussions about the scientific aspects of this dataset. I understand this is a data description paper but the manuscript in the current form looks more like a technical report, rather than a data paper. I notice there are several plots adapted from previous studies based on this dataset. So it would be necessary to summarize the findings based on this dataset. This would help the readers to understand the importance of this dataset and leverage its key scientific implications.

Answer: The journal's requirements stated that: *Articles in the data section may pertain to the planning, instrumentation, and execution of experiments or collection of data.* ***Any interpretation of data is outside the scope of regular articles****. Articles on methods describe nontrivial statistical and other methods employed (e.g. to filter, normalize, or convert raw data to primary published data) as well as nontrivial instrumentation or operational methods. Any comparison to other methods is beyond the scope of regular articles.* Therefore, we focused on the data report, not focusing on the results. Also, as suggested, we have added the brief discussion on the data and their scientific aspects in each section (at the end of each sub-section).

Specific comments:

Line 390: strike through text

Answer: Revised.

Line 518: It’s not necessary to mention ‘which is of great importance to scientific communities worldwide’ as it has been addressed in the introduction.

Answer: Agree and deleted.