

***Interactive comment on “Drought-induced biomass burning as a source of black carbon to the Central Himalaya since 1781 CE as reconstructed from the Dasuopu Ice Core” by Joel D. Barker et al.***

**Anonymous Referee #2**

Received and published: 16 November 2020

This manuscript presents an ice-core-based black carbon (BC) record starting in 1781 CE from Dasuopu glacier in central Himalaya. BC is deposited is mainly deposited during the non-monsoon season. An increase in BC concentration and frequency after 1877 was observed and attributed to biomass burning associated with periods of drought in neighbouring regions. BC records are scarce from that region and are needed to constrain emission estimates used in modelling the aerosol effect on climate. Generally, the manuscripts is well written and structured and mostly scientifically sound (see comments below). The manuscript deserves publication, after taking into

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account the comments and suggestions listed in the following.

Presentation of the data and spectral analysis: To give the reader the chance to assess the quality of the data, the rBC concentration should be shown first on a depth scale before transformation onto a time scale. To me it is not clear what is given in fig. 2a and all the subsequent figures. Are those raw data or annual averages? Considering the variable sampling resolution with depth and time (as shown in fig. S1), only averaged data (e.g. annual averages) can be interpreted with respect to signal intensity and frequency. This also applies to the spectral analysis. The principle of spectral analysis is that values represent similar time intervals. Please clarify and correct if necessary.

Attribution of BC to biomass burning: I was surprised to see that BC was purely interpreted as emitted from biomass burning. Potential contributions from combustion of fossil fuels are not discussed. This is in contrast to the emphasis given to anthropogenic BC in the introduction, and to the interpretation of other ice core-based BC records from the Himalaya (Ming et al., 2008, Kaspari et al., 2011). The latter show rather similar trends with peak values in 1970s and 1990s and a minimum in the late 1980s, which is also visible in the Dasuopa record. I suggest including a comparison with those records in the manuscript, since they are located so closely. The biomass burning hypothesis is also in contradiction to the interpretation of trace metal enrichment being related to fly ash from European Industrial Evolution (Gabrielli et al., 2020, partly the same authors). If larger fly ash particles were transported that far, why not BC? There are BC records from Europe to compare with (Lim et al. 2017, Sigl et al. 2018). The attribution to biomass burning is based on the comparison with the Palmer Drought Severity Index. This is an interesting idea. As indication, individual events are discussed, when they match or do not match, which is a rather descriptive section and hard to follow. To convince the reader about this hypothesis try to use a more robust statistical approach, for instance a spatial correlation analysis with the PDSI maps. In summary, the biomass burning hypothesis needs a more convincing argumentation.

The effect of BC on glaciers is discussed in the introduction and was presumably a

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motivation for this study. Overall, the BC concentrations are rather low. What does this mean for the albedo? This deserves a statement in the conclusions.

BC analysis: Losses of BC in melted snow/ice have been observed before. I am a bit worried about your transfer of the melted sample from the storage bags into the 50 ml polypropylene centrifuge tubes. Did you check if you have losses during this step? Explain Aquadag standards. Define baseline conditions and background level.

BC shows often a pronounced seasonality (see for example Ginot et al. 2014) as you show as well for the Dasuopu record in fig. S2. It would be interesting to see in a figure if this is the case throughout the continuous record. Have you cross-checked the previous dating with annual layer counting using the BC seasonality and if not why not?

The introduction is overall very descriptive. Could you add some summarizing?

Minor comments

L 57: "the European Industrial Revolution", why only European?

L 99: "Similarly, Liu et al. (2008) report high elemental carbon (a form of BC)". EC is not a form of BC, be more precise about the difference.

L 118: What is the importance of being the highest, explain.

L 127: What do you mean with mixed free tropospheric composition? Explain. What is the percentage of real free tropospheric conditions over the year?

L 136: I suggest to include the earlier paper on BC terminology: Petzold, A., et al., Recommendations for reporting "black carbon" measurements, Atmos. Chem. Phys., 13, 8365–8379, <https://doi.org/10.5194/acp-13-8365-2013>, 2013.

L 137: "sub-annual resolution in the glacier ice portion". What do you mean by that?

L 152: "Here, we examine the upper section of the C3 ice core". Give more details on how many cores were collected. Was the chronology developed for the same core? If

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not, comment on how the cross-dating was conducted.

L 174: Here and in entire manuscript: Rephrase: "ultra-pure water", and add quality.

L 184: Add concentration of acid.

L 186: Ziploc bags. Ziploc is a brand, replace by material of the bag.

L 249-258: Is this data from Gabrielli et al. (2020)? If yes, this has to be stated.

L 261: "topography" instead of "geomorphology"

L286: For comparison add the percentage of snow deposited during monsoon conditions in the ice section.

L 289: rBC concentration and not deposition.

L 289-291: This is a rather qualitative statement made only for selected times periods. Can you support that with correlation coefficients over the entire record?

L 551: all of the trace element EFs

Fig. 2: The 5-year median looks strange to me, e.g. at 1790 and 1975 and generally in the firn part the median is higher than any single value. Please check.

Fig. 5: Add colour code values for the frequencies.

References Ginot, P., et al. (2014). "A 10 year record of black carbon and dust from a Mera Peak ice core (Nepal): variability and potential impact on melting of Himalayan glaciers." *The Cryosphere* 8(4): 1479-1496.

Lim, S., et al. (2017). "Black carbon variability since preindustrial times in the eastern part of Europe reconstructed from Mt. Elbrus, Caucasus, ice cores." *Atmos. Chem. Phys.* 17(5): 3489-3505.

Sigl, M., et al. (2018). "19th century glacier retreat in the Alps preceded the emergence of industrial black carbon deposition on high-alpine glaciers." *The Cryosphere* 12(10):

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3311-3331.

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Interactive comment on Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2020-1052>, 2020.