

Interactive comment on “A Holocene black carbon ice-core record of biomass burning in the Amazon Basin from Illimani, Bolivia” by Dimitri Osmont et al.

Anonymous Referee #1

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“A Holocene black carbon ice-core record of biomass burning in the Amazon Basin from Illimani, Bolivia” presents a fire record from location and across a time frame where this information is sorely needed. This biomass burning record is an important contribution to fire science and to paleoclimatology. The well-written paper is within the scope of *Climate of the Past*, clearly presents the methodology and assumptions, and contains high-quality figures. It is evident that the authors carefully examined all aspects of the paper before submission, rather than trying to rush a draft through to submission, where the current presentation is well structured and clear. However, the authors should address the following concerns before publication:

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The authors assume (Page 3, Lines 8-9) that “Aerosol source apportionment studies in Amazonia have shown that recent BC emissions in this region originate only from biomass burning (Artaxo et al., 1998)”. This previous statement pertains to Amazonia, and does not include the major urban areas of La Paz and El Alto which are located only 10s of kilometers from Illimani. The recent article “Black carbon emission and transport mechanisms to the free troposphere at the La Paz/El Alto (Bolivia) metropolitan area based on the Day of Census (2012)” clearly demonstrates the production of traffic-related BC and deposition on regional mountains (Wiedensohler et al., 2018). I realize that this article was published recently, and that the authors may not have known of its existence when they were writing their manuscript. However, as some of the authors of the Wiedensohler et al., 2018 paper collaborate with the authors of this *Climate of the Past* submission, it seems likely that the authors of the submitted paper may have known about this major source of BC. Previously-published literature also clearly demonstrates the effects of BC from urban centers on Andean glaciers (Schmitt et al., 2015). Although Schmitt et al. (2015) investigate glaciers in the Cordillera Blanca, these Peruvian glaciers still have the same main moisture source of the Amazon (and by extension, of the Atlantic) as Illimani. Molina et al. (2015 and references therein) mention that 50% of the BC in the Andean region is from biomass burning, which leaves the other 50% to be produced by other sources, of which fossil fuel burning (e.g. diesel-powered vehicles) is a major component. Therefore, the assumption that BC in Illimani after industrialization is only from biomass burning is does not accurately portray regional emissions.

The authors carry the above assumption through all of their work in section 3.2, and in section 3.3, page 7, lines 22-23. The authors do account for the possibility of a fossil fuel source for the BC from ~1730 AD onwards (Page 7, Lines 24-37) including comparing their results to lead and nitrate concentrations in the IL-99 core from Eichler et al., 2015 where these concentrations reflect motor vehicle emissions. Comparing the rBC concentrations with the lead and nitrate records is a good idea, however, such a direct comparison may not be applicable. The authors only visually compare these

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records (Figure 5; second paragraph on page 7) and do not numerically investigate any correlations. The 10-year averages of lead drop after the switch to unleaded gasoline, while the 10-year nitrate averages continue to climb, which is similar to the increase in rBC (Figure 5). The sampling resolution is 10-cm samples, so in this uppermost section of the core, it should be possible to examine the data at a higher resolution than 10-year averages (as nicely demonstrated in Figure 2). What is the relationship between lead, nitrate and rBC over the past century when examined at a higher resolution? (As 10-year fixed averages are a rather arbitrary number, the decadal cut-off points may introduce errors when comparing the three records. E.g. one high value can inordinately influence an entire decadal mean). What happens if you compare the records with higher resolution moving averages from 1750 AD onward? If 50% of the BC is from biomass burning, then this source would moderate the rBC concentrations where you would not expect to see an equal rise in rBC as in lead and nitrate. Therefore, the conclusion (Page 9, lines 34 and 35) “Lastly, the rise in rBC concentrations since 1730 AM seems only driven by increased biomass burning levels due to higher temperatures and more intensive deforestation in the last decades but does not relate to fossil fuel rBC emissions” is misleading.

Molina, L.T., Gallardo, L., Andrade, M., Baumgardner, D., Borbor-Córdova, M., Bórquez, R., Casassa, G., Cereceda-Balic, F., Dawidowski, L., Garreaud, R., Huneeus, N., Lambert, F., McCarty, J.L., Mc Phee, J., Mena-Carrasco, M., Raga, G.B., Schmitt, C., Schwarz, J.P., 2015. Pollution and its impacts on the South American cryosphere. *Earth's Future*, 3, 345-369, <http://dx.doi.org/10.1002/2015EF000311>.

Schmitt, C.G., All, J.D., Schwarz, J.P., Arnott, W.P., Cole, R.J., Lapham, E., Celestian, A., 2015. Measurements of light-absorbing particles on the glaciers in the Cordillera Blanca, Peru. *Cryosphere* 9, 331–340

Wiedensholer, A., Andrade, M., Weinhold, K., Mueller, T., Birmili, W., Velarde, F., Moreno, I., Forno, R., Sanchez, MF., Laj, P., Whiteman, D.N., Krejci, R., Sellegri, K., Reichler, T. (2018) Black carbon emission and transport mechanisms

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to the free troposphere at the La Paz/El Alto (Bolivia) metropolitan area based on the Day of Census (2012). *Atmospheric Environment*, 194, 158-169, DOI: <https://doi.org/10.1016/j.atmosenv.2018.09.032>

Page 8, Lines 5 and 6: Higher lake levels in Lake Titicaca would certainly indicate a wetter climate, but why do you infer that these higher lake levels also depict a cooler climate? Due to less evaporation? The lake is also not “overflowing” when it has higher lake levels than present. Yes, the shorelines are higher than present, but the lake did not create continuous catastrophic floods.

Figures 1 and 6: I realize that there are few paleofire records for this region and so it is difficult to find records with which to compare your rBC results. (This lack of records does nicely increase the value of your work). However, as charcoal only records local to semi-regional fires, Laguna La Gaiba is too far away to provide a useful comparison with the Illimani ice core record. Illimani is more of a regional record than any lake, but comparisons between individual records are limited by the spatial record of any individual record. The four lakes contain three different ecosystems (llanos, Amazon rain forest, and seasonally dry tropical forest) and so your decision to keep these records separate rather than making a composite record makes sense. However, the current comparison with Laguna La Gaiba is beyond the geographic limits of charcoal.

Miscellaneous:

Please use a comma in numbers with five places or more.

Line 1, Page 12: Place “the” before “Illimani”.

Page 1, Line 22: Omit “an” before “exceptional biomass burning activity”.

Page 1, Line 24: Place “in fire activity” or “in biomass burning” after “decrease”. In the previous sentence you mention both increasing temperatures and deforestation. Therefore, it is necessary to re-define what is decreasing in the following sentence.

Page 3, Line 27: Change “boreholes” to “borehole”. Even if you have multiple bore-

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holes, the plural is already included in the word “temperatures”.

Page 3, Line 27: Remove “the” before “Illimani”.

Page 3, Line 27: Change “can receive moisture influx also during the dry season” to “can also receive moisture influx during the dry season”.

Page 5, Line 11: Change “peaking” to “peak”

Page 5, Line 12: Change “are not in agreement with” to “do not agree with”

Page 5, Line 21: Change “starting only” to “only starting”

Page 5, Line 27: Change “East” to “east”

Page 6, Line 13: Omit the word “explain” as the explanation is implicit in the word “contribute”

Page 6, line 16: Change “western part of the Andes” to “western Andes”

Page 6, Line 26: Replace “average” with “mean”

Page 7, Line 28: Replace “of” with “for”

Page 7, Line 30: Place “the” before “second half”

Page 7, Line 32: Change “charcoal composite records” to “composite charcoal records”

Page 7, Line 35: Change “could be” to “could also be”

Page 8, Line 39: Change “responsible of drier conditions” to “responsible for drier conditions”

Page 9, Line 23: Change “Eastern part of the Andes” to “eastern Andes”

Interactive comment on Clim. Past Discuss., <https://doi.org/10.5194/cp-2018-136>, 2018.