

Interactive comment on “An optimized tracer-based approach for estimating organic carbon emissions from biomass burning in Ulaanbaatar, Mongolia” by Jayant Nirmalkar et al.

Anonymous Referee #2

Received and published: 11 November 2019

The manuscript is well-written; it is apparently the first study for Mongolia in which use was made of levoglucosan to assess the impact from biomass burning on the PM_{2.5} aerosol and the authors made a noteworthy attempt to obtain the optimum OC/levoglucosan ratio to derive that impact. However, as indicated below, the manuscript has several shortcomings and major revision is definitely needed before it can be published in ACP.

Major comments:

1. The number of samples in this study is quite limited, i.e., only 34 in total; besides, samples were only taken in two seasons (winter and spring) and it is really unfortunate

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that no PM_{2.5} mass data were obtained. Because the PM_{2.5} mass is unknown, the authors cannot state, like they do in lines 18-19, "that OC was the predominant species in the total aerosol compositions", in line 271 "that OC is a major contributor to PM_{2.5}", and in line 401 that "OC was the major component of PM_{2.5}"; "in the total aerosol compositions" should be replaced by "of the quantified aerosol components", and "to PM_{2.5}" and "of PM_{2.5}" should be replaced by "of the quantified aerosol components in PM_{2.5}".

2. With regard to the application of PCA to the separate winter and spring sample sets of 17 samples each: Although the results in Tables 2 and 3 look reasonable, that application is not justified at all. Henry et al. state on page 1512 of their seminal 1984 paper (full reference: Henry, R.C., Lewis, C.W., Hopke, P.K., Williamson, H.J., 1984. Review of receptor model fundamentals. Atmos. Environ. 18, 1507-1515) that, in order for a multivariate receptor model to be acceptable, the number of samples N should be larger than $30 + (V + 3)/2$, with V being the number of variables. As V is 13 in Tables 2 and 3, this means that the number of samples in each of the authors' sample sets should be larger than 38. Their number of 17 is very much smaller. Although there are only 34 samples in the combination of the winter and spring sample sets and the criterion of 38 is then also not fulfilled, it might be worthwhile to apply PCA to that combined sample set. Furthermore, instead of using PCA for source apportionment, the preferred method nowadays is positive matrix factorization (PMF). I suggest that PMF be used instead of PCA, although the number of 34 samples may make the use of PMF difficult; many researchers suggest to have at least 50 samples (and some even 100) for PMF. Furthermore, the authors talk in line 217 of "eigenvalues >1". Do they mean here eigenvalues before or after Varimax rotation? More important, the high loadings (or total variance explained by a component) do not tell anything about the importance or contribution of a component to a species or the aerosol mass. In order to obtain the contribution, one has to apply absolute PCA (APCA) or PMF. Thus, the statements in lines 226, 228 and 272 that "BB is the major source of OC" are not justified.

3. The authors' approach to arrive at the optimum OC/levoglucosan ratio needs to be much better explained. In lines 348-350 they write "candidate OCBB in this study was estimated from OC/levoglucosan ratios for softwood burning in the previous chamber experiment (Cheng et al., 2013 and papers cite therein)", but they fail to give actual numbers for the candidate(s) OCBB. Why was only use made of Cheng et al. (2013) and the references cited therein? Why not also of data from other publications or even hypothetical OC/levoglucosan ratios? It seems from Fig. 11a that a higher OC/levoglucosan ratio than the highest one used could lead to better results.

4. The authors should refer to the study of Davy et al. (full reference: Davy, P.K., Gunchin, G., Markwitz, A., Trompetter, W.J., Barry, B.J., Shagjjamba, D., Lodoysamba, S., 2011. Air particulate matter pollution in Ulaanbaatar, Mongolia: determination of composition, source contributions and source locations, *Atmos. Poll. Res.*, 2, 126-137). In that study coarse (PM_{10-2.5}) and fine (PM_{2.5}) aerosol samples were collected twice a week from 2004 to 2008 and analysed by ion beam analysis techniques. PMF was used for source apportionment. For PM_{2.5} (see Fig. 10 in that publication) and winter, coal combustion (2 factors) was by far the major contributor and the contribution from biomass burning was almost two orders of magnitude smaller. This is in very large contrast with what is concluded in the authors' manuscript. Possible explanations for that discrepancy are definitely needed.

Minor comments:

1. Lines 26-27: R₂ is not a "correlation coefficient" but a "coefficient of determination".
2. Section 2.1 and Fig. 1: There is no reference made to Fig. 1 within the text; it should be made within this Section.
3. Section 2.1 and line 128: It is unclear whether blank filter samples were taken. If so how? And does the "blanks" in line 128 refer to "blank filters" or simply to procedural blanks without the use of any blank filter?

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4. Lines 160-162 and Fig. 3: It is unclear to me what the R^2 , Intercept and Slope within the boxes in the Figure denote. Also, in contrast to what the authors state, the characteristics ($R^2 = 0.36$, slope = 1.04) of the relationship between OC and temperature are not shown in Fig. 3b. Furthermore, I do not understand how "volatilization of SVOCs during periods of elevated temperature" can lead to increased OC in the particle phase.

5. Lines 171-174: Do the numeric data given in parentheses pertain to spring and winter, respectively? If so, "In winter and spring" should be replaced by "In spring and winter". If, in contrast, the numeric data pertain to winter and spring, respectively, then, what is written here is in contrast with what the authors wrote in lines 169-171.

6. Lines 257-259: I cannot follow why the "correlation between OC and K^+ suggests that BB is one of the major sources of ambient aerosol in Ulaanbaatar".

7. Lines 317-318: Why are the K^+ concentrations similar in both seasons? Possible explanations should be given.

8. Line 369: replace "where aerosols" by "where BB aerosols".

9. Lines 379-380: It is unclear to me why it should be that "the similarity between seasons indicates that OCnon-BB originated mainly from local background sources".

10. Line 399: replace "Conclusion" by "Conclusions".

11. Pages 21-29, Reference list: There are several problems:

- Titles of journal articles should all be in lower case instead of in Title Case.
- For references with three or more authors, there should be ", and" preceding the last author.
- For references with only two authors, there should be " and" (without a comma) preceding the second author.

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- Journal names should be properly abbreviated and the abbreviated words should end on a period (".").
- The reference "Jung et al., 2009" is incomplete; the article number is missing.
- "Jung et al., 2010" should come before "Jung et al., 2014". Besides, the reference "Jung et al., 2010" is incomplete; the article number is missing.
- "Nirmalkar et al., 2015" should come before "Nirmalkar et al., 2019".
- There is not referred to "Pio et al., 2008" within the text.
- The reference "Puxbaum et al., 2007" is incomplete; the article number is missing.
- "Sullivan et al., 2008" should come before "Sullivan et al., 2019".

Technical corrections:

- Lines 15 and 112: replace "quartz filters" by "quartz fibre filters".
- Line 30: replace "of OC" by "of the OC".
- Line 32: replace "and indicate" by "and it was found".
- Line 46: replace "in future" by "in the future".
- Line 47: replace "power-plant" by "power plants".
- Line 118: replace "of quartz filter" by "of each quartz fibre filter".
- Line 130: replace "were analyzed" by "were measured".
- Lines 141-142: replace "of quartz filter" by "of the quartz fibre filter".
- Line 146: replace "analytical errors" by "analytical uncertainties".
- Line 182: replace "Table 4" by "Fig. 4".
- Line 350: replace "the previous" by "a previous" and replace "cite therein" by "cited

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therein".

- Line 351: replace "in this" by "at this".
- Line 354: replace "closed to" by "close to".
- Line 374: replace "likely to be due" by "likely due".
- Line 409: replace "of OC" by "of the OC".
- Line 412: replace "spring due" by "in spring due".
- Line 419: replace "Batmunkh Tsatsral" by "Tsatsral Batmunkh".
- Line 642: replace "2008a" by "2008".
- Line 679: replace "Asia. Sci." by "Asia, Sci.".
- Page 34, caption of Fig. 7: replace "in during" by "during".

Interactive comment on Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2019-831>, 2019.

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