

Interactive comment on “Aerosol and VOC emission factor measurements for African anthropogenic sources” by Sekou Keita et al.

Anonymous Referee #1

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General Comments

In this manuscript Keita et al. describe a set of field measurements in West Africa to better characterize emissions from several major emission sources specific to this region. Total particulate matter was collected on quartz filters and volatile organic compounds (VOCs) were sampled using sorbent tubes from all emission sources studied. Emission factors for organic carbon (OC), elemental carbon (EC, called black carbon in the manuscript), total particulate mass (TPM), and speciated VOCs were determined for the following emission sources: several African vehicles of various ages, trash burning, combustion of two wood fuels, charcoal burning, and charcoal making. Combustion emissions from a subset of the fuels studied in the field campaigns were also measured in the lab to gain more detailed information on particle size distributions

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of the particulate emissions.

Given the extreme dearth in emissions data available that is relevant to Africa, this work is important and should be published to improve global and African emission inventories. However, the manner in which this work was presented in this manuscript does not provide convincing enough rationale that the work has enough atmospheric relevance to merit publication in ACP specifically. Authors would first need to give a clearer picture of the state of the science regarding African relevant emissions measurements from major sources and then show how their work significantly improves our understanding of African pollutant emissions and their environmental impacts. As part of this, the EF literature comparisons with this work can focus more on previous emissions measurements that are more relevant to African sources instead of seemingly randomly selected emissions studies of sources that have little to no relevance to African emissions. One suggestion to better demonstrate the environmental impact of this work is to make specific recommendations to update the African Regional Inventory. Another suggestion is to use relevant activity data and emission factors from this work to calculate total particulate and speciated VOC emissions for West Africa and compare the environmental impacts of major West African emission sources. Another possible route I would suggest to increase the scientific impact of this paper to merit publication in ACP is to expand in greater detail the discussion of the more scientifically novel speciated VOC/IVOC measurements while giving a more concise discussion of the OC/EC measurements. The VOC measurements are not only scientifically impactful due to the lack of this kind of measurements for Africa, but also the measurement/analytical methods used in this study and the specific compound list including difficult to measure IVOCs and carbonyls are also of great scientific interest for atmospheric/emissions scientists. The authors focus much of the paper on OC/EC measurements (and a surprising amount to predictable MCE values), discussing these measurements in great detail for each emissions source, whereas the VOC measurements are essentially glossed over. In fact, only a small fraction of the emission factor data generated from the VOC measurements (15 out of 50+ VOCs) in this study was

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actually presented (including SI). How can others improve emissions inventories and assess the atmospheric impacts of these emissions if the emissions data is not reported? This seems to run counter to the objectives of this work.

The final major concern that needs to be dealt with before being considered for publication is that the authors do not provide enough detail for the reader to understand how the measurements were conducted. The only exception involves the chamber measurements, which only make up a minor part of the results but are discussed in great detail in the methods. More specific suggestions to add detailed information on the emissions measurements are given in the specific comments below.

Specific Comments

Page 1

Title. Aerosol measurements weren't presented. I suggest changing "Aerosol" to "Particle". It would also be helpful to make location more specific, i.e. West Africa. Abstract

Line 17. Acronym is not used again, so it's not needed. Please put acronyms in parentheses.

Line 20. THE "NM" in NMVOCs is redundant. VOCs is sufficient.

Line 23. Particles were collected not aerosols. State what is measured by these methods.

Line 24. What is meant by systematic? What kind of sampling, what analysis? What type of wood was used?

Line 25. Be clear that calculations were based on mass fuel burned not dry matter?

Line 28-29. A comparison of PM EFs and VOC EFs is not useful.

Line 33. This statement is too vague.

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Introduction: This section needs a summary of previous emissions measurements for major emission sources in Africa/West Africa.

Line 11. This statement suggests that no significant pollution related health impacts are to be expected until 2030. Is this what is meant?

Line 13-14. According to Louisse et al. 2010: "Predominant emissions in the BC class are related to use of diesel fuels, animal waste, fuelwood, charcoal making and coal." "OC emissions are mostly impacted by animal waste, charcoal making, fuelwood and two-wheeled vehicle fuels." Please give a more detailed discussion of African emission sources.

Line 15. What type of carbon is referred to here- gas or particle carbon or both?

Line 16-18. The focus of this paper is on Africa, so why discuss global energy use?

Line 19. Second hand is not an indication of age.

Line 20. What is the reference - Robert 2007a or b? Peltier is not in the reference list.

Line 22. This statement is awkward. Why is this important and how big of a problem is this?

Line 25. Multiple sources are mentioned, but only discuss one. Please make clear that this is discussing trash burning not animal waste burning?

Line 32. This statement is vague. Can you be more specific? What is meant by not well documented EFs? Activities?

Page 3

Line 1. Vague sentence – please clarify.

Line 6-9. Aren't all published EFs literature EFs? What does this mean? What does very rare mean? What about nontraffic sources? What studies have been done on EF measurements relevant to Africa?

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Line 9. Please add a reference for Africa Regional Inventory.

Line 11-16. When EF measurements are so rare, differences between methods is not particularly important.

Line 16. This suggests that particulate OC/EC is the only pollutant worth measuring in emissions. Is this what is meant?

Line 18-20. Sentence is awkward. "is" should be "are" See above comment on NMVOC. Particulate matter should lower case.

Line 22. Acronym should be in parentheses. Work Packages should be capitalized.

Line 26. Primary is redundant.

Line 31-32. Section 1 and 2 don't correspond to sections in the paper. Please state whether this work is being presented in other papers and which measurements this paper will cover and which will be covered in other papers.

Methods. It would be more helpful if measurements were discussed before calculations.

Page 4

Line 7. Should it be Ward et al. 1993?

Line 15. This equation is incorrect to me as it is currently written. I do not understand why the MCE was added to this equation; it adds unnecessary terms that make the equation no longer correct. If this is how the emission factors were calculated, I believe all the EF values in this manuscript need to be corrected by removing the MCE term. If the authors feel this is correct, they need to provide an explanation and a reference where this equation was used for EF calculations.

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Line 3. List countries.

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Line 5. Show site on a map.

Line 5,8. What is meant by "measurement points" and "samplings" - eight locations or eight tests from different plumes, or eight samples from the same plume?

Line 10-11. Please elaborate on "different characteristics". Does "services" mean electricity?

Line 12-14. More details are needed for these measurements. How much fuel was used? Was the fuel prepared, e.g. dried before use? Were any fuel properties tested such as moisture content? What were the cookstove/kiln characteristics, designs and models; show pictures/diagrams of these. Show sampling setups. Show location where these measurements were conducted on a map if they were field measurements. How exactly were the burn experiments initiated and conducted- what were the exact protocol? Please give this information for each emissions sources studied.

Line 20-23. State make/models, model years, mileage, engine specifications of all vehicles tested. Please list the tests conducted and number of replicate tests for each vehicle. What fuel was used and where was it sourced? How exactly were the vehicles operated during testing? Was a dynamometer used? What was the specific driving protocol? Show a diagram of the sampling setup.

Line 26. State Equation 1 or Eq. 1 instead of "equation".

Line 30. How often was the instrument's calibration checked? Was this done in the field?

Page 6.

Section 2.4. Misleading title. The combustion didn't occur in the chamber, the chambers were just used for dilution. Why were these chamber experiments conducted? Were they part of this initiative? Please include rationale in the Introduction.

Line 1. Why was air used? I believe heated air (oxygen) damages the sorbent.

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Line 4. State the pump vendor/model.

Line 5. Why was no size cutoff selected? State quartz filter vendor PN, size

Line 9. Which sources?

Line 14. Does this mean room temperature or lower? What is meant by “homogeneous”? There are gas and particles, thus it is not homogeneous. Do you mean well mixed? Which stove was used for the combustion – give more details or reference with details.

Line 24. What were the conditions in this study?

Line 28. This statement is misleading. It has not been made clear that these chamber measurements have already been discussed in detail in Haslett et al. Why are these measurements being discussed again in this paper? If the sampling details are given in this reference, they do not need to be repeated in detail here.

Page 7

Line 3. This is not a complete sentence.

Line 10-14. This section describes the sampling media that should be discussed in Section 2.3.

Line 11. Please change “absorbent” to “sorbent”.

Line 12. Please elaborate in more detail why these two types of tubes were used. Did these tubes capture different volatility ranges or different classes of VOCs? State vendor and part number for tubes or if hand packed, state so.

Line 14. Where was LAMP located? Need to discuss how samples were transported and hold times between sampling and analysis for all samples. Has it been confirmed that stability times for all target compounds on the tubes exceed the hold times in this study? Were any quality control samples, such as field blanks or controls, included?

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Line 21,27. Please list the compounds that were measured and discuss why these compounds were selected. If they are listed in SI, note here. Were there overlapping VOCs? If so how did they compare between the two tube methods? Also provide method detection limits for each VOC and each instrument in SI.

Line 25. Why were different types of tubes analyzed in different labs? Spell out acronym.

Line 26,27. State exact number of compounds. See above comment.

Line 28. This is misleading. For this study, only TPM is measured.

Line 31,32. This should be called elemental carbon instead of black carbon. Correct the manuscript accordingly. Also, these are particles and not aerosol measurements – please correct sentence.

Page 8

Line 2. By “the thermo-optical method”, this refers to the IMPROVE method? Isn't the method used in this study also a thermo-optical method? What was the rationale behind using this less well validated method as opposed to IMPROVE or NIOSH? Which samples were used in the comparison; were they from this study or other samples? Was the analysis done on the same instrument? What instrument was used, and how was it calibrated?

Line 4. What is considered suitable?

Line 15-18. “Residential sources” is too vague. Need complete sentences between semicolons.

Line 20. Please change “aerosol” to “particulate” or “particle”. Tables should be numbered in order of when they are first mentioned in the text. This Table should be Table 1. Only 15 VOCs are listed. Why is only a subset of compounds listed here? It is mentioned that three tests per source were performed – how many samples per test

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were taken? Please list exactly how many tests (and samples taken per test) were conducted for each source. This could go in the SI.

Line 21-22. Why geometric mean? Which sectors are being referred to?

Line 26. Fossil should not be capitalized.

Line 28. Please state the biofuels.

Page 9

Section 4.1.1. I suggest removing Section 4.1.1 as much of it is quite predictable and not scientifically interesting, and instead discuss MCEs along with the EFs in other sections.

Line 1. Why are MCEs summarized in a Table and Figure – this is redundant. The MCEs can easily be summarized in Tables 2 and 3 with the emission factors. Modified combustion efficiency should be lower case. Both MCE and CO/CO₂ are both combustion indicators – it is redundant to discuss both.

Line 2-4. The meaning of this sentence is not clear. Please clarify.

Line 14. BC/TC ratios are mentioned here before showing any results on their emission factors. This relationship with MCE should be brought up during discussion of “BC” emission factors.

Line 19. Title is too vague. Residential heating? Residential cooking? Is charcoal making a residential source? For these subsections (4.1.2-4.1.4) only particulate EFs are discussed, so make that clear in the subsection titles.

Line 20,22. EF should be plural – EFs. Please check the entire manuscript for this error. Please reference Equation 1 consistently.

Line 21. Table should be capitalized and it should be Table 2. Please check the rest of the manuscript for this error.

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Line 22. “Dry matter” is misleading. The calculation is per kg fuel burned not dry matter. Please make this clear.

Line 23-25. Is there any evidence behind these assumptions?

Line 26-28. This is a contradictory statement. Are they in agreement or higher than literature? What fuels did these other studies test? Have emissions from Hevea, Iroko or any other African-specific fuel been measured previously?

Page 10.

Line 1. This is too vague. What studies?

Line 2-4. I do not agree with this argument. If carbon is left in the fuel, it is not burned and not emitted - so it is not included in “mass of fuel burned” using the mass balance method. Therefore, I do not believe adding this additional multiplication factor is correct.

Line 11. This should be Table 2. Please check entire manuscript for this error in Table numbering.

Line 13. This statement is contradictory, as it was earlier stated that CHM conditions in Cachier et al. were similar to this study.

Line 18. Recent and old are not age groups and are thus meaningless adjectives. Please state model year groups.

Line 19-22. Which “literature values” are being discussed in Line 19? Why were these particular studies selected for comparison given the large number of vehicle emission studies available? Do they have any applicability to West African vehicle fleet? If not, then what is the reason for the literature comparison? State units for EF values in Line 19.

Line 23. Please explain the meaning of “coherent with Fig 4”. Figure 4 does not show this statement to be true for diesel EFs in this study, if I understood what was mean.

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Line 27-31. This is probably one difference of lesser importance than vehicle age and lack of emission controls. Therefore, it is unclear why it is emphasized over other more important differences. Provide reference for evidence supporting these statements/assumptions in Lines 28-31. What is meant by “park vehicle”?

Lines 32-33. Include units.

Page 11

Line 3. Why compare to HDDVs? They are not relevant.

Line 4. Please report all EFs for individual vehicles in the SI. I don't see how these average values are helpful and why they require a separate table. How are these values expected to be used?

Line 8. Why are these values compared to European inventory? What is the usefulness if this comparison?

Line 11. This statement is misleading. Approximate agreement of OC/EC ratios does not justify this general statement.

Line 13-15. This is the most relevant literature comparison I've seen in this section, so this needs to be discussed in much greater detail.

Line 16. Weren't all the vehicles classified the same way?

Line 27-29. See comment for line 13-15.

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Line 2. Instead of “bad” I suggest “less efficient”.

Line 11-13. Were these different phases observed during the same test/sample or different tests? Can you include a Figure showing real time CO₂, CO measurements during a burn to demonstrate this? Please expand in greater detail.

Line 23. Why are only these VOCs shown? Did they have the highest EFs for all C₁₁

sources? Where are the emission factors for the other VOCs?

Line 25-27. Aren't all VOCs important for atmospheric reactivity to some degree?

Line 29. Given that no background samples are taken, how is it known that these are not solely from biogenic emissions? Please discuss.

Line 31-32. These analytical uncertainties between methods needs to be discussed in greater detail in the Methods section. Please clarify the statement “different sources associated to the emission sector analysed”.

Page 13

Line 1. What is meant by “most important”?

Line 10. What do these values represent?

Line 20. Since a full VOC target list has not been given, it is impossible to evaluate whether enough compounds were measured to be representative of the different species groups.

Line 26. If the aldehydes were a large contribution, why were they omitted from Table 7 or discussed earlier in this section?

Line 29. The relevance of these particular studies for comparison needs to be explained. They do not seem to be at all applicable to this work, so this comparison is not helpful.

Page 14

Line 1. I am not convinced that this is true based on the discussion above.

Lines 5-10. This should be moved to the Methods section on EF calculations.

Line 14. There are many possible reasons for these discrepancies. Were the fuels burned using the same cookstoves under the same protocol? Were the MCEs similar? Were the fuels of the same moisture and carbon content? Perhaps the sampling meth-

ods/particle losses were different? Dilution can certainly affect OC (and this should be discussed further), but how will it affect EC EFs? Please elaborate.

Section 4.2.1. These measurements have already been compared in the previous paragraph. Why is there subsection here in the middle of this continuing discussion on the topic?

Line 26. If CO/CO₂ ratios are that different that is a measure of combustion efficiency, then aren't the combustion conditions also very different between field and lab? Why are BC/TC ratios used as a combustion efficiency indicator instead of MCE values?

Line 31. Filter method in this study measured EC not BC. There could be differences due to the different methods that should be discussed here.

Page 15.

Section 4.2.2. What can be said about size distributions from the other emission sources in this study? Please discuss this issue for each emissions source and give appropriate references.

Line 7. Diesel engines are not relevant.

Line 17. This sentence is too vague.

Line 20. Please state that it is particle mass.

Line 21. What EFs are being referred to? None of the EFs were shown as a function of vehicle age or maintenance, so this conclusion has not been confirmed by the previous discussion.

Line 24. "Published EF values" for what specific source?

Line 26. EFs of all VOCs have not been provided, so there is no evidence given that this statement is correct.

Line 30-32. The meaning of this sentence is unclear.

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Page 16.

Line 1. State the fuel used for this measurement.

Table 9. Please state the emission source/fuel burned in the caption.

Interactive comment on Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2017-944>, 2017.

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