

## ***Interactive comment on “Global anthropogenic emissions of particulate matter including black carbon” by Zbigniew Klimont et al.***

### **Anonymous Referee #1**

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The paper reports on the development of a global inventory for spectated, primary particulate matter emissions. To my knowlege, this is the most thorough effort of its type and is an important contribution. Overall, the methodology and assumptions are well described.

The description of the methodology is strong, and the overall results are well described. The paper could use more presentation of intermediate results. The calculations often incorporate substantial technology and emission control details, however the results of this detail are only presented at a fairly aggregate level. Some key intermediate results here would be very useful to present. In particular, for some key sector/fuel combinations, I suggest that the emission factors over time for different regions (perhaps PM or BC in the main paper, and other species in the supplement). One key sector is on-road diesel, for example, where aggregate emission factors have changed over time

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in many regions. Other key sectors might be residential biomass, off-road diesel, etc. Where these emission factors are largely constant, this could be mentioned in the text without a figure, but where these have changed some figures and/or tables and some discussion would be useful.

The main presentation focuses on emissions by region, and global emissions by sector. There is a lot of material here, and this is a reasonable choice for the main paper, however many readers will want to see emissions by sector for specific regions. It would be useful to present the equivalent of Figure 3 for the different regions in the supplement. (Hopefully the codes that generated that figure can readily be generalized.). As noted below the authors should also provide an electronic supplementary file with more detailed emissions. Some further suggestions for details that would be useful to supply are below.

Overall, its not clear how equipment vintages are treated. There is a mention of old/new power plants, but not as much discussion for other sectors. For vehicles, for example, is the model based on aggregate emission factors by year, or are vintages of vehicles tracked over time? This should be clarified in the manuscript.

Specific comments Section: 2.2.1 Residential combustion: cooking, heating, lighting

It is not clear if assumptions such as the use fraction of different technologies and also splits between end-use services (e.g. cooking, heating in particular) are constant over time within a given country or region?

There is quite a bit of good work here and some sort of summary later on in terms of the evolution of aggregate emission factors (either over time – if the above assumptions change over the historical period) would be useful. For example, do PM emissions per unit biomass fuel use for cooking change over time in a given region? (Some of this could be in the supplement, with main points summarized in the text). While there are too many details to do this comprehensively, it would be important to summarize where emission factors for important sectors change over time (either as a result of

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different technology fractions, or emission controls). This is clearly going to be the case for diesel fuel use in road transportation in many regions, but how much change was assumed for the various regions. How about off road, agriculture, or residential sectors? Did controls or technology mix (beyond shifts in type of fuel use) have a noticeable impact on emission factors in these regions?

Pg 14 - "the independent fuel estimate by Denier van der Gon et al. (2015)". van der Gon et al. state "A consistent set of PM10, PM2.5 and PM1 emission data for Europe was obtained from the GAINS model...", so these do not appear to be independent.

pg 16 - "The resulting fuel use was compared and calibrated to the diesel consumption reported in the power and commercial sector." Not clear what this means.

pg 17, last portion of diesel generator section. There is some discussion of emission reduction options, but no mention the extent to which these were assumed to be applied in the emission estimates.

pg 17 - line 25. IEA energy statistics contain separate lines for agriculture and construction - while these are not available for all years, these data seem to be becoming more complete in more recent years, even for non-OECD countries. It appears that this data is not used? Some further explanation would be useful.

pg 17 - line 31 "Also old and often poorly maintained vehicle fleet is reflected in measurements of emission factors" - not clear what is meant here.

pg 20 line 14. This "fuel consumption data for 2007 were extrapolated to 2010 using GDP". The result of this assumption should be compared to the fuel consumption estimates from IMO, who compared both bottom up and top down methodologies. ("Third IMO Greenhouse Gas Study 2014")

Page 23 top regarding coke ovens. It is not quite clear what the technology representation is here. "uncontrolled ovens" are mentioned, is the split between controlled and uncontrolled? Is this assumed to change over time? It appears there is little detail in

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terms of emission factors available in the literature (and emissions seem likely to depend on site specific characteristics in any event), so some comment might be useful on what are the most important data that would be needed to improve estimates.

Page 26. Might be useful to also mention that Agricultural waste burning can also be seasonally concentrated, so that it might be particularly important in some months.

Page 26 line 12. "This database has been further extended and updated" perhaps edit to clarify that this refers to the data presented in the current paper.

Page 27 "3.9 Other sources" Is dust included? Its not mentioned until the discussion section.

Page 28 line 13 - " for barbeques, a per capita emission factor is established, i.e.,...". Presumably this varies by region?

Page 32 line 19-20. Probably useful note here that the emissions in Granier et al., past about 2000/2005 were based on projections, where as the estimates here up to 2010 are (to the extent available) based on reported data and practices.

Page 35 line 3, this presumably is a typo? "confidence intervals to be 160-500% for the developing countries"

Page 35 while "error compensation" is, indeed important, it might be useful to note that this might only be partial compensation. (e.g., some errors, such as measurement or enforcement issues, could be correlated across sectors.)

Wasn't sure about the meaning of this sentence: "In fact, they could be even lower considering that they typically rely on a harmonized data set and include a simultaneous calculation of emissions of several species using the same principal activity and technology data." I would presume most country-level inventories are similar in this respect?

Would be useful to mention in this section that there is also uncertainty in the speciation

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fractions (but this is constrained across species since these must sum to  $\leq 1$ ).

Page 36 In addition to this "Our new global estimate of BC emissions suggests higher numbers than previously published...", perhaps useful to also mention something about BC trends over time here (since there is substantial interest in BC, and it looks like BC trends can be different from PM trends).

Supplement When GAINS values are listed in the tables, these are sometimes listed as ranges. I assume these are not uncertainty ranges (as in some of the other ranges in the table), but are GAINS central values and that the range represents the range used in different GAINS regions? It would be useful to clarify this.

I suggest providing a more detailed summary of the emissions data. It would make this data more readily useful to the community to have an electronic file (either csv or excel) that provides emissions of the various species by country/region and by sector and fuel (I appreciate that some aggregation with regard to sector/fuel might be necessary). I realize much of this (or perhaps all of this) would be available on-line, but providing this in a supplement will be more accessible and also provide for an archival record of these important results.

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