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Atmospheric Chemistry and Physics Discussions

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

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We thank the reviewer for useful comments which have been helpful in improving the manuscript. The responses to specific points raised by the reviewer are provided below.

REVIEWER: The title mentions that the paper focuses on anthropogenic emissions. However, the paper also discusses open fires. Since the paper is already very long, it might be better to only focus on anthropogenic emissions as stated in the title. The inclusion of emissions from fires (which come from other authors) is a bit confusing.

RESPONSE: Indeed, the paper documents the methodology for PM estimation in GAINS focusing on anthropogenic sources, including also open burning of agricultural waste, but at the same time documents also the complete dataset of ECLIPSE emissions. The latter includes explicit information about what has been used in modelling

exercises (see for example Stohl et al., 2015; Eckhardt et al., 2016) and here the reference to the open fires, or more specifically forest and savannah fires is referred to. We allocate one section in the paper to agricultural burning (not all open fires) [see section 3.7] and make explicit references to work on forest and savannah fires on page 13 in the introduction to section 3. We feel that it is justified to provide full documentation of sources used in the entire ECLIPSE set, including forest savannah fires and allocate a page to discuss specific aspect of agricultural burning for which national and regional inputs were used beyond remote sensing data of GFED.

REVIEWER: Abstract and line 24, page 2: the abstract claims this paper is " the first comprehensive assessment of historical (1990-2010) global anthropogenic particulate matter (PM): : :". However, the EDGAR4.3 inventory described in Crippa et al. (2016) provides emissions for 1970-2010 for PM2.5 and PM10. The statement about being "the first comprehensive assessment" is true for PM1, but not for the other species. Please rephrase.

RESPONSE: As a matter of fact, the word 'comprehensive' is referring here to the comprehensive assessment of several PM species (as well as forming the base for the development of the particulate number inventory referred to in the abstract) within one system assuring that consistent framework is used for the assessment of all of the considered species including PM1, PM2.5, PM10, PMTSP, BC, OC, and OM. But in order to avoid any possible misinterpretation or confusion we simply delete the word 'first' in the abstract as well as in the introduction.

REVIEWER: Page 18, line 6: " exceptions are old vehicles running on leaded gasoline and preregulation 2-stroke mopeds : : : while latest gasoline direct injection engines have PM mass emissions comparable or even higher than latest diesel engines with particle filter, however, the absolute level is about one order of magnitude lower than for older generations. This sentence is not clear. What does "absolute level" refer to?

RESPONSE: Thank you for pointing this out. We will rephrase this sentence making

clear that the ‘absolute level’ refers here to the modern (Euro5 and Euro 6) diesel vehicles which have reduced their PM emissions significantly compared the pre or early control stages. Below an example for Italy to illustrate the point with COPERT data for emission factor for PM10 [in g/km]

g/km No-control Advanced controls Two-stroke 0.176 0.018 (Euro 3) Light duty gasoline 0.0024 0.0010 (Euro 3 and younger) Light duty diesel 0.216 0.0018 (Euro 5 and younger)

Interpretation: => old 2-strokes are as bad polluters as uncontrolled diesel cars. Modern diesel cars have reduced their emission rate by a factor 100, such that they are today at the level of or even lower than modern gasoline cars.

REVIEWER: Page 26, line 20: The authors use quite old data for emission factors for agriculture waste burning. Akagi et al. (Atmos. Chem. Phys., 11, 4039–4072, 2011) have published a more recent and detailed review of all data available on emission factors. The authors should indicate why they did not use this more recent review.

RESPONSE: The paper by Akagi et al (2011) is included in the references and in fact we have considered it while comparing and deriving emission factors for this work. Our emission factors derived from several studies listed compare well with the ones provided in the review by Akagi since they mostly refer to the same work already listed in our previous text. We add explicit reference to Akagi paper in the revised text.

REVIEWER: Page 29, lines 1-4: these lines should be rephrased. Many recent global chemistrytransport and chemistry-climate models now include detailed aerosols schemes, and PMs distribution are calculated as the sum of the mass of all the components included in the models. Maybe a few older models use the "BC + 1.4 OC" formula to calculate the mass of PM, but the recent models are much more advanced and calculate the mass of PMs in a more accurate way.

RESPONSE: Thank you for pointing this out, in fact we would be interested to know

which models are these so that we could an example reference. The mentioned paragraph was meant to highlight two elements, the issue of oversimplifying the total carbonaceous mass in PM where often 1.4 ratio was used to convert OC to POM and the fact that the BC+POM often represents total fine anthropogenic PM in global (not regional) models. Taking into account your comments we have revised one of the sentences in this paragraph that reads now: “This total fine PM mass has been typically estimated as BC+1.4*OC and only recently a number of models included more detailed aerosol schemes accounting for varying BC/OC ratios while still largely neglecting the anthropogenic dust component (e.g., Philip et al., 2017)”

REVIEWER: Page 31, lines 14-15: The sentence starting with "combined : : :" is unclear

RESPONSE: We have rewritten that sentence, specifically the second part starting with ‘combined’, and the whole sentence reads now: “However, as further discussion shows, the largest discrepancy for PM10 and PM2.5 is for China as well as Europe and Russia; the sum of the differences in these three regions represents about 90% and over 50% of all the difference for PM10 and PM2.5.”

REVIEWER: Page 25 of the supplement: the authors should add in their table the TNO-MACC and TNO-MACCII (Kuenen et al., ACP, 2014) inventories, which provide emissions of PM for Europe and neighboring countries. The TNO-MACC inventories are now becoming a reference for atmospheric modeling in Europe, and these emissions should be mentioned in the paper.

RESPONSE: Thank you for this suggestion. We have included MACCII reference and also added the respective emission estimates to the table

REVIEWER: Page 25 of the supplement: The emissions provided by US EPA are given as the sum of anthropogenic and wildfires. The dataset provided by EPA (note that the las release of the emissions is 2016 and not 2011 as mentioned in the supplement) provides emissions with and without wildfires. It would be better to include the emissions

without wildfires, in order to be consistent with the other data in the table.

RESPONSE: Thank you for suggesting the review of this numbers. We retrieved new numbers from the US EPA website (https://www.epa.gov/air-emissions-inventories/national-emissions-inventory-nei) for both 2011 and 2014. This allows now for a better comparison to our numbers constructing a similar sector set excluding wildfires. The reference to this EPA source is also included in the manuscript.

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