

## ***Interactive comment on “Continental anthropogenic primary particle number emissions” by P. Paasonen et al.***

**Anonymous Referee #2**

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The authors add primary aerosol particle number distributions to an emissions scenario model (GAINS). Number emissions are presented for a group of components (e.g. sulphate, OC) and explicitly for black carbon (BC). The primary emissions of number are based on a three-mode representation of the aerosol smaller than 1  $\mu\text{m}$  diameter. The mass emissions already in the model are distributed according to various observations in the literature for primary particle emissions. The focus is on the year 2010 and those estimates are compared with estimate for 2020 and 2030 based on future scenarios. Overall, I believe it is a very useful contribution to the literature and appropriate to ACP. The paper is generally well presented, but there are several places where some improvements are needed. I have several minor comments.

Specific comments:

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- 1) Page 1, line 16 - Define “GAINS”.
- 2) Page 2, line 12 – Avoid “Clearly” (and use of similar terms in other places). Arctic Haze is one example of a broad aerosol that has more numbers  $>100$  nm than smaller. Biomass burning is another aerosol that provides more larger particles. Most often, UFP dominate the numbers, but not always.
- 3) Page 2, lines 16-19 – In fact, correlations of particle volume (and sulphate mass concentration) and number have been published (e.g. Leaitch et al., Tellus, 1986; Hegg and Russell, JGR, 2000), and these scenarios may well exist as often as not.
- 4) Page 3, lines 1-3 – Explain what you mean by neglecting the warming from BC due to their ability to form cloud droplets. This is an important point, but it is poorly described here.
- 5) Page 3, lines 3-5 – Discussions of the impact of reducing sulphur emissions started at least as far back as 1989 (Wigley, Nature).
- 6) Page 3, lines 5-8 – Please re-write this sentence so the meaning is clear.
- 7) Page 3, line 10 – New particle formation can result from primary emissions. Just refer to this as particle nucleation in the atmosphere.
- 8) Page 3, Lines 12-15 – Another sentence needing clarification. I believe you intend this as an indication of particle formation during direct emissions, but it follows the sentence about nucleation in the atmosphere without connecting with direct emissions.
- 9) Page 3, line 32 – Comment 3 above relates to this also.
- 10) Both Amann references on pages 4 and 5 – The first refers to EMS and the second to TSAP. Both of these need explanations.
- 11) Page 6, line 26 – define TNO.
- 12) Page 6, line 28 to page 7, line 3 - You refer to sizes and sectors using “i”, which is

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confusing. In equation 1, "i" is used to refer to a region, whereas in equation 2 it refers to a size class. Make it easier.

13) Page 6, Line 27 – Add a sentence or two to indicate what factors are used to distinguish primary emissions without influence from secondary processes.

14) Page 7, lines 4-6 - EF<sub>pn</sub>:S? Is it intended as a plural of EF<sub>pn</sub>?

15) Page 8, line 23 – “New PSDs were” or “A new PSD was”?

16) Page 9, lines 3-5 - By black carbon mode, I assume you mean "pure" black carbon mode. Please clarify in the text.

17) Page 9, lines 9-14 - The Sorensen et al. work focussed on the morphology of larger particles. Their techniques and interest limited the discussion of smaller particles, and indeed their micrographs indicate BC particles smaller than 50 nm. See Liggio et al. (Environ. Sci. Technol. 2012, 46, 4819–4828). It may be that your modal representation includes sufficient BC at sizes smaller than 50 nm, but the discussion needs to be a little more objective on this point.

18) Page 9, lines 18-21 – There has been significant debate as to what constitutes primary OC. This should be reflected in the response to comment 13 above.

19) Page 9, line 30 – “except for BC formed through condensation”. This is confusing. I assume you mean PM<sub>1</sub> minus the BC component. Please clarify.

20) Page 18, lines 23-24 – “are smaller”

21) Page 19, line 19 – “. . . the primary emissions of . . .”

22) Page 21, line 17 – “primary emissions”

23) Page 21, line 21 – what do you mean by aerosol formation: secondary processes; nucleation?

24) Page 22, lines 1-15 – I am surprised that you have chosen to focus only on the

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warming aspect of BC, when your work seems suited to address the question about how much BC affects the number distributions and therefore the number concentrations of CCN; see Chen et al 2010, GRL. Estimating how the total number concentrations compare with the BC number concentrations from Figures 6 and 7 is very difficult, and in Figures 8 and 9 you only refer to BC mass. I would like to see a plot comparing the average number distribution from Figure 6 and the average BC mode and core number distributions from Figure 7. Of course there are still particles formed from secondary processes to be considered, but more knowledge of the importance of BC to primary emissions would be immensely useful.

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