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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Experimental studies on particle emissions from cruising ship, their characteristic properties, transformation and atmospheric lifetime in the marine boundary layer" *by* A. Petzold et al.

Anonymous Referee #1

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The aim of this paper is to characterize the number and mass of particles in ship emission plumes observed in the Marine Boundary Layer (MBL). In order to understand the aerosol transformation process and the development of cloud condensation nuclei (CCN) in ship plumes, the authors analyze the chemical composition of the emissions and compute particle size distributions. This study also includes a laboratory investigation of a ship engine's emissions to provide more information on the source of the plume. The authors make use of a Gaussian plume model to place the observations into the context of a growing plume that entrains air from the surrounding MBL as it

ages.

This data and modeling in this paper add to the body of knowledge on the character of ship effluent. I think that their effort to connect the emission from ship engines in a test facility setting to ship emissions in the MBL is important for a more complete and precise understanding of what substances ships are actually emitting into the MBL.

Specific Comments: P = Page number L = Line number

P 15108 L26-29: Does the average ratio attributed to Eyring et al. (2007) take into account the types of ship engines which produce the emissions in this study?

P 15109 L 4: This part of the sentence is unclear or perhaps unfinished,"for emission conditions"?

P 15113 L 1 and L 6: The range for Aitken and accumulation mode (ACC) particles is given as 0.05 micro m to 1-2 micro m. However, in L 6 the Aitken mode particles have a lower bound less than 0.05 and the ACC have an upper bound greater than 2. How did the range given in L1 increase? Are we talking about the same data in each paragraph?

P 15114 Eqn 2: Is the derivative taken of concentration cpl or of delta(cpl), the difference between concentration and the background value?

P 15115 Eqn 3: It would be clearer if all of the symbols used in Eqn 3 were defined in the text above which explains the calculation of exhaust emission factor.

P 15116 L 15-18: For a load of 110% the distribution no longer appears bimodal, but you state that this for load conditions $>$ 75% the structure is bimodal.

P 15116 L 15-18: Loads of 100% and 85% appear to have identical distributions for Dp$<$0.1. Can you explain this? It looks interesting.

P11520 L 26-27: Why is it that plumes last longer when the analysis depends on lower time and space resolution ECMWF wind data? Is it due to the assumptions in the

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Gaussian plume model? (Note that the regression line given for plume age t_ECMWF is as a plus or minus. I think that just the plus sign is needed because you state that the ages for ECMWF-derived plumes are larger than for the t_measured.)

Technical Corrections:

Page 15107 Line 16: should read "expected to have a strong impact"

P 15108 L24: Which particles are emitted at a rate of 1-8x10ˆ15 per kWh?

P 15110 L 14: wt% should be defined

P 15112 L 14: should read "On board the DLR Falcon"

P 15113 L 10 should enclose equivalent BC in quotation marks as in "The terminology "equivalent BC"..."

P 15114 L 4 should read "The respective initial values for w and h are 10 m and 5.5m..."

P 15114 L 6. Should read: "cross-sectional parameters, axes of a semi-ellipse, of a plume after 1 s"

P 15114 L 9. Should enclose (Pi/8) on right side of area equation.

P 15114 L 11: Should read "The rate of change in concentration..." or is it rate of change in change of concentration?

P 15115 L 7 should read "multiplying by the molar weight"

P 15116 L 18 should read: "vanish at the lowest load condition."

P 15116 L 22 Have you defined OM before this point?

P 15116 L 21 Should place comma here: "...similar test experiment, but.."

P 15117 L 1 "increase in the sulphate"

P 15117 L 1 "Similar..." should remove "A"

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P 15117 L 11 "nor chemical compositions"

P 15117 Beginning of Section 3.2 might be clearer if it read something like: "Now we move from marine diesel engine studies to studies of ship plumes embedded in the MBL. The ship plumes encountered by our aircraft are easily identified as peaks in the time series of both particle number concentration and CO2 in figure 4."

P15118 L 3-4 Should read "Coincident with..." not "Parallel to..."

P15118 L 4 "increases in both AITK mode ... and in equivalent..."

P15118 L 20-21 "...the corridor flight frame the analysis and interpretation of the data from the single plume study described in the following section."

P15118 L 26 Is the sulphur content % mass or % wt in Table 3. Inconsistent units across the paper for the % wt.

P15119 L 2 What does"as far as possible"mean exactly? "...until the plume is indistinguishable from the background MBL air"?

P15119 L 13 The acronym "a.s.l." should either be defined, or just explicitly written as "above sea level"

P15119 L 22 The CO2 emission factor is actually BELOW the range of values given."Fits well" is a vague statement and implies that it lies within the range instead of near the range of literature-based CO2 emission factors.

P15120 L 2-5 May I suggest a re-write: "Figure 8 shows that near the source, the BC mass concentration increased to 10 micro g smˆ-3. However, the Condensation Particle Counters (CPC) did not respond to the increasing number of exhaust particles. Thus, while delta CO2 and BCe simultaneously increase "

P11520 L 12 percentile

P11521 L 11 field

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P11521 L16 transition

P11521 L18 write out "approximately"

P11521 L19-20 clearer perhaps to write: "The earliest that ship tracks can form is at this stage, when the emitted particles have reached the top of the MBL."

P11521 L22 Ought to refer back to figure 9 as evidence for this statement about the good fit of the Gaussian plume model.

P11521 L27 "EX(t) to delta CO2"

P11522 L17: not "mid panel" but "top right corner of right panel"

P11523 L6 "assessed"

P11523 L12 "A snapshot of the ..."

P11523 Eqn 4: The sum runs from i=1 to 2. I thought that there were at least 4 sets of measurements taken which can be used to fit to the distribution. Could you clarify this?

P15124 L11 "..for the fitted size distribution."

P15124 L17 It would be interesting to know a little more about the marine cloud residues at this point in the paper, for example, what is the known size range of the marine cloud residues?

P15125 L 7 "to Aitken mode"

P15125 L13 "have vanished after about 1000 s, presumably due to coagulation..."

P15125 L26 "middle panel"

P15126 L24 "fraction"

P15127 L12-14 "Experimental data from the plume encounters are plotted along with a dilution function given by a Gaussian plume model shown as a dashed line."

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P15127 L14-16 "The model input used to compute the dilution function alpha=... reflected the conditions for 30 July 2004."

Figures: F 2 Sentence 2: "Short bars indicate ship age ...vessel (thick gray line)."

F 7 Specify in the caption which of ACC and AITK particles is shown as the dashed and which is show as the solid line.

F 8: Specify in the figure caption that delta N4 and 13 are constrained by the instrumentation to be below 2x10ˆ4 scm-3.

F 9 Specify what the solid and dashed lines represent exactly in the caption. Solid is m= alpha + beta; dashed is m=alpha.

F 9 What is the difference between gray and black filled diamonds?

F10 Explain the arrow on the diamond in the right panel in the figure caption. It is in the text, but would be helpful to have it both places.

F10 "Emission factors derived from measurements MAERSK vessel's plume with a linear regression:..."

F 10 Define LOD.

F 10 In the text you write 2x10ˆ4 scmˆ-3. Is this correct or is it just cmˆ-3?

F12 Point out the cloud residue mode in the figure caption.

F 13 The EM have not been added to the top panel. You say "...values for emission conditions (EM) are added to each panel."

F14 L2: marine BL should be MBL

F14 In the caption, should state what the diamonds and the dashed line represent exactly.

Tables:

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T 6 Define "EI" in the caption as the number emission factor.

T 7 Same as above

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