General comments

Author Response: We thank the referee for the positive and insightful comments. Our point-by-point responses to the reviewer's general and specific comments are presented below. The changes to the initial manuscript text and supplement illustrations are marked in red. Any page or paragraph reference is to the original manuscript and the reviewers' original comments are in italic. The manuscript has been updated accordingly.

This study reports roadside measurements of 556 heavy-duty trucks in Sweden. The paper uses these measurements to investigate how several pollutants of interest vary by each truck's Euro pollutant emissions standard and carries out several additional analyses including the skewness of the distribution of emitters. In addition, the study does a very extensive comparison to past relevant literature. I think the paper is a valuable contribution to the literature and should be published after considering the comments below. The comments below that I think require the most attention have to do with adding additional analysis or at least discussion on how various amounts of exhaust dilution paper impact your particle number emission factors. This includes both variability in dilution among different trucks in your measurements, and especially differences between your study and the past work used for comparison.

1. Line 104: Please consider adding a short statement here related to how the uphill conditions could impact results. You discuss this later in the paper, but you might want to alert the reader to this, and point to where you discuss it.

Author Response and action: Thanks for your suggestion, we have added a statement at the suggested position in the text (line 104):

"Pollutant emissions from HDTs were measured at a roadside location in Gothenburg, Sweden (Fig. 1). The HDTs passed the sampling location with an average speed of 27 km h^{-1} and acceleration of 0.7 km h^{-1} s^{-1} on a slight uphill slope (~2°). Under such uphill driving conditions, vehicles are expected to emit higher levels of pollutants than during downhill and cruise driving. This will be further examined in Sect. 3.3."

2. Line 163: Please discuss how you chose t1 and t2 for the integration. And more importantly, how did you deal with the different plume widths for NOx versus other pollutants? How sensitive are results to chosen t1 and t2?

Author Response: In previous applications of this peak integration method to characterize particle and gaseous pollutant emission factors for heavy-duty diesel trucks, t_1 and t_2 were determined by identifying inflection points to the left and right of the individual pollutant peaks (Dallmann et al., 2011; Preble et al., 2015). A similar method was used here, examples of chosen t_1 and t_2 are given in Fig. R1.

Author action: We have added a statement after line 166 in the revised manuscript "The time interval of t_1 to t_2 represents the period when the instruments measured the concentration of an entire pollutant peak from an individual HDT (see Fig. 1c-e). Dallmann et al. (2011) and Preble et al. (2015) used the concepts of inflection points to identify t_1 and t_2. In our study, t_1 and t_2 were determined similarly: t_1 is the point before the pollutant concentration intensity increases abruptly and t_2 is when the intensity becomes relatively flat and undistinguishable compared to background levels. It is noted that the integrated peak intensity is insensitive to the exact location of t_2 since the added integrated signals at or beyond this point are fluctuating around zero. t_1 and t_2 were determined independently of each pollutant peak to account for differences in the time response of individual instruments to the exhaust plume."

If we use the same t_1 and t_2 for different pollutants, the integrated peak area would be biased, so the choices of t_1 and t_2 are sensitive to the peak width, or more specifically pollutant type.

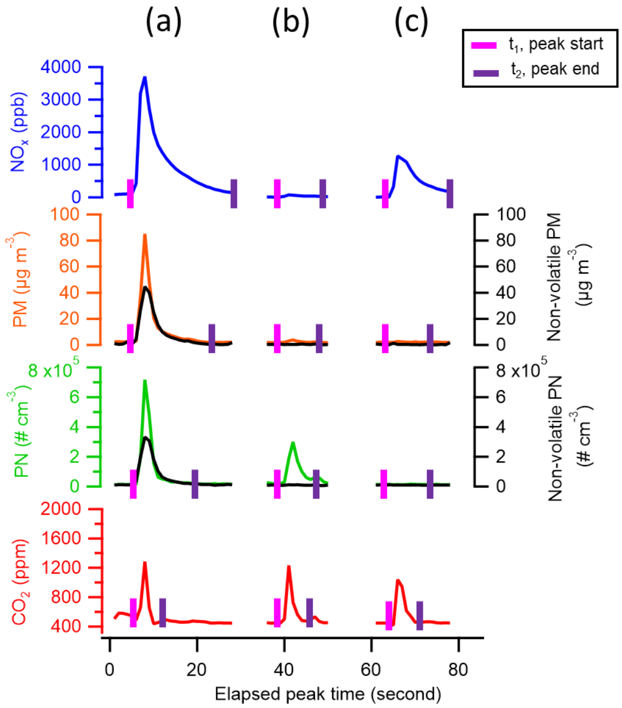

Figure R1. Concentrations of CO_2, PN, non-volatile PN (black line), PM, non-volatile PM (black line), and NO_x from (a) a typical Euro III HDT and (b) a typical Euro VI HDT and (c) a Euro VI HDT with low PN emission.

3. Line 188-200: See major comments above. PN measurements would be highly dependent on the amount of dilution the plume has undergone between the engine and the measurement. I would imagine this would contribute to differences between your measured emission factors and emission standards. What are the dilution requirements when certifying for Euro standards?

Line 200-202: Could variability in dilution contribute to the scatter too? Please think this through for all sections that discuss PN emissions results.

Author Response: To compensate for different dilution levels, particle emissions from individual HDTs were normalized by the CO_2 concentration as illustrated in Eq. (1).

$$EF_{pollutant} = \frac{\int_{t_1}^{t_2}([pollutant]_t - [pollutant]_{t_1})dt}{\int_{t_1}^{t_2}([CO_2]_t - [CO_2]_{t_1})dt} \times EF_{CO_2}\ . \qquad (1)$$

In principle, EFs calculated by Eq. (1) would not be dependent on the amount of dilution the plume has undergone between the engine and the measurement if there is no transformation of the pollutants. Nowadays, the legislation in Europe prescribes the Constant Volume Sampling (CVS) as the reference sampling for particle emission certification, in which the sample mixed gas of exhaust and diluent gas is controlled to have a constant flow rate. The dilution ratio has been left out of direct regulation and is only implicitly controlled by the need to achieve sufficient exhaust cooling before particle sampling (Ntziachristos et al., 2004). The regulations regarding PN is following the PMP protocol, where only the solid particle fraction > 23 nm is accounted for, hence a fraction that is less sensitive to the dilution.

However, the effective emission of all nucleation mode particles is depending on nucleation, coagulation, and evaporation that could be happening on the time scale of the dilution and cooling of the exhaust gases. The relationship between the number emission factor of nucleation mode particles and CO_2 peak areas are shown in Fig. R2. Higher CO_2 concentrations indicated a lower dilution level. Since EF data was not normally distributed, the strength and direction of the association between nucleation mode particle number emission factors and CO_2 peak areas were assessed with the Kendall's tau-b correlation. It is a nonparametric alternative to the Pearson's correlation. The p-values are calculated at the 95% confidence level. Intuitively, one would expect that lowering dilution, i.e., increased observed CO_2 concentrations, might result in a higher EF_{PN} in nucleation mode. However, as shown in Fig R2, no significant enhancement of the formation of nucleation mode particles was evident under lower dilution levels and the nucleation mode particle number emission factors remained practically constant for all Euro III-V HDTs (p>0.05) while Euro VI HDTs showed a weak negative correlation (correlation coefficient of −0.3, p<0.01), i.e. opposite to what could be expected from coagulation/evaporation. This demonstrates that any potential dilution effect on the variability of the measurements was limited and well represents typical dilution one observes at kerb-sites.

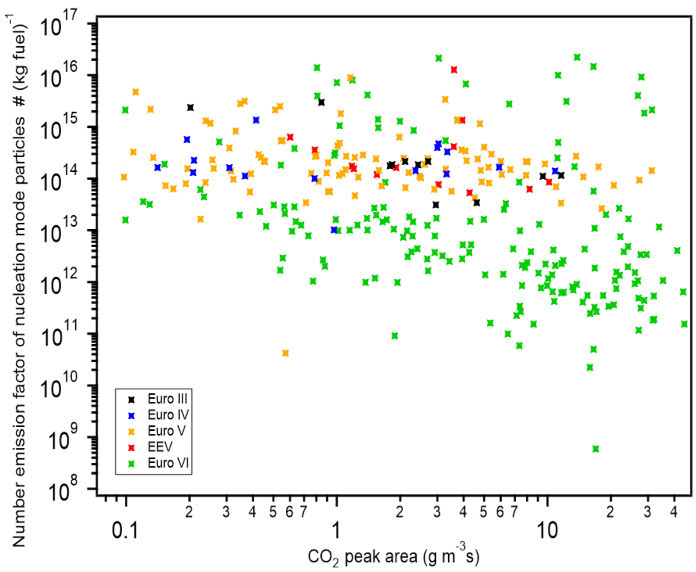

Figure R2. The relationship between number emission factor of nucleation mode particles and CO_2 peak areas

4. Line 240-241: Please make sure to include text in figure captions when you are not including data from all trucks. Are you sure that leaving these data out doesn't lead to a problem with biasing the results? I would imagine that if you are not including results for trucks that have measured concentrations below measurement detection limits, you'd be leaving out the cleanest trucks (though could also be due to the plume missing the sample line). Please think this through for all sections that report results that remove trucks with measurements below detection limits.

Author Response: Thanks for the suggestion. We have added the description of the excluded data in the figure captions. We apologize for the confusion caused; we indeed included the emission data lower than the set detection limit (four times the standard deviation of the pollutant background signal) into the analysis throughout the whole manuscript. As we mentioned in Sect. 2.3, emission factors for plumes with pollutant concentrations lower than our set detection limit were replaced by the minimum value among all recorded emission factors (EF_{min}) rather than being omitted to avoid inflating emissions from low-emitting HDTs. The concentration data below the detection limits were removed from the figure only for the purpose of a clearer figure presentation.

Author action: We have added the following statement after line 253-254 in the revised manuscript:

"HDTs with either EF_{NO2} or EF_{NOx} lower than the detection limits of the instruments were removed in Fig. 2d for illustration purposes, while all the presented statistical analyse include all the data as outlined above."

5. Table 1: I don't understand how you've categorized this table. For example, I see studies in this table that are not performed in Europe but are under the Euro VI category. Also, I noticed papers that you are citing in the study and that have emission factor results, but are not in this table. Please ensure you have considered all relevant studies.

Author Response action: Thanks for review's suggestions. We have rearranged some rows in Table 1 and Table 2 and separated the studies of non-European HDV emissions with Euro VI HDV emissions in each Table. Additionally, more emission factor results have been added to the tables.

Table 1. Comparison of the average emission data[a] for PM and PN from the present study with literature data.

PM/PN						
Vehicle type	Speed km h^{-1}	Dp range nm	Method	Instrument	EF_{PM} mg (kg fuel)$^{-1}$	EF_{PN} # (kg fuel)$^{-1}$ 10^{14}
Euro III HDT in this study	26±6[b]	5.6-560	roadside	EEPS	684±365	20.3±11.7
Euro III bus (Hallquist et al., 2013)	acceleration	5.6-560	roadside	EEPS	6.7-2074	0.11-45
	constant speed	5.6-560	roadside	EEPS	151-273	0.12-4.2
Euro III bus with DPF (Hallquist et al., 2013)	acceleration	5.6-560	roadside	EEPS	62-2465	1.9-23
	constant speed	5.6-560	roadside	EEPS	41-142	1.1-9.7
Euro III bus (Pirjola et al., 2016)	≤25 (bus depot)	PM_1 $D_p \geq 2.5$	plume chasing	ELPI[c] CPC	1240±220[b]	20.6±3.2[b]
	≤45 (bus line)	PM_1 $D_p \geq 2.5$	plume chasing	ELPI[c] CPC	500	17.7
Euro III bus with DPF+SCR (Watne et al., 2018)	acceleration	5.6-560	roadside	EEPS	8.9±0.2	0.12±0.12
Euro III bus with DPF+SCR (Liu et al., 2019)	stop and go (bus stop)	5.6-560	roadside	EEPS	30±26[b]	14.0±3.0[b]
Euro III diesel bus and truck (Zavala et al., 2017)	driving cycle	35-1000	plume chasing & roadside	SP-AMS[f]	4300	-
Euro IV HDT in this study	23±8[b]	5.6-560	roadside	EEPS	172±68	8.7±3.0
Euro IV bus with EGR (Hallquist et al., 2013)	acceleration	5.6-560	roadside	EEPS	562-3089	13-44
	constant speed	5.6-560	roadside	EEPS	91-489	5.8-47
Euro IV bus with EGR+DPF (Hallquist et al., 2013)	acceleration	5.6-560	roadside	EEPS	177-650	5.1-13
	constant speed	5.6-560	roadside	EEPS	58-61	2.6-3.1
Euro IV bus with EGR+DPF	≤25	PM_1	plume chasing	ELPI[c]	1190±520[b]	

(Pirjola et al., 2016)	(bus depot)	$D_p \geq 2.5$		CPC		8.9±1.6[b]
Euro IV bus with SCR (Watne et al., 2018)	acceleration	5.6-560	roadside	EEPS	145-560	3-13
Euro IV diesel bus and truck (Zavala et al., 2017)	driving cycle	35-1000	plume chasing and roadside	SP-AMS[f]	1800	-
Euro V HDT in this study	27±7[b]	5.6-560	roadside	EEPS	146±49	9.7±2.7
Euro V bus+SCR (Hallquist et al., 2013)	acceleration	5.6-560	roadside	EEPS	125-766	4.4-92
	constant speed	5.6-560	roadside	EEPS	41-509	2.7-33
Euro V bus (Watne et al., 2018)	acceleration	5.6-560	roadside	EEPS	145±70	3.0±1.7
Euro V HDV with SCR (Rymaniak et al., 2017)	average at 45	PM/ 5.6-560	PEMS	MSS[e] EEPS	1840 [d]	0.09 [d]
Euro V bus with SCR (Liu et al., 2019)	stop and go (bus stop)	5.6-560	roadside	EEPS	180±15[b]	6.5±2.9[b]
Euro V diesel bus and truck (Zavala et al., 2017)	driving cycle	35-1000	plume chasing and roadside	SP-AMS[f]	720	-
EEV HDT in this study	25±8[b]	5.6-560	roadside	EEPS	78±35	16.5±23.6
EEV bus with EGR +DPF (Pirjola et al., 2016)	≤25 (bus depot)	PM_1/ $D_p \geq 2.5$	plume chasing	ELPI[c] CPC	400±280[b]	2.1±0.1[b]
EEV bus with SCR (Pirjola et al., 2016)	≤25 (bus depot)	PM_1/ $D_p \geq 2.5$	plume chasing	ELPI[c] CPC	280±170[b]	7.0±3.8[b]
EEV with DOC+DPF+SCR (Rymaniak et al., 2017)	average at 45	PM/ 5.6-560	PEMS	MSS[e] EEPS	236 [d]	0.02 [d]
EEV bus (Jarvinen et al., 2019)	stop and go	PM_1/ $D_p \geq 3$	plume chasing	ELPI[c] CPC	200	8.6
Euro VI HDT in this study	29±8[b]	5.6-560	roadside	EEPS	5±2	8.5±4.6
Euro VI bus (Jarvinen et al., 2019)	stop and go	PM_1/ $D_p \geq 3$	plume chasing	ELPI[c] CPC	70	5
Euro VI HDGV (Moody and Tate, 2017)	13-86	-	PEMS	-	28-33[d]	-
Euro VI HDT (Grigoratos et al., 2019)	65-74	-	PEMS	-	-	0.002-0.01[d]
HDT without available Euro type information	27±7[b]	5.6-560	roadside	EEPS	47±23	7.5±7.3
Total Swedish HDT	28±7[b]	5.6-560	roadside	EEPS	96±36	9.6±2.7
Total non-Swedish HDT	26±8[b]	5.6-560	roadside	EEPS	117±42	11.1±4.2
Non-European HDV with different ATS						
HDV with DPF (Wang et al., 2017; Quiros et al., 2016)	13-80	PM $D_p \geq 5$	PEMS	gravimetric CPC	12-41[d]	0.006-13.2
Heavy-duty HDV with DPF+SCR (Thiruvengadam et al., 2015)	driving cycle	PM	chassis dynamometer	gravimetric	6-29 [d]	-
HDV with DPF+SCR (Jiang et al., 2018)	driving cycle	$PM_{2.5}$	chassis dynamometer	gravimetric	3-97 [d]	-
HDT (model year 2004- 2006) (Preble et al., 2015)	accelerating or cruise at 48	$D_p \geq 2.5$	roadside	CPC	-	47.2±9.7
HDT with SCR+DPF (model year 2010- 2013) (Preble et al., 2015)		$D_p \geq 2.5$	roadside	CPC	-	15.9±11.5

HDV (mean model year 2005) (Bishop et al., 2015)	15.7-16.8	$PM_{1.2}$	OHMS[g]	digital mass monitor	650	-
HDV (mean model year 2009) (Bishop et al., 2015)	7.7-9.3	$PM_{1.2}$	OHMS[g]	digital mass monitor	31	-
HDV without after-treatment (Quiros et al., 2018)	driving cycle	$PM_{2.5}$	chassis dynamometer	gravimetric	1980[d]	-
HDV+DPF (Quiros et al., 2018)	driving cycle	$PM_{2.5}$	chassis dynamometer	gravimetric	6-9[d]	-

[a] Given errors are at 95% CI.
[b] Standard deviation.
[c] ELPI, Electrical Low-Pressure Impactor.
[d] Average fuel consumption of 0.26 L km^{-1} for HDV during long haul and regional delivery tests (Rexeis et al., 2018), the density of 0.815 kg dm^{-3} (Swedish Environmental Protection Agency, 2013) of diesel particles were assumed for unit conversion.
[e] MSS, Micro Soot Sensor.
[f] SP-AMS, Soot Particle Aerosol Mass Spectrometer.
[g] OHMS, On-Road Heavy-Duty Vehicle Emissions Monitoring System.

Table 2. Comparison of the average emission data[a] for NO_x, NO_2/NO_x, CO and HC from the present study with literature data.

Vehicle type	Speed km h^{-1}	Method	EF_{NOx}[b] g (kg fuel)$^{-1}$	EF_{NO2}/ EF_{NOx}[b] mass ratio %	EF_{CO}[c] g (kg fuel)$^{-1}$	EF_{HC}[c] g (kg fuel)$^{-1}$
Euro III HDT in this study	26±6[d]	roadside	43.3±31.5	7.5±4.1	36.0±13.2	0.8±1.3
Euro III bus (Hallquist et al., 2013)	acceleration	roadside	16.1±9.7	-	16.1±16.1	<13
Euro III bus (Pirjola et al., 2016)	≤25 (bus depot)	plume chasing	12.7±1.8[d]	-	-	-
	≤45 (bus line)	plume chasing	20.5	-	-	-
Euro III bus with DPF+SCR (Watne et al., 2018)	acceleration	roadside	-	-	13±10	0.02
Euro III HDV (Lau et al., 2015)	64 ± 13[d]	plume chasing	-	24±4	-	-
Euro III &IV HDV (Kousoulidou et al., 2008)	-	model	-	14	-	-
Euro III HGV (Carslaw et al., 2011)	Average at 31	remote sensing	16.2±1.0[f]	-	-	-
Euro III HGV (Carslaw and Rhys-Tyler, 2013)	28-60	remote sensing	-	24.1±4.7	-	-
Euro IV HDT in this study	23±8[d]	roadside	19.8±10.1	2.7±2.9	22.1±10.3	0.7±1.1
Euro IV bus (Hallquist et al., 2013)	acceleration	roadside	12.9±6.5	-	16.1±16.1	<13
Euro IV bus with EGR+DPF (Pirjola et al., 2016)	≤25 (bus depot)	plume chasing	23.4±6.1[d]	-	-	-
Euro IV bus with SCR (Watne et al., 2018)	roadside	acceleration	-	-	220-230	0.3-0.6
Euro IV HDV (Lau et al., 2015)	64 ± 13[d]	plume chasing	-	28±5	-	-

Euro IV HGV (Carslaw et al., 2011)	average at 31	remote sensing	10.3±1.4[f]	-	-	-
Euro IV HGV (Carslaw and Rhys-Tyler, 2013)	28-60	remote sensing	-	3.1±0.7	-	-
Euro V HDT in this study	27±7[d]	roadside	22.2±3.8	6.0±2.8	22.8±5.1	0.9±0.4
Euro V bus (Hallquist et al., 2013)	acceleration	roadside	35.5±9.7	-	9.7±3.2	<13
Euro V bus with SCR (Liu et al., 2019)	stop and go (bus stop)	roadside	9.8±3.5[d]	3.7±1.5[d]	28[e]	2.2[e]
Euro V HDV (Lau et al., 2015)	64 ± 13[d]	plume chasing	-	40±14	-	-
Euro V HDV (Kousoulidou et al., 2008)	-	model	-	18	-	-
Euro V HGV (Carslaw et al., 2011)	average at 31	remote sensing	13.3±5.8[f]	-	-	-
Euro V HGV (Carslaw and Rhys-Tyler, 2013)	28-60	remote sensing	-	3.7±0.7	-	-
EEV HDT in this study	25±8[d]	roadside	13.6±6.7	6.3±3.7	18.0±10.1	0.2±0.4
EEV bus with EGR +DPF (Pirjola et al., 2016)	≤25 (bus depot)	plume chasing	32.9±7.6[d]	-	-	-
EEV bus with SCR (Pirjola et al., 2016)	≤25 (bus depot)	plume chasing	39.8±4.2[d]	-	-	-
Euro VI HDT in this study	29±8[d]	roadside	3.1±1.0	22.5±4.2	15.5±2.2	1.0±0.5
Euro VI HDT (Grigoratos et al., 2019)	65-74	PEMS	0.3-31.3	-	2.8-22.3	0.3-3.1
Euro VI HDV (Kousoulidou et al., 2008)	-	model	-	35	-	-
Euro VI HDV (Moody and Tate, 2017)	driving cycle	PEMS	2.2[f]	-	-	-
HDT without available Euro type information	27±7[d]	roadside	7.8±4.5	13.9±6.3	20.7±5.6	0.8±0.6
Total Swedish HDT	28±7[d]	roadside	10.7±1.8	15.9±2.5	18.6±1.9	0.9±0.3
Total non-Swedish HDT	26±8[d]	roadside	13.0±2.5	12.7±3.0	19.1±3.0	0.9±0.6
Non-European HDV with different ATS						
Heavy-duty HDV with DPF+SCR (Thiruvengadam et al., 2015)	driving cycle	chassis dynamometer	3.8-27.8[f]	-	0.1-13.4[f]	<0.64[f]
HDV with DPF+SCR (Jiang et al., 2018)	driving cycle	chassis dynamometer	0.2-66.4[f]	-	0.006-14.9[f]	<1.3[f]
HDV with DOC+DPF+SCR (Quiros et al., 2016)	12.7-85.6	mobile laboratory	1.7-11.8[f]	-	0.9-2.8[f]	0.1-0.4[f]
HDV (May et al., 2014)	driving cycle	chassis dynamometer	30-43	-	-	-
HDV with SCR (May et al., 2014)		chassis dynamometer	11	-	-	-
HDV fleet average (Haugen et al., 2018)	22.5±0.9	remote sensing	12.4±0.6	8.9	5.9±0.9	2.2±0.4
HDT (model year 2004- 2006) (Preble et al., 2015)	accelerating or cruise at 48	roadside	16.5±1.7	3.4±1.8	-	-
HDT with SCR+DPF (model year 2010- 2013) (Preble et al., 2015)		roadside	5.1±1.2	22.1±8.4	-	-
HDT (model year 2001)	5-25	roadside	-	9.1±0.5	26.0±2.1	1.8±0.6

(Burgard et al., 2006)						
HDT (model year 2000) (Burgard et al., 2006)	20-40	roadside	-	6.1±0.1	37.9±1.6	3.3±0.4
Fleet average in 2006 (Bishop and Stedman, 2008)	28-36	roadside	2-5	-	17-24	1.9-2.3
HDT fleet average (Dallmann et al., 2012)	65	roadside	28±1.5	7.0	8.0±1.2	-
HDT (mean model year 2004) (Bishop et al., 2013)	22.2±0.4	remote sensing	20.6±0.6[d]	9.7	8.2±0.6[d]	3.7±0.1[d]
HDT (mean model year 2009) (Bishop et al., 2013)	7.8±0.1	remote sensing	19.9±0.3[d]	9.0	7.3±0.5[d]	0.6±0.6[d]

[a] Given errors are at 95% CI.
[b] In NO_2 equivalents.
[c] RSD data. For the RSD data sets of multiple individuals, negative values were replaced by zero when calculating the averages.
[d] Standard deviation.
[e] Median.
[f] Average fuel consumption of 0.26 L km^{-1} for HDV during long haul and regional delivery tests (Rexeis et al., 2018), the density of 0.815 kg dm^{-3} (Swedish Environmental Protection Agency, 2013) of diesel particles were assumed.

6. Figure 2: For Euro III, it seems that the EF for black carbon is higher than for PM. How could this be?

Author Response: In the conversion of number concentrations to particle mass, particle sphericity and unit density were assumed. This might lead to an underestimation of PM. Nevertheless, we use this in the paper for easy comparison with the literature using similar experimental methodologies (Hallquist et al., 2013; Liu et al., 2019; Preble et al., 2015; Watne et al., 2018) in which unity density was used for the calculation of EF_{PM}.

In Fig. 2a, EF_{PM} includes both semi-volatile and non-volatile fractions. Using measurements with and without thermal desorption, we found that the ratio of $EF_{non\text{-}volatile\ PM}$ to EF_{PM} is generally higher for Euro III HDTs than other Euro type HDTs (Fig. R3). This explains why only Euro III HDTs show a higher EF_{BC} than EF_{PM}. In fact, there is a good linear relationship at EF_{PM} larger than 1 mg (kg fuel)$^{-1}$ between the BC mass measured by the Aethalometer and the non-volatile particle mass measured at the outflow of a TD by the EEPS (Fig. S3). Compared to the EEPS, the detection limit of the Aethalometer is five times higher, which may influence the correlation between BC and PM at low mass loading conditions (when EF_{PM} is lower than 1 mg (kg fuel)$^{-1}$).

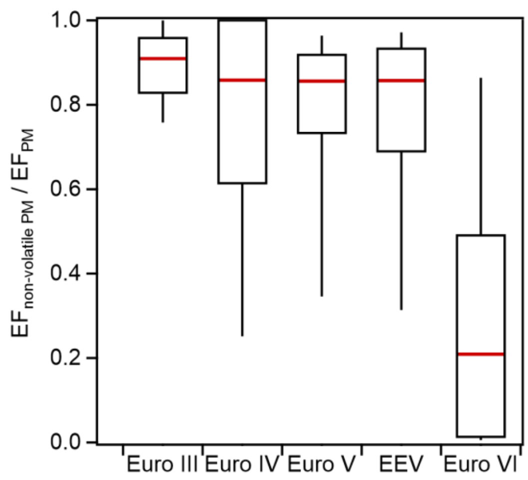

Figure R3. $EF_{non\text{-}volatile\ PM}$ / EF_{PM} for Euro III to Euro VI HDTs. Non-detectable pollutant emission signals for captured plumes have been replaced by EF_{min}. For box-and-whisker plots, the top and the bottom line of the box are 75th and 25th percentiles of the data, the red line inside the box is the median, and the top and bottom whiskers are 90th and 10th percentiles.

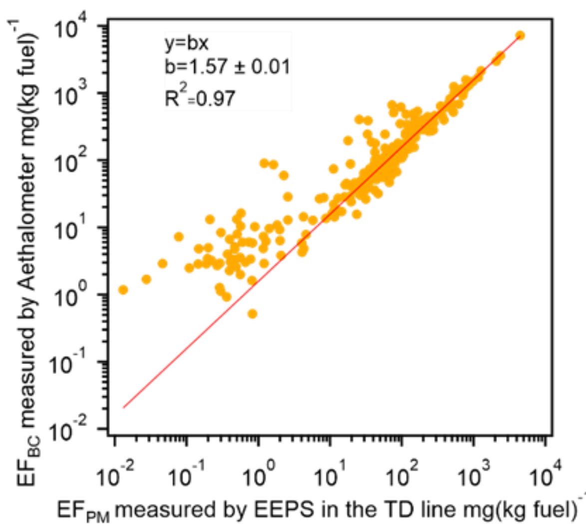

Fig. S3. Relationship between EF_{BC} measured by the Aethalometer and $EF_{non\text{-}volatile\ PM}$ measured by the EEPS in the TD line (unity density of particles was assumed).

7. Figure 4: This is very interesting. You might consider comparing these size resolved emission factors to previous studies that report similar EFs.

Author response and action: Thanks for your suggestion, we have added the following discussion in red and Fig. 4f to the manuscript:

The EF_{PN} of the accumulation mode particles shows a decreasing trend from Euro III to EEV HDTs. The accumulation mode of the Euro VI HDTs was insignificant. For heavy-duty diesel engines without a particulate filter, nucleation mode particles are mainly formed from organics. For vehicles with DPF both organics and the fuel sulphur content might influence the formation of nucleation mode particles (Vaaraslahti et al., 2004). Thiruvengadam et al. (2012) found a direct relationship between exhaust nanoparticles in the nucleation mode and the exhaust temperature of the DPF-SCR equipped diesel engine. These factors lead to high variability in the nucleation mode fraction of EF_{PN}. Figure 4f shows that HDVs with DPF (dashed lines) exhibited lower emissions of accumulation mode particles, with no significant reduction in nucleation mode particles when compared to HDVs without DPF (solid lines). In general, the absence of significant accumulation mode particles from Euro VI HDTs was consistent with observations made from DPF equipped HDVs. High emissions of accumulation mode particles from Euro III HDTs were consistent with measurements from HDVs without DPF in previous studies (Liu et al., 2019; Hallquist et al., 2009; Preble et al., 2015).

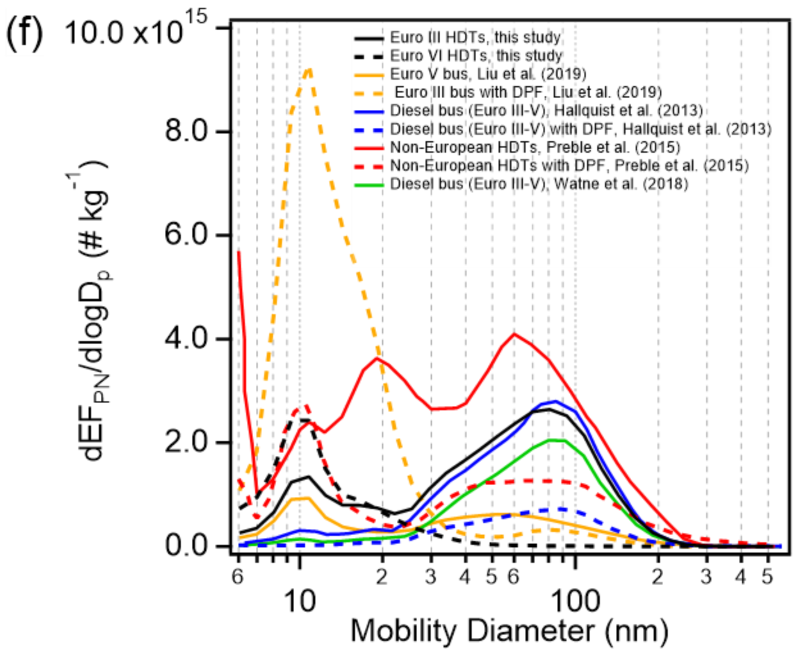

Figure 4f. Comparisons of mean size-resolved EF_{PN} of HDVs in this study and previous studies.

Reference

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