Response to comments from anonymous referee #2

The authors conduct a solid analysis of on-road data collected in different freeways of Los Angeles/California to obtain EF and ER in this area. It is important that issues like this analysis are raised and discussed to enable future research into real-world emissions in order to benefit from this kind of experience. However, certain details should be addressed to facilitate understanding of the research and possible limitations of the methodology employed.

1- As it is extensively reported in the article, the study captures the variability in EFs due to inter-vehicle differences (P18716L11, P18720L4 and P18724L5, Discussion Paper). The final results show very large deviations for some pollutants in some conditions. I suggest the authors to specify more exactly the causes of this variability depending on:

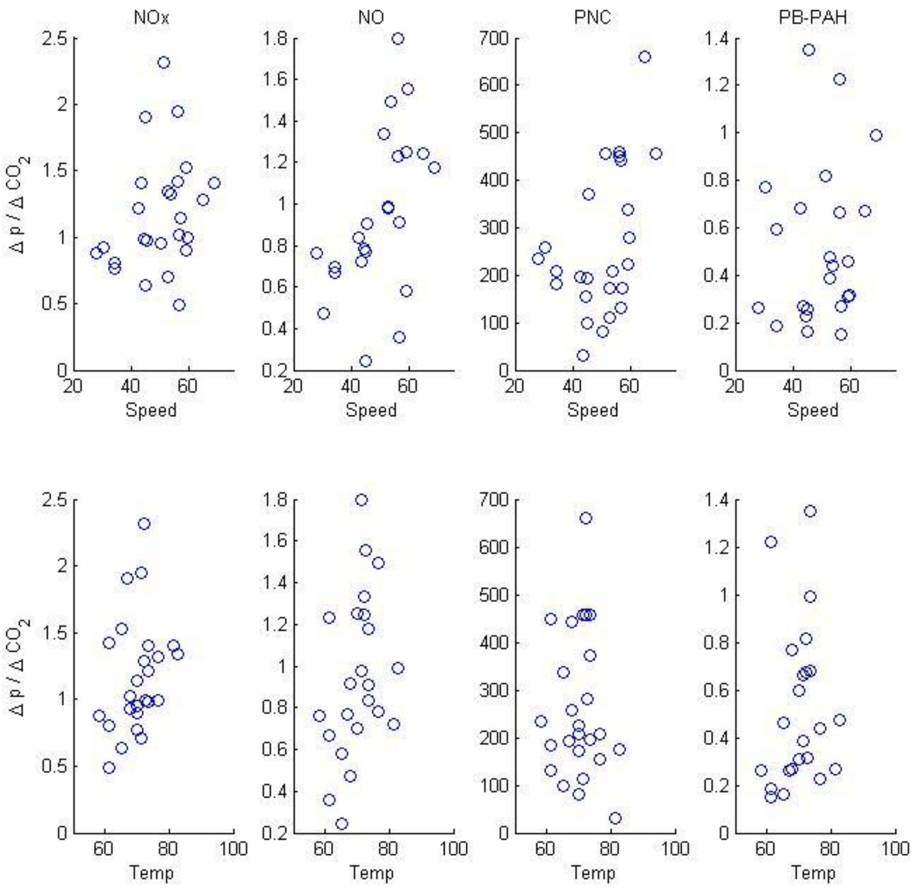
- *a) Weather conditions.*
- *b) Background pollutant concentrations.*
- *c) Traffic conditions. I guess that in a highly congested traffic state, the variability of EFs will increase due to pollutant contributions from other vehicles.*
- *d) Quality of the plume or plume size. Absolutely critical aspect when conducting experiments with other methodologies (RSD).*
- *e) EFs variability due to speed and/or acceleration conditions (see point 3).*

We recognize that the term “inter-vehicle” should better be changed to “intra-fleet” to reflect that our EFs are capturing both inter-vehicle differences as well as intra-vehicle EF differences due to variations in driving conditions, speed, etc. This was mentioned in Lines 4-5/Page 18724.

In the interests of reducing the length of our responses and avoiding repetition, please see our response to Comment #1 from Referee 1 regarding background (baseline) concentration and Comments 2 and 3 to Referee 1 regarding sources of variability and uncertainty in our EFs.

Each run reflects a different fleet composition not only in terms of fraction that was HDV, but also a new set of vehicles. Therefore, it is not possible with our methodology to quantify the components of variation that results from changes in fleet composition or traffic congestion, for example. The important thing is that it appears we were able to capture this combined variability under a range of conditions that were representative of real-world driving conditions.

In response to this comment, however, we tried to determine if our data indicated any trend with respect to speed or temperature. The figure below suggests there wasn’t a consistent correlation between ΔP/ΔCO2 ratios for different pollutants and temperature or speed.



As soon as the possible external reasons for the variability of the emission factors are detailed and limited, it will be easier to conclude that there is variability in EFs due to inter-vehicle differences. Nevertheless, I think it would be interesting in the EFs study (perhaps in a future article) to use OCR cameras for license plate recognition and to calculate EFs according to vehicle category (age, vehicles' engine technology, vehicle's weight class) and independent operating conditions of the vehicle (speed, acceleration, and slope).

Please see our response to Comments 2 & 3 from Referee 1, where we have discussed at length the uncertainty and variability in EFs.

Multiple studies conducted by Bishop, G.A., Steadman, D.H. et al. have captured license plate data to identify age, engine technology, etc. A list of relevant publications can be found at: http://www.feat.biochem.du.edu/pub_list.shtml. We agree that this will shed light on specifics and is an approach that can be taken in the future. This will be especially relevant while addressing the Comment 1/Referee 3, i.e., addressing the affect of fleet turnover vs. retrofit in changing emissions.

2- Does this technique recognize high emitting vehicles? - If this is the case, what percentage of vehicles are high emitters? How do high emitters contribute to EFs and ERs? - Otherwise, it must be recognized in the article that this is a limitation.

As detailed in other responses (comments 2 and 5 from Referee 4 and comment 2 from Referee 1), we are not calculating EFs for individual vehicles and it is not possible to calculate the specific percentage of high emitters. However, due to the extended measurement time used in each EF calculation, we believe a high EF likely represents a strong influence from a high emitting vehicle.

3- It would be interesting to find a correlation (R2) between the average speed for each segment and the emission factor. Although this is not the aim of this study, it could represent an important scientific contribution and could give very realistic data values as input in emission models.

Our data aren't comprehensive enough to make such suggestions (Please see the figure above for LDV ΔP/ΔCO2 ratios versus speed). However, it certainly is possible using our approach if enough measurements are conducted in a targeted manner to specifically answer that question.

4- According to what was said by referee #4, I find absolutely necessary to indicate how this methodology would be put into practice in a mixed fleet gasoline-diesel. Could this methodology be used in other places such as Europe?

On the issue of applicability in Europe**,** as long as reliable statistics on the fuel type division are available the same methodology of partitioning emissions could be extended to three groups (HDV – diesel, LDV – diesel and LDV – gasoline). Though mathematically feasible, we think it will be challenging to obtain the fuel type statistics required. The technique requires at least two of the three $\Delta P/\Delta CO_2$ ratios to be known for direct application. These could be obtained from roadway measurements in areas where only vehicles with certain fuel type are allowed (if they exist in Europe, though authors are not as familiar with European roadways). It is unlikely that there are places where only gasoline or diesel LDV are allowed, ruling out the possibility for two known $\Delta P/\Delta CO_2$ ratios. But it is probably possible to find locations near ports/railway yards that are heavily dominated by heavy duty diesel truck traffic. Once at least one, i.e., $\Delta P/\Delta CO_2$ ratios for diesel HDV are known, our suggestion is to first apportion diesel HDV emissions out from mixed fuel traffic measurements as opposed to our approach where we had access to only gasoline LDV traffic emission and we apportioned those out using the measured ratios. The remaining emission will then have to be apportioned out in diesel LDV and gasoline LDV fractions, but since both $\Delta P/\Delta CO_2$ ratios are unknowns, they will have to be estimated. Each observation post HDD apportionment would give a set of linear equations (of the type below for each observation) which could be solved to get an approximate solution through linear least squares for an over-determined linear system.

Equation for each observation, where ‘o’ is number of observations:

$$(\Delta P/\Delta CO2\ )\_LDG * \text{fraction of } LDG_o + (\Delta P/\Delta CO2\ )\_LDD * \text{fraction of } LDD_o = (\Delta P/\Delta CO2\ )\_apportioned_{LD}$$

However, the accuracy of regressed LDG and LDD ΔP/ΔCO2 ratios would depend on the accuracy of fraction of LDG and LDD input, which is likely to be less accurately known than the division between LD and HD vehicles. If fraction of LDG and LDD estimates is very uncertain, it might be a better approach to chase individual vehicles and calculate individual EFs.