

## Reply to Referee #2

We thank Referee #2 for positive evaluation of the manuscript. All suggested corrections have been made in the revised manuscript. Also English and punctuations have been checked through the paper. The changes made in the manuscript are below written by blue color.

### General comments

**This paper presents the finding of a multi week field study performed in Helsinki, Norway that focussed on emissions from traffic and how those emissions impacted nearby ambient air and changed with distance from the traffic sources. Much of the data were collected with an instrumented mobile van that slowly transited from the road side of several roads. High time resolution instrumentation was included to allow one second collection of particle size composition, particle numbers, and common traffic-generated gaseous and particle phase chemistry. Changes in particle size distribution and composition were also assessed with distance from the roadway. Finally, emission factors were developed for common traffic related pollutants. The information presented makes a very important contribution to the complex issues of the dynamic processes that occur once pollutants are emitted and moves from the roadway to the community. It is quite comprehensive and only a few technical question appeared as it was reviewed. Upon consideration of these comments and others from the reviewing community the paper should prove quite useful.**

### Specific comments

**Page 6, line 5~Tthe weather was described as “rather mild”. The conditions include data collection under what most researchers might consider quite cold and wet. It appears that sampling was conducted in sub-freezing at one site and most all was performed when temperatures were below 5 degrees C. Average humilities were approximately 90% at one site. The terminology of “mild” is important for clarification, however, much more important is that the nature of the study was to consider the dynamic processes that occur between tailpipe and the first few hundred meters from a roadway. It is well known that temperature plays a key role along with concentration in these processes. It is likely that humidity is also important. It clearly critical for PM related factors, but could even play a role in NOx conversions observations. Thus one very key point for further including in the paper is a science-based appraisal of the somewhat extreme conditions should be viewed, how they might impact particle and gas dynamics how others might use the data collected and conclusions drawn.**

The referee is right, “rather mild” was not the best phrase, even though this kind of weather is rather typical, but not yet extreme, for a few months in Finland and in the northern hemisphere. The sentences (p. 7, lines 21-24) were substituted by: “Typical to Finnish autumn weather, the temperature was around 0.8-4.7°C, relative humidity 77-89%, and wind speed around 3-5 m s<sup>-1</sup>, monitored at the meteorological measurement site at Ämmässuo (Fig. 1) by the HSY. The measurement altitude was 15 m so these values represent regional air mass properties.”

We added more discussion in Introduction (p. 3 lines 20 - p. 4. line 6) concerning dilution and aerosol dynamics, their dependence on temperature, relative humidity and wind speed, and their effects on particle size distribution during dispersion. “These studies showed that the concentration levels and gradient shapes of UFP and other primary vehicular emissions near major roads depend in a complex way on many factors, including meteorological conditions such as atmospheric stability, temperature, wind speed, wind direction, and surface boundary layer height (Durant et al., 2010). Dilution is a very crucial process, additionally it is accompanied by aerosol dynamics processes such as nucleation, coagulation, condensation, evaporation and deposition (Kumar et al., 2011 and references therein). In the diluting and cooling exhaust new particles are formed by homogeneous nucleation during first milliseconds (Kittelson, 1998), after that they immediately grow by condensation of condensable vapours. Low temperature favours nucleation and condensation, whereas evaporation becomes important during high ambient temperature. On the other hand, the majority of volatile organic compounds is emitted by vehicles during cold starts (Weilenmann et al., 2009). Consequently, Padro-Martinez et al. (2012) report that the gradient concentrations were much higher in winter than in summer, even 2-3 times higher as observed by Pirjola et al. (2006). Also relative humidity might affect PM emissions by vehicles. Typically, in the street scale (around 200 m from the roadside) coagulation is too slow to modify particle size distribution. However, under inefficient dispersion conditions (wind speed < 1m s<sup>-1</sup>) self- and inter-modal coagulation as well as condensation and evaporation might become important transforming the particle size distribution (Karl et al., 2016 and references therein). Besides dilution and aerosol dynamics, traffic fleet and flow rate (e.g. Zhu et al., 2009; Beckerman et al., 2008), background concentrations (Hagler et al., 2009), and atmospheric chemical and physical processes (Beckerman et al., 2008; Clements et al., 2009), all affect pollutant concentrations near the highways.”

As in the referred published studies, also in our study, the results are strongly dependent on the local environmental conditions. Therefore, it is true that readers should always take the environmental conditions into account if the data and drawn conclusions are used in other studies. In Conclusions, we changed the sentence (p.

22, lines 10-15) “Although the traffic pollutants near the highways seemed to vary greatly depending on meteorological conditions and flow dynamics, the results obtained in this study confirm that people living close to high traffic roads are generally exposed to pollutant concentrations that are even double or triple of those measured at 200 m or more away from the road” to “Although the traffic pollutants near the highways seemed to vary greatly depending on meteorological conditions and flow dynamics, the results obtained in this study under these environmental conditions confirm that people living close to high traffic roads are generally exposed to pollutant concentrations that are even double or triple of those measured at 200 m or more away from the road. “

It is well known that for NO to NO<sub>2</sub> conversion photochemical production of O<sub>3</sub> is important. However, during our campaign solar radiation was weak due to the short sunshine time (7:30 - 16:30) and large zenith angle, besides the measurements occurred during sunrise (7-10 am) and sunset (3-6 pm), and furthermore, most of the days were partly cloudy. This was mentioned on p. 12 “The sunrise and sunset during the measurement period coincided with the rush hours, thus making the analysis of photochemistry more difficult.” Photochemical oxidation might not be the reason for high and rather constant normalized NO<sub>2</sub> gradients in Malmi (Fig. 2). As explained on p. 12, high number of diesel passenger cars directly emitting NO<sub>2</sub> affect the concentrations. It should also be noted that the highway and gradient concentrations were not simultaneous measurements.

Added references:

Canagaratna, M. R., Onasch, T. B., Wood, E.C., Herndon, S.C., Jayne, J. T., Cross, E.S., Miake-Lye, R.C., Kolb, C.E., and Worsnop, D. R.: Evolution of vehicle exhaust particles in the atmosphere, *J. Air & Waste Manage. Assoc.*, 60, 1192-1203, 2010.

Karl, M., Kukkonen, J., Keuken, M.P., Lützenkirchen, S., Pirjola, L., and Hussein, T.: Modelling and Measurements of Urban Aerosol Processes on the Neighbourhood Scale in Rotterdam, Oslo and Helsinki, *Atmos. Chem. Phys. Discuss.*, 15, 35157–35200, 2015

Kittelson, D.B.: Engines and nano-particles: a review, *J. Aerosol Sci.*, 29, 575-588, 1998.

Pirjola, L., Lähde, T., Niemi, J.V., Kousa, A., Rönkkö, T., Karjalainen, P., Keskinen, J., Frey, A., Hillamo, R.: Spatial and temporal characterization of traffic emission in urban microenvironments with a mobile laboratory, *Atmos. Environ.*, 63, 156-167, 2012.

Weilenmann, M., Favez, J.-Y., and Alvarez, R.: Cold-start emissions of modern passenger cars at different low ambient temperatures and their evolution over vehicle legislation categories, *Atmos. Environ.*, 43, 2419-2429, 2009.

**Page 6, line 28~A~TPM 2.5 m might contribute to the evolution ass data were produced by a DustTrak. The operational conditions of this unit were not described beyond inclusion of a mass calibration factor from a prior study published in 2012. The calibration factor reported in that study was 1.46. This is a critical correction factor and the findings related to PM 2.5 would be far more supportable had a proper contemporary calibration factor been made. Further, there is no mention of whether humidity was considered as the data were used while average humidities at one site were 89%. The authors are suggested to raise this point for caution to reader and if possible, should address what was done and perhaps quickly determine a mass calibration for the instrument to either confirm it is appropriate, to correct the data or perhaps consider elimination of PM mass data entirely. It is not a key factor in this study. Some data from nearby ambient monitoring stations may also be used to evaluate the correction factor in the paper.**

Since the DustTrak was not calibrated to the aerosol measured in this study, we decided to eliminate the PM<sub>2.5</sub> as suggested by the referee. Instead we estimated the PM<sub>1</sub> concentration as the sum of the concentrations of the BC measured with the AE33, and the organic and inorganic species measured with the SP-AMS. The PM<sub>1</sub> concentrations (μg/m<sup>3</sup>) were added in Fig. 2 and Table 2, and the emission factors EF<sub>PM1</sub> (g/kg fuel) in Table 3.

In section 2.2 Instrumentation (p. 9, lines 22-23) we added: “In this study, the PM<sub>1</sub> concentration was estimated as the sum of the concentrations of BC, measured with the Aethalometer, and the organics and inorganics, measured with the SP-AMS.”

**Page 17, line 28~A~Trelated to the PM2.5 points above~A~Tshould either the calibration or Rh considerations prove troublesome to correct It is at least important to inform the reader of possible problems with this data.**

This comment is not relevant any more, since the PM<sub>2.5</sub> data was eliminated.