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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Short-term variation in near-highway air pollutant gradients on a winter morning" *by* J. L. Durant et al.

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Author's responses to Reviewers' comments on "Short-term variation in near-highway air pollutant gradients on a winter morning" by J. L. Durant et al.

Ms. # ACP-2010-14

We are grateful to the two anonymous reviewers for their thoughtful comments on our manuscript. The original comments from the reviewers follow with our responses directly below each comment.

Anonymous Referee #1

Received and published: 3 March 2010

General Comments: This manuscript describes a study characterizing short-term temporal variation of vehicular pollutant gradients within 200–400m of a major highway (>150 000 vehicles/d) near Interstate 93 in Somerville (Massachusetts) from 06:00 to 11:00 on 16 January 2008 using a mobile monitoring platform equipped with instruments that measured ultrafine and fine particles (6–1000 nm, particle number concentration (PNC)); particle-phase (>30 nm) NO-3 , SO2- 4 , and organic compounds; volatile organic compounds (VOCs); and CO2, NO, NO2, and O3. The results of this interesting and well executed study show that pollutant levels change rapidly as a function of atmospheric mixing conditions and chemical reactions over short distances near highways, consistent with many other recent publications of the past several years. Indeed the spatial variability of air pollutants emitted by traffic sources a significant challenge in conducting population exposure assessment to these pollutants and increases the likelihood of exposure misclassification.

The paper is well written and generally easy to follow. The experimental part, data analyses and discussion are all well presented and articulated. The biggest issue that I have with this paper is the limited data, literally taken during the course of one day in January of 2008, and thus the generalizability of the results as well as the new information or insight that they bring to na over-studied topic.

Looking at the data presented in figures 1-7, they are all consistent with prior studies, which they authors properly acknowledge, so I am left with the question of what is new, exciting and noteworthy about this new data set (again taken over 1 day in winter fo 2008), other than a new location (which is not terribly different than any other US freeway) and more or less the same set of instruments plus the AMS. The data generated by the latter are "fancy" but don't shed any new light on the observations of many publications already on the same subject.

Response: This point is well taken; there are indeed a number of studies on this subject in the literature. However, what makes our results a unique contribution to this literature is the demonstration of the rapid changes in near-highway pollution gradients. We have

not found any other studies that so clearly demonstrate this. Our findings suggest that to improve the accuracy of exposure estimates to near-highway pollutants, short-term (hourly) temporal variations in pollutant gradients must be measured to reflect changes in traffic patterns and local meteorology. This may have significance for the design of future near-highway air pollution studies.

I will leave it up to the editor to decide on whether an extra study that corroborates the result of many others warrants publication. As I noted earlier, other than this point, the paper is well written and the approach and overall findings sound and robust.

Few additional comments: âĂć Figures 4 an and 4 b have been mixed up in the text

Response: This will be corrected in the revised manuscript.

âĂć Significance section- again I applaud the authors effort to add this section in an attempt to highlight the importance and perhaps uniqueness of their results. What troubles me is that none of the conclusions are new or contradict the results of freeway based studies with which we have frankly been inundated over the past several years. All of these studies are internally consistent and show essentially the same and obvious finding, i.e., that pollutants from vehicular emissions decay exponentially with distance from freeways, with the decay rates depending on meteorological factors , time of day, and traffic volumes. How many additional studies of this nature in simply different locations do we really need?

Anonymous Referee #2

Received and published: 26 April 2010

General Comments This study used a mobile instrumentation approach to study near-freeway air pollution concentrations for a large number of pollutants during winter morning hours near a freeway in Somerville, Massachusetts, near Boston. Their instrumentation appears state-of-the-art for such a study and the results appear of high quality. It is a well written paper.

The primary weakness of the paper is having only a single day of sampling. The potential for a single day to have unusual meteorological or traffic characteristics is high, and without more details and more analysis of how representative this day was of typical, I feel it is incomplete and not ready for publishing. This is unfortunate because it seems to be a well-conducted study. Are more days of measurements available? If yes, they should be added and I think the paper will easily be publishable.

Response: Monitoring was performed only on the morning of 16 January 2008.

If not, much more detail about the meteorological conditions are needed and an analysis of how they well they represent typical conditions is absolutely necessary.

Response: Based on this comment we performed an analysis of traffic and meteorological conditions in our study area over the winter of 2008. These details will be better described in the revised manuscript. Our results indicate that 16 January was fairly typical of winter-time traffic volume and meteorological conditions for the Boston area. As shown in Figure A, traffic volume as a function of time that morning was not significantly different than the seasonal average. Wind speed one hour before sunrise during the winter in our study area is a gentle breeze (i.e., 3.6-5.4 m/s) 31% of the time and a light wind (i.e., <6.2 m/s) 82% of the time. The average wind speed in our study area during the hour preceding sunrise on 16 January 2008 was $\sim$4 m/s. The predominant wintertime wind direction in the Boston area is northwesterly, which is what was observed on 16 January 2008. We were unable to find temperature vs. elevation data for Boston, thus we do not have direct evidence for a surface inversion that morning – however, the O3 data in Figure 5 strongly suggests that stratification was present before sunrise. Based on data from the MA-DEP vertical-temperature profiler in Stowe, MA, located about 40 km to the west of our study area, early-morning surface inversions were present on about $\sim$20% of days during the winter of 2008 (URL: http://madis-data.noaa.gov/cap/profiler.jsp?options=full).

Also, if only one day of data is available, I would strongly recommend presenting more

information about how well the different pollutants correlate with each other, what factors might be used to predict pollutant concentrations like particle number concentration (PCN) as a function of downwind distance, and how those compare to the other studies such as those listed in Table 1. For example, the relationship between CO2 and particle number concentration (PNC) is as strong as I have ever seen. Could CO2 (or other pollutants that are easier to measure than PNC) possibly function as surrogate PNC measures?

Response: In response to this very interesting comment we have prepared Figure B which shows the relationships between CO2 and PNC and between NOx and PNC downwind of I-93. The figure shows that early in the morning the correlations are much stronger – as indicated by higher R2 values – compared to later in the morning. This figure further illustrates one of the main points of our article that gradients in near-highway air pollutants can be highly variable and therefore exposure assessment efforts require a monitoring and modeling approach that is able to capture this variability. We will consider adding this figure to the revised manuscript.

I agree with the authors' assertion that more information about the temporal variation in near-road traffic emissions gradients is needed for health-related studies, especially in areas like epidemiology of ultrafine particle exposures. This study would fit the bill if the number of days sampled were higher.

Specific Comments Page 5, line 14: Jan. 16 was chosen out of how many days?

Response: Only one day of monitoring was performed. Our goal was to characterize a relatively typical weekday morning in the winter when the combination of light pre-sunrise winds (<4 m/s), rush hour traffic, and cold-temperature combustion conditions would yield high concentrations of traffic-related air pollutants near the highway. Wednesday, Jan. 16 met these requirements.

Section 2.3: How many instances of data removal occurred? (Line 11, page 8). Were these confirmed by video?

Response: <10% of the collected data was removed due to self-sampling or because the monitoring van was stuck in traffic behind a high-emissions vehicle. This was confirmed by video and written log. This will be better described in the revised manuscript.

Section 3.1. Do you have estimates of average vehicle speed during the times of measurements? (Sometimes traffic slows down during rush hour more than the vehicles per hour indicate, and vehicle speed can strongly influence dilution rate and PCN.)

Response: No, we did not note this, nor was this data available from the Massachusetts Highway Department (the main collector of highway data in the commonwealth). This was mentioned in the original MS on page 8, lines 13 and 14.

Section 3.2. (line 19, page 9) Can you provide an estimate of what time the "surface boundary layer" lifted?

Response: Based on the O3 data in Figure 5, the surface boundary layer lifted between 8:07 and 9:22. This was noted in the original MS on page 11, lines 16 and 17, but apparently needs greater emphasis. This will be better described in the revised manuscript.

Was this a nocturnal (radiation) surface inversion? Does it occur routinely over the winter season?

Response: Yes, we believe this is evidence for a nocturnal surface inversion. We were unable to find vertical temperature data for Boston, which makes it difficult to generalize about the frequency of surface inversions. However, based on data from the MA-DEP vertical temperature profiler in Stowe, MA, located about 40 km to the west of our study area, early-morning surface inversions were present on about ∼20% of days from 21 December 2007 to 21 March 2008 (URL: http://madis-data.noaa.gov/cap/profiler.jsp?options=full) . Thus, to the extent that vertical temperature profiles from Stowe reflect conditions in east Somerville, we conclude that surface inversions occur regularly in our study area. It should be noted that surface inversions

are more likely to occur in our highly urbanized study area compared to rural Stowe. This point will be emphasized in the revised manuscript.

In Figure 3, you have a very nice set of gradient curves, but how were the specific times chosen?

Response: The specific times were not explicitly chosen, but were rather a consequence of our study design. The goal of the monitoring effort was to characterize spatial and temporal variations in near-highway air pollution gradients throughout the morning. We drove the circuit illustrated in Figure 1, which took the better part of an hour to complete driving at about 15-20 kph, continuously for 5 hrs, with a couple of breaks to switch drivers and to do spot monitoring in other parts of the neighborhood. In this way we were able to measure the downwind gradient 5 times and the upwind gradient 3 times (see Figure 3). Our goal was to maximize the number times we completed the circuit, not to drive on any one particular street at a specific time.

The largest drop in concentrations happens between 8:07 and 9:22. It might be worthwhile to tighten that interval (or else include one more curve) to better characterize this time of rapid change.

Response: This is a very good point. Unfortunately, we do not have data between 8:07 and 9:22 to add to Figure 3; monitoring was being done elsewhere in that time window. This will be clarified in the revised manuscript.

How long an averaging time does each curve represent? Do they represent more than one reading as you imply in line 15 of page 8?

Response: Each point on our plots represents about 10 (+/- 5) 1-second data points that have been averaged together. For example, in the "8:07" run for PNC in Figure 3, that run actually took place from 8:06 to 8:10 as the AML drove from 395 to 35 meters from the highway. The mean and standard deviation are shown for locations at which the AML stopped during a particular run. During the "8:07" run the AML stopped at

150 m from the highway to measure wind from 8:07 to 8:09 and 116 data points were collected.

You indicate that the spikes marked by arrows in figure 3 likely represent the plumes from vehicles passing nearby. Can this be checked by video? Can you make corrections using CO2?

Response: Yes, this was confirmed by video and by the written log. We did not correct for this because it only happened a few times and it did not significantly affect our results. Also, we felt there was value in showing these spikes to illustrate the factors that must be considered in monitoring near highways in urban areas.

Figures 4a and 4b should be switched since 4b is referred to first on page 10, line 12.

Response: This will be corrected in the revised manuscript.

The multiple graphs of the C/Ctot might be better replaced with a single graph of the particle size distribution at multiple distances.

Response: It is not clear what the proposed graph would add. Our intent is to show how particle size distribution profiles change over time. By combining them as suggested by the reviewer, the temporal variation is lost.

Referring to the concave shape of the top curve of figure 4a, are your data sufficiently precise to make such inferences about the shape of the curves? I agree that in general they appear to show stable particle size over several hundred meters,

Response: The reviewer asks a fair question: there may be too much noise in the data to distinguish concavity from linearity. However, we make this exact point in the text on page 10, lines 12-21, and we do not feel that what we have written requires amendment.

Minor Corrections Lines 20 to 22 on page 6 looks like they might belong in the results section.

Response: This will be corrected in the revised manuscript.

Interactive comment on Atmos. Chem. Phys. Discuss., 10, 5599, 2010.

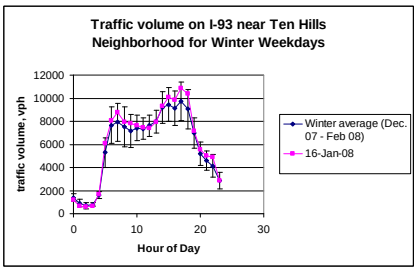

Figure A. Weekday hourly average traffic volume (± one standard deviation) on I-93 during the winter of 2008 compared to hourly volume measured on 16 January 2008. All data is from Mass Highway station # 8449; this is the closest station to our study area.

Fig. 1. Figure A. Weekday hourly average traffic volume ($\pm$ one standard deviation) on I-93 during the winter of 2008 compared to hourly volume measured on 16 January 2008.

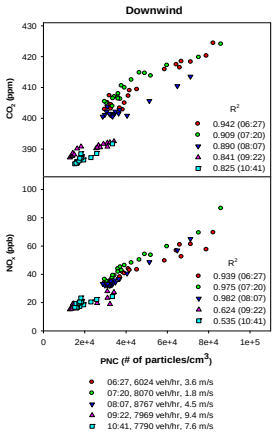

Figure B. Relationship between CO2 and PNC and NOx and PNC measured downwind of I-93 throughout the morning on 16 January 2008.

Fig. 2. Figure B. Relationship between CO2 and PNC and NOx and PNC measured downwind of I-93 throughout the morning on 16 January 2008.