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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Vertical distribution of aerosols in Mexico City during MILAGRO-2006 campaign" *by* P. A. Lewandowski et al.

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General Comments: This paper describes how a lidar system was deployed during the MILAGRO field campaign and presents some sample results. It is useful to have some sort of documentation of what was measured in the field, especially for non-standard or routine instrumentation. However, this paper fails to utilize other available measurements that could be used to help interpret the lidar measurements and the authors have not provided the scientific purpose for deploying such an instrument. There is a wealth of information that could be employed to strengthen the analyses in this study and put their measurements into perspective with other studies already published. I have made a number of suggestions to improve the scientific content of the paper.

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Interactive Discussion

Discussion Paper

Response to the General Comments:

We greatly appreciate the work and effort revising the paper.

The primary scientific purpose of the study was twofold. First, the purpose that initially drove the study (presented in page 6830 line 2–9) has been satisfied as presented in figure 6. Second, this paper presents an innovative approach to quantifying aerosol concentrations to the scientific community. The approach involved a mobile elastic lidar and aerosol size distribution measurements. This pioneering approach (or any ground-based mobile lidar aerosol measurements for that matter) is virtually non-existent in the literature. The authors intended to showcase this technique to the aerosol community with a Mexico City North-to-South transect of March the 7th, 2006, and demonstrate that such a technique can provide valueable information for aerosol research.

The manuscript was not intended to serve the purpose of an overview article linking the vertically resolved and point measurements of studies carried out at 3 supersites in MCMA. The authors are aware that an overview article is in preparation are are willing to provide necessary data from the findings.

With respect to the comments; they are much appreciated and we have made appropriate changes in the text to improve the quality of the manuscript and to meet the standards of the ACP journal.

Major Comments:

Comment: 1) What was the measurement strategy for the mobile lidar measurements and what were the scientific objectives that were going to be addressed? Right now the paper sounds like the investigators have an instrument; therefore, they deployed it in the field and to see what they would find. What problem was this deployment supposed to address? Did the measurement strategy include coordination with other instrumentation? For example, was the sampling coordinated with aircraft that could be used to intercompare the measurements (in a similar manner as the RAMA data)? A

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few additional paragraphs that answer these questions is warranted in the introduction.

Response: Yes, there was a strategy behind the measurements. The ground mobile lidar measurements followed the general coordination plan between other airborne platforms stationed in Veracruz airport. Nonetheless the logistics behind the coordination was unrealistic for a ground mobile lidar platform (traffic, timing, location, etc).

The instrument was supposed to address the problem of horizontal and verical distribution of the aerosols in Mexico City described in page 6830 line 7–9. On the day of the transect, the winds were predominantly blowing from the N to the S, with the only effluent stream to the south and out the pass, the route that was taken.

An appropriate paragraph was added to the introduction stating the difficulty of the coordination between the platforms.

Comment: 2) Was there only one transect made during the entire campaign? Or were there others that are not being described? Please be specific. If there were other transects, why not include a description of them in this paper? Will analysis of other measurements be a subject of future research?

Response: That is a good comment. As a rule, routes were selected for the mobile system based upon the daily weather prediction. Essentially the routes would cross the location of the expected plume from the city. There was only one day with the winds in the direction N-to-S. There was more than one transect but unfortunately the other transects suffered from various problem such as instrumentation malfunction, clouds in the lower troposphere, clouds obstructing the aerosol size distribution measurements, etc. The transect of March 7th shown is single most complete set of the data and therefore is most appropriate to successfully accomplish the purpose of the study. The other datasets (or parts of the datasets) from other routes have a potential for future reasearch although the research would not be directly related to March the 7th, 2006, transect.

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Comment: 3) The authors bring up an important point on page 6840 (line 13). Yes, quantities derived from lidars would be useful for modelers because it provides vertical and time variations that point samples cannot provide. But the uncertainties need to be relatively low, and I'm not sure this study shows they are low enough. A 30% overestimation in optical depth is large and the present analyses do not adequately show the uncertainties in particulate mass. It would be useful to include another plot that includes ground concentrations derived from the lidar that has been averaged to hourly intervals and then overlaid with RAMA measurements (only those within a time frame when the lidar passed by). It is difficult to assess the differences by comparing Fig. 6b and 8.

Response: The independent measurements of the optical depth from the solar photometer and the lidar provide the most reliable measure of uncertainty of the lidar inversion. The value of 30% may seem high for modelers but on the other hand it's a question of a high uncertainty or no data at all. While this level of uncertainty may seem high, it is not unusual for surface measurements of particulate properties to have similar levels of uncertainty. The uncertainty contrubution from MEE used for the study (Figure 4b, MEE=0.90$\pm$0.17 m2/g) adds to the overall uncertainty of 35%. Text complementing the uncertainty analysis of the results was added to the manuscript.

The authors do not agree that plotting ground concentrations in Figure 8 would be helpful. Nevertheless to address the comment, we would like to point out that there are certain objections in directly comparing RAMA results (and any other point measurements) and aerosol mass concentrations. First, the lidar concentrations were retrieved at 200m above the ground and RAMA measurements were ground based (while there are lidar measurements lower than 200m, the uncertainty increases as one gets closer to the ground). Second, the averaging in time would only address part of the problem, as the lidar was also moving in space. The question of averaging the concentration values in space would require some degree of spatial interpolation and could confuse readers more than clarify the problem. Lastly, the lidar measures particulates of all

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sizes while the RAMA were PM10, so to some extent they measured different things. The figure 8 is presented in the article only for the purpose of showing the order of magnitude of the concentrations and to provide a sanity check for the data analysis.

Minor Comments:

Comment: I suggest changing the title to "Vertical distribution of aerosols in the vicinity of Mexico City during the MILAGRO-2006 campaign" since the measurements were not made only within Mexico City.

Response: The title was changed as suggested.

Comment: Page 6829, line 19: It is true that vertical gradients in particulates can be used to infer PBL height, but not definitively. There can be multiple layers of particulates present, such as those from residual layers, so that defining the PBL height from vertical gradients alone would not necessarily agree with PBL height derived from meteorological measurements.

Response: Good point from the reviewer. There can be multiple layers of aerosols in the lower troposphere. It is not simply "the highest gradient" method that determines the height of the PBL. There is an established body of literature on this topic. The papers referenced in page 6829 line 19 recognize the problem of determining the height of the boundary layer using elastic lidar. Suffice it to say that lidar operators are familiar with the problem and that it is relatively easy to distinguish between residual layers and active convection layers. Having said that, it is true that it is not as simple as looking at gradients of concentrations, the text was misleading and has been modified.

Comment: Page 6830, line 26: Are the sun photometer measurements instantaneous at 1-2 intervals or are they averaged quantities over the 1-2 periods? Please define.

Response: We take that the reviewer meant page 6829 line 26. The sun photometer measurements were instantaneous at 1-2 h intervals. The text was clarified.

Comment: Page 6835, line 19: It is strange to refer to windblown dust as biogenic

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pollution. Also, wind blown dust in Mexico City usually occurs late in the afternoon when the surface wind speeds often increase. So it seems a bit odd that there would be a lot of dust around during the early morning. It would be useful to indicate the surface wind speeds from some of the RAMA stations at those times. There are also measurements of crustal material made at the T1 site.

Response: Good comment. This was an overstatement. The manuscript was changed.

Comment: Page 6836, line 19: If the winds were northerly, why is a substantial portion of the Mexico City plume extends northward between T1 and T2 (Figure 9)? In fact, the winds shown in Fast et al. (2007) are a bit more complicated than indicated here. As indicated by my other comments, the authors have not fully utilized other measurements to help explain their data.

Response: That is an excellent point. Indeed the meteorological situation was vastly more complicated than presented in the manuscript. The statement that the wind was predominantly blowing from the North to the South on March 7th, 2006, is an oversimplification. Although the reviewers opionion that the authors have not utilized other measurements is rather unfair. We have based our statements on a detailed weather report provided by Veracruz Center of Operations presenting soundings at the Mexico City airport at 12 UTC. The soundings clearly show NE to N flow between 780 and 600 mb (near the ground) and NW flow between 600 and 400 mb (where the PBL height was observed and the plume was transported from the basin to the SE). To address the question of why is the portion of the Mexico City plume extending northward. This plume infact came from a major industrial area source that is to the north of the city, E or NE of the point where it was observed by the lidar and was advected with the low level NE air flow as shown in the sounding.

Comment: Page 6836, starting at line 27: Although the authors provide a plausible explanation of the changes in the “residual layer” at 4500 ASL, there is no direct evidence of aerosol water. There were soundings made during the experiment that could

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be used to confirm whether RH was relatively high at that elevation and whether it decreased during the day. Those special sounding probably did not start yet on March 7, but the 12 UTC and 18 UTC soundings from Mexico City could be used. Another plausible explanation is that the aerosol layer was simply transported away. One must be a bit cautious on these explanations since both time and space vary in this plot.

Response: Another good point from the reviewer. We agree that there is no direct evidence of condensation of water on aerosol. The 12 UTC soundings from the Mexico City airport in fact indicate Lifted Condensation Levels (LCL) at around 580 mb which corresponds to about 4500 ASL. This strongly implies condensation of water on particles (which occurs when the RH increases above 85%, and is common at the top of the boundary layer).

The appropriate text was added to the manuscript.

Comment: Page 6837, line 21: Suggest changing “relaxed” to “decreased”.

Response: The text was changed as suggested by the reviewer.

Comment: Page 6838, lines 1-4: Again there is no evidence to support the hypothesis that the terrain acts to trap the ground pollution. Are there meteorological measurements that suggest that a shallow stable layer persists until _10 am? What about the surface wind patterns measured in the city?

Response: We agree with the reviewer. The statement is too strong. The text was changed to reflect the comment.

Comment: Page 6838, lines 5-9: In addition to PBL mixing, the lidar is moving out of the basin which also likely leads to lower concentrations.

Response: The manuscript was changed to address the reviewer’s comment.

Comment: Page 6838: lines 21-26: I do not see how plotting lidar data in 3-D is novel, nor have they described how the topography affects the vertical structure of the

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boundary layer.

Response: We agree, plotting lidar in 3D is not novel. The manuscript was changed to reflect the reviewer's comment.

Comment: Page 6840: line 8: The RAMA stations are hourly averaged values, so that would explain some of the differences as well. This is mention later in the text, but is relevant here. It seems pretty obvious that the major roadways would have localized concentrations not representative over a large area, so why were transects not performed on minor roads?

Response: The transect was not performed on minor roads because for security reasons, the risk of equipment damage (conditions of the roads) and logistics (heavily congested traffic off the highways). In many cases, there is only one route through an area (through the pass for example). Navigation through Mexico City on side streets is not quick. Although in favorable situations transects should be performed on minor roads.

Comment: Page 6840, line 26: Unless it was very windy (not shown), I would not expect the major differences between RAMA and lidar to be attributed to particles greater than 10 microns. Big particles would readily fall out otherwise.

Response: The information on vertical wind profile was added to the response earlier in the data analysis. While the major differences may have not been attributed to particles greater than 10 microns, the fact that the RAMA particle sizers had the instrumental limitation is worth mentioning in the text. That potentially could have an effect in certain conditions and therefore should have been mentioned.

Comment: Page 6841, line 1: I'm not sure what the first sentence means at all. What is the impact that is being examined?

Response: The sentence was rephrased for clarity.

Comment: Page 6841, line 2: The fact that ground pollution can reach as high as 1500

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m is inferred from boundary layer mixing (after 10 am on this particular day). This is not a very useful conclusion given that there is a lot of aircraft data over the city that has been used to infer how high material is transported above the city and on different days. The authors use the word “pollution” here, but what they really mean is aerosols, since the lidar cannot differentiate between anthropogenic and natural sources.

Response: The text was changed to stress that the findings correspond to March 7th, 2006. The word “pollution” was changed to particulate matter.

Comment: Page 6841, lines 7-12: The authors should acknowledge they are only looking at one case.

Response: Very good point. The text was changed to reflect the suggestion.

Comment: Page 6841, lines 15-16: The authors really didn’t show this, but my suggestion of an additional figure in my major comments would substantiate this statement.

Response: This comment was addressed in the major comments section. But again, averaging the lidar-derived concentrations in time/space domain would only introduce confusion for the purpose of comparing 2 points (for 7 and 8 am) for measurements that are 200 m apart vertically. The point of bringing up the RAMA measurements in this study was to give a rough order of magnitude comparison and sanity check for the lidar results.

Comment: Figure 2: The RAMA site names are far too small.

Response: The font was increased in figure 2.

Comment: Figure 6: I suggest capping the y-axis on b) to 5000 m. Right now the scale is such that much of the details near the surface are very hard to see.

Response: The scale was adjusted to match the scale of the instrument. Since the article is in the electronic format, the reader will have the ability to zoom in within the document.

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Comment: Figures 6 and 7: Why choose 200 m for these plots. Please state so in the text. Does the lidar not see anything between the surface and 200 m? That would also complicate comparisons with the RAMA surface measurements.

Response: This is a very good point. The appropriate explanation was added to the manuscript. There is a major reason why the concentrations from the lidar were retrieved from 200 meters above the ground in Figures 6c and 7. It is related to the dynamic range of the digitizer (12bit ADC). The signal observed by the detector decreases with distance as 1/R2, so within the first 200 m the signal is huge compared to the signal at for example 2000 m. By disregarding the signal from the first 200 m, the maximum cap of the signal (governed by 1/R2) is brought down to the lower values and therefore increased the dynamic resolution of the digitizer in the range of interest (500 – 3000 m). Ignoring the signal in the first few hundred meters is a common practice in co-axial lidar systems (laser coaxial with the telescope). It is a trade-off between the minimal useful range and the dynamic resolution of the signal.

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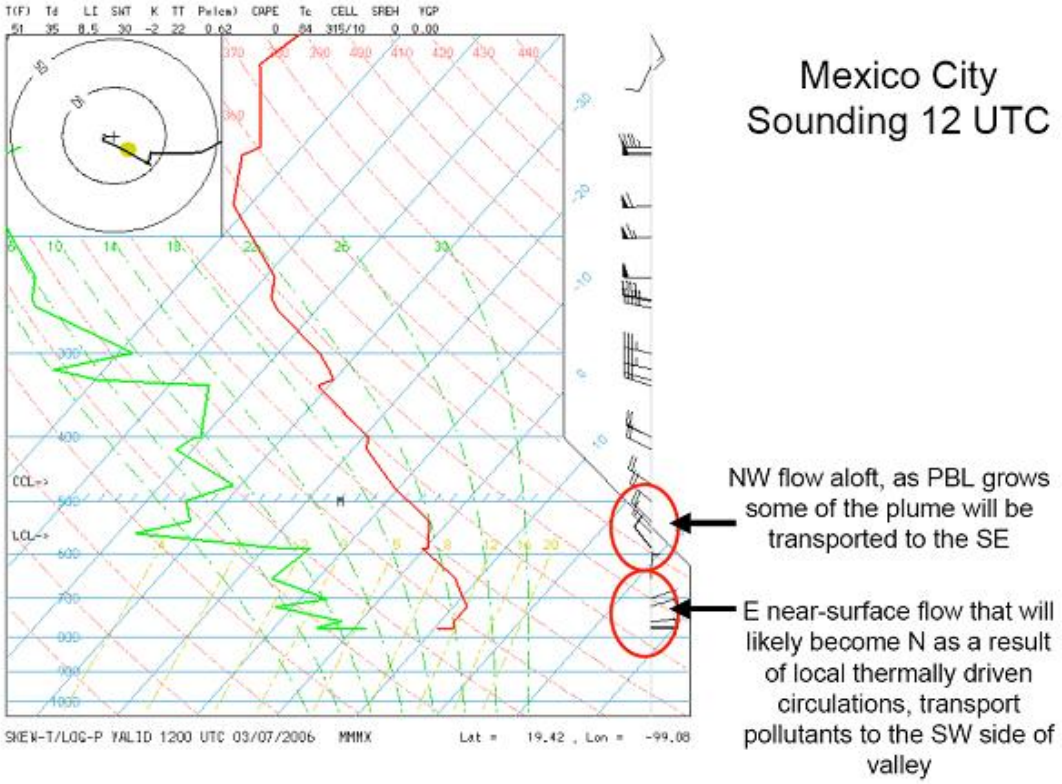

Fig. 1.

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Interactive Comment