Appendix F

Estimation of Background Concentrations for Diesel Particulate Matter

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Introduction:

Background concentrations are an essential part of the total air quality concentration to be considered in determining source impacts. Background air quality includes pollutant concentrations due to: 1) natural sources; 2) nearby sources that are unidentified in the inventory; and 3) long range transport into the modeling domain. Typically, monitored air quality data should be used to establish background concentrations.

The ASPEN model is based on the Industrial Source Complex Long Term, Version 2.0 (ISCLT) Gaussian plume model. The ASPEN model calculates concentrations at receptors at a concentric grid of 12 rings and 16 radial distances with a maximum distance 50 km. Gaussian type models are not applied for distances greater than 50 km. However, sources at distances more than 50 km from the receptor contribute to the total concentration at the receptor location.

A modeling-based approach was developed to provide a rough approximation of diesel PM concentrations due to transport from sources located between 50 km and 300 km from the receptor. This approximation was based on results from existing CALPUFF simulations from an elevated source (35 m) and a surface release (2 m) for three geographical areas: Boise, ID, Medford, OR, and Pittsburgh, PA. These simulations were made as part of a series of simulations to compare ISC results with CALPUFF results (EPA, 1993). CALPUFF is a Lagrangian puff model that was originally designed for mesoscale applications, and it can operate in a range of 0-300 km from the source (EPA, 1995). For these CALPUFF simulations, CALPUFF was run using ISC meteorology. Therefore, these CALPUFF results are not the result of a full-scale refined analysis, in which the meteorological conditions are allowed to vary in space and time.

Approach to develop concentration versus distance:

The annual average CALPUFF concentration estimates, normalized by the emission rate, are shown in Figure 1 as a function of distance from the source for 3 cases. We used a spline polynomial approximation to get analytical representation for the results shown in Figure 1. These parameterizations provide annual average concentrations in [$\mu g/m^3$], at a distance 50 km < x < 300 km from a low release source (Eq.1a) and an elevated source (Eq.1b).

$$C=6.18022\_10^{-10}\_x^{4}-5.22255\_10^{-7}\_x^{3}+1.61998\_10^{-4}\_x^{2}-2.22567\_10^{-2}\_x+1.215630 \qquad (1a)$$

$$C=3.37367\_10^{-10}\_x^{4}-2.91373\_10^{-7}\_x^{3}+9.32310\_10^{-5}\_x^{2}-1.34110\_10^{-2}\_x+0.784964 \qquad (1b)$$

Average curves for all 3 geographical areas are shown in Figure 2. The approximations 1(a-b) are also shown in the figure for a low level release and a release from the elevated source. The source emission rate is assumed to be equal 100 [g/s].

Estimating a background concentration based on the above equation:

We introduce a method to calculate the Abackground@ concentrations due to contribution from emission sources located farther then 50 km. The method is based on a simplistic approach: for each receptor, all emission sources located at a distance greater than 50 km and less than 300 km from the receptor are considered. These census tract emissions are based on the 1996 NTI (same as those used in the ASPEN model). The emissions from each source located from 50 to 300 km away from the receptor are multiplied by a distance dependent factor defined in equation 1a and summed up to obtain a concentration at the center of the grid box. In this analysis, diesel PM emissions are from on-road and non-road mobile sources, which are released at ground level. Therefore, equation 1a is applicable. In these estimates, no adjustment has been made to account for the variation in transport due to the climatology of wind direction for the area being modeled.

A schematic plot showing the relationship between the census tract centroids at a distance 50 - 300 km and modeling receptors allocated at census tract centroids is shown in Figure 3. Here the receptor is shown as a blue star and a contribution from emission sources within a ring of 50 B 300 km (shown in red) is considered. The Abackground@ concentration at each receptor is the sum of concentrations resulting from all sources within the 500-300 km radius.

Results:

Gridded diesel PM emissions from on-road and non-road sources are shown in Figures 4a and 4b. In this figure, all emissions are in equal size grids of 0.2º latitude by 0.5º longitude. This equal spacing allows for easy comparison. Emissions from mobile on-road sources are shown in Figure 4a and emissions from mobile non-road sources are shown in Figure 4b.
Modeled Abackground@ concentrations for diesel PM (on and non road) are shown in Figure 5. As can be seen from this figure, the spatial distribution of these Abackground@ concentrations is not uniform. The higher values of the Abackground@ concentrations are in the East coast and lower values are in the Midwest and West coast. There are areas where concentrations of approximately 0.6 [$\mu g/m^3$] are estimated around almost all metropolitan areas. In rural areas, the values of Abackground@ concentrations are close to 0. The overall mean value of Abackground@ concentration for the entire U.S. is 0.61 [$\mu g/m^3$], median is 0.54 [$\mu g/m^3$], 90th percentile is 1.07 [$\mu g/m^3$], and 10th percentile is 0.21 [$\mu g/m^3$].

On a national scale, the average diesel PM concentrations with background are: 0.63 [$\mu g/m^3$] for on-road emissions, 1.43 [$\mu g/m^3$] for non-road emissions, and 2.06 [$\mu g/m^3$] for total emissions.

Study limitations:

The approach described above has several limitations. The estimates assume a complete and accurate inventory. Use of the ISC meteorology in CALPUFF does not account for wind flow in rivers and valleys as in mountainous terrain. The local wind flow patterns could cause concentrations to be significantly different at specific locations. Using three specific locations to obtain a national average parameterization is simplistic. Finally, using CALPUFF with site specific information on emission release height, stack parameters, wet and dry deposition, meteorological wind field, etc. would give different estimates. Thus, these estimates of the impact of emissions located greater than 50 km but less than 300 km are considered as an approximation of Abackground@ concentration until more reliable estimates can be obtained from monitoring data or when improved modeling techniques are developed.

This analysis suggests that the limitations of ASPEN model to calculate dispersion not farther than 50 km model may cause underestimates of concentrations in certain areas, where many sources with a high emission rate are located close to each other. Using a constant value for the Abackground@ concentrations does not seem to be accurate enough and these results suggest a value for Abackground@ should be computed for each receptor.

References:

1. EPA; *Interagency Workgroup on air Quality Modeling (IWAQM), Phase 1 Report: Interim Recommendation for Modeling Long Range Transport and Impacts on Regional Visibility,* EPA-454/R-93-015; U.S. Environmental Protection Agency; Research Triangle Park, 1993.

2. EPA; *A User=s Guide for the CALPUFF Dispersion Model*, EPA-454/B-95-006; U.S. Environmental Protection Agency; Research Triangle Park, 1995.

Figure 1. Concentrations from CALPUFF for a surface and elevated release

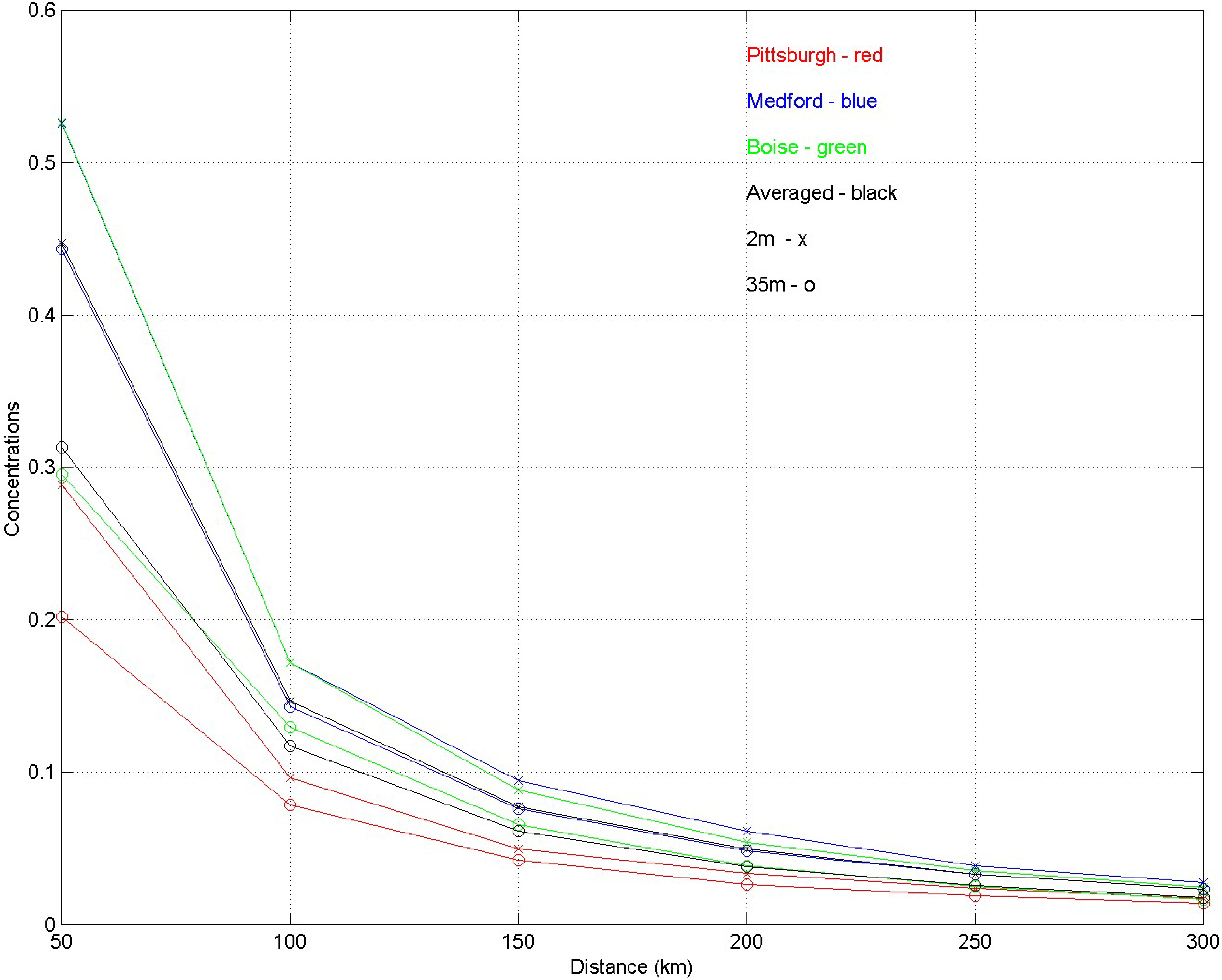

Figure 2. Concentrations from CALPUFF, average for Pittsburgh, Medford, Boise

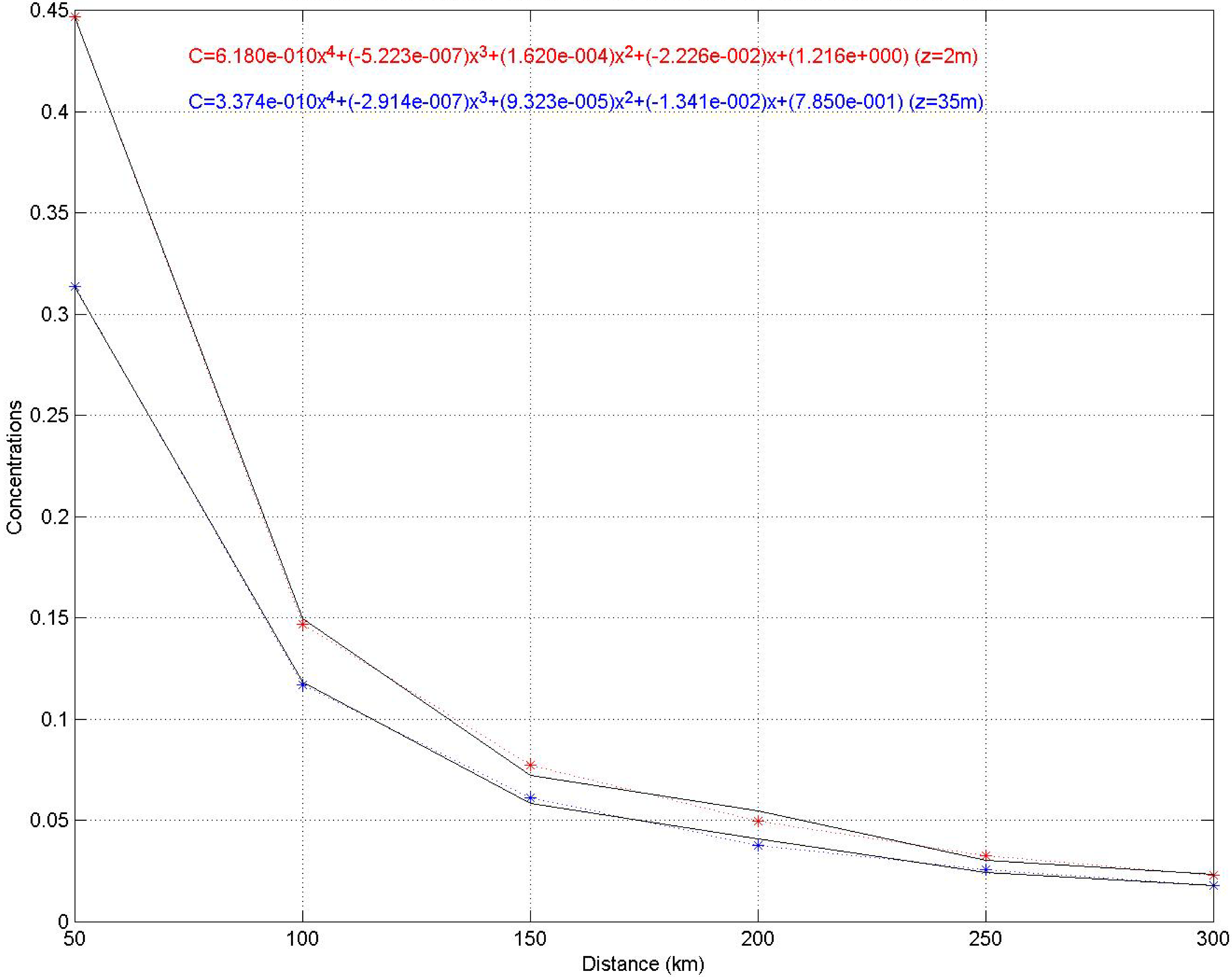

Fig.3. Schematic map of census tract centroids and a ring of 50-300 km radius

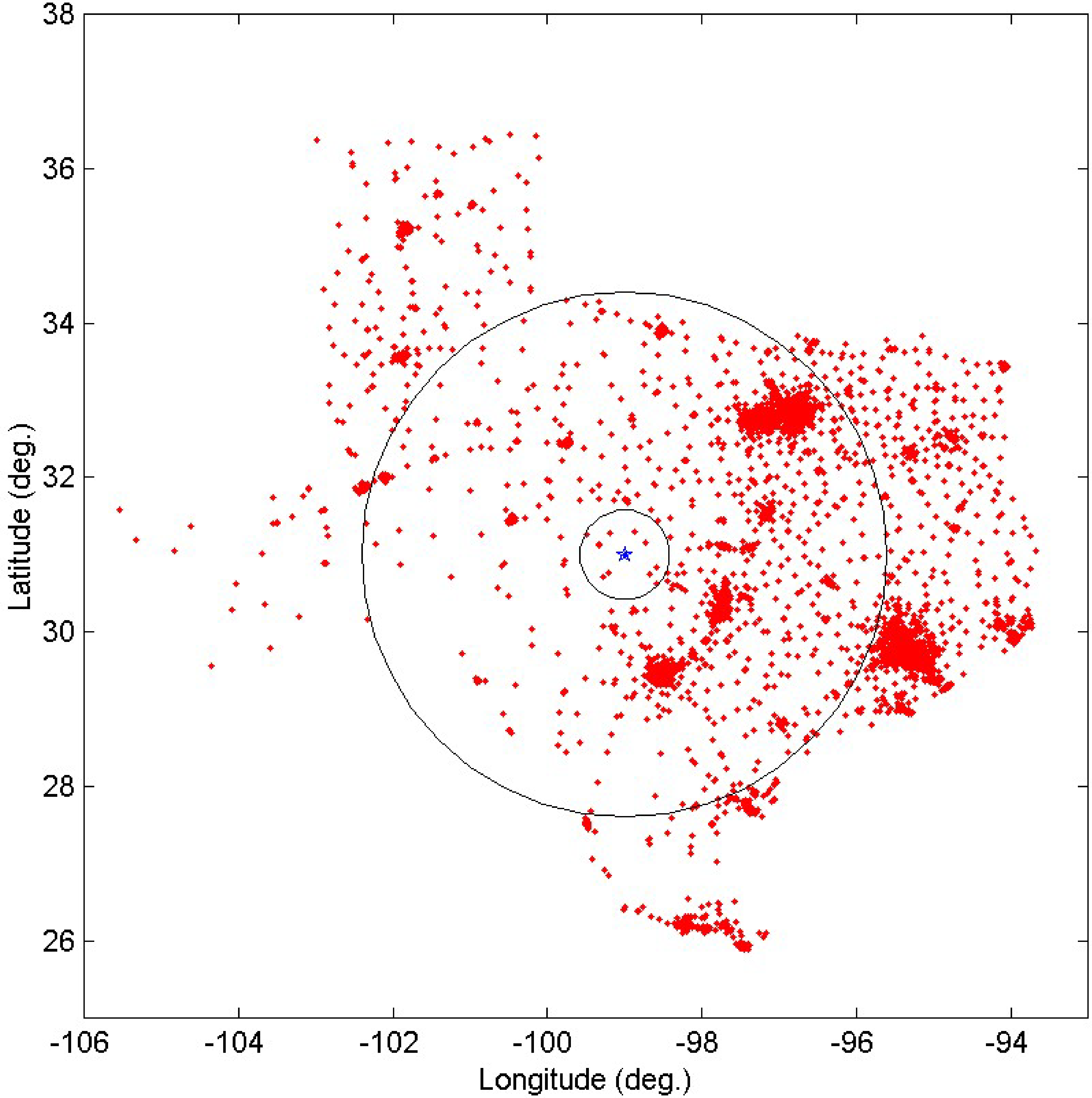

Fig.4a. Diesel PM emissions [g/s] from mobile on-road sources, 1996

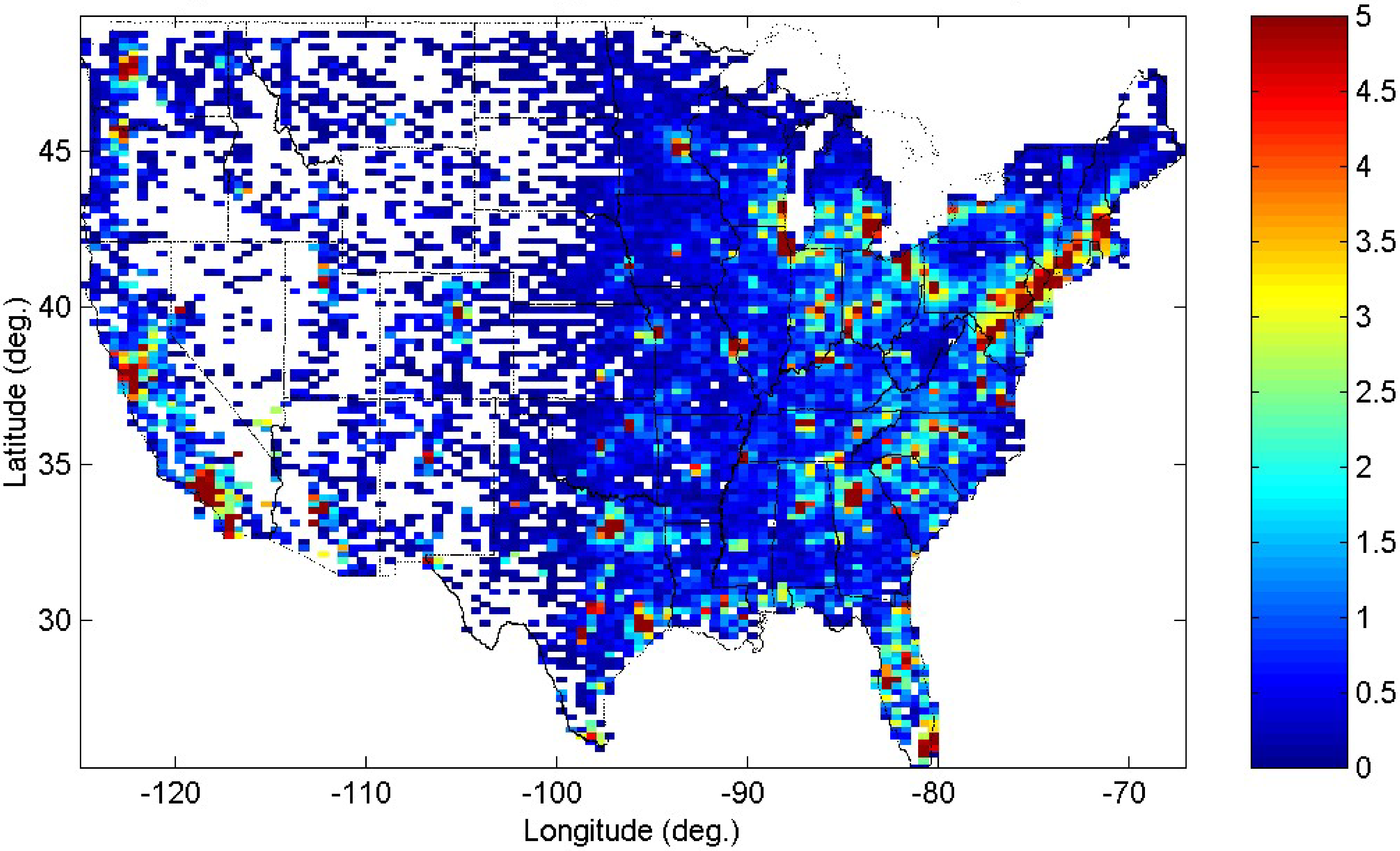

Fig.4b. Diesel PM emissions [g/s] from mobile non-road sources, 1996

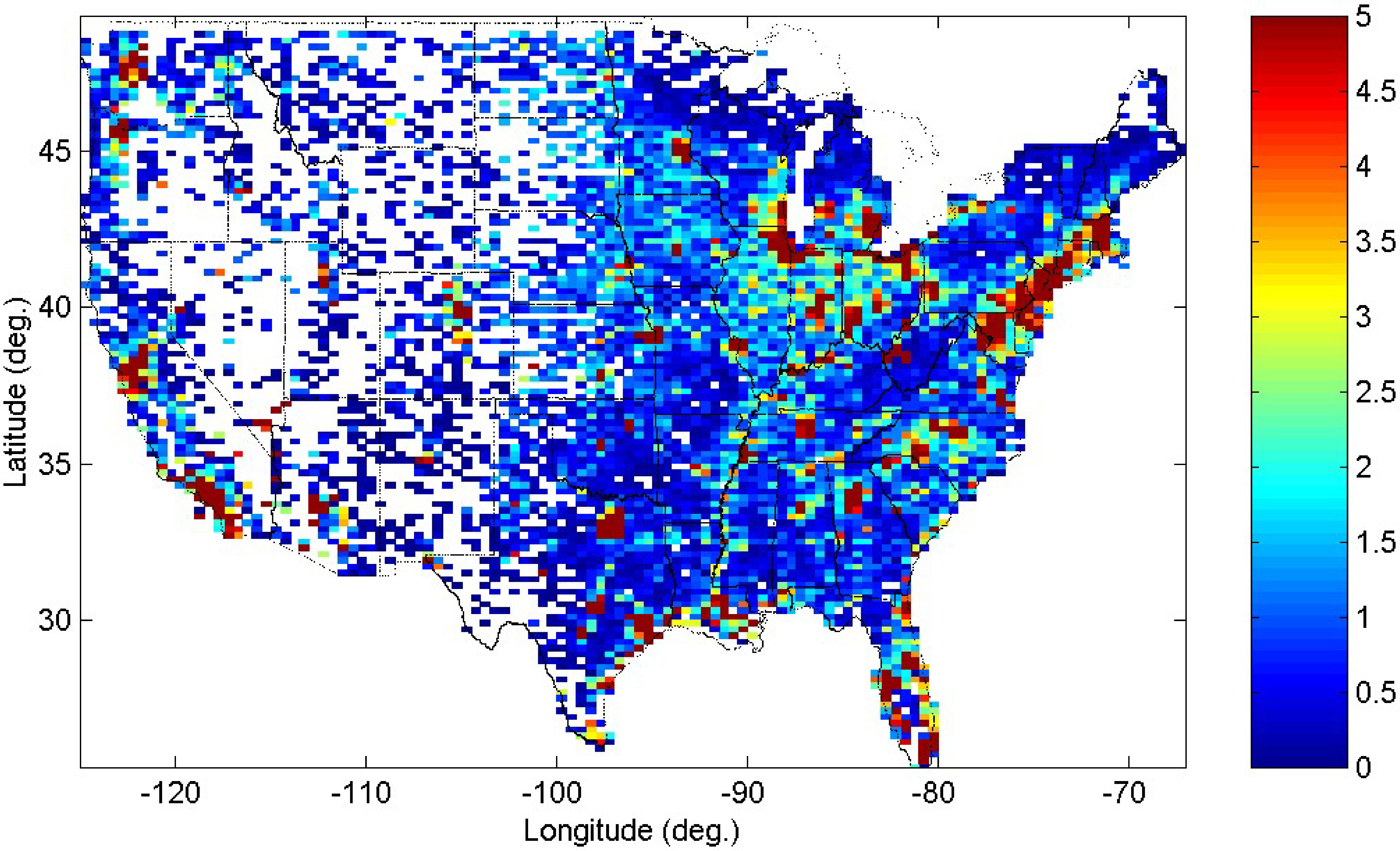

Fig.5. Diesel PM "background" concentration [$\mu g/m^3$] (CALPUFF,r=50-300km), 1996