Supplemental Material of

Spatial $PM_{2.5}$ Mobile Source Impacts Using a Calibrated Indicator Method

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Estimation of diesel and gasoline weighting factors

We use the spatial distribution of ratios of diesel/gasoline to mobile emissions in 36km resolution and ratios of mobile sources to total emissions in 4km resolution to downscale the weighting factors to 4km resolution based on Equation S1. We assume homogenies ratios of diesel to mobile emissions and gasoline to mobile emissions across the 81 4km-by-4km grids within each 36km-by-36km grid. As mobile emissions and total emissions in 36km resolution are found to be the same with the 4km resolution aggregated emissions for mobile sources and total in the same areas (slopes about 1 and R^2=0.99, Figure S1), we assume that if the 36km emissions are downscaled to 4km resolution, the spatial distributions of ratios of mobile to total emissions are the same with the 4km resolution. Therefore, we use the spatial distribution of ratios of mobile to total emissions in 4km resolution to downscale the diesel to total emission ratios. The 36km resolution emissions are for 2006, which is readily prepared in the Southeastern Center for Air Pollution & Epidemiology (SCAPE) study. We use emission ratios instead of directly using ratios of diesel/gasoline to total emissions so the results depend on relative fractions from the same platform of emission profiles.

$$\frac{E_{i,DV}}{E_{i,total}}(4km) = \frac{E_{i,DV}}{E_{i,mobile}}(36km) \times \frac{E_{i,mobile}}{E_{i,total}}(4km) \qquad \textit{Equation S1}$$

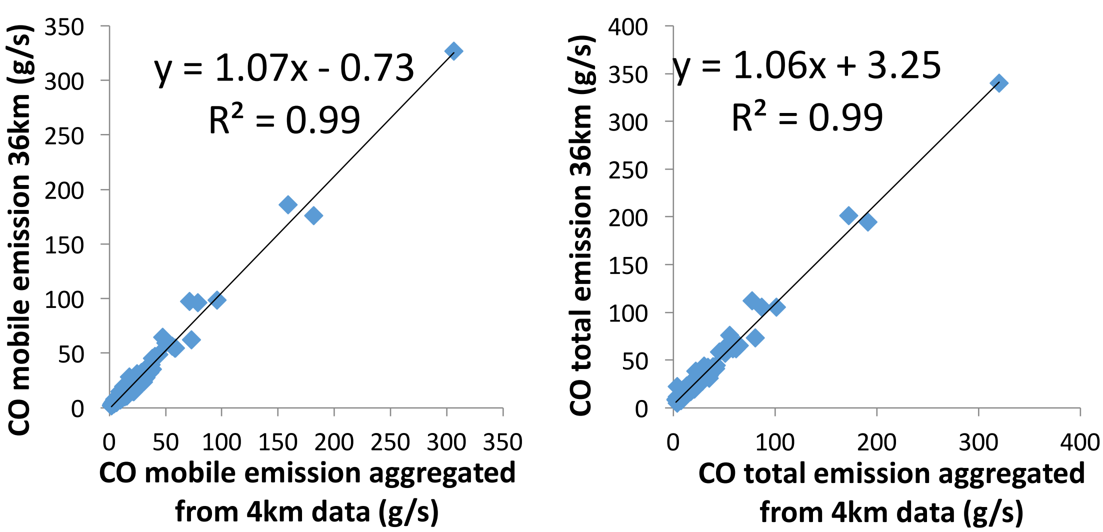

Figure S1. Comparison of the 36km emissions with 4km emissions.

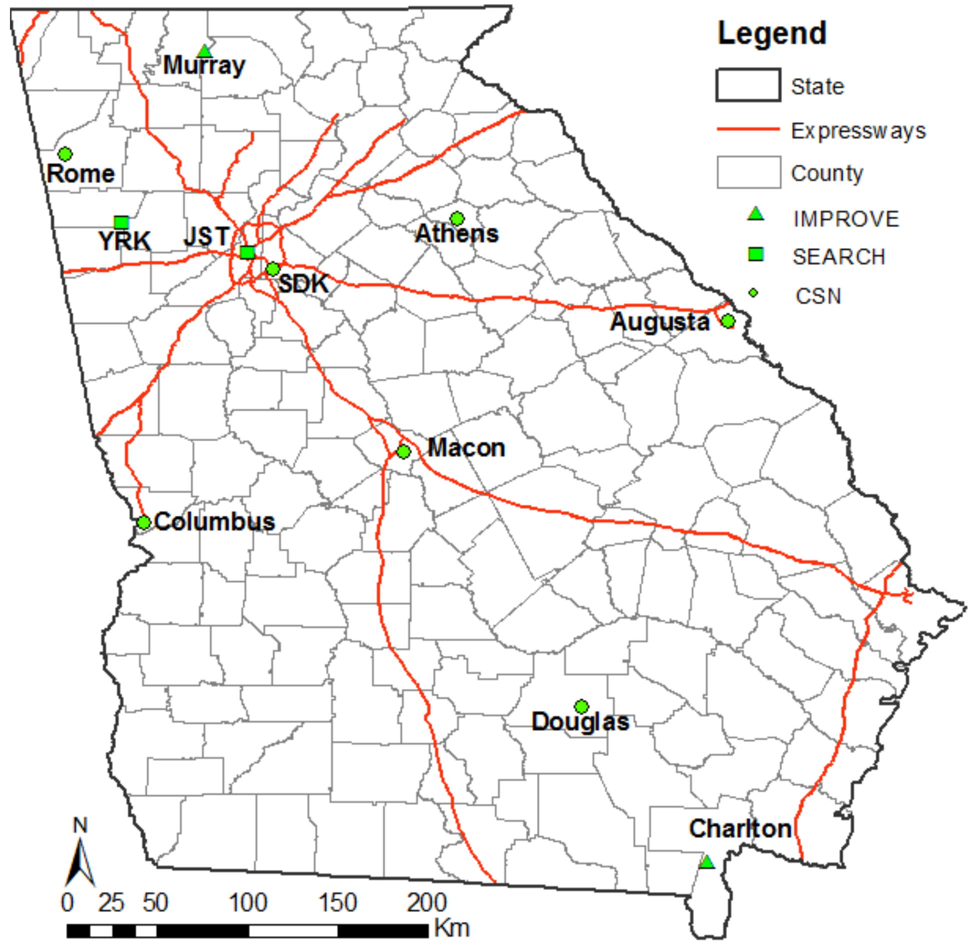

Figure S2. $PM_{2.5}$ sites with species measurements in GA.

Local IMSI method

The normalization method of the concentrations can impact the variation of the estimated IMSI indicators. Therefore, we performed the local IMSI method that uses a local standard deviation for each location in the step of normalizing the concentrations (see EQ. 1-3). This way the concentrations are normalized to their local levels and the variations of the generated indicators are representative of the local source impact variations over time. These indicators do not provide any spatial information.

In the local IMSI method, estimated CMB annual averages are obtained using the regression of the scaled spatial distribution of the $PM_{2.5}$ mobile emissions to annual averages of CMB mobile source impacts. We estimated the spatial distribution of mobile source impact calibration for each year using power regressions. Annual CMB mobile source impacts at 11 available monitoring sites in Georgia (Fig. S2) are used with $PM_{2.5}$ mobile emissions at the corresponding locations. We used one set of $PM_{2.5}$ mobile emissions for spatial distributions to avoid the impact of changes in emission model platforms over time. $PM_{2.5}$ annual average emissions for GV and DV are calibrated similarly with the weighting factors described above with Equation S3 and S4.

CMB annual averages for total, gasoline and diesel impacts at 4 km or 12 km resolutions were spatially resolved using regressions between CMB annual averages and the $PM_{2.5}$ annual average emissions for total, gasoline and diesel sources (Fig. S3). When using the emission distributions for the spatial distribution of the source impacts, we include the impact from surrounding grids. The impacts are weighted using the inverse of area weighted distance as calculated by Equation S2. We include impacts from all surrounding grids in a 36km by 36km area. The distances for each surrounding grid to central grid are shown in Figure S4. Table S3 provides regression results of the local IMSI annual averages with CMB annual averages for all years.

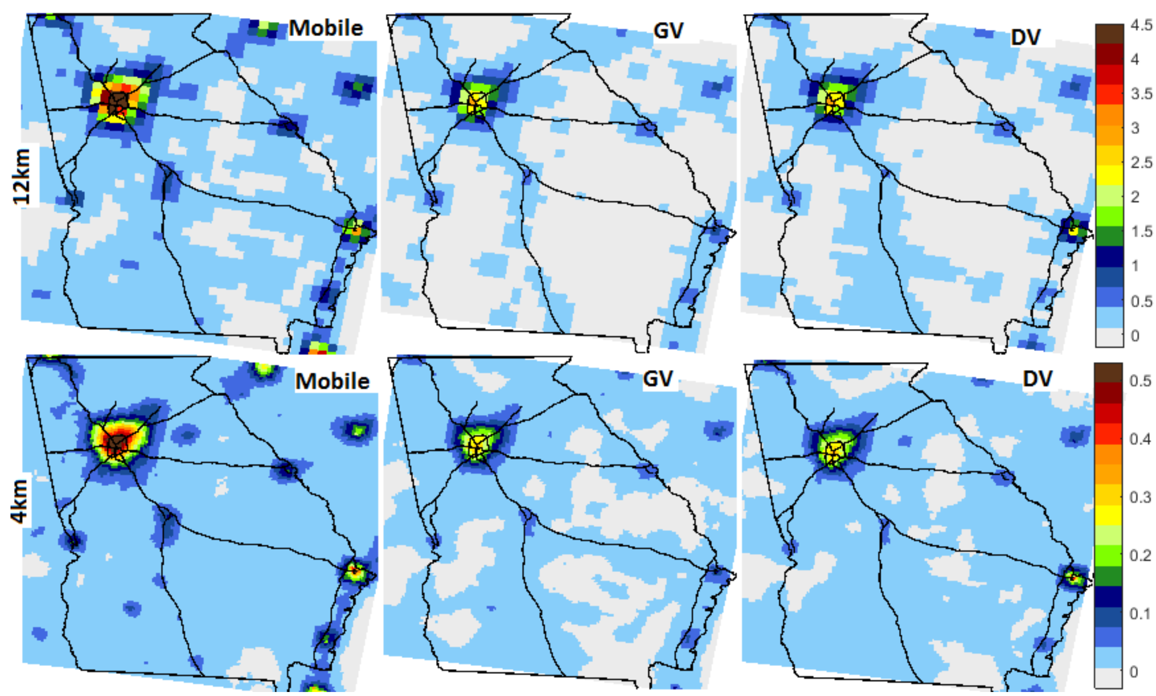

Figure S3. Spatially weighted $PM_{2.5}$ emissions (g/s) from mobile sources and GV/DV sources at 4 km and 12 km resolutions.

$$r^2 = \frac{1}{\Delta x \Delta y} \int_{x1}^{x2} \int_{y1}^{y2} (x^2 + y^2) dx dy$$

Equation S2

22.7	20.0	17.9	16.5	16.0	16.5	17.9	20.0	22.7
20.0	17.0	14.5	12.7	12.1	12.7	14.5	17.0	20.0
17.9	14.5	11.4	9.0	8.1	9.0	11.4	14.5	17.9
16.5	12.7	9.0	5.8	4.2	5.8	9.0	12.7	16.5
16.0	12.1	8.1	4.2	**1.5**	4.2	8.1	12.1	16.0
16.5	12.7	9.0	5.8	4.2	5.8	9.0	12.7	16.5
17.9	14.5	11.4	9.0	8.1	9.0	11.4	14.5	17.9
20.0	17.0	14.5	12.7	12.1	12.7	14.5	17.0	20.0
22.7	20.0	17.9	16.5	16.0	16.5	17.9	20.0	22.7

Figure S4. Distances of surrounding grids to central grid (km). The weighting factor is the inverse of distance to the sum of all inverse distances.

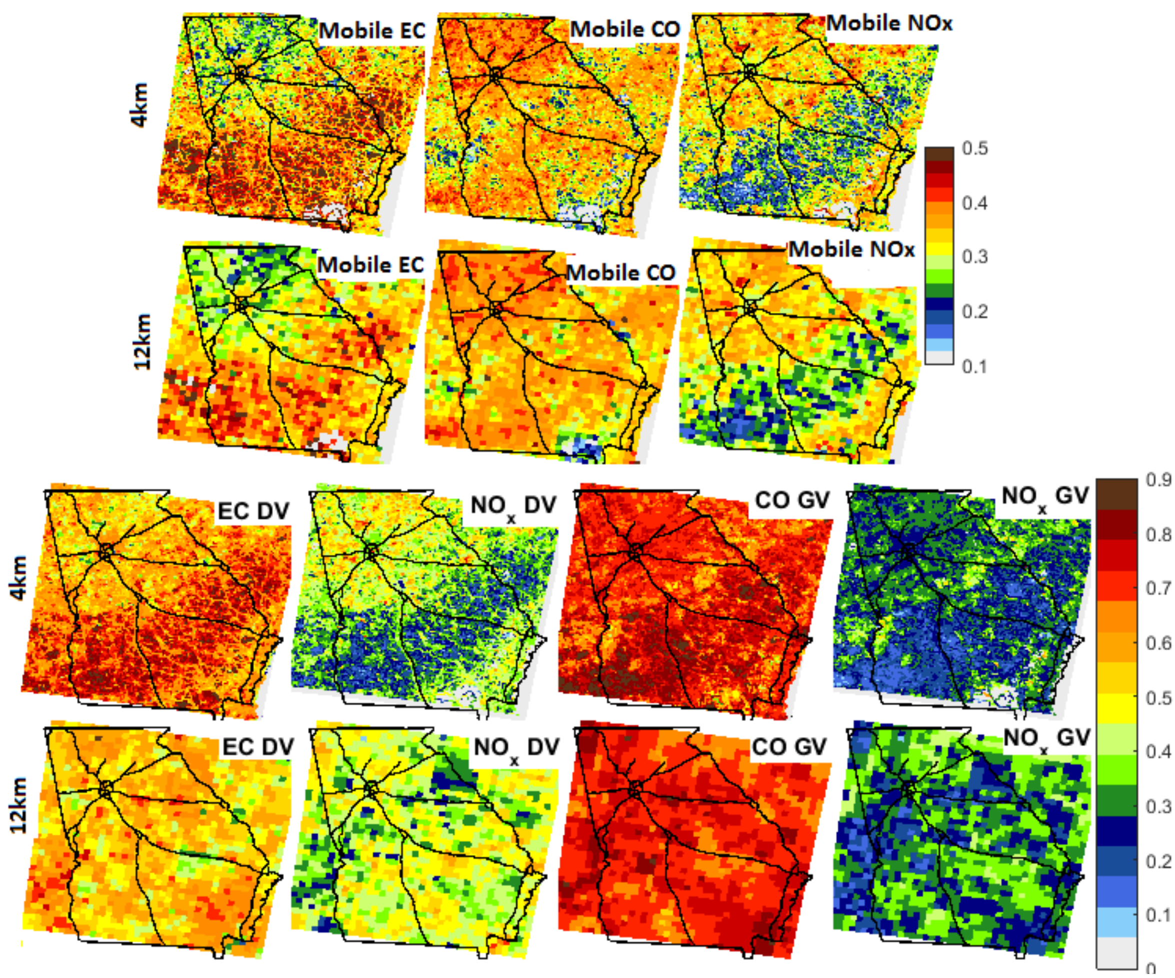

Figure S5. Weighting factors for 4km and 12km total Mobile sources, GV, and DV.

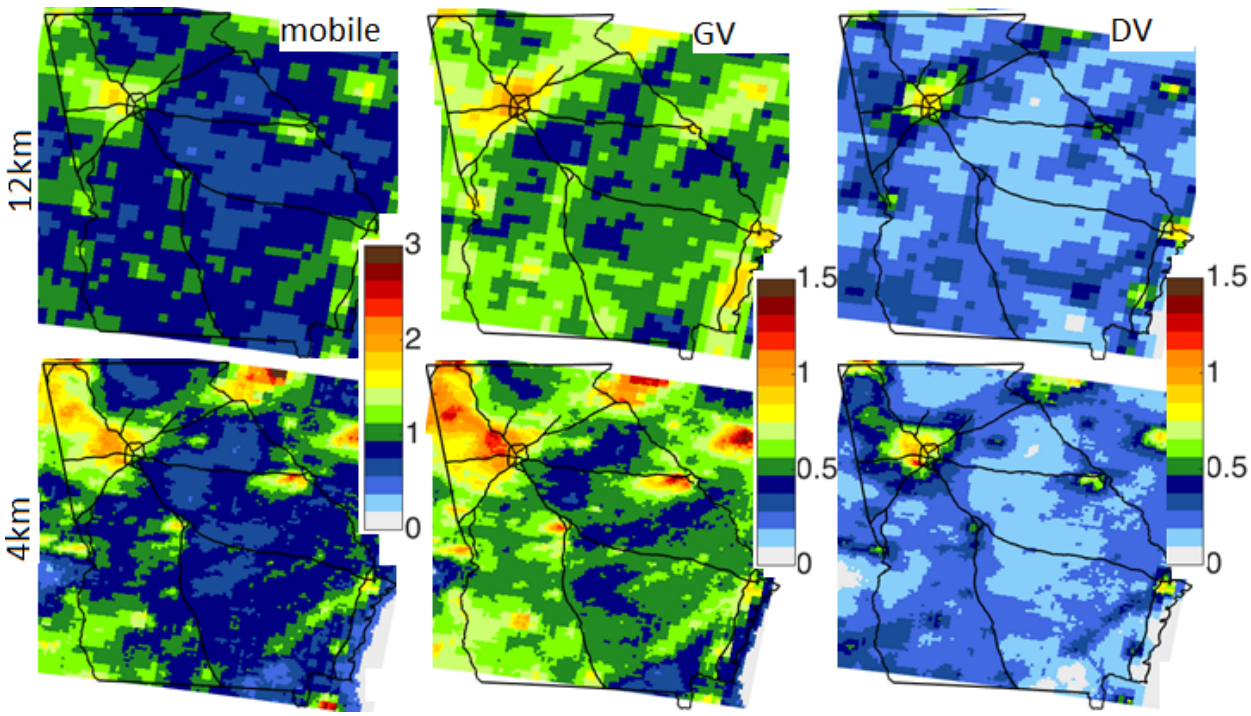

Figure S6. Daily source impact (µg/m3) spatial distribution on 2008/1/21 at 12 km and 4 km resolutions for mobile source, GV, and DV using the local IMSI method.

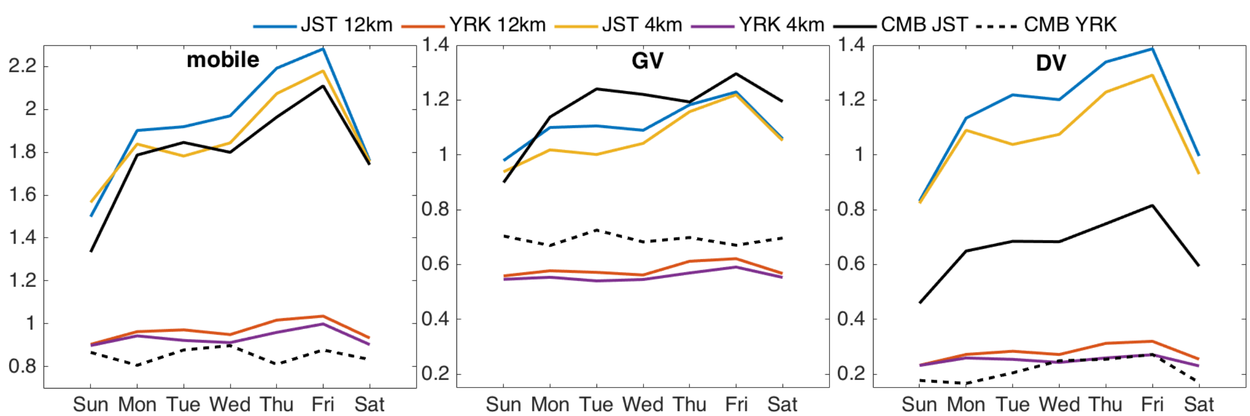

Figure S7. Weekly trends of estimated source impacts (µg/m^3) using the local IMSI method in 2008 at JST and YRK sites for comparison with CMB estimates. JST is an urban site in Midtown Atlanta and YRK is a rural site about 70 km away from Midtown Atlanta.

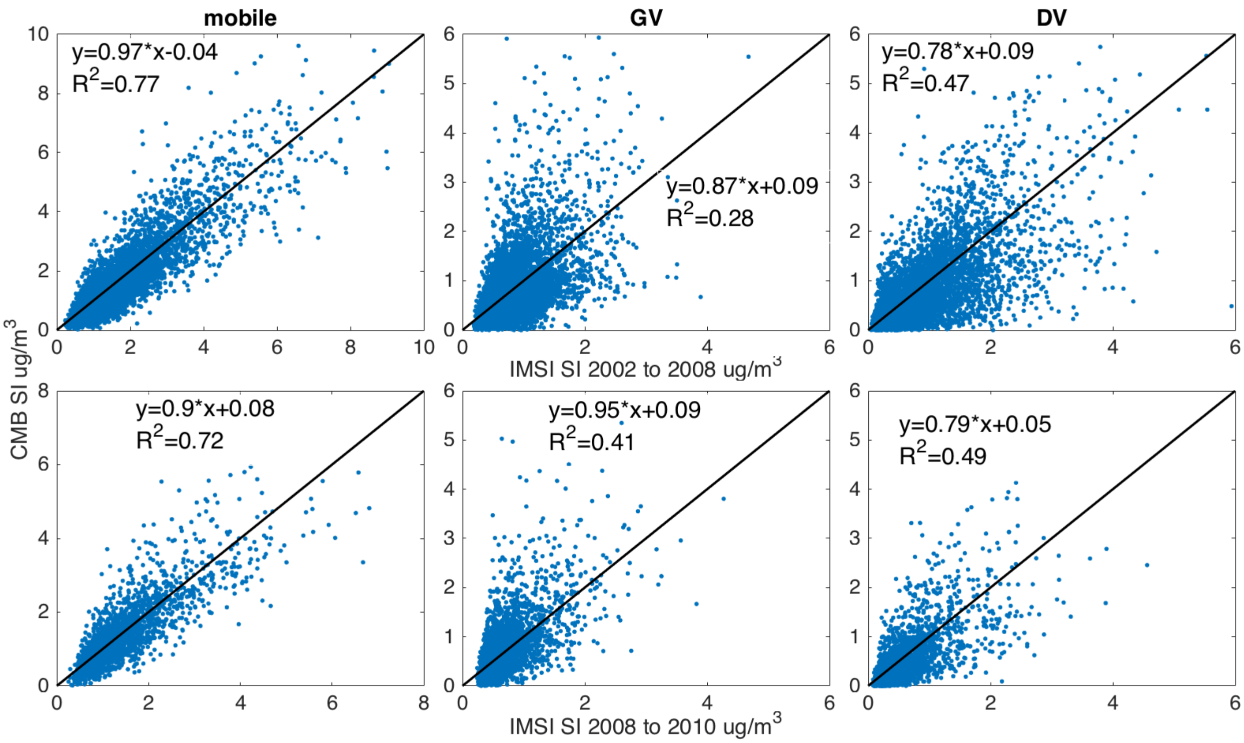

Figure S8. Daily mobile source impacts by CMB and by the local IMSI method (µg/m3) at all sites and years for total mobile, GV, and DV in 12 km resolution (2002 to 2008) and 4 km resolution (2008 to 2010).

$$PM_{2.5\_GV}(12km) = \frac{PM_{2.5\_GV}}{PM_{2.5\_mobile}}(36km) \times PM_{2.5\_mobile}(12km) \qquad \textit{Equation S3}$$

$$PM_{2.5\_DV}(4km) = \frac{PM_{2.5\_DV}}{PM_{2.5\_mobile}}(36km) \times PM_{2.5\_mobile}(4km) \qquad \textit{Equation S4}$$

Table S1. Distribution of the weighting factors.

		4 km resolution in GA			12 km resolution in GA		
		median	2.5%	97.5%	median	2.5%	97.5%
mobile	EC	0.35	0.21	0.54	0.34	0.23	0.46
	CO	0.35	0.19	0.43	0.36	0.25	0.42
	NO_x	0.31	0.15	0.42	0.31	0.19	0.39
DV	EC	0.63	0.44	0.84	0.56	0.39	0.69
	NO_x	0.37	0.14	0.53	0.44	0.26	0.56
GV	CO	0.72	0.56	0.86	0.71	0.61	0.81
	NO_x	0.28	0.09	0.39	0.31	0.17	0.41

Table S2. Weighting factors in Atlanta by Pachon et al. (2012) and in Denver and Huston by Oakes et al. (2014b).

		County level		
		Atlanta	Denver	Houston
mobile	EC	0.33	0.33	0.22
	CO	0.36	0.37	0.40
	NO_x	0.31	0.29	0.38
DV	EC	0.69	0.70	0.55
	NO_x	0.31	0.30	0.44
GV	CO	0.63	0.68	0.65
	NO_x	0.37	0.32	0.35

Table S3. Power fit regression ($y=ax^b$, where y=CMB) coefficients for calibrating the indicators to CMB source impacts. The Local IMSI method uses power fit regressions of CMB annual averages and fused $PM_{2.5}$ emissions (x) of total mobile sources, GV, and DV. The coefficients (a, b, and R^2) are calculated using the linear regression of log-transformed data.

Source		Mobile			GV			DV		
Resolution	Year	a	b	R^2	a	b	R^2	a	b	R^2
12 km	2002	0.33	1.18	0.94	0.22	0.91	0.89	0.53	0.63	0.82
	2003	0.30	1.31	0.90	0.20	0.90	0.80	0.45	0.87	0.85
	2004	0.33	1.50	0.91	0.19	1.03	0.84	0.47	0.81	0.79
	2005	0.31	1.48	0.89	0.20	0.98	0.85	0.47	0.88	0.81
	2006	0.30	1.58	0.94	0.18	0.99	0.86	0.46	0.89	0.84
	2007	0.28	1.41	0.88	0.15	0.83	0.82	0.57	0.98	0.73
	2008	0.23	1.30	0.83	0.20	0.90	0.79	0.50	0.69	0.72
4 km	2008	0.22	2.08	0.77	0.19	1.32	0.76	0.48	1.85	0.71
	2009	0.25	1.83	0.70	0.17	1.04	0.77	0.24	0.83	0.42
	2010	0.32	2.54	0.79	0.20	1.28	0.80	0.43	1.72	0.57

Table S4. NMB and NRMSE for mobile source, GV, and DV impacts, on PM2.5 in comparison with CMB source impacts using Local IMSI method.

		mobile	GV	DV
NMB	12km	0.132	0.010	0.280
	4km	0.193	-0.002	0.426
NRMSE	12km	0.514	0.675	1.146
	4km	0.581	0.628	1.098