SECRETARÍA DE MEDIO AMBIENTE Y RECURSOS NATURALES

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Mobile source emission estimates using remote sensing data from Mexican cities

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Motivation and study goals

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Air quality in Mexican cities

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Urban area	Population (millions)	First pollutant of concern		Second pollutant of concern	
		Pollutant	Days in which NAQS are exceeded (%)	Pollutant	Days in which NAQS are exceeded (%)
Ciudad Juárez	1.3	Ozono	1.1%	PM_{10}	na
Guadalajara Metropolitan Area	3.7	Ozono	16.7%	PM_{10}	7.7%
Mexico City Metropolitan Area	19	Ozono	50.5%	PM_{10}	0.12%
Monterrey Metropolitan Area	3.7	PM_{10}	28.7%	Ozono	7.9%
Toluca Metropolitan Area	1.8	PM_{10}	41.3%	Ozono	2.2%

na= not applicable (six-days sampling) total number.

SEMARNAT, 2009. "Tercer Almanaque de datos y tendencias de la calidad del aire en nueve ciudades mexicanas", Instituto Nacional de Ecología, México, D.F.

National Emissions Inventory (NEI 1999)

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- México's NEI shows transport is the main source of NOx and VOC emissions
- However, in Mexican cities, mobile source emission inventories are traditionally calculated using emission factors and deterioration rates developed by the US-EPA

México-specific data for urban areas besides Mexico City is required to improve emissions estimates from mobile sources (vehicle characteristics, activity data, emission factors), to design adequate policies and measure progress of on-road fleet.

Goals

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- Assess the emission characteristics of in-use vehicle fleet, in terms of vehicle age and type
- Obtain emission factors, activity data and relevant characteristics of in-use vehicles in the Monterrey Metropolitan Area
- Derivate a fuel-based emissions inventory based on information gathered through the use of a remote sensing device and surveys.

Provide national policymakers and city officials with input for decision making.

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Method

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Emissions

- Remote sensing system (RSD4600)
- CO, HC, NO, CO2 and opacity measurements
- License plates, speed and acceleration were registered by the RSD
- Valid readings with matching license plate were used for the analysis

Emissions

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- Duration: ten days (May 27 to June 5, 2008), approx. six hours (3 to 4 thousand vehicles per day)
- Ten different sampling sites in seven different municipalities in the MMA
- Sites were selected to ensure diversity of land use and socioeconomic strata
- Vehicle counts at selected sites: 200 to 2,000 per hour
- Average vehicle speed: 5-65 mph
- Vehicles were under slight acceleration

Fleet characteristics

- **RSD readings:**

  - Vehicle types distribution (automobiles, pick-ups, SUVs) from license plates database

- **Vehicle counts:**
  - To estimate actual size of on-road fleet
  - Carried out at selected intersections near RSD sampling sites

- **Sales statistics:**
  - From national Association of Automobile Manufacturers (AMIA)
  - To estimate mortality curves and size of on-road fleet

Activity

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- Surveys
  - At selected service stations near the RSD sampling points
  - To estimate VKT per vehicle type

Emissions inventory

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$$E_{ijk} = Ef_{ijk} * VKT_{ik} * N_{ik}$$

Where E_{ijk} = Emission per type of vehicle (i), pollutant (j) and stratum (k), (g/year)

EF_{ijk} = Emission factor per type of vehicle (i), pollutant (j) and stratum (k), (g/km)

VKT_{ijk} = Vehicle kilometers traveled per type of vehicle (i) and stratum (k), (km)

N = Number of vehicles per type (i) and vehicular stratum (k)

EF: from the data collected by the RSD

VKT: Data collected through surveys

N: estimated with vehicle counts and local sales statistics

Emissions inventory (2)

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Fuel-based emission factors:

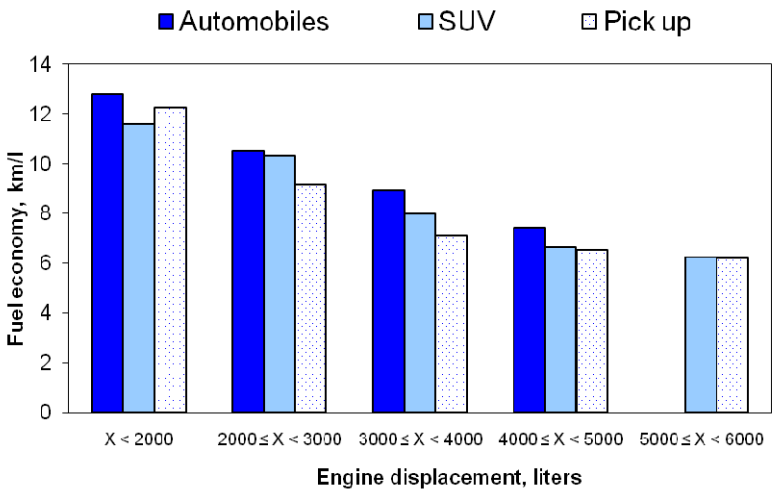
- g CO/gallon = 5506 * %CO/(15 + 0.285 * %CO + 2.87 * %HC)
- g HC/gallon = 8644 * %HC/(15+ 0.285 * %CO + 2.87 * %HC)
- g NO/gallon = 5900 * %NO/(15+0.285 * %CO + 2.87 * %HC)

where %CO = %v exhaust concentration of CO

%HC = %v exhaust concentration of HC

%NO = %v exhaust concentration of NO

Fuel economy was used to transform the emission factors of mass/volume (g/gallon) units to mass/distance (g/km) units.



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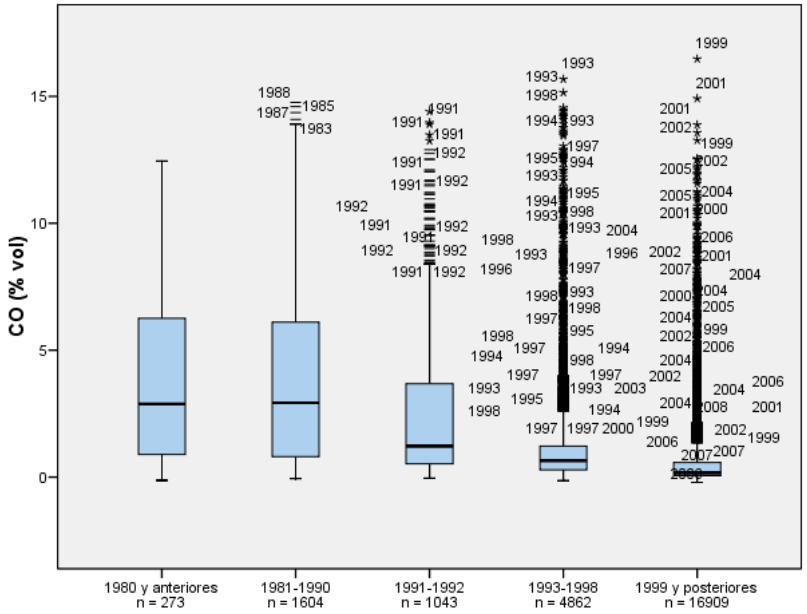
Results



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Number of readings per sampling site

Date	Site	Total readings	Valid readings with matching plate
27-May-08	1	5,171	3,026
28-May-08	2	4,375	2,463
29-May-08	3	4,801	2,986
30-May-08	4	3,966	2,760
31-May-08	5	4,513	3,144
01-June-08	6	3,045	1,928
02-June-08	7	6,123	4,313
03-June-08	8	3,767	2,199
04-June-08	9	4,966	3,367
05-June-08	10	2,232	1,056
	Total	42,959	**27,248**
Readings used for the analysis (%)			**63.43**

Location of sampling sites

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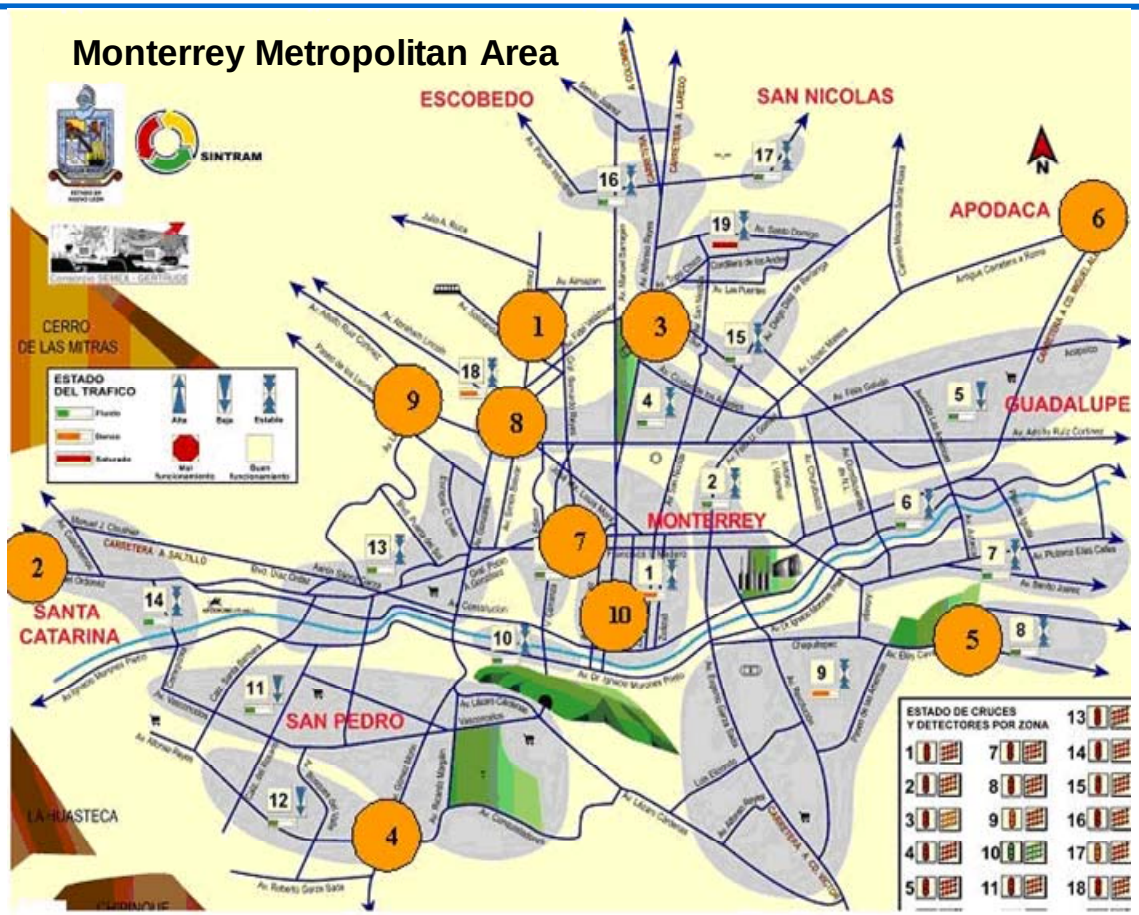
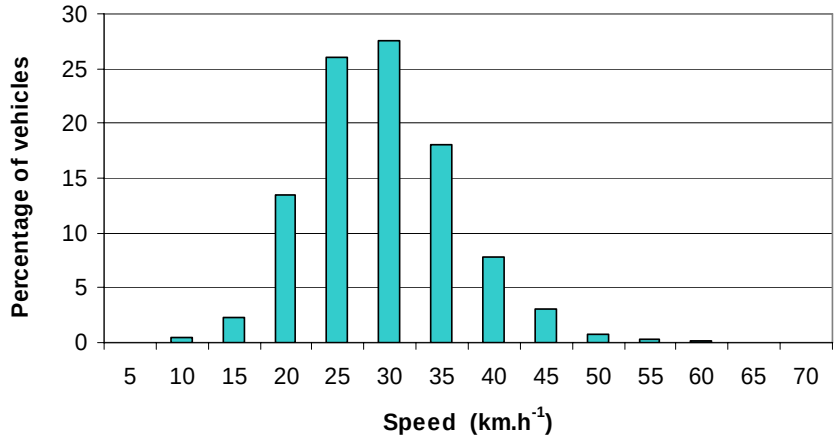
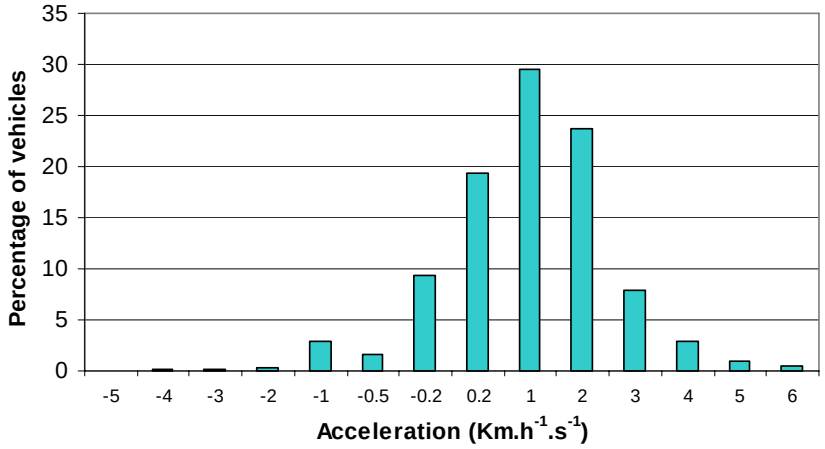


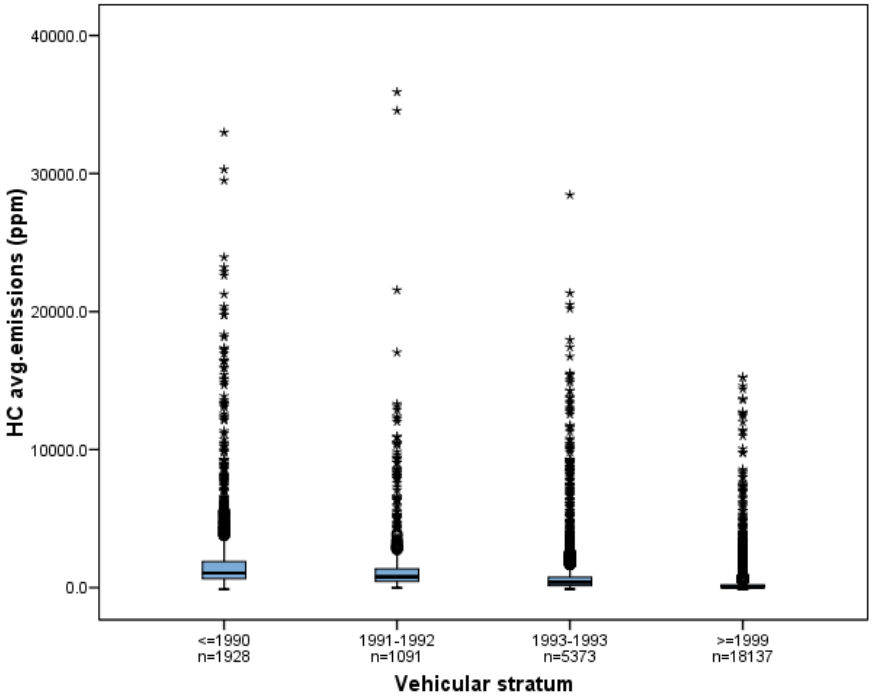
Speed and acceleration distribution

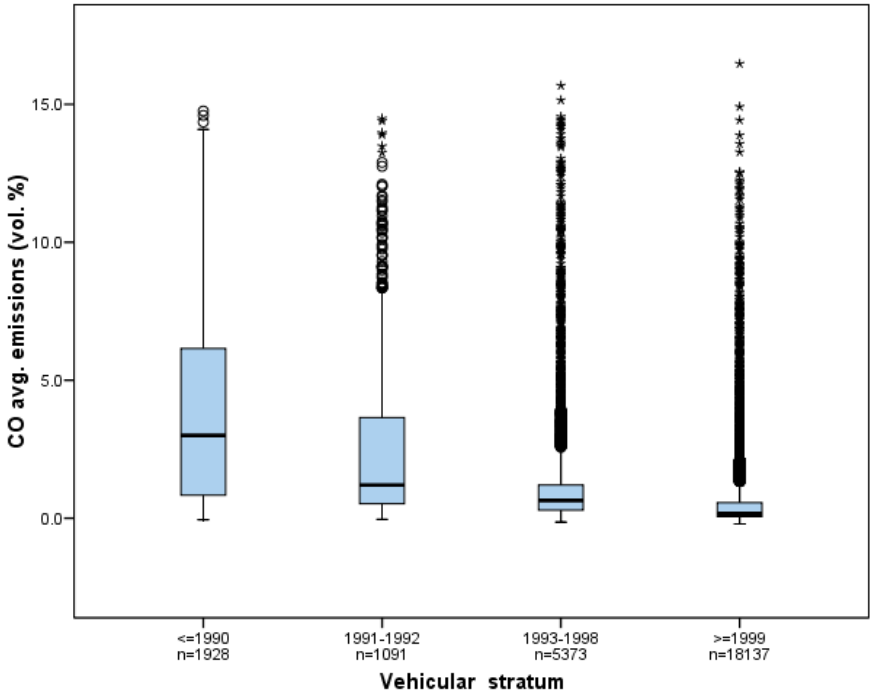




- Vehicles were driven between 20 and 35 km/hr
- Approx. 50% of the vehicles were driven between 25 to 30 km/hr
- 7% of the sample was driven in deceleration mode, about 85% in acceleration and 8% were in cruising mode
- This behavior of speed and acceleration is consistent with other studies

Emissions vs. technology





- 1990 and previous model-years: vehicles with no emission control systems (1,928)
- 1991-1992 model-years: vehicles with two-way catalytic converters (1,091)
- 1993 and onwards: this group includes, vehicles with three-way catalytic converters, electronic fuel injection (23,510)

Emissions per sampling site

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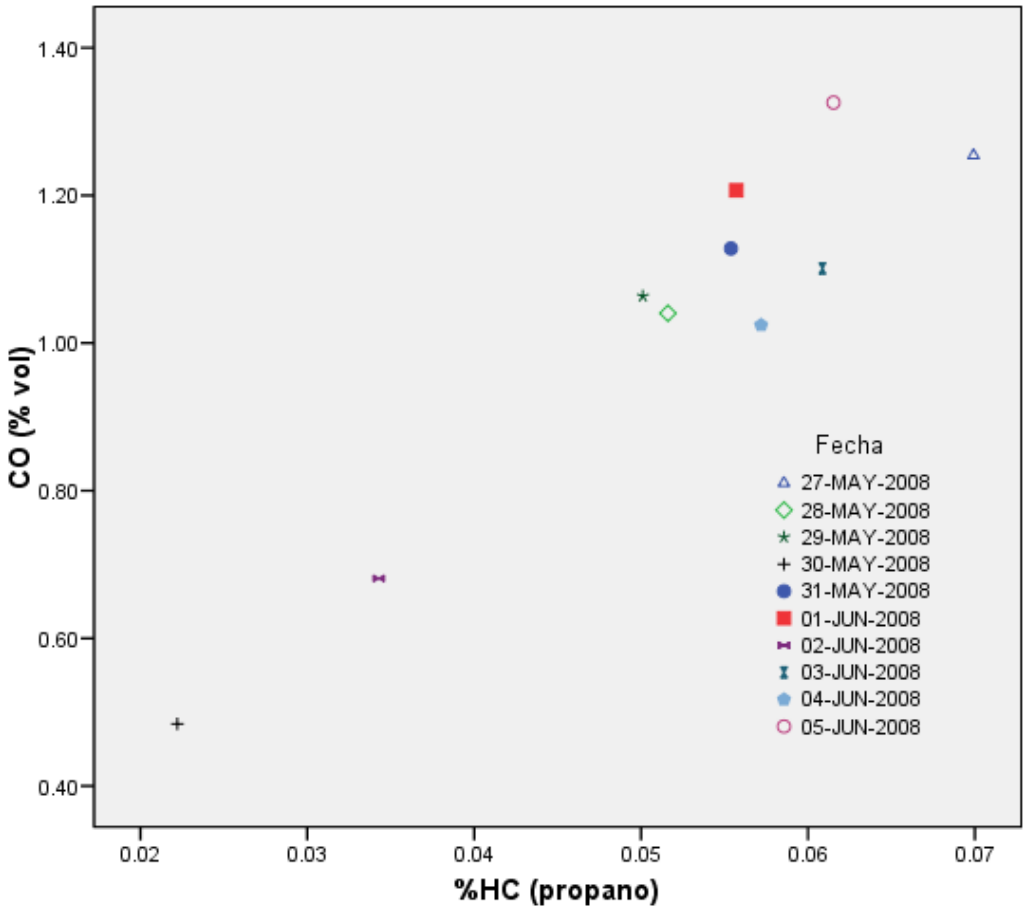
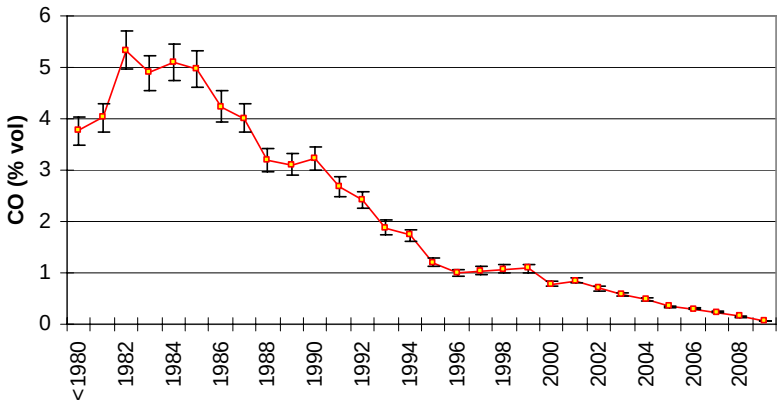
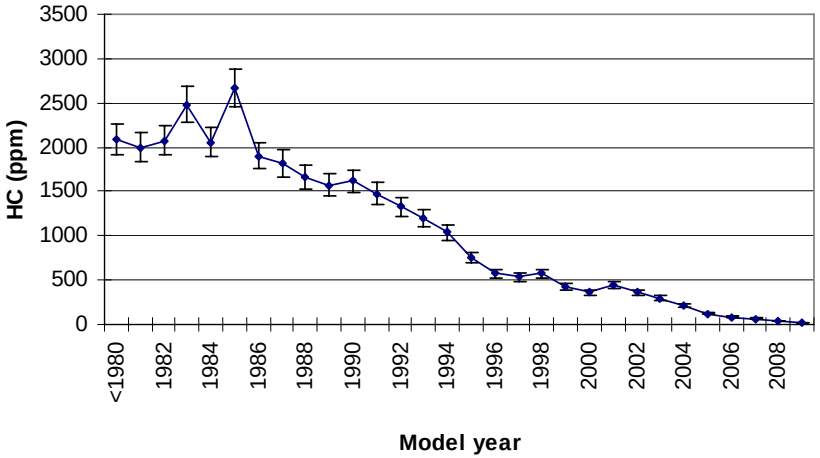
The vehicular emission per sampling site is strongly related whit the following aspects:

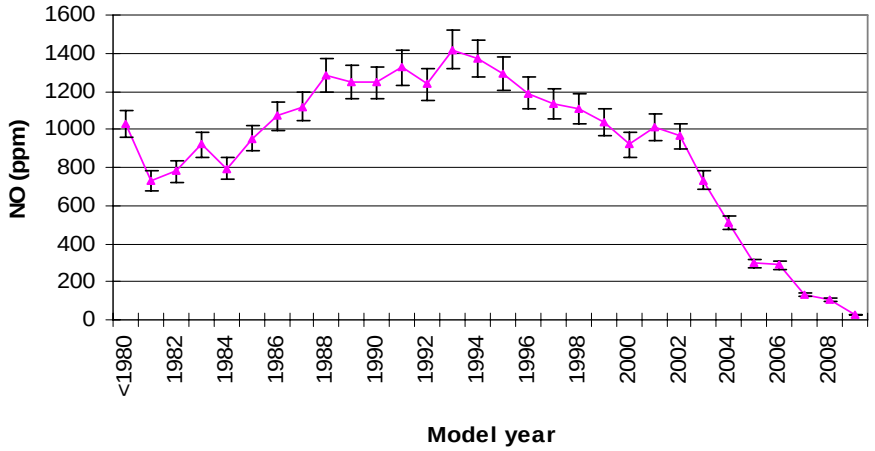
- Socioeconomic activity
- Vehicle fleet distribution by type
- Vehicle model-year



Emissions vs. model-year







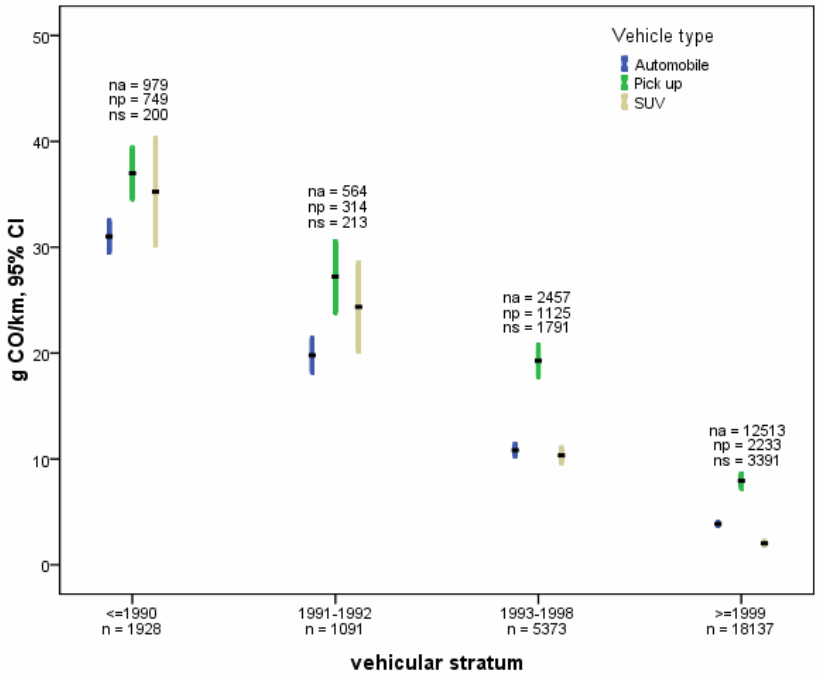
Fleet characteristics and activity

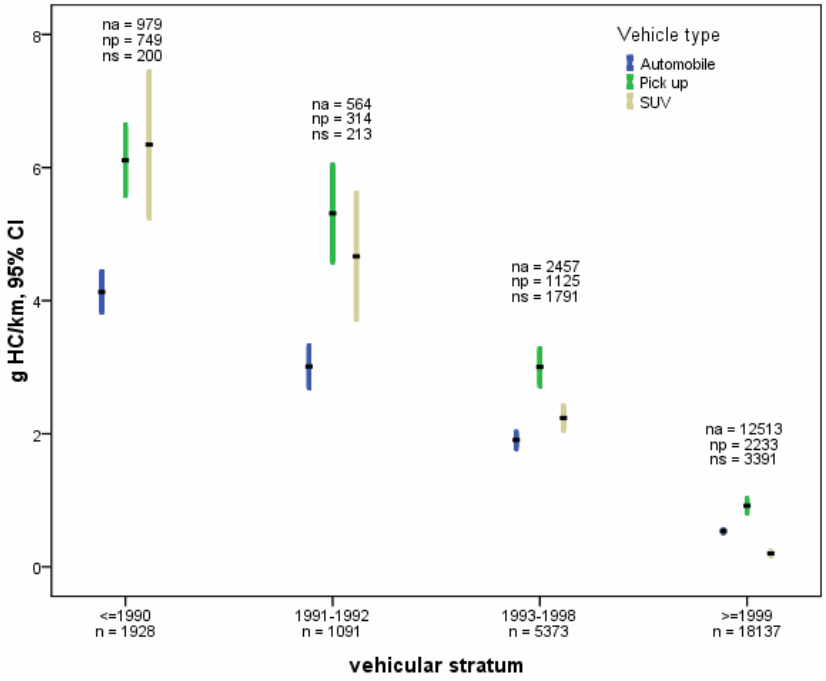
Type of vehicle	Technolgy stratum	Technology	Number of vehicles	Traveled km yr^{-1} (millions)
Automobiles	>=1999	MPFI[a], TWC[b]	421,064	14,889
	1993-1998	MPFI[a], TWC[b]	82,831	2,929
	1991-1992	Carburetor, oxidative catalyst	19,014	672
	<=1990	Carburetor, no emission control	33,004	1,167
Pick up	>=1999	MPFI[a], TWC[b]	103,589	2,440
	1993-1998	MPFI[a], TWC[b]	51,910	1,223
	1991-1992	Carburetor, oxidative catalyst	14,489	341
	<=1990	Carburetor, no emission control	34,560	814
SUV	>=1999	MPFI[a], TWC[b]	121,129	2,696
	1993-1998	MPFI[a], TWC[b]	63,769	1,419
	1991-1992	Carburetor, oxidative catalyst	7,584	169
	<=1990	Carburetor, no emission control	7,121	158

[a] Multipoint injection; [b] Tree way catalyst

Results:

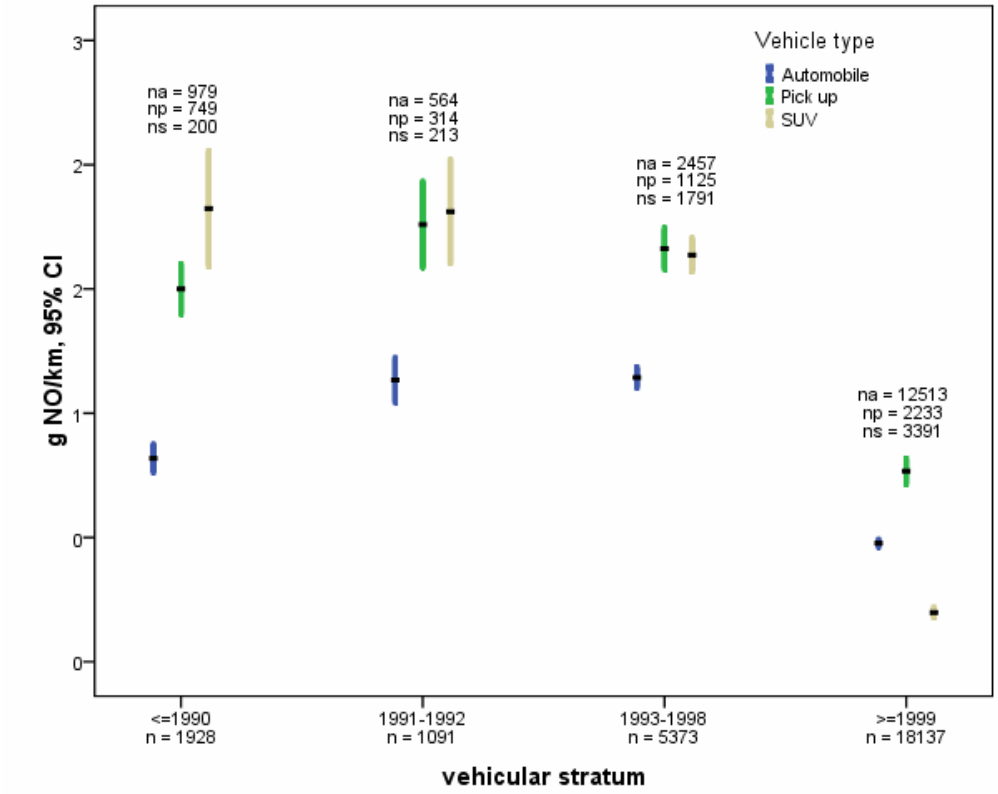
Emissions factors





Results:

Emissions factors



Emissions inventory vs. technology stratum

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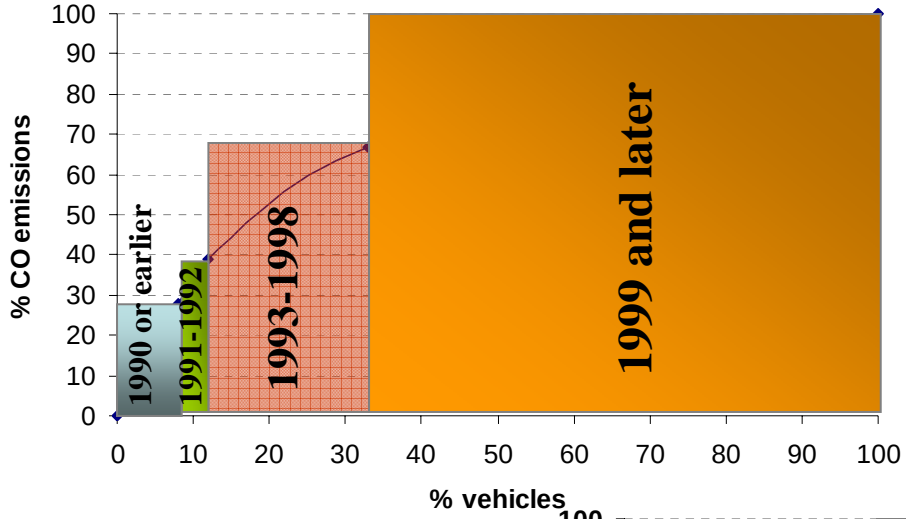
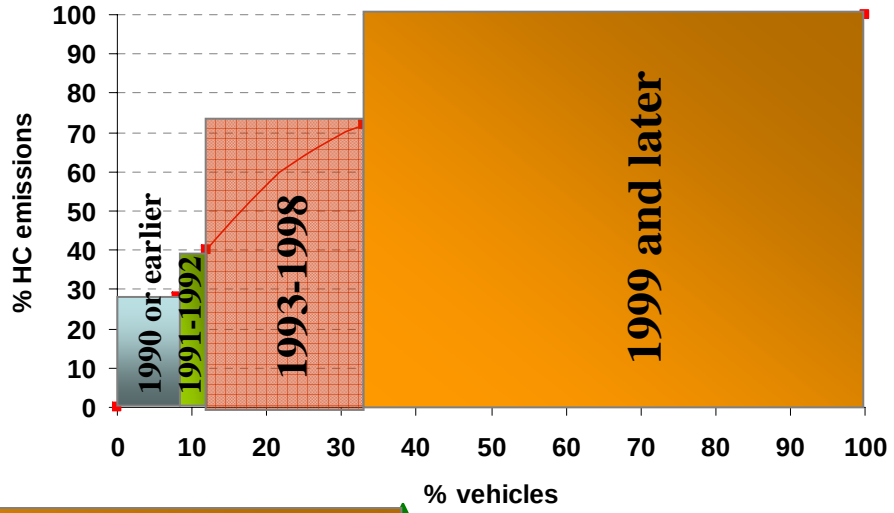
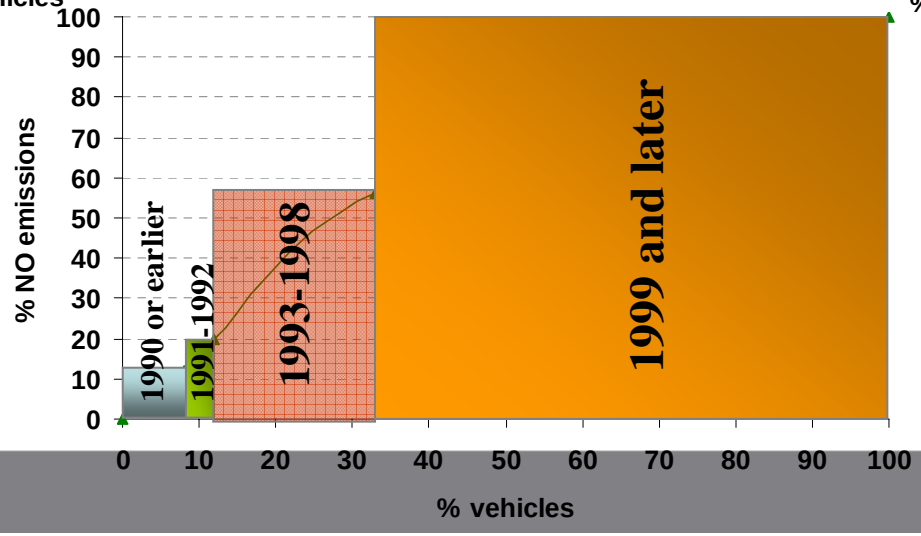
Vehicular stratum	Number	% of vehicles	Emission (Ton/year) ± 95% CI contributions (%)					
			CO	%	HC	%	NO	%
≤1990	74,685	**8**	71,897 ±2 ,529	**28**	10,801 ± 491	**28**	2,465±165	**12**
1991-1992	41,086	**4**	26,712 ± 1,911	**11**	4,624 ± 371	**12**	1,668±124	**8**
1993-1998	198,509	**21**	69,951 ± 4,172	**28**	12,428 ± 811	**32**	7,706±272	**36**
≥1999	645,781	**67**	82,216 ±7,464	**33**	10,747±1,450	**28**	9,511±486	**44**
Total	**960,062**	**100**	**250,776±16,076**	**100**	**38,600±3,124**	**100**	**21,350±1,046**	**100**

Emissions inventory vs. technology stratum (2)







Emissions inventory vs. vehicle type

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Type of vehicle	Vehicles in MMA		Emission (Ton/year) ± 95% CI contributions (%)					
	Number	%	CO	%	HC	%	NO	%
Automobiles	555,912	**58**	138,730 ±8,336	**55**	20,402±1,620	**53**	12,183±543	**57**
Pick up	204,547	**21**	82,218±4,427	**33**	12,685±860	**33**	5,716±288	**27**
SUV	199,603	**21**	29,829±3,314	**12**	5,513±644	**14**	3,451±216	**16**
Total	**960,062**	**100**	**250,776±16,076**	**100**	**38,600±3,124**	**100**	**21,350±1,046**	**100**

Emissions inventory vs. vehicle type (2)

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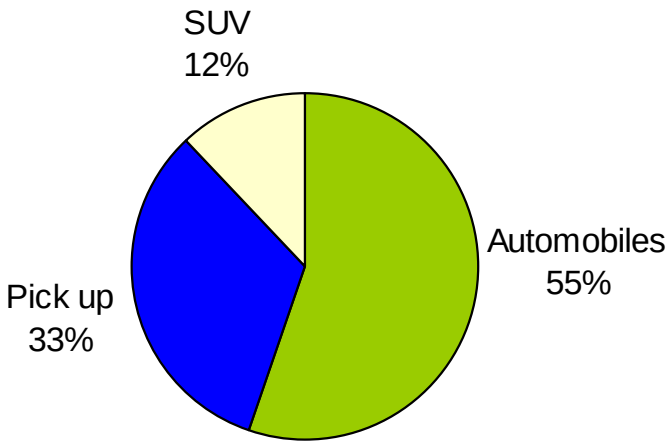
CO



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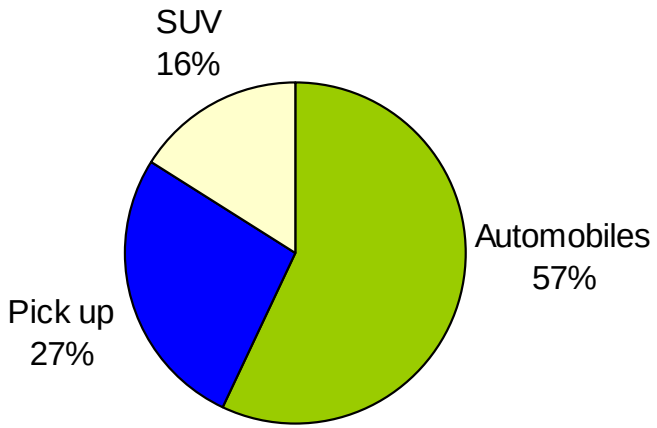
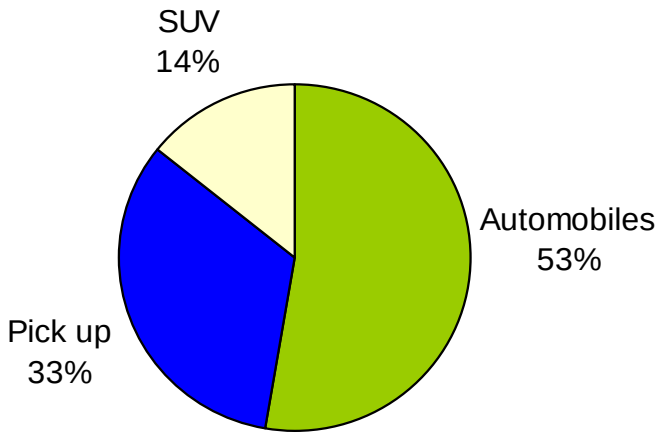


HC



Conclusions

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- The inventory shows that even though the fraction of vehicles older than 10 years is not large, their contribution to emissions is quite significant
- The differences in the emission factors calculated for pick-up trucks vs. SUVs and automobiles in the two newer strata suggest that emissions from pick-ups increase more rapidly with age, probably because pick-ups are mostly used for more intensive uses than SUVs and automobiles.
- These results provide local officials with field input for the development of a local mandatory I/M program
- Future work includes comparing our results with existing mobile source emissions inventories in the MMA

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Thanks for your attention

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