On-Road Transport Emissions in the Metropolitan Area of Buenos Aires, Argentina

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SUMMARY

Annual emission inventories of criteria pollutants and greenhouse gases from on-road mobile sources were developed for the period 2000-2006 for the metropolitan area of Buenos Aires (MABA), Argentina. We employed a bottom-up approach with a spatial resolution considering the 25 districts that compose MABA, including the City of Buenos Aires. Because of the scarcity of locally measured emission factors, we compiled the information that, to the best of our knowledge, is available for Latin American fleets and driving conditions. The sources comprise the algorithms of the COPERT III methodology because of the large share of European models of the Argentinean fleet, and emission factors measured in dynamometers and circulating vehicles in Argentina, Brazil, Chile and Colombia. In addition, a campaign was carried out in the City of Buenos Akires to assess local driving conditions and the dynamic composition of the local fleet.

As there are no up-dated inventories for this large area, within the SAEMC Project, a 4-year regional project that is financed by the International Institute for Global Change Research (IAI), we are developing emission inventories to provide input data for the modeling of regional air pollutant transport.

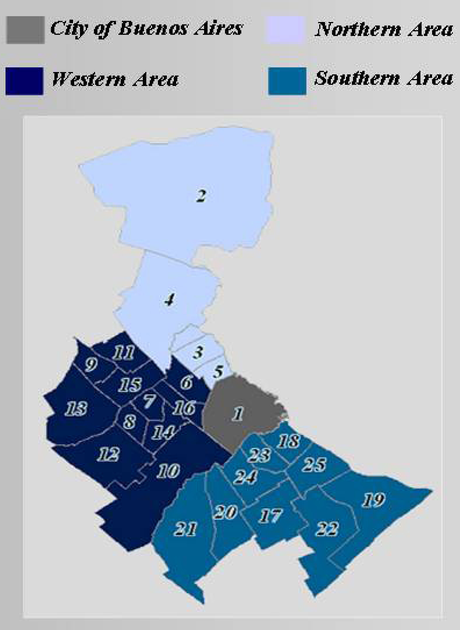
To point out the role of MABA as a concentrated site of pollutant emissions, we report our estimates of specific CO emissions from MABA and the city of Buenos Aires (CBA) and compare them with the national emissions as reported in the official Greenhouse Gas Inventory for the year 2000. They are in ton CO km^{-2}: 0.7 (country-wise) << 122 (MABA) < 815 (CBA).

Studied Area: *the Metropolitan Area Buenos Aires*

The Metropolitan Area of Buenos Aires (MABA) constitutes the political and economical centre of Argentina. It is located in the Northeastern portion of the province of Buenos Aires, limiting with de La Plata River and comprising an area of 3,647 km^2 and an extent of 110 km N-S and 70 km E-W. It concentrates 30% of the total population in only 0.14% of the national territory. According to the 2001 census, MABA's population reached 11,460,575 inhabitants, of which 25% congregate in the City of Buenos Aires, the capital of the country. Being located in the *Pampas*, it is situated on a flat terrain with a benign weather all year round.

BAMA consists of 25 districts that can be gruped into four zones according to their geographical location and their socioeconomical characteristics: City of Buenos Aires, Northern, Western and Southern Areas. Of these four, the City of Buenos Aires has the highest population density, 13,6380 persons/km^2, whereas the Western area posseses the highest population, almost 40% of MABA's population.

MABA Zonification



Districts of MABA:

1) City of Buenos Aires
2) San Fernando
3) San Isidro
4) Tigre
5) Vicente López
6) General San Martin
7) Hurlingham
8) Ituzaingó
9) José C. Paz
10) La Matanza
11) Malvinas Argentinas
12) Merlo
13) Moreno
14) Morón
15) San Miguel
16) Tres de Febrero
17) Almirante Brown
18) Avellaneda
19) Berazategui
20) Esteban Echeverria
21) Ezeiza
22) Florencio Varela
23) Lanús
24) Lomas de Zamora
25) Quilmes

Inventory Procedure

The process of estimating emissions was undertaken in different stages according to the successive availability of data. We firstly focused on the compilation of both emission factors (EF) and activity data (AD), including the number of registered vehicles and the annual distance traveled by each vehicle category.

Different sources of information were considered for the AD: the National Vehicle Registration Directory (DNRPA), the Gas Regulator National Organism (ENARGAS), the Vehicles Factories Association (ADEFA), the Transport Regulation National Commission (CNRT), and the Government of the City of Buenos Aires (GCBA).

- ✓ The DNRPA provided the total number of vehicles distributed by vehicle type and fuel used in different time periods: registered until December 31st 1996, between January 1st 1997 and the December 31st 2000, between January 1st 2001 and the December 31st 2003, and finally between January 1st 2004 and the December 31st 2006.
- ✓ ENARGAS provided the total number of vehicles discriminated by type that run on Compressed Natural Gas (CNG).
- ✓ From ADEFA's yearbooks we obtained the gasoline/diesel relationship of the national vehicles production according to vehicle type, and the distribution of EURO I and II technology categories by vehicle type and fuel used.
- ✓ The CNRT informed the number and annual distance traveled of Light and Heavy-Duty transport vehicles as well as Buses and Coaches. Furthermore, CNRT experts informed the Vehicles' Kilometers Traveled (VKT) for the different vehicle categories.
- ✓ The GCBA provided the number of taxi-cabs that travel around the City of Buenos Aires, discriminated by fuel used.

The selected time periods in which the fleet is categorized represent the implementation of the national Act 24,449 with its resolutions 779 (year 1995) and 731 (year 2005) that stipulates the inclusion of emissions control devices in new vehicles. This Act establishes that new models produced since January 1997 must possess a three-way catalyst (TWC) and that at all new vehicles produced since January 1999 must possess the named emissions control device. According to experts' assumptions, these devices have a life expectancy of 5 years. However, a control and maintenance program has not been thus far enforced. Therefore, vehicles registered before this law entered into force (1996) are considered to be the oldest, highest-emitting vehicles, while those registered between 1997 and 2000 are cleaner but we assumed that they do not have a working TWC. On the other hand, vehicles registered after year 2000 are considered to be equivalent to the European emission standards of EURO I vehicles and those registered after 2003, to EURO II vehicles.

The resulting fleet was classified in 35 categories (*Table 1*) discriminated by vehicle type, year of registration, and fuel used. Two-wheelers were not considered for their information is currently being compiled by the DNRPA.

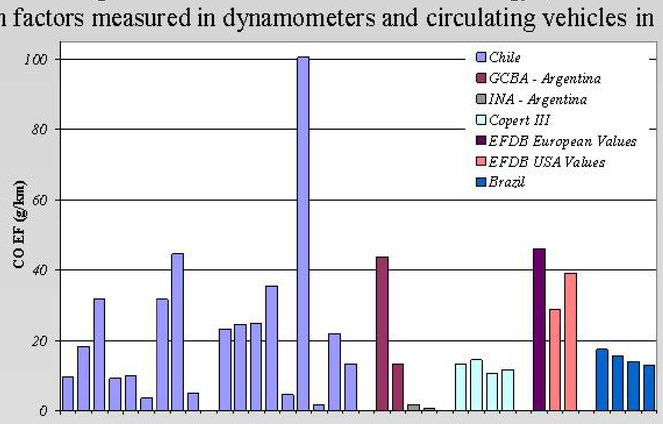
ID	Type	Period of Registration in Vehicle National Registry	Population (year 2006)	VKT (km)	FE CO (g/km)	FE NOX (g/km)	FE THC (g/km)	FE CO2 (g/km)	FE PM (g/km)
1	Gasoline PC	until 12/31/1996	760,465	12,000	23.81	1.56	2.95	200.29	0.00
2	Gasoline PC	between 1/1/1997 and 12/31/2001	304,656	12,000	13.29	1.40	1.33	288.16	0.00
3	Gasoline PC	between 1/1/2001 and 12/31/2003	335,950	12,000	4.67	0.31	0.48	255.43	0.00
4	Gasoline PC	between 1/1/2004 and 12/31/2006	82,384	12,000	2.05	0.29	0.08	251.09	0.00
5	Diesel PC	until 12/31/2000	111,429	15,000	1.05	1.10	0.23	263.21	1.55
6	Diesel PC	between 1/1/2001 and 12/31/2003	60,392	15,000	0.73	1.30	0.63	195.97	0.81
7	Diesel PC	between 1/1/2004 and 12/31/2006	11,964	15,000	0.25	1.30	0.63	195.97	0.81
8	CNG PC	until 12/31/1996	123,490	15,000	1.86	1.84	0.70	284.37	0.00
9	CNG PC	between 1/1/1997 and 12/31/2006	144,609	15,000	5.60	0.90	1.39	178.15	0.00
10	Gasoline SUV	until 12/31/1996	56,081	12,000	21.59	1.71	3.00	255.35	0.00
11	Gasoline SUV	between 1/1/1997 and 12/31/2001	13,527	12,000	13.41	1.61	2.23	301.61	0.00
12	Gasoline SUV	between 1/1/2001 and 12/31/2003	17,257	12,000	7.19	0.68	1.00	298.00	0.00
13	Gasoline SUV	between 1/1/2004 and 12/31/2006	1,394	12,000	5.11	1.35	0.56	314.82	0.00
14	Diesel SUV	until 12/31/2000	48,941	15,000	1.60	1.12	0.41	276.94	1.03
15	Diesel SUV	between 1/1/2001 and 12/31/2003	40,789	15,000	1.60	1.67	1.12	219.67	0.84
16	Diesel SUV	between 1/1/2004 and 12/31/2006	908	15,000	1.30	1.44	0.73	255.10	0.82
17	CNG SUV	until 12/31/2017	12,670	15,000	2.73	1.95	0.21	305.00	0.00
18	CNG SUV	until 12/31/2018	16,983	15,000	0.38	0.90	0.78	270.73	0.00
19	Diesel Taxi-cabs	until 12/31/2000	22,660	50,000	1.05	1.10	0.23	263.21	1.55
20	Diesel Taxi-cabs	between 1/1/2001 and 12/31/2003	2,459	50,000	0.73	1.30	0.63	195.97	0.81
21	Diesel Taxi-cabs	between 1/1/2004 and 12/31/2006	2,472	50,000	0.25	1.30	0.63	195.97	0.81
22	CNG Taxi-cabs	until 12/31/1996	10,536	50,000	1.86	1.84	0.70	284.37	0.00
23	CNG Taxi-cabs	between 1/1/1997 and 12/31/2006	2,293	50,000	5.60	0.90	1.39	178.15	0.00
24	Gasoline LD vehicles	until 12/31/2019	35,571	44,000	24.95	1.79	4.58	313.18	0.00
25	Gasoline LD vehicles	between 1/1/2001 and 12/31/2003	10,963	44,000	7.82	1.83	3.29	325.00	0.00
26	Gasoline LD vehicles	between 1/1/2004 and 12/31/2006	847	44,000	5.46	1.60	1.95	333.89	0.00
27	Diesel LD vehicles	until 12/31/2022	35,270	45,000	1.18	1.40	0.41	281.06	0.57
28	Diesel LD vehicles	between 1/1/2001 and 12/31/2003	25,913	45,000	1.60	1.79	0.76	254.96	0.84
29	Diesel LD vehicles	between 1/1/2004 and 12/31/2006	552	45,000	0.89	1.55	0.33	254.96	0.12
30	CNG LD vehicles	until 12/31/1996	5,272	44,000	2.20	2.10	0.90	305.00	0.00
31	CNG LD vehicles	between 1/1/1997 and 12/31/2006	13,241	44,000	0.30	0.50	4.05	133.00	0.00
32	Diesel HD vehicles	until 12/31/2000	26,208	20,000	6.24	10.73	1.96	986.00	0.54
33	Diesel HD vehicles	between 1/1/2001 and 12/31/2006	5,798	20,000	2.24	5.08	0.89	594.06	0.18
34	Diesel Urban Buses	until 12/31/2006	9,272	93,000	2.07	3.01	0.21	347.00	0.12
35	Diesel Coaches	until 12/31/2006	10,827	13,000	5.82	14.87	1.39	1194.00	0.29
	TOTAL FLEET		2,364,041						

PC = Passenger Cars / SUV = Sport Utility Vehicles / LD = Light-Duty Vehicles / HD = Heavy-Duty Vehicles / CNG = Compressed Natural Gas / VKT = Vehicles' Kilometers Traveled

Table 1: Fleet Composition discriminated by vehicle type, technology and fuel used. Computed emission factors for the compounds CO, CO_2, NOx THC, and PM and VKT for each vehicle category are presented.

During May 2007, a campaign was carried out in the City of Buenos Aires with the aim to characterize local driving conditions and identify the running local fleet. The information collected was used as input for the International Vehicle Emissions model (IVE), computer model developed by the University of California at Riverside and its College of Engineering – Center for Environmental Research and Technology (CE-CERT), along with Global Sustainable Systems Research (GSSR), in cooperation with the U.S. Environmental Protection Agency, and specifically designed with the flexibility needed by developing nations in their efforts to address mobile source air emissions. The collected information comprises start-up patterns, dynamic fleet composition, local driving conditions for passenger cars, taxi-cabs, motorcycles, buses and trucks in different types of streets (residential, arterial, highway) and different areas (low and high-income, commercial).

With regards to EF, these were obtained from both local, regional and international databases. The Emission Factors Database (EFDB, 2005) and the algorithms of the COPERT III methodology (Ntziachristos and Samaras, 2000), together with emission factors measured in dynamometers and circulating vehicles in Argentina, Brazil, Chile and Colombia were analyzed. The more appropriate mean and median values for the local fleet were identified and presented in *Table 1*. In *Graph 1* we can observe the analyzed EF for gasoline Passenger Cars without an emissions control device registered between the years 1997 and 2000: in this case the median value of 13.29 was chosen over the mean value of 18.86 g/km as the dataset did not follow a normal distribution and the outlier values have an impact on the mean value.



Graph 1: CO Emission Factor Analysis for Gasoline PC registered between 1997 and 2000.

SAEMC Project : South American Emissions, Megacities and Climate
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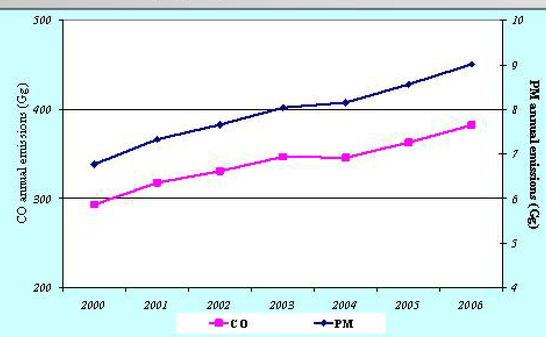
Main Results and Conclusions

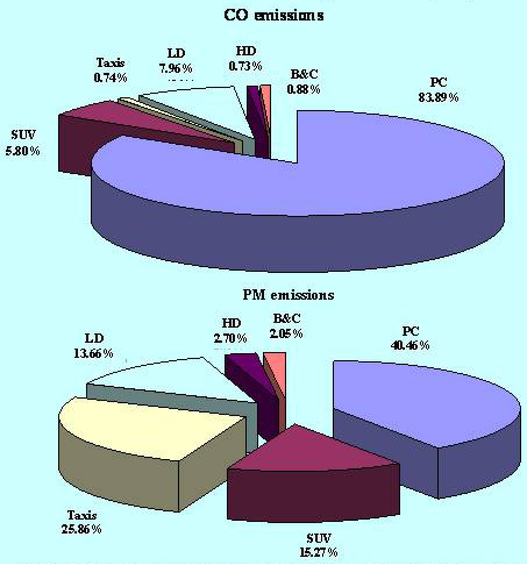
In Graph 2, the evolution of CO and PM emissions for the analyzed period 2000 to 2006 is presented. A different rate of increase is observed due to the increment of the diesel HD transport sector, which has a direct effect on PM emissions. In addition, we can observe a different behavior between the years 2003 and 2004. This may be due to a change in the scrappage methodology applied by the DNRPA from this year onwards, but this is still under analysis.

In *Graph 3 a)* and *b)* we can observe the vehicle type distribution of CO and PM emissions for the year 2000. Regarding CO, PC represent the highest emitting category, of which the oldest gasoline vehicles are responsible for 60% of total emissions, whereas with PM emissions, diesel PC still represent an important share of emissions, but are closely followed by diesel SUV and taxis. Throughout the analyzed period the fleet presents an increase of LD vehicles, whose share doubles by decreasing the PC share.

The inventory for MABA is hereby presented, improving data quality and its transparency, extending the previous attempts to all greenhouse gases and criteria pollutants, and incorporating an EF analysis. As it was highlighted in *Graph 1*, there is a high variability with regards to emissions among the different measured vehicles. PC represent almost 90% of the total fleet, therefore special attention must be paid to the selection of their EF.



Graph 2: CO and PM emissions evolution throughout the analyzed period 2000- 2006



Graph 3 a) and b): PM and CO emissions for the year 2000 according to Vehicle Category