Vehicular emission inventory using SMOKE in the Metropolitan Area of Sao Paulo

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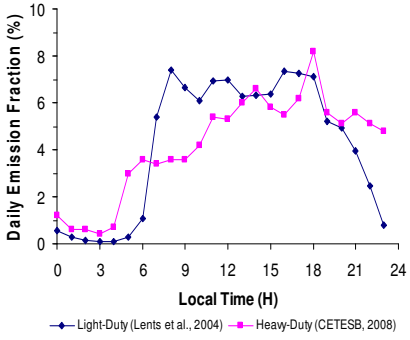
Introduction

Emissions inventory is crucial to air quality modeling. The information given in the official inventory for the Metropolitan Area of São Paulo (MASP) is limited to the whole area annual emission for CO, NOx, SO_2, PM_{10} and VOC´s. Therefore, we used the Sparse Matrix Operator Kernel Emissions (SMOKE) system to prepare spatially and temporally (hourly) averaged vehicular emissions for MASP and surrounding areas for the year of 2008.

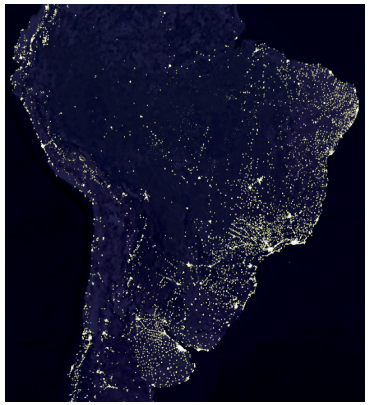
SMOKE model inputs

- *Spatial distribution surrogate*:
  - Earth's city lights created with data from the Defense Meteorological Satellite Program (DMSP) Operational Linescan System (OLS) [1].
- *Temporal distribution*:
  - Same for the whole area
  - Light-duty fleet: Lents et al., 2004[2]
  - Heavy-duty fleet: CETESB, 2008[3]
- *Fleet distribution and activity*: SPtrans[4] and CETESB, 2008[3]
- *Emission Factors*:
  - CO, NOx and PM_{10}: Sanchez et al., 2009[5]
  - VOC´s and SO_2: CETESB, 2008[3]
  - NH_3: Fraser and Cass, 1998[6]
- *Vehicular Density:*
  - Each "city light intensity value" was equivalent to 24,8 vehicles.km^{-2} [7].

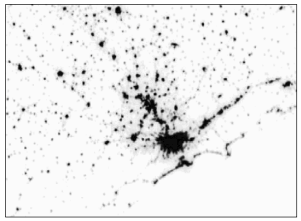
Temporal Distribution



Spatial Distribution



City Lights: part of South America



Negative of City Lights in our study area: MASP and surroundings

Fleet Distribution and Activity

	Vehicle Category	MASP Fleet Fraction (%)	km/day/vehicle
Light	Gasoline	56.3	41.1
Light	Ethanol	11.4	
Light	Flex-Fuel	10.1	
Light	Natural Gas	4.7	
Heavy	Truck (diesel)	5.12	109.6
Heavy	EuroII Bus (diesel)	0.15	164.6
Heavy	EuroIII Bus (diesel)	0.13	
	Motorcycle (gasoline)	12.1	137.0

Emission Factors (g/km)

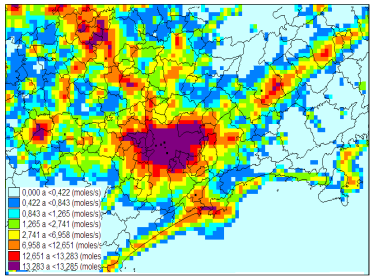
	Vehicle Category	CO[5]	NOx[5]	PM10[5]	VOC[3]	SO_2[3]	NH_3[6]
Light	Gasoline	15,0	1,60	0,197	3,160	0,070	0,061
Light	Ethanol	15,0	1,60		3,660		
Light	Flex-Fuel	0,5	0,08		0,110		
Light	Natural Gas	0,8	0,90		0,440		
Heavy	Truck (diesel)	21,0	22,00	0,755	2,110	1,300	
Heavy	EuroII Bus (diesel)	2,1	22,00	0,755	1,720	0,130	
Heavy	EuroIII Bus (diesel)	2,1	22,00	0,755	0,220	0,130	
	Motorcycle (gasoline)	15,0	1,60	0,197	2,910	0,020	

MASP Emissions inventory (ktons/year)

	CO		NOX		PM	
	SMOKE	CETESB	SMOKE	CETESB	SMOKE	CETESB
Gasoline	1143,7	650,2	122,0	43,0	15,0	4,6
Ethanol+FlexFuel	238,4	200,2	25,8	14,0		
Natural Gas	5,1	1,9	5,7	2,1		
Diesel (all)	391,5	398,8	440,2	291,2	15,1	24,9
Motorcycle (gasoline)	819,4	267,4	87,4	3,1	10,8	1,2

	VOC		SO2		NH3	
	SMOKE	CETESB	SMOKE	CETESB	SMOKE	CETESB
Gasoline	240,9	199,1	5,3	3,8	4,7	
Ethanol+FlexFuel	58,0	43,9				
Natural Gas	2,8	1,0				
Diesel (all)	40,6	61,4	24,2	4,1		
Motorcycle (gasoline)	159,0	69,6	1,1	0,5		

CO emission at 08 LT



Results

- Large discrepancies between this work and official inventory:
  - Motorcycle and gasoline fueled vehicles emissions much higher than official inventory
  - Heavy-duty vehicle emissions higher for NOx and SO_2, but lower for PM_{10} and VOC´s.
- Despite low fraction of MASP fleet, heavy-duty vehicles contributions to SO_2 and NO_x are much higher than the other categories. PM_{10} contribution, in our inventory, was the same amount of gasoline-fueled vehicles.

References:

1. http://www.ngdc.noaa.gov/dmsp/dmsp.html
2. Lents et al., 2004:São Paulo vehicle activity study. International Sustainable Systems Research Center (ISSRC), California, EUA, 86p.
3. CETESB (2008). Relatório Anual de Qualidade do Ar no Estado de São Paulo 2008. CETESB-Companhia de Tecnologia de Saneamento Ambiental, São Paulo, Brazil.
4. http://www.sptrans.com.br/ganhosambientais
5. Martins et al., 2006: Emissions Factors for Gas-Powered Vehicles Traveling through Road Tunnels in São Paulo, Brazil. Environmental Science & Technology, v.40, p.6722 – 6729, 2006.
6. Fraser and Cass, 1998. Detection of excess ammonia emissions from in-use vehicles and the implications for fine particle control. Environmental Science and Technology 32:1053-1057.
7. Martins et al, 2010: Desenvolvimento de inventários de emissão de alta resolução: Intensidade de luzes noturnas e distribuição espacial de veículos. XVI CONGRESSO BRASILEIRO DE METEOROLOGIA, Belém – PA, Brazil.