Determination of black carbon emission factors under real-world driving conditions, using fixed-site measurements

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Why study emission factors (EF)?

- We need accurate and updated EF for different vehicle categories to prepare reliable emission inventories.

- Emission inventories are strategic tools for AQM:
  - to identify major emission sources
  - to provide input data for dispersion models
  - to assess the effectiveness of policies to control emissions
  - to assess the health impacts of different sources of exposure.

- **The road-transport sector is still a large contributor to NOx emissions and other pollutants in Europe.**

- **Studies on vehicle EF in South America are very scarce.**

Franco et al. (2013)

How to measure vehicle EF?

Laboratory

- Chassis dynamometer
- Engine dynamometer

+ Repeatability
+ Standarized
- Not representative of entire fleet

Real world

- Tunnel
- Remote sensing
- **On road (**chase; **fixed site)**
- On board (PEMS)
- Eddy covariance

+ Wider coverage of engine operation
+ Used to validate laboratory EF
- Less precise, less repeatable

Black carbon EF in real-world conditions are scarce!!

Roadside measurements of BC, $PM_{2.5}$, particle number and NOx vehicle emission factors: Implications for inventory development at local and national levels

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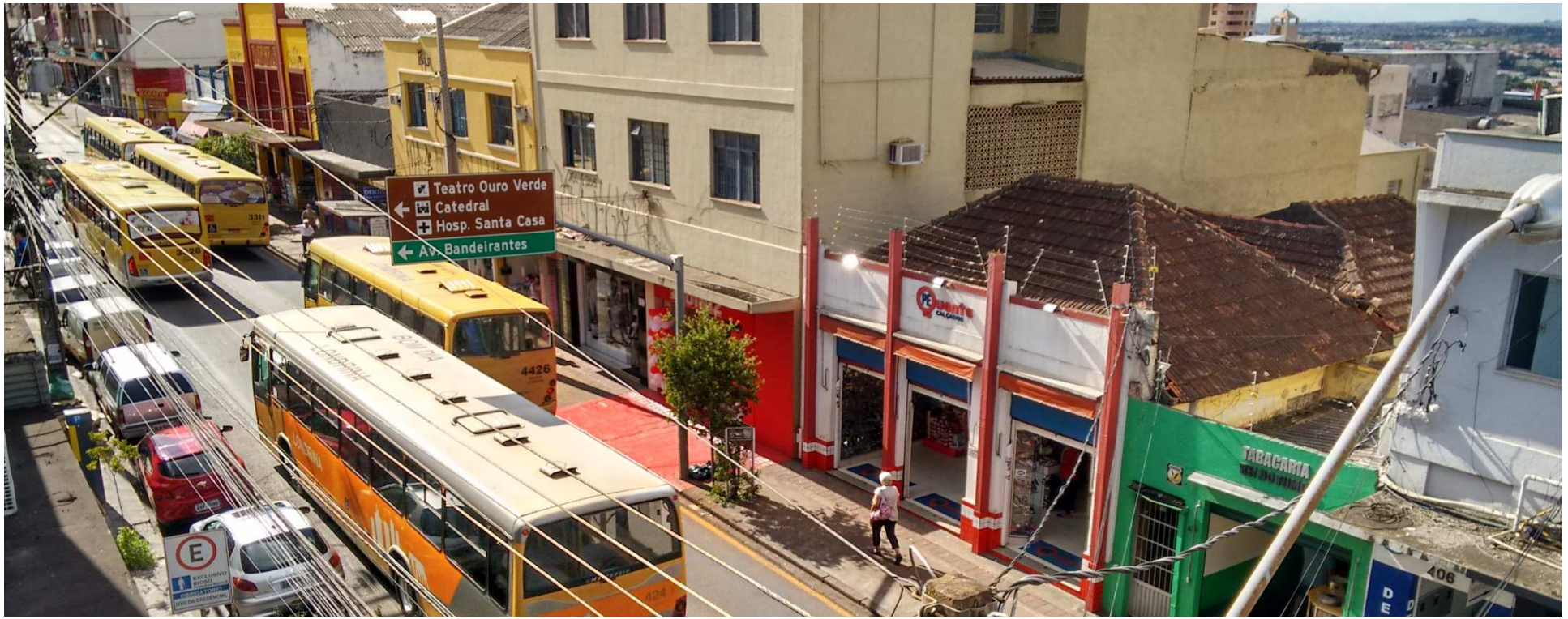

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1. Methodology: Measurements (summer 2016)

Londrina, Brazil
Population: 550,000

<u>STREET CANYON: SERGIPE</u>
H/W=0.7
10,000 veh/day

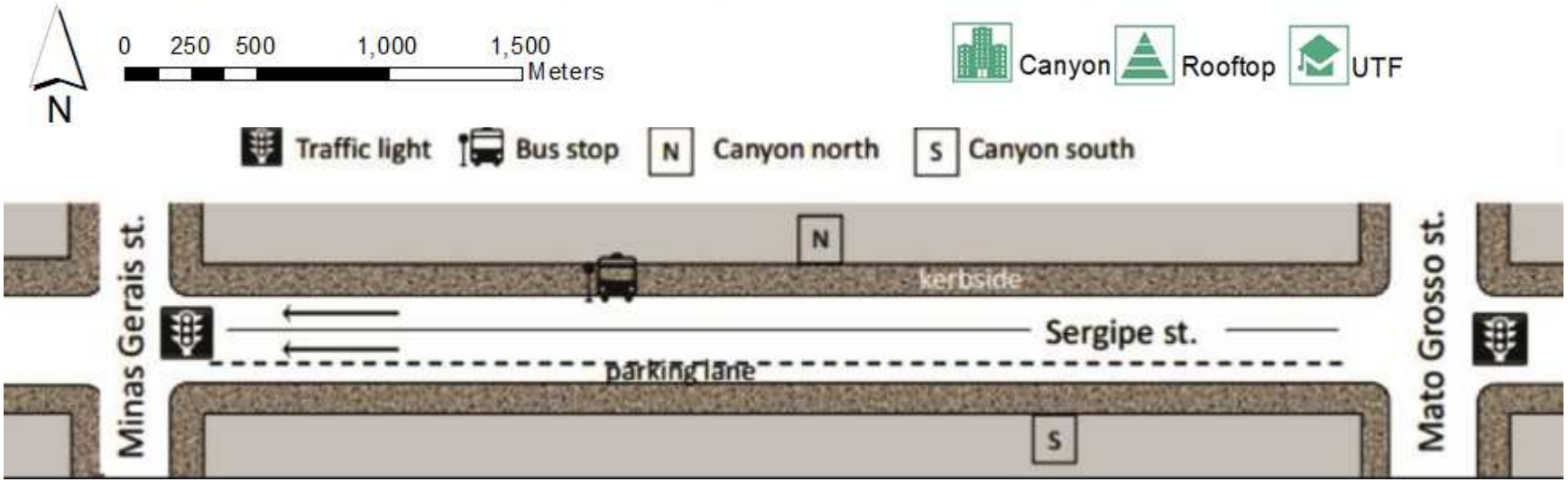
- BC (South and North facades)
- $PM_{2.5}$
- Particle number: total N_{10}
- NOx
- Traffic rate (TR), vehicle speed

<u>ROOFTOP SITE</u>: city center (20 m)

- BC
- $PM_{2.5}$

- Meteorology (WS, WD, T, RH, precipitation)

1. Methodology: Measurements (summer 2016)

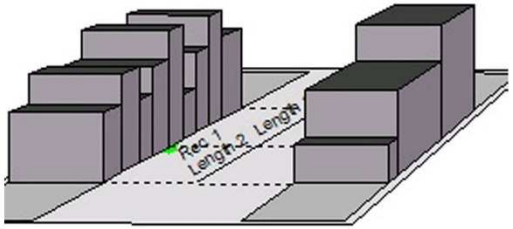


1. Methodology: EF calculations

Mixed fleet: based on measurements of street increments concentrations (ΔC_i) and inverse modelling using OSPM, assuming dilution as the dominant process.

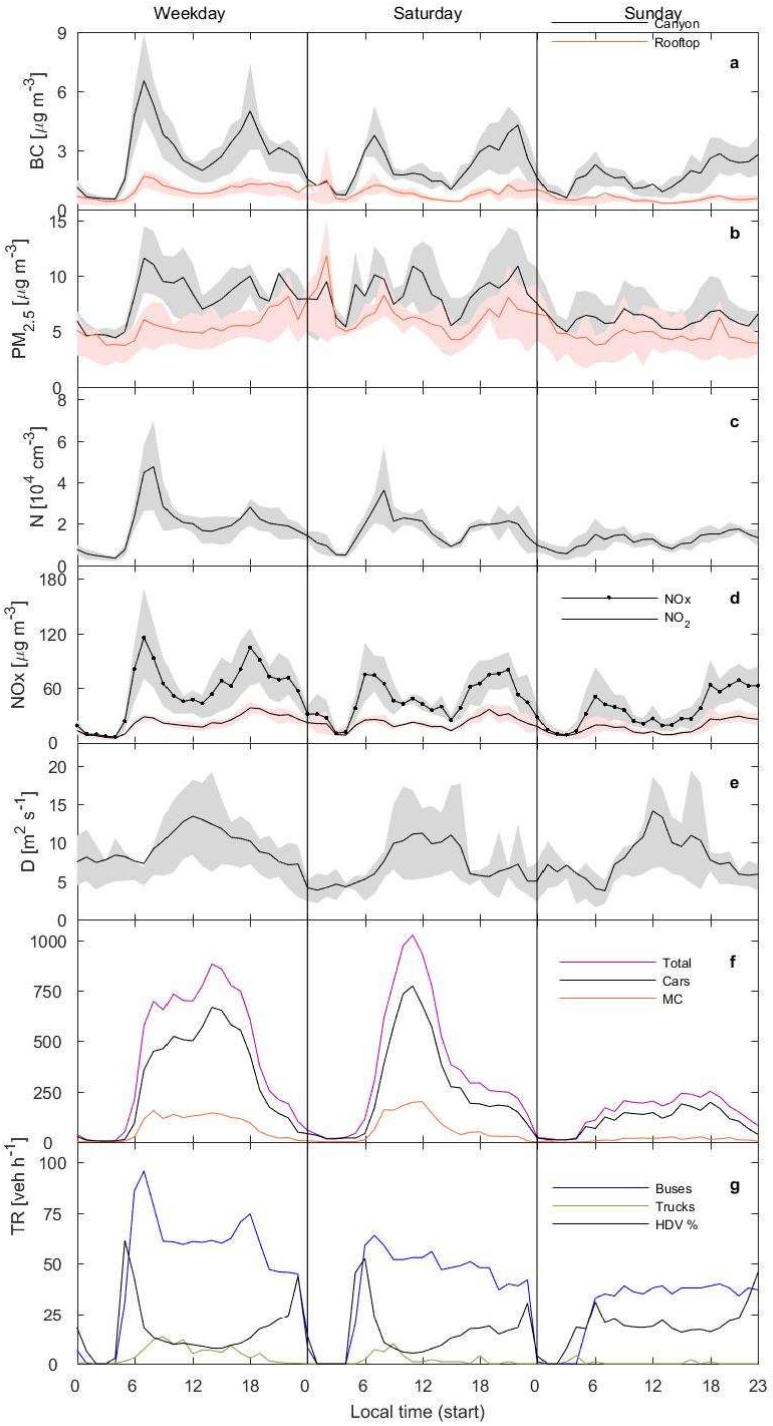
$$EF_i = \frac{\Delta C_i(t).\ D(t)}{TR(t)}$$

Dilution rate from OSPM



LDV and HDV fleets: by applying multiple linear regression on the TR for the LDV and HDV fleets.

$$TR(t).EF_i = EF_{i,LDV}.TR_{LDV}(t) + EF_{i,HDV}.TR_{HDV}(t) + \varepsilon_i,$$



2. Results

Mean diurnal cycle of several atmospheric pollutants at the canyon and rooftop sites (a-d), simulated dilution rate (e), traffic rate (total and per category) and fraction of HDV (f-g) at the canyon site.

The shaded areas represent the interquartile range.

2. Results

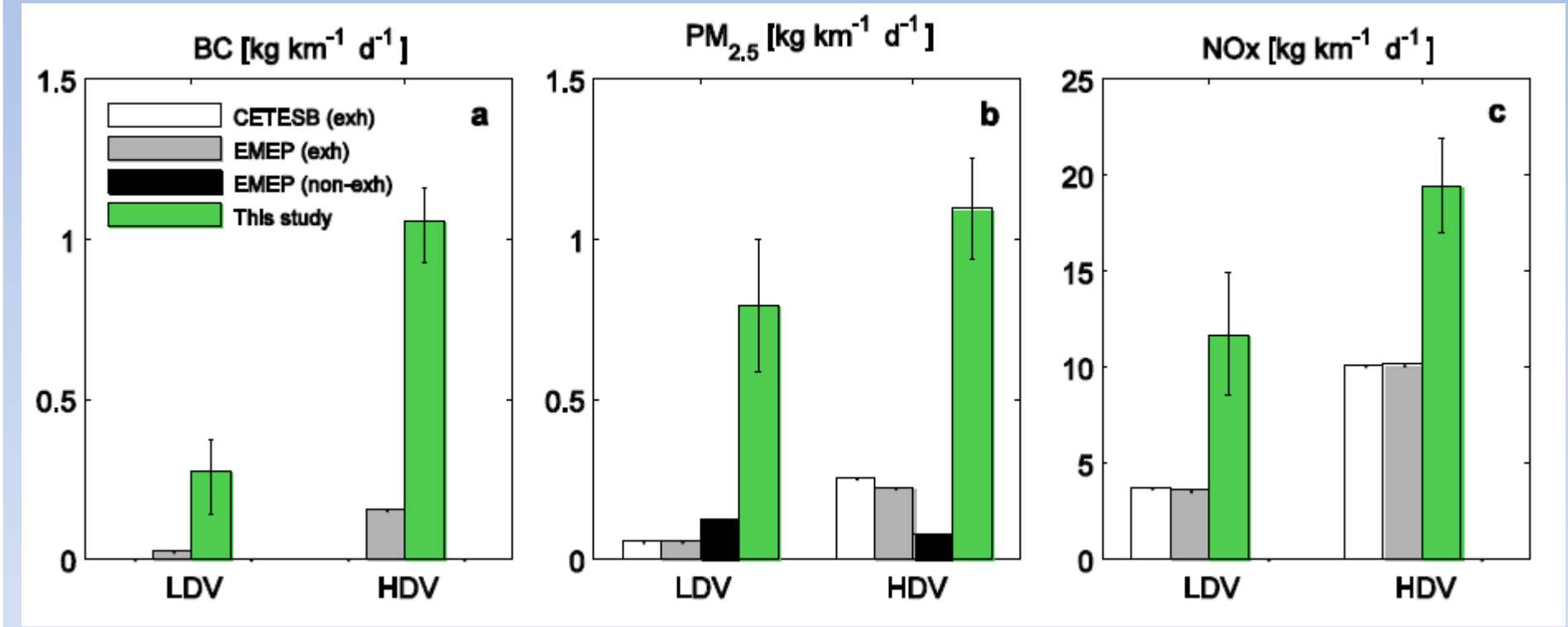
Real-world EF_{BC} for the LDV and HDV fleets in Brazil.
Mean (±SE) for this study and mean (±SD) for the other references.

Reference	EF_{BC} [mg veh^{-1} km^{-1}]		City	Road type	Year	RS [km h^{-1}]	HDV [% of fleet]	Method for EF determination
	LDV	HDV						
This work	25.7 (±12.4)	690.7 (±66.7)	Londrina	Canyon	Summer 2016	40	34	Street increment + modelling
Sánchez-Ccoyllo et al. (2009)	[a,b]16 (±5)	[a,c]462 (±112)	São Paulo	Tunnels	Fall 2004	70	4 (TJQ) 14 (TMM)	Carbon balance
Miranda et al. (2017)	41 (± 63)	170 (± 259)	São Paulo	Highway	2005	90 (HDV) 120 (LDV)	20	Street incr. + NOx tracer

[a]Reflectance method for BC determination. [b]Tunnel Jânio Quadros (TJQ). [c]Tunnel Maria Maluf (TMM).

2. Results: Total emissions per vehicle type

Daily emissions per km driven on Sergipe St. for the LDV and HDV fleets, calculated using EF from databases (CETESB, EMEP) and this study.



- Total exhaust emissions and per vehicle category were very similar for the same pollutant when using databases, but lower than based on real-world EF.
- HDV emissions > LDV emissions (except for $PM_{2.5}$ non-exhaust).

3. Conclusions

i) Atmospheric concentrations

- Data analysis confirmed that traffic was the main source of BC, N and NOx inside the canyon.

ii) Emission factors

- EF (BC, $PM_{2.5}$, NOx) are consistent with values reported by Brazilian studies (São Paulo city).
- EF_N are similar to European values for HDV fleet but much higher for LDV fleet.
- Total emissions and per vehicle type are very similar for the same pollutant when using database EF, but much lower than results using real-world EF.

- ❑ Revise EF (BC, NOx and $PM_{2.5}$) derived from laboratory tests for all vehicle categories.
- ❑ Quantify non-exhaust EF_{PM}
- ❑ Determine mileage deterioration for all pollutants and vehicle categories

THANK YOU!

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