On-road emission factors of PM pollutants for light-duty vehicles (LDVs) based on urban street driving conditions

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Related Publications

1. Kam, W., Delfino, R. J., Schauer, J. J., & Sioutas, C. (2013). A comparative assessment of PM2. 5 exposures in light-rail, subway, freeway, and surface street environments in Los Angeles and estimated lung cancer risk. *Environmental Science: Processes & Impacts*, *15*(1), 234-243
2. Kam, W., Liacos, J. W., Schauer, J. J., Delfino, R. J., & Sioutas, C. (2012). Size-segregated composition of particulate matter (PM) in major roadways and surface streets. *Atmospheric Environment*. 55 : 90-97,
3. Kam, W., Liacos, J. W., Schauer, J. J., Delfino, R. J., & Sioutas, C. (2012). On-road emission factors of PM pollutants for light-duty vehicles (LDVs) based on urban street driving conditions. *Atmospheric Environment*. 61:378-386
4. Liacos, J. W., Kam, W., Delfino, R. J., Schauer, J. J., & Sioutas, C. (2012). Characterization of organic, metal and trace element PM< sub> 2.5</sub> species and derivation of freeway-based emission rates in Los Angeles, CA. *Science of the Total Environment*, *435*, 159-166.

State of the Art

Light-duty vehicle (LDV) studies

Caldecott Tunnel bore (no heavy-duty vehicles (HDVs))

- *Kirchstetter et al. 1999; Geller et al. 2005; Ban-Weiss et al. 2008*

I-110 Freeway portion (no HDVs)

- *Ning et al. 2008; Kuhn et al. 2005; Phuleria et al. 2007*

Chassis dynamometer studies for various LDVs

- *Schauer et al. 1999; Yanowitz et al. 1999; Fujita et al. 2007*

On-road studies

Mobile laboratory equipped with continuous instruments

- *Fruin et al. 2004; Westerdahl et al. 2005; Weimer et al. 2009; Weiss et al. 2011; Gouriou et al. 2004*

Sampling instrumentation

Vehicle used:

- Honda Insight Hybrid 2011

Instruments used:

- **7 Personal Cascade Impactor Samplers (PCIS)**
  - collect $PM_{10-2.5}$, $PM_{2.5-0.25}$, and $PM_{0.25}$
  - Teflon and Quartz substrates
  - **Total flow 70 LPM**
- **Battery-powered pumps**
- TSI Q-trak
  - CO_2 measurements
- Garmin GPS for tracking

Sampling Campaign Details

PCIS Impactor Set Up

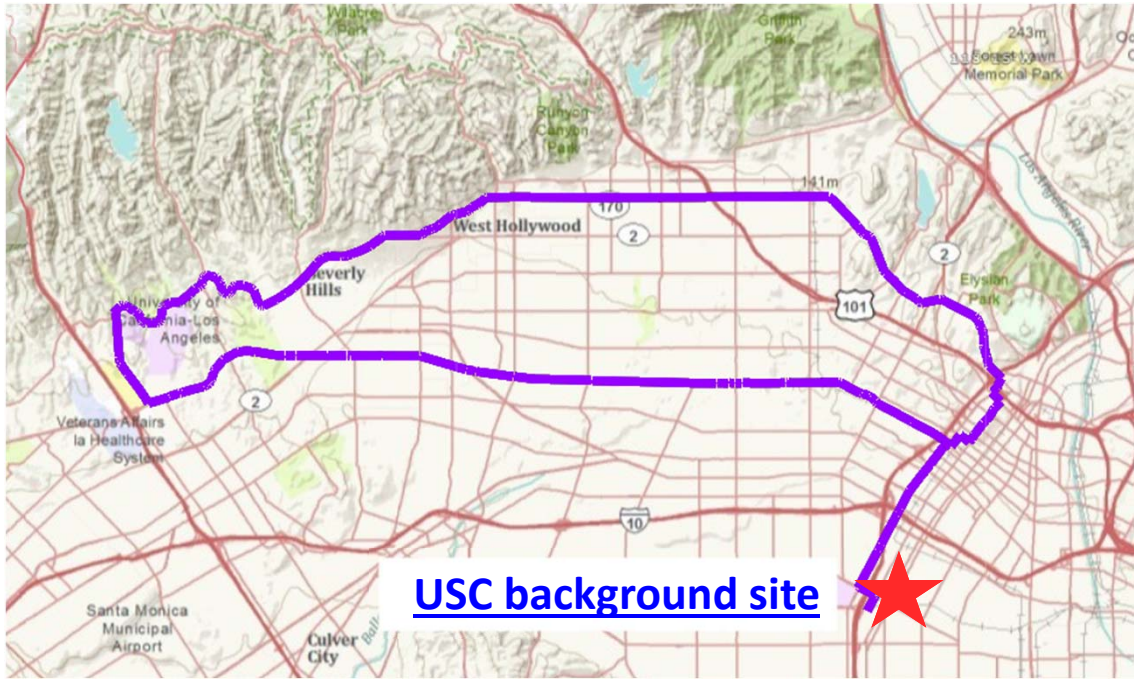
On-road campaign

Honda Insight Hybrid 2011

Sampling Logistics and Chemical Analysis

Logistics:

- **Wilshire and Sunset Boulevards**
- M-F from 6AM – 5PM on March 9-16 and April 26-May 5, 2011
- N=2, each representing ~60h of sampling per run



Chemical analysis:

- ✓ Total metals (SF-ICPMS)
- ✓ Organic species (GC/MS)
- ✓ EC/OC (Thermal Evolution/Optical Transmittance)

Fuel-based Emission Factors (EFs)

E_p = emission factor of pollutant P in mg/(kg of fuel burned)

[P] = pollutant concentration in $\mu g/m^3$

$[CO_2]$ = CO_2 concentration in C/m^3

st and bg refer to streets and background site (USC campus), respectively

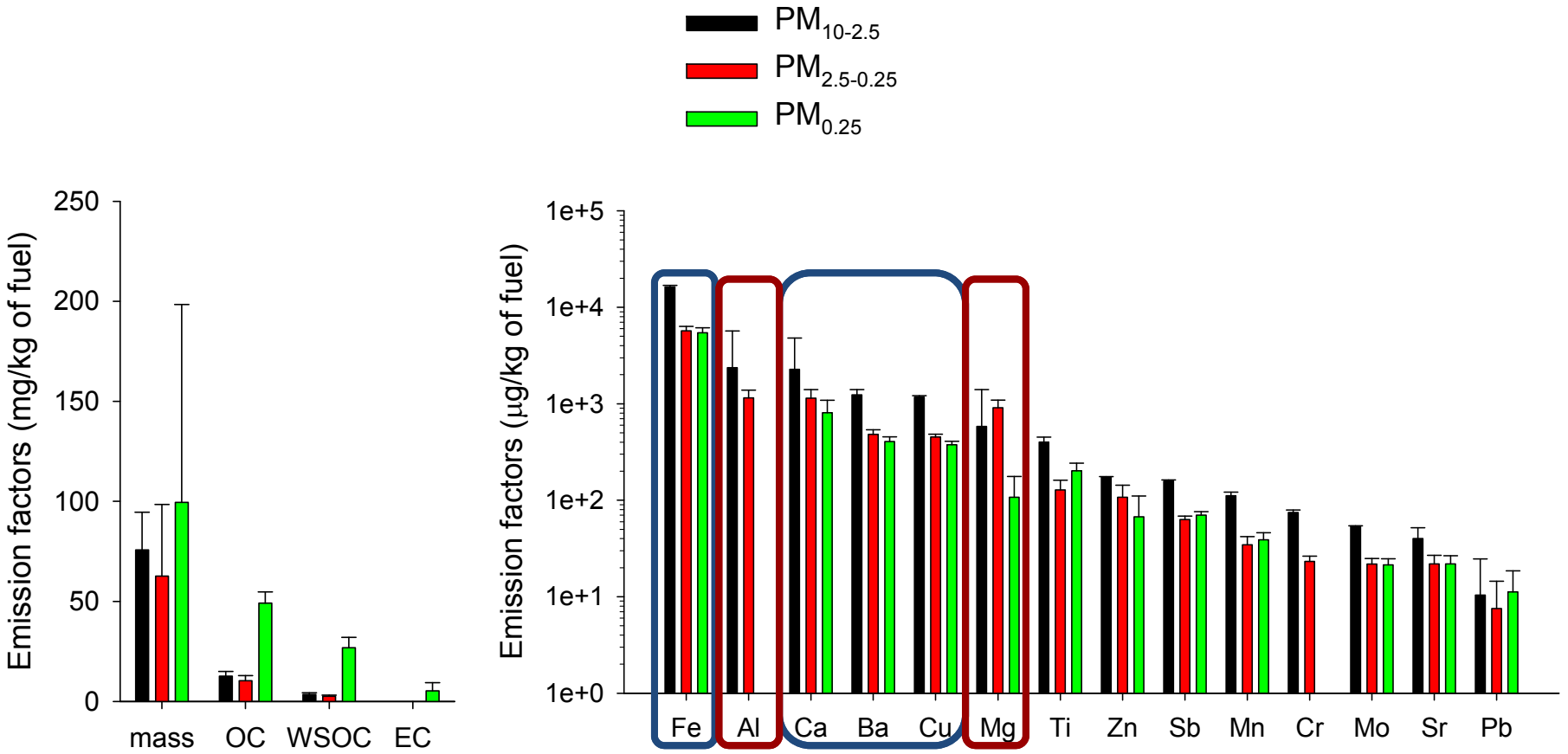
w_c = carbon weight fraction of gasoline, 0.85

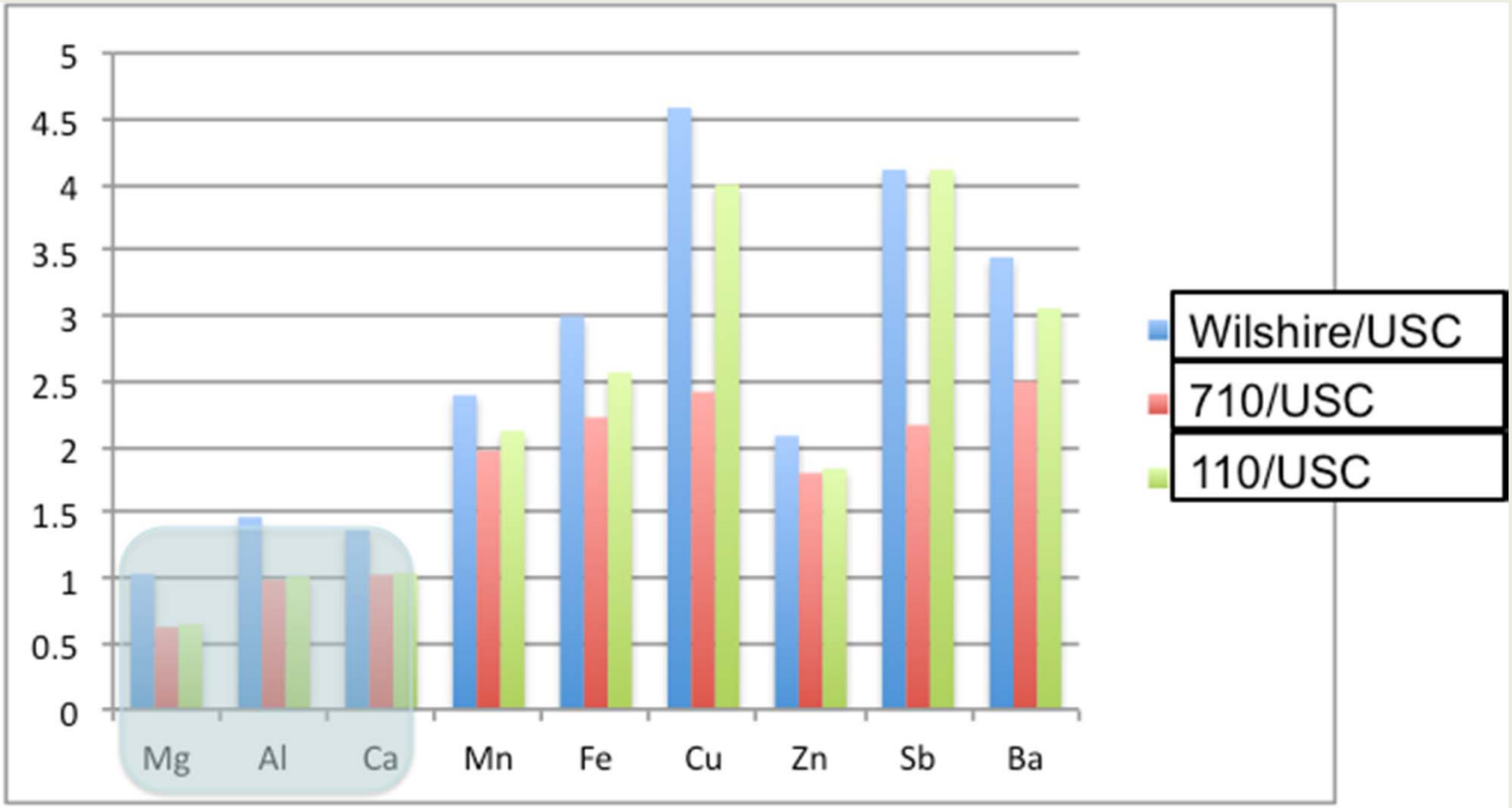
(Kirchstetter et al. 1999; Phuleria et al. 2006; Ning et al. 2008)

Earlier LDV studies

Sampling location/test cycle	Sample/test period	Relevant results for comparison	Reference
Wilshire/Sunset Blvds	March-May 2011	-	current study
LDV freeway (northern portion of I-110)	May-Jun 2004, Jan 2005	mass, EC, OC, metals, PAHs, hopanes and steranes	Ning et al. (2008)
LDV tunnel (Bore 2 of Caldecott Tunnel)	Aug-Sept 2004	PM mass, EC, OC, metals	Geller et al. (2005)
LDV tunnel (Bore 2 of Caldecott Tunnel)	Aug-Sept 2004	PAHs, hopanes and steranes	Phuleria et al. (2006)
LDV dynamometer study (warm-start UDC)	Summer 2001	mass, EC, OC, metals, PAHs, hopanes and steranes	Fujita et al. (2007)
LDV dynamometer study (cold-start FTP)	-	PM mass, PAHs, hopanes	Schauer et al. (2002)

EFs – PM components and elements

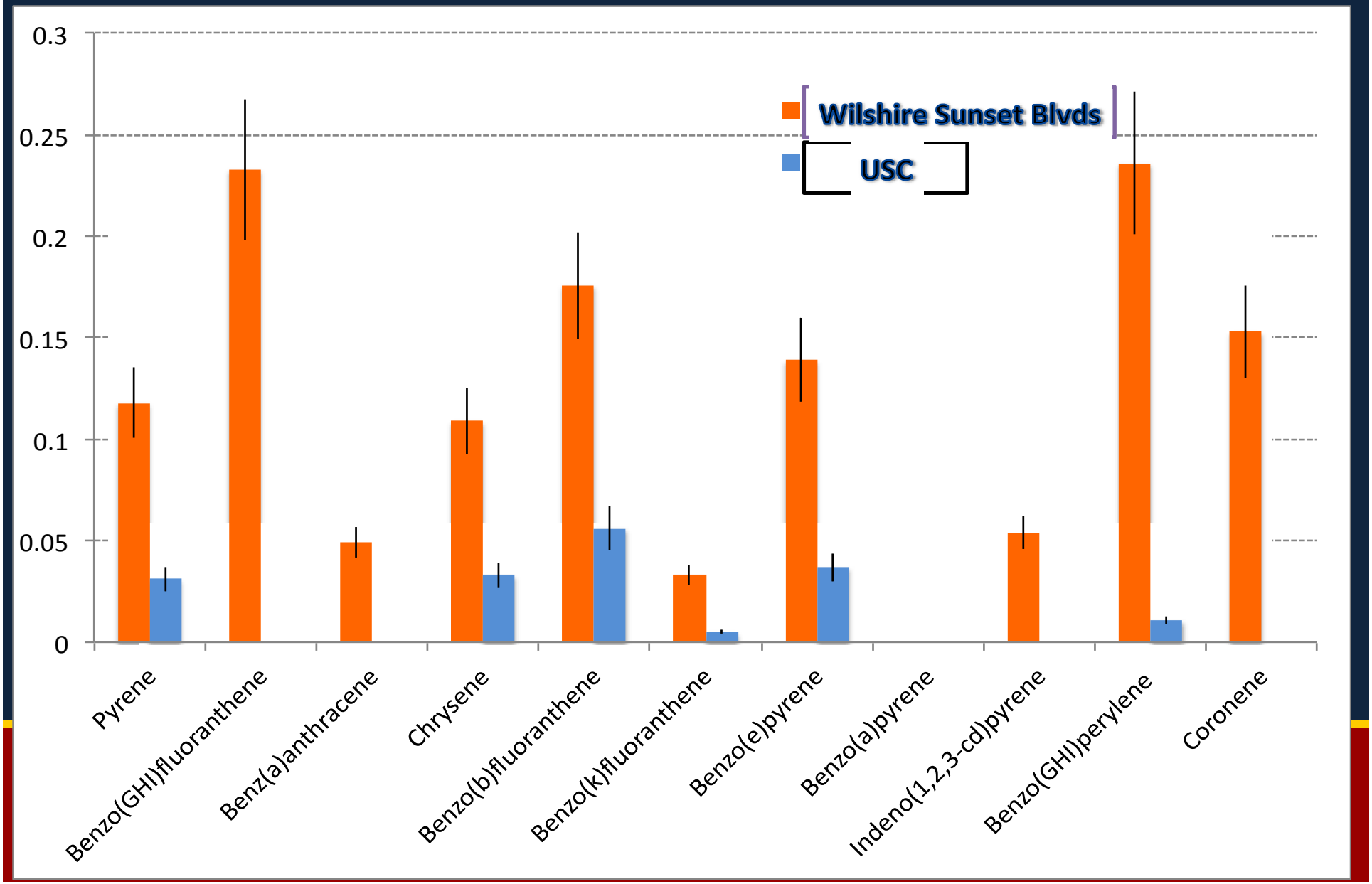




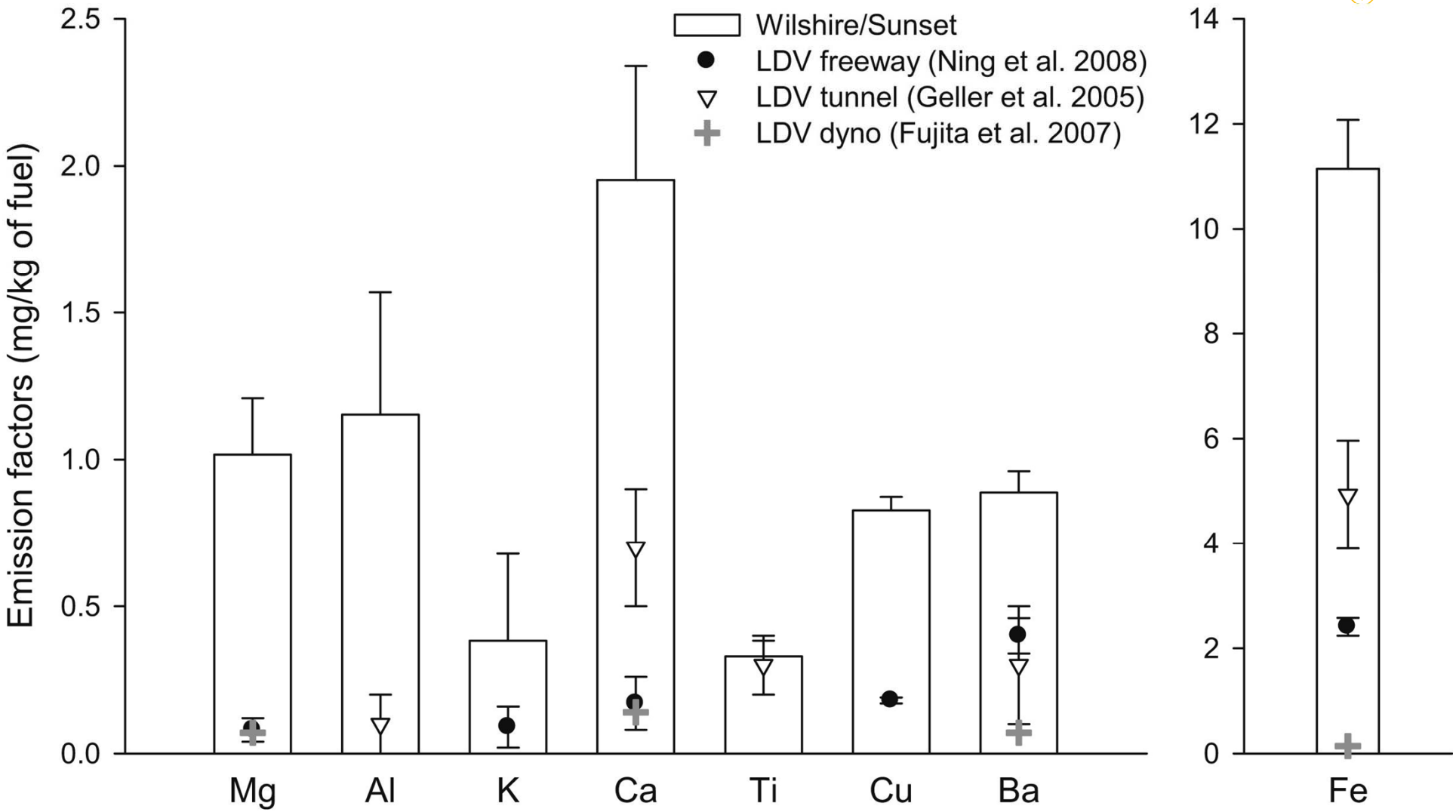
Ratios of $PM_{2.5}$ in Various LA Freeways and busy streets vs USC (urban background site)- from *Kam et al Atmos Environ 2012*

2-5 fold higher levels of PM-bound metals from road dust in busy streets compared to urban background

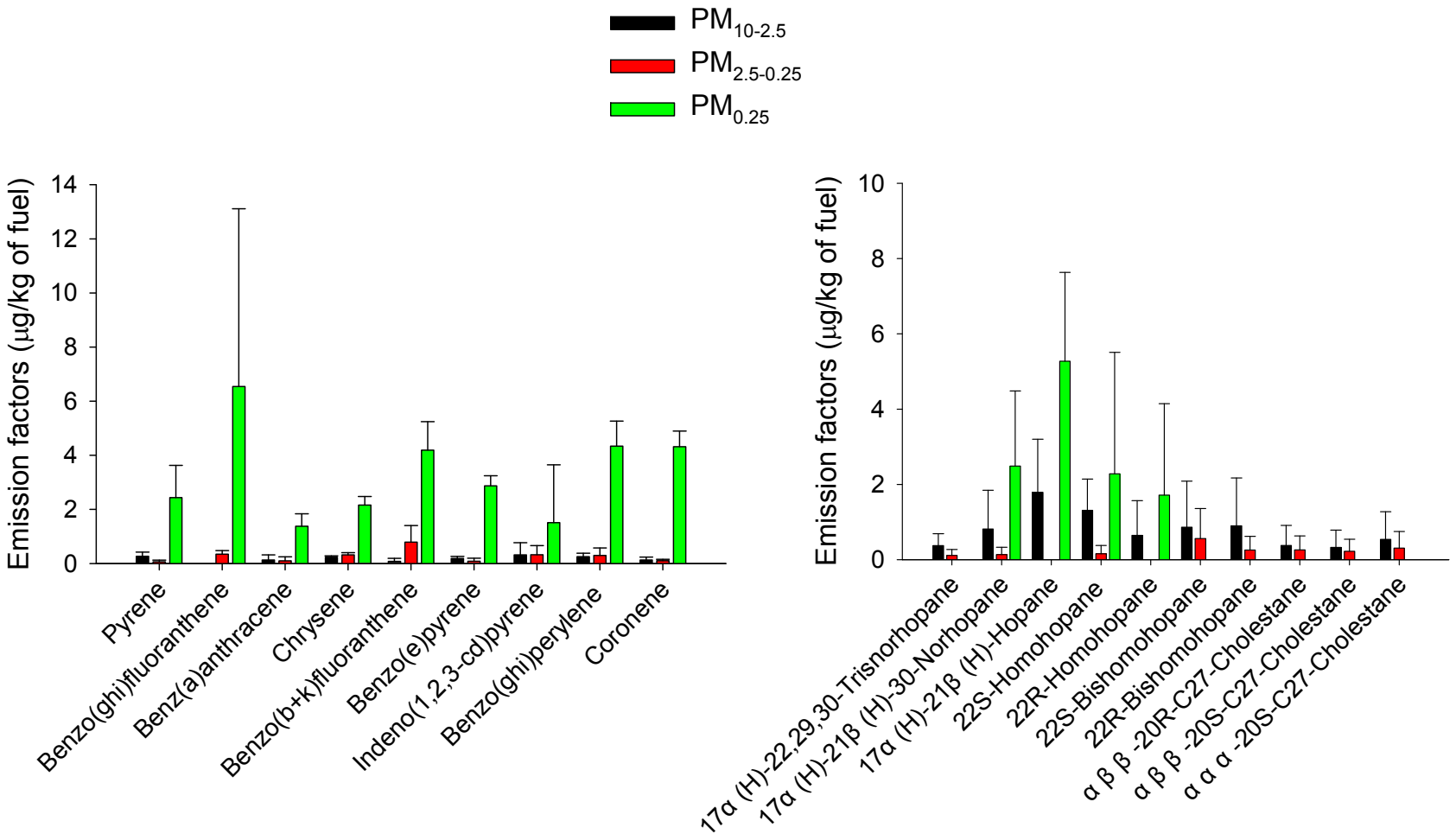
Total PM2.5 PAH concentrations in Wilshire/Sunset Blvds 8 times higher than urban background site of USC (*Kam et al , Atmos Environ, 2012*)



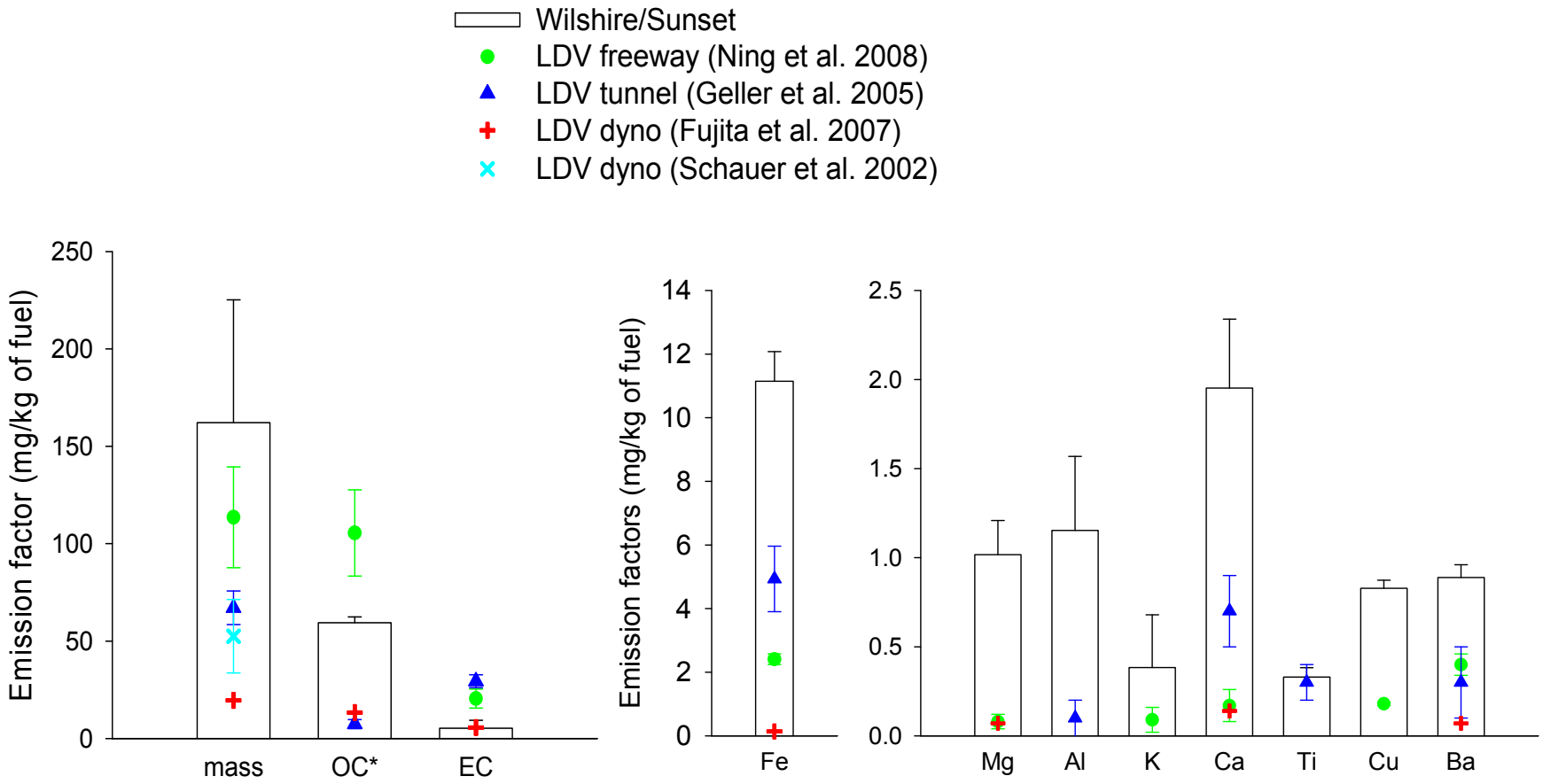
Significant non tailpipe emissions of metals



EFs – PAHs and Hopanes and Steranes

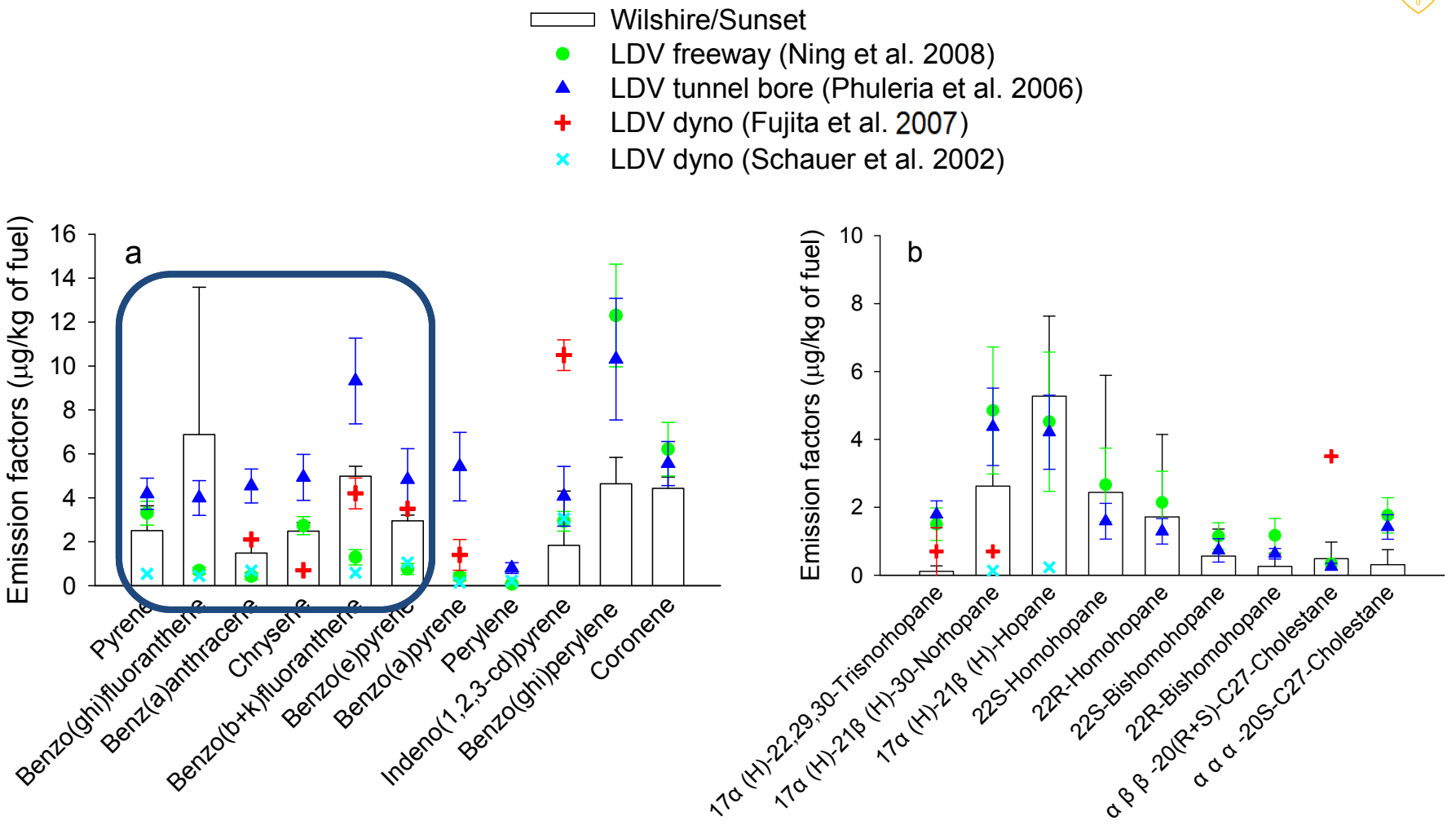


$PM_{2.5}$ EF comparison to earlier studies



* Ning et al. 2008 reported positive OC adsorption artifact; Geller et al. 2005 omitted ultrafine fraction

$PM_{2.5}$ EF comparison to earlier studies



Concluding Remarks

- On-road sampling of two major surface streets (Wilshire/Sunset Blvd) in Los Angeles, CA
- Emission factors are representative of a LDV fleet characterized by frequent acceleration and deceleration
- Previous LDV studies were conducted near freeway and tunnel, and chassis dynamometers
- **EFs from current study showed higher levels of metals and trace elements associated with vehicular abrasion (Fe, Ca, Cu, and Ba) and crustal origins (Mg and Al)**
- PAH EFs from current study are lower than LDV from tunnel studies and higher than LDV freeway studies
- Hopane and sterane EFs are comparable between studies

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