

***Michelin's latest results  
on quantification of  
airborne TRWPs : from  
vehicule usage to micro***

***TRWPs : Tire and Road Wear Particles***

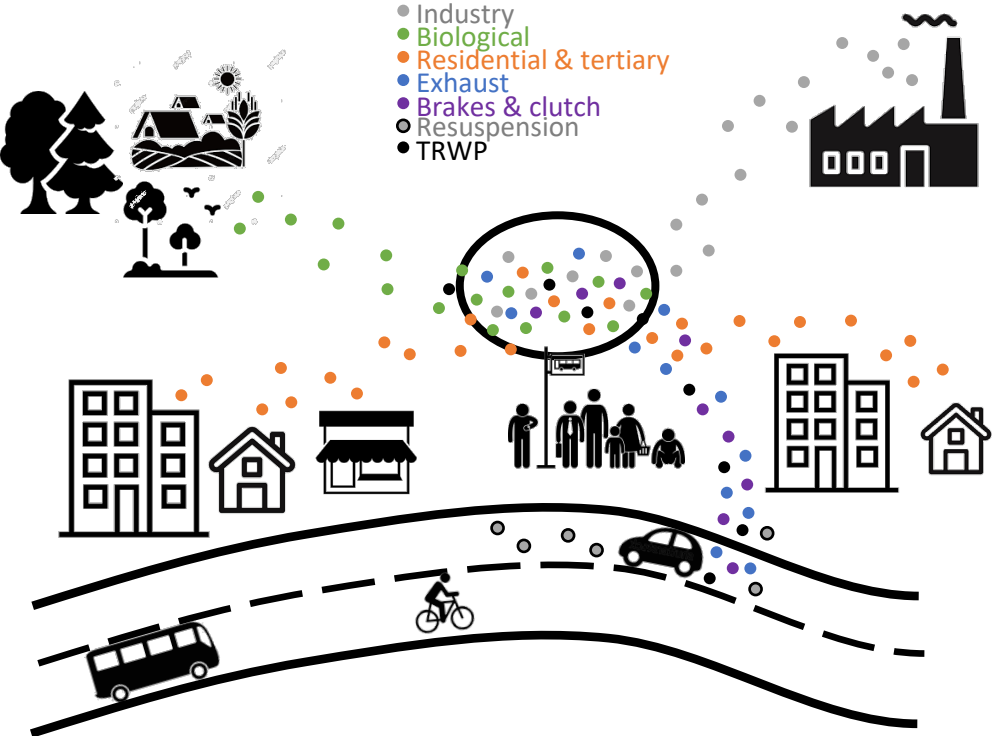


Guillaume LEMASSON, Senior Fellow Tire Physics & Modelization

Frédéric BIESSE, Senior Fellow Tire Physics & Modelization





# Importance of the Emission Factors to assess air quality



## Measuring the tire's Emission Factor is a technical challenge



We want to measure only TRWP : 

If no special care many other particles are counted as TRWP : 

## We further develop our experimental approach to minimize the bias



**Direct measurements** (to identify the origin of the particles)



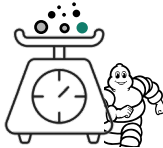
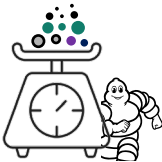
**Models + Emission Factors** (for Emission Inventories and Air Quality Assessment)

Tire's Emission Factors have been established 20 years ago with indirect measurements.

2020-2023

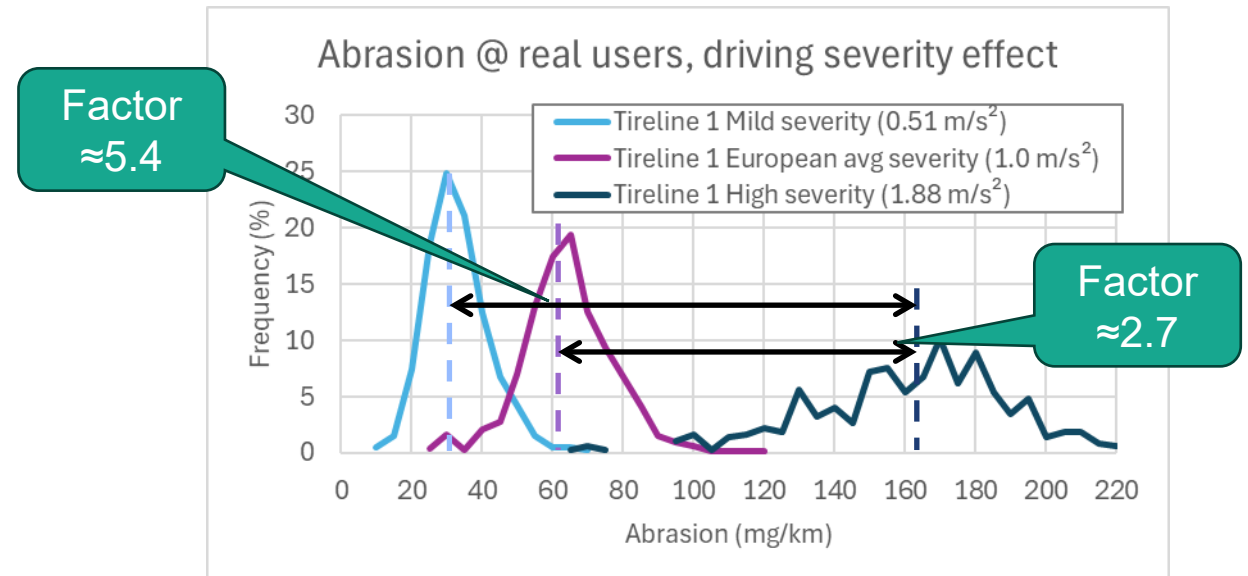
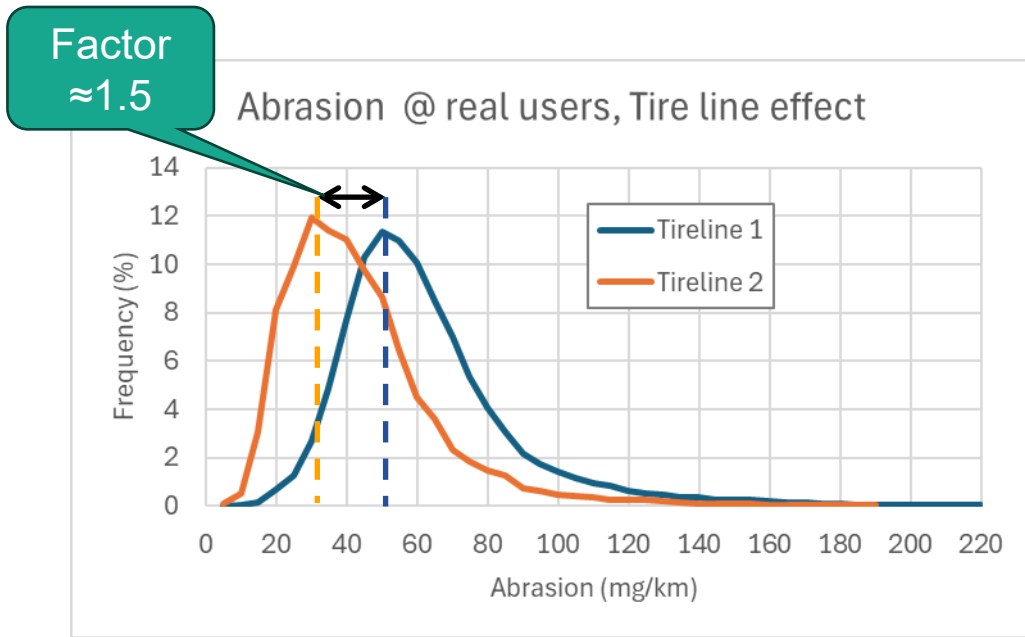
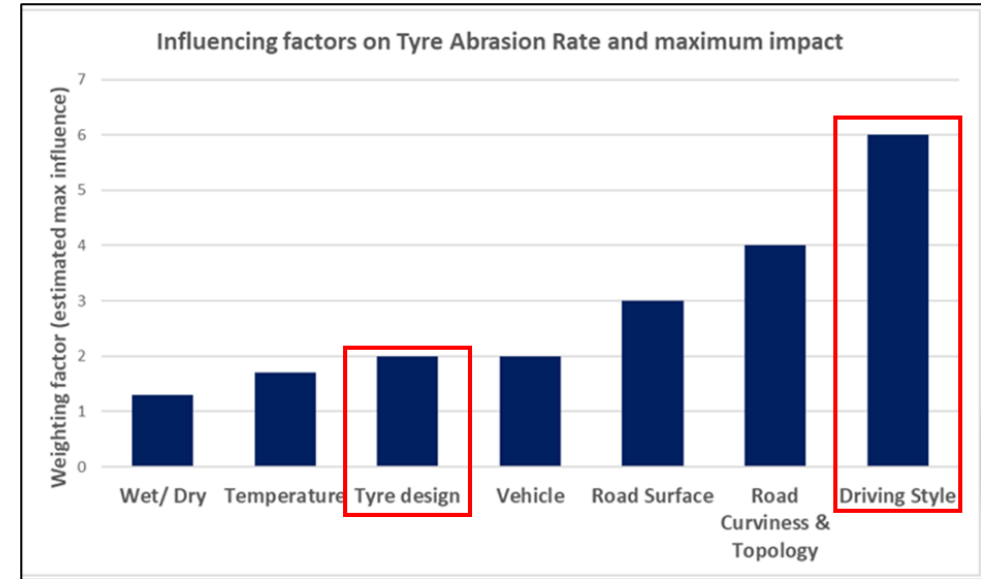
2024-2026

Target



# Tire abrasion and TRWP : driving severity is the most impacting factor

- ◎ TRWP are generated by tire abrasion
- ◎ Tire abrasion is mainly influenced by driving severity
- ◎ It can affect abrasion for up to a factor 6



NB : severity evaluated by quadratic mean of Sigmax and Sigmay

# Emission Factors direct measurement : test equipment



## Main vacuum : to catch all the TRWP

- 3 vacuums, 1 400 W & 75 m<sup>3</sup>/h each
- Total air flow rate = 225 m<sup>3</sup>/h
- 6kw power generator



## GPS + X/Y accel data

- Gathered in a cloud
- Allow to rebuild tire forces

## Connection to Real-time particles measurement : ELPI+ <sup>(1)</sup>

- Cascade impactor particle counter : 14 channels between 6 nm to 10 μm
- Sampling frequency = 1 Hz
- Air flow = 10 l/min

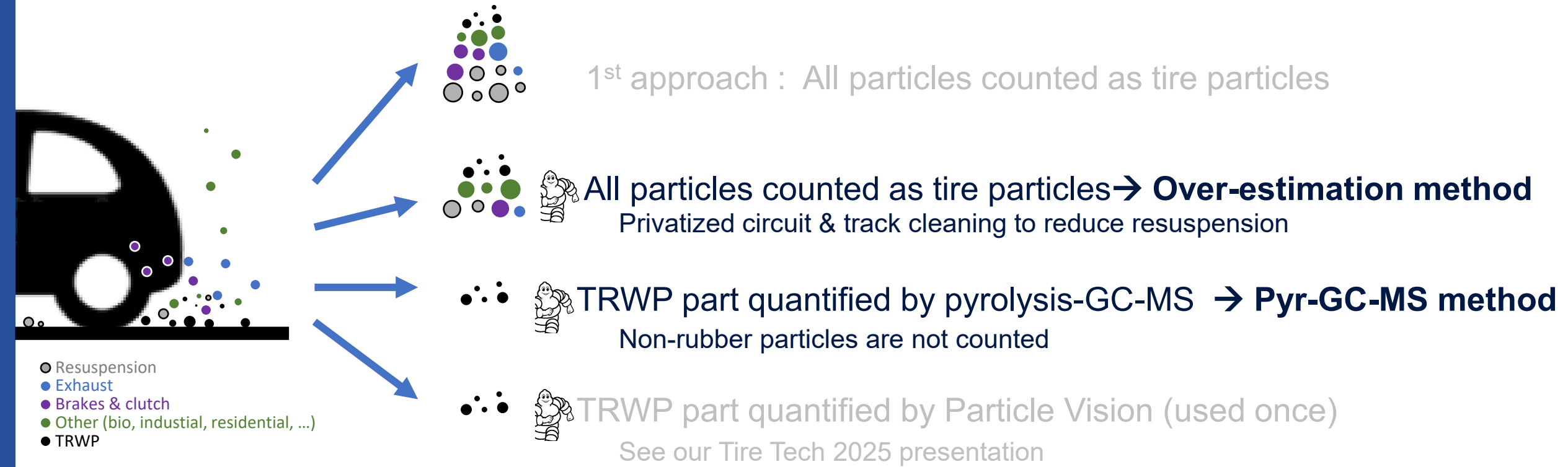


(1) ELPI : Electrical Low pressure Impactor

Aspiration system located in the tire-road contact area



# How to estimate the tire Emission Factor



Since end 2024, we apply Pyr-GC-MS in addition to over-estimation



# TRWP measurement : procedure

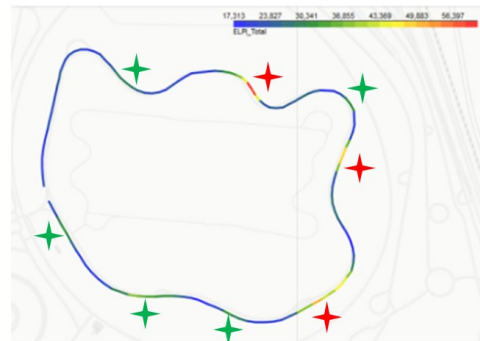
## Highway track (circuit, not privatized)

- Low emission level close to background noise
- Random peaks due to external events

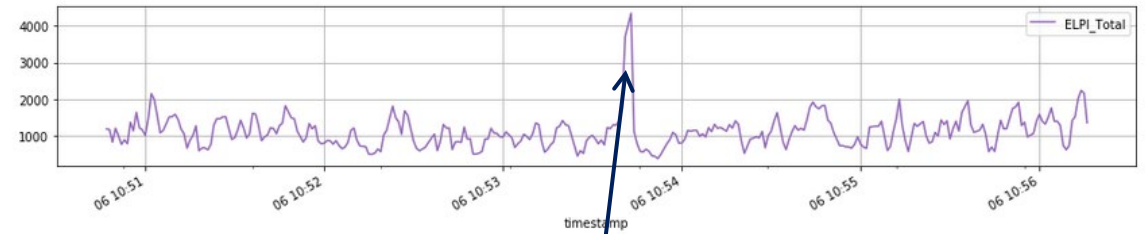


## Procedure to limit the bias

- Test on circuit (no open road)
- Privatized circuit : only the test vehicle is on the track
- Cleaned circuit to reduce re-suspension
  - 8h sweeping before each test
- Collect enough TRWP

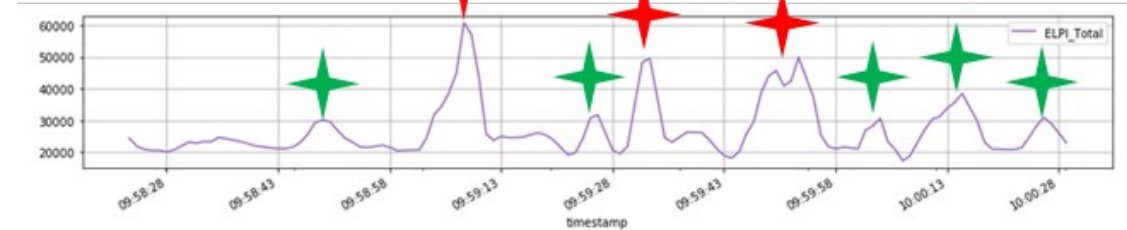


Max 2 500 #/cm3



**Random peaks = other vehicles overtaking**

Max 60 000 #/cm3



## Twisting track

- Repeatable laps with higher forces level
- Particle emission peaks localized at curve exit, consistent with tire wear influencing factors
- Higher emission level, above background
- Abrasion level  $\sim$ 250 mg/km: severity is higher than average customer

# How to estimate the tire Emission Factor: Pyrolysis GC-MS enables to isolate TRWPs only

Comparison of PM emission with Over-estimation vs Pyr-GC-MS methods :

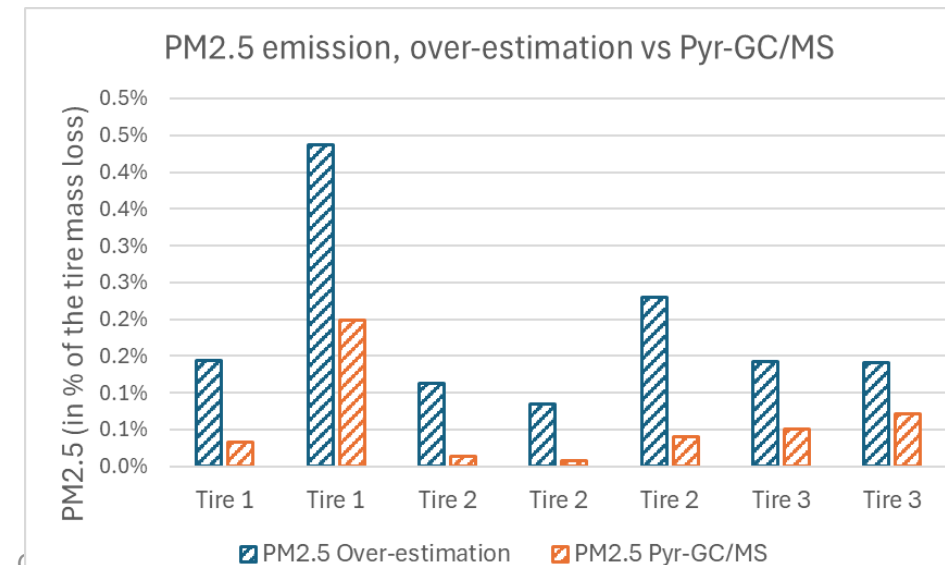
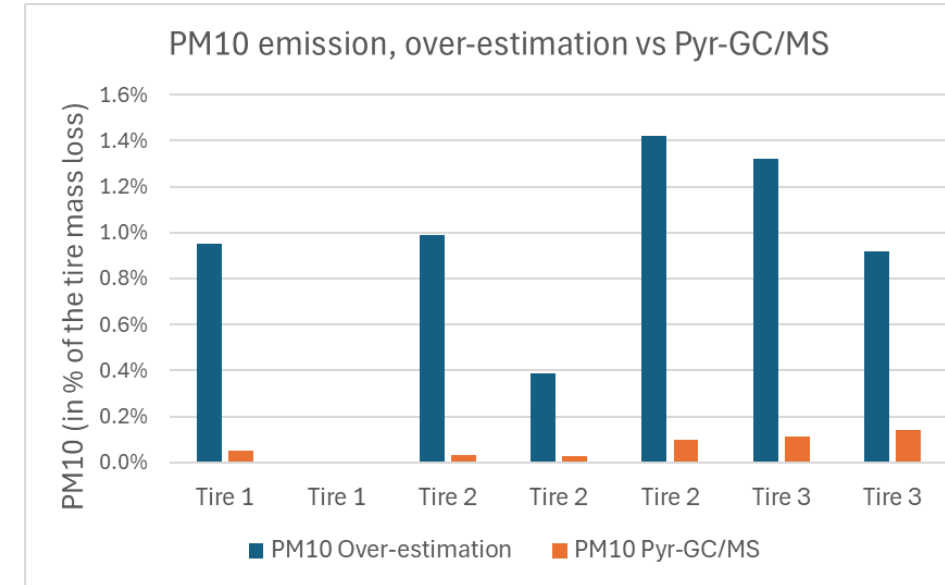
Size	Over-estimation	Pyr-GC/MS	Ratio
PM10	1.00%	0.08%	12.9
PM2.5	0.18%	0.06%	3.1

NB : Values in % are the mass of PM (10 or 2.5) divided by the tire mass loss during the test

- ⦿ The ratio of 12.9 for PM10 raises questions
  - ⦿ With “Particle vision” approach(\*), we found a ratio  $\approx 3$  for both PM10 and PM2.5 (vs over-estimation)
- (\*) See our Tire Tech 2025 presentation

➔ To be conservative, let's keep the ratio 3 for PM10 & PM2.5

= 1/3 of all particles collected are TRWPs



# How to estimate relative and absolute Emission Factors

## Our proposal for a global computation

### 1. PM10-PM2.5 test to get relative Emission Factors

- ➔ Result is % PM10 / tire mass loss (stable vs severity) and %PM2.5/tire mass loss.
- ➔ **1.58%** as mean value for PM10

- Integration of correction factors in these figures
  - Share of TRWP in all collected particles = 1/3 (in our test)
  - Aspiration efficiency : x3.2 for PM10, x4.5 for PM2.5 (in our test)

### 2. Abrasion value : from a dedicated representative abrasion test or representative value

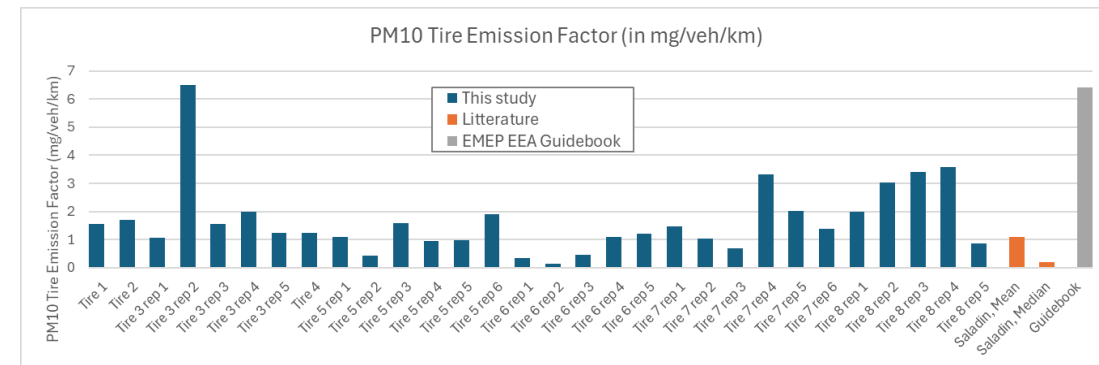
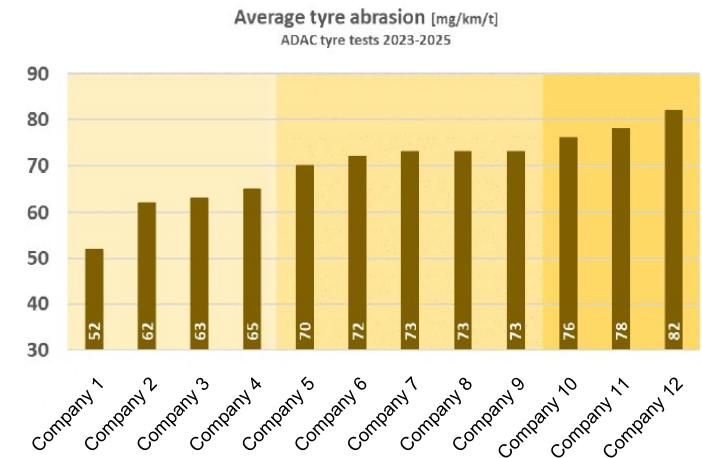
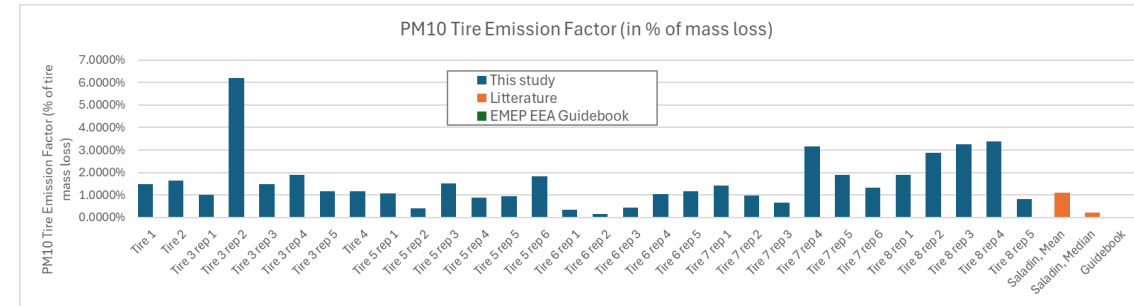
1st step : test ADAC 2025 ; 2nd step : EURO7 regulatory abrasion method

➔ **Avg tire mass loss = 69.9 mg/km/t (ADAC test mean value)**

➔ Avg vehicle = 1.5 t ➔ 104.9 mg/veh/km

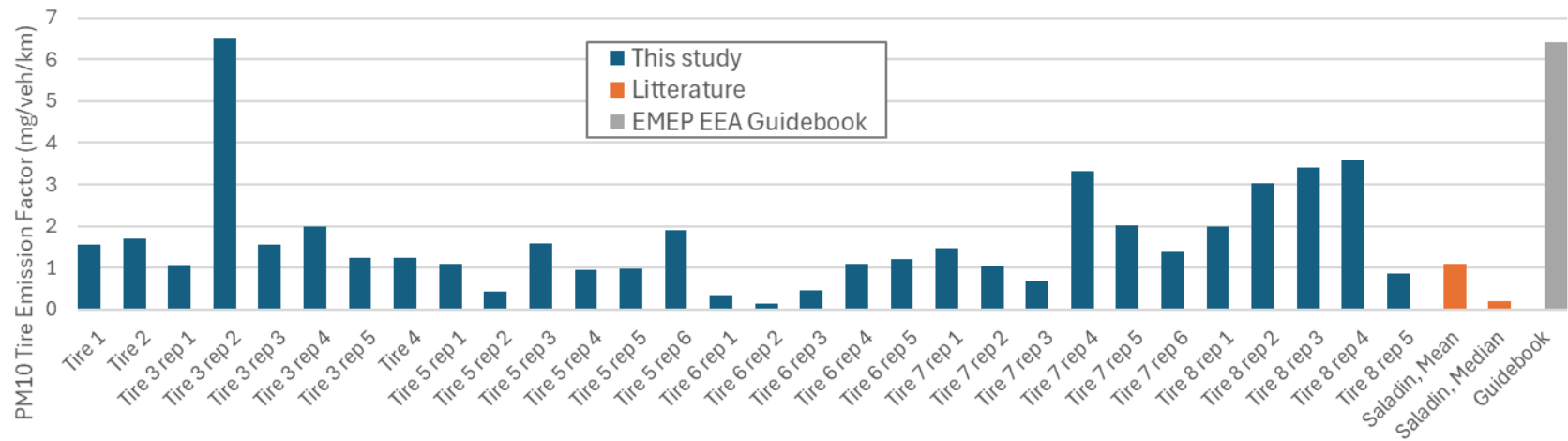
### 3. Recombination of tire mass loss & %PM10 (resp. PM2.5)

- ➔ **104.9 mg/veh/km x 1.58% for PM10 Emission factor**  
(resp. x 0.25% for PM2.5)



# 2026 update of absolute Tire Emission Factor results

PM10 Tire Emission Factor (in mg/veh/km)



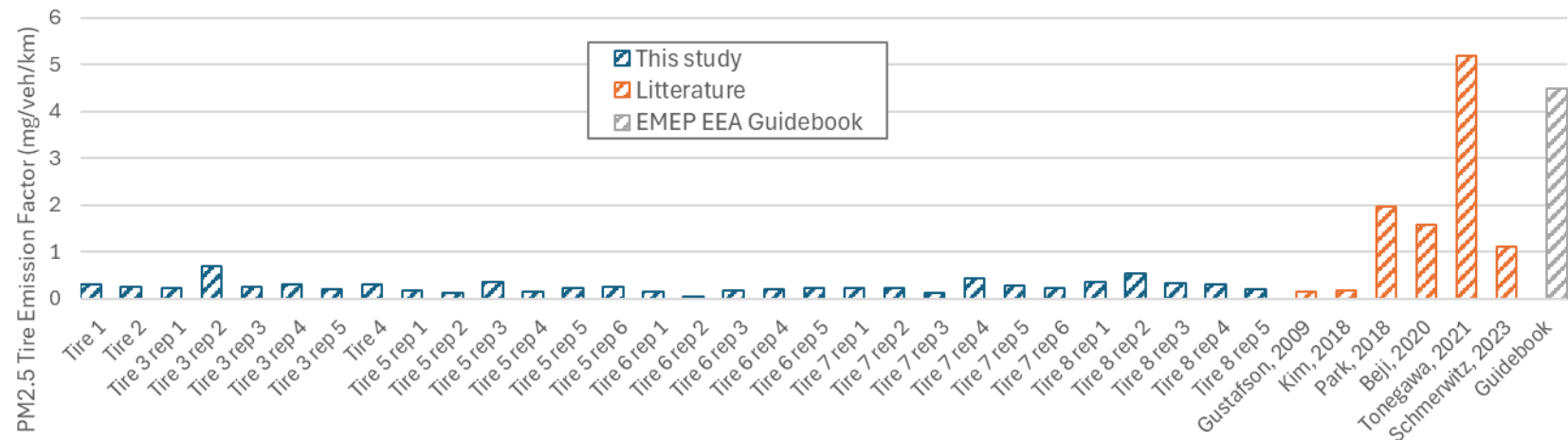
Tire Emission Factor:  
(in mg/veh/km)

	Our results	Standard value
PM10	1.66	6.42
PM2.5	0.27	4.49

Our results are in line with the recent literature (1)

The tire Emission Factors deserve an update

PM2.5 Tire Emission Factor (in mg/veh/km)



(1) Saladin, S., Boies, A., & Giorio, C. (2024). Airborne Tire Wear Particles: A Critical Reanalysis of the Literature Reveals Emission Factors Lower than Expected. *Environmental Science & Technology Letters*, 11(12), 1296-1307. <https://doi.org/10.1021/acs.estlett.4c00792>

# Synthesis

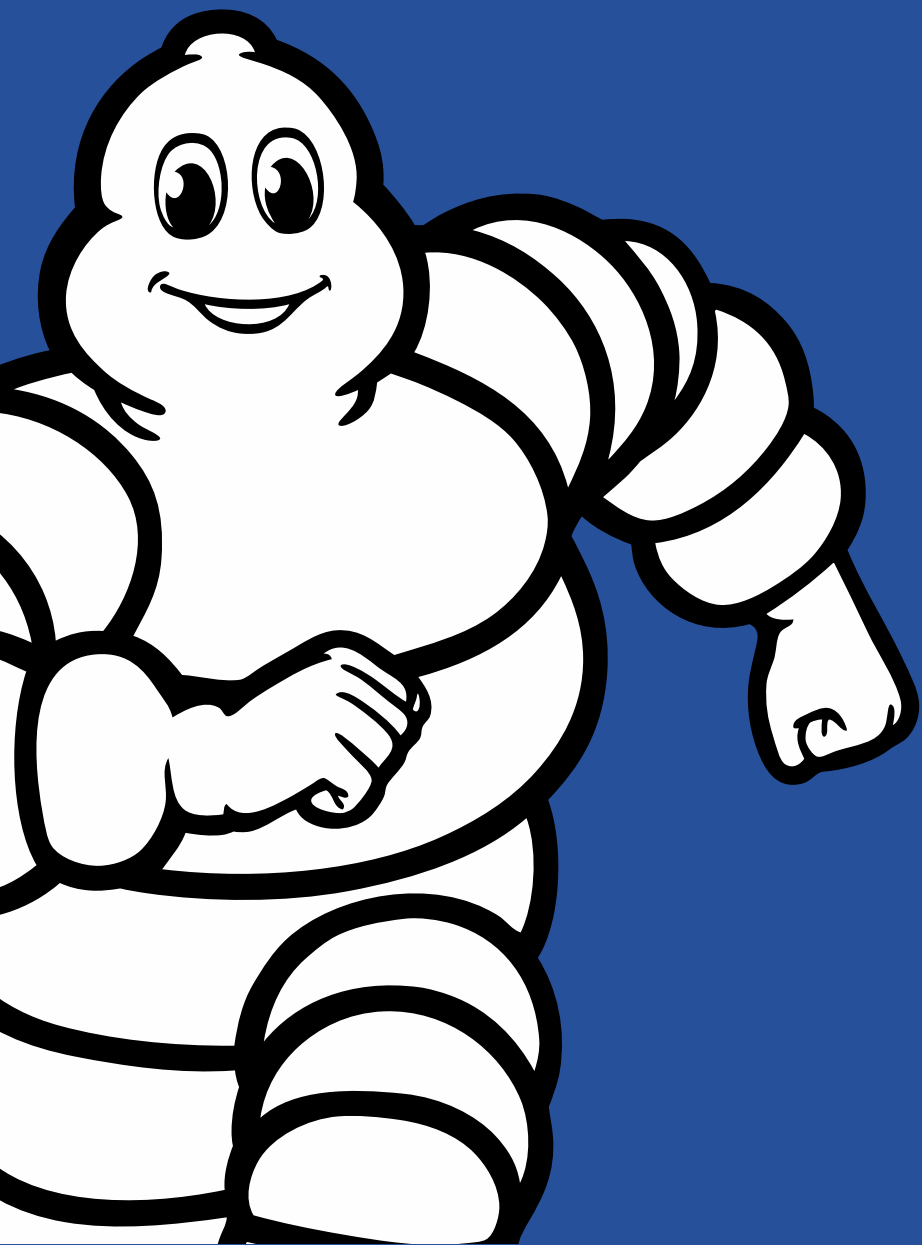
Tire abrasion and TRWP PM10 / 2.5 emission is influenced by many factors

Measuring **accurately** tire airborne particle emission is a **technical challenge**

A **relevant methodology** is needed **to derive relative then absolute Tire Emission Factors** from this tests

**Tire's Emission Factors** are overestimated and **deserve an update**





***MOTION  
FOR  
LIFE***

---