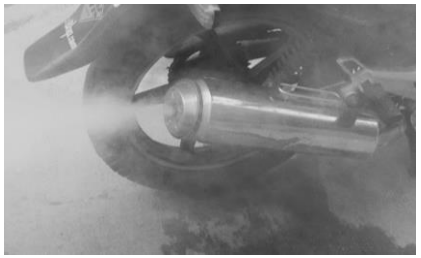


Real-World Motorcycle Emissions

Karl Ropkins

Presented at the
9th UCR International PEMS Conference
(Riverside, California)

14th to 15th March 2019

UNIVERSITY OF LEEDS
Transport Studies, Environment,
University of Leeds, UK
Email: k.Ropkins@its.leeds.ac.uk

Introduction

London Motorcycle Restrictions:

9th April 2019 LONDON Ultra Low Emissions Zone (ULEZ)

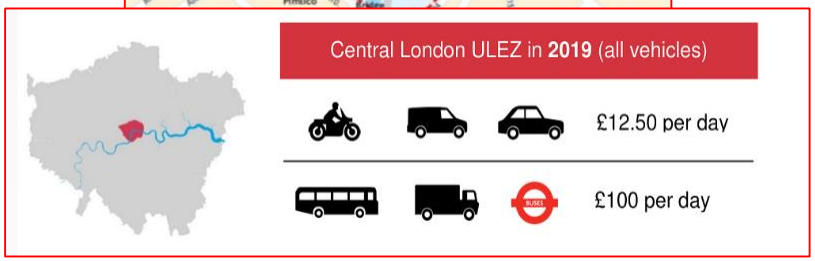
Includes charging for pre-EURO3 Motorcycles, Mopeds and Scooters

This received (perhaps understandably) negative feedback

Motorcycles make a small contribution to on-road emissions

Currently about 2% and 0.3% to PM and NO_x

(2019 ULEZ; expected to be extended by 2021)



(Charging to include motorcycles and other L-class vehicles)

Emissions impossible; what Euro 4 really means

Published: 30 December 2016

MOTORCYCLE ACTION GROUP TO HOLD ULEZ PROTEST RIDE THROUGH LONDON

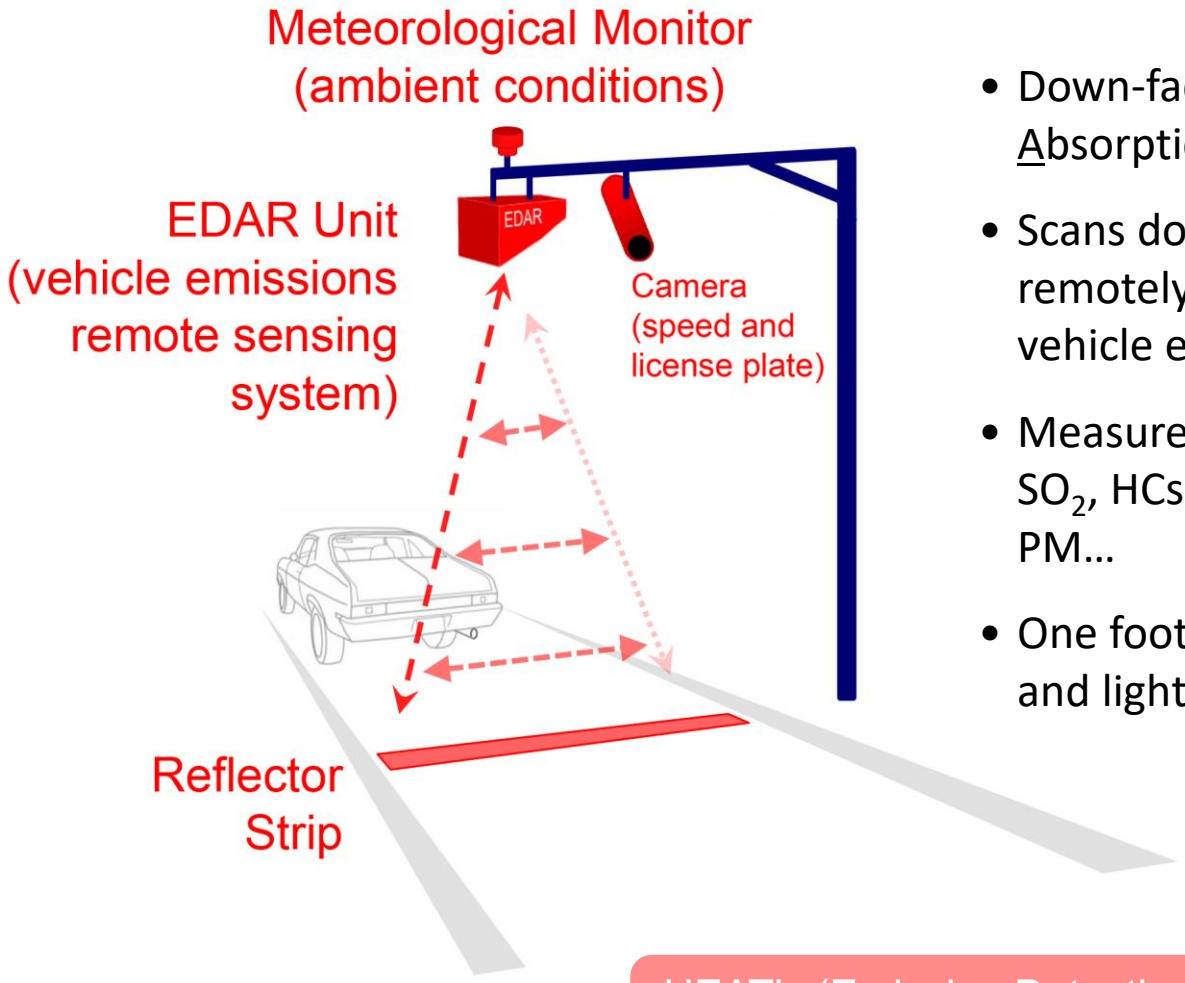
The £12.50 ULEZ

ULEZ CHARGE TO BRING MISERY TO LONDON'S MOTORCYCLISTS FROM APRIL

Find out if your motorcycle will be affected by the £12.50 ULEZ charge here...

(Sources: Motorcycle News, Retro-RR, VisorDown, Dec 2018)

EDAR



- Down-facing (Differential Absorption LIDAR) DiAL VERSS
- Scans down onto road to remotely measure passing vehicle emissions
- Measures CO_2, CO, NO, NO_2, SO_2, HCs (total, CH_4, C_3H_8, etc.), PM…
- One footprint for both heavy and light duty vehicles

HEAT's (Emission Detection And Reporting) EDAR
https://www.heatremotesensing.com/

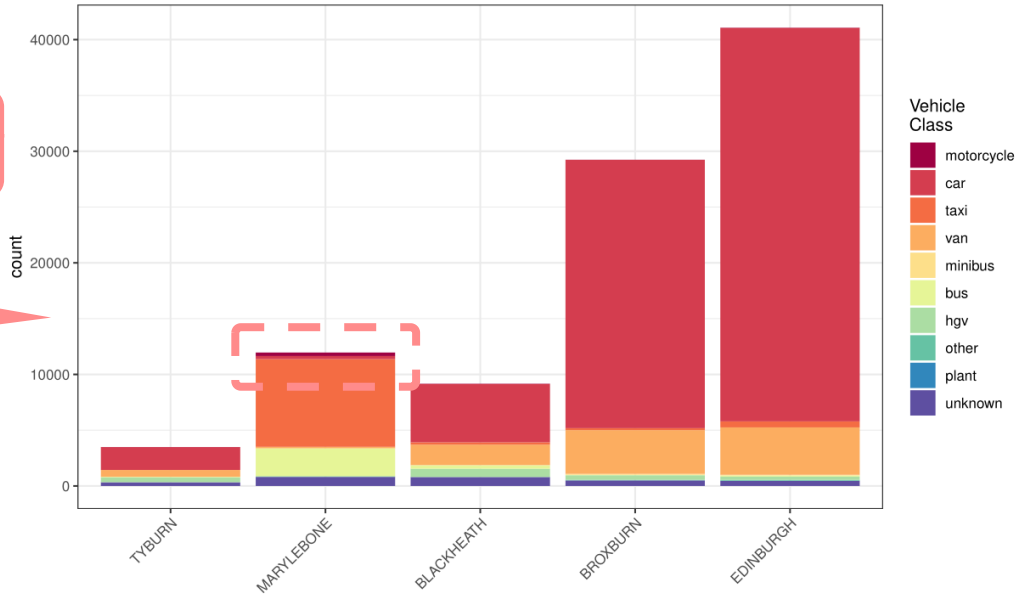
EDAR Motorcycle Data

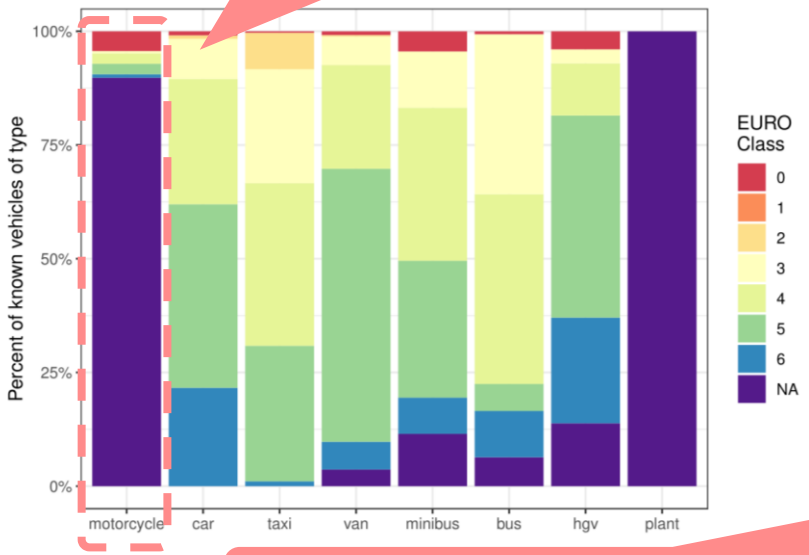
Motorcycle counts are relatively low…

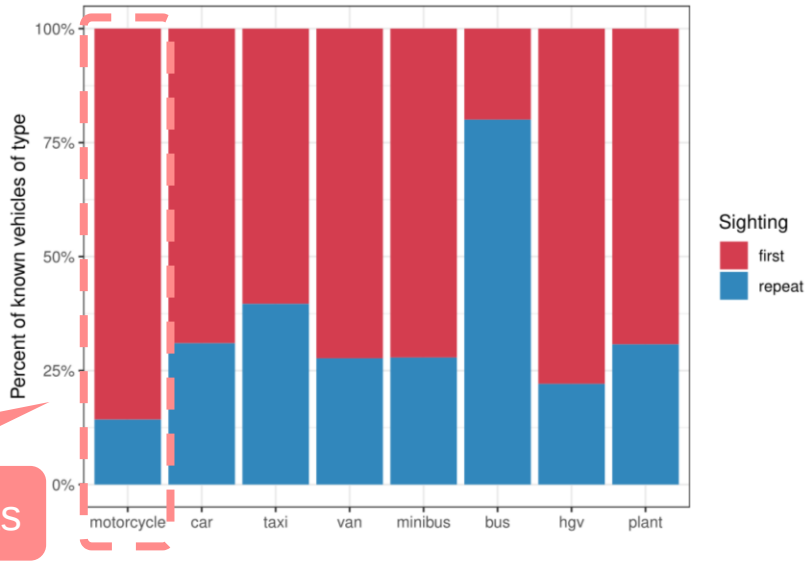
… and mainly seen at atypical remote sensing sites

Relatively little national archive information

Less repeat sightings than other fleets

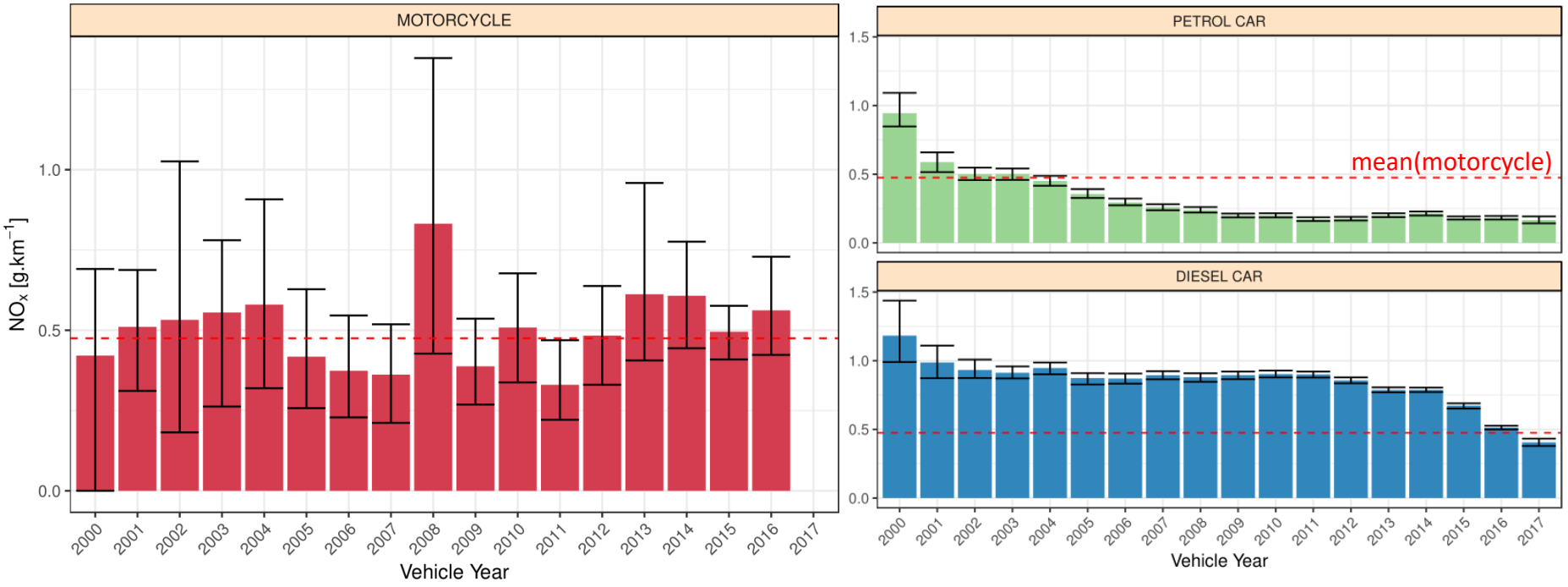






EDAR Motorcycle Emissions Trends

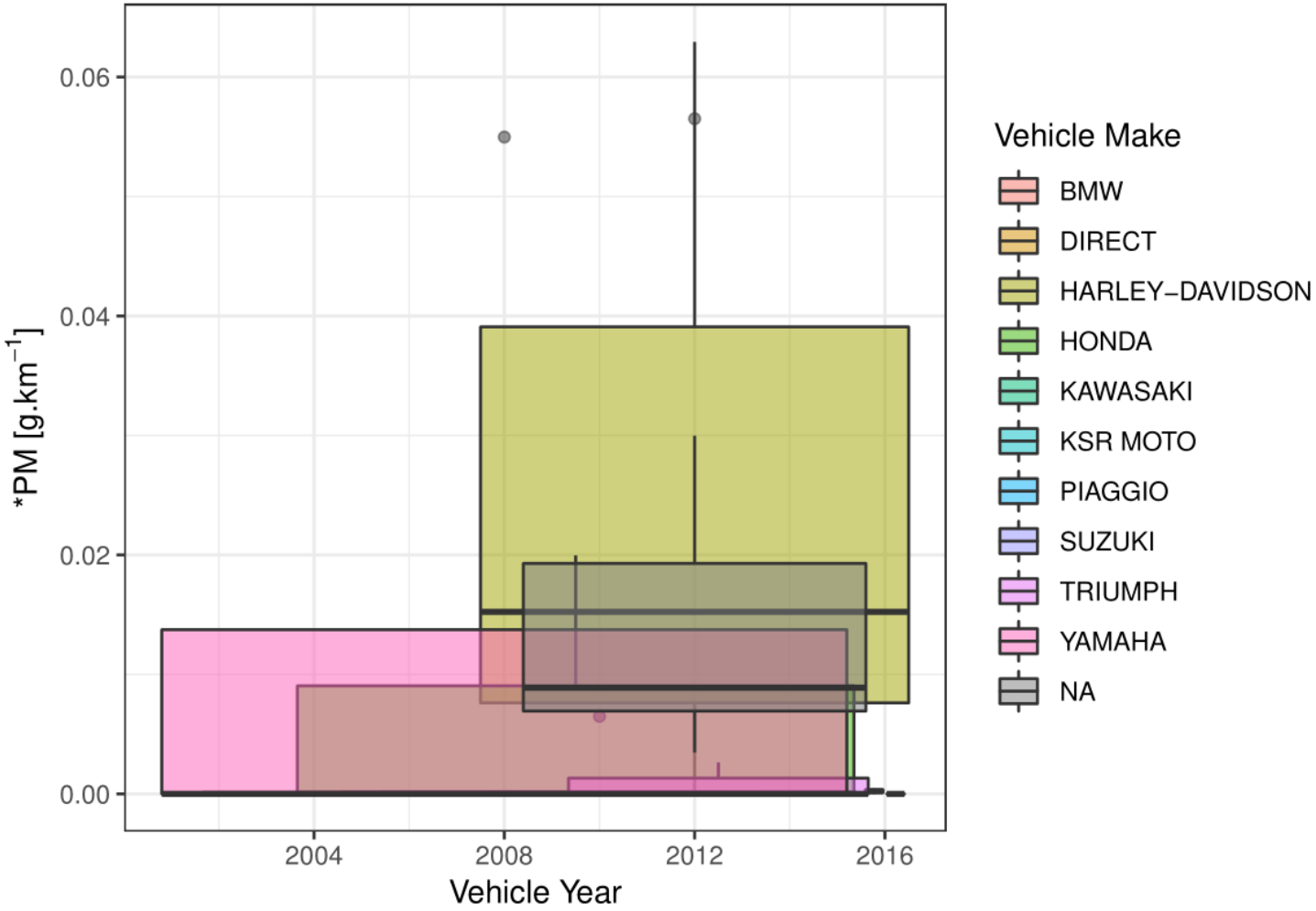
Little evidence for recent improvements in motorcycle emissions



- Over the same period, emissions have improved for most other vehicle types, so motorcycles emissions are becoming increasing important
- This trend most pronounced for CO (and most likely HC) where improvements to other fleets are largest but even significant for NOx (shown here)

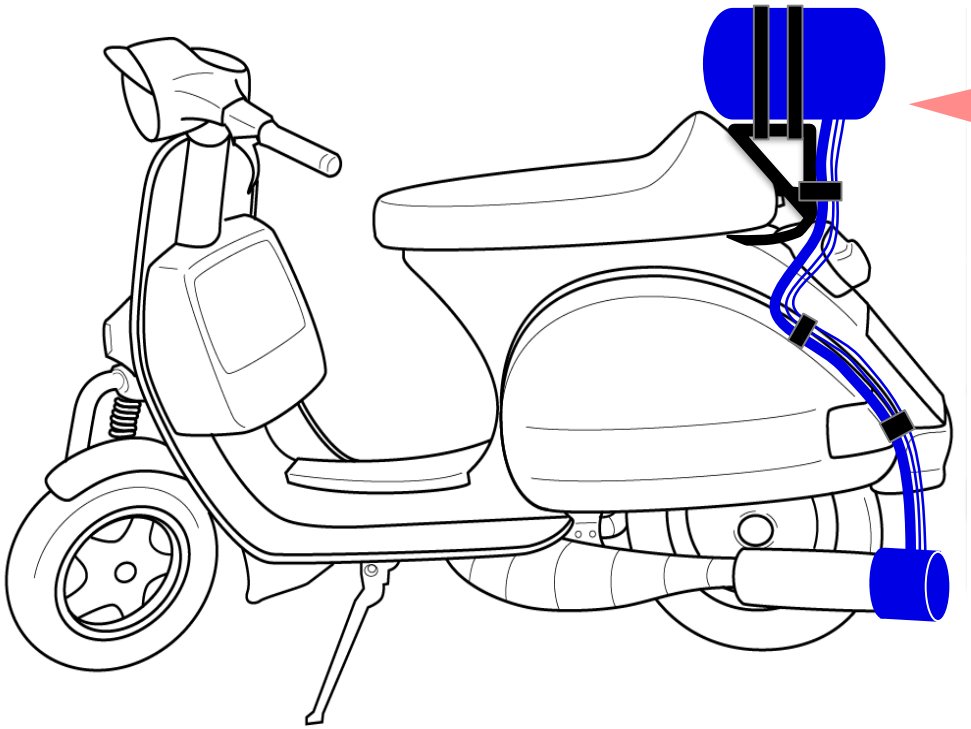
EDAR Motorcycle Emissions Trends (2)

Very few cases where motorcycle information is complete, so this is NOT STATISTICALLY SIGNIFICANT but some early indications of POSSIBLE trends



PEMS

Presenting example data here from a Scooter
(4-Stroke, EURO3, 150cc, Air-cooled, carburettor)



Motorcycle PEMS
Modified parSYNC:

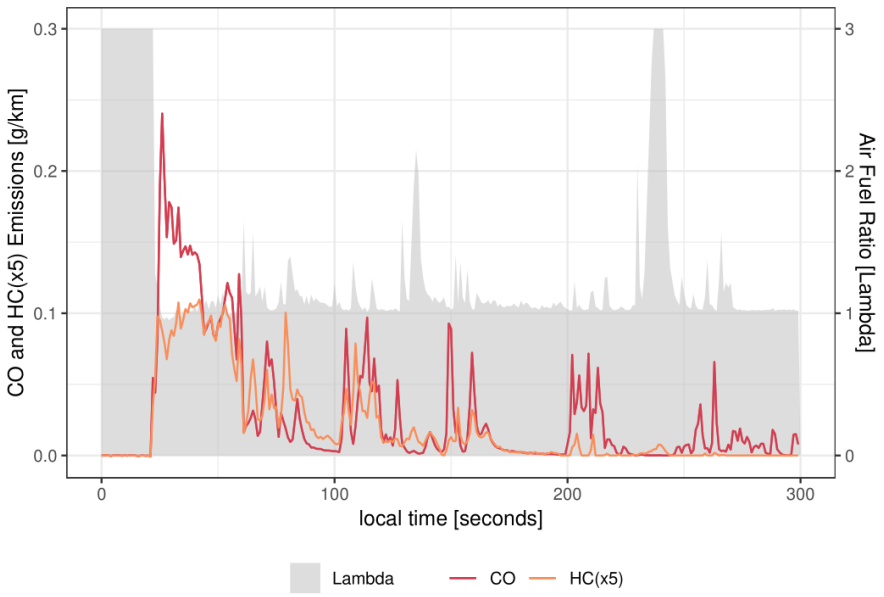
- Gases CO_2, CO, HC (IR), NO, NO_2 (EC)
- PM (Banbury PM mod)
- PITOT, GPS, AFR
- (in Astro Top-Box)

Early days and we are still working on the design, including:

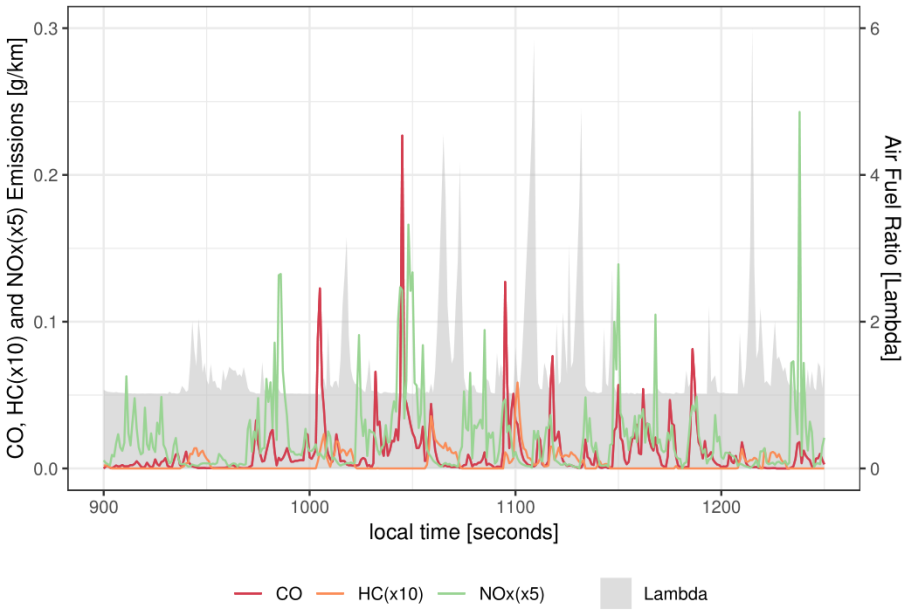
- Exhaust attachment and sample inlet
- Luggage box (box) or panniers (saddle bags) deployment
- Activity tracking

PEMS Single Motorcycle Emissions

Example real-world motor emissions data



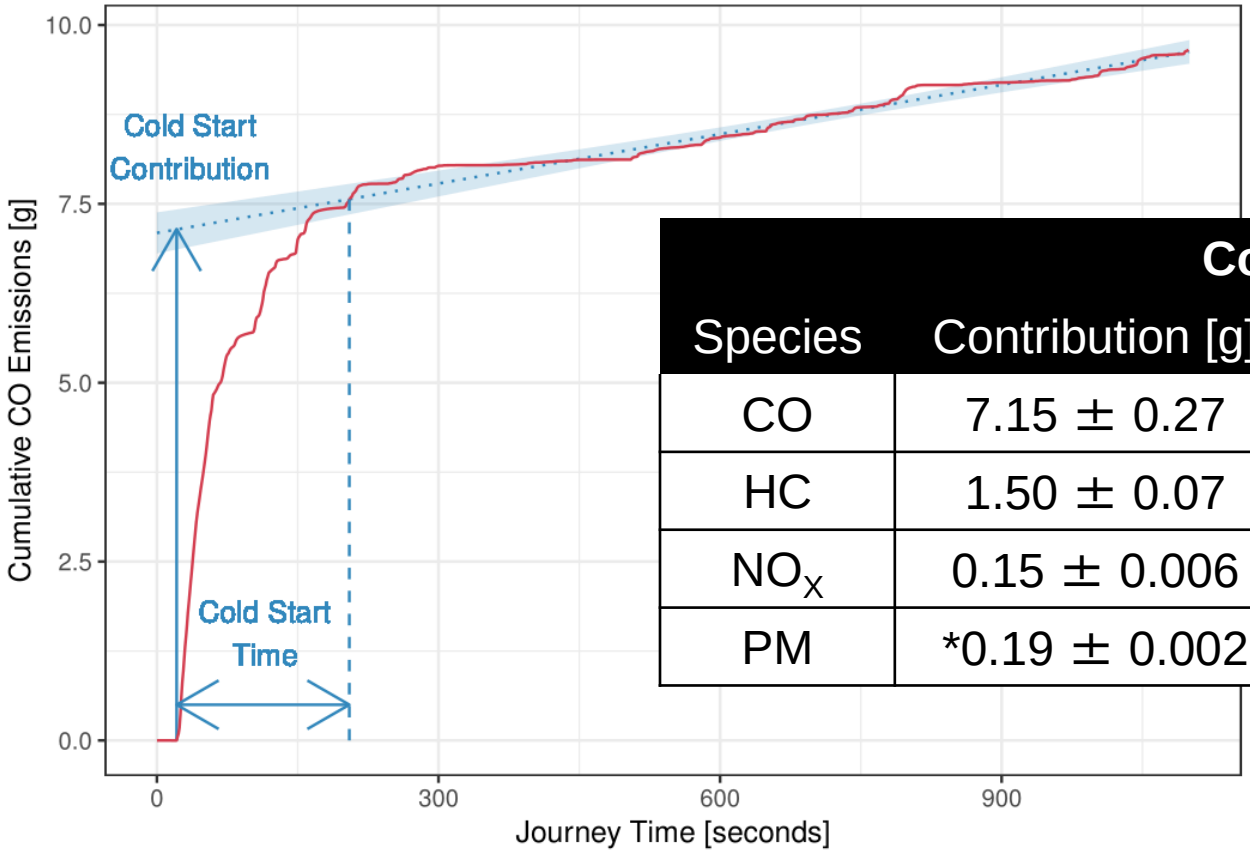
Large fuel enrichment emission penalty during cold start



And a very delicate balance between lean and rich emissions during hot transient operation

PEMS Single Motorcycle Emissions (2)

Cold start emission contributions

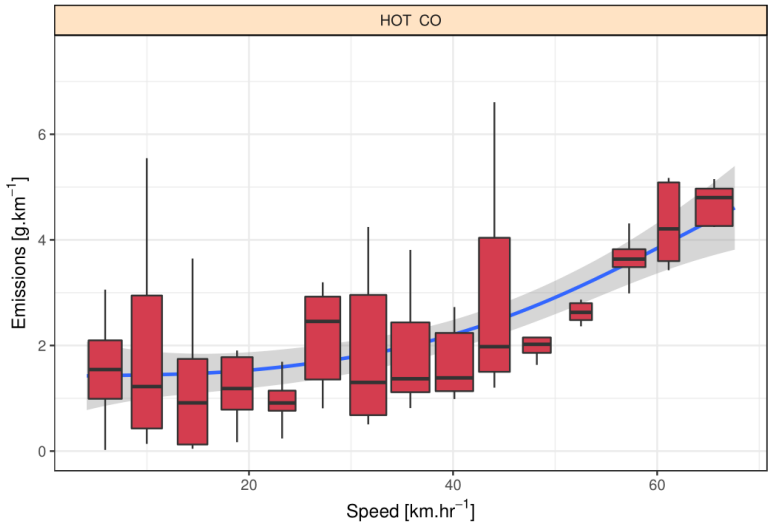


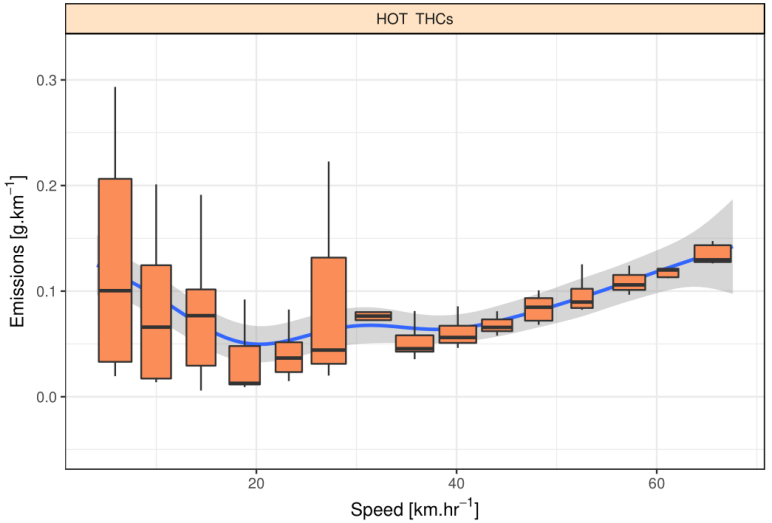
	Cold Start	
Species	Contribution [g]	Time [seconds]
CO	7.15 ± 0.27	181
HC	1.50 ± 0.07	202
NO_X	0.15 ± 0.006	172
PM	*0.19 ± 0.002	169

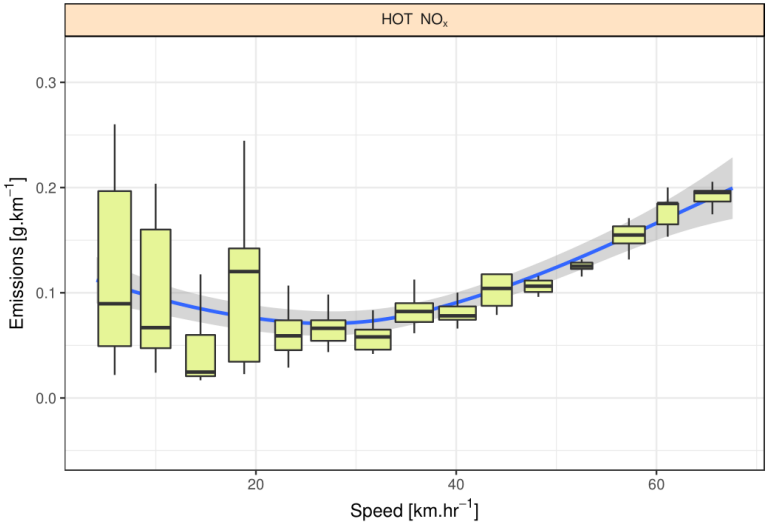
(*not pre-conditioned, so maybe some residual PM contribution from previous run)

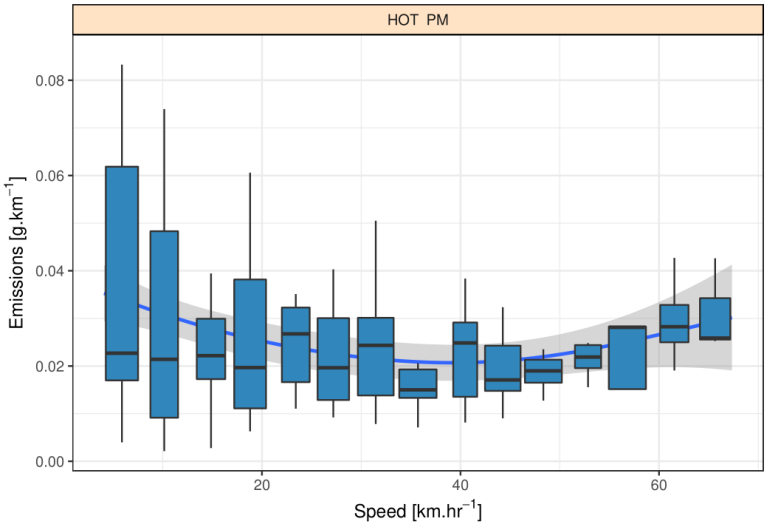
PEMS Single Motorcycle Emissions (3)

Hot (post cold-start) exhaust g.km^{-1} emissions









Final Comments

Observations:

Early, tentative, findings indicate motorcycle CO, HC, NO_x and CO_2 emissions have not changed significantly in the last two decades

This likely reflects both the more aggressive regulation of car emissions and the larger challenges for real-world motorcycle emissions control

In recent years, an increase in smaller motorcycle, moped and scooter use, linked with increased high usage by delivery services in urban areas, means that while motorcycle emissions are still by no means equal to those of cars, they are becoming increasing significant in more populated areas, supporting the case for early preventive action

Although at an early stage in the work we already expect that small, light-weight sensor-based PEMS will be critical for the collection of representative real-world motorcycle emissions data

Acknowledgements

Acknowledgements:

HEAT, Department for Transport, Transport Scotland, Transport Systems Catapult, University of Birmingham and King's College London for their contributions to EDAR studies

Dave Miller and all at 3DATx for their input and support on Motorcycle PEMS development

A Scooter owner who wished to remain anonymous…

Any Questions?

Additional Information

The followings slides are supplied as background and supporting information to the prior presentation

Conference Abstract

Real-World Motorcycle Emissions

Karl Ropkins[1]
(1) Transport Studies, Environment, University of Leeds, UK; email: k.ropkins@its.leeds.ac.uk.

The recent announcement that from 8th April 2019, the London Ultra Low Emission Zone (ULEZ) scheme will include charging for motorcycles, mopeds and scooters that do not meet EURO3 standards was met with negative feedback from both trade and public media. Many noted that the national motorcycle fleet is small and contributes relatively little to road transport emissions (e.g. about 2% and 0.3% to PM and NOx, respectively). Some even went on to identify the strategy as a mistake and to highlight a move from cars to motorbikes as a mechanism for reducing both emissions and congestion. But, most importantly, many noted that most other cities were not planning similar actions and asked by London was picking on motorcyclist?

Here, as part of that discussion we present recent evidence on motorcycle emissions from both remote sensing and PEMS studies.

Early findings, although tentative, indicate that motorcycle CO, HC, NO_x and CO_2 emissions have not changed significantly in the last two decades, and, CO and HC motorcycle emissions now exceed those of modern cars and even NO_x emissions are not negligible on a g/km basis. This trend most likely reflects both the more aggressive regulation of car emissions and also the greater challenges in the engine management of the much more transient real-world emissions of motorcycles. PEMS data, in particular, provides significant evidence on the delicate balance between lean and rich engine modes, and the emission penalties of combinations like cold start fuel enrichment and hot transient exhaust flow rates. Here, we also acknowledge the critical role of small, light-weight sensor-based PEMS in collecting representative real-world motorcycle emissions data.

In recent years, a relatively large increase in smaller motorcycle, moped and scooter use, linked in part with increased high-intensity use by delivery services in urban areas, means that while motor cycles emissions inventory contributions are still by no means equal to those of cars, they are becoming increasing significant in the most populated and polluted areas, supporting the case for early preventive action.

UK (EU) Motorcycle Legislation

L-class vehicle (motorcycle and related) classifications

Category	Category name	Classification criteria
L1Ae	Light 2-wheel powered vehicle	• Engine aids pedaling of vehicle • Engine $V_d \leq 50$ cc • $V_{max} \leq 25$ km/h • No aux. propulsion above V_{max} • $P_{max.cont} \leq 1$kW [1]
L1Be	2-wheel moped	• $V_{max} \leq 25$ km/h • $P_{max.cont} \leq 4$ kW
L2e	3-wheel moped	• Engine $V_d > 50$ cc • $V_{max} \leq 45$ km/h • $P_{max.cont} \leq 4$ kW
L3e –A1	2-wheel motorcycle Low performance	• Engine $50 < V_d \leq 125$ cc • $V_{max} > 45$ km/h • $4 < P_{max.cont} \leq 11$ kW power/weight ≤ 0.1 kW/kg
L3e –A2	2-wheel motorcycle Medium performance	• Engine $V_d > 50$ cc • $V_{max} > 45$ km/h • $4 < P_{max.cont} \leq 35$ kW power/weight ≤ 0.2 kW/kg
L3e –A3	2-wheel motorcycle High performance	Any other L3e category motorcycle
L5Ae	Tricycle	• Engine $V_d > 50$ cc • $V_{max} > 45$ km/h • $P_{max.cont} > 4$ kW
L5Be	Commercial tricycle	• Engine $V_d > 50$ cc • $V_{max} > 45$ km/h • $P_{max.cont} > 4$ kW • Open and Enclosed driver and passenger (2• 4 people including driver) • Carriage of goods (bed area > 30% of vehicle length times width)
L6Ae	Light quadricyle	• Engine $V_d \leq 50$ cc • $V_{max} \leq 45$ km/h • $P_{max.cont} \leq 4$ kW • Mass ≤ 350 kg (not including weight of gaseous fuel tanks)
L6Be	Light mini-car	• Engine $V_d \leq 50$ cc • $V_{max} \leq 45$ km/h • $P_{max.cont} \leq 6$ kW • Mass ≤ 350 kg (not including weight of gaseous fuel tanks) • Enclosed driver and passenger (2 people including driver) • Carriage of goods (bed area > 30% of vehicle length times width)
L7Ae	Heavy on-road quadricycle	• $V_{max} > 45$ km/h • $P_{max.cont} \leq 15$ kW • Mass ≤ 400 kg for passengers (w/o including weight of gaseous fuel tanks) • 2 people max (Includes passenger)
L7Be	Heavy mini-car	• $V_{max} > 45$ km/h • $P_{max.cont} \leq 15$ kW • Mass ≤ 400 kg for passengers • Mass ≤ 500 kg for goods (w/o including weight of gaseous fuel tanks) • Enclosed driver and passenger (2• 4 people including driver) • Carriage of goods (bed area > 30% of vehicle length times width)

(Source: ICCT Policy Update, Proposed New Emissions Standards for Two-and Three- Wheeled)

Tailpipe (after cold-start) Emission Limits

Dates	Vehicle category	Vehicle cat. description	Test cycle	Propulsion class	CO (g/km)	THC (g/km)	NOx (g/km)	PM (g/km)[4]	THC+NOx (g/km)
Euro 3 [1]									
NV: 01 July 2013 (Optional) 01 Jan 2014 (Obligatory) AV: 01 Jan 2015 (Obligatory)	L1Ae	Powered cycle [4]	UNECE R47	PI/CI/Hybrid	0.56	0.10	0.13	-	-
	L1Be	Two-wheel moped		PI/CI/Hybrid	1.00	-	-	-	1.20
	L2e	Three-wheel moped		PI/CI/Hybrid	3.50	-	-	-	1.20
	L3e [5] L4e L5Ae L7Ae	• Two-wheel motor-cycle w and w/o sidecar • Tricycle • Heavy on-road quad	WMTC, phase 2	PI, $V_{max} < 130$ km/h	1.97	0.56	0.13	-	-
				PI, $V_{max} \geq 130$ km/h	1.97	0.25	0.17	-	-
				CI/ Hybrid	1.00	0.10	0.57	0.10	-
	L5Be	Commercial tricycle	UNECE R40	PI	4.00	1.00	0.25	-	-
				CI/ Hybrid	1.00	0.15	0.65	0.10	-
	L6Ae L6Be	Light on-road quadricyle Light mini-car	UNECE R47	PI	3.50	-	-	-	1.20
				CI/ Hybrid	1.00	0.15	0.65	0.10	-
	L7Be	Heavy mini-car	UNECE R40	PI	4.00	1.00	0.25	-	-
				CI/ Hybrid	1.00	0.15	0.65	0.10	-
Euro 4 [2]									
NV: 01 Jan 2015 (Optional) 01 Jan 2017 (Obligatory) AV: 01 Jan 2018 (Obligatory)	L1Ae	Powered cycle	UNECE R47	PI/CI/Hybrid	0.56	0.10	0.07	-	-
	L1Be	Two-wheel moped		PI/CI/Hybrid	1.00	0.63	0.17	-	-
	L2e	Three-wheel moped		PI/CI/Hybrid	1.90	0.73	0.17	-	-
	L3e [5] L4e L5Ae L7Ae	• Two-wheel motor-cycle w and w/o sidecar • Tricycle • Heavy on-road quad	WMTC, phase 2	PI, $V_{max} < 130$ km/h	1.14	0.38	0.07	-	-
				PI, $V_{max} \geq 130$ km/h	1.14	0.17	0.09	-	-
				CI/ Hybrid	1.00	0.10	0.30	0.08	-
	L5Be	Commercial tricycle	UNECE R40	PI	2.00	0.55	0.25	-	-
				CI/ Hybrid	1.00	0.10	0.55	0.08	-
	L6Ae L6Be	Light on-road quadricyle Light mini-car	UNECE R47	PI	1.90	0.73	0.17	-	0.08
				CI/ Hybrid	1.00	0.10	0.55	0.10	-
	L7Be	Heavy mini-car	UNECE R40	PI	2.00	0.55	0.25	-	-
				CI/ Hybrid	1.00	0.10	0.55	0.10	-
Euro 5 [3]									
NV: 01 Jan 2018 (Optional) 01 Jan 2020 (Obligatory) AV: 01 Jan 2021 (Obligatory)	L1Ae	Powered cycle	Revised WMTC	PI /CI/ Hybrid	0.50	THC 0.010 NMHC 0.068	0.060	0.0045	-
	L1Be-L7e [3]	All other L-category vehicles	Revised WMTC	PI	1.00		0.060	0.0045	-
			Revised WMTC	CI / Hybrid	0.50		0.060	0.0045	-

(1) Category L3e: Euro 4
(2) Category L3e: Euro 5
(3) Category L3e: Euro 6
(4) Bicycle with auxiliary engine
(5) PM measured in CI engines or in hybrids with CI engines

NV: New vehicle
AV: All vehicles
NMHC: Non-methane hydrocarbon.