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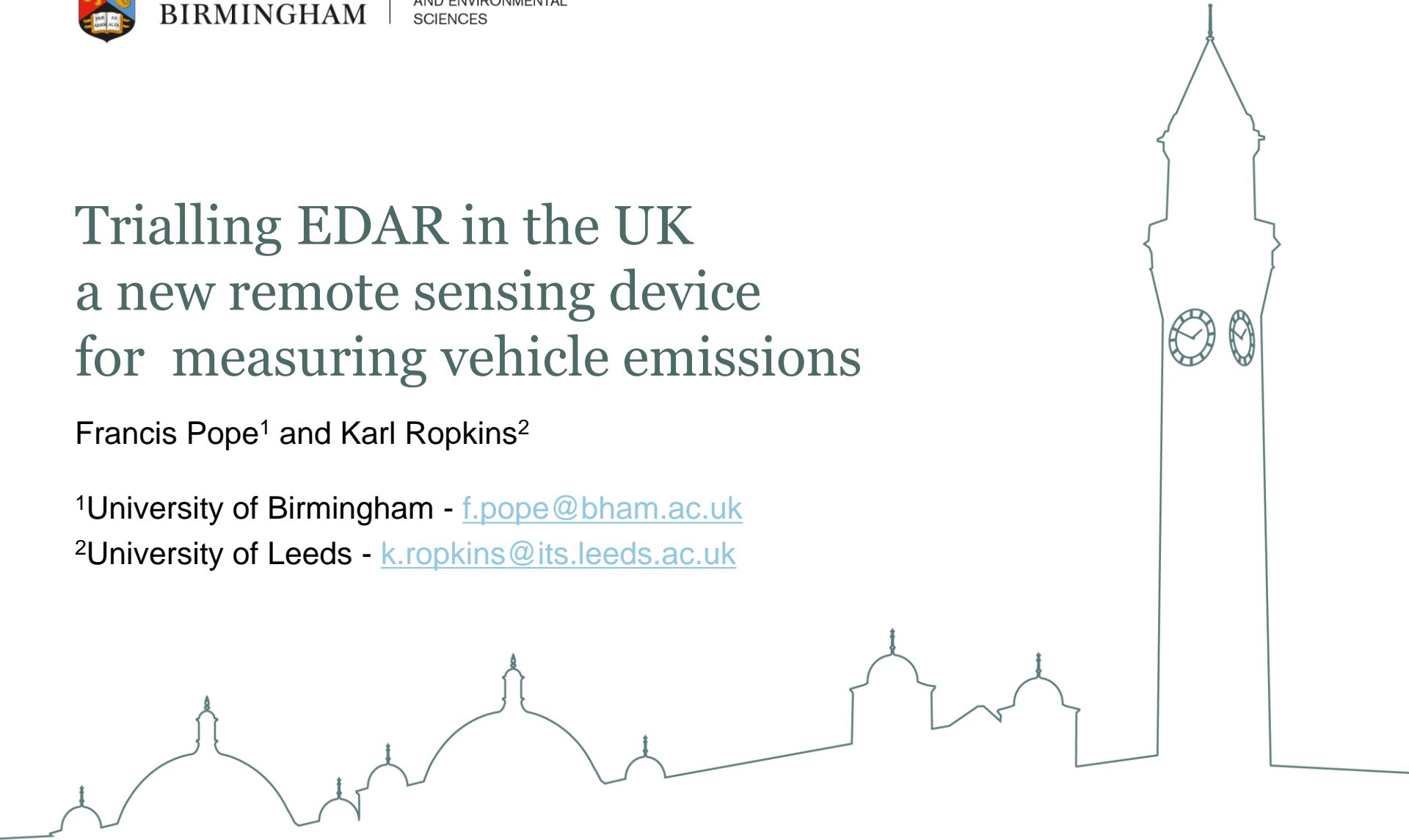
COLLEGE OF LIFE
AND ENVIRONMENTAL
SCIENCES

Trialling EDAR in the UK a new remote sensing device for measuring vehicle emissions

Francis Pope¹ and Karl Ropkins²

¹University of Birmingham - f.pope@bham.ac.uk

²University of Leeds - k.ropkins@its.leeds.ac.uk



Project

Birmingham and London EDAR (Emissions Detection And Reporting) Demonstration and Evaluation

EDAR Developers:
Project Partners:

HEAT LLC
King's College London
University of Birmingham
University of Leeds

*DfT LOCAL TRANSPORT AIR QUALITY
CHALLENGE INNOVATION GRANT
OCTOBER 2015*



Department
for Transport

Points of Contact

For further technical information about EDAR

- **Yolla Hager (HEAT LLC)**

Yolla@heatrsd.com; WWW.heatremotesensing.com

For further information about London Deployments

- **Dr Karl Ropkins (University of Leeds)**

k.ropkins@its.leeds.ac.uk

For further information about Birmingham Deployments

- **Dr Francis Pope (University of Birmingham)**

F.Pope@bham.ac.uk

The Technology: EDAR

(Emission Detection And Reporting)



EDAR units
(one Gases; one PM)



Reflector
Strip



EDAR deployed at
Marylebone Road, London

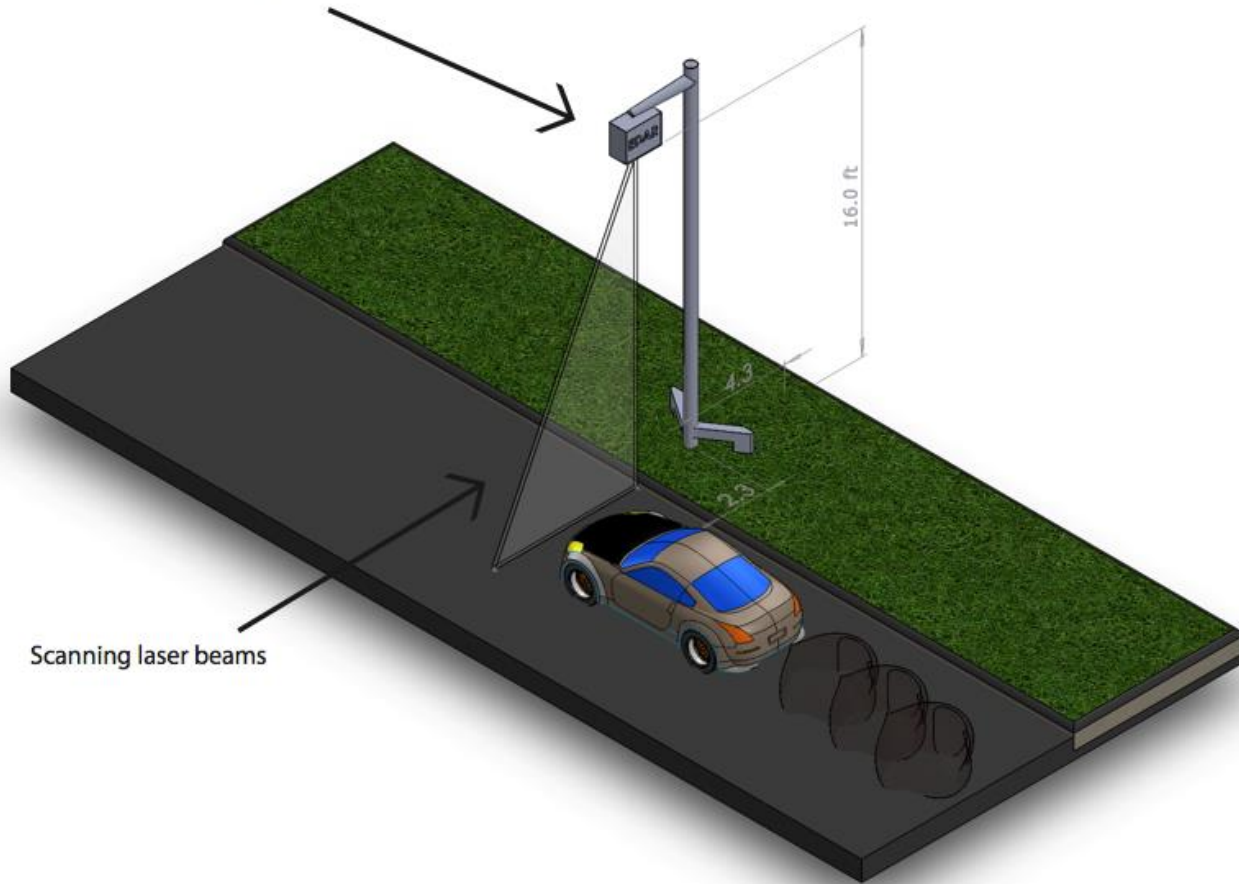
Differential Absorption Spectroscopy, DAS, developed in the NASA Activity Sensing of CO₂ Emissions Nights, Days and Seasons (ASCENDS) satellite program that reportedly provides superior analytical sensitivity and resolution by comparison to conventional absorption spectroscopy based remote sensing systems:

- Down-facing geometry; scans down onto road to remotely measure passing vehicle emissions
- Measures CO₂, CO, NO_x, SO₂, HC, PM...*
- One footprint for both heavy and light duty vehicles

*(This study CO₂, CO, NO, NO₂ and PM)

EDAR system includes:

- License plate Recognition Camera
- Speed & Acceleration Detector
- Laser Remote Sensing of Vehicle Exhaust



EDAR000004
02/10/2016
04:01:01.3 PM
#000149
13.8 °C
990.2 mBar
39.7 % RH
1.6 mph NE

CO₂



CO



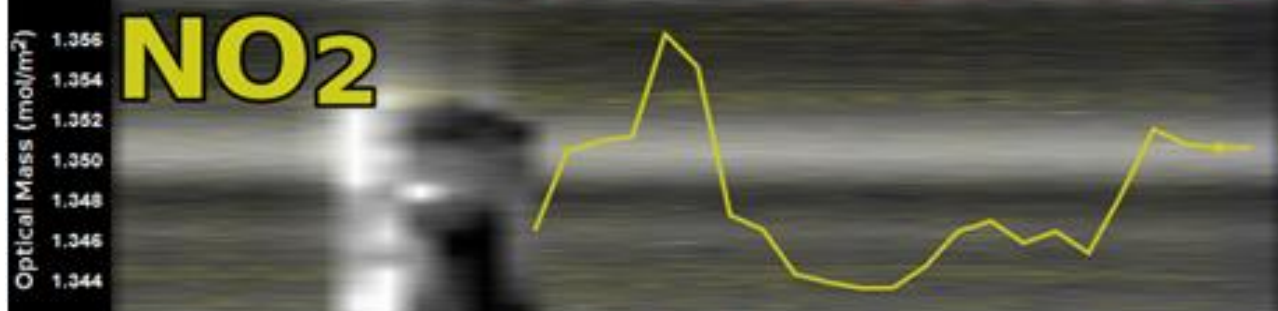
0.02852

NO



0.00538

NO₂



0.00015

0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8
Time (s)

EDAR Calibration Gas Audit

At the start of the field campaign, the EDAR unit was set up at the University of Birmingham.

Purpose was two-fold:

1. allow the HEAT team to check equipment after flight
2. check EDAR response to calibrated gas cylinder

Experiment number	Measured ratio (CO:CO ₂)	Measured ratio (NO:CO ₂)	Measured ratio (NO ₂ :CO ₂)
1	0.003271	0.003186	0.000067
2	0.003322	0.003129	-0.000180
3	0.003229	0.003137	-0.000140
4	0.003249	0.003326	0.000491
5	0.003290	0.003187	-0.000151
6	0.003339	0.003281	-0.000109
7	0.003375	0.003377	-0.000199
8	0.003296	0.003195	0.000137
9	0.003176	0.003283	0.000187
Mean average	0.003283	0.003233	1.14E-05
Standard deviation	6.01E-05	8.66E-05	0.00023
Actual ratios	0.003333	0.003333	0.00000



Preliminary Evaluation

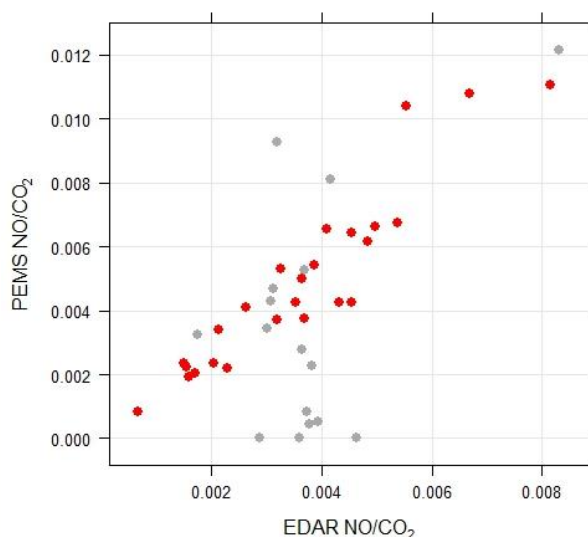
PEMS drive-through comparison



PEMS/EDAR comparison (data alignment using a refinement of Ropkins et al, 2008*)

Despite being very different measures, PEMS and EDAR in good agreement

NO/CO_2 $R^2 \sim 0.97$
 NO_2/CO_2 $R^2 \sim 0.83$



Other comparisons and points of reference: (analysis on-going)

- Gas Calibration Audit
- Car-chaser drive-through comparison
- AURN Air Quality Monitoring Station
- AQMESH sensors

*Ropkins, K., Oates, C. and Tate, J.E. Evaluation of a Remote Sensing System 'Dirty Emitter' Measurement. 18th CRC On-Road Vehicle Emission Workshop. San Diego, US, 31 March - 2 April, 2008.

Deployments

Birmingham Tyburn



On A38 in Tyburn outside the above approximately 700 metres to the north of the M6 motorway

London Marylebone



On Marylebone Road opposite Madame Tussauds, by (6 lane) A501 in area that is frequently congested

London Blackheath



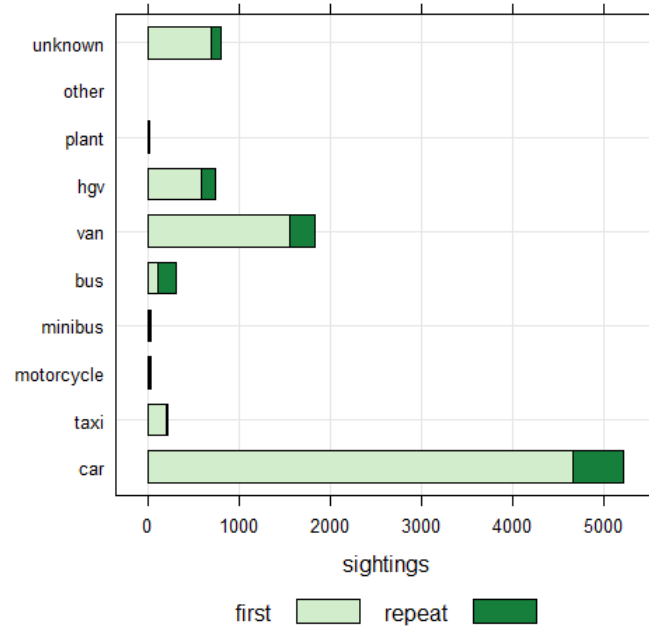
On Blackheath Hill, on steep gradient on A2, a major arterial route in residential area

(All deployment sites adjacent to an AURN Roadside Station)

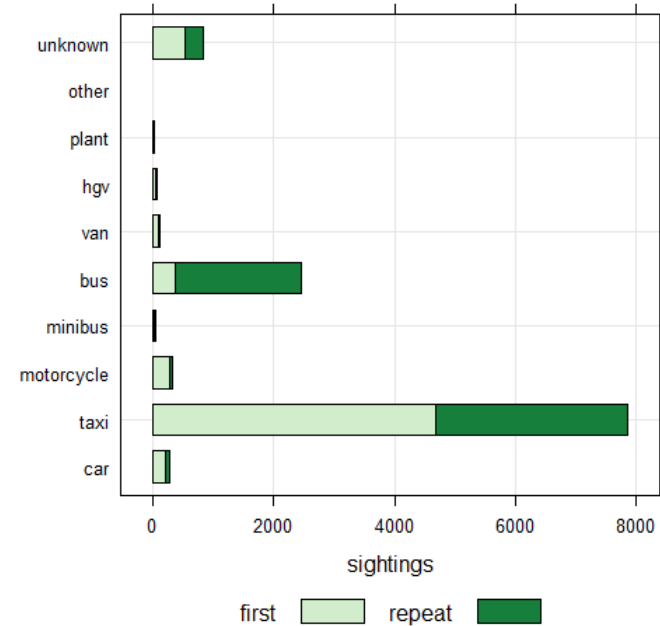


Vehicle Distributions

Blackheath Vehicle Counts



Marylebone Vehicle Counts



- Blackheath and Tyburn:**
- Local traffic pattern typical, mainly cars and vans
 - Relatively small proportion of repeat visitors

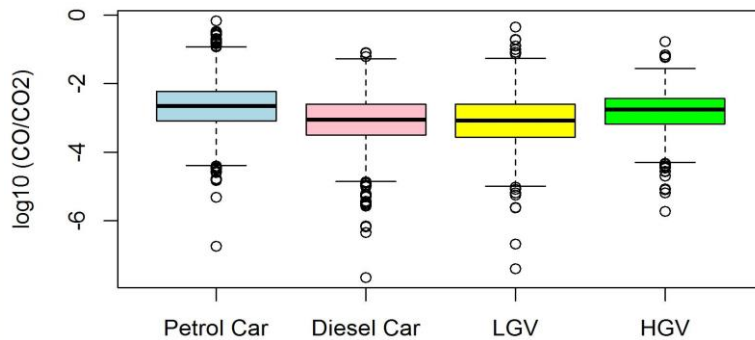
Marylebone Central

London:

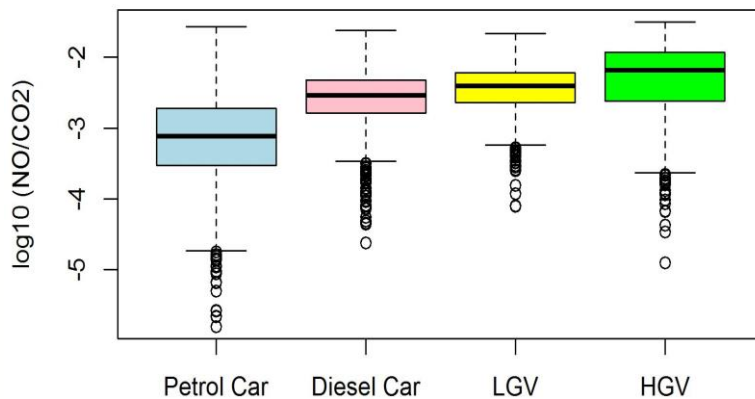
- 'Bus' lane, so mainly taxis and buses
- Also a higher motorcycle count
- More repeat visitors

Results - disaggregation into the four most common vehicle classes observed at Birmingham Tyburn Road

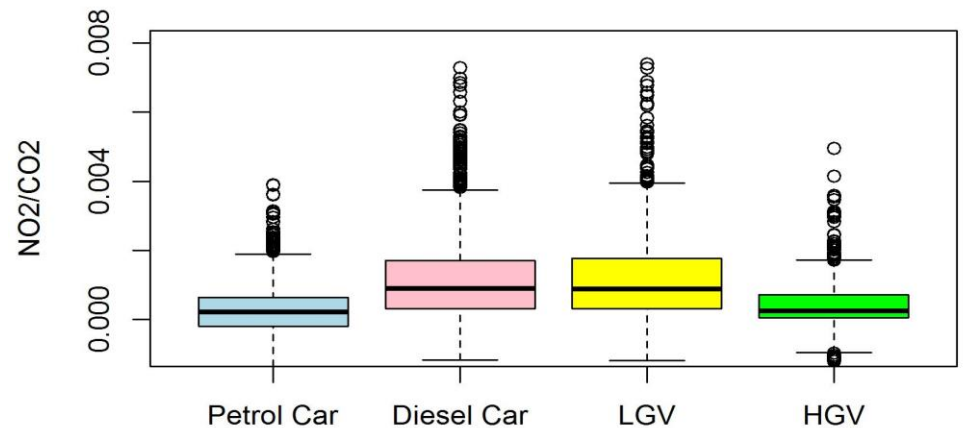
CO/CO2 emissions for different vehicle classes



NO/CO2 emissions for different vehicle classes

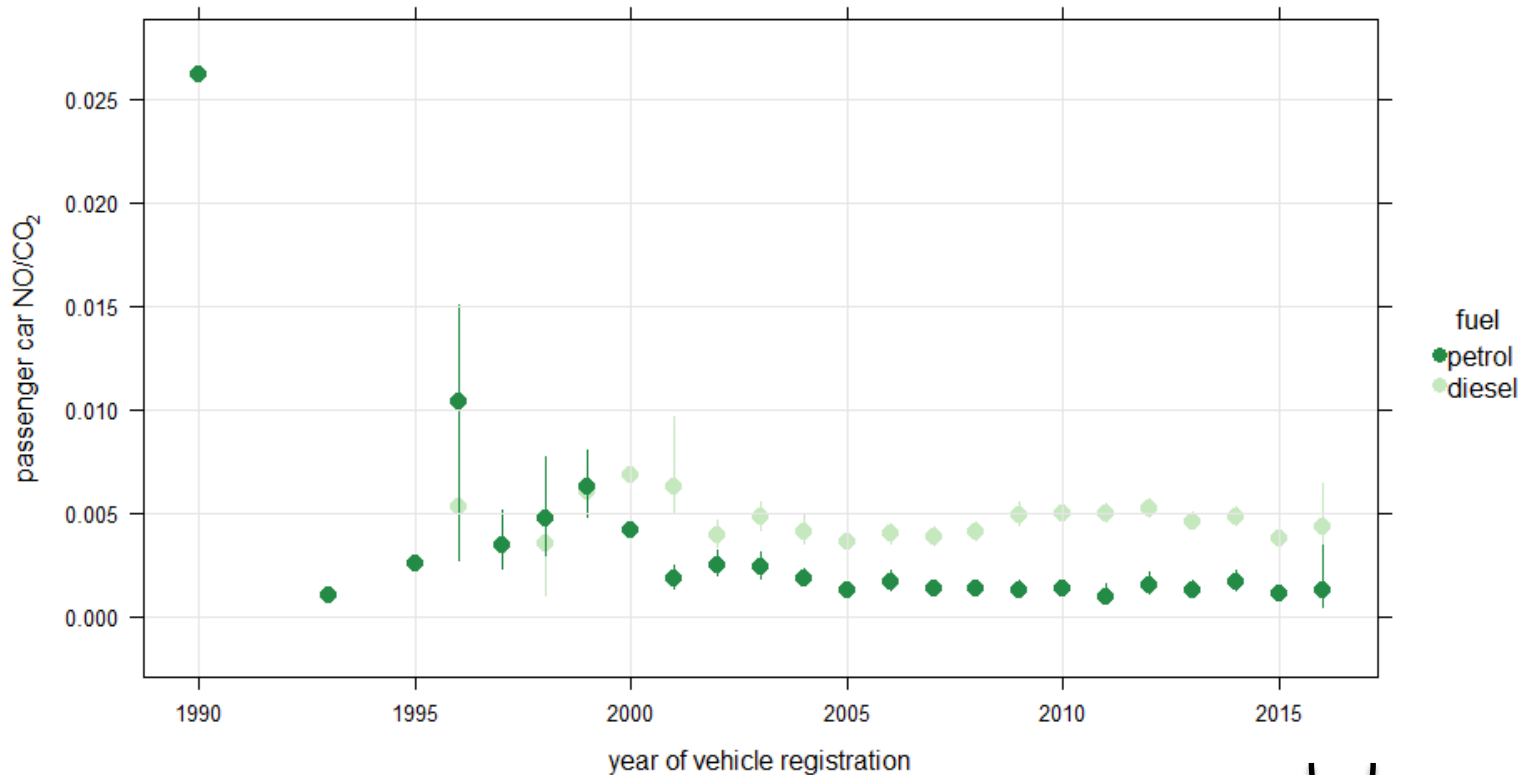


NO2/CO2 emissions for different vehicle classes



Car NO/CO₂ Distributions

Blackheath Greenwich:

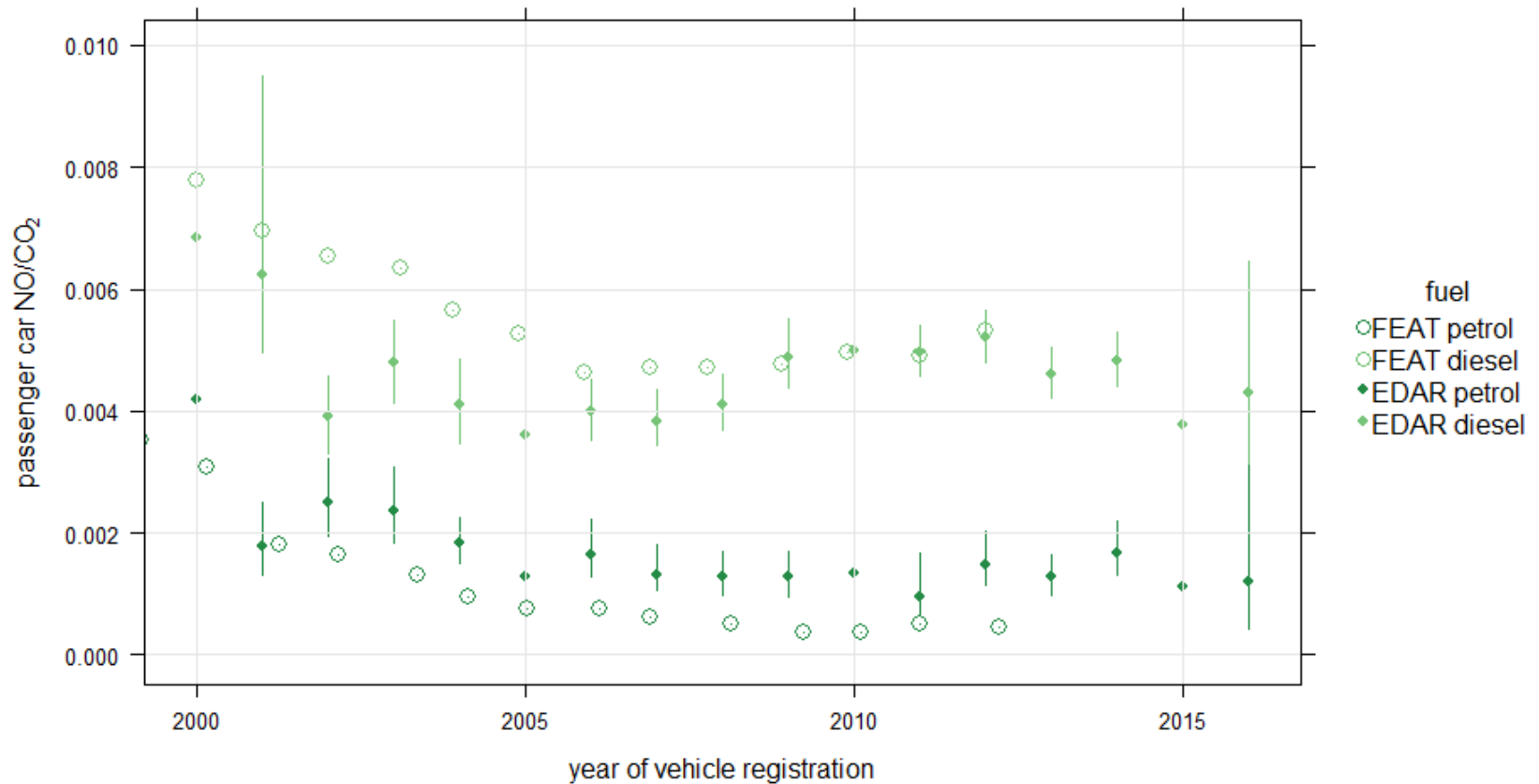


NOTE:

lower vehicle counts in these regions, so measurements (boot strapped means) are less certain in these regions.

Car NO/CO₂ Distributions

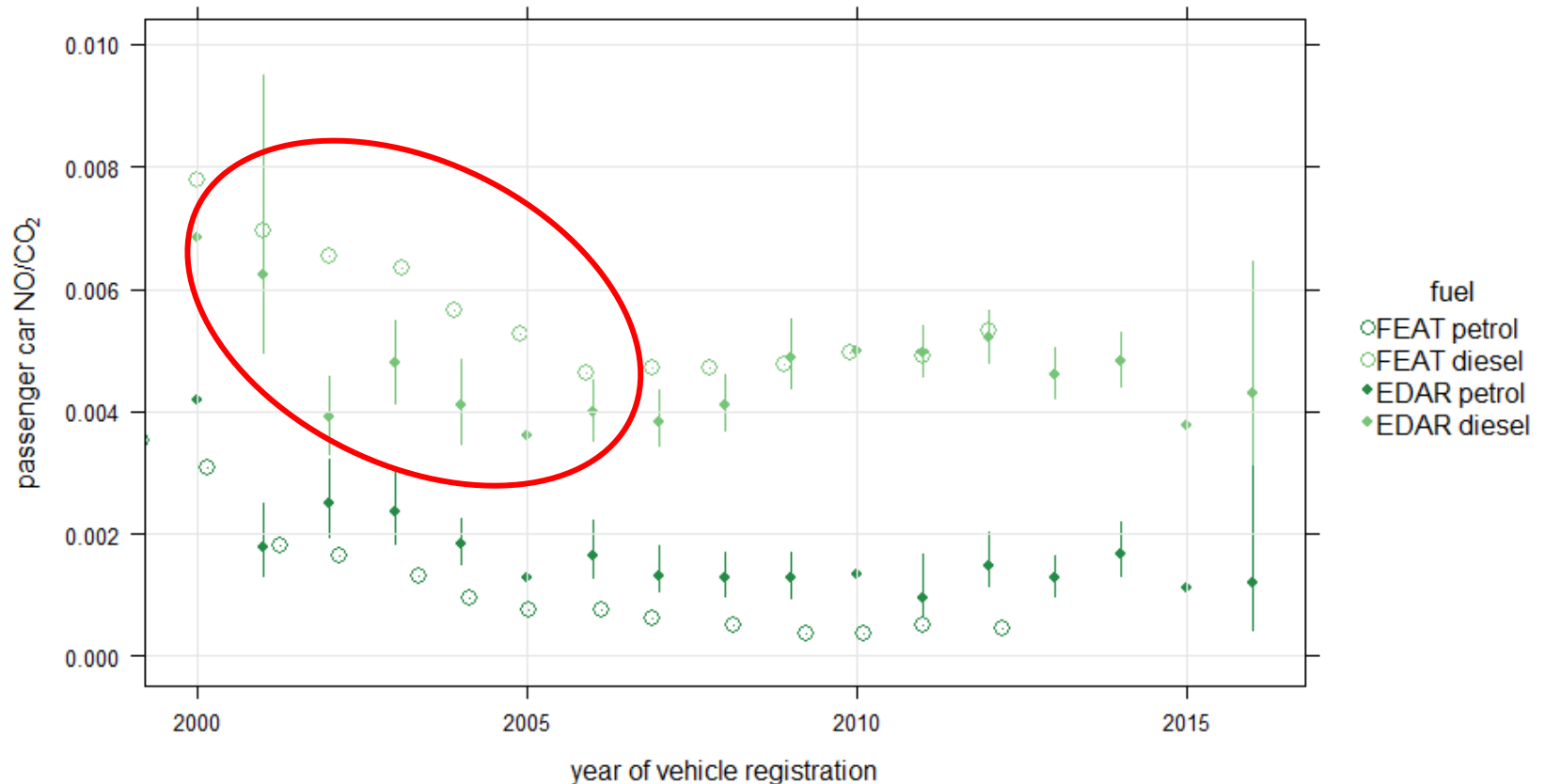
Comparison with other similar work:
(Carslaw & Rhys-Tyler 2013 FEAT study)



Across range where both are most certain we see similar trends
NOTE: Carslaw & Rhys-Tyler data current proximate and without error bars

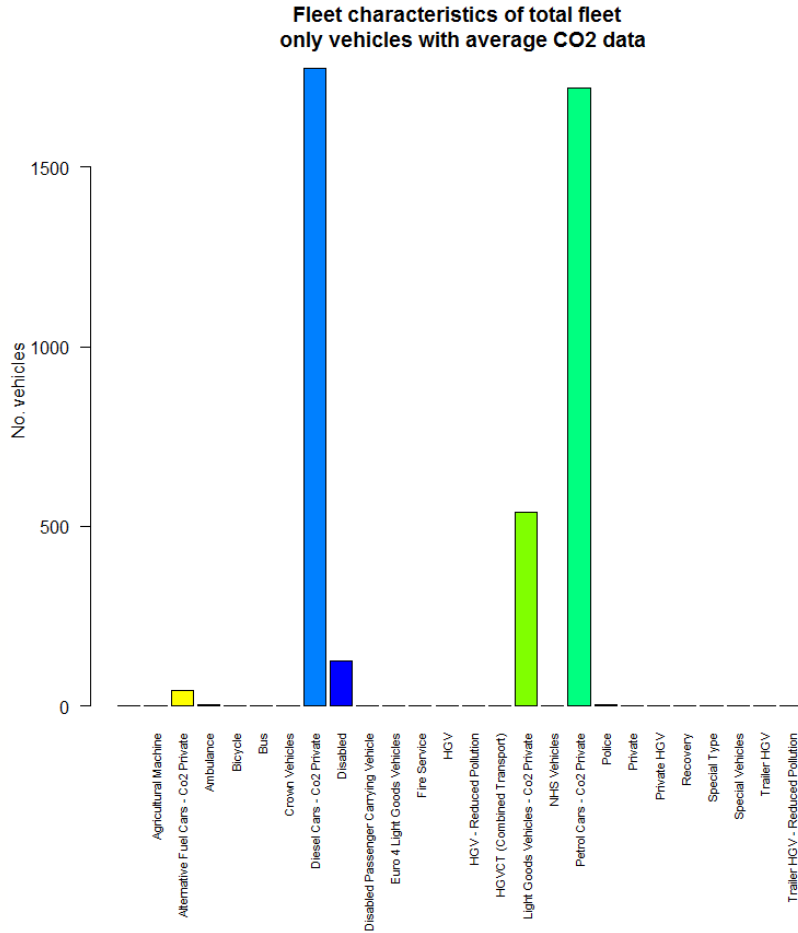
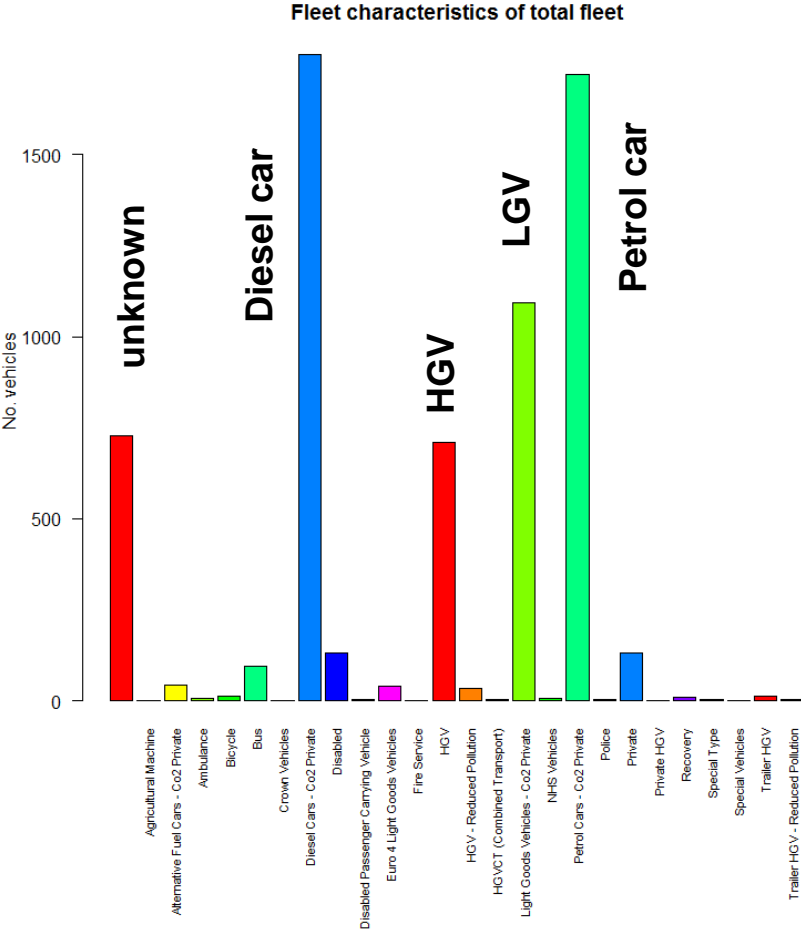
Car NO/CO₂ Distributions

Comparison with other similar work:
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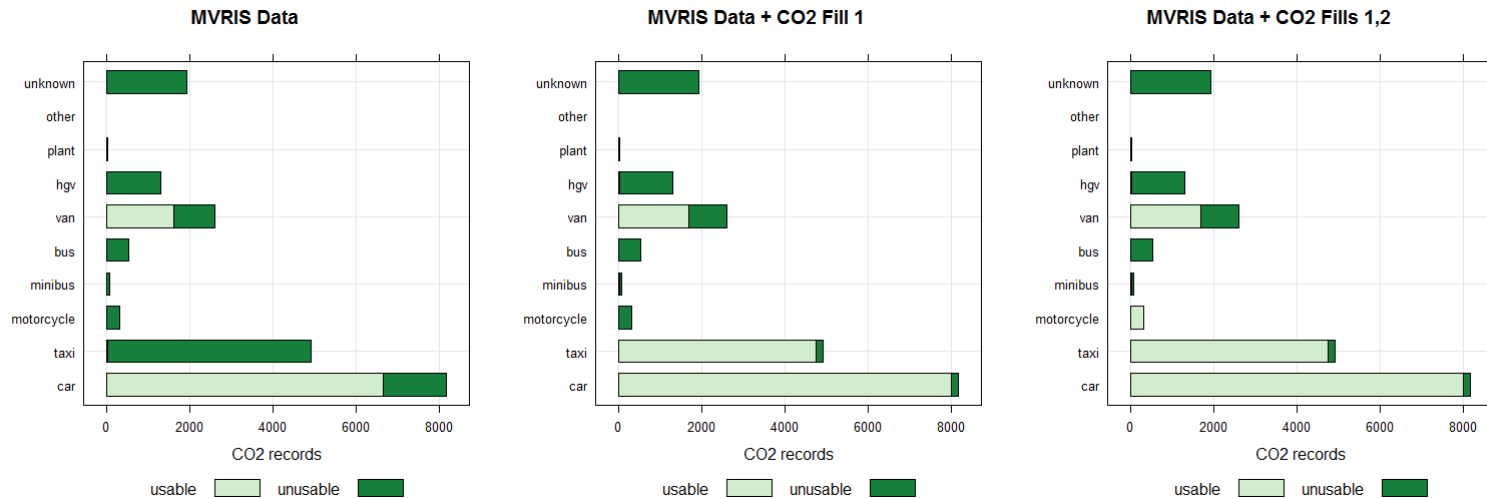
Our measurements tend to be cleaner for older diesel cars which could reflect the less well maintained vehicles leaving fleet earlier... (possibly something to look into?)

Number and type of Vehicles Measured in Birmingham deployment



Missing CO₂ Values

Progress hole-filling unusable (missing/invalid) vehicle CO₂ g/km records
(needed for other emission g/km calculations)...

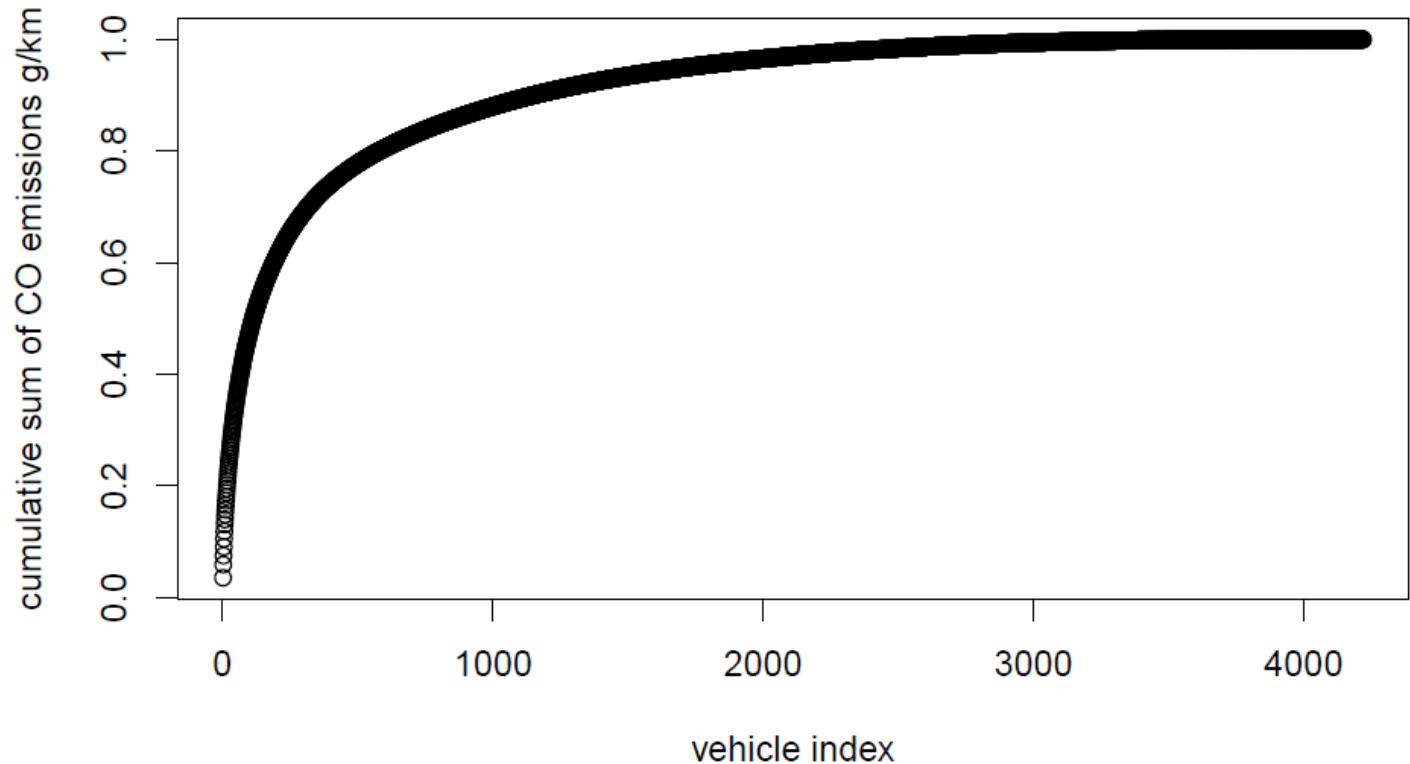


Initial DVLA/SMMT Data

Fill 1: M1 Model;
(replaces some suspect car data and fills most missing cars and taxis)

Fill 2: L* Model;
(fills all missing motorcycles)

Pareto style analysis of CO emissions



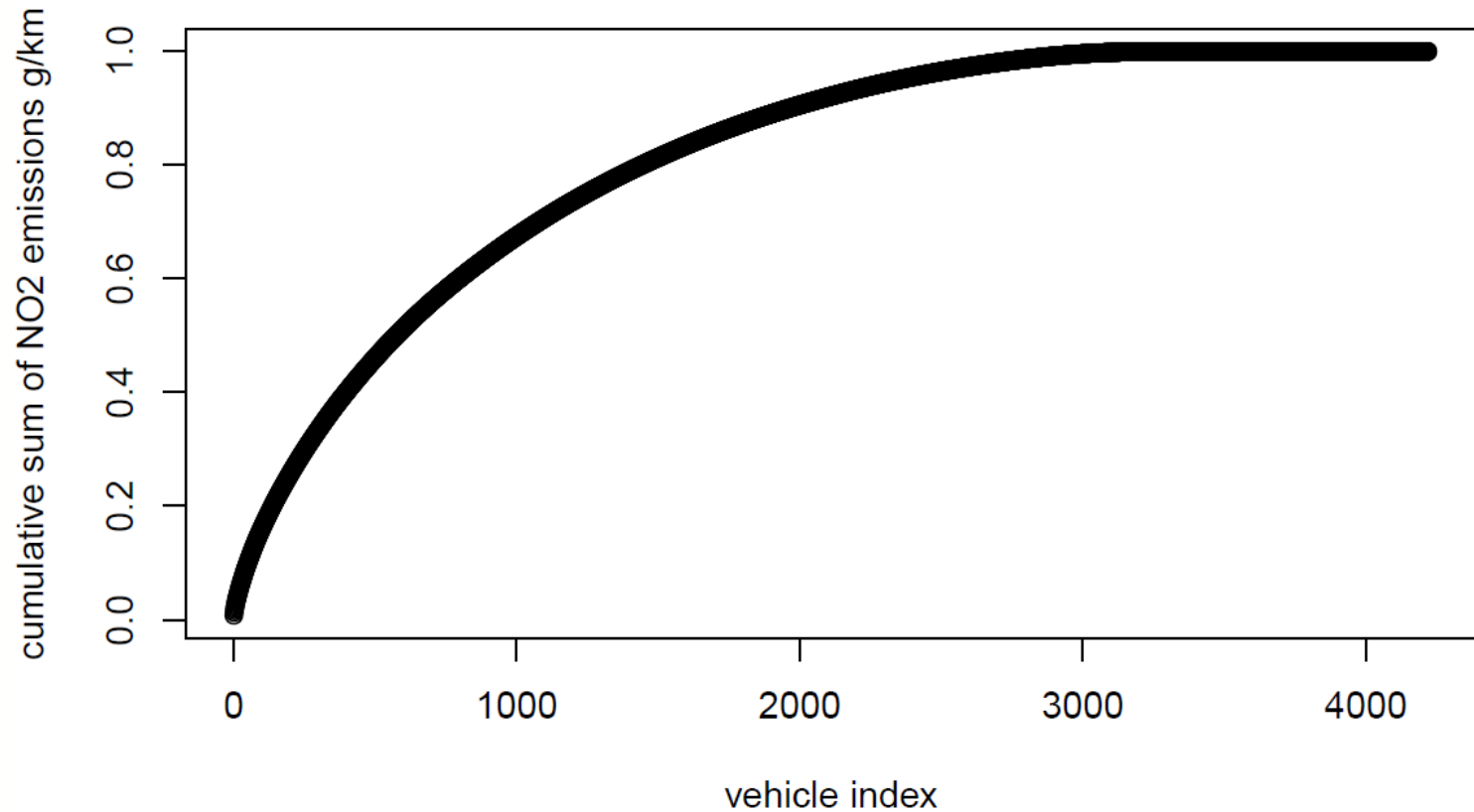
CO emissions = EDAR CO/CO₂ * CO₂ emissions from vehicle stock database

15 vehicles are responsible for **20%** of the CO emissions.

20% of vehicles are responsible for **86%** of CO emissions.

Note most non-car vehicles are omitted from this analysis because of lack of average CO₂ emission data.

Pareto style analysis of NO2 emissions



137 vehicles are responsible for **20%** of the CO emissions.

20% of vehicles are responsible for **62%** of CO emissions.

Note most non-car vehicles are omitted from this analysis because of lack of average CO2 emission data

Summary

- EDAR trials in Birmingham and London were very successful.
- ca. 25k measurements of CO/CO₂, NO/CO₂ and NO₂/CO₂ emissions performed.
- Fleet can be subset into different polluter groups using DVLA or other databases.
- Pareto analysis shows that small proportion of fleet is responsible for large proportion of pollution.
- Reference CO₂ values are missing for large set of data (in particular LGV and HGV)
- Sniffer van and PEMS work provided complimentary measurements.
- Analysis is ongoing...



Acknowledgements

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University of Leeds

Karl Ropkins and team

King's College London

Gary Fuller, David Green and team

University of Leicester (NO₂ measurements in sniffer van)

Steve Ball and team

DfT

Iarla Kilbane-Dawe, Mike Dark and team

