



Remote Sensing Data for Emission Inventories and Modelling NO₂ Concentrations in the UK

Daniel Mehlig & Prof Helen ApSimon (Imperial College, London)

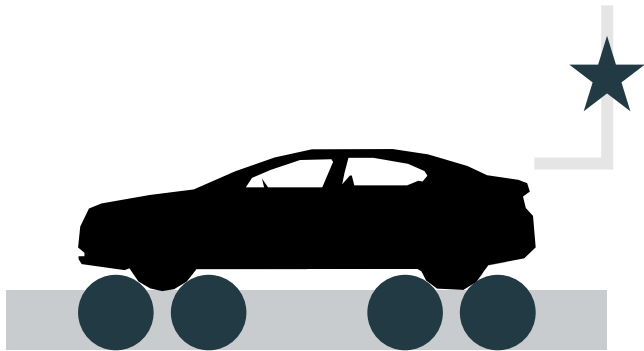
Tim Murrells, Rebecca Rose & David Carslaw (Ricardo, UK)

TFEIP Workshop – Transport, Oxford 18th April 2023

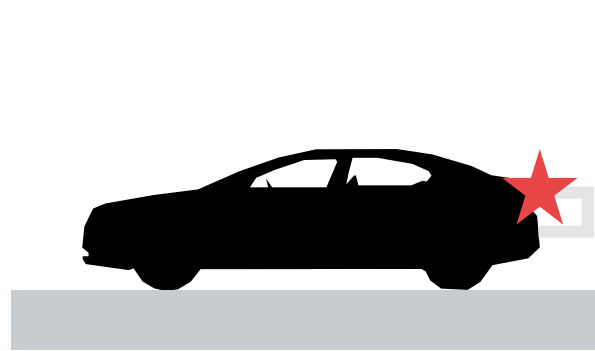
Overview of Presentation

- National Atmospheric Emissions Inventory in the UK (NAEI) uses a Tier 3 approach with COPERT 5.5 emission factors combined with detailed road transport activity data from UK Department for Transport
- Current work for Defra
 - Continuous improvement, verification and use of inventory in air quality modelling for Defra policy development
- Investigation of roadside remote sensing data for UK fleet specific emission factors
 - Brief introduction of method by Tim Murrells (Ricardo)
- Application of emission factors to air quality modelling of NO_x and NO₂ in the UK
 - Daniel Mehlig (Imperial College London)

Methods for Measuring Vehicle Emissions



“In-Lab”
Chassis Dynamometer



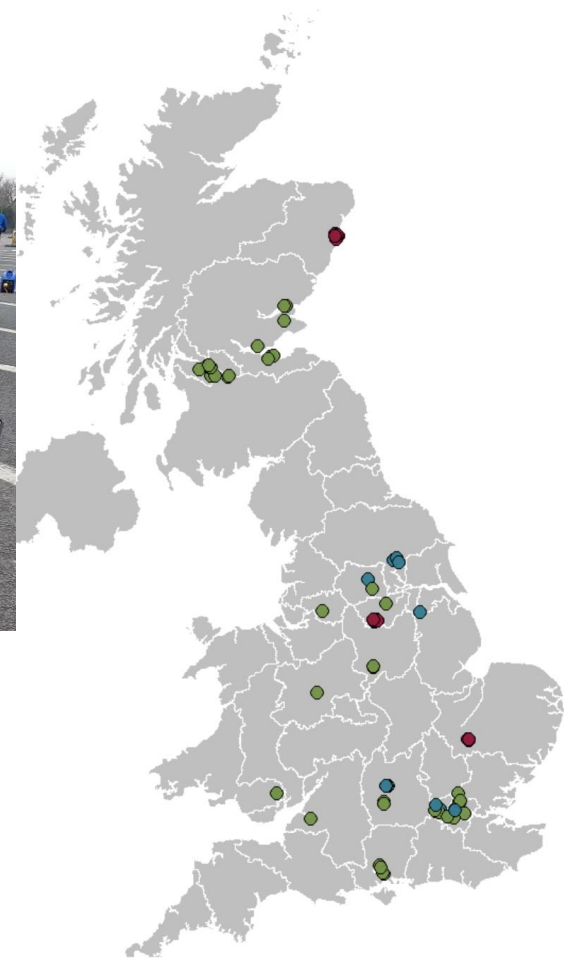
“On-Board”
Portable Emissions Measurement System



“On-Road”
Vehicle Emission Remote Sensing

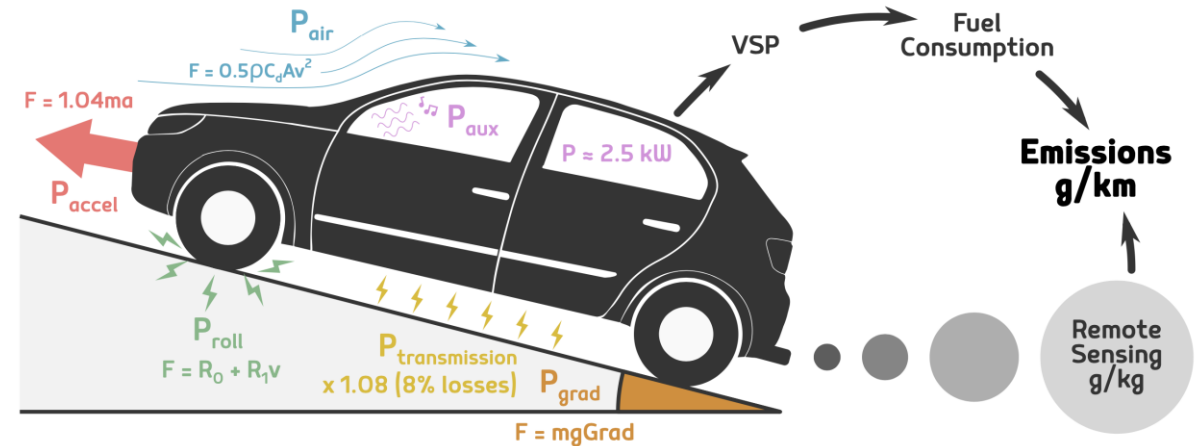
Vehicle emission remote sensing in the UK - attractive qualities for emission inventory development

- Use of two types of vehicle emission remote sensing instruments – Opus RSD 5000 and University of Denver FEAT
- >600,000 measurements since mid-2017 at over 30 different locations – **UK fleet under wide range of UK operating conditions**
- Wide range of fleets measured, variable mileage and environmental conditions such as ambient temperature (~ 0 to 30 °C)
- Measurements of NO, NO₂, HC, CO and NH₃ as ratios relative to CO₂
- Detailed vehicle technical data from DVLA and SMMT including individual vehicle mileage (useful for understanding deterioration)



Vehicle power-based approach to emission factor development

- Development and application of a vehicle power-based approach for emission factors
- Calculate vehicle power demand and estimate instantaneous fuel consumption for each VERS vehicle measurement
 - Measured speed, acceleration, road gradient
 - Vehicle mass, type and size
 - Assumptions about rolling resistance, drag coefficients etc.
- Map to real-world 1 Hz drive cycles – removes bias introduced through siting requirement of RSD
- Develop emission factors
 - Apply at national scale – inventory verification
 - National or local air quality modelling



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Article

Verification of a National Emission Inventory and Influence of On-road Vehicle Manufacturer-Level Emissions

Jack Davison,* Rebecca A. Rose, Naomi J. Farren, Rebecca L. Wagner, Tim P. Murrells, and David C. Carslaw*



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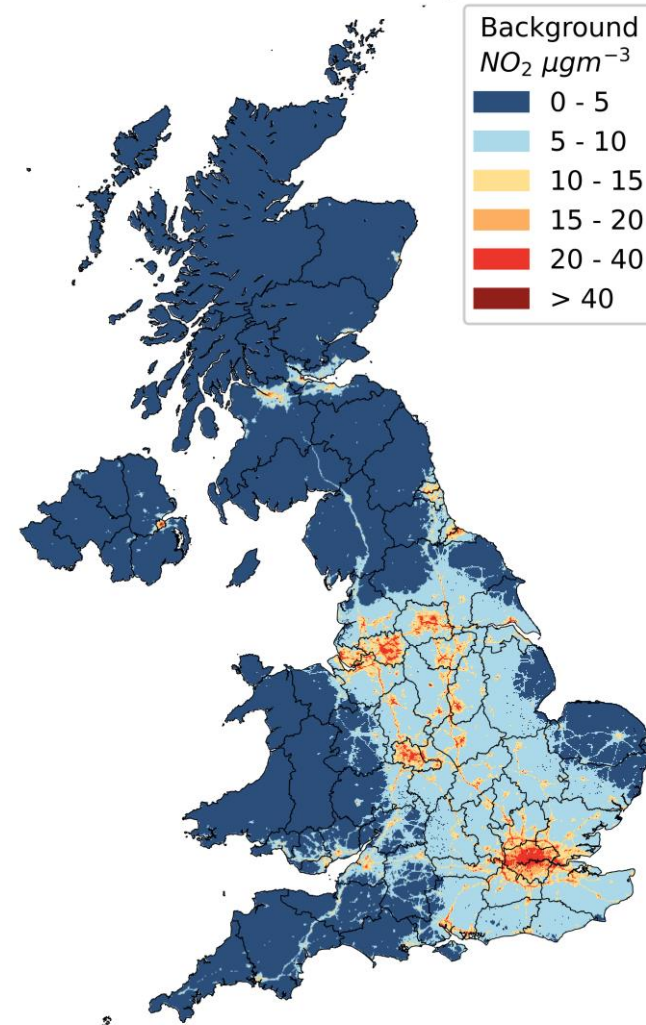
Using Remote Sensing Emission Factors in UKIAM

UK Integrated Assessment Model – UKIAM

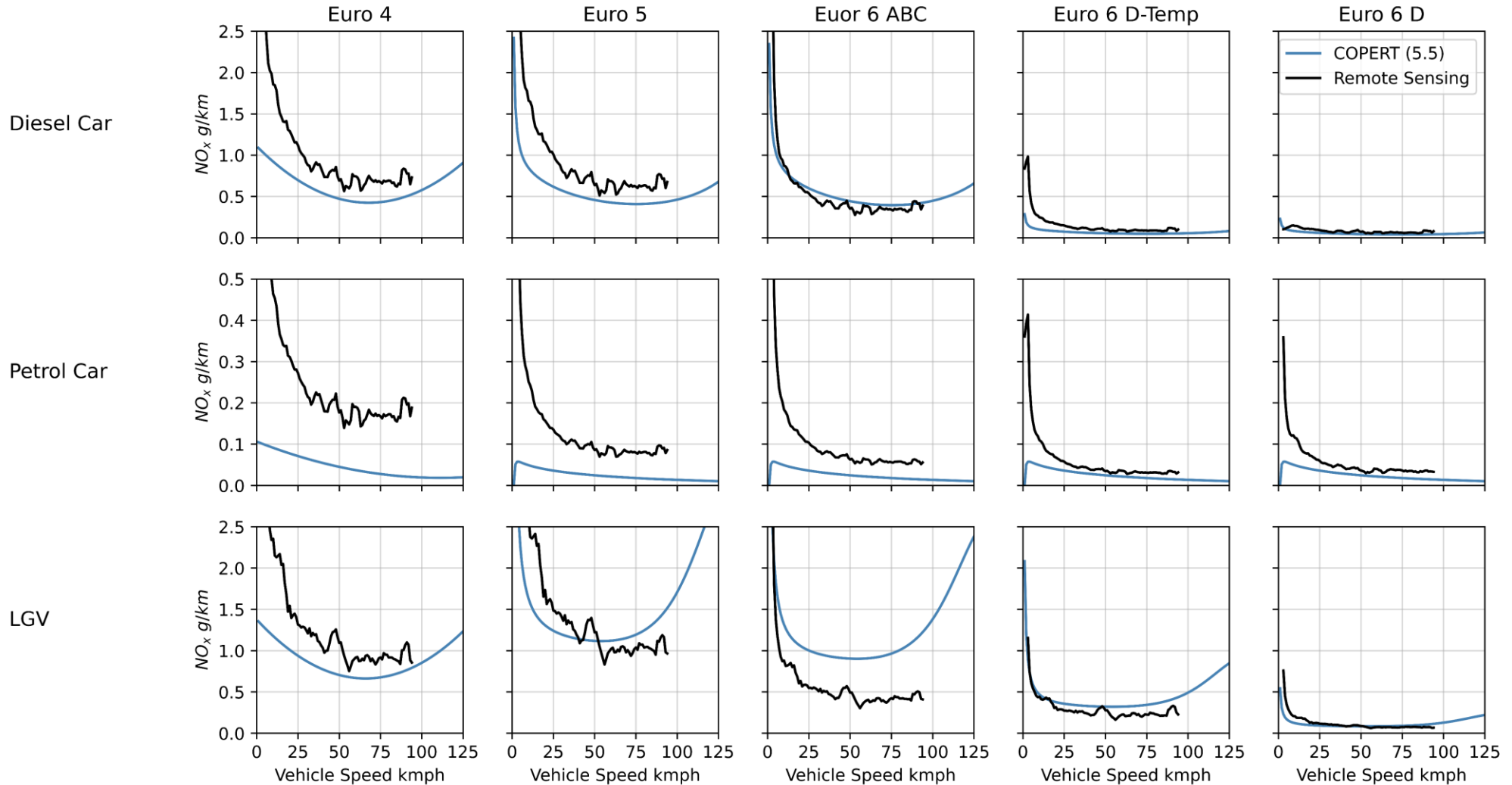
- **Background** and roadside concentrations
- **NO_x**, **NO₂**, **PM_{2.5}**
- 1km x 1km resolution
- Bottom-up approach, using **COPERT emission factors**
- **Underpredicts NO_x and NO₂**

Recent UKIAM publications:

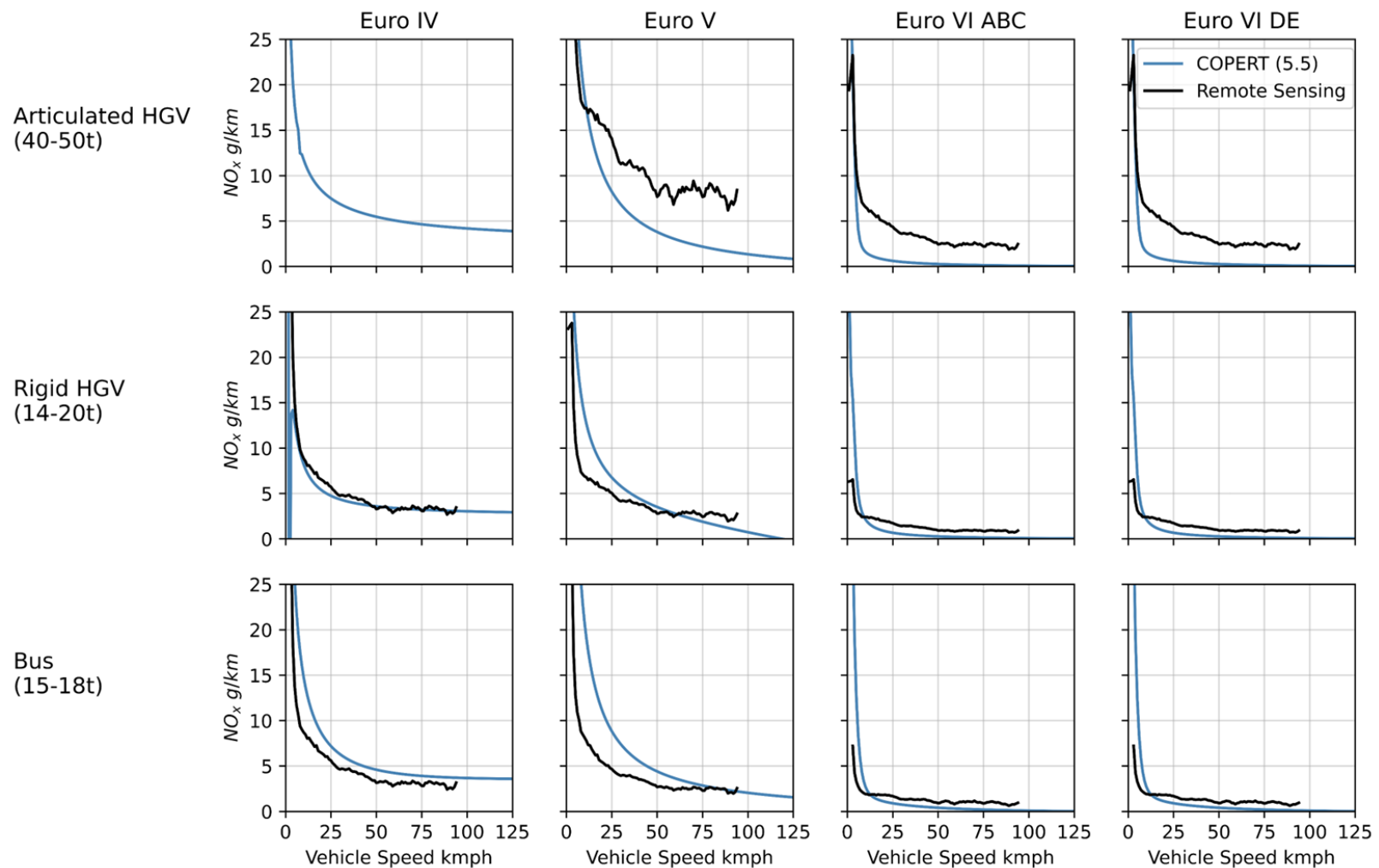
- ApSimon et al. (2023). Integrated Assessment Modelling of Future Air Quality in the UK to 2050 and Synergies with Net-Zero Strategies. Atmosphere, DOI 10.3390/atmos14030525.
- Mehlig et al. (2021) Electrification of road transport and the impacts on air quality and health in the UK, Atmosphere, DOI 10.3390/atmos12111491.



COPERT & Remote Sensing Speed Dependant Emission Factors



COPERT & Remote Sensing Speed Dependant Emission Factors

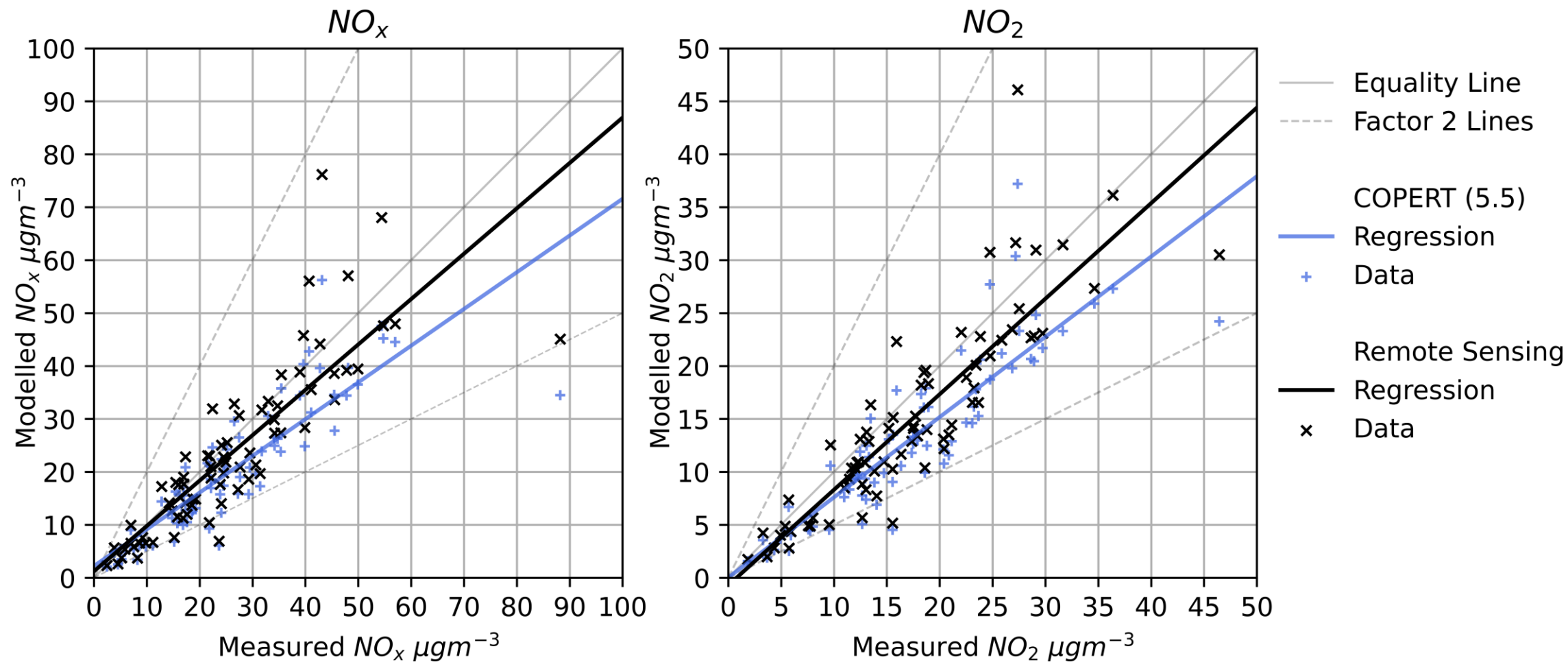


UKIAM Results: NO_x Emissions

Vehicle	National NO _x Emissions (kt)			London NO _x Emissions (kt)		
	COPERT	Remote Sensing	Change	COPERT	Remote Sensing	Change
Diesel Cars	118.0	144.8	+26.8	6.7	8.6	+1.9
Petrol Cars	16.5	28.8	+12.4	1.7	2.7	+1.0
LGVs	88.5	67.9	-20.6	6.4	4.6	-1.8
HGVs	22.0	79.0	+57.0	2.2	3.9	+1.7
Buses	10.0	7.9	-2.1	0.9	1.3	+0.3
Total	254.9	328.4	+73.4	12.0	21.0	+9.0

- Increase of 29%, primarily due to HGVs, followed by Diesel and Petrol Cars
- Decrease in LGV emissions

UKIAM Results: Background NO_x and NO_2 Concentrations



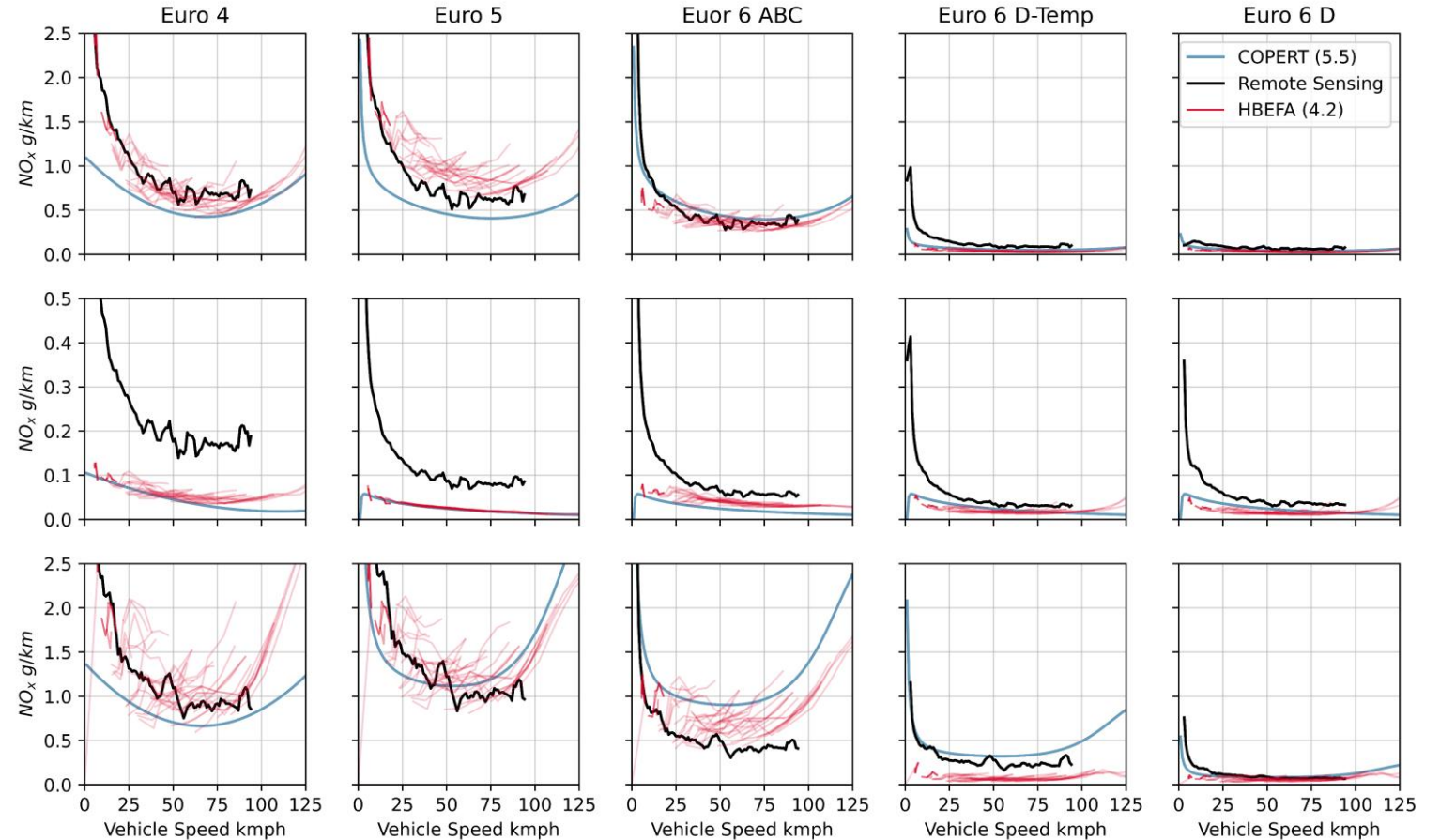
Adding HBEFA to UKIAM

- How to map **Traffic Situations** across the UK?

- Highway Capacity Manual (USA)
- **Level of Service:**
 - **Uninterrupted flows (e.g. motorways)**
 - Interrupted flows (e.g., traffic lights)

- Activity Data
 - Annual Average Daily Flows
 - Average speeds
 - Speed limits

- Road Network Data:
 - Road lengths
 - Road widths – number of lanes



Summary

- Comprehensive vehicle emission remote sensing campaigns have been undertaken in the UK since 2017
- Measurements can be used to verify trends in emission factors and were used to show that changes to COPERT emission factors for Euro 6 diesel cars were an improvement
- Bottom-up estimates of UK emissions based on remote sensing data suggests:
 - HGV and passenger car NO_x emissions are underestimated nationally and in urban areas, compared to using COPERT 5.5 emission factors
- The use of remote sensing emission factors in air quality modelling results in improved agreement between modelled and measured concentrations of NO_x and NO₂ and has significant implications for SIA formation in regional models

Proposed Further Work

- Comparison with factors from HBEFA and exploring use of HBEFA “traffic situation” emission factor approach for UK emission inventory and air quality modelling
- Further analysis of Ricardo’s current database of remote sensing data to determine
 - Degradation rates
 - Ambient temperature dependence
 - High emitters
 - Retrofits
 - NH₃ emission factors
- Alternative approach to fill gaps on vehicle types and roads with fewer measurements using current remote sensing method , e.g. HGV emissions on motorways
 - Collaboration with University of York