Ricardo
Energy & Environment

Roadside Vehicle Emissions Monitoring Demonstrates Benefits of Euro 6 over its Predecessors for Diesel Vehicles

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Aims

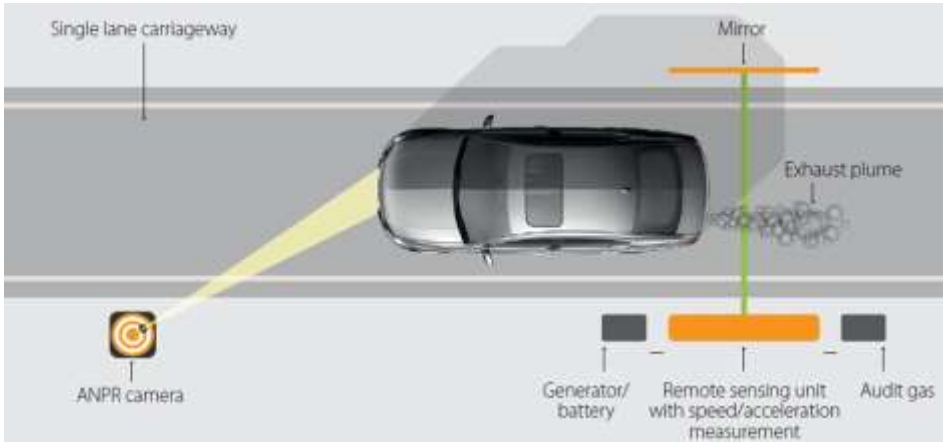
- Present evidence from vehicle emissions monitoring on the improvements of Euro 6/VI over earlier Euro standards for real world NO_x emissions from diesel vehicles

- Investigate vehicle characteristics and environmental factors which affect NO_x emissions from vehicles

- Provide a link between inventory emission factors and real world emissions factors from vehicle emissions monitoring

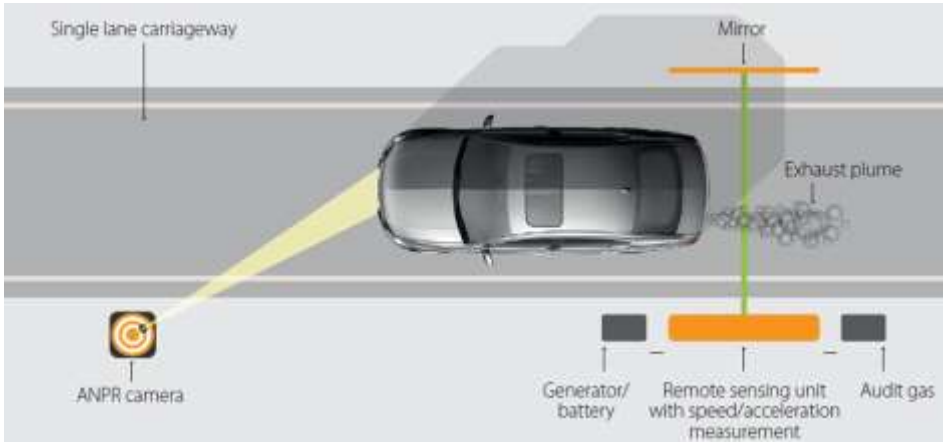
Vehicle Emission Measurements

- Three main ways of measuring vehicles emissions
  - In the laboratory
  - Portable Emission Measurement System (PEMS)
  - Vehicle emission remote sensing
- The three techniques are highly complementary, but:
  - Remote sensing can provide data that is closely aligned to air quality problems …
  - Measures the whole vehicle fleet
  - Can be used to derive emission factors for use in emission inventories
  - ‘real’ real world in the sense that there is no interference of the vehicle being tested



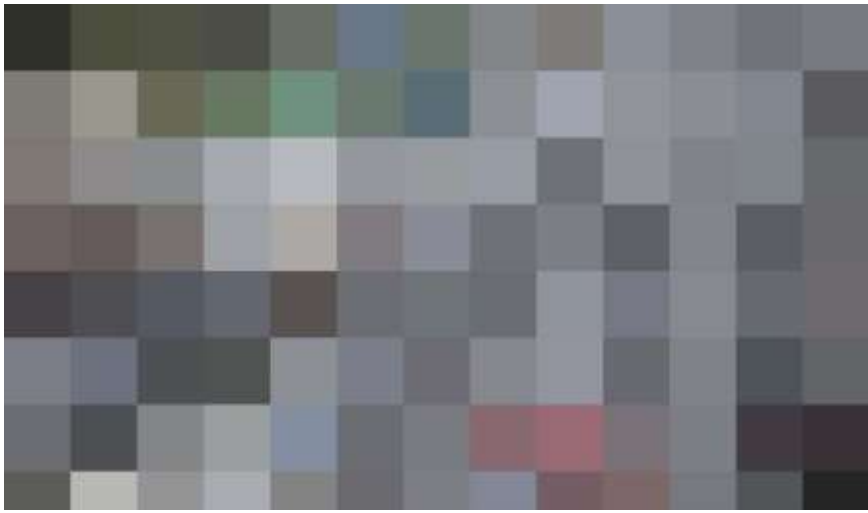
Vehicle Emission Remote Sensing

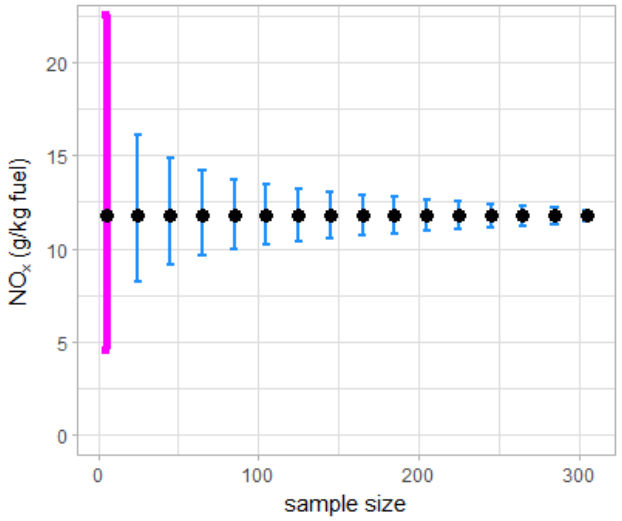
- We have ~100,000 measurements from 10 different measurement locations across UK from a 6 month trial of a commercial instrument from OPUS
- The technique:
  - UV/Infrared beam to measure emissions – different gases absorb in different wavelength regions
  - Measure NO, NO_2 (hence NO_x), CO, HC, PM and NH_3
  - 100 scans in 0.5 seconds of exhaust plume
  - **Emissions expressed as ratios to CO_2** and through combustion equations, grammes of pollutant per unit fuel (mostly commonly g/kg)
  - Measure speed and acceleration of each vehicle
- Photograph each vehicle to obtain number plate
  - Detailed cross reference with SMMT-derived databases…more than 80 vehicle characteristics, down to the colour of the vehicle!



Remote sensing and sample size

- Consider measurements of 1.6 litre diesel Euro 5 VW Golf
  - Use random sampling to calculate uncertainty (95% confidence interval) as a function of sample size
- 0.56% of the fleet we have measured
- Need to measure **900 vehicles to get sample size of 5** measurements
- Uncertainties driven by:
  - Instrument uncertainty
  - Plume ‘snapshot’ – only part of a drive cycle
  - Driving conditions
  - ‘Real’ differences between vehicles e.g. maintenance, degradation effects
  - Any changes within Euro class
  - Misspecification of vehicle being considered





Remote sensing and sample size

- Consider measurements of 1.6 litre diesel Euro 5 VW Golf
  - Use random sampling to calculate uncertainty (95% confidence interval) as a function of sample size
- 0.56% of the fleet we have measured
- Need to measure **4475 vehicles to get sample size of 25** measurements
- Uncertainties driven by:
  - Instrument uncertainty
  - Plume ‘snapshot’ – only part of a drive cycle
  - Driving conditions
  - ‘Real’ differences between vehicles e.g. maintenance, degradation effects
  - Any changes within Euro class
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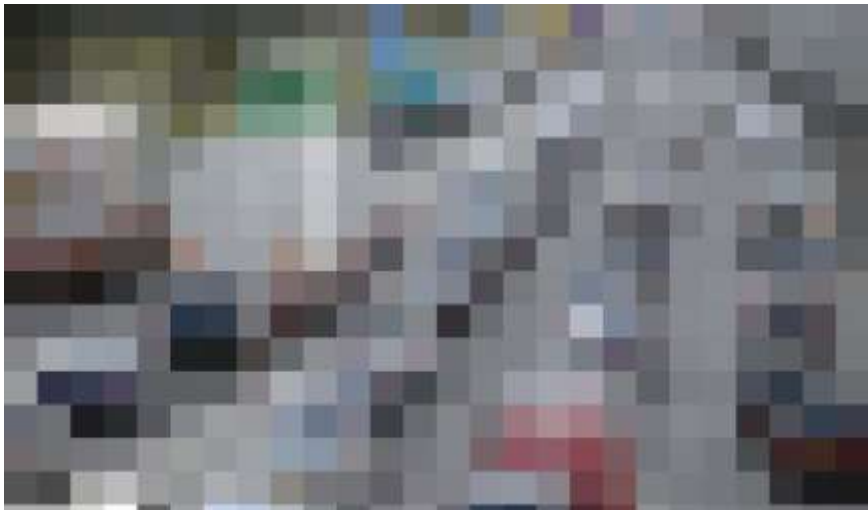
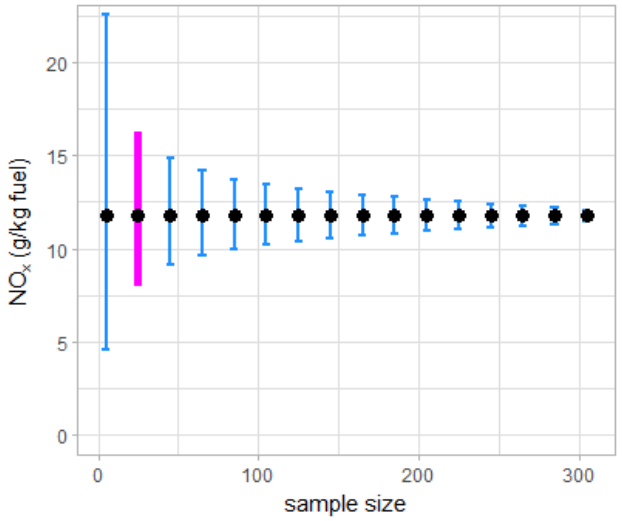
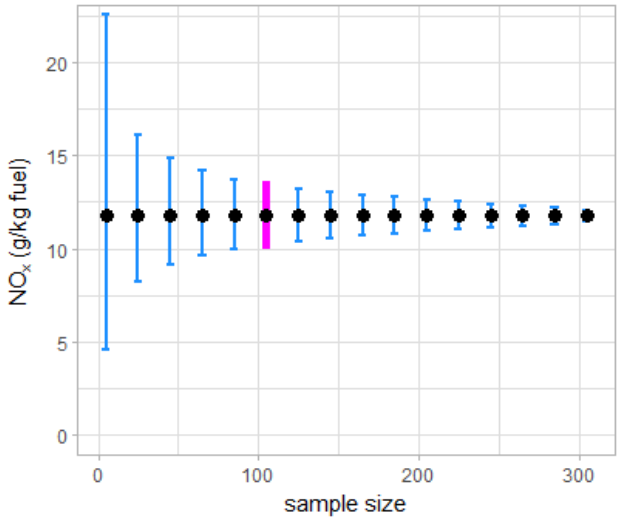




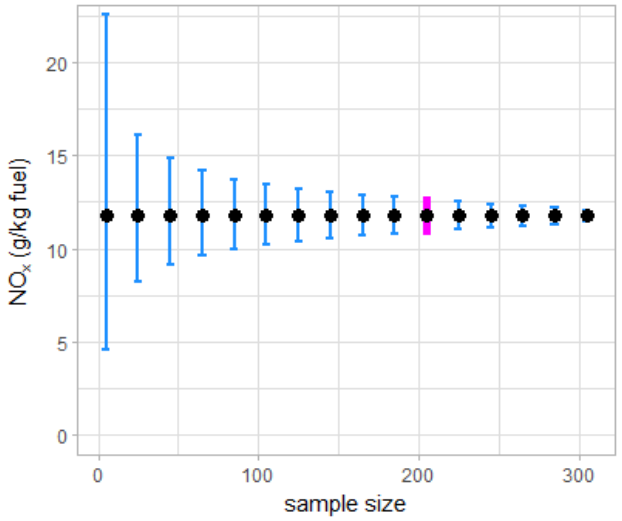
Remote sensing and sample size

- Consider measurements of 1.6 litre diesel Euro 5 VW Golf
  - Use random sampling to calculate uncertainty (95% confidence interval) as a function of sample size
- 0.56% of the fleet we have measured
- Need to measure **18000 vehicles to get sample size of 100** measurements
- Uncertainties driven by:
  - Instrument uncertainty
  - Plume ‘snapshot’ – only part of a drive cycle
  - Driving conditions
  - ‘Real’ differences between vehicles e.g. maintenance, degradation effects
  - Any changes within Euro class
  - Misspecification of vehicle being considered



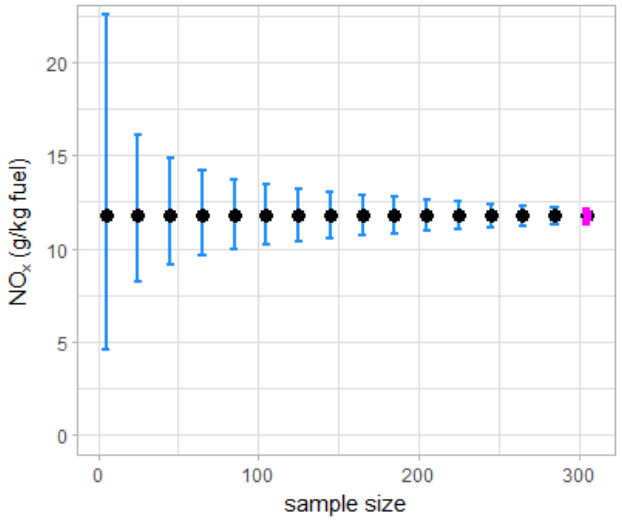
Remote sensing and sample size

- Consider measurements of 1.6 litre diesel Euro 5 VW Golf
  - Use random sampling to calculate uncertainty (95% confidence interval) as a function of sample size
- 0.56% of the fleet we have measured
- Need to measure **35800 vehicles to get sample size of 200** measurements
- Uncertainties driven by:
  - Instrument uncertainty
  - Plume ‘snapshot’ – only part of a drive cycle
  - Driving conditions
  - ‘Real’ differences between vehicles e.g. maintenance, degradation effects
  - Any changes within Euro class
  - Misspecification of vehicle being considered



Remote sensing and sample size

- Consider measurements of 1.6 litre diesel Euro 5 VW Golf
  - Use random sampling to calculate uncertainty (95% confidence interval) as a function of sample size
- 0.56% of the fleet we have measured
- Need to measure **58000 vehicles to get sample size of 320** measurements
- Uncertainties driven by:
  - Instrument uncertainty
  - Plume ‘snapshot’ – only part of a drive cycle
  - Driving conditions
  - ‘Real’ differences between vehicles e.g. maintenance, degradation effects
  - Any changes within Euro class
  - Misspecification of vehicle being considered



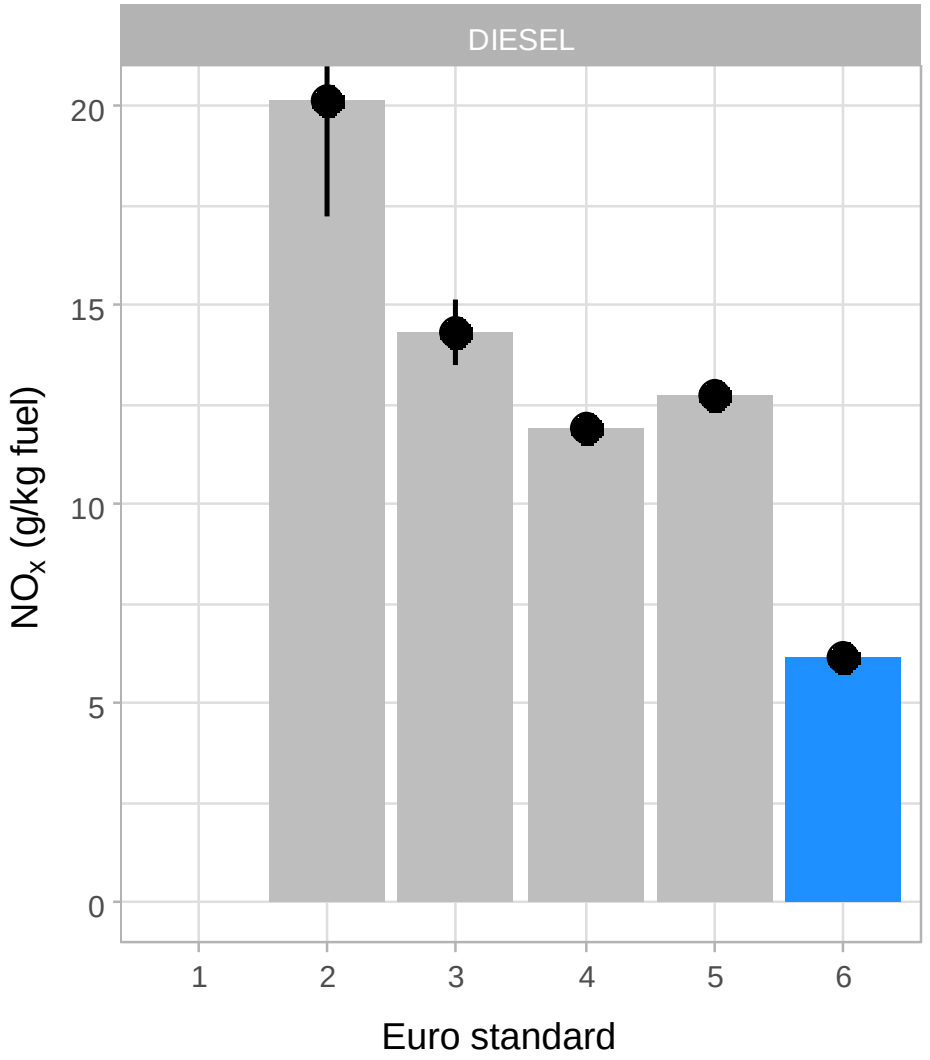
Link to inventories: Real world emission factors

- Remote sensing provides ratios of pollutant to CO_2 from which g per kg fuel estimates of emissions can be made
- Inventories provide emission factors in g per km
- Methods available to calculate real world g per km emission factors from remote sensing data
- Remote sensing data can be directly aligned with COPERT emission factor categories
- Can go ***beyond*** COPERT emission factor categories
  - Road gradient
  - Acceleration
  - Temperature
  - Vehicle manufacturer and model
- Informative for air quality modelling and assessment

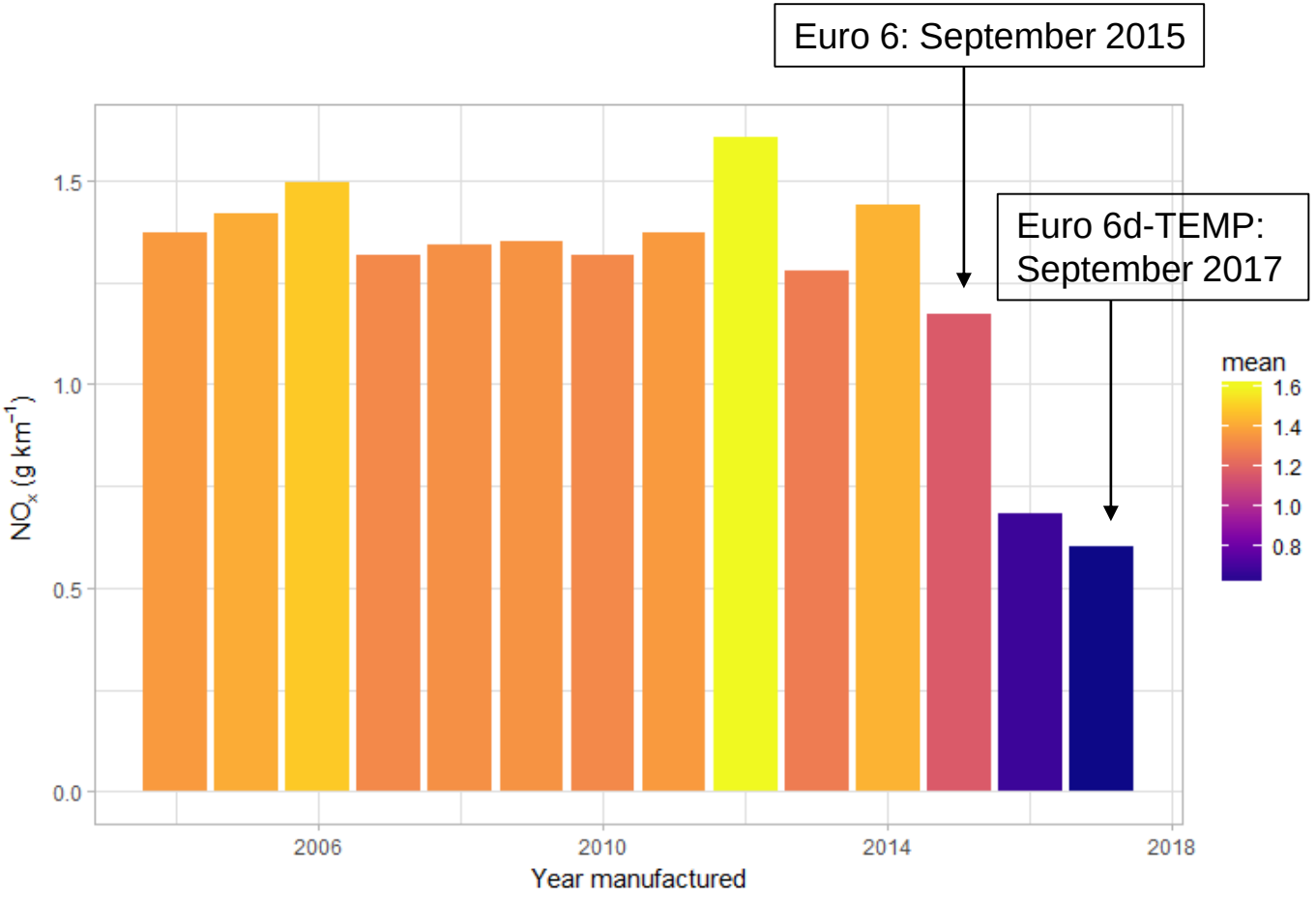
Work in progress: some results will be shown in g per kg fuel, but first results in g per km for diesel cars will be presented

NO_X emissions from diesel passenger cars

- Euro 6 diesel cars emit about 55% less NO_X than Euro 5 cars

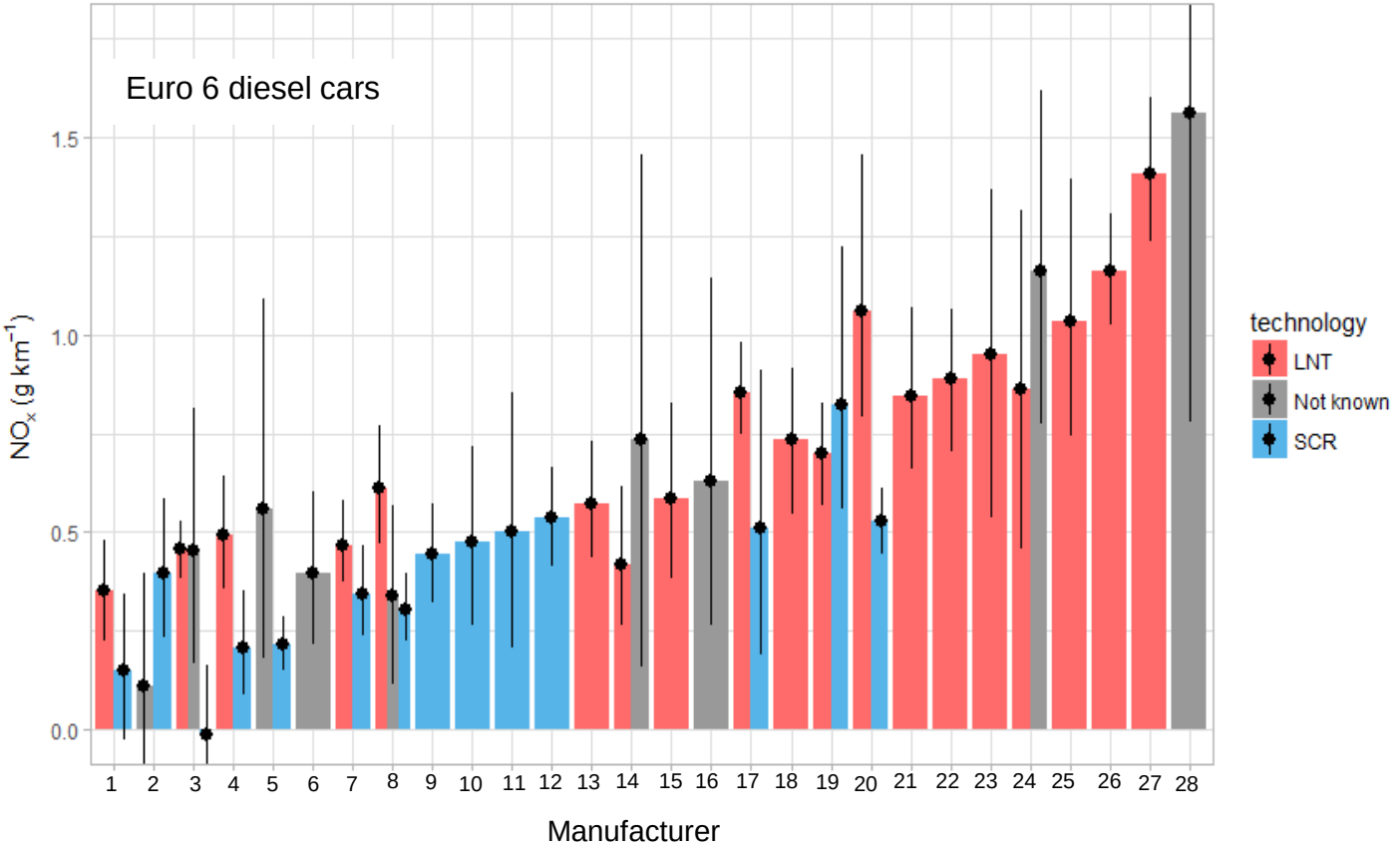


Emissions by year of manufacture for diesel cars



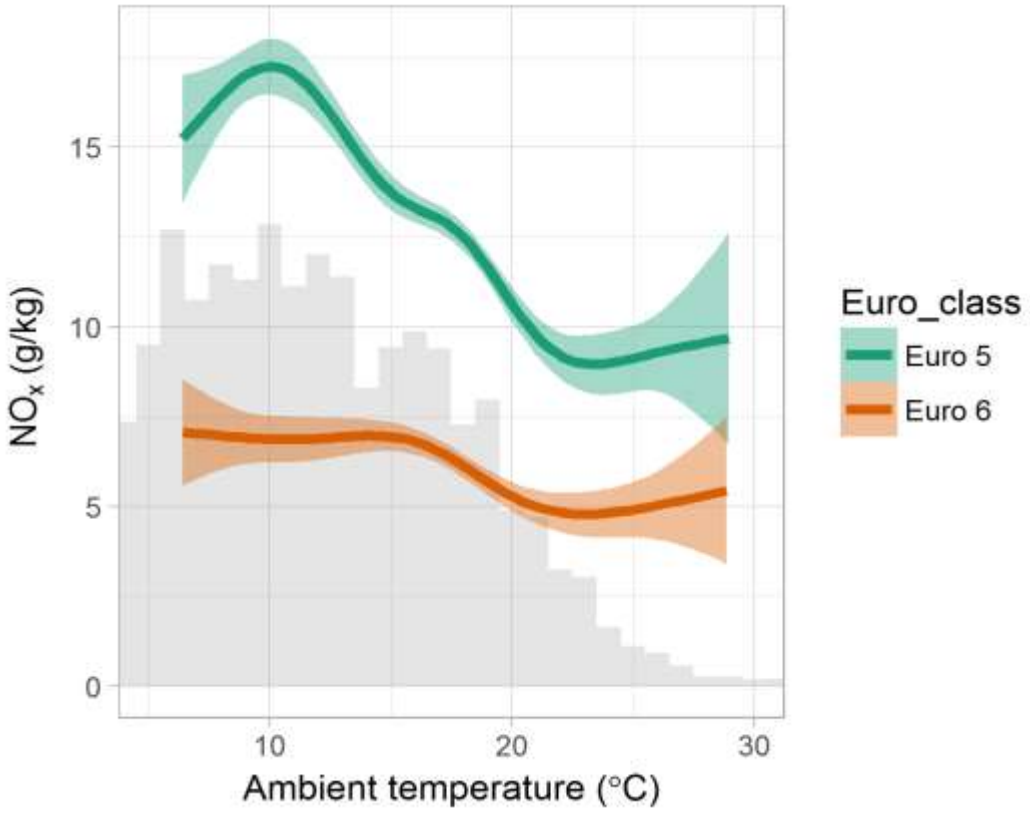
- Clear decrease from 2015 onwards i.e. Euro 6
- Vehicles seem to be improving over time – manufacturers getting better at controlling NO_x

Emissions of NO_x from Euro 6 diesel cars: manufacturer & technology



- Considerable range in NOx emissions for different manufacturers
- Generally shows SCR is associated with lower emissions

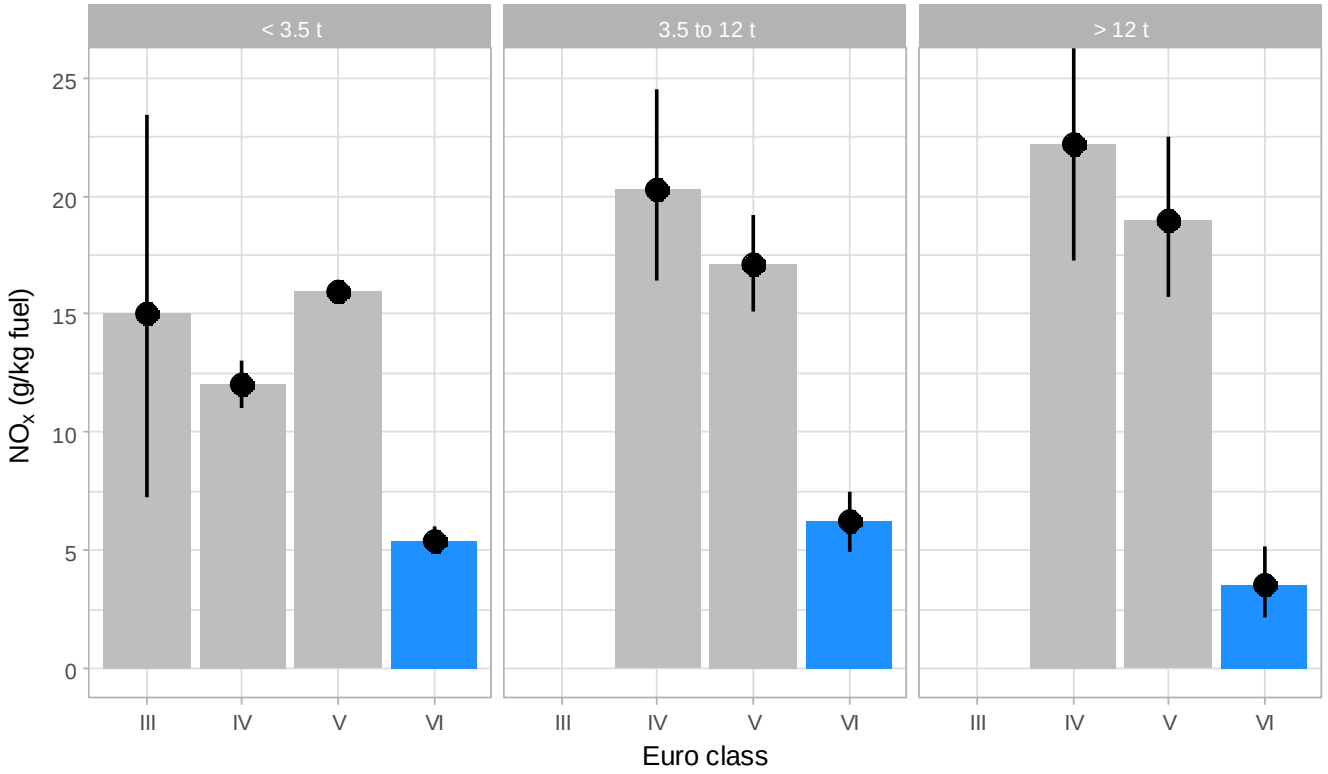
Effect of ambient temperature



- Increased emissions under lower temperatures
- Important for air quality
- Inventories used in air quality modelling and assessment do not include temperature effects

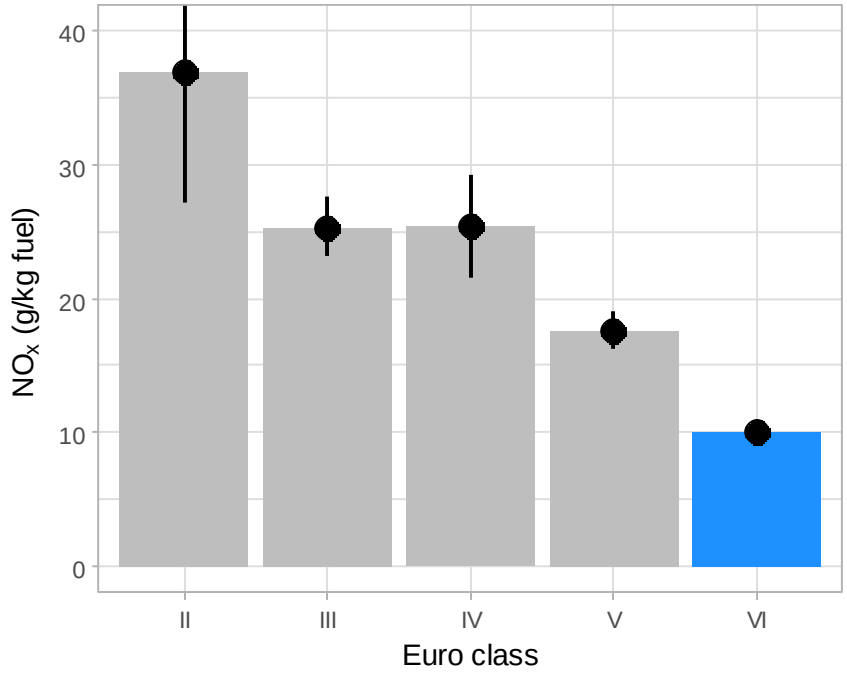
NO_X emissions from vans and HDVs

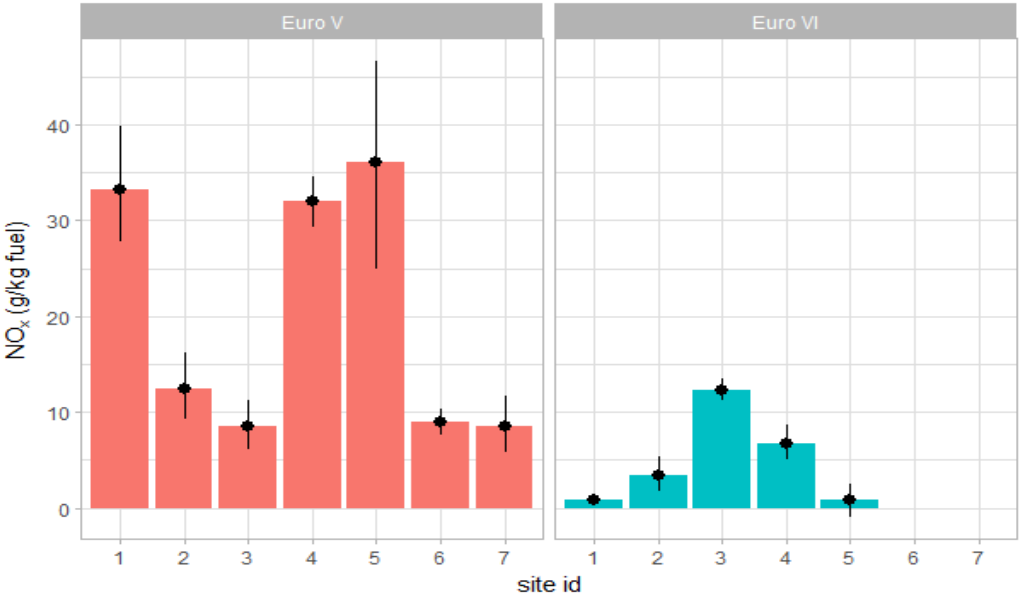
- Euro VI < 3.5 t emit 66% less NO_x than Euro V
- Euro VI <3.5 - 12 t emit 63% less NO_x than Euro V
- Euro VI > 12 t emit 81% less NO_x than Euro V



NO_X emissions from buses

- Euro VI on average 42% less than Euro V





- Local authorities can have very specific bus fleets – different emissions driven by different bus technologies used (and local driving conditions)
- Important for urban areas

Conclusions and future developments

- Evidence for considerable reductions in NO_x emissions for most major classes of Euro 6/VI diesel vehicles
  - 40-80% reductions for cars, buses, LGVs and HGVs
  - Variation by manufacturer, exhaust after treatment technology and temperature
- Can derive real-world emission factors in the same categories as COPERT and going beyond COPERT categories (temperature, manufacturer…)
  - Can inform inventories and air quality modelling and assessment (e.g. CAZ implementation)
  - Further work to compare real world emission factors in g/km to emission factors in inventories
- Working with ICCT, OPUS and University of York to measure further 100,000 vehicles in London
  - Evidence for improvements as staged Euro 6 legislation with RDE test requirements come in
  - Inter-comparison with alternative remote sensing instrumentation

Thank you for your attention!

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