New findings from vehicle emission remote sensing in London

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LAQN seminar
21st June 2013

Outline

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Problems with NO_2 then with NO_x ...

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- Exceedances of NO_2 dependent on primary NO_2 *and* total NO_x
- **Need to know what vehicles *really* emit when driving around**

How best to acquire more robust data?

Options for measuring vehicle emissions

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- Could use PEMS (Portable Emission Measurement System)
  - Very useful for *individual* vehicles
- Vehicle emission remote sensing
  - **Measure 1000s of vehicles under actual driving conditions**
  - Defra-sponsored work published on this in 2011, but no measurements of NO_2 ...

Outline

The University of Denver instrument

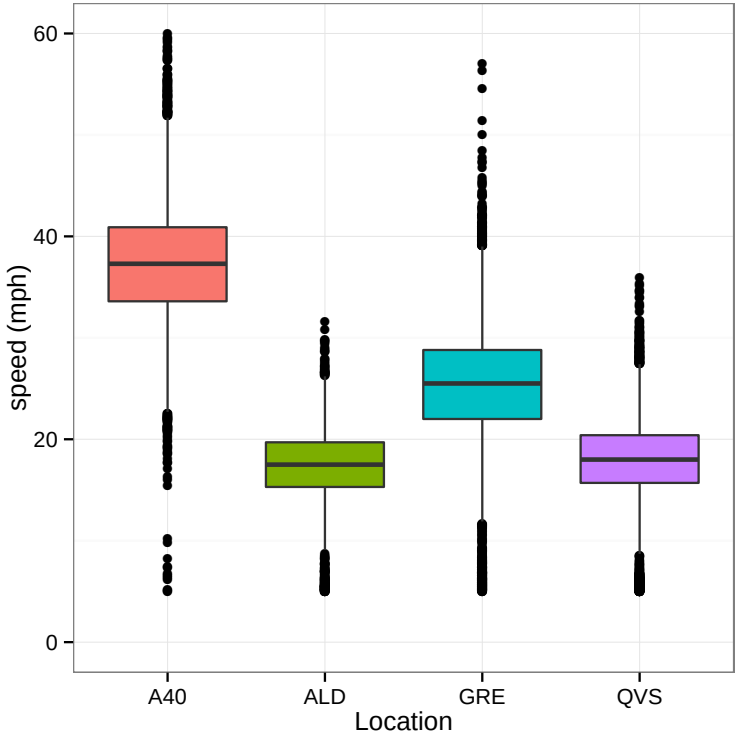
Overview

- Unique in the world because it measures NO_2 and NH_3
- First use in the UK
- Shine UV/Infrared beam through exhaust of passing vehicle
- Measures NO, NO_2, CO, HC, SO_2, NH_3 and infrared opacity
- CO_2 is measured and emissions expressed as a ratio to CO_2
- Carefully match number plate with comprehensive vehicle information databases

Measurement campaigns

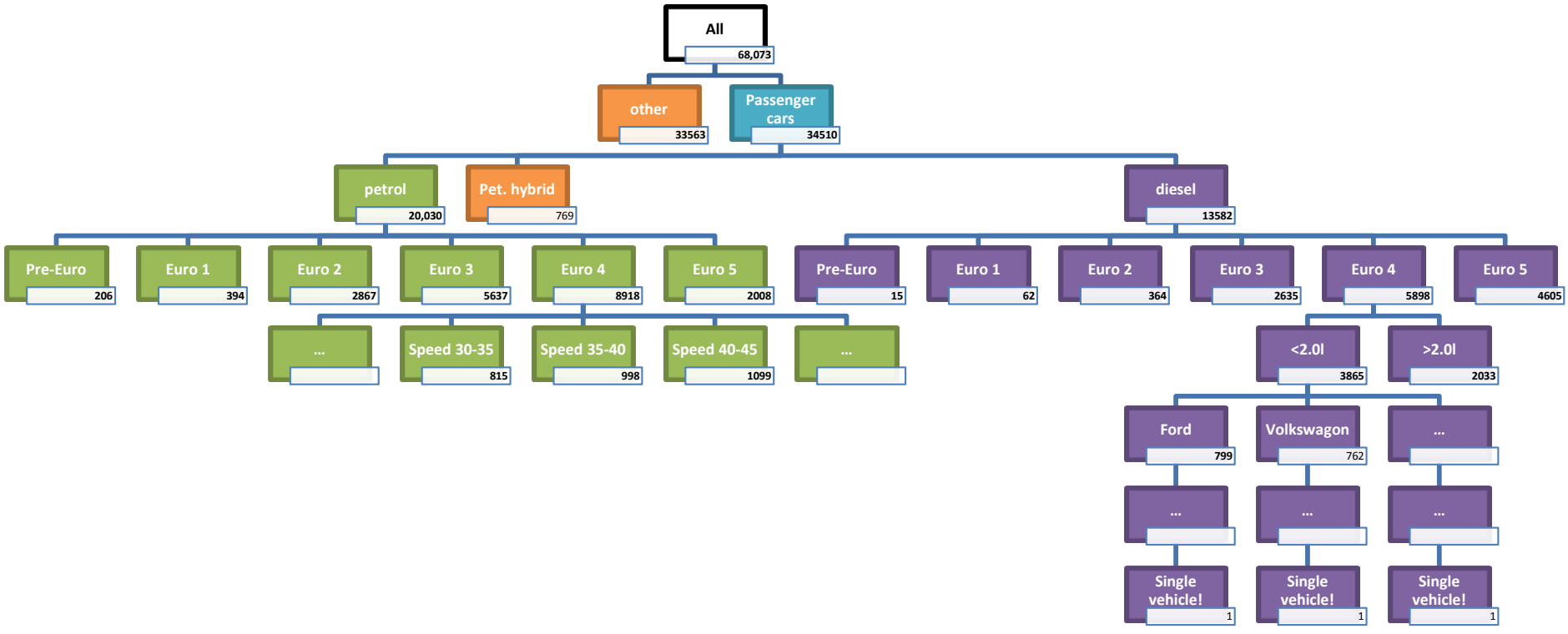
Summary of the measurements that were made

- Measured in two locations in the City of London and two in Ealing
- Speeds range from 5 to 60 mph
- Central London high in buses and taxis; outer London more mixed



Opportunities for data analysis

Example for passenger cars



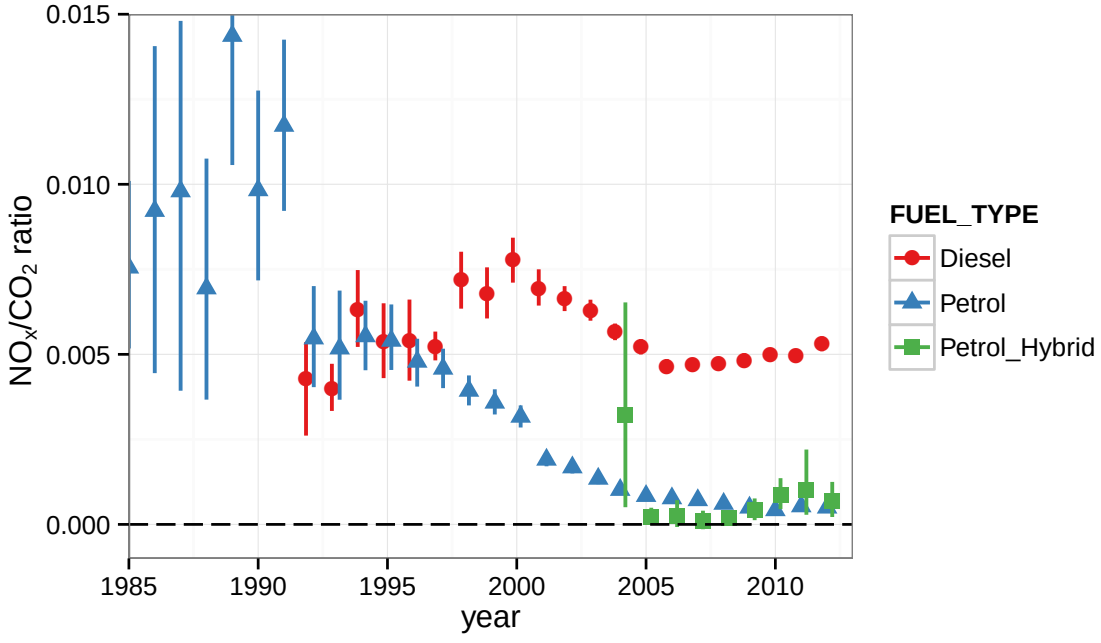
- This is one reason why vehicle emission remote sensing is such a powerful technique

Outline

Emissions from passenger cars

By year and type for NO_x

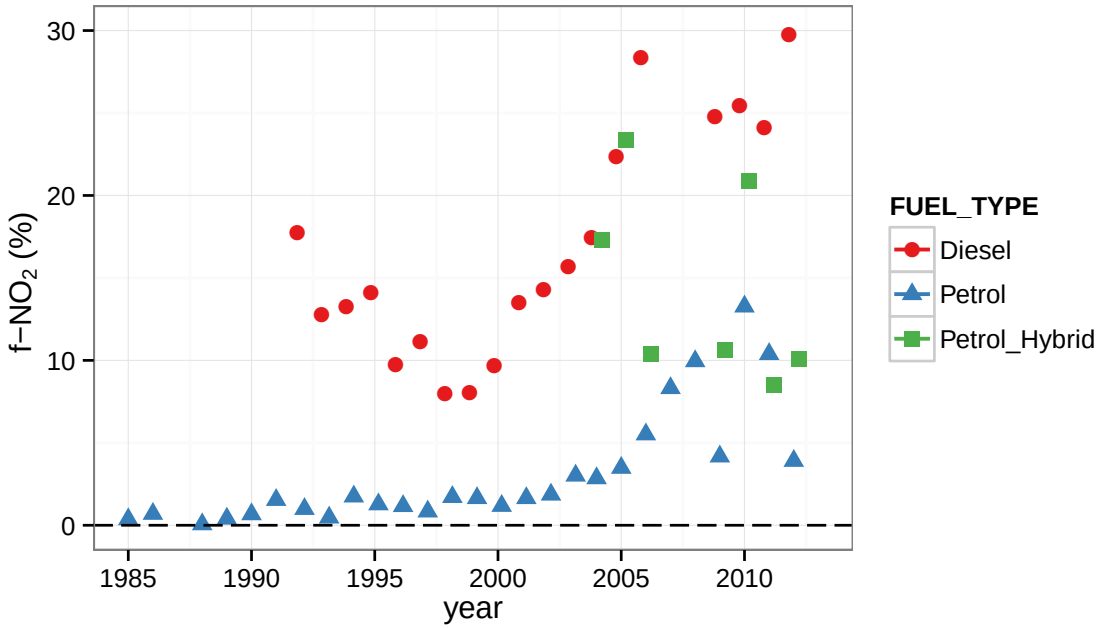
- Clear reduction for petrol cars — clear effect of three-way catalytic converter
- Petrol hybrids essentially identical
- Emissions from diesel same in 2012 as they were in 1992
- Peaked in 2000 (Euro 3), gradual increase since 2006



Emissions from passenger cars

By year and type for NO_2

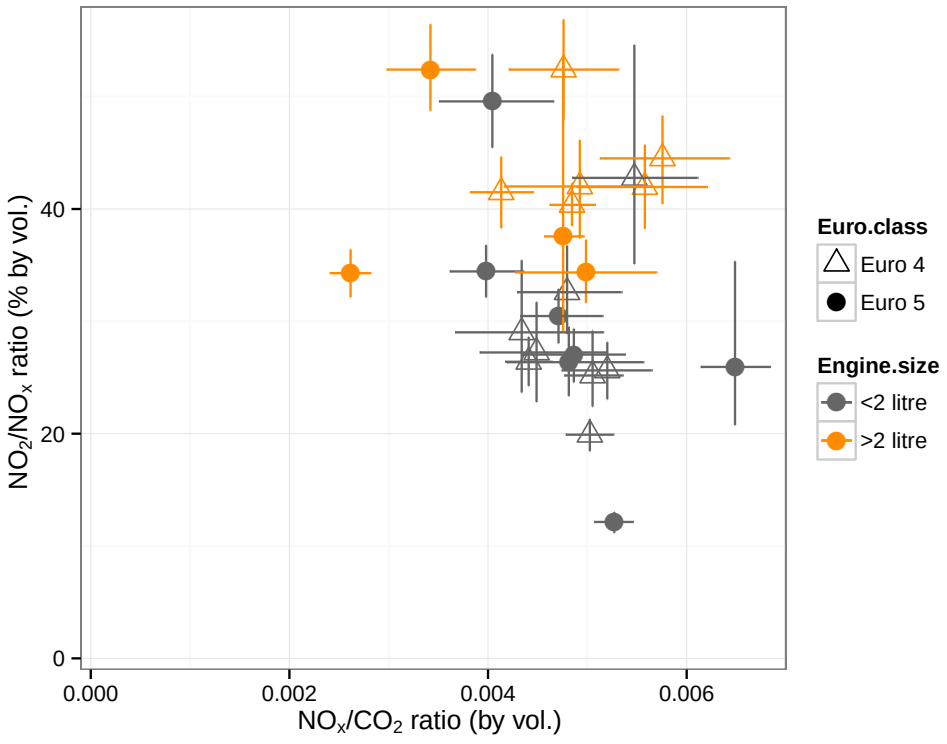
- Petrol NO_2 is very low — and irrelevant because of such low total NO_x
- Diesel NO_2 has increased markedly from Euro 3
- Typically around 25–30% for new Euro 5 vehicles



Effect of vehicle manufacturer

Euro 4/5 diesel passenger cars

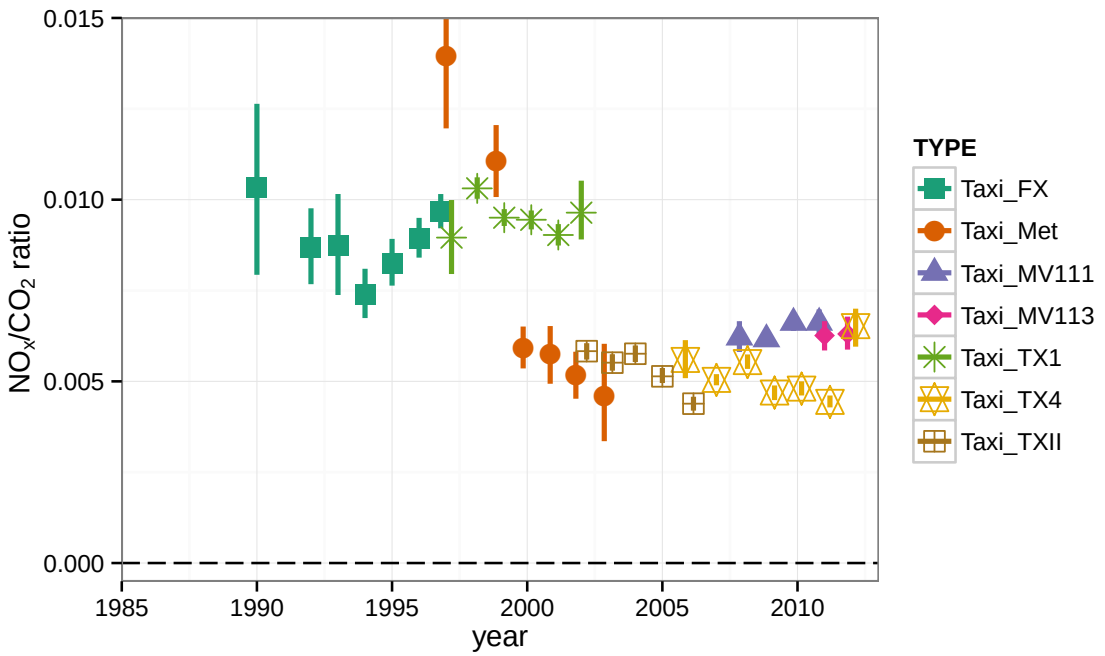
- Much smaller range in NO_x by manufacturer compared with f-NO_2
- Vehicles with engines >2.0 litres have higher f-NO_2
- Scope for reducing f-NO_2 by selecting a particular manufacturer (range from 12 to 55%)



Emissions from London taxis

By year and type for NO_x

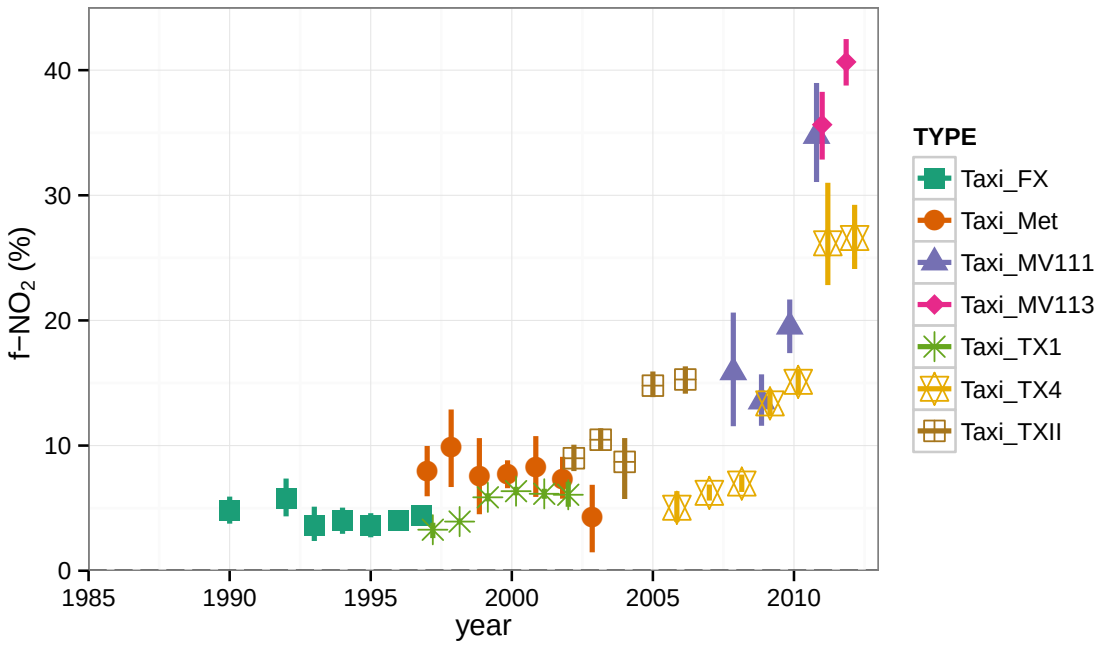
- Two groups: ‘high’ and ‘even higher’ emitting for NO_x
- Post-2000 taxis similar to modern diesel cars
- Higher emitting taxis accounted for ≈ 1/3 of taxis sampled



Emissions from London taxis

By year and type for NO_2

- Clear increases in NO_2 emissions from taxis
- Some models emit up to 40% of their NO_x as NO_2
- . . . these are the newest model vehicles



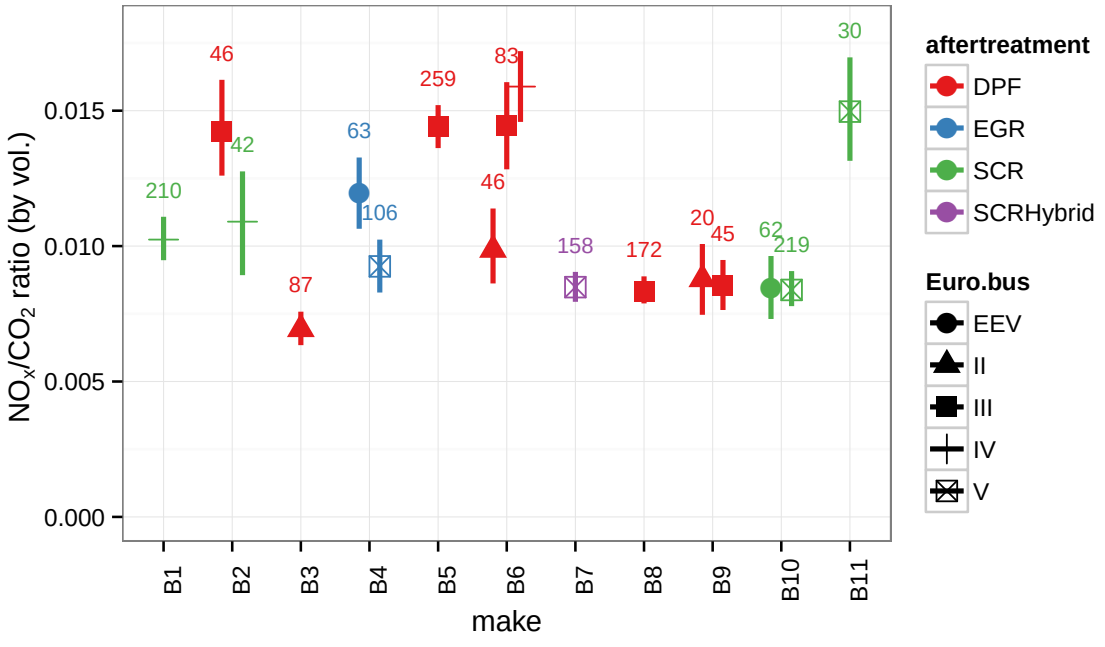
Emissions from TfL buses

- Analysis greatly assisted by information from TfL (Finn Coyle)
  - Detailed information provided by individual bus — can matched exactly with emissions data
  - Information on engine size, after-treatment e.g. particle filter, use of selective catalytic reduction (SCR), Euro class etc.
  - Note — SCR measured were all Original Equipment Manufacturer systems (OEM) and not those optimised as part of TfL's retrofit programme
- Data actually useful in understanding emissions from other heavy vehicles

Emissions from TfL buses

By manufacturer and type for NO_x

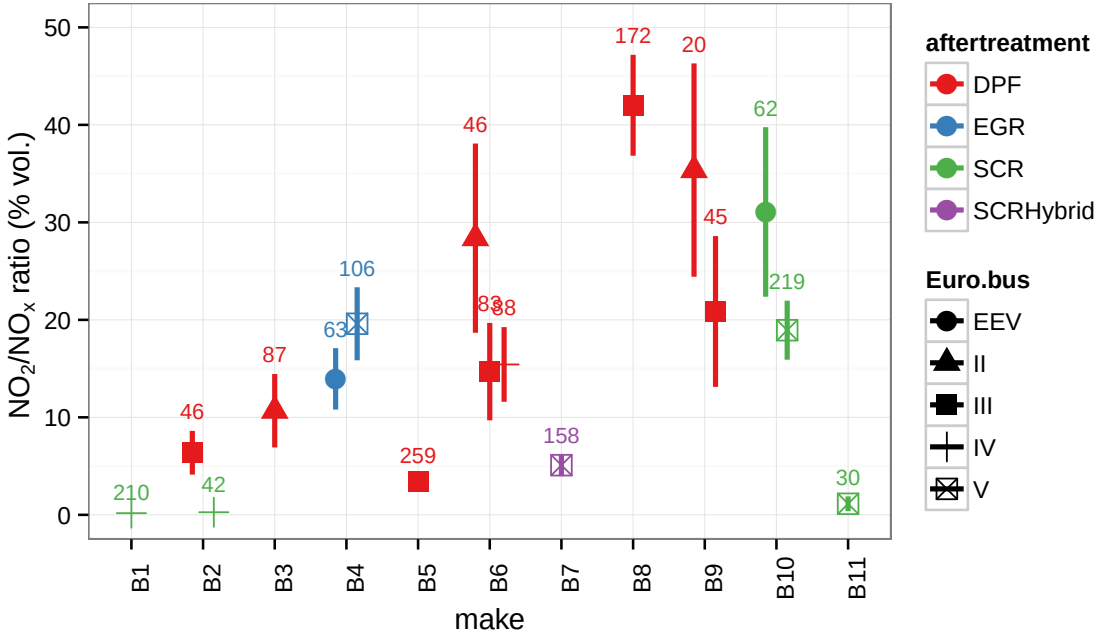
- Little evidence that more modern buses reduce NO_x
- In particular, SCR (a system designed to reduce NO_x) is ineffective
- Reasonably consistent emissions across manufacturers, but some variation



Emissions from TfL buses

By manufacturer and type for NO_2

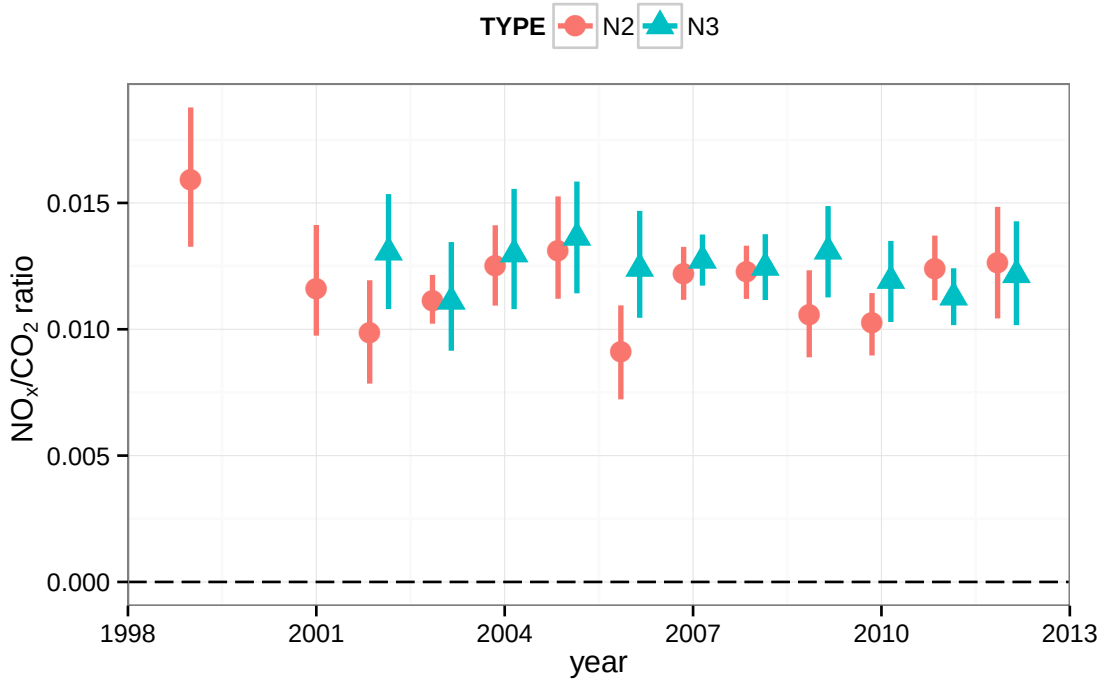
- Large variation in NO_2 emissions — from almost all NO to $>40\%$ NO_2
- Older SCR systems (Euro IV) emit very low amounts of NO_2 — low engine-out NO_2?
- Modern SCR systems (EEV) associated with much higher levels of NO_2 — stronger oxidation?



Emissions from HGVs

By manufacturer and type for NO_x

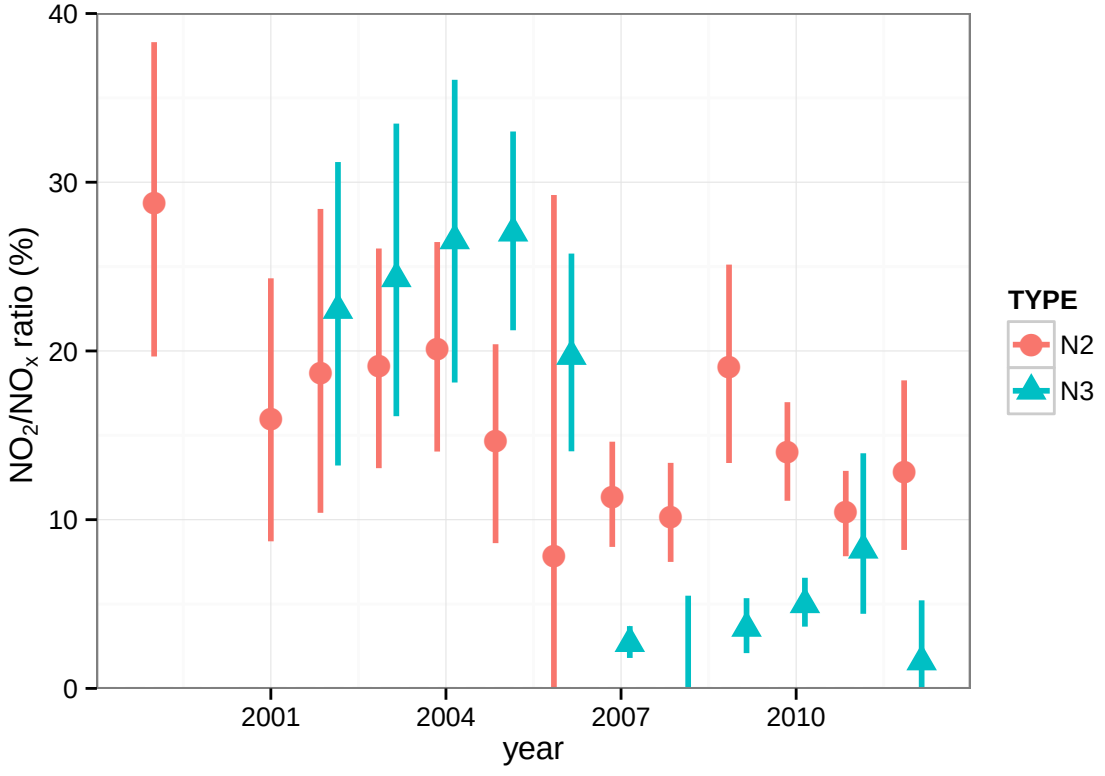
- Little, if any change in NO_x since 2001
- Note N2 = 3.5 to 12 t and N3 = >12 t



Emissions from HGVs

By manufacturer and type for NO_2

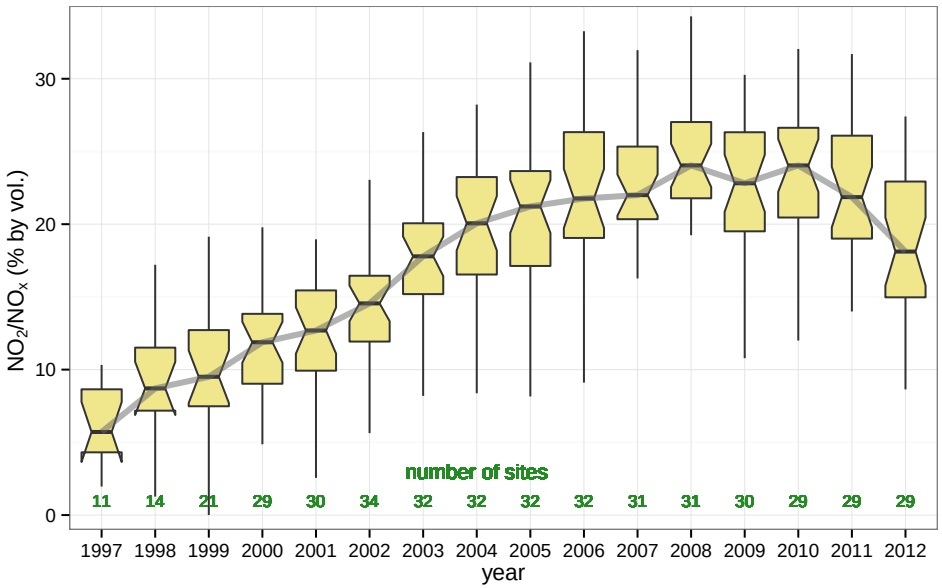
- Euro IV/V vehicles much lower emitters of NO_2
- Findings similar to TfL buses — low engine-out NO_2
- Lower NO_2 for large HGVs for Euro IV/V



Linkage with ambient measurements

Can estimate f-NO_2 from measurements at sites in London

- Simple hourly chemistry model[a]
- f-NO_2 steadily increased from 1997 to about 2010
- Recent decreases would be consistent with f-NO_2 reductions seen in emissions data from heavy vehicles
- Potentially large effect on NO_2 concentrations close to *some* roads



[a] Carslaw, D. C., & Beevers, S. D. (2005). Estimations of road vehicle primary NO_2 exhaust emission fractions using monitoring data in London. *Atmospheric Environment*, 39(1), 167-177

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7. We need to know what the in-use emissions from Euro VI/6 are

Acknowledgements

- Dr Glyn Rhys-Tyler, University of Newcastle (now Oxford Brookes) — academic partner
- Defra (with City of London and Ealing) for funding
- Professor Don Stedman and team — University of Denver
- Ruth Calderwood (City of London), Dr John Freeman and Rizwan Yunus (Ealing), and Bill Legassick (Southwark)
- Colin Oates (lead RSD technician) and Enviro Technology who organised use of RSD in the UK
- Camilla Ghiassee (now at Public Health England)
- Finn Coyle (TfL) for bus infromation

Thank you for you attention...

Questions?

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