From roadside to nationwide

Remote sensing measurements for emission inventory development

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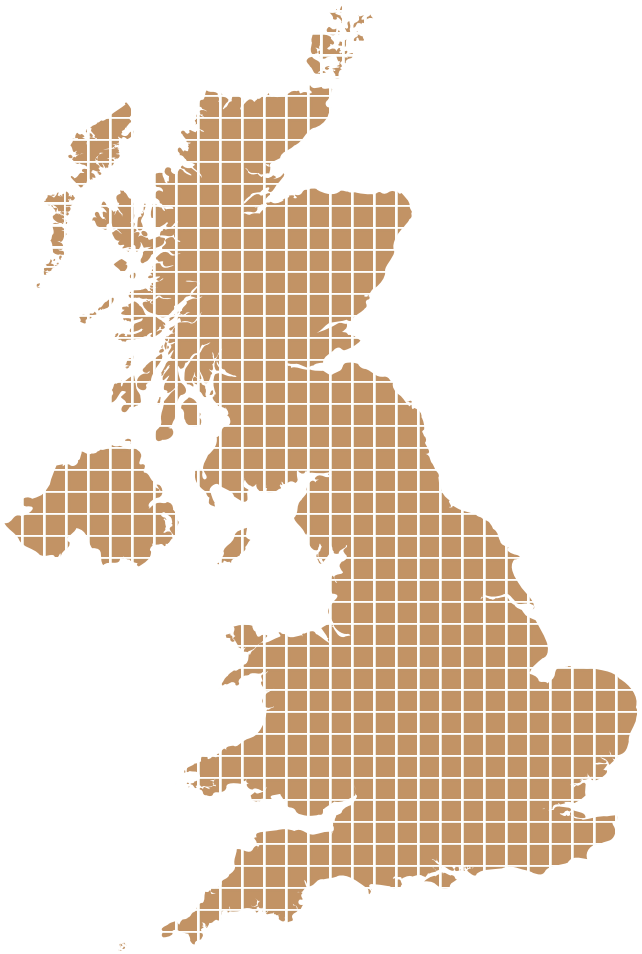
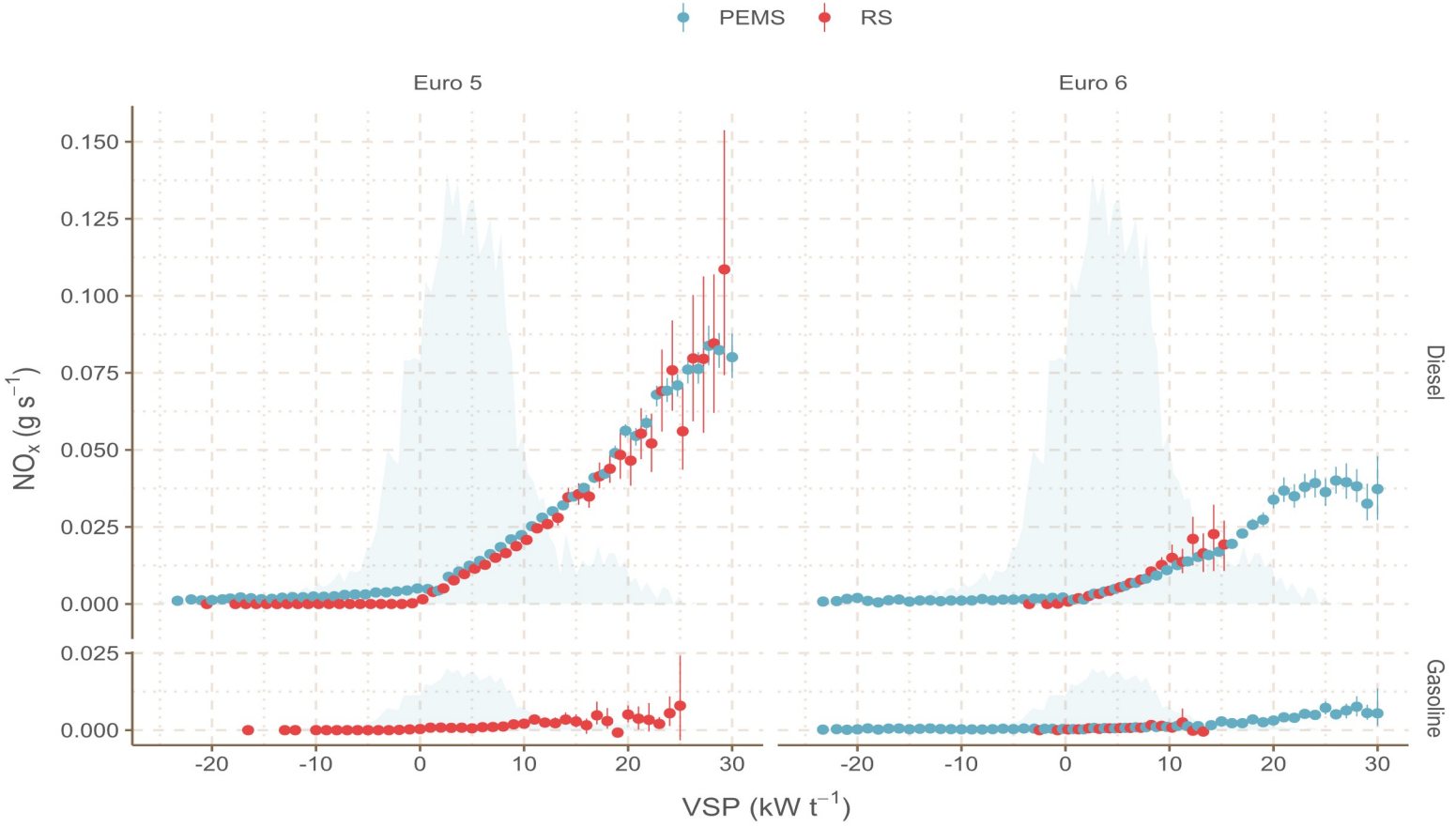
Remote sensing data for emission inventory development

- Remote sensing data has some attractive qualities for inventory development
  - Real world measurements under a wide range of conditions
  - Very good coverage of vehicle fleets – vehicle type and manufacturer
  - Implicit account of factors such as ambient temperature, mileage degradation, share of km driven
  - Large sample sizes possible ~ 500k in UK



Remote sensing data for emission inventory development – challenges

- Key challenge is calculation of absolute emissions in g/km
- Calculate fuel consumption
- Use vehicle power-based approach
- Grounded in forces acting on a vehicle and can account for vehicle weight, road gradient etc
- Good agreement with comprehensive PEMS data

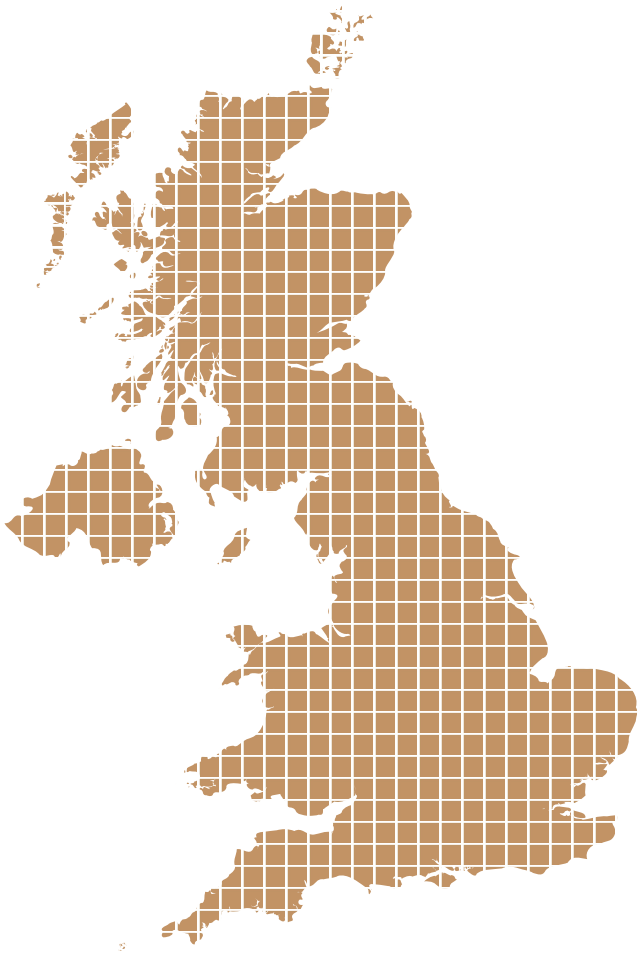


Adapted from Davison *et al.*, 2020

Davison, J., Bernard, Y., Borken-Kleefeld, J., Farren, N. J. Hausberger, S., Sjodin, A., Tate, J. E., Vaughan, A. R., Carslaw, D. C. (2020). Calculation of Distance-Based Emission Factors from Vehicle Emission Remote Sensing Measurements. *Science of the Total Environment*. 739 (2020) 139688.

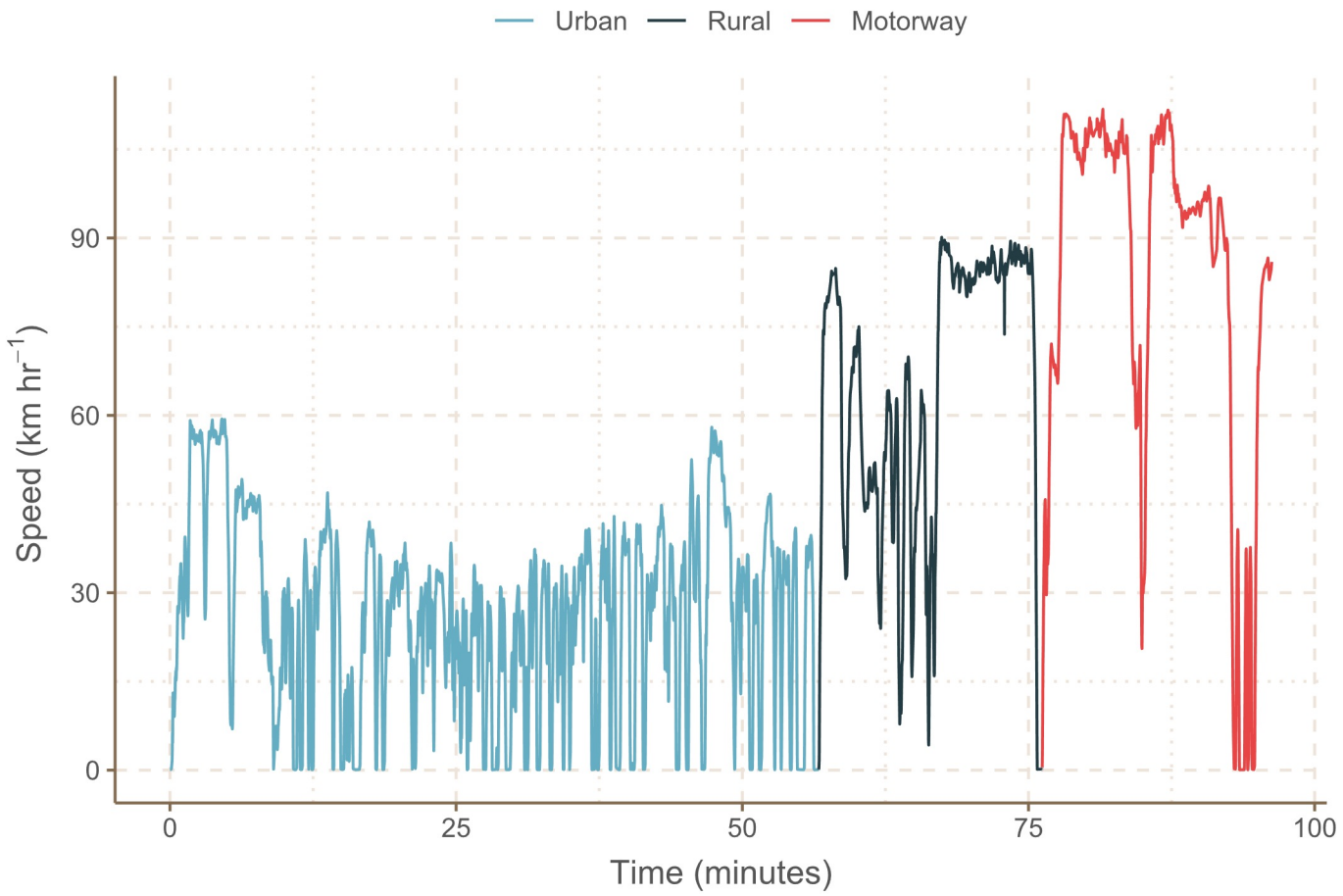
The UK is a very good location for emission inventory verification

- It is an island (well, GB) … more so than ever perhaps!
  - Negligible transborder movement of vehicles; especially LDVs
  - Almost all road transport fuel sold in UK is used in the UK
- Additional checks and comparisons possible at a country level
  - Fuel sales known to (very) high accuracy
  - Carbon / fuel / energy balance can be evaluated



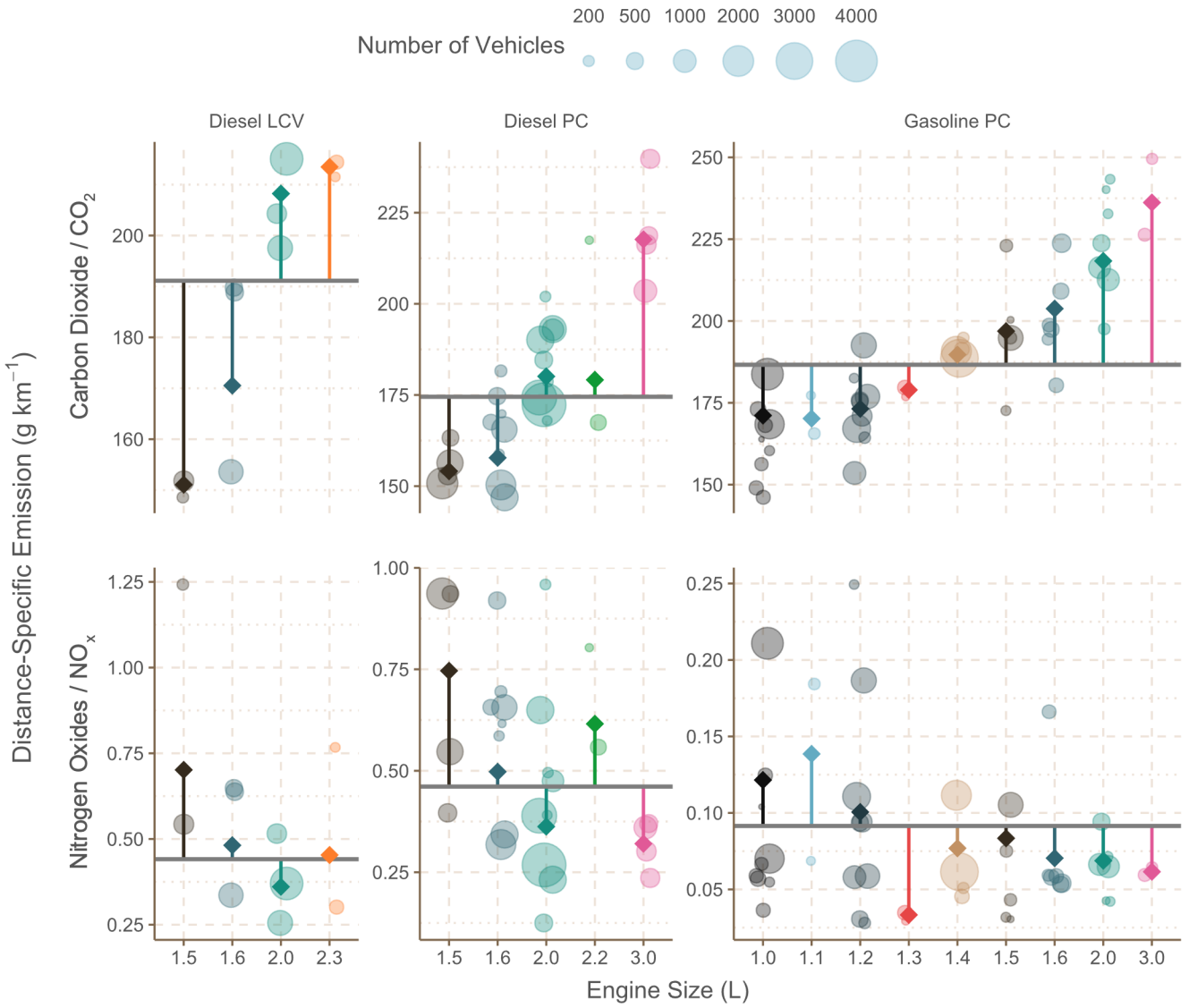
Using PEMS drive cycles to calculate emissions

- Use over 4,000 km of PEMS data to quantify emissions for urban, rural, motorway conditions
  - Remote sensing measurements tend to be made under higher load conditions than average urban driving
  - Predict over PEMS drive cycles
- Remote sensing counts provide urban fuel mix (more gasoline than diesel use)
  - Also provides actual mileage by Euro class e.g., older vehicles do not travel as far as newer vehicles



Vehicle and fuel type effects

- Emissions of CO_2 and NO_x by vehicle type, engine size and manufacturer
- Can partition the data in many ways
- Sample sizes become increasingly important



Example findings

- For LDVs the bottom-up calculations give near carbon balance at a UK level (within 1.5%)
  - Encouraging check on methods
- LDV NO_x is underestimated by 24–32%, and up to 47% in urban areas, compared with the UK national inventory
  - Some of the difference is not related to emission factors but activity data / assumptions
- UK gasoline ammonia emissions are underestimated
  - 7.8 ± 0.3 kt compared with NAEI 3.0 ± 1.7 kt
  - Factor of 17 underestimate in urban areas

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Article

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

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Cite This: *Environ. Sci. Technol.* 2021, 55, 4452–4461

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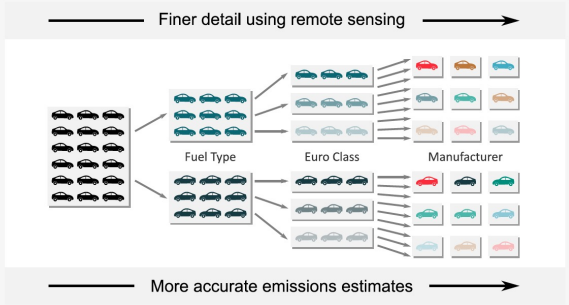
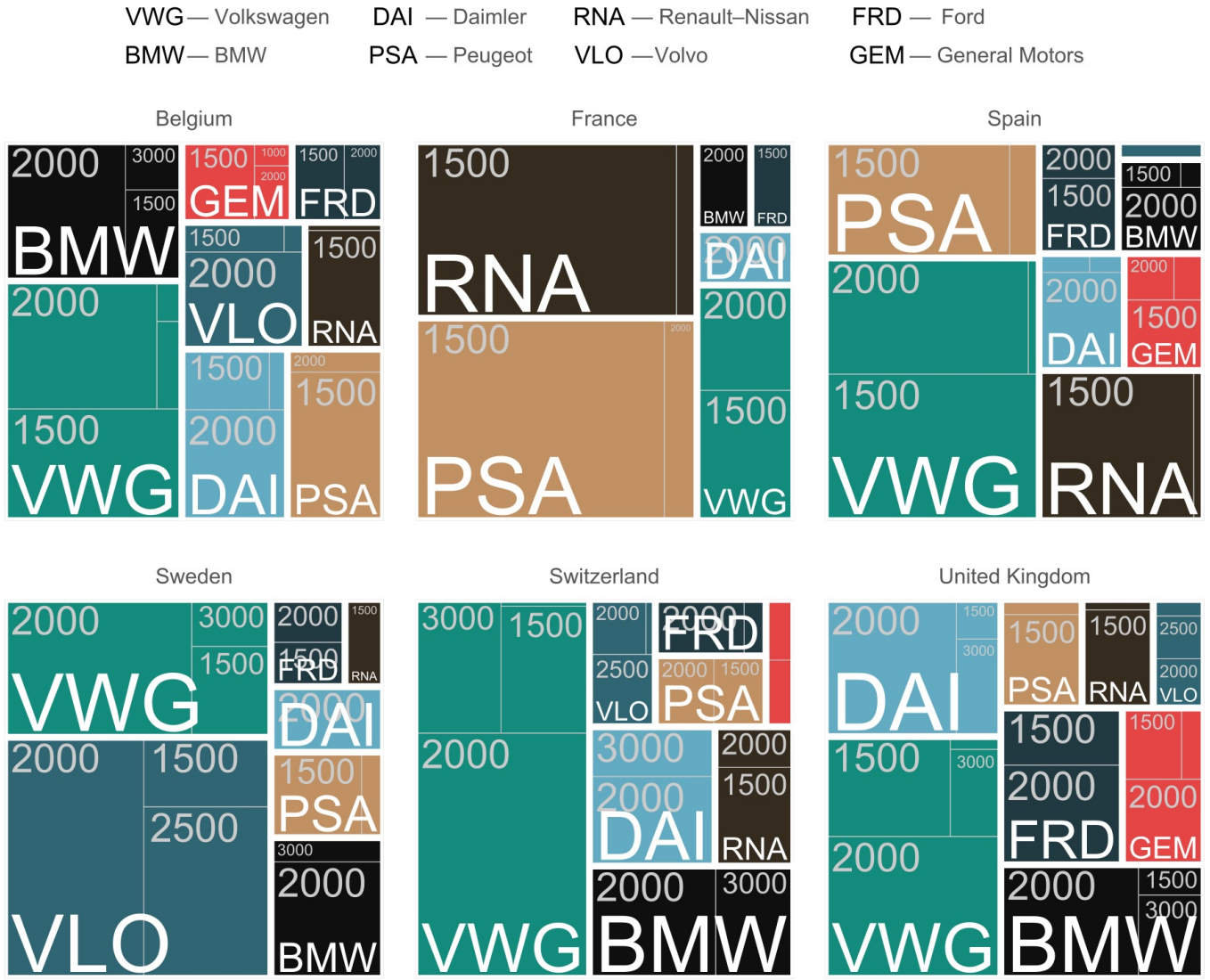
ABSTRACT: Road vehicles make important contributions to a wide range of pollutant emissions from the street level to global scales. The quantification of emissions from road vehicles is, however, highly challenging given the number of individual sources involved and the myriad factors that influence emissions such as fuel type, emission standard, and driving behavior. In this work, we use highly detailed and comprehensive vehicle emission remote sensing measurements made under real driving conditions to develop new bottom-up inventories that can be compared to official national inventory totals. We find that the total UK passenger car and light-duty van emissions of nitrogen oxides (NO_x) are underestimated by 24−32%, and up to 47% in urban areas, compared with the UK national inventory, despite agreement within 1.5% for total fuel used. Emissions of NO_x at a country level are also shown to vary considerably depending on the mix of vehicle manufacturers in the fleet. Adopting the on-road mix of vehicle manufacturers for six European countries results in up to a 13.4% range in total emissions of NO_x. Accounting for the manufacturer-specific fleets at a country level could have a significant impact on emission estimates of NO_x and other pollutants across the European countries, which are not currently reflected in emission inventories.



Application: European Fleet Characteristics

- Key benefit of remote sensing data is comprehensive manufacturer information
- Manufacturer share varies across different European countries from CONOX
- What of the UK had these vehicle manufacturer proportions?



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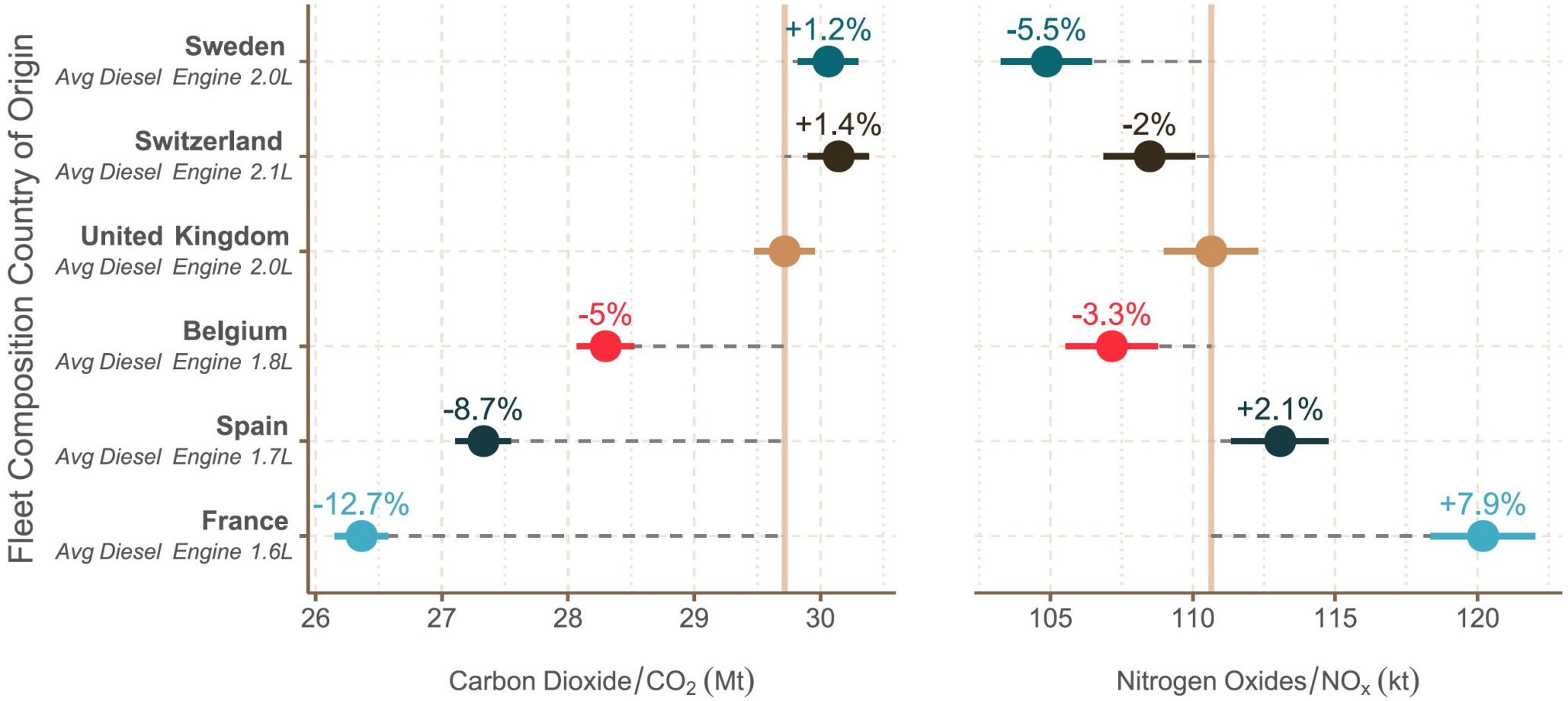

Recent Papers from the University of York Group

Farren *et al.* (2020), Underestimated Ammonia Emissions from Road Vehicles,
Environmental Science & Technology
Top-down and bottom-up emissions estimates of UK LDV ammonia using RS emission factors & fleet data

Grange *et al.* (2020), Post-Dieselgate: Evidence of NO_x Emission Reductions Using On-Road Remote Sensing,
Environmental Science & Technology Letters
Understanding the effects of emission reductions after the dieselgate scandal

Grange *et al.* (2019), Strong Temperature Dependence for Light-Duty Diesel Vehicle NO_x Emissions,
Environmental Science & Technology
Quantifying the extent to which NO_x emissions are sensitive to ambient temperature

Davison et al. (2021), Verification of a National Emission Inventory and Influence of On-road Vehicle Manufacturer-Level Emissions,
Environmental Science & Technology
Bottom-up inventory verification using RS and effects of manufacturer fleet mix in different countries