Beyond NO_x – future air pollution impacts of road vehicles

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Background

Over the last few years vehicle emissions of nitrogen oxides (NO_x) have been in the spotlight because of the VW 'dieselgate' scandal. This focus highlighted the inadequate information available on the 'real world' emissions from vehicles. The term 'real world' is frequently used in this area because measurements of vehicle emissions have mostly been undertaken under laboratory conditions on rolling roads. It is now widely established there is an enormous gap between the emissions under lab conditions and on roads and much more focus on quantifying emissions under real driving conditions. While the aim of making 'real world' emissions sounds straightforward, in reality there are myriad reasons that make the accurate quantification of emissions highly challenging. These reasons include a source type comprising of millions of individual sources that vary in space and time, depend on vehicle technology, the age of the vehicle, how vehicles are driven and ambient conditions – and many other factors.

Road vehicles are not only important sources of NO_x but also a range of other pollutants that have to a large extent been neglected. These other pollutants include ammonia (NH_3), aldehydes, alcohols, nitrous acid which all have potentially important direct effects (e.g. to human health) or indirect effects (in contributing to the formation of other important air pollutants). Currently, there is a considerable paucity of information on the real-world emissions of these and many other species. Vehicle emissions control technology is also changing rapidly with the use of after-treatment technologies such as Lean NO_x Traps and Selective Catalytic Reduction increasingly being used. These technologies have the potential to reduce emissions such as NO_x, but it is much less certain what their impact will be on other pollutants – and indeed whether these technologies remain effective over time.

Project Aims

This project aims to couple two sophisticated measurement techniques to better characterise a broader range of vehicle emissions under real driving conditions. The first is vehicle emission remote sensing (RS), which is a non-intrusive technique for measuring emissions from individual vehicles. The technique is increasingly used in Europe and can measure the emissions of 10,000s of vehicles under real driving conditions for common pollutant such as NO_x and CO. The second is Selected Ion Flow Tube Mass Spectrometry (SIFT-MS), which can measure a wide range of individual hydrocarbons, alcohols, aldehydes, NH_3 and many other species at high time resolution and the high sensitivity. The coupling of vehicle emissions remote sensing with SIFT-MS has the potential to bring a step change increase in the information on vehicle emissions under real driving conditions.

Figure: The Opus RSD 5000 RS instrument.

At present, two measurement approaches are envisaged. First, the co-location of RS and SIFT-MS at a roadside location to measure individual vehicles plumes, using the co-measurement of fast-response CO_2 concentrations to derive fuel-based emission factors. Second, the use of the SIFT-MS as a 'plume chase' instrument where individual vehicles are followed for a period of minutes to sample their plumes. Between them, the two approaches would potentially provide an enormous amount of much-needed new data. Such data would form the basis of deriving new emission factor information and the development of fuel-based emission inventories, which would provide improved input to air quality models.

Requirements

Undergraduate training in any physical/chemical science. An interest in developing effective data analysis skills and working with the CASE partner is also required.

Training

The student will work under the supervision of both Dr David Carslaw and Dr Marvin Shaw (University of York) and will be based at the Wolfson Atmospheric Chemistry Laboratories, part of the Department of Chemistry. You will also spend part of your project working with the CASE partner, Ricardo (see below). This project will provide training in a variety of atmospheric measurement and 'modern' data analysis techniques. The student will receive training in the operation of the SIFT-MS by Dr Marvin Shaw who has operated the instruments in a variety of field and laboratory locations. The student would be trained on the use of the RS instrument and conduct both field and laboratory-based studies.

The University of York and the wider NERC PANORAMA DTP provide comprehensive training programmes for PhD students with a range of courses on both hard and soft skills. The student will have the opportunity to present their work to the scientific community at national and international meetings and conferences. They will also be encouraged to take part in outreach events organised by both WACL to disseminate the research beyond the immediate scientific community (e.g. to policymakers and the public).

Research Environment

The student would join a growing and active group on vehicle emissions research at the Wolfson Atmospheric Chemistry Laboratories, which is part of the Department of Chemistry at the University of York. These laboratories were established in 2013 and comprise a state of the art 800 m² dedicated research building, the first of its kind in the UK, which in 2018 has been further extended.

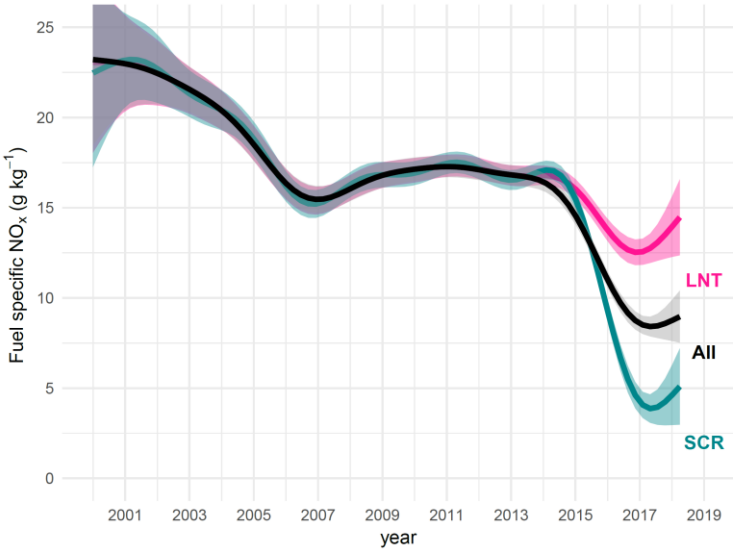

Figure: Emissions of NO_x from diesel passenger cars as a function of year of manufacture and emissions control technology (LNT = Lean NO_x Trap, SCR = Selective Catalytic Reduction).

The vehicle emissions group has recently acquired a vehicle emission remote sensing instrument RSD 5000 (one of the few in Europe). Additionally, we have several SIFT-MS instruments which have been used for a wide range of research purposes where fast response measurements of many VOCs are required. In 2018, WACL also acquired a dedicated mobile laboratory which can accommodate the SIFT-MS and is capable of plume chase experiments.

An important part of this research project is the CASE funding support from Ricardo. Ricardo is a vehicle engineering company with £10m state of the art rolling road laboratories and several PEMS instruments (Portable Emission Monitoring Systems) to allow individual vehicles to be instrumented. The student would work closely with Ricardo and have access to these facilities – and importantly – the opportunity to develop knowledge of vehicle emission control technologies, which is commonly poor in environmental science research. Ricardo (Energy & Environment) also leads important national projects on behalf of Defra including the National Atmospheric Emissions Inventory (NAEI) and the national air quality network (the Automatic Urban and Rural Network). As such, the research conducted by the student will have direct policy relevance and many opportunities to understand the relevance and use of such measurements to national and international programmes on air

quality. The student would be expected to spend time at Ricardo facilities and offices, which would help broaden their knowledge in how data on vehicle emissions are collected and used in an applied setting.

Useful reading

New study quantifies global health, environmental impacts of excess nitrogen oxide emissions from diesel vehicles. https://www.theicct.org/news/nature-impacts-diesel-nox-may2017

About the diesel NO_x issue https://www.theicct.org/spotlight/use-nox-emissions

Carslaw, D.C. and Rhys-Tyler, G. (2013). New insights from comprehensive on-road measurements of NOx, NO2 and NH3 from vehicle emission remote sensing in London, UK. Atmospheric Environment, Vol. 81 339-347. (use of remote sensing to measure vehicle emissions in London). https://www.sciencedirect.com/science/article/pii/S1352231013007140

Use of SIFT-MS for vehicle emissions https://www.syft.com/industries/vehicle-emissions/