Lifting the lid on London's air

When scientists flew a research plane over London in 2013, they didn't just establish that a new sensing technique could let us monitor emissions in real time. They also stumbled on the traces of one of the biggest corporate scandals ever. Tom Marshall finds out more.

Many people think of London air pollution as a problem we solved long ago. We've certainly come a long way from the great smogs of the mid-twentieth century – 'pea-soupers' that cut visibility to a few metres and killed thousands. These days there's rarely more to see than a thin haze above the city.

But if the capital's air usually looks clear and isn't the horrifying brew of noxious chemicals it was, it's still nowhere near clean enough. It routinely breaches EU air quality guidelines, causing an estimated 10,000 premature deaths a year – not just through breathing problems like asthma and chronic obstructive pulmonary disease, but also through less obvious consequences like heart disease, cancer and strokes.

One problem group of pollutants is the oxides of nitrogen (NOx) – specifically, nitric oxide (NO) and nitrogen dioxide (NO_2). The first isn't harmful itself, but it quickly reacts in the atmosphere to form NO_2 which damages respiratory health, particularly for those who already have lung problems. NOx comes from many sources, but in big cities vehicle engines account for more than half the total.

NOx levels have puzzled scientists for some time – based on the data we had on what was being emitted, they seemed far too high, often exceeding EU standards by some 50 per cent. Official UK emissions inventories, which estimate how much pollution is entering the atmosphere in a particular area by adding up all the sources we know of – from power stations and factories to cars – persistently suggested NOx should be much lower than the actual readings taken in London and elsewhere.

'It's been clear for years that NOx levels in UK cities and towns are disturbingly high and often breach regulatory limits,' says Professor Nick Hewitt, an atmospheric chemist at Lancaster University. 'We know it's a big problem and that we need to do something, but we didn't understand what was causing it; until recently it was a real puzzle as we thought vehicle emissions were falling.'

Taking to the skies

In 2013, a group of NERC-funded researchers including Hewitt set out to investigate by flying over London in the Dornier aircraft of NERC's Airborne Research and Survey Facility. They took some of the first airborne measurements of the rate at which NOx and other pollutants were being emitted – also known as their fluxes – using an innovative technique called eddy covariance.

Of course, there are plenty of air-quality sensors on street corners and buildings around London. But they usually measure each pollutant's concentration – how much there is in the atmosphere – and not how much is being emitted right now. For that, you need much more sophisticated sensors – and plenty of computer power to make sense of the results. The instruments the scientists installed on the Dornier were among the first that could pull this off, and flying them high over the city let them survey emissions from all over London rather than in just one place. Comparing the results with traffic data gave them even more insight into the sources of pollution.

What they found confirmed the strange discrepancy between what the inventories predict and measurements show. Even using an improved, more accurate version of the London pollution inventory, NOx emission rates were between 30 and 40 per cent higher than they should have been. The team were baffled. 'We kept looking for alternative explanations,' Hewitt explains. 'Maybe hospitals in central London were emitting more NO2 than we thought? Maybe it was coming from diesel trains? But none of them added up.'

When the VW emissions scandal broke last year, it turned out the answer was surprisingly simple – car companies were gaming the system. Pollution inventories work by taking emissions data for each kind of vehicle and multiplying by the estimated number on the road. These emissions numbers come not from vehicles' on-road performance, but from how it does in lab tests. And many manufacturers have been manipulating these. 'As we now know, most diesel cars emit much more NOx on the road than they do in tests,' Hewitt explains.

Rigging the system

VW, the worst offender we know of, created special software so its diesel cars could sense when they were being tested and tweak their

Opposite: An aerial view of London from the NERC Dornier aircraft. Adam Vaughan

Below: The Olympic park. Adam Vaughan

engine settings to slash NOx emissions at the cost of fuel efficiency and carbon emissions. Other carmakers didn't go as far, merely optimising engines to do well in emissions tests rather than entering a special test mode with completely different performance characteristics. But the result was similar.

'We strongly suspected the test cycles weren't that representative of real-world performance, but we had no idea the difference was so huge. NOx emissions were supposedly falling, but concentrations in the atmosphere hadn't dropped in a decade – that told us something was wrong,' says Dr James Lee of the University of York, another atmospheric chemist involved with the research. 'In retrospect we were naïve to trust the inventories. Now we know the tests are misleading, everything becomes much easier to understand.'

The UK government has encouraged people to buy diesel cars with favourable fuel and vehicle excise duty treatment – but these emit more NOx. To meet NOx emissions regulations without hurting fuel efficiency, VW cheated. 'The NOx issue is really an unintended consequence of the move to diesel, intended to cut CO_2 emissions,' says Lee. 'Dealing with this is going to be the next big challenge for regulators.'

What now for NOx?

Technology is improving faster than ever before. Eddy covariance instruments that were at the cutting edge of design when they flew on the plane in 2013 are now available for constant real-time monitoring, and Lee plans to install them at the BT Tower atmospheric measurement station in 2017 – he's already made some flux measurements from the tower, but from next year they'll be routine. The eddy covariance sensor's been improved, and the data-processing software backing it up has been streamlined so it can now be left alone with only occasional checks.

BT Tower measurements don't cover as much of the city as those taken from the plane – just part of central London. But research planes are expensive, and have to be booked months ahead. Instruments on towers can stay for years, giving scientists their first detailed information on how air quality changes from season to season. In the future we won't just know that levels of various pollutants are too high; we'll also be able to see precisely where they're coming from. This is the first step towards creating policies to cut them.

How? In the short term, carmakers are being punished financially for their transgressions. VW's updating its software in a way that should cut NOx emissions, and other manufacturers are likely to roll back some of the moves they've made to optimize their engines in ways that have proved harmful. And from 2017, European regulations will mean vehicles have to pass a test of real-world driving emissions. Yet more radical changes are needed. Lee suggests that trucks and other heavy vehicles could be kept off the streets at certain times of day in cities, and that enthusiasm for diesel cars is likely to wane as governments and people realize their fuel economy comes at the cost of local air quality.

'I think the situation will probably improve as the percentage of diesel vehicles falls, congestion charging starts to target particularly polluting vehicles and development of electric cars accelerates,' he explains. He says flux measurements don't show much improvement yet, but that things should get better, particularly as the fleet of buses moves from diesel to electric engines.

Hewitt believes a major shift in the culture of how we get around is needed. 'There's great reluctance to change people's driving habits, but we really need to reduce numbers of cars and lorries passing through our cities and encourage more people to cycle, walk and use public transport,' he says. 'It's too easy for able-bodied people to drive everywhere in cities. That isn't just bad for their health; the pollution they create means it's bad for us all.'

The team with the NERC Dornier aircraft.
Adam Vaughan

Spatially resolved flux measurements of NOx from London suggest significantly higher emissions than predicted by inventories.
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