Topic 2c - Part 1: (Applications case study) - Street level sensing – the role of ultra-local monitoring

This is Oxford Street in central London. And it's long had a reputation for being one of the dirtiest roads in the city. But Oxford Street today offers grounds for optimism, because things have got better here. The bus that just went past me is far cleaner than the ones that used to come down here. And policies have been put in place that are having an effect. And the air monitoring that's happening shows that all those policies are making a difference to the air that I'm breathing right now.

Tell me, first of all, where we are. What are we standing on top of?

So we're standing on top of the Marylebone Road Supersite, which is right next to the busy Marylebone Road, right in the middle of central London.

So that's what's causing all this noise right behind us here.

Yep.

And what all-- what is all this going on around us?

Well we've got 80,000 to 90,000 vehicles a day going up and down this road. So we're trying to measure the concentrations close to one of the busiest roads, right in the middle of London.

So all of these are taking in air. What are you measuring in that air?

So we're measuring both particles and gases. So we're sucking in lots and lots of air that's being either collected and taken away for analysis later, or it's analyzed in real time down inside the cabin.

So these are really detailed measurements.

Oh, yeah.

What sort of things are you finding out here?

OK. So we can track the concentration of the different chemical components of particulate matter, the really small stuff that goes deep inside your lung. And seeing how what goes past on the road and what comes in from outside, how that chemical composition changes over time with wind direction, back trajectory, et cetera.

And the nice thing about this is that it's really local, right? This is not a big view of the city. So

this is a tiny little detail. But what do you see? What changes the particulates and the gases in the air here? What's going on around us?

Well, if you think about particles to start with, the particles we find here don't only come from this location. They also come from a long distance away. So particles are either directly emitted, primarily from the back of vehicles, or they come from their tires or their brakes, but they're also formed in the atmosphere from chemical reactions of the gases that are released, again from vehicles, or from industry a long way away.

It's just past rush hour. So I imagine you must-- do you see a peak for rush hour traffic?

There is. The concentrations change over time during the day. So obviously if there's not a lot being emitted at night, the concentrations are low. And then in the early morning, as the vehicles start to emit, it builds up. And it's worse in the early morning, because the sun hasn't had a chance to heat the ground and heat the atmosphere to increase that volume.

How about the weather and the buildings around us?

Well, it varies a lot on wind direction. We've got a big junction just down the road here, at Baker Street, where you got four busy, busy roads coming into one another. And that's the real local polluter. So when wind blows up this canyon, we see high concentrations. Or when wind blows across the canyon, and the wind hits the building on the other side, and it recirculates air, and blows it back across the canyon to us.

I like that you describe it as a canyon. Because it is-- I mean, it is a-- it's an artificial canyon.

Yeah.

But it's funneling wind and pollutants down this channel.

Yeah. Exactly. So where you have a big emitter, down the canyon, then you get more-- and the wind blows up it, we get high concentrations here.

And this has been here now for 20 years, something like that?

Yeah, over 20 years now.

And what changes have you seen during that time?

The concentrations generally have gone-- for particle pollution-- have gone down. As we have diesel particle filters, that's reduced the direct emission of particles from vehicles. The gases has changed a little bit, because some unintended consequences of this abatement technology has meant NO2 has actually gone up at some times over history.

With the three-way catalyst, you're recycling gas through the exhaust to burn off those particles. The unintended consequence is that, directly, nitrogen dioxide is released from the exhaust. And that causes a higher concentration close to the roadside.

So there's this weird thing where a technology came along which was designed to fix one set of pollutants, and actually something else rose that no one was expecting.

Yes. Completely, well, unintended. And that's why it's really, really important to continue measuring the atmosphere. Because there are things that happen when they design a catalyst, or they design some kind of abatement technology, you don't know exactly how it's going to influence everything else.

This is a special site in London, right? But there must be lots of monitoring going on around London. Tell me about that.

Yeah. We haven't got all sites as big as this. Some are really kind of small, and, like, the size of a telephone box. Others are a small kind of portacabin. And this is the largest by far in the middle of London. There are around 80 or 90 of various sizes.

How are they positioned? Are they in high pollution spots, or are they just randomly sprinkled around? How do you decide where they go?

Well, local authorities really decide where they go. So most of them are in locations of high pollution, because they're trying to understand where the worst concentrations are. But we do have them in background locations, like school playgrounds, trying to understand what kids are exposed to, or what you'd be exposed to in your back garden. Something like that.

A child is probably-- they're breathing in air from down here. You and I are quite tall, so we're breathing in air from higher up.

Yeah.

And obviously we can walk closer to roads or further away. How does all that kind of thing affect what we're breathing in?

Well, concentrations reduce almost exponentially away from the exhaust. And that goes in both distance away from the curb and height above the curb. Close to the road is very turbulent. As vehicles whoosh past, you know, you're getting a lot of mixing. But generally, the further you are away from the curb, or the higher up you are, the lower the concentration.

All these monitoring sites are here for regulatory purpose. You know, we have to monitor the air. We have to report it to Europe. And we are assessed on concentration limit values and

target values. That drives policy. And that drives public perception, which, in turn you can pressure politicians to do stuff about reducing air pollution.

Tell me about the low-emission buses, and the difference that they've made.

Well, air pollution is a very emotive subject. And so politicians really latch on to it as something they can do something about. Buses were seen as key emitters. They are large vehicles. They have these three-way catalysts to drive down the concentrations of particle pollution, but they ended up releasing quite a lot of nitrogen dioxide. So they brought in lower emission buses.

We've got new buses with SCR. This is a catalytic converter that changes the NO2. So it reduces the NO2 concentration by mixing it with urea, so that we don't get direct NO2 out of the buses. They were phased in over a period of time, and some of them aren't directly owned by TfL. So there is a target date for the installation. But many bus companies are slightly ahead of that date to install them. So understanding exactly when they came in is proving a little more difficult than we first envisioned.

But have you seen a difference from having them?

Oh, yeah. Concentrations going down. The concentrations at Putney High Street have dropped dramatically. The concentrations here are dropping dramatically as well.

And, you know, every year we hear sometime in January that London has already exceeded its pollution targets-- limits for the year. How do you see that changing in the future? And how bad is it?

Well, it's a fairly arbitrary target, the number of ours exceeding the EU limit value. The GLA are targeting areas which are their first exceeders. So Putney High Street, or Lambeth, or here, or Oxford Street. These are all seeing these low pollution buses. So we're going to see that date creep back through January into February, which is a good thing. And it also reflects of why the dropping concentrations as well.

This kind of monitoring, how important is that for policy makers to decide what they're going to do? How is this helping to support reducing air pollution in London.

You need the scientific evidence base to understand the impact of your policies. If you don't have that, then you don't know whether things are working.

It's great to have individual monitoring stations that give you lots of detail about one place. But really, if you're interested in policy for a city, you need some understanding of the whole area. So how does all of that work?

Well, you need to understand the whole area. And you also need to understand what will happen when you vary emissions. So underneath it all, we have an emissions inventory that describes all the emissions from the vehicles as they're coming up and down every single road in London. And we have that at a 20 meter resolution. So each 20 meters of road, we know how fast the cars are going, what cars and trucks and buses are going up and down those roads as well.

And then where does that information all go?

That all goes into a model which processes the emissions as they would be processed in the atmosphere. And then you can vary the emissions to understand what would happen with a policy intervention, or through a different time of day, or a different time of year.

So you've basically got a computer simulation of the city that's just calculating the pollution that you think is coming and going. And then you can compare that to the measurements.

Yeah. So you can compare what the model produces to what the measurements are outputting, to make sure your model has got it right.

Another thing about a model is that you can tweak things, right?

Exactly. So when the GLA defined the low-emission zone, or the congestion charging scope, it was the modeling done within our organization that really told them what policies they need to implement to get the desired results.

Was your modeling borne out in reality? Because you did the modeling before they introduced some of those policies. Did it work?

It's very, very difficult to tell, because a, the policies are still in process. The changes are very small, and they're over a long period of time. And even with all the expensive and detailed measurement equipment we have here, it's difficult to pick up very small changes.

And it's those very small changes that-- they're making a big difference. You know, because people are shifting to electric vehicles, for example. But it's very hard to do a controlled study of that.

It is. Because you have variation in the weather, variation from day to day, and vehicles from day to day that come down these roads. It's really difficult to pick out those small changes within a complex, changing environment. We've had the London low emission zone, which progressively banned heavy goods vehicles from coming into London unless they met certain emissions standards. And we've got things like the T-Charge and the ULEZ. And we're on the very boundary of the ULEZ here. And what we're trying to do--

So that's the Ultra Low Emission Zone.

That's right. The Ultra Low Emission Zone, which is trying to target the most heavily polluting vehicles and incentivize their removal from London. Lots of modern vehicles don't release a great deal of pollution at all. So the most polluting vehicles, really, they should be targeted for removal.

So, but overall, how optimistic are you about air pollution in London? I mean, you work here. Presumably you care about what you're-- we're breathing right now. How do you feel about it?

I'm optimistic. I think if we keep going, and the political will is there to keep reducing emissions, then, yeah, we can make a real difference to people's health.