Topic 2b - Part 2: Mobile in situ measurements

Normally, when we think about an instrument, we think about something that's fixed, and it's in one place, and that's where it measures. But you've got a system here that does something a bit different. Tell me about that.

Yeah, so, here, we have a unique combination of instruments, so covering both in situ and remote sensing observations. And the unique thing is that we can do it while driving with this nice car.

So there's a van behind us.

Yeah, that's a big van behind us. And of course, with that, we are able to get an idea on horizontal gradients, both on the bottom and also high up in the atmosphere.

So where on the van do you measure?

So we have an intake tube on the roof. And we have also a MAXDOAS telescope, also, on the roof.

Right.

So maybe we should--

So the roof is the critical place.

Yeah. The roof is a critical place, yeah, where we suck in the air. And also, we get the spectra to analyze for different atmospheric trace gases for species, most of them are relevant for photochemistry, ozone chemistry in the atmosphere. Yeah, so that's the reason. Yeah, so that's something-- we put everything on top of our truck.

Can we go and have a look?

Yeah, sure.

It does sway, doesn't it?

Yeah.

So, here we are on the top. And what's the important bits here?

Yeah, the most important bits, I think, is this tube. With this tube, we are sucking in air. And this air is splitted up into different directions and sucked into different instruments, analyzing, for instance, for nitrogen oxides, for SO2, for ozone, and a lot of stuff more.

So it's being sucked in the sides here and then up and down--

Exactly.

--into the middle of the van.

Exactly.

And then, so that's gases, that you're sampling directly. And what else have we got here?

We also analyzing for black carbon, so for soot. Yeah, moving to this instrument, that's a telescope of our so-called MAXDOAS instrument. MAXDOAS is standing for Multi Axis Differential Optical Absorption Spectroscopy. And we are just measuring spectra, stray light spectra in the UV and the visible. And we analyze them for different trace gases.

So this is given you gases a bit-- that thing is gases here.

That's really gases down to the bottom. And that's something a bit more higher, to the atmosphere.

So it's looking up.

Of course, we also get a signal from the bottom but not very close to the whole instrument, because that depends, of course, on viewing conditions. Like now, like today, we have a range of up to 15 kilometers, where we can get the information--

So it can look a long way away.

--on the different trace gases.

Yeah. And then the last bit, I recognize that. That's something for measuring wind speeds, right?

Exactly. So in terms of interpretation of the different data sets, both in situ and also all the MAXDOAS data, we need, of course, some met observations.

So that's weather observations?

Weather observations. And here, we have some standard instrumentation, in the anemometer for doing measurements of the wind speed and wind direction. And we have temperature, pressure, and everything on everything.

So all of these things, while the van can be driving, and these can all be measuring as you're moving.

Not all the different things, of course, for the wind speed, it does not make sense while driving. So we are not able to put it up when we are driving. But everything else, in situ observations and also MAXDOAS observations, we are doing, also, while driving, which is really a big benefit.

Yeah, as I told you, these horizontal gradients are also quite important in terms of when we are thinking about satellite validations. And new satellites have a better resolution, so we can really detect, also, some areas where there is a lot of pollution going on. And that's quite important to have an idea if this is really true, if this is also supported by measurements on the surface.

So a wind speed measurement isn't much good down there. So this doesn't stay there when it's operating.

Exactly. So there's a standard of height for doing met observations. That's 10 meters. So that's the reason that we are putting it up.

OK.

So let's see if it works. It's very slow, sometimes. But with this antenna, we are getting information on shipping.

So it's actually detecting-- so the instruments on the ships that tell them where they are?

All the ships are forced to send out a so-called AIS signal, Automatic Identification System. So we get information on the name of the ship, on the length, how powerful the ship is, and where is it heading for, if it's heading to Singapore or whatever.

And then you can measure how much pollution it's generating.

Exactly. So with wind information and with our measurements of, for instance, nitrogen oxides and SO2, we're able to really identify which ship is responsible for which peak.

So this is the weather station going up to 10 meters.

Yeah, because that's the standard position for weather observations, for met observations.

So we've got wind here.

We have wind direction and wind speed here. Then we have temperature and pressure inside there. Humidity, of course, on top. So that's what we have on this mast. In addition, we have also some information on the radiation, on the total radiation going on with this one.

And then all of these-- so the cables and the intake, they're all feeding back down into the van. So that's where the real analysis happens.

Exactly, yeah. So we are collecting all the data, with several computers, and analyze them, some of them in real-time, inside the truck, and some of them we have to analyze later in our office.

We've looked at what there is up here. So should we go down and see where the data goes?

I think that's a good idea.

OK. All right.

We've got an example, here, of the sort of data that all of that's measuring. Tell me what we're looking at.

Yeah, on the screen, I put a typical example when we're talking about shipping emissions. So that's a short time-series, for one day, eight hours of one day, for the measurement site, in Bremerhaven, close to the harbor.

4 o'clock in the afternoon here, and midnight is up there.

To midnight, so eight hours. And what you can see here are different types of peaks for nitrogen oxides and also for SO2 in green, so nitrogen oxide in red and SO2 in green.

So nitrogen oxide here is kind of low. And then there's these little-- so what's causing this?

Then we have really steep peaks to really reasonable high values. And that's something we get when a ship is passing.

So one ship does that?

Every peak is related to one ship.

And what's this line along the top here?

That's ozone. And that's something which is also typical then. Whenever you have high peaks of NO, then ozone is going down. Because you have the reaction of ozone with NO to NO2 plus oxygen, so that means, with every peak, you would expect also a decrease in ozone.

So that's interesting. A ship doesn't just put stuff into the atmosphere, but that chemistry means that other things go down. It's very quick, isn't it? Because that's what?

Yeah, that's a quite quick reaction.

Five or 10 minutes.

Of course, that does not mean that, in general, the ozone would not go up again. So that's really a very fast reaction, which is going on. And for the whole story of ozone chemistry, of course, you need much more information and also much more time. So it might happen that you have, later on, something like high ozone, which is also related to human health.

For other reasons. And how far away were you from the ships here? I mean, was this 100 meters?

That's a couple of hundred meters in this case. So we are quite close to the shipping lane. But we have also done some measurements much more far away from the shipping lanes, so something like five to six kilometers.

The thing that strikes me is that there's all these very small patterns. Like a single ship, one road, all of these are changing local patterns, very strongly. And this van let's you measure those. But then the satellites can see the big picture.

Exactly. So for the satellite, of course, we are also able to see the shipping lanes but only if they are far away from other sources. And of course, that's not the case in our area. So in northern Germany, we have a lot of different sources of emissions, industry, ground traffic. So, it is really difficult to discriminate the different sources. And of course, with this measurement, that's just one possibility to get a better overall picture and a better idea on really the strength of the different sources.

And it's so clear, isn't it? It's brilliant.

In this case, it's really clear. Of course, that's not always the case. When wind direction is not very favourite, then it takes a bit more work to find out the impact of, for instance, shipping emissions. But it's possible.