EUMETSAT

Topic 2d – Part 1: Air quality, NO2, CO & the ozone layer

A phrase we hear talked about a lot not now is air quality. Tell me what air quality is.

So air quality is change in the air that we breathe, which is being altered by emissions of pollutants from traffic or from industrial processes.

So let's start with some of those. So the ones that we tend to care about most are the ones that impact human health. So what are the sorts of measures of air quality that affect health that you can measure from a satellite?

So the species which mostly affects human health in terms of air quality are the particular matters. So these are PM 10, which are particles of a diameter less than 10 microns. Or PM 2.5. And those are dangerous, because they can get into the lungs and cause, they cause respiratory illness and they're associated with high mortality.

There's also gaseous species, such as nitrogen dioxide and ozone, which is a secondary pollutant coming from those emissions, which have real human health impacts.

And what we've got here, you've got this map which is global emissions of nitrogen dioxide, which has a lot of detail on it. Tell me a little bit about what we're looking at.

So this is a global map of the, actually the surface concentration of NO2 from our forecast system. And where we see the red colors is where there's very high values. And those are correlated in a lot of cases with pollution sources, such as cities and urban areas. And what it shows us is that there's really a wide distribution of those sources and not just over the land surface, but the lines that cross the ocean are actually coming from shipping routes. And these are NO2 emissions that are coming from ships.

So NO2, nitrogen dioxide, is something that comes as fuel is burned.

Yeah.

And that's what we're seeing here. We're seeing the sources of that pollution. But this is just the sources. What happens to it after this?

So after NO2 has been emitted, it goes through various chemical transformations. Has quite a short photochemical lifetime at the surface, where it's turned into ozone potentially, and other pollutants, which then once they get into the, out of the boundary layer and into the free troposphere, have much longer photochemical lifetime.

And what that means is, they can then be transported by the winds over much greater distances away from the source region. So they can affect air quality and human health, not

imperative space

just in the local place where they're emitted, but potentially much further downwind. And indeed, we see this between different countries, but also at the intercontinental scale as well.

And you've got this data, you can build these maps here at CAMS, but the thing you're doing is trying to make this available. And tell me, there's this phrase that gets bandied around, which is a data product. Tell me what one of those is.

So what we mean in CAMS by a data product is, an output from our analysis or forecast system in which we run our chemical modeling. But we also take in all that information from satellites to produce something value added, if you like. And then that's the product that we make available to anybody that wants to use it.

So if I was a member of the public who is concerned about asthma, for example, or had a particular health issue or something where I wanted to know about nitrogen dioxide, you're building these datasets, which allow someone like me to go and look.

Exactly, exactly, precisely. So we produce graphs like this and maps like this, which are available constantly on our website. And they're updated in near real time as new forecast data becomes available. But one of the other things of the Copernicus program as a whole is to provide downstream services using those products to then focus in on specific needs and specific applications for those.

One of the things that we do at ECMWF in terms of CAMS, is we're running just the global model at a reasonably coarse resolution of about 40 kilometers. That information can be used then for regional air quality at the continental scale. But it could also be what they call downscaled to much finer spatial resolution to the city scale and this is already being done in fact, for some cities around Europe.

And this is why it's so useful for you to be in the same building as the people doing weather forecast. Because obviously, if we've got a source here in North America, once this nitrogen dioxide has been produced, it's carried, and it's carried by the wind. And it's the weather forecast that tells you where the wind is going to go.

Precisely. And the weather forecasting also incorporates in the same that we incorporate satellite measurements of atmospheric composition, the weather forecast is incorporating observations from satellites of those weather parameters as well. And all of that information is also included in the CAMS system.

Images like this are beautiful and they look very detailed, but there's this question, which is, how do you know yes, there are satellites, but they're a long way away. How do you check that this is right?

Well, the satellite, what the satellites are measuring goes through a process of validation. And that includes using measurements which are made either at the ground surface or from aircrafts. And those are usually quite specific for a location and a particular time. There are also ground-based monitoring networks.

And as the satellites are also validated, we also go through a validation process with our products and with NO2. And they incorporate as much independent data as they can to then really evaluate how far we are away from that ground truth, if you like.

And this term gets used a lot, especially with satellite data. Validation. And it sounds very impressive. But it's really important, isn't it? Because without validation, you don't know that you're interpreting things correctly. So just explain to me what validation is.

Yeah. So you said, this is a critical part of what we do. And really shows that there is a benefit and there is a need for doing it in the way that we do it. So validation, this essentially means that we compare what we create against an independent dataset of the same parameter to evaluate whether we're estimating the amounts in the same way, and if we're capturing the trend and the variability as the atmosphere changes over time.

So for example, in this map here, you can see that you might have some data from a satellite that perhaps says there's a very strong source of nitrogen dioxide here. And you can actually go to that place with a monitor on the ground or use data from one that is actually physically in that environment and say, does the number from my data match the actual number measured on the ground? And that's the heart of it.

Precisely, that's exactly what we do in terms of validation. We do it over a period of time. So say the last three months are validated, and that is reported on so that that information is available for the users of the products.

And that allows your users to trust your data.

Exactly.

And let's, so we were talking about health impacts. So NOx gases, nitrogen dioxide is just one of the gases that you can detect in the atmosphere. How about things that have potentially had a higher profile recently? What other species can you measure?

We measure a wide variety of species. And the species that we make the most use of in CAMS, the NO2, as we're showing here. But also carbon monoxide. So carbon monoxide is a tracer of incomplete combustion. So it comes from traffic. It comes from industrial processes. And it also comes from forest fires. And it also has a very long photochemical lifetime, which is about 30 to 40 days. And what that means is, that we can really use that as a means of seeing where this pollution goes all around the world from different source regions.

And this plot is of 2003, which seems like a long time ago. So you're still using and looking at data from 15 years ago.

Yeah. So we have this process called a reanalysis, which is also one of the products of CAMS. And what a reanalysis means, is that we go back in time to rerun say 2003 in this case. But we use the very modern version of the model, which has all the physical understanding that has been improved in the intervening period.

What other gases are there beyond carbon monoxide?

So beyond carbon monoxide, we also look at ozone in the troposphere where it's a pollutant. We also look at formaldehyde and sulfur dioxide. And then greenhouse gases and aerosols, as well.

And of course, ozone is very well known, because of the ozone hole, especially over Antarctica and how it's changed over the years. So you can watch that change happen.

Yeah. So what we're seeing here is if we take the total column ozone, because most of the ozone in the atmosphere is in the stratosphere, and this is the ozone layer, which is very famously known in the media and to the lay audience you would think. And what we're seeing here is from 2002 till 2017, the development and evolution of the Antarctic ozone hole as it occurs through September and October each year.

So we're looking up at the South Pole of the planet here. Antarctica is here. And the colors are telling us how much ozone is present.

Precisely, yes. So the red and orange values are what you would expect as typical values of ozone. What happens is, when the polar vortex starts over the South Pole, is that you get when the sun rises and releases chlorine, and that leads to this very dramatic loss of ozone. And the blue colours are then when that ozone is really greatly reduced.

And so data products like this allow you to sort of watch that process changing in time, and include all of the physical understanding. And this, I imagine, is good for a citizen to know, but mostly this is useful for policymakers, right?

Yeah, for policy. So the Montreal Protocol was signed in 1987 to curb ozone depletion related to CFCs in particular. What we're seeing here is that it's a very long process of the ozone layer recovering. But we have a means here of then showing really that that policy and those mitigation efforts are actually having an effect.