Topic 2a - Air quality and types of atmospheric pollution

[MUSIC PLAYING] Welcome to week two, when we're going to be covering pollution, air quality, and health. We'll be looking at various man-made additions to our atmosphere. So that's both gases and tiny particulates called aerosols, and the effects that they have for air quality and for our health. I'll be looking at how you can both monitor and predict their presence using data both from satellites and from in situ observations.

Looking at what is the air composition is for sure an important tool in order to try to understand how the health of our citizens is affected. And it can also help us to understand what other kinds of emissions that we have in urban areas, and to see if there are ways, possibly, to limit these emissions. This is what we can do today.

But I think what can be done in the future, climate change is for sure a challenge for us. In our first priorities, for example, observation of CO2. We don't have real capacity today to observe anthropogenic emission of CO2, but this would be extremely helpful in order to try to understand which are the sources of CO2 emissions. Are we respecting COP 21 requests? So we are also looking to evolve in all these areas.

This is just demonstrating the type of things we can do. So we can see, for example, oxides of nitrogen coming from Europe, or from the US, or from China. We see clouds of these gases, OK, which are coming out. We fly by, measure it, and then we see how it changes on a day to day basis. Something like Envisat was like a pioneer in its day, so it's a research instrument providing pre-operational service of this type. Now we need to move to a global observing system where we have adequate fit for purpose measurements all the time.

But we can't measure individual hydrocarbons other than methane, which is very important. It's a greenhouse gas. But we do measure what are called oxygenated volatile organic compounds, hydrocarbons, and these are formaldehyde and glyoxal, actually, is the name of it, but these are part of this air quality, air pollution soup. OK, so the sun shines down, we have a mixture of oxides and nitrogen and volatile organic compounds, and that results in ozone and aerosols being formed, these short lived climate pollutants, and other toxic and nasty substances along the way, OK?

That's the mixture, that's the soup, and so you get this soup now being generated all over the world. We see here also, we can see biomass burning emissions of oxides of nitrogen, carbon monoxide, CO2 we see in Amazonia or in Africa. Here is the Highveld that's the large industrial zone close to Johannesburg and Pretoria which produces a lot of coal and minerals and a lot of metals, heavy metals, but there's a large amount of energy produced. And we can see that very nicely, and that flows across South Africa into we see Africa is actually the continent of fire. So you see lots of things like that. Over in India, you see here the emissions from the megacities and the urban agglomerations. We're talking about same in China.

CAMS itself covers the whole globe, but you're looking just at one region.

Yes, we are looking at Europe. And actually, we are managing the system within areas, and it works also with different institutes in Europe, which provide their model outputs to us. We combine them to provide the best possible forecast and analysis of air quality in Europe.

So you have a big team that's creating data for people to look at, and then you've got a web page as well, where people can go and look at the data.

Yes, there is a web page and also access to data, archived data, and also near real time data, so that we can use forecasts on a daily basis and also re-analyze the past conditions of air quality in Europe.

And we've got the website here. Show me what's on here.

Of course. We can have a look first at, for instance, nitrogen dioxide concentrations in Europe at surface. So here we have a single chart, which is the median concentrations, the best possible estimate of concentrations in Europe. If we have a look, for instance, at urban area that we know that is frequently polluted, we can have concentrations of ozone nitrogen dioxide, sulfur dioxide, PM10 aerosols, as a function of the hour four days ahead.

So that provides useful information for the general public, also for the authorities to take decisions in case of air pollution events. What we model here, when we analyze is the background pollution. We don't analyze what occurs near a road, near an industry. It's really the regional scale pollution.

Where does the data come from that goes in to make this happen?

Actually in area regional models, we have anthropogenic emission inventories, which provide the emissions of the pollutants, and then the models transport and model the chemical transformations of these primary pollutants. So actually the result here is the result of the modeling of transport and all these chemical transformations. For other pollutants, which are not emitted, such as ozone, the modeling is the result of all the chemical transformations that lead to ozone. We also combine in the system with model outputs observations, in situ observations, and also we are preparing for the use of future satellite observations, such as the ones from the Sentinels.

Let's talk about NOx gases, then. Where specifically do they come from and how can you monitor and learn about them using satellite data? So NOx gases come exactly out of these combustion processes, and especially out of combustion processes at very high temperatures. And NOx is basically quite reactive with the environment, especially with the hydrocarbons. If you have a lot of them around, then they combine and they form acids, nitric acids, for

example, which then stick on all these little particles around, and they get this brownish little color that we then in the end call smog.

So these NO2 molecules have a very specific signature as they also absorb light in the atmosphere, and these signatures we're detecting with our instruments, and we can detect them so accurately that you really see how much of the NO2 or the NO is actually emitted at a certain point, and over a certain amount of time.

So you can identify that perhaps there's a factory here which is producing this pollution, or maybe there's a busy motorway, there's lots of cars, so you can actually see where it's coming from very specifically, as well as then following it through the atmosphere?

Yes. Or let's say we are working towards that. What we currently very well can observe is larger regions, because you usually have larger industrial regions, let's say like here in Germany, the Ruhrgebiet, but also a lot of the Benelux countries, or you will see very well the south of England emitting a lot of NO2. So you see large regions which are very industrialized, have a lot of combustants very much sticking out, and that is very interesting in itself, because you can see the overall emission coming out of specific combustion processes out of specific regions.

We can go down to more smaller levels. Currently we're working at levels between 1,040 to down to seven kilometers, with the newest generation of satellites, and we will even go down further with them, with newer satellites, so that we can actually identify individual sources, like even streets or individuals small cities. Large cities we can already see quite well.

What sort of instruments do you need to be able to monitor NO2, for example? What does it do, and what does it looks like?

So basically, as I said, these molecules leave specific signatures in the reflected light from the Earth. They then take out a certain type of light, and these fingerprints we can look at with spectrometers like we have, for example, on Metop, like the GOME ozone monetary experiments, for example.

So this here, this isn't the Metop satellite, second generation?

No, this is the first generation Metop. So we have three copies built of those satellites, of these big beasts with a lot of instruments on them. The first one has been launched in 2006 already, and the second one already in 2012.

And then we will have three copies of them with a lot of instruments, measuring various energy regions of light scattered back from the atmosphere or transmitted from the earth, and in this light we can detect all the little signatures from very, very high energy regions like the UV region, where this instrument, the GOME-2, is particularly good in, to the thermal

infrared, so red part of the spectrum where we measure more like temperatures with the IASI instrument, and all these instruments capture these signatures of the molecules, and we can trace therefore where they're coming from. And because we have the satellites up there for a very long time, we can also monitor how these emissions evolve over time.

[MUSIC PLAYING]