EUMETSAT

Topic 4b - Part 1: Monitoring aerosols with satellite data products & in situ LiDAR

You have a complicated sounding title, which is that you're project manager of AC SAF. Tell me what a SAF is and what your version of it does.

SAF is satellite application facility. And in fact, we are part of EUMETSAT application ground segment. This is our mandate. We are processing the satellite products and disseminating on behalf of EUMETSAT.

So there's lots of SAFs, and each of them has a different area. So what's the area of your focus?

We are focusing on atmospheric chemistry products and also UV and aerosol products. So, in fact, as our name says, it's composition of atmosphere.

And what are the things in the atmosphere that you care about? Because obviously, most of the atmosphere is oxygen and nitrogen, a little bit of argon. But then, there's all these other things. Tell me a bit about the other things.

Yeah, there's a lot of other things also, all kind of gases, trace gases. Like, for example, formaldehyde, glyoxal, nitrogen dioxide, and OClO, But on top of those trace gases, there's aerosols. Aerosols come mainly from desert areas and volcanoes. We can observe those. But also one important source is forest fires, like last year in the California area and also in last October in Portugal.

So the AC SAF based here in Finland is looking at the data on these different gases and then processing it into a form that's useful for the people. Is that it?

Yes, in fact, yes. But we are not only based in Finland, we have eight different countries here and 12 institutes involved into this project. So this is quite a large project. And yes, we are developing the algorithms, which are used in the processing of the products. And then we are taking care also the dissemination of the products and then user services.

And what sort of products are these? So a product to someone who's never come across a satellite is something they buy at the supermarket, right? What are your products, and how could people use them?

So far, we have had to only level two, so-called level two products. We saw, in fact, like what is the ozone value in different points in global spatial resolution. But in future, we will also deliver, let's say, global net maps of ozone in all of our products. It's much easier to use for our users. You can take one global map and see ozone content or nitrogen dioxide content in it.

imperative space

And we've got some examples here. Tell me what we've got on the screen here.

In upper left, we have BrO values, and BrO is produced early springtime over sea, snow surfaces. It needs special condition, like usually quite cold temperatures and high winds. This is very nice example, that these episodes can happen from beginning of February until late springtime, like April.

So this is a bromine compound, which is emitted upwards. So what's causing all of this stuff we can see?

In fact, these sort of take meterological conditions that we know. But first of all here is sea ice and then quite strong winds and solar light. And what is important is also those sea salt aerosols. Because those are the primary components for BrO.

And so that's the sort of thing that would go into a weather model, perhaps. Who else might use that data?

This is mainly for scientists, I suppose. I suppose that because these are only very low levels, near ground levels. They cannot be used as such in, let's say, weather models, for example. So, this product is one example of it's scientists are interested and can be used in their studies about atmospheric chemistry processes and so on.

So there is a difference here, because we talk about all these gases and particles going into the atmosphere, as though they behaved in the same way. But they last for different amounts of time, don't they? Tell me about which gases last for a very long time and which last a very short time.

Well, this BrO is one example of very short-lived species. But then we all know the CFCs, which affect the ozone loss. And they can last several decades in atmosphere. These are the two extremes.

And then everything else falls somewhere in between.

Yeah, somewhere between.

And what else have we got here then?

Upper right, we have aerosols coming from Sahara Desert to southern Europe. And this happened also 2018. And this is also one good example that things which happened quite far away from our countries, we can feel and see the results when there is a long range transportation.

So even though this is dust off the Sahara-- so it's produced thousands of miles away-- it comes to visit you. How might that matter to a citizen in Helsinki, perhaps?

For example, in this case, in Greece there was reduced visibility. So the visibility of order of some kilometers or even less, in this case, and in some cases, even airports have to be closed down because of these effects.

And if you remember the last October, when was this red sun episode in Europe, it started in London. And a day after that, it was in Baltic countries and Finland. And that didn't affect so much to economy or flights. But it was interesting, and general public had a lot of interest. We were getting phone calls. What's going on? Fortunately, we had this data, so we could show where the sources were and how the aerosols were transported to our areas.

And I guess, normally, when you're talking about things in the air, we think of pollutants. And we think of it being a bad thing. So if people saw a red sky, they might think this is dangerous. But actually, because you can see where it comes from, you can say it's fine. It's just dust.

Yeah, more or less like this.

And how about the other two things here?

Yeah, in lower row, we have California area. In left, we have normal, more or less like normal situation. We have NO2, nitrogen dioxide coming from transportation, traffic.

So this is-- we can see LA.

This is traffic. LA is here.

Lots of traffic.

Yeah. And on right, we have a situation when there was also forest fires going on. So we can see it increased in O2 levels there. So now we have two sources. We have forest fires and normal traffic.

So lots of data about the atmosphere comes from satellites, from being at the top looking down. But you work on something which goes the other way, from the bottom looking up. Tell me about that.

Yes. It's also interesting to have information coming from the ground up to the atmosphere. When there are clouds, we see under the clouds, but the satellites see above the clouds. And we also can see more precisely the layer close to the ground, which are the atmospheric boundary layers and the things like that.

What's your method for looking up into the sky?

The method we use is the LiDAR, which is a kind of radar, but working with light. It works with the laser beam to emitting light and measuring the tiny fraction of light reflected by aerosols, which are ash, dust, all kinds of tiny particles. And, of course, also, clouds, which reflect light back to our instruments.

So it's almost like shining a laser torch--

Exactly.

Upwards. Météo-France has a network of these. Tell me about the network.

Well, we have a network of six instruments. Five of them are fixed all around France. And one can be moved to the most suitable place, in case of volcanic eruptions or any kind of event.

So you've got different places in France, and you're looking at what's in that, collecting data all the time.

Yes, seven days a week, 24 hours of the day.

Right. So let's have a look at how they actually work then.

It's very simple. In fact, I can show you with simple things. So, we have to switch off the light. And then if I have a laser beam, you see it on the wall, but you don't see it--

So I can see it there. That's definitely switched on.

Yes, you'll see it on your hand. And if there is something in the light dust, like droplets, you can really see the beam.

The little particles here are getting in the way.

Yes, and they scatter all the light in all direction. And they also scatter the light back into the direction of the origin of the laser. And that's what we measure with LiDAR. The more droplets or ash there is in the atmosphere, the more back scattered light we get.

So let's turn the lights back on a second. All right, now we can see. So that's the demonstration, the simple demonstration.

It was, simple principle, yes.

But this is the real thing. So tell me about this.

Well, here, you have exactly the same thing. This is the laser, so it's larger than my pointer. And this is the telescope, which measures the back scattered light. And there are the controls on all kinds of instruments to measure the light behind it.

So this could point in any direction. At the moment, it's pointing sideways, and not up.

Yes, this is not exactly the LiDAR we use in our operational network. This is the research LiDAR, which can scan in all directions. The one we used in the operational network is static and points upward, giving us a profile from the ground up to 20 kilometers.

So we've got a laser beam here that's shining out. And there's some little particles over here. Some of the light, just a tiny bit, goes back down the telescope.

Exactly.

And that's your sensor. And how far away can that detect a particle, or a cloud?

Well, these instruments can measure very high in the sky. For example, last August, we detected smoke coming from the Canadian fires that crossed the Atlantic and over Europe, there were, at between 17 and 20 kilometers. And we could detect the smoke.

And there's lots of different things that could scatter. There's clouds, and there's aerosols. What sorts of things can you see?

Well, at first, our light, our network was designed to measure ash from volcanoes. It's just to protect the aircraft, both to measure precisely where the ash plume is and also to measure the clear zone to allow an aircraft to fly in the clear zone. And then we can also measure this dust. It does come in from Sahara, when there is a sandstorm in Sahara and southerly winds that bring us the dust. That's important for our radiation budget and climate matters.

And we can also measure very close to the ground, the dust that we see in everyday life. And this corresponds to what meteorologists call the atmosphere boundary layers, which get thicker in the day, thinner in the night. And it's very important for our air quality matters. Because this is the air we breathe, and this is the layer into which the pollutants are emitted. So, it's very important to measure all this.

And it amazes me. The thing that amazes me about these instruments is how sensitive they are. Because we look with our eyes up to the atmosphere, and maybe there's a little bit of haze. And maybe there's a cloud. But we look straight through it. And yet, with enough tiny particles and a strong enough laser, you can see all the way up.

The magic of modern technology. Well, at first that's a telescope, so that amplifies light. And then there are very sensitive detectors. And some even can count to one photon alone. And so this allows us to have a very sensitive detection.

So these are very useful tools. And this data gets added to all the other data that we see. So we need to see the atmosphere in lots of different ways.

And in the future, there will be also LiDAR from space. There are, already, the French-US satellite, CALIPSO, the European project, ADM-Aeolus, the Earth Sphere project. And so, that's still a technical challenge to send the LiDAR in space, but there will be more and more in the future.

And where else could you put a LiDAR? Could you put one on a balloon or an aircraft?

It has already been done. But for regular, systematic monitoring, it's easier to have them either on the ground or on a satellite.

If it's a very dark night, I can imagine shining a laser up into the sky and seeing something. But during the day, there's all this other light around. So how does the instrument manage that?

Well, of course, the difference between the night and the day. At night, we can see things up to 20 kilometers. During daylight, it's only about 12 or 15 kilometers. But these instruments are sensitive enough to provide us information, even during daylight.

And what color are they using? What sort of light?

The one we use in the personal network use our green LiDARs, in 532 nanometers.

And so you can see the signal degrades in quality a little bit during the day. But it's nice and bright at night.

Yes, because during the day, we measure both the back scattered channel and the light from the sky. And at night, we have a black background, and we only measure all the back scattered channels. So it's easier.