EUMETSAT

Topic 3d - Part 2 - Measurements from aircraft - data examples from Iagos

[MUSIC PLAYING] A researcher could send up a research aircraft specifically just to measure the atmosphere. Why would you use commercial aircraft rather than using special research aircraft?

Well, one thing is the continuity of the measurements. Research aircraft are great for investigating one particular problem over several days or maybe a month, but we can't monitor long-term with a research aircraft. So the advantage of commercial aircraft is that they're flying all the time every day. We don't have any control about where they're actually flying. So sometimes we might pick up on an event, sometimes we might miss it completely. But the advantage is that it's flying continuously, and it has been for about 25 years.

Tell me about this map in front of us.

Right, so these are all the aircraft that have been involved with the IAGOS, which was previously called Mosaic, since it started in 1994. So we have all the different companies that are involved in different colors. We can see that the majority of the flights are going from Europe to the US. So we've got really good coverage in the North Atlantic flight corridor, and recently, we've been trying to expand the network so that we cover the Pacific.

So we have China Airlines, which is flying from Taipei across the Pacific to Vancouver. We have Cathay Pacific, which is doing the same from Hong Kong down to Australia and New Zealand. And most recently, Hawaiian Airlines, which is flying from the Central Pacific, as you can see, down to Australia and New Zealand, up to Japan and also to the west coast of the USA.

So even though you can't control where the gaps are, the fact that there's just so much data coming in makes it useful.

Yeah. We'd be interested in getting new airlines involved to try and fill in some of the gaps. You can see, obviously, there's a big gap over the south Atlantic and also from Australia over to South Africa, but that would be a very difficult gap to fill in.

But you're also measuring in the places where the aircraft travel. So are you measuring the effect of the aircraft? Because they're in those places adding things to the atmosphere. Or can you be sure that they're just measuring whatever's there without the aircraft?

Yeah, I mean that's right. There have been concerns that the aircraft are measuring what other aircraft have emitted, but I think that's something that's been largely disproved, partly because the aircraft fly with a separation of at least 1,000 feet, and they're not flying so close to each other as we might imagine. Also, obviously, you've got the atmospheric conditions at the time. So you've got mixing processes that are going on. You've got turbulence that's mixing up the atmosphere. So yeah, on a windy day, a lot of that pollution from the aircraft in front will be blown away.

So you're getting a measurement of the atmosphere in a very specific place. At what heights are you measuring out? Have you got some data on that?

Yeah, so we have aircraft taking measurements all the time from takeoff until landing. So we tend to separate the flight into profiles during landing and take off, and analyze that differently from what's going on at cruise altitude, which is between about nine and 12 kilometers.

And you had an example of that. Should we look at that?

Well, this was a flight from Honolulu down to Auckland, and this is a very interesting flight because what you find is that over the Pacific Ocean, it's flying in the tropics anyway. It's flying in the in the troposphere. So what's going on is much more difficult. You don't really see much of a signal.

So what we've got here-- so this is a map and Honolulu's up there.

Yeah, Honolulu is up here. So this is the equator here. Sorry, and this is the outline of Australia, and we've got New Zealand here. So the aircraft's coming through the troposphere and this is a profile of ozone. We're not seeing very much ozone in the troposphere, which is completely normal. And then, suddenly, we see a big increase in the amount of ozone, the yellow dots here, and that corresponds to the aircraft really just hitting the edge of the subtropical jet here. And at that point, it basically enters the stratosphere, and we see a very strong-- very sharp signal as it enters the stratosphere, and then the ozone increases.

So you can actually see what's happening even though the aircraft might fly at the same height. The atmosphere, it's not exactly like a layer cake.

Yeah, that's right. So as you approach the polar regions, we're flying more and more in the stratosphere at the same altitude.

And so you can see-- so this is just ozone. So this is just one of the types of molecules that you can measure using this, but it's really valuable data, isn't it? Because you can see these enormous differences, and they are right there in the atmosphere, which is really important. What does that sort of data give you?

Yeah, that's right. So normally, we would also do an ozone versus carbon monoxide plot, for example. Carbon monoxide is emitted in the troposphere, so it's called a tropospheric tracer, whereas ozone would be considered as a stratospheric tracer. So when we plot those against each other, then we get that relationship, which changes depending on where you are in the atmosphere.

And it's not just chemical composition that is monitored. You're also looking at weather events. So if a big weather event happens, you can look at the data during that period as well.

Yeah, that's right. So this was one example, a very recent example, from when we had a very severe cold snap over Europe. So we can see on this image that comes from Météo-France on this animation, this big cold air mass coming down from the polar regions, which is very rich in ozone. And we can see profiles of Paris airport, for example, of ozone and carbon monoxide. And before the event comes on, we've got the troposphere. The tropopause is ending at about 9,000 meters. And then as this event hits, the tropopause has fallen by about 3,000 meters down to 6,000, and then it starts to gradually go up again at the end.

So that's a huge difference in height.

Yeah, that's a huge difference.

And the aircraft are crossing that barrier in and out, and in and out.

Yeah, that's right. And of course, these are the kind of events that we're trying to monitor on a daily basis. This will be just one of several events that will happen over the winter. It might happen here in Europe. We might see one in the US. We might see one in Asia, but the aim is to have enough measurements in different parts of the globe to be able to monitor as much as possible, these kind of events.

You're producing this vast amount of data. What happens to it afterwards?

Well, that goes into a big database, and anyone can have access to that database. So the database now goes back about 25 years of measurements, and then you would download the data that you require for the project or the idea that you've got in mind, compare that with satellite data, or compare it with model data, validating models.

Did you ever look out of the window in a plane that you're in and wonder what the instruments would be seeing if they were there on the same plane?

Yeah, definitely. We also have cloud probes on the aircraft. So obviously, that's very interesting as well. If you're just heading through some cloud, and you're thinking is it going to pick up on this or not? And yeah, as an indicator of what weather conditions you're likely to get on your flight. Is it going to be bumpy or not? I think those are kind of issues that, well, concern me in particular.

[CHUCKLES]

You're not a fan of bumpy fights?

Not really, no.

That's interesting, though, isn't it? Because that is all to do with atmospheric dynamics, and waves in the atmosphere that we can't see.

Yeah, that's right.

But the planes are flying right through them.

And there's safety issues, obviously, involved with that kind of thing. The pilots tend to download the weather conditions before they take off, and they're not updated until landing. So on a 12-hour flight, there can be a difference of 12 hours between what they're forecasting and what they're actually getting.

And can you see a future where, perhaps, almost all aircraft had some kind of sensors like this or a higher proportion? Like what's the overall aim? How big could this get?

Yeah, that would be fantastic. And I think also at the moment we're focusing on A330, A340 aircraft, which are long range aircraft, and it would be really nice if we had some short range aircraft that were doing many more takeoffs and landings throughout Europe, for example, on a smaller aircraft like an A320 or something similar.

So since the aircraft are there, you might as well make use of them if you can.

Yeah, definitely. It's a lot cheaper than sending a satellite into space. Obviously, we're not getting the same type of coverage, but the two things are complementary. We need both.

So there's a more specific example here of measurement during a big event. Tell me about that.

So in June this year, there was a heat wave across Europe, particularly in Portugal and in Spain, and this led to very dry woods and forests, and therefore, to forest fires. And these were some of the most intense forest fires, I think, that have been seen in Europe for many, many years. So we feed our data into the Copernicus Atmospheric Monitoring Service. So here, we have a simulation from their website, which is of aerosol optical depth, and we can see the intense forest fires here over Portugal, and how this spreads up and covers France.

So what we're looking at here is when we talking about aerosol optical depth, we're looking down through the atmosphere. So aerosols are these tiny particles, and it's the sum of everything in that column.

Yeah, that's right. This is what's being given out by the forest fires. And at the same time, burning products such as carbon monoxide increase, and we can see this in the takeoff and landing profiles of Paris on that particular day, this very increased amount of carbon monoxide in the boundary layer and in the free troposphere.

So even though-- these fires are down here in Portugal, Paris is up there, but because the atmosphere is all connected-- nothing had to stop flying because of this event, at least not near Paris. But you can see the chemistry change, even hundreds of miles away.

Yeah, that's right. That's right. We can see the plume as it spreads up over Europe, and along with that go all the other pollutants such as the carbon monoxide. We can see that over Paris. I think we also saw that over Frankfurt on that particular day as well. This was an event that really affected a large part of Western Europe, not just locally in Portugal.

And having the planes contribute to the outputs here means that you've got much more accurate measurements right in the middle of what's going on, and that makes these more accurate.

Yeah. There's a network of surface measuring stations across Europe, but they don't give any information about the depth of the anomaly that you're measuring. So one advantage of the aircraft is that we are getting-- we could see that this is an event that's really effecting a whole depth of the atmosphere-- 4,000 meters in depth.

And you're right in there, measuring it all.

We're right in there, yeah, measuring it all.

[MUSIC PLAYING]