

Topic 3d - Part 1: Measurements from aircraft - overview of IAGOS

[MUSIC PLAYING] Valerie, people have lots of ways of getting up into the atmosphere to measure it. Tell me how you do it here at IAGOS.

With IAGOS, we have the objective, more than 20 years ago, to use commercial aircraft as a platform to monitor the atmospheric composition on a long term basis.

So it sounds very sensible because there's so many of them in the sky all the time. But they're not your aircraft. How does it work? How do you get to use those planes?

So the idea was to use one type of aircraft at first. Because the constraint was to get appropriate instrumentations robust enough, accurate enough to make measurements over a long period, not to interfere with the aircraft operations. So at the beginning, we used only the A340 aircraft. And now, we also use A330 for now. So we have this two types of aircraft for now.

And whose aircraft do you use?

We are trying to choose the partner airlines to get the global coverage with our measurements. We have partnerships with our historical and national airlines. So Air France, Lufthansa, but we also have now non-European airlines. We have Cathay Pacific, based in Hong Kong. We have China Airlines. We also have, from very recently, Hawaiian Airlines, based in Honolulu.

So Hawaiian Airlines are right in the middle of the Pacific since we're flying--

Yes, that was a major huge gap of in situ data in our database. So that's definitely a very good added value in our network.

What sort of data can you get from these aircraft? Where are they? And what sorts of things can they measure?

Because we are using these type of aircrafts, so long haul flying aircraft. So most of the measurements are taken between 9 and 12 kilometers altitude. And at, let's say, at mid-latitude, that corresponds to the most critical region of the atmosphere regarding greenhouse gases effect. That's what we call the UTLS - upper troposphere, lower stratosphere. Between 9 and 12 kilometers, that's--

So troposphere is the first part of the atmosphere. So it's the upper bit of that and the lower bit of the stratosphere, which is the next bit down. So it's right in the boundary in the middle.

In the transition between the troposphere and stratosphere. But of course, we also have measurements during takeoff and landing. So we are sampling all the troposphere. And that's also very important for air quality issues, for example. So we used to say that the UTLS is important for climate issues, although troposphere is also important, in addition, to air quality issues.

And how many aircraft are involved in this?

So far, in IAGOS, we have nine aircraft. So eight of them are what we call the regular aircraft. So they are flying. They are transporting our instrumentations all day long on the long term basis. And we also have another aircraft, which we call the Flying Laboratory. It's also an A340. But the difference with the other eight are that this aircraft is flying a big container with one off set of instruments. So it's complementary to the other eight aircraft. Because it's measuring hundreds of components, but only once a month.

And so that's not a commercial aircraft.

It is.

It's a commercial as well.

It is a commercial. And the container is in the container for luggage, for example. That's basically the big containers for luggage. But one of them is filled with scientific instrumentation.

So it's all designed to piggyback onto these planes that are traveling normally. And you just stick a little bit extra in there. And then you can see things that they can't see. And so you've got an eye in the sky, almost. And what are they measuring?

So far, we are measuring ozone and water vapor for the last 20 or 24 years. That's the historical measurements. We have added carbon monoxide and nitrogen oxides as well, in the beginning of the year 2000. More recently, we have added greenhouse gases, CO₂ and methane. And we also plan in the near future to have, also, aerosols. In addition, we also have cloud particles, along with ozone, and CO, and water vapor.

You're in this place in the sky, which is really hard to get to. You might as well get everything. That's like the principle.

Yeah, because IAGOS fills the gap of measurements at global scale. It's definitely complementary to the surface stations, everything we can measure from the ground and everything we can measure from the satellites, for example. And we need this bridge in the troposphere and the UTLS as in situ measurements. And definitely, commercial aircraft has been the ideal platform to do that.

Was it difficult to persuade different airlines to help you out with this project?

It was not difficult on a scientific argument because airlines are definitely sensitive and committed to-- not to damage the atmosphere. And I remember at the very, very beginning of the program in the 90s, the question was a very hot topic. How do the aircraft contribute to climate change or to the loss of ozone in the ozone layer? So usually, they fully understand the scientific argument the ozone constraints is to have this equipment, which is not insignificant in terms of additional weight in the aircraft. And in terms also of maintenance, that's why we need the most robust instrument not to be maintained more frequently than every six months.

So it's got to be really reliable. So it can just go wherever the aircraft goes. It just works.

And it works without any intervention of anybody from the aircraft at all. But the way it is, yeah, 120 kilograms for the small version, or the basic version, of the IAGOS instrumentation and up to 160 kilograms with the full options of measurements. And the airlines participating to IAGOS agreed to transport recent instrumentation free of charge. That's very, very important to us because we could not afford, on the scientific budget, to pay for transportation, in addition to the instrumentation and the maintenance.

Because that's the weight of one passenger and a lot of luggage or two passengers.

Yeah, yes, it's a passenger with a lot of luggage, flying everyday on the same aircraft.

But because they're committed to learning about the science, they're happy to help out.

So Philippe, you've got a lab that's building these instruments. That's in here, is it?

Yes, I show you the place.

There's lots of activity here.

You can see instrument open.

So this would be inside, hidden away.

Yes, these instruments are installed inside the aircraft. Here, we have also instrument to be installed on the aircraft, installed in the avionics compartment of the aircraft.

So is it just on the side?

Just below the cockpit.

Right.

And we get the index plate of the IAGOS system. The index plate is installed on the fuselage of the aircraft, just below the cockpit.

So these bits face-- so the air is coming this way.

Yes, it's coming this way, under to the bit of tube. And then it's measured by the system. And then air goes out. And we have additional fences for water vapor. And we have a window for laser, for the laser, which is installed here, to measure the cloud.

So it's all in one panel. And the air is rush-- I mean, this is hundreds of miles an hour. But it can sample enough to--

Yes, we have a pumping system to get pressurized air. We pressurize the outside air to the cabin pressure. And then we do the measurement with the system.

And then on the inside, that's where you have the analysis.

Yes, we have the analysis of the gases here and with the small boxes. And after the flight, we have data transmission with GSM. We receive the data directly to the laboratory just after landing of the aircraft.

Oh, so it doesn't send the signal home as it's flying. So it collects, collects, collects, collects. And then, everything gets sent.

Yeah, that's true. That's true. We collect from takeoff to landing.

And are these very sensitive instruments? Because an aircraft, there's lots of bumping and shaking and--

Yes, yes. You can see. If you want to see inside the instrument, we have the system, which is mounted on shock absorbers.

Oh, it moves.

Yes, It moves from inside.

You're shaking that quite well!

Yeah, well, I can shake hard.

And so it stays put.

This is aeronautics materials. The aluminum is aeronautic. Everything is satisfied to fly on commercial aircraft.

So it will stay running, whatever bumping and bouncing. It's completely fine.

Yes, hopefully.

Hopefully! And then when it comes-- so, because this is a lab in a box, but how many different sensors are in here?

Yes, we measure ozone with this tube here with a UV lamp. We measure our carbon monoxide below with infrared lamp. And then here is all the electronics of the equipment. Here is a computer for that articulation, communication with aircraft, we get the position of the aircraft by the aircraft computer. And we also have an external instrument of the box for water vapor and for clouds. We have a laser.

You've got bits all over the floor here.

We have a laser installed on the plate. It's on the skin of the fuselage and it--

So it's looking outwards.

Yes, and the laser goes out from the aircraft and is reflected by clouds. So we get the numbers of particles and droplets of the cloud.

So it's a huge amount of info-- it's not a very big box, but it's a huge amount of information.

Yes, yes. We get many information with the system, hopefully working fully automatically. And the crew has nothing to do.

Right, it just happens.

The system is powered when the aircraft is powered. So it stops collecting data just after takeoff, up to landing.

And do you build all of them? Do all of the instruments come from this lab?

Yes, we designed all the instrumentation here, in our French National Research Center. And the instruments are manufactured by a subcontractor, by an aeronautic company, which is building the instrument. But all the design was made in France with CNRS development.

So are these ones that have come back for maintenance, or are these new ones?

Yes, yes, this one comes from maintenance. We let them operate on the aircraft for six months, about. When everything works, it's six months. And then after removal, we calibrate here. We have a calibration system with bottles and calibration gases. We calibrate here and check the instruments. And it goes back to the flying panel.

So the work never stops. It just keeps going.

It never stops. We actually have eight aircraft operating. And the goal of IAGOS is to operate up to 20 aircraft.

You're going to be busy for the next few years.

Yeah, I'm really busy. It's really fun to go to foreign countries for installing the system. So IAGOS system installation, it takes about three weeks to install the system. So we do that during a layover of the aircraft. And we collaborate with the airline company, who is in charge to install the rack and the electrical connection. This is a very complex system, and I run the system.

Yeah. So it's really impressive. Thank you very much. Thank you.

You're welcome.

[MUSIC PLAYING]