Chemical composition of aircraft exhaust aerosols investigated

February 9 2018

Ready for the next flight: NASA's flying laboratory, the DC 8 is fitted with 14 measuring instruments. One of them 'made in Mainz'. Credit: Carsten Costard

Can aircraft pollutant emissions be reduced by using biofuels? And what influence does an alternative fuel have on the formation of contrails? In mid-January, a joint German Aerospace Center (DLR) and US space agency NASA research project, with the participation of the Max Planck Institute for Chemistry and the Institute for Atmospheric Physics (IPA) of the Johannes Gutenberg University (JGU) in Mainz, addressed these questions. For three weeks, the scientists took off from the US Air Base in Ramstein, in Germany's Palatinate region, to fly a total of eight test flights at different altitudes and with variable thrust.

Two aircraft were used to perform the investigations. While DLR's Airbus A320 ATRA was refueled with a different kerosene blend for each test flight over Germany, NASA's "flying laboratory," a DC-8, followed a few kilometers behind and dove into its exhaust plume. A total of 14 measuring instruments aboard the DC-8 continuously collected data during flights.

These included ERICA (ERc Instrument for the Chemical composition of Aerosols) from the Max Planck Institute for Chemistry and the JGU Mainz. "ERICA is a globally unique aerosol particle mass spectrometer, developed and built in Mainz," explains MPIC Director Stephan Borrmann, a professor at the Institute for Atmospheric Physics at JGU.

"We are the only people on board who can study the chemical composition of individual particles, both in the exhaust gases themselves and in the interior of the ice crystals that form the contrails," says postdoc Oliver Appel, who, together with Andreas Hünig, Sergej Molleker and Antonis Dragoneas from the Particle Chemistry Department, operates the device aboard the aircraft. Two of them always accompanied the monitoring flights.

Look inside the DC 8 with its numerous scientific measuring instruments.
Credit: Carsten Costard

Inside ERICA, the smallest dust and soot particles—referred to as aerosols—are evaporated either by laser bombardment or by rapid heating. The gaseous material released in this process is converted into electrically charged ions, the masses of which can be measured with the help of a mass spectrometer. This directly provides the scientists with information on the chemical composition of individual particles within the particulate matter in the atmosphere.

ERICA was deployed for the first time last summer on a Russian high-altitude research aircraft up to 20 kilometers above Nepal. The opportunity to participate in the DC-8 campaign came at very short notice. "Modifying our instrument for use in the DC-8 in just about six weeks and getting an aerospace permit to finally install it in NASA's aircraft posed a major challenge. But we absolutely wanted to take part in this measurement campaign, because such an invitation from NASA surely represents great appreciation of our metrology," says postdoc Antonis Dragoneas, who had been instrumental in the conversion works.

Monitoring the measurements made by the ERICA aerosol particle mass spectrometer: Andreas Huenig (left) and Antonis Dragoneas. Credit: Carsten Costard

Objective: making the air cleaner

The standard kerosene was mixed with oil of Camelina for the test flights. For some time, NASA and DLR have been researching whether using such a biofuel is more eco-friendly. Initial results from previous studies have already shown that between 50 and 70 percent less soot particles form with a 50 percent biofuel mixture with 50 percent normal kerosene.

"We are interested in the chemical composition of the exhaust particles, among other things, because we want to know how many soot particles the exhaust gas contains, how many metal-containing particles, if they are coated with condensable materials, and how the particles change in contrail formation," says postdoc Sergej Molleker from the Particle Chemistry Department of the MPI for Chemistry. At altitudes of eight kilometers, soot particles and water vapor form ice crystals at -50 degrees Celsius, which can be seen in the sky as contrails. Among other things, the ice crystals prevent heat from escaping the atmosphere into space, meaning that every contrail creates its own small greenhouse effect.

"If we find a way to reduce the soot particles in the aircraft exhaust, the climate-warming effect could be reduced by new fuel blends," says Stephan Borrmann. "We also have the opportunity to make rare and valuable measurements of the natural ice clouds (cirrus) at this altitude, the properties and effects of which are also a key research topic."

The Mainz-based researchers expect initial results from the measurement flights from Ramstein in two months at the earliest.

Provided by Universitaet Mainz

Citation: Chemical composition of aircraft exhaust aerosols investigated (2018, February 9) retrieved 19 April 2024 from