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Aerodynamic condensation trails: iridescent ice clouds from aircraft wings

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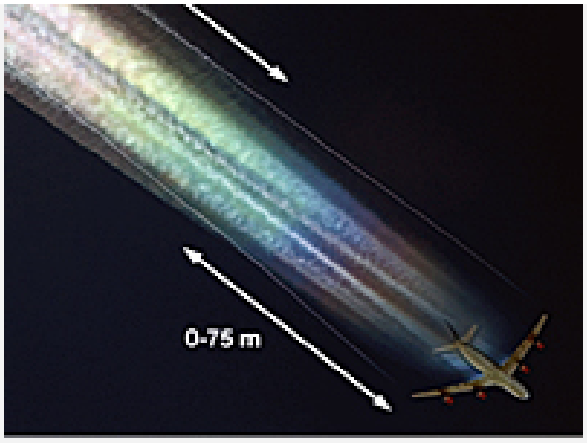

Sometimes visible in the sky: aerodynamic condensation trails

New source of anthropogenic high cloud analysed scientifically for the first time

Not all condensation trails are the same. Scientists from the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt; DLR) have, for the first time, been able to describe how condensation trails are created not only from the exhaust gas of jet engines but, under certain conditions, also by the wings of aeroplanes. It is unclear to what extent this new class of condensation trail influences climate change, as up until now it has not been considered in climate models.

The cause of the condensation trails, which are initially very thin and can only be observed directly behind an aeroplane at cruising altitude under certain conditions, is the rapid decrease in pressure above the wings of an aeroplane. Due to the drop in pressure, the temperature of the air falls in a few hundredths of a second and, provided that there is sufficient moisture in the air, tiny ice particles are formed. Scientists from the DLR Institute of Atmospheric Physics (Institut für Physik der Atmosphäre) in Oberpfaffenhofen have, for the first time, been able to conclusively describe the formation mechanism for aerodynamic condensation trails. "We have developed a physical model with which we have been able to explain the observations of aerodynamic condensation trails very precisely", says the institute's Professor Bernd Kärcher.

Extremely small ice particles of uniform size are formed in the steady stream over the wings that, provided sufficient water vapour is present in the atmosphere, continue to grow evenly at first. This even growth is also the reason for the iridescence of the condensation trail. At a distance of around 50 metres behind the aeroplane the ice particles are still small and they reflect blue light in particular; the larger the ice particles become – that is, the further they are from the aeroplane – the longer the wavelength of the light they reflect. The colour of the condensation cloud thus changes from blue to green to yellow and finally enters the red part of spectrum. After around 175 metres, the condensation trail appears white because the ice particles are drawn, little by little, into the turbulence of the wake behind the aeroplane. Here, the ice particles no longer grow evenly; due to their different sizes they reflect the light diffusely at all wavelengths and therefore appear white.

New challenge for climate models

All condensation trails caused by high-flying aeroplanes are ice clouds, of a type known as cirrus. They increase the degree of cloud coverage and change the natural cirrus clouds, thus influencing the climate. Aerodynamic condensation trails represent an additional anthropogenic source of cloud that contributes to the effect of air traffic on the climate and which to date has not been taken into account. "This type of condensation trail has always existed, but now we need to estimate the magnitude of their effect with the aid of climate models", says Professor Kärcher. The researchers' goal is to integrate aerodynamic condensation trails into a climate model that determines the global effect of air traffic on climate in order to identify the role it plays in climate change. Within the framework of DLR's 'environmentally friendly air transport system' project, the researchers are also looking for approaches to enable the effect of air traffic on the climate to be minimised, for example through appropriate air routes or aeroplane designs.

Aerodynamic condensation trails are formed in the tropics in particular

Conventional condensation trails generally form when the air surrounding the aeroplane is colder than 40 degrees Celsius. This condition is often fulfilled on air travel routes in the temperate zones and over the polar caps. The atmosphere must, however, be considerably warmer than minus 40 degrees Celsius for the formation of aerodynamic condensation trails that affect the climate. Only then is sufficient water vapour present in the air to allow ice particles to grow to an appreciable size. Thus, we can assume that aerodynamic condensation trails frequently appear in the sub-tropics and tropics where the atmosphere is generally warmer and moister. Because very high growth rates are currently being forecast for air routes to south Asia, for example, it is important to estimate the effect that these clouds with an anthropogenic source will have on the climate.

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