Measurements of short-lived contrails embedded in subvisible cirrus clouds

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Aircraft contrails frequently occur in the upper troposphere. They consist of ice particles having the potential to directly affect the Earth’s climate. The frequency of ice crystal size spectra and their relative properties of contrails depend strongly on the ambient distribution of the relative humidity with respect to ice (RH_ice). In air with RH_ice below 100%, contrails are believed to be short-lived, while persistent contrails require an ambient RH_ice of at least 100% (Gao et al., 2006, Atmospheric Environment).

During the mid-latitude aircraft experiment CONCERT 2008 (CONtrail and Cirrus Experiment), RH_ice inside of contrails were measured using the high precision Tool for the Stratospheric Lyman-α Hygrometer (FISH). The ice crystal size distribution in the size range d_ice = 2 - 1000 µm is recorded simultaneously using an FSSP (Forward Scattering Spectrometer Probe), a CPI (Cloud Particle Imager) and a 2D-C (2D-Cloudprobe). We here present results from about 1.7 hours of observation time during 6 flights. Most of the observed contrails are short-lived, i.e. the ambient air was subsaturated. Nevertheless, ice crystals > 200 µm were detected inside of the contrails, contradicting our understanding that contrails consist of a high number of small ice crystals.

Here, analysis of the vertical structure of the atmosphere indicates that the contrails were embedded in subsaturated air. Simulations with the kinetical microphysical model MIMD reproduce the conditions leading to large ice crystal formation, showing that 200 µm ice crystals form only at very low cooling rates typical for frontal systems. During contrail formation very high cooling rates (> 360 K/sec) predominate.

Overview

R.H. observations in mid-latitude contrails

Relative humidities in contrails

Cirrus & Contrail RH_ice

Large ice crystal formation

Model study with kinetical microphysical model MIMD