Geophysical Research Abstracts,
Vol. 11, EGU2009-5128, 2009
EGU General Assembly 2009

Optical depth of cirrus and embedded contrails from airborne Lidar and models

U. Schumann and M. Wirth

Deutsches Zentrum für Luft- und Raumfahrt, Institut für Physik der Atmosphäre, Oberpfaffenhofen, Germany (ulrich.schumann@dlr.de, +498153-28-1841)

A new developed high performance airborne Lidar is applied to measure the backscatter, extinction, depolarization and water vapor profiles from above a thin cirrus cloud along a flight path of about 1000 km over Germany with high temporal/spatial resolution (about 0.2 s, 40 m). The observations revealed surprisingly many embedded contrails within the cirrus. The observations are roughly explained by a simple multiple-plume model simulating the many contrails that formed during the four hours before the observations.

Direct airborne measurements of the optical thickness tau of thin cirrus layers have been performed using the high spectral resolution lidar (HSRL) channel at 532 nm wavelength of the Lidar instrument called WALES (Water Vapour Lidar Experiment in Space). During the 4 h flight, more than 1000 aircraft passed below the flight path of the Falcon. The observations show variable optical depth with a mean value of about 0.3 and large fluctuations with many sharp isolated peaks of typically 200 - 1000 m width up to or even exceeding unity.

The observations are explained using a combination of two models versions. First we use the ice water content and extinction predicted with various versions of weather prediction models (ECMWF and COSMO, initiated at various times between 3 and 12 hours before start of the observations). These models explain roughly the mean behavior of the measured tau. The peaky structure of the tau signal is qualitatively explained by a multiple-plume contrail model. This model is based on a Gaussian plume model. It uses the known air traffic waypoint sequences for all the aircraft passing Germany during the day before the observations (provided by air traffic control, DFS). For each waypoint a Lagrangian calculation is started identifying flights under ambient conditions for which contrails are expected to form according to the Schmidt-Appleman criterion. The plume moves horizontally with the wind at constant potential temperature. This implies sinking or rising motions of typically a few hundred meters during the life time of the contrail. The cross section grows with plume age as a function of vertical wind shear and turbulent diffusion. The ice water content and particle sizes are estimated from aircraft parameters (fuel consumption, soot emissions), ambient humidity, initial sinking in the young wake vortex, and the vertical sinking or lifting of the plume during its life cycle until the time of observation. The model results explains some of the individual peak values in vertical extinction profiles. It appears that some aircraft effect occur also at rather low altitudes where no contrail should form. Otherwise the model explains the general structure of the measured optical thickness.

The results indicate that Germany was covered by aviation induced cloudiness (mainly contrail cirrus) which roughly doubled the mean optical depth of the extended cirrus cloud in this case, which may be of climatic importance. The optical depth of the observed peaks is larger than explained by the simple model, which now triggers further investigations.