Investigating an aviation induced indirect aerosol effect on cirrus clouds using airborne and spaceborne lidar measurements

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Emissions from aviation have a large effect on the Earth's radiation budget and impact the Earth's atmosphere by a combination of different processes. E.g. line shaped contrails can form in the exhaust plume of an aircraft and might evolve into contrail induced cirrus clouds in the aftermath. Those contrails and contrail induced cirrus clouds are supposed to have the largest aviation induced impact on the Earth's radiation budget with a clearly warming effect. Furthermore, aviation induced aerosols might change the micro-physical and thus optical properties of naturally formed cirrus clouds. Model studies investigating the impact of this aerosol-cloud interaction show large differences in the resulting effective radiative forcing. Our understanding on how aviation induced aerosols affect cirrus cloud properties is still poor. Observations of an aviation induced indirect aerosol effect on cirrus clouds are rare or even missing.

Measurements with our polarization sensitive airborne high spectral resolution lidar system performed over the European mid-latitudes show differences in the measured particle depolarization ratio of cirrus clouds formed in rather pristine regions and those formed in regions with enhanced background aerosol due to air traffic exhaust. For the first time we could thus show an indication of an aviation induced indirect aerosol effect on naturally formed cirrus clouds. But, high resolution airborne measurements are limited in time. Spaceborne measurements with the Cloud Aerosol Lidar with Orthogonal Polarization (CALIOP) onboard CALIPSO (Cloud Aerosol Lidar and Infrared Pathfinder Satellite Observations) are not limited to specific flight experiments. During the past years civil aviation over Europe showed a large increase with respect to flight density. Long-term satellite lidar observations are used to investigate if this increase in civil aviation has also an effect on cirrus cloud properties. We find a trend in the measured particle linear depolarization ratio of cirrus clouds over Europe over the past ten years that might be related to changes in civil aviation. Additionally, in spring 2020 air traffic over the European mid-latitudes was reduced by about 80% due to the COVID-19 pandemic. This reduction offers a unique opportunity to study cirrus clouds in a situation less affected by aviation.