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Satellite observations of the impact of individual aircraft on ice crystal number in cirrus clouds

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Aviation outflow is the only anthropogenic source of pollution that is directly emitted into the upper troposphere. This emission has the potential to modify the cloudiness directly by forming linear contrails and indirectly by injecting aerosols, which can act as cloud condensation nuclei (CCN) and ice nucleating particles (INP). Contrail cirrus can persist either in cloud-free supersaturated air, increasing high-cloud cover or inside natural cirrus cloud, and therefore modifying the microphysical properties of already existing cirrus clouds. Even though the situation that an aircraft flies through a natural cirrus is one of the highly probable situations in the upper troposphere, its subsequent impact is unclear with the present state of knowledge. Quantifying such impact is necessary if we are to properly account for the influence of aviation on climate. One main limitation preventing us from better identifying these impacts is the lack of height resolved measurements inside the cirrus clouds.

In this study, we used new retrievals from combined satellite cloud radar and lidar (CloudSat/CALIPSO; DARDAR-Nice algorithm), which provide height resolved information of ice crystal number concentration, at intercepts between the CALIPSO ground track and the position of civil aircraft operating between the west coast of the continental United States (Seattle, San Francisco and Los Angeles) and Hawaii during 2010 and 2011 from an earlier study.

Comparing cloudy air behind the aircraft inside the flight track to the adjacent regions and to ahead of the aircraft revealed a notable difference in ice number concentration at 300 m to 540 m beneath the flight height. These differences are derived from the reduction of ice number concentrations as we proceed toward the cloud base in regions unaffected by aviation and the increase of ice crystals as we distance a few hundreds of meters beneath the flight level in the regions affected by aviation.