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Optically thin ice clouds in Arctic; Formation processes

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Arctic ice cloud formation during winter is poorly understood mainly due to lack of observations and the remoteness of this region. Yet, their influence on Northern Hemisphere weather and climate is of paramount importance, and the modification of their properties, linked to aerosol-cloud interaction processes, needs to be better understood.

Large concentration of aerosols in the Arctic during winter is associated to long-range transport of anthropogenic aerosols from the mid-latitudes to the Arctic. Observations show that sulphuric acid coats most of these aerosols. Laboratory and in-situ measurements show that at cold temperature (< -30°C), acidic coating lowers the freezing point and deactivates ice nuclei (IN). Therefore, the IN concentration is reduced in these regions and there is less competition for the same available moisture. As a result, large ice crystals form in relatively small concentrations. It is hypothesized that the observed low concentration of large ice crystals in thin ice clouds is linked to the acidification of aerosols. To check this, it is necessary to analyse cloud properties in the Arctic.

Extensive measurements from ground-based sites and satellite remote sensing (CloudSat and CALIPSO) reveal the existence of two types of extended optically thin ice clouds (TICs) in the Arctic during the polar night and early spring. The first type (TIC-1) is seen only by the lidar, but not the radar, and is found in pristine environment whereas the second type (TIC-2) is detected by both sensors, and is associated with high concentration of aerosols, possibly anthropogenic. TIC-2 is characterized by a low concentration of ice crystals that are large enough to precipitate.

To further investigate the interactions between TICs clouds and aerosols, in-situ, airborne and satellite measurements of specific cases observed during the POLARCAT and ISDAC field experiments are analyzed. These two field campaigns took place respectively over the North Slope of Alaska and Northern part of Sweden in April 2008. The airborne microphysical instruments include a complete set of dynamic, thermodynamic, radiation, aerosol and microphysical sensors such as the Polar Nephelometer probe, the Cloud Particle Imager probe (CPI) and standard PMS probes: 2D-C, 2D-P, FSSP. Analysis of cloud type can be done from these observations, and a first classification has been performed. Results are then compared to satellite data analysis. The new retrieval scheme of Delanoë and Hogan, which combines CloudSat radar and Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) measurements, is used to recover profiles of the properties of ice clouds such as the visible extinction coefficient, the ice water content and the effective radius of ice crystals. Comparisons with in situ airborne measurements allow to validate this retrieval method, and thus the clouds and aerosols properties, for selected cases where flights are coordinated with the satellite overpasses. A comparison of combined CloudSat/CALIPSO microphysical properties retrievals with airborne ice clouds measurements will be presented. The Lagrangian Particle Dispersion Model (LPDM) FLEXPART is use to study the origin of observed air masses, to be linked with pollution sources.