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A comparison between CloudSat and aircraft data for mixed-phase and cirrus clouds

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Nowadays, space remote sensing measurements are a very useful way to study the atmosphere on a global scale. Among the numerous scientific satellites in space, the A-Train is a constellation of 6 satellites flying together with on board complementary instruments of new generation (radiometers, radar, lidar, spectrometers…) to study all parts of the atmosphere: gas composition, clouds and aerosols distribution and properties, and radiation budget. Among these satellites, two of them where launched in 2006: CALIPSO and CloudSat, respectively with a Lidar (532 and 1064 nm channels with depolarization) and a 94 GHz radar on board. They are especially dedicated to the study of clouds and aerosols, and will allow to obtain for the first time the vertical profiles of clouds and aerosols on a global scale during 3 years.

However, to determine clouds and aerosols properties from space raw data, retrieval methods need to be developed. In order to validate these retrieved techniques, and thus the clouds and aerosols properties, numerous validation plans take place around the world, included different ways as ground based measurements, in situ measurements, or airborne remote sensing instruments in collocation with the satellite tracks.

In this context, the ASTAR-2007 and POLARCAT-2008 campaigns took place respectively in the Arctic region of Spitzbergen-Norway in April 2007 and in North part of Sweden in April 2008 to study mixed-phase clouds and the CIRCLE-2 campaign was carried out in Western Europe in May 2007 to sample mid-latitude cirrus clouds. The main objectives are the study of microphysical and optical properties of mixed-phase and ice clouds with particular interest on the validation of clouds products derived from CloudSat and CALIPSO data during co-located remote and in situ observations.

The airborne microphysical instruments include the Polar Nephelometer probe to measure the scattering phase function and asymmetry parameter of cloud particles, the high resolution Cloud Particle Imager probe (CPI) for imaging the ice particle morphology (2.3 microns pixels size) and standard PMS probes: 2D-C, FSSP-100 and FSSP-300.

This presentation focuses on the validation of the standard parameter of the Cloud Profiling Radar (CPR) of CloudSat (equivalent radar reflectivity factor Z). The different IWC(ice water content)-Z relationships determined from combined CloudSat and in situ data are then discussed.

The method to derive equivalent reflectivity factor from the CPI data is first presented. According to the particle shape, a mass-diameter relationship and thus a reflectivity factor is determined for each type of ice crystal. This technique noticeably decreases the discrepancies of radar reflectivity-derived values due to the natural variability of ice crystal shapes.

Comparisons of the reflectivity factor deduced from CPI and those from CloudSat for various types of clouds are then discussed. The next step to the interpretation of the CloudSat product is to derive IWC-Z relationships for assessing IWC distributions on a global scale, which is an important improvement to constrain global scale modelling.

Several IWC-Z relationships are determined from in situ measurements according to the various case studies including Arctic mixed-phase clouds, Arctic and mid-latitude cirrus. The improvements on the results by using the CPI data-processing method are discussed.

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