



Remote sensing of polar ice and mixed phase clouds properties by means of far infrared spectral measurements over the Antarctic Plateau

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Ice and mixed phase clouds play a key role in the Earth's radiation budget but there is a large uncertainty about their infrared radiative impact due to the high variability in the size/shape distribution of ice particles. Their radiative effect is very strong in the mid and far infrared (FIR) spectrum, between $200\text{-}1000\text{ cm}^{-1}$ ($10\text{-}50\text{ }\mu\text{m}$). In particular the FIR part of the spectrum (under 600 cm^{-1}) shows a strong sensitivity to the ice particle properties, such as crystal habits, and allows the discrimination of the clouds phase, since in this spectral region the refractive index of ice is very different from the water ones. Despite this, only few measurements exist in the FIR that could be used to improve the characterisation of polar clouds radiative effect.

The present work describes the synergy of different instruments deployed at Concordia base, Dome C (Antarctica, 3230 m a.s.l.), to study the optical and micro-physical properties of the ice and mixed phase clouds. Currently at Italian-French base Concordia, there are different instruments devoted to the measurements of the Antarctic clouds properties, such as the Fourier transform spectroradiometer REFIR-PAD (Radiation Explorer Far Infrared – Prototype for Applications and Development), operating in the FIR spectral region, a backscattering/depolarization lidar, which allows to monitor the passage of clouds, an ice camera for the estimate of the size distribution of ice particles and, finally, a micro rain radar (MRR) operating at 24 GHz , installed during this last summer campaign in order to estimate the Ice Water Content (IWC) of the clouds.

REFIR-PAD spectroradiometer is operating in ground-base zenith-looking observation geometry in continuous mode at Dome-C since December 2011, allowing to collect a very large database of the spectral radiances of the Antarctic atmosphere both in clear and cloudy sky conditions.

The retrieval of the clouds parameters is performed by using the spectral measurements of REFIR-PAD and the Simultaneous Atmospheric and Clouds Retrieval (SACR) code, which is based on the optimal estimation approach. This code allows to perform the retrieval of the atmospheric variables, such as the vertical profiles of water vapour and temperature, and the clouds properties simultaneously, by using the single scattering coefficients of different ice crystal habits, provided by specific databases.

The SACR algorithm allows to retrieve the effective diameter of the ice crystals and water droplets, the optical depth/ice water content and the ice fraction of the clouds. The comparison of the effective diameters and the ice water content with the measurement given by the ice camera and the radar represents one of the aims of the FIR CLOUDS (Far Infrared Radiative CLOUDS) project selected by the Italian PNRA (Programma Nazionale di Ricerche in Antartide), in order to validate the current cirrus clouds model. Furthermore the analysis of the whole database collected by REFIR-PAD will allow to obtain a statistics of the Antarctic clouds properties and studying the correlations between these clouds and the other atmospheric variables.