IASI cloud detection on the Antarctic plateau and comparison with ground-based interferometric measurements

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ABSTRACT

The identification of clouds on ice surfaces, as in polar regions, is extremely challenging since the temperatures and radiative properties of the surface and of the cloudy layers are often very similar.

In this work, we analyze the Infrared Atmospheric Sounding Interferometer (IASI) L2 cloud products derived from observations collected by MetOp-A, -B, and -C satellites on the Antarctic plateau. Comparisons are performed against co-located products obtained from ground-based measurements taken at the Concordia station (-75.10, 123.33), located in Dome-C, where, since 2012, downwelling radiance spectra in the 100-1400 cm^{-1} interval are measured by the Radiation Explorer in the Far Infrared-Prototype for Applications and Development (REFIR-PAD) spectroradiometer.

The ground-based products are obtained by processing the REFIR-PAD spectra with an automatic algorithm named Cloud Identification and Classification (CIC). CIC is a machine learning algorithm based on the principal components analysis. In this experiment CIC is used in a modified and improved version of the one chained in the End-2-End Simulator (FE2ES) of the Far-infrared Outgoing Radiation Understanding and Monitoring (FORUM), which is the ESA 9th Earth Explorer.

Co-located lidar measurements are used to define training sets, each one composed of 70 radiance spectra characterizing clear sky, ice clouds, and mixed-phase clouds. A test set of 650 spectra is used to assess the classification performances. Unprecedented cloud occurrence statistics, covering more than nine years, are provided for multiple time scales, and related to meteorological parameters such as surface air temperature. The results indicate a clear sky mean annual occurrence of 67.4%, while ice and mixed-phase clouds are observed in 29.8% and 2.8% respectively, with an inter-annual variability of a few percent units.

Cloud occurrence at Dome-C is studied based on both IASI L2 cloud products and CIC classifications of REFIR-PAD downwelling spectra. Annual and monthly statistics (from 2012 to 2020) are presented and compared. Also, temporally co-located ground-based and satellite-based observations are used to produce one-to-one statistics and assess the agreement between the different classification techniques. In order to evaluate the effect of the field of view and the impact of the exploitation of the shortwave radiation in the classification process, the Moderate Resolution Imaging Spectroradiometer (MODIS) products are also taken into consideration and compared with respect to REFIR-PAD and IASI results.

Finally, a small number of case study is identified, and a cloud properties synergistic retrieval is performed using co-located REFIR-PAD and IASI spectral observations.