Geophysical Research Abstracts
Vol. 19, EGU2017-14179, 2017
EGU General Assembly 2017

A statistical retrieval of cloud parameters for the millimeter wave Ice Cloud Imager on board MetOp-SG

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The meteorological observations from satellites in the microwave domain are currently limited to below 190 GHz. However, the next generation of European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) Polar System-Second Generation-EPS-SG will carry an instrument, the Ice Cloud Imager (ICI), with frequencies up to 664 GHz, to improve the characterization of the cloud frozen phase. In this paper, a statistical retrieval of cloud parameters for ICI is developed, trained on a synthetic database derived from the coupling of a mesoscale cloud model and radiative transfer calculations. The hydrometeor profiles simulated with the Weather Research and Forecasting model (WRF) for twelve diverse European mid-latitude situations are used to simulate the brightness temperatures with the Atmospheric Radiative Transfer Simulator (ARTS) to prepare the retrieval database. The WRF+ARTS simulations have been compared to the Special Sensor Microwave Imager/Sounder (SSMIS) observations up to 190 GHz: this successful evaluation gives us confidence in the simulations at the ICI channels from 183 to 664 GHz. Statistical analyses have been performed on this simulated retrieval database, showing that it is not only physically realistic but also statistically satisfactory for retrieval purposes. A first Neural Network (NN) classifier is used to detect the cloud presence. A second NN is developed to retrieve the liquid and ice integrated cloud quantities over sea and land separately. The detection and retrieval of the hydrometeor quantities (i.e., ice, snow, graupel, rain, and liquid cloud) are performed with ICI-only, and with ICI combined with observations from the MicroWave Imager (MWI, with frequencies from 19 to 190 GHz, also on board MetOp-SG). The ICI channels have been optimized for the detection and quantification of the cloud frozen phases: adding the MWI channels improves the performance of the vertically integrated hydrometeor contents, especially for the cloud liquid phases. The relative error for the retrieved integrated frozen water content (FWP, i.e., ice+snow+graupel) is below 40% for 0.1kg/m^2 $<$ FWP $<$ 0.5kg/m^2 and below 20% for FWP $>$ 0.5 kg/m^2.