Evaluation of the CloudSat products with ACTRIS lidar/radar measurements over the Eastern Mediterranean

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Introduction

Clouds play a crucial role in weather and climate, producing precipitation and impacting the Earth's radiation budget. The processes governing their formation, evolution, geometrical and microphysical properties, as well as their radiative effects, are far from being well understood [1]. State-of-the-art methodologies use combined lidar-radar satellite observations to provide high-resolution vertical profiles of cloud properties. Combined CloudSat and CALIPSO observations provided globally cloud geometrical and microphysical properties from 2006 to 2017 (e.g., DARDAR-MASK product; https://www.icare.univ-lille.fr/dardar/, [2]). However, these data have not been used to provide cloud statistics over the Mediterranean and this is partially attributed to the lack of evaluation studies of the products above the region. In this study, we perform an evaluation of the CloudSat geometrical and microphysical products using measurements performed in the frame of the Aerosol, Clouds, and Trace Gases Research Infrastructure (ACTRIS, https://www.actris.eu/).

Combined ground-based lidar-radar observations performed in the framework of the PRE-TECT experiment during April 2017 at the Greek atmospheric observatory are used to evaluate the CloudSat performance in detecting hydrometeors.

Results and discussion

A case study of collocated lidar–radar ground-based, and space-based observations is analyzed to retrieve the cloud properties and to discuss the CloudSat performance above the Eastern Mediterranean region. The ground-based data used in our study were acquired during the PRE-TECT experimental campaign [3], the first ever Cloudnet campaign that was held in Greece [4]. The campaign was organized by the National Observatory of Athens (NOA) in the framework of ACTRIS project and the ERC project "Does dust TriboElectrification affect our ClimaTe?" (D-TECT) and took place on 1–30 April 2017, at the Greek atmospheric observatory of Finokalia (35.338°N, 25.670°E), in Crete (finokalia.chemistry.uoc.gr).

In our study we used collocated measurements from the PollyXT lidar system of NOA [5] and the MIRA36 cloud Doppler radar system [6] of the Italian National Research Council's Institute of Methodologies for Environmental Analysis (CNR-IMAA). The whole set of instruments that performed measurements during the campaign are presented in Figure 1.

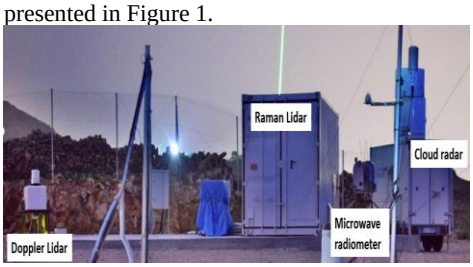

Figure 1. The PRE-TECT campaign Cloudnet station (35.338°N, 25.670°E) in Greece on 11 April 2017.

The acquired ground-based radar and lidar observations for the study case of 11 April 2017 are shown in Figure 2. The cloud radar was able to detect the entire cloud structure above the station from 13:00 to 24:00 UTC, with the vertical in-cloud extent exceeding 5 km, while the lidar was able to penetrate only the first 2 km inside the cloud. In contrast, the lidar detected thin layers with high attenuated backscatter coefficient values at altitudes between 3 and 4 km, from 06:00 to 12:00 UTC, which are not visible from the radar. The MIRA36 cloud Doppler radar system's reflectivity

values are found below the detection limit value (< -30dBz) until 12:00 UTC, indicating the presence of small cloud particles.
At 10:41 UTC, CloudSat overpassed within 100km of Finokalia station. Cloudsat monitored a deep cloud layer located between 2.5 and 10km inside the 2°× 2° domain and a thinner layer above Finokalia (not show here). The ground-based radar retrievals ± 0.5h of the overpass, indicate the existence of high-level clouds with mean base at 7.1 ± 0.4km and mean top at 8.2 ± 0.35km. The cloud boundaries are also calculated from the PollyXT, by applying the wavelet covariance transform (WCT) to the 1064 nm signal, following the steps of [7].

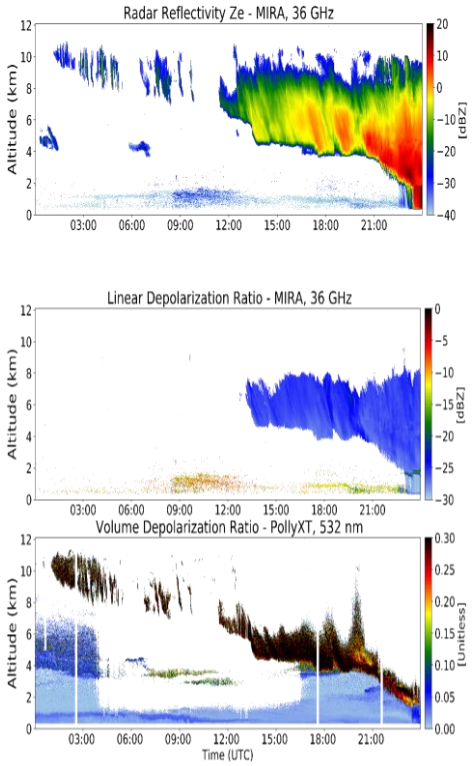

Figure 2. Observations of the MIRA36 radar reflectivity (up), the PollyXT attenuated backscatter coefficient (center) and lidar volume depolarization ratio (down) measured on 11 April 2017 above Finokalia, Crete.

CloudSat CPR observations detect the hydrometeor layer with a top higher than that detected by the collocated ground-based cloud Doppler radar system (9.0 vs. 8.4km) and a base higher than that detected by the lidar system (7.1 vs. 6.5km).
In the future, we will extend our study in evaluating the CloudSat geometrical and microphysical products over more Mediterranean stations, combining lidar/radar retrievals. Our study is a step towards the use of CloudSat products for a decade cloud statistic over this understudied region.

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