PERFORMANCE OF CLOUD LIQUID WATER RETRIEVALS FROM GROUND-BASED REMOTE SENSING OBSERVATIONS OVER LEIPZIG

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ABSTRACT

Since August 2011, liquid water clouds have observed continuously at Leibniz-Institute for Tropospheric Research (IfT) in Leipzig, Germany by mainly using cloud radar, passive microwave radiometer and lidar ceilometer data. By applying algorithms which were developed within the CLOUDNET program, parameters like cloud type, liquid water content, and ice water content are calculated semi-operationally for these data.

The challenge to retrieve cloud liquid water content (LWC) and its vertical distribution from ground-based cloud radar observations is the non-linear relationship between the radar reflectivity Z and LWC. Using additional information like cloud base height (from lidar), integrated cloud water (from microwave radiometer), or temperature profiles allows estimating the LWC distribution within a cloud.

In this work, different approaches to retrieve LWC are compared. In particular, the differences between adiabatic cloud water distributions and a scaled adiabatic method are discussed.

Case studies of liquid water clouds under different atmospheric conditions are presented, with the focus on the dependence of retrieval performance on parameters like season, water vapor content, or cloud height and depth.

1. INTRODUCTION

The detailed and continuous observation of microphysical cloud properties remains a challenging task. Within the last decade, the ground-based remote sensing instrumentation for cloud observation strongly improved. A set of similar instruments to perfom this task became available at several places throughout Europe. Therefore, a common standard to derive cloud properties was developed within the CLOUDNET program [1]. Following a target classification, algorithms for the retrieval of cloud liquid and ice water content as well as other cloud properties are applied. The observations are performed by a combination of a millimeter cloud radar, a lidar ceilometer and a passive microwave radiometer.

Since August 2011, all these instruments which are needed to apply the CLOUDNET algorithms have been operating at the IfT in Leipzig, Germany. This paper will present first results from these observations.

2. LWC RETRIEVAL METHODS

The challenge to retrieve cloud liquid water content (LWC) lies in the non-linear relationship between the radar reflectivity Z and the LWC. Cloud radars give a good view of the vertical cloud structure, but the quantitative information on the LWC is limited. Passive microwave radiometers can determine the integrated liquid water (LWP) with a high accuracy [2], but cannot give the vertical distribution of LWC [3].

However, knowing the temperature and humidity profiles as well as the cloud boundaries, an adiabatic cloud liquid water profile following [4] can be derived. This adiabatic LWC can then be scaled by the LWP measured by the microwave radiometer.

Another method to derive is a combined radar-lidar method following [5] which relates the optical extinction from a lidar with the reflectivity from the cloud radar in order to estimate cloud effective radius and LWC.

3. EXAMPLES

A first investigation of the difference between adiabatic LWC and scaled LWC has been performed for the period of August to November 2011 for data from Leipzig. Only cases with pure liquid water clouds

were considered in this study. Time periods with additional ice clouds, as well as drizzle or rain have been neglected. The first results show that the adiabatic approach in many cases gives an overestimation of LWP (Fig. 1). This is especially the case when several cloud layers were present (see Fig. 2).

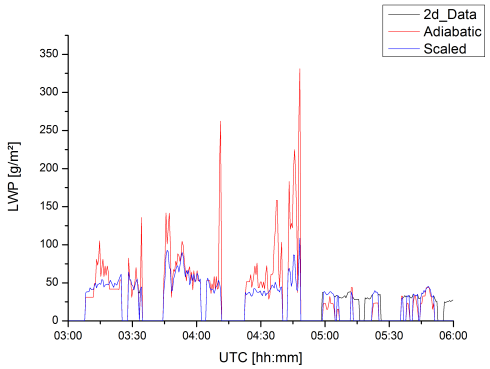

Figure 1. Vertical integral (LWP) over adiabatic LWC (red) and scaled LWC (blue) for data from 17 August 2011 in Leipzig.

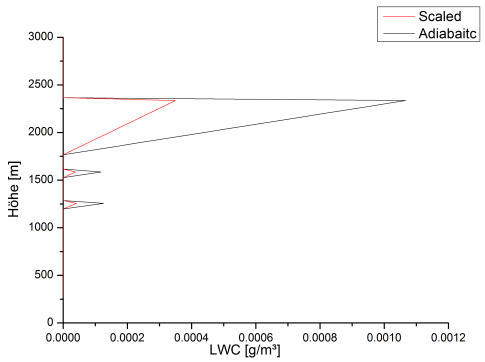

Figure 2. Vertical profile of LWC (red: adiabatic, black: scaled) for 17 August 2011, 04:48 UTC.

Fig. 3 presents another day (27 August 2011). For this day, the adiabatic assumption of LWC seems to be too high by a factor of 2-3. This might be due to the lower cloud base (1200 m compared to >2000 m on 17 August). However, further investigation will be done to examine the conditions under which LWC is largely overestimated by the adiabatic approach.

4. SUMMARY AND OUTLOOK

The performance of CLOUDNET retrievals for cloud liquid water properties has been evaluated for ground-based remote sensing observations in Leipzig by using the adiabatic and scaled adiabatic retrieval methods. The second approach using the combined Radar-

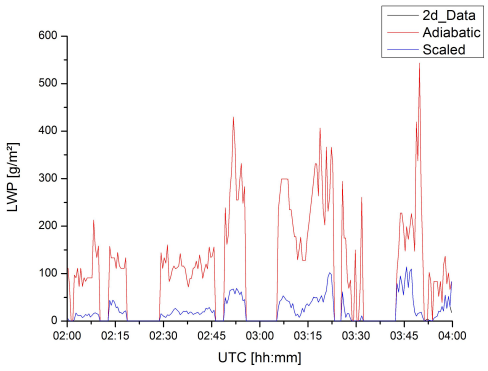

Figure 3. Vertical integral (LWP) over adiabatic LWC (red) and scaled LWC (blue) for data from 27 August 2011 in Leipzig.

Lidar approach after [5] will be evaluated in the next step.

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