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# 1 Retrieval of cloud liquid water content profiles with radar and lidar: application to multi-annual data sets and comparison with microphysical cloud simulations.

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This paper describes a synergetic radar-lidar technique for deriving the liquid water content profiles of water clouds. It is specifically developed to overcome the difficulties arising from the “large droplet issue”, which imposes a large uncertainty in the relationship between the radar reflectivity factor and the liquid water content. The presented technique uses the ratio between simultaneously measured radar reflectivity and lidar’s optical extinction for the detection of the presence of drizzle particles in water clouds and the classification water cloud cells into three classes – “the cloud without drizzle”, “the cloud with light drizzle” and “the cloud with heavy drizzle”. Different relationships between the radar reflectivity and liquid water content then can be applied for different types of cloud cells to retrieve actual liquid water content. The existence and stability of initial relationships for such technique were studied and demonstrated using in-situ measured with aircrafts water cloud microphysics data for a few field campaigns that took place in different geographical regions, inside different

cloud types, and under different meteorological conditions. The implementation of the proposed technique to real remote sensing data is limited by strong extinction of lidar's signals above cloud base. To overcome such limitation in clouds regions, where lidar signals are completely attenuated, the possibility to use the radar reflectivity alone for the cloud type categorization was demonstrated. The initially appropriate threshold values of the radar reflectivity were statistically estimated from in-situ microphysical data and compared to cloud microphysical model output.

The proposed technique was applied to the multiyear radar and lidar data from the Cloudnet dataset for three sites in Europe – Cabauw (the Netherlands), Chilbolton (UK), and Palaiseau (France). The long time series of the radar reflectivity and radar-to-lidar ratio were used for the technique improvement via the estimation of the statistically-reliable values for the radar-to-lidar ratio and radar reflectivity thresholds for cloud type categorization. The results of liquid water content retrieval are included in Cloudnet dataset and available on-line.

The comparison of the radar-lidar technique retrievals with integrated liquid water contents from microwave radiometer shows good correlation and reasonable agreement for situations when both algorithms are applicable. For the cases without precipitation, when microwave radiometer's liquid water path is less then 400 g/m$^2$, the statistical difference between radiometer's and proposed technique's integral water content is of the order of 50 g/m$^2$.

The resulting liquid water content retrievals can be used also for the comparison with such profiles, derived in numerical weather forecast and climate models. The data from a few such models - UK Met Office Global and Meso-scale, ECMWF, Meteo France, KNMI HIRLAM and RACMO, - are available in the Cloudnet dataset. The statistical analysis of the models/retrieval inter-comparison will be given during presentation.