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Aerosol profiling by calibrated ceilometer data

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Recently, networks of automated single-wavelength backscatter lidars ("ceilometers") were implemented, primarily by weather services. As a consequence, the potential of ceilometers to quantitatively determine the spatiotemporal distribution of atmospheric aerosols was investigated, to derive mixing layer heights for air quality studies and to assess optical properties. The main issues are the limited signal-to-noise ratio and the inherent problems of the calibration.

We have studied several approaches for calibrating ceilometers, based on different numerical solutions and on auxiliary data of different remote sensing techniques. As a result, the backscatter coefficient can be determined with a relative accuracy of typically 10% and a time resolution in the order of 5 minutes. This parameter is used to estimate the mixing layer height by applying different techniques of averaging and pattern recognition. In this context, it is assumed that aerosols are a good tracer for the thermodynamic stratification of the troposphere. Our algorithm is fully automated and was tested for several commercially available ceilometers. For this purpose, a simplified version for non-calibrated ceilometers, based on the so called range corrected signal, was additionally developed.

We used data of the CHM15k-x ceilometer (manufactured by Jenoptik) from more than 5 years of continuous operation by the LMU-MIM in Munich (Germany) to establish climatologies of mixing layer heights (MLH), cloud cover, cloud heights and vertical profiles of the backscatter coefficient. Among others, the mean diurnal cycle and the interannual variability of the MLH for different months were determined. Ceilometer derived MLH were also used to validate different parameterization of chemistry transport models and to validate forecasts of the dispersion of aerosol layers. For the latter applications backscatter coefficients are required. That means, a calibration of the ceilometers is mandatory.