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Integration of remote sensing methods for continuous determination of mixing layer height

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The knowledge of the layering of the atmospheric boundary layer and especially the mixing layer height (MLH) is important for the characterisation of air pollution, because this variable controls the vertical space for rapid mixing of near-surface pollutants. The determination and modelling of the MLH is especially important in urban meteorology. Different remote sensing methods are applied for this task as ceilometers (mini lidar), sodar and RASS. It is the aim of this study to present the results of using the RASS information about the temperature profile in a long-term study.

Remote sensing provides information about layering of the atmospheric boundary layer. We apply active remote sensing methods which comprise devices that emit a well defined signal and then receive the backscatter from the atmosphere. These are two Vaisala ceilometers CL31 which are eye-safe commercial lidar systems. The routine retrievals of lower atmosphere layering from vertical profiles of laser backscatter data are available from a special software. The ceilometer measurements contain information about the range-dependant aerosol concentration; gradient minima within this profile mark the borders of mixed layers. A sodar from Metek is operated which detects the height of a turbulent layer characterized by high acoustic backscatter intensities due to thermal fluctuations and a high variance of the vertical velocity component. This information is extended by measurements with a RASS from Metek which provide the vertical temperature profile from the detection of acoustic signal propagation and thus temperature inversions which mark atmospheric layers. These data are the input for a software-based determination of MLH developed with MATLAB.

The remote sensing instruments were operated at two different sites in the city of Augsburg simultaneously since autumn 2008: at the northern edge (CL31, RASS) and in the middle (CL31); the CL31s with equal operational settings. Also the data from a radiosonde launched about 50 km east of Augsburg in Oberschleißheim twice a day are used for comparison of the different methods.

The two ceilometers of the same type are compared. The aerosol distribution and size affects the backscattering intensity. The humidity contributes to different aerosol sizes, leading to differences in backscatter intensities. The horizontal advection of aerosols can influence the MLH analyses from ceilometer data. During cloudy periods the height of the lower cloud edge is detected only which can be used as MLH. Therefore, the optical backscatter intensity from the ceilometers can only be interpreted qualitatively. Furthermore, the displayed features can only be seen as a result of thermally induced local mixing processes if horizontal advection can be neglected.

The remote sensing devices sodar and RASS provide vertical profiles of dispersion parameters and temperature during periods of stable or neutral atmospheric conditions. During well-mixed conditions i.e. during the afternoon hours too less information for determination of MLH is available.

The aerosol structures seen in lower layers by both ceilometers agree well with the RASS temperature measurement results. All these characteristics of ceilometers, sodar and RASS data will be summarised for the task to observe the MLH automatically and continuously.

The information about MLH is used in the presentation of Höß et al. at that conference (Stadt-, Umwelt- und Biometeorologie) also.