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Boundary layer heights from Doppler lidar using aerosol backscatter and wind data

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The height of the convective boundary layer (CBL) is estimated using the 2 micron Doppler lidar ‘WindTracer ’. The instrument provides an along-beam-resolution with independent range gates of 72 m length, and a temporal resolution of 1 Hz (accumulating 500 pulses). Two sets of automatically working algorithms were implemented, one based on aerosol backscatter, the second on vertical wind velocity variance. An overview about the different Doppler lidar based techniques for CBL determination and an intercomparison of the respective results based on measurements over coastal gently rolling terrain (Convective Storm Initiation Project, CSIP, 2005), over continental gently rolling terrain, as well as over complex terrain (Convective and Orographically-induced Precipitation Study, COPS, 2007) are presented.
Additionally the influence of the local vertical wind field on small-scale boundary layer height fluctuations, which are known to be important for entrainment processes, is investigated.

Using the signal-to-noise-ratio of the Doppler spectra, a non-calibrated aerosol backscatter profile can be determined. Aerosol backscatter shows typically a large negative gradient at the interface between the mixed layer and the free atmosphere. Four well established algorithms to detect automatically the boundary layer height were used: (i) a threshold method, (ii) the detection of the minimum derivative, (iii) a fit to an idealized profile, described by an error function and (iv) a simple wavelet method. A comparison between the different techniques and the corresponding CBL-heights will be given in the presentation. The advantage of using aerosol backscatter data is the extremely high temporal resolution of 0.1 Hz. This provides the possibility to analyse the influence of local vertical wind fluctuations on the small-scale variability of the boundary layer height. The simple approach of a direct correlation between an updraft and a corresponding CBL increase and vice versa seems to be invalid. Rather the small-scale CBL height fluctuations are determined by processes, the interface between CBL and the free atmosphere experienced upstream.

The second set of methods to determine CBL heights uses the wind velocity information. The vertical wind velocity variance is a direct measure for turbulence. Therefore this method determines a boundary layer height in the sense of the original mixed layer definition. Three different techniques are used: (i) a threshold technique, (ii) the maximum vertical velocity variance approach and (iii) a fit to an idealized profile described by an empirical profile from previous studies. A comparison between the different techniques will be given in the presentation.

Comparing the results from the two sets of boundary layer height estimations, differences between the aerosol-based height and the turbulence height, especially during periods of CBL growth in the morning and during the afternoon transition time, were obvious. The daily evolutions based on the two sets, were compared with each other and to boundary layer heights determined from potential temperature profiles measured by radiosondes.