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Turbulence structure of the convective boundary layer by means of Doppler lidar measurements

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The results of a comparison between lidar and aircraft measurements taken during the Convective Storm Initiation Project CSIP 2005 are presented as well as results from continuous measurements over a two month summer period in 2008 at Forschungszentrum Karlsruhe.

The Doppler lidar "WindTracer" was operated during CSIP at Chilbolton Observatory, UK with a range gate length of 72 m and a temporal resolution of 1 Hz in continuous vertical stare mode. In situ airborne measurements were performed with the Dornier 128 research aircraft D-IBUF of the Technical University of Braunschweig with a sampling frequency of 100 Hz. The flight path was centered to the lidar location with legs of 40 km length at 6 to 7 levels adjusted to the prevailing boundary layer height. Five cases with simultaneous aircraft and lidar measurements are investigated with respect to vertical velocity turbulence statistics.

In order to account for the different sampling frequencies of lidar and aircraft and the restricted spatial resolution of the lidar, a bandpass filter is applied to the measurement data. The difference between the variance of the filtered and unfiltered aircraft data is used to estimate the loss of variance in the lidar data because of its discrete range gates and lower temporal resolution. The comparison confirms the reliability of the continuous and throughout the depth of the convective boundary layer (CBL) available lidar measurements, which enable further detailed insight into the structure and dynamics of the boundary layer under various conditions.

Continuous measurements with the "WindTracer" during Summer 2008 from June 23rd to September 30th in combination with turbulence measurements in 40 and 200 m height at the 200 m tower at Forschungszentrum Karlsruhe are providing the data basis for an extended investigation of the CBL. The "WindTracer" was operated in a mode with 57 min vertical stare per hour and PPI scans during the last 3 minutes from which the profile of horizontal wind speed was calculated using the VAD-algorithm. The lidar range gates were configured overlapping with a distance between range gate centers of 36 m for these measurements to get a virtually higher space resolution.

CBL height and cloud base heights are detected using an automated algorithm based on the aerosol backscatter signal of the "WindTracer". The time series of vertical wind velocity in different heights are separated into up- and downdraft regions, using the standard deviation of the up- and downdraft velocities as a threshold value. Horizontal wind speed is used for calculating the spatial length of the structures assuming Taylors hypotheses. The high spatial resolution of the "WindTracer" throughout the CBL, starting at 400 m agl, enables detailed studies of the mean characteristics of the thermals structure and their variations with height.

The profiles of the vertical velocity variance are calculated from this large set of data and characteristics of the profiles under cloudless and cumulus cloud topped conditions as well as correlations between the turbulent fluxes measured at the 200 m tower and vertical velocity variance in the CBL from lidar data are examined.