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Water vapour fluxes in the convective boundary layer over heterogeneous terrain measured by ground-based lidar systems

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Water vapour is transported from the earth's surface by turbulent and convective motion into higher atmospheric regions. Evaporation at the surface reflects the heterogeneity due to different landuse, soil characteristics and soil wetness. Area-averaged surface fluxes are needed for validation of model simulations, but are hard to measure. The water vapour fluxes in the convective boundary layer over hereogeneous terrain can be considered as areal averages in cases when the scales of the mixing processes are larger than the scales of the surface heterogeneity. Ground-based remote sensing systems are promising instruments to continuously record turbulent fluxes up to the top of the boundary layer.

The DEKLIM field experiment LITFASS-2003 took place in May/June 2003 in an agricultural area southeast of Berlin, Germany. Among a variety of near-surface, soil and atmospheric measurements, ground-based lidar systems were operated, two Differential Absorption Lidar (DIAL) systems measuring the absolute humidity and one Heterodyne Doppler lidar system measuring the vertical wind. Time resolution was 10 s and height resolution 90 m. Water vapour fluxes are determined by the eddy-covariance method. The joint measurements cover 14 days from early morning to late afternoon and the region from 400 m above ground to the top of the boundary layer.

The measured profiles of water vapour fluxes show different structures depending on whether there is entrainment of dry air from above or not. On days with dry air lying above the humid boundary layer, entrainment leads to an increase of the water vapour flux in the upper part of the boundary layer. This layer can comprise up to 50% of the boundary layer and entrainment fluxes can exceed the surface fluxes. On days with humid air lying over the boundary layer the entrainment flux is nearly zero and does

not contribute to the humidity concentration within the boundary layer. Nearly all flux profiles show a linear course in the lower 1000 m.

A first test to extrapolate fluxes within the boundary layer to the surface gives promising results. Fluxes between 400 and 900 m are linearly extrapolated. They can be compared with area-averaged fluxes which were calculated for the LITFASS agricultural area from more than 10 energy balance stations located over the dominant landuse types. Although the extrapolated fluxes are unrealistic in the morning, good agreements with the LITFASS composites can be found in the afternoon. Thus this method may help to derive area-averaged surface fluxes.