Understanding the Spatiotemporal Structures in Atmosphere-Land Surface Exchange at the Jülich Observatory for Cloud Evolution

In this study the spatial and temporal patterns of surface-atmosphere exchange parameters from temporal and spatial highly-resolved measurements as well as long-term observations are identified. For this objective the Jülich ObservatorY for Cloud Evolution (JOYCE) provides a combination of state-of-the-art ground-based remote sensing techniques. The constantly growing multi-year data set at JOYCE offers detailed insight into boundary layer development concerning turbulence, clouds and winds. Studying the mixing processes and their evolution in the lower atmosphere is essential in order to understand the coupling between near surface turbulence and cloud formation.

A classification of the boundary-layer into specific types based on Doppler wind lidar measurements provides information on the strength and origin of the turbulence with a high temporal resolution. In this method, the backscatter coefficient and higher moments (variance, skewness) of Doppler lidar measured vertical velocity are used together with horizontal winds derived from azimuth scans. In this way, a discrimination between surface and cloud driven turbulence can be made.

The first statistical analysis of the classification showed the potential of characterizing processes like the diurnal cycle of atmospheric mixing, cloud coupling and turbulence related to low-level jets. Due to the emerging Doppler wind lidar network in Europe, the classification can also be applied at other sites in different climatic regimes, including maritime and high latitude sites.

Furthermore, the classification can be used to select specific conditions favoring the evaluation of coupling processes between near surface turbulence and cloud evolution to surface and vegetation properties. In these predominantly convective cases, the land surface heterogeneity is assessed by exploiting the time series of a eddy-covariance station at the ground level and a land use classification. Following this, the spatial variability of the surface fluxes is connected to horizontal gradients in water vapor and liquid water path measurements of a scanning microwave radiometer. Depending on the mean wind flow, to exclude advection related phenomena, the orographic and vegetation based influences can be identified.

In addition, the boundary layer classification can also be used for evaluating parameterizations of mixing processes and in terms of coupled boundary layer clouds in the ICOsahedral Nonhydrostatic unified modeling system (ICON), that performs as a large eddy simulation.