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Turbulence classification of the atmospheric boundary-layer for Doppler wind lidar networks

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Mixing processes and their evolution in the lower atmosphere are essential to understand coupling between near surface turbulence and cloud formation. Classifying the boundary-layer into specific types could help to improve parameterizations and the choice of mixing schemes in numerical weather prediction models. A long-term and continuous observational dataset of boundary-layer types at various sites would enable to evaluate the model performance and characterize the location specific boundary-layer processes. In this regard, the emerging Doppler lidar network of TOPROF (COST Action ES1303) shows a large potential in identifying the strength and origin of the turbulence with a high temporal resolution.

The classification is able to provide a set of boundary-layer types distinguishing between clouds, convection, wind-shear and cloud-driven turbulence. The algorithm requires measurements of the vertical velocity and estimates of the horizontal wind components. The work-flow of the boundary-layer classification includes a signal-to-noise ratio background correction of the Doppler lidar to increase the sensitivity and data availability. After the pre-processing step, the uncertainty estimates and required quantities are calculated from the radial wind measurements, including the three components of the wind vector and the turbulent kinetic energy (TKE) dissipation rate for detecting mixing regions. The skewness, as a higher order moment of the vertical velocity, can give information about cloud coupling and turbulence generated by cloud-top cooling. Low-level jets as a further potential source of turbulence are important for wind energy production and can be identified by an additional classification.

A first analysis of the boundary-layer classification is made based on a long-term data set from the Jülich Observatory for Cloud Evolution (JOYCE) in western Germany. JOYCE provides constantly growing multi-year observations for detailed insight into patterns related to clouds and atmospheric conditions since 2011 and the continental site is embedded in a rural environment. The classification is also used for evaluating parameterizations of mixing processes in an ICOsahedral Non-hydrostatic unified modeling system (ICON) that performs as a large eddy simulation. Furthermore, other sites in different climatic regimes, such as coastal and high latitude sites, are investigated and compared in terms of their boundary-layer characteristics.