Statistical properties of the cloudy boundary layer at the Jülich ObservatorY for Cloud Evolution

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The Jülich ObservatorY for Cloud Evolution (JOYCE) is a newly established ground-based observatory aiming at investigating the physical processes leading to cloud formation, sustainment and decay. To be to able to accomplish this goal, various instruments are currently set up at the Forschungszentrum Jülich, Germany for continuously monitoring water vapor, clouds, and precipitation over many years. Only such observations will eventually make it possible to improve the prediction of clouds by weather and climate models.

The main JOYCE instruments consist of a MIRA Doppler cloud radar, a HATPRO microwave radiometer, a HALO-Photonics Doppler wind lidar, an AERI infrared interferometer, ceilometers, a CIMEL sun photometer (AERONET), a Micro Rain Radar (MRR), radiation sensors and a 120 meteorological tower. The first three instruments can be rotated in all spatial directions, thereby obtaining an impression of the three dimensional structure of water vapor and clouds.

In this contribution, the focus is on the relationship between dynamics and microphysics of the cloudy boundary layer as analyzed from the available remote sensors. The Cloudnet categorization scheme, applied to the JOYCE instruments, allows for the classification of the detected radar/ceilometer signals into aerosol, cloud phase (liquid/ice/mixed) and precipitation. Statistical properties are derived for a whole year of single-layer non-precipitating liquid clouds. Specifically, the Cloudnet categorization yields cloud base, top, temperature and pressure (the latter two derived from a numerical weather prediction model), which can be used to calculate the vertically integrated adiabatic liquid water content (LWP_ad) within the cloud boundaries. LWP_ad can be interpreted as the maximum liquid water content a cloud can obtain considering the adiabatic ascent of a parcel that experiences saturation with respect to liquid water and maintains all of its liquid water. The actual LWP can be retrieved from the microwave radiometer with an accuracy of approx. 20 gm^{-2}. Clouds with LWP values lower than LWP_ad are called diluted and this dilution of liquid water can be either attributed to loss of liquid water through precipitation or mixing of drier air through turbulent entrainment. An analysis of dilution in the detected single-layer, non-precipitating liquid water clouds is presented and the dilution factor 1-(LWP/LWP_ad) is related to cloud vertical extent, turbulence (at cloud base, cloud top and throughout the mixing layer) and surface coupling of the cloud.

A further indicator for the strength of turbulence in the mixing layer is the variance of the integrated water vapor (IWV), also observable by the microwave radiometer. The analysis of clear-sky pre-convective conditions in the summer months shows a significant increase in IWV variability during the growth of the mixing layer. This increase in water vapor variability can also be observed spatially through analysis of hemispheric scans down to elevation angles of 15°. The influence of water vapor variability on cloud formation and decay is discussed.

These statistical evaluations will not only give observational insight into the coupling of boundary layer turbulence and cloud microphysical properties, but also deliver means for the evaluation of cloud resolving models involving, i.e. Large Eddy Simulation (LES) models that explicitly resolve turbulence down to spatial/temporal scales comparable to the observations.