Boundary layer cloud life cycle in ICON-LEM and ground-based observations

Boundary layer clouds are important for climate because they reflect incoming shortwave solar radiation and contribute to the water cycle with precipitation/evaporation processes. Predicting the response of boundary layer clouds to climate change is associated to large uncertainties, mainly due to their parameterization in climate models. Climate models parameterize turbulent motions in the planetary boundary layer (PBL) by applying so-called PBL-schemes. They are needed to estimate vertical turbulent fluxes and condensation which are not resolved by GCMs. Since the choice of one PBL scheme can dramatically affect the model output, it is essential to evaluate with observations. PBL parametrizations are developed and tuned based on LES models, that are used as virtual las. LES are evaluated and developed with the help of observations.

The high-resolution (150 - 300 m) Icosahedral non-hydrostatic model (ICON) is developed by the Max Planck Institute for Meteorology (MPI-M) and the German Weather Service (DWD). ICON-LEM is an LES model with special characteristics that makes is especially interesting to be compared to ground-based observations.

In this work, we exploit ground-based observations as well as radiosoundings from the JOYCE-CF supersite in Germany to evaluate the PBL representation by ICON-LEM based on two PBL case studies, one representing a convective PBL and the other a cloud topped PBL with drizzle. The goal is to understand if the mechanisms for cloud formation are properly described in the model and in which conditions differences and biases are observed.

We first evaluate the description of the dynamics and the thermodynamics during the day. Then, we examine in detail cloud properties investigating correlations with biases observed in dynamic and thermodynamic properties. In addition, we use the radar forward simulator PAMTRA to evaluate cloud microphysical properties and the process of drizzle formation in the measurement space by deriving radar Doppler moments: we apply a criterion for drizzle detection to model output as well as observations and we develop an analysis of clouds in a multivariable space including liquid water path, center of gravity and radar Doppler moments.

Preliminary results show that the diurnal evolution of the variance of vertical velocity in the model is too high compared to the observations, and wind shear is underestimated except in the late afternoon. Despite thermodynamic description of cumulus cloud formation due to surface heating is in very good agreement with observations, clouds are not always forming when they are expected from the thermodynamics. The reasons for such discrepancies are investigated and discussed in detail.

We show that ICON-LEM can be valuable for improving PBL schemes as well as for indicating possible improvements in warm cloud microphysical parametrizations.