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Evaluation of realistic LES simulations using remote-sensing forward operators

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A detailed understanding of clouds and their macrophysical structure is crucial to reduce the uncertainty of cloud feedbacks in current general circulation models (GCMs). Due to the coarse resolution of GCMs of $O(100\text{ km})$, clouds often have to be parameterised. Relevant cloud processes instead act on scales of $O(100\text{ m})$. Large-eddy simulations on huge domains with realistic weather forecast like boundary forcing are an emerging method to bridge this gap. But still careful evaluation based on observations is crucial to ensure realism of these LES simulations.

We will present a comprehensive evaluation of the ICON-LES simulations at 156 m resolution covering central Europe. Observational reference is based on the remote-sensing measurements of the Jülich ObservatorY for Cloud Evolution (JOYCE) supersite. To better assess for uncertainties than at retrievals, physical consistent forward operators for a cloud radar, microwave radiometer and a simple LiDAR are applied on the model output. The high spatial and time resolution (up to 9 sec.) of the LES output allow for comparable synthetic observations with an unprecedented detail. For the first time a full synthetic Cloudnet supersite is created. One of the Cloudnet products is the cloud classification, which is one of the most intuitive and comprehensive observational product to gain detailed information about cloud type and structure. The cloud classification can now be derived from the LES, which is a powerful tool for investigating clouds.

The simulated cloud radar observations show an overestimation of frozen hydrometeors in the upper troposphere, indicated by too high reflectivities. Small scale variability of the simulated water vapour microwave channels is well captured, which shows an added value of the LES. Rain events are too rare and the intensity is often overestimated by ICON, which is seen by less high reflectivity bands, whereas the reflectivity within the rain event is by 10 dbZ higher than of the observations. The cloud base heights of the LiDAR simulations are in good agreement with the measurements. A first cloud classification based on the forward simulations for the ICON LES is presented and its potential discussed.