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Studying scale-adaptivity of PDF cloud parametrizations using super-large LES

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Cloud schemes which rely on probability density functions (PDFs) to describe the subgrid-scale variability of thermodynamic state variables, rely heavily on large eddy simulation (LES) data to provide information on the distributions of state variables. Until recently LES simulations were commonly limited to small domains and highly idealized prototype regimes, but large-scale reanalysis forced simulations are now available such as the HD(CP)^2 simulations. The day long HD(CP)^2 simulations produced by the ICON-LEM model cover Germany with a resolution of 156 meters and are forced with reanalysis data. We use these simulations to detect and quantify error sources of a PDF parametrization, which represents variability with a beta function of total water, and compare against a classic first-generation parametrization still used in some present-day GCMs, which diagnoses cloud cover from relative humidity. We focus on how cloud errors relate to spatial scales to understand the resolution dependence of the cloud parameterizations when used in an atmospheric model. While both parameterizations perform best at the low resolution of 100 km, the classic parametrization is much more scale-dependent and performs much worse across all scales studied. We also show that reducing the complexity of the PDF parametrization can achieve better results at high resolutions.