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Scale dependency of total water variance, and its implication for cloud parameterizations

Vera Schemann (1), Bjorn Stevens (1), Verena Grützun (1), and Johannes Quaas (2)

(1) Max Planck Institute for Meteorology, The Atmosphere in the Earth System, Hamburg, Germany (vera.schemann@zmaw.de), (2) Universität Leipzig, Institute for Meteorology, Leipzig, Germany

Cloud process and cloud cover parameterizations are known to be a main driver of uncertainties in simulations of climate change. All parameterizations rest on the representation of subgrid-scale variability of total water. With the ongoing increase in resolution and the new opportunities to use grid refinement, the question of scale (in)dependency of parameterizations becomes more important.

In this study the scale dependency of variance of total water mixing ratio is explored by analyzing data from a General Circulation Model (ECHAM6), a Numerical Weather Prediction Model (COSMO-DE and COSMO-EU) and Large Eddy Simulations (UCLALES). Additionally data from Direct Numerical Simulations is included. The aim is to define a general scaling law, which can be used to evaluate and improve cloud process parameterizations. Especially the large scale models (ECHAM6 and COSMO-DE/EU) show a consistent and continuous scaling around a power law exponent of -2. The scaling continues also for the higher resolution datasets but the variability of the scaling exponent increases. Nevertheless neither a spectral gap nor a strong scale break was found. This is of special interest for the transition between resolved and parameterized scales in a general circulation model. The results point out the need for scale dependent cloud process parameterizations. As a first step in this direction the evaluation of the parameterized total water variance of a state of the art statistical scheme is also presented.