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Uncertainties related to the representation of momentum transport in shallow convection

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The vertical transport of horizontal momentum by convection has an important impact on the general circulation of the atmosphere as well as on the life cycle and track of cyclones. So far convective momentum transport (CMT) has mostly been studied for deep convection, whereas little is known about its characteristics and importance in shallow convection. In this study CMT by shallow convection is investigated by analyzing both data from large-eddy simulations (LES) and simulations performed with the Integrated Forecasting System (IFS) of the European Centre for Medium-Range Weather Forecasts (ECMWF). In addition, the central terms underlying the bulk mass-flux parametrization of CMT are evaluated offline. Further, the uncertainties related to the representation of CMT are explored by running the stochastically perturbed parametrizations (SPP) approach of the IFS.

The analyzed cases exhibit shallow convective clouds developing within considerable low-level wind shear. Analysis of the momentum fluxes in the LES data reveals significant momentum transport by the convection in both cases, which is directed down-gradient despite substantial organization of the cloud field. A detailed inspection of the convection parametrization reveals a very good representation of the entrainment and detrainment rates and an appropriate representation of the convective mass and momentum fluxes. To determine the correct values of mass-flux and in-cloud momentum at the cloud base in the parametrization yet remains challenging. The spread in convection-related quantities generated by the SPP is reasonable and addresses many of the identified uncertainties.