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Response of convective boundary layer and shallow cumulus to soil moisture heterogeneity: A large-eddy simulation study

Cunbo Han (1), Slavko Brdar (2), and Stefan Kollet (1)

(1) Forschungszentrum Jülich, Agrosphere (IBG-3), Jülich, Germany (cunbo.han@hotmail.com), (2) SimLab TerrSys, Jülich Supercomputing Centre, Research Centre Jülich, Jülich, Germany

The land surface is heterogeneous in various aspects (e.g., land cover, land use, soil type, soil moisture, and topography) over a wide range of spatial scales, which strongly influences the atmospheric boundary layer. In this study, the impact of soil moisture heterogeneity on the development of the convective boundary layer (CBL) and shallow cumulus clouds was investigated. Based on results from large-eddy simulations (LES) applying soil moisture patterns generated utilizing spatially correlated Gaussian random fields and idealized atmospheric vertical profiles as initial conditions, this study provides insights in the influence of spatial variance of soil moisture on the ensuing growth of the CBL and shallow cumulus clouds development. The simulation results show that domain-averaged land surface sensible heat flux, latent heat flux, and Bowen ratio change strongly with changing soil moisture variance, while domain means of soil moisture and available energy are almost identical. Domain-averaged vertical profiles of wind variance, buoyancy flux, and moisture flux are significantly different between each other. Interestingly, the liquid water path is higher in large soil moisture case than that in small soil moisture variance case, while the total cloud cover is high in small soil moisture variance case.