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Sensitivity of clouds and precipitation to surface inhomogeneities over Germany

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The evolution of deep moist convection and subsequent precipitation is strongly linked to the heterogeneity of the underlying surface. Mountains, for example, have a strong influence on the wind field by blocking, flow deviation and/or lifting of air masses but also thermally induced secondary circulations are important. The soil moisture content, on the other hand, primarily influences the surface energy budget and leads to a partitioning of the available energy into sensible and latent heat. Both, dynamic and thermal processes interplay with each other and make it difficult to properly represent precipitation in numerical weather models due to insufficient understanding and description of physical processes.

Within this study we investigate the effect of terrain structure and soil moisture on deep moist convection over Germany, using the COSMO model at high spatial resolution (horizontal grid length of 500 m). Sensitivity studies with modified terrain height and soil moisture were performed for days with weak synoptic forcing. The numerical results show that role of individual mountains is complex and its effect on precipitation varies. Despite different feedback signs, all simulations with altered terrain show that the low-level wind convergence strongly influences the initiation of deep convection. Simulations with modified soil moisture content show a more systematic dependency, as differential heating leads to secondary circulations and affects precipitation amounts and vertical cloud structures locally.

Our findings from this study demonstrate the complexity of multiple processes on different spatial scales for the initiation of deep convection due to surface inhomogeneities. Within this work we assess the contributions of terrain structure and soil moisture perturbations to the timing, amount and location of precipitation.