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Sensitivity of deep convection to perturbations of soil, boundary layer and cloud condensation nuclei

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Forecasting the location and intensity of convective storms is one of the major challenges for convective scale weather prediction. Sources of uncertainties in the convection triggering processes often originate from local, small scale processes in the boundary layer and are furthermore dependent on the prevalent synoptic regime. In this study, we examine the relative impact of different perturbation types, such as initial soil moisture perturbations, boundary layer perturbations or perturbations of the amount of cloud condensation nuclei (CCN) on deep convection and subsequent precipitation over Central Europe.

A series of COSMO experiments at 2.8 km grid spacing is performed for several case studies during different synoptic regimes chosen from the high impact weather period in spring 2016 over Central Europe. The uncertainty of soil moisture observations is mimicked in one ensemble of experiments by applying bandpass filtered initial soil moisture conditions. In a second ensemble, boundary layer uncertainties are expressed as stochastic perturbations using the physically-based stochastic boundary layer perturbation scheme (PSP). A third ensemble consists of different concentrations of CCN in the atmosphere.

Preliminary results reveal different behaviors for the soil moisture and atmospheric perturbations. While the latter continuously increase ensemble variability, soil moisture perturbations only become active shortly before the onset of convective precipitation. Interestingly, the spatial variability caused by the PSP scheme is comparable to the one from the operational COSMO-DE-EPS forecasting system, whereas CCN and soil moisture perturbations account for about 30% of the benchmark variability emanating from COSMO-DE-EPS. Investigating the vertical cloud structure and the dynamics of the lower troposphere give further insight how the different perturbation types affect deep convection.