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Collective impact of temporal and spatial soil moisture anomalies on deep convection over Central Europe

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Different sources of uncertainty are accounted for in modern convective-scale ensemble prediction systems. However, research on the relative role of various lower boundary uncertainties is in its infancy. For example, opposing signs in soil moisture precipitation coupling as well as its scale dependence are challenging processes in soil atmosphere interactions. In this study, the collective impact of soil moisture bias and soil moisture heterogeneity on the precipitation forecast in real case scenarios over Central Europe is examined.

A series of COSMO experiments at 2.8 km grid spacing is performed for several synoptically weakly forced summer case studies. Under such synoptic conditions, soil atmosphere interactions are a crucial factor influencing the boundary layer. We investigate the influence of explicit perturbations of the soil moisture conditions, such as the collective effects of soil moisture bias and heterogeneities on different scales. Different heterogeneity length scales between 30 and 110 km are introduced by chessboard patterns and superposed with a bias of $\pm$ 25%.

According to our experiments, a large scale soil moisture bias is positively correlated to the domain-averaged precipitation for several synoptically weakly forced case studies. In contrast to that, we found a negative local soil moisture precipitation coupling with increased precipitation over the dry tiles of the chessboard pattern. This negative spatial coupling was traced back to an interaction between thermally induced circulations and the background wind causing a persistent updraft region on the downwind flank of the dry patches. These enhanced circulation cells are dominant for tile sizes of 50 to 80 km leading to preferential triggering of convective precipitation and result in a smaller day-to-day variability. At other scales, this spatial locking of precipitation is less evident.