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Aerosol effects on clouds and precipitation over Germany in different weather regimes

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The response of clouds to changes of the aerosol concentration is complex and may differ depending on the cloud type, the aerosol regime, and environmental conditions. Several previous studies used idealized simulations with changes in the environmental conditions to study the aerosol effect in different environments. In this study, we perfom realistic simulations for 6 cases over Germany with the COnsortium for Small-scale MOdeling (COSMO) model. The cases were chosen to include 3 cases with strong synoptic forcing and 3 cases with weak synoptic forcing. Besides reference runs with more or less operational settings, initial and boundary temperature profiles are modified for all cases with linear increasing temperature increments from 0–5 K between 3–12 km agl. All simulations were repeated with 3 different cloud condensation nuclei (CCN) concentrations. Results show a systematic decrease of total precipitation with increasing CCN for the cases with strong synoptic forcing (consistently for both the reference runs and the simulations with modified environmental conditions) due to a suppressed warm rain process. For the cases with weak synoptic forcing, however, there is no systematic behaviour of total precipitation despite a systematic dependance of the total cloud water, rain water, and ice. Possible reasons for this discrepancy like evaporation of rain drops at lower levels or feedbacks between stronger cold pools and initiation or intensification of secondary cells are discussed.