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Lightning climate prediction: Added value of convection permitting simulations

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Lightning climate predictions show large uncertainties caused by limited empirical knowledge and strong assumptions inherent to coarse-grid climate modelling. This study addresses this issue by implementing and applying the lightning potential index parameterisation (LPI) into a fine-grid (with a horizontal grid spacing of 2.8 km) convection-permitting regional climate model (CPM). This configuration takes advantage of the explicit representation of deep convection in CPM and allows for process motivated LPI inputs such as buoyancy, vertical velocity, and microphysical mixing. Our implementation of the LPI in the regional climate model COSMO-CLM successfully represents the lightning climatology (in central Germany) including its daily distribution, diurnal and annual cycles, and latitudinal gradient. In addition, the modelled temperature dependence of lightning reflects the observed dependence. With the CPM nested into a global climate projection simulated with the model EC-Earth assuming the RCP8.5 scenario, lightning flash rates are projected to decrease by the end of the 21st century. Even though the projected change favours large-scale circulation patterns with high lightning probability, changes in local processes (esp. less favourable microphysical mixing within convective clouds) reduce the number of lightning flashes. Coarse-grid models cannot represent the local processes sufficiently, and thus lightning prediction with CPMs is recommended.