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Can convection permitting simulations help to investigate the distribution of lightnings in a changing climate?

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Lightning plays a crucial role in the climate system. Not only may its energy impact the production of diverse atmospheric chemicals, but it is also a source of aerosol through the triggering of wildfires. While most theoretical frameworks agree on the main mechanism leading to lightning (i.e. charge separation during the mixed-phase cloud formation), it occurs on scales too small to be explicitly represented in current climate models.

The climate projections of lightning activity performed with these models are, therefore, based on parameterizations. While their implementations can differ significantly from each other, they all rely on theoretical or empirical relationships between the observed lightning activity and the modeled properties of the convective clouds. The calibration of these relationships often results in a good agreement with the observational datasets. However, when applied to climate projections, they result in a large spread which can notably be explained by the large uncertainty inherent to convection parameterizations.

The use of convection permitting models (CPMs) can circumvent this issue by representing more realistically updraft, cloud growth, and microphysical processes. While parameterizations are still needed to represent the electrification processes, their implementations can get closer to the theoretical framework. For example, the improved distribution of solid hydrometeors in convection permitting simulations compared to coarser simulations allows parameterizations to be mixed-phase-dependent. Still, the question remains, are CPMs able of modeling the electrification processes realistically and are they a potential source of added value for climate projections?

To answer these questions, the lightning potential index (LPI) was ported to the COSMO-CLM regional climate model. For the present-day climate the LPI provides a close-to-observed representation of flash rates in central Germany for all temporal scales. In addition, a detailed study assessing the impact of relevant physical processes on the representation of lightning provides a new light on its possible evolution in a warmer climate.