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Precipitation Cell Tracking in Convection-Resolving European-Scale Simulations

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The study of individual precipitation cells is relevant meteorologically, such as to asses the frequency of thunderstorms or the combined impact of many weak shower cells, as well as for modeling, for instance to improve parameterizations. Many studies focus on one of two aspects: either they address relatively large precipitation features originating from, e.g., mesoscale convective systems, which are long-lived and can thus be studied with temporal resolutions on the order of an hour, which allows to produce climatologies with manageable computational resources; or they track small-scale convective cells, but are restricted to individual cases or short periods, because the required temporal resolutions are on the order of minutes. In this study, we aim to bridge this gap by tracking precipitation cells of all sizes at minute resolution in a decadal kilometer-scale regional climate simulation over Europe.

Our goal is a ten-year climatology, which will be possible thanks to a novel approach to on-the-fly analysis. Right now, however, we are still restricted to a small number of multi-day case studies. Our simulations are conducted with a GPU-enabled version of the COSMO model at 2.2 km horizontal resolution (1542 x 1542 x 60 grid points). Deep convection is resolved explicitly, which vastly improves the representation of convective precipitation compared to models with parameterized deep convection, for instance regarding the diurnal cycle of summer precipitation or convective organization at cold fronts. The model domain includes most of Europe and the Mediterranean.

We define precipitation cells using a simple threshold criterion corresponding to a precipitation rate of 1 mm/h. Then we track the cells using a newly developed tracking algorithm suitable for high-resolution data. The tracking algorithm is based on a combination of spatial overlap and size comparison of features, and accounts for cell merging and splitting. The resulting tracks may be complex and non-linear, i.e. made up of multiple branches connected by merging and splitting events. Overly complex tracks, which might result from spurious overlap, can be split up using an objective splitting method.

We present results for two five-day case studies: a summer case with diurnal convection, and a winter case with a cyclone followed by extended cold advection with abundant showers. While our main objective is to study the precipitation cells from a meteorological point of view, we also analyze in detail the impact of temporal resolution and certain identification parameters on the resulting tracks, in order to strike the right balance between robust results and computational demand in anticipation of the upcoming ten-year analysis.