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Storm-tracking analysis of simulated thunderstorms in the Alpine region

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Thunderstorms are frequent warm-season phenomena in the Alpine region. Severe storms can produce significant damage through high winds, hail, and heavy precipitation and resulting flooding. Climate change is expected to affect thunderstorm properties, including their frequency and severity, in the future. However, significant uncertainty remains on these expected changes. In this study we test an object-based approach to characterise the properties of simulated thunderstorms. Our aim is to show the feasibility of a method that could be used to compare simulations of the current thunderstorm environment to simulated future climate scenarios in Switzerland and the Alpine region, and therefore to better understand the expected impacts of climate change on severe storms in these complex regions.

Simulations were produced using the Advanced Research Weather Research and Forecasting (ARW-WRF) weather model at convection-resolving resolution, for time periods within the convective season of 2018, and over a domain centred on Switzerland. Simulated radar reflectivity fields were processed using the well-established Thunderstorm Identification and Tracking And Nowcasting (TITAN) algorithm, such that the properties of individual thunderstorms, seen as areas of high reflectivity, were calculated and compiled. This object-based approach provides a statistical summary of the thunderstorm activity in the simulations, which can be compared to other simulations or observations while accounting for possible temporal or spatial mismatches in storm occurrence. While TITAN has been previously applied to WRF output, in this study we apply the method to an Alpine domain, and compared the results to thunderstorm properties derived from observations using an independent technique.

The properties of the simulated storms were compared to independent observations to test the ability of the simulations and storm tracker to characterise thunderstorms in the current climate. The observations used were a database of storm properties calculated independently by MeteoSwiss using their Thunderstorm Radar Tracker (TRT) applied to radar observations. TRT was developed specifically to track thunderstorms in the Alpine region. It takes full advantage of the high spatial and temporal resolution of MeteoSwiss' radar network, is well-tested, and has been proven to cope well with radar data issues encountered in regions with complex topography. These features make the TRT thunderstorm database a reliable reference dataset to which our simulation results can be compared. The match between simulated and observed storm properties was investigated in detail, and the results show that the they match closely enough to justify continuing use of TITAN on WRF output to characterise thunderstorms in simulated future climate scenarios.