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A Probabilistic Cell Tracking Algorithm

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The research described below was carried out during the EU-Project Lolight – development of a low cost, novel and accurate lightning mapping and thunderstorm (supercell) tracking system. The Project aims to develop a small-scale tracking method to determine and nowcast characteristic trajectories and velocities of convective cells and cell complexes. The results of the algorithm will provide a higher accuracy than current locating systems distributed on a coarse scale.

Input data for the developed algorithm are two temporally separated lightning density fields. Additionally a Monte Carlo method minimizing a cost function is utilizied which leads to a probabilistic forecast for the movement of thunderstorm cells. In the first step the correlation coefficients between the first and the second density field are computed. Hence, the first field is shifted by all shifting vectors which are physically allowed. The maximum length of each vector is determined by the maximum possible speed of thunderstorm cells and the difference in time for both density fields. To eliminate ambiguities in determination of directions and velocities, the so called Random Walker of the Monte Carlo process is used. Using this method a grid point is selected at random. Moreover, one vector out of all predefined shifting vectors is suggested - also at random but with a probability that is related to the correlation coefficient. If this exchange of shifting vectors reduces the cost function, the new direction and velocity are accepted. Otherwise it is discarded. This process is repeated until the change of cost functions falls below a defined threshold. The Monte Carlo run gives information about the percentage of accepted shifting vectors for all grid points. In the course of the forecast, amplifications of cell density are permitted. For this purpose, intensity changes between the investigated areas of both density fields are taken into account.

Knowing the direction and speed of thunderstorm cells is important for nowcasting. Therefore, the presented method is based on IC discharges which account for most lightning discharges and occur minutes before the first CG discharge. The cell tracking algorithm will be used as part of the integrated LoLight system.

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