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Rain cell-based identification of the vertical profile of reflectivity as observed by weather radar and its use for precipitation uncertainty estimation

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The wide scale implementation of weather radar systems over the last couple of decades has increased our understanding concerning spatio-temporal precipitation dynamics. However, the quantitative estimation of precipitation by these devices is affected by many sources of error. A very dominant source of error results from vertical variations in the hydrometeor size distribution known as the vertical profile of reflectivity (VPR). Since the height of the measurement as well as the beam volume increases with distance from the radar, for stratiform precipitation this results in a serious underestimation (overestimation) of the surface reflectivity while sampling within the snow (bright band) region.

This research presents a precipitation cell-based implementation to correct volumetric weather radar measurements for VPR effects. Using the properties of a flipping carpenter square, a contour-based identification technique was developed, which is able to identify and track precipitation cells in real time, distinguishing between convective, stratiform and undefined precipitation. For the latter two types of systems, for each individual cell, a physically plausible vertical profile of reflectivity is estimated using a Monte Carlo optimization method.

Since it can be expected that the VPR will vary within a given precipitation cell, a method was developed to take the uncertainty of the VPR estimate into account. As a result, we are able to estimate the amount of precipitation uncertainty as observed by weather radar due to VPR for a given precipitation type and storm cell. We demonstrate the possibilities of this technique for a number of winter precipitation systems observed within the Belgian Ardennes. For these systems, in general, the precipitation uncertainty estimate due to vertical reflectivity profile variations varies between 10-40%.