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Radar-based quantitative precipitation estimation (QPE) using concepts from information theory: Analysing the potential of data-based, dynamic Z-R relations, and investigating information losses from cloud to ground

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High-quality and high-resolution quantitative estimates of ground precipitation (QPE) are an important prerequisite of hydrological simulation and prediction. Weather radar data have a large potential to contribute to QPE due to their high space-time resolution. However, due to the strongly non-linear and time-variant relation of observed radar reflectivity factor Z, typically measured at height, and the ground rainfall rate of interest R, this potential is not straightforwardly exploited.

Applying a data-based approach in an information-theoretic framework, the work presented here has three major aspects: Firstly, the potential of applying a purely data-based and probabilistic Z-R relation instead of the standard functional form of a power-law relation is analyzed. Applying a probabilistic relation has the benefit to provide joint estimates of R and the related estimation uncertainty. Secondly, we test the potential of various operationally available observables such as the large-scale Circulation Pattern (CP), convective and other meteorological indices like the convective available potential energy (CAPE), ground meteorological variables (relative humidity, air temperature, wind speed and direction) and season indicators to distinguish typical time-variant Z-R relationships. The idea here is to improve QPE by applying specific Z-R relationships conditional on the current hydro-meteorological situation expressed by the predictors. Thirdly, we use a comprehensive data set from four years of 1-h data available from a C-band weather radar, two vertical micro rain radars (MRR), six disdrometers and six rain gauges set up in the 250 km^2 catchment of the Attert, Luxembourg to evaluate the amount and losses of information about ground rainfall along the pathway of precipitation observation: We start with Z measured by radar at height, continue with Z measured by MRR along a vertical profile in the atmosphere and end with Z observed by disdrometer measured directly at the ground. Knowing where along this path the main losses of information occur can help to design better observation strategies in the future.