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Analyzing and modeling complex weather radar data with data-driven approaches

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In the field of radar hydrology the utilization of data-driven models seems promising because the data volume produced by weather radar networks is considerably large. Reams of gigabytes of data are stored in the archives. However, these complex datasets are not easy to investigate. Data-driven approaches aim to extract and model patterns and regularities that are hidden in the datasets.

This study presents data-driven models for three aspects of radar hydrology: data analysis, rainfall-runoff prediction, and radar rainfall estimation. The Principle Component Analysis (PCA) has been used to capture the essence in weather radar measurements and to provide methods for describing patterns in the spatial radar data. For this analysis, volumes that are scanned concurrently by two radar stations of the Austrian weather radar network were used for plausibility reasons.

Artificial Neural Networks (ANNs) were applied to predict the runoff of a small Alpine catchment. Several input configurations and network architectures were investigated. The models were trained on various lead times and the ANNs consistently perform better than simpler approaches like Model Trees (MTs) applied on the same dataset. When forecasting three time steps ahead, the ANN model reaches an efficiency coefficient of 97.4 % compared to 90.9 % of the MT.

Data-driven models were also used to improve weather radar estimates of rainfall. By means of ANNs the radar reflectivity Z above a rain gauge was mapped to the rain rate R on the ground. The so modeled relationship was tested on a different location. The deviations could be decreased and the correlation coefficient increased compared to applying the standard $Z-R$ relationship. The relative improvements range from 7 to 34 % depending on model and performance measure. The measures are even better than the $Z-R$ relationship retrospectively optimized for this very location.