DeepPrecip: A deep neural network for retrievals of precipitation

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Abstract

Remotely-sensed vertical radar reflectivity profiles of the lower atmosphere can be linked to precipitation through empirical power-law relationships at high spatiotemporal frequency. These relationships are tightly coupled to particle phase, shape, size and density, which contributes to uncertainty and error when applied to unseen data. In this work, we develop an alternative precipitation retrieval using a deep convolutional multilayer perceptron (DeepPrecip), to estimate surface precipitation from eight measurement sites across the northern hemisphere. Using a combination of K-band micro-rain radar (MRR) retrievals up to 3 km, surface meteorology observations, and ERA-5 atmospheric data, a total of $N = (60307 \times 45)$ data points spanning 2012 to 2020 are used to train DeepPrecip against collocated 20-minute-average in situ precipitation accumulation records. DeepPrecip displays strong predictive skill on unseen data and is able to accurately model snowfall with a mean square error (MSE) of 1.3×10^{-4} mm, rainfall with a MSE of 1.2×10^{-4} mm, and displays positive Pearson correlations of $r \approx 0.64$. These MSE values are $\approx 170\%$ lower, on average, than current commonly used methods. We find that both near-surface and top-of-profile radar observations provide the most important information contributing to model skill. These results highlight the value of the relative structure of the full vertical column in contributing to improved retrieval accuracy. DeepPrecip also displays skill in capturing changes in precipitation magnitude across different sites/climates, and over multiple seasons; without explicit descriptions of precipitating particle microphysics or geospatial covariates being provided to the model. This research reveals the important role for deep learning in extracting predictive information about precipitation from radar retrievals.