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A Deep Learning Method for Short-Range Point Forecasts of Wind Speed

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In this study, we present a deep learning-based method to provide short-range point-forecasts (1-2 days ahead) of the 10-meter wind speed for complex terrain. Gridded data with different horizontal resolutions from numeric weather prediction (NWP) models, gridded observations, and point data are used. An artificial neural network (ANN), able to process several differently structured inputs simultaneously, is developed.
The heterogeneous structure of inputs is targeted by the ANN by combining convolutional, long-short-term-memory (LSTM), fully connected (FC) layers, and others within a common network. Convolutional layers efficiently solve image processing tasks, however, they are applicable to any gridded data source. An LSTM layer models recurrent steps in the ANN and is, thus, useful for time-series, such as meteorological observations. Further key objectives of this research are to consider different spatial and temporal resolutions and different topographic characteristics of the selected sites.

Data from the Austrian TAWES system (Teilautomatische Wetterstationen, meteorological observations in 10-minute intervals), INCA's (Integrated Nowcasting through Comprehensive Analysis) gridded observation fields, and NWP data from the ECMWF IFS (European Center for Medium-Range Weather Forecast's Integrated Forecasting System) model are used in this study. Hourly runs for 12 test locations (selected TAWES sites representing different topographic characteristics in Austria) and different seasons are conducted.

The ANN's results yield, in general, high forecast-skills (MAE=1.13 m/s, RMSE=1.72 m/s), indicating a successful learning based on the used training data. Different combinations of the number of input field grid points were investigated centering around the target sites. It is shown that a small number of ECMWF IFS grid Points (e.g.: 5x5 grid points) and a higher number of INCA grid points (e.g.: 15x15) resulted in the best performing forecasts. The different number of grid points is directly related to the models' resolution. However, keeping the nowcasting-range in mind, it is shown that adding NWP data does not increase the model performance. Thus, for nowcasting a stronger weighting towards the observations is important. Beyond the nowcasting range, the deep learning-based ANN model outperforms the more basic machine learning algorithms as well as other alternative models.