EMS Annual Meeting Abstracts
Vol. 16, EMS2019-79, 2019

Short-Range Wind Speed Forecasts by Convolutional Neural Networks

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Due to Austria's complex terrain, it is still challenging to provide reliable wind forecasts which are required for a wide range of applications (e.g.: wind speed and power forecasts for wind farms, wind speed forecasts for aviation and transport, and other costumer services). Current approaches involve classical statistical methods (e.g., based on regression), numerical weather prediction models (NWPs) and rapid update cycle models (RUC) which are faster than NWPs but still computationally expensive. Machine learning and deep learning turned out beneficial in several meteorological forecasting skills – particularly, artificial neural networks in conjunction with meta-heuristics were already successfully applied to applications in weather forecasting. Convolutional neural networks, a special type of artificial neural network (ANN) often used in image processing tasks, turned out to work well in precipitation forecasts. In a previous work we successfully applied a simple feed forward artificial neural network for wind speed forecasts and here address gridded input data by a convolutional neural network architecture (CNN).

We aim to to predict wind speed in 10 meters height for the nowcasting and short-range for a particular location by a computational efficient machine learning methodology. In particular, we employ convolutional neural networks (CNNs) to combine several meteorological parameters of gridded data of high-resolution numeric weather prediction models and observation data of weather stations in Austria. A suitable selection of meteorological input features, spatial and temporal dimension of the input, and a reasonable setup of the CNN's network architecture is investigated. All shown methods are implemented efficiently and still able to give fast forecasts. We implement different CNN based network architectures for this problem including two dimensional convolutional layers, three dimensional convolutional layers, and a combination of convolutional layers with fully connected layers.

To achieve good performance we conduct computational experiments with our developed methodology using a Python based frontend and compiled backend on a GPGPU/multi-core shared memory machine in a Linux environment. We work with data from the Austrian TAWES system (Teilautomatische Wetterstationen, TAWES, meteorological observations in 10 minute intervals) and use high resolution NWP data from the AROME model (computed every three hours, hourly forecasts for 48 hours, 2.5 km grid resolution). We give forecasts on a specified test episode each day and hour in our test episode for selected observation sites. We validate them by statistical scores (e.g.: mean absolute error, correlation etc.) and compare our results with alternative statistical models and the input models.