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Using Recurrent Neural Network to Improve Forecasting of Fog and Visibility

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Low-visibility conditions heavily influence aviation, navigation and urban road traffic. Accurate visibility forecasting is difficult due to its highly non-linear features. Artificial Neural Network (ANN) such as Back Propagation Neural Network (BPNN) were used to try to solve this problem and some effect was obtained. With the rapid development of mathematics and computer technology, some novel neural networks are proposed, developed and known as deep learning. Deep learning, which can extract a high-level representation of raw data, has been widely used to deal with non-linear problems in various fields. Recurrent Neural Network (RNN) is one of the deep learning architectures where connections between nodes form a directed graph along a sequence. This allows it to exhibit temporal dynamic behavior for a time sequence and use their internal state to process sequences of inputs. The present study builds statistical models for nowcasting of fog and visibility, which is based on the Long Short-Term Memory Recurrent Neural Network (LSTM-RNN) and the surface observational data at Fuzhou weather station (119.3E°,36.1N°). The observational data is sampled every 5 minutes and is from January 2016 to August 2018. The predictor variables include wind speed, wind direction, surface pressure, temperature, dew point temperature, precipitation and visibility. All the predictor variables were reframed as a 12-hour time series with 5-minute intervals for the input data. The dataset was composed of 200000 samples, randomly divided into a training set (160000) and a testing set (40000) for model building and validation. The forecasting results were evaluated using mean absolute error (MAE), root mean square error (RMSE) and equitable threat score (ETS), and were compared with results from the BPNN. The experimental results show that the prediction errors are significantly reduced using the LSTM-RNN compared with the BPNN, especially in the forecasting of low visibility events such as fog. The variation tendency of visibility predicted by our model is basically in conformity with the measured data, indicating that LSTM-RNN is effective for accurate visibility nowcasting. The present study provides a new solution for the forecast of meteorological elements that are highly non-linear.