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Topic of Research: Development of Artificial Neural Network Based Air Quality Prediction Model for Sub-Tropical Semi-arid (Steppe) Climate of Delhi.

FINDINGS

Fine Particulate matter ($PM_{2.5}$) remains one of the most dominant contributors to air pollution in Delhi and its acute or chronic exposures have exerted serious health implications. An accurate and reliable $PM_{2.5}$ forecasting model is needed to improve the public awareness towards $PM_{2.5}$ pollution events and also to assist vulnerable population groups in accessing useful information that would enable them to limit their exposure time. Therefore, in the present study, ANN based $PM_{2.5}$ forecasting models (Multi layer Feed Forward Neural Network and Long Short-Term Memory Network) have been developed on the inputs of classical air quality and meteorological parameters. In addition, a novel parameter such as Aerodynamic roughness coefficient (Z_0) has been computed using the logarithmic wind profile equation and applied as an input for the ANN based forecasting models. The study compares the performances of these ANN based models with other Machine learning (ML) models (Support Vector Machine, Random Forest and Gaussian Process Regression) in forecasting $PM_{2.5}$ concentrations. Daily averaged air quality and meteorological data with 731 observations, in a two year period (i.e., 2015-2016), recorded at R K Puram and Safdarjung airport have been collected from Delhi Pollution Control Committee (DPCC) and Indian Meteorological Department (IMD) for the model development.

A large fraction of this collected data is used for training the model i.e., 80%, and the remaining 20% is used for the testing operation. Based on the Min-Max normalization technique this distributed data has been preprocessed and prepared for the model development. The MLFFNN model is developed on the basis of Levenburg Marquardt algorithm with a topology 19-20-10-1.

The number of epochs has been fixed at 1800 with a learning rate 0.1 for training. Moreover, the LSTM model is built using tanh and sigmoid as state and gate activation functions. The number of epochs has been fixed as 350 with a learning rate of 0.1 and a momentum of 0.9 for training. The results for the MLFFFNN indicate that the model is suited to forecast $PM_{2.5}$ concentrations with high NSE, IA, R^2 and R values of 0.883 and 0.825, 0.965 and 0.948, 0.898 and 0.831, 0.948 and 0.912, and low RMSE values of 31.13 and 38.367 during both training and testing stages, respectively. The LSTM model also presents better performance in both training and testing stages with a NSE, RMSE, IA, R^2 and R values of 0.928, 24.389, 0.981, 0.928 and 0.964, and 0.885, 31.052, 0.969, 0.887 and 0.942, respectively. The results for the residual error analysis clearly indicate that the LSTM model presents the highest prediction accuracy with the lowest residual error range during both training and testing phases. Lastly, the sensitivity analysis of the best performing model i.e., LSTM model suggests that PM_{10}, wind speed, NH_3 and Z_0 are the most influential parameters in $PM_{2.5}$ forecasting. The study concludes that ANN model (LSTM) outperforms the other models in $PM_{2.5}$ forecasting and is the best modeling approach for studying high Particulate matter (PM) pollution incidents.