Development of Post-processing for Chemical Weather Forecasting Using Machine Learning Method

Principal Investigator: Keiya YUMIMOTO
Institution: Research Institute for Applied Mechanics, Kyushu University
6-1 Kasuga Park, Kasuga 816-8580, Fukuoka, JAPAN
Tel: +81-92-583-7772 / Fax: +81-92-583-7774
E-mail: yumimoto@riam.kyushu-u.ac.jp
Cooperated by: Central Research Institute of Electric Power Industry

[Abstract]

Key Words: Machine learning, PM2.5, Photochemical oxidant, Guidance, Air pollution forecasting system, big data, Atmospheric Environmental Regional Observation System

The National Institute for Environmental Studies (NIES) operates an air pollution forecasting system (VENUS) to call for early warning of photochemical oxidants and PM2.5, thereby contributing to reducing their impact on social life and health. This air pollution forecasting is increasingly recognized as an important part of the social infrastructure against the backdrop of public concern over health effects. However, its forecasting accuracy is not quantitatively sufficient. In this project, we applied machine learning techniques to develop a post-process (guidance) that corrects the prediction results of the air pollution forecasting system by learning from observation data accumulated by Atmospheric Environmental Regional Observation System (AEROS).
The guidance was constructed by training a multilayer neural network using four years of observed data from 2013-2016 as teacher data. Forecasting experiments were conducted for the year 2017, which is outside the training period, to quantitatively evaluate changes in forecast accuracy using the constructed guidance. The guidance was constructed for PM2.5 and photochemical oxidant concentration forecasts and was performed for five cities across Japan. In addition, a chemical transport model and calculation setups identical with those used in VENUS were employed to develop the system for implementation in VENUS.
For PM2.5 concentration forecast, the determination coefficient increased by 27.4-48.6% and the mean squared error decreased by 22.8-49.5%. Validation using the model performance criteria proposed by Boylan and Russell (2006) showed that the application of the guidance achieved the model performance goal in all five cities.
For photochemical oxidant concentrations, the determination coefficient increased by 7.5-14.3% and the mean squared error decreased by 39.1-59.8%. Normalized mean bias and mean fractional bias, which measure deviations between observation and forecast, decreased by 86.8-96.8% and 51.6-96.5%, respectively. Validation using the model performance criteria proposed by Emery et al. (2017) showed that the application of the guidance achieved the model performance criteria in all five cities. These results indicate that the guidance method developed in this study is effective in improving the prediction accuracy of PM2.5 and photochemical oxidant concentrations.