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Postprocessing of numerical forecasts of ground-level ozone and particulate matter concentrations in the Moscow region using machine learning models

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Concentrations of ground-level ozone (O_3) and particulate matter (PM_{10}) are priority indicators for air quality assessment according to the World Health Organization [1]. Modern air quality forecasting is based on chemical transport models (CTM) calculations. Verification of CTM's forecasts is performed using measurement data from automatic air pollution monitoring stations. To improve the quality of forecasts, researchers adjust CTM parameterizations, initial data (pre-processing), and use statistical post-processing methods [2]. Of particular relevance are concentration forecasts for periods of unfavorable meteorological conditions for pollution dispersion (UMC) [3].

A new tool for post-processing of CTM's forecasts has been developed based on artificial neural networks (ANN). The ANN training is aimed at minimizing deviation of concentration forecast from measurement. The training set is formed using hourly forecasts of concentrations, meteorological parameters and land use data, and the target variable is hourly measurements of concentrations in the corresponding grid cells. Measurements at all stations in the region are used in the training set. Two machine learning models have been developed for post-processing of O_3 (MLM-O_3) and PM_{10} (MLM-PM_{10}) numerical forecasts.

Verification on an independent test sets demonstrated the justification of use of the developed MLMs. The deviations of forecasts from measurements have been significantly reduced by 12-43% for O_3 concentrations and by 25-62% for PM_{10}. Forecasting of daily concentrations variability is also significantly improved: correlation coefficients between hourly O_3 forecasts and measurements increased from 0.5 (CTM) to 0.7–0.9, PM_{10} from 0.1–0.2 (CTM) to 0.4–0.6. The developed MLM-O_3 and MLM-PM_{10} can be used to improve CTM's forecasts for periods of high concentrations under UMC. There is demonstration of the efficiency of post-processing using MLMs of O_3 and PM_{10} forecasts in grid cells where there are no concentration measurements. The results of applying the developed MLMs to the CTM's forecast fields of O_3 and PM_{10} concentrations for the Moscow region are presented.

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