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Short-term pollution forecasts based on linear and nonlinear methods of time series analysis

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Urban air pollution is a complex mixture of toxic components, which may induce acute and chronic responses from sensitive groups, such as children and people with previous heart and respiratory insufficiencies.
However, air pollution, presents a highly chaotic and non-linear behavior.
In this work we analyzed several pollutants time series recorded in the urban area of Lisbon (Portugal) for the 2002-2006 period. Linear and nonlinear methods were applied in order to assess NO_2, PM10 and O_3 main trends and fluctuations and finally, to produce daily forecasts of the referred pollutants. Here we evaluate the potential of linear and non-linear neural networks (NN) to produce short-term forecasts, and also the contribution of meteorological variables (daily mean temperature, radiation, wind speed and direction, boundary layer height, humidity) to pollutants dispersion. Additionally, we assess the role of large-scale circulation patterns, usually referred as Weather types (WT) (from the ERA40/ECMWF and ECMWF SLP database) towards the occurrence of critical pollution events identified previously.
The presence and importance of trends and fluctuation is addressed by means of two modelling approaches: (1) raw data modelling; (2) residuals modelling (after the removal of the trends from the original data). The relative importance of two periodic components, the weekly and the monthly cycles, is addressed. For the three pollutants, the approach based on the removal of the weekly cycle presents the best results, comparatively to the removal of the monthly cycle or to the use of the raw data.
The best predictors are chosen independently for each monitoring station and pollutant through an objective procedure (backward stepwise regression). The analysis reveals that the most significant variables in predicting NO_2 concentration are several NO_2 measures, wind direction and speed and global radiation, while for O_3 correspond to several O_3 measures, O_3 precursors and WT classification. Finally, for PM10, several PM10 measures, NO_2 and CO, maximum temperature, wind direction, humidity and BLH, i.e. pollutants related to road traffic emissions and meteorological variables related to atmospheric stability.
Moreover, validation results showed that non-linear NN models, on average, perform as well or worse as linear models for NO_2, O_3 and PM10. The results attained with an independent sample reveal a very good correlation between the predicted and observed values which confirms that linear models generalize well for independent data.
The applied methods permit producing, in a simple and cost efficient way, different results for each monitoring station, which allows a good spatial resolution for Lisbon's urban area. Consistent with the performance measures, high pollutants' peak values were reproduced in most cases by each model. The attained results raises good prospects for urban air quality characterization, allowing further developments in order to produce an integrated air quality surveillance system for the area of Lisbon.