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Space-Time Urban Air Pollution Forecasts

A. Russo (1), R.M. Trigo (1), and A. Soares (2)

(1) IDL, Lisbon, Centro de Geofísica da Universidade de Lisboa, Lisbon, Portugal (arusso@fc.ul.pt), (2) CERENA, Instituto Superior Técnico, Lisbon, Portugal

Air pollution, like other natural phenomena, may be considered a space-time process. However, the simultaneous integration of time and space is not an easy task to perform, due to the existence of different uncertainties levels and data characteristics.

In this work we propose a hybrid method that combines geostatistical and neural models to analyze PM10 time series recorded in the urban area of Lisbon (Portugal) for the 2002-2006 period and to produce forecasts. Geostatistical models have been widely used to characterize air pollution in urban areas, where the pollutant sources are considered diffuse, and also to industrial areas with localized emission sources. It should be stressed however that most geostatistical models correspond basically to an interpolation methodology (estimation, simulation) of a set of variables in a spatial or space-time domain. The temporal prediction of a pollutant usually requires knowledge of the main trends and complex patterns of physical dispersion phenomenon. To deal with low resolution problems and to enhance reliability of predictions, an approach based on neural network short term predictions in the monitoring stations which behave as a local conditioner to a fine grid stochastic simulation model is presented here.

After the pollutant concentration is predicted for a given time period at the monitoring stations, we can use the local conditional distributions of observed values, given the predicted value for that period, to perform the spatial simulations for the entire area and consequently evaluate the spatial uncertainty of pollutant concentration. To attain this objective, we propose the use of direct sequential simulations with local distributions. With this approach one succeed to predict the space-time distribution of pollutant concentration that accounts for the time prediction uncertainty (reflecting the neural networks efficiency at each local monitoring station) and the spatial uncertainty as revealed by the spatial variograms.

The dataset used consists of PM10 concentrations recorded hourly by 12 monitoring stations within the Lisbon's area, for the period 2002-2006. In addition, meteorological data recorded at 3 monitoring stations and boundary layer height (BLH) daily values from the ECMWF (European Centre for Medium Weather Forecast), ERA Interim, were also used. Based on the large-scale standard pressure fields from the ERA40/ECMWF, prevailing circulation patterns at regional scale where determined and used on the construction of the models.

After the daily forecasts were produced, the difference between the average maps based on real observations and predicted values were determined and the model's performance was assessed. Based on the analysis of the results, we conclude that the proposed approach shows to be a very promising alternative for urban air quality characterization because of its good results and simplicity of application.