AIR QUALITY FORECASTING BY STATISTICAL METHODS: MODEL EVALUATION FOR LISBON AND OPORTO

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INTRODUCTION

As stated in the ANNEX XVI of the Directive 2008/50/EC, regarding public information, *"Member States shall ensure that timely information about actual or predicted exceedances of alert thresholds, and any information threshold is provided to the public. Details supplied shall include at least the following information: (a) information on observed exceedance(s); (b) forecast for the following afternoon/day(s); (c) information on the type of population concerned, possible health effects and recommended behaviour; (d) information on preventive action to reduce pollution and/or exposure to it: indication of main source sectors; recommendations for action to reduce emissions; (e) in the case of predicted exceedances, Member State shall take steps to ensure that such details are supplied to the extent practicable."*

The above citation was already present in the Annex 2 of previous Directive 2002/3/EC on air quality. Along with high ozone and particulate matter levels registered in Portugal, sometimes exceeding the legal limit values established by European legislation (Directive 2008/50/EC), the motivation for the PREVQUALAR project was more than justified. This project aims to forecast the air quality index (AQI) for Portuguese zones and agglomerations of air quality assessment and management. This index is calculated based on the statistical forecast of air pollutants concentrations, subsequently converted in indexes for each PM10 and O_3 pollutants. The global AQI is given by the contribution of the worst pollutant index. The project involves the collaboration between the Portuguese Environment Agency (APA), the Portuguese Meteorological Institute (IM) and the Faculty of Sciences and Technology of New University of Lisbon (FCT/UNL). The present work regards the evaluation of the statistical models developed by the FCT/UNL, operating since 2006 over Lisbon and Oporto.

METHODOLOGY

In the last years, a statistical approach, based on Classification and Regression Trees (CART) and Multiple Regression (MR) analysis, first used by Casmassi (1987), has been systematically used and improved in order to develop local forecast regression models. These models use daily concentrations of the atmospheric pollutants and the local meteorological conditions. Broadly, the developed forecast models include surface meteorological information at noon, maximum temperature, relative humidity data, and their daily variation. It is also considered the pressure gradient between Lisbon or Oporto, depending on the region of the model, and the pressure measured at the meteorological stations representative of the nearby districts at noon. Regarding information on altitude (delivered by the forecast of the European Centre for Medium-Range Weather Forecasts), the model takes into account maximum value of the boundary layer mixing height, base and thickness of the inversion layer, temperature and relative humidity at pressure levels of 925, 850 and 700 hPa, and geopotential height at 1000, 850, 700 and 500 hPa. Concerning air quality inputs, they are, if available, daily averages of PM10, NO_2 and SO_2 for the previous 24 hours of the forecast time deliver; daily O_3 maximum of the hourly data and octo-hourly moving averages; and maximum octo-hourly moving averages of CO. Finally, a flag for week and weekend day is introduced.

The time frame for the model development was 2001 – 2002 for greater robustness of the data base (previous studies were performed between 1998 2002 and were important for gathering knowledge, but data gaps were very expressive).

The models allowed forecasting the average daily concentrations for particulate matter (PM10) and average maximum hourly ozone levels (O_3). Based on these concentrations an AQI is established and the forecast daily delivered around 16H00 UTC. The described methodology was used to develop regression models for 11 air quality stations in the metropolitan area of Lisbon and 13 in the metropolitan area of Oporto.

RESULTS AND DISCUSSION

Observed and predicted daily mean concentrations, for each pollutant, were obtained as the average of the metropolitan area sets of regression models, for the 2006-2010 period.

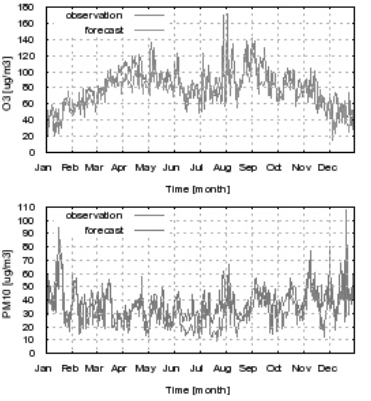

Fig. 1.- Observed and predicted O_3 (top) and PM10 (bottom) mean concentrations in Lisbon 2007.

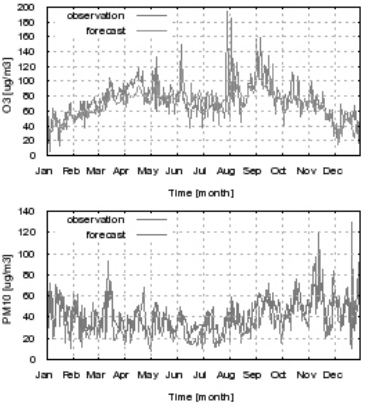

Fig. 2.- Observed and predicted O_3 (top) and PM10 (bottom) mean concentrations in Oporto 2007.

The results obtained for the year 2007 show (Figure 1 for Lisbon and Figure 2 for Oporto) a good agreement between the forecasted and measured concentrations as shown in previous studies Ferreira et al (2000) and (2004), Marques et al (2006).

A first analysis of the Figures 1 and 2 seems to indicate that the persistence of chemical species concentrations has a major contribution on the statistical model of both regions.

However, it is of paramount importance to understand the reason why the statistical model does not perform well, to act on it and modify it, in order to get better results. Hence, an evaluation of the individual air quality station contributing to each pollutant index was attempted for the period between 2006 2010, over both metropolitan areas. As expected, results show (Figure 3) a local variability over each agglomeration region regarding ozone. Except for Loures air quality station, AQI hit rate over the Lisbon stations are higher than 75 %.

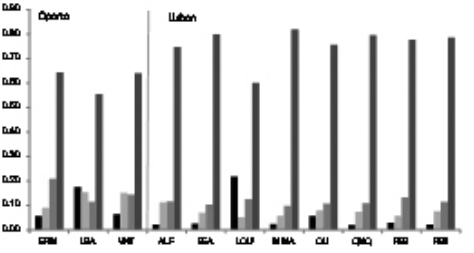

Fig. 3.- Hit rates, under and overestimated of the AQI for ozone over Lisbon and Oporto air quality stations considered in the statistical forecast models.

Lower hit rates are associated with air quality stations with high missing data. When the AQI between the models forecast and the observed are not paired, the Lisbon region tends to be underestimated by the AQI while for Oporto the opposite trend occurs.

REFERENCES

• Casmassi, J. (1987): Development of an objective ozone forecast model for the south coast air basin. 80th Annual Meeting of APCA (The Association Dedicated to Air Pollution Control and Hazardous waste Management). New York – June 21-26, 1987

• Directive 2008/50/EC of the European Parliament and of The Council of 21 May 2008 on ambient air quality and cleaner air for Europe.

• Ferreira, F., Tente, H., P., Cardoso, S. & Palma-Oliveira, J.M. (2000): Air Quality Monitoring and Management in Lisbon, Environmental Monitoring and Assessment 2000, 65, pp. 443-450.

• Ferreira, F., Torres, P., Neto, J. & Tente, H. (2004): Ozone Levels in Portugal: the Lisbon Region Assessment. In Proceeding of Air & Waste Management's 97th Annual Conference & Exhibition. June 22-25, 2004, Indianapolis, Indiana. CD-ROM, pp. 18.

• Marques, F., Cassmassi, J., Ferreira, F., Mesquita, S. (2006). Air quality forecast for Lisbon, Portugal: from data analysis to outreach., 2006 National Air Quality Conferences: Air Quality Forecasting, Mapping, and Monitoring and Communicating Air Quality and Communities in Motion "Quality of Air Means Quality of Life", February 5-8, 2006, San Antonio, Texas.