

Urban Mobility and Atmospheric Pollution within the Torino Metropolitan Area ¹

Mobilità Urbana e Inquinamento Atmosferico nell'Area Urbana Torinese

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Riassunto: Questo lavoro studia le relazioni tra il traffico veicolare, l'inquinamento atmosferico da monossido di carbonio e le principali grandezze meteorologiche nella città di Torino per l'anno 2004. Vengono descritti i risultati preliminari di un modello di regressione che analizza la dinamica spazio temporale del fenomeno.

Keywords: Urban area, vehicular traffic, CO concentration, spatio-temporal analysis.

1. Introduction and data description

In this work a model based approach is used to consider the joint effect of traffic and meteorology on Carbon Monoxide (CO) concentration for the case study of Torino urban area for the year 2004.

Used traffic data are collected in 35 sites, normally related to important crossroads spread throughout the city area. Original data are provided in 5 minutes step measurements and are aggregated hourly; complete data set involves about 500 loops aggregated by the same source with an average hourly reliability of 87 % for the whole year. Selection of the working locations is a delicate and timeconsuming issue, thus all the locations having less than 80 % of available data for the all source loops have been discarded. Finally the missing data problem has been solved using a time series regression based on a set of significantly dummy temporal variables. CO concentrations are measured hourly by four stations, while the meteorological variables (wind speed, air temperature, relative humidity and pressure) are given hourly by one station referred to the whole city.

2. Some preliminary results

Regression models considering traffic and meteorology related to air pollutants concentration has been tackled, for instance, by Aldrin and Hobæk Haff (2005) and Mendola

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(2003). The former study uses generalised additive models and generalised estimating equations (GEE) for five pollutants and four different locations in Oslo urban area, where traffic loops and pollutant stations are displaced. The resulting models still have correlated residuals and the squared correlation coefficients are on average around 0.6. The latter study particularly refers to traffic regulation management and proposes two methods: one for pulse regulation and the other for long time period. In the first case a GEE model with dummy variables is proposed, in the second case a multiplicative seasonal ARMAX is used.

This work starts from similar bases moving toward a spatio-temporal approach in order to find out a general description of the pollution variation over the whole urban area. As first step only the spatial traffic behavior is analysed. Using the principal component method the 35 locations have been well-described through six components on the basis of the explained variance: the first component explains the 95 % and at the sixth the 98 % of the total variance. It is interesting to note that the first component is the traffic common factor while the remaining ones are generally defined by the main streets of the city or explain the temporal traffic dynamic (e.g. the second component is positively correlated particularly with two specific avenues, *C.si Regina M.*, *M. D’Azeglio* while the third one explains the weekly trend).

Then for each CO station we have implemented some linear regressive models of this sort $z(s_i, h) = \alpha_0 + \alpha_1 z(s_i, h - 1) + \alpha_{24} z(s_i, h - 24) + \beta X(h) + \gamma P(h) + \varepsilon(h)$, where $z(s_i, h)$ is the measured CO level at site s_i and at hour h ($i = 1, \dots, 4$; $h = 1, \dots, 8784$), $X(h)$ and $P(h)$ are respectively the vectors of the meteorological covariates and of the six principal components at hour h . All the parameter estimates obtained for the four models are significantly different from 0; the residuals $\varepsilon(h)$ are uncorrelated in time and reasonably normally distributed even if with a Kurtosis coefficient around 5. This preliminary analysis shows that traffic and meteorology together explain on average around 60% of CO concentration variability; the autoregressive components improve model fitting close to 90% reducing residual autocorrelation to white noise. Moreover the correlations calculated between the four residual series show a relationship which could depend on the euclidean distance between the CO stations. For these reasons the model will be extended using a hierarchical structure that, as well exposed in Wikle (2003), is particularly useful for complex environmental phenomena affected by many sources of variability and for observed data characterized by measurement errors and missing data problems. For example, a state-space approach similar to the one proposed in Fassò *et al.* (2007) could be suitable, introducing hidden processes for modeling the “real” unobserved traffic and CO levels and spatial autocorrelated errors for considering their relationship.

References

- Aldrin A. and Hobæk Haff I. (2005) Generalised additive modeling of air pollution, traffic volume and meteorology, *Atmospheric Environment*, 39, 2145–2155.
- Fassò A., Cameletti M. and Nicolis O. (2007) Air quality monitoring using heterogeneous networks, *Environmetrics*, 18, 3.
- Mendola D. (2003) Road traffic restrictions and air pollution in an urban area. A case study in Palermo., *Working Paper GRASPA n. 16*, www.graspa.org.
- Wikle C.K. (2003) Hierarchical models in environmental science, *International Statistical Review*, 71, 181–199.