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The role of local urban traffic and meteorological conditions in air pollution: A data-based case study in Madrid, Spain

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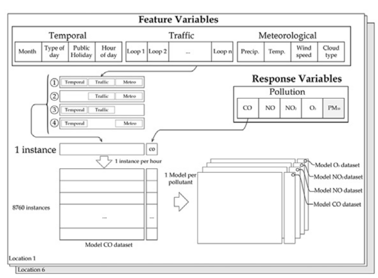
HIGHLIGHTS

- We present a data-based method to inspect the interplay among traffic, meteorological conditions and pollution in Madrid.
- We examine the coupling between traffic, meteorological features and different pollutants over districts of this city.
- Background pollution is found to be scarcely influenced by local traffic emissions.

GRAPHICAL ABSTRACT



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ABSTRACT

Urban air pollution is a matter of growing concern for both public administrations and citizens. Road traffic is one of the main sources of air pollutants, though topography characteristics and meteorological conditions can make pollution levels increase or diminish dramatically. In this context an upsurge of research has been conducted towards functionally linking variables of such domains to measured pollution data, with studies dealing with up to one-hour resolution meteorological data. However, the majority of such reported contributions do not deal with traffic data or, at most, simulate traffic conditions jointly with the consideration of different topographical features. The aim of this study is to further explore this relationship by using high-resolution real traffic data. This paper describes a methodology based on the construction of regression models to predict levels of different pollutants (i.e. CO, NO, NO_2, O_3 and PM_{10}) based on traffic data and meteorological conditions, from which an estimation of the predictive relevance (*importance*) of each utilized feature can be estimated by virtue of their particular training procedure. The study was made with one hour resolution meteorological, traffic and pollution historic data in roadside and background locations of the city of Madrid (Spain) captured over 2015. The obtained results reveal that the impact of vehicular emissions on the pollution levels is overshadowed by the effects of stable meteorological conditions of this city.

1. Introduction and related work

Madrid is the capital city of Spain, with 3.1 million inhabitants and a densely populated urban area (5225 inh/km^2) situated at an

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elevation of 667 m over the sea level. As shown in Fig. 1, the star-shaped design of the Spanish road network makes Madrid the central transport hub of the entire country. This fact, combined with the 4.2 million registered vehicles in the region, yields a heavy traffic supporting metropolis undergoing severe congestion issues through its road network. As a consequence of this, road traffic is widely acknowledged as the main source of air pollutants in Madrid (Informe de calidad y evaluación Ambiental, 2012). In quantitative terms, NO_x and CO emissions are related to traffic in more than 80% in the city (Monzón and Guerrero, 2004), 48% of PM_{10} mass was proven to be contributed by vehicle emissions (Salvador et al., 2004), and 65% of tropospheric O_3 formation is on account of traffic-related precursors (Valverde et al., 2016). This close relationship between traffic and pollution comes along with severe health implications: indeed, worldwide epidemiological and toxicological studies have linked these traffic related pollutants to respiratory issues (Brauer et al., 2002; Zuurbier et al., 2011), cardiovascular health effects (Hoek et al., 2013) and lung cancer risk (Raaschou-Nielsen et al., 2011). In 2013, the specialized cancer agency of the World Health Organization – the International Agency for Research on Cancer (IARC) – announced that outdoor air pollution has been officially classified as an carcinogenic agent for humans (Group 1) (IARC, 2013).

Even though the number or vehicles has increased significantly over the last two decades (DGT, 2012), levels of NO, NO_2, CO and PM_{10} have featured a decreasing trend in Madrid (Salvador et al., 2015) as a result of the pollution abatement policies promoted by the European Parliament (Directive 98/69/EC (European Parliament and Council of the European Union, 1998)). The implementation of such regulatory laws and other subsequent sets of measures involves not only administrations, which are compelled to materialize control and management over traffic, home and industry pollutants, but also vehicle manufacturers, with more severe regulations for the exhaust emissions. Another relevant factor for this decreasing trend is the economic recession, which started in Spain in 2008 and has led to lower levels of fuel consumption (Salvador et al., 2015). On the other side, despite this NO_x reduction an upward trend is found in tropospheric O_3 concentration in the last decade (Valverde et al., 2016). O_3 is formed within a complex photochemical process that requires, among others, anthropogenic and natural sources of NO_x and Volatile Organic Compounds (VOC), collectively referred to as ozone precursors, enhanced by favorable meteorological conditions (high temperatures and strong solar radiation).

Although vehicle emissions, industry and heating produce most of the atmospheric pollutants, the climatological characteristics of

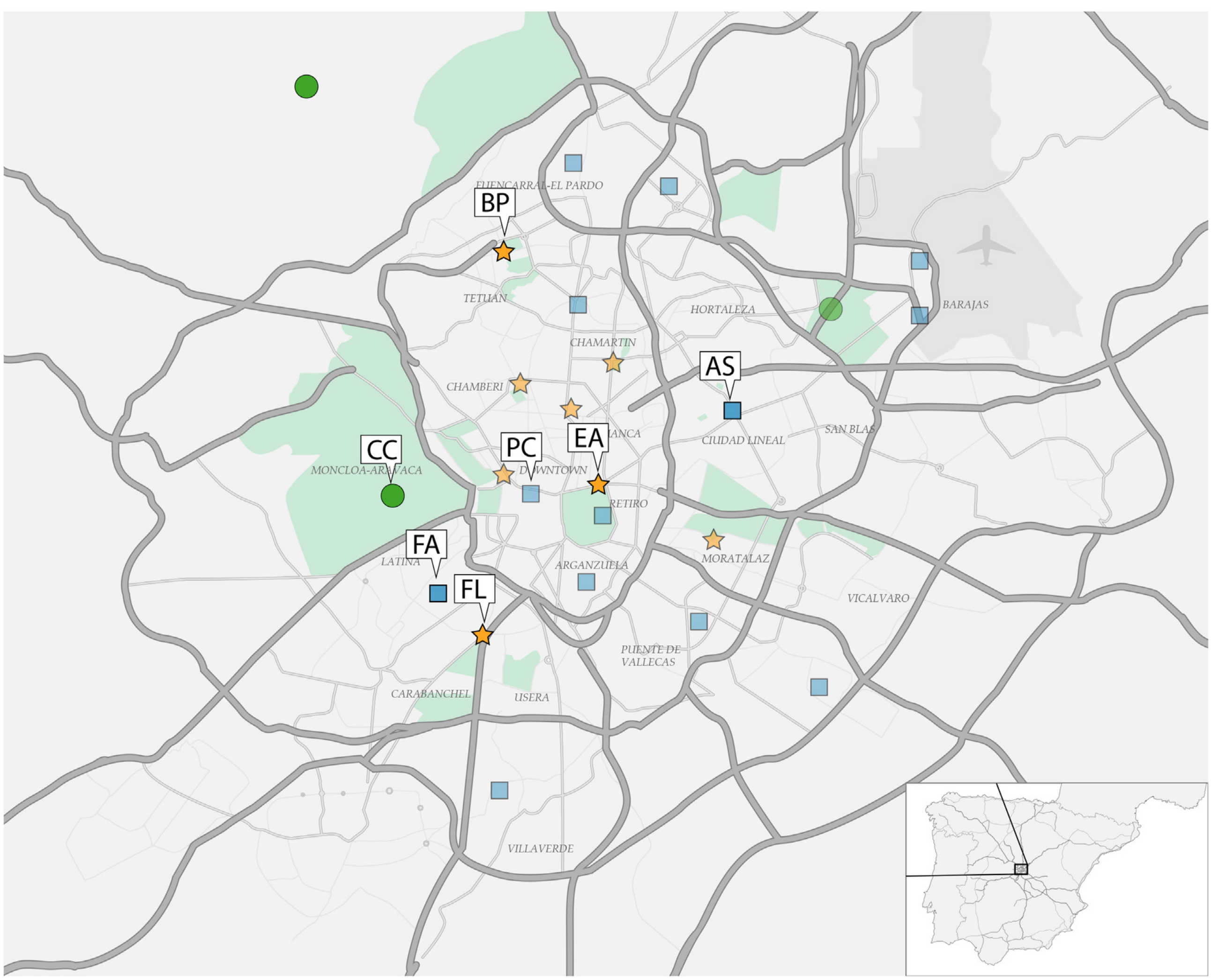

Fig. 1. Radial distribution of the road network around Madrid, and location of the 24 urban air quality stations deployed over Madrid: urban background (□), roadside traffic (☆) and Suburban (○). Selected stations are tagged.