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Air quality modelling over Bogota, Colombia: Combined techniques to estimate and evaluate emission inventories

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Abstract

Two versions of the Emission Inventory (EI) are generated for the city of Bogota, Colombia. In the first version (EI-1), CORINAIR traffic emission factors (EFs) are used. In the second (EI-2), bulk traffic EFs calculated for the city, using in situ measurements and inverse modelling techniques at street level, are used. EI-2 traffic emissions are 5, 4 and 3 times bigger than the corresponding values in EI-1, for CO, PM_{10} and NMVOCs, respectively. The main goal of this study consists in evaluating the two versions of the EI when introduced into a mesoscale air quality model. The AOT (accumulated exposure over a threshold) index is calculated for comparison between observed and simulated concentrations of primary pollutants. Simulated concentrations using EI-2 are closer to the observed values. This comparison allows us to extract some conclusions of the methodology used to calculate the EFs. Local factors like the driving behavior, the altitude, vehicle technology and an aged fleet cannot be totally included and corrected in the standard methodologies, and seem to be more important than obtaining very detailed and precise information on the classification of the fleet or driving speeds. Under financially limited and fast changing situations, as in the case of many developing countries, a simple methodology to estimate bulk traffic EFs and to evaluate the EI, is of utmost importance. The use of combined techniques such as in situ measurements to estimate bulk traffic EFs, and further evaluation of the inventories with numerical models, proved to be a useful tool for this purpose.

Keywords: Bogota; Emission inventory; Real-world emissions; Urban air pollution; Air quality management

1. Introduction

Urban agglomerations are major sources of regional and global atmospheric pollution. This case is especially severe in cities of developing countries, where population, traffic, industrialization and energy use increase as people continue to migrate to the cities (Mage et al., 1996). Consequently, it is urgent to develop an air quality management policy and to establish strategies of atmospheric pollution prevention and control for such cities. Main limitations are, however, that either environmental authorities are not always effective, or air pollution mitigation may not be

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an immediate priority for the city (Mayer, 1999). Even if it is, there may be a strong lack of information and knowledge. Bogota, capital of Colombia, is to some extent a representative case of the latter condition. By 2001, it had reached 6.6 million inhabitants inside the urban perimeter (Skinner and Reinhard, 2004) and about 8.0 million taking into account the suburbs. It is the 5th biggest city in Latin America with nearly one million vehicles circulating every day, among which 50 000 are diesel-powered heavy vehicles. Bogota (4.6°N and 74.1°W) lies in a plateau placed in one of the three Andean mountain ranges crossing the country. The plateau is about 40 km wide and 100 km long, and aligned from the southwest to the northeast. It has an average elevation of 2600 masl, while mountainous complex terrain borders the plateau (Fig. 1(a)).

Bogota has an air quality monitoring network administrated by the DAMA (Departamento Técnico Administrativo del Medio Ambiente). Since 1997, it has been registered that the air quality standards of PM_{10} ($170\,\mu g\,m^{-3}$, 24 h average), O_3 (83 ppb, hourly average) and NO_2 (168 ppb, hourly average) are frequently exceeded. For example, in 2001 those standards were exceeded 281 times out of 49 913 hourly measurements for O_3 (seven monitoring stations) and 510 times out of 98 612 hourly measurements for PM_{10} (14 monitoring stations). The maximum values attained during the same year were $393\,\mu g\,m^{-3}$ (1 h) for O_3 and $225\,\mu g\,m^{-3}$ (24 h average) for PM_{10}. The center and southwest parts of the city are highly polluted zones (Fig. 1(b)): MMA and Cazuca stations indicate the most frequent exceedances for O_3, Merck and Sony stations for PM_{10}, and Nacional and MMA for NO_2 (DAMA, 2006).

Aiming to improve air quality in Bogota, the research project entitled *Development of an air quality management system for Bogota* was conceived. This project comprises the development of a set of tools which will facilitate the understanding and management of the air pollution problem in the city. Uncertainty regarding the response of pollutant concentrations to reductions of emissions, has made of modelling an essential tool to test abatement strategies (Vivanco and Andrade, 2006; Martilli et al., 2003); hence meteorological modelling in combination with air quality simulations is part of the set of tools to be developed. The modelling in turn will depend on an optimal spatially and temporally distributed emission inventory (EI). The goal of the project is to quantify emissions and to evaluate their implications on air quality, by applying a combined meteorological–photochemical air pollution model to the case of Bogota. The ultimate purpose is to implement efficient pollution control plans, following a careful

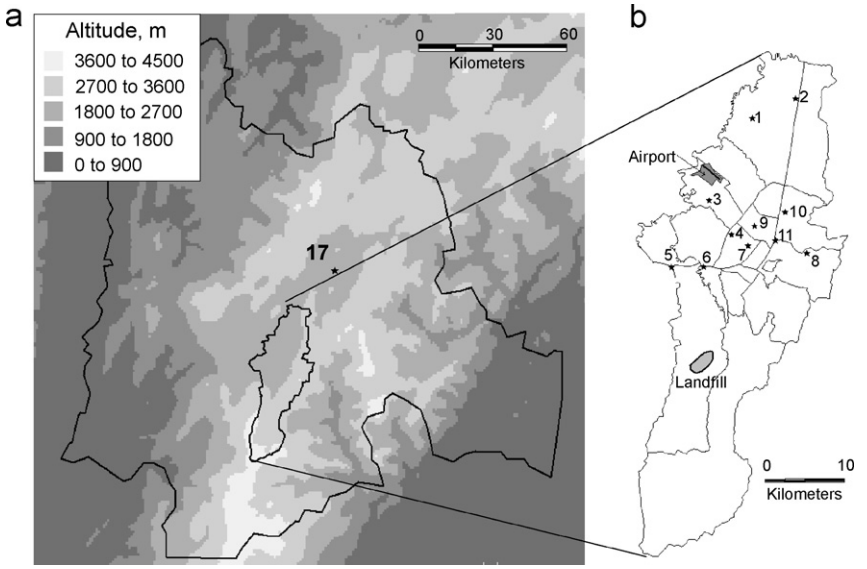

Fig. 1. Domain chosen for the emission inventory and simulations. (a) Topography of the domain of study (212 km × 212 km, lower left corner 3.9°N and 75.0°W) and city of Bogota. Cundinamarca department and Bogota's urban perimeter are delimited in thick black. Monitoring station number 17 (Duque) is also shown. (b) Bogota's urban perimeter, street network and measuring stations: 1. Corpas, 2. Escuela, 3. Fontibón, 4. Merck, 5. Cazucá, 6. Sony, 7. Cade, 8. Monserrate, 9. Nacional, 10. Santo Tomás, 11. MMA.