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Spatial accuracy of a simplified disaggregation method for traffic emissions applied in seven mid-sized Chilean cities

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Abstract

The spatial accuracy of top-down traffic emission inventory maps obtained with a simplified disaggregation method based on street density was assessed in seven mid-sized Chilean cities. Each top-down emission inventory map was compared against a reference, namely a more accurate bottom-up emission inventory map from the same study area. The comparison was carried out using a combination of numerical indicators and visual interpretation. Statistically significant differences were found between the seven cities with regard to the spatial accuracy of their top-down emission inventory maps. In compact cities with a simple street network and a single center, a good accuracy of the spatial distribution of emissions was achieved with correlation values >0.8 with respect to the bottom-up emission inventory of reference. In contrast, the simplified disaggregation method is not suitable for complex cities consisting of interconnected nuclei, resulting in correlation values <0.5. Although top-down disaggregation of traffic emissions generally exhibits low accuracy, the accuracy is significantly higher in compact cities and might be further improved by applying a correction factor for the city center. Therefore, the method can be used by local environmental authorities in cities with limited resources and with little knowledge on the pollution situation to get an overview on the spatial distribution of the emissions generated by traffic activities.

Keywords: Emission inventory map; Traffic; Spatial accuracy; Top-down emission inventory; Latin America

1. Introduction

1.1. Traffic emission inventories

Emission inventories have many applications, e.g. for developing efficient strategies for pollution prevention and reduction (Orthofer and Winiwarter, 1988; Costa and Baldasano, 1996; NRC, 2000; Berkowicz et al., 2006), for studying emission

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trends, compliance and regulatory purposes (Romano et al., 2004). Traffic emission inventories also allow for analyzing how the different types of vehicles contribute to the overall emissions in the study area (Bellasio et al., 2007). They are also useful in assessing how changes in fuels or traffic technology can affect the overall emissions (Colvile et al., 2001; Bellasio et al., 2007). If emission inventories are spatially resolved, they are useful in assessing pollution exposure and to identify problem zones, which can then be studied in detail (Orthofer and Winiwarter, 1988; Loibl et al., 1993). Furthermore, one of their most important applications is as input into pollution transport and chemical models (Costa and Baldasano, 1996; Kühlwein et al., 2002; Winiwarter, 2002). According to emission inventories good practice guidance, emission inventories should be transparent, accurate, complete, comparable and consistent and time-based (UNFCCC, 1999; Penman et al., 2000).

1.2. Bottom-up vs. top-down emission inventories

The spatial distribution of emissions in an emission inventory map can be addressed basically with two approaches, namely ''bottom-up'' and ''top-down'' (Loibl et al., 1993). The bottom-up approach is based on a traffic model on the street level. The modeled traffic activities for each street segment are linked with a traffic emission model resulting in street-wise emission assessments, which can be aggregated to grid cells. The top-down approach is based on the total amount of traffic emissions within the city area. This number is usually assessed based on the local car register and assumptions on the average annual mileage. The total traffic emissions are then spatially disaggregated on a grid, using e.g. the average street density per grid cell (Tuia et al., 2007). The top-down approach has advantages over the bottom-up approach in that it is less time- and resource-consuming, requires fewer technical skills from the developers of the emission inventory maps and is in consequence more practical (Loibl et al., 1993; Costa and Baldasano, 1996; Palacios et al., 2001). Moreover, the data about emissions generating activities are often more accurate at the more aggregated level, such as at country or city level (Loibl et al., 1993; Costa and Baldasano, 1996). However, the accuracy of the spatial distribution of the emissions (i.e. the spatial accuracy[1]) can be much lower when applying top-down approaches (Orthofer and Winiwarter, 1988; Loibl et al., 1993; Palacios et al., 2001).

Top-down approaches for the spatial distribution of traffic emissions in emission inventory maps—particularly if they are based on simplified surrogate variables—can be a very useful option for cities with limited resources, as is often the case in Latin America. Nevertheless, it is necessary to know about and be aware of the spatial accuracy of these simplified approaches. In a previous study, different simplified top-down approaches for disaggregation of traffic emissions have been evaluated in the Chilean mid-sized city of Gran Concepcion, and the method based on street density showed the best spatial accuracy when compared to the reference, a bottom-up emission inventory map (Tuia et al., 2007). This disaggregation method has the advantage that it is based on data available in most, if not all, cities in Latin America. However, in order to extend the conclusions of this study about the applicability of the method to other Latin American cities, it was necessary to apply the same approach to other cities. Furthermore, the use of additional comparison methods would make it possible to know more about the limitations of the disaggregation method, the sources of error and the possibilities of improvement.

1.3. Goal and scope

The goal of this study was to evaluate the spatial accuracy of a simplified method for the disaggregation of traffic emissions in mid-sized cities in Latin America. An approach based on street density was applied, which is based on data that are widely available in Latin American cities, the aim being to identify the limitations and sources of errors in the disaggregation method.

In this study only hot emissions have been considered,[2] as the reference available for analysis

[1]The general accuracy of the inventory can be seen as resulting from the accuracy of the estimates of total emissions, the accuracy of their temporal disaggregation and the accuracy of their spatial distribution.

[2]Traffic emissions are the result of three types of emissions, namely hot, cold start and evaporative emissions. Hot emissions are those emissions generated by a vehicle during its normal activity, i.e. the emissions occurring under thermally stabilized (hot) engine operation. Cold start emissions are additional emissions of a vehicle during the transient thermal engine operation, i.e. the engine-warm-up phase. Finally, evaporative emissions are the emissions of non-methane volatile organic compounds (NMVOC) from gasoline evaporation, with or without the vehicle in operation.