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Philippe Thunis



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# On the validity of the incremental approach to estimate the impact of cities on air quality

Philippe Thunis

European Commission, Joint Research Centre (JRC), Ispra, Italy

## Abstract

The question of how much cities are the sources of their own air pollution is not only theoretical as it is critical to the design of effective strategies for urban air quality planning. In this work, we assess the validity of the commonly used incremental approach to estimate the likely impact of cities on their air pollution. With the incremental approach, the city impact (i.e. the concentration change generated by the city emissions) is estimated as the concentration difference between a rural background and an urban background location, also known as the urban increment. We show that the city impact is in reality made up of the urban increment and two additional components and consequently two assumptions need to be fulfilled for the urban increment to be representative of the urban impact. The first assumption is that the rural background location is not influenced by emissions from within the city whereas the second requires that background concentration levels, obtained with zero city emissions, are equal at both locations. Because the urban impact is not measurable, the SHERPA modelling approach, based on a full air quality modelling system, is used in this work to assess the validity of these assumptions for some European cities. Results indicate that for PM<sub>2.5</sub>, these two assumptions are far from being fulfilled for many large or medium city sizes. For this type of cities, urban increments are largely underestimating city impacts. Although results are in better agreement for NO<sub>2</sub>, similar issues are met. In many situations the incremental approach is therefore not an adequate estimate of the urban impact on air pollution. This poses issues in terms of interpretation when these increments are used to define strategic options in terms of air quality planning. We finally illustrate the interest of comparing modeled and measured increments to improve our confidence in the model results.

**Keywords:** urban increment, urban impact, Lenschow approach, source apportionment

## 1. Introduction

Most European cities suffer from poor air quality and regularly exceed both the thresholds prescribed by the Air Quality Directive (EEA, 2016) and guidelines recommended by the World Health Organization (WHO). This is particularly the case for fine particulate matter (PM<sub>10</sub>) for which both the daily ( $50 \mu\text{g}/\text{m}^3$  not to be exceeded more than 35 days a year) and yearly average limit values ( $40 \mu\text{g}/\text{m}^3$ ) are regularly exceeded in many cities and several regions in Europe. Similar conclusions hold for PM<sub>2.5</sub> where few cities manage to keep concentrations below the levels recommended by the WHO ( $10 \mu\text{g}/\text{m}^3$  on an annual basis). Adverse health effects and premature deaths are two of the major impacts resulting from poor air quality and an average life loss of about 8 to 10 months is the current estimate for the most polluted European regions (Southern Poland, Po Valley, Benelux...) and cities,

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