LIFEINDEXAIR

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Air Quality and Exposure Modelling Results for Lisbon

Deliverable D-B3.4

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TÉCNICO LISBOA universidade de aveiro NATIONAL INSTITUTE FOR HEALTH AND WELFARE

CONTENTS

1. EXECUTIVE SUMMARY

The present deliverable presents the air quality and population exposure modelling results obtained for Lisbon case study, according to the objectives of Action B3. The main objective of action B3 is to determine the exposure of the general population and of the target subgroup (children) to the selected pollutants using a modelling approach.

2. INTRODUCTION

Under Action B3, air quality and human exposure numerical modelling are used to determine both individual and population exposure: first a meteorological model is applied to obtain meteorological data, which together with emission data, drive the air quality/dispersion simulations which, in turn, produce the pollutants concentration patterns that, combined with measurements, allow determining human exposure by the application of an exposure model.

The methodology and modelling setup were described in Deliverables D-B3.1, for air quality and D-B3.2 for human exposure. As referred in D-B3.2, to model exposure, different sets of input data are needed. The outputs of air quality modelling represent air quality levels outdoors and are used to compute the concentrations in indoor microenvironments based on indoor-outdoor ratios. These are combined with population data spatially distributed in the modelling domain and time-activity patterns (information of in which type of microenvironment people are at each hour of the day).

The population exposure to atmospheric PM10 and PM2.5 was estimated for the year 2015, as the base year of the LIFE Index-Air modelling application, for the general population resident in the Lisbon region domain and for the 5 to 9 year-old children, based on the data acquired at homes and schools in the Lisbon municipality. The following sub-sections present the results of the air quality modelling application for the Lisbon region and the population exposure estimation.

3. AIR QUALITY MODELLING

The WRF-CAMx air quality modelling system was applied to the whole year of 2015 for the Lisbon area domain at 1x1km^2 resolution. The obtained hourly PM10 and PM2.5 concentrations were used to compute annual average concentrations over the study region. Results are presented in Figure 1.

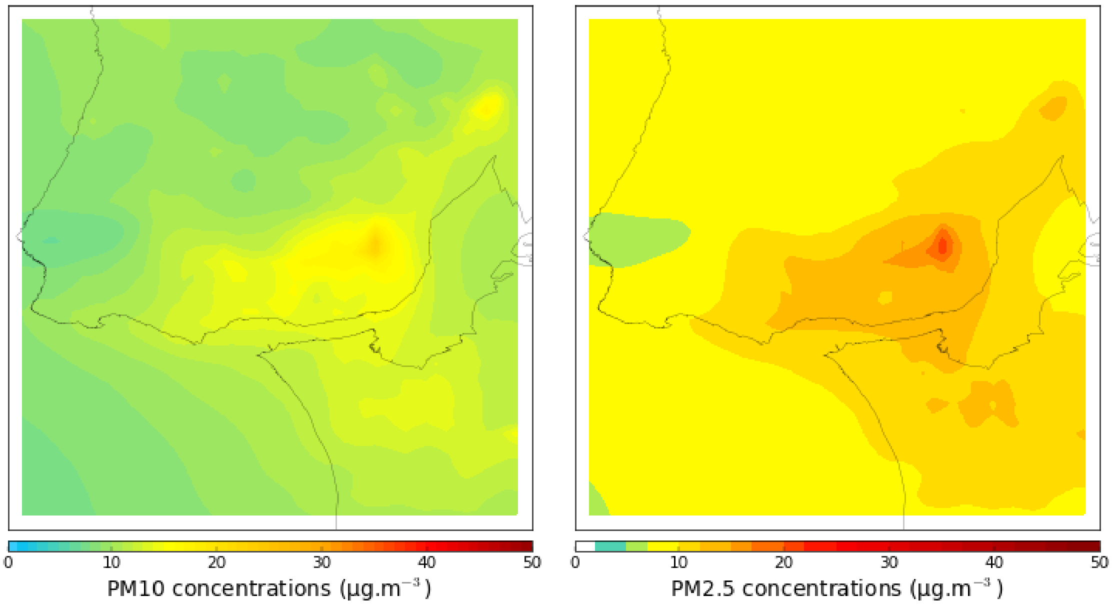

Figure 1. Spatial distribution of PM10 and PM2.5 annual concentration averages over the Lisbon domain (1 km^2 horizontal resolution) for the year 2015.

The validation procedure presented in Deliverable D-B3.3 revealed a tendency of the model to overestimate the PM levels observed. In this sense, the model outputs here presented and used in the exposure estimation were adjusted to measurements using a bias correction technique.

According to the concentration maps, PM10 and PM2.5 air quality levels are higher in the Lisbon municipality area, where higher emissions occur, reaching values between 20 and 30 μg.m^{-3}. The hourly modelled concentrations for each modelling grid cell were used for the estimation of human exposure as presented in the following section.

4. POPULATION EXPOSURE MODELLING

The used population exposure module permits the estimation of the population exposure to air pollutants on an hourly basis for a defined gridded domain, based on the target population distribution, time-activity patterns, and pollutant concentrations at microenvironments. Figure 2 presents the general methodology for population exposure estimation.

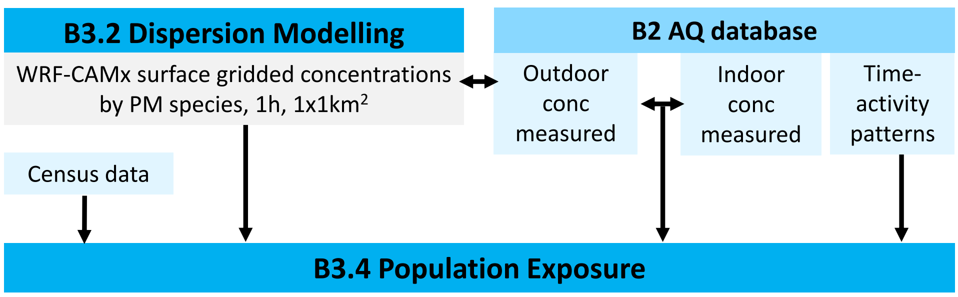

Figure 2. Methodological scheme and input data for the population exposure estimation.

Population census data are available at subsection level (smallest administrative area) by age ranges. Total resident and present population are also available and were used to get the spatial distribution of the population during the day and at night on a typical weekday. Figure 3 shows the resident and the present total population and the subgroup of 5 to 9 years old children, by subsection, in Lisbon region.

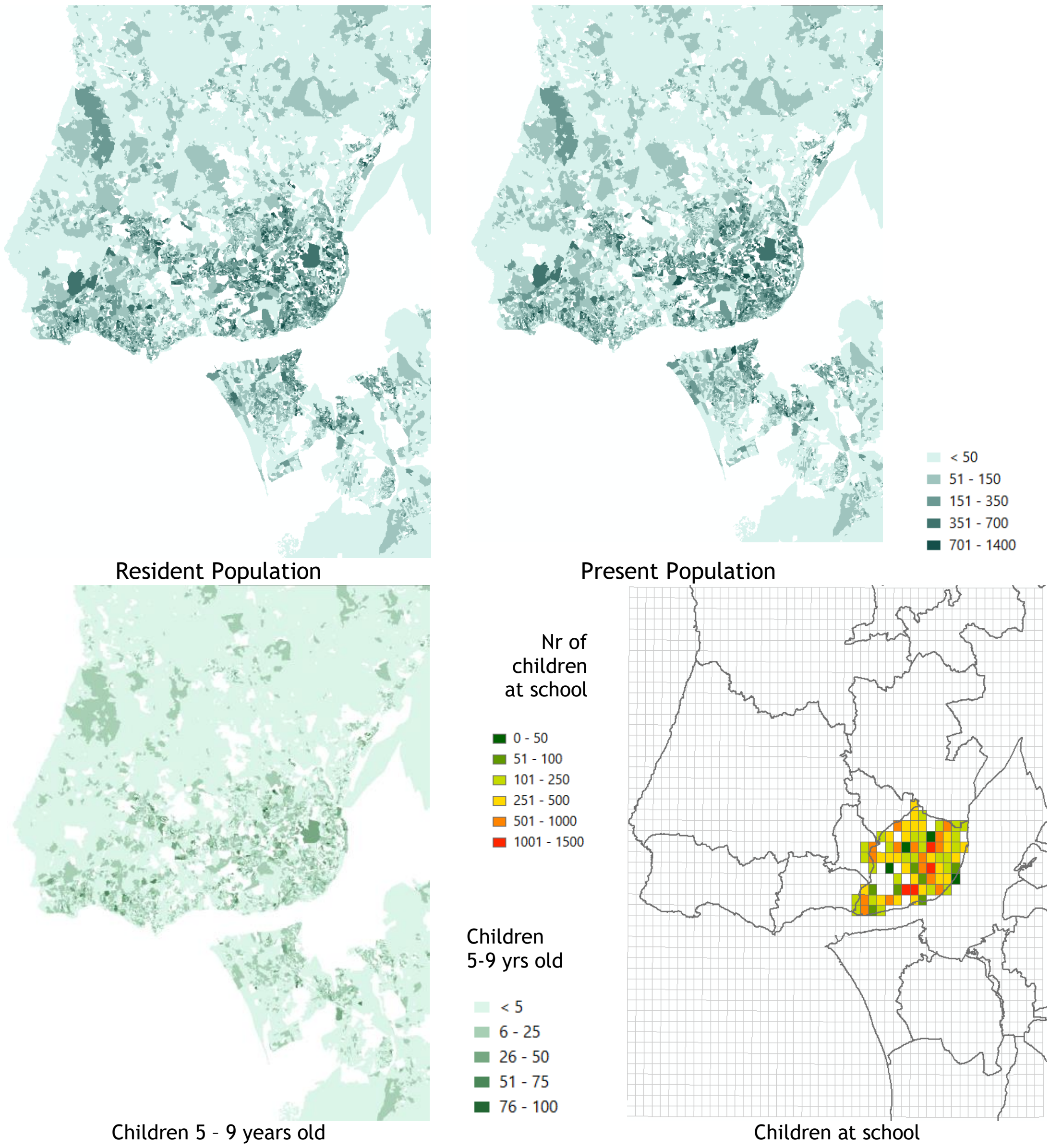

Figure 3. Distribution of the population (number of individuals) in each subsection of the Lisbon modelling domain - resident and present total population, resident children aged 5 to 9 years old, number of students (5-9 years old) at schools.

For the general population, a typical time-activity pattern was considered. For the 5 to 9 years-old subgroup, time-activity patterns based on questionnaires performed under task B2.1 were used to characterize the daily routine of children over the study areas.

The exposure model also calculates the indoor concentrations using the outdoor concentrations simulated by the WRF-CAMx modelling system and indoor/outdoor relations. Based on time-activity profiles, the most visited microenvironments can be grouped into three main types: home, outdoors, other indoors (school for children's group). The monitoring campaign performed under action B2 and described in Deliverable B2.2, included indoor and outdoor measurements at different homes and schools, allowing to compute indoor-outdoor relations for PM10 and PM2.5, displayed in Table 1, that were used in the exposure module. For other indoor microenvironments, the indoor-outdoor relation was assumed to be similar to the one for homes discounting a fraction of home specific indoor sources 1 [Gulliver and Briggs, 2004; USEPA, 1997]. Moreover, the location of schools in the Lisbon municipality and the number of students per school allowed calculating the number of children at school microenvironment by grid cell (Figure 3).

Table 1 - Indoor-Outdoor relations for PM10 and PM2.5.

	Home	School	Other Indoors (workplace, …)
PM10	$C_{in} = 0.55 * C_{out} + 4.83$	$C_{in} = 1.29 * C_{out} + 24.62$	$C_{in} = 0.55 * C_{out} + 4.83 * (1 - 0.14)$
PM2.5	$C_{in} = 0.65 * C_{out} + 4.51$	$C_{in} = 1.18 * C_{out} + 10.55$	$C_{in} = 0.65 * C_{out} + 4.51 * (1 - 0.14)$

The exposure module delivers hourly population exposures by grid cell of the modelling domain. It also estimates the population exposure taking into account the number of people in each grid cell and the cumulative exposure for a certain period of time. Hourly outputs were treated to get annual exposures' population averaged for PM10 and PM2.5, for the general population and the children subgroup.

4.1. GENERAL POPULATION EXPOSURE

Figure 4 presents the spatial distribution of the annual average exposure weighted by the number of people present in the Lisbon study case domain. Blank areas represent null exposure due to the non-presence of people. The highest exposures are obtained for the Lisbon urban area and for the areas with higher population density (as seen in figure 3) with non-zero concentration values.

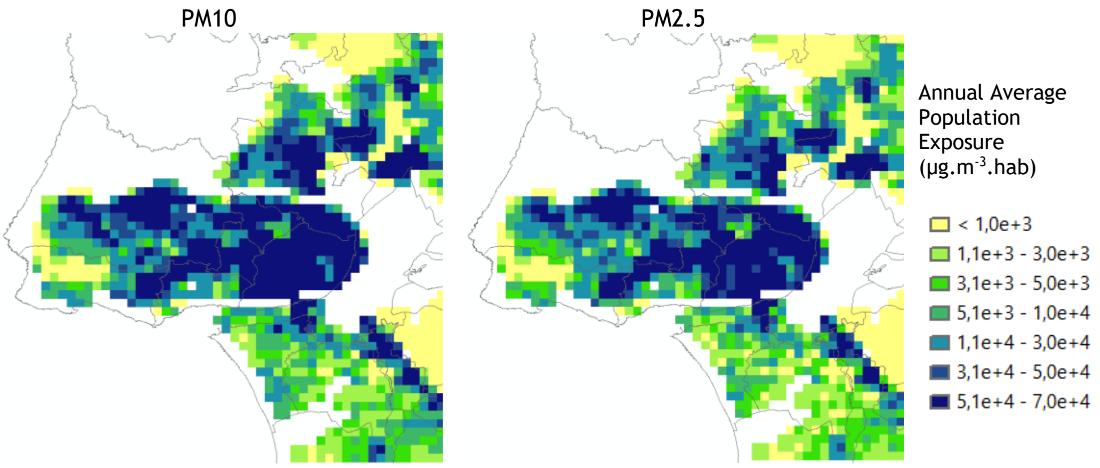

Figure 4. Annual population averaged exposure (µg.m^{-3}.hab) to PM10 and PM2.5 in the Lisbon modelling domain for the general population.

Since exposure to PM is mainly influenced by outdoor concentrations (Table 1), these results highlight the need to improve air quality in Lisbon city centre where most people live and where higher emissions are released to the atmosphere, by implementing emission control strategies and emission reduction measures.

4.2. CHILDREN'S EXPOSURE

Regarding the exposure estimation for the subgroup of children aged 5 to 9 years old (Figure 5), the results are depicted for a subdomain, since the information on location and number of students per school was compiled for the Lisbon municipality, under Action B2 (Figure 3).

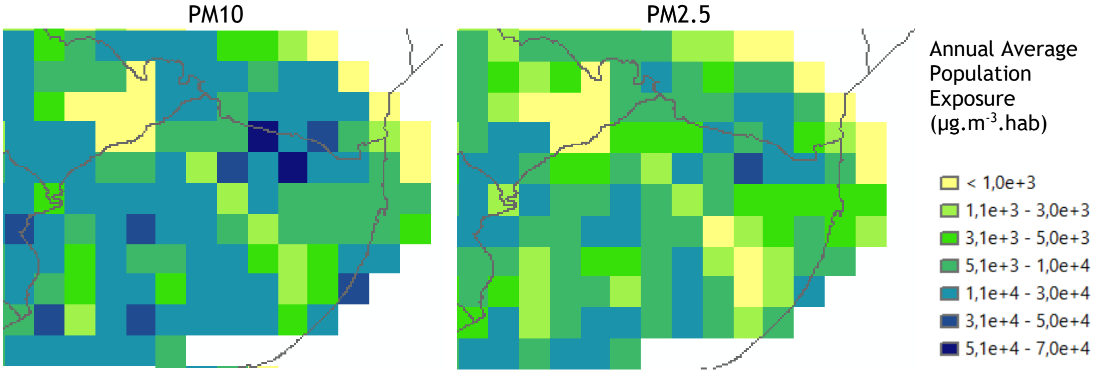

Figure 5. Annual population averaged exposure (µg.m^{-3}.hab) to PM10 and PM2.5 in the Lisbon modelling domain for children (5 - 9 yrs).

The highest exposure values are modelled for the areas where more students spent most of their day time, at school. In fact, the indoor-outdoor ratios obtained in action B2 and presented in Table 1 show that PM concentrations in schools have a great contribution from indoor sources, increasing, in this way, the children's exposure to these pollutants.

5. CONCLUSIONS

The present deliverable presents the air quality and population exposure results obtained by the application of the air quality and exposure modelling system to the Lisbon case study for the year 2015.

The general population exposure to PM10 and PM2.5 is mainly influenced by outdoor concentrations, either when people are outside or inside, as indoor microenvironments concentrations are mainly a result of outdoor levels. In this sense, emission reduction strategies aiming to improve air quality should be encouraged, especially in Lisbon city center, where most people live.

The focus on children, as the subgroup of interest in the scope of the LIFE Index-Air Project, in terms of exposure to PM highlights the importance of taking specific actions in schools to reduce PM concentrations, since children spend most of their time there.

The subsequent dose and health modules in the LIFE Index-Air chain will help to define these air quality improvement strategies towards a better health for the Lisbon region population.

6. REFERENCES

Gulliver, J., Briggs, D.J. 2004. Personal exposure to particulate air pollution in transport microenvironments, Atm. Env. 38, pp. 1–8.

USEPA. 1997. Air Quality Criteria for Particulate Matter, v.1.