Forecasting human exposure to atmospheric pollutants in Portugal

C. Borrego, **A. Monteiro**, E. Sá, J. Ferreira, A. I. Miranda

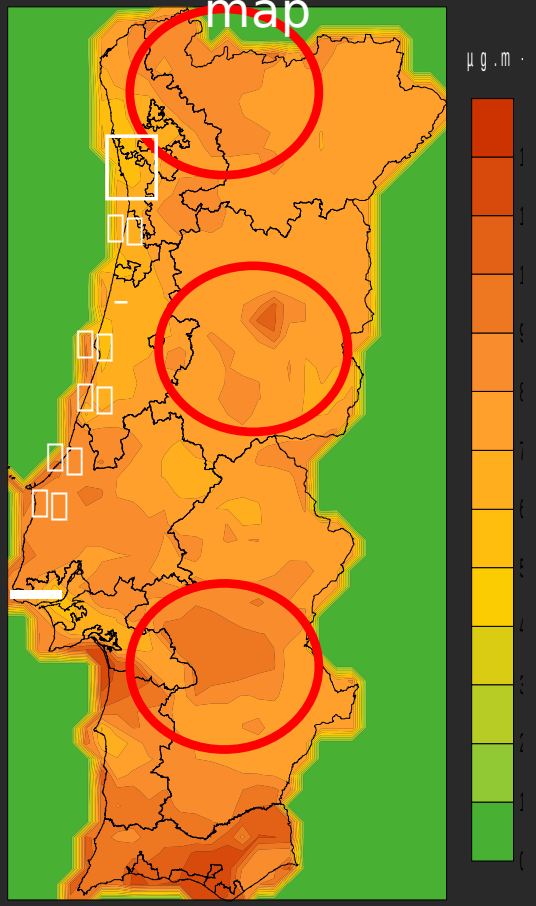
CESAM, Department of Environment and Planning
University of Aveiro

12th International Conference on Harmonization, Cavtat, 6-9 October 2008

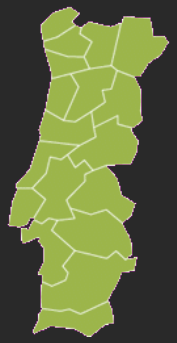
Exposure to air pollution

Why should we care about human exposure?

Pollutant concentration map



The objective



Forecast human exposure to atmospheric pollutants in Portugal

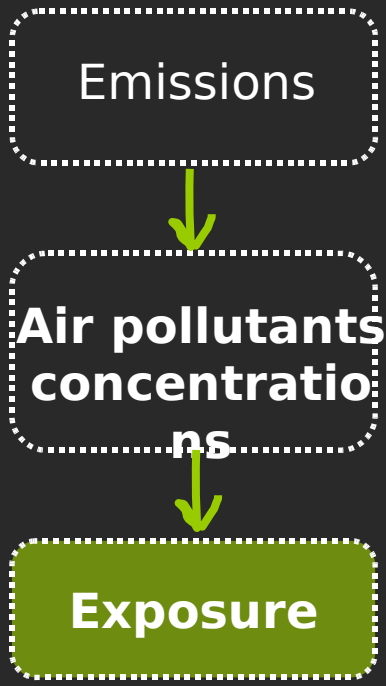
↓

Development of a module to calculate the human exposure

+

Incorporation into the operational air quality forecast system for Portugal

The methodology

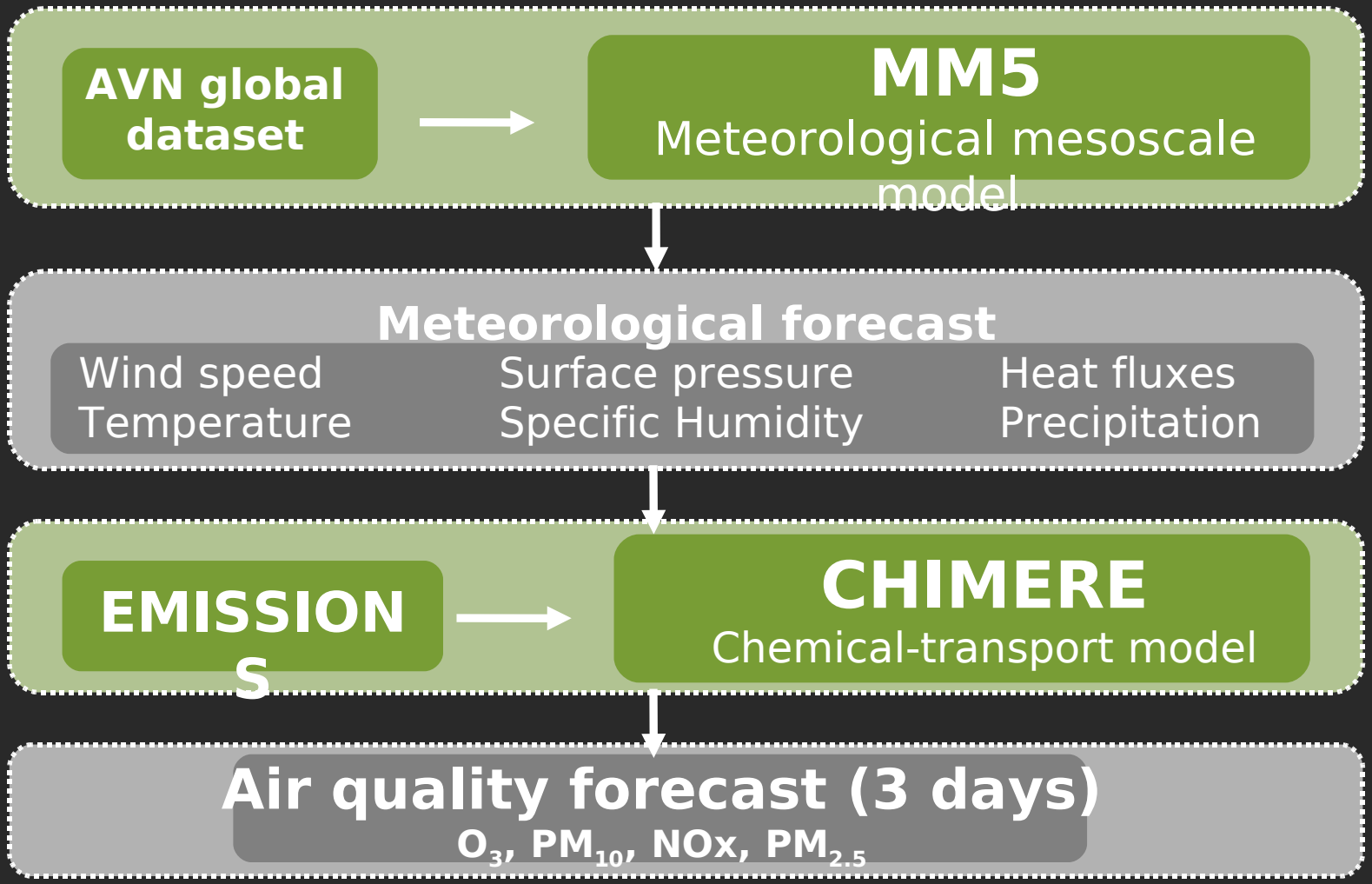


1. Comprehension and use of the air quality forecasting system

2. Development of a model to calculate the human exposure

3. Incorporation and testing of the human exposure model on the air quality forecasting system

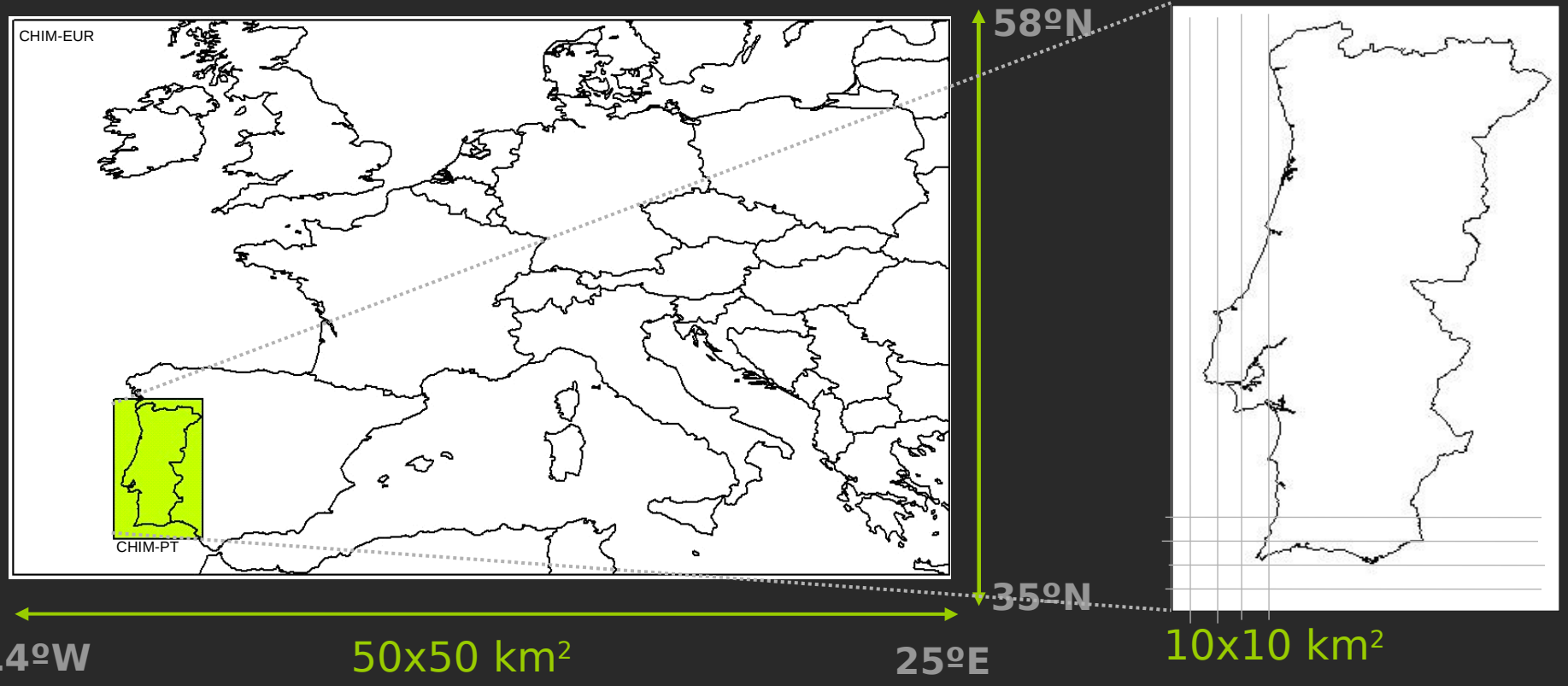
The air quality forecasting system



The air quality forecasting system

1st simulation European domain

2nd simulation domain



The air quality forecasting system

- Beginning: 2005

  2 years of testing and validation
- Information available: 2007

  Internet and Media

www.dao.ua.pt/gemac/previsao_qar

Human exposure

How it is calculated?

Individual:

$$E_i = \sum_{j=1}^{J} e_j = \sum_{j=1}^{J} C_j t_{ij}$$

concentration of the pollutant in microenvironment j

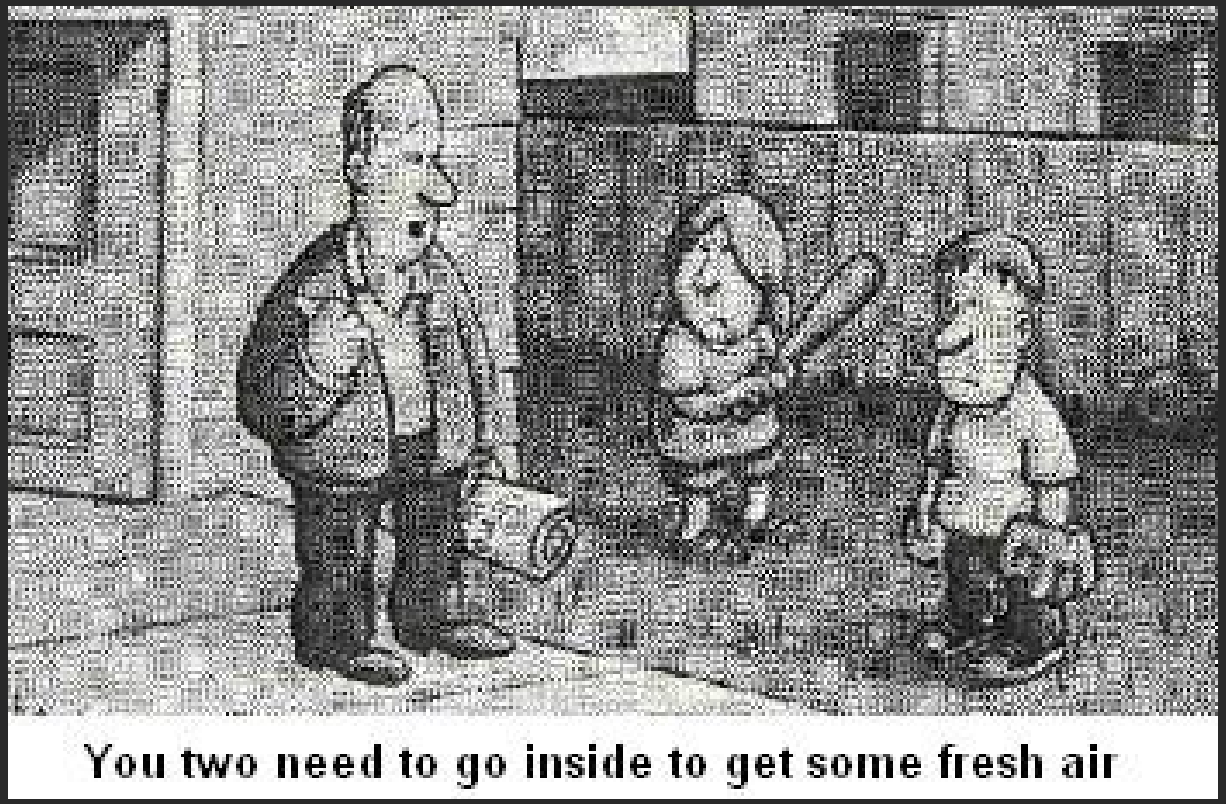
time spent by the person i in microenvironment j

Population:

$$E_{pop} = \sum_{i=1}^{I} E_i = \sum_{i=1}^{I} \sum_{j=1}^{J} C_j t_{ij} = I \sum_{j=1}^{J} C_j t_j$$

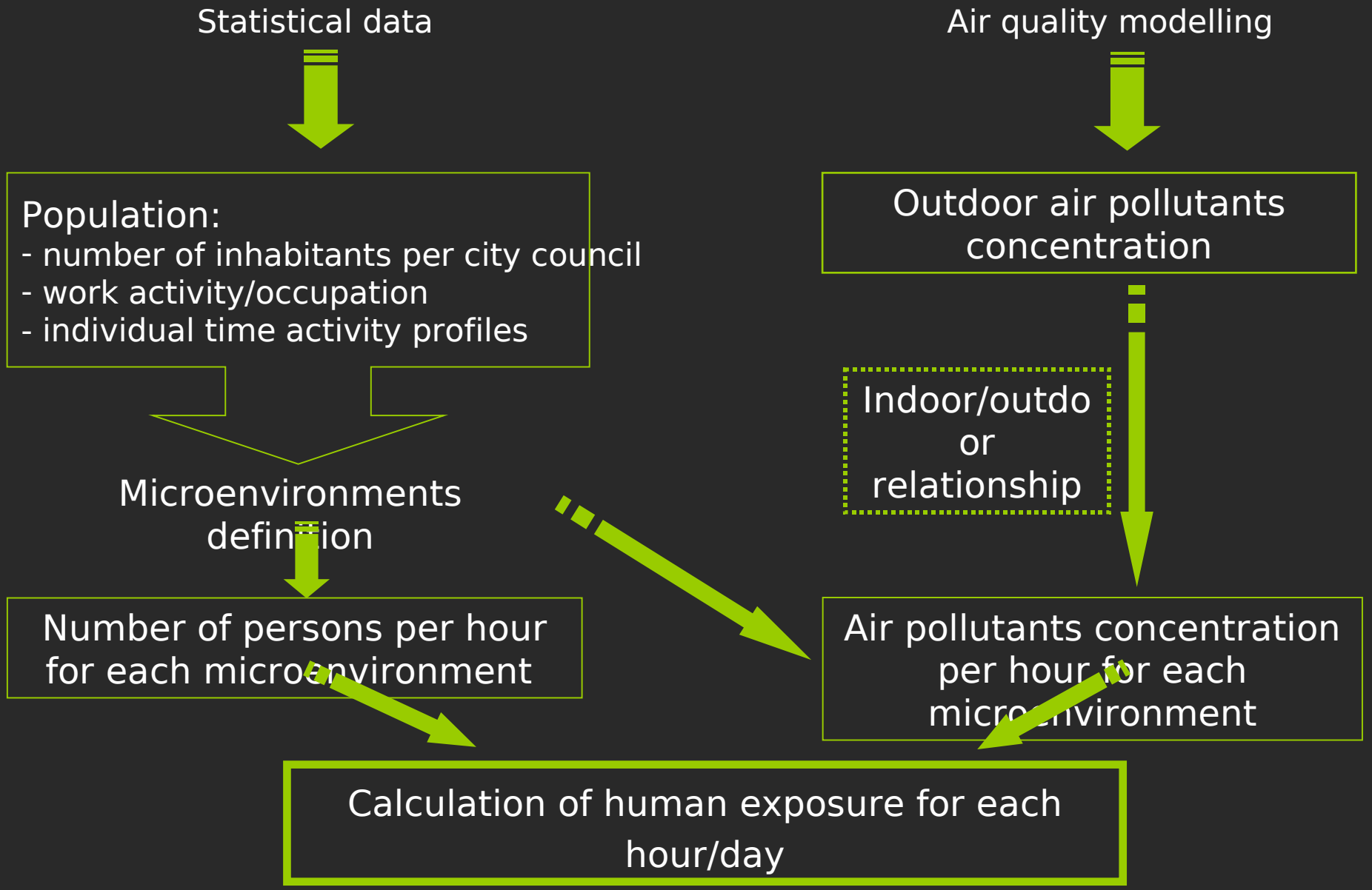
Human exposure

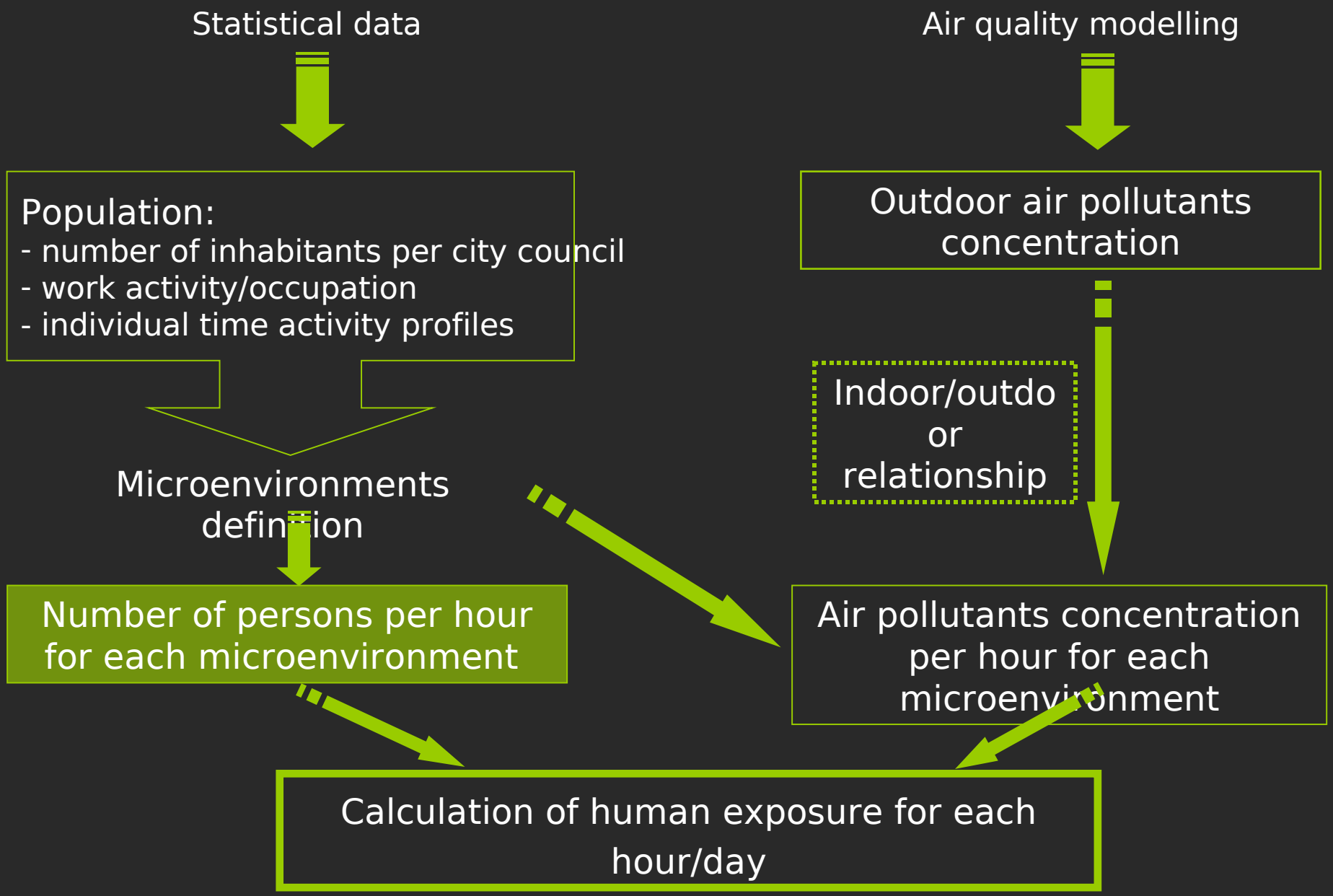
Which microenvironments?



The human exposure model

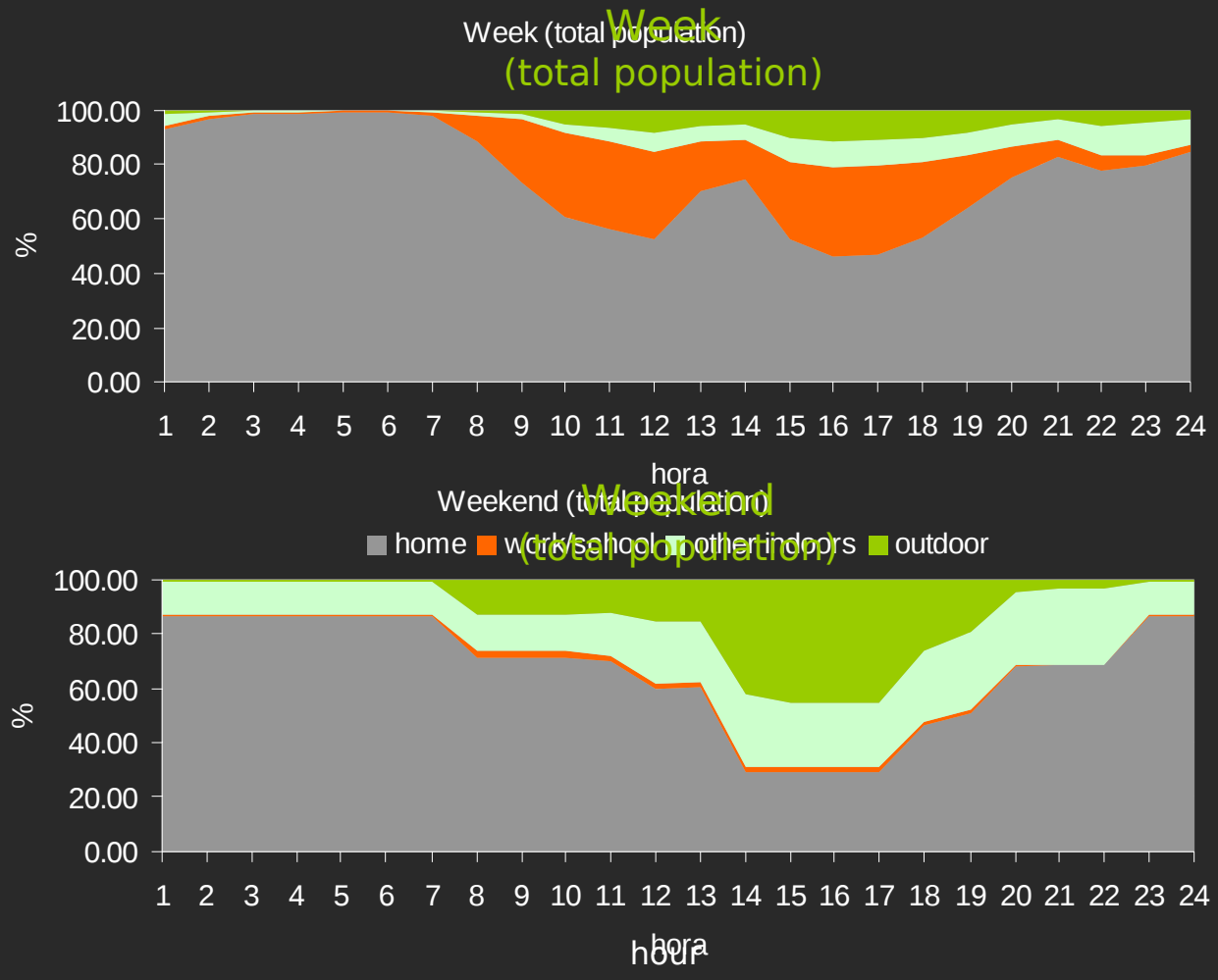
- *Fortran* programme that can be linked to air quality models
- Indoor sources not considered
- Pollutants: O_3, NO_x, PM_{10} and $PM_{2.5}$
- Microenvironments:
  - Home
  - Work/school
  - Other indoors (restaurants, gyms, shopping centre, cinema/theatre)
  - Outdoor


Statistical data
Air quality modelling
Population:
- number of inhabitants per city council
- work activity/occupation
- individual time activity profiles
Outdoor air pollutants concentration
Indoor/outdoor relationship
Microenvironments definition
Number of persons per hour for each microenvironment
Air pollutants concentration per hour for each microenvironment
Calculation of human exposure for each hour/day


Statistical data
Air quality modelling
Population:
- number of inhabitants per city council
- work activity/occupation
- individual time activity profiles
Outdoor air pollutants concentration
Indoor/outdoor relationship
Microenvironments definition
Number of persons per hour for each microenvironment
Air pollutants concentration per hour for each microenvironment
Calculation of human exposure for each hour/day

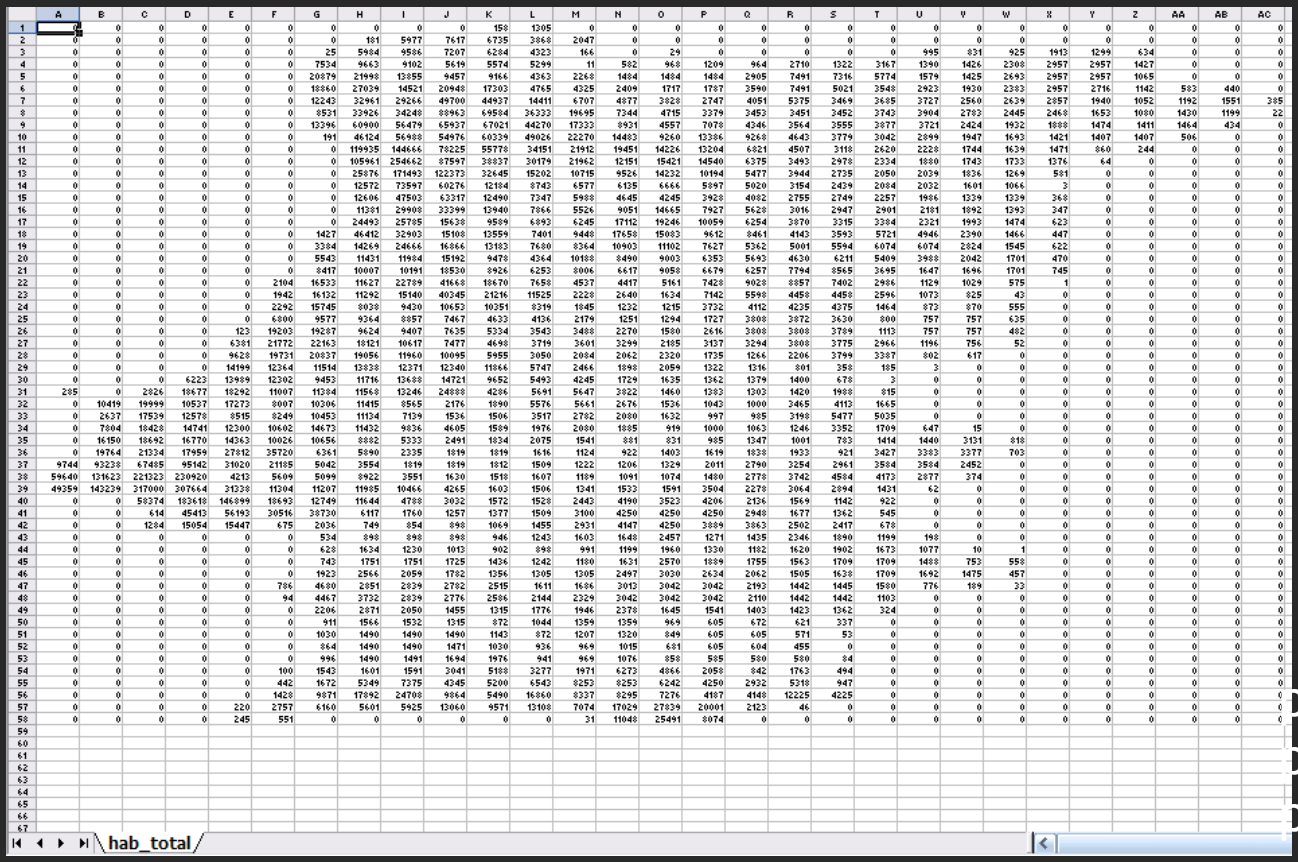
Input data to human exposure model

Population distribution in each hour of the day for each microenvironme



Input data to human exposure model

Population distribution

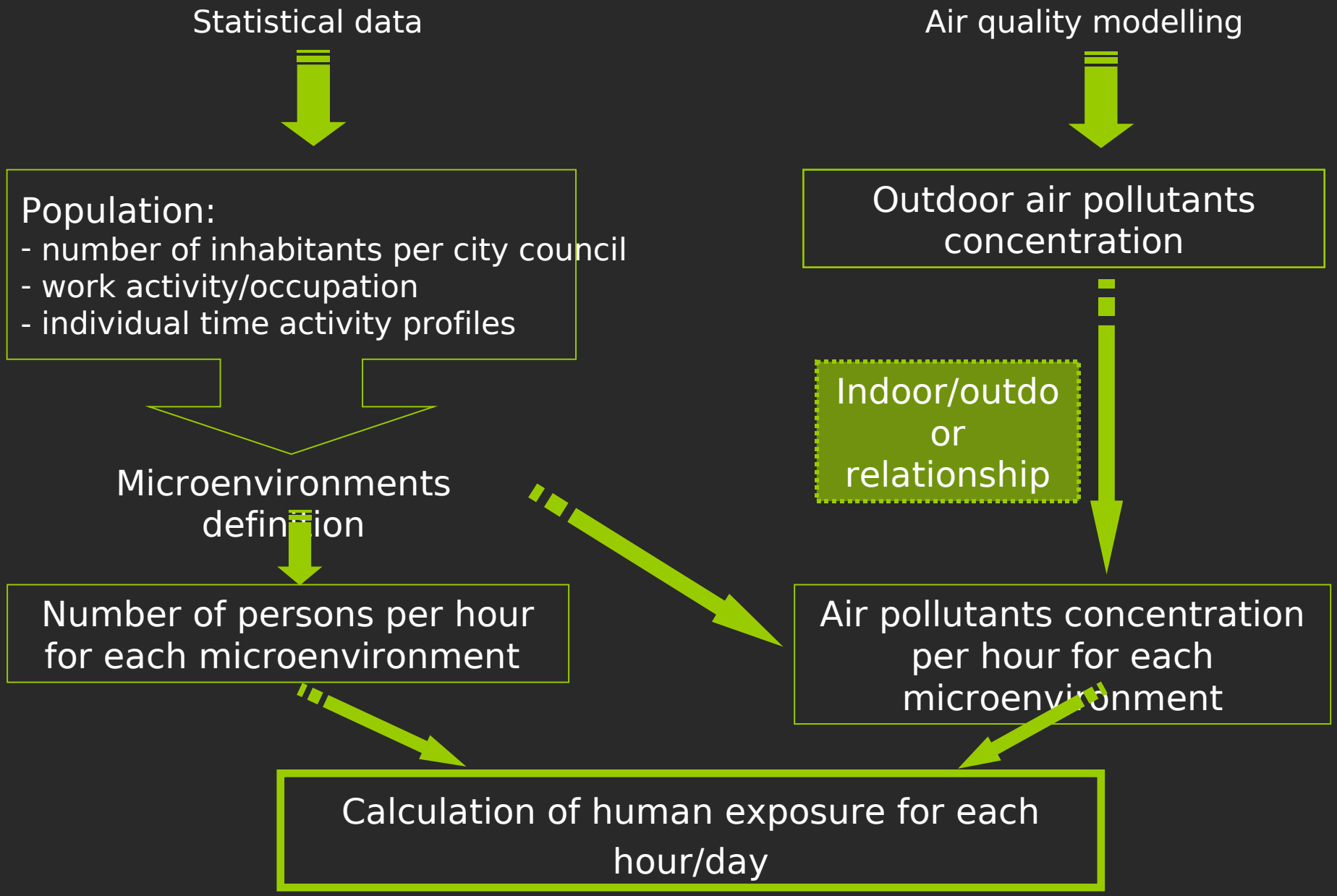


hab_total

per hour

per microenvironment

per week / weekend


Statistical data
Air quality modelling
Population:
- number of inhabitants per city council
- work activity/occupation
- individual time activity profiles
Outdoor air pollutants concentration
Indoor/outdoor relationship
Microenvironments definition
Number of persons per hour for each microenvironment
Air pollutants concentration per hour for each microenvironment
Calculation of human exposure for each hour/day

Input data to human exposure model

Indoor/outdoor coefficients for each microenvironment

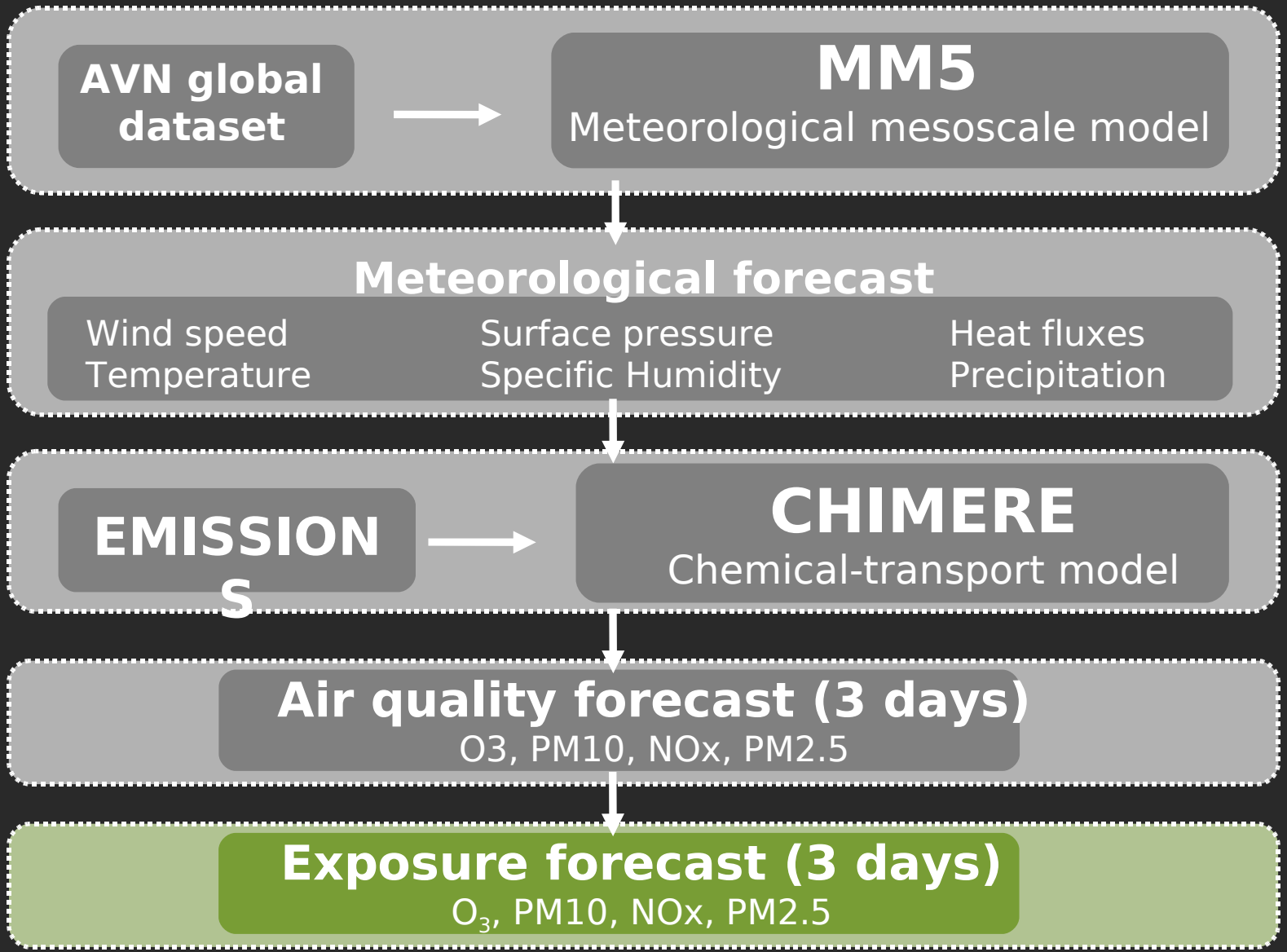
	Microenvironments					
	Home		Work/school		Others indoors	
	Summer	Winter	Summer	Winter	Summer	Winter
O_3	0.60	0.40	0.80	0.60	0.80	0.60
NO_x	0.80	0.70	0.85	0.75	0.90	0.80
PM_{10}	0.75	0.65	0.80	0.70	0.80	0.70
$PM_{2.5}$	0.60	0.48	0.80	0.70	0.90	0.80

[Poupard et al., 2004] ; [Baek et al., 1996] ; [Lee et al., 1997] ; [Dimitroulopoulou et al., 2006] ; [Chau et al., 2001]; [Wallace et al., 2005] ; [Franck et al., 2003] ; [Hanninen et al., 2004] ; [Lazaridis et al., 2003]

The influence of outdoor concentrations is higher in summer (ventilation!)

Home is the microenvironment with a smaller indoor/outdoor coefficient.

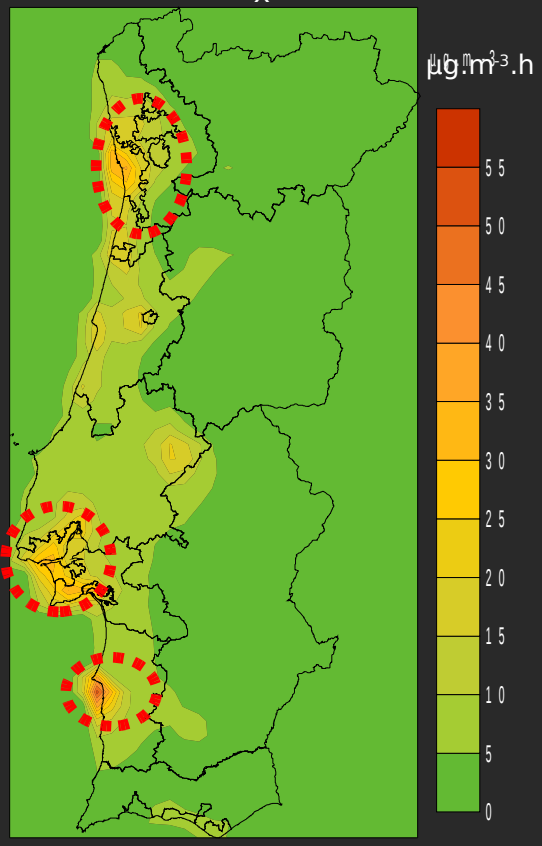
Exposure forecasting system



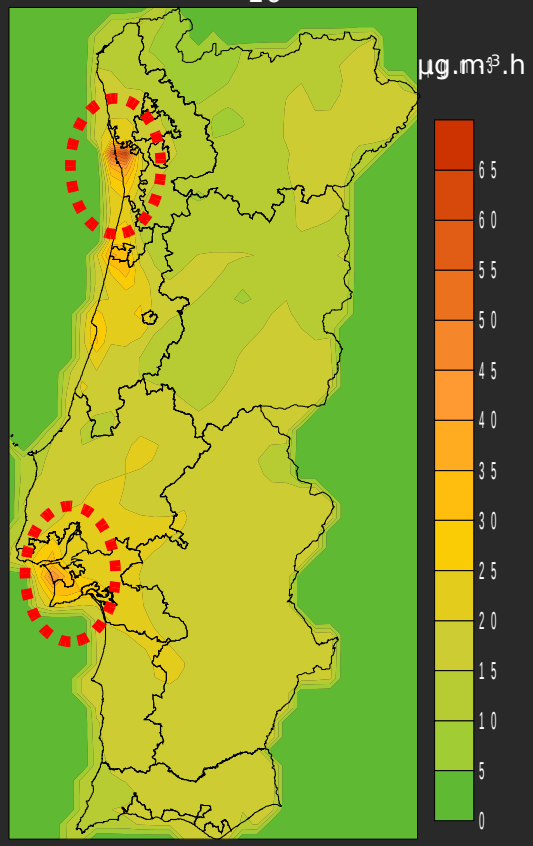
Results – 2007 year application

Annual average per inhabitant

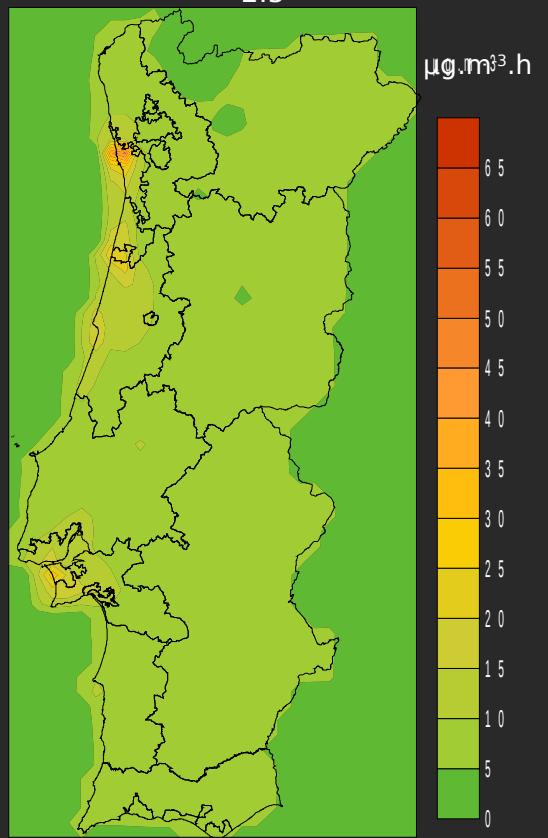
NO_x



PM_{10}



$PM_{2.5}$



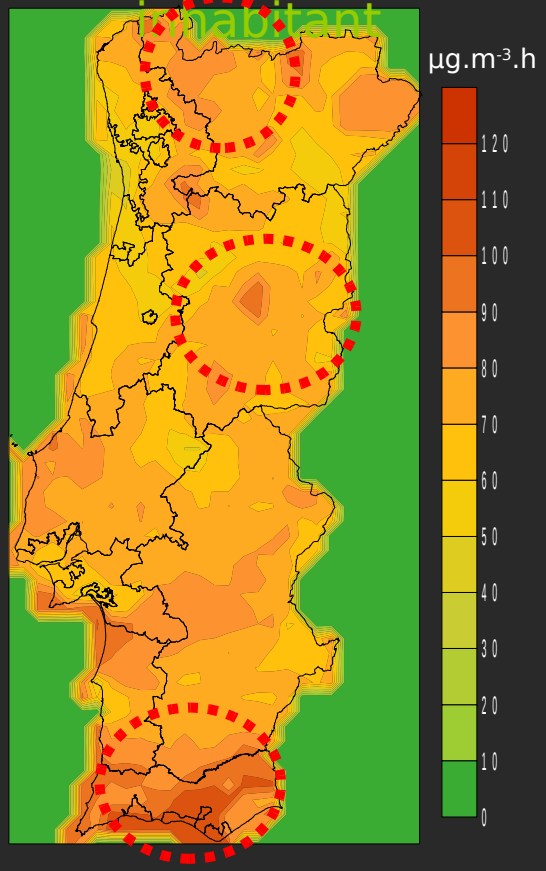
Monitoring values

NO_x 22 - 102 µg.m^{-3}.h (15 Countries from America, Asia and Europe)

PM_{10} 10 - 120 µg.m^{-3}.h $PM_{2.5}$ 20 - 40 µg.m^{-3}.h (Lisbon)

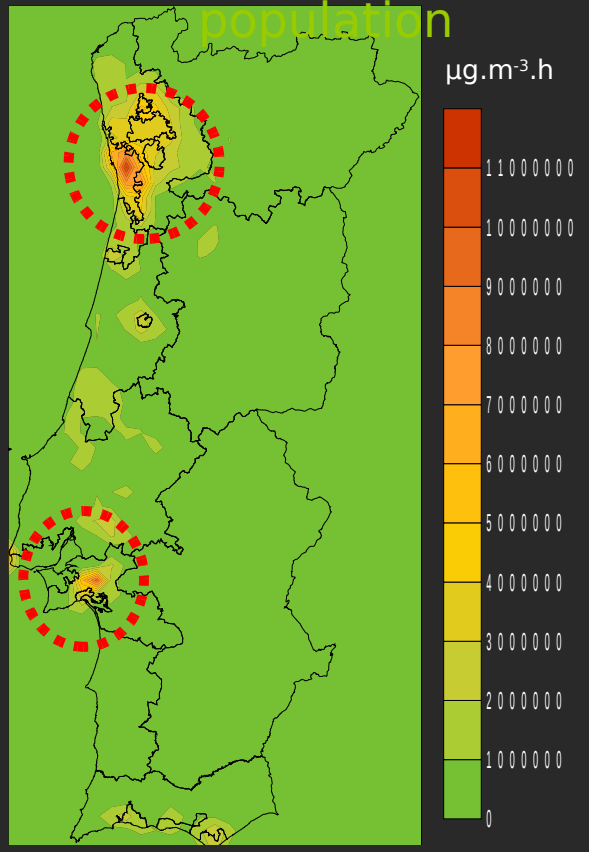
Results – 2007 year application

8h maximum value per inhabitant



O_3

8h maximum value for total population



O_3 exposure higher in the northern inland and southern regions

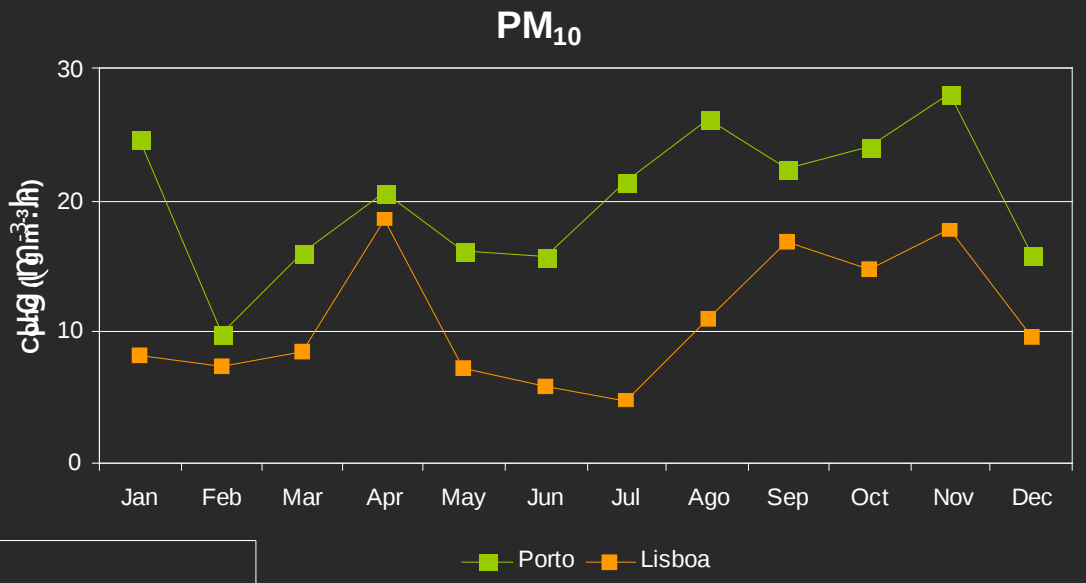
O_3 total exposure higher in metropolitan areas of Porto and Lisbon

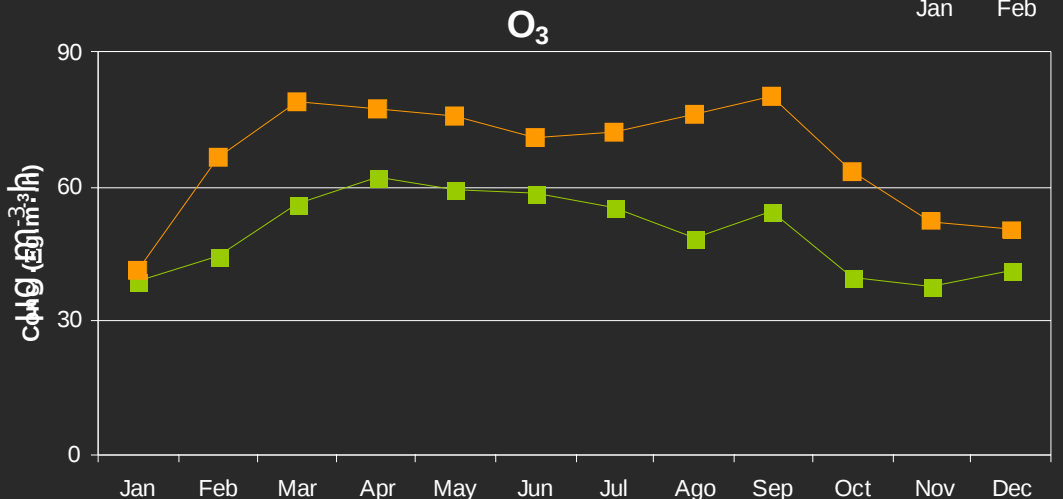
Results – 2007 year application

Human exposure time series for Porto and Lisbon

Porto

Lisbon





Final comments

The methodology developed is the main goal to retain because the uncertainty of results greatly depends on the input data used.
This application is a valuable tool for people awareness and health protection.

- Possibility of application of this human exposure model with different air quality models (forecast mode or not)

- High individual exposure values for NOx and PM were found in the metropolitan area of Porto (and also Lisbon)

- High individual exposure values for O_3 are found in the northern and inland regions of Portugal.

Future work

- Improvement of the exposure model:
  - estimation on indoor sources (in particular for PM)
  - indoor/outdoor coefficients
  - microenvironments description and quantification

- Investment on **field campaigns** with direct human exposure monitoring, also useful for model validation

Thank you for your attention