European Network on New Sensing Technologies for Air Pollution Control and Environmental Sustainability - *EuNetAir*

COST Action TD1105

INTERNATIONAL WG1-WG4 MEETING on

New Sensing Technologies and Methods for Air-Pollution Monitoring

European Environment Agency - EEA

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Challenges for a New Air Quality Directive: The Role of Monitoring and Modelling Techniques

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2008 Air Quality Directive

Guidelines and requirements for:

- ✓ **Air quality measurements**
- ✓ **Air quality assessment**
- ✓ **Limit and target values for air pollutants**
- ✓ **Public information and reporting**

OBJECTIVES

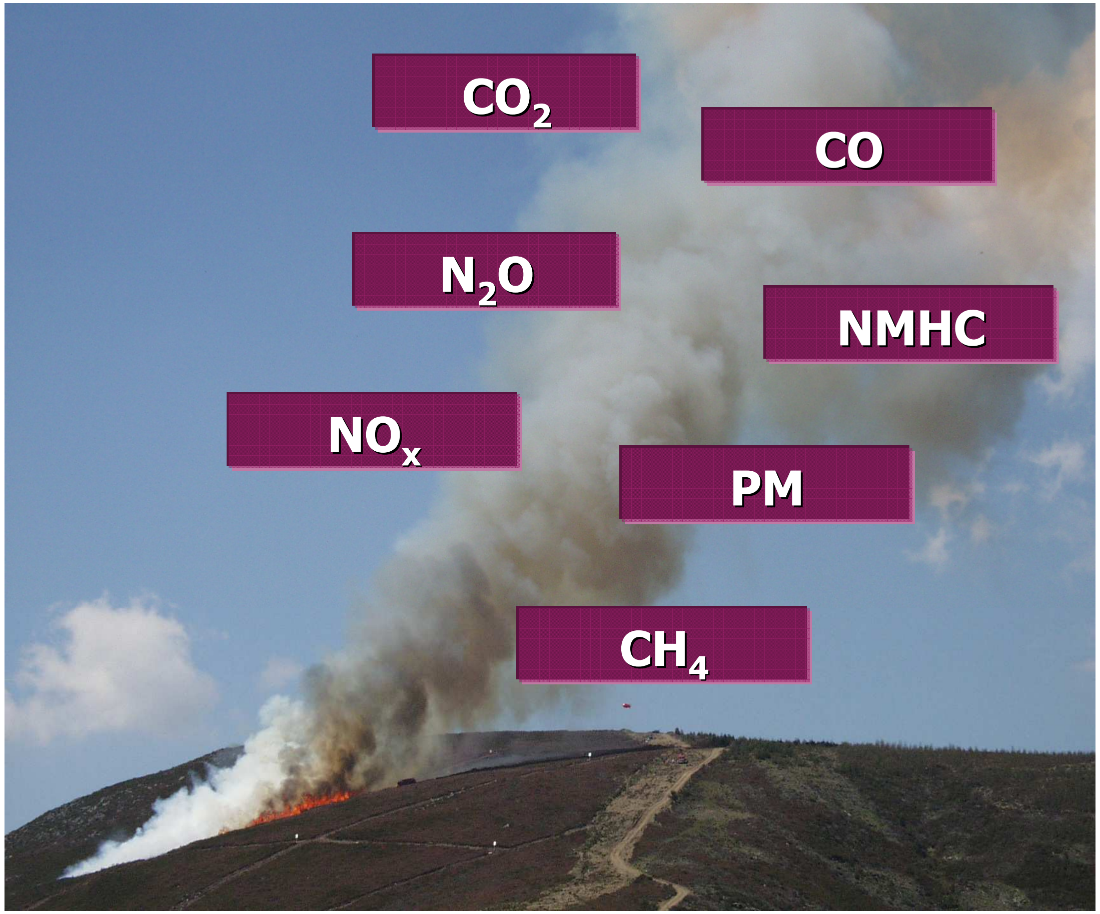
- **To protect human health, paying particular attention to sensitive populations;**
- **To minimise harmful effects on the environment as a whole (ecosystems, vegetation, materials and ozone layer);**
- **To prevent air pollution in advance;**
- **To improve the monitoring and assessment of air quality;**
- **To provide information to the general public.**

major goals

protect human health

promote cleaner air for Europe

Forest Fires | example



global scale → **climate change**

regional scale → **photochemical pollution**

local scale → **acute air quality problems**

Contributions from natural sources can be assessed but not controlled.
Smoke has to be considered as one of the several disturbing effects from forest fires.
Its impacts on air quality and human health can be considerable.

Objective

What are the critical air pollutant levels a fire-fighter is exposed?

What could be the effects on his health?

How to do it?

Monitoring

smoke exposure measurement

PM2.5
NO_2
CO
VOC

10 fire-fighters

+ meteorology + air quality

Individual exposure

Individual exposure measurements of a group of ten firefighters equipped with portable "in continuum" measuring devices.

Equipment criteria:

- toughness,
- weight,
- possibility of continuous data acquisition,
- easiness of operation.

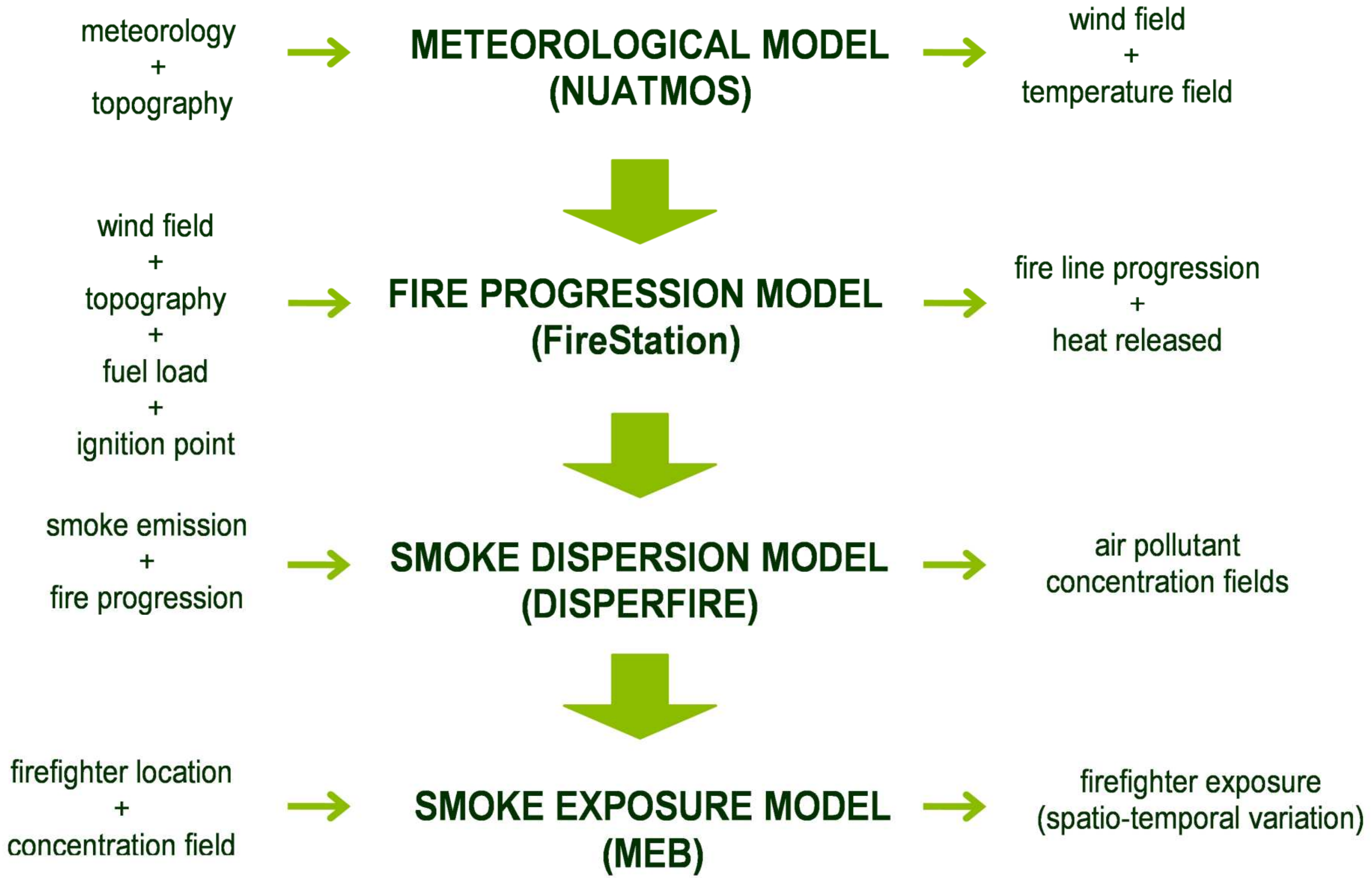
GasAlertextreme (CO)

TSI AM510 (PM2.5)

But, can we go measuring anytime we need to know exposure and health effects?

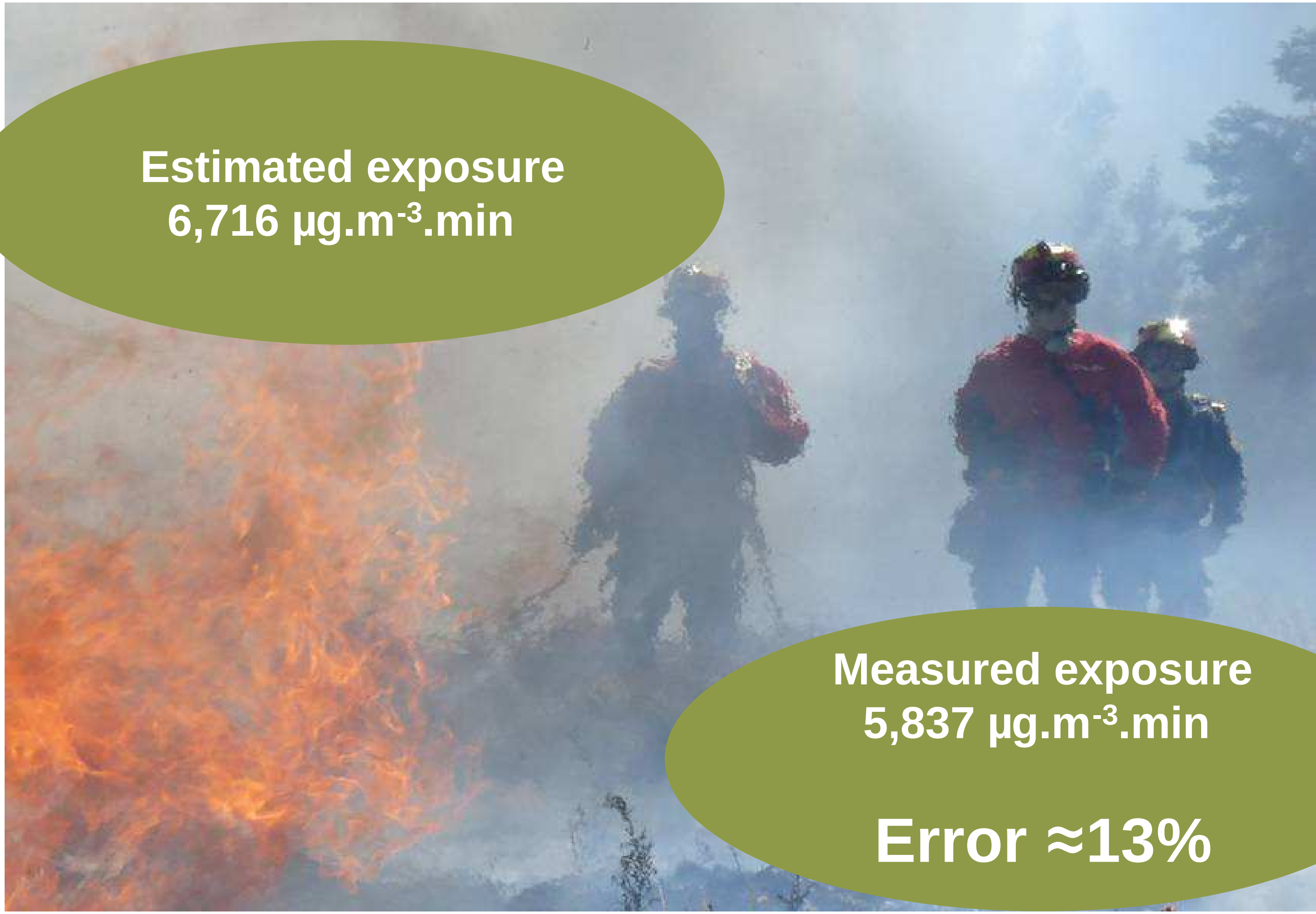
NO!

Modelling!!!!



(IJWF, Valente et al., 2007)

Results for VOC



Estimated exposure
6,716 µg.m^{-3}.min

Measured exposure
5,837 µg.m^{-3}.min

Error ≈13%

2008 Air Quality Directive

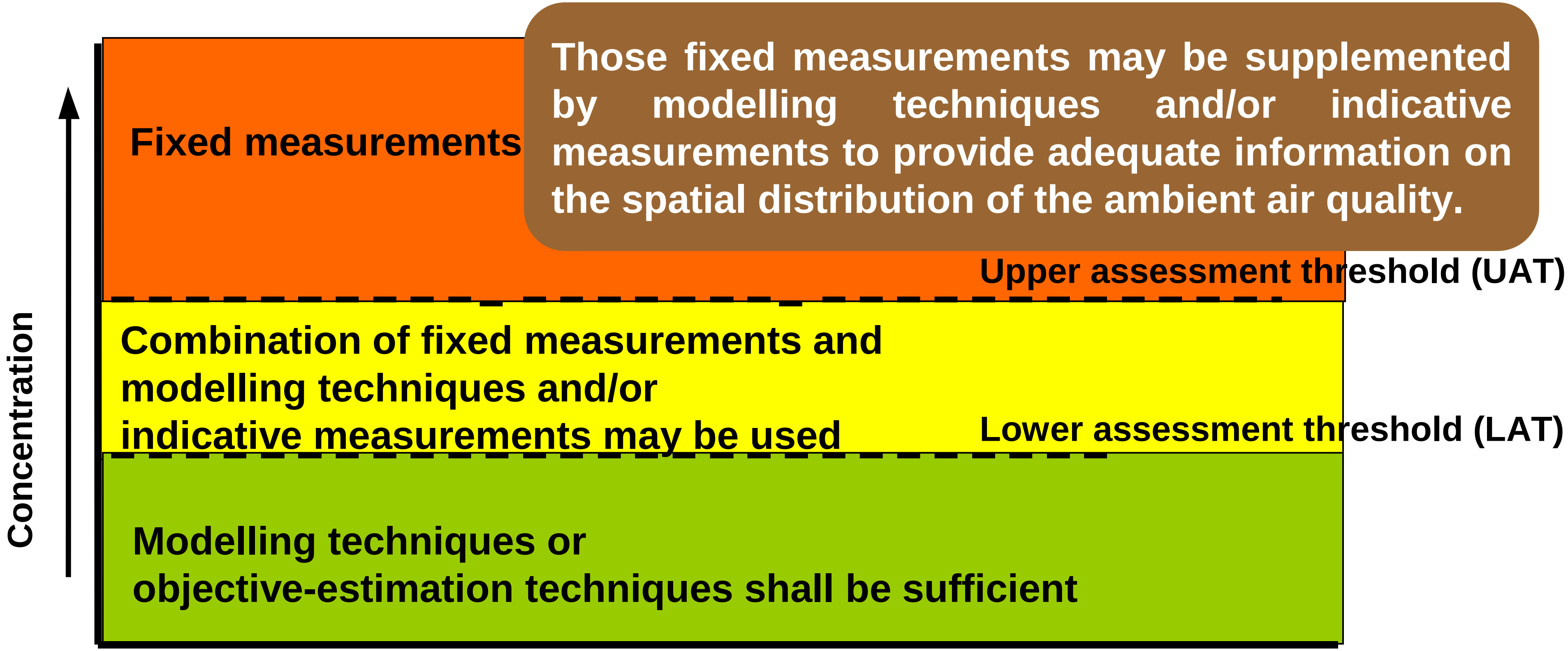
important goal

improve the monitoring and assessment of air quality

- ‘assessment’ shall mean any method used to measure, calculate, predict or estimate levels.

2008 Air Quality Directive| air quality assessment

Assessment strategy depends on upper and lower assessment thresholds



SO_2, NO_2, NOx, PM10, PM2.5, Pb, C_6H_6, CO

AQ assessment: measurement and model

- Traditionally, AQ assessment has been based on monitoring data, but due to the sparse spatial coverage of fixed monitoring stations, this assessment has some limitations.

- According to the AQ Directive, Member States can also report their AQ assessment based on modelling techniques alone.

- Modelling approaches can provide complete spatial coverage information, but models always are uncertain and their results can be biased.

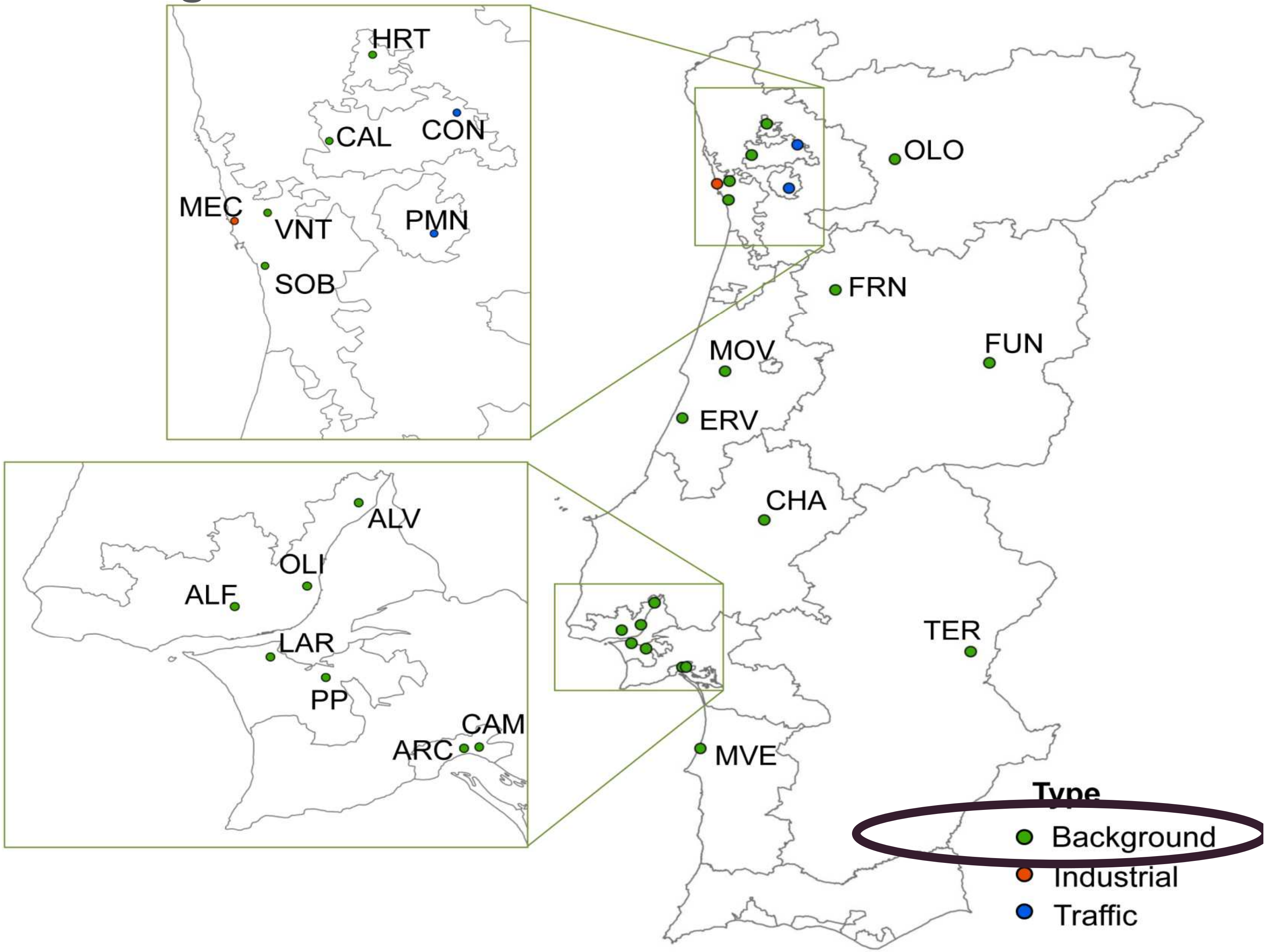
Example: AQ assessment for 2010, considering the period 2006-2010 (5 years)

Portugal data | example

Zone/ agglomeration	Related to limit values								Related to critical levels	
	NO_2		PM10		PM2.5	CO	C_6H_6	SO_2		NOx
	1hr mean	annual mean	24h mean		annual mean			24hr mean	winter mean	annual mean
Braga										
Vale do Ave										
Vale do Sousa										
Porto Litoral										
Norte Litoral										
Norte Interior										
Aveiro/Ílhavo										
Coimbra										
Z.I. Estarreja										
Centro Litoral										
Centro Interior										
AML Norte										
AML Sul										
Setúbal										
VTO										
P. Setúbal/AS										
Alentejo Litoral										
Alentejo Interior										
Portimão/Lagoa										
Albufeira/Loulé										
Faro/Olhão										
Algarve										

For zones < UAT it is possible to use combined data from modelling and monitoring as a supplementary assessment method!

Monitoring stations



Bias-correction technique

a multiplicative ratio correction

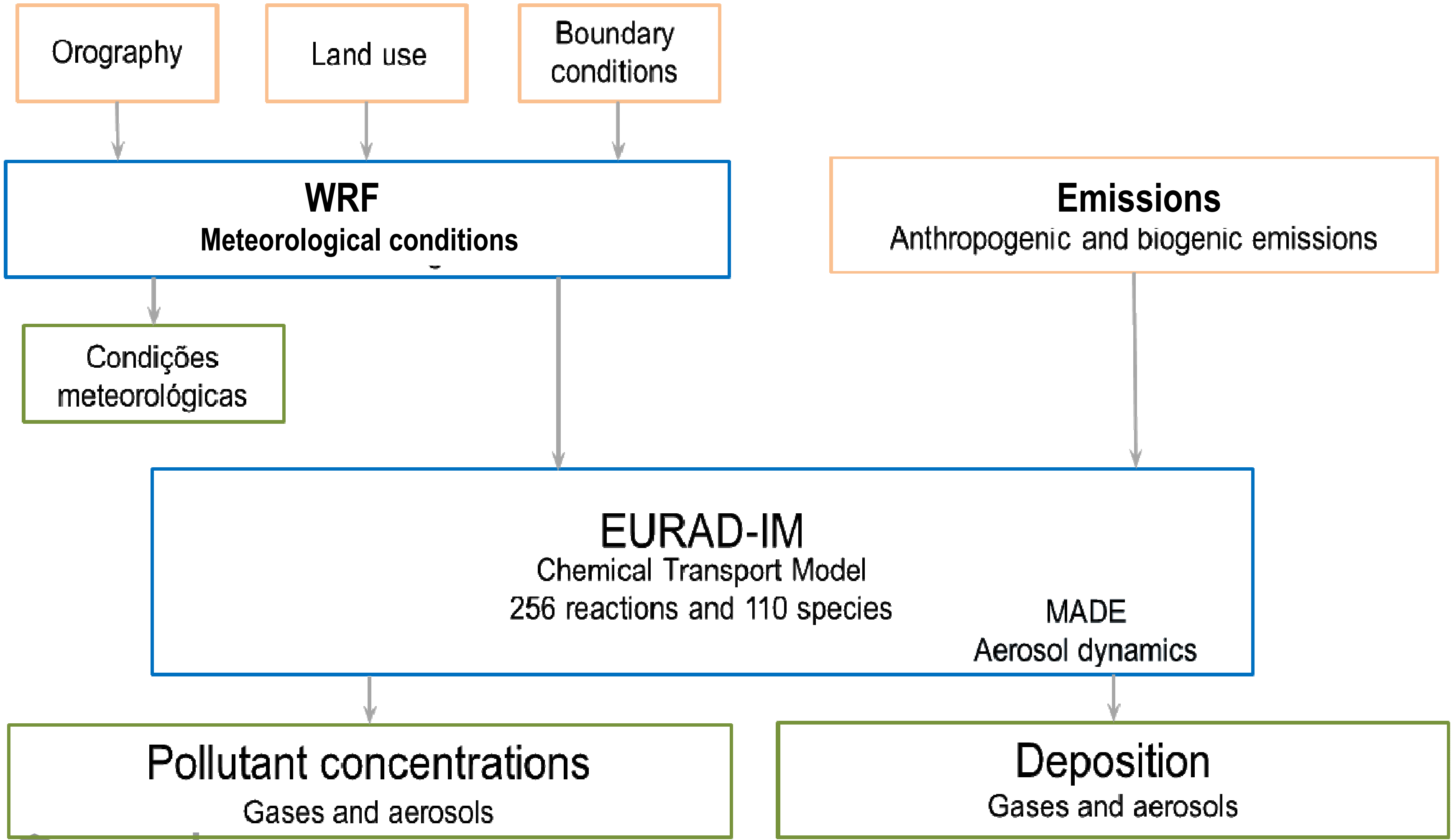
$$C^{corrected}(h,day) = \frac{\sum_{ndays} C^{obs}(h,day)}{\sum_{ndays} C^{model}(h,day)} \times C^{model}(h,day)$$

After BIAS correction, model results have a decrease > 70% on the average systematic error

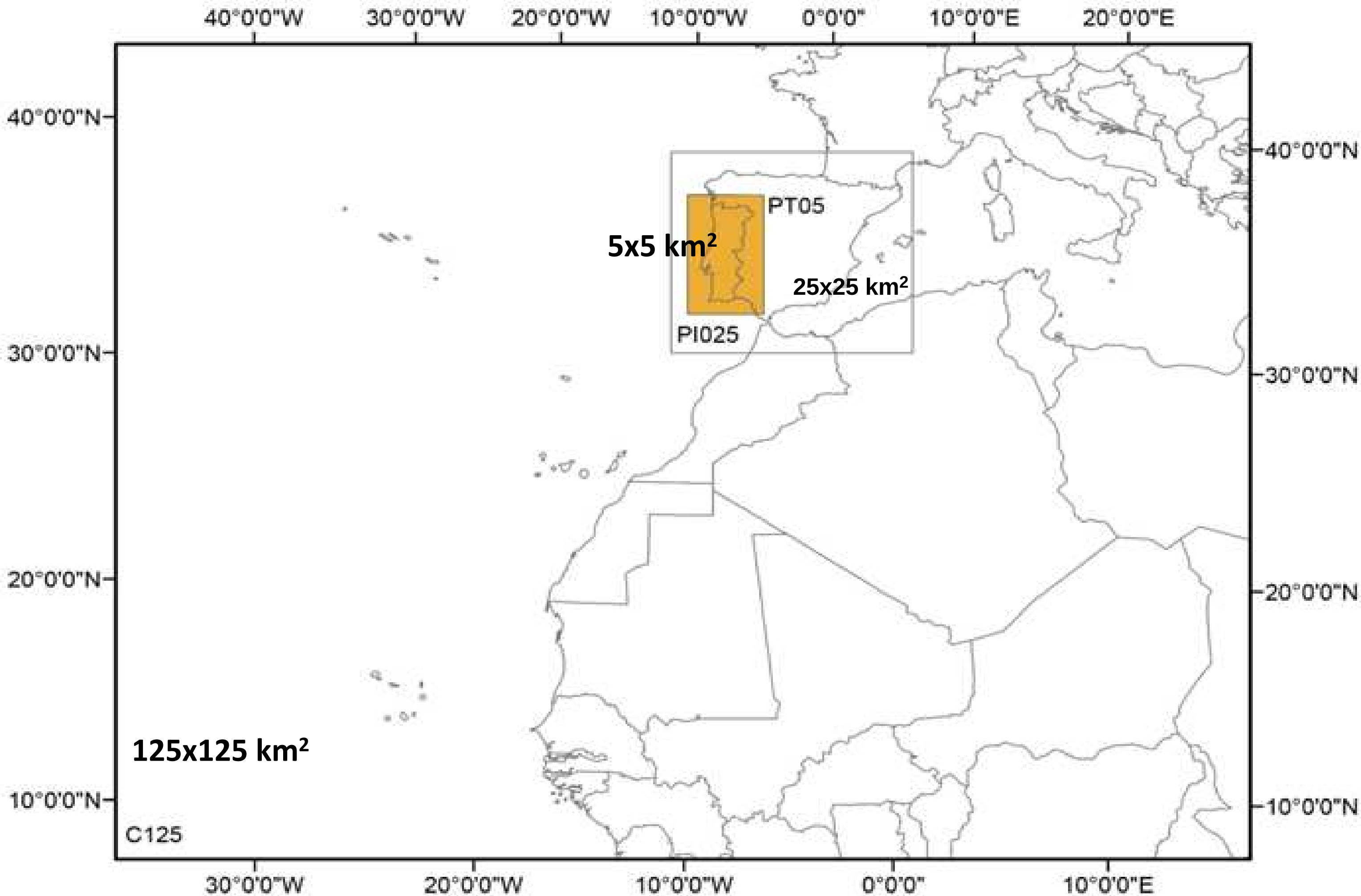
It improves the modelling data and combines pollutant concentration values from a fixed monitoring station and from a numerical modelling system.

Air quality modelling system (with bias correction

WRF / EURAD-IM



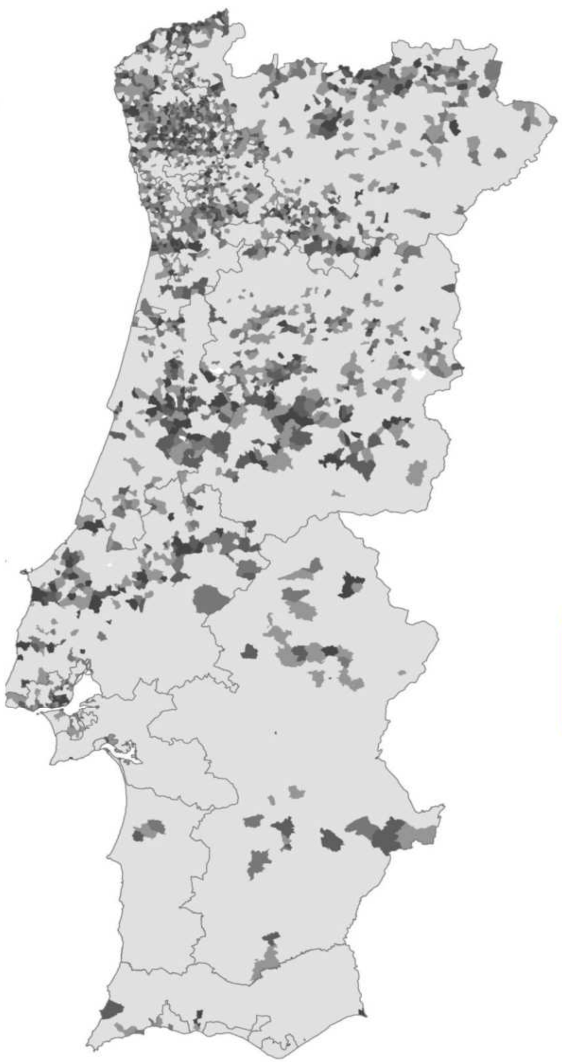
Air quality modelling system
Simulation domains



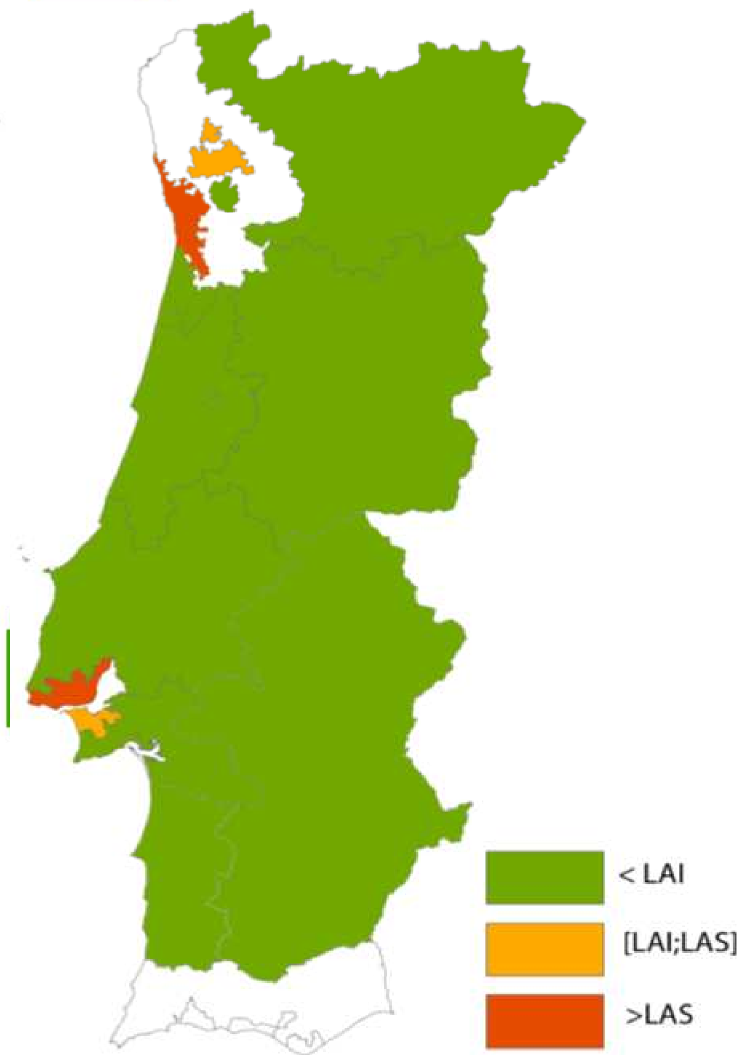
Data needed to AQ supplementary assessment method

Road network

Population



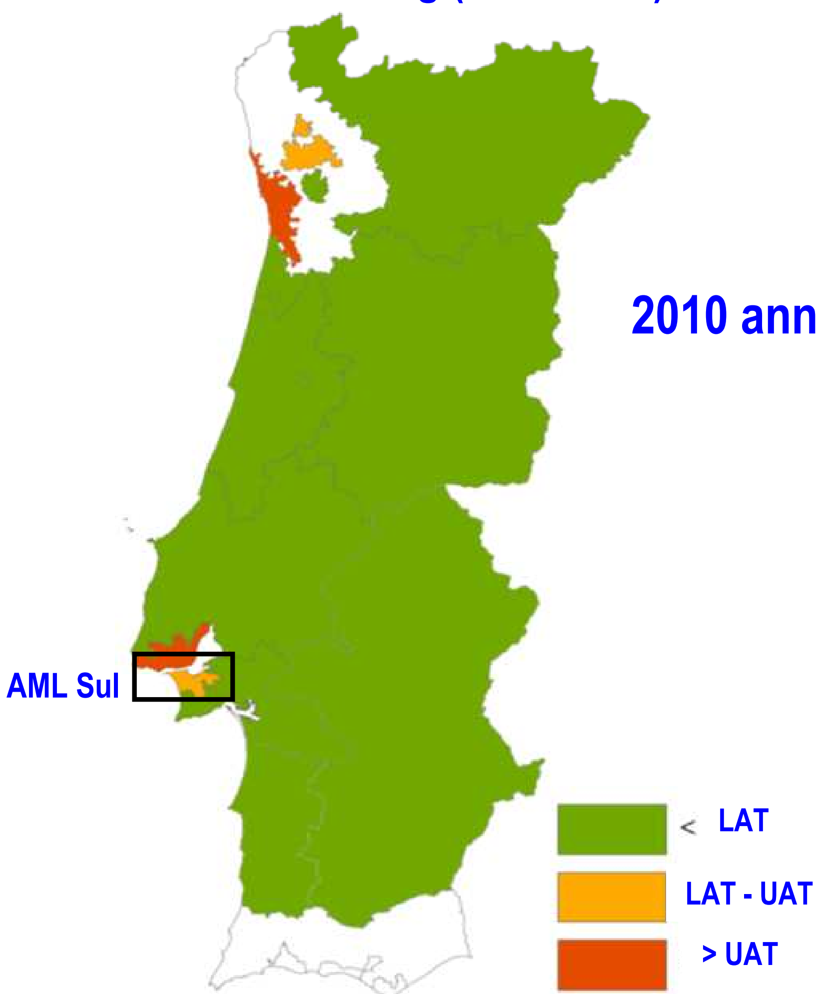
NO_2 Concentration fields



AQ assessment | NO_2

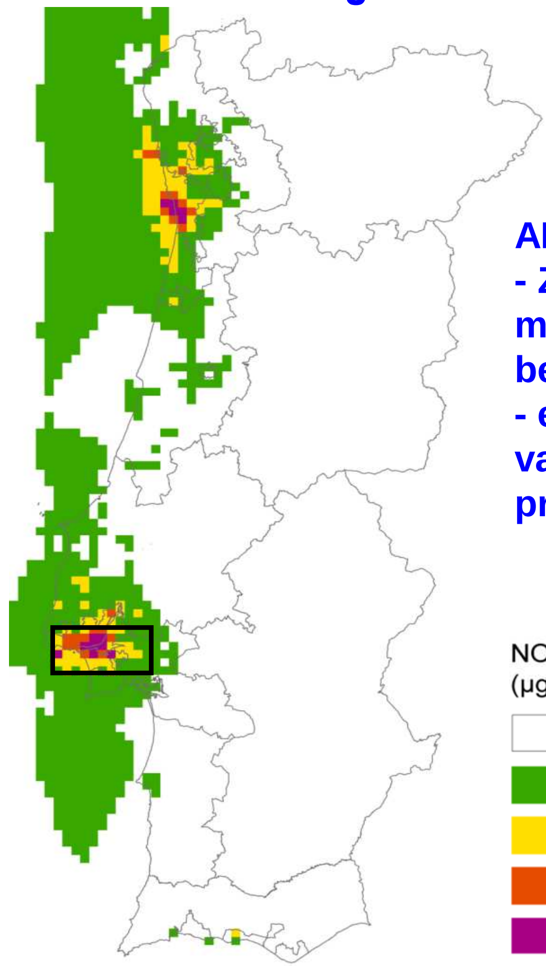
data combination from monitoring and modelling systems

Monitoring (2006-2010)

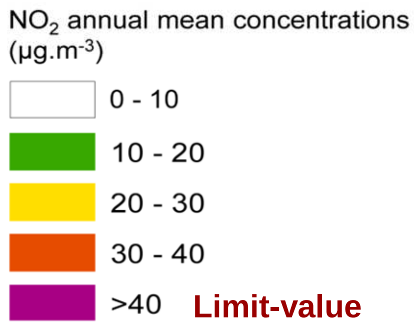


2010 annual mean

Modelling

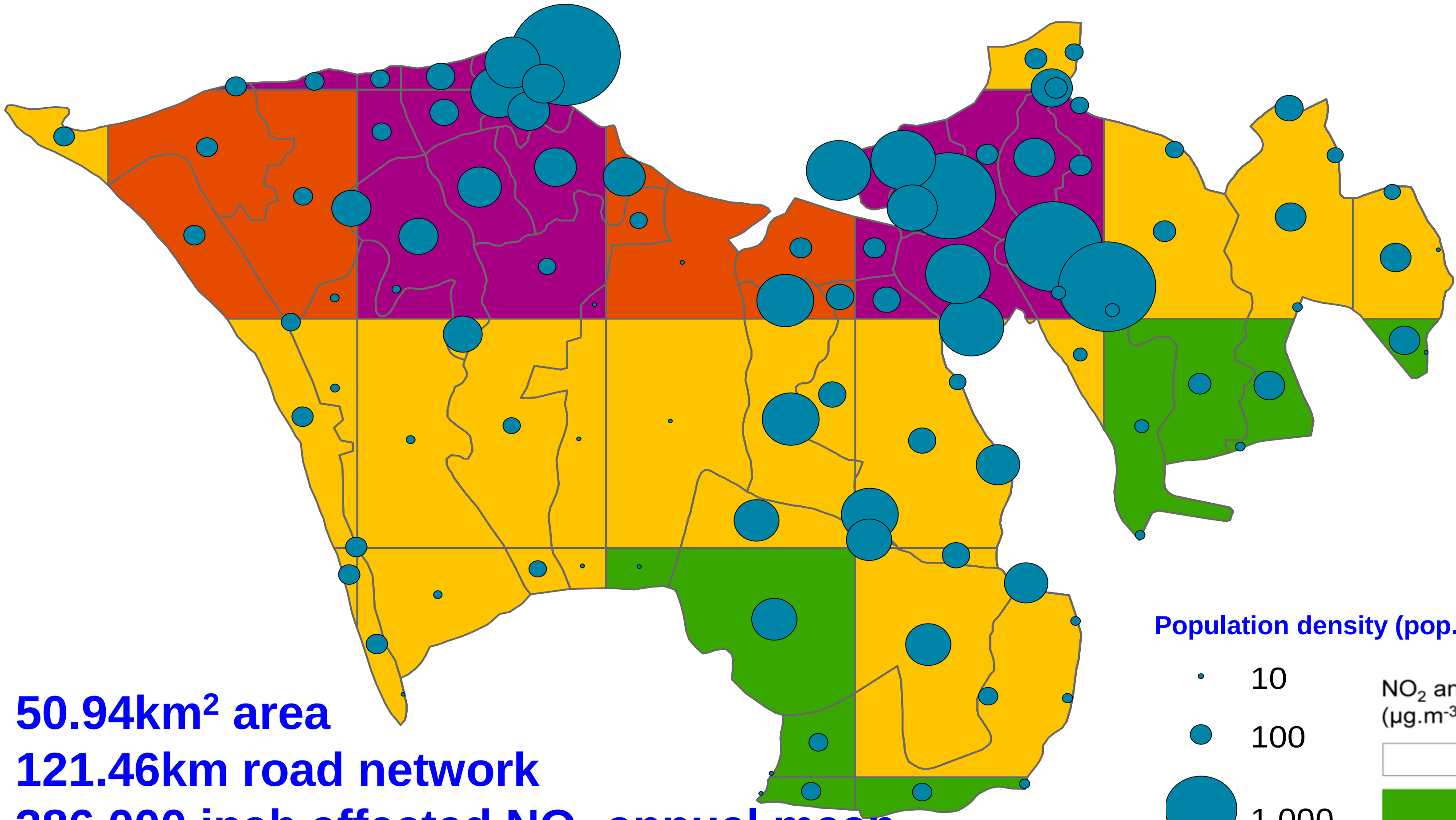


AML-Sul:
- **ZA with NO_2 annual mean concentration below UAT;**
- **exceedance of limit value for human health protection.**



AQ assessment | NO_2

2010 annual mean – AML Sul



- **50.94km^2 area**
- **121.46km road network**
- **386.000 inab affected NO_2 annual mean concentration values > limit value**

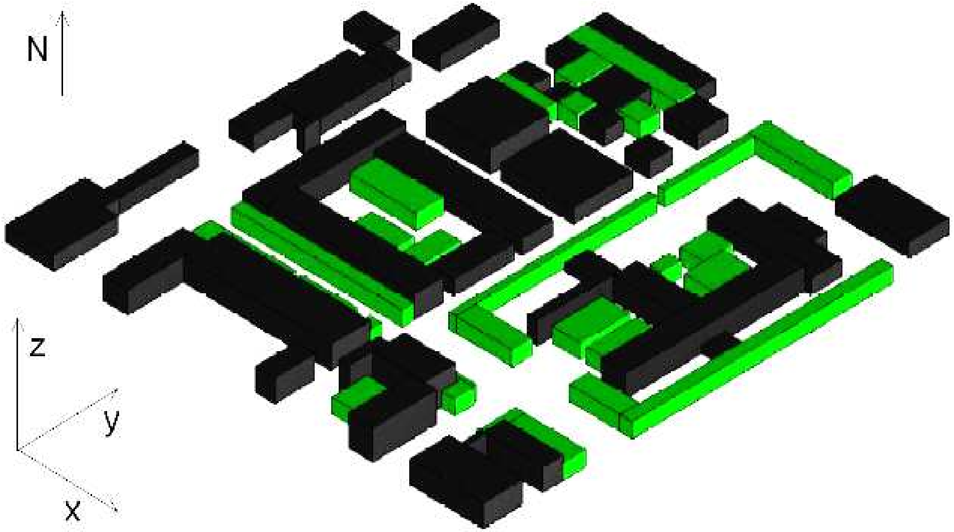
Improved information for reporting to EC!

Study area in Aveiro, Portugal

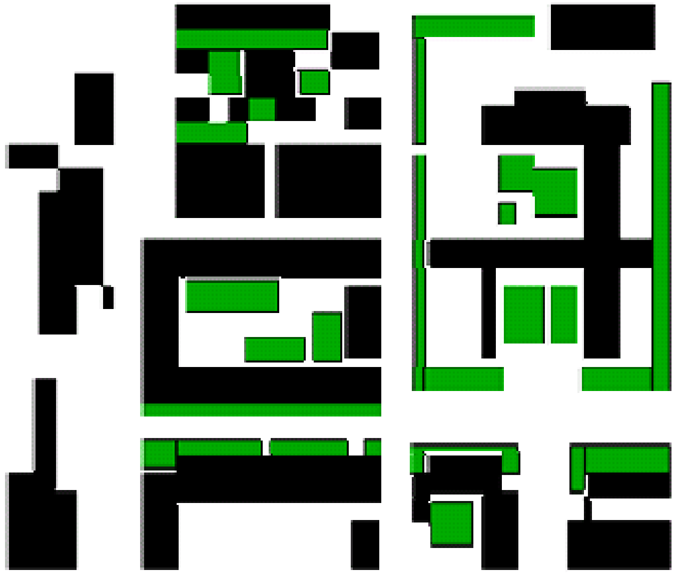
Study area School

- 8.4 ha with residential buildings and a school
- one of the most important thoroughfares of the town ("25 de Abril" Av.)
  - main Avenue flanked by **dense tall trees**

Study area - virtual domain -



3D perspective

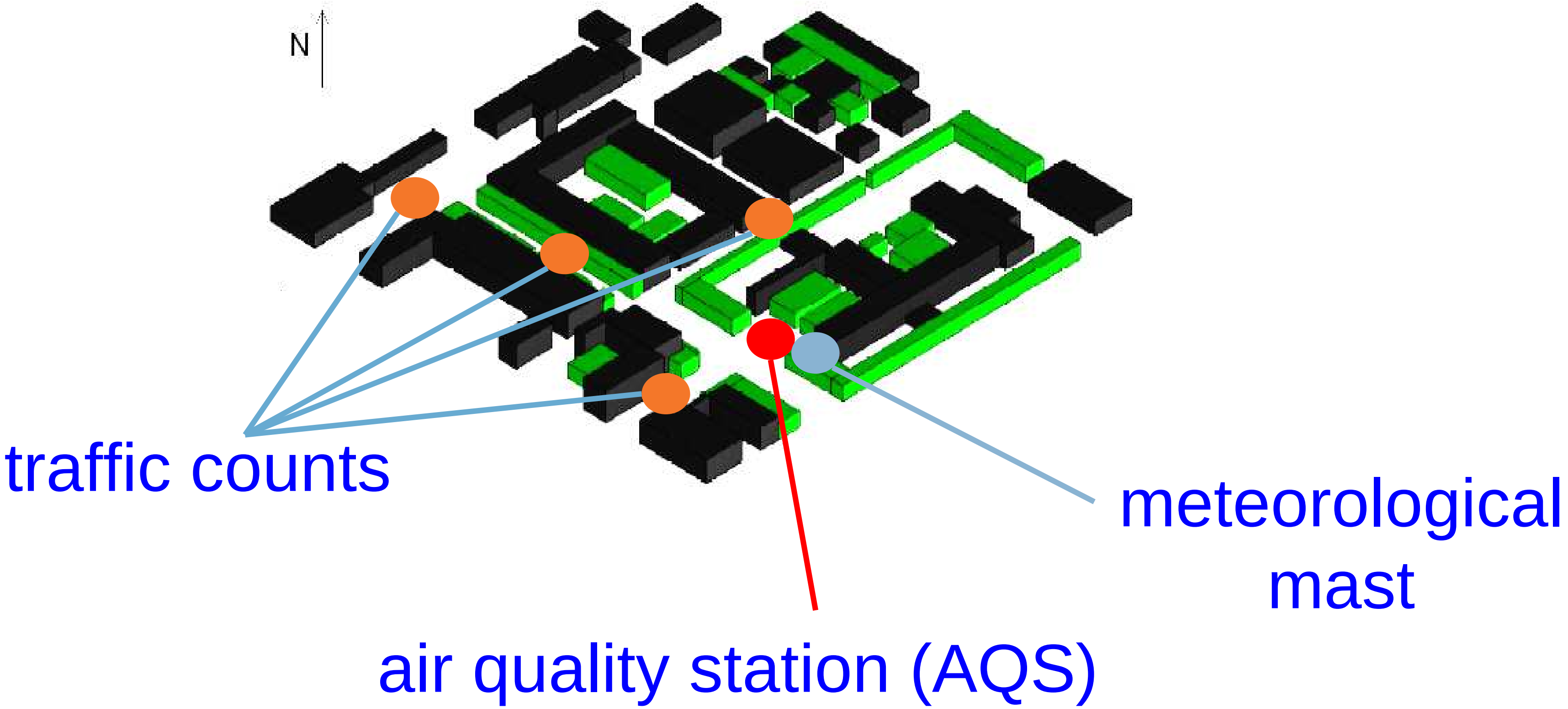


top view

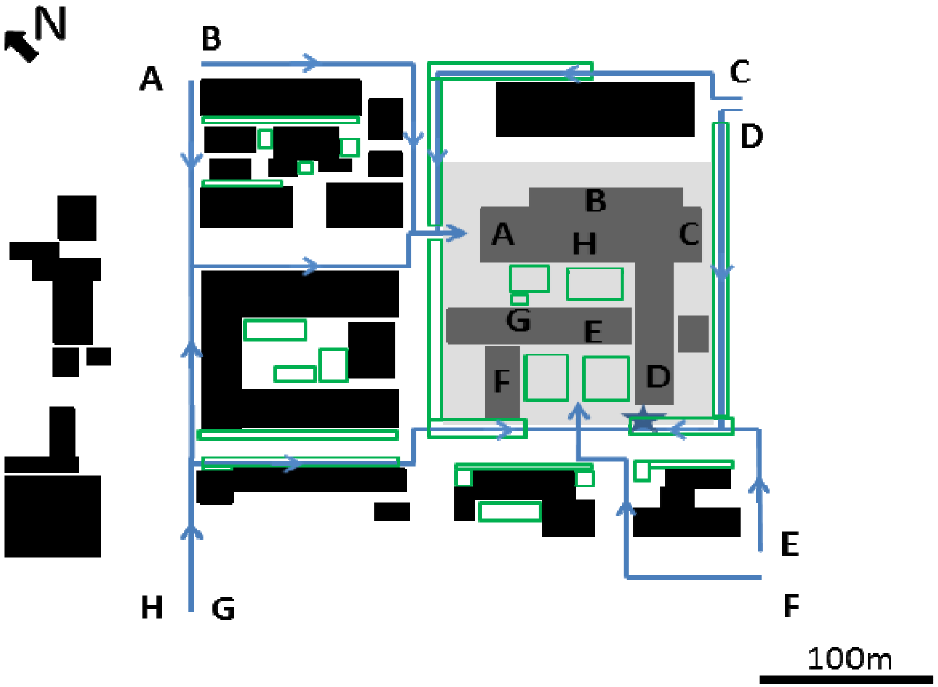
buildings
trees

- 3D geometry typology
- buildings shape simplified as regular blocks (due to model structured grid)
- contiguous buildings assembled based on configuration and height
- trees are defined as porous blocks (porosity $\propto$ Leaf Area Density LAD)

Field campaign



Walking routes

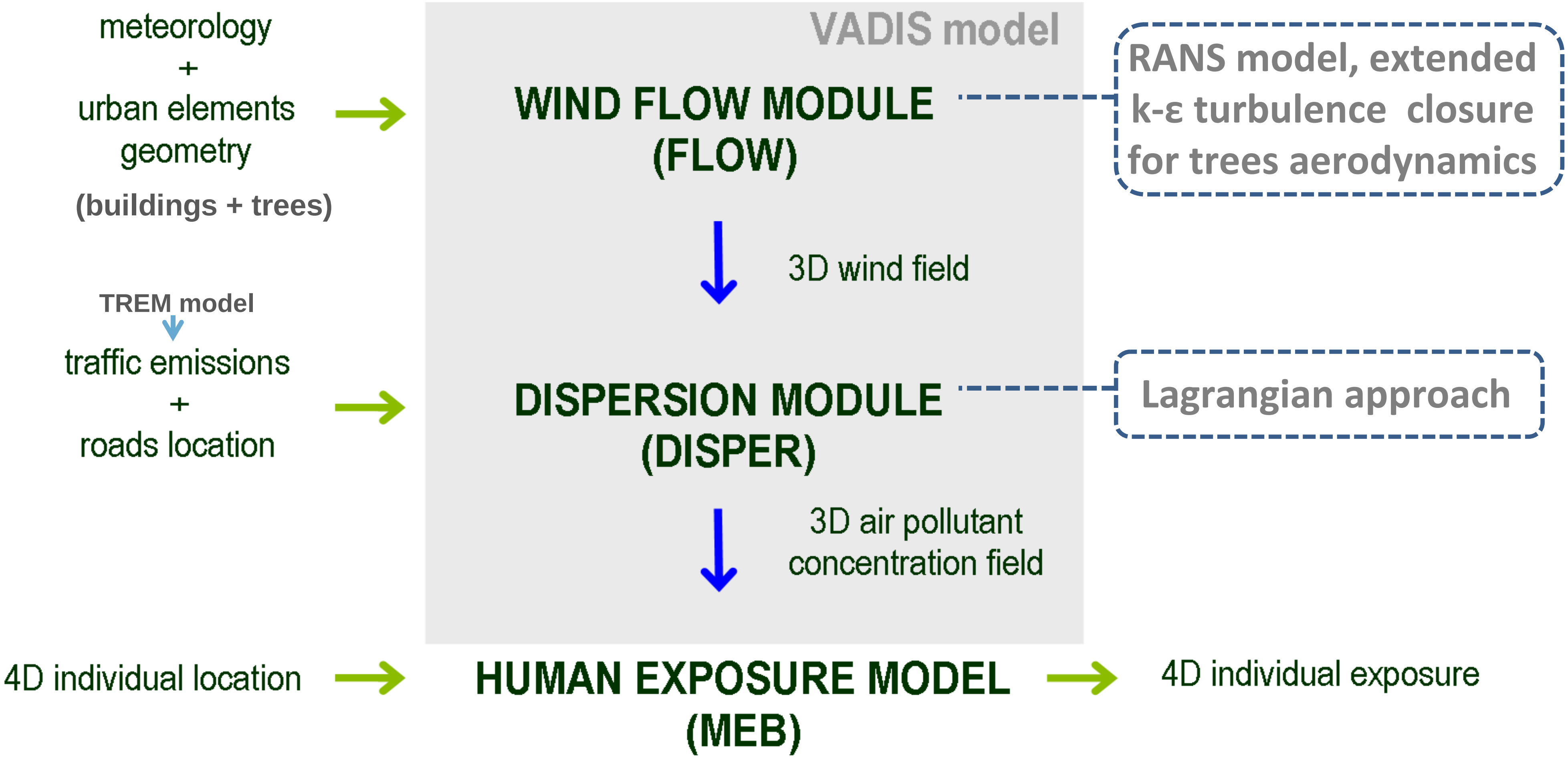


Selection of 8 alternative walking pathways to the school

The time profile of each route was monitored using a GPS

Numerical modelling approach

- estimation of individual human exposure in a city -



Numerical modelling approach

- outdoor human exposure -

the model tracks the time evolution of the personal exposure by matching, in each time-step, the georeferenced position of the individual with the concentration in that spot

$$Eout_{i,c} = Cout_{i,xy}\, t_{c,xy}$$

***E* – exposure**

***C* – concentration**

***t* – time**

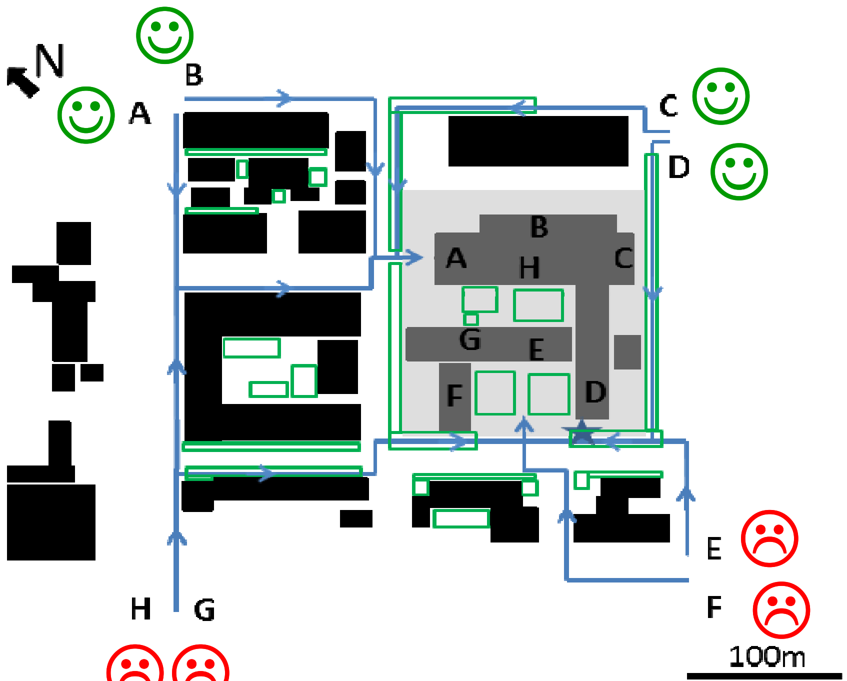
- indoor human exposure -

$$Ein_{i,c} = \left[\left(\frac{S_r + pQ_{i,r}Cout_{i,xy} - Q_{i,r}Cin_{i,r}}{V_r}\right)t_{c,r} + Cin_{i,r}\right]t_{c,r}$$

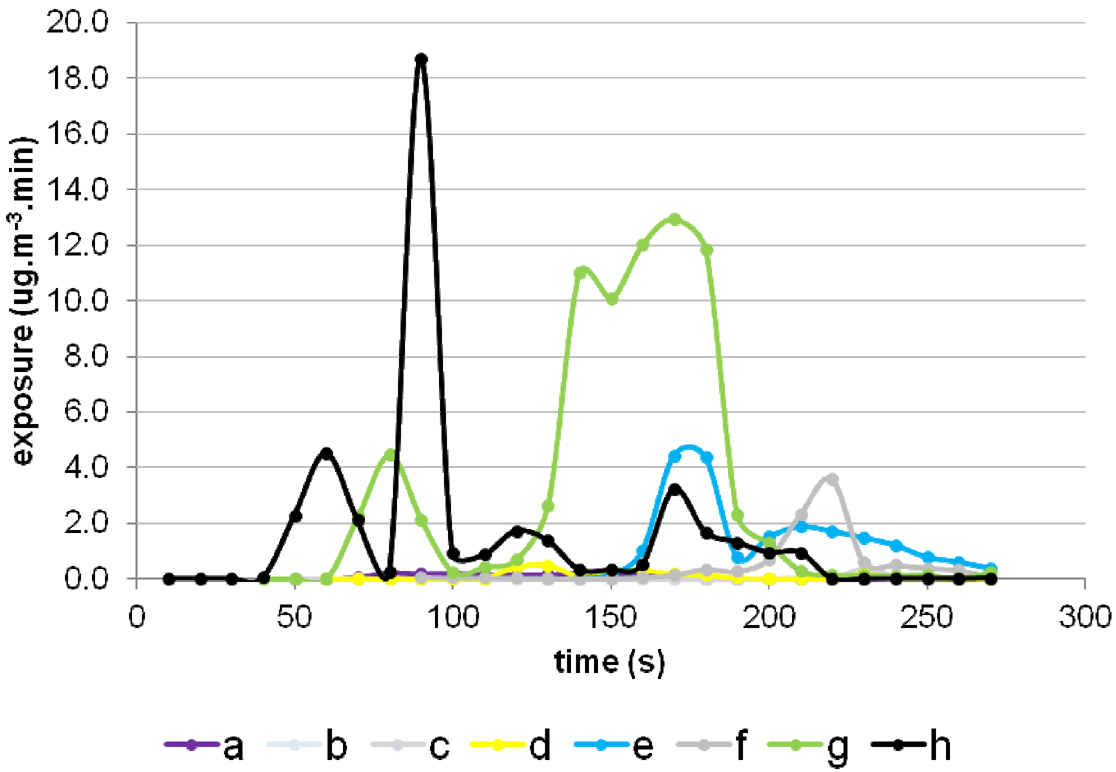
output data: instant and mean exposure values

Modelling results

- human exposure during the walk (outdoors) -



temporal evolution of PM10 exposure:



- **PM10 exposure varies significantly with the route, ranging from 0 to 19 µg.m^{-3}.min.**
- **Similar behavior for CO (range: 0 – 1376 µg.m^{-3}.min)**
- **Children coming from SW/SE have higher exposures on their walk to school**

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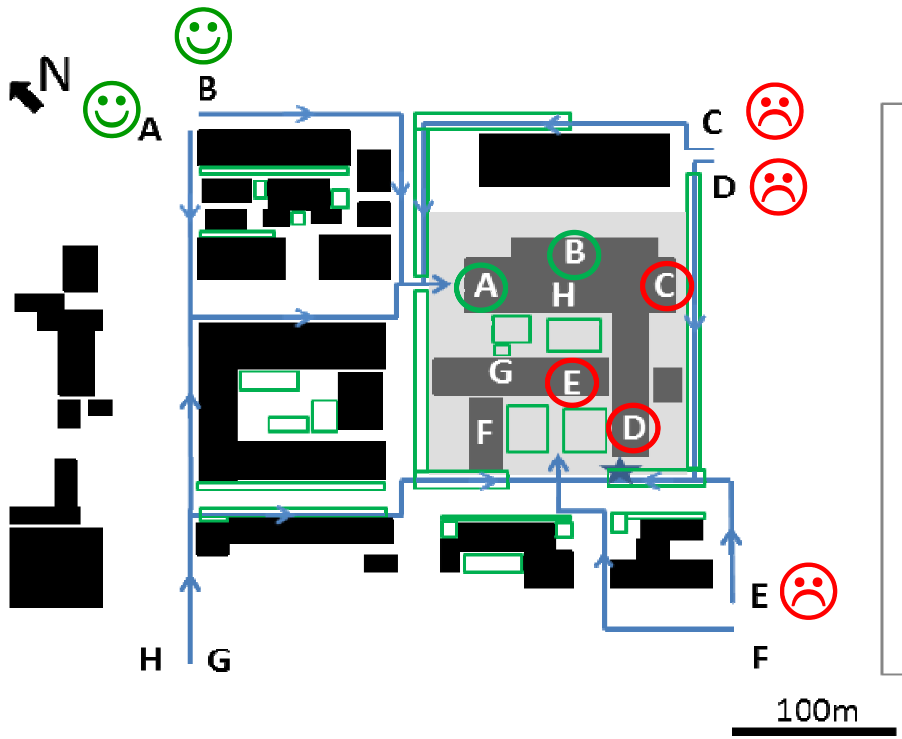
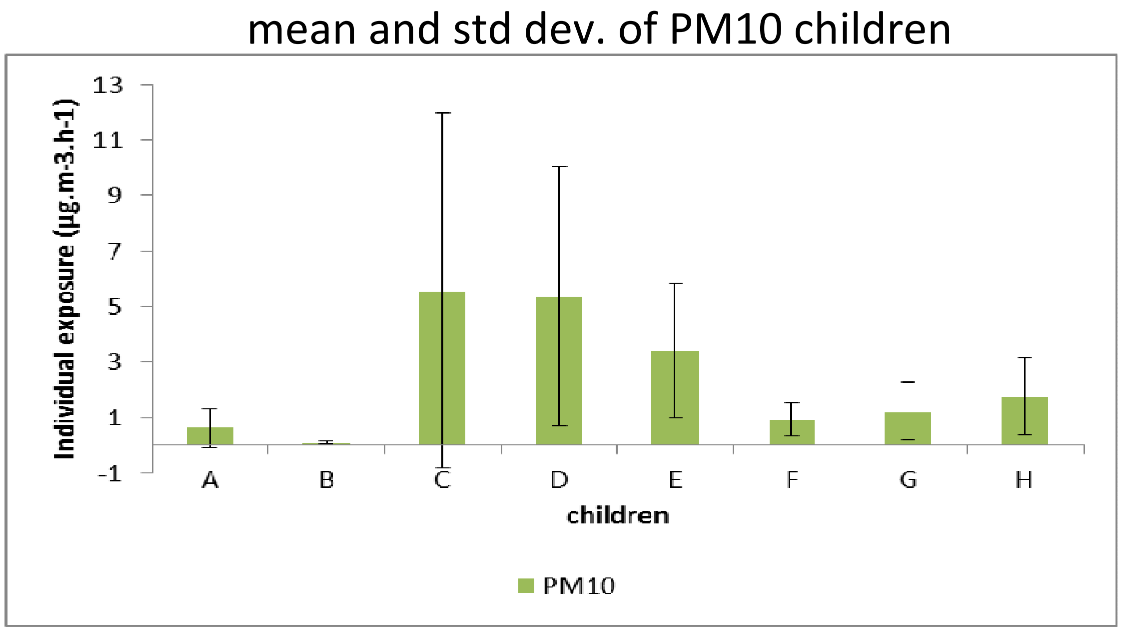
Modelling results

- human exposure during the morning (outdoors+indoors) -

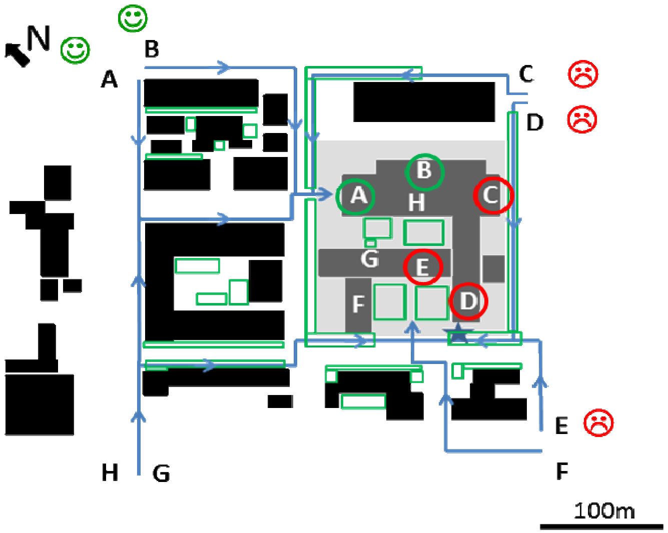




- **PM10 mean exposure varies significantly (range: 0.1 – 5.6 µg.m^{-3}.h)**
- **Similar behavior for CO (range: 9 – 527 µg.m^{-3}.h)**
- **Relation between the orientation of classroom's façade and resulting exposure wasn't found**
- **Children in the S/E part of the domain have higher exposures during the study period**

Conclusions for exposure

The children exposure varies significantly with the route and classroom location:



In the outdoor, child G has an average PM10 exposure 157x higher than child B, and 108x higher for CO

During the entire morning (out+in), child C attained an average PM10 exposure 69x higher than child B, and 56x higher for CO

Last remarks on exposure

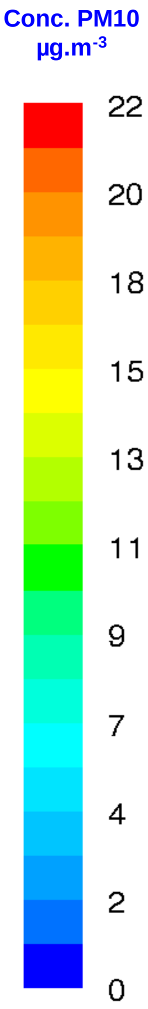
Due to the time and space variability of individual exposure, even in a small domain, a significant error can occur if a mean air quality value is used as a proxy for the exposure of the individuals that use that space.

CFD models can be used as basis for intelligent routing systems aiming to promote lower exposure of urban citizens to air pollutants in typical daily travels.

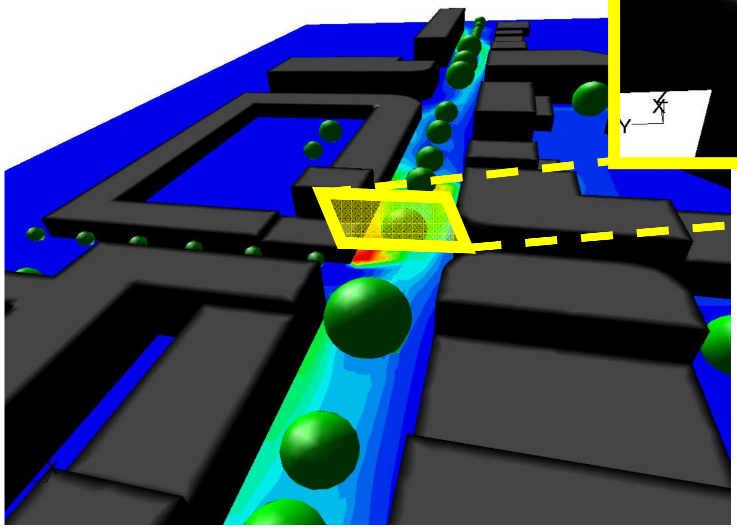
It is important that new Directive addresses this issues!

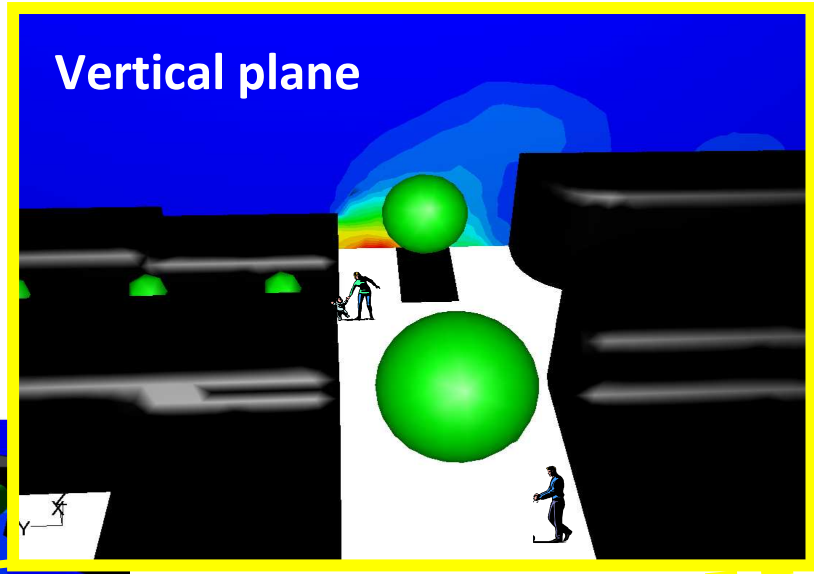
Street canyon is an example

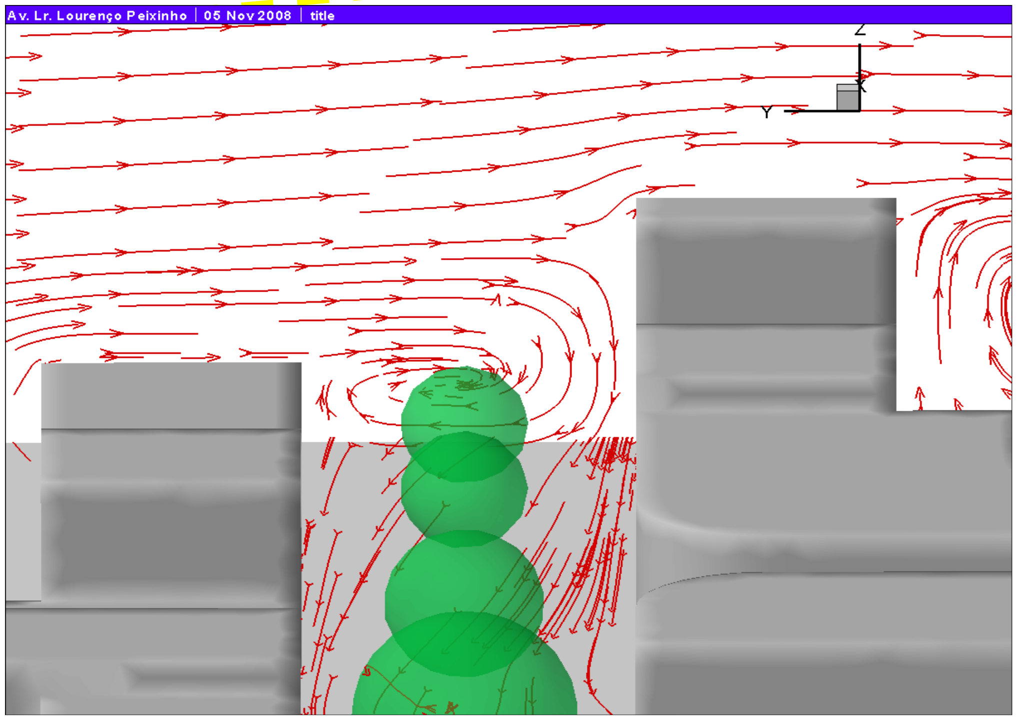
PM10 simulated levels



Horizontal plane







The decrease in the vertical component of wind velocity on the north side of the Avenue produces the pollutant accumulation

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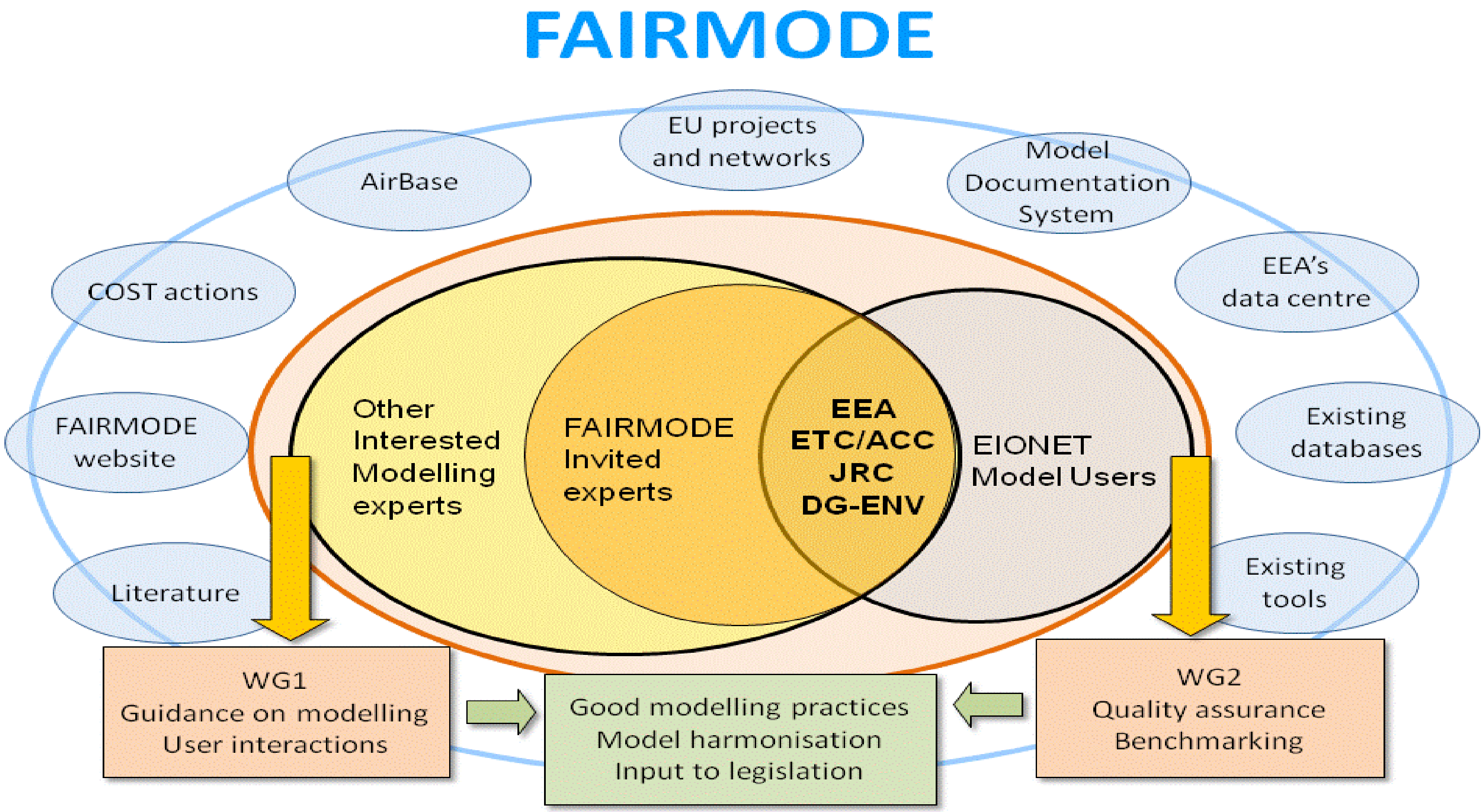
FAIRMODE | Forum for AIR Quality MODelling in Europe

Joint response action of the European Environment Agency to promote and support the harmonised use of models by EU member countries, with emphasis on their application to the European Air Quality Directive.



FAIRMODE | recommendations for the new AQ Directive

1. ON THE USE OF MODELS FOR REGULATORY PURPOSE AND TO SUPPORT AQ POLICY

strongly recommends the **use of models for AQ applications**. Text should be clarified:

- assessment of AQ levels to establish the extent of exceedances and population exposure;
- forecasting air quality levels for short term mitigation and public information;
- source allocation to determine the origin of exceedances and basis for planning strategies;
- development and assessment of plans and measures to control AQ exceedanc

2. MODEL QUALITY OBJECTIVES

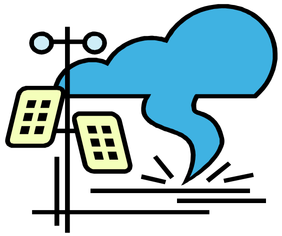
recommends a revision of **the data quality objectives for modelling**.

3. FORUM OF EU AQ REGULATORY MODELLING

recommends that, in parallel to what has already been established for the monitoring of AQ, **competent authorities for modelling activities are nominated** by the Member States (quality assurance of modelling).

4. QUALITY ASSURANCE AND CONSISTENCY OF EMISSION INVENTORIES

recommends to investigate and improve the **compilation, consistency and quality assurance of emissions data** suitable for AQ modelling under the directive.



Thank you

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