12th International Conference on
Harmonisation within Atmospheric Dispersion
Modelling for Regulatory Purposes

Determination of background concentrations using spectrum analysis of monitoring data

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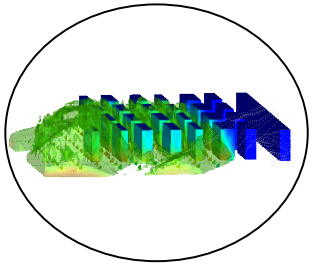
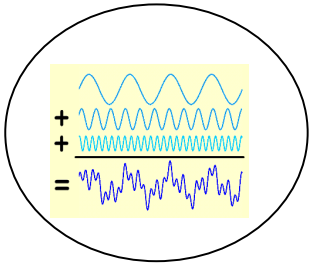
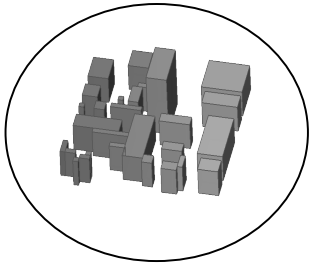
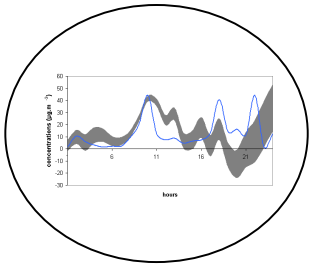
Presentation outline

- Introduction
- Objectives
- Methodology
- Application example
- Results
- Conclusions



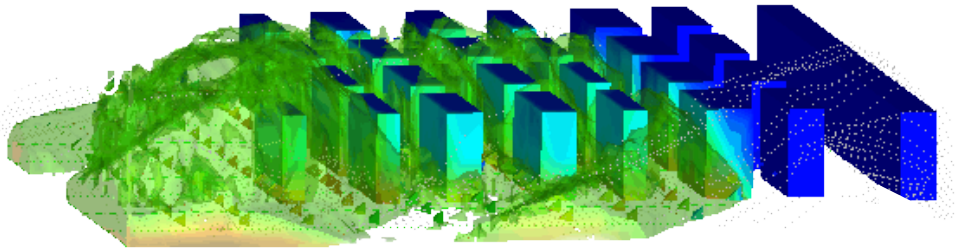






Introduction

"Background concentration" - due to the impact of nearby sources other than the ones currently under consideration



Background concentrations for the local scale application:

Representativeness ?

Uncertainty ?

Double counting of the sources?

1) **AQ Measurements** → **CFD model**

???

2) **Mesoscale model** → **CFD model**

Objectives

inappropriate selection of background pollutant levels could be a significant source of uncertainty in the modelling results

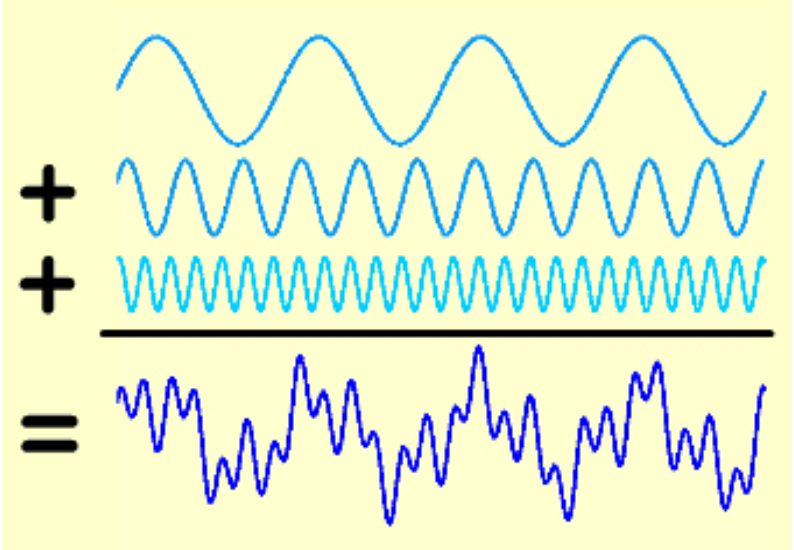
development of a methodology to determine representative background concentrations from air quality monitoring data to be used by local scale models

1. spectral analysis of the data ⇨ Contribution of different frequencies to the variance

2. decomposition of the time series ⇨ Remove the short-term variations

Methodology

- **spectral analysis of the data**



a time series X_t of length N is presented as a linear combination of harmonic functions with frequencies $\{f_j\}$ and amplitudes $\{A_j\}$ and $\{B_j\}$:

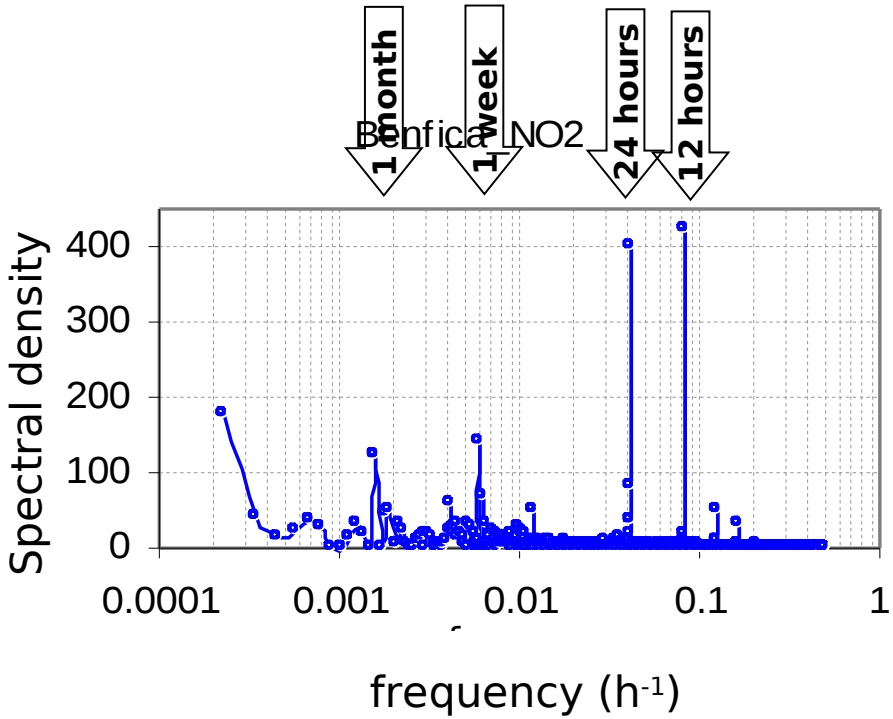
$$X_t = \mu + \sum_{j=1}^{[N/2]} \left[A_j \cos(2\pi f_j t) + B_j \sin(2\pi f_j t) \right],$$

FFT

Methodology

- **spectral analysis of the data**

  1 year measurements at the frequency domain

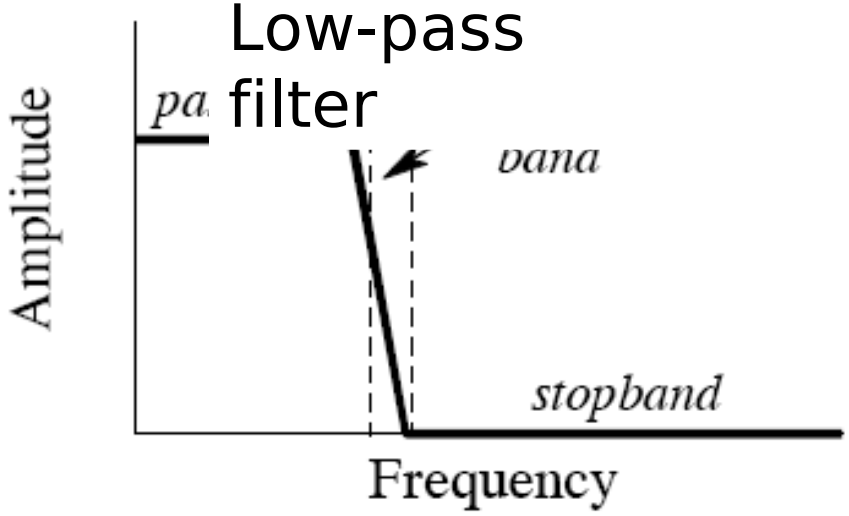


Methodology

2) decomposition of the data

Data filtering

Low-pass filter



Kolmogorov-Zurbenko filter

Multiple-pass moving average filter:

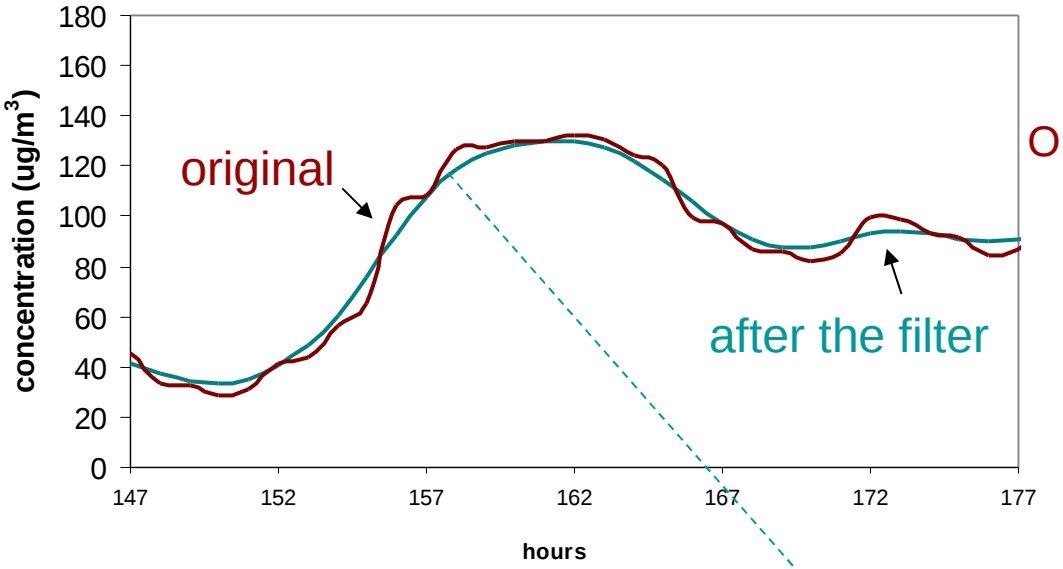
The KZ(*m*,*k*) filter of the original time series is computed as a simple moving average of *m* points applied *k* times (number of iterations)

$$w_c \approx \frac{\sqrt{6}}{\pi}\sqrt{\frac{1-(1/2)^{1/2k}}{m^2-(1/2)^{1/2k}}}$$

separation frequency

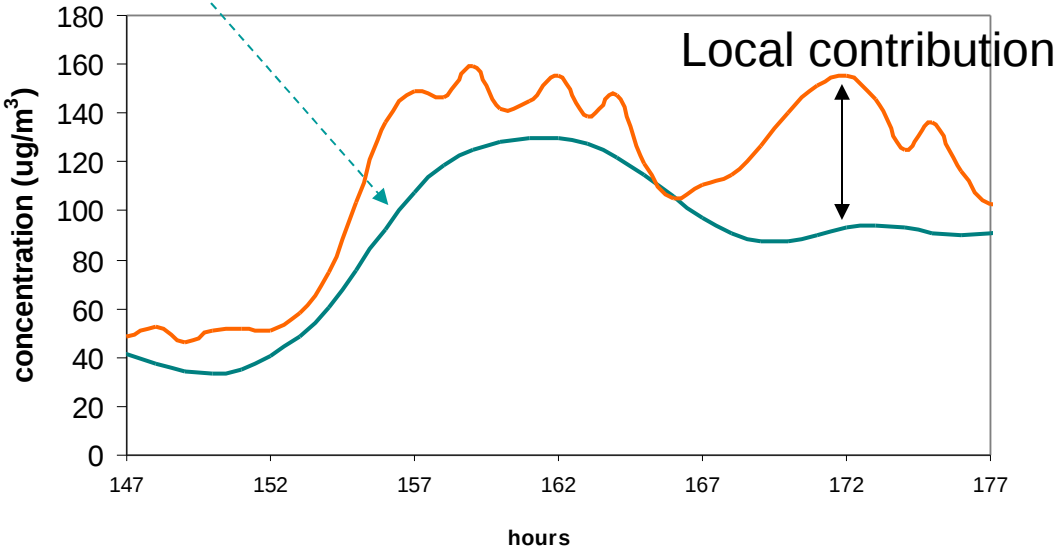
$$C(t)=C^B(t)+C^S(t)$$

Methodology



Urban background station:
Original data and after the filtering

Background concentrations
after the filtering and
Urban traffic station data



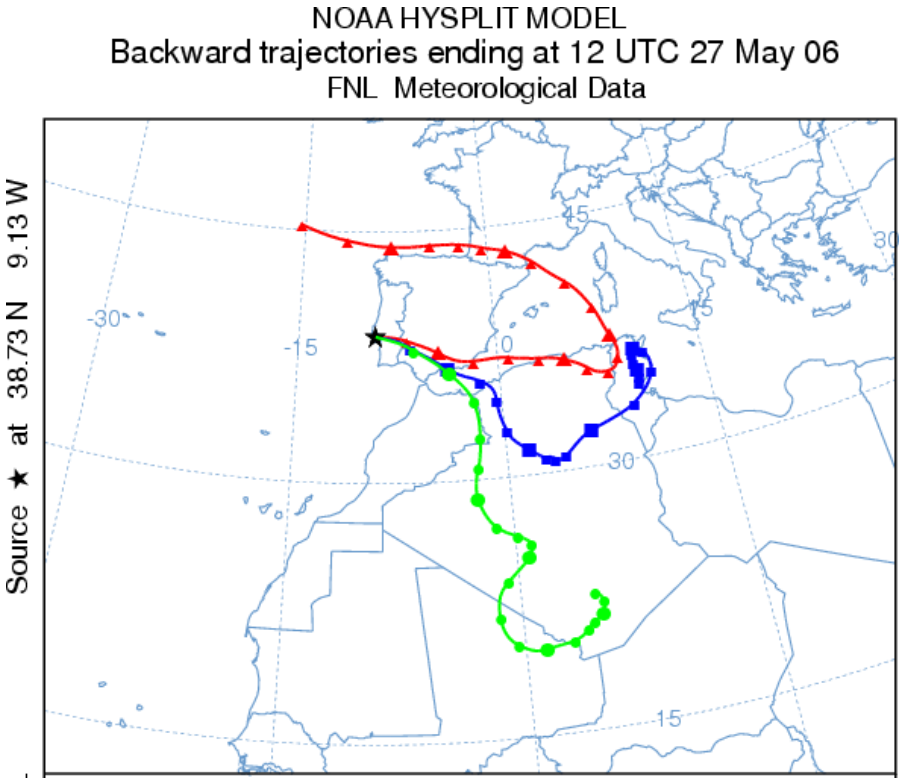
Application example

Simulation period:

27 - 28 of May 2006

Entrecampos urban station:

- 81 days with PM_{10} exceedences in 2006
- >30% due to natural events



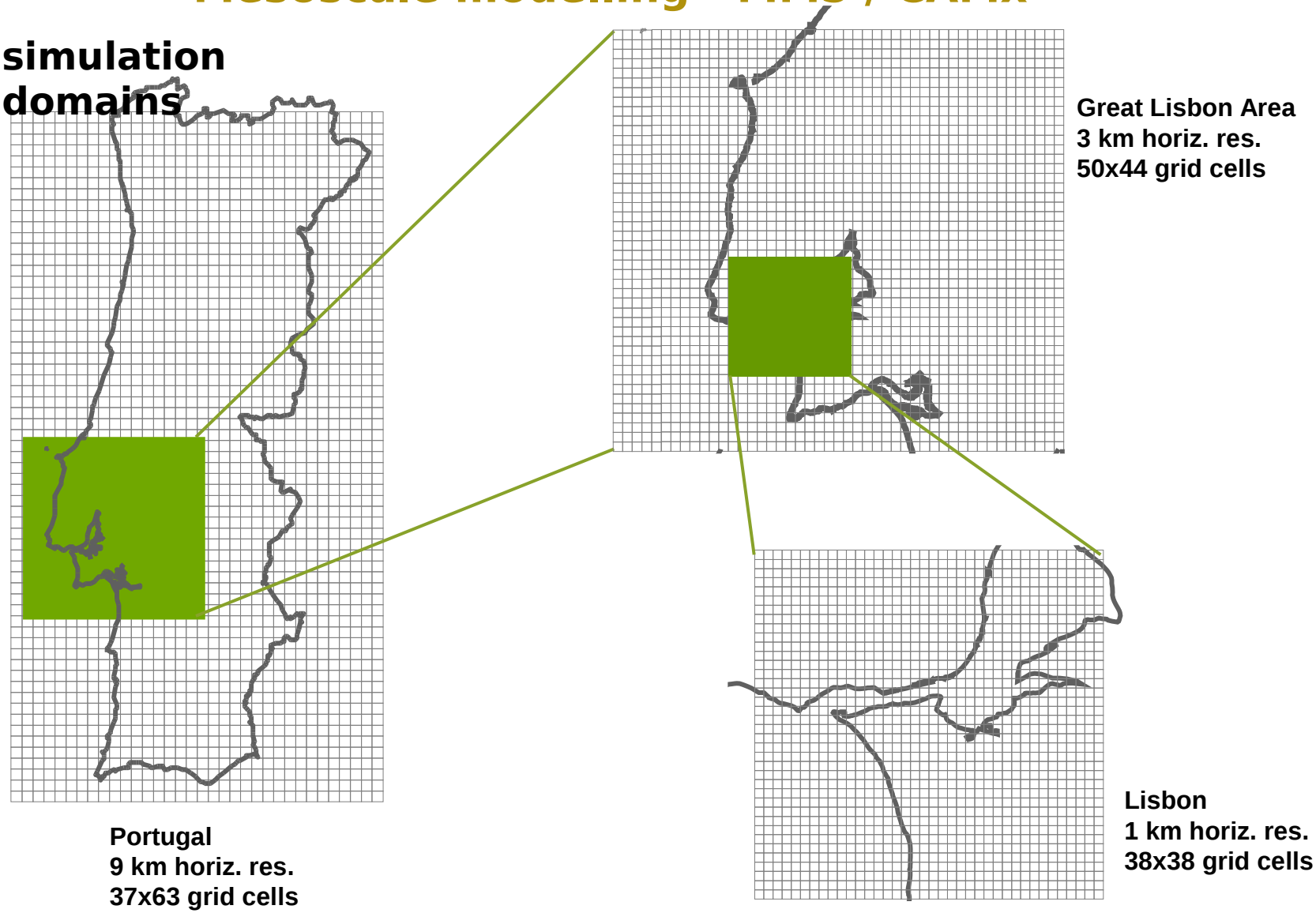
Mesoscale model → **CFD model**

AQ measurements → **CFD model**

Application example

Mesoscale modelling - MM5 / CAMx

simulation domains



Portugal
9 km horiz. res.
37x63 grid cells

Great Lisbon Area
3 km horiz. res.
50x44 grid cells

Lisbon
1 km horiz. res.
38x38 grid cells

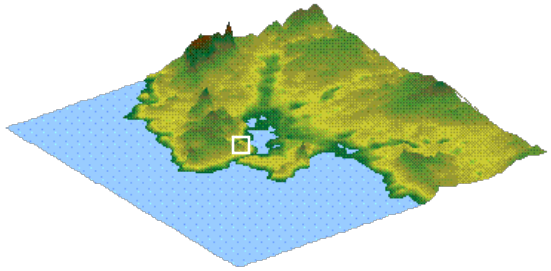
Application example

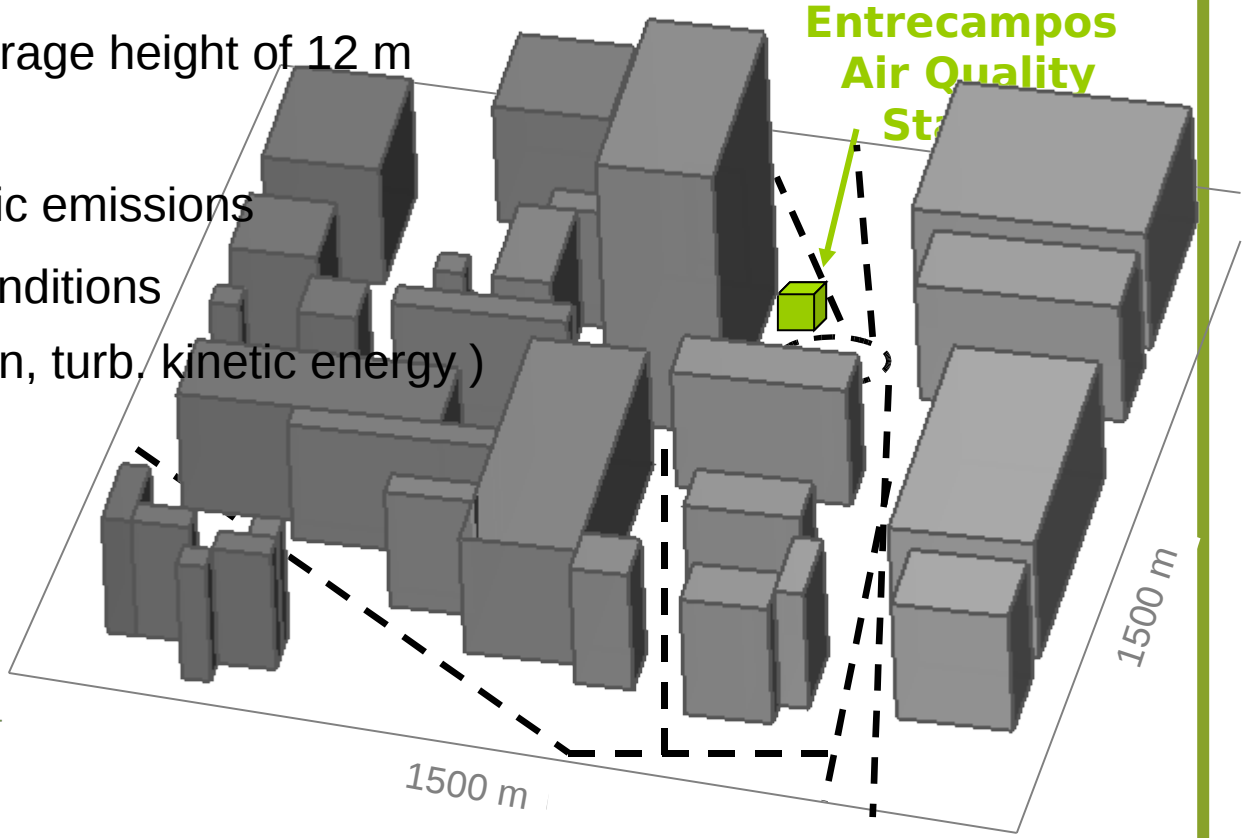
Local scale modelling

VADIS – Eulerian / Lagrangian CFD model

- 1500m x 1500m x 60m in Lisbon city centre
- resolution 10m x 10m x 5m
- 29 buildings with an average height of 12 m
- 8 main roads
- TREM: hourly PM_{10} traffic emissions
- MM5: meteorological conditions

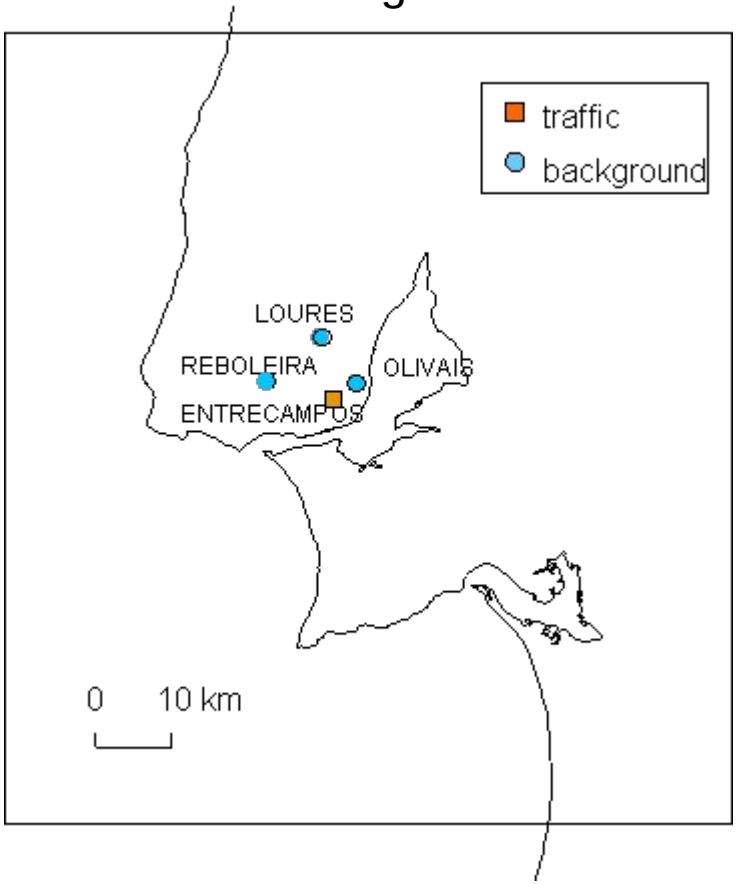
(wind velocity and direction, turb. kinetic energy)



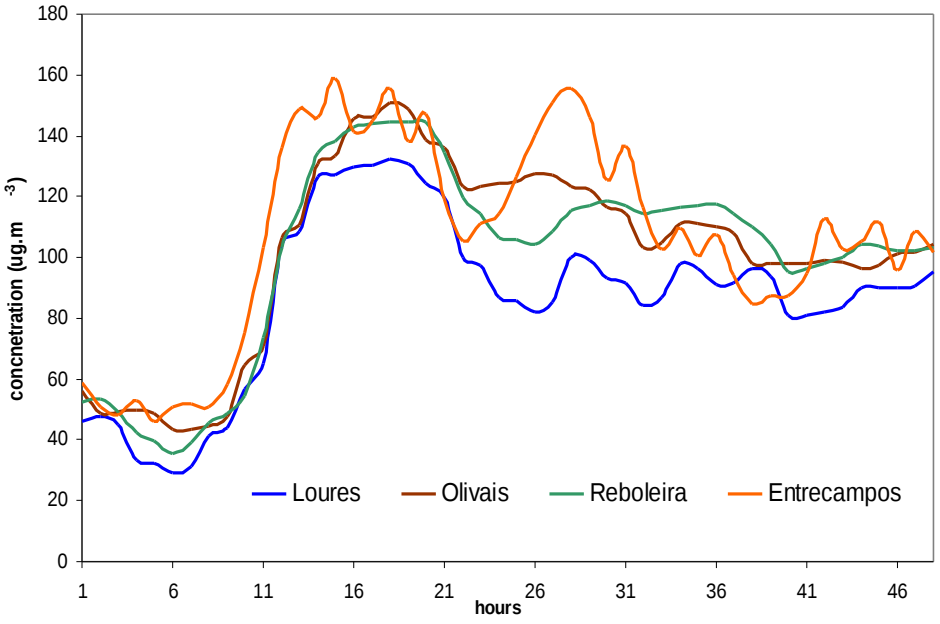


Application example

Locations of air the quality monitoring stations

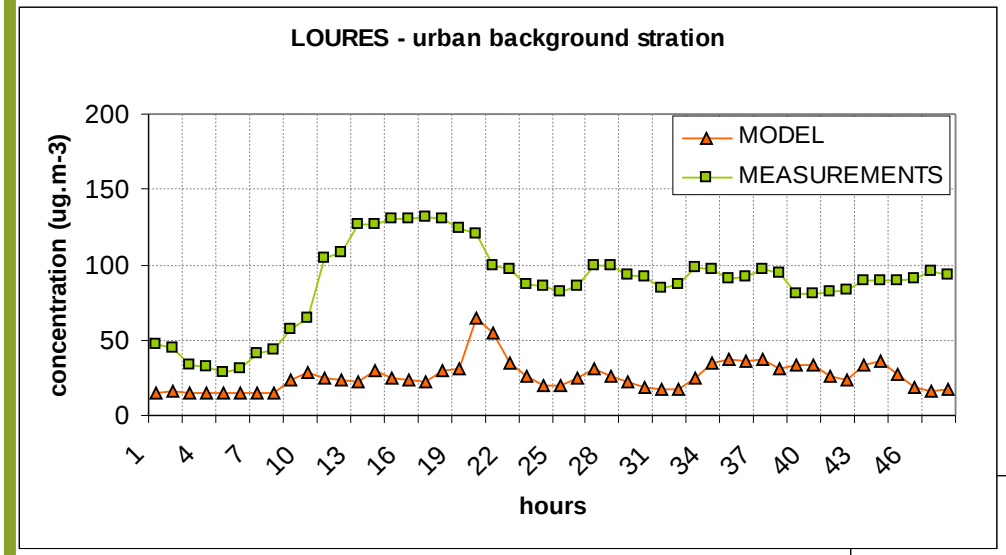


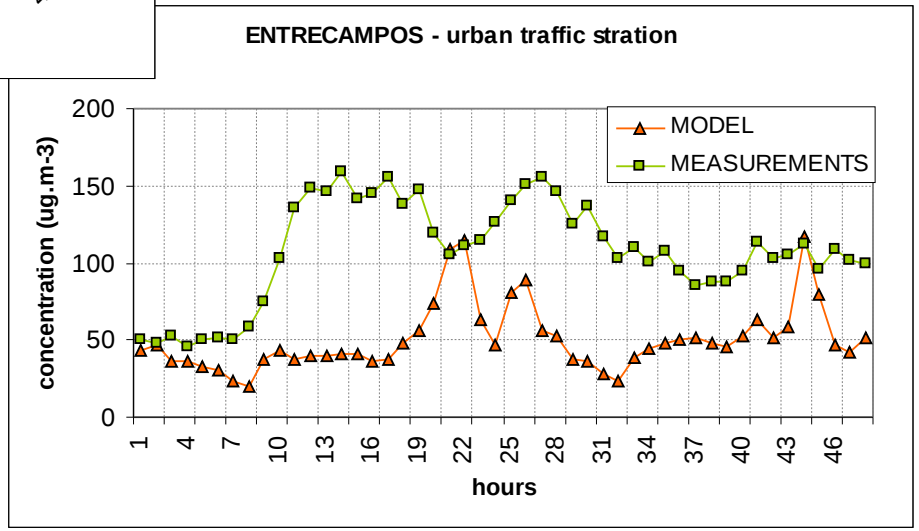
PM_{10} measurements
(27-28 of May, 2006)



Results

Mesoscale model results : PM_{10} concentrations





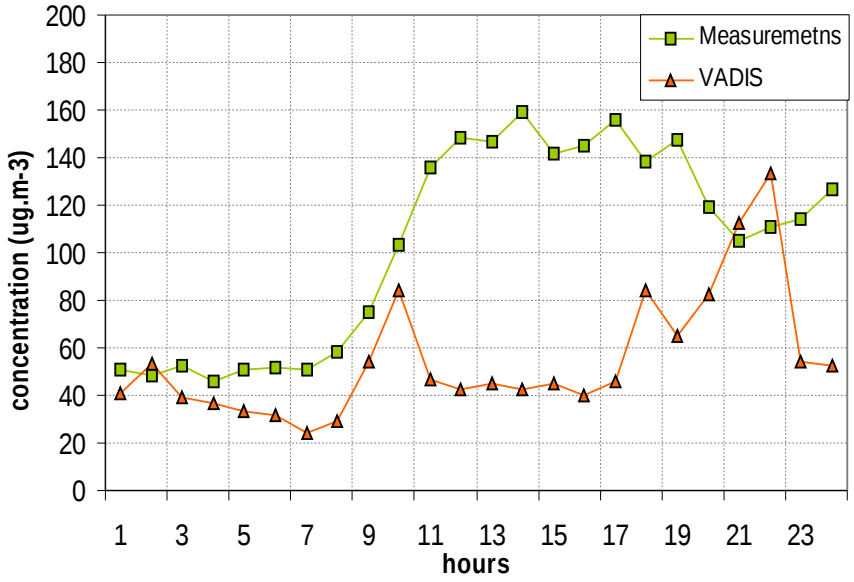
PM_{10} concentrations are underestimated primarily because long-range transport from North Africa is not considered in the model application

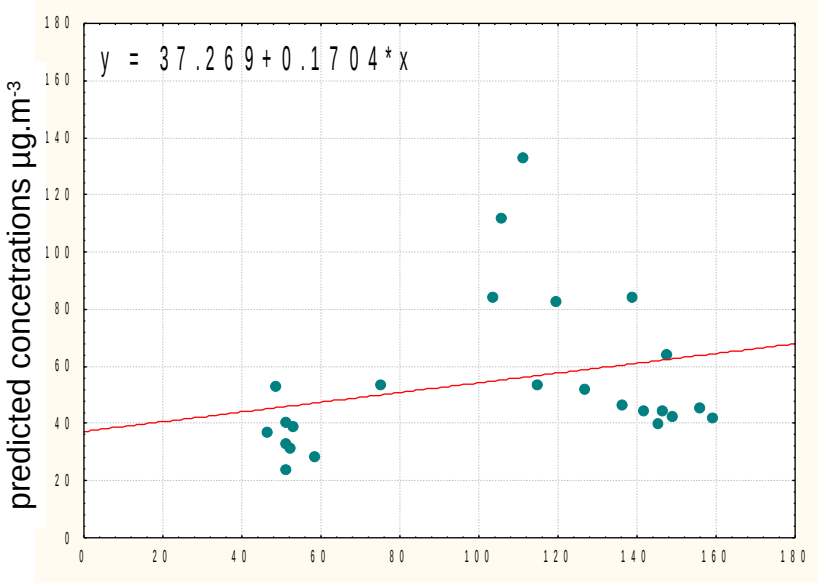
Results

Background concentrations from the mesoscale model

CAMx → **VADIS**

VADIS results: PM_{10} concentrations



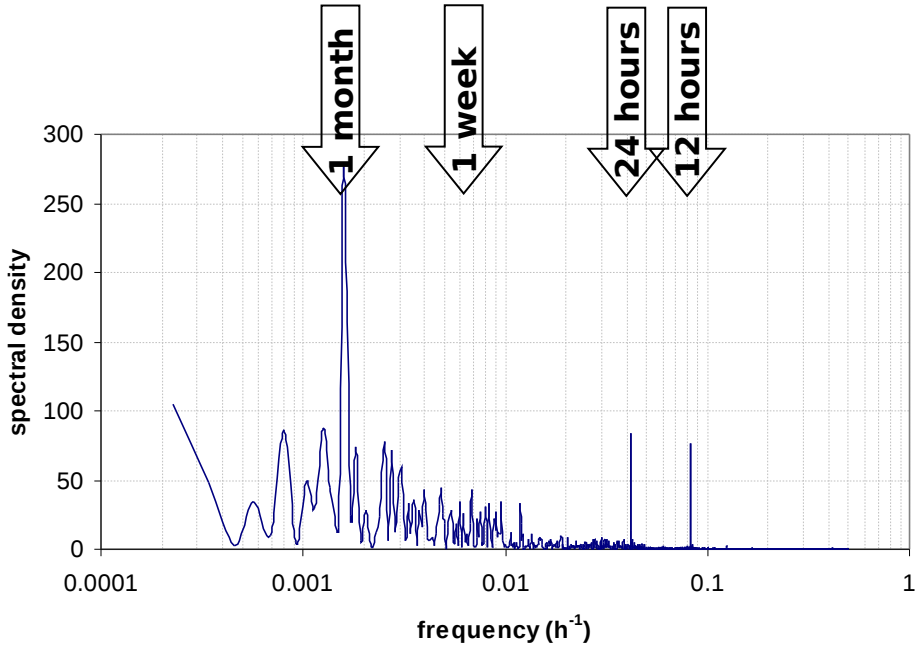


Results

Background concentrations from the monitoring data

AQ monitoring filtered data → **VADIS**

1) FFT



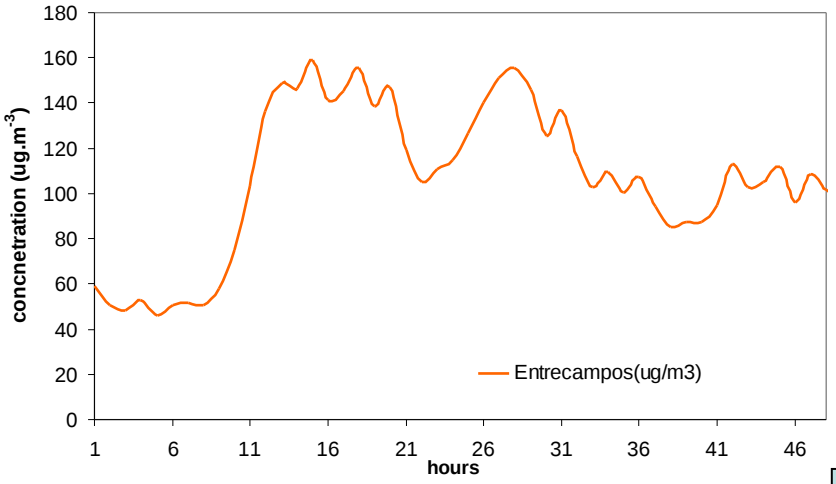
2) $KZ_{3,3}$

filter width m=3
number of iterations n=3
separation frequency w=0.0905 h^{-1}

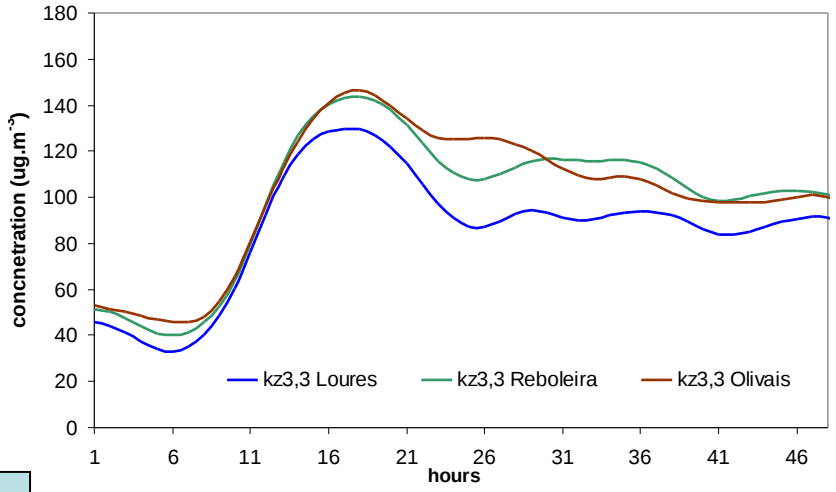
KZ filter is designed to remove short-term fluctuations with the period < 12h:

Results

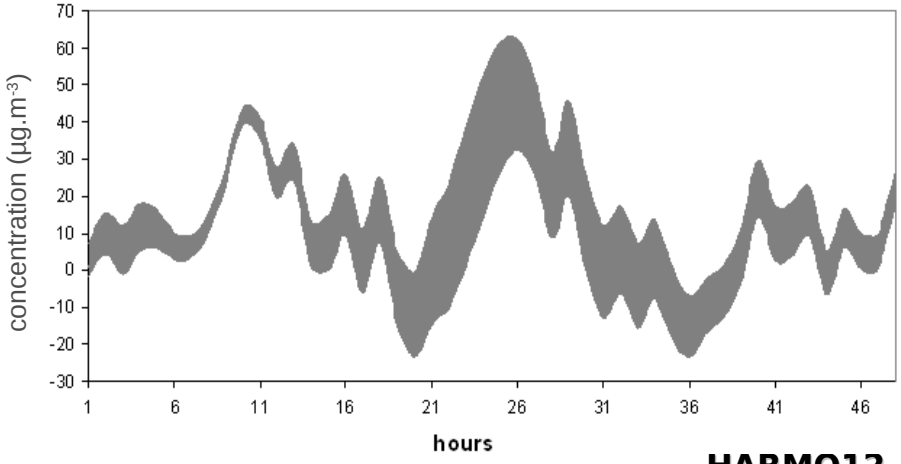
Entrecampos measurements



Background concentrations

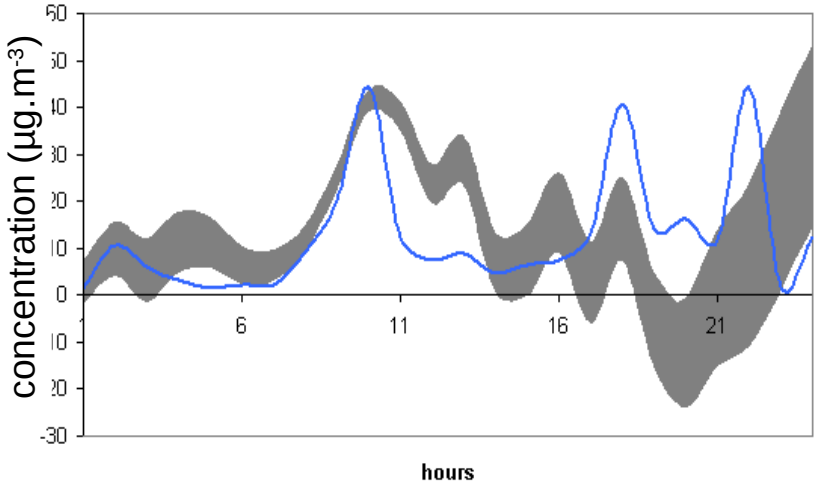


Local contribution



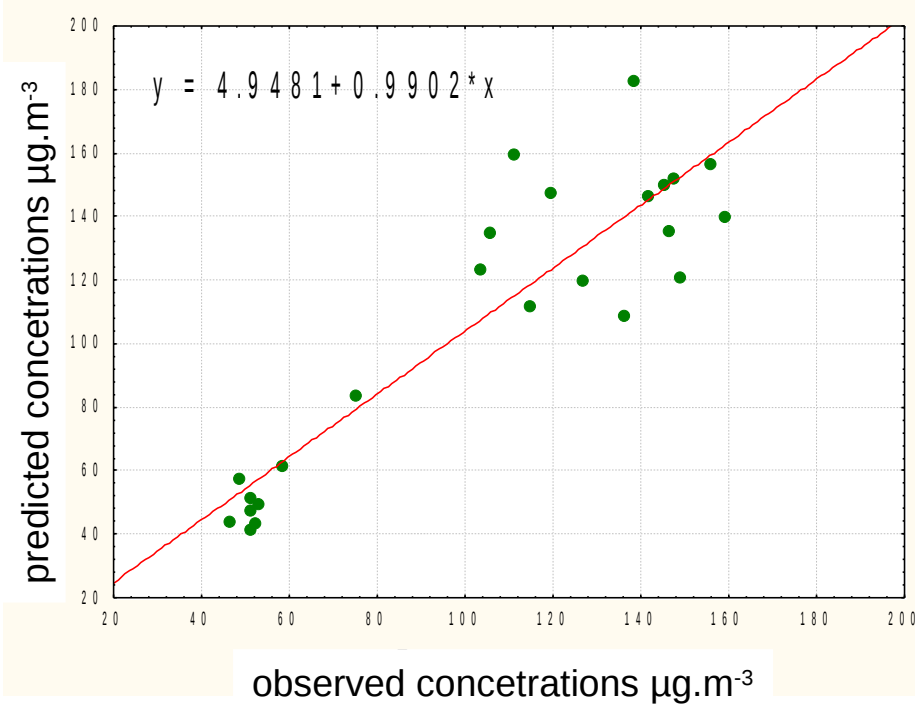
Results

PM_{10} concentrations estimated by VADIS model



VADIS results

range of the expected values



Range of the expected values is defined as a difference between measurements at urban traffic station and the background concentrations => negative values!!!

Conclusions

- A new methodology to derive background concentrations based on decomposition of time series is proposed

- The background concentration estimated by application of this methodology allow to improve the local-scale model performance and to reduce the uncertainty of modelling results.

- Application of the proposed methodology to the episodes when background stations reveal higher values than the traffic station is limited.

- Future research is required to understand how urban background concentrations are related with the concentrations observed at street level.