HARMO 11 Conference
11th International Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes

Cambridge, United Kingdom
July 2nd-5th, 2007

High resolution maps of annual NO_x and NO_2 concentrations in an influenced rural area using a deterministic modelling method

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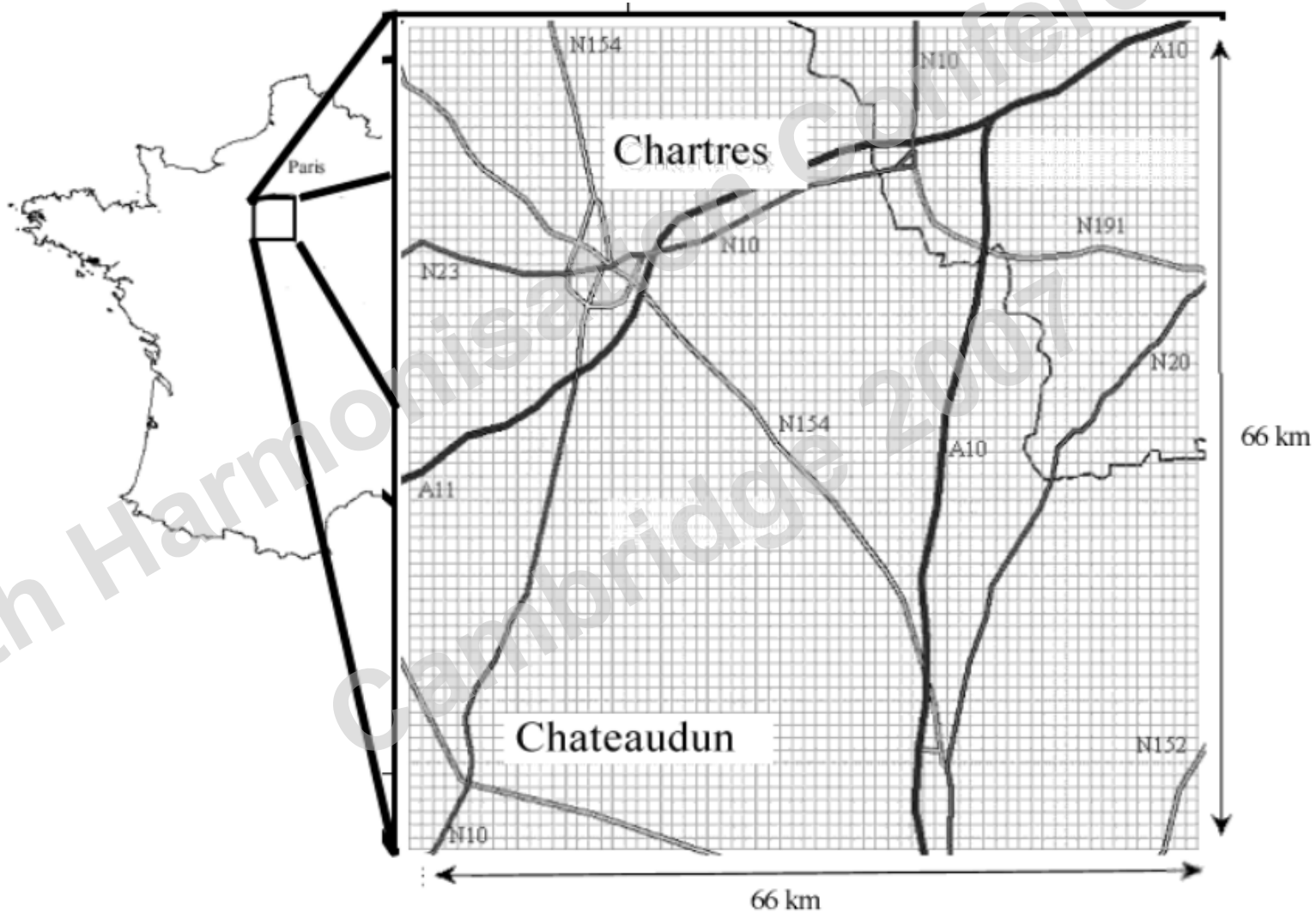
Objectives

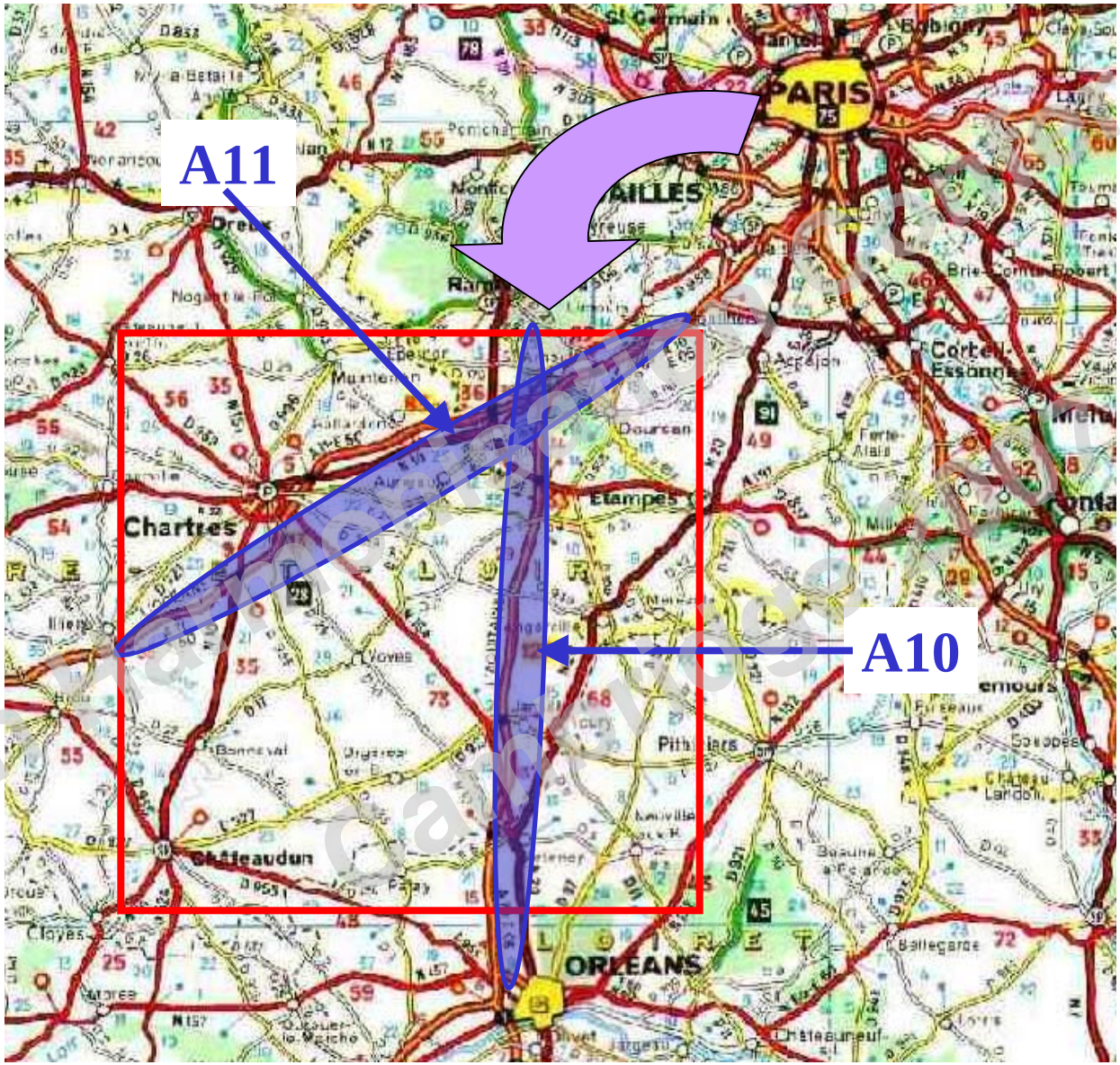
The application of Directive 1999/30/EC on Ambient Air Quality Assessment and Management requires the assessment of air quality all over the territory included rural areas.

In these area we have generally a few number of monitoring stations because of the low density of emission sources. Therefore we have to used numerical tools to generate concentrations fields in these areas and to determine maps of average annual values.

The main goal is to select the most operational technique using Eulerian numerical model to determine, with a miminum of data, the yearly concentration field, and to evaluate this model in front of geostatistical or statistical techniques.

Overview of study area




A11
A10
PARIS
Chartres
Etampes
Châteaudun
ORLEANS

Emission inventory

We used two types of annual NO_x emissions inventories:

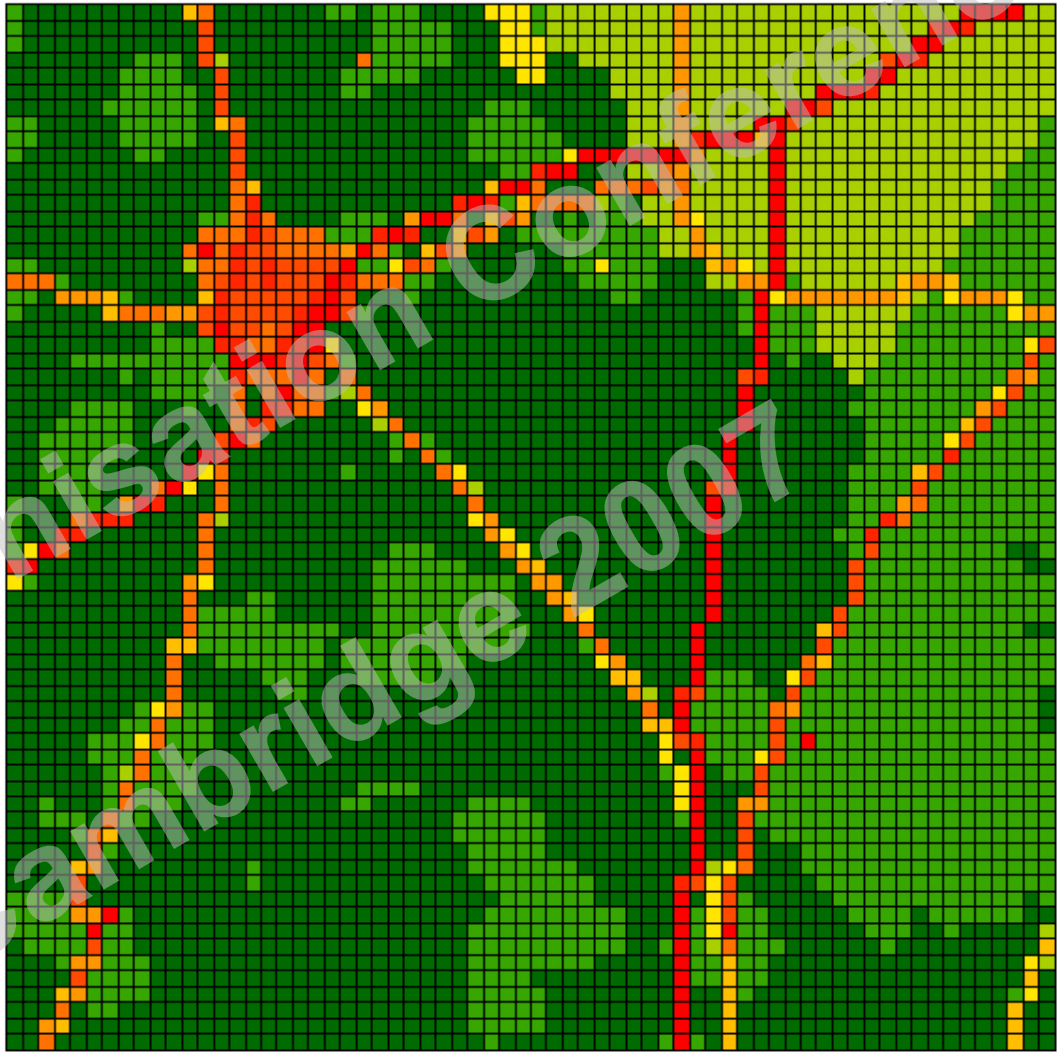
a local inventory (based on CORINAIR methodology) at 1x1 km² resolution.

the large scale EMEP inventory at 50x50 km² resolution.

We build two inventories, one for cold period and an other without domestic heating for warm period.

NO_x (équ. NO_2)
Kg / an . km²

52 000 -	214 000
32 000 -	52 000
21 000 -	32 000
15 000 -	21 000
11 000 -	15 000
8 000 -	11 000
6 000 -	8 000
4 000 -	6 000
3 000 -	4 000
2 000 -	3 000
0 -	2 000



Dispersion model and Boundary conditions

Simulations were performed with the 3D transport Eulerian model TRANSCHIM.

The horizontal resolution is 1 km and the vertical one 10 m. It was used without chemistry (i.e., no photo-oxydant mechanism).

Concentrations data of CHIMERE continental provided the boundary conditions.

Since the CHIMERE horizontal resolution is larger than the one use in TRANSCHIM, CHIMERE data were interpolated on the TRANSHIM grid.

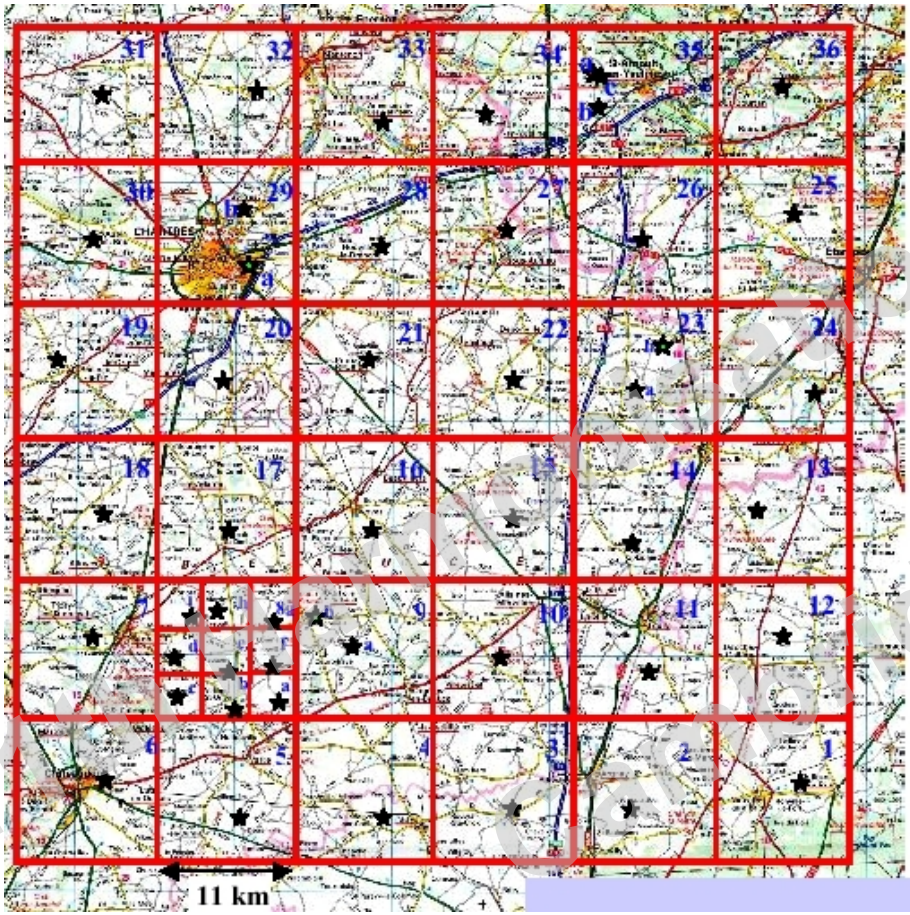
The model was calibrated with two nitrogen dioxide diffusive tube sampling measurement campaigns (15 days each) carried out over the 4356 km² of the domain.

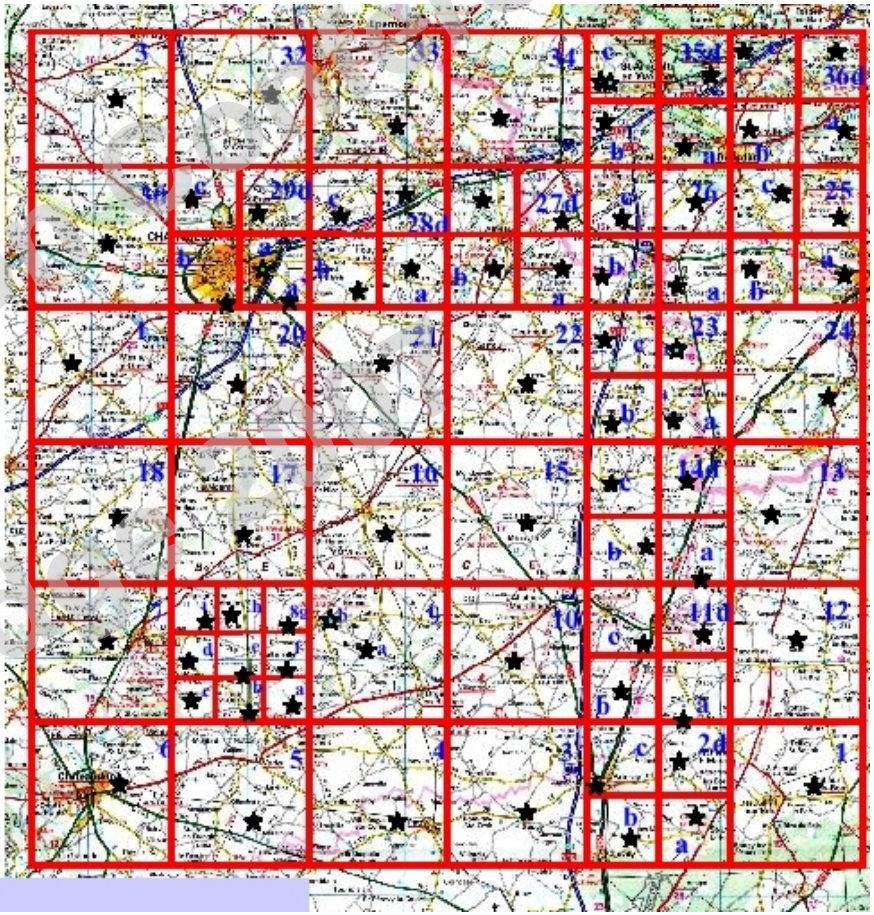
We used Passam tubes with a preconcentrated gas chromatography analysis

The spatial resolution of sampling was 11 km and 5.5 km when refined. These campaigns have been used to check the model result accuracy

Campaign 1 (July 2002)

Campaign 2 (April 2003)



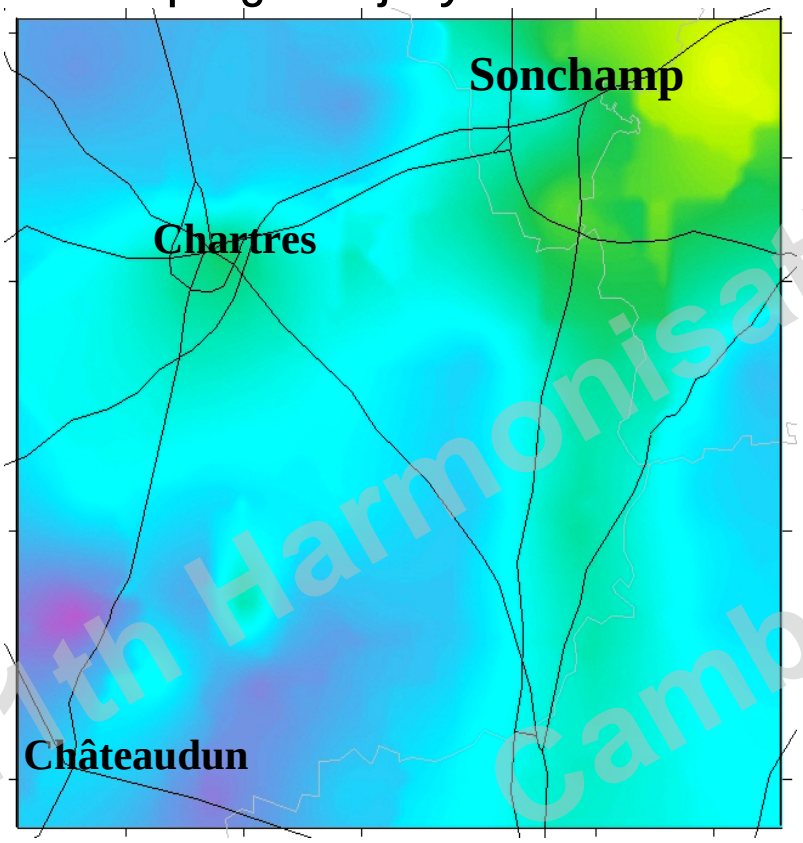


50 tubes

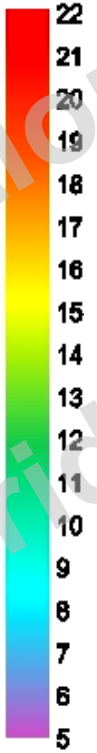
100 tubes

Results

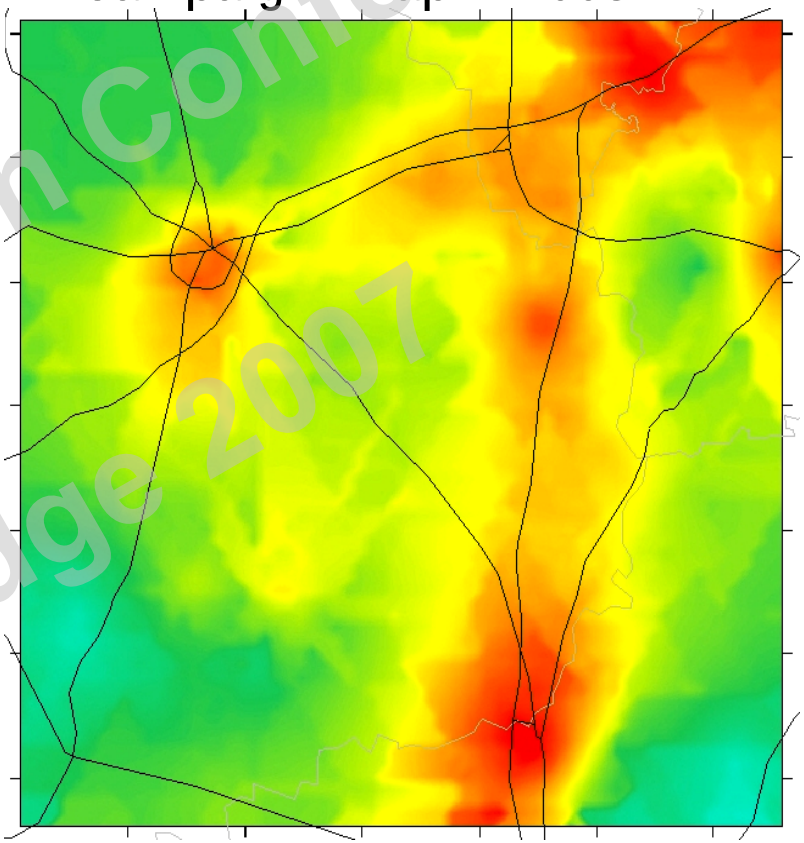
Campaign 1: july 2002



NO_2 µg/m³

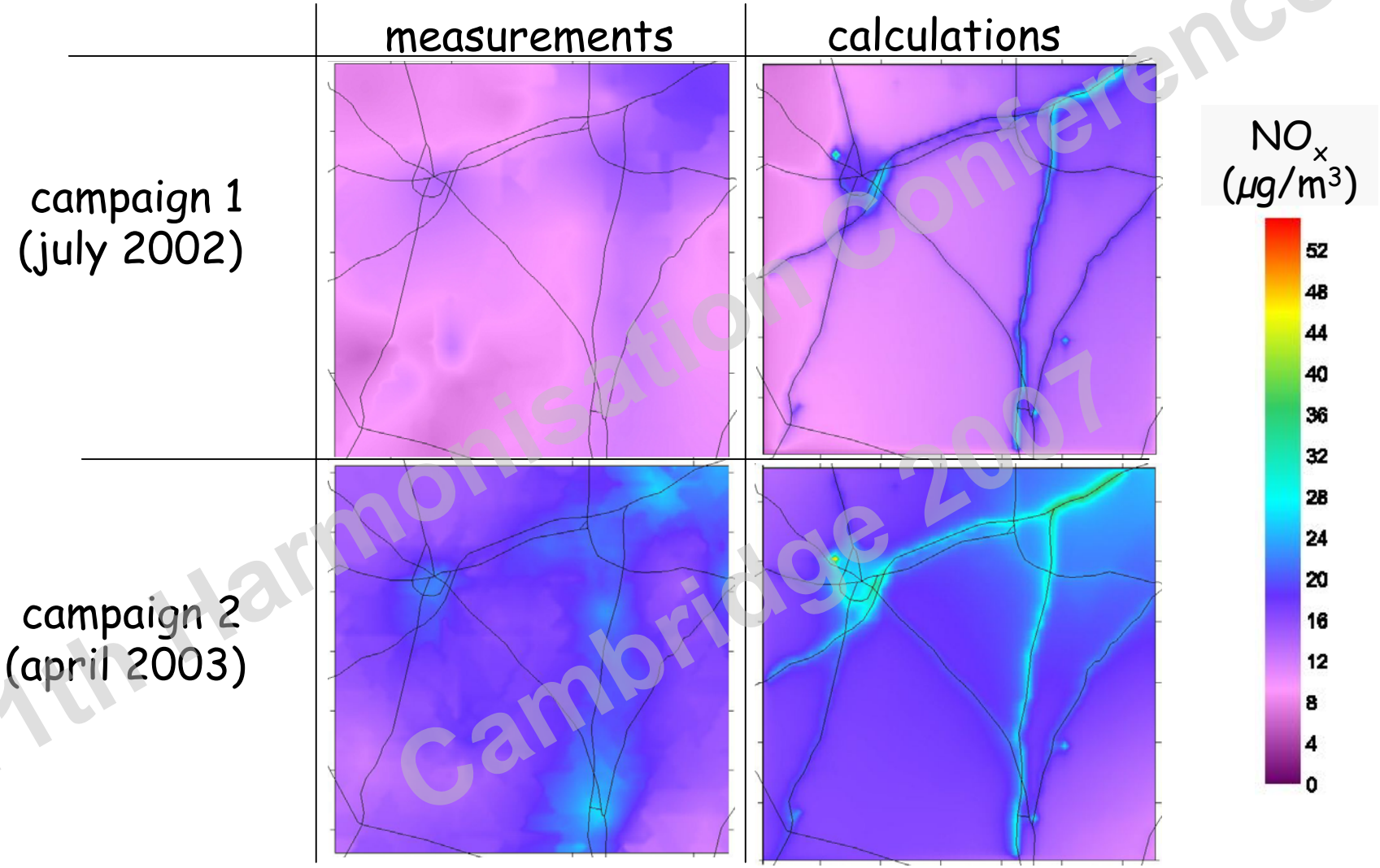


Campaign 2: april 2003

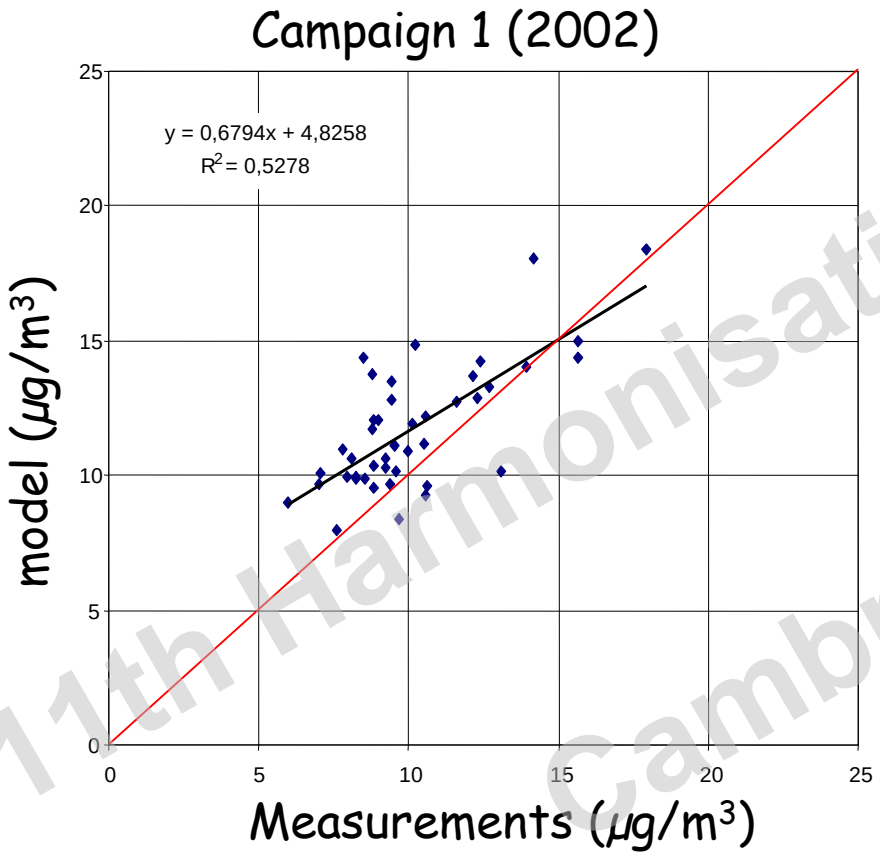


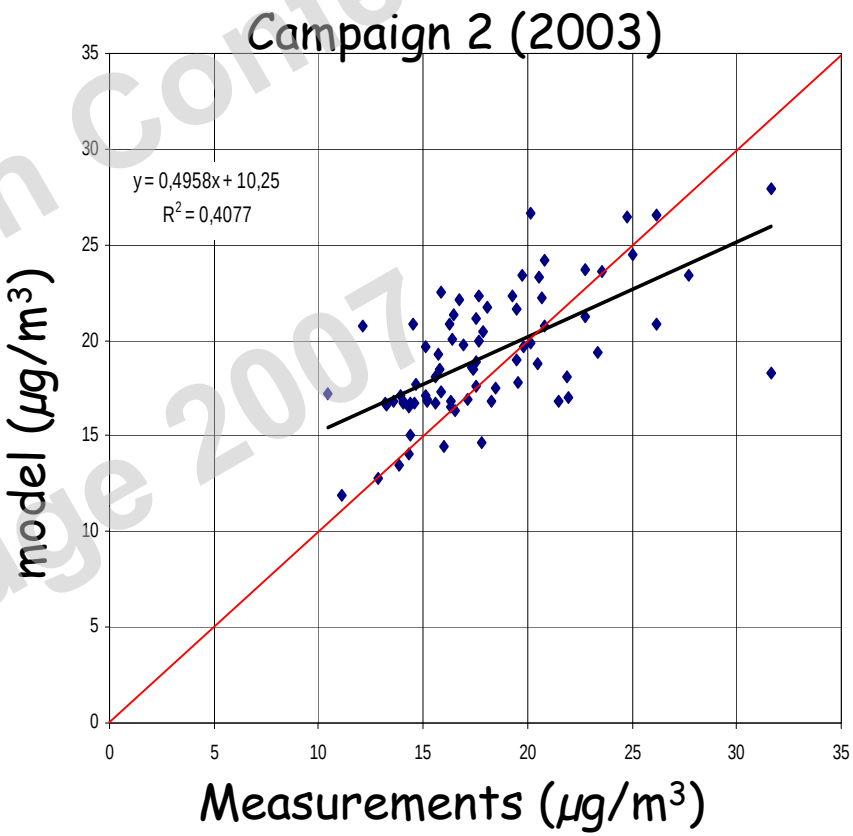
mean = 8 µg/m³
max = 15 µg/m³
min = 5 µg/m³

mean = 15 µg/m³
max = 22 µg/m³
min = 8,7 µg/m³



Results





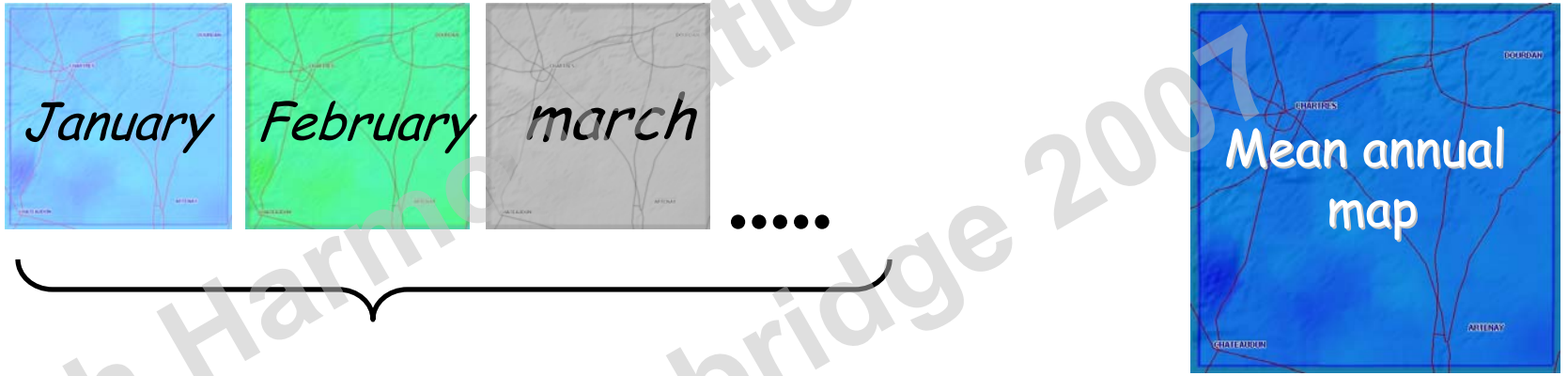
To reach this goal we have to evaluate the influence of input meteorological data sets.

different kinds of data sets have been used: Chronological and statistical.

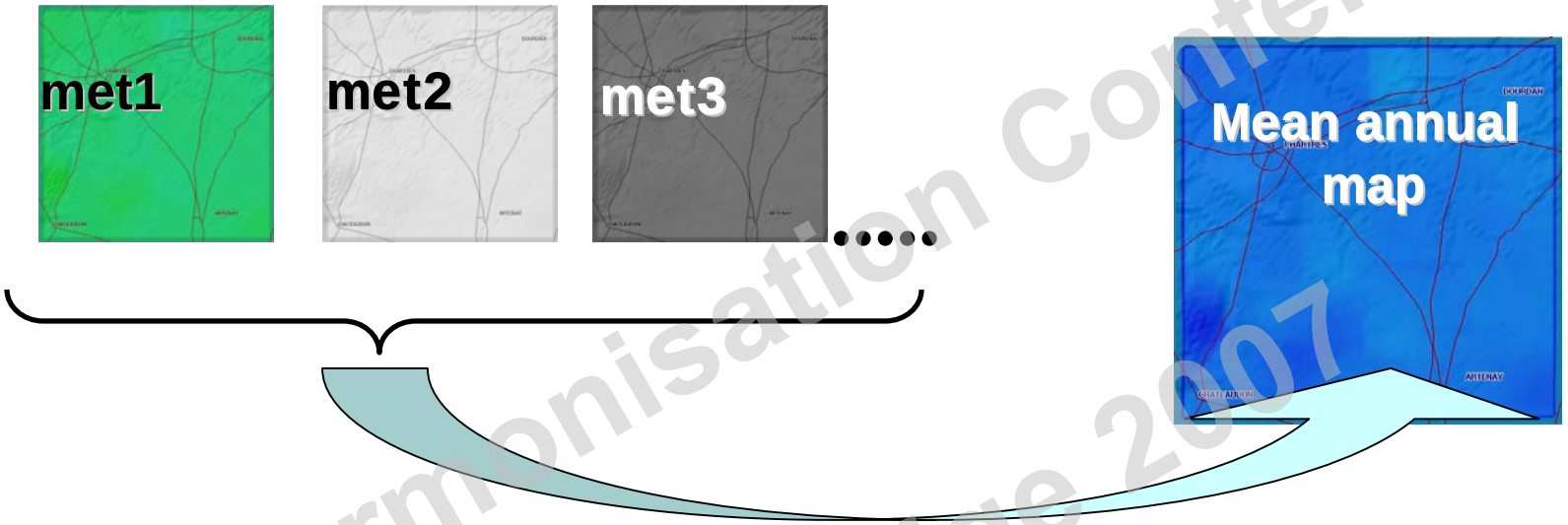
Statistical data are obtained by extracting a limited number of meteorological conditions which are supposed to be representative of the whole year.

We used two methods to extract such data, the hierarchical clustering and the statistical wind rose.

Chronological approach



Statistical approach



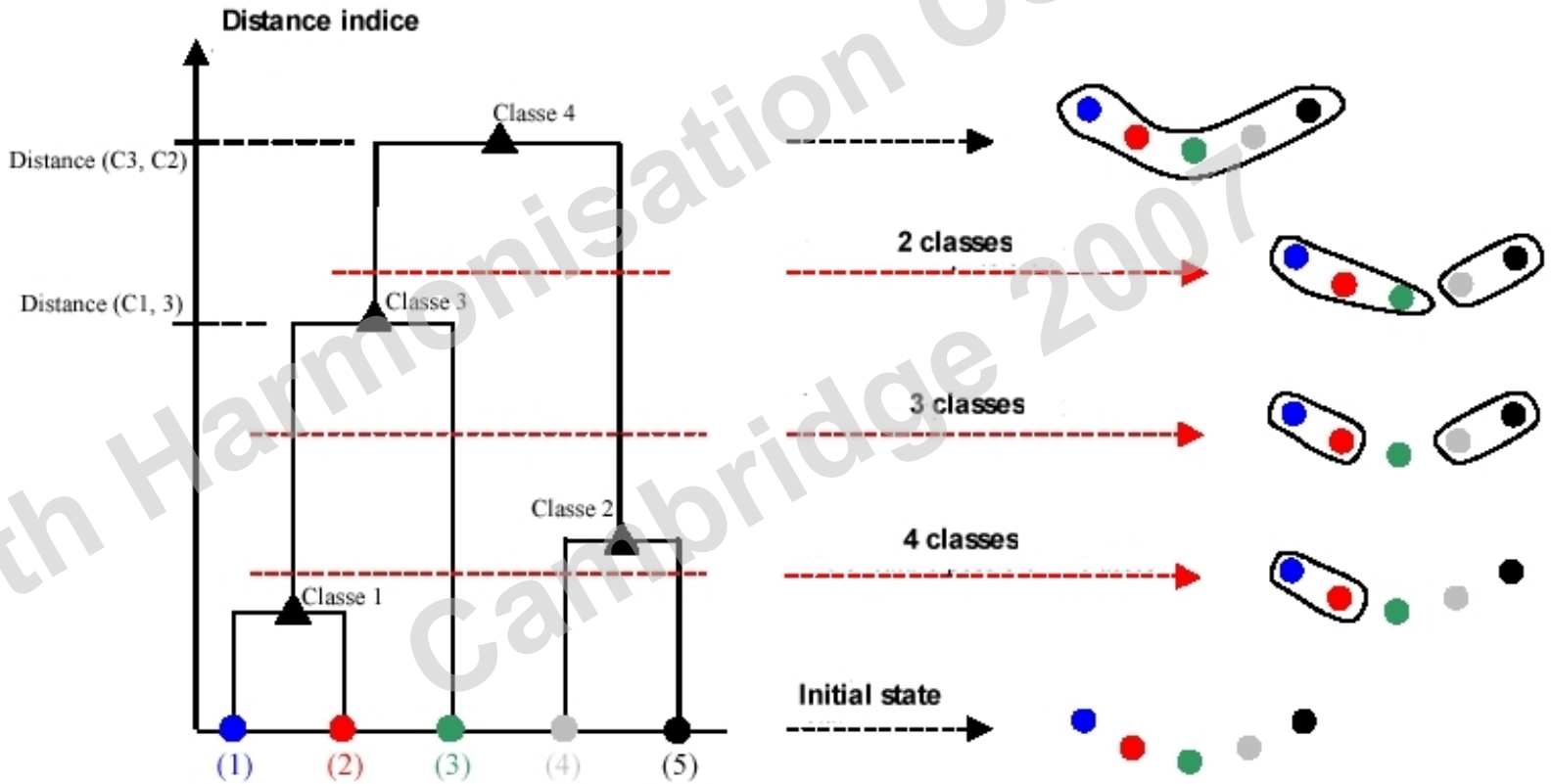
Mean value weighted from the accurancy

Two ways :

- the hierarchical clustering,
- the statistical wind rose.

Statistical approach
hierarchical clustering

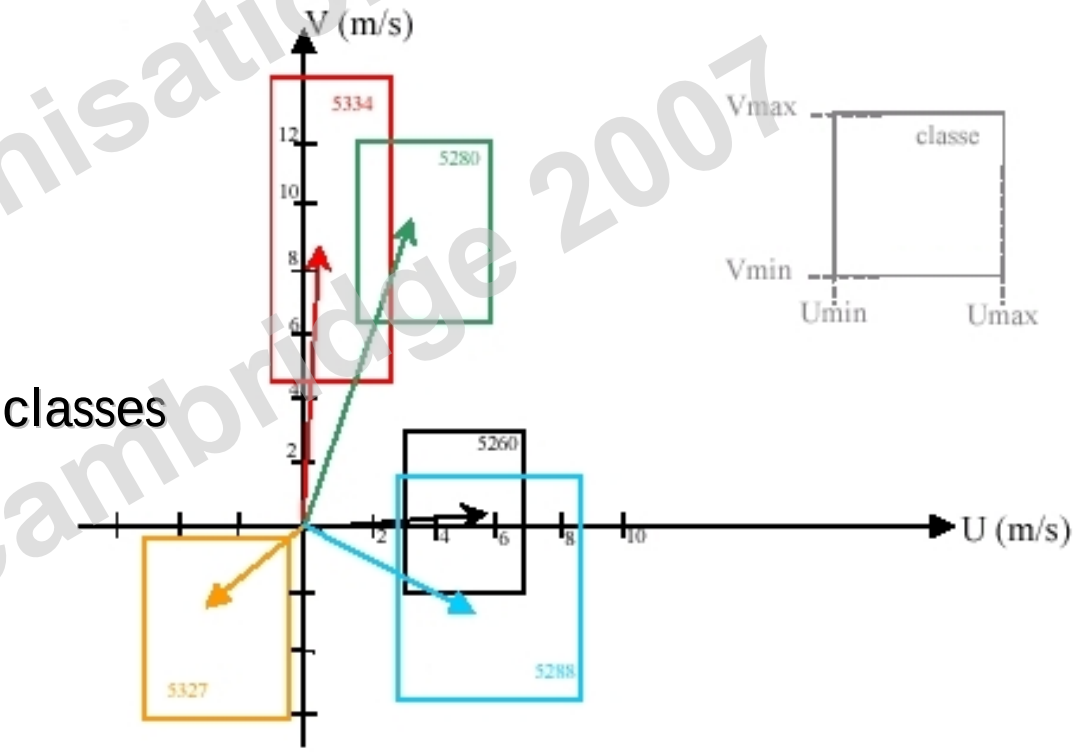
Ward classification



Statistical approach
hierarchical clustering

64 classes of wind speed and direction

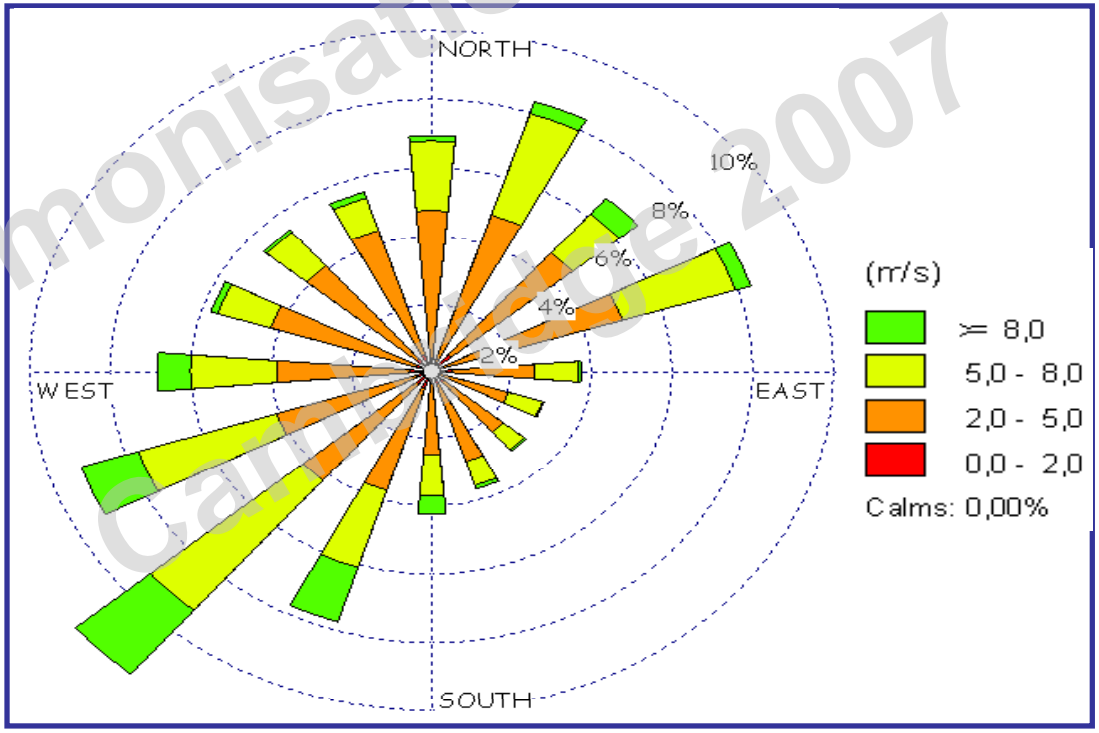
Exemples of 5 classes



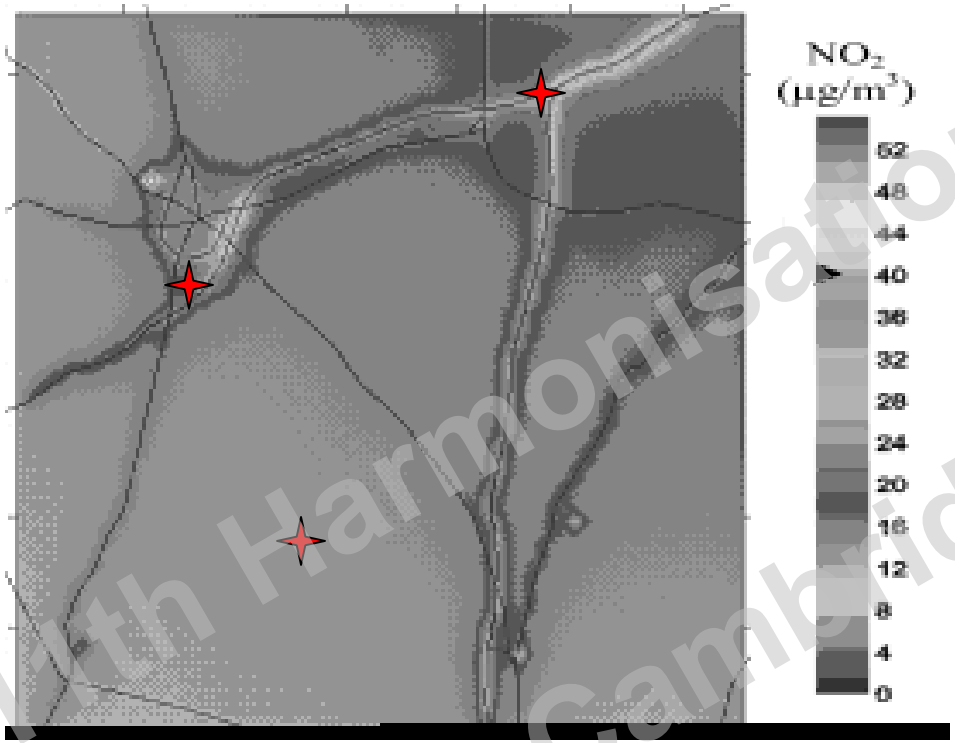
Statistical approach

statistical wind rose

16 classes of wind direction (every 22.5 degres)
4 speed classes (<2 m/s, 2-5, 5-8, >8 m/s)



Results



Maps of annual mean concentrations of NO_x and NO_2 were calculated.

The results obtained with this methods were compared with measurements at three monitoring stations

- two urban, one rural

Model provide a NO_2 annual mean average value of 17.0 µg/m3 in the domain, and the influence of the major sources (motorway and city area) was truly depict by the simulation

Scores

	Chronological data	Wind rose	Clustering
Bias (µ/m3)	0.13	0.16	0.15
R^2	0.98	0.97	0.96
RMSE (µ/m3)	0.71	0.72	0.73
NMSE	0.0016	0.0017	0.0019

COMPARISON OF MAPPING TECHNIQUES

To evaluate the performance of deterministic model, we compared the previous calculated annual maps with two others approaches.

Geostatistic approach : The geostatistical mapping algorithm, called kriging, is based on the specific spatial behaviour of the mapped pollutant via a spatial correlation function calculated from the sample measurements. This method need to define a variogram, which is a function describing the degree of spatial dependency of the phenomena.We used the variogram in the kriging of the yearly maps.

COMPARISON OF MAPPING TECHNIQUES

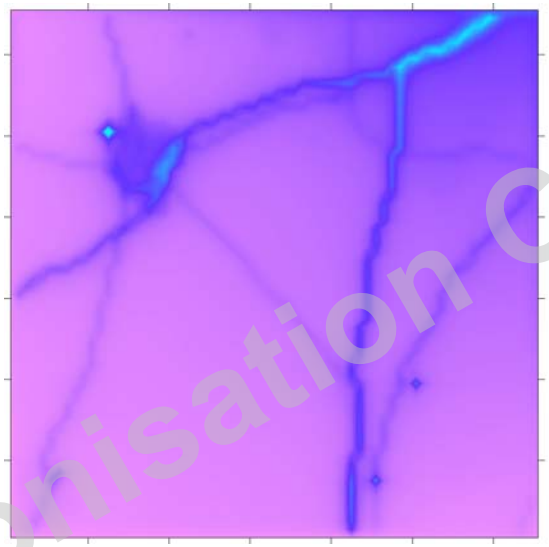
Regression approach :

We considered the NO2 concentration determined from NO2 rural concentration (*Stedman J.R*, 1995) by equation :

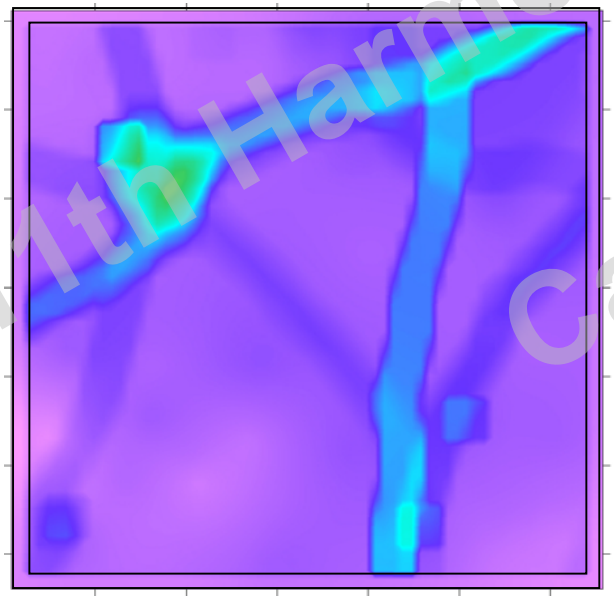
$$Conc(NO2) = Conc(NO2)rural + k.Emission(NO2)$$

The NO2 concentration in every points of the domain was linked with rural NO2 concentration measure with the equation. With this equation, the concentration at a location in the domaine is determined knowing the rural concentration and the local NO2 emissions.

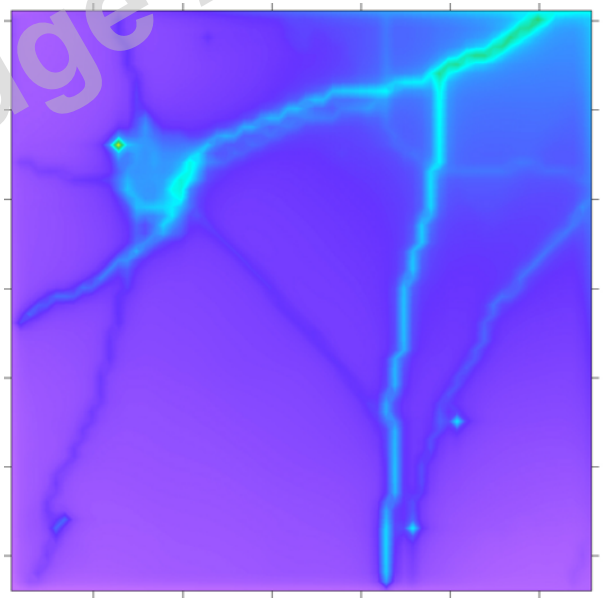
COMPARISON OF MAPPING TECHNIQUES



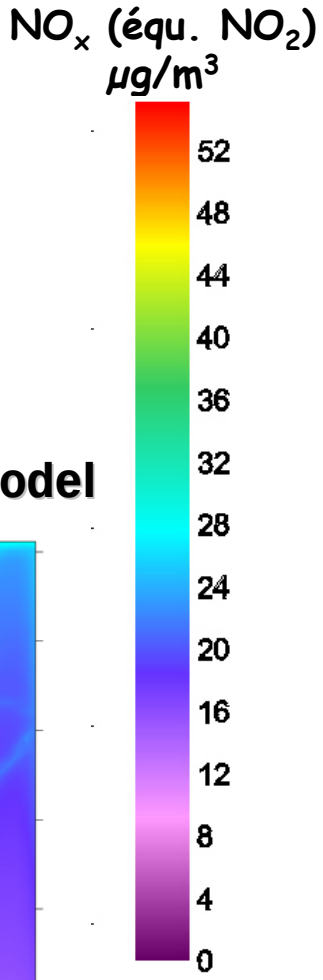
Geostatistic



Regression approach



Transchim model



COMPARISON OF MAPPING TECHNIQUES

	Min (µ/m3)	Max (µg/m3)	Average (µg/m3)	Std dev (µg/m3)
Transchim model	**14.52**	**49.45**	**17.06**	**2.69**
Geostatistic	**6.49**	**27.84**	**12.86**	**3.30**
Regression	**7.69**	**22.52**	**12.41**	**2.70**

CONCLUSION

The aim of this study is to demonstrate the accuracy of using numerical operational model to describe the air quality all over the territory including rural areas.

In these area we have a few number of monitoring stations, therefore we have to used mapping tools to generate maps of average annual values.

The main goal is to select the most operational technique using a miminum of data.

CONCLUSION

The study shows what we can use an Eulerian model with meteorological data provided by the weather forecast national organisms to generate annual concentration maps of NO2 on rural zone influenced by urban zones.

The result show also an uncertainty lower than the air quality guideline.

A better resolution of concentration gradients is achieved with the eulerian transport model than for the others methods (statistics, and geostatistics).

Acknowledgement

This study has been supported by :

French Environmental Ministry
ADEME agency

This study has been realised in collaboration between :
INSA Rouen and Ecole des Mines de Douai

Special thanks to Philippe Olivier who realised this study