Air quality assessment in Bologna by an urban dispersion model

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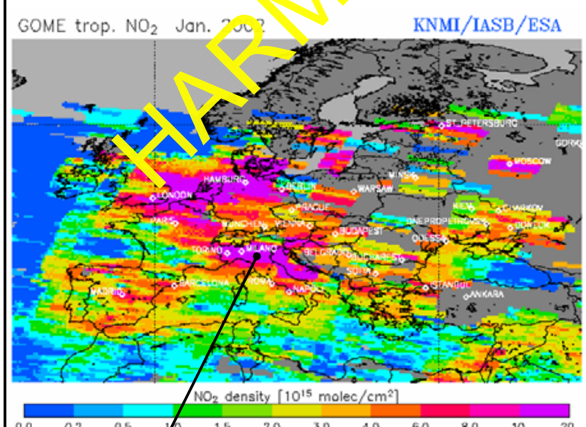
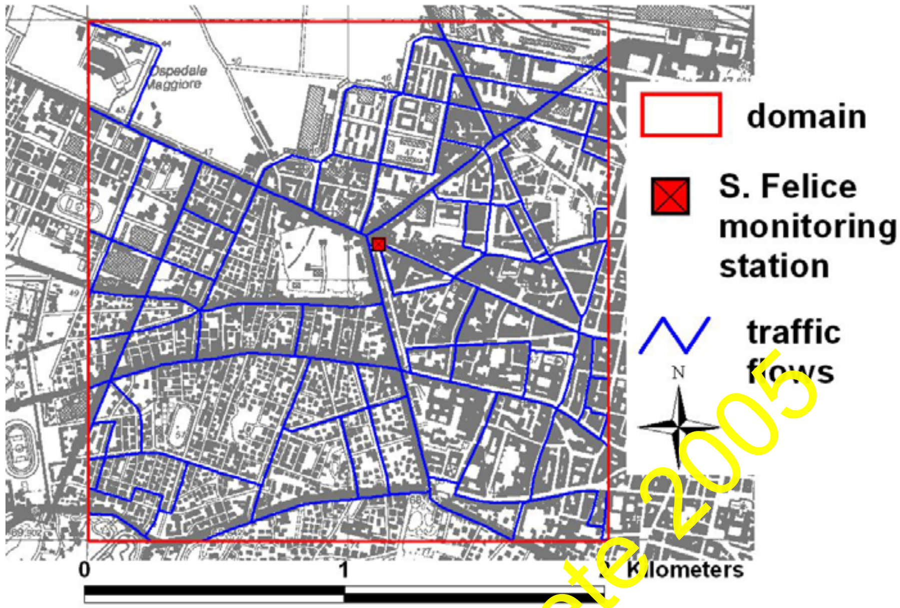
NO_2 and PM_{10} are critical pollutants in the urban area of Bologna



Bologna (380,000 inhabitants) **is located in the Po Valley**

- **Porticoes: about 37 km**
- **Street Canyon: the ratio between the height of the buildings and the width of the streets is often 1.5-2**

Domain of the simulation with ADMS - Urban



Modelling integrated system

Emissions:
- ❖ Traffic flows on 213 road links: Bologna Council -ATC
- ❖ Splitting of vehicles into categories: ACI-PSC
- ❖ Emission factors: Corinair 2000 and TNO

Meteorological datasets: CALMET / LAMA

Urban Model
ADMS-Urban

Background concentrations: CHIMERE

Output: NO_2 and PM_{10}
- values required by EU directives

+

- outdoor concentrations used to calculate population exposure

RUN

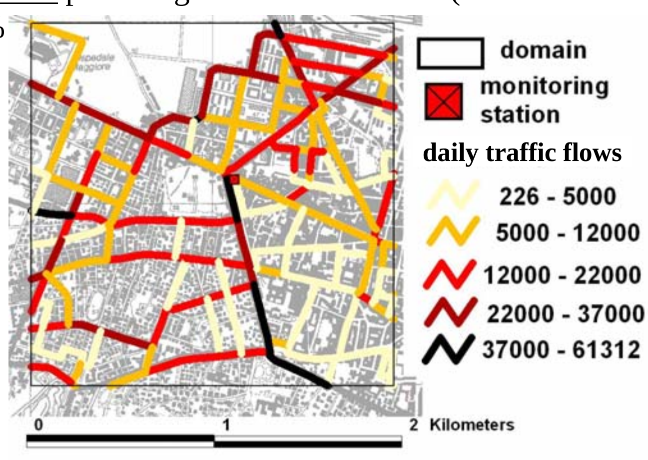
- *1 year period*: April 2003 ÷ March 2004
- *Summer pollution episode*: 10 – 16 June 2003 with max observed value $[O_3] = 250\ \mu g/m^3$, 11/06/03
- *Winter pollution episode*: 12 – 19 February 2004 with max observed value $[PM_{10}] = 164\ \mu g/m^3$, 26/02/04

Emissions for road sources (213 road links)

- Cars and duty vehicles (source Bologna Council)
- Buses were considered for each road link (source ATC)
- Mopeds and Motorbikes percentages inside ZTL 73% (source PSC BO), outside ZTL 17%

Vehicle categories
from ACI Bologna
(source Copert 2002)

Emissions Factors
Corinair 2000 for CO, NOx, NMVOC
+ EF exhaust and non exhaust for PM_{10}, TNO (95)

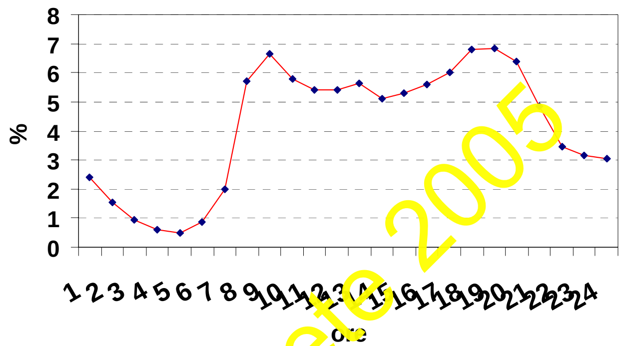


Emissions from road sources in S. Felice domain

	CO t/y	NOx t/y	VOC t/y	Benzene 3%VOC t/y	PM_{10} t/y	NH3 t/y
Road sources (links 213)	**2352**	**166**	**370**	**11**	**16**	**4**

Road sources daily pattern

(source PSC- BO)



Two different meteorological datasets

- CALMET: mass consistent meteorological pre-processor which uses the meteorological data taken from surface and upper air stations (northern Italy)

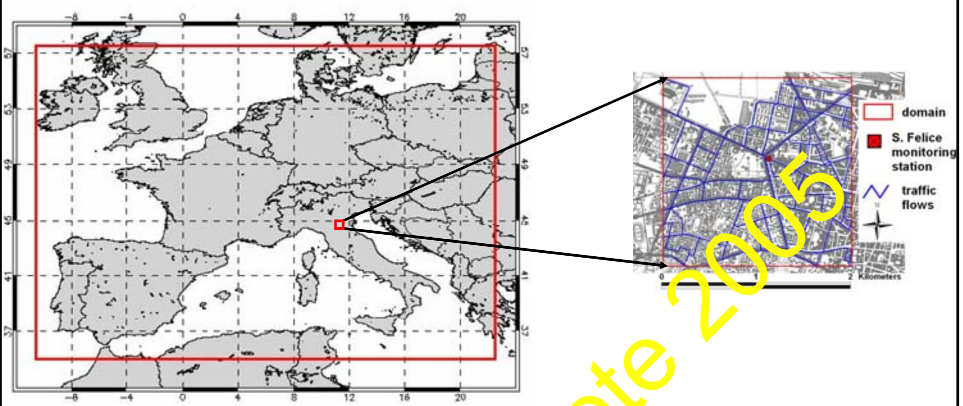
- LAMA: non-hydrostatic meteorological model Lokal Modell with a continuous assimilation of surface and upper air stations (italian peninsula, the Alps and part of the Mediterranean Sea)

Background hourly concentrations: CHIMERE

Eulerian photochemical– transport model with the aerosol module (from Prev'air – INERIS www.prevair.org)

Continental CHIMERE: 50 km horizontal resolution

ADMS-Urban: 50 m horizontal resolution



Urban model results for 1 year period

(April 2003 - March 2004)

S. Felice receptor point	**NO_2** annual mean µg/m³	**NO_2** 18th highest hourly value µg/m³	**PM_{10}** annual mean µg/m³	**PM_{10}** 35th highest daily value µg/m³
simulated	68	195	46	68
observed	52	123	42	73

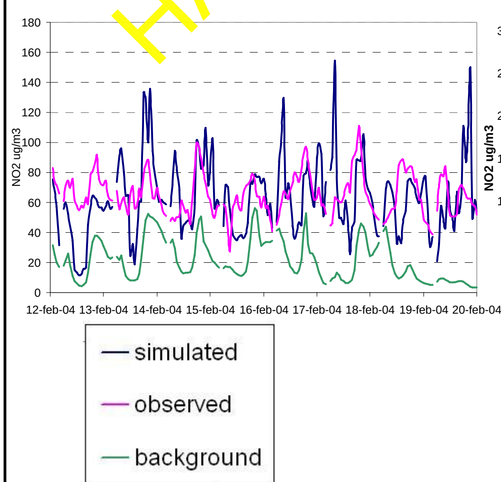
Urban model results for the pollution episodes (in square brackets results obtained with LAMA meteorological input)

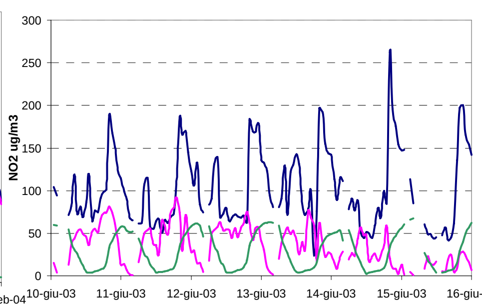
Averaging period	**NO_2** simulated period mean µg/m³	**NO_2** observed period mean µg/m³	**PM_{10}** simulated period mean µg/m³	**PM_{10}** observed period mean µg/m³
Summer episode (10 – 16 June 2003)	102 [136]	35	50 [69]	32
Winter episode (12 -19 February 2004)	63 [71]	65	55 [66]	87

NO_2 : 1 hour average

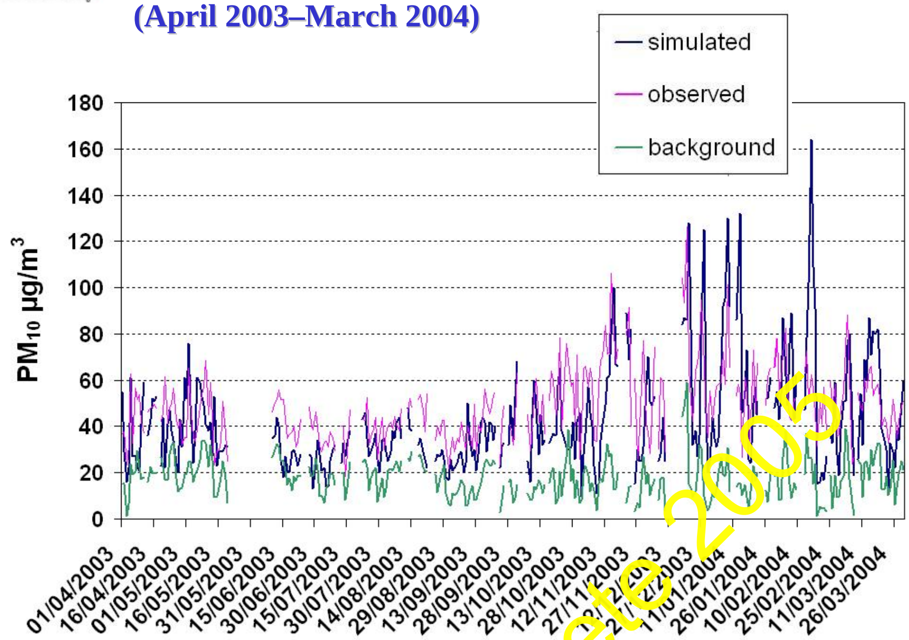
winter episode
(12 -19 February 2004)

summer episode
(10 -16 June 2003)

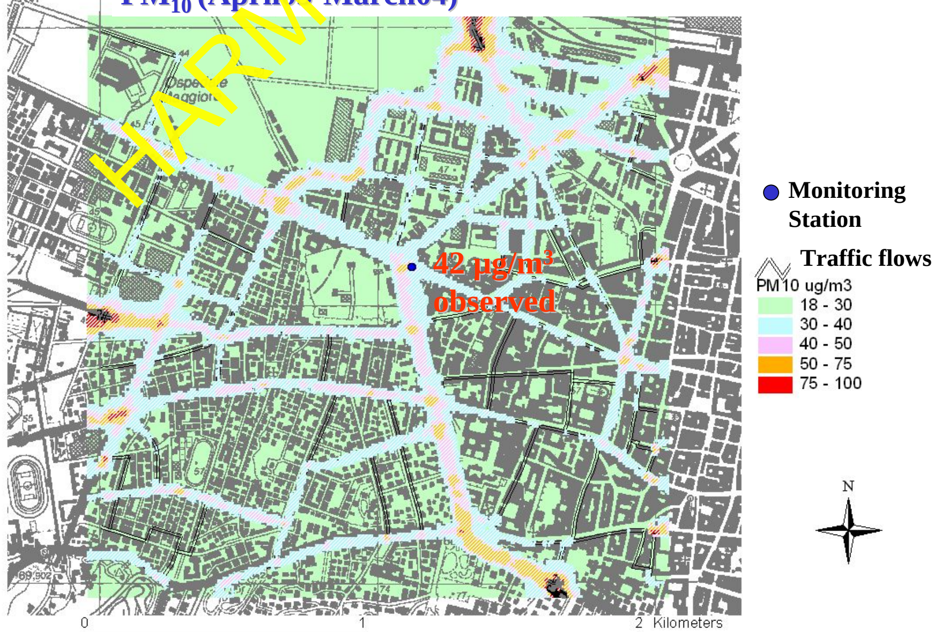




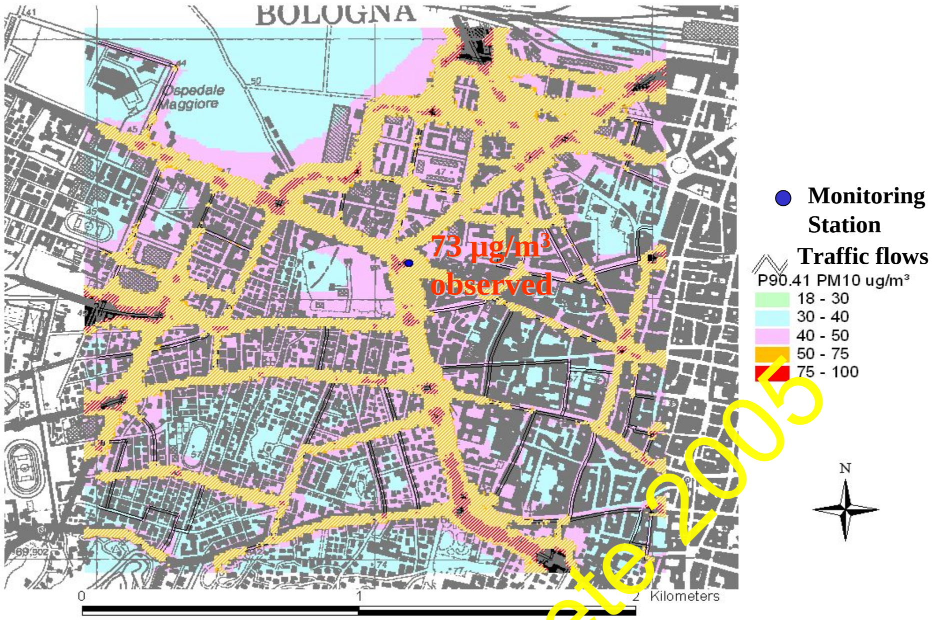
PM_{10} daily average for the period (April 2003–March 2004)



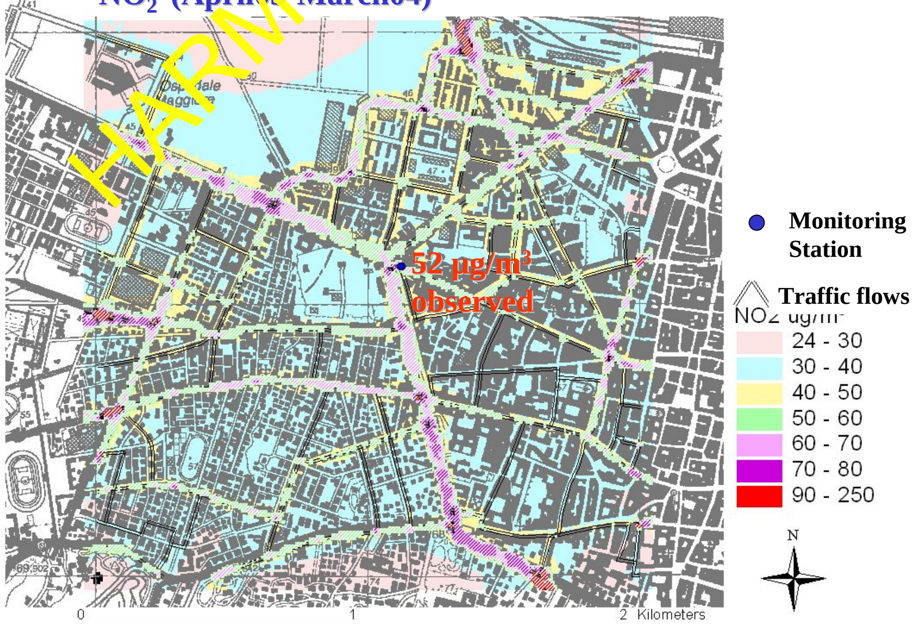
Spatial variation map of simulated annual average for PM_{10} (April03-March04)



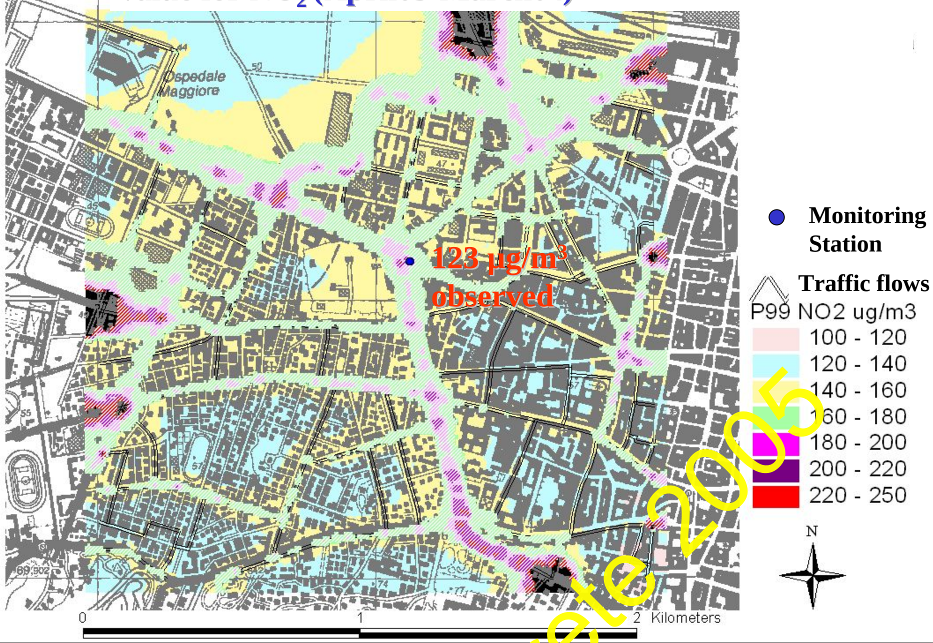
Spatial variation map of simulated 35th highest daily value for PM_{10} (April03-March04)



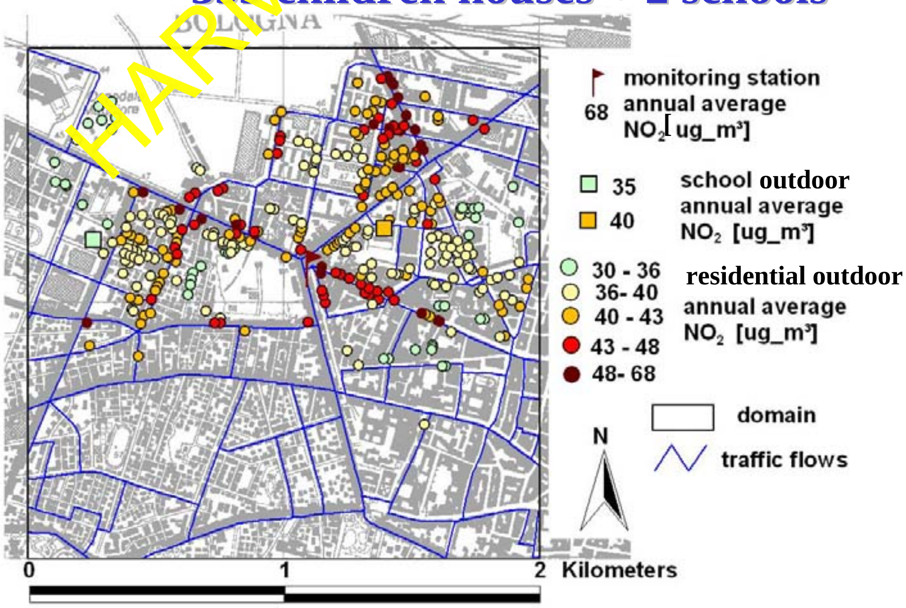
Spatial variation map of simulated annual average for NO_2 (April03-March04)



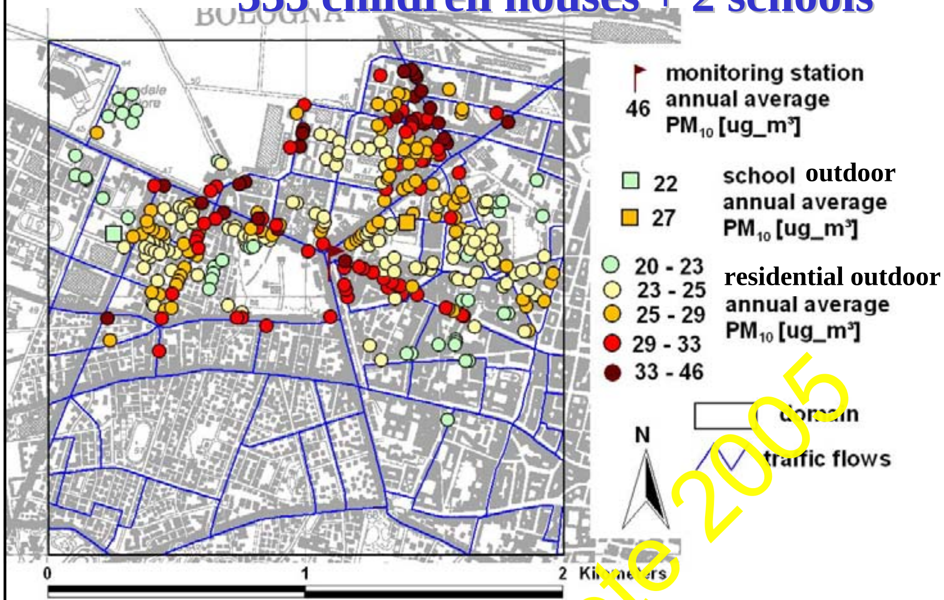
Spatial variation map of simulated 18th highest hourly value for NO_2 (April03-March04)



NO_2 outdoor concentration levels in 333 children houses + 2 schools



PM$_{10}$ outdoor concentration levels in 333 children houses + 2 schools



Population exposure (1)

We will identify mean population (children) fractional time spent in the different micro-environment. We will use only three micro-environments:

- *Residential indoor*
- *School indoor*
- *Traffic*

Residential Indoor = Derived from the residential outdoor concentrations applying the EXPOLIS infiltration factors

School Indoor = Derived from the school outdoor concentrations applying the EXPOLIS infiltration factors

Traffic = Derived from Italian and European studies as function of the mean concentration in the streets of the interested area

Population exposure (2)

Annual Mean Children Exposure

=

Residential Indoor x F_{RI} + School Indoor x F_{SI} + Traffic x F_T

(a weighted mean)

F_{RI} = Fractional time spent in Residential Indoor

F_{SI} = Fractional time spent in School Indoor

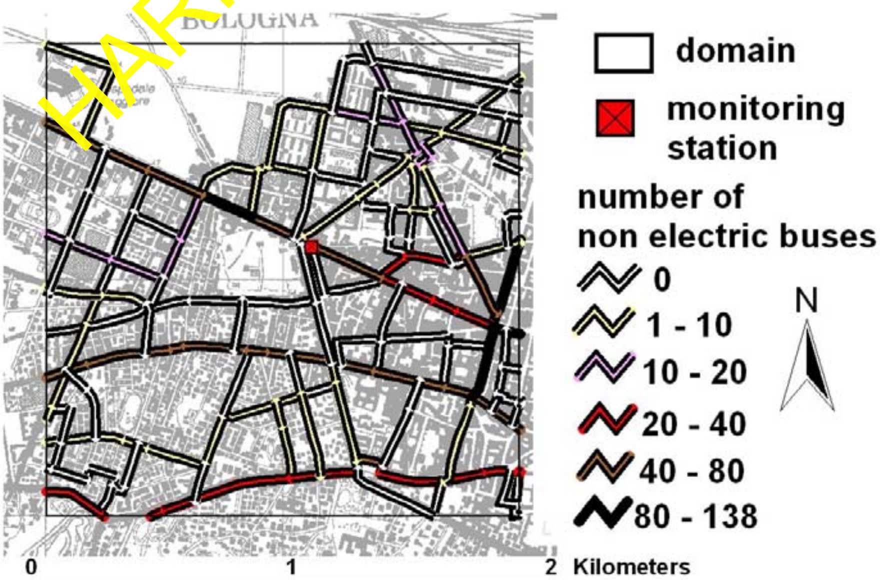
F_T = Fractional time spent in Traffic

Conclusions

- Urban model, combined with the regional chemical transport model, performs quite well to assess long term averages of PM_{10} and NO_2
- Peak pollutions are poorly reproduced
- Modelling integrated system in the analysis of present and future scenarios can be a valuable support for the local administrations in applying EU directives on air quality
- Methodology for population exposure estimates , based on infiltration factors, is now in progress.

EXTRA

Buses were considered for each road link (source ATC)



CALMET

- Wind speed (m/s)
- Wind direction (°)
- Reciprocal of theMonin-Obukhov length (m^{-1})
- Mixing height (m)
- Near surface temperature (°C)
- Surface albedo

+

- Incoming solar radiation incidente (W/m^2)

(local station Sasso Marconi)

LAMA

- Wind speed (m/s)
- Wind direction (°)
- Near surface temperature (°C)

+

- Incoming solar radiation incidente (W/m^2)

(local station Sasso Marconi)

Focus on Children – Why?

1) Children have increasing importance in public health evaluations

2) Children's mobility is usually short-radius. Bologna high-resolution outdoor AQ simulations are referred to a small area of the city and so short-radius mobility could be a great advantage. Furthermore, we can estimate a simplified but realistic time-activity table without surveys

3) Mobility surveys on children could be more easily done in the schools of the area. In the future, monitoring data could also be collected inside and outside next to the school.

Time serie of CALMET mixing heigth and NO_2 concentration in the summer episode