METHODOLOGIES FOR CALCULATING ROAD TRAFFIC EMISSIONS IN MILAN

FAIRMODE **April 28th, 2014**

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Comune di Milano

EXPO MILANO 2015-ITALY

AGENZIA MOBILITÀ AMBIENTE TERRITORIO

WHO WE ARE

The Mobility, Environment and Land Agency is an in-house technical company totally owned by the Administration of the City of Milan

POPULATION OF LARGEST CITIES IN THE EU

1	London	United Kingdom	7,074,000
2	Berlin	Germany	3,387,000
3	Madrid	Spain	2,824,000
12	Milan	Italy	1,303,000

	MILAN	**LOMBARDY**	**ITALY**
surface	182 km^2	23,861 km^2	301,200 km^2
inhabitants	1,303,000	9,642,000	59,619,000
pop. density	7,150 inh/km^2	404 inh/km^2	198 inh/km^2

1. WHY WE ESTIMATE LOCAL EMISSIONS?

In Italy there are at least two Public Authorities competent in estimating atmospheric emissions:

✓ the **Ministry of Environment** that reports to the European Commission the national atmospheric emissions data, the communications on the obligations of Directive 2008/50/EC etc..;

✓the **Regions** that have to define and adopt Regional Plans in order to improve air quality and to recover EU standards. Air quality Plans can include regional laws and actions aimed to reduce the air pollution levels (e.g. traffic limitations, emission reduction obligations etc ..).

1. WHY WE ESTIMATE LOCAL EMISSIONS?

Municipalities don’t have specific competences on air quality, but they manage and organise the urban private traffic circulation, the local Public Transport Systems, the buildings and land use. Moreover, in Italy the Mayors are the local Public Health Authority.

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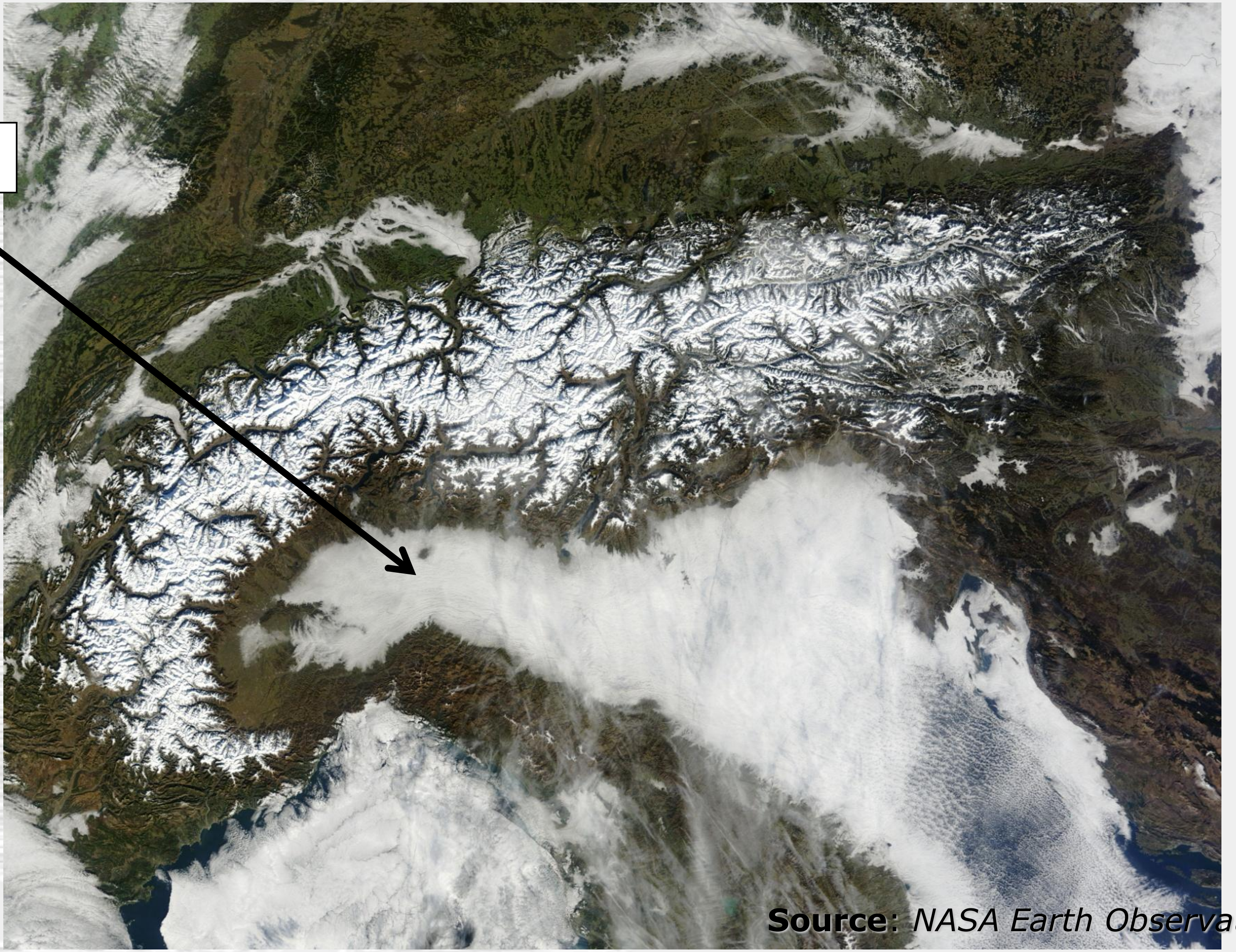
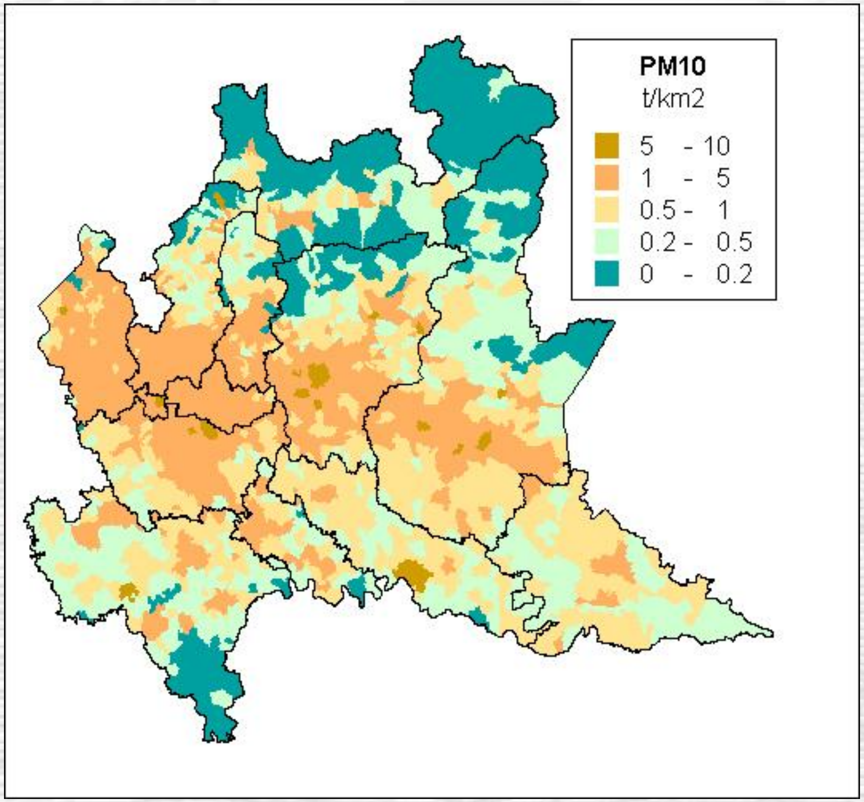
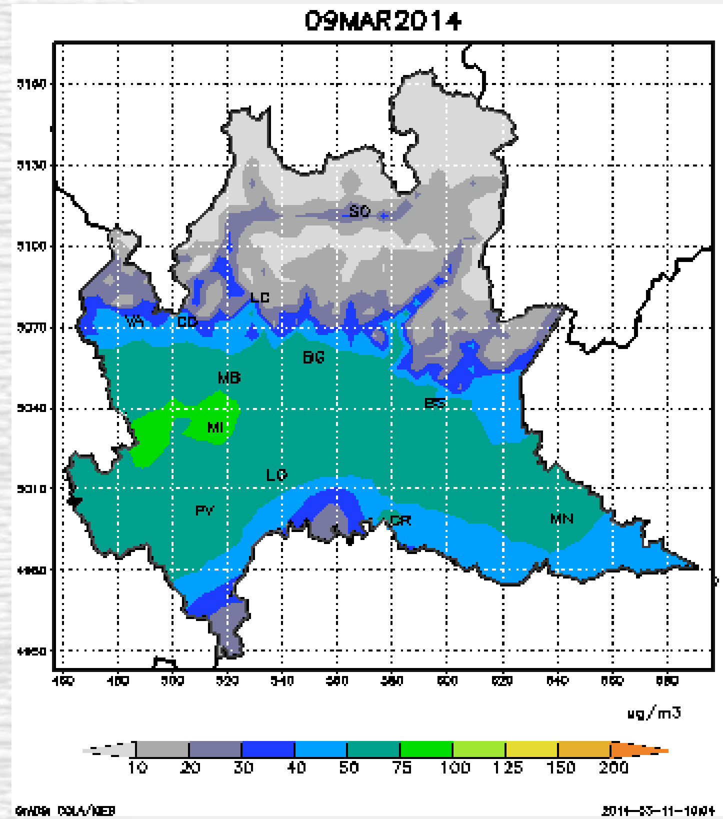
1. WHY WE ESTIMATE LOCAL EMISSIONS?



1. WHY WE ESTIMATE LOCAL EMISSIONS?

The **Regions** carry out evaluations over large domains

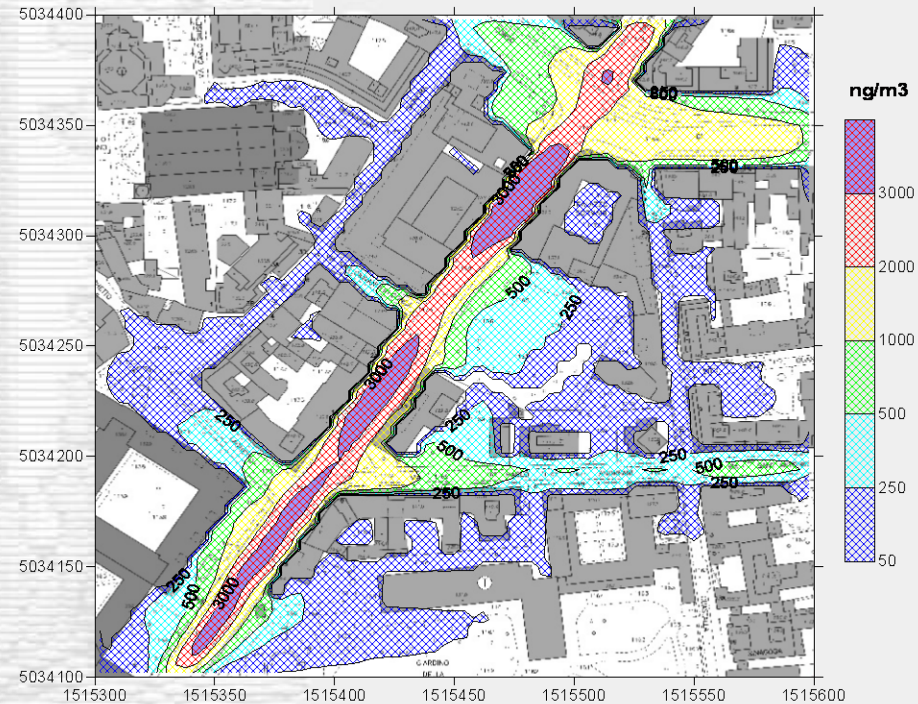




Source: *www.arpalombardia.it*

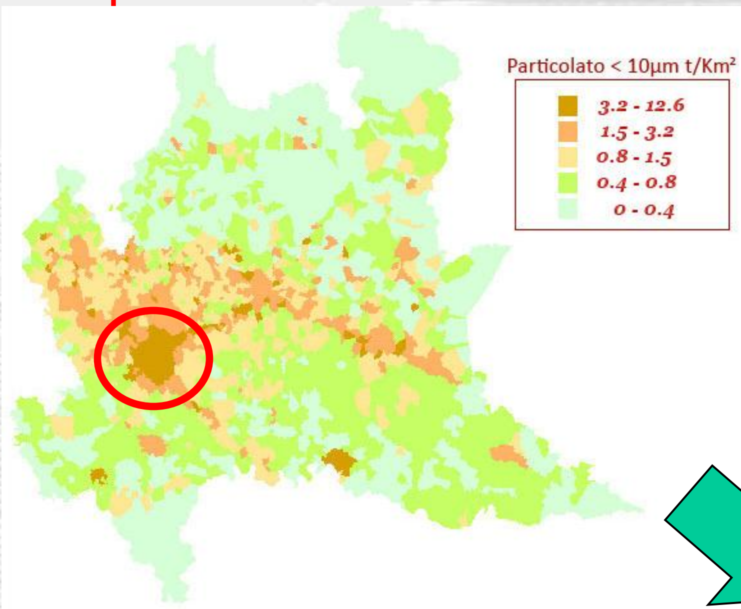
1. WHY WE ESTIMATE LOCAL EMISSIONS?

The **Municipalities** carry out evaluations at city / district / microscale level

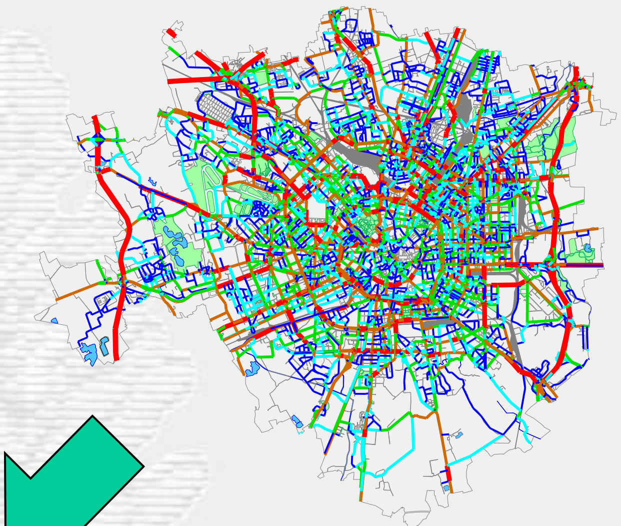


1. WHY WE ESTIMATE LOCAL EMISSIONS?

Regions



Municipalities



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	PM10 (ton)	NH_3 (ton)	CO_2 (kton)	CO_2 cars (kton)	CO_2 LDV + HDV (kton)	CO_2 motorbykes (kton)
LOMBARDY	422	53	1.490	776	693	21
MILAN	337	81	1.554	1.102	407	45
	25%	-34%	-4%	-30%	71%	-55%

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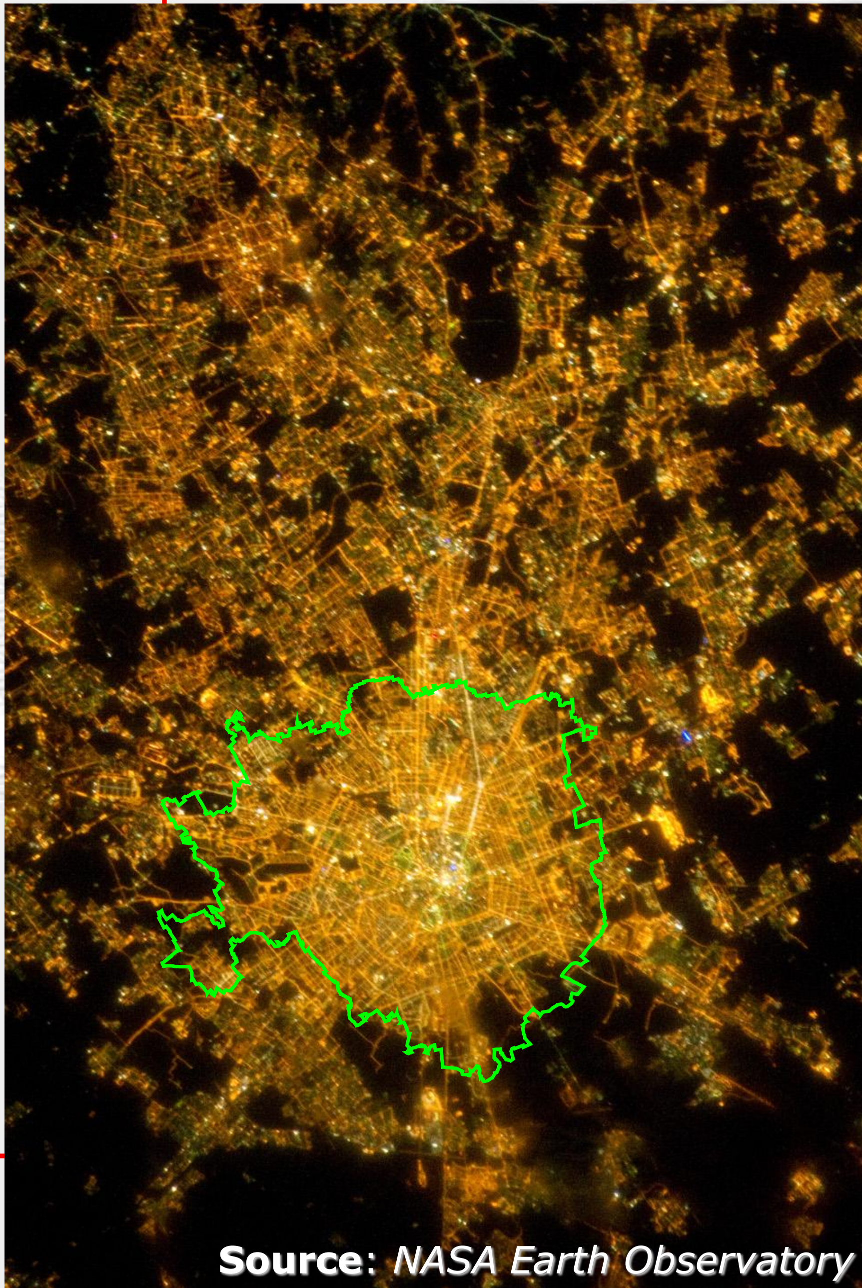
2. WHAT IS AN 'URBAN EMISSION'?



Source: *NASA Earth Observatory*

Only the municipal territory is under the jurisdiction of a city.

Outside the borders of the city, local data are managed by other Municipalities.

Thus, sometimes the 'urban emissions' are not related to a unique municipality.

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3. THE METHODOLOGY

$$E_{p,j} = FE_{p,j} * M_i * f_{j(i)}$$

where:

- $E_{p,j}$ and FE are the total emission and the emission factor for the pollutant ‘p’ and the vehicle sub-type ‘j’
- M_i is the total mileage for the vehicle category ‘i’
- $f_{j(i)}$ is the fraction of the total mileage for the vehicle sub-type ‘j’ that belongs to the category ‘i’

Example: the vehicle sub-type ‘passenger car diesel Euro 4 > 2.0 l’ belongs to the vehicle category ‘passenger cars’

3.1 THE EMISSION FACTORS

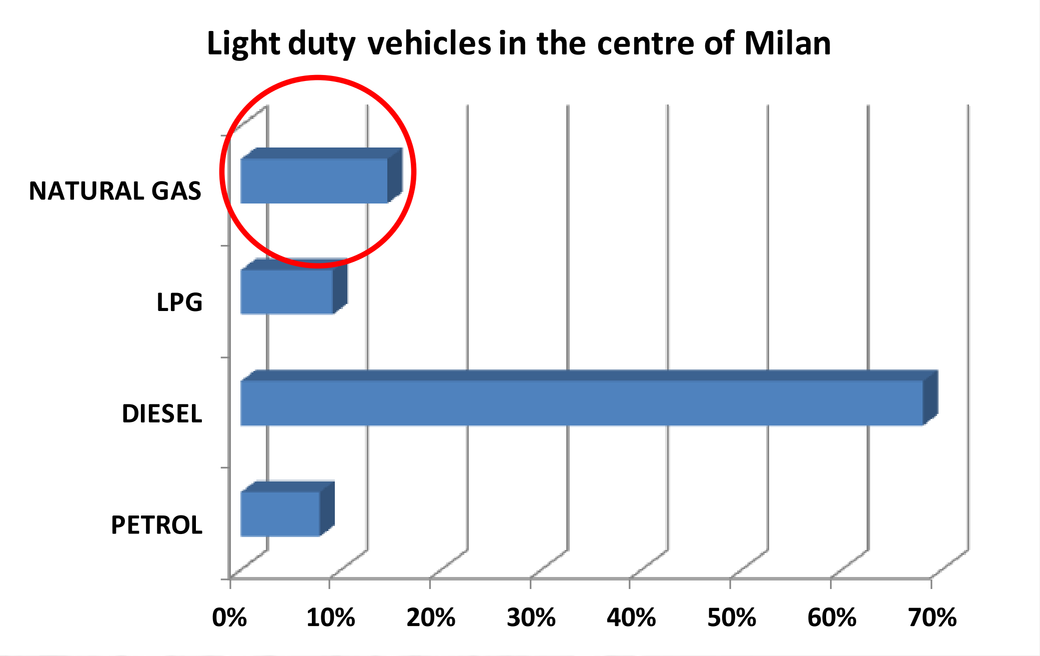
$$E_{p,j} = FE_{p,j} * M_i * f_{j(i)}$$

EMEP/EEA inventory guidebook emission factors are used. The main reasons are:

- the need to compare the obtained results with the emission data estimated using the same emission factors with different approaches (i.e. top-down);
- the need to use a scientifically robust dataset of emission factors, in order to obtain results in agreement with the state-of-the-art methodologies;
- the need to defend local measures in case of appeals before the Regional Administrative Court.

3.1 THE EMISSION FACTORS

Sometimes an integration of the EMEP/EEA guidebook emission factors is needed. In these cases consolidated scientific data are used or, occasionally, local experimental measures are carried out.



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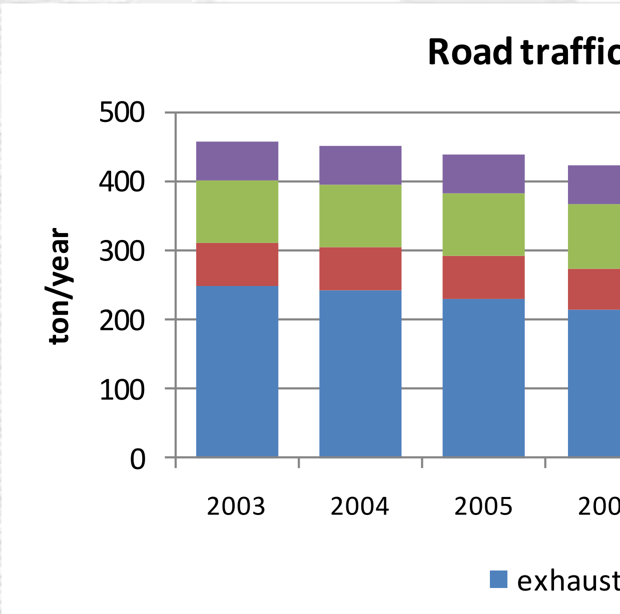

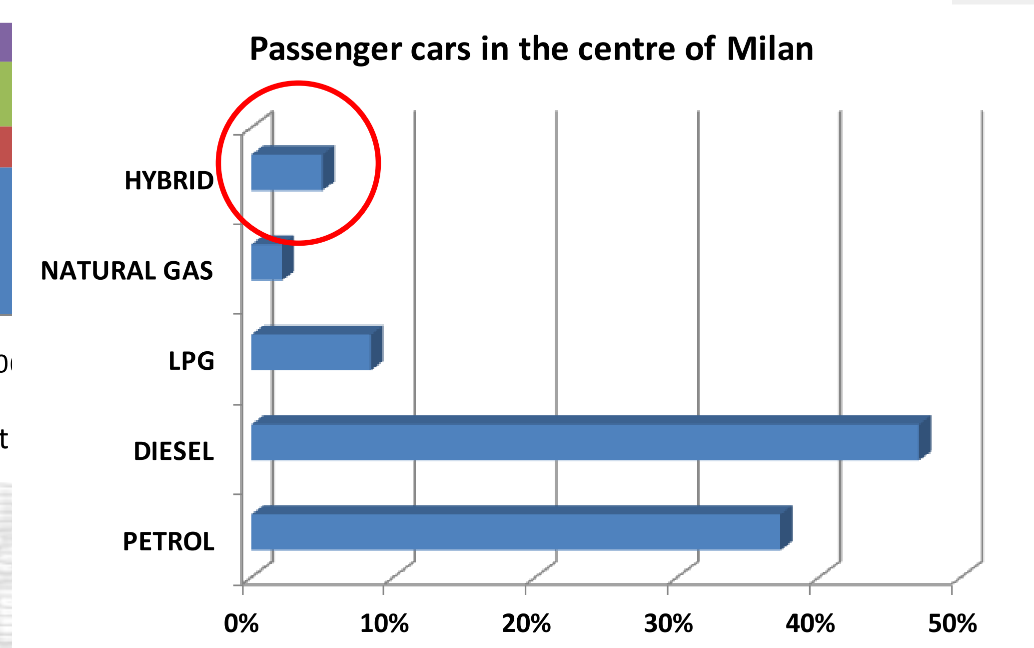

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3.1 THE EMISSION FACTORS

$$E_{p,j} = FE_{p,j} * M_i * f_{j(i)}$$

Uncertainties

In addition to their intrinsic uncertainties, EMEP/EEA inventory guidebook emission factors are function of several variables that introduce other uncertainties, among others:

- the mean speed;
- the fraction of mileage driven with a cold engine or the catalyst operated below the light-off temperature;
- some meteorological parameters (temperature, relative humidity ..).

3.1 THE EMISSION FACTORS

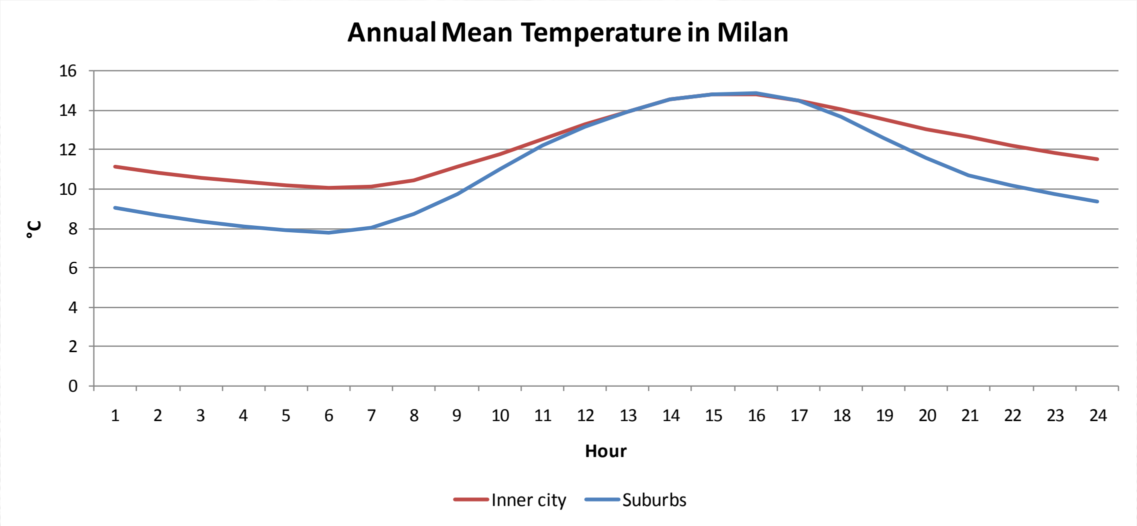
Cold start emissions

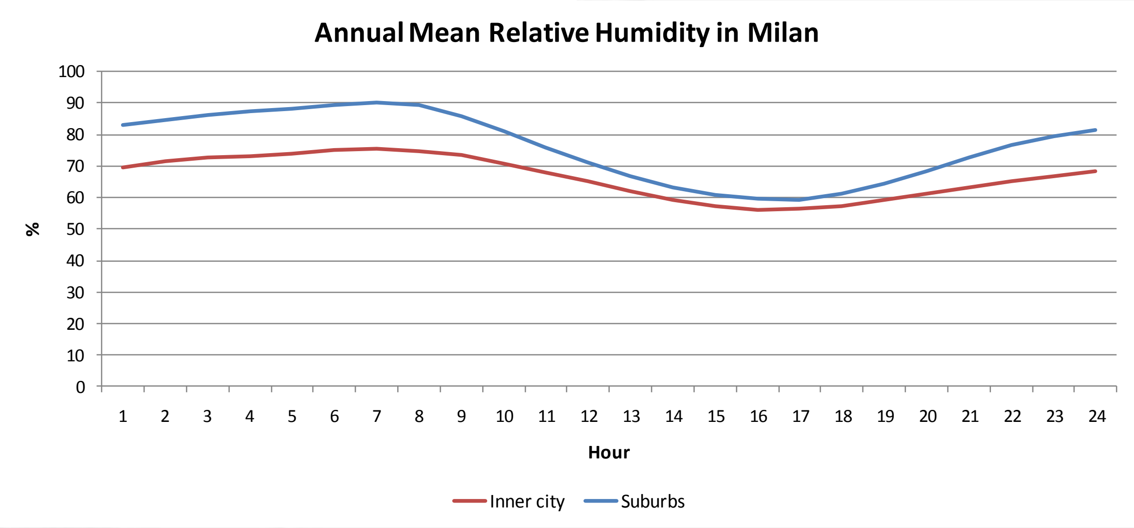
Generally, EMEP/EEA guidebook approach is used for estimating the fraction of mileage driven in Milan with a cold engine, if the citywide emissions are estimated.

In case of smaller areas, specific analysis are carried out on the base of the trip distribution (by origin / destination) and the traffic count data.

3.1 THE EMISSION FACTORS

Uncertainties: meteorological parameters





3. THE METHODOLOGY

$$E_{p,j} = FE_{p,j} * M_i * f_{j(i)}$$

$$E_{HOT;\,i,\,k,\,r} = N_k \times M_{k,r} \times e_{HOT;\,i,\,k,\,r} \qquad (8)$$

where,

$E_{HOT;\,i,\,k,\,r}$ = hot exhaust emissions of the pollutant i [g], produced in the period concerned by vehicles of technology k driven on roads of type r,

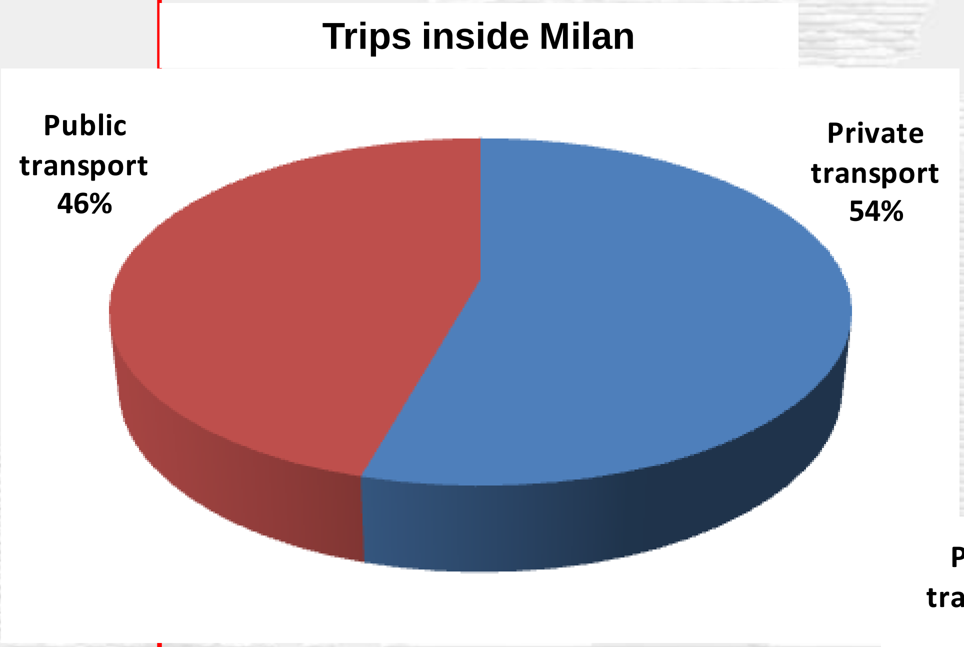
N_k = number of vehicles [veh] of technology k in operation in the period concerned,

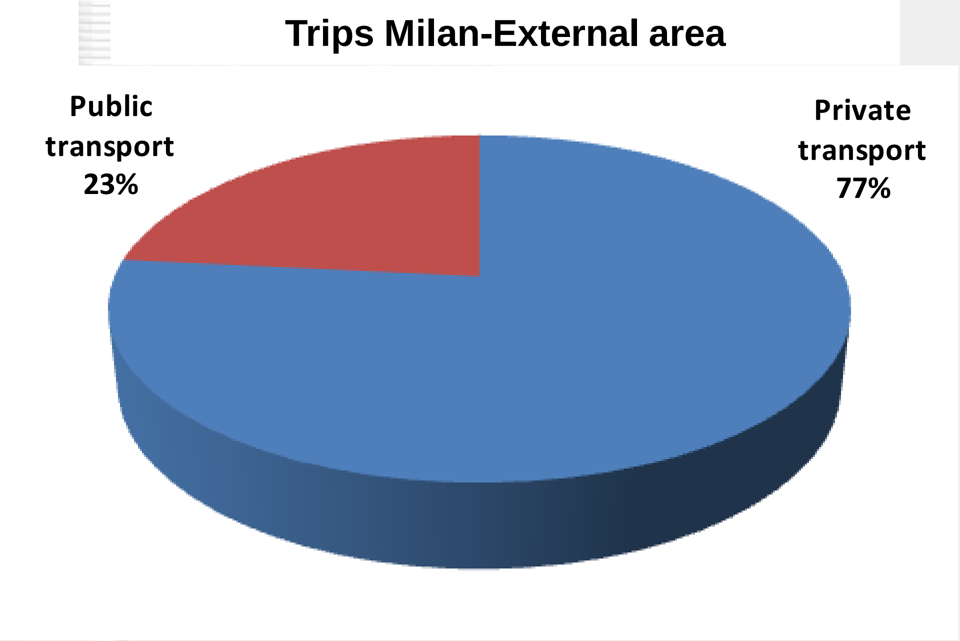
$M_{k,r}$ = mileage per vehicle [km/veh] driven on roads of type r by vehicles of technology k,

$e_{HOT;\,i,\,k,\,r}$ = emission factor in [g/km] for pollutant i, relevant for the vehicle technology k, operated on roads of type r.

Source: *EMEP/EEA emission inventory guidebook 2013*

3. THE METHODOLOGY



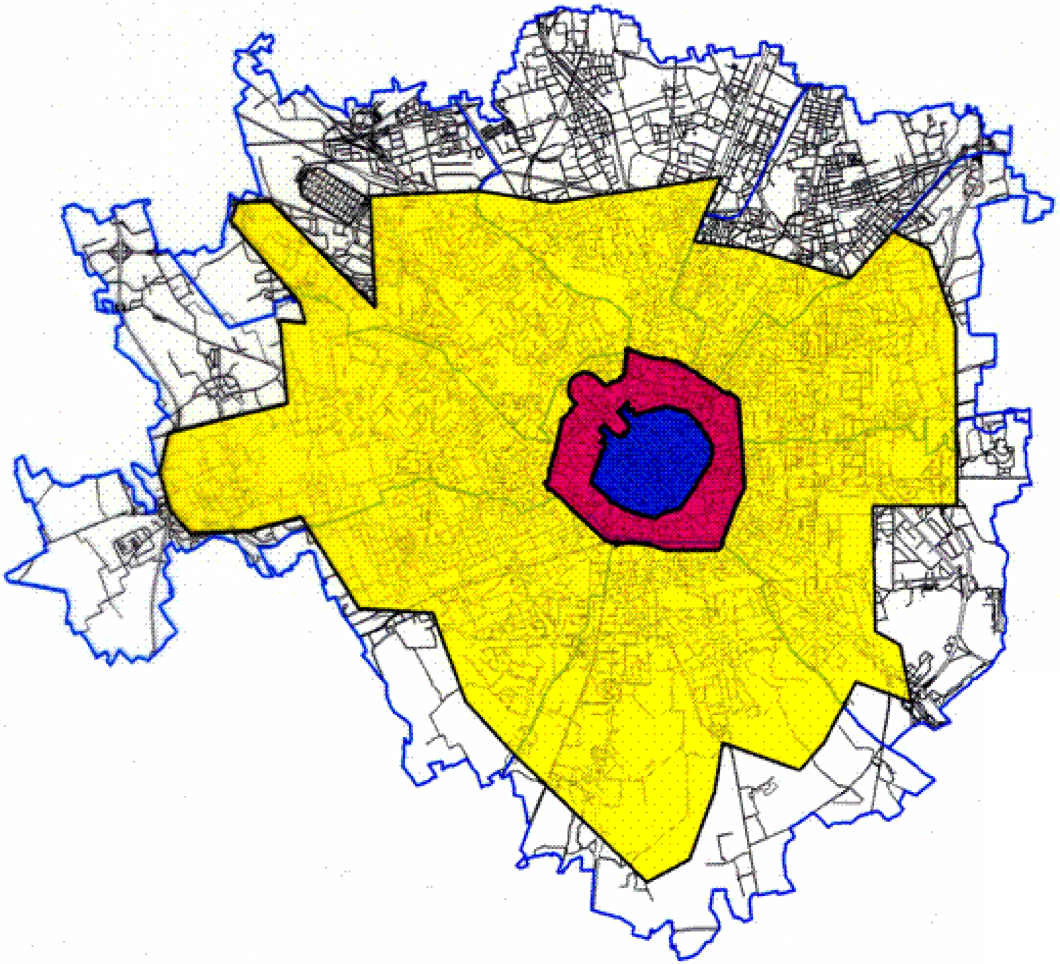


3.2 THE TOTAL MILEAGE

$$E_{p,j} = FE_{p,j} * M_i * f_{j(i)}$$

The daily total mileage (together with the mean speed) of each vehicle category 'i' is usually provided by traffic models.

3.2 THE TOTAL MILEAGE



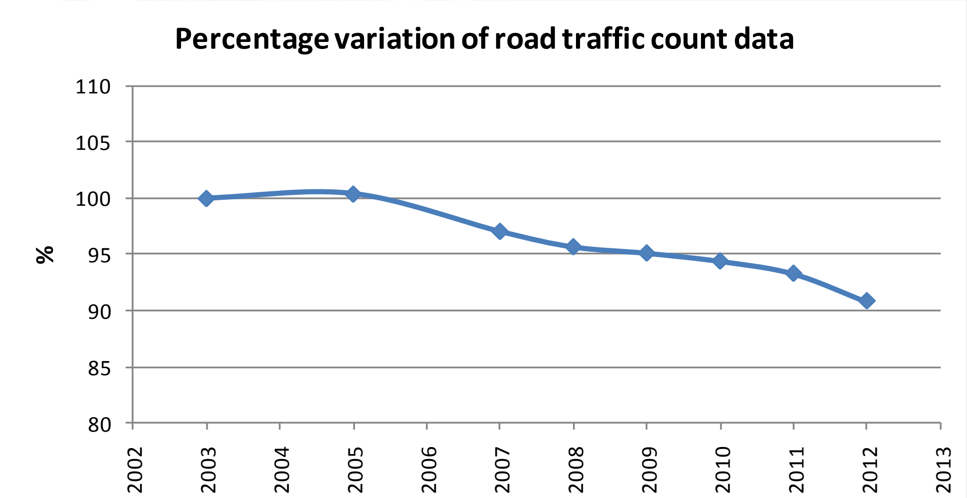
Example: urban circulation plan for vans and lorries

3.2 THE TOTAL MILEAGE

The uncertainties in the mileage provided by traffic models can be quantified comparing the traffic count data with the model data at the same road where the counters are placed.

Another uncertainty is due to the fact generally the traffic models provide mean hourly or daily data, but in order to estimate atmospheric emissions the annual mileage is required.

The day-to-year factors are obtained analysing the traffic data provided by the counters in the city.



3.3 THE FRACTION OF TOTAL MILEAGE

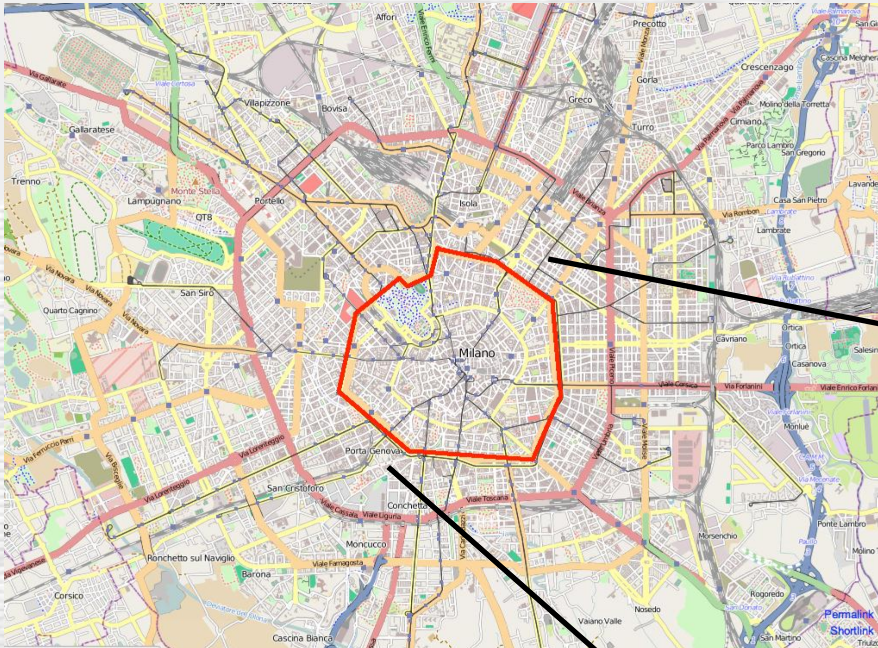
$$E_{p,j} = FE_{p,j} * M_i * f_{j(i)}$$

The fraction of the total mileage for the vehicle sub-type 'j' that belongs to the category 'i' is another important information.

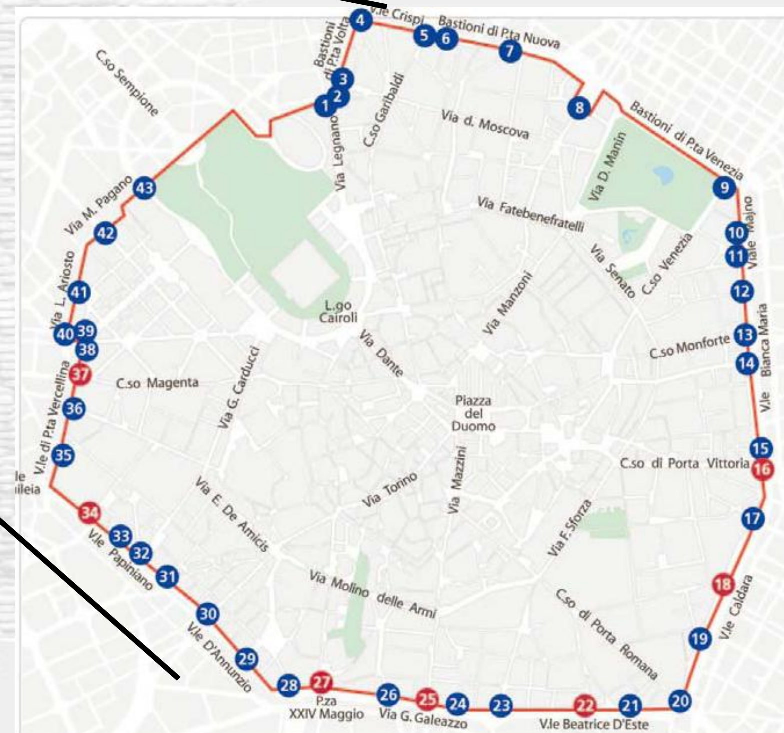
Before 2007, the national public register data were used together with suitable numeric factor in order to take into account the smaller mileages of the oldest vehicles.

Starting from 2008, in Milan the fractions of the total mileage are directly provided by several traffic cameras designed to recognise the type of each vehicle detected.

3.3 THE FRACTION OF TOTAL MILEAGE



The 43 entrance points to the historical centre of the city are all equipped with cameras designed to recognise and record the license plate numbers.



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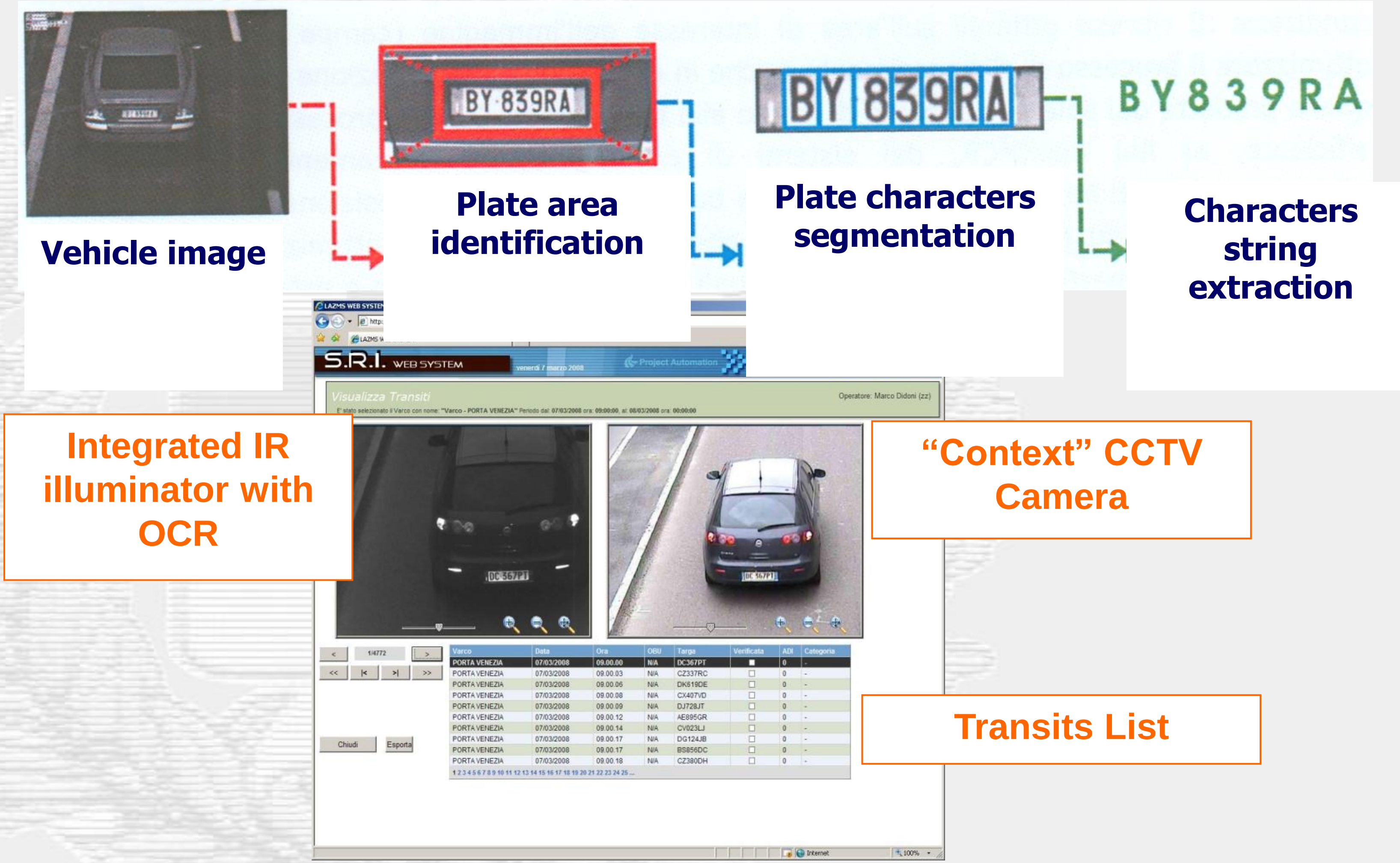

3.3 THE FRACTION OF TOTAL MILEAGE

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The surveillance cameras at the access points detect the number plate of each entering vehicle. A central system collects data and identifies the vehicle type (passenger car, lorry, bus, motorcycle ..), the category (public or private vehicle, inhabitant, free-access, access not allowed ..) and the main characteristics (fuel, Euro class, DPF). In this way hundreds of vehicles sub-types are identified and grouped into ~ 100 categories used for estimating emissions.

CategoriaVeicolo	AlimentazioneVeicolo	FAP	CategoriaEuro	ClasseInqu	veicoli
AUTOBUS PER TRASPORTO DI PERSONE	ALIM. ELETTRICA	NO	EURO0	0	0
AUTOBUS PER TRASPORTO DI PERSONE	BENZINA/METANO	NO	EURO3	1	1
AUTOBUS PER TRASPORTO DI PERSONE	DIESEL	NO	EURO0	5	5
AUTOBUS PER TRASPORTO DI PERSONE	DIESEL	NO	EURO1	5	2
AUTOBUS PER TRASPORTO DI PERSONE	DIESEL	NO	EURO2	5	17
AUTOBUS PER TRASPORTO DI PERSONE	DIESEL	NO	EURO3	5	32
AUTOBUS PER TRASPORTO DI PERSONE	DIESEL	NO	EURO4	4	0
AUTOBUS PER TRASPORTO DI PERSONE	DIESEL	NO	EURO5	4	0
AUTOBUS PER TRASPORTO DI PERSONE	DIESEL	SI	EURO3	5	0
AUTOBUS PER TRASPORTO DI PERSONE	DIESEL	SI	EURO4	4	6
AUTOBUS PER TRASPORTO DI PERSONE	DIESEL	SI	EURO5	4	0
AUTOCARAVAN	BENZINA + IMPIANTO GPL	NO	EURO1	1	0
AUTOCARAVAN	DIESEL	NO	EURO0	5	0
AUTOCARAVAN	DIESEL	NO	EURO1	4	1
AUTOCARAVAN	DIESEL	NO	EURO2	4	1
AUTOCARAVAN	DIESEL	NO	EURO3	4	3
AUTOCARAVAN	DIESEL	NO	EURO4	2	0
AUTOCARAVAN	DIESEL	SI	EURO3	4	0
AUTOCARAVAN	DIESEL	SI	EURO4	2	1

3.3 THE FRACTION OF TOTAL MILEAGE

The uncertainty in sub-type vehicle identification with cameras is very low (less than 5%), but currently we can obtain information only about the fleet composition in the centre of the city.

Other cameras at the borders of the city will be activated next summer, thus in the next future we'll:

- have direct measure on the fleet composition for the remaining part of the city;
- have better information for the validation of the traffic model and reduce its uncertainty;
- have direct measures on the mean speeds across the city.

4. VALIDATION

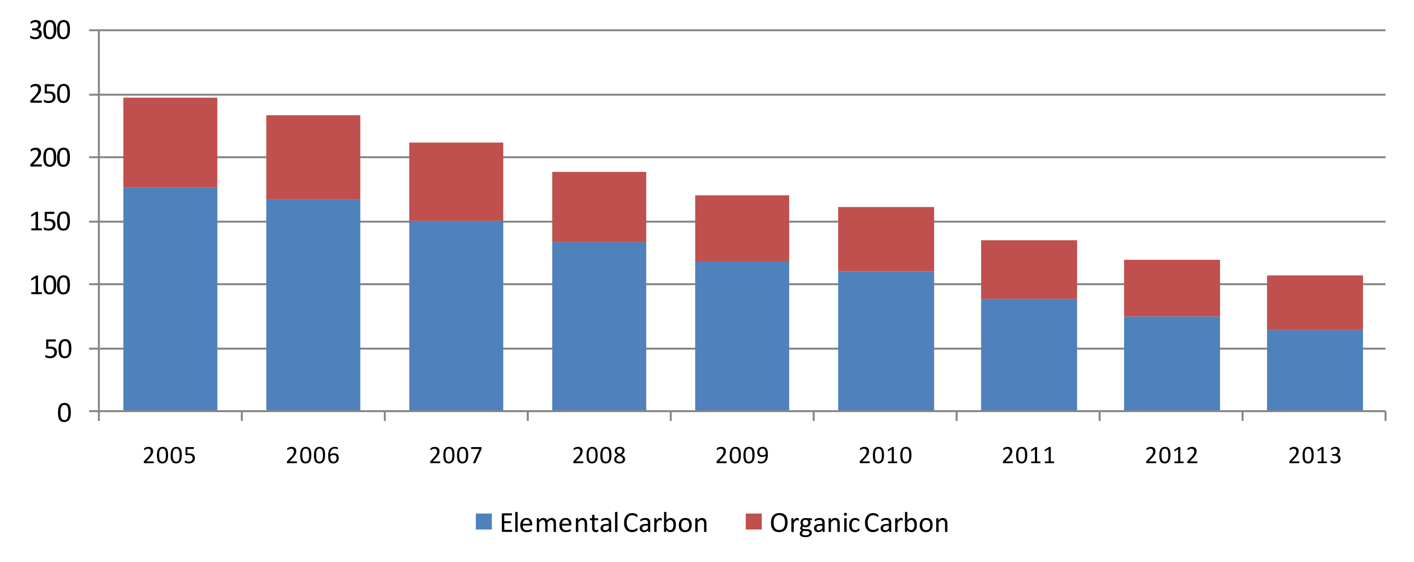
It is very difficult to find "validation" criteria of an emission inventory.

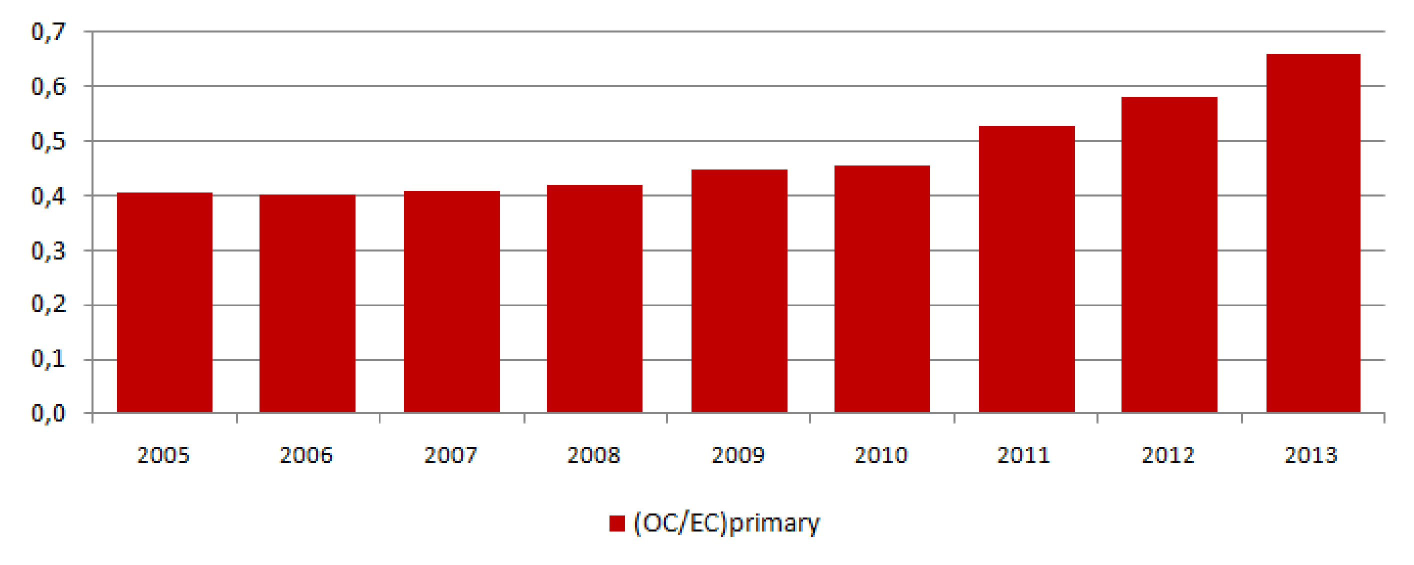
- We compare our estimations with other emission inventories (for example, the Regional inventory) in order to understand the reasons of the possible inconsistencies.

- We compare the results of dispersion or chemical and transport models with the measured concentration data in order to understand if there are important inconsistencies in the emission inventory.

- We try to compare some estimated emission information with the available experimental data related to the local road transport emissions.

4. VALIDATION





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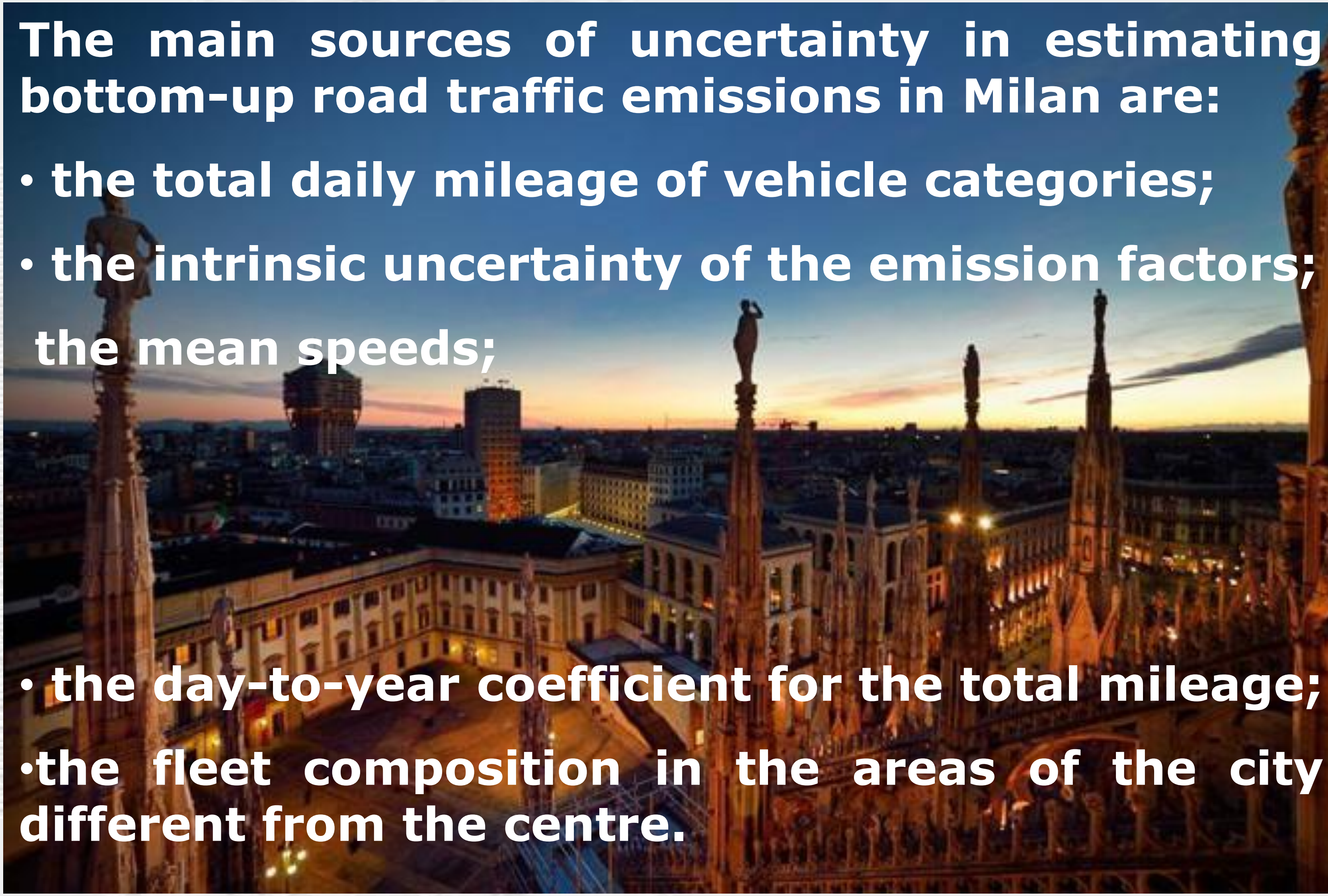
5. UNCERTAINTIES



The main sources of uncertainty in estimating bottom-up road traffic emissions in Milan are:

- **the total daily mileage of vehicle categories;**
- **the intrinsic uncertainty of the emission factors;**
- **the mean speeds;**
- **the day-to-year coefficient for the total mileage;**
- **the fleet composition in the areas of the city different from the centre.**

5. UNCERTAINTIES

We are working in order to reduce the uncertainty for:

- **citywide fleet composition;**
- **mean speed;**
- **total urban mileage of HDV;**
- **emission factors for some non-exhaust phenomena.**

THANK YOU FOR

YOUR ATTENTION !