Development and deployment of the traffic emission model in Bolzano

Ing. Gianluca Antonacci, Ph.D.
CISMA Srl, Bolzano / Bozen

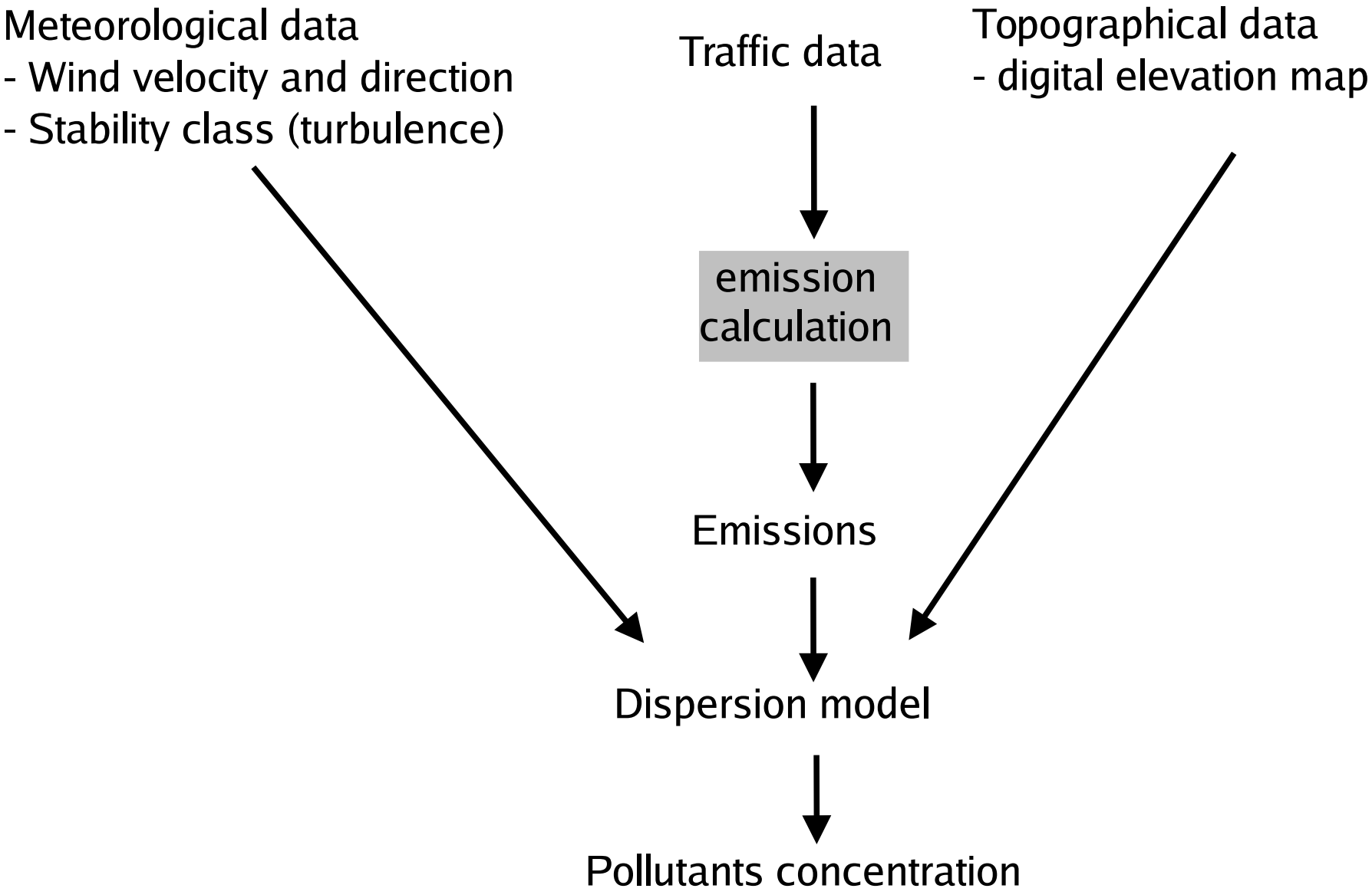
Introduction

Aim of the work:
Provide a calculation method to estimate emission from traffic source in the town of Bolzano

Logical scheme:
Traffic data → distribution over the road network → pollutant **emission calculation** → pollutant dispersion in the atmosphere

Field of application:
municipality of Bolzano, on major road network (in principle extensible, as the method is implemented in generalized way)

Model scheme



Methodologies for emission calculation

Known and established methodologies for pollutant emission from traffic and their peculiar characteristics caratteristiche

- Mobile6 (USA, Canada) – not easily adapted to EURO classification
- ARTEMIS (France) – most detailed but difficult to apply at a practical level
- HBEFA (Austria, Switzerland, Norway)
- COPERT IV (Italy, UK, Greece, Spain, Germany) – compliant to EMEP standard and compatible with the methodology already adopted from the Province of Bolzano for itsemission inventory → was chosen for the INTEGREEN project

COPERT methodology

Fuel Variables
- consumption
- specifications per fuel type

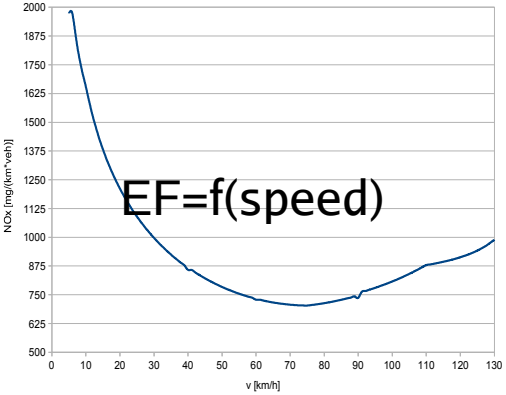
Activity Data
- number of vehicles per vehicle category
- distribution of vehicles into different exhaust emission legislation classes
- mileage per vehicle class
- mileage per road class

Driving Conditions
- average speed per vehicle type
- average speed per road

Other Variables
- climatic conditions
- mean trip distance
- evaporation distribution

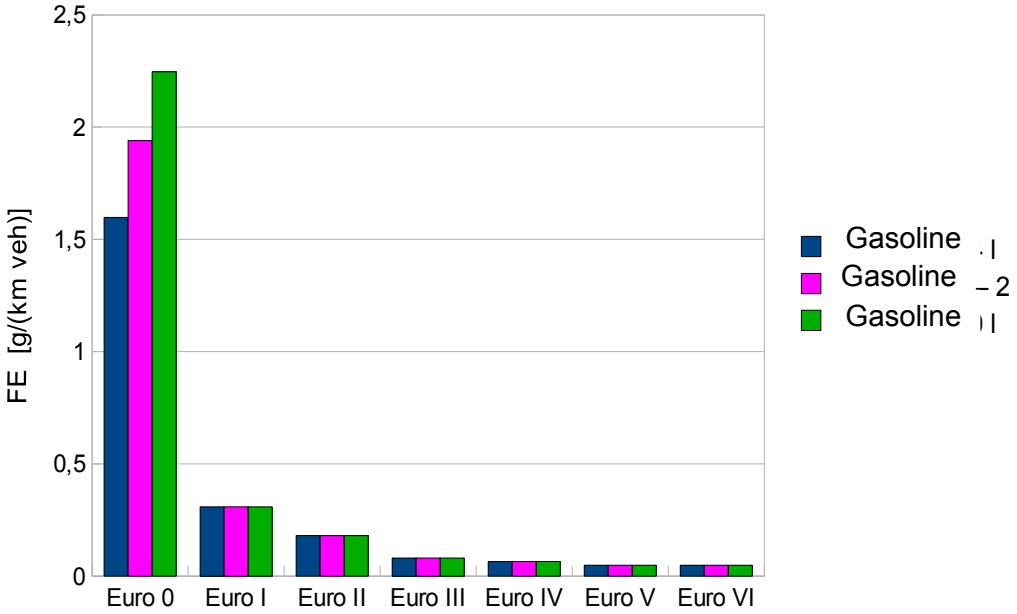
Emission Factors
- per type of emission (hot, cold, evaporation)
- per vehicle class
- per road class

COPERT procedure, as Adopted by European Environmental Agency

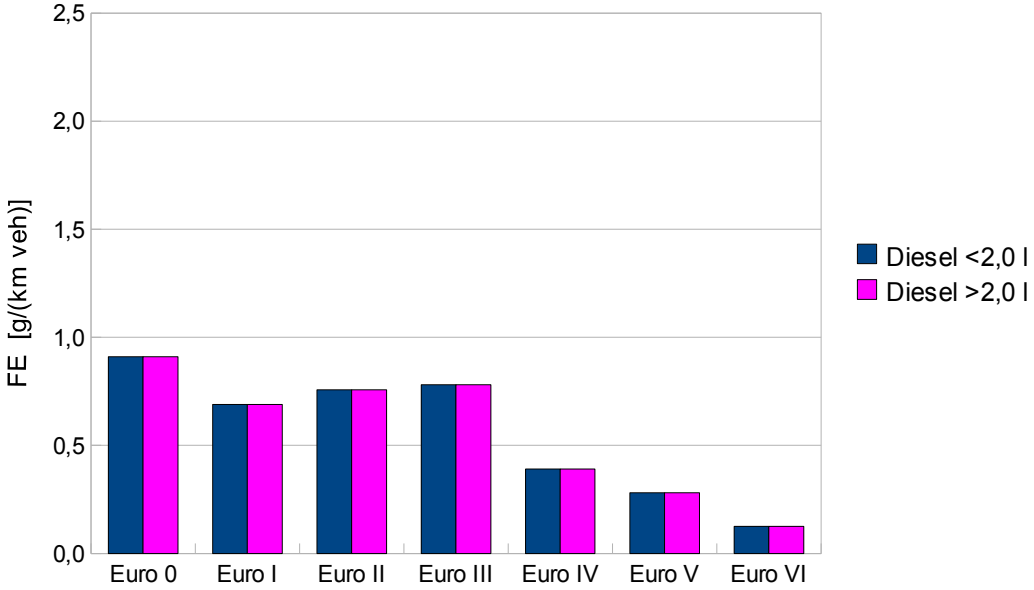


Emission factors

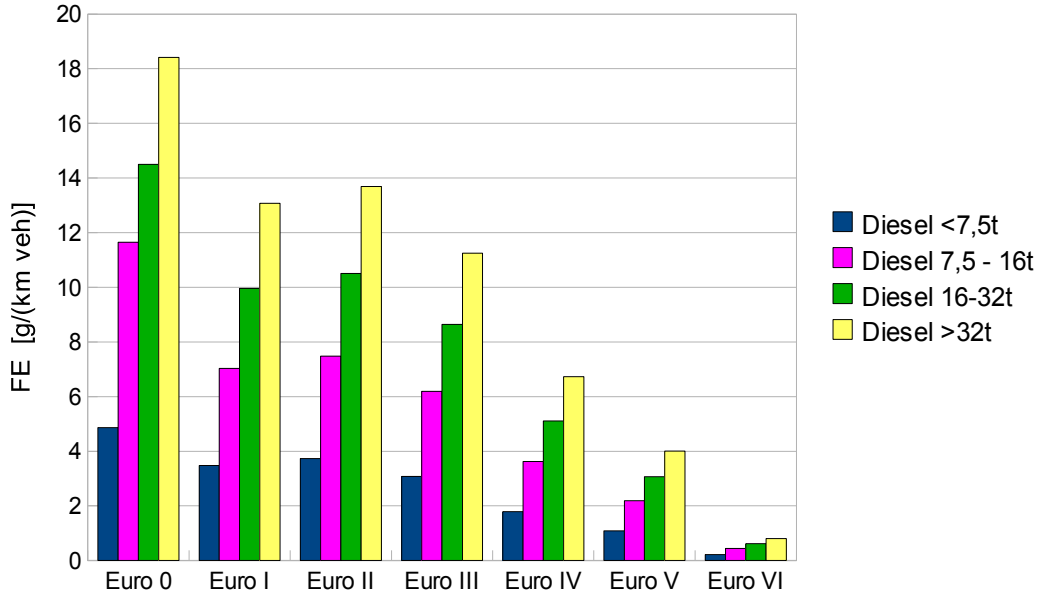
Emission factors – Gasoline passenger cars



Emission factors – Diesel passenger cars



Emission factors – Light Duty Vehicles



COPERT algorithm (1/2)

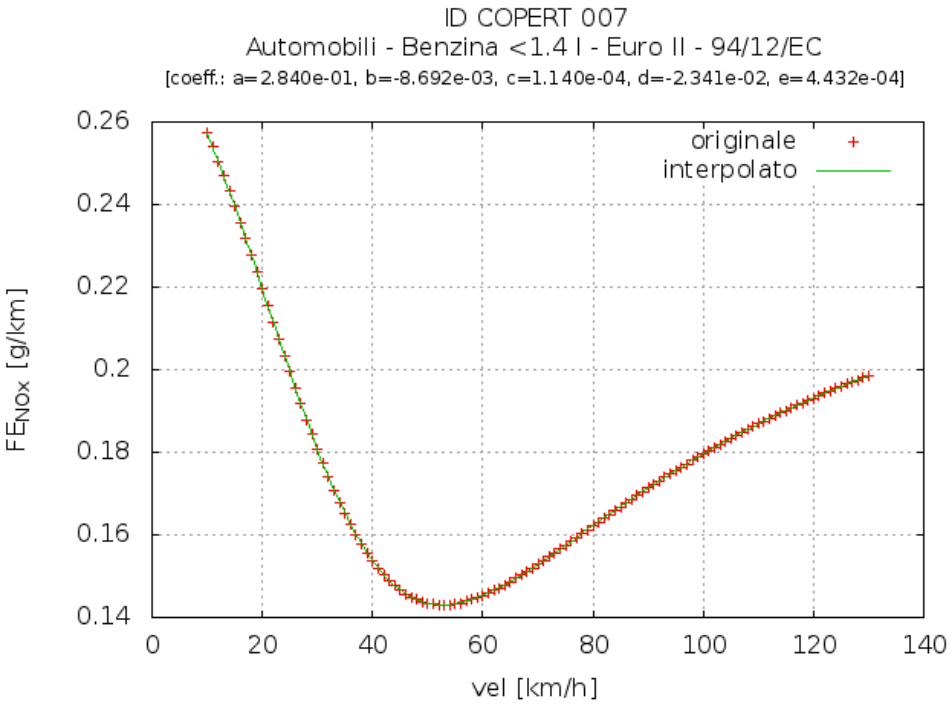
COPERT formulation was adapted to be general and to deliver results with acceptable calculation time → can also be used in real-time application

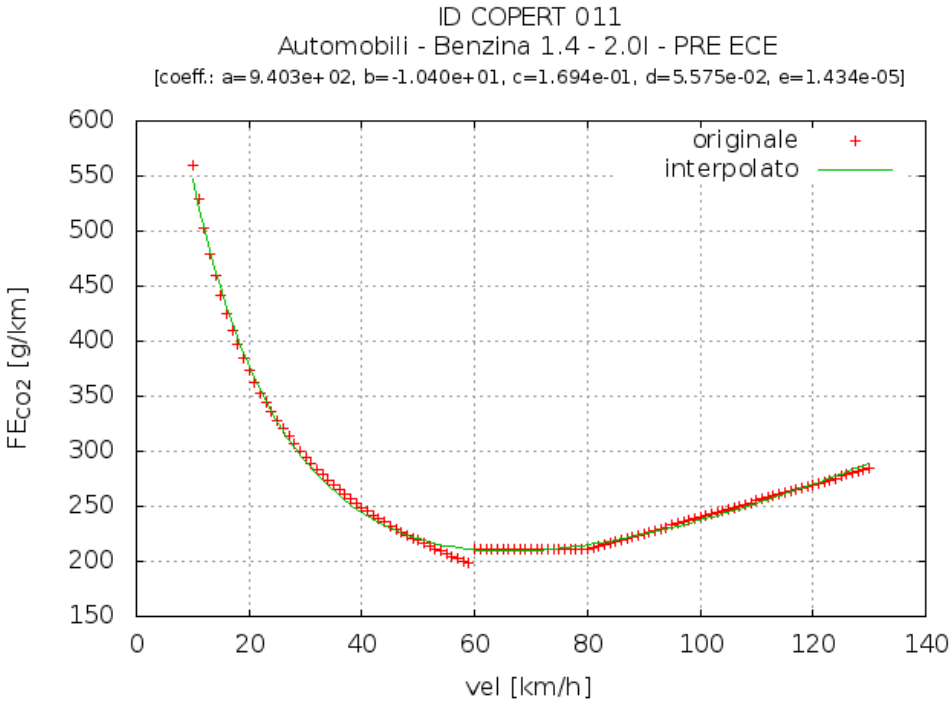
All the emissions are expressed in the generalized version with a simple formula

$$EF = (A+B*v+C*v^2)/(1+D*v+E*v^2)$$

EF [g/(km*veh)] emission factor
v [km/h] mean vehicle speed on the road stretch

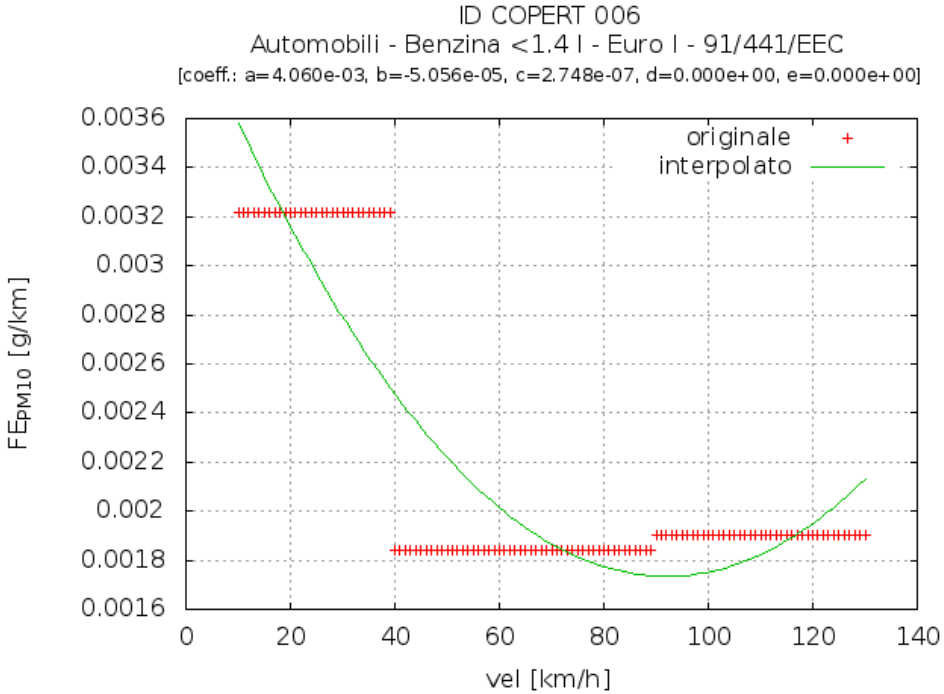
COPERT algorithm (2/2)





2 types of original “EF” curves:
- continuous formulation → OK
- not continuous or step-wise formulas → problems if we want to derive continuous (smooth) results

The interpolation solves and simplifies the issue and in most cases the difference with respect to the original formulation is negligible



Calculation method

The work was split into 2 phases

1. Derivation of continuous curves through min-square adaptation (146 vehicle classes x 11 pollutants = 1606 formulas)

2. Creation of a calculus software taking advantage of the derived EF database, in three versions:

- A “stand-alone” software able to read / write files in industry standard SHP+DBF, which can be used in a common GIS environment (es. Arcview)
- An excel/openoffice compatible spreadsheet, intended for quick calculation of overall emissions
- A full database version intended to be used in real-time application, based on Postgresql + Python scripting

Pollutants

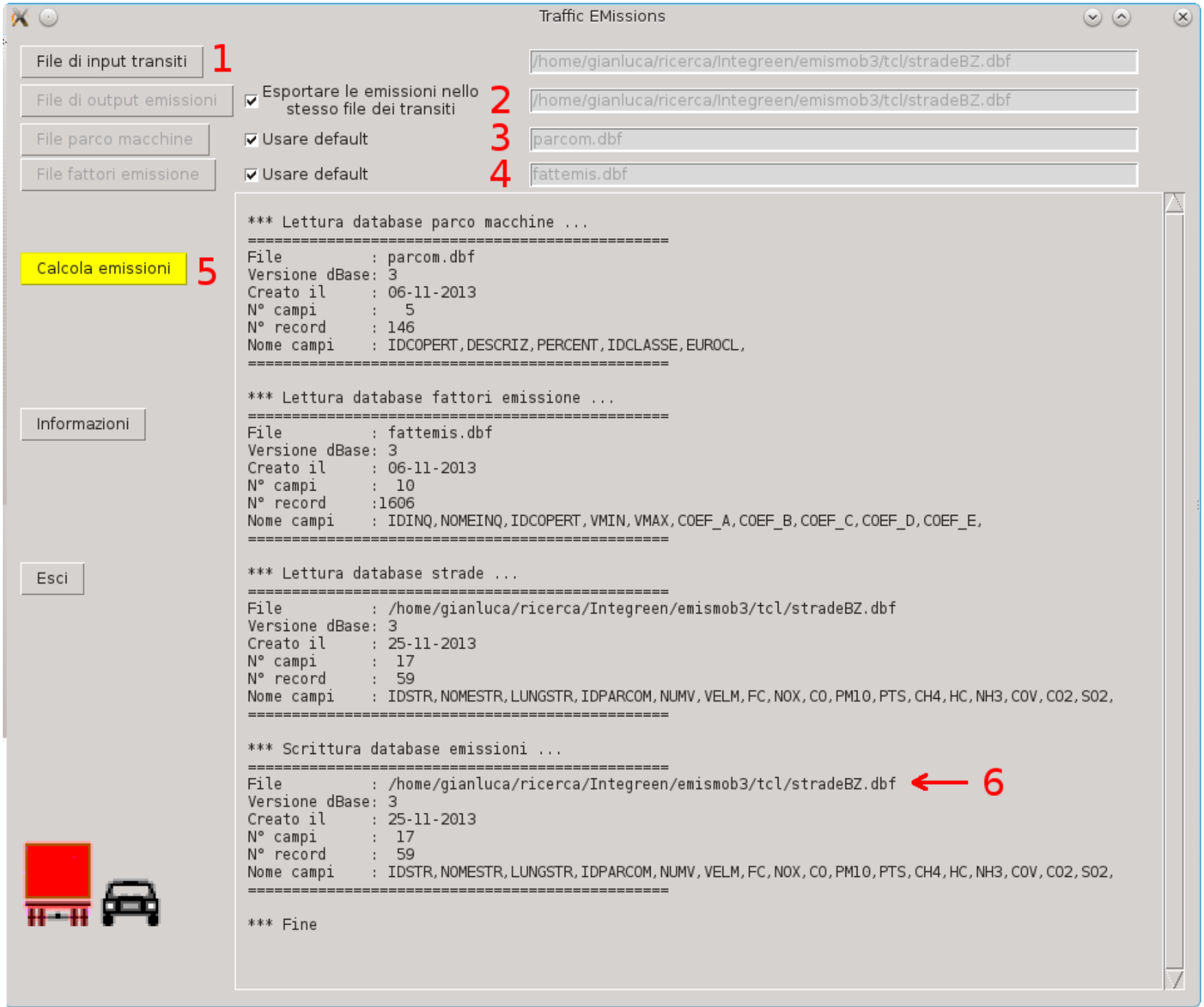
Considered pollutants:

NOx (nitrogen oxides), CO (carbon monoxide), VOC (volatile carbone organic compounds), NH3 (ammonia), **PM10 (fine particulate matter)**, TSP (total suspended particulate matter), SO2 (sulphur dioxide), CH4 (methan), HC (unburnt hydrocarbons)

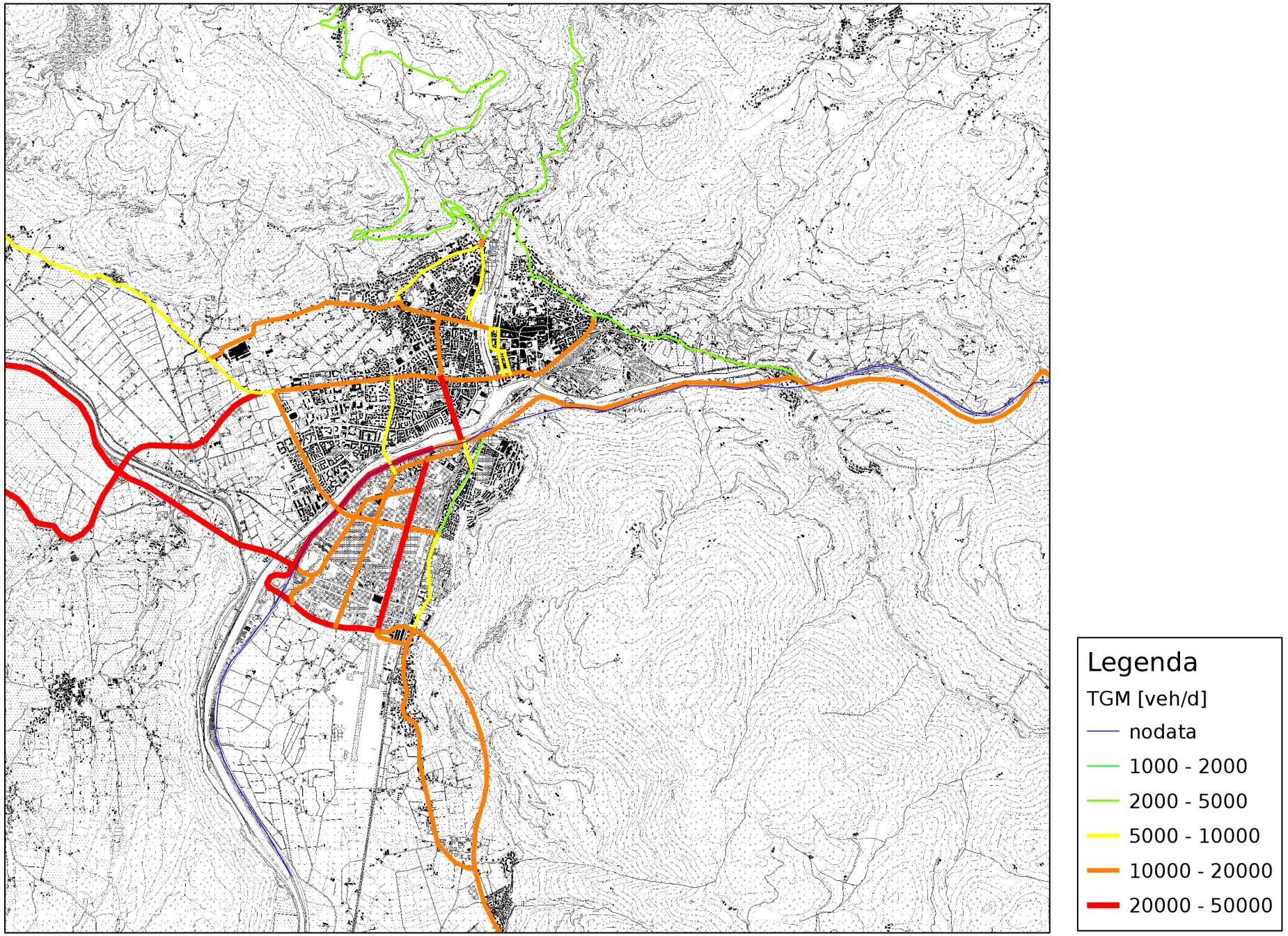
And moreover

CO2 (carbon dioxide) & FC (fuel consumption) which are directly bound each other

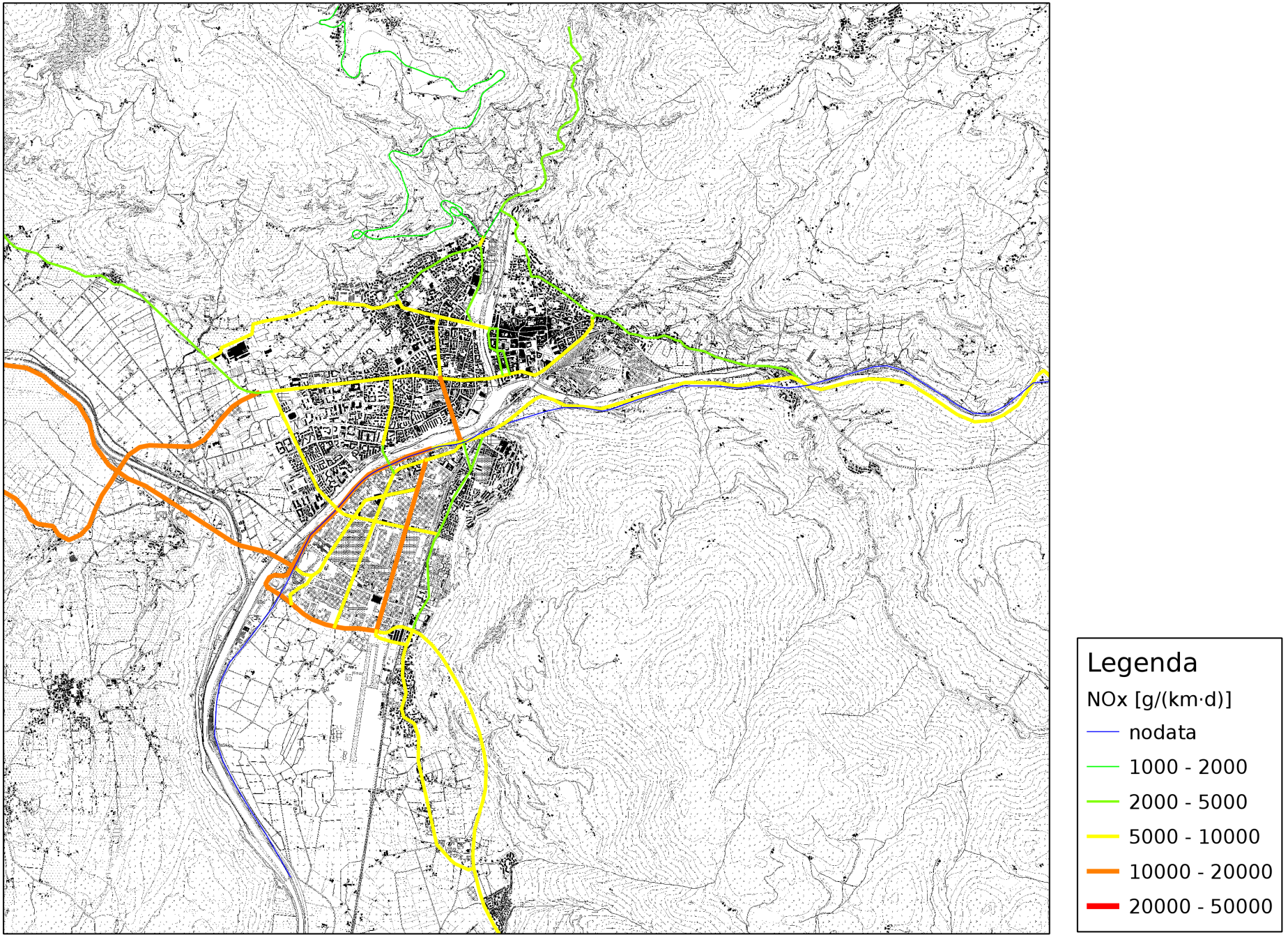
TEM (“stand-alone” program)



Example: traffic data (input)



Example: emission data (result)



TEM (spreadsheet version)

Compact quick-use version: the front end is very simple

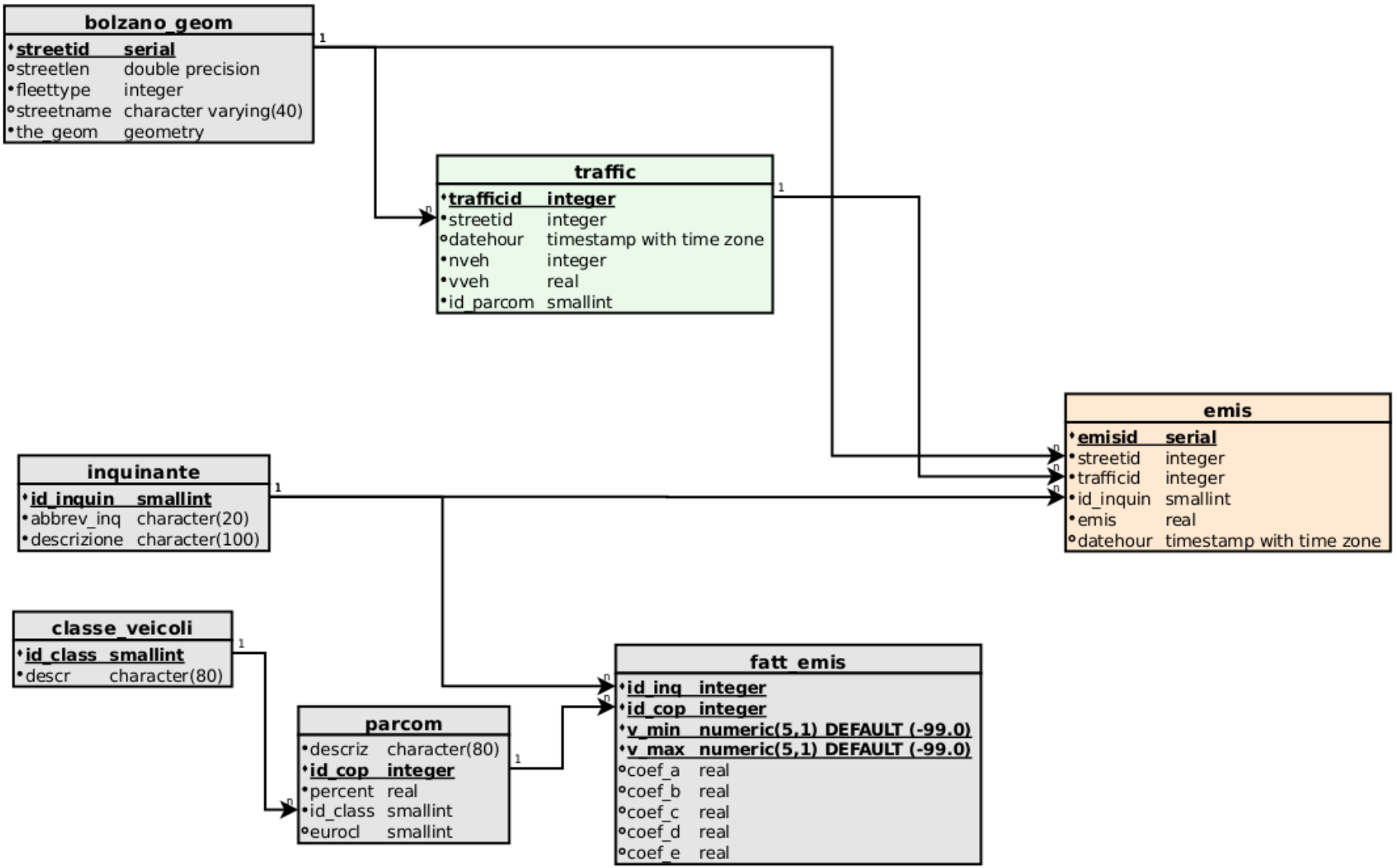
Yellow = input
Blue = output

All the calculation is hidden to the user

Unità misura transiti	2	*[veh/d]*	
Disaggregazione transiti	1		
Transiti	*Transiti [veh/d]*	*Velocità [km/h]*	
Totale veicoli	14000	44,0	**(valore non usato)**
Transiti	*Transiti [veh/d]*	*Velocità [km/h]*	
Autovetture	11600	38,0	**<--- compilare qui**
Commerciali leggeri	1800	37,0	**<--- compilare qui**
Commerciali pesanti	350	32,0	**<--- compilare qui**
Autobus	50	28,0	**<--- compilare qui**
Motocicli	295	39,0	**<--- compilare qui**
Totale	*14095*	*37,7*	
Parco macchine	1	*ACI 2012 Prov. BZ (default)*	
Lunghezza strada	2,500	*km*	

Inquinante	*Emissione specifica [kg/(km·d)]*	*Emissione [kg/d]*
CO2	2727,4	6818,6
NOx	8,9	22,3
CO	18,3	45,7
COV	2,6	6,5
PM10	0,3	0,8
PTS	0,3	0,8
SO2	0,0	0,0
CH4	0,2	0,4
NH3	0,3	0,7
Carburante	868,5	2171,2
Incombusti	15,3	38,2

TEM (database version)



Input data

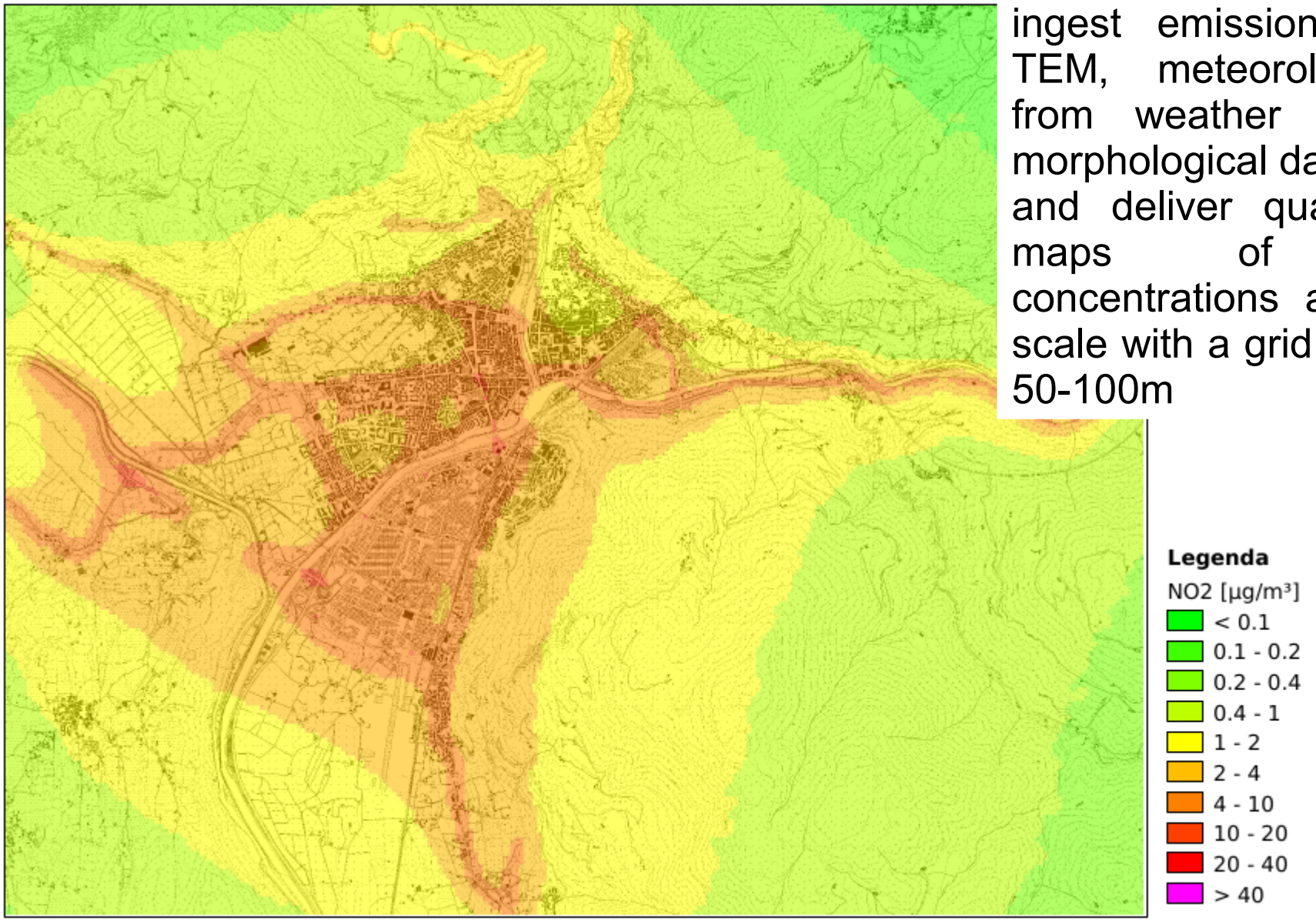
How do we ingest traffic data in Traffic Emission software?

When using TEM in real-time mode traffic assignment on the basis of measured data at traffic station should be ingested. There are some possibilities:

- Use a scaling coefficient to derive the number of vehicle transit on each road stretch with reference to the nearest traffic station – needs to be calibrated at least once (present simplified method)
- Adopt simple traffic model based on traffic data to be run “on-the-fly” before the emission estimate
- Use a complete traffic data (to be verified if this is feasible in a real-time environment)

Next steps (1/2)

Next step (task foreseen for year 2014) is to couple a dispersion model able to ingest emission data from TEM, meteorological data from weather station and morphological data...
and deliver quasi-real time maps of pollutant concentrations at the urban scale with a grid resolution of 50-100m



Next steps (2/2)

From a first overview in specialized literature we propose the adoption of one of the following air quality models, both open source and therefore adaptable to our case:
- CALINE (U.S.EPA)
- AUSTAL (D-BUWA)

AUSTAL is more precise and evolved, the state of the art of local scale air quality dispersion model for urban areas; on the other hand very demanding in term of computational resources → hardly to be used in real time, especially in the hypothesis of scaling up of the computed road network

CALINE is more simplified and flexible, can also be adapted to peculiar situations such as emissions in “urban canyon”, over bridge, in parking lots, etc...+

A comparison test with both test is foreseen and after the functionality check the best in terms of computational time and accuracy will be chosen.

Thanks for your attention