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VEHICULAR EXHAUST IMPACT SIMULATED AT MICROSCALE FROM TRAFFIC FLOW AUTOMATIC SURVEYS AND EMISSION FACTOR EVALUATION

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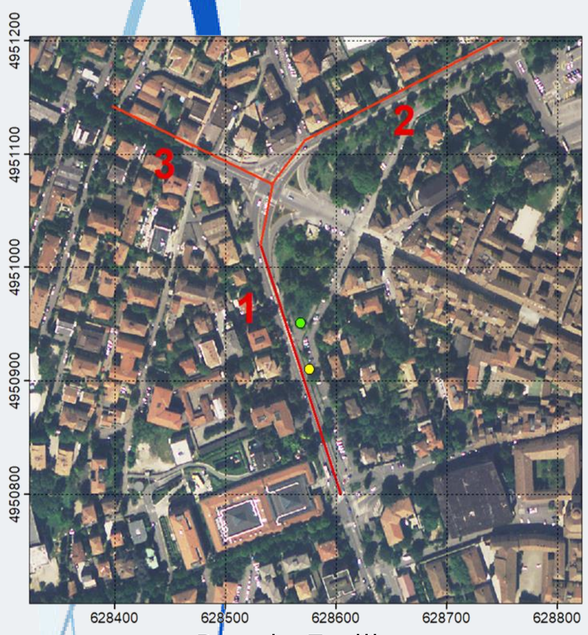
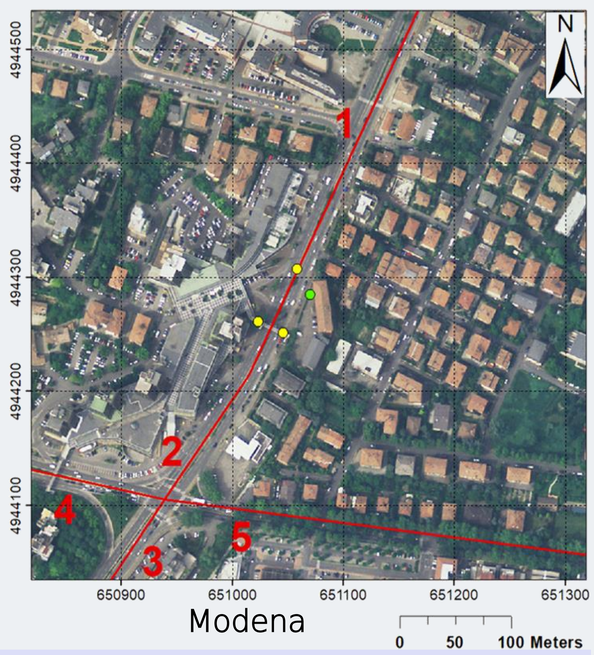




ABSTRACT

In order to assess the impact of heavy traffic roads on local air quality, a micro-scale simulation of pollutant (NO_x and CO) concentration fields was produced: the investigated areas are in downtown of Reggio Emilia and Modena, two cities in central Po valley, Italy, and focused on high traffic intersections. Urban traffic stations of the regional air quality monitoring network are present in both investigated areas (green point in the maps on the left) .

The simulation has been performed by the micro-scale model suite Micro-Swift-Spray (Aria Technologies, France and ARIANET, Italy) a Lagrangian particle dispersion model directly derived from the SPRAY code.

Direct measurements of traffic flow have been continuously collected for 12 day survey periods with radar traffic counters (Easy Data SDR) and used for the hourly modulation of vehicular emissions (radar sites = yellow points in the maps on the left).

Specific emission factors were obtained by the combination of radar counts with vehicular fleet composition for each municipality (depending on vehicle type, fuel type, speed and EURO category) and calculated according to the EMEP/EEA guidelines for air pollutant emission inventory. Simulated concentration fields were evaluated over the period with direct traffic counts for the two studied areas: for both areas the results were compared to local air quality measurements collected at the traffic urban monitoring stations and also at the respective urban background stations.

MATERIAL AND METHODS

TRAFFIC DATA
Reggio Emilia: recorded by a two channel doppler radar traffic counter, from January 13 to 24, 2014.
Modena: recorded by four one channel doppler radar traffic counters, from October 28 to November 8, 2016.

The road sections (red lines) 1,2,3 in Reggio Emilia and 1,2,3,4,5 in Modena were considered in the simulations as linear emission sources (maps on the left).

The recorded vehicles were divided in 5 groups: motorcycles (1 m ≤ L ≤ 2.5 m), cars (2.5 m < L ≤ 6 m), light commercial vehicles (6 m < L ≤ 8 m), heavy vehicles (8 m < L ≤ 12 m) and buses (12 m < L ≤ 15 m).

DOMAINS
500 m x 500 m with 2 m square cells, domain top 10 m and the first layer 2 m high above ground level (the domains correspond to the areas represented in the maps on the left) .

METEOROLOGICAL DATA
CALMET (Reggio Emilia) and COSMO (Modena) mesoscale model simulations by Arpae.

EMISSION FACTORS

The vehicles were subdivided in 14 speed classes from the radar counts. The speed value distribution into each class was estimated, with the median value taken as representative of the corresponding class, and used to obtain emission factors (EF) for NO_x and CO as a function of vehicle speed, following the European guidelines EMEP/EEA (EMEP/EEA, 2013).

The vehicles were further subdivided, by reference to the composition of the local fleet (up-to-date data provided by Automobile Club Italia, ACI), depending on the type of fuel (diesel, gasoline, LPG, methane) and the EURO emission.

EF (g/km)	cars		motorcycles		light commercial vehicles		heavy vehicles		buses	
	RE	MO	RE	MO	RE	MO	RE	MO	RE	MO
NO_x	0.40	0.36	0.09	0.09	1.00	0.84	11.48	8.63	8.19	7.77
CO	0.75	0.67	8.61	8.74	0.79	0.54	2.58	1.94	2.33	1.83

The traffic fluxes for the street sections (2,3 for Reggio Emilia and 3,4,5 for Modena, in the maps above) not directly monitored by the radars, but included in the simulations, derive from modeled data for rush hours provided by the Municipality of Reggio Emilia and Modena, to which the hourly emission modulation obtained in this study was applied.

RESULT

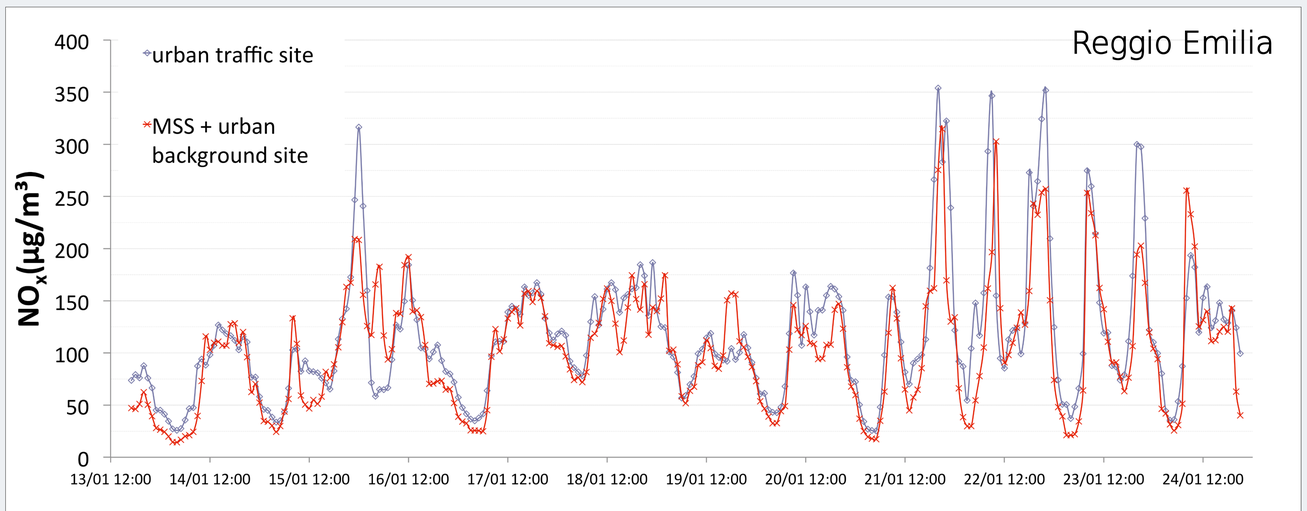
MSS simulated and urban traffic site observed concentrations show a fair agreement (Pearson coefficients reported on the right) .
The correlation for CO is impaired by the low sensitivity of the CO monitoring instruments, given the high regulatory limits for CO concentration in atmosphere.

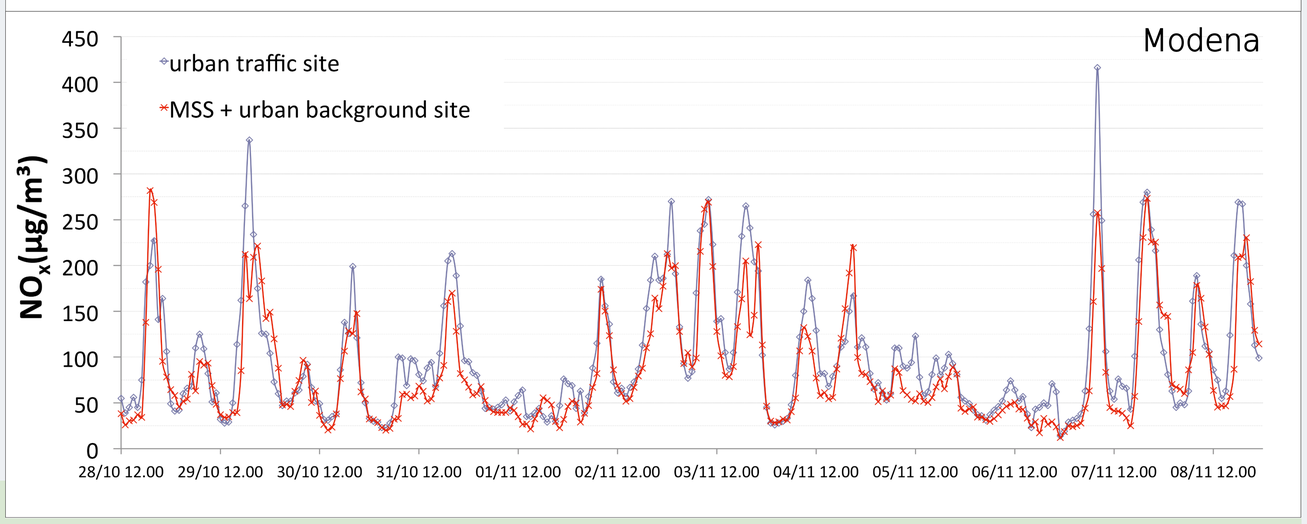
Pearson coeff.	NO_x	CO
Reggio E.	0.49	0.43
Modena	0.27	0.12

The time series of urban traffic sites observed concentrations for Reggio Emilia and Modena were compared with the MSS simulated concentrations added to the concentrations measured at the urban background sites of Reggio Emilia and Modena and for the same periods.

Pearson coeff. NO_x	
Reggio E.	0.84
Modena	0.89

The comparisons between NO_x time series (traffic site measured and sum of MSS simulated plus background site measured concentrations) are reported in the figure on the right. The two series show very high correlations: Pearson coefficients are reported on the left.





CONCLUSIONS

The simulated NO_x hourly concentrations show a very large agreement with the observations, even if they result underestimated compared to the observed atmospheric concentrations at the traffic site (about 30% in Reggio Emilia and almost 50% in Modena). The underestimation is mainly due to have considered, in both the case studies, only sections of the busiest streets as traffic pollutant sources and not the whole road network within the simulation domain. Simulated and observed concentrations show a fair agreement for CO.
The results also confirm the great significance of Arpae fixed monitoring sites in representing conditions and levels of pollution due to the predominant influence of certain sources.
This work highlights the high reliability of the Micro Swift Spray model to simulate concentration fields and concentration trend in urban environment, and suggests its application for impact assessment studies. The obtained results show also the effectiveness of the use of direct measurements of traffic flows, detailed classification of vehicular fleet of and accurate evaluation of pollutant Emission Factors as input to MSS traffic emission simulation.

REFERENCES

Bigi, A., Ghermandi, G., 2015: Long-term trend and variability of atmospheric PM10 concentration in the Po Valley. Atmos. Chem. Phys., 14, 4895–4907.
Bigi, A., G. Ghermandi, 2016: Trends and variability of atmospheric PM 2.5 and PM 10–2.5 concentration in the Po Valley, Italy. Atmos. Chem. Phys., 16, 15777–15788.
Ghermandi, G., S. Fabbi, M. Zaccanti M. M., A. Bigi A.,S.Teggi , 2015: Micro-scale simulation of atmospheric emissions from power-plant stacks in the Po Valley. Atm. Poll. Res., 6, 382-388.
Ghermandi G, S.Fabbi, A.Bigi, S.Teggi, L. Torreggiani, 2016: Microscale simulation of road traffic emissions from vehicular flow automatic surveys and comparison with measured concentration data, Proc. 17th Int. Conf. on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes, 9-12 May 2016, Budapest, Hungary.