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URBAN SCALE AIR QUALITY ASSESSMENT WITH A HARMONIZED MULTI-SCALE MODEL

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Abstract: The performances of an open-source multi-scale air quality model are discussed in this work. The model CAMx-LPiG is implemented to assess air quality in urban areas, with a special focus on road traffic emissions. We aim for developing a flexible and adaptable modelling tool, able to capture from intra-urban up to basin scale processes of both primary and secondary pollutants. Such tool could become a standard to monitor air quality and assess the effects of mobility policies in urban areas.

Key words: *Urban air quality; air pollution; Po Valley; road traffic emissions; hybrid model*

INTRODUCTION

The Po Valley basin is of the most polluted places in Italy and the city of Milan is affected by even more poor air quality that is harmful to the local population. According to Pepe, et al., 2019, 72% of NO_2 and 28% of $PM_{2.5}$ annual average concentrations are due to road traffic in Milan city center, so more and more incisive mobility policies should be applied to contain this problem. Urban models can be very useful tools to suggest which could be the most effective mitigation measures. Hence the ability to simulate carefully road traffic emissions and related concentrations at a local scale is very crucial. This work aims at developing and using the Linear Plume in Grid (LPiG) scheme in CAMx model to represent road emissions as linear sources, similarly to Plume in Grid (PiG) scheme which is already available in CAMx model for point sources (Ramboll Environ, 2016). A hybrid modelling system (HMS), based on CAMx Eulerian model and AUSTAL2000 Lagrangian particle model, has been developed and used so far to simulate the pollutant concentrations in the Milan city center (Pepe, et al., 2016). The latter approach is very promising but it can lead to some inconsistency issues because of the off-line link between the models, particularly concerning modelling setup and emission double counting. CAMx-LPiG model allows to model the streets as linear sources and it could be a promising modelling alternative to the HMS system. LPiG is designed to be fully consistent with the Eulerian host model and it does not require any ad-hoc treatment of source double counting. Moreover LPiG takes advantage of the chemistry scheme available in CAMx, being therefore able to simulate also reactive compounds through a detailed and consistent chemical pathway.

METHODS

Model set-up

Figure 1 shows the system of nested domains used in this work. LPiG scheme is applied in an urban domain (URB), over a 1.7 x 1.7 km cell of the metropolitan domain (MIL). On its turn, MIL is nested in POV and ITA domains, which have a resolution of respectively 5 and 15 km. The sampling grid in which LPiG scheme is implemented has 50 m of resolution which is appropriate an urban road network. The Milan city road network used in this work is developed by the Mobility Environment and Territory Agency AMAT and it is available on the web site https://www.amat-mi.it/it/servizi/verifiche-sostenibilita-trasportistica/. In this test only 82 streets inside the URB domain are simulated with CAMx-LPiG scheme. The selected roads are the primary and secondary roads of the domain according to

AMAT's classification (Figure 1) into four types, local streets have been omitted and there are no highways in the URB domain. A yearly simulation with CAMx model is performed, for the year 2010.

Emissions

To avoid double-counting, road transport emissions (including cars, mopeds, light and heavy vehicles) are split between the modelled roads and the remaining grid cell area(URB domain). The hourly emissions associated with each explicitly modelled road are calculated starting from the URB domain emission density input data, where the LPiG scheme is implemented. For each road, road transport emission is calculated starting from the geometry of the street assuming that the larger is the road, the higher is the emission. According to this methodology, 22% of the URB domain's road transport emissions are simulated within CAMx-LPiG scheme.

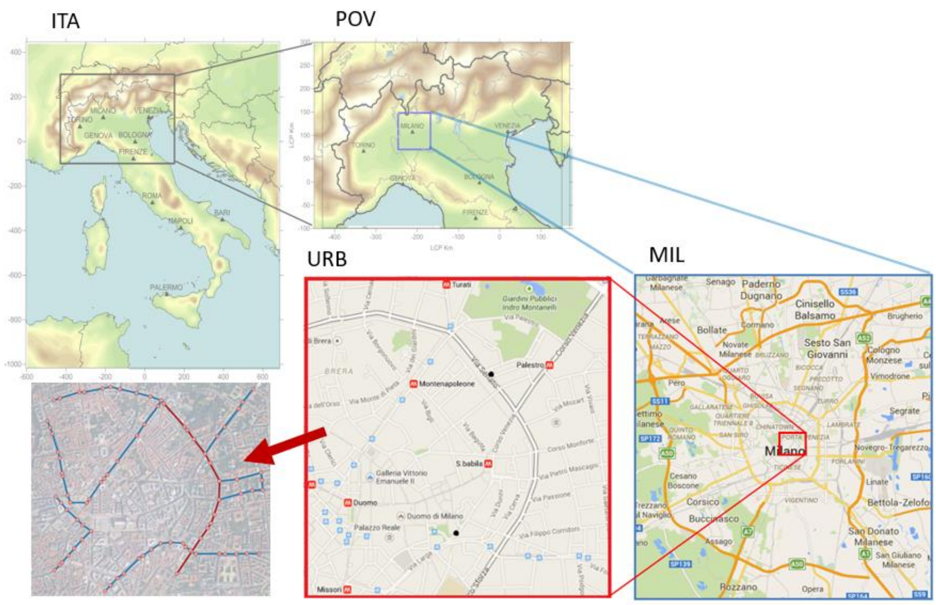


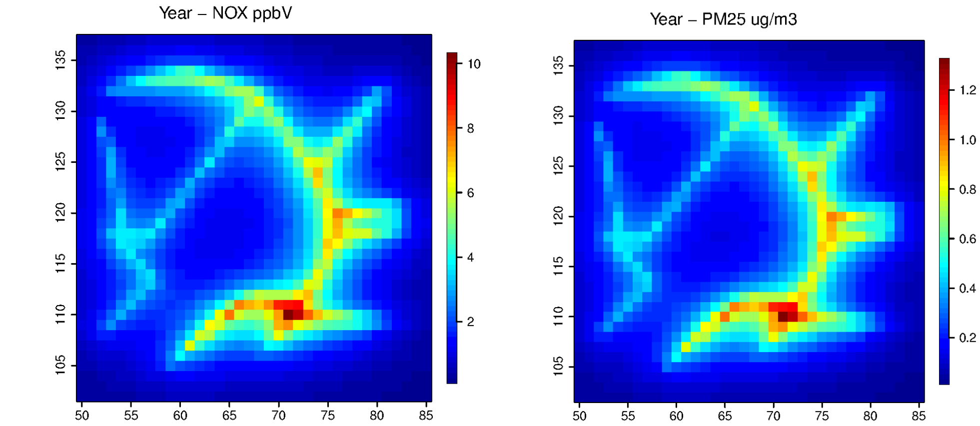
Figure 1. CAMx model system of nested domains: ITA, POV, MIL, URB. CAMx-LPiG scheme is implemented in URB domain in a 50 m of resolution sample grid, for the road network shown in the lower left box.

RESULTS

In this work the main pollutant concentrations fields are calculated with CAMx-LPiG scheme. As a preliminary case study, only a subset of the Milan city center road network is modelled, with 50 m of horizontal resolution in a parent grid of about 1.7 km. The results of two simulations are shown:

- CAMx-LPiG Only (CLO): where only the LPiG scheme is activated;
- CAMx-LPiG Background (CLB): where both CAMx-LPiG and background concentrations are considered.

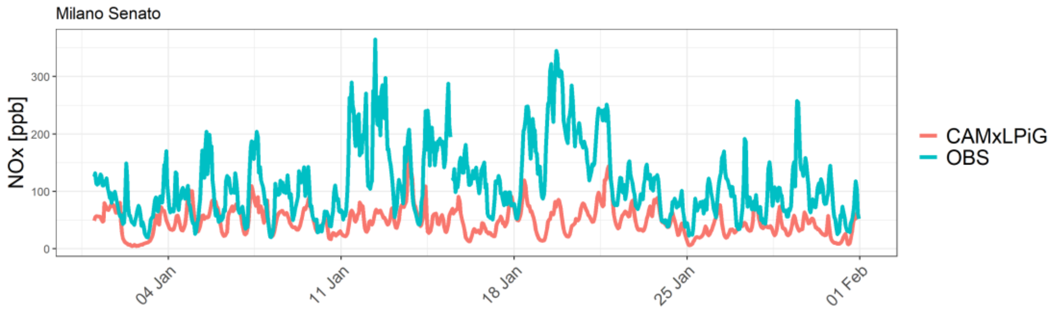
CLO test is aimed at verifying the correct representation of the road network with the CAMx-LPiG scheme. For this purpose, only the contribution to the concentration fields of the road emission sources is highlighted (Figure 2). Thanks to the sub-sampling grid with a high spatial resolution (50 m), the scheme allows to simulate properly the emission contribution due to road traffic.



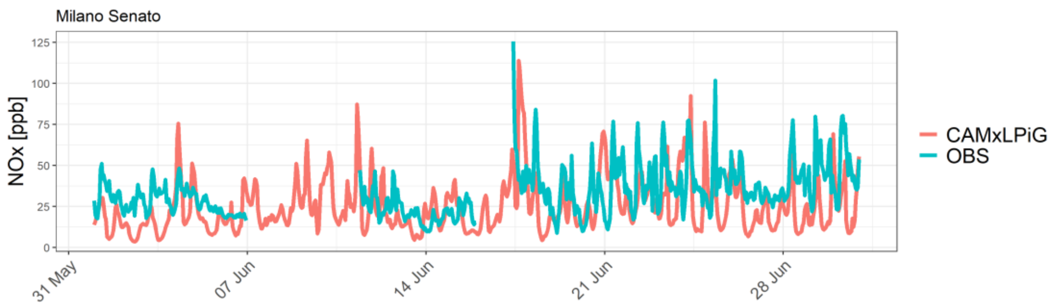
(a) (b)

Figure 2. NO_X (a) and $PM_{2.5}$ (b) concentration simulated with CAMx-LPiG on URB domain for the CLO test.

CLO test provides reasonable results, being able to capture the sub-grid spatial variability of concentration fields due to the road network. On the other hand CLB test allows calculating the concentration fields as a whole and the comparison with observed values. Modelled and observed temporal variation of NOx concentration is shown in Figure 3 for the monitoring station of ARPA (Agenzia Regionale per la Protezione dell'Ambiente) Lombardia, located in Via Senato [6] for January and June which are respectively the most and the less polluted months. The NOx concentration simulated with CAMx-LPiG scheme is comparable to the result obtained with HMS model (not shown), although the concentration peaks are slightly lower. The comparison with the measured values reveals a slight underestimation of the modeling values, especially in the case of high peaks, as in the central part of January month. The discrepancy between simulated and observed values is lower during June, when nitrogen oxide pollution is more contained.



(a)



(b)

Figure 3. NO_X concentration simulated with CAMx-LPiG (CLB test) and measured values at Senato site (city center of Milan) during January (a) and June (b) 2010.

CONCLUSIONS

Compared to the hybrid modelling system (HMS), based on CAMx Eulerian model and AUSTAL2000 Lagrangian particle model the strength of CAMx-LPiG is the capability to estimate multi-scale pollutant concentration fields using the same physical parameterizations and chemistry scheme. Moreover, compared to the HMS, this new scheme allows greater flexibility in the modelling design, according to the mobility policy we need to assess. Another advantage of the explicit simulation of the road network with the CAMx-LPiG scheme is the flexibility in the simulation area which can be easily extended. This is a crucial point for the assessment of mobility policies in a metropolitan area. According to the methodology adopted, the road network was represented in a fairly realistic way, the NOx and $PM_{2.5}$ concentration are proportional to the type of road. Anyway further calibrations are needed so that the concentration values could be more and more consistent with the observed values.

REFERENCES

Environ, 'CAMx User Guide v6.3', p. 273, 2016.

N. Pepe, G. Pirovano, G. Lonati, A. Balzarini, A. Toppetti, G. Riva e M. Bedogni, «Development and application of a high resolution hybrid modelling system for evaluation of urban air quality,» *Atmospheric Environment*, vol. **141**, pp. 297-311, 2016.

N. Pepe *et al.*, 'Enhanced CAMx source apportionment analysis at an urban receptor in Milan based on source categories and emission regions', *Atmos. Environ. X*, vol. **2**, no. April 2018, p. 100020, 2019