MICRO-SCALE MODELLING OF URBAN AIR QUALITY TO FORECAST NO_2 CRITICAL LEVELS IN TRAFFIC HOT-SPOTS

G. Carlino (1), L. Pallavidino (1), R. Prandi (1), A. Avidano (2), G. Matteucci (2), F. Ricchiuti (2), P. Bajardi (3) and L. Bolognini (3)

(1) Simularia Srl, via Principe Tommaso 39, Torino, Italy; (2) CSP S.c.a.r.l. - Innovazione nelle ICT, Via Nizza, 150, Torino, Italy; (3) Data Driven Innovation Dep., Aizoon Srl, Strada del Lionetto 6, Torino, Italy

Presenting author email: r.prandi@simularia.it

Summary

In this work we present a forecast modelling system implemented in the city of Torino to provide up-to-date hourly NO_2 concentrations at vey high horizontal resolution (6 m) on a 6 x 7.2 km^2 domain. Each day meteorological fields and background regional concentrations are provided by the forecasting system "QualeAria" (Kukkonen, 2012) while bottom-up traffic emissions are directly simulated with the three-dimensional parallel Lagrangian model PMSS, taking into account the presence of obstacles (buildings), on a 16 core (dual) workstation (64 GB total memory). Comparison of so far simulated values (about 3000 hours in the period April - September 2015) with measures in three monitoring sites (one urban background, one roadside in LEZ and one roadside) shows good agreement in reproducing peaks, daily behaviour and long term averages.

Introduction

NO_2 concentrations in the urban environment have shown little improvements in past years: monitoring stations, especially in road/kerbside sites, indicate that large urban areas are not in compliance with the legal limits, based on WHO guidelines. While atmospheric modelling systems are now routinely used both for assessment and informative purposes on regional and local scales, modelling pollution at street level on a city domain is still a challenging task, often demanded to gaussian-like models. On the other hand, not-stationary three-dimensional models need to be employed if we want to capture inhomogeneities in the ground level concentrations, forecast critical levels and successfully plan effective actions for reducing air pollution in cities.

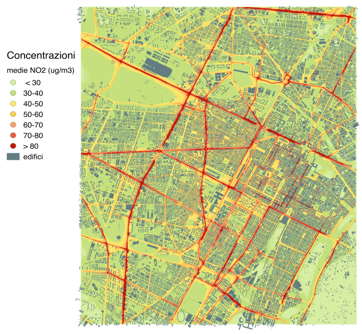

Fig.1 Monthly averaged NO_2 concentrations.

Methodology and Results

Micro-scale simulations are conducted on a 3d grid with 26 vertical levels, up to 1250 m. A parallelized 3d mass-consistent wind field model (Pswift) performs the downscaling of meteorological forecasts down to 6 m, taking into account buildings (filled grid cells). Bottom-up NOx traffic emissions on the main roads (Pallavidino, 2014) are complemented with diffuse emissions assigned to secondary streets, for a total of 13060 linear sources. NO_2 ground concentrations are computed hourly by using a parametrised box model (Kiesewetter, 2014), employing modelled O3 and NOx on a regional scale as a background, coherent with the meteorological forecast. Average values in the first month of simulation (see Fig. 1) reproduce in a realistic way observed differences between background and traffic sites. Compared with the regional model, the micro-scale forecast system is able to improve the modelling of peak events in traffic hot-spots as shown by the quantile-quantile plots in Fig. 2. In the considered period (April - September 2015) the absolute bias was -5 µg/m3 (28 µg/m3 average value) in the background station, 6.3 µg/m3 (36 µg/m3 average value) in the LEZ traffic station, -4.2 µg/m3 (53 µg/m3 average value) in the traffic station.

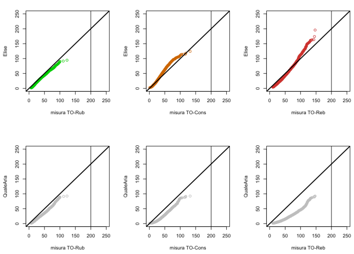

Fig.2 qqplot of microscale (above) and regional scale (below) model results in three monitoring sites (from the left: background, traffic in LEZ, traffic).

Conclusions

The forecast modelling system implemented for the city of Torino has so far proven to be in good agreement with measures and provides a solid framework to the Elise Project, focused on participatory sensing. Simulation of winter months, usually characterized by higher NO_2 concentrations and few exceedances of the hour limit value, will supply a more complete set of data for quality assessment in order to evaluate its suitability as informative tool and decision support system.

Acknowledgement

This work is part of the ELISE (Environmental LIve SEnsing) Project, partially supported by Regione Piemonte under POR/FESR 2007-2013 programme. Helpful discussions were held with G. Tinarelli (Arianet Srl) and A. Bertello (Città Metropolitana di Torino); Regione Piemonte and Città di Torino are kindly acknowledged for providing emission and cartographic data.

References

Kiesewetter G. et al., 2014. Modelling NO_2 concentrations at the street level in the GAINS integrated assessment model: projections under current legislation. Atm. Chem. Phys., 14, 823-829.

Kukkonen J. et al., 2012. A review of operational, regional-scale, chemical weather forecasting models in Europe. Atm. Chem. Phys., 12, 1-87.

Pallavidino L. et al., 2014. Compilation of a road transport emission inventory for the Province of Turin: advantages and key factors of a bottom–up approach. Atm. Poll. Res. 5, 648-655.