μ-MO

ASSESSING THE CONTRIBUTION OF NO_X TRAFFIC EMISSION TO ATMOSPHERIC POLLUTION IN MODENA BY MICROSCALE DISPERSION MODELLING

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ABSTRACT

Based on the air pollutant emission inventory data (INEMAR – Arpa Emilia-Romagna 2010) road traffic in Modena, a city in the central Po valley (Northern Italy), contributes up to the 60% of the total emission in terms of NO_x, followed by Domestic Heating (15%) and Industrial Combustion (14%). Goal of the μ-MO project is to assess the road traffic impact on air quality in the urban area of Modena by a combined experimental and modelling approach. Dispersion of vehicular NO_x was simulated by Parallel-Micro-SWIFT-SPRAY (PMSS, ARIANET srl, Italy and Aria Technologies, France) over a domain of 6 km x 6 km, including most of the urban areas of Modena, with a horizontal resolution of 4 m. The atmospheric emission sources were estimated by merging local fleet composition data, traffic flux at rush hours simulated by PTV VISUM mobility software and direct measurements collected by radar traffic counters, provided by the Municipality of Modena. The modelling system, implemented on a 16 cores cluster (64 GB of total memory), includes PSWIFT, a parallelized mass-consistent diagnostic wind field model, and PSPRAY, a three-dimensional parallel lagrangian particle dispersion model, both able to take into account obstacles (buildings). A run of the system on an entire day has been performed and is presented. In the next step of the work, NO_x atmospheric concentration measurements will be provided by the two urban air quality monitoring sites and by a set of 10 monitoring boxes distributed over the domain and featured by small sensors for NO, NO_2 and particulates. Among the final goals of the μ-MO project there is the tentative source-apportionment of urban atmospheric NO_x between traffic emissions, domestic heating and regional background, to support epidemiological studies and finally future urban development strategies.

MATERIALS AND METHODS

Materials:

Model: PMSS (Parallel-Micro-SWIFT-SPRAY)

Domain Size: 6 km x 6 km

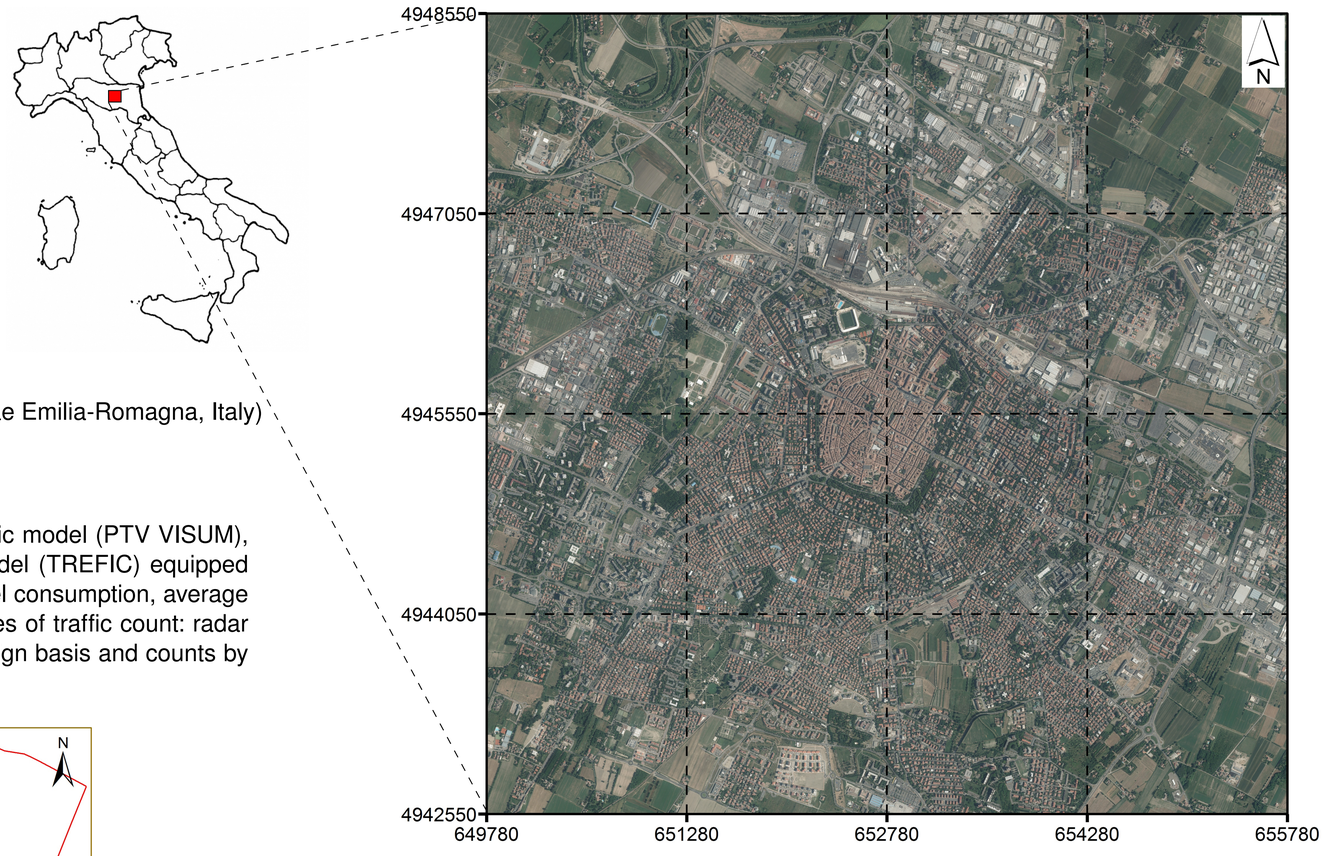
Horizontal grid step: 4 m x 4 m

Domain Subdivision: 16 Tiles

Computing Resources: 16 core cluster architecture with 64 GB of total memory

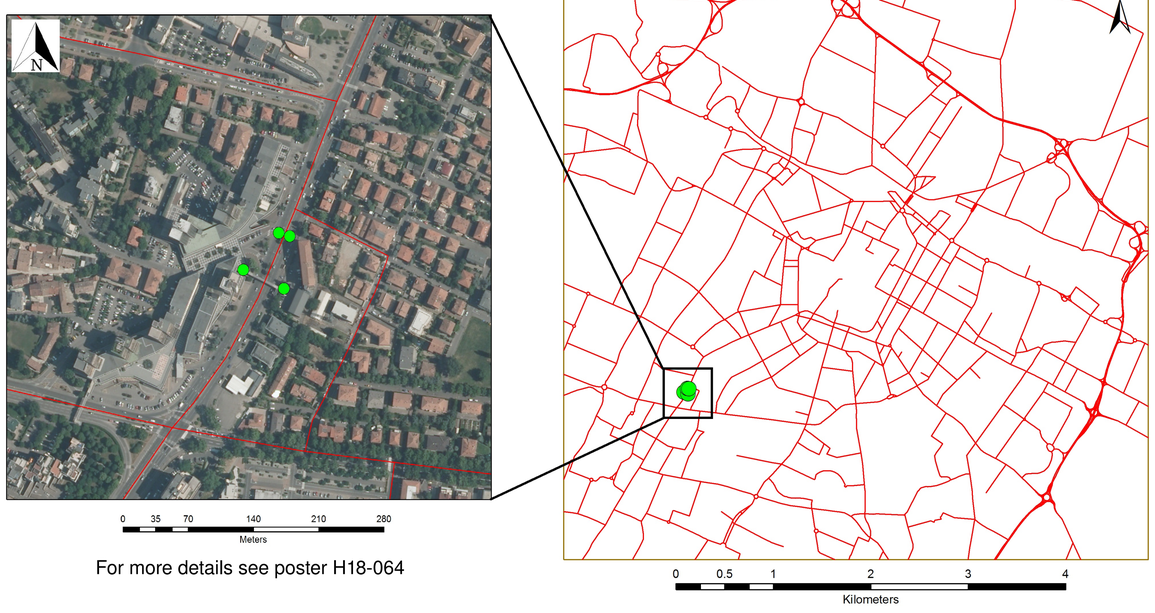
3D buildings reconstruction: 25,600 polygons provided by Geoportale Regione Emilia-Romagna

Meteorological Dataset: Hourly data derived from CALMET and COSMO mesoscale model simulation (Arpae Emilia-Romagna, Italy)



Methods:

The methodology chosen to estimate pollutants emission from the main streets of Modena coupled a traffic model (PTV VISUM), which allows to map processes occurring in transport system such as traffic flows, with an emission model (TREFIC) equipped with road vehicles emission factor (EF) evaluated taking into account specific features (i.e. vehicle type, fuel consumption, average traveling speed and road type). In order to obtain detailed traffic data, PTV VISUM used two different types of traffic count: radar traffic counts collected during rush hour (from 7:30 a.m. to 8:30 a.m.) at selected main streets on a campaign basis and counts by inductive loop.



For more details see poster H18-064

In addition, direct flow measurement campaigns were carried out continuously over two weeks between October 28 and November 8, 2016, with 4 doppler radar counters (one for each road lane) in a four-lane road in the proximity of the intersection with the urban ring road. The road network considered includes about 1100 sections with a total length of 210 km. Vehicles fluxes, estimated by VISUM, were further subdivided by TREFIC on the basis of the local fleet composition (implementing the COPERT IV official methodology) depending on the type of fuel (diesel, gasoline, LPG, methane), engine capacity, load displacement and the EURO emission standard. Finally, to appropriately describe NO_x emissions under typical working day flow conditions, hourly modulation rate for all road network was made by considering the real traffic flow recorded in intense traffic road by the radar counters from October 28 to November 8, 2016, in the mentioned measurement campaign.

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RESULTS

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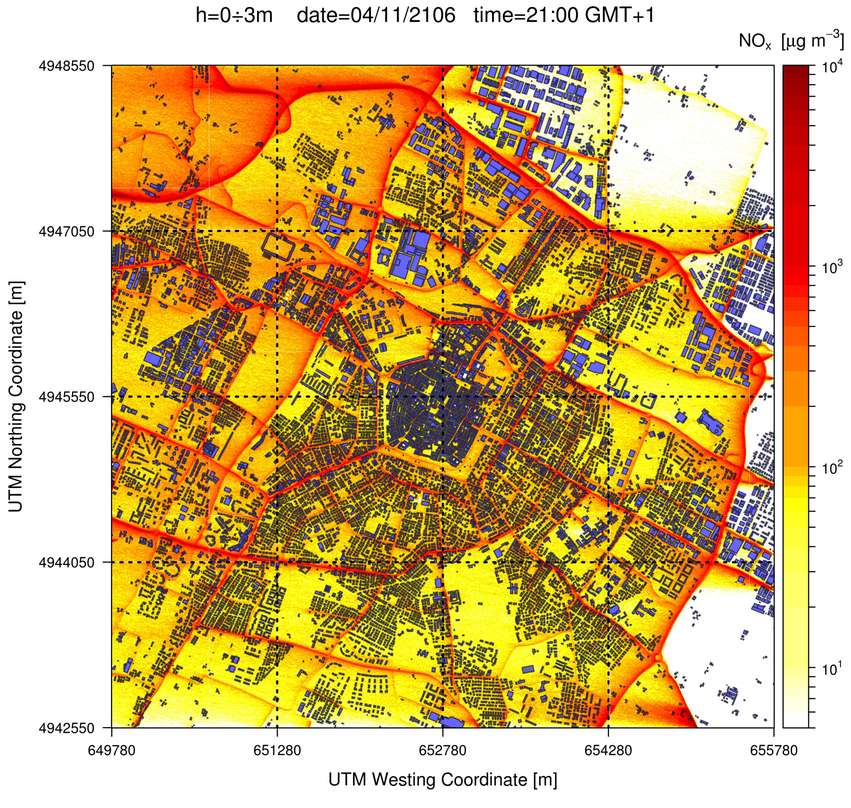

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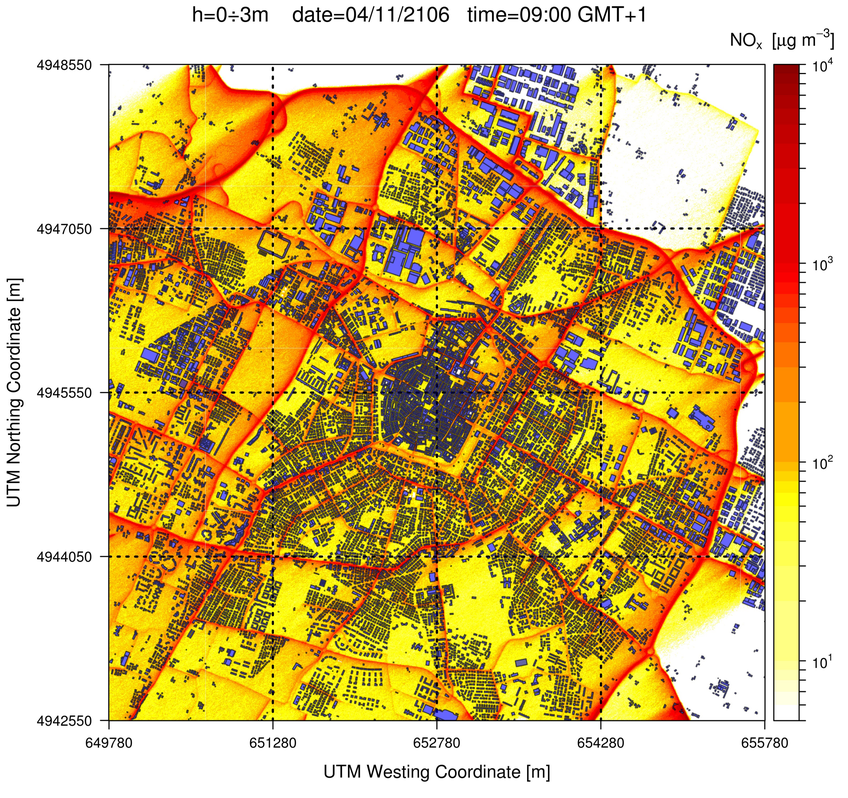

Consistently with meteorological and emission data, hourly NO_x dispersion simulation was performed on November 4, 2016 with PMSS model. The obtained output contains 3D hourly average concentration fields of NO_x due to vehicular emission from the considered road traffic network. The estimated concentrations clearly reflect the emission trend reproduced by TREFIC: in the early hours of the day, from 1:00 a.m. to 4:00 a.m., average hourly NO_x concentrations are very low with a spatial mean value, over whole 6 km x 6 km domain, lower than 15 μg m^{-3} (values lower than 5 μg m^{-3} are not considered). From 5:00 a.m. to 8:00 a.m. hourly average pollutant concentrations undergo exponential growth up, until at 8:00 a.m. the spatial average concentration at ground over the domain is about 210 μg m^{-3}. In central hours of the day and in the early afternoon, street network vehicular traffic reduces its flow and NO_x concentrations slightly decrease to 130 μg m^{-3}. Then, between 6:00 p.m. and 8:00 p.m., a second daily concentration pick is reached and the spatial average concentration during these two hours is about 270 μg m^{-3}. Finally, at night time in the last hours of the day, road traffic and consequently computed NO_x concentration drop down. At 11:00 p.m. the spatial average concentration is less than 70 μg m^{-3}. Throughout the simulation period the effects of local meteorology are not negligible. In the first hours of the day the pollutant plume appears stretched approximately from North-East to South-West and subsequently, in the afternoon and in the evening, it gradually moves and looks stretched from East to West.

CONCLUSIONS

The μ-MO project is now in its first stage of development and this poster shows some preliminary results. In particular it is highlighted the great capability of the PMSS model to simulate 3D air pollutant dispersion with a very high-resolution on a sizeable domain. This can be exploited to estimate the source-apportionment of urban NOx between road traffic emission, domestic heating and regional background with high level of accuracy in Modena.

Acknowledgments:

We thank Comune di Modena for the traffic data provided (PTV VISUM software application)