MODELLING AS INSTRUMENT FOR AIR QUALITY ASSESMENT. TIMISOARA CASE STUDY

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Abstract. This paper focuses on a technique for developing and implementation of a numerical modeling procedure meaning a simulation approach of air quality over the Timisoara urban area, Romania. Simulation is achieved for a reference year in the past (2010), for which all required input data (meteorology, emission & topography data) were available on a full year, in order to have a first main validation of the model. The research/study is based on (i) *numerical simulation with SIRANE*, meaning an urban dispersion model that integrates the street network from Timisora with the specific data for traffic and pollutant sources, and (ii) *validation of the developed program*, for the specific case study, upon Timisoara. The data used in model was from emissions from the traffic and the sources of pollution for Timisoara. Campaign measurements are planned in order to validate the modeling results and adapt the code, based on the on line results of the achieved on line episodes. The novelty cosnists also in the approach of the fuel consumption calculation transferred, as main source, to the tarfic pollution.
Keywords: air quality, modeling, pollutants, dispersion, urban area.

1. INTRODUCTION

Situated on the southeastern edge of the Pannonia plain, Timisoara (45°46' N, 21°26' E) lies at an altitude of 85 m. Timisoara is one of the largest Romanian cities, with a population over 300 thousands inhabitants and more than 170 thousands automobiles.

The air quality in urban areas is determined by the intensity of emissions [1, 2]. The principal sources of pollution are from transportation (emission from traffic), industrial and households. Timisoara has a complex system of regional transportation, providing road, air and rail connections to major cities in Romania and Europe. It also, features a public transportation system consisting of bus (20 bus lines), trolleybus and tram lines. Apart from domestic local investment, there are significant foreign investment from the European Union, particularly from Germany and Italy.

The main pollutants tend to be airborne particles, sulphur dioxide, nitrogen dioxide, carbon monoxide, ozone and volatile organic compounds (VOCs), for example benzene.

Health effects of air pollutants is an old issue in cities and urban areas around the world, but became evident during severe air pollution episodes in the first part of the 21th century [3].

This paper relates to approaches achieved in the frame of a collaborative Romania-France program, namely AIRQ (www.mec.upt.ro/airq/) jointly selected and funded by the ANR (in France for LMFA, and Numtech) and the UEFISCDI (in Romania for UPT) international program. It aims to improve the operational modeling and monitoring of urban air quality, with application to the city of Timisoara.

The main steps refer to:

1. The construction of a proper emission cadastre over the urban site of Timisoara taking into account some local specificities, mainly the local fleet and the industrial effluents description.
2. The implementation of a detailed parameterization for the turbulent exchanges between the urban canopy flow and the turbulent boundary layer. This advanced parameterization was accounted for the specificities of the poorly documented configurations generally met in suburban areas.
3. The code validation, as well as operational simulation over the city of Timisoara based on real local data recordings, such as standard meteorological recordings, LIDAR measurements, concentrations sampling for the following pollutants: SO_2, NO, NO_2, NO_x, CH_4, NMHC, THC, PM10, PM4, PM2.5 and PM10.

Point 1 and 2 are addressed in this paper.

The SIRANE model is presented in detail in two articles [4], [5]. SIRANE is an operational model for urban air pollution that adopts parametric relations in order to simulate the pollutant

dispersion phenomena in the urban boundary layer and in the urban canopy [4] namely, the advection along the street axes, the dispersion in street intersection and the transfer of pollutant between street and the overlying atmosphere.

2. EXPERIMENTAL DATA

In the SIRENE model are introduced data obtained by measurenets and GIS maps. Second part of the study is based on measurements with an accredited laboratory (www.mediu.ro) [6], and interpreted in addition to non-standard systems as LIDAR [7, 8] sun photometers data [9], DOAS performances, etc. (see www.energieregen.mec.upt.ro).

The intensity of car emissions (nitrogen oxides, PM and volatile organic compounds) was estimated by merging the information provided by direct measurement (hourly value) and simulations of traffic fluxes (number of cars). This was done by applying a modulation curve inferred by direct measurements, which gives information on the temporal evolution of traffic fluxes.

Also, meteorological measurements (wind speed and direction, temperature, pressure, humidity and precipitation) are taken hourly.

Figure 1 gives some indications about the information needed the locations of the sources, as considered, etc. The pollutant sources, one identified, are subject to attributing emission factors [5, 10]. The cadastre input data as well GIS map with streets network generated data are necessary to be taken into account.

The street network is made up by segments, which cannot cross buildings walls, and nodes, which represent street intersection. It is important to know the width, the height and the length of the street.

Fig. 1. Traffic data collected in specified assumed traffic network.

To define the street network geometry in SIRANE we can use directly the information provided by the GIS data set on height, width and length of the streets, which are generally known with a high degree of accuracy.

3. RESULTS AND DISSCUTIONS

Figures 2-7 bring first results from the modelling research, as starting demonstration, for the selected demonstration year 2010 [11] upon Timisoara. The concentration values are expressed in microgram/m^3, under normal pressure and reference temperature de 15 ^{o}C conditions. It consists of depicting regional pollution levels (for different species) according to the input data, specific for Timisoara.

The results presented are not relevant yet, as the program is under construction still, but they surly proof the possibility of answering to the general scope: to depict specific pollution levels in urban area of Timisoara, after the validation of the program, through in situ measurements [11].

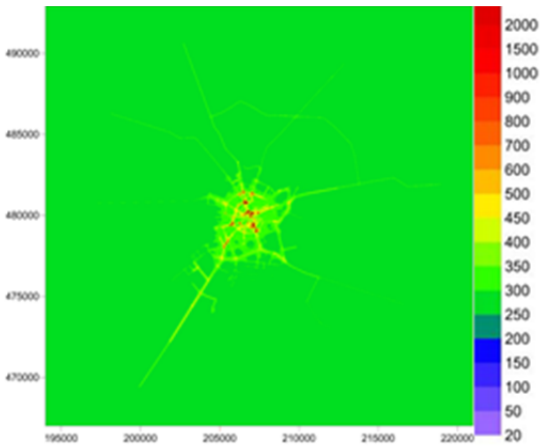

Fig. 2. Dispersion of max concentrations of CO.

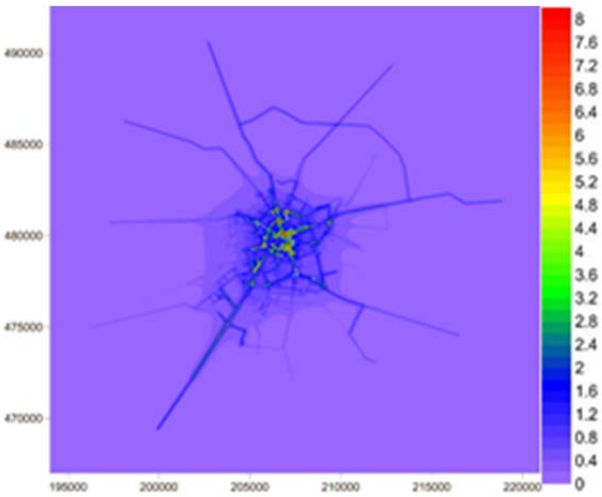

Fig. 3. Dispersion of max concentrations of PM10.

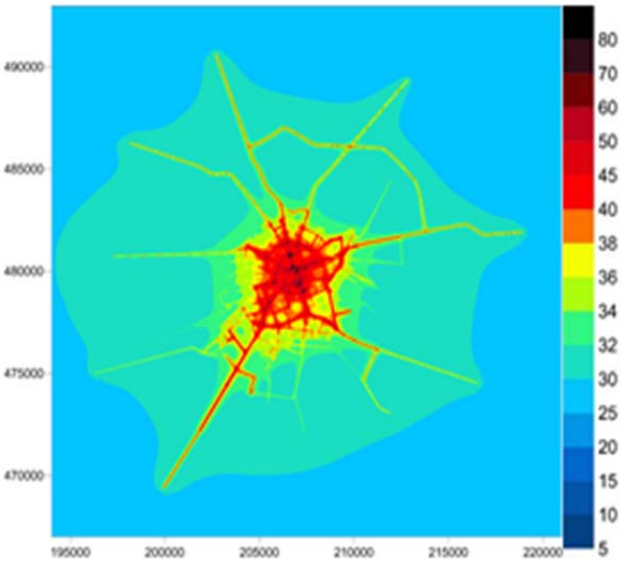

Fig. 4. Dispersion of max concentrations of NO_2.

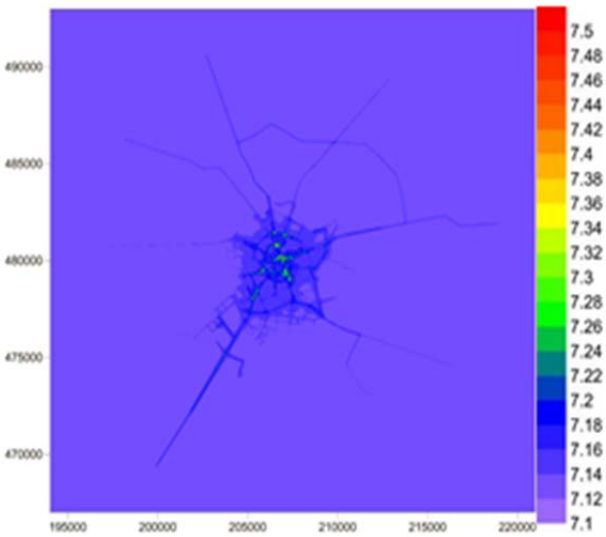

Fig. 5. Dispersion of max concentrations of SO_2.

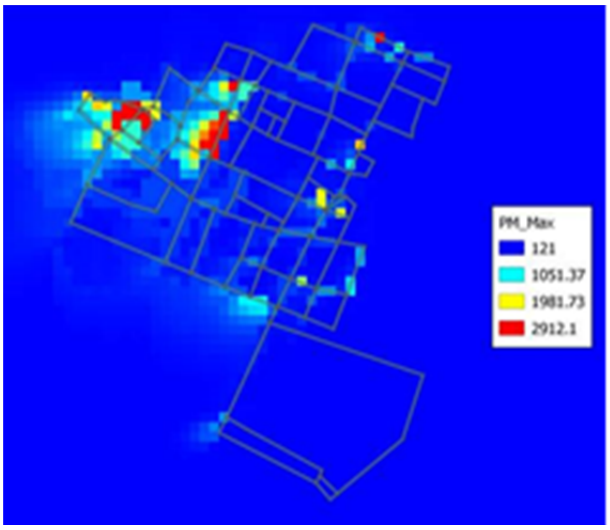

Fig. 6. Dispersion of max concentrations of PM.

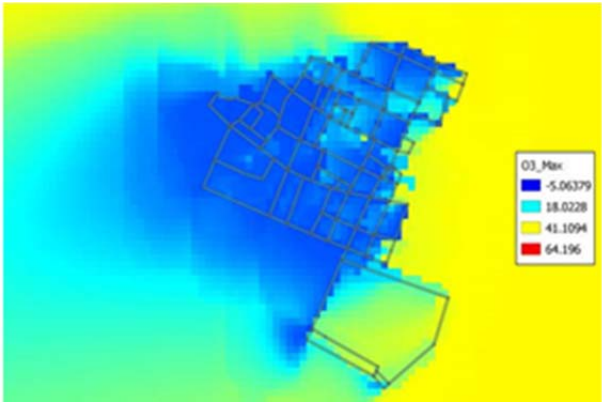

Fig. 7. Dispersion of max concentrations of O_3.

Different forms of data/information were used to construct the emission inventory:

a) Data to help to map some emission source over the whole domain or to facilitate the construction of the cadastre: Distribution of the population of the study area, Geographical location of large industrial areas and activity on the study area,

b) Data to extrapolate values in 2010 from past years or to extrapolate inventory to 2013: Evolution of the population by territorial units (urban and rural),

c) Evolution of the number of industrial workers in the area,

d) Evolution of regional GDP (Gross domestic product).

Energy balance as exhaustive as possible is required as well. The objective was, to get data, for the year 2010, covering:

i) The energy consumption per year in the area, by sector and by fuel type.

ii) The total amount of fuel consumed in the area expressed in tons per year and fuel.

iii) The distribution of fuel consumption in the area by industry (SNAP classification).

"Fuel" means fuel oil, light fuel oil, gasoline, heating oil, diesel, kerosene, natural gas (butane), coal, wood, etc., consistent with the NAPFUE 94 nomenclature.

In order to calculate/evaluate the emissions from road traffic, COPERT IV [10], emission factors and various parameters were used, such as:

1) The vehicle fleet known as much as possible in detail (sixty types of vehicles is possible),

2) The level of emissions control (EURO I, EURO II, EURO III, EURO IV, etc.),

3) The types of vehicles (passenger car, light of heavy duty vehicles, motorcycles, buses, etc.),

4) The types and consumption of fuels (gasoline or oils),

5) The physical and chemical characteristics of these fuels,

6) The average specific consumption of each types of vehicles depending on their size and speed (liter / 100 km),

7) The average speed running on different road types (urban, rural, highway),

8) The annual mileage of each type of vehicle,

9) The distribution of mileage done by each type of vehicle on different road types (urban, rural, highway),

10) The maximum and minimum monthly temperatures.

Among these various data, the following main aspects were analyzed:

The regional vehicle fleet, including the following breakdown:

- the different types of vehicles (passenger cars, light duty vehicles, heavy duty vehicles, motorcycles, buses, etc.);
- for each type of vehicle, the consumption of fuels (gasoline or oils), otherwise the average annual mileage made by each type of vehicle on each road type (urban, rural or intercity highway) and the specific consumption of each type of vehicle;
- for each type of vehicle and fuel, the level of emission control (EURO I, EURO II, EURO III, EURO IV, etc.).

Ideally this information was available over the Timisoara area, and this is a very important aspect, as thus no national data were used, as an alternative.

On each main road (at least those who are selected to be explicitly modeled), it is necessary to obtain (or calculate) the emissions for different pollutants: if emissions of road sections are not known, it is then necessary to retrieve the following data:

- average speeds limit for each road;
- traffic data as AADT (Annual Average Daily Traffic) that corresponds for each section to the number of vehicles per day.

In general, this information is available for the whole road network if a traffic model is used.

Main industrial emitters (Large point sources - LPS). These correspond to stack emission for main industrial emitters. For each source, it must be known:

- The height of discharge above ground level,
- The temperature of the discharge,
- The velocity rate,
- The inner diameter of the chimney,
- The emission in units of mass per unit time (flow in g / s or kg / day). In the absence of emission data, it must then recover the amount of fuel consumed in the year by the unit (or the whole site), and the type of fuel,
- The temporal profiles of the emission source, or at minimum for the industrial site (any information relating to periods of activity on the site is interesting, for example if work is based on 3 x 8h cycle, closed period, seasonal influences, days of the week, etc.),

4. CONCLUSIONS

The paper is focusing on the disturbances generated by pollutants and the difficulties in evaluating them by numerical simulation, as well on a first attempt realized for Romania, mainly to generate a suitable, adapted model for a large city, in order to make possible to analyze in real time or prognosis, the air quality, based on the local topography, meteorological conditions and eminent pollution sources. In this case, SIRANE is used as an operational urban dispersion model using a Gaussian model.

Acknowledgements

The work was supported by the AIRQ project – Novel Tool for Urban Air Quality Monitoring (www.mec.upt.ro/airq/), No. 93/03.01.2012/ 5 Ro – Fr 2012.

The RADO research group (http://environment.inoe.ro/article/150/what-is-rado), part of ACTRIS (http://www.actris.net/TransNationalAccess.aspx), is also acknowledged for scientific support. Appreciations are addressed as well to the Sectoral Operational Programme Human Resources Development (SOP HRD), financed from the European Social Fund and by the Romanian Government under the project number POSDRU/159/1.5/S/134378 as well.

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