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DOMESTIC HEATING SOURCES IDENTIFICATION IN COMPLEX TERRAIN RURAL AREA BY LOCAL SCALE DIAGNOSTIC MODELING SYSTEM

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Abstract: Zasavje is an industrial region in Slovenia. It is located around the Sava river steep canyon and surrounding hills and valleys. In the region especially PM10 air pollution is a major problem, but also other pollutants such as SO2 and NO2 rich significant level. Beside the industry, region has other sources of pollution such as coal and wood domestic heating, traffic, bio-mass burning and several stone-pits. The industry in the region is located on several places, some in the local small towns, but other also in completely rural area. The industrial air pollution in the area is added to significant pollution from domestic heating in the area especially in the winter conditions. The pollution from domestic heating is significant for the PM10 as wood and coal are used. Two extensive air pollution environmental measuring systems are operating in the area, the System of the Environmental Agency of Slovenia and the System of the Thermal Power Plant Trbovlje. In the area a research prognostic and diagnostic air pollution modelling system is operation based on meteorological measurements, prognostic meteorological data obtained by WRF and local scale modelling system based on Swift and numerical Lagrangian particle model Spray (by Arianet, Italy). The measurements on several automatic stations in the region show significant PM10 pollution. Episodes with measured high peaks were selected to determine the **local heating emissions using inverse modelling technique.** The task was not simple as firstly the contribution of other sources such as industry or stone-pits had to be eliminated. To achieve realistic results the locations of villages with such domestic heating and number of houses were determined using geographical data. Practical examples will show some good results and also limitations of such a method due to extremely complex terrain nature of the area under examination. **The presented method of domestic heating emissions determination gives some good results, although some questions remain open, but it is still important because it gives some new knowledge about PM10 air pollution in the area where this is a major problem.**

Key words: *Zasavje region, domestic heating, source identification, complex terrain, rural area, local scale diagnostic Lagrangian particle air pollution modelling system*

INTRODUCTION

Article represents study of air pollution in Zasavje region. The region is a good example of very complex terrain in the central part of Slovenia. The area is represented by low winds and often winter thermal inversions. In the area PM10 air pollution is significant and is on several measuring places exceeding the allowed limit values (number of accidences of daily limit values). In the area several industrial sources that are the source of PM10 are placed in the Sava river canyon. In addition traffic on roads is a source of PM10 pollution, during winter time due to salting of the roads, during summer time due to other sources of dust pollution coming on the wheels of tracks from the stone-pits and then being re-suspended, primary traffic emissions and similar. One of important sources of pollution in the winter period is also domestic heating. Some villages are not yet connected to the distant heating or gas supply networks. In these villages some people use oil as source heating, but many other use local coal or wood. The area is especially rich with forest. Many village people own forest and can make their own supply. Other can pick up the remaining wood or buy the wood cheaply from their neighbours. As the area is over the brown coal mine, people also know how to pick – up small amounts of coal in the surroundings. All this means of supply can of course not be traced and can not be evaluated from the trade data. The aim of our study was to determine average domestic heating dust (PM10) emission from villages using modelling approach.

CHALANGES OF THE STUDY

Determination of emissions of domestic heating in such a complex area using modelling is in principal very hard task. We were firstly looking for a village where there is no network for hot water supply (distant heating) or no network for distribution of gas. It is also needed that other possible sources of pollution do not influence the situation under examination. In addition a reliable PM10 monitoring station with on-line measurements at least on hourly basis is needed for ambient air concentrations measurements. Station Prapretno is ideal location for our study. Environmental information station Prapretno of the Thermal Power plant Trbovlje is located at the village border. This is a unique opportunity to examinate PM10 air pollution in the village.

Village air pollution enhanced by complex topography and related meteorological features can be even a harder problem to study than urban air pollution. Many studies are dealing with urban air pollution but people in the villages also suffer from the same problem, but without measurements the problem is usually neglected and there is no formal policy on the European level that would take this problem into account. These somehow generate secondary class citizens as not so many people leave in the village and their problems are not emphasized at policy makers.

VILLAGE AIR POLLUTION STATION PRAPRETNO

During the winter period domestic heating is important source of PM10 air pollution at the station Prapretno which is located at the border of the distributed village Prapretno in complex terrain. The possible sources of PM10 pollution at this location are also the near by Thermal Power Plant Trbovlje and their ash depot and on the other side the stone – pit Plesko (see Figures 1 and 2). Therefore the situations have to be chosen when these two sources of pollution can be eliminated.

ZASAVJE AREA DESCRIPTION AND AIR POLLUTION MODELLING SYSTEM.

Detail description of the area is given in another article at this conference (Mlakar, P. et al., 2011, Božnar, M. Z., P. Mlakar, and B. Grašič, 2011) and description of the modelling system is given in another article at this conference (Mlakar, P. et al., 2011, Božnar, M. Z., P. Mlakar, and B. Grašič, 2011).

DOMESTIC HEATING SOURCES OF PM10 EMISSIONS REPRESENTATION IN THE MODELLING SYSTEM

Domestic heating sources of PM10 pollution in the area around village Prapretno are presently given as 8 point sources that comprise the data about the villages surrounding the point locations. Data are determined according to the number of private houses in the areas taken from GIS data. GIS for public use is available on Internet portal (PISO, 2011). The small village of Prapretno was grouped into several "quarters" to obtain as accurate as possible source locations. At each group of houses we have counted the number of people registered there. Our hypothesis was that emission is proportional to the number of people living in the group of houses. This clearly has some error but it is not so big. For each quarter we have put a common source. For each virtual common source we have put the chimney at 10 m height above the ground with exit velocity of gases 1.5m/s. This later number was determined purely empirically by observation of plumes from the houses chimneys. The temperature of exhaust gasses was set to 50 deg. Celsius on average, because domestic heating systems are usually not optimised for burning and exhaust parameters. Figure 1 presents the areas that were taken into account as possible sources of domestic heating PM10 pollution. We have taken into account that other houses (mainly on the east from Prapretno towards Hrastnik) are already having distant heating and they do not contribute to local PM10 air pollution on regular basis.

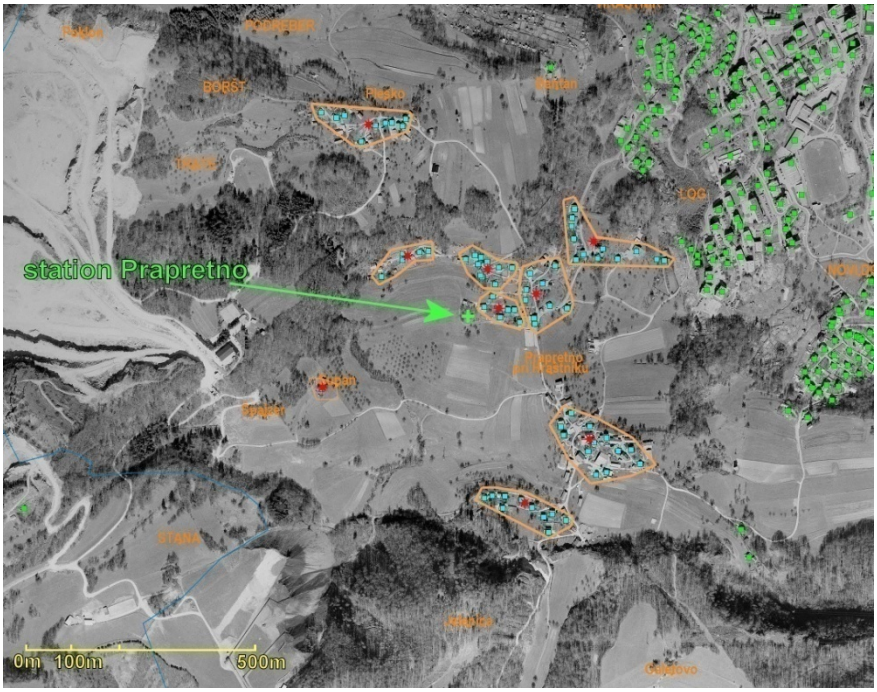

Figure 1: Picture presents the village Prapretno, the location of Environmental station at the village border (sign +) and areas taken into account as possible sources of domestic heating (sign * for centres and orange lines for grouping of houses)

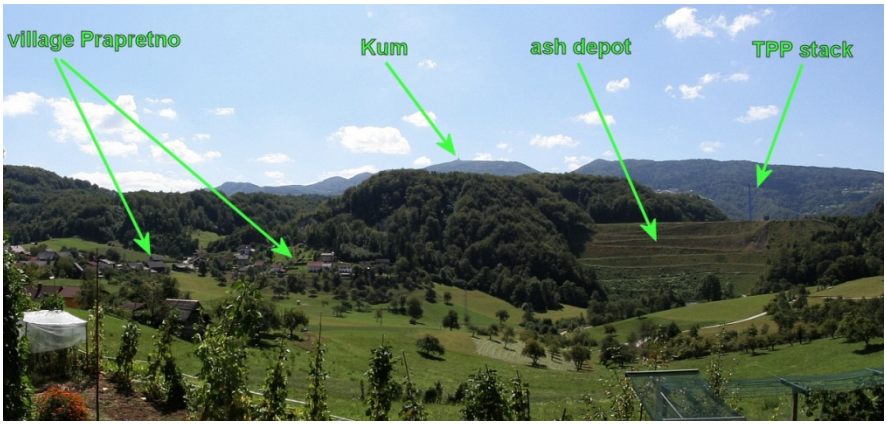

Figure 2: Picture presents the village Prapretno on the left and ash depot from TPPT on the right (picture taken from stone-pit Plesko facing at Kum and stack of TPPT).

The present installation of the modelling system has horizontal resolution 200m, because we need to take into account wider area due to extremely complex terrain that determines the overall meteorological situation. It would be better to have smaller cells but this is only possible for case studies. The existing system is designed for yearly and on-line studies. For the simulation we were using Lagrangian particle model Spray, because in comparison to Eulerian approach it allows more precise location of sources (even if summarised for few houses together), and it allows to calculate precise plume rise. For the same level of accuracy for this two features Eulerian approach would require much smaller grid cells in horizontal and thinner layers in vertical.

SELECTION OF THE POLLUTION EPISODE

There are several episodes when PM10 air pollution in the village of Prapretno was high during the last winter. We have been looking for an episode when the daily peak was at least 40 μg/m^3. In addition the main winds should be in such directions that air pollution coming from the TPP Trbovlje and its ash depot were dispersing their pollution in other areas, not in Prapretno. Also during the relatively wet December 2010 the depot and the stone - pit are not so significant source of PM10 air pollution.

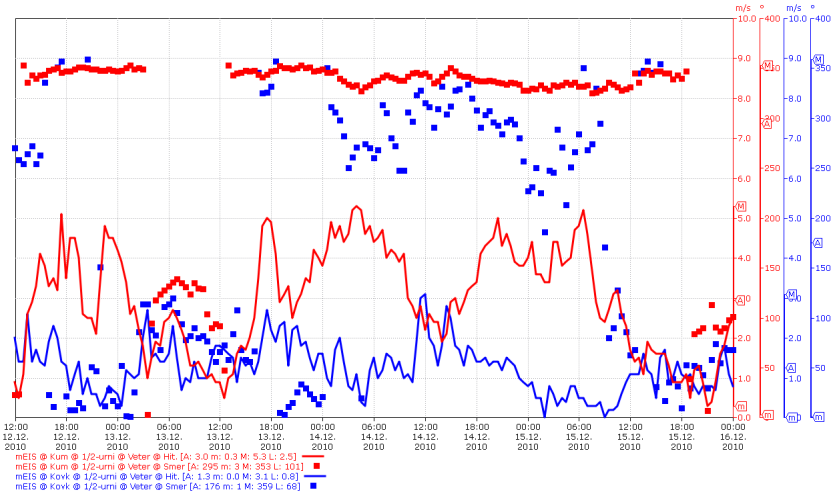

Figure 3: Wind measurements at most relevant meteorological stations Kovk in Kum for selected episode (data from public portal of municipality of Trbovlje, 2010)

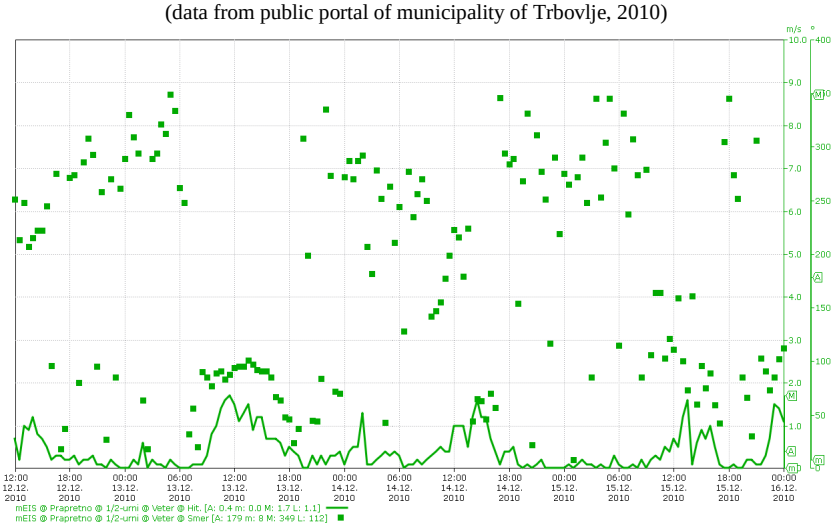

Figure 4: Wind measurements at meteorological station Prapretno for selected episode (data from public portal of municipality of Trbovlje, 2010)

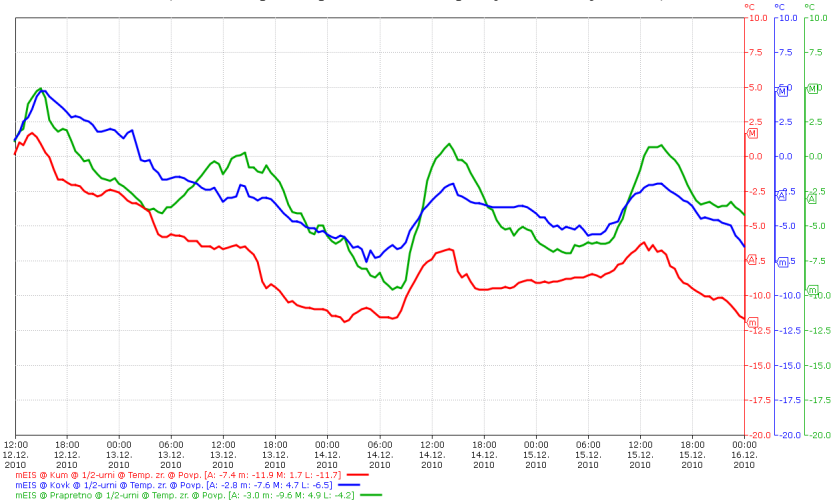

Figure 5: Air temperature measurements at most relevant meteorological stations Kovk, Kum and Prapretno for selected episode (data from public portal of municipality of Trbovlje, 2010)

Then we were examining relatively high December time series of PM10 to find an interval when TPP PM10 pollution for sure does not influence the location, directly or indirectly through accumulation from past hours. The situation on 14th December 2010 from 18:00 to 24:00 is a good example of such situation and the picture of winds on the relevant meteorological stations in the vicinity clearly show that locally there was almost calm, but on the hills peak winds were blowing from TPP to other directions not towards Prapretno (see Figure 3). On the other hand low wind speed at Prapretno points to accumulation of the emissions from domestic heating over the village area (see Figure 4).

It has to be stressed that the proposed calculation in such a complex topography area only makes sense if we found ideal meteorological situation that allows us to eliminate the industrial point and area sources and traffic sources in the area and that on the other hand show the possibility of accumulation of the emitted PM10 over the area of the village.

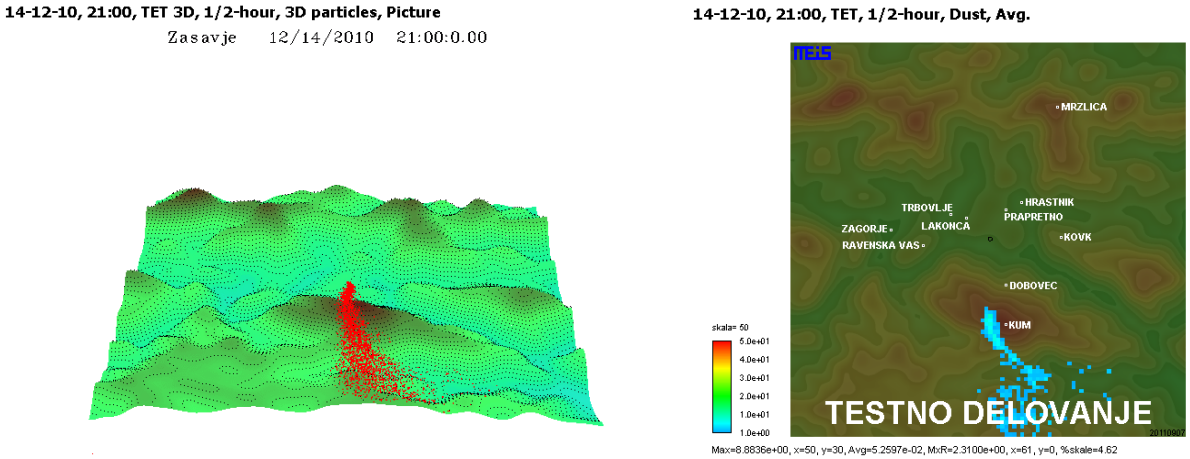

Figure 6: 3D picture of particles emitted and ground concentrations of PM10 from one of the industrial source (Thermal power plant Trbolje) showing that air pollution from main industrial sources is going in opposite direction of Prapretno village (figures taken from KOOREG project (KOOREG, 2010)).

GOAL OF SIMULATION

The goal of simulation is to adjust the village domestic heating PM10 emission to such value that the corresponding PM10 modelled concentrations in the village station match the measured ones.

PRESENTATION OF MODELLING RESULTS

Using iteration method we determined that the PM10 emission of value: **overall daily constant 0.0039 kg/h of PM10 per person registered in the area** is giving very good match of measured and modelled PM10 ambient concentrations at station Prapretno.

Measured and modelled ambient PM10 concentrations are shown for the emission from the village on the following picture.

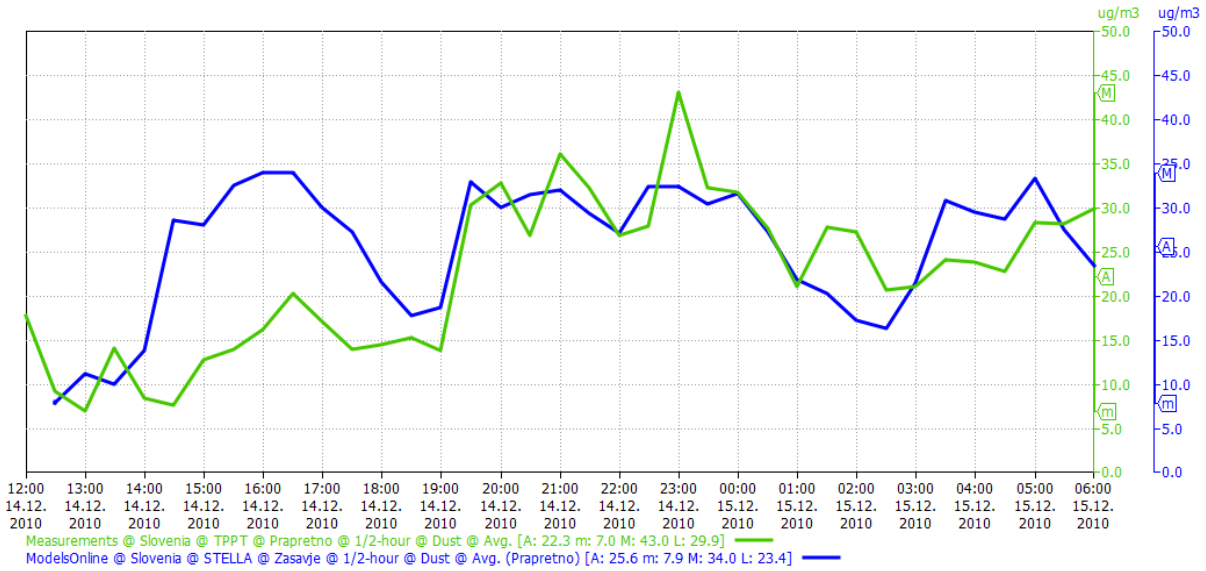

Figure 7: Comparison of measured (green) and modelled (blue) PM10 concentrations at the location of station Prapretno for selected episode (measured data from public portal of municipality of Trbovlje, 2010)

The following pictures are showing the area results for ground level concentrations.

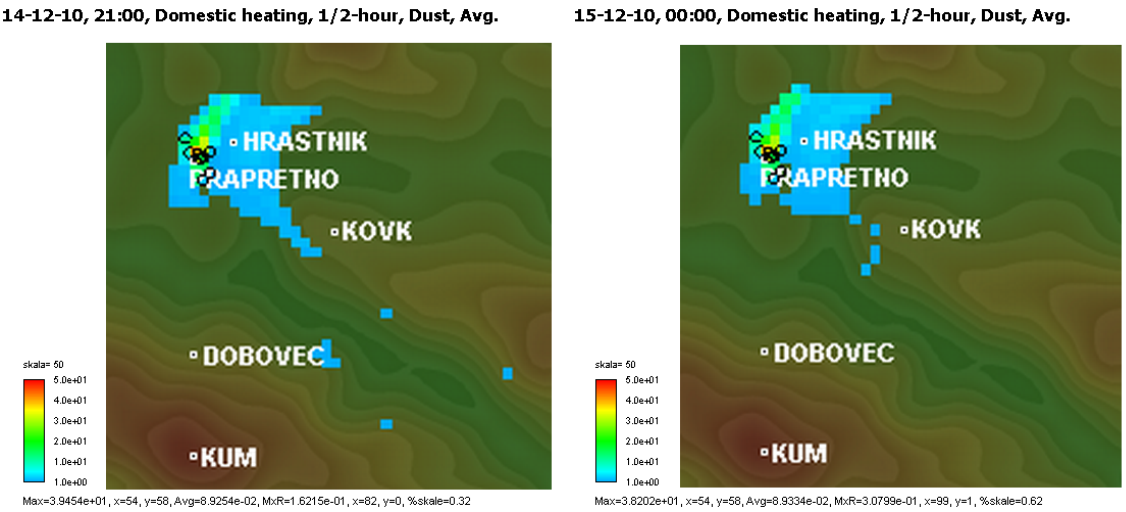

Figure 8: Modelled 2D ground PM10 concentrations from domestic heating around village Prapretno for selected episode

POSSIBLE ERRORS OF THE MODELING PROCEDURE

There are several possible sources of the error.

The first one is extremely complex topography which is taken into account only in the resolution of 0.2 km, which is hardly sufficient.

Then the source of error is representation of the houses in the Lagrangian air pollution model. For excellent results more dense grid of the model and representation of each house as single source would be needed, but we only had an estimated source at several centres with all the emission summarised in these points.

Therefore the results should be taken just as first approximation from the measurements and modelling. But they are important because the area is characteristic for burning low quality wood and even local coal. Emission factors estimation for such fuel is not easy task and is not well elaborated yet.

CONCLUSIONS

The presented study is a first attempt of the domestic heating sources identification in complex terrain rural area by local scale diagnostic modeling system in the Zasavje region using inverse modelling technique.

Its findings are important because the private houses in the area burn wood and also coal. By doing so they contribute to local air pollution in addition to other sources in the area such as industry and traffic.

ACKNOWLEDGEMENT

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