AIR QUALITY MODELING OF NON-ATTAINMENT AREAS AS A BASIS FOR AIR QUALITY PLANS

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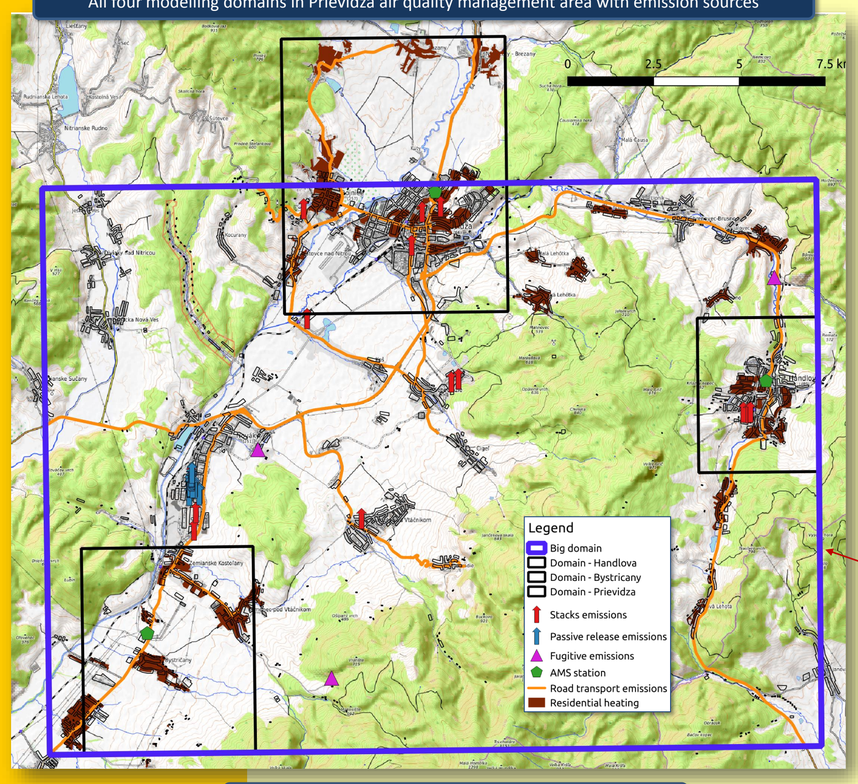
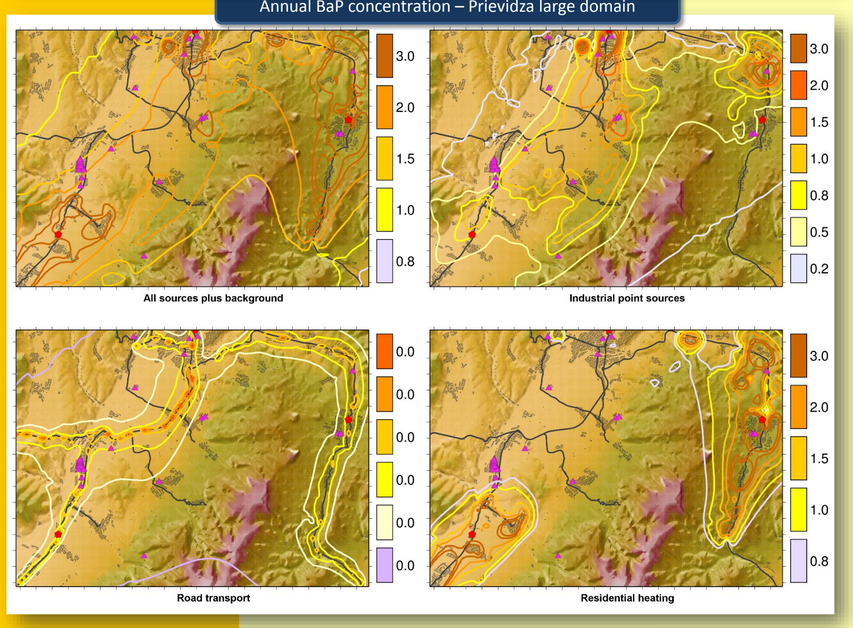
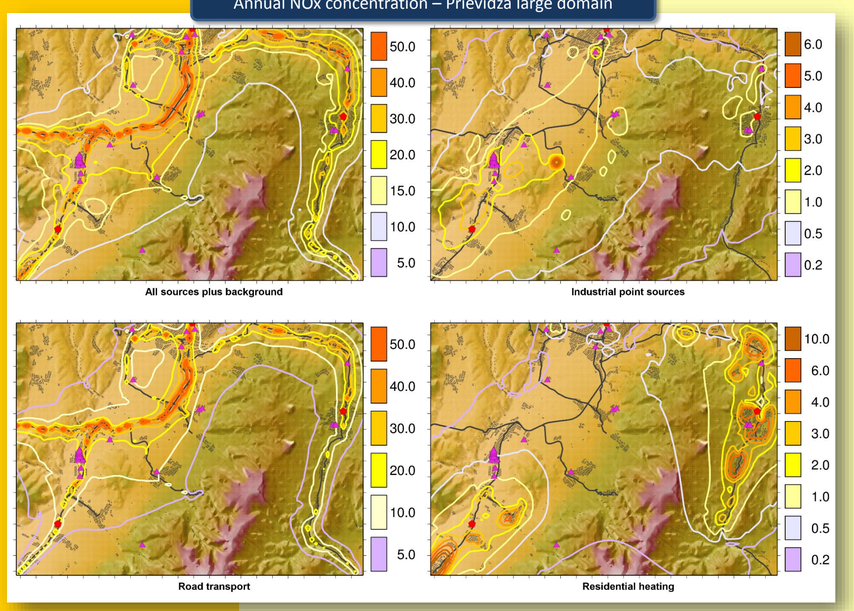
All four modelling domains in Prievidza air quality management area with emission sources



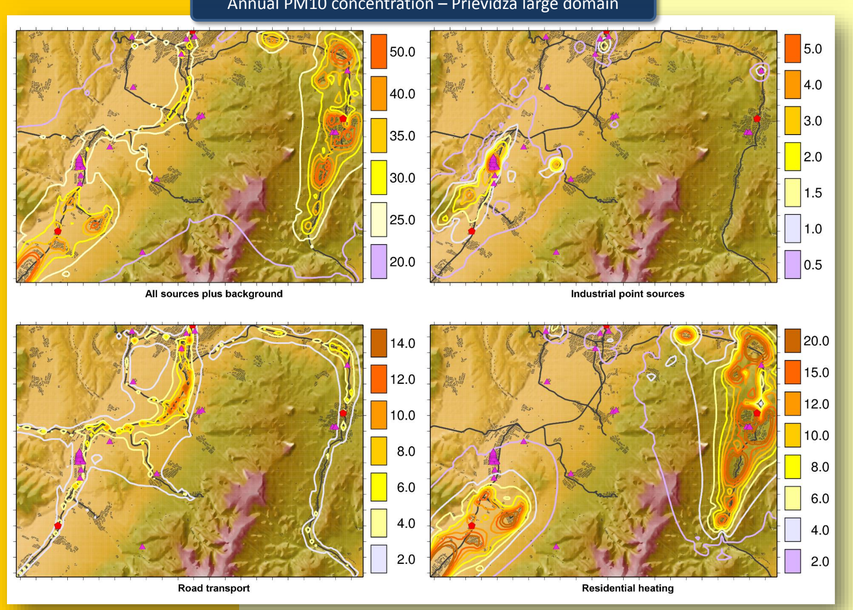
Annual BaP concentration – Prievidza large domain



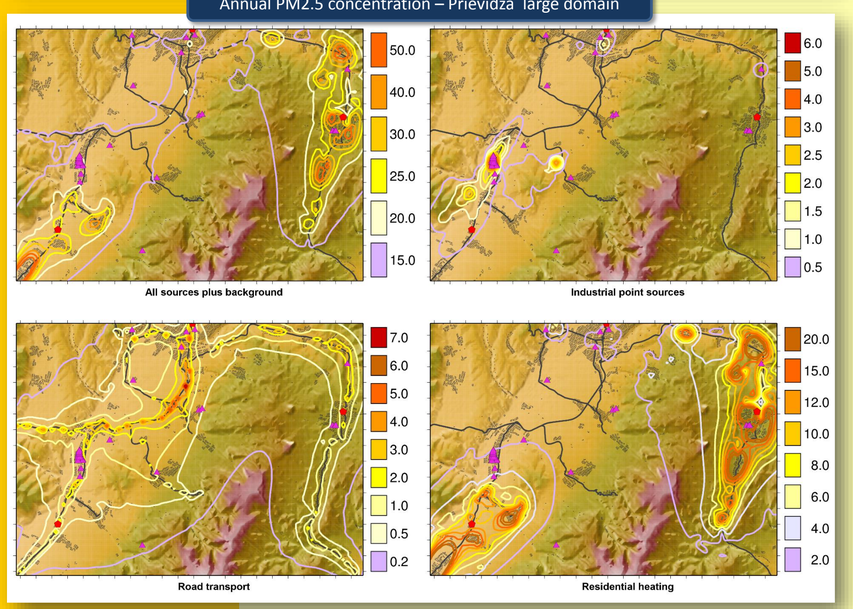
Annual NOx concentration – Prievidza large domain



Annual PM10 concentration – Prievidza large domain



Annual PM2.5 concentration – Prievidza large domain

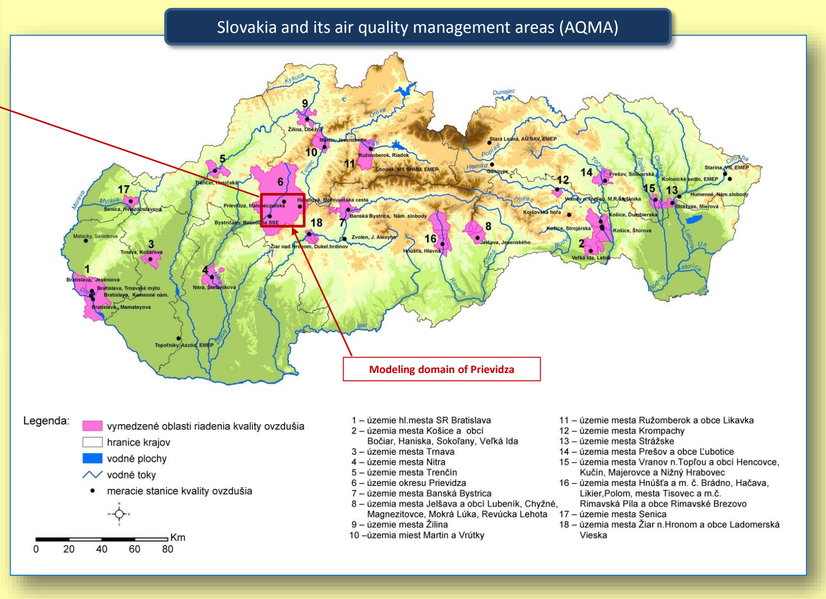


PRIEVIDZA AIR QUALITY MANAGEMENT AREA

INTRODUCTION

High concentrations of PM_{10} and $PM_{2.5}$ have been a major problem in most regions of Slovakia for a long time. In addition, exceedances of NO_2 and BaP limit values has been observed in some monitoring locations. Currently, there are 17 so called air quality management areas in Slovakia, which are areas where a limit value of one or more pollutants has been exceeded. Air quality plans has had to be prepared for all such areas and for most of them the plans are regularly revised and updated as the problems with high concentrations persist. Air quality management of Prievidza region is an example.

Slovakia and its air quality management areas (AQMA)



RELEVANT SOURCES OF PM10 EMISSIONS

Large and medium sources from NEIS database

They comprise of seasonal point sources (centralized heating), non-seasonal point sources (industrial stacks), and fugitive industrial sources, represented as volume sources in the simulations.

Seasonal sources of residential heating

Emissions from residential heating are based on the statistical census data (ŠÚSR, 2011), containing number of households using solid fuels for heating, sizes, age and insulation status of houses and other useful parameters for each census element. Climatological parameters have also been included in the model, which computed amount of combusted wood. Consequently, emission factors for each pollutant (PM_{10}, $PM_{2.5}$, NO_x, BaP and SO_2) have been applied. These emissions has been geographically allocated to residential areas identified using Google Earth.

Road transport

Exhaust and non-exhaust vehicle emissions were calculated using a top-down method from the total national emissions (COPERT 4). The emissions were distributed throughout the roads in the domain based on the road category and length, vehicle counts and categories.

Resuspension of dust was estimated based on the AP 42 (US EPA, 2011) methodology using bottom-up approach.

MODELING TOOLS AND SETUP

As the district of Prievidza is a mountainous region, CALPUFF model (Scire et al., 2000b) was used as our modelling tool, driven by diagnostic meteorological model CALMET (Scire at al., 2000a). The terrain model (SRTM – Farr et al., 2007) and landuse (CORINE – Bossard et al., 2000) together with full year of 2013 meteorological data from three surface meteorological stations within the domain and three upper air sounding stations outside the domain were input to CALMET model, which calculated high resolution three dimensional wind fields reflecting local orography and circulation systems.

Industrial sources from NEIS database were modeled as point sources (part of them seasonal), residential heating sources were modeled as grids of volume sources with the horizontal resolution of 20 m, and road emissions were modeled as segments consisting of volume sources. As CALPUFF only takes into account emission sources located within the modeling domain, a regional background (nearest available EMEP station has been used) was added to the contributions of the above mentioned source groups in order to compute totals.

The size of the basic large domain has been set to 33.5 x 27.5 km, covering almost the whole district of Prievidza. As the number of sources to be modeled was high (almost 5000 in total), we used horizontal resolution is 500 m (meteorological fields), and larger road segments (100m). In order to achieve better accuracy in places of interest (Prievidza city, Handlová, Bystričany), we also made 3 separate simulations on much smaller domains with higher horizontal resolutions of 250m (met fields), with the road segments of 20m. There are 10 vertical layers with top at 3000 m. Only road transport and residential heating sources were simulated on the small domains; industrial stack sources are subject to longer-range transport and were the main subject of the large domain simulation.

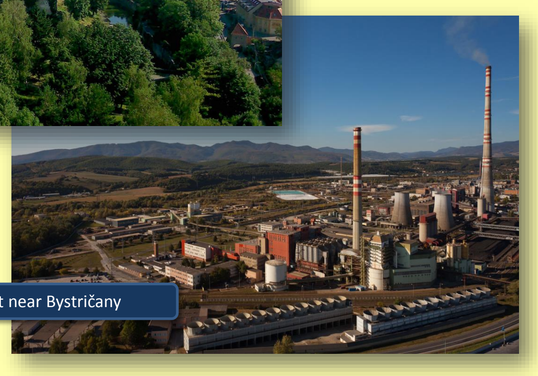
RESULTS AND DISCUSSION

Not all the modelled pollutants are measured at the monitoring stations. Where measurements are available, they compare quite well with the simulation results. The exception is SO_2, which is underestimated by the model, but as it is well below the limit values for vegetation protection, it is not so interesting. However, it suggest that the model may underestimate high stack contributions.

High concentrations of PM_{10} and $PM_{2.5}$ are concentrated in and around residential areas with local heating in Handlová and Bystričany. Prievidza is a larger town where wood combustion does not occur as frequently as in the previous two domains. As expected, NO_2 is concentrated along the roads, with small contribution from residential heating

Benzo(a)pyrene is pollutant of concern. The modelling suggests that it highly exceeds concentration limits not only in Prievidza, but also in the other two sites and it should be measured. According to model results, NO_2 should also be measured at least in Prievidza city.

The Castle of Bojnice near Prievidza city



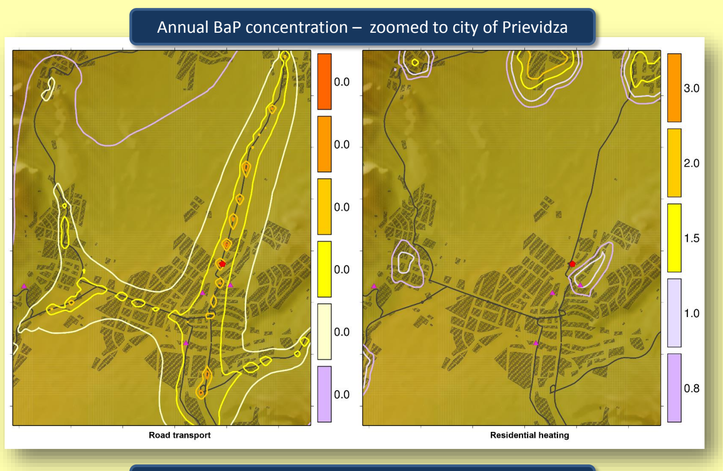
Coal power plant near Bystričany

DISTRICT OF PRIEVIDZA

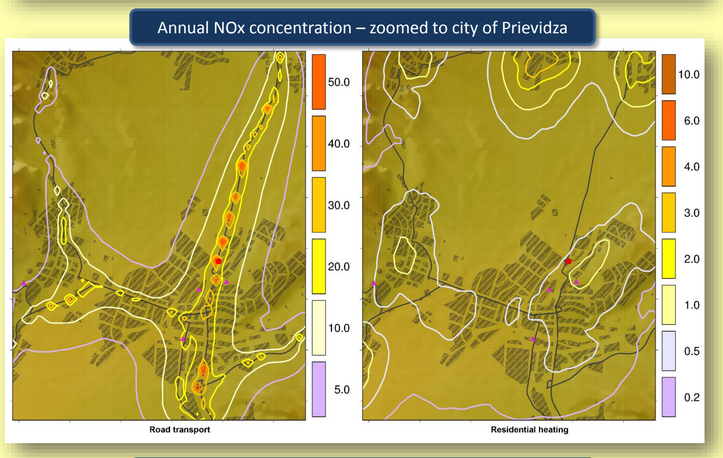
It covers largely industrialized district of the size of 960 km², with the population of 136 500 inhabitants. The district capital is **Prievidza** located in the NW. **Handlová**, located in a narrow valley in the NE is a smaller mining town. **Bystričany** is a village in the SW, where third monitoring station is located, due to its vicinity to a large chemical plant in Nováky and coal power station in Zemianske Kostoľany. The population density of the district is 142 people per km². It has been historically one of the most polluted regions, hosting some heavy chemical and energy production industry and several coal mines producing low quality coal. Today, due to technological advances, the emissions from industry has been continuously decreasing. However, due to increasing costs, local heating has been shifting from natural gas to wood burning, with the emissions replacing in their importance those of the industry.

The modeling simulations were performed for 2013 year. Besides PM_{10}, other pollutants has been included - $PM_{2.5}$, NO_x, SO_2 and BaP.

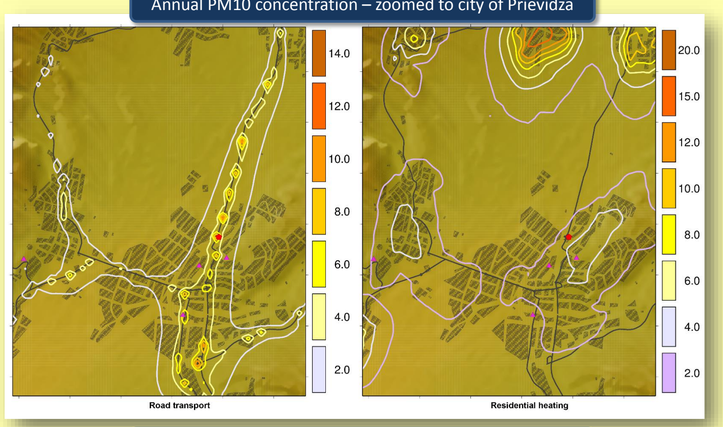
Annual BaP concentration – zoomed to city of Prievidza



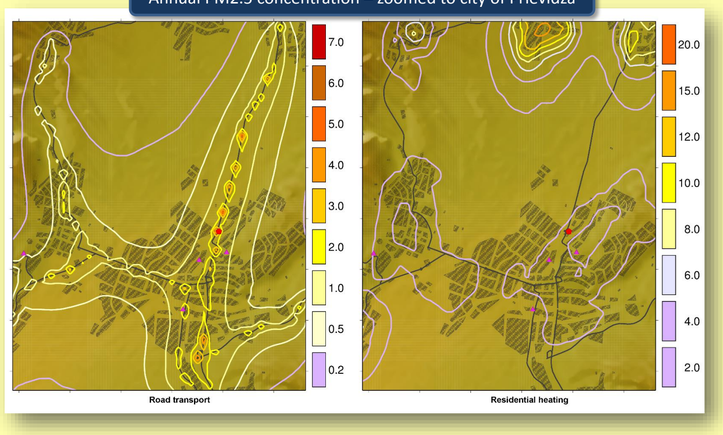
Annual NOx concentration – zoomed to city of Prievidza



Annual PM10 concentration – zoomed to city of Prievidza



Annual PM2.5 concentration – zoomed to city of Prievidza



Modelled vs. measured concentrations at the monitoring stations

Station	Point (μg.m⁻³)	Road (μg.m⁻³)	Residential heating (μg.m⁻³)	Regional background (μg.m⁻³)	Total (μg.m⁻³)	Measured (μg.m⁻³)
NO_2						
Prievidza	0.6	50.3	0.3	4.3	55.5	-
Bystričany	2.6	14.3	2.2	4.3	23.4	-
Handlová	0.7	22.3	1.5	4.3	28.8	-
SO_2						
Prievidza	1.6	0.1	0	1.5	3.1	10.7
Bystričany	9.1	0	0	1.5	10.6	17.4
Handlová	0.7	0	0	1.5	2.2	8.3
PM_{10}						
Prievidza	0.5	6.4	1.4	18.1	26.4	32
Bystričany	1.1	2.6	10.8	18.1	32.6	35
Handlová	0.1	3.1	7.5	18.1	28.9	24
$PM_{2.5}$						
Prievidza	0.4	3.2	1.3	11.8	16.7	25
Bystričany	0.7	1.1	10.2	11.8	23.8	22
Handlová	0.1	1.5	7.1	11.8	20.5	16
BaP*						
Prievidza	0	0	0.3	0.7	1	1.8
Bystričany	0	0	2.2	0.7	2.9	-
Handlová	0	0	1.5	0.7	2.2	-

** (ng.m⁻³)*

Emission factors from residential heating

Emission factors	Unit	Dark coal	Coke	Brown coal	Briquettes	Wood
EF_{TSP}	kg/t	11,25	10,93	8,33	10,98	15,00
PM_{10}/TSP		95%	95%	95%	95%	95%
$PM_{2.5}$/TSP		90%	90%	90%	90%	90%
EF_{SO2}	kg/t	10,075	9,610	18,875	13,500	0,000
EF_{NOx}	kg/t	5,50	5,50	3,00	3,00	3,00
EF_{BaP}	g/t	1,500	1,500	0,845	0,845	2,480

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