LOCAL PM10 SOURCE APPORTIONMENT FOR NON-ATTAINMENT AREAS IN SLOVAKIA

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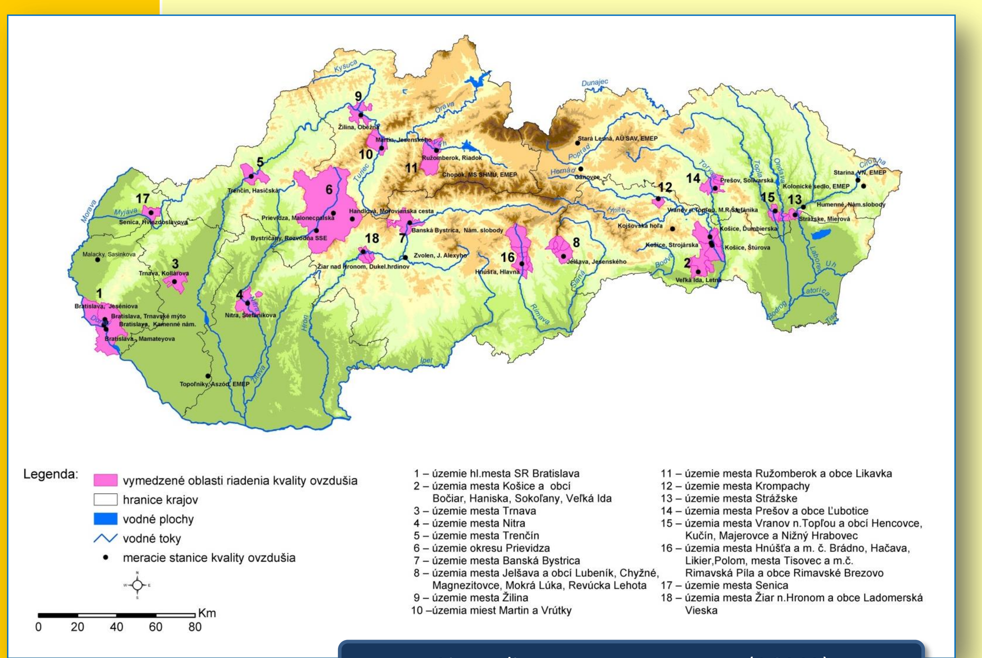
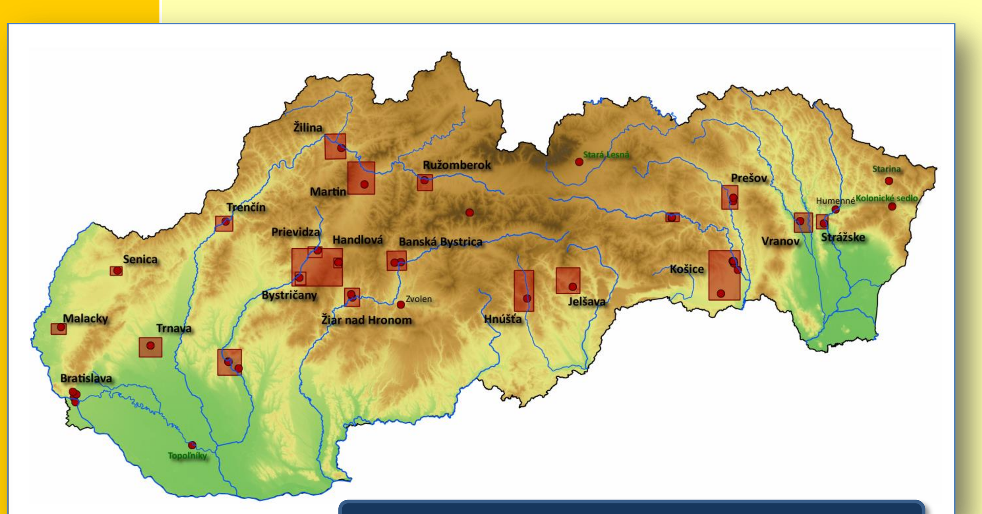
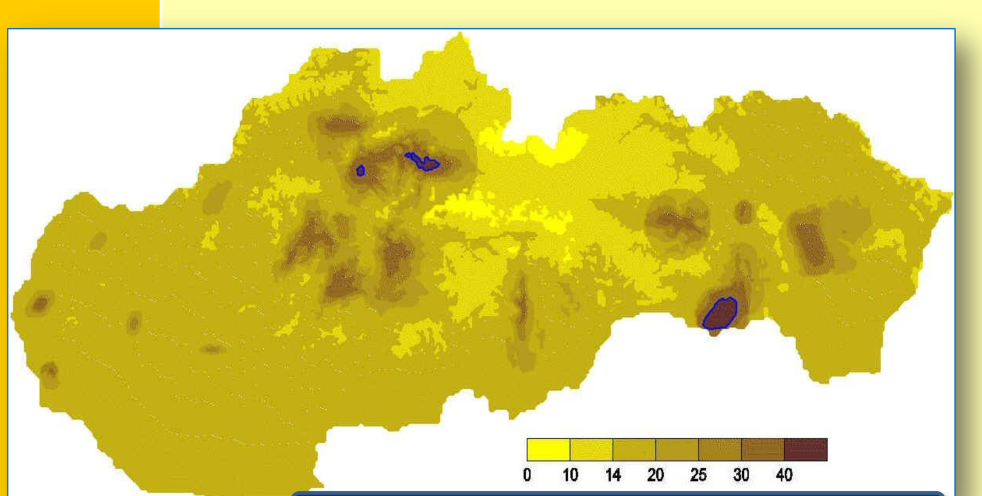
All air quality management areas (AQMA)



Air quality management areas (AQMA)



Modeling domains corresponding to AQMA



Mean annual PM10 concentrations calculated by CEMOD model

Contributions of different source groups to monthly PM10 concentrations

AQMA monitoring station	LSM coefficients				Rho	RMSE	FB_n	FB_p	FB
	k_1	k_2	k_3	k_4*					
Nitra (UB)	1	0.5	2	-	0.77	9.85	0.27	0.06	0.21
Žiar nad Hronom (UB)	1.3	0.2	2	-	0.75	8.94	0.13	0.11	0.02
Malacky (UT)	1.5	0.1	2	-	0.73	10.12	0.14	0.09	0.05
Hnúšťa (SB)	1.5	0.4	2	-	0.66	13.71	0.2	0.11	0.09
Jelšava (UB)	1.5	2.0	2	-	0.62	19.7	0.25	0.16	0.09
Krompachy (UB)	1.5	1	2	-	0.71	12.84	0.18	0.12	0.06
Martin (UT)	1.5	0.16	2	-	0.7	12.58	0.15	0.11	0.04
Prešov (UB)	1.5	0.2	2.3	-	0.63	15.1	0.18	0.14	0.04
Senica (UT)	1.55	0.41	1	-	0.77	8.54	0.14	0.10	0.04
Strážske (UB)	1.1	0.3	0.5	-	0.71	10.36	0.2	0.14	0.06
Trenčín (UT)	1.2	0.1	0.5	-	0.64	10.99	0.15	0.17	-0.03
Trnava (UT)	1.5	0.3	3	-	0.7	13.16	0.19	0.1	0.09
Vranov nad Topľou (UB)	1.5	0.1	2.5	-	0.66	14.02	0.16	0.13	0.03
Žilina (UB)	1.5	0.2	0.9	-	0.71	14.09	0.17	0.14	0.02
Ružomberok (UB)	1.5	0.2	3	-	0.73	13.99	0.14	0.14	0.00
Banská Bystrica (UT)	1.3	0.2	1.7	-	0.54	23.86	0.26	0.14	0.12
Veľká Ida (SI)	1	0.1	2	2	0.47	22.21	0.31	0.08	0.23
Košice – Štúrova (UT)	1	1	1	1	0.7	14.76	0.11	0.24	-0.13
Košice – Strojarska (UB)	1	1	1	1	0.72	13.31	0.15	0.14	0.00
Prievidza (UB)	1.4	0.7	0.2	-	0.76	10.32	0.13	0.11	0.02
Handlová (UB)	1.4	2.3	0.2		0.71	10.29	0.17	0.10	0.07
Bystričany	1.36	2	0.3		0.69	10.53	0.16	0.12	0.03

Rho – Spearman correlation coefficient, **RMSE** – Root mean square error, **FB_n, FB_p, FB** – Fractional biases: negative, positive and total, Station classification: UB – urban background, UT – urban transport, SB – suburban background, SI – suburban industrial

Linear statistical model coefficients and correlation statistics between measured and modeled mean daily PM10 concentrations

INTRODUCTION

Slovakia, as many other EU countries, encounters problems with exceeding the daily, and in some cases also the annual concentrations of PM10. Directive 2008/50/EC states the conditions under which air quality plans are required to be established. Annex XV contains the list of information to be included in those plans, namely, the origin of the pollution and details of those factors responsible for the exceedances. The methodology and results of PM10 source apportionment as applied to 18 *air quality management areas* (AQMA) is presented. The source apportionment was used as a basis for measures to be taken in order to combat the high levels of PM10 concentrations as efficiently as possible in the framework of current valid national legislation and available financial resources.

RELEVANT SOURCES OF PM10 EMISSIONS

PM10 is a pollutant of multiple origin, moreover, part of the emissions is a natural component of living environment. Only a small part – large sources – are registered in the National Emission Information System (NEIS). The remaining anthropogenic sources have to be assessed based on the combination of different statistical and geographic data and respective emission factors. Methods for determination of these emissions are of varying accuracy depending on the quality of available inputs.

The following source groups have been included in the simulations:

- Large and medium sources from NEIS database
  - Point non-seasonal sources (industrial stacks and vents)
  - Point seasonal sources (stacks of centralized heating facilities)
  - Industrial fugitive sources (e.g., quarries)
- Seasonal sources of residential heating (geographical areas covered by family houses)
- Road transport (exhaust, abrasion and resuspension)

MODELING TOOLS AND SETUP

Most of Slovak territory is formed by a rather complex terrain with most of the AQMA situated in mountain valleys, causing generally low average winds and high percentage of calms over the year. This motivated the selection of CALPUFF (Scire a kol., 2000b) as our modeling tool, driven by diagnostic meteorological model CALMET (Scire a kol., 2000a). Modeling domains are between 60km² and 400km² in size, with the uppest level at 3000m over the surface. Horizontal resolutions are 200m to 500m, depending of the complexity of the terrain, with 10 vertical layers. The terrain model (SRTM – Farr et al., 2007) and landuse (CORINE - Bossard et al., 2000) together with meteorological profiles and surface meteorological measurements are input to CALMET model, which calculates high resolution three dimensional wind fields reflecting local orography and circulation systems. CALPUFF is a lagrangian puff model which is capable of treating low wind and calm situations, while it contains basic chemical parametrizations for secondary aerosol formations.

SIMULATION AND POSTPROCESSING

Involving large number of sources and long time period, CALPUFF simulations are computationally demanding. In order to manage the computing times efficiently, in each domain we divided the emission sources into 3 main groups: point sources – treated as stacks and volumes, small (local heating) sources – treated as adjacent volume sources covering continuous areas, and roads – treated as lines consisting of adjacent volumes. Each of the three main groups had several subgroups determined mostly by their geographic integrity. These geographically integral subgroups were simulated separately, keeping in mind a possible future scaling of their emissions.

As mentioned above, the estimates of local heating emissions and roads were associated with quite large uncertainties; one could therefore call it as a „first guess" estimate. Therefore, the post processing included an application of linear statistical model (LSM) at each receptor point located at the measurements site, in order to determine a scaling coefficient for each emission group in each particular AQMA. As the same emission estimation methods have been used in most of AQMAs, it was supposed that if the scaling coefficients resulting from linear statistical models are consistent among different AQMAs, they may reflect the level of under- or overestimation of our first guess values, while background coefficients reflect the geographical variability of regional background (the background stations are not located inside the AQMA domains).

In our case, the LSM is expressed as follows:

$$C_{oi} = k_1.C_{obi} + k_2.C_{mvi} + k_3.C_{mdi} + k_4.C_{mpi} \text{ ,}$$

where

- C_{oi} is mean daily concentration measured at day *i* at the monitoring station,
- C_{obi} is mean daily concentration measured at day *i* at background monitoring station,
- C_{mvi} is the contribution of local heating at day *i*, modeled at the monitoring station using CALPUFF model,
- C_{mdi} is the contribution of road transport at day *i* modeled at the monitoring station using CALPUFF model,
- C_{mpi} is the contribution of point sources at day *i* modeled at the monitoring station using CALPUFF model,
- k_1,k_2,k_3,k_4 are coefficients of LSM for background, local heating, road transport and point sources.

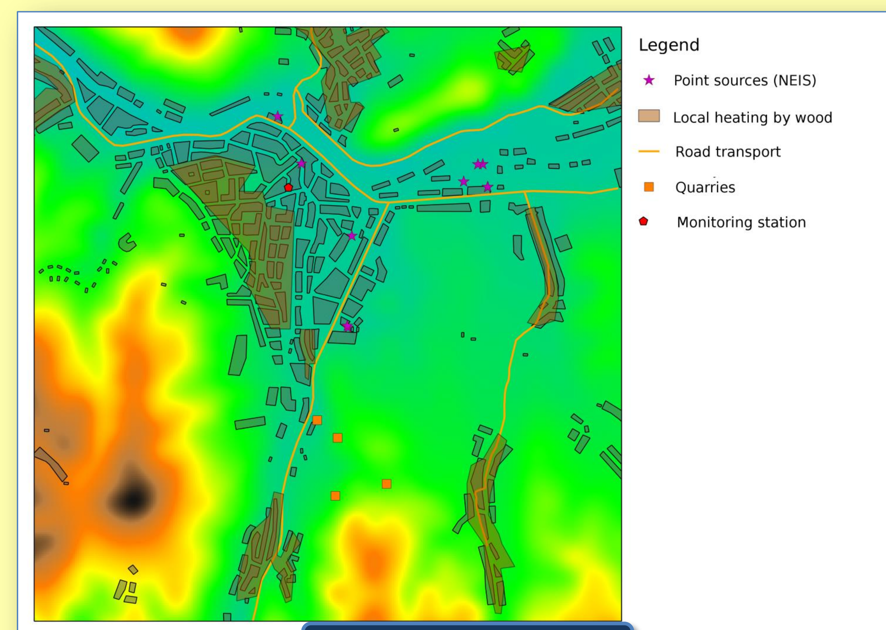
RESULTS AND DISCUSSION

The LSM coefficients resulting from the simulations and subsequent post processing seem to be relatively consistent among the domains. As can be seen from Table 1, their values suggest a relatively high original overestimation of local heating emissions (k_2 = 0.1-0.5), and underestimation of road transport emissions (k_3 = 0.5-2.5). These results are in agreement with our suspicions regarding the uncertainties associated with the emission estimations. These results clearly indicate that the improvement of our emission database, especially local heating and traffic, is a crucial point where it is necessary to focus our attention. However, in current situation, the simulation results adjusted by the respective emission coefficients can be viewed as closest to reality under current conditions.

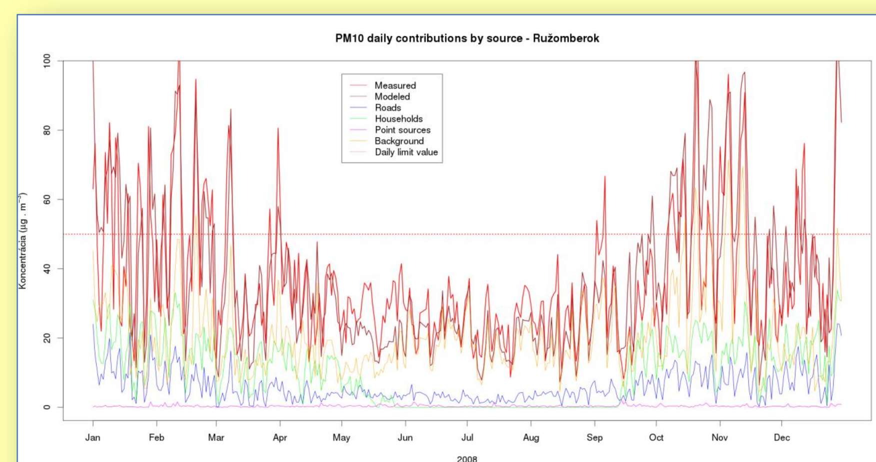
The diagrams showing mean monthly contributions of different source groups suggest that in most cases regional background contribute more than half of the measured PM10. On the other hand, large and medium point sources only slightly contribute to local PM10 concentrations, with the exception of industrial background stations of Veľká Ida and Bystričany and Handlová. The most significant local contributors are traffic and local heating by wood – these are the sectors towards which reduction measures should be focused in most AQMAs.

An example: Ružomberok

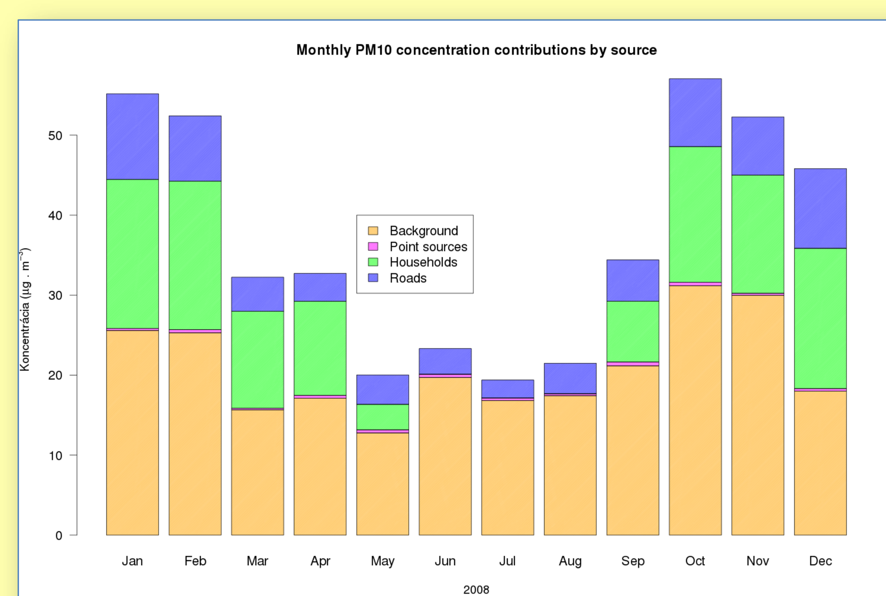
Air quality management area of Ružomberok



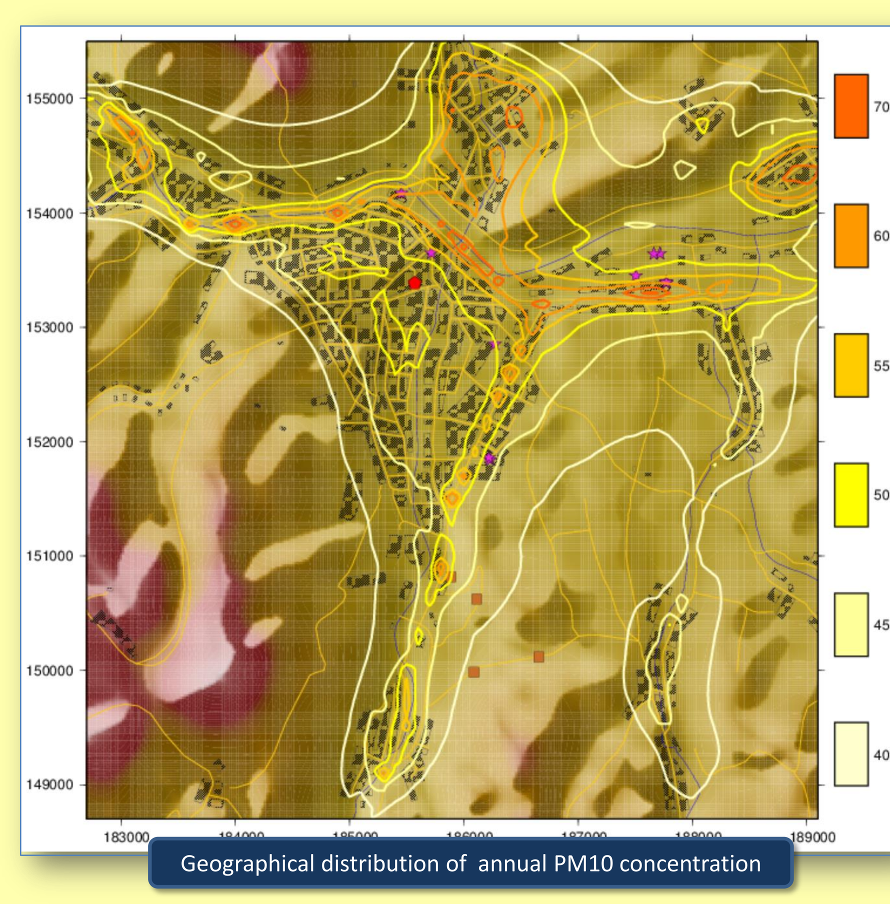
PM10 emission sources



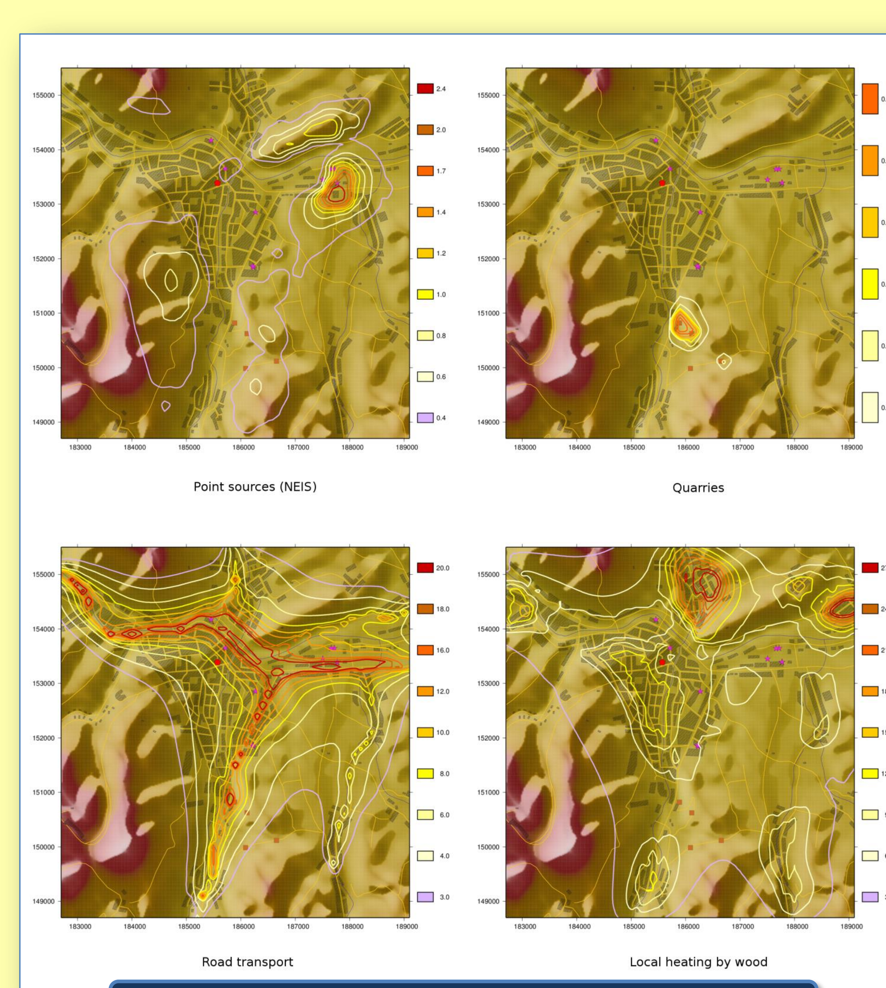
Contributions of different source groups to mean daily PM10 concentrations



Contributions of different source groups to mean monthly PM10 concentrations



Geographical distribution of annual PM10 concentration



Annual PM10 concentration fields from different source groups

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