PM_{10} Source Apportionment for Non-attainment Areas Based on Routinely Available Data

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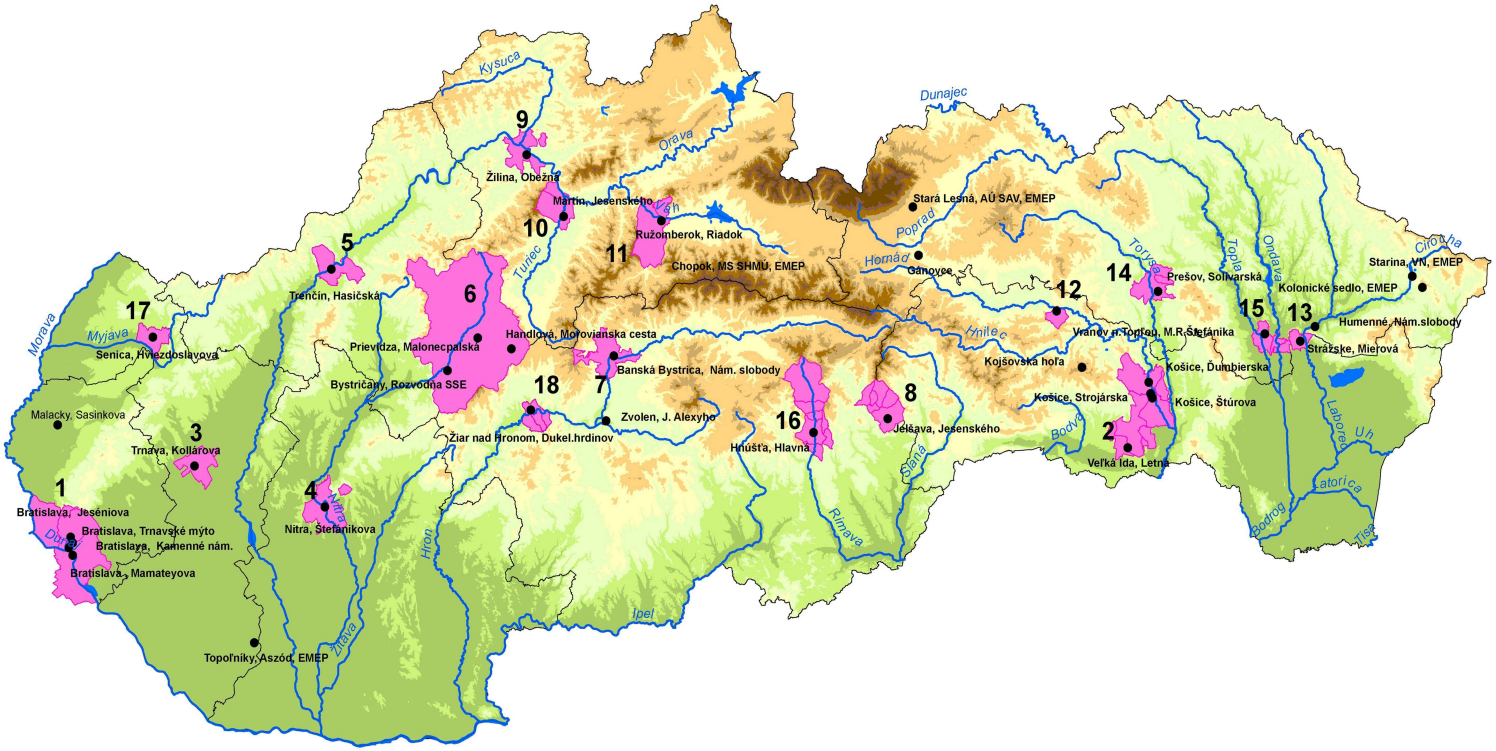
Directive 2008-50/EC:

Postponement of attainment deadlines of PM_{10} concentrations can be granted, if:

- adverse dispersion characteristics
- adverse climatic conditions
- transboundary contributions



Legenda:

- vymedzené oblasti riadenia kvality ovzdušia
- hranice krajov
- vodné plochy
- vodné toky
- meracie stanice kvality ovzdušia

0 20 40 60 80 Km

1 – územie hl.mesta SR Bratislava
2 – územia mesta Košice a obcí Bočiar, Haniska, Sokoľany, Veľká Ida
3 – územie mesta Trnava
4 – územie mesta Nitra
5 – územie mesta Trenčín
6 – územie okresu Prievidza
7 – územie mesta Banská Bystrica
8 – územia mesta Jelšava a obcí Lubeník, Chyžné, Magnezitovce, Mokrá Lúka, Revúcka Lehota
9 – územie mesta Žilina
10 –územia miest Martin a Vrútky
11 – územie mesta Ružomberok a obce Likavka
12 – územie mesta Krompachy
13 – územie mesta Strážske
14 – územia mesta Prešov a obce Ľubotice
15 – územia mesta Vranov n.Topľou a obcí Hencovce, Kučín, Majerovce a Nižný Hrabovec
16 – územia mesta Hnúšťa a m. č. Brádno, Hačava, Likier,Polom, mesta Tisovec a m.č. Rimavská Píla a obce Rimavské Brezovo
17 – územie mesta Senica
18 – územia mesta Žiar n.Hronom a obce Ladomerská Vieska

SOURCE APPORTIONMENT

- It is necessary regardless of justification argument (i.e., transboundary contributions, adverse climatic conditions)
- It is necessary to perform for all exceedance situations at all monitoring sites: In case of daily limit exceedances each case should be analyzed

Ref. number	Air quality management area (AQMA)	No. of monitor. stations	Pollutant above LV	Population	Justification
1	Bratislava	3	PM_{10}	428 791	T
2	Košice, Veľká Ida	3	PM_{10}	239 524	T
3	Trnava	1	PM_{10}	67 726	T
4	Nitra	1	PM_{10}	84 070	T
5	Trenčín	1	PM_{10}	56 826	A,T
6	District of Prievidza	3	PM_{10}, SO_2	139 639	A,T
7	Banská Bystrica	1	PM_{10}, NO_2	80 106	A
8	Jelšava	1	PM_{10}	6 180	A
9	Žilina	1	PM_{10}	85 327	A
10	Martin, Vrútky	1	PM_{10}	65 821	A
11	Ružomberok	1	PM_{10}	32 794	A,T
12	Krompachy	1	PM_{10}	8 929	A
13	Strážske	1	PM_{10}	4 594	A
14	Prešov	1	PM_{10}	94 239	T
15	Vranov nad Topľou	1	PM_{10}	26 952	A
16	Hnúšťa	1	PM_{10}	12 331	A
17	Senica	1	PM_{10}	20 751	A
18	Žiar nad Hronom	1	PM_{10}	20 347	A

NATURE OF PM_{10} EMISSIONS

- efficient long range transport
- multitude and variety of emission sources
- industrial stacks mostly minor contributors
- fugitive emissions and wind erosion play important role

MAIN COMPONENTS OF PM_{10} SOURCE APPORTIONMENT

- Regional (including transboundary) transport
- Local household heating in winter
- Traffic exhaust and non-exhaust emissions
- Dust resuspension from roads and open surfaces (arable land in spring and winter, quarries, landfills, construction sites …)
- Industrial fugitive and stack emissions
- Seasonal agricultural activities

QUANTITATIVE SOURCE APPORTIONMENT - MODELING

- Regional (including transboundary) transport
- Traffic exhaust and non-exhaust emissions
- Industrial stack emissions

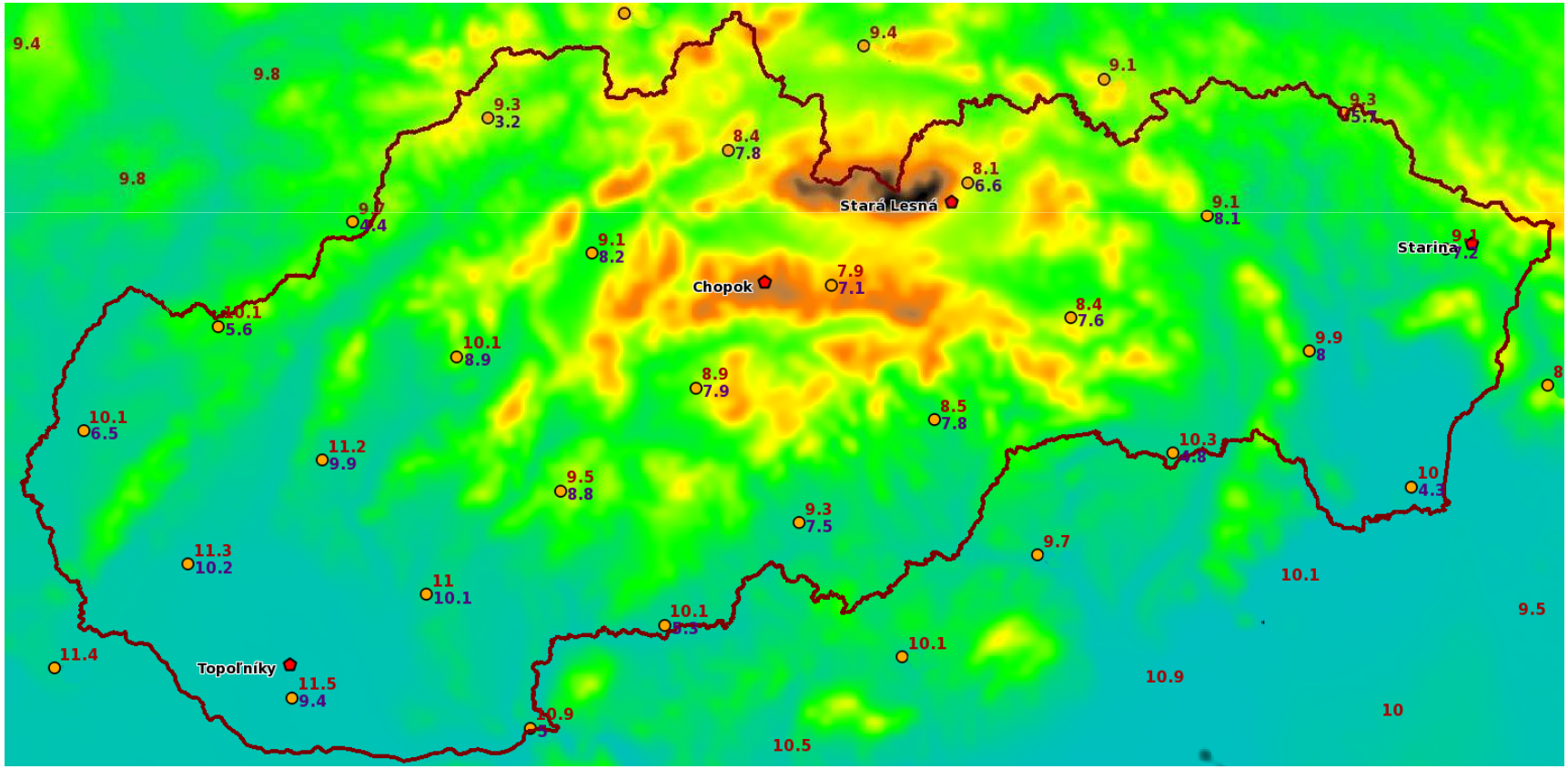
TWO ISSUES HAVE TO BE CONSIDERED:

1. determine the portion of PM_{10} concentration which is to be subtracted from the measured concentration (postprocessed EMEP model)
2. prove that the PM_{10} measured at the day of an exceedance originated outside the territory of Slovakia

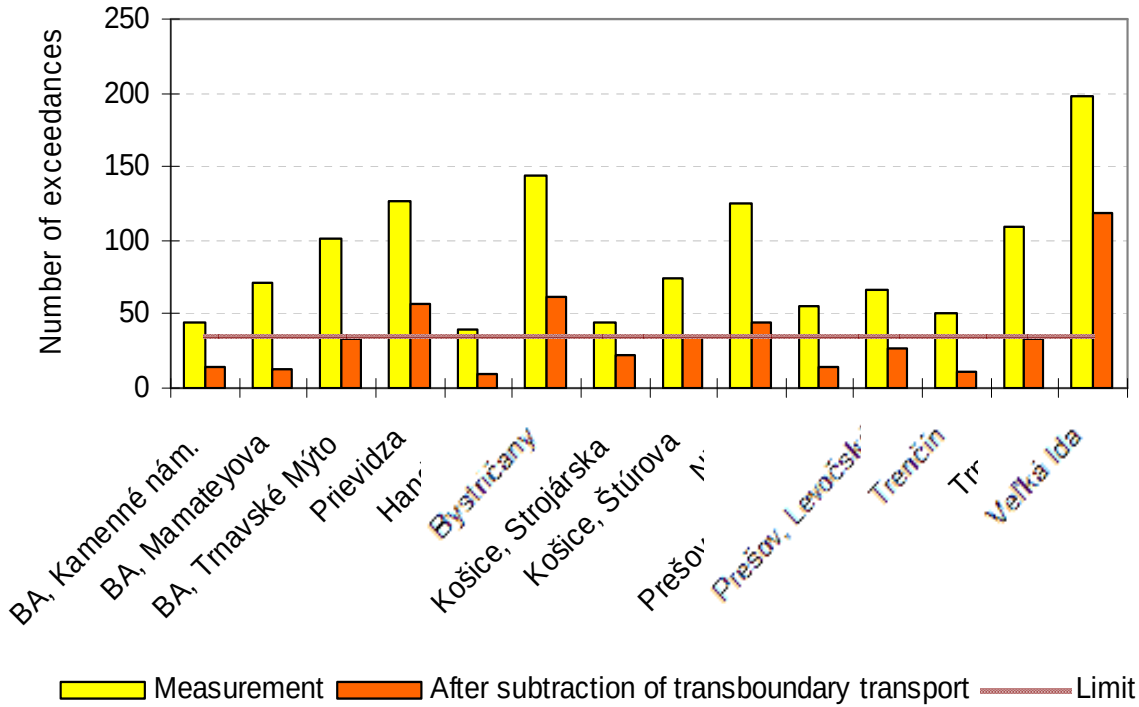
   (EMEP and HYSPLIT model backward trajectories)

Results of EMEP annual modeling with and without SK emissions

Total mean annual PM_{10} concentrations (red values, in µg/m^3) and mean annual transboundary contributions (blue values, in µg/m^3) at gridpoints.



Number of exceedances in 2005 - evaluation of transboundary transport



CEMOD model – annual simulation

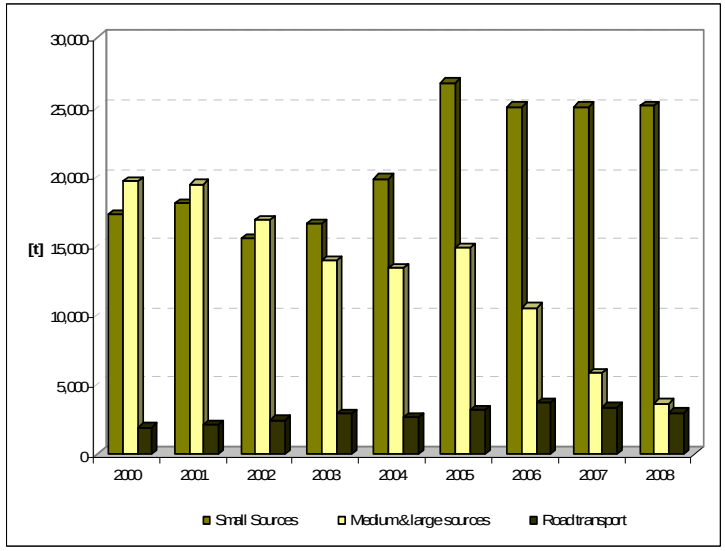
AQMA/AMS station	Large and medium stationary sources (50%)	Mobile sources (%)	Regional background (%)		*Other* sources (%)
			Domestic	Transboundary	
Kamenné námestie	0.3	6.9	9	57	26.8
Trnavské mýto	0.3	12.0	6	41	40.3
Mamateyova	0.3	6.2	8	54	31.4
Košice Štúrova	3.3	20.7	7	47	21.9
Košice, Strojárska	3.2	3.9	8	56	28.8
Banská Bystrica	0.0	1.6	5	42	51.0
Jelšava	0.3	0.3	4	41	51.5
Hnúšťa	1.3	0.5	5	45	48.6
Žiar nad Hronom	1.7	0.8	7	61	29.2
Veľká Ida	18.3	0.0	4	27	51.2
Strážske	0.9	0.6	8	52	39.1
Krompachy	0.6	0.3	6	52	41.6
Nitra	0.0	0.8	8	44	47.4
Humenné	0.7	0.7	6	57	35.4
Prešov	1.6	0.9	6	48	43.7
Vranov	1.3	0.3	5	44	49.5
Prievidza	0.6	0.4	5	28	67.0
Bystričany	1.0	0.0	5	29	64.7
Handlová	1.5	0.3	7	43	47.9
Trenčín	0.0	0.9	6	45	48.7
Senica	0.0	0.3	5	48	46.3
Trnava	0.3	1.0	6	42	49.9
Martin	1.7	0.9	5	34	58.6
Ružomberok	0.2	0.3	2	22	75.1
Žilina, Obežná	0.0	0.7	9	57	55.5

THE MOST IMPORTANT "*OTHER*" SOURCES:

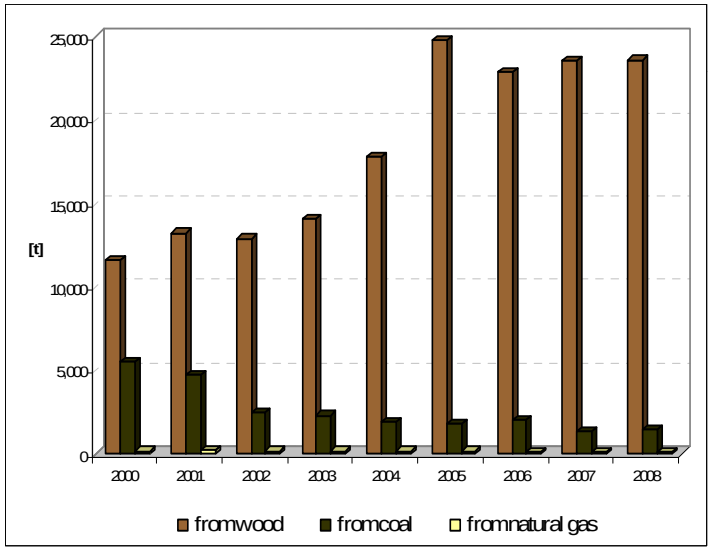
- Domestic heating (wood, coal)
- Resuspension from roads and other open surfaces

PM_{10} EMISSIONS IN SLOVAKIA

a) according to individual sectors



b) small sources according to type of fuel



High Resolution
PM_{10} Emission Database
From Domestic Wood Combustion

DATA

Data available for each municipality:

- Census data (2001):
  - number of inhabited apartments in family houses - N_{rd}
  - number of inhabited apartments in apartment blocks – N_{bd}
  - population per apartment – P_{ap}
  - average area of an apartment – A_{ap}
  - portion of apartments equipped with a bathroom – NP_{kup}

- Annual data:
  - population – P
  - natural gas sold to households - S_p (in m^3)
  - number of connections to natural gas supply - N_{gas}

- GIS data
  - vector map of municipalities
  - raster map of CORINE landuse data

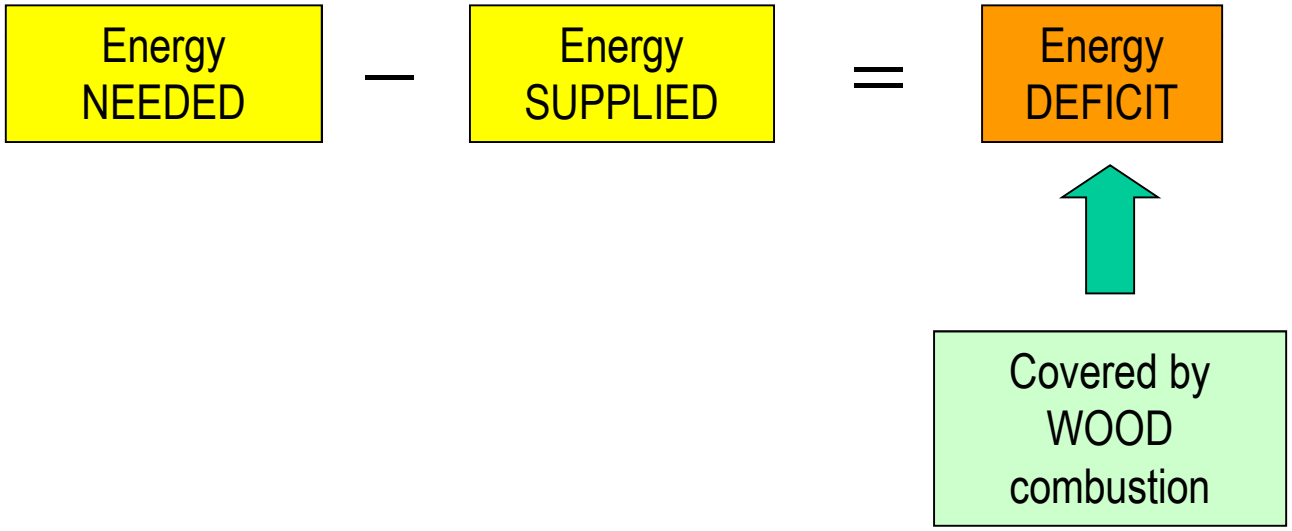
Data available for each district:

- Annual data:
  - coal and coal products sold in retail
  - length and average temperature of heating season

Data available for the whole territory of Slovakia:

- Annual use of electrical energy for heating of households

ENERGY BALANCE METHOD



ENERGY NEEDED

For heating of each municipality is a function of:

- $Q_{vr}\,(Q_c, T_{es}, d)$

  where

  Q_{vr} is annual energy needed for heating of a building (GJ),
  Q_c is thermal loss of the building (kW),
  d is the length of heating season (days), and
  T_{es} is the average temperature of the heating season (degrees of Celsius).

- Statistical data on:
  - number of inhabited apartments in family houses - N_{rd}
  - population per apartment – P_{ap}
  - average area of an apartment – A_{ap}
  - portion of apartments equipped with a bathroom – NP_{kup}

ENERGY SUPPLIED

$$E_k = G_h HV_g EF_g + \sum_i F_i HV_i EF_i$$

where

E_k	is the total energy supplied by all sources (J),
HV_g, HV_i	are heat values of particular fuels (J/m3, J/kg),
EF_g, EF_i	are efficiencies of mass to energy conversions of particular fuels.

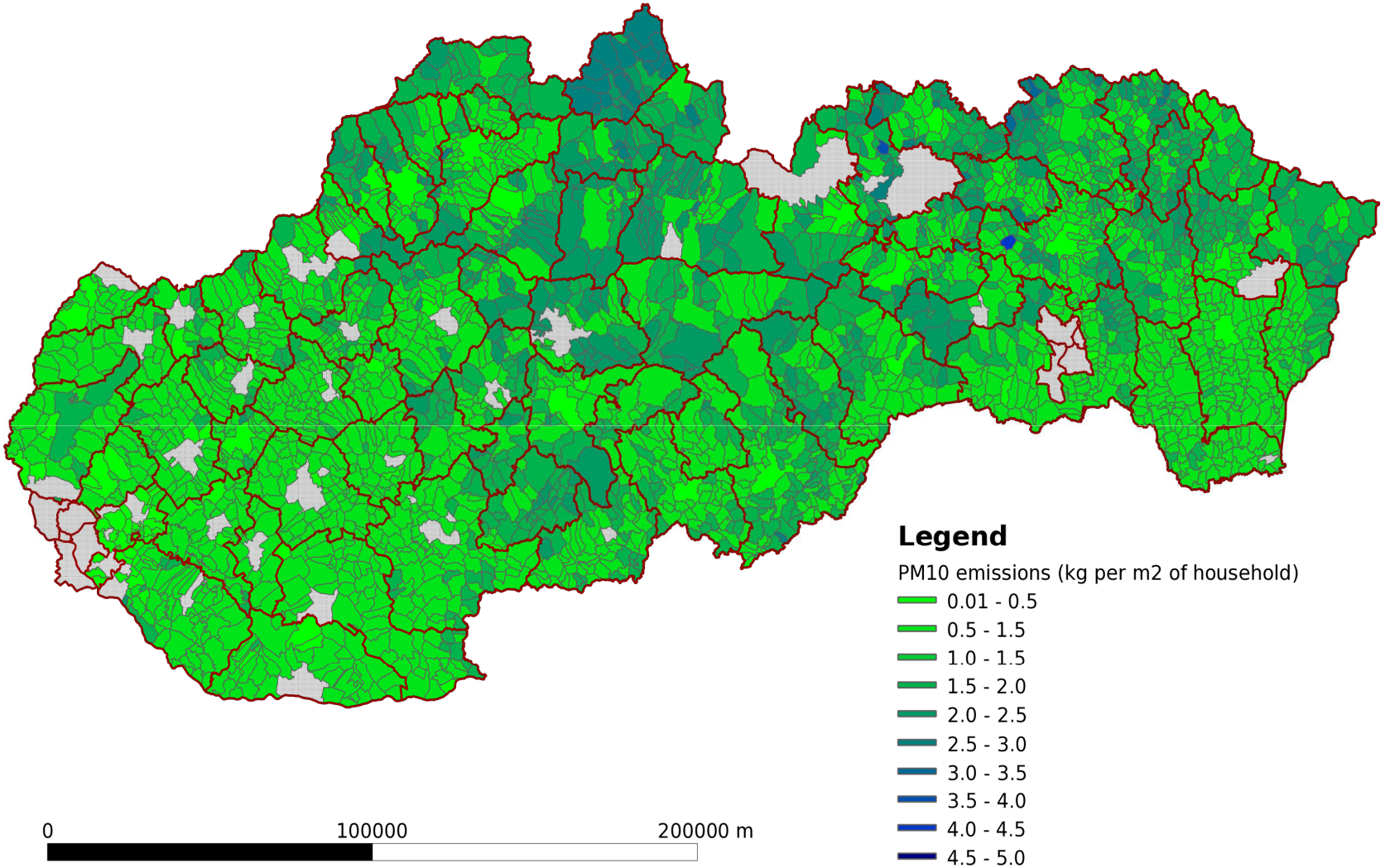
PM_{10} EMISSIONS FROM WOOD COMBUSTION

$$PM_{wood} = \frac{G_{wood}}{HV_{wood} EF_{wood}} EM_{wood}$$

where

G_{wood}	is the energy deficit covered supposedly by wood combustion
PM_{wood}	are the total annual emissions of PM_{10} for the municipality from residential wood combustion (kg/year),
HV_{wood}, EF_{wood}	are heat value and energy conversion efficiency of wood, and
EM_{wood}	is PM_{10} emission factor of wood combustion, as given in MZP SR (2007)

PM_{10} annual emissions from wood combustion



FUTURE WORK – IMPROVEMENT OF THE EMISSION DATABASE

- Obtain more disaggregated data on the gas consumption and the number of gas connections (household vs. commercial), especially in cities.
- Introduce regionally and population-varying thermal loss factor,
- Investigate the most appropriate value for the PM_{10} emission factor for wood,
- Obtain newer housing and household-associated data (new population census in 2011) (number and age of apartments in family houses vs. apartment blocks, household equipment statistics),

FUTURE WORK - MODELING

- Implementing CAMx model (long range transport)
- Local modeling on small domains using CALPUFF (source apportionment)

Thanks for your attention !