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New Trends and Challenges for Air Quality Control

University of Latvia - Faculty of Geography and Earth Sciences

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REVIEW OF AMBIENT PARTICULATE MATTER LEVELS AND SOURCE CONTRIBUTION IN SERBIA

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Regulation of PM monitoring in Serbia

Particulate matter (PM) is the air pollutant that currently receives most attention from the atmospheric research community, the legislative authorities and the general public.

European and Serbian legislation currently regulates PM in two size fractions that are PM_{10} and $PM_{2.5}$.

In Serbia the adopted *Law of Air Protection* and the *Regulation for condition for monitoring and requirement for air quality* enable harmonization with EU legislation in air pollution monitoring and management.

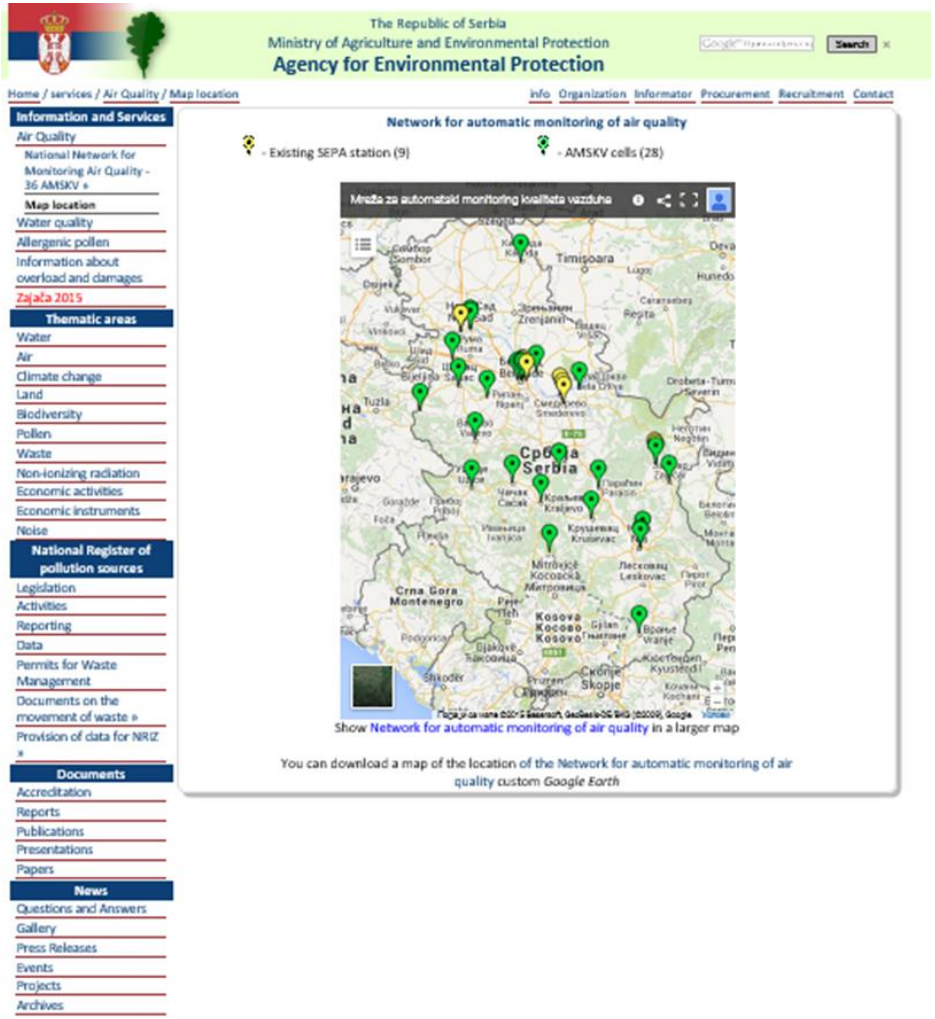
Instead of collecting TSP, the historically monitored air pollutant, the current *Law* and *Regulation* introduce mandatory monitoring of PM_{10} and $PM_{2.5}$, and require determination of heavy metals and BaP.

National network of AMS in Serbia

Public Health Institute of Belgrade (PHI) has started first to monitor of PM_{10} in Serbia in Belgrade in 2003, while The Serbian Environmental Agency (SEPA) has started measuring air pollution including PM_{10} at **automatic monitoring stations (AMS)** in 2006.

Jurisdiction over the national network for monitoring air quality at the level of the Republic of Serbia is SEPA that currently running 35 AMS all over the Serbia.

http://www.sepa.gov.rs

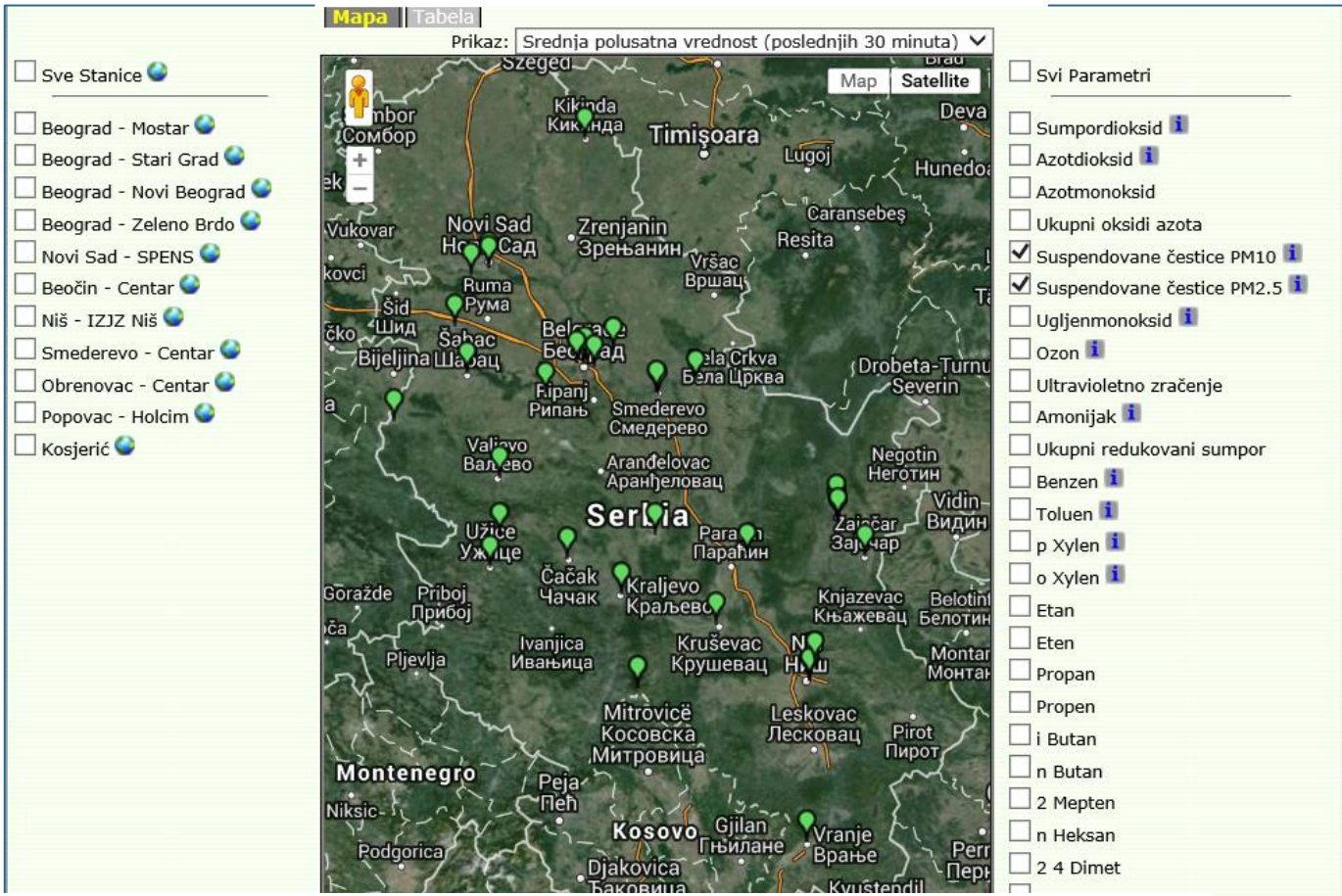


AMS of PM in Serbia running under SEPA

http://www.sepa.gov.rs

PM10 and PM2.5 are measuring at 11 AMS: urban areas of Niš, Obrenovac, Smederevo, Novi Sad; in vicinity of cement kiln in Beočin, Popovac, Kosjerić; 4 AMS in Belgrade central zone.

Pollutants levels are presented at SEPA's portal:



- table with air pollution values in real time, update every 30 min,
- graphs for last 24h, 3 days, 1 week and 1 month.

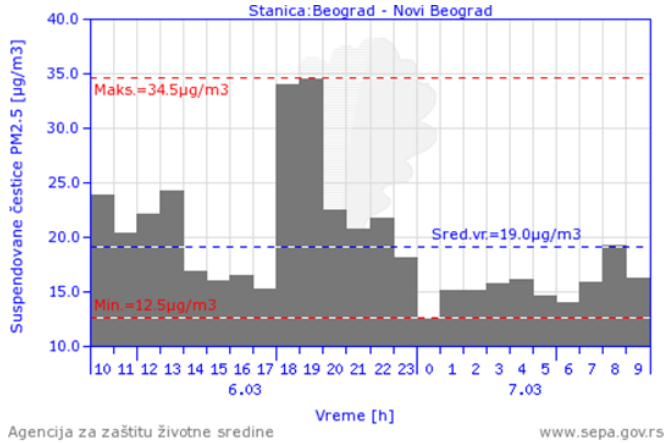
AMS of PM in Serbia running under SEPA

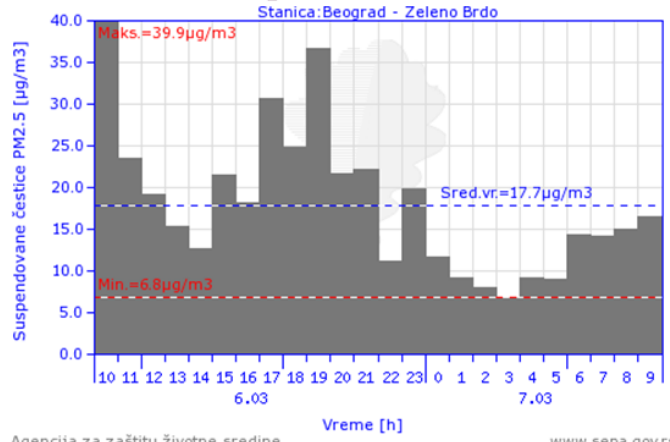
AMS running under SEPA-State Network

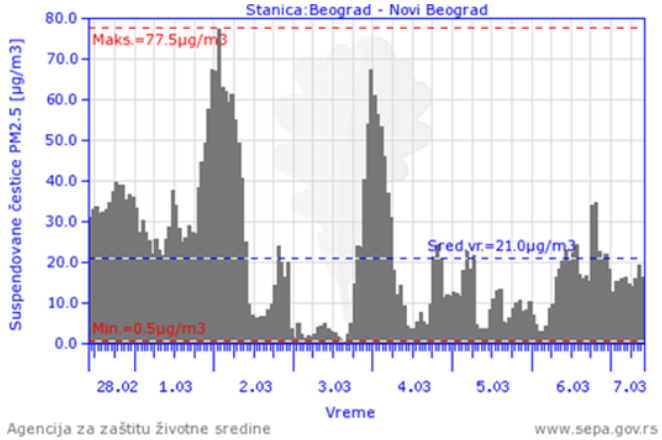
http://www.sepa.gov.rs/

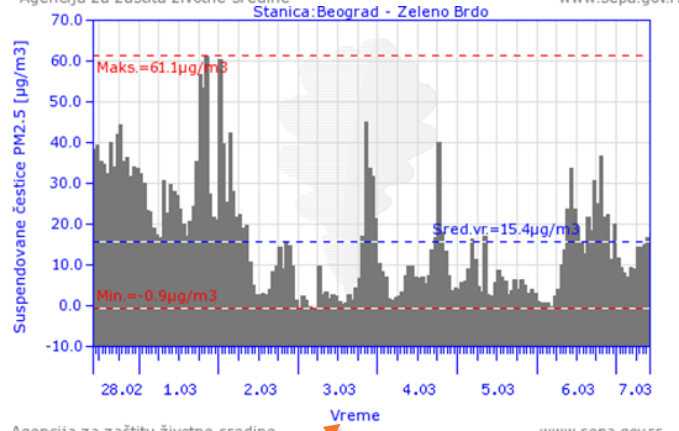
IPA project recently has been started and till summer 2015. all AMS in Serbia will be presented at unique web address

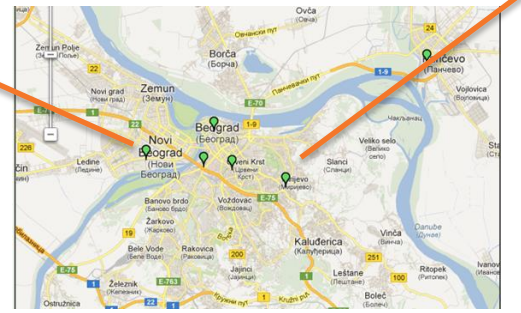
http://www.sepa.gov.rs











Regional network for PM monitoring in Serbia

Further, monitoring has been done since 2008 under. the auspices of Province of Vojvodina Secretary of Environmental Protection, http://www.eko.vojvodina.gov.rs/?q=node/264.

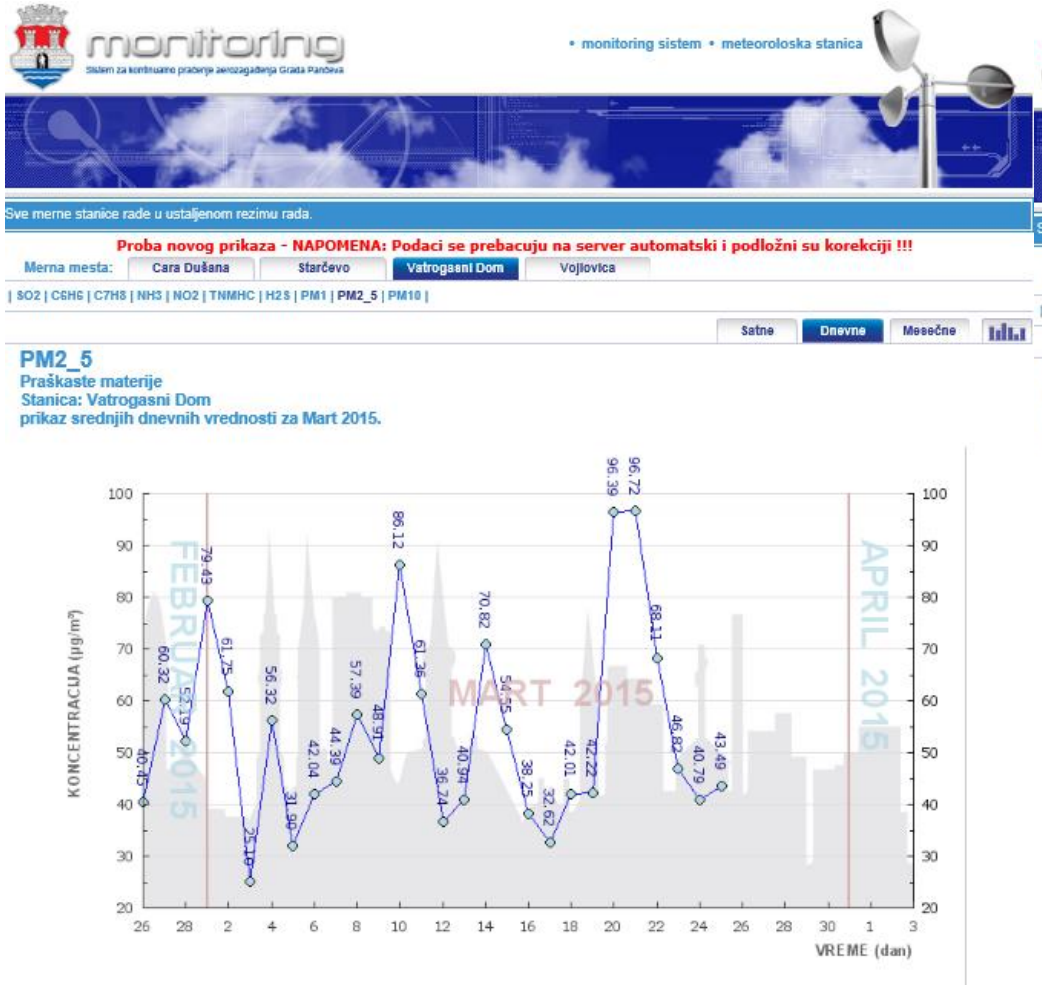
In 2013. regional monitoring network consist of 7 AMS, where PM_{10} is currently collected only in town of Zrenjanin.

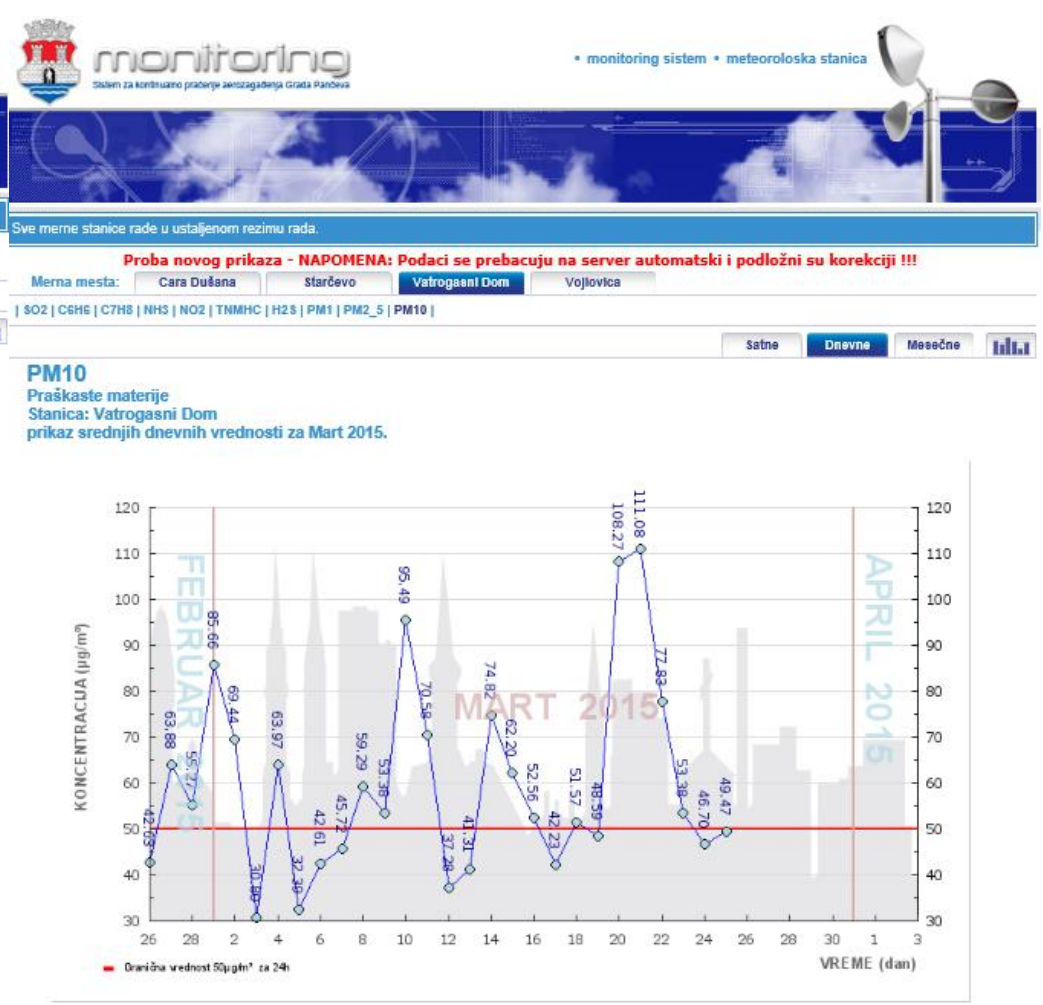
If existing data for each of pollutants they may be available with resolution of 60 minute, but not in the real-time.

Local network for PM monitoring in Pančevo

Pančevo, town where it the petrochemical complex, is located 13 km NE from city center of Belgrade. Municipality of Pančevo conducts monitoring of air pollution with AMS at 4 sites, where 3 sites are equipped with PM_{10} and 1 with $PM_{2.5}$ monitors, http://www.pancevo.rs/Monitoring-163-1

Local network for PM monitoring in Pančevo





http://monitoring.pancevo.rs/monitoring/15/19/VD10v.txt/PM2_5/

http://monitoring.pancevo.rs/monitoring/15/19/VD10v.txt/PM10/

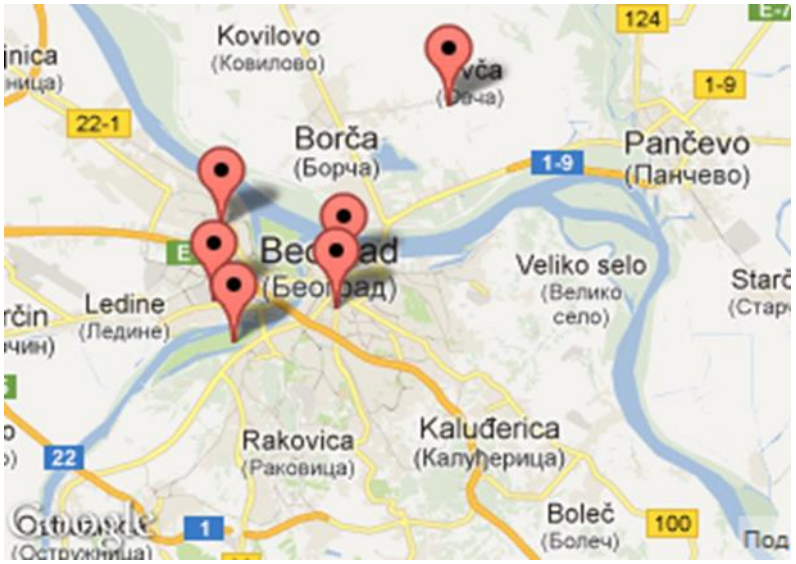
Local network for PM monitoring in Belgrade

Today there are 8 automatic stations running in Belgrade Metropolitan under PHI: local monitoring network - 4 in city center and 2 in region of Belgrade in vicinity of thermal power plants Obrenovac and Kolubara, national network - more 2 AMS located in city center

AMS running under Public Health Institute of Belgrade-Municipal Network

http://www.beoeko.com/

Wireless data transfer as well as web presentation of data not working since middle of 2014.



Spatial coverage of PM monitors at AMS in Serbia

In summary of all networks in Serbia, there are currently running 21 AMS that monitor PM_{10} while there are only 6 that register $PM_{2.5}$.

Spatial coverage of Serbia by PM monitors is uneven as more than 70% of PM monitors are concentrated in Belgrade Metropolitan and towns in its surrounding.

Beside real time monitoring at AMS SEPA continualy or periodicaly collected PM_{10} data with 15 sequential samplers, that improve spatial coverage of PM_{10} measurements and reporting.

Annual Report of Air Quality in Serbia for 2013

- For assessment of air quality in agglomerations and zones SEPA takes in account both, PM verified values from AMS and PM data collected with reference gravimetric samplers.
- During 2013, the annual limit value for PM_{10}, 40 µg/m3, was exceeded on most of locations.
- The highest annual average concentrations were recorded at the following locations: Valjevo (63µg/m3), Užice (61µg/m3) and Belgrade_Despota Stefana_PHI (55 µg/m3).
- Exceedances of daily limit values, 50 µg/m3, during 2013, occurred most frequently in Belgrade: Beograd_Despota Stefana_PHI 146 days, Beograd_Ovca_PHI 123 days, in Smederevo-Smederevo_Centar 119 days and Valjevo 118 days

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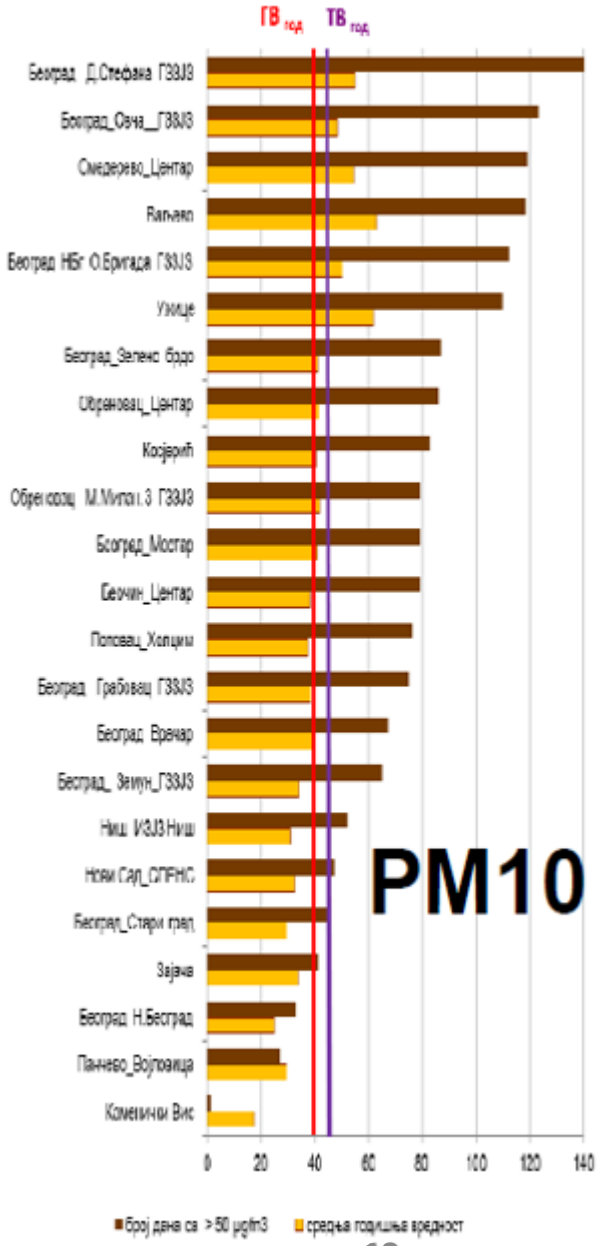
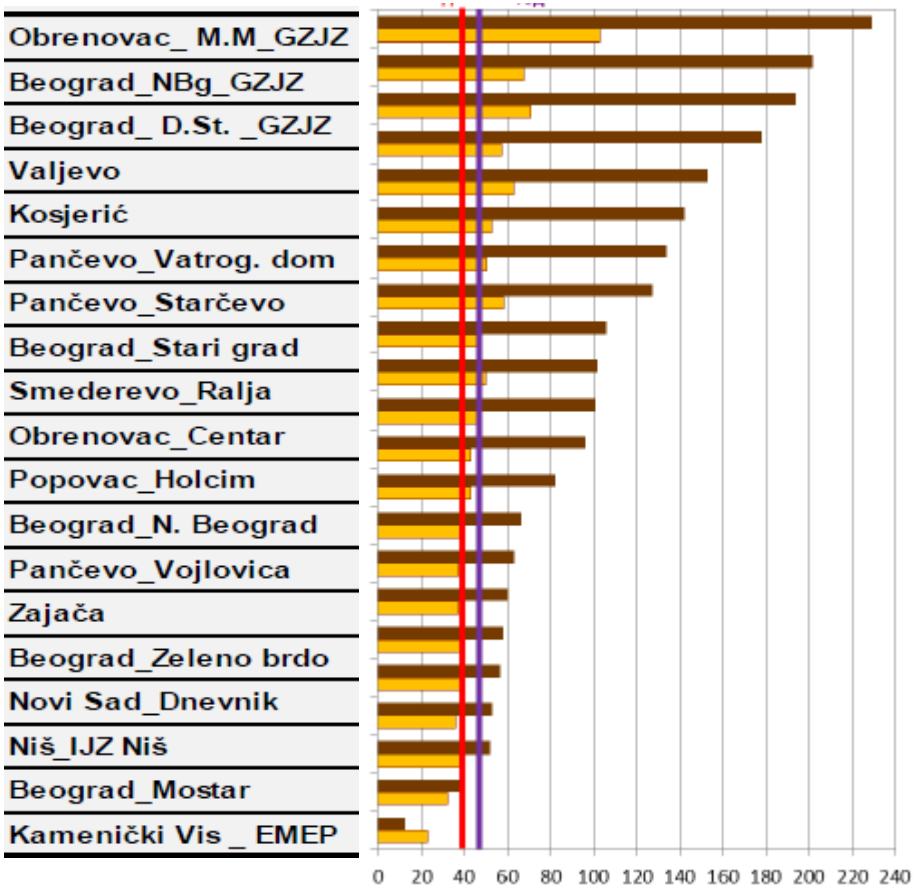


Exceedances frequency of PM10 at National network 2012

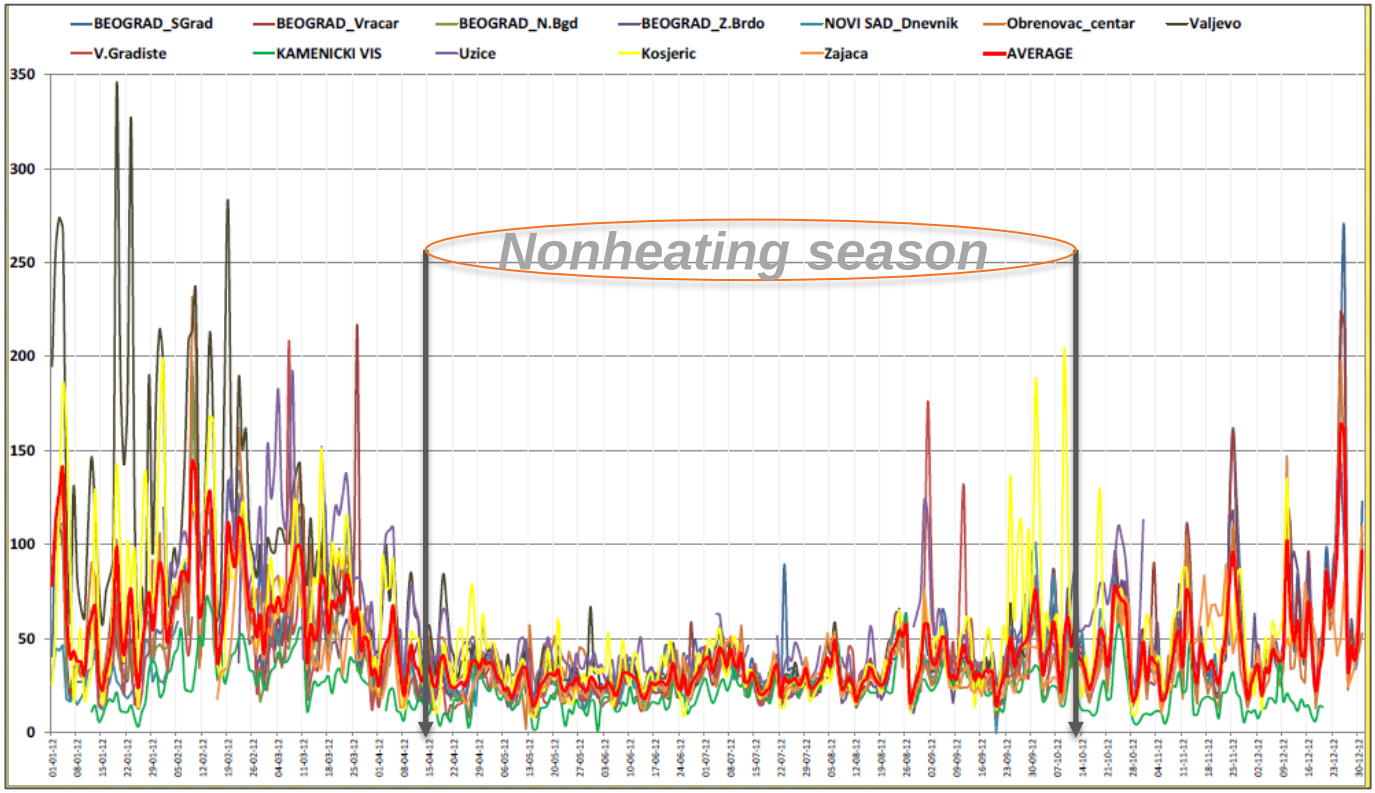
2012



Variation of 24h average concentration through 2012

12 monitors and reference pumps running under SEPA:

- 11 located in urban areas
- 1 located at regional background site, Kamnicki Vis



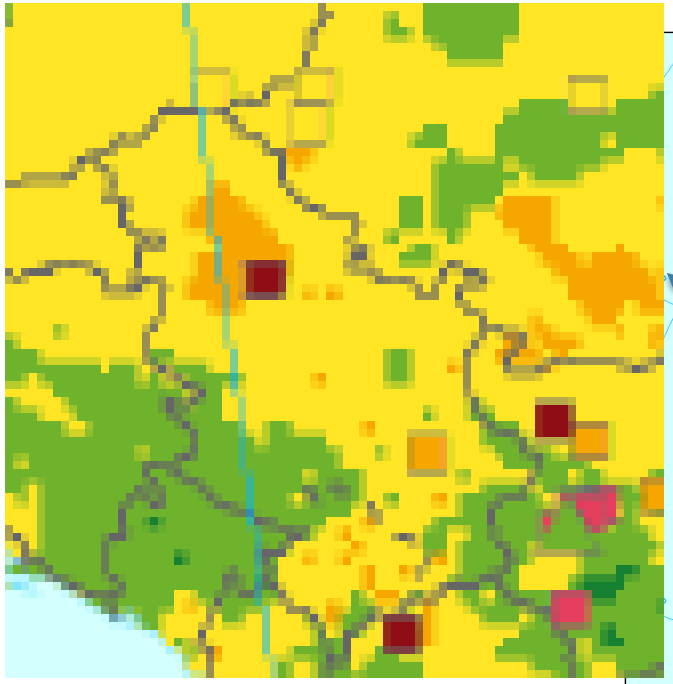
Strong difference in PM10 level during heating and non-heating season

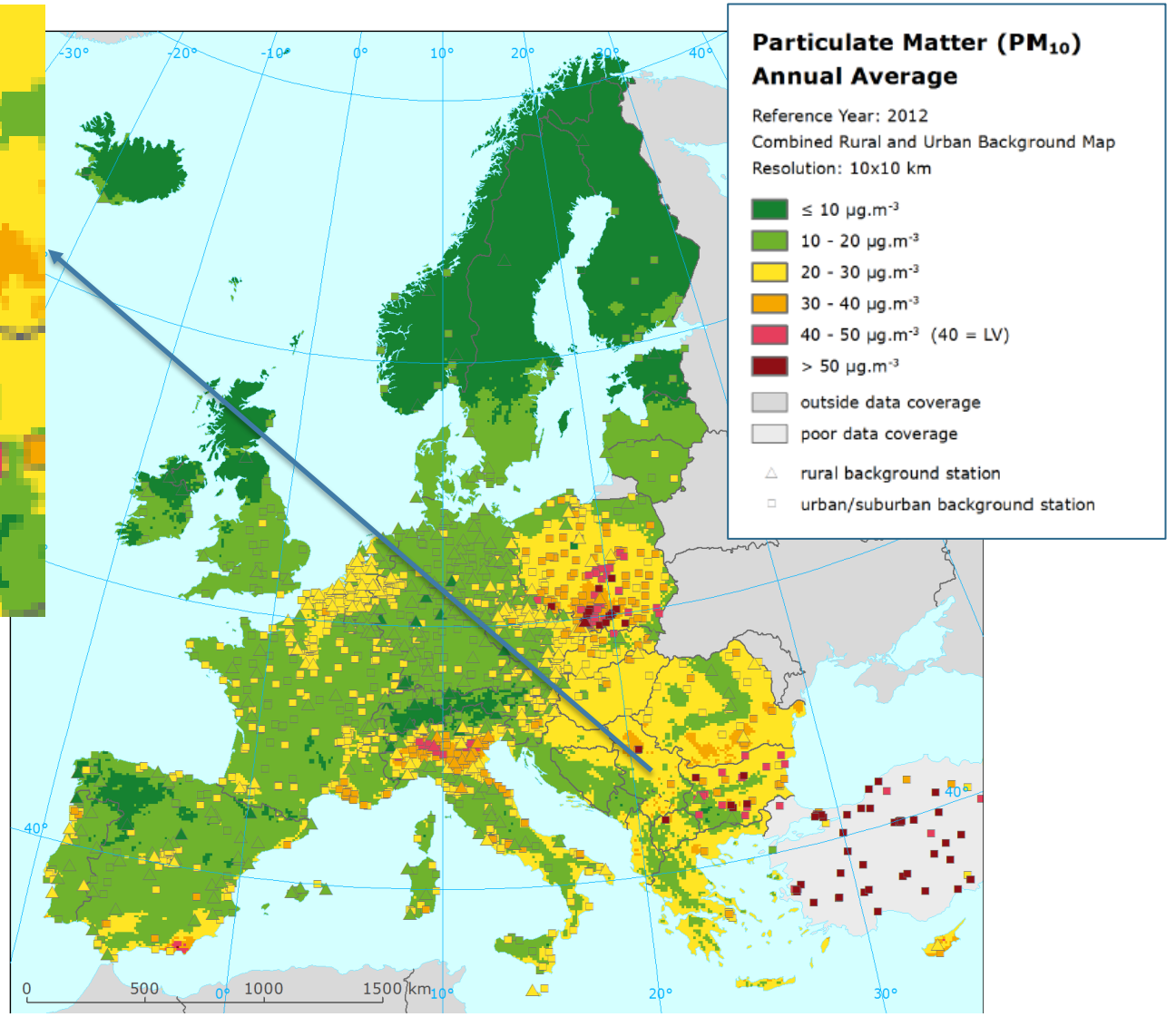
PM_{10} and $PM_{2.5}$ assessment for Serbia for 2012.

Data about air pollution in Serbia have been reported into the EEA operated AirBASE since 2003.

In recently published ETC/ACM Technical Paper 2014/4 with maps for PM and O_3, that are analysis based on interpolation of annual statistics of observational data from 2012 there are presented maps for Europe including Serbia with levels of annual average of combined rural and urban background PM_{10} and $PM_{2.5}$.

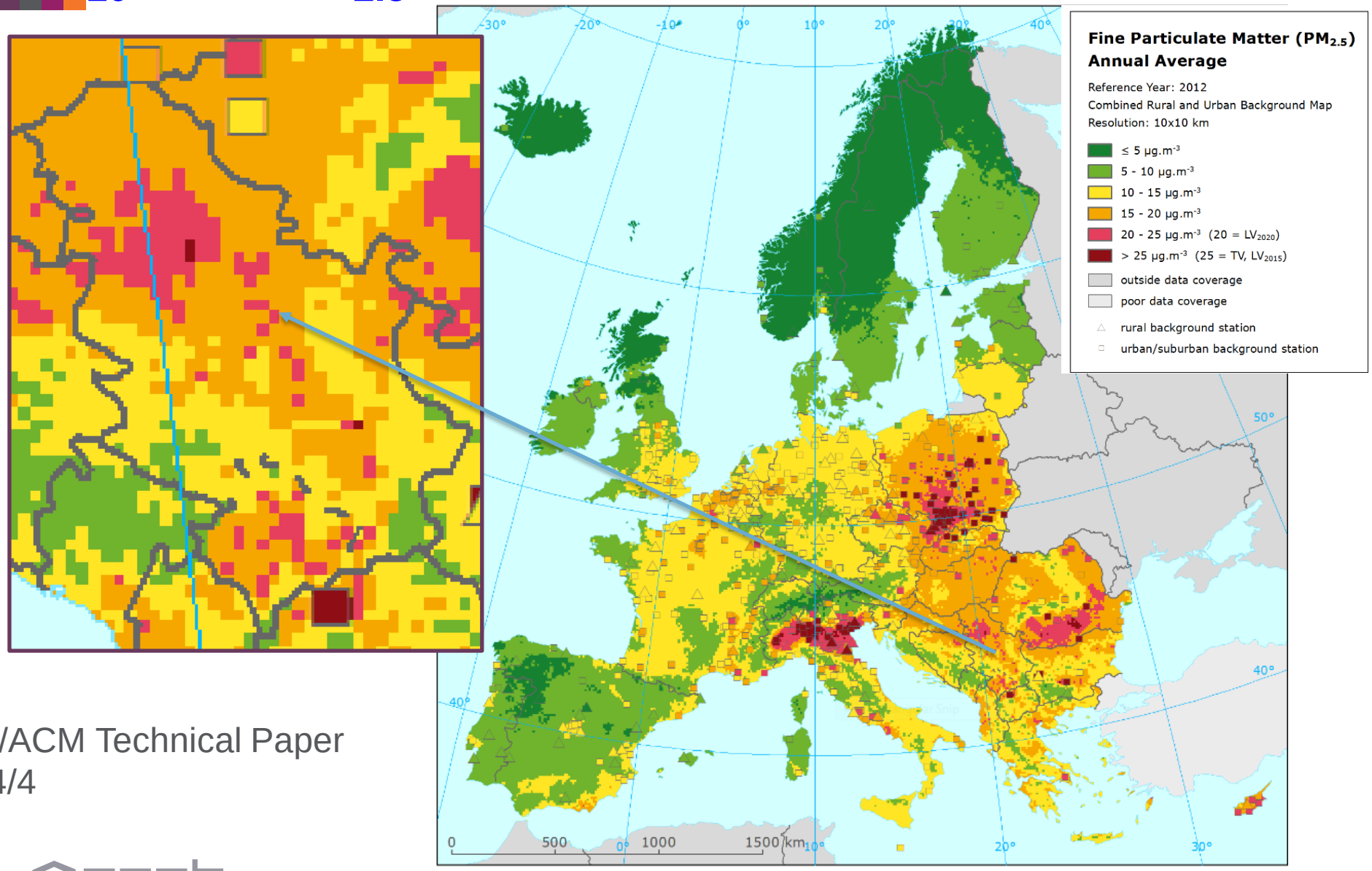
PM_{10} and $PM_{2.5}$ assessment for Serbia for 2012





ETC/ACM Technical Paper 2014/4

PM_{10} and $PM_{2.5}$ assessment for Serbia for 2012



ETC/ACM Technical Paper 2014/4

Examples of research studies of PM in Serbia

In last decade it has been performed research studies in urban areas in Serbia on the bases of data observed at local monitoring network or due to campaigns performed during winter and summer season.

During winter at almost all cities PM level were twice as during summer period.

Average values were >40 μg/m3 during heating and < 40 μg/m3 during non-heating period.

Examples of research studies of RPM in Serbia

Overview of monitoring instruments, sampling periods and levels of PM10 and PM2.5 observed at automatic stations or during campaigns in cities in Serbia

Sampling site(s)	Sampling period and duration	Sampling instrument and flow	Main results and remarks m(mg/m^3)
Belgrade **3 sampling sites in city center**	June-December 2002; 24h data sets; 47 of PM_{10} and 49 of $PM_{2.5}$ samples	Mini-Vol LVS Airmetrics, Co. Inc. 75 lpm	PM_{10} :μ=56 summer, μ=96 winter $PM_{2.5}$: μ=35 summer, μ=75 winter
Belgrade **2 sampling sites in city center**	June 2003-July 2005 209 PM_{10} and 64 $PM_{2.5}$	Mini-Vol LVS Airmetrics, Co. Inc. 75 lpm	PM_{10} : μ=68 (σ= 46.4) $PM_{2.5}$: μ= 61.4 (σ= 52,2)
Belgrade **1 sampling sites**	November 2007-May 2008 4 sessional campaigns each 20 days 24h data sets	LVS Leckel / 37,3 lpm	PM_{10} : μ=96 autumn, μ=89 winter, μ=40 spring μ=32 summer $PM_{2.5}$: μ=73 autumn, μ=66 winter, μ=22 spring μ=18 summer PM_{1} : μ=48 autumn, μ=38 winter, μ=14 spring μ=11 summer
Belgrade **1 sampling site**	November 2008- November 2009 4 campaigns each at least 20 days 24h data sets	LVS Leckel/ 37,3 lpm	PM_{10} : μ=23.1 summer, μ=69.7 winter $PM_{2.5}$: μ=12.8 summer, μ=49.8 winter $PM_{1:}$ μ=8.8 summer, μ=28 winter
Belgrade **1 sampling site city center**	March-May 2010 40 days, 24h data sets	LVS Leckel/ 37,3 lpm	Belgrade (traffic-residential) PM_{10} : μ=44.84 $PM_{2.5}$: μ=40.04

Examples of research studies of RPM in Serbia

Overview of monitoring instruments, sampling periods and levels of PM10 and PM2.5 observed at automatic stations or during campaigns in cities in Serbia

Sampling site(s)	Sampling period and duration	Sampling instrument and flow	Main results and remarks m(mg/m^3)
Novi Sad **AMS, state network**	-November 2009- July 2011 -PM_{10} continual monitoring	GRIMM	μ=38,35 s=26,27 -rush hours 7-10 and 18-22 slight increase, while slight decrease over weekend -heating period m>40, nonheating m<40
Zrenjanin **AMS, regional network**	- 2005-2007 -PM_{10} continual monitoring	MP101 Teom	Daily average calculated for 676 days: μ=33.76; nonheating period 417 samples μ=27.95, exceedence 7.43%; heating 263 samples m =42.68 exceedance 28.51%
Bor **Niš**	-September 2009-July 2010 -4 sessional campaigns each 20 days in both towns -24h data sets	LVS Leckel/ 37,3 lpm	Bor (residential-industrial) PM_{10} : μ=34.1 summer, μ=53.4 winter $PM_{2.5}$: μ=22.8 summer, μ=42.5 winter -Nis (residential-traffic) PM_{10} : μ=31.8 summer, μ=57.7 winter $PM_{2.5}$: μ=23.8 summer, μ=42.5 winter
Vršac, Zrenjanin, Bor, Kikinda **1 sampling site per city**	-summer and autumn 2011 -6 days	LVS 24 h gravimetric data set and/or TSI-DRX Dust Track, continuous data, 10 sec resolution;	- Pančevo(urban) TSI: m=40,91 (s=3,02) LVS: μ=40,40 (s=4,40) - Vršac (urban) TSI: μ=43,34 (s=6,07) LVS: μ=47,04(s=4,55) - Zrenjanin (urban) TSI: μ=43,75 (s=6,87) - Bor-Krivelj (industrial) TSI: μ=41,48 (s=7,46) - Kikinda- Banatsko Novo Selo (rural) TSI: μ=12,87 (s=2,17) LVS: μ=13,61 (s=2,17)

Examples of research studies of RPM in Serbia

Overview of receptor modelling studies for PM in the Belgrade

Sampling site(s) location	Period of collecting & no. samples	Sampling instrument(s)/ sampling flow	Analyses	Main results and remarks
Belgrade **3 sampling sites in the city centre**	June 2003 - July 2005 ; 50 PM_{10} samples	Mini-Vol LVS Airmetrics, Co. Inc. sampling flow 5 lpm; Teflon and Quarz filters, $PM_{2.5}$, PM_{10}	Perkin Elmer FAAS, AA 200 And GFAAS AA 600: Pb. Cu, Zn, Mn, Fe, Cd, Ni, V, Al, Cr	UNMIX modelling-$PM_{2.5}$ Fossil fuel 40%, metallurgical industry 13%, resuspended road dust 47% PSCF* and CWT**: PM_{10} high probability for NW and W; V similarly distributed in NE, Al and Mn dominant from local sources, Mn transport from SE;
Belgrade **3 sampling sites, city centre**	July 2003-December 2006	Mini-Vol LVS Airmetrics, Co. Inc. sampling flow 5 lpm; Teflon and Quarz filters, PM_{10}	Perkin Elmer FAAS, AA 200 And GFAAS AA 600: Pb. Cu, Zn, Mn, Fe, Cd, Ni, V, Al, Cr	UNMIX modelling-PM_{10} Fossil fuel 34%, regional transport mainly from steel and petrochemical industry 26%, resuspended road dust (19%) and traffic exhaust (21%). PSCF* and CWT**:PM_{10} high concentrations probability W-SW and S pathway.
Belgrade **3 sampling sites, city centre**	2004-2008	Mini-Vol LVS Airmetrics, Co. Inc. sampling flow 5 lpm; Teflon and Quarz filters, $PM_{2.5}$, PM_{10}	-Perkin Elmer FAAS, AA 200 And GFAAS AA 600 : Pb. Cu, Zn, Mn, Fe, Cd, Ni, V, Al, Cr -SEM/EDX JEOL 840A with INCAPentaFETx3	PSCF*, CWT** modelling: most frequently arriving directions W, NW, SW, during winter period N and SE; major contribution of PM_{10} from local and regional sources; $PM_{2.5}$ in heating period mean size value 1.32 μg (s.=52)while 0.44 μg (s=0.27) μg in non-heating period

*PSCF - Potential Source Contribution Function, **CWT - Concentration Weighted Trajectory

Examples of research studies of RPM in Serbia

Overview of receptor modelling studies for PM in the Belgrade

Sampling site(s) location	Period of collecting & no. samples	Sampling instrument(s)/ sampling flow	Analyses	Main results and remarks
Belgrade, city centre **1 sampling site**	-Jun-Dec 2008; -36 samples, every 6th day	HV Cascade Impactors, Model TE-236, collected particles size range Dp<0.49, 0.49< Dp<0.95, 0.95<Dp<1.5, 1.5< Dp<3.0, 3.0<Dp< 7.2 and Dp<7.2 mm.	-IC system Metrohm, type 761 Compact IC, conductometric detector: Na, NH_4,K, Mg, Ca, Cl, NO_3, PO_4, SO_4,	-Mean mass concentration show maximums in 0,49<Dp<0,95 and Dp>7,2 μg/m^3 range -The absolute highest concentration is SO_4^{-2} in the range 0,49<Dp=1,55 μg/m^3 -Main sources for the generation of the particles were the gas precursors SO_2 and NH_3 over Belgrade urban area -PCA suggested the influence of marine aerosol

WeBIOPATR project (2006-2009), partners: NILU, VINCA, PHI

Series of 8 campaigns were performed at one site in Belgrade central zone in framework of WeBIOPATR project (2006-2009).

There were analysed metals, metalloid, cations, anions, OC/EC and 16 priority EPA PAHs.

Collected data were basis for two PhD theses.

Examples of research studies of RPM in Serbia

Overview of receptor modelling studies for PM in the Belgrade

Sampling site(s) location	Period of collecting & no. samples	Sampling instrument(s)/ sampling flow	Analyses	Main results and remarks
Belgrade **1 sampling site**	2007-2008	LVS	ICP-OES: Al, Ba, Ca, Fe, K, Mg, Na, Ti, Zn ICP-MS:As, Cd, Co, Cr, Cu, Mn, Mo, Ni, Pb, Sb, Se,V IC:NO3 -, SO4 2-, NH4 +, K+, Ca2+, Na+. TOT: OC/EC HPLC and HRMS-TOF: biomass burning tracers	-UNMIX modelling PM_{10}: Winter: Biomass burning (52%), crustal/soil (36%), gasoline (5%), diesel (5%), , secondary aerosols (2%) source Summer: soil/crustal (28%) and secondary aerosols (27%) dominant sources, diesel (14%) , gasoline (11%), wood burning (20%) Diesel and gasoline contribution was higher during the summer (25%) than during the winter period (10%).
Belgrade **1 sampling site**	2008-2009	LVS	ICP-OES: Al, Ba, Ca, Fe, K, Mg, Na, Ti,Zn ICP-MS:As, Cd, Co, Cr, Cu, Mn, Mo, Ni, Pb, Sb, Se,V IC:NO3 -, SO4 2-, NH4 +, K+, Ca2+, Na+. PAHs:	-PMF modelling metals, cations and $PM_{2.5}$: Winter mixed coal-fired thermal power plant and fuel oil combustion in heating plants (29.9%); diesel and gasoline (27.7%); (secondary aerosol (23.1%); resuspended dust from road (10%); mixed resuspended salt from road and coal combustion from domestic heating (9.2%). Summer: -PMF modeling PAH in PM_{10}: Winter: coil and oil combustion 62.1% (~18 ng/m^3) , diesel and gasoline 30.4 % (~ 8.8 ng/m3), wood burning 7.5% (~2.9 ng/m3) Summer: coil and oil combustion 29.8 % (~ 0.7 ng/m^3), diesel and gasoline 37.2 % (~ 0.9 ng/m3), 33.2 % (~0.9 ng/m3) wood burning

WeBIOPATR project (2006-2009), partners: NILU, VINCA, PHI

Depending on season, total carbon content was 25-40 %; ions, 20-35 %; elements, about 5-10 % and content of 30-40 % of PM_{10} mass was chemically unidentified.

Analyses suggest differences in source contribution during winter and summer seasons. Contribution of PM from traffic is higher in winter than in summer. Biomass burning including domestic heating was identified as the most dominant man-made source in winter. Other significant sources include soil erosion and secondary aerosol formation that are dominant in summer.

The total mass of 16 measured PAHs in PM_{10} is much higher in winter (29 ng/m3) than in summer (2.4 ng/m3); ratio of PAH in PM_1 to PM_{10} is about 0.5 for both seasons. Average values of BaP are higher than 1 ng/m3 in winter and less than 0.1 ng/m3 in summer period in both PM fractions, PM_{10} and PM_1.

During and after WeBIOPATR project

In the aim of providing an arena for the scientists and regulators, for mutual information about advances related to atmospheric particulate matter issues, covering sources and their contribution, ambient and indoor levels, effects on health and ecosystems, monitoring techniques and assessment methods it was organized:

- 1st and 2nd International WeBIOPATR Workshop: PARTICULATE MATTER: RESEARCH AND MANAGEMENT
  May 2007, Belgrade; August-September, 2009, Mokra Gora

We follow with:

- 3th and 4th International WeBIOPATR Workshop and Conference: PARTICULATE MATTER: RESEARCH AND MANAGEMENT
  November 2011,Belgrade; October 2013, Belgrade

Coming

- **5th International WeBIOPATR Workshop and Conference: PARTICULATE MATTER: RESEARCH AND MANAGEMENT**
  October 2015, Belgrade

Examples of research studies of RPM in Serbia

Tasic et al. compared PM_{10} and $PM_{2.5}$ mass concentration in urban industrial area and in its rural surroundings. There is a significant seasonal difference in $PM_{2.5}$ levels on all rural sites, because they are affected by domestic heating emissions in cold periods.

CONCLUSIONS (1/2)

- For sustainability of established air monitoring networks AMS need to be properly maintained.
- Compared to EU countries, there is a lack of PM data and research studies from Serbia not only for rural and sub-urban areas, but also for urban areas.
- Distributed network with lower-cost sensors for air pollutants including PM may be install as supplementary/preliminary solution for monitoring.

CONCLUSIONS (2/2)

- In framework CITI-SENSE project we are establishing distributed network of devices using low-cost sensors with aim to increase spatiotemporal resolution of PM_{10} and $PM_{2.5}$ in Belgrade central zone and to cover whole Belgrade Master Plan.
- In framework of CITI-SENSE project we prepared fist maps for Belgrade Master Plan area on the basis of European LUR model developed in ESCAPE project.
- We are planning now to build our LUR model according to predictors important for situation in urban areas in Serbia.

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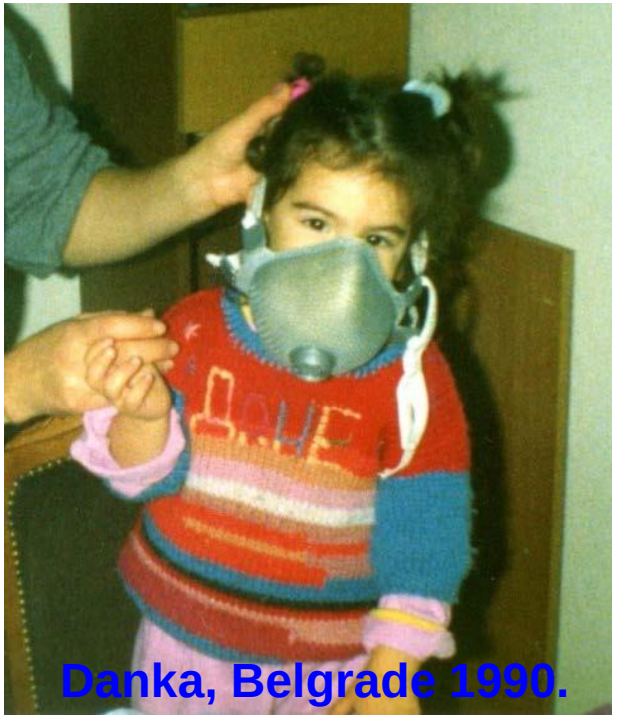
Thank you for your attention



Danka, Belgrade 1990.