



Supplement of

Chemical characterization and source apportionment of PM₁₀ in Belgrade, Serbia: influence of local and regional anthropogenic and natural sources

Bojana Petrović et al.

Correspondence to: Milena Jovašević-Stojanović (webiopat.prj@vin.bg.ac.rs)

The copyright of individual parts of the supplement might differ from the article licence.

Table S1. Overview of the source apportionment studies conducted in Belgrade for the period 2003-2015.

PM fraction	Sampling site	Period	N	PM concentration ($\mu\text{g}/\text{m}^3$)	Chemicals analyzed	Factors resolved	Model used	Reference
1 $\text{PM}_{2.5}$, PM_{10}	1. 44°49'06.7"N 20°27'27.3"E 2. 44°47'39.8"N 20°27'56.3"E	Jun 2003 - Jul 2005	$\text{PM}_{2.5}$: 64; PM_{10} : 209	$\text{PM}_{2.5}$: 61.4 PM_{10} : 68.4	Pb, Cu, Zn, Mn, Fe, Cd, Ni, V, Al, Cr	$\text{PM}_{2.5}$: resuspended road dust (Zn, Al, Mn, Fe) (29%), traffic and oil refineries (Cr, Pb) (17.8%), oil combustion (V, Ni) (17.7%), diesel fuel and local industry (Cu, Cd) (13.5%) PM_{10} : road dust (Mn, Zn, Fe, Al, Ni) (26.1%), fuel oil (V, Ni) (17.4%), road traffic emission (Cu, Cd, Pb) (16.8%), traffic exhaust (Cr, Pb) (13.2%)	PCA	Rajšić et al. 2008
2 PM_{10}	1. 44°49'06.7"N 20°27'27.3"E 2. 44°47'39.8"N 20°27'56.3"E	Jul 2003 -Dec 2006	277	70.1	Al, V, Cr, Mn, Fe, Ni, Cu, Zn, Cd, Pb	Fossil fuel combustion (V, Ni, Fe, Cu, Mn) (34), traffic exhaust/regional transport from industry (Zn, Fe, Mn, Cu, Ni) (26%), traffic related particles/site specific industrial processes (Cu, Pb, Mn, Cd) (21%) , mineral/crustal matter (Al, Fe, Cu, Mn, Ni, Cd) (19%)	Unmix USEPA	Mijić et al. 2012
3	$\text{Dp} \leq 0.49\mu\text{m}$ $0.49 \leq \text{Dp} \leq 0.95$; $0.95 \leq \text{Dp} \leq 1.5$; $1.5 \leq \text{Dp} \leq 3.0$; $3.0 \leq \text{Dp} \leq 7.2$; $\text{Dp} \geq 7.2\mu\text{m}$	44°49'14.25"N 20°27'44.81"E	Jun - Dec 2008	$\text{Dp} \leq 0.49\mu\text{m}$: 7.9 $0.49 \leq \text{Dp} \leq 0.95$: 2.7 $0.95 \leq \text{Dp} \leq 1.5$: 1.8 $1.5 \leq \text{Dp} \leq 3.0$: 2.0 $3.0 \leq \text{Dp} \leq 7.2$: 3.3 $\text{Dp} \geq 7.2\mu\text{m}$: 1.3	Na^+ , NH_4^+ , K^+ , Mg^{2+} , Ca^{2+} , Cl^- , NO_3^- , SO_4^{2-} , PO_4^{3-}	Ammonium sulphate (SO_4^{2-} , NH_4^+ , Cl^- , Mg^{2+}) (16.4%); marine aerosol (Na^+ , Cl^-) (14.9%); construction activities (Ca^{2+}) (10%); fertilizer plant (PO_4^{3-}) (8.5%); industrial zone (Cl^- , SO_4^{2-} , NH_4^+ , K^+); (8.1%) biomass burning (K^+) (8%)	PCA	Đorđević et al. 2012
4 PM_{10}	1. 44°38'42.15"N, 20°26'52.48" E 2. 44°36'11.74"N, 20°06'09.30" E 3. 44°48'03.5" N, 20°27'57.8" E	2010 - 2011		1. Summer: 31.86 Winter: 80.31 2. Summer: 26.16 Winter: 62.38 3. Summer: 44.37 Winter: 88.46	Nap, Acy, Ace, Flu, Phe, Ant, Flt, Pyr, BaA, Chry, BbF, BkF, B[a]P, Ind, DahA, BghiP	*Diesel and gasoline exhaust (traffic 1) (BbF, BkF, B[a]P, Ind, DahA, BghiP) (55.2% winter, 38.5% summer); Unburned petroleum from vehicles (traffic 2) (Nap, Ace, Phe) (13.5% winter, 17.4% summer); Stationary sources (Flt, Pyr, BaA, Chry, BkF, BbF) (31.3% winter, 43.9% summer)	USEPA PMF 3.0	Cvetković et al. 2015
5 PM_{10}	44°49'00.42"N 20°28'12.85"E	2011 - 2015	254	60.51	B[a]P, As, Cd, Cr, Mn, Ni, Pb, Cl^- , Na^+ , Mg^{2+} , Ca^{2+} , K^+ , NO_3^- , SO_4^{2-} , NH_4^+ , OC, EC	Solid fuel burning (B[a]P, As, OC, SO_2 , CO, NO_3^-) (29.8%), Industrial emissions (Cd, Pb) (21.9%), Secondary aerosols (NH_4^+ , SO_4^{2-} , NO_3^-) (19.5%), vehicle derived and particle resuspension (EC, NO_x , soot) (28.7%)	Unmix USEPA	Stojic et al. 2016
6 $\text{PM}_{2.5}$	44°47'12.17"N 20°31'16.63"E	May 2014 - May 2015	133	20.8	Al, Si, P, S, Cl, K, Ca, Ti, V, Cr, Mn, Fe, Ni, Cu, Zn, Br, As, Ba, Pb, NH_4^+ , NO_3^- , SO_4^{2-}	Biomass burning (K, Cl, S, Zn) (14.5%), Traffic (Fe, Pb, Mn, Cu, Zn) (3.9%), secondary sulphate from regional combustion sources (S, NH_4^+) (28.8%),	USEPA PMF 5.0	Todorovic et al. 2020

							local combustion sources and ammonium nitrate (V, Ni, NO ₃ ⁻ , NH ₄ ⁺) (29.7%), soil (Si, Ca, Ti, Fe, Mn) (5.4%) unaccounted (17.8%)		
7	PM _{2.5}	44°47'12.17"N 20°31'16.63"E	Apr 2014 - Aug 2015	166	20.7	Al, Si, S, Cl, K, Ca, Ti, V, Mn, Fe, Cu, Zn, Pb, Ni, P, Cr, As, Br, Ba	Soil (Al) (8%), Biomass burning (Cl, K, Zn, Pb) (15%), Traffic (Ca, Si, Fe, Ti, Mn) (3%), fuel oil combustion (V, Ni) (38%), secondary sulfate (S, Pb, Cu, Ti) (3%), unaccounted (33%)	USEPA PMF 5.0	Almeida et al. 2020
8	PM ₁₀	44°47'25.4"N 20°25'02.5"E	Jun 2023 - May 2024	84	23.9	OC, EC, Na, Mg, Al, K, Ca, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, As, Se, Rb, Sr, Cd, Ba, Pb, P, Ti, Zr, Mo, Sb, Sn, Cl, NO ₃ ⁻ , SO ₄ ²⁻ , NH ₄ ⁺ , galactosan, mannosan, levoglucosan, 2- methylerythritol, 2-methylthreitol, glucose, fructose, mannitol, arabitol, trehalose	Biomass burning (galactosan, mannosan, levoglucosan, K, Cl-, Rb, OC) (21%), Long-range transport and road-salt/local combustion (Na, NO ₃ ⁻ , Cl-) (9%), Mineral dust (Al, Ti, Sr, Mg, Ca) (17%), Primary biological aerosol particles (glucose, fructose, trehalose, mannitol, arabitol) (10%), Biogenic secondary organic aerosol from isoprene (2-methylerythritol, 2-methylthreitol) (10%), Ammonium sulphate (SO ₄ ²⁻ , NH ₄ ⁺) (18%), Traffic/industry (EC, Fe, Sb, Cu, Sn, Mn, Pb, V, Cd, As) (15%)	USEPA PMF 5.0	This study

N – number of samples

*factors resolved in sampling site in urban zone of the city (Slavija)



Figure S1. Map of Belgrade with monitoring sites included in the studies from the Table S1 (Source: © Google Earth 2026, images: Airbus).

Rajšić et al. 2008, Mijić et al. 2012: Roof of Rector's Office (1), Faculty of Veterinary Medicine (2); Đorđević et al. 2012: Knjeginje Ljubice 21 (3); Cvetković et al. 2015: Lazarevac (4.1.), Grabovac (4.2.) Slavija (4.3.), Stojić et al. 2016: Institute of Public Health Belgrade (5); Todorović et al. 2020, Almeida et al. 2020: Zeleno brdo (6, 7); this study: Ada Marina (8).

Table S2. Seasonal levels of analysed species (ng m^{-3}) in Belgrade during WeBaSOOP campaign (N=84).

Species	N	Average ($\pm$ SD)	Spring ($\pm$ SD)	Summer ($\pm$ SD)	Autumn ($\pm$ SD)	Winter ($\pm$ SD)	NH ($\pm$ SD)	H ($\pm$ SD)
PM ₁₀ *	84	23943 ($\pm$ 14867)	20107 ($\pm$ 9724)	20289 ($\pm$ 7754)	23283 ($\pm$ 19876)	32537 ($\pm$ 17456)	19272 ($\pm$ 7750)	28189 ($\pm$ 18259)
OC	84	8185 ($\pm$ 6489)	5288 ($\pm$ 1790)	6412 ($\pm$ 2326)	8441 ($\pm$ 8330)	12996 ($\pm$ 8313)	5936 ($\pm$ 2255)	10230 ($\pm$ 8227)
EC	84	1384 ($\pm$ 1030)	927 ($\pm$ 450)	933 ($\pm$ 362)	1636 ($\pm$ 1106)	2140 ($\pm$ 1371)	955 ($\pm$ 492)	1774 ($\pm$ 1225)
OM	84	11459 ($\pm$ 9085)	7403 ($\pm$ 2506)	8977 ($\pm$ 3257)	11818 ($\pm$ 11662)	18194 ($\pm$ 11638)	8310 ($\pm$ 3157)	14322 ($\pm$ 11518)
Cl ⁻	84	135 ($\pm$ 185)	70 ($\pm$ 119)	25 ($\pm$ 49)	178 ($\pm$ 169)	285 ($\pm$ 237)	26 ($\pm$ 39)	234 ($\pm$ 208)
NO ₃ ⁻	84	1294 ($\pm$ 1498)	615 ($\pm$ 345)	364 ($\pm$ 131)	1647 ($\pm$ 1486)	2709 ($\pm$ 1894)	478 ($\pm$ 364)	2035 ($\pm$ 1740)
SO ₄ ²⁻	84	2531 ($\pm$ 1874)	2140 ($\pm$ 1194)	3201 ($\pm$ 2176)	2213 ($\pm$ 2564)	2532 ($\pm$ 1296)	2967 ($\pm$ 2174)	2135 ($\pm$ 1467)
NH ₄ ⁺	84	673 ($\pm$ 541)	444 ($\pm$ 299)	776 ($\pm$ 609)	672 ($\pm$ 652)	815 ($\pm$ 522)	716 ($\pm$ 572)	634 ($\pm$ 514)

Na	83	158 (± 132)	156 (± 159)	74 (± 31)	196 (± 123)	211 (± 135)	82 (± 73)	225 (± 137)
Mg	84	109 (± 105)	128 (± 174)	82 (± 49)	107 (± 80)	117 (± 61)	79 (± 69)	135 (± 125)
Al	83	409 (± 426)	572 (± 694)	347 (± 219)	282 (± 253)	412 (± 291)	338 (± 303)	471 (± 506)
K	84	353 (± 385)	219 (± 162)	142 (± 67)	411 (± 439)	672 (± 488)	157 (± 88)	531 (± 459)
Ca	84	492 (± 413)	611 (± 643)	432 (± 252)	395 (± 246)	507 (± 328)	416 (± 320)	561 (± 476)
V	84	1.67 (± 1.48)	1.35 (± 1.27)	0.91 (± 0.57)	1.67 (± 1.21)	2.83 (± 1.89)	0.91 (± 0.69)	2.37 (± 1.66)
Cr	66	2.59 (± 2.41)	4.62 (± 2.80)	1.24 (± 0.94)	0.84 (± 0.90)	3.21 (± 2.22)	1.67 (± 1.90)	3.42 (± 2.53)
Mn	81	7.29 (± 5.20)	7.82 (± 6.66)	6.09 (± 3.20)	6.59 (± 4.02)	8.66 (± 6.10)	5.87 (± 3.79)	8.49 (± 5.92)
Fe	80	497 (± 375)	512 (± 444)	412 (± 234)	463 (± 291)	603 (± 477)	391 (± 246)	584 (± 439)
Co	80	0.12 (± 0.12)	0.14 (± 0.17)	0.10 (± 0.08)	0.12 (± 0.13)	0.13 (± 0.10)	0.08 (± 0.08)	0.15 (± 0.14)
Ni	84	2.07 (± 1.24)	2.49 (± 1.20)	1.43 (± 0.86)	1.94 (± 0.97)	2.42 (± 1.55)	1.67 (± 0.84)	2.44 (± 1.43)
Cu	64	6.00 (± 7.06)	2.67 (± 2.58)	2.66 (± 2.18)	9.38 (± 8.20)	8.49 (± 8.91)	2.40 (± 2.14)	8.46 (± 8.16)
Zn	54	19.17 (± 20.80)	3.52 (± 4.02)	6.93 (± 6.82)	26.38 (± 18.70)	24.48 (± 25.36)	9.22 (± 13.21)	23.00 (± 22.02)
Ga	71	0.10 (± 0.10)	0.17 (± 0.18)	0.07 (± 0.05)	0.07 (± 0.07)	0.09 (± 0.05)	0.08 (± 0.07)	0.11 (± 0.12)
As	80	1.01 (± 0.90)	0.59 (± 0.48)	0.57 (± 0.39)	1.28 (± 0.77)	1.63 (± 1.21)	0.62 (± 0.52)	1.34 (± 1.01)
Se	82	0.33 (± 0.17)	0.32 (± 0.19)	0.36 (± 0.11)	0.32 (± 0.20)	0.34 (± 0.17)	0.33 (± 0.15)	0.33 (± 0.18)
Rb	84	0.86 (± 0.88)	0.68 (± 0.75)	0.49 (± 0.27)	0.87 (± 0.95)	1.44 (± 1.10)	0.45 (± 0.34)	1.24 (± 1.04)
Sr	84	1.97 (± 2.13)	2.67 (± 3.48)	1.46 (± 1.10)	1.71 (± 1.46)	1.98 (± 1.22)	1.61 (± 1.33)	2.31 (± 2.62)
Cd	84	0.16 (± 0.15)	0.09 (± 0.08)	0.08 (± 0.06)	0.17 (± 0.15)	0.29 (± 0.17)	0.08 (± 0.06)	0.22 (± 0.17)
Ba	83	11.24 (± 8.38)	5.78 (± 2.95)	8.05 (± 4.74)	15.84 (± 6.67)	16.35 (± 11.29)	7.41 (± 5.04)	14.80 (± 9.32)
Pb	81	3.27 (± 2.90)	2.60 (± 2.46)	2.39 (± 1.58)	3.50 (± 2.56)	4.64 (± 3.99)	2.36 (± 2.12)	4.04 (3.21)
P	84	19.31 (± 12.32)	25.73 (± 16.60)	21.62 (± 7.63)	11.22 (± 7.75)	16.80 (± 9.78)	21.20 (± 11.05)	17.59 (± 13.26)
Ti	81	20.09 (± 27.58)	35.83 (± 46.59)	16.30 (± 9.64)	12.33 (± 11.82)	16.81 (± 9.67)	17.08 (± 15.11)	24.63 (± 34.94)
Zr	58	1.98 (± 1.60)	2.76 (± 1.72)	1.98 (± 1.40)	1.54 (± 1.87)	1.65 (± 1.32)	2.07 (± 1.59)	1.92 (± 1.62)
Mo	66	12.46 (± 12.25)	11.56 (± 5.24)	26.50 (± 14.37)	7.01 (± 12.48)	7.79 (± 7.14)	20.66 (± 13.66)	6.04 (± 5.42)
Sb	83	1.11 (± 0.92)	1.14 (± 1.03)	0.82 (± 0.52)	0.96 (± 0.70)	1.50 (± 1.15)	0.76 (± 0.52)	1.41 (± 1.08)
Sn	74	6.41 (± 6.79)	3.15 (± 2.40)	2.73 (± 2.58)	11.65 (± 8.77)	7.76 (± 6.68)	3.32 (± 4.15)	8.52 (± 7.45)
Galactosan	84	12.51 (± 22.34)	1.76 (± 3.10)	0.57 (± 0.37)	16.21 (± 25.82)	33.60 (± 26.91)	0.90 (± 1.12)	23.05 (± 26.89)
Mannosan	84	55.3 (± 103.3)	7.9 (± 14.1)	2.1 (± 1.2)	65.6 (± 116.1)	154.0 (± 128.8)	3.6 (± 4.9)	102.2 (± 125.9)
Levoglucosan	84	413.0 (± 682.3)	74.8 (± 116.7)	34.3 (± 15.5)	545.7 (± 779.6)	1066.4 (± 804.1)	48.4 (± 59.1)	744.4 (± 812.0)
2-methylerythritol	84	5.01 (± 7.97)	3.51 (± 4.58)	14.44 (± 9.75)	1.01 (± 1.50)	0.21 (± 0.10)	10.15 (± 9.14)	0.35 (± 0.34)
2-methylthreitol	84	2.05 (± 2.78)	1.43 (± 1.51)	5.51 (± 3.14)	0.78 (± 0.85)	0.21 (± 0.09)	3.97 (± 3.03)	0.31 (± 0.28)

Glucose	84	39.69 (± 25.93)	46.60 (± 25.94)	60.27 (± 24.71)	31.97 (± 15.09)	17.16 (± 10.43)	58.46 (± 23.73)	22.62 (± 12.72)
Fructose	84	10.16 (± 8.46)	15.37 (± 8.73)	15.09 (± 7.56)	6.41 (± 4.76)	2.51 (± 1.44)	16.32 (± 7.54)	4.57 (± 4.41)
Mannitol	84	39.50 (± 32.85)	45.73 (± 27.52)	74.03 (± 28.88)	24.81 (± 16.04)	9.12 (± 5.58)	66.68 (± 27.15)	14.80 (± 10.14)
Arabitol	84	34.84 (± 26.85)	43.67 (± 25.22)	57.73 (± 24.05)	25.02 (± 16.57)	9.63 (± 5.55)	56.75 (± 21.63)	14.93 (± 10.73)
Trehalose	84	16.17 (± 11.51)	20.41 (± 13.15)	25.17 (± 9.36)	11.07 (± 5.26)	6.48 (± 3.49)	24.51 (± 11.17)	8.59 (± 4.37)
Inositol	77	3.15 (± 2.16)	3.55 (± 2.48)	3.83 (± 1.77)	2.92 (± 1.55)	1.71 (± 2.28)	3.96 (± 2.12)	2.26 (± 1.85)
Erythritol	84	4.36 (± 5.17)	4.08 (± 5.07)	8.19 (± 7.13)	2.77 (1.99)	2.00 (1.34)	6.95 (± 6.42)	2.00 (± 1.54)

NH – non-heating season (April 15th – October 15th), H – heating season (October 15th – April 15th), N- number of samples, N – number of samples used for the source apportionment.

*A complete gravimetric PM₁₀ time series, aligned with co-measured species (EC, OC, ions, and trace elements), was unavailable. Missing PM₁₀ values were gap-filled using data from the GRIMM instrument when it agreed to within ±20% of aerosol mass closure derived from the other measured variables; when GRIMM PM₁₀ was outside this range, the mass-closure value was used instead. Mass closure (MC) was calculated as MC = Ions + Mineral Dust + OM + EC + Trace Elements, where OM = OC × 1.4 and mineral dust was reconstructed as Dust = Ca × 1.5 + Al/0.53 + Al/0.53 × 2.5 + Na + Mg + K + Fe. This resulted in final PM₁₀ assignments for 40 samples from GRIMM, 25 from mass closure, and 19 from offline gravimetry.

Table S3. Correlation coefficients between the species included in the PMF.

	PM ₁₀	OC	EC	Cl ⁻	NO ₃ ⁻	SO ₄ ²⁻	NH ₄ ⁺	Na	Mg	Al	K	Ca	V	Mn	Fe	Cu	As	Rb	Sr	Cd	Pb	Ti	Sb	Sn	Gala	Manno	Levo	2-ME	2-MT	Glu	Fru	Manni	Ar	Tre
PM ₁₀	1.00																																	
OC	0.91	1.00																																
EC	0.79	0.88	1.00																															
Cl ⁻	0.61	0.63	0.58	1.00																														
NO ₃ ⁻	0.75	0.77	0.72	0.76	1.00																													
SO ₄ ²⁻	0.56	0.48	0.30	0.11	0.27	1.00																												
NH ₄ ⁺	0.57	0.53	0.34	0.25	0.48	0.91	1.00																											
Na	0.50	0.42	0.46	0.75	0.51	-0.03	0.04	1.00																										
Mg	0.46	0.19	0.19	0.28	0.15	0.11	0.00	0.58	1.00																									
Al	0.36	0.09	0.04	0.19	0.13	0.10	0.07	0.45	0.81	1.00																								
K	0.87	0.93	0.85	0.69	0.76	0.32	0.38	0.53	0.34	0.19	1.00																							
Ca	0.54	0.26	0.26	0.21	0.17	0.20	0.04	0.48	0.94	0.77	0.36	1.00																						
V	0.76	0.70	0.73	0.48	0.59	0.27	0.27	0.49	0.56	0.40	0.81	0.61	1.00																					
Mn	0.73	0.55	0.60	0.35	0.39	0.31	0.20	0.56	0.82	0.65	0.62	0.88	0.78	1.00																				
Fe	0.74	0.58	0.65	0.36	0.40	0.30	0.19	0.53	0.76	0.55	0.64	0.81	0.81	0.97	1.00																			
Cu	0.57	0.66	0.67	0.47	0.55	0.15	0.20	0.36	0.09	0.00	0.67	0.14	0.47	0.38	0.42	1.00																		
As	0.67	0.75	0.76	0.53	0.68	0.35	0.45	0.38	0.26	0.16	0.74	0.27	0.66	0.52	0.53	0.52	1.00																	
Rb	0.90	0.86	0.78	0.65	0.68	0.33	0.33	0.61	0.59	0.43	0.94	0.62	0.86	0.81	0.81	0.59	0.70	1.00																
Sr	0.42	0.19	0.16	0.23	0.08	0.11	-0.01	0.45	0.90	0.75	0.35	0.84	0.55	0.71	0.68	0.06	0.26	0.56	1.00															
Cd	0.77	0.83	0.78	0.58	0.80	0.34	0.47	0.40	0.21	0.14	0.81	0.24	0.69	0.53	0.55	0.58	0.75	0.76	0.15	1.00														
Pb	0.65	0.72	0.72	0.51	0.53	0.35	0.34	0.42	0.20	0.09	0.69	0.28	0.59	0.53	0.57	0.58	0.65	0.69	0.20	0.69	1.00													
Ti	0.28	0.02	0.01	0.07	-0.05	0.00	-0.13	0.44	0.86	0.82	0.17	0.82	0.43	0.66	0.59	0.04	0.06	0.43	0.83	0.05	0.04	1.00												
Sb	0.70	0.66	0.74	0.46	0.51	0.30	0.27	0.52	0.40	0.34	0.64	0.52	0.68	0.71	0.71	0.50	0.60	0.72	0.34	0.62	0.68	0.30	1.00											
Sn	0.42	0.49	0.66	0.40	0.46	0.04	0.11	0.42	0.17	0.01	0.52	0.16	0.49	0.43	0.47	0.61	0.48	0.47	0.07	0.51	0.47	0.01	0.49	1.00										
Gala	0.82	0.94	0.85	0.72	0.82	0.28	0.39	0.46	0.13	0.02	0.95	0.15	0.69	0.45	0.49	0.69	0.73	0.84	0.14	0.83	0.66	0.04	0.58	0.51	1.00									
Manno	0.81	0.93	0.85	0.77	0.83	0.28	0.38	0.50	0.15	0.04	0.94	0.18	0.68	0.47	0.50	0.67	0.71	0.84	0.14	0.82	0.68	0.03	0.62	0.52	0.98	1.00								
Levo	0.80	0.94	0.87	0.73	0.79	0.27	0.37	0.47	0.13	0.03	0.95	0.15	0.69	0.47	0.50	0.71	0.73	0.84	0.13	0.83	0.70	0.04	0.60	0.54	0.99	0.98	1.00							
2-ME	0.02	0.10	0.22	0.38	-0.36	0.52	0.35	0.37	0.09	0.02	0.30	0.03	0.24	0.04	0.04	0.20	0.20	0.21	0.08	0.27	0.02	0.06	0.08	0.27	0.32	-0.31	0.33	1.00						
2-MT	0.04	0.12	0.23	0.40	-0.38	0.46	0.29	0.37	0.07	0.02	0.31	0.04	0.26	0.03	0.03	0.22	0.21	0.22	0.07	0.30	0.07	0.05	0.10	0.27	0.34	-0.33	0.35	0.97	1.00					
Glu	0.31	0.29	0.33	0.48	-0.47	0.06	-0.10	0.49	0.34	0.30	0.44	0.27	0.44	0.35	0.35	0.37	0.36	0.43	0.24	0.45	0.24	0.21	0.35	0.32	0.41	-0.41	0.41	0.46	0.46	1.00				
Fru	0.14	0.23	0.29	0.50	-0.43	0.22	0.03	0.40	0.08	0.02	0.39	0.07	0.30	0.07	0.12	0.30	0.31	0.28	0.03	0.38	0.20	0.02	0.12	0.36	0.42	-0.41	0.44	0.53	0.51	0.67	1.00			
Manni	0.30	0.30	0.35	0.53	-0.51	0.15	0.00	0.50	0.29	0.23	0.49	0.23	0.48	0.30	0.29	0.39	0.38	0.45	0.19	0.49	0.27	0.18	0.33	0.35	0.47	-0.46	0.48	0.58	0.58	0.88	0.69	1.00		

Ara	-	0.34	0.34	0.39	0.54	-0.52	0.08	-0.05	0.50	0.30	0.23	0.48	0.26	0.50	0.35	0.36	0.38	0.39	0.47	0.21	0.52	0.35	0.16	0.39	0.38	0.48	-0.47	0.49	0.48	0.48	0.82	0.70	0.92	1.00
Tre	0.21	0.23	0.26	0.47	-0.46	0.19	0.01	0.46	0.25	0.21	0.41	0.16	0.37	0.22	0.21	0.34	0.33	0.37	0.15	0.40	0.20	0.13	0.24	0.30	0.41	-0.41	0.42	0.57	0.55	0.81	0.68	0.88	0.80	1.00

Correlation coefficients were interpreted according (Schober et al. 2018). Correlation coefficient between 0.40 and 0.69 was considered as moderate correlation (yellow), 0.70 to 0.89 strong correlation (green) and 0.90 to 1 very strong correlation (blue). Gala –galactosan, Manno – mannosan, levo – levoglucosan, 2-ME – 2-methylerythritol, 2-MT – 2-methylthreitol, Glu – glucose, Fru – fructose, Manni – mannitol, Ara – arabitol, Tre – trehalose.

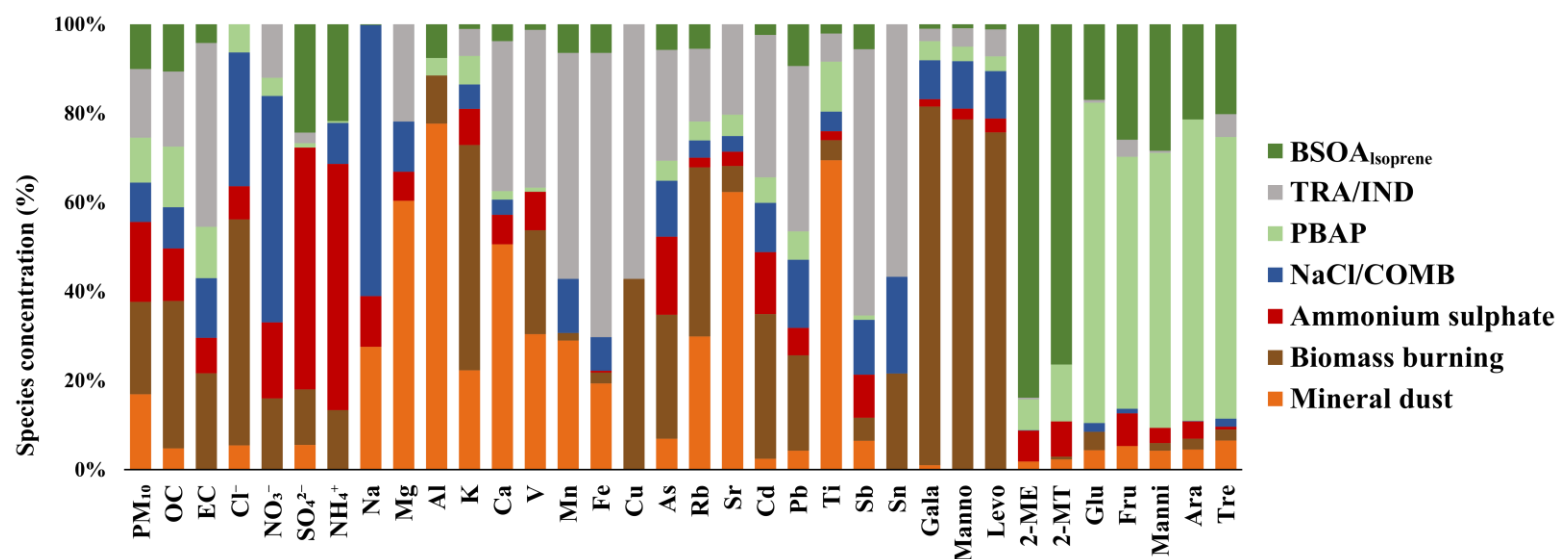


Figure S2. Fingerprints of identified factors in Belgrade; Biomass burning (BB); Long range transport and local combustion (NaCl/COMB); Mineral dust (MD); Primary biological aerosol (PBAP); Biogenic secondary organic (BSOA_{Isoprene}); ammonium sulfate; Traffic/ Industry (TRA/IND); Gala –galactosan, Manno – mannosan, levo – levoglucosan, 2-ME – 2-methylerythritol, 2-MT – 2-methylthreitol, Glu – glucose, Fru – fructose, Manni – mannitol, Ara – arabitol, Tre – trehalose.

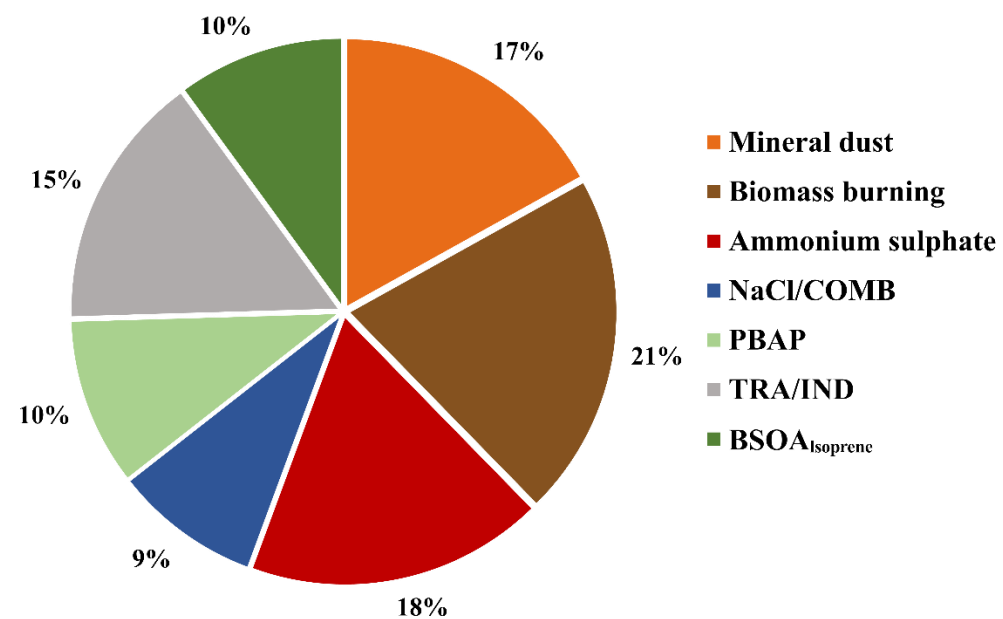


Figure S3. Factor contributions to total PM₁₀ mass concentration. Biomass burning (BB); Long range transport and local combustion (NaCl/COMB); Mineral dust (MD); Primary biological aerosol (PBAP); Biogenic secondary organic (BSOA_{Isoprene}); ammonium sulfate; Traffic/ Industry (TRA/IND).

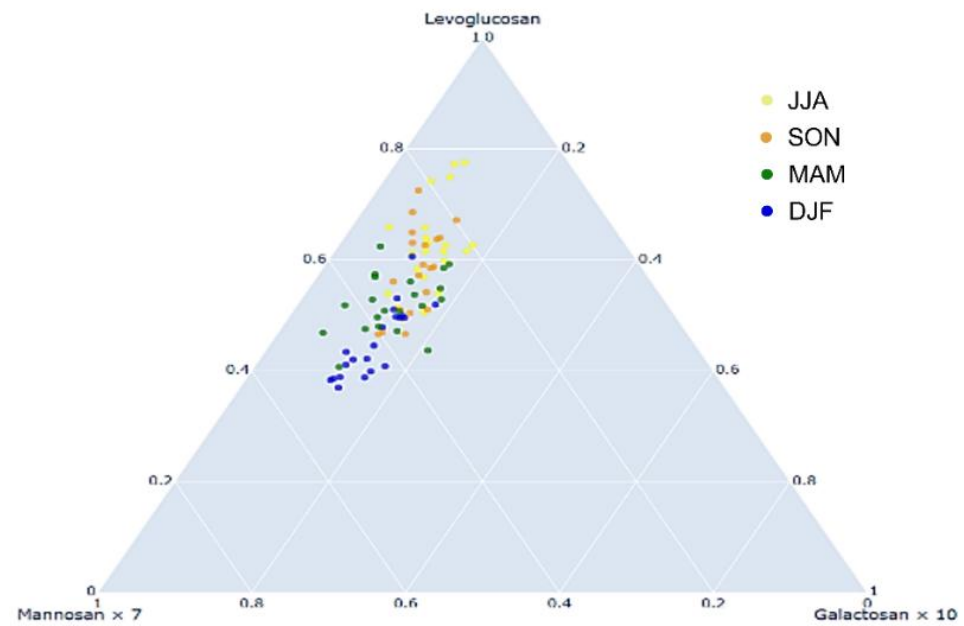


Figure S4. Ternary plot of levoglucosan, mannosan and galactosan concentrations during different seasons. JJA – June, July, August; SON – September, October, November; MAM – march, April, May; DJF – December, January, February.

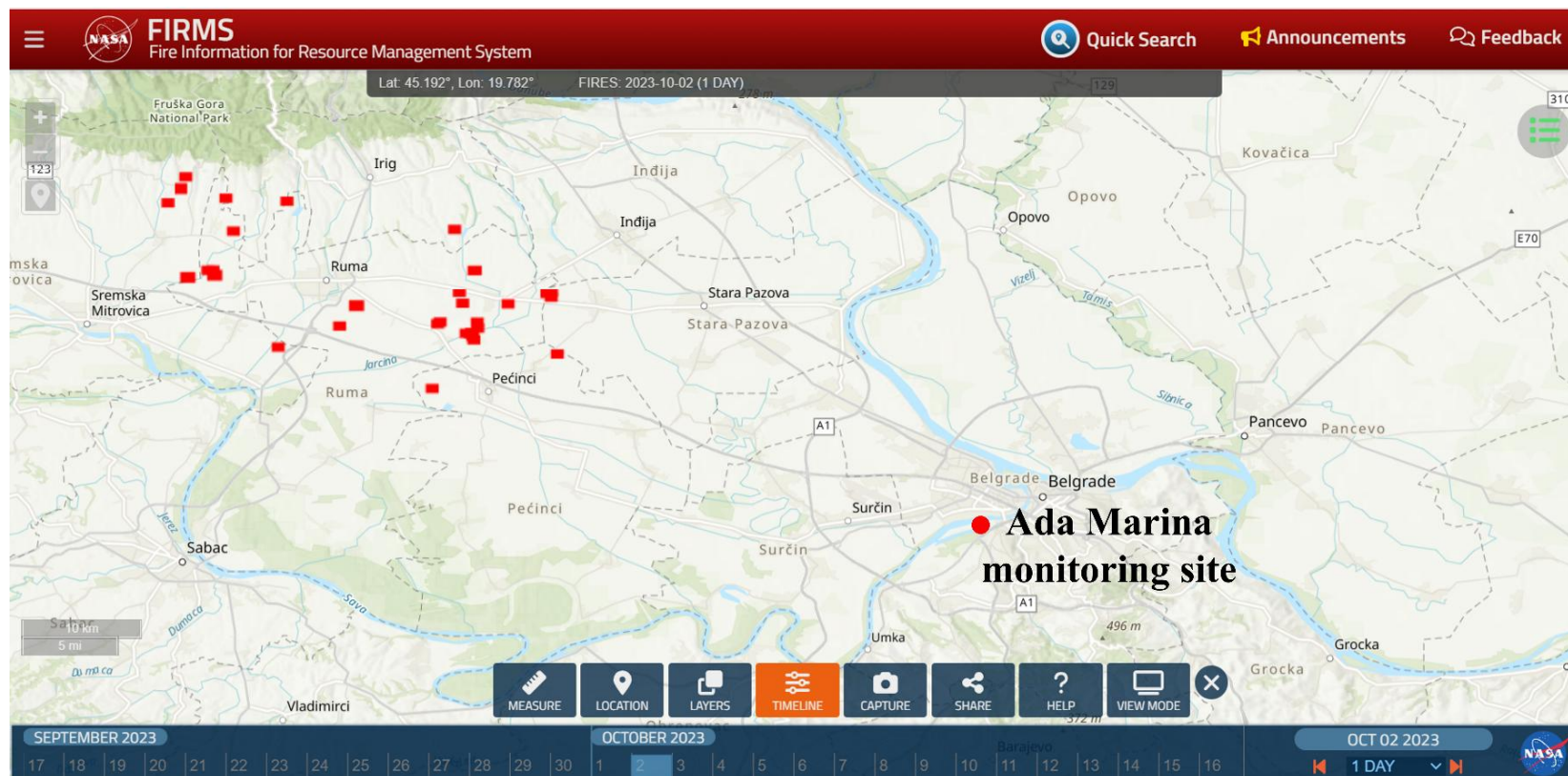


Figure S5. Open fire occurrence on day October 2nd (Source: https://firms.modaps.eosdis.nasa.gov/map/#d:2023-10-02;l:fires_all,topo;@20.24,44.87,10.32z).

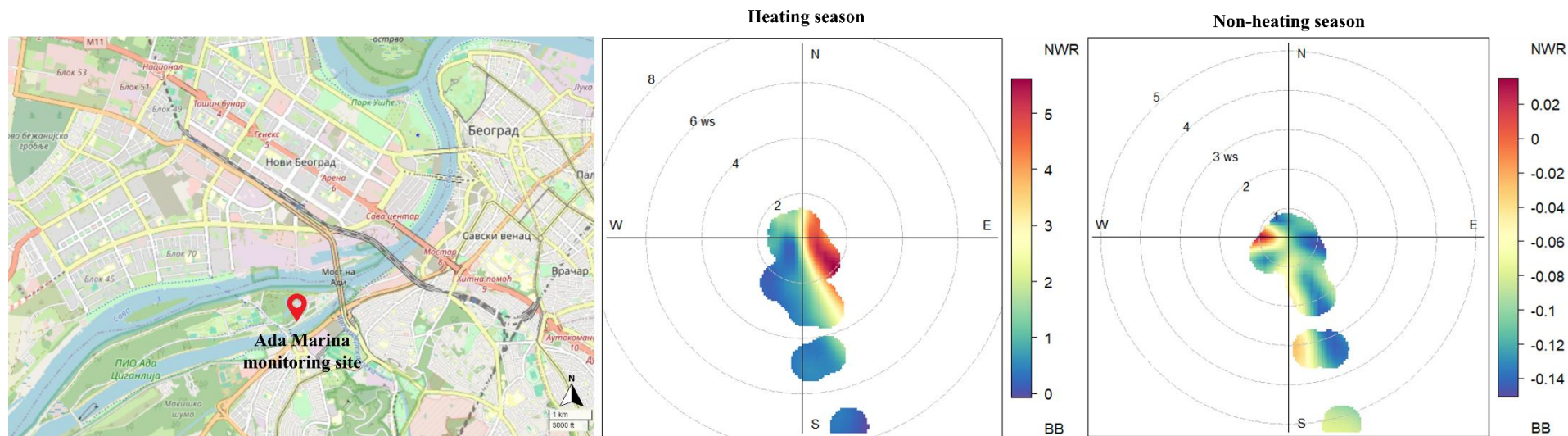


Figure S6. Location of the Ada Marina monitoring site and wind polar plots for heating and non-heating season (Source: © OpenStreetMap contributors).

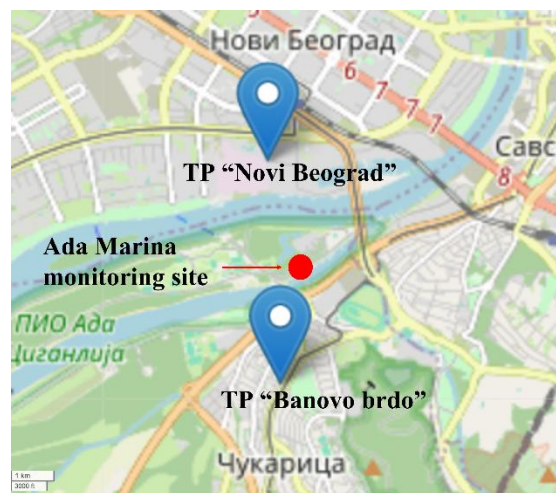


Figure S7. Locations of the thermal power plants closest to the Ada Marina monitoring station. TP – thermal power plant (Source: © OpenStreetMap contributors).

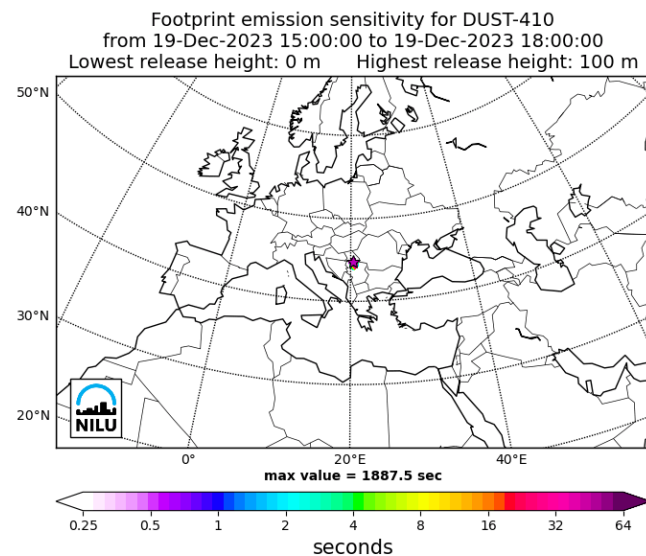
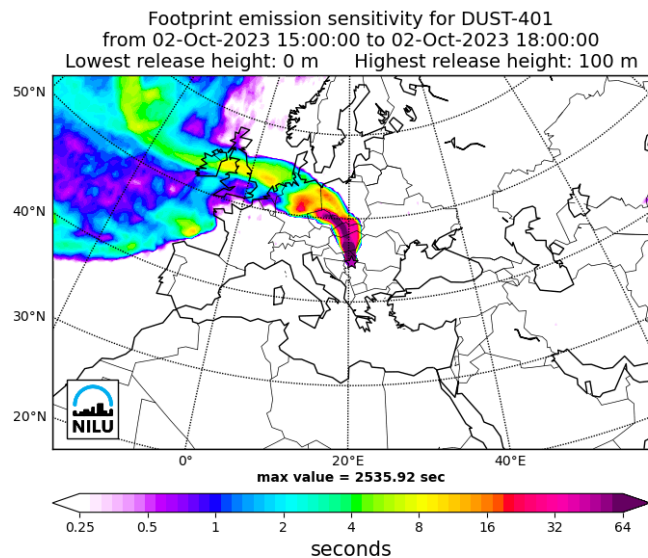


Figure S8. Mean 3 hour surface footprint (residence time of an air mass over the surface before reaching the receptor) of the PMF factors for Ada Marina and for the four peak days in the NaCl/COMB factor time series, obtained from FLEXPART model runs.

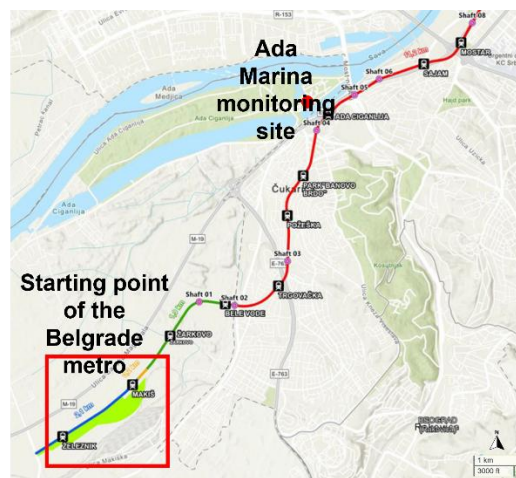


Figure S9. Location of the main depot of Belgrade metro that was being built during the sampling campaign (Makiš station); source: Belgrade metro and train (<https://bgmetro.rs/index.php/en/bg-metro/projects/line-1-phase-1>).

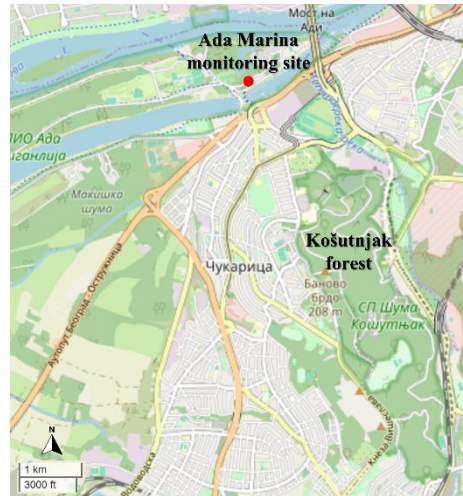


Figure S10. Location of the Košutnjak forest and Ada Marina monitoring site (Source: © OpenStreetMap contributors).

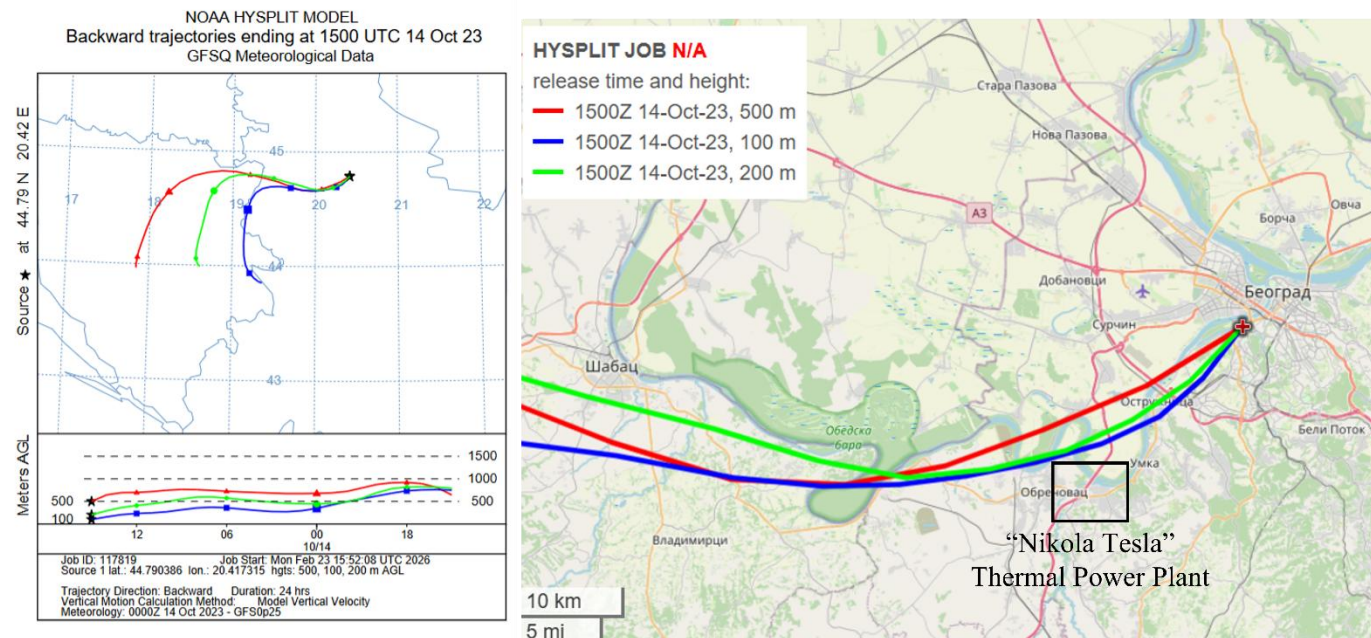


Figure S11. HYSPLIT model on 14th October 2023 and location of the monitoring site and “Nikola Tesla A” Power Plant (Source: © OpenStreetMap contributors).

References

- Almeida, S., M., Manousakas, M., Diapouli, E., Kertesz, Z., Samek, L., Hristova, E., Šega, K., Padilla Alvarez, R., Belis, C. A., Eleftheriadis, K., The IAEA European Region Study Group: Ambient particulate matter source apportionment using receptor modelling in European and Central Asia urban areas. *Environ. Pollut.* 266, 115199, <https://doi.org/10.1016/j.envpol.2020.115199>, 2020.
- Cvetković, A., Jovašević-Stojanović, M., Marković, D., and Ristovski, Z.: Concentration and source identification of polycyclic aromatic hydrocarbons in the metropolitan area of Belgrade, Serbia. *Atmos. Environ.*, 112, 335-343, <https://doi.org/10.1016/j.atmosenv.2015.04.034>, 2015.
- Dorđević, D., Mihajlidi-Zelić, A., Relić, D., Ignjatović, L., Huremović, J., Stortini, A. M., and Gambaro, A.: Size-segregated mass concentration and water soluble inorganic ions in an urban aerosol of the Central Balkans (Belgrade). *Atmos. Environ.*, 46, 309-317, <https://doi.org/10.1016/j.atmosenv.2011.09.057>, 2012.
- Glojek, K., Thuy, V. D. N., Weber, S., Uzu, G., Manousakas, M., Elazzouzi, R., Džepina, K., Darfeuil, S., Ginot, P., Jaffrezo, J. L., Žabkar, R., Turšič, J., Podkoritnik, A., and Močnik, G.: Annual variation of source contributions to PM₁₀ and oxidative potential in a mountainous area with traffic, biomass burning, cement-plant and biogenic influences. *Environ. Int.*, 189, 108787, <https://doi.org/10.1016/j.envint.2024.108787>, 2024.
- Mijić, Z., Stojić, A., Perišić, M., Rajšić, S., and Tasić, M.: Receptor modeling studies for the characterization of PM₁₀ pollution sources in Belgrade. *CI&CEQ*, 18, 623-634, <https://doi.org/10.2298/CICEQ120104108M>, 2012.
- Rajšić, S., Mijić, Z., Tasić, M., Radenković, M., and Joksić, J.: Evaluation of the levels and sources of trace elements in urban particulate matter. *Environ. Chem. Lett.*, 6, 95-100, <https://doi.org/10.1007/s10311-007-0115-0>, 2008.
- Todorović, M. N., Radenković, M. B., Onjia, A. E., and Ignjatović, L. M.: Characterization of PM_{2.5} sources in a Belgrade suburban area: a multi-scale receptor-oriented approach. *Environ. Sci. Pollut. Res.*, 27, 41717-41730, <https://doi.org/10.1007/s11356-020-10129-z>, 2020.
- Schober, P., Boer, C., & Schwarte, L. A.: Correlation coefficients: appropriate use and interpretation. *Anesth. Analg.*, 126, 1763-1768, <https://doi.org/10.1213/ANE.0000000000002864>, 2018.