Soil Monitoring in Lower Austria

Walter W. Wenzel

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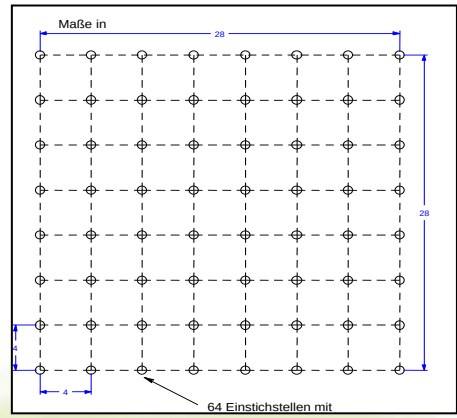

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Content

- Needs for soil monitoring
- Approaches to soil monitoring
- Results of soil monitoring in Lower Austria
- Conclusions

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Needs for soil monitoring

Do we need soil monitoring?

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- Environmental changes
- Soil as component in biogeochemical cycling
- Baseline data
- Recognize risks an losses of soil functions
- Document changes in soil properties. soil functions and related services
- Soil threats
- Traditional versus emerging pollutants

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Approaches to soil monitoring

Approaches to soil monitoring

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- Baseline
  - Soil mapping
  - Soil inventories
- Recognize / predict changes
  - Monitoring factors and processes impacting soils
  - Input – output monitoring
  - Modelling
- Document changes
  - Permanent soil monitoring plots. repeated sampling
  - Achive soil samples

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Results of soil monitoring in Lower Austria

Lower Austrian soil map

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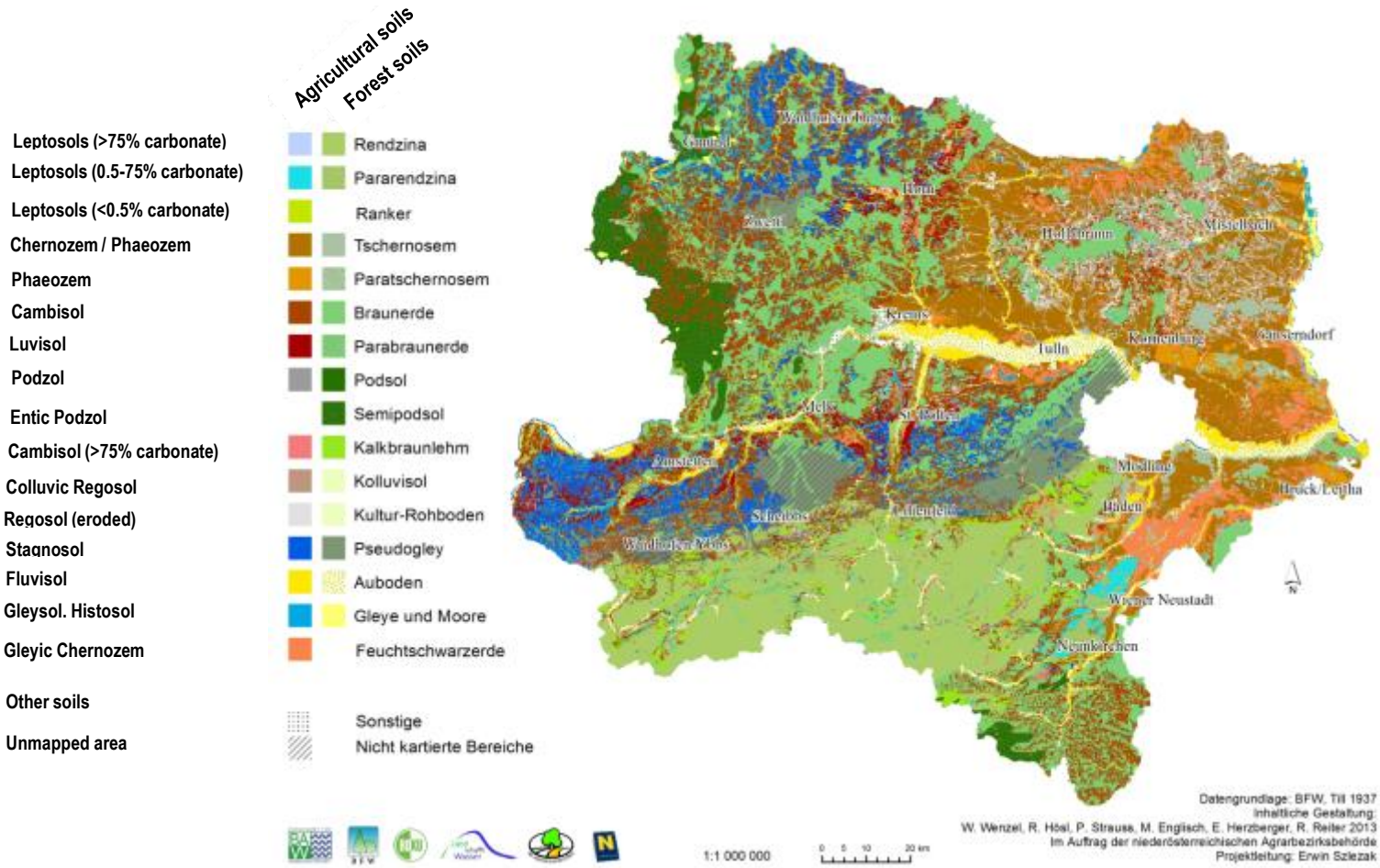
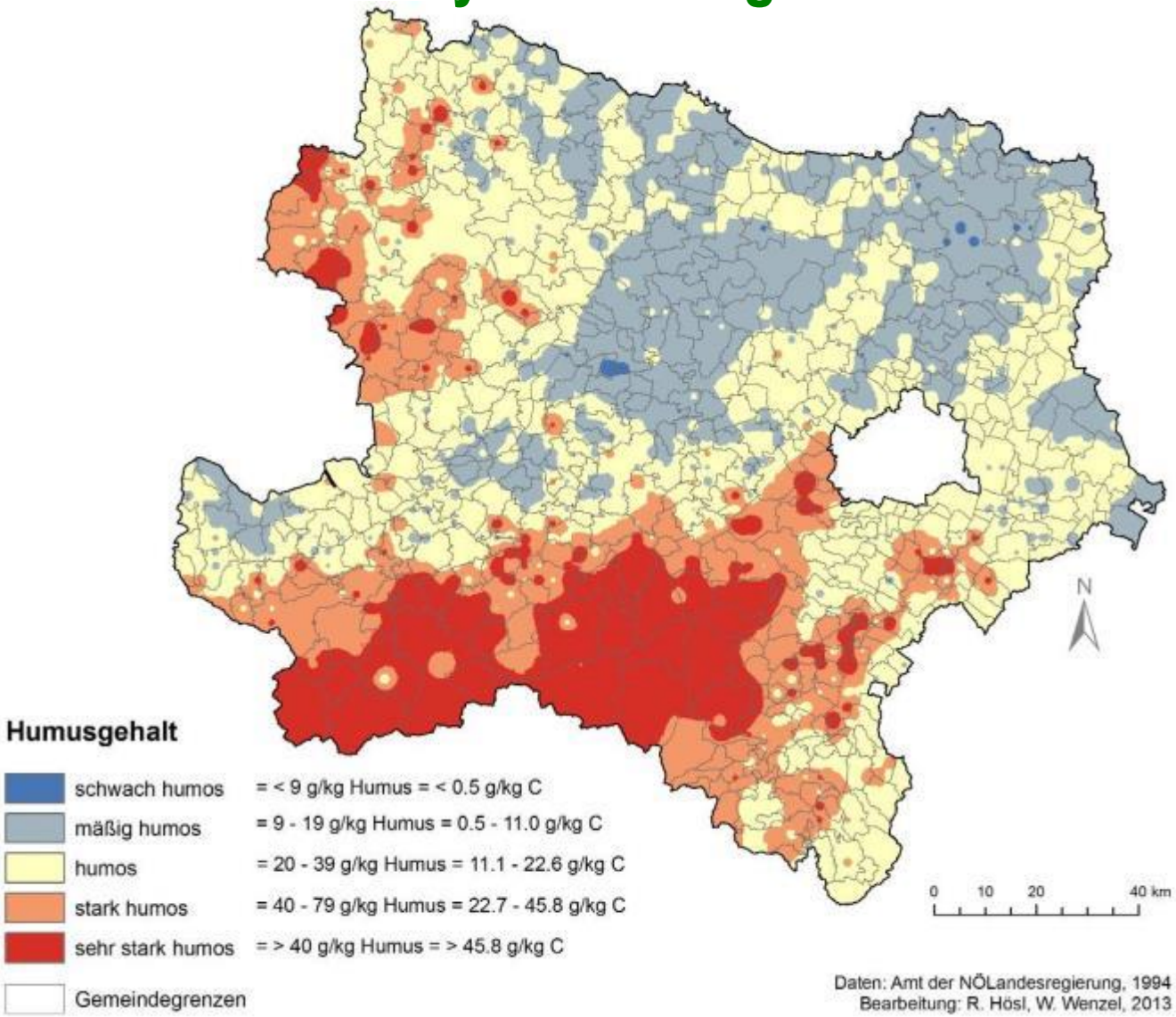
Soil map of Lower Austria



Soil inventory 1994 – Organic carbon



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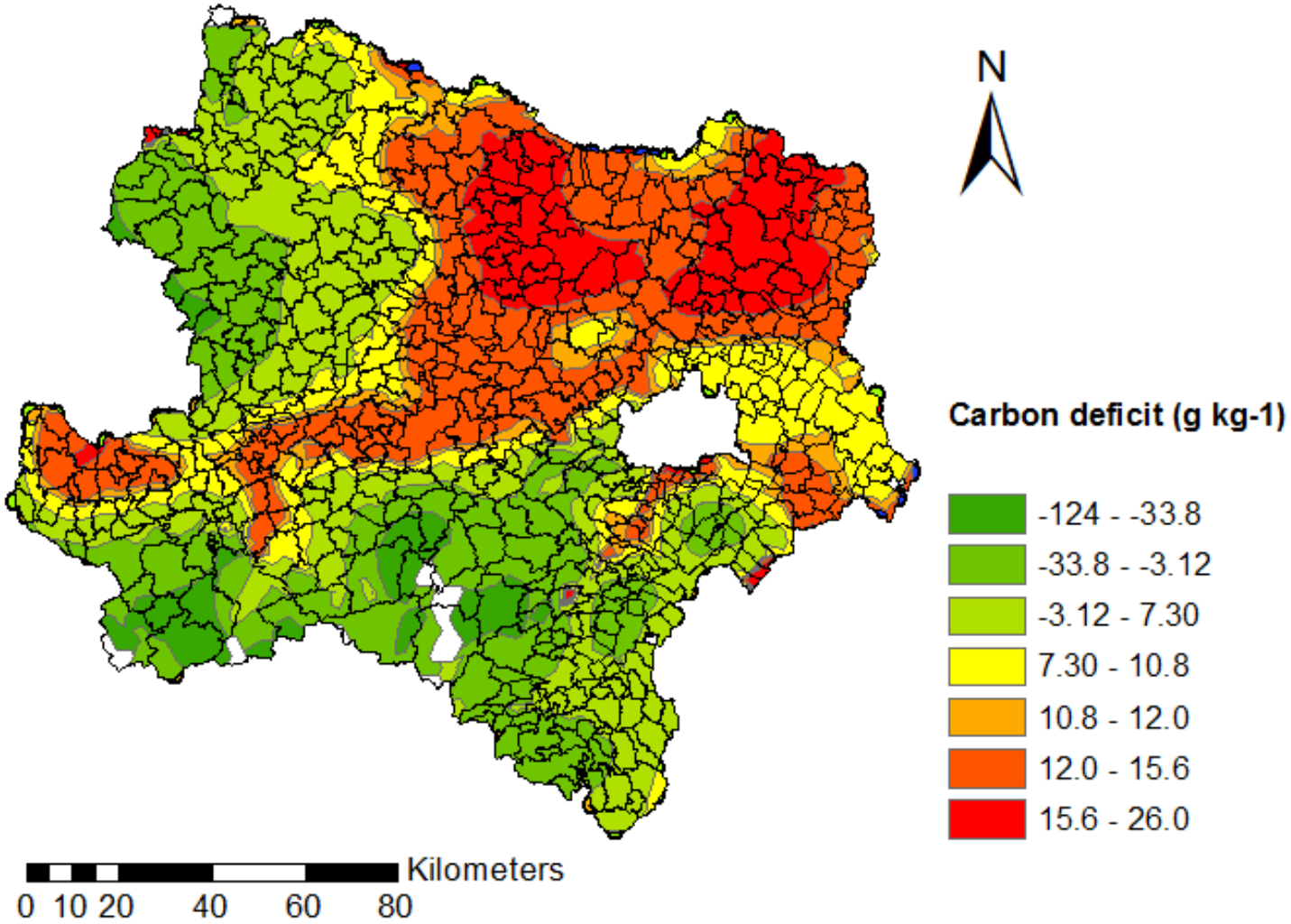
Modeling carbon deficits



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Modeling carbon saturation and deficits

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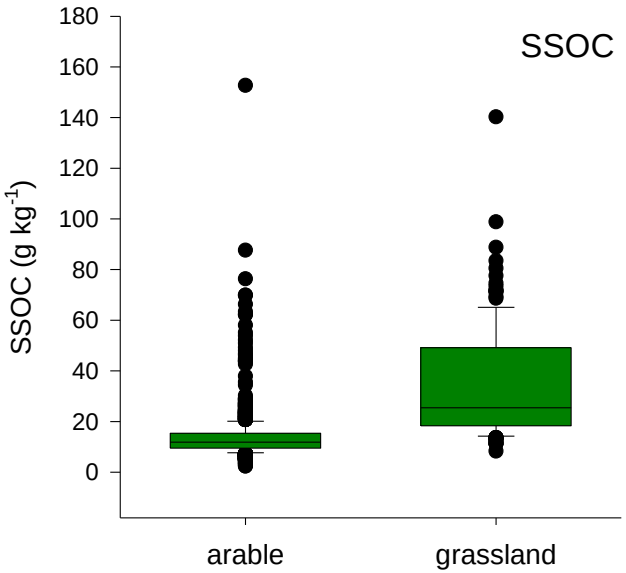
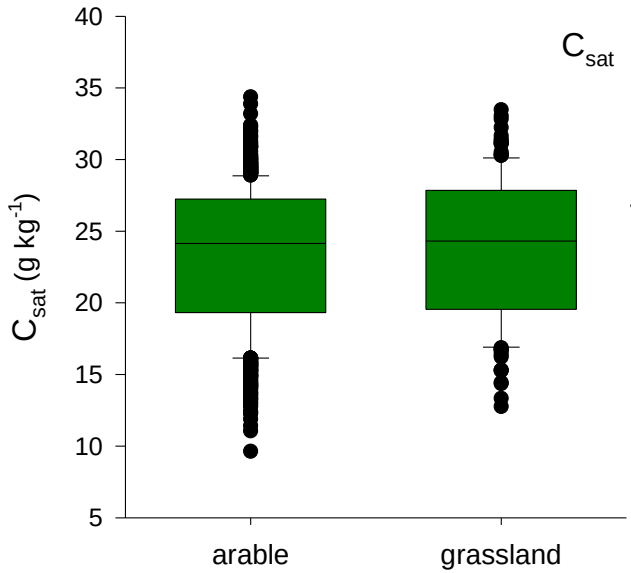
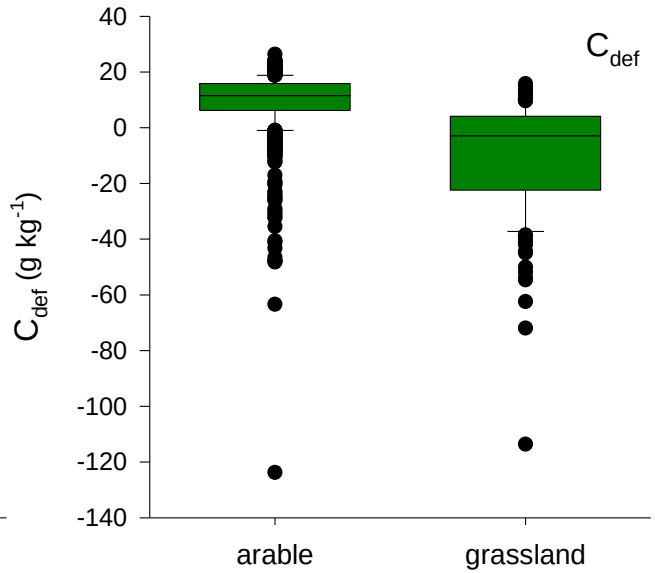
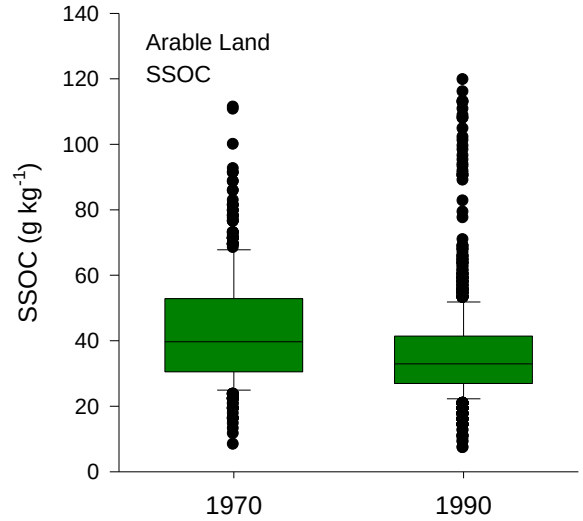
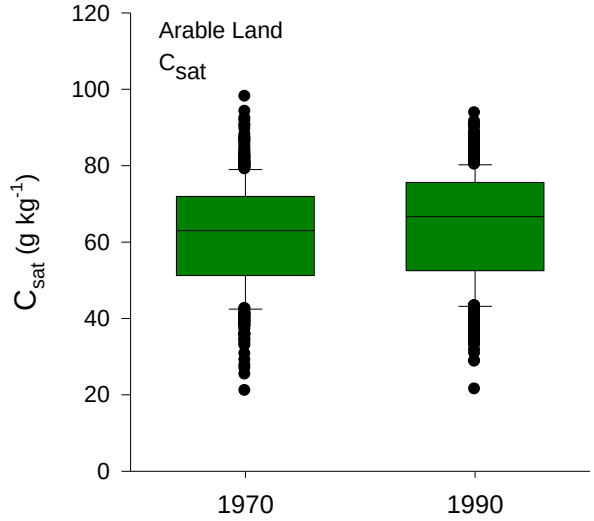


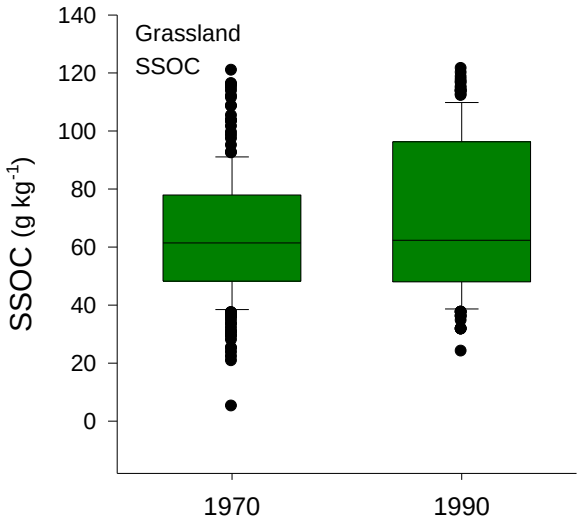


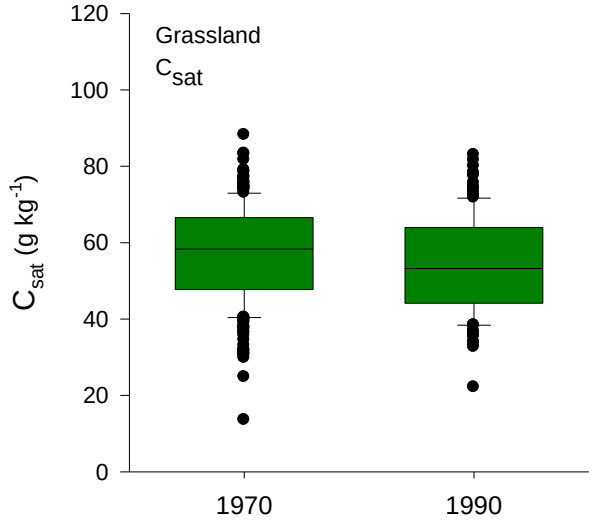


Temporal changes of OC and OC saturation









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Temporal changes of OC and OC saturation

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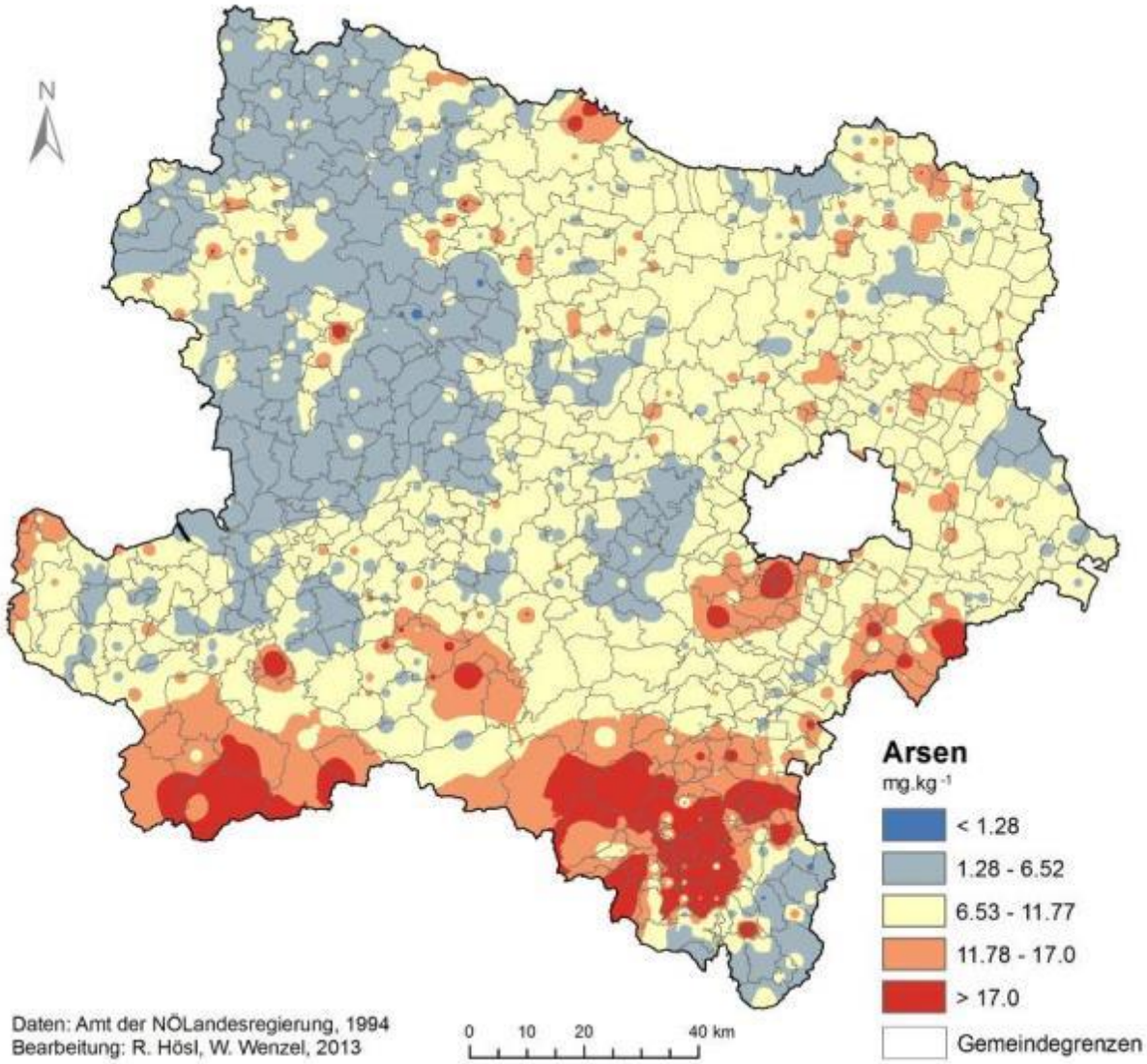
Comparison of predicted total C_{def} pools in arable topsoils of Lower Austria and the annual Austrian C emissions.

			Mt C yr^{-1}	base year	Reference
Annual C-emissions for Austria		--	16.9	1990	United Nations. s.a.
	Mg C ha^{-1}	**Area (ha)***	**Mt C**		
C_{def} for Lower Austria	32.4	699.870	22.6	1990/1991	own calculation

*** The area correspond to the year 1990. Statistik Austria. 2013**

Soil inventory – metals and metalloids



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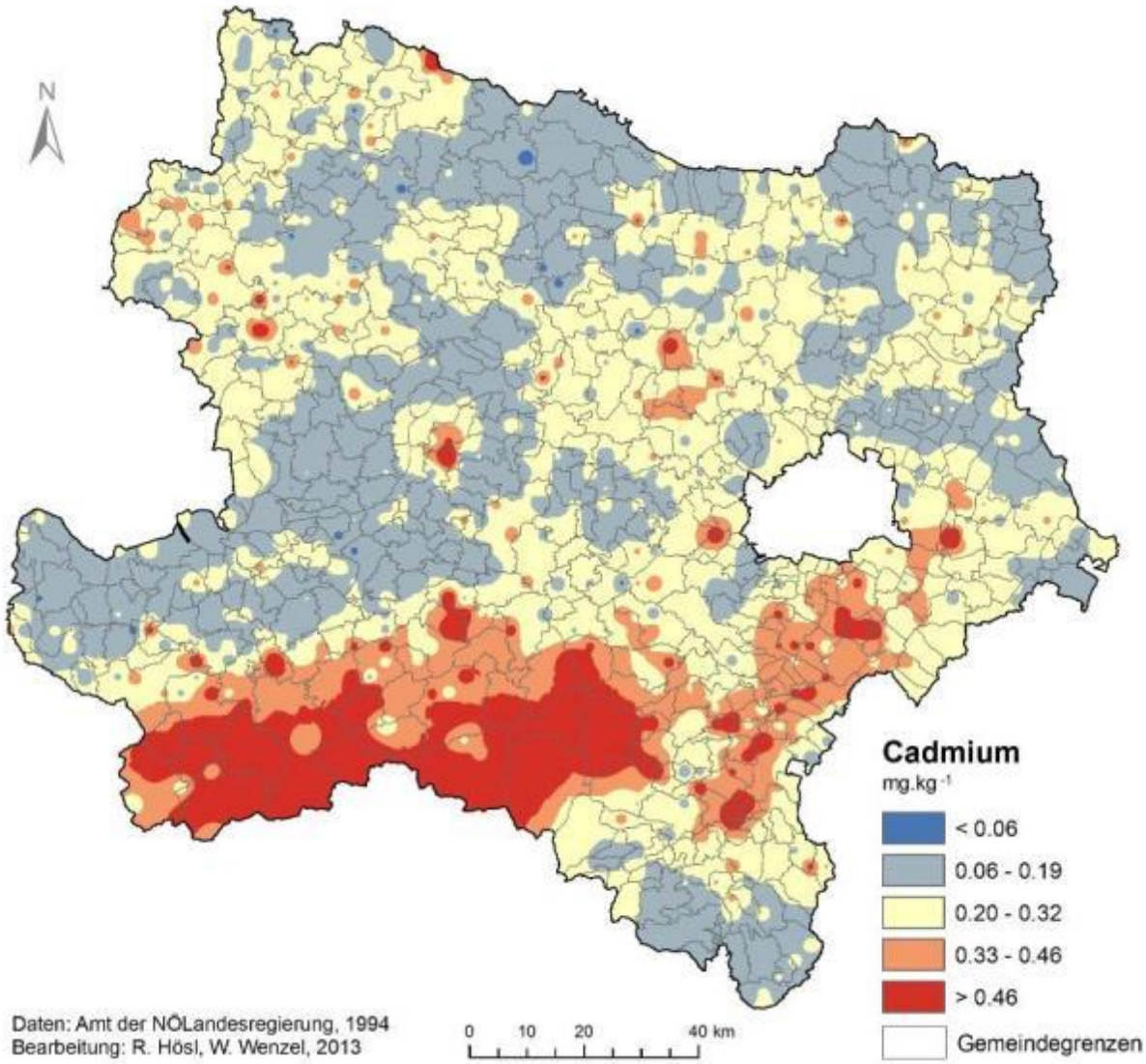
Soil inventory 1994 – metals and metalloids



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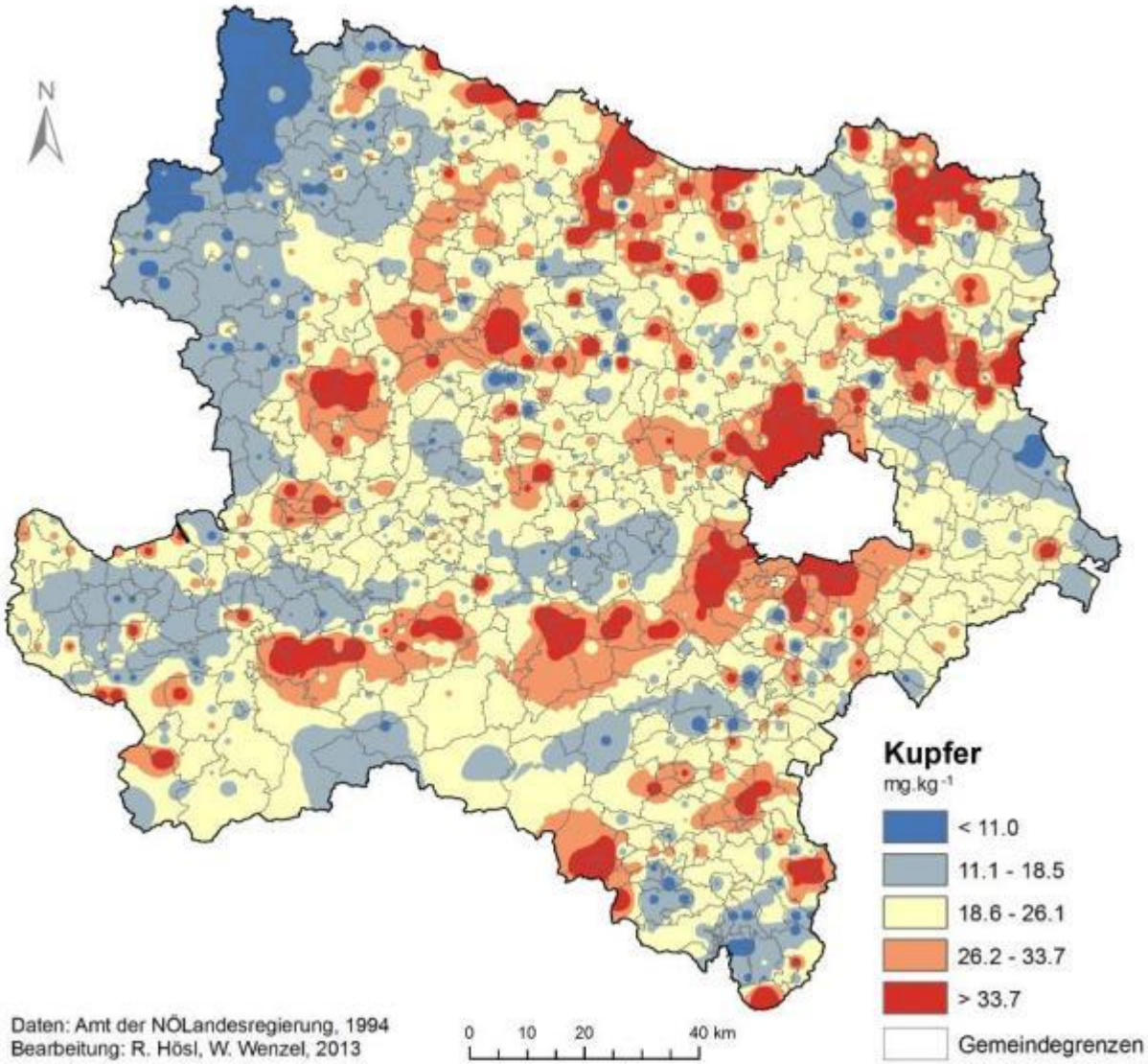
Soil inventory 1994 – metals and metalloids



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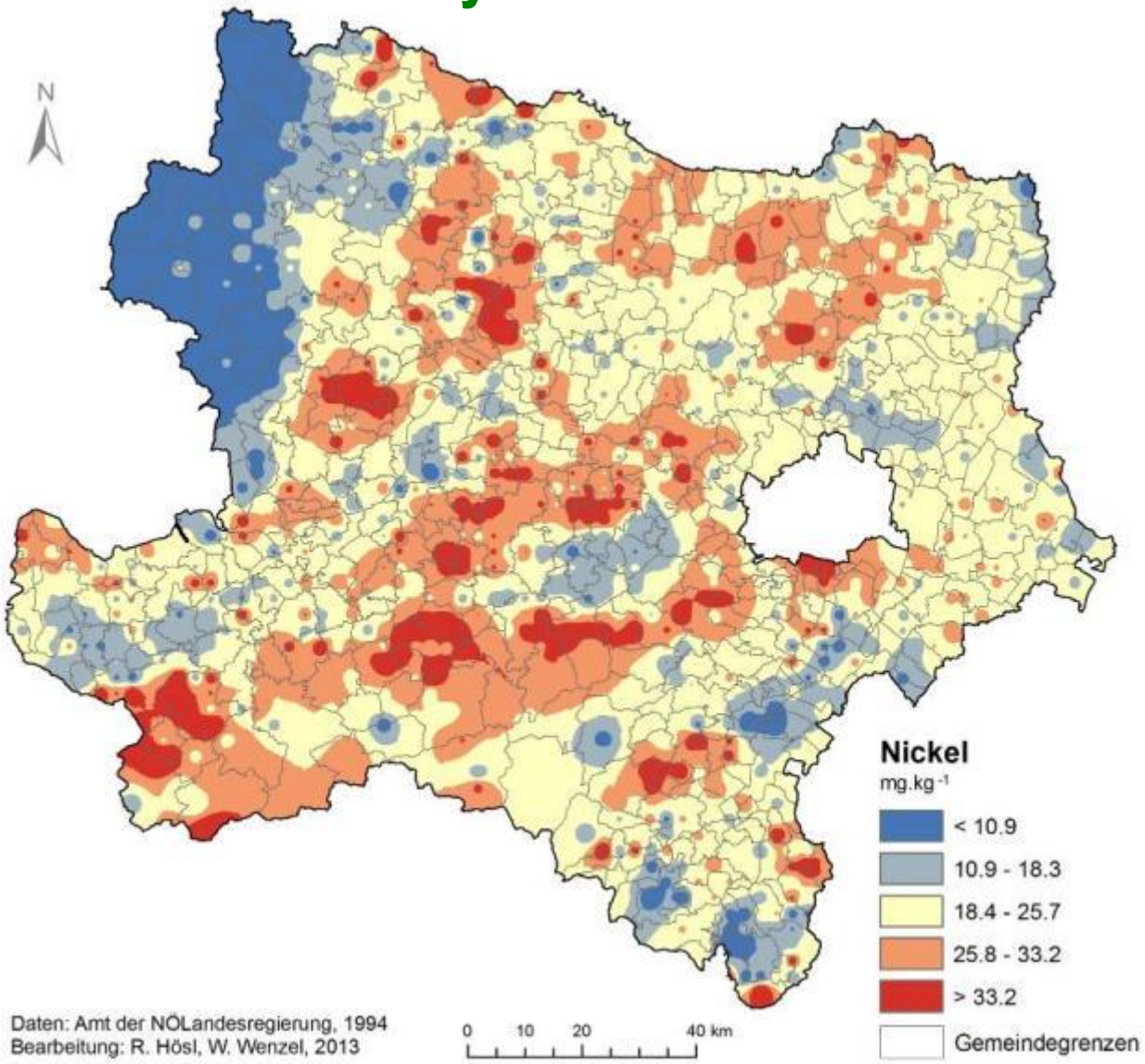

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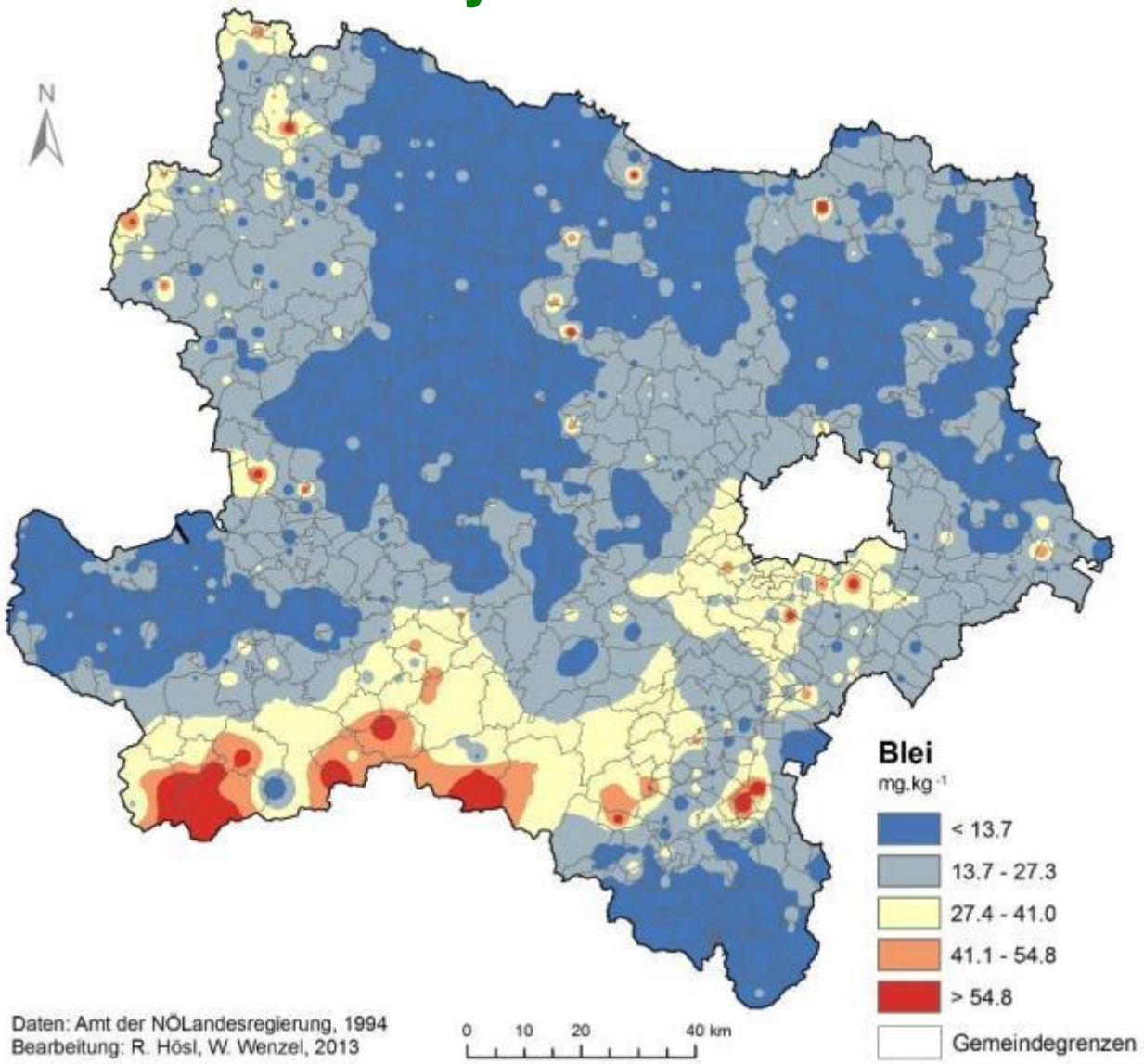
Soil inventory 1994 – metals and metalloids



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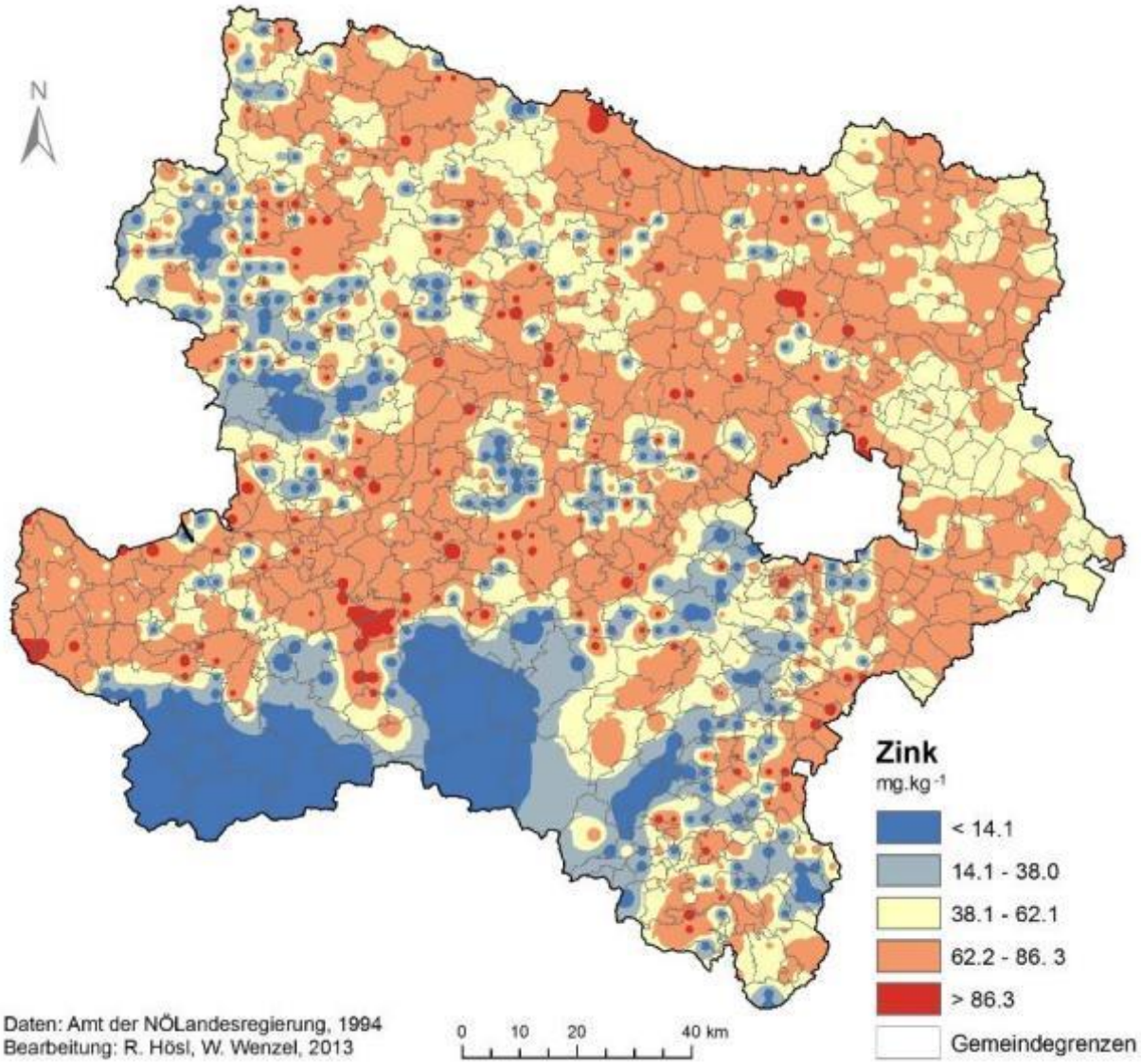
Soil inventory 1994 – metals and metalloids



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Permanent soil monitoring plots – Tulln region

31 permanent soil monitoring plots

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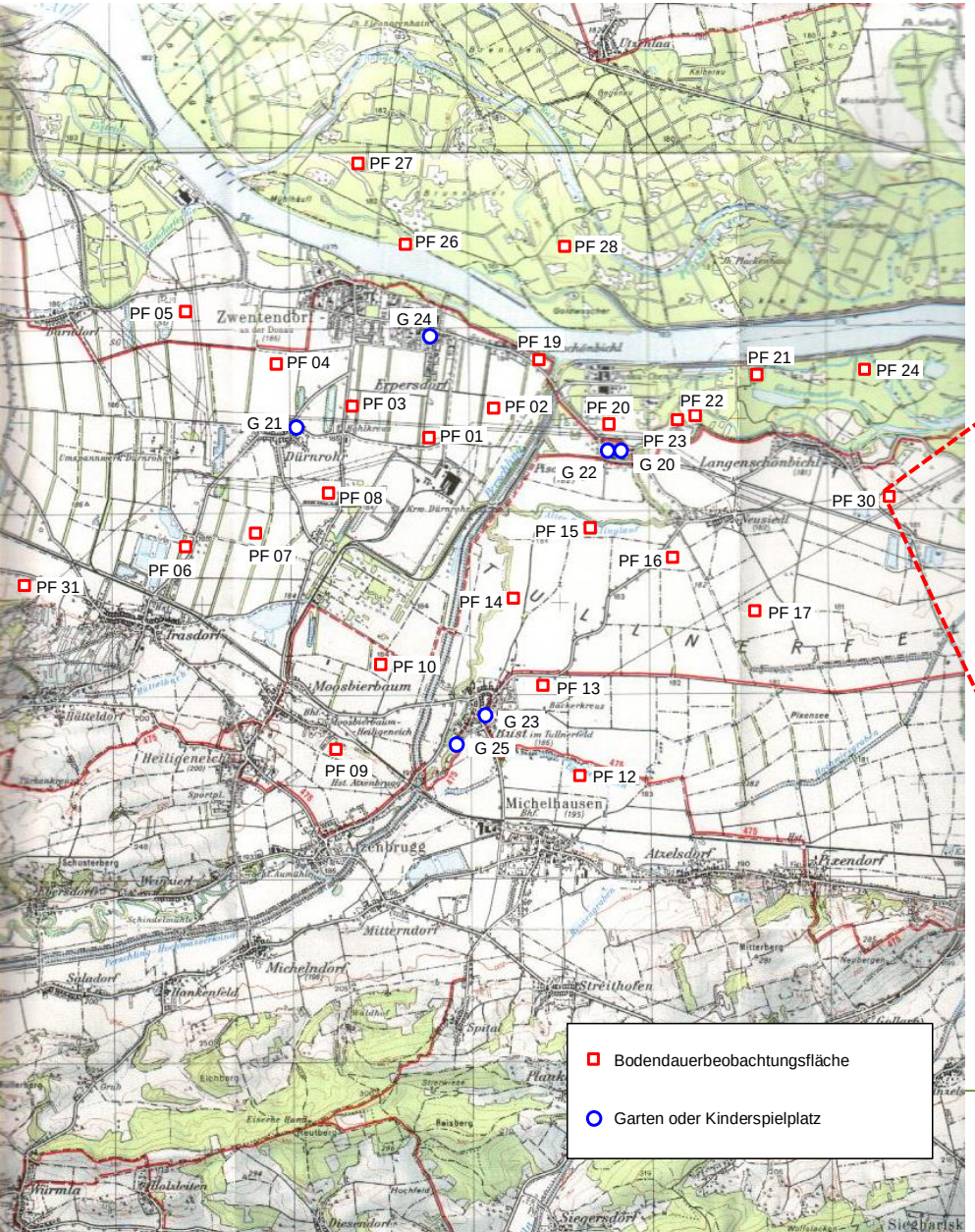

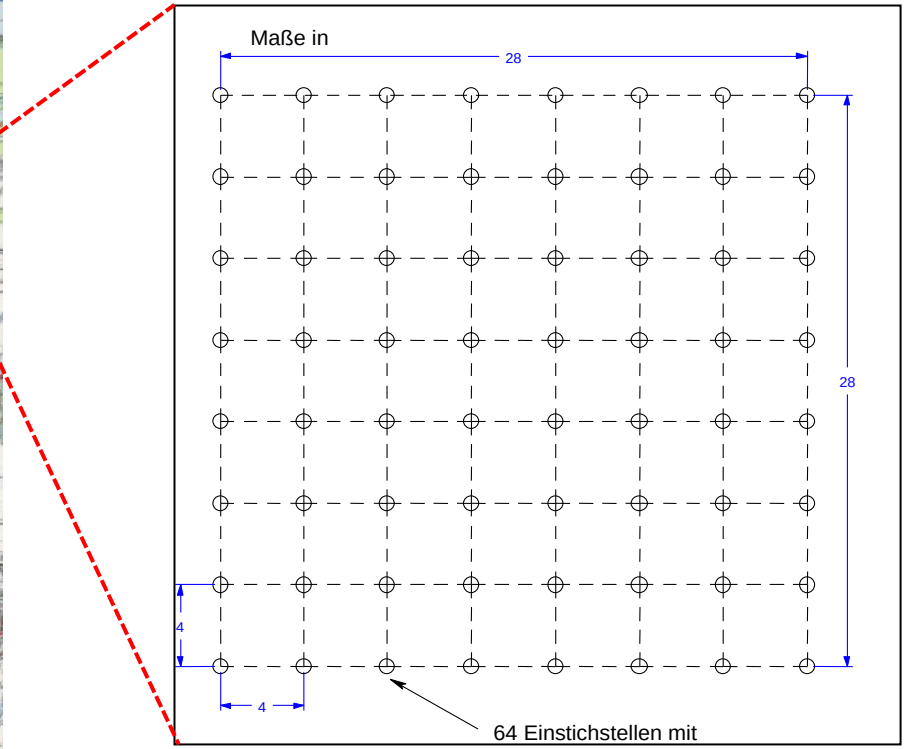

Permanent soil monitoring plots – Tulln region

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Metals and metalloids (mg kg^{-1}), sampling 2003 and 1998

		Permanent soil monitoring plot (sampling 2003)													Area mean	
		1	2	3	5	6	8	14	16	20	21	22	23	24	2003	1998
As	Mean	10.8	13.2	12.3	11.6	12.5	18.6	5.91	11.9	11.5	10.4	10.1	8.20	10.7	11.4	8.34
	SE (SD)	0.15	0.47	0.18	0.39	0.24	0.44	0.39	0.53	0.20	0.49	0.40	0.73	0.57	2.91	2.08
Cd	Mean	0.209	0.228	0.229	0.183	0.243	0.226	0.192	0.262	0.195	0.338	0.230	0.199	0.323	0.235	0.457
	SE (SD)	0.005	0.001	0.008	0.008	0.006	0.004	0.024	0.007	0.007	0.013	0.005	0.005	0.005	0.048	0.239
Cu	Mean	26.7	27.1	25.7	25.2	26.7	25.9	18.4	45.6	27.7	39.6	33.8	25.2	41.9	30.0	21.4
	SE	0.59	0.36	0.28	0.22	0.46	0.71	0.32	0.46	0.51	0.63	0.24	0.48	0.16	7.9	5.7
Cr	Mean	27.4	31.2	28.1	27.9	29.4	29.2	17.2	56.5	30.3	28.6	28.0	25.3	28.8	29.8	25.3
	SE (SD)	0.73	1.67	1.21	0.28	2.03	0.77	0.99	1.84	0.44	0.56	1.26	0.91	0.48	8.7	9.9
Co	Mean	7.57	9.25	8.64	8.20	9.00	8.01	6.06	11.92	8.49	8.05	8.65	7.62	8.66	8.47	-
	SE (SD)	0.09	0.22	0.14	0.10	0.19	0.10	0.11	0.03	0.06	0.10	0.07	0.14	0.07	1.31	-
Hg	Mean	0.051	0.059	0.073	0.064	0.089	0.054	0.055	0.061	0.058	0.414	0.111	0.110	0.447	0.127	0.105
	SE (SD)	0.003	0.010	0.001	0.001	0.029	0.001	0.003	0.001	0.007	0.006	0.003	0.001	0.009	0.137	0.090
Ni	Mean	17.9	22.8	21.6	17.9	21.8	18.5	12.5	36.7	19.9	19.1	20.3	15.8	21.4	20.5	21.3
	SE (SD)	0.37	1.83	1.34	0.22	0.60	0.41	0.76	0.76	0.48	0.23	0.19	0.26	0.16	5.6	5.11
Pb	Mean	18.2	19.0	19.2	17.3	24.0	18.5	12.7	27.3	16.6	29.4	17.8	17.6	29.9	20.6	13.3
	SE (SD)	0.23	0.36	0.14	0.13	0.37	0.35	0.25	0.61	0.22	0.43	0.10	0.18	0.31	5.3	2.84
V	Mean	31.5	36.5	33.2	33.0	34.2	34.3	19.3	65.9	32.4	24.9	28.2	25.9	24.3	32.6	29.6
	SE (SD)	1.05	2.43	1.43	0.33	2.38	0.87	1.10	2.17	0.55	0.61	1.67	1.03	0.65	11.2	12.9
Zn	Mean	62.5	67.4	62.0	61.8	60.6	57.5	49.6	105	68.8	129.3	66.4	60.4	128	75.3	58.0
	SE (SD)	1.08	1.04	0.58	0.56	1.77	1.16	1.01	1.76	0.80	1.86	0.53	1.93	1.74	26.9	18.3

Permanent soil monitoring plots – Tulln region

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PAH (mg kg^{-1}), sampling 1998

Compound	PF 01/10	PF 02/10	PF 06/10	PF 08/10	PF 20/10	PF 22/10	PF 23/10	PF 24/10	PF 24/10	Mean	SD
Naphthaline	0.0186	0.013	0.0154	0.0198	0.0131	0.0154	0.0196	0.0195	0.0195	0.0168	0.00291
Acenaphthylene	0.000829	0.000618	0.000383	0.000709	0.000947	0.000835	0.000726	0.00229	0.00229	0.000917	0.00058
Acenaphthene	0.0152	0.00149	0.000887	0.0015	0.00249	0.00121	0.00136	0.00699	0.00699	0.00389	0.00498
Fluorene	0.0168	0.00268	0.00174	0.00299	0.00371	0.00278	0.00294	0.0133	0.0133	0.00587	0.00577
Phenanthrene	0.186	0.0229	0.0129	0.0308	0.0832	0.0231	0.0209	0.107	0.107	0.0609	0.0609
Anthracene	0.0366	0.00172	0.000893	0.00275	0.0128	0.00157	0.00139	0.0114	0.0114	0.00864	0.0123
Fluoranthene	0.134	0.0193	0.0136	0.0548	0.358	0.0147	0.0176	0.0996	0.0996	0.0890	0.118
Pyrene	0.103	0.0137	0.0106	0.0421	0.308	0.0099	0.0129	0.0751	0.0751	0.0719	0.101
Benzo(a)anthracene	0.049	0.0066	0.00499	0.0203	0.156	0.00463	0.00612	0.0431	0.0431	0.0363	0.0515
Chrysene	0.0614	0.0116	0.00779	0.0285	0.177	0.00713	0.00985	0.0597	0.0597	0.0454	0.0578
Benzo(b)fluoranthene	0.0511	0.0134	0.0106	0.0354	0.257	0.00884	0.0117	0.0738	0.0738	0.0577	0.0838
Benzo(k)fluoranthene	0.0198	0.00495	0.00368	0.0131	0.0675	0.00296	0.0042	0.0234	0.0234	0.0174	0.0217
Benzo(a)pyrene	0.0403	0.00891	0.00659	0.023	0.150	0.00611	0.00752	0.0494	0.0494	0.0365	0.0488
Indeno(123,cd)pyrene	0.0213	0.00682	0.00522	0.0163	0.100	0.00403	0.00556	0.0311	0.0311	0.0238	0.0322
Dibenz(ac,ah)anthracene	0.00303	0.00107	0.000664	0.00192	0.00865	0.000577	0.000742	0.00385	0.00385	0.00256	0.00274
Benzo(ghi)perylene	0.0214	0.00663	0.00608	0.0184	0.0982	0.00421	0.00721	0.0322	0.0322	0.0243	0.0314
Total sum	0.778	0.135	0.102	0.312	1.80	0.108	0.130	0.652	0.652	0.502	0.587
∑ PAH w/t Naphthaline	0.760	0.122	0.087	0.293	1.78	0.093	0.111	0.632	0.632	0.485	0.585
∑ 6 Comp. DIN 38409	0.288	0.060	0.046	0.161	1.03	0.041	0.054	0.310	0.310	0.249	0.334

Permanent soil monitoring plots – Tulln region

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PCB (Balschmitter, ng kg^{-1}), sampling 1998

Congenere	Nr.	PF 01/10	PF 02/10	PF 06/10	PF 08/10	PF 20//10	PF 22/10	PF 23/10	pF 24/10	Mean	SD
2,4,4'-Cl3BP	28	478	229	247	359	370	199	360	203	306	101
2,2',5,5'-Cl4BP	52	281	109	177	235	257	145	248	158	201	62
2,2',4,5,5'-Cl5BP	101	583	250	443	539	683	328	626	490	493	148
2,2',4,4',5,5'-Cl6BP	153	1000	478	923	925	1330	638	1410	1710	1052	410
2,2',3,4,4',5,-Cl6BP	138	1020	484	952	874	1460	654	1520	1980	1118	498
2,2',3,4,4',5,5'-Cl7BP	180	303	142	262	225	457	196	579	982	393	278
Summe PCB		3670	1690	3000	3160	4560	2160	4740	5520	3563	1319

BTEX (mg kg^{-1}), sampling 1998

Compound	PF 01/10	PF 02/10	PF 06/10	PF 08/10	PF 20/10	PF 22/10	PF 23/10	PF 24/10	Mean	SD
Benzol	nn	nn	nn	nn	nn	nn	nn	nn	nn	
Toluol	0.291	0.441	0.339	0.495	0.277	0.385	0.930	0.0112	0.39615	0.2601
Ethylbenzol	nn	nn	nn	nn	nn	nn	nn	nn	nn	
m,p-Xylol	0.00146	0.00178	0.00170	0.00200	0.00679	0.00209	0.00457	0.00253	0.002865	0.00186
o-Xylol	nn	nn	nn	nn	nn	nn	nn	nn	nn	
Summe	0.292	0.443	0.341	0.497	0.284	0.387	0.935	0.0137	0.3991	0.2606

Permanent soil monitoring plots – Schwechat region

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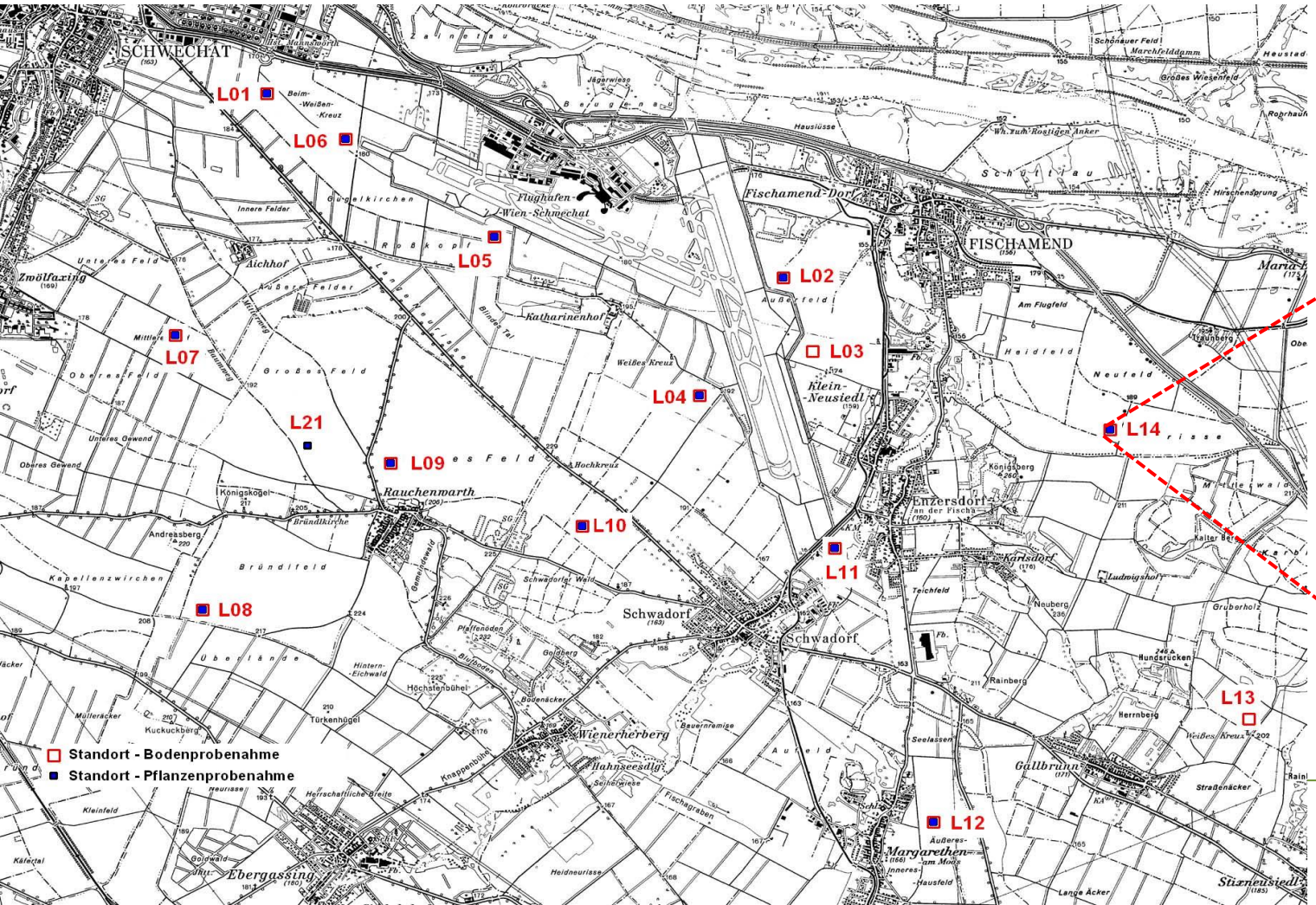
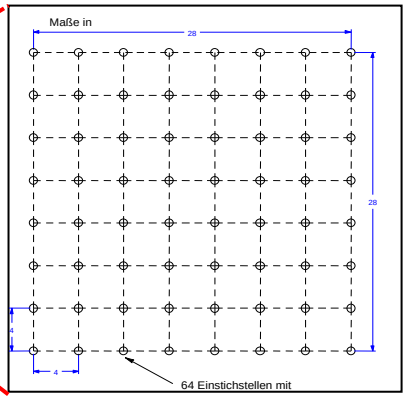


14 permanent soil monitoring plots



Permanent soil monitoring plots – Schwechat region

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Monitoring plot	Year or sampling	As	Cd	Co	Cr	Cu	Hg
		mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
L 01	2004	11.4	0.39	10.8	32.2	31.1	0.18
L 02	2000	15.3	0.40	10.8	37.3	20.3	0.08
L 03	2000	13.3	0.40	10.8	32.8	17.0	0.06
L 03	2004	10.9	0.35	10.9	31.1	23.2	0.06
L 04	2000	15.0	0.30	12.3	37.5	23.3	0.07
L 05	2000	14.0	0.30	11.0	34.5	23.5	0.18
L 06	2000	12.0	0.40	8.0	25.5	17.8	0.08
L 09	2004	11.3	0.36	11.4	35.1	32.3	0.25
L 14	2000	13.5	0.23	10.0	31.3	15.3	0.08
	Minimum	10.9	0.23	8.0	25.5	15.3	0.06
	Maximum	15.3	0.40	12.3	37.5	32.3	0.25
	Arithmetic mean	**13.0**	**0.35**	**10.7**	**33.0**	**22.6**	**0.12**

ÖNORM L 1075 (1)	20	1	50	100	100	0.5
Soil inventory Lower Austria (2)	8.4	0.2	9.6	44.0	22.8	0.2

(1) ÖNORM L 1075 Edition 2004, for arable land use
(2) Soil inventory of Lower Austria, 1994, Arithmetic mean of all topsoil samples (arable and grassland), n= 3100

Permanent soil monitoring plots – Schwechat region

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Monitoring plot	Year or sampling	Ni	Pb	Tl	V	Zn
		mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
L 01	2004	30.0	30.8	0.28	41.6	78.8
L 02	2000	26.5	22.5	0.29	44.3	77.5
L 03	2000	23.8	19.0	0.27	40.8	74.5
L 03	2004	28.0	20.0	0.23	38.1	65.5
L 04	2000	29.0	21.8	0.30	45.8	67.8
L 05	2000	26.5	25.5	0.28	42.0	67.0
L 06	2000	21.0	16.0	0.23	33.8	47.8
L 09	2004	30.7	33.5	0.30	43.0	72.7
L 14	2000	22.5	16.8	0.25	38.5	51.8
	Minimum	21.0	16.0	0.23	33.8	47.8
	Maximum	30.7	33.5	0.30	45.8	78.8
	Arithmetic mean	**26.4**	**22.9**	**0.27**	**40.9**	**67.0**

ÖNORM L 1075 (1)	100	100	1	100	300
Soil inventory Lower Austria (2)	24.4	14.0	-	-	78.7

(1) ÖNORM L 1075 Edition 2004, for arable land use
(2) Soil inventory of Lower Austria, 1994, Arithmetic mean of all topsoil samples (arable and grassland), n= 3100

Permanent soil monitoring plots – Schwechat region

Monitoring plot	Year or sampling	**Σ PAH (16)[1]**	**Σ PAH (12)[1]**	**Σ PAH (6)[1]**	**BAP[2]**
		µg.kg^{-1} TS	µg.kg^{-1} TS	µg.kg^{-1} TS	µg.kg^{-1} TS
L01	2000	540	496	256	25
L01	2004	558	548	286	26
L02	2000	356	310	176	22
L03	2000	404	380	225	51
L03	2004	126	109	48	3
L04	2000	191	157	81	10
L05	2000	225	200	109	13
L06	2000	317	308	161	19
L07	2000	165	148	79	9
L08	2000	327	318	167	15
L09	2000	451	442	246	25
L09	2004	302	288	153	22
L10	2000	134	121	68	9
L11	2000	265	257	150	23
L12	2000	120	106	53	5
L13	2000	175	160	85	9
L14	2000	135	116	43	5
Minimum		120	106	43	3
Maximum		558	548	286	51
Arithmetic mean		**282**	**262**	**140**	**17**

BZI-OÖ [3]	-	493	-	-
BZI-Kärnten [4]	-	228	-	21
Köchl, 1988 [5]	-	-	211	-
LABO, 1998 [6]	193			
Eikmann-Kloke Bodenwert I [7]	-	-	-	1.000
Baden-Württemberg Hintergrundwert [8]	1.000	-	-	100

([1]) Sum PAH-16
([2]) BAP = Benzo(a)pyren
([3]) Oberösterreichischer Bodenkataster, Bodenzustandsinventur, 1993, Arithmetic mean of 115 arable and grassland soils, 0-20 cm and 0-5 cm, respectively. Areas of low population density.
([4]) Bodenzustandsinventur Kärnten, 1999, Arithmetic mean of 100 arable and grassland soils, 0-20 cm and 0-5 cm, respectively.
([5]) Köchl, A., 1988, Mittelwert aus 25 Ackerböden (0 - 25 cm) des Marchfeldes.
([6]) LABO – Background values for soils in Baden-Württemberg, median of 65 grassland soils, rural area.
([7]) Eikmann-Kloke, Soil value I, Nutzungs- und schutzgutbezogene Orientierungswerte für (Schad-)Stoffe in Böden, 1993
([8]) Baden-Württemberg, background value according to *Vierte Verwaltungsvorschrift des Umweltministeriums zum Bodenschutzgesetz über die Ermittlung und Einstufung von Gehalten organischer Schadstoffe im Boden, 1995*

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Soil monitoring plots – St. Pölten region

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Plot (depth)	As	Cd	Co	Cr	Cu
	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
B01 (0-20 cm)	9,17	0,27	11,0	36,7	14,1
B02 (0-5 cm)	9,62	0,33	7,40	25,9	11,8
B03 (0-20 cm)	8,03	0,26	10,3	30,4	13,2
B04 (0-5 cm)	10,42	0,34	11,7	44,3	18,9
B05 (0-20 cm)	7,22	0,34	6,03	23,5	13,2
B06 (0-20 cm)	7,71	0,43	6,53	29,7	15,4
B07 (0-20 cm)	8,44	0,49	8,44	36,1	19,9
B08 (0-20 cm)	7,70	0,52	7,11	33,8	22,5
B09 (0-20 cm)	7,26	0,65	6,66	32,1	19,4
MIN	7,22	0,27	6,03	23,5	11,8
MAX	10,4	0,65	11,7	44,3	22,5
Meant	**8,40**	**0,40**	**8,36**	**32,5**	**16,5**

Soil monitoring plots – St. Pölten region

Plot (depth)	Ni	Pb	Tl	V	Zn
	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
B01 (0-20 cm)	21,4	37,9	0,39	41,0	54,4
B02 (0-5 cm)	18,5	68,1	0,41	31,1	55,5
B03 (0-20 cm)	21,8	36,1	0,38	39,0	63,1
B04 (0-5 cm)	31,9	43,0	0,53	53,4	78,1
B05 (0-20 cm)	20,5	28,9	0,42	31,3	45,11
B06 (0-20 cm)	24,3	30,9	0,62	40,4	65,3
B07 (0-20 cm)	30,1	36,2	0,73	48,2	78,4
B08 (0-20 cm)	23,7	56,9	0,64	45,6	88,9
B09 (0-20 cm)	21,8	66,6	0,59	42,4	93,2
MIN	18,5	28,9	0,39	31,1	45,1
MAX	31,9	68,1	0,73	53,4	93,2
Mean	**23,8**	**44,9**	**0,52**	**41,4**	**69,1**

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Soil monitoring plots – St. Pölten region

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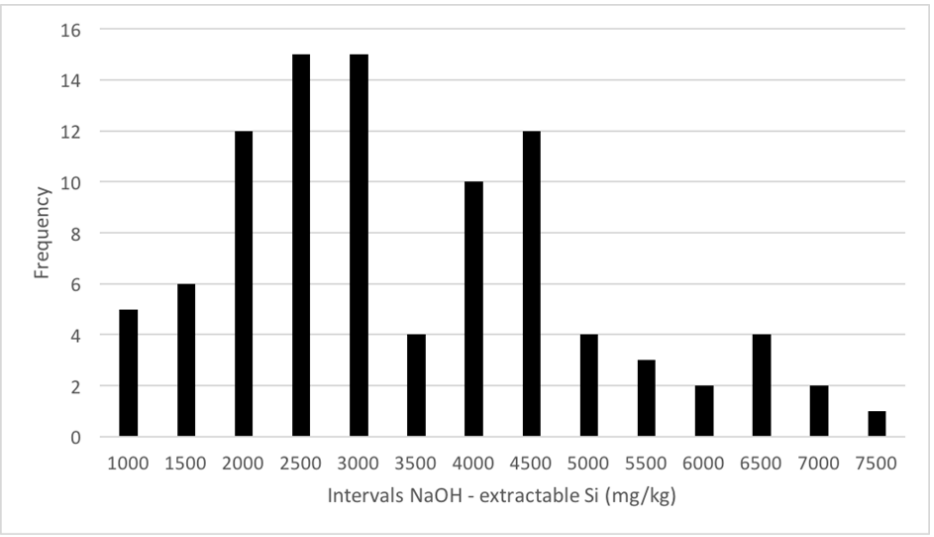
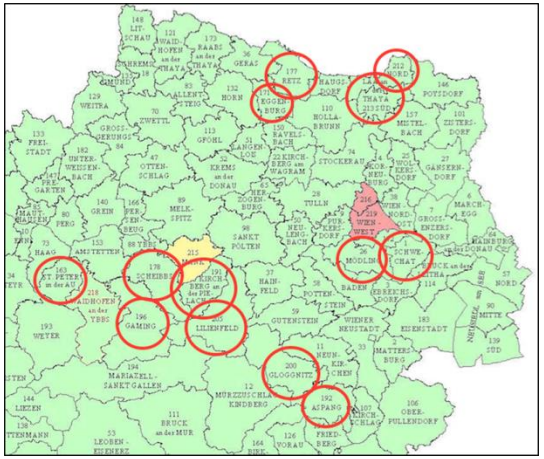
Polycaclic aromatic hydrocarbons	Plot								
	B01	**B02**	**B03**	**B04**	**B05**	**B06**	**B07**	**B08**	**B09**
	µg kg^{-1}	µg kg^{-1}	µg kg^{-1}	µg kg^{-1}	µg kg^{-1}	µg kg^{-1}	µg kg^{-1}	µg kg^{-1}	µg kg^{-1}
Naphtaline	<10,0	<10,0	<10,0	<10,0	71,5	<10,0	<10,0	13,9	<10,0
Acenaphtylene	<1,0	18,4	<1,0	1,2	<1,0	<1,0	<1,0	<1,0	<1,0
Acenaphtene	<1,0	<1,0	<1,0	<1,0	<1,0	<1,0	<1,0	<1,0	<1,0
Fluorene	<1,0	<1,0	<1,0	<1,0	<1,0	<1,0	<1,0	<1,0	<1,0
Phenantrene	2,1	19,5	6,3	13,2	5,2	5,6	2,3	1,7	1,2
Anthracene	<1,0	2,4	<1,0	2,0	<1,0	1,0	<1,0	<1,0	<1,0
Fluoranthene	8,9	47,4	8,3	30,0	23,9	18,7	3,4	4,0	5,4
Pyrene	7,2	34,5	7,1	20,3	20,6	15,1	3,1	3,5	4,8
Benzo(a)anthracene	2,7	12,5	3,6	8,6	11,5	9,3	1,5	1,9	2,6
Chrysene	8,1	34,2	6,7	16,6	18,3	12,1	2,9	3,8	4,7
Benzo(b)fluoranthene	5,9	31,2	5,1	12,8	14,5	7,3	1,7	2,9	3,7
Benzo(k)fluoranthene	7,0	14,7	4,4	10,1	13,2	7,0	1,7	2,2	2,4
Benzo(a)pyrene	4,0	16,1	4,5	10,2	14,1	9,4	1,8	2,3	3,6
Indeno(1,2,3-cd)pyrene	<2,0	14,4	3,0	6,3	9,4	7,3	<2,0	2,0	2,2
Dibenzo(ah)anthracene	4,6	3,3	<1,0	1,6	2,3	1,3	<1,0	<1,0	<1,0
Benzo(ghi)perylene	5,2	13,4	3,8	8,0	9,2	7,2	1,7	2,9	3,5
Σ PAH (16)[4, 5]	63,8	268,1	60,5	146,7	215,6	107,7	28,6	43,6	41,4
Σ PAH (15)[3, 5]	58,8	263,1	55,5	141,7	144,1	102,7	23,6	29,7	36,4
Σ PAH (12)[2, 5]	57,3	243,8	54,0	139,6	142,6	101,2	22,1	28,2	34,9
Σ PAH (6)[1, 5]	32,1	137,4	29,3	77,3	84,2	56,8	11,3	16,2	20,6

Inventory and temporal monitoring of silicon





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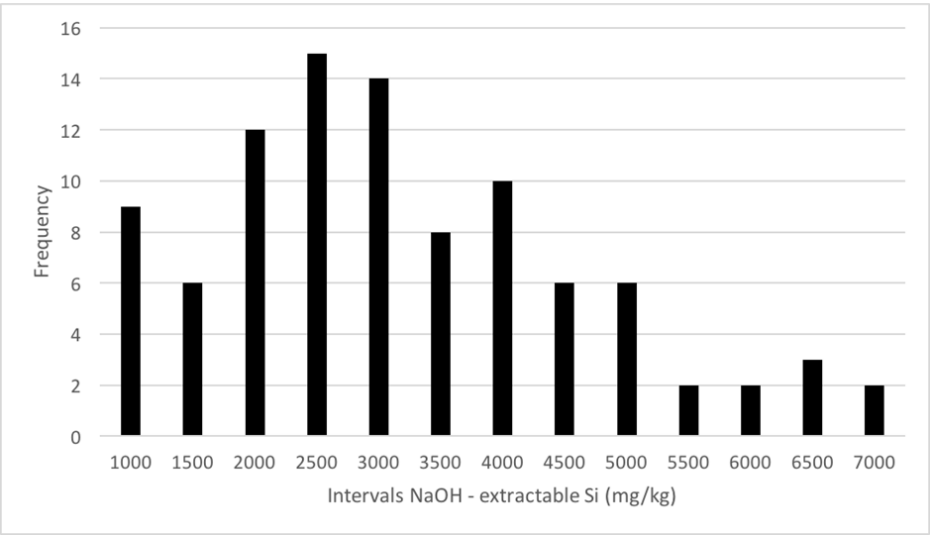

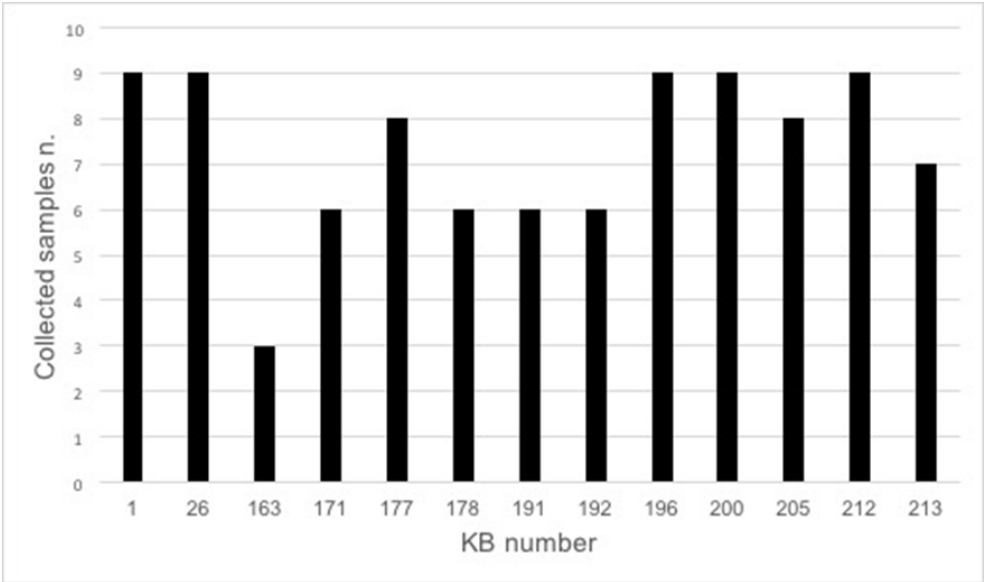

Atmospheric deposition – dust

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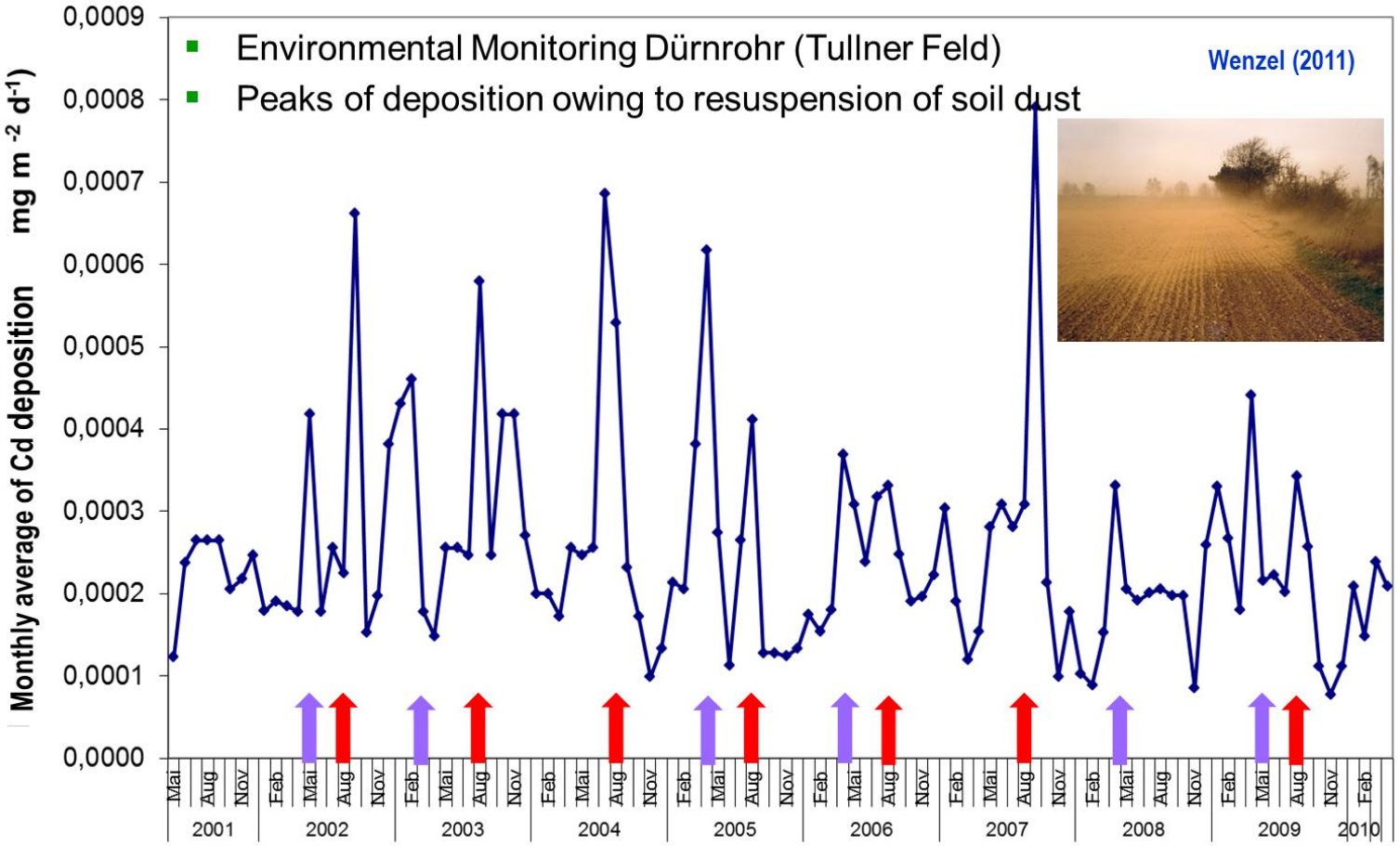

Atmospheric deposition – dust

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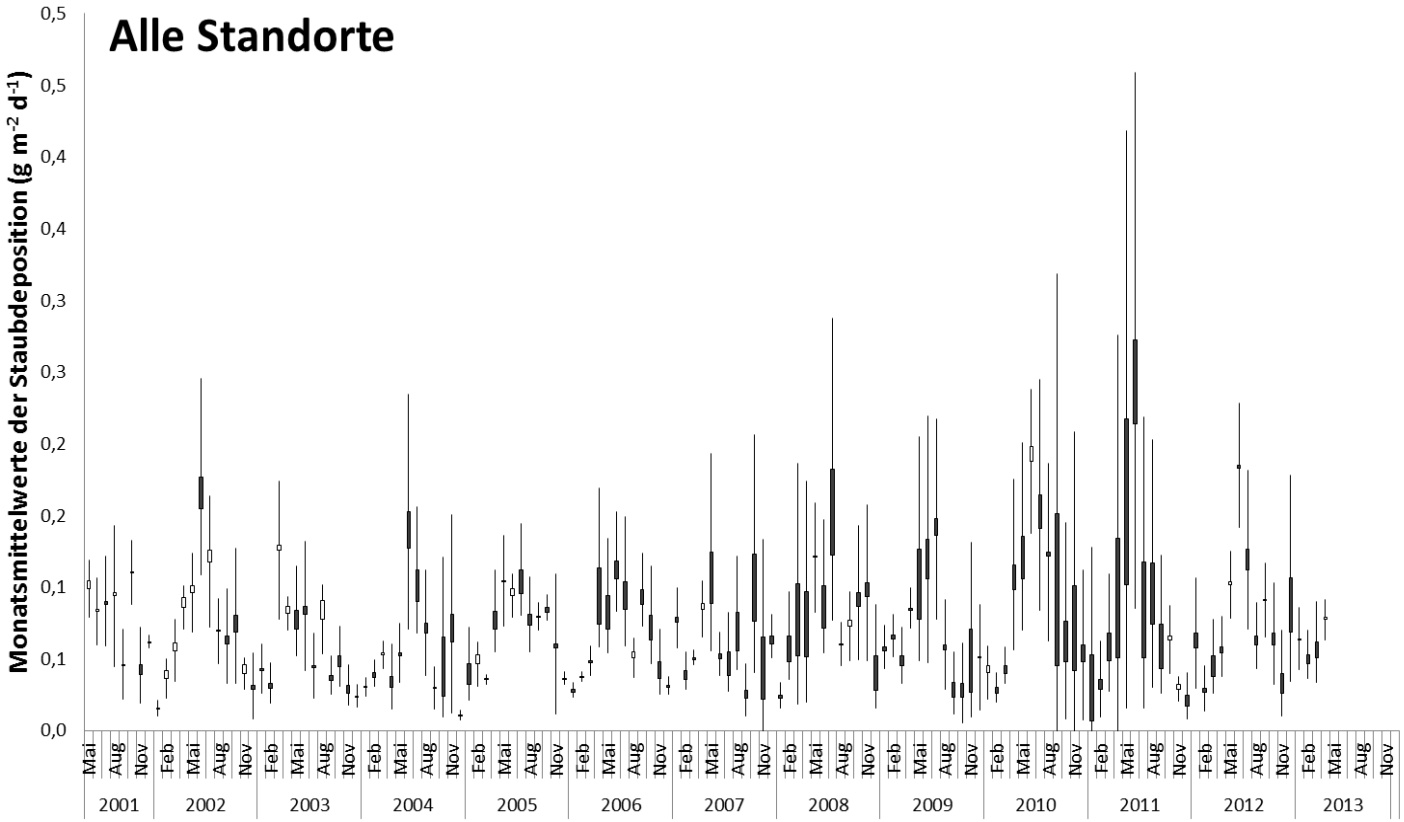

Atmospheric deposition – metals and metalloids

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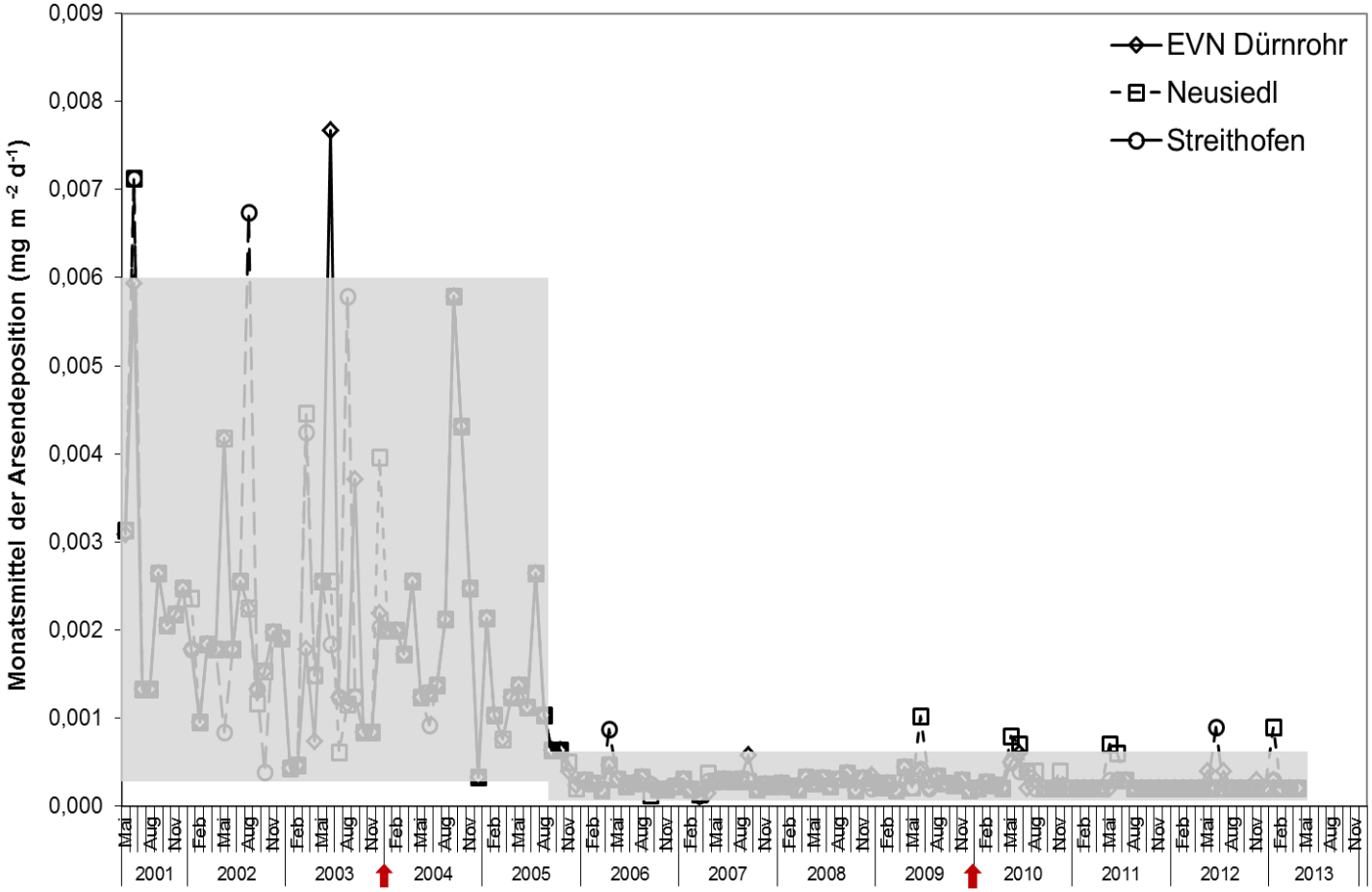

Atmospheric deposition – metals and metalloids

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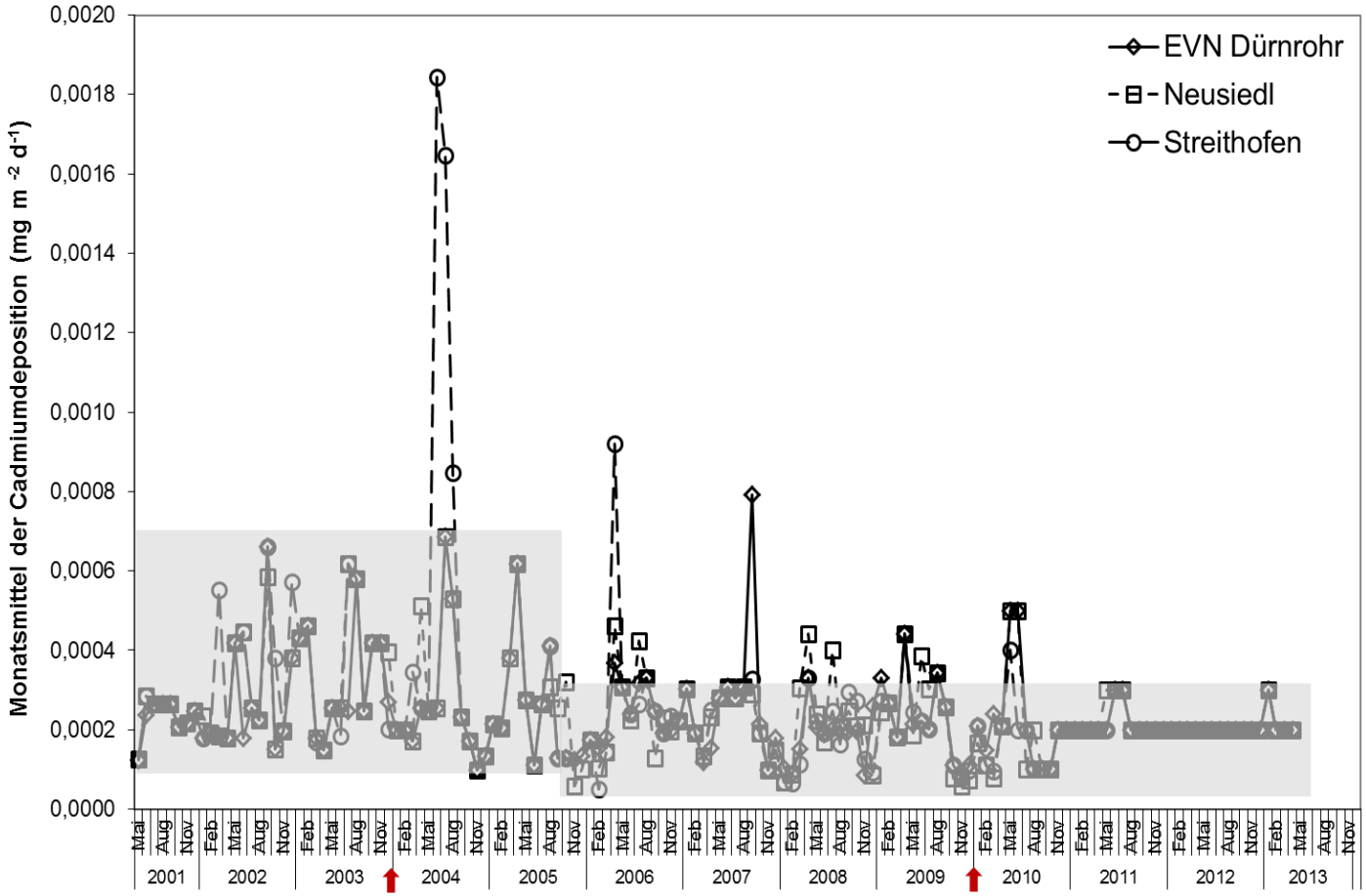
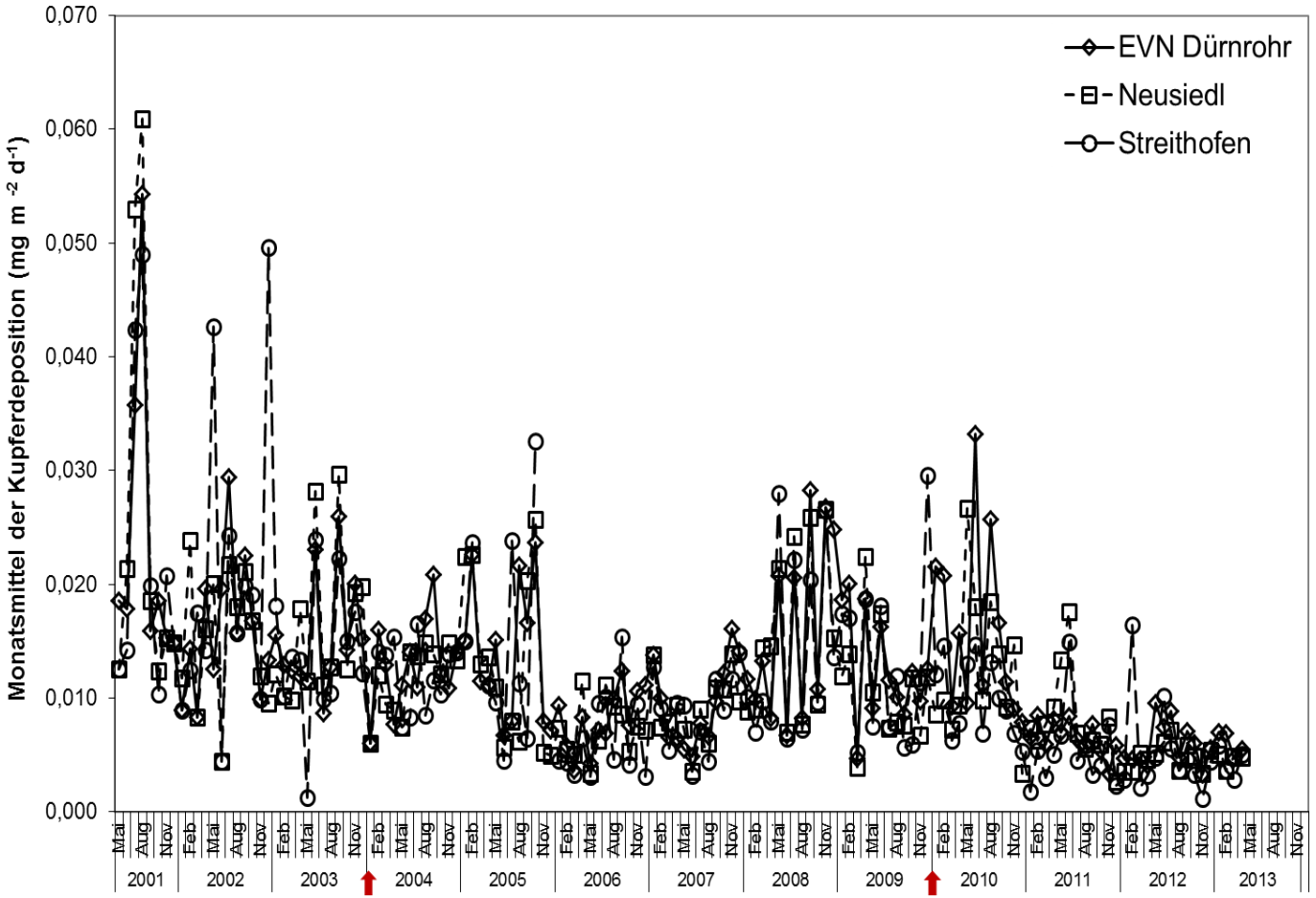


Atmospheric deposition – metals and metalloids



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Atmospheric deposition – dust

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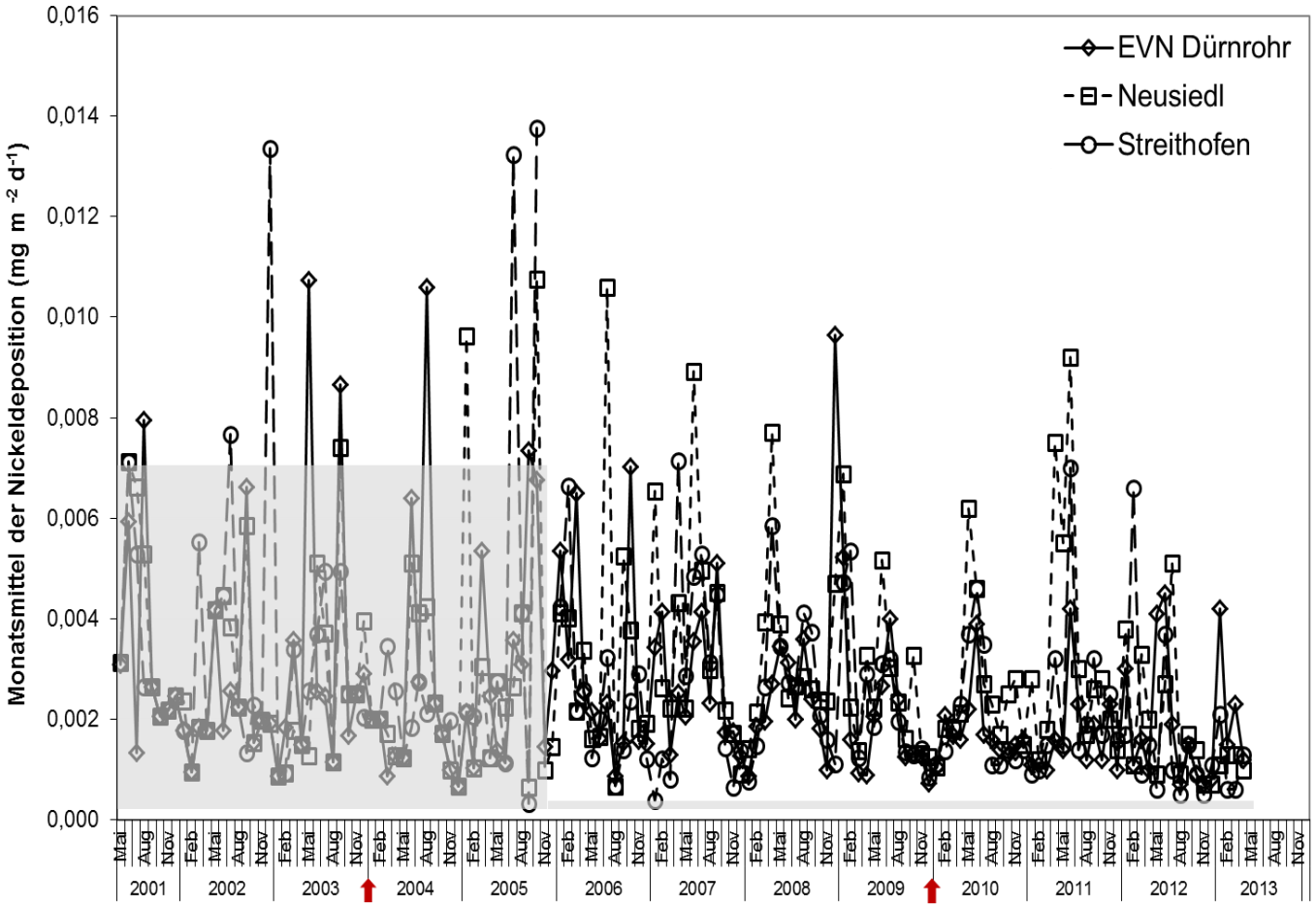

Monitoring atmospheric deposition – metals and metalloids

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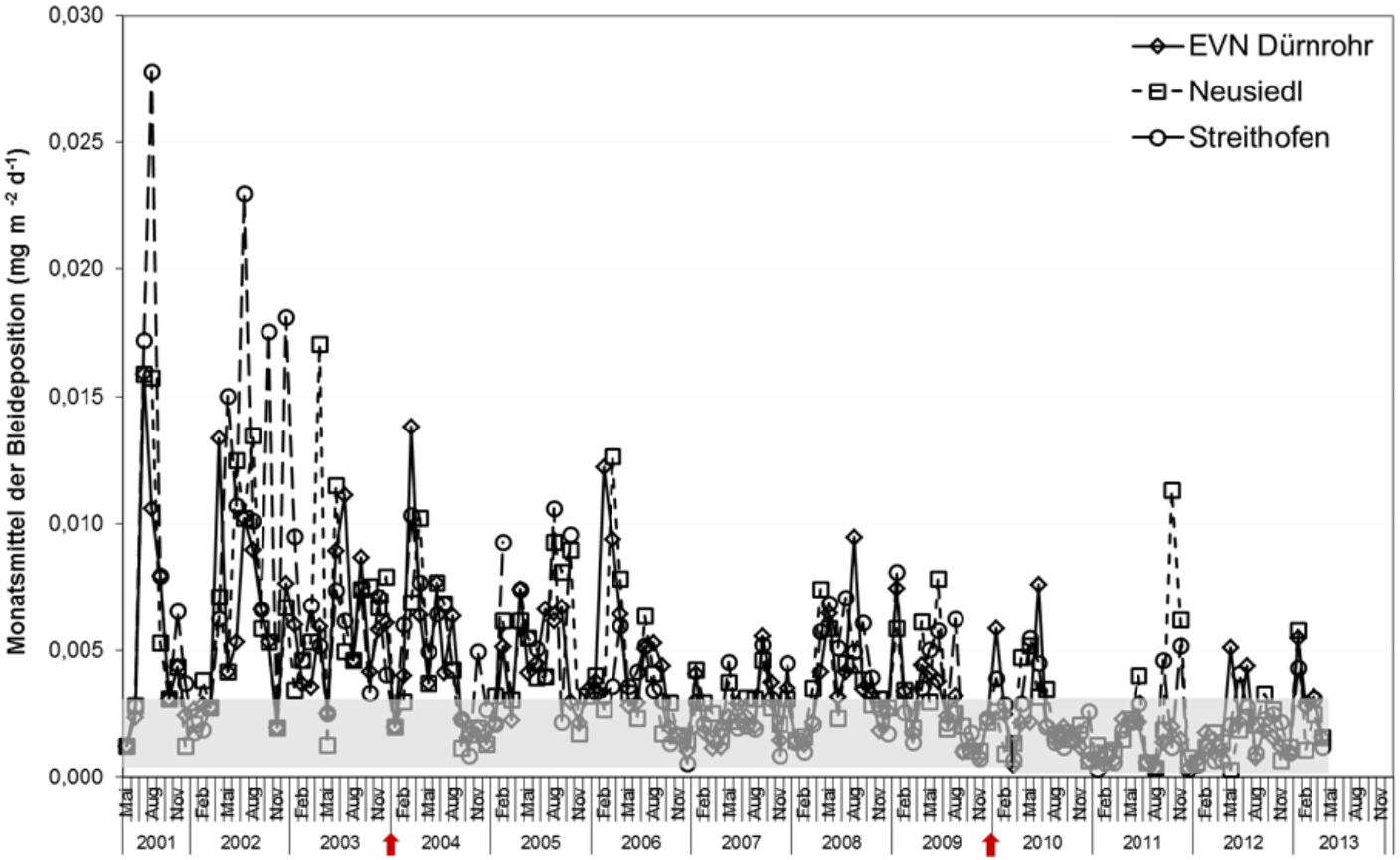

Atmospheric deposition – dust

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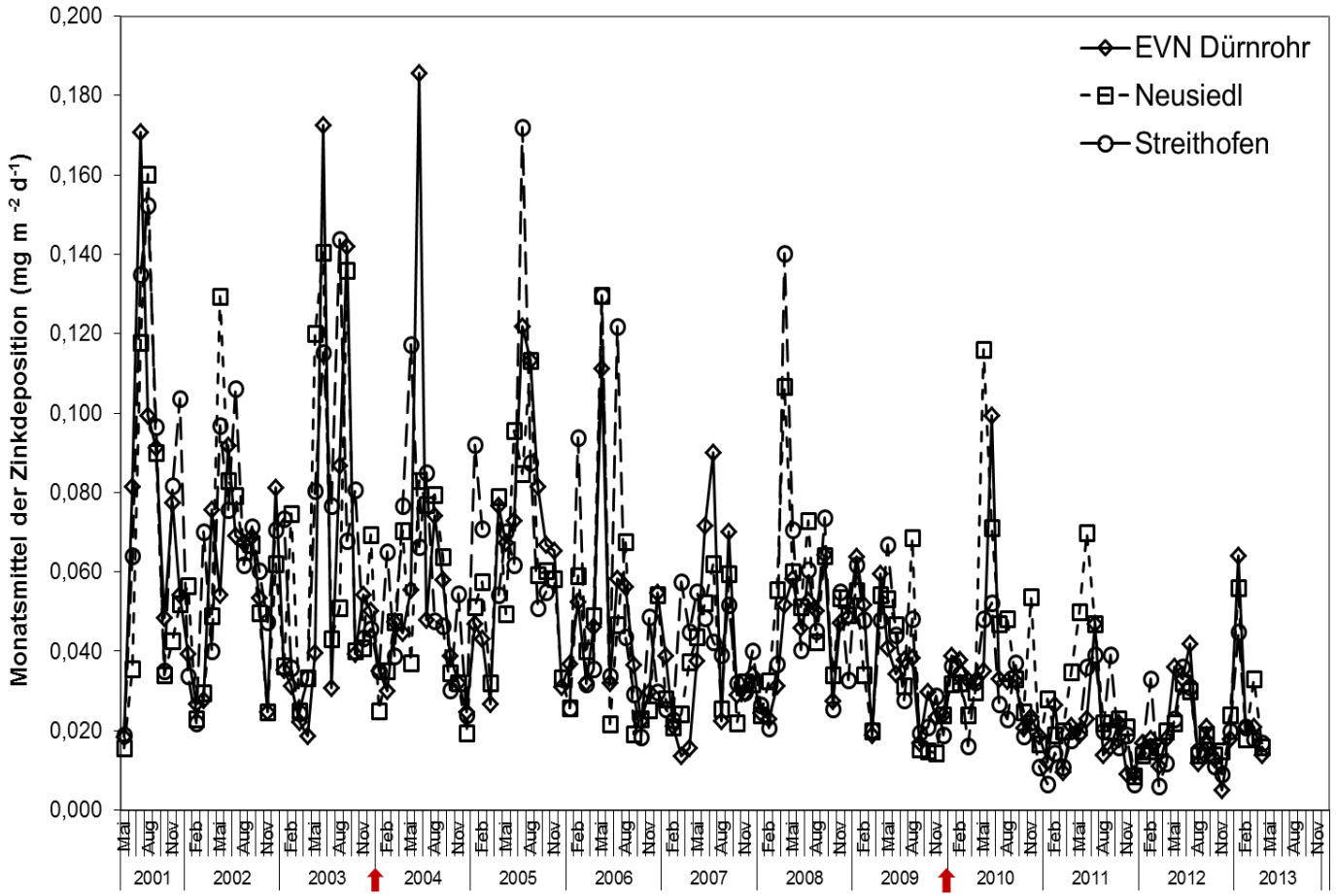

Atmospheric deposition – Metals and metalloids

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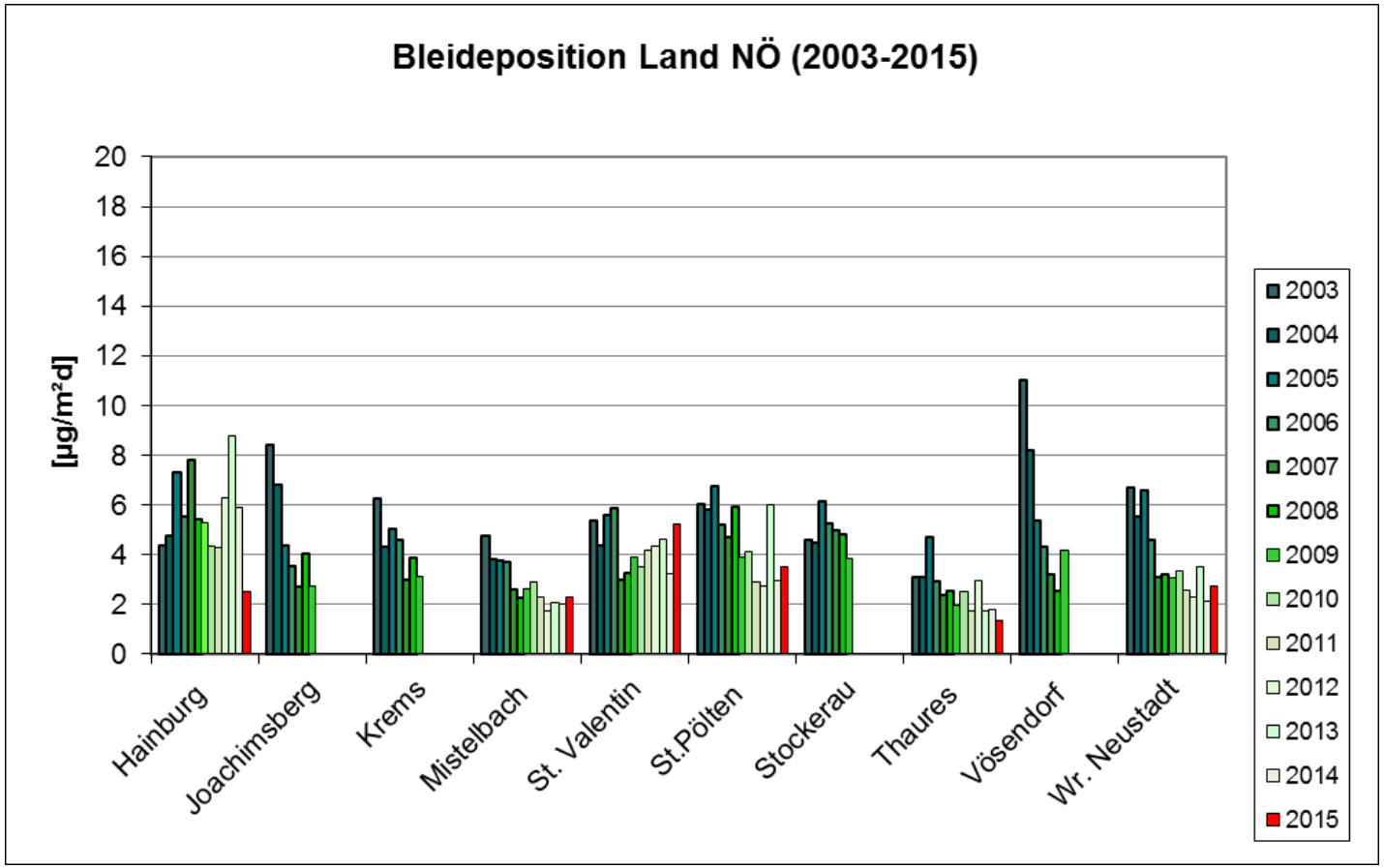

Source: Land NÖ, Luftgüteüberwachung NUMBIS, DI. Manfred Brandstätter

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Conclusions

Conclusions

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- Comprehensive data available
- But need to be compiled in one database
- Data mining, assessment and compilation required
- Cover potential gaps
- Integrate with other databases of Lower Austria
- Expand to emerging pollutants