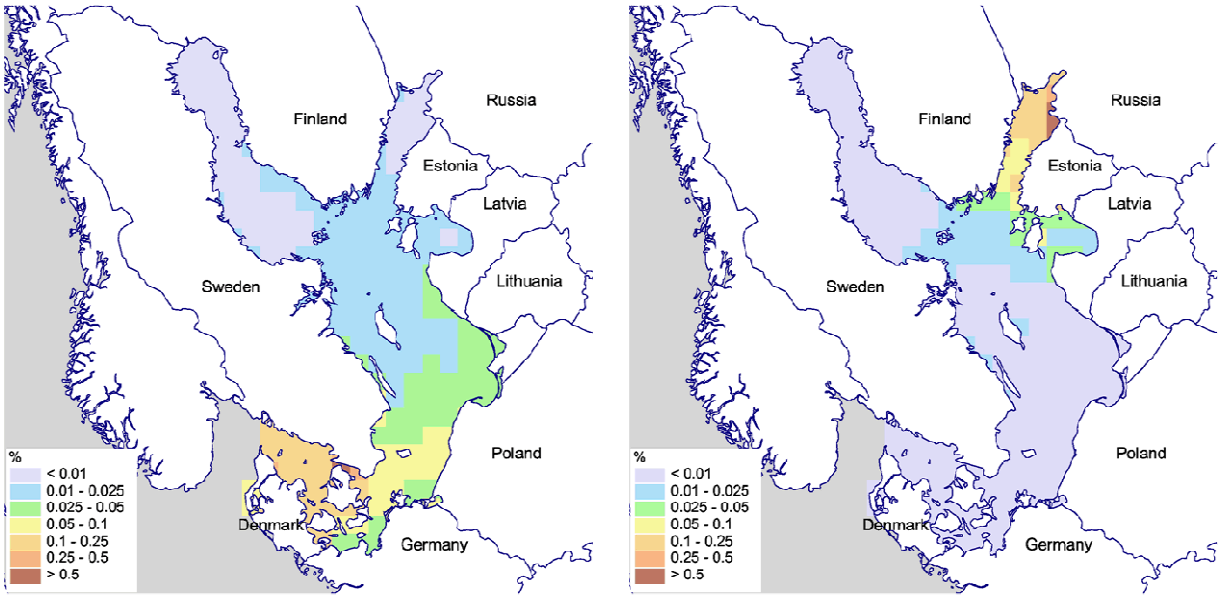
4. Atmospheric Supply of Lead to the Baltic Sea in 2005

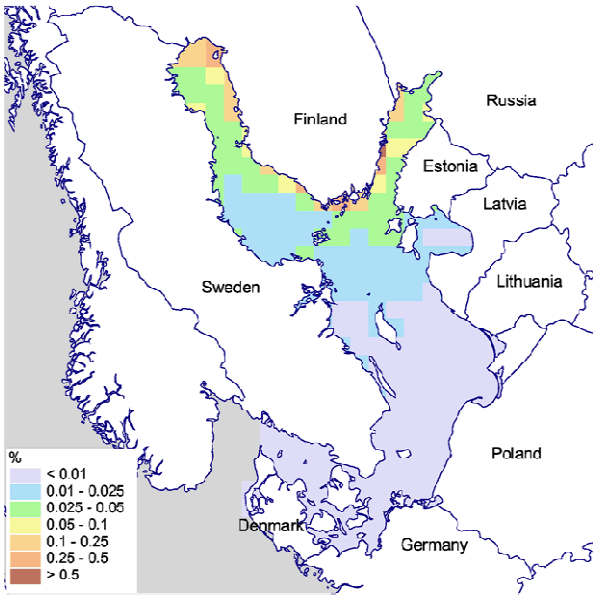
In this chapter the results of model evaluation of lead atmospheric input to the Baltic Sea and its sub-basins for 2005 is presented. Modelling of lead atmospheric transport and depositions was carried out using MSC-E Eulerian Heavy Metal transport model MSCE-HM (Travnikov and Ilyin, 2005). Latest available official information on lead emission from HELCOM countries and other European countries was used in computations. Based on these data levels of annual and monthly lead depositions to the Baltic Sea region have been obtained and contributions of HELCOM countries emission sources to the depositions over the Baltic Sea are estimated. Model results were compared with observed levels of lead concentrations in air and precipitation measured at monitoring sites around the Baltic Sea in 2005.

4.1 Lead emissions

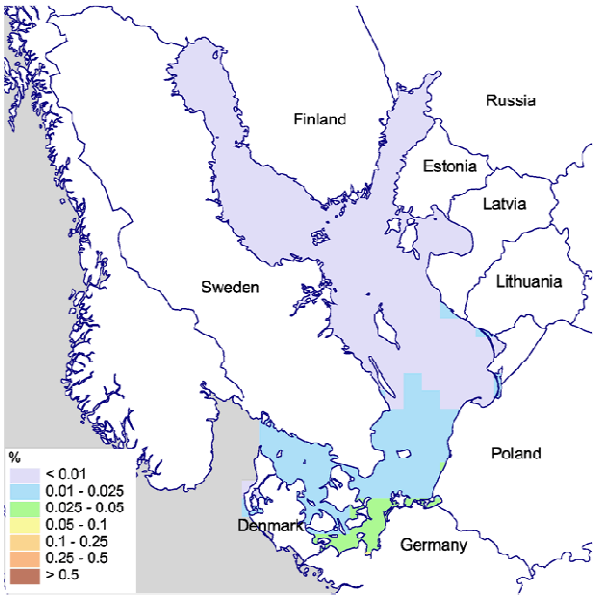


Denmark Estonia

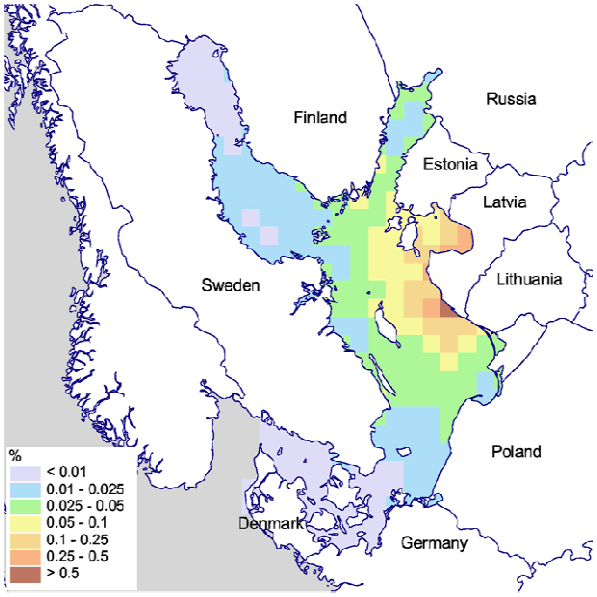
Figure 4.1. Maps with the fractions (in %) of annual total anthropogenic lead emissions from HELCOM Parties deposited into the Baltic Sea in 2005.



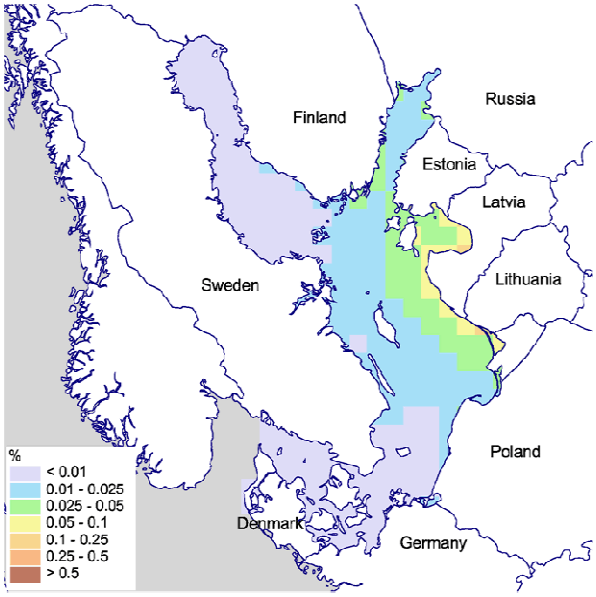
Finland



Germany

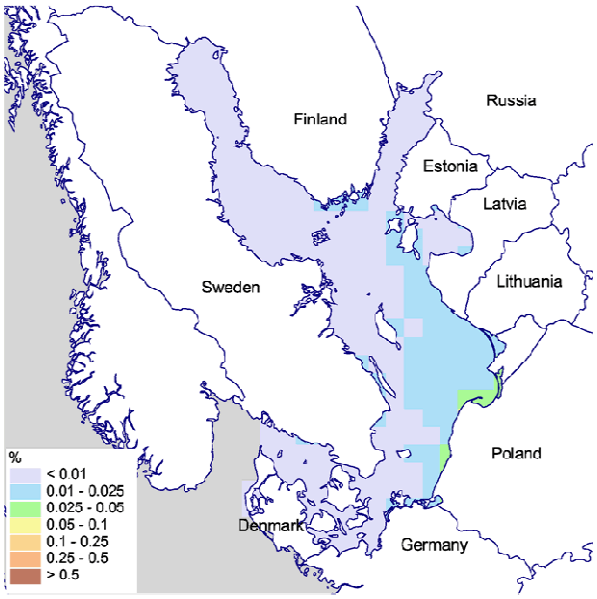


Latvia

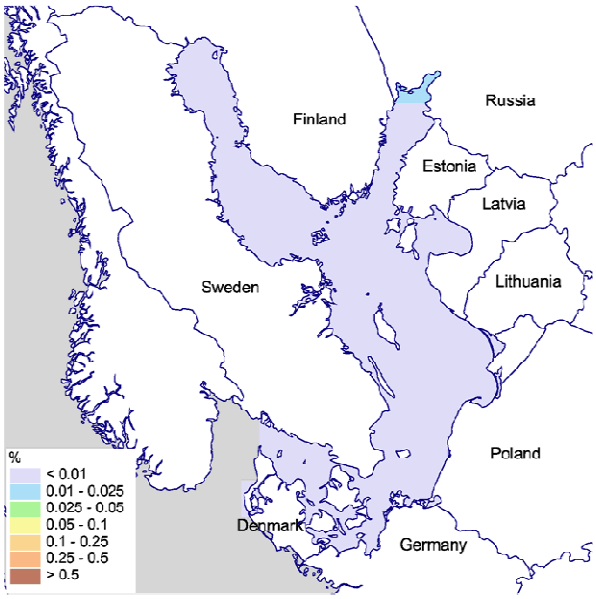


Lithuania

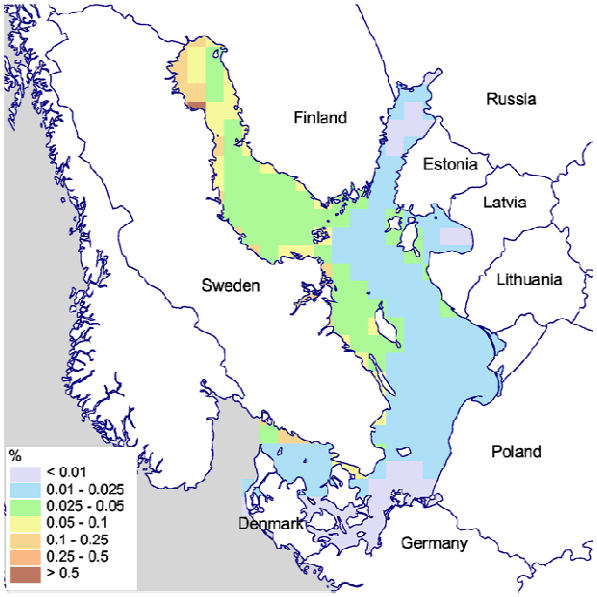
Figure 4.1 (cont.). Maps with the fractions (in %) of annual total anthropogenic lead emissions from HELCOM Parties deposited into the Baltic Sea in 2005.



Poland



Russia



Sweden

Figure 4.1 (cont.). Maps with the fractions (in %) of annual total anthropogenic lead emissions from HELCOM Parties deposited into the Baltic Sea in 2005.

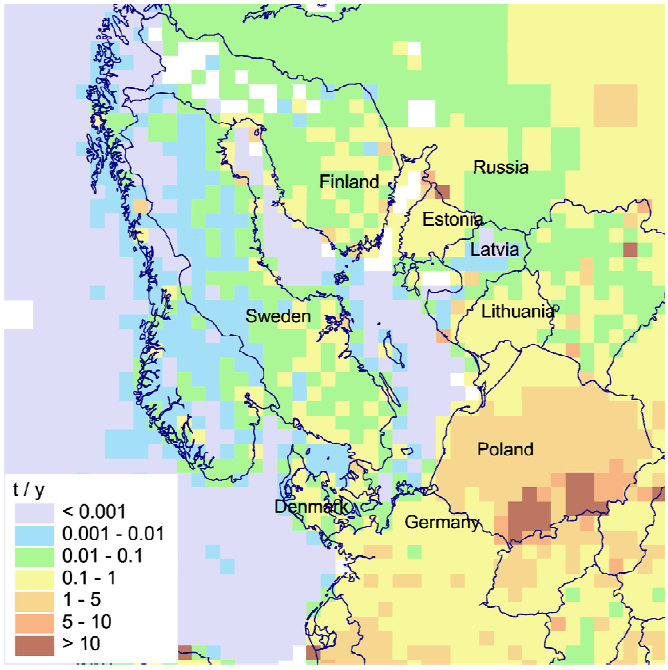


Figure 4.2. Annual total anthropogenic emissions of lead in the Baltic Sea region for 2005, t/y.

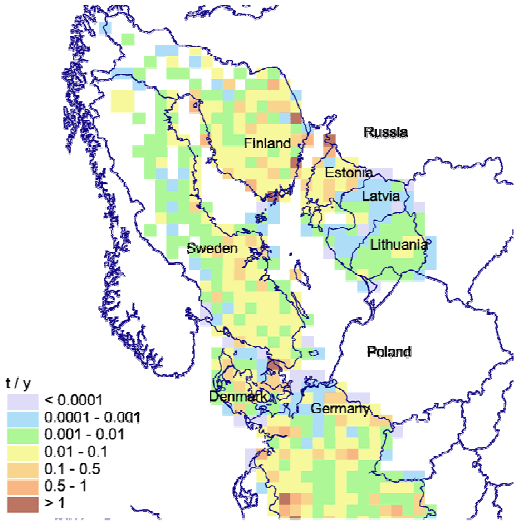


Figure 4.3. Annual lead emission from Combustion in Power Plants and Industry sector for 2005.

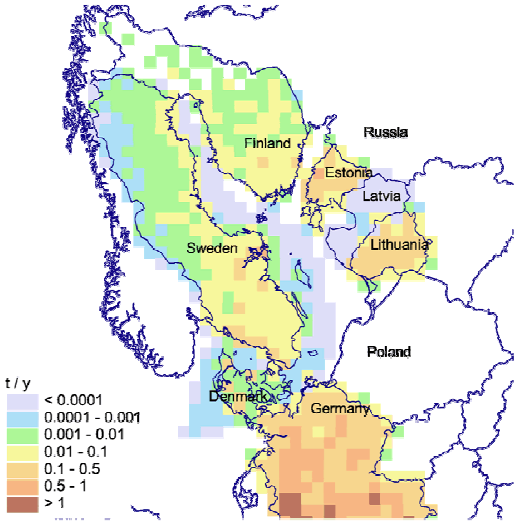


Figure 4.4. Annual lead emission from Transport sector for 2005.

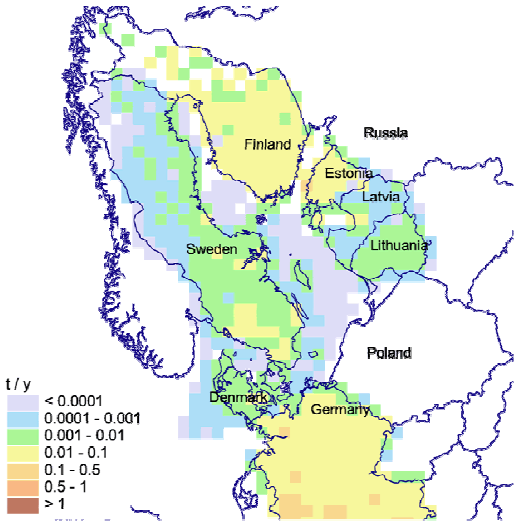


Figure 4.5. Annual lead emission from Commercial, Residential and Other Stationary Combustion sector for 2005.

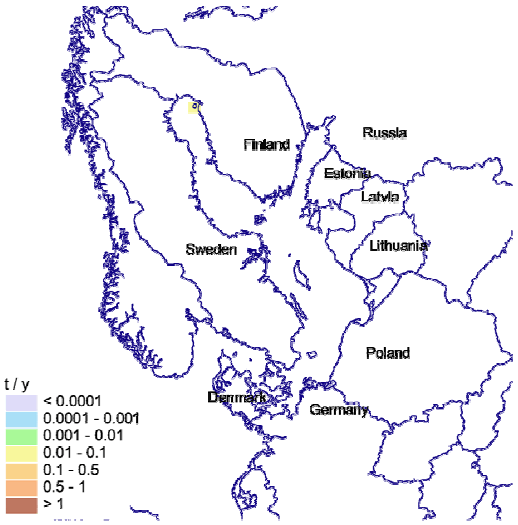


Figure 4.6. Annual lead emission from Fugitive emissions from fuels sector for 2005.

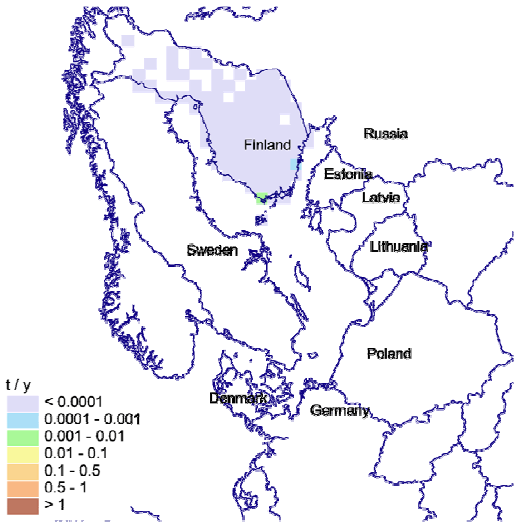


Figure 4.7. Annual lead emission from Solvent and Other Product Use sector in Finland for 2005.

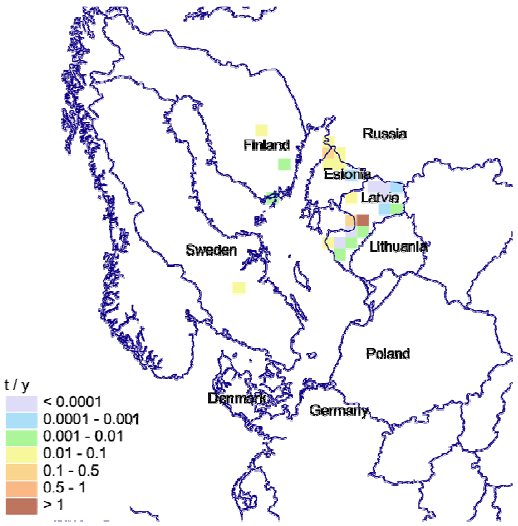


Figure 4.8. Annual lead emission from Waste sector in Latvia for 2005.

Table 4.1. Annual total lead anthropogenic emissions of HELCOM countries from different sectors for 2005, in tonnes per year

NFR emission sector	Sector name	Denmark	Estonia	Finland	Germany	Latvia	Lithuania	Poland	Russia	Sweden
1	Combustion in Power Plants and Industry	3.6	31.7	15.6	14.1	0.06	0.6	270	355	4.1
2a	Transport above 1000m	0	NA	0.0005	NA		0		0	NA
2b	Transport below 1000m	1.4	3.8	2.02	82.4	0.002	4.9	16.5		6.6
3	Commercial, Residential and Other Stationary Combustion	0.2	0.9	2.6	10.3	0.06	0.09	170		0.8
4	Fugitive Emissions From Fuels	0	0	0.02	NA		0	1.9		0
5	Industrial Processes	0.4	0	2.7	NA	14.1	0	75		5.1
6	Solvent and Other Product Use	0	0	0.006	NA		0			NE
7	Agriculture	0	NA		NA	0	0			NA
8	Waste	0	0.3	0.02	7.4E-06	2.5		3.05		0.03
9	Other				NA			0.43		
Total		**5.6**	**36.7**	**23.0**	**106.8**	**16.7**	**5.7**	**536.6**	**355**	**16.5**

NA – not available
NE – not estimated

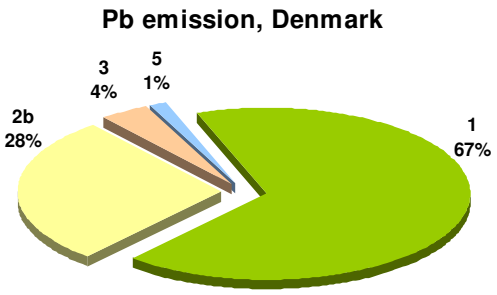


Figure 4.9. Percentage of annual total lead emission from different sectors in Denmark for 2005.

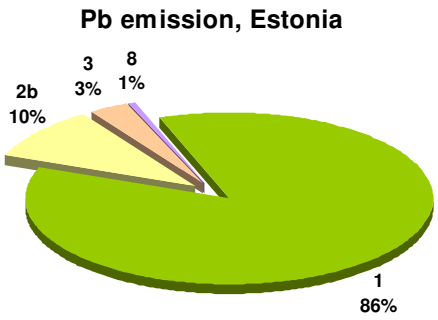


Figure 4.10. Percentage of annual total lead emission from different sectors in Estonia for 2005.

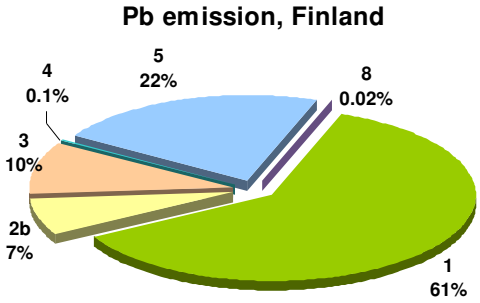


Figure 4.11. Percentage of annual total lead emission from different sectors in Finland for 2005.

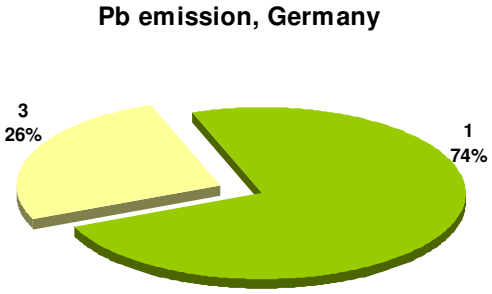


Figure 4.12. Percentage of annual total lead emission from different sectors in Germany for 2005.

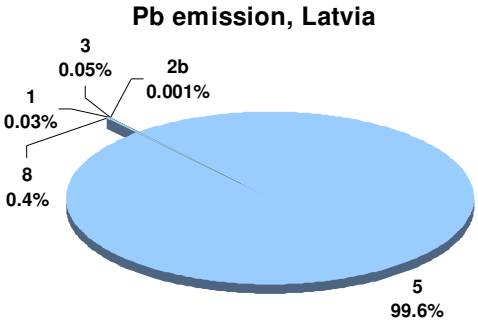


Figure 4.13. Percentage of annual total lead emission from different sectors in Latvia for 2005.

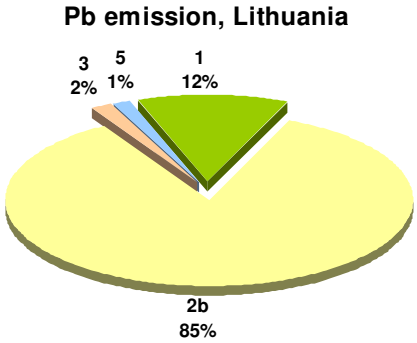


Figure 4.14. Percentage of annual total lead emission from different sectors in Lithuania for 2005.

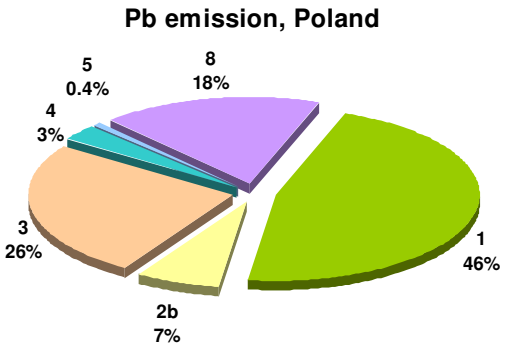


Figure 4.15. Percentage of annual total lead emission from different sectors in Poland for 2005.

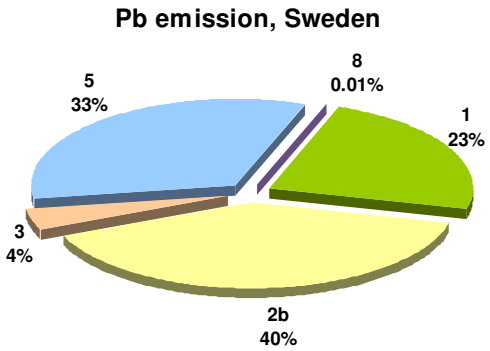


Figure 4.16. Percentage of annual total lead emission from different sectors in Sweden for 2005.

Table 4.2. Annual total anthropogenic emissions of lead of HELCOM countries and other EMEP countries in period 1990-2005, tonnes (Expert estimates of emissions are shaded)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Denmark	122	95	86	44	11	10	9.9	7.7	7.0	7.1	7.0	6.3	5.5	5.0	5.5	5.6
Estonia	201	185	121	101	124	84	65	52	46	44	37	34	34	39	38	37
Finland	326	247	175	100	60	57	35	19	20	14	38	38	40	34	27	24
Germany	1801	1055	761	606	405	330	222	96	94	96	102	105	106	107	109	107
Latvia	21	17	9.8	7.6	9.6	8.1	9.9	12	14	13	13	13	13	14	14	17
Lithuania	47	49	32	28	33	30	18	20	22	19	16	15	15	15	5.2	5.7
Poland	1372	1336	986	997	966	937	960	896	736	745	647	610	588	596	600	536
Russia	3591	3553	3095	3276	2643	2426	2304	2247	2262	2339	2352	2235	2118	2207	330	355
Sweden	352	307	287	135	41	27	23	24	23	21	19	19	17	18	18	17
HELCOM	**7832**	**6844**	**5553**	**5294**	**4293**	**3910**	**3647**	**3371**	**3224**	**3298**	**3231**	**3074**	**2935**	**3035**	**1147**	**1103**
Albania	33	34	35	36	37	38	39	40	41	42	43	39	35	32	28	24
Armenia	11	0.820	0.610	0.790	0.340	0.334	0.009	0.009	0.010	0.005	0.005	0.005	1.0	2.5	2.5	2.5
Austria	207	171	119	86	59	16	15	15	13	13	12	12	13	13	13	14
Azerbaijan	12	12	12	12	12	12	12	12	12	12	12	13	13	13	13	14
Belarus	794	519	450	377	348	147	46	42	41	38	46	41	44	43	45	50
Belgium	442	418	397	320	259	247	221	195	169	144	118	102	72	68	81	78
Bosnia and Herzegovina	97	97	97	97	97	97	97	97	97	97	97	91	85	79	72	66
Bulgaria	436	408	381	353	325	297	279	231	251	224	213	177	105	148	143	115
Croatia	466	426	385	345	304	264	268	190	183	178	147	107	60	23	16	16
Cyprus	31	31	33	33	33	34	33	32	31	29	59	66	59	50	9.8	3.8
Czech Republic	269	240	247	232	202	180	165	180	169	157	108	47	47	39	37	47
France	4283	2876	2090	1833	1630	1450	1276	1127	1010	776	250	213	206	145	135	134
Georgia	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	7.0	7.2	7.3	7.5	7.6
Greece	505	499	493	488	482	476	470	470	470	470	470	470	470	470	470	470
Hungary	663	488	208	187	155	130	100	90	82	39	42	51	34	34	34	38
Iceland	6.4	5.8	5.1	4.5	3.9	3.3	2.7	2.1	1.4	0.816	0.197	0.197	0.197	0.197	0.197	0.197
Ireland	116	111	107	96	84	76	65	54	39	24	15	11	9.1	8.2	8.4	7.9
Italy	4375	3315	2437	2237	2046	1925	1801	1607	1447	1262	932	701	236	240	252	252
Kazakhstan	256	256	256	256	256	256	256	256	256	256	256	260	264	268	271	275
Luxembourg	77	71	65	59	53	30	26	18	6.8	2.3	1.8	2.0	1.9	1.9	1.9	1.9
Monaco	3.9	4.1	4.2	3.8	2.2	0.815	0.698	0.620	0.518	0.465	0.060	0.063	0.057	0.047	0.042	0.041
Netherlands	340	299	251	225	193	164	120	73	50	42	35	39	43	40	44	44
Norway	187	144	127	87	24	22	9.9	9.4	9.5	8.6	7.3	6.4	7.6	7.3	8.2	5.8
Portugal	621	646	694	674	649	631	615	591	586	417	228	250	253	248	252	244
Republic of Moldova	249	220	103	71	23	34	28	22	7.9	11	2.8	3.4	3.3	11	2.3	5.1
Romania	585	573	561	550	538	526	514	502	491	420	402	476	411	347	282	218
Serbia and Montenegro	597	567	538	508	478	448	419	389	359	329	300	275	250	225	200	176
Slovakia	150	149	148	116	84	71	73	73	70	58	67	68	69	64	70	71
Slovenia	462	398	402	409	406	196	98	80	60	50	43	18	15	16	14	14
Spain	2681	1809	1220	1115	1104	932	902	839	779	709	589	389	268	265	261	266
Switzerland	420	380	335	281	247	184	156	137	117	52	30	27	24	21	20	20
The FYR of Macedonia	210	198	185	173	161	148	136	124	112	99	87	83	79	74	70	66
Turkey	765	765	765	765	765	765	765	765	765	765	765	717	669	620	572	524
Ukraine	3878	3586	3293	3001	2709	2417	2124	1832	1540	1248	955	663	145	123	195	195
United Kingdom	2912	2657	2434	2159	1859	1549	1314	1151	849	495	165	156	143	130	134	118
EMEP	**34984**	**29228**	**24442**	**22494**	**19932**	**17686**	**16103**	**14626**	**13349**	**11773**	**9738**	**8656**	**7078**	**6913**	**4916**	**4686**

Expert estimates:

§ *Denier van der Gon, H.A.C., M. van het Bolscher A.J.H. Visschedijk P.Y.J. Zandveld [2005]*

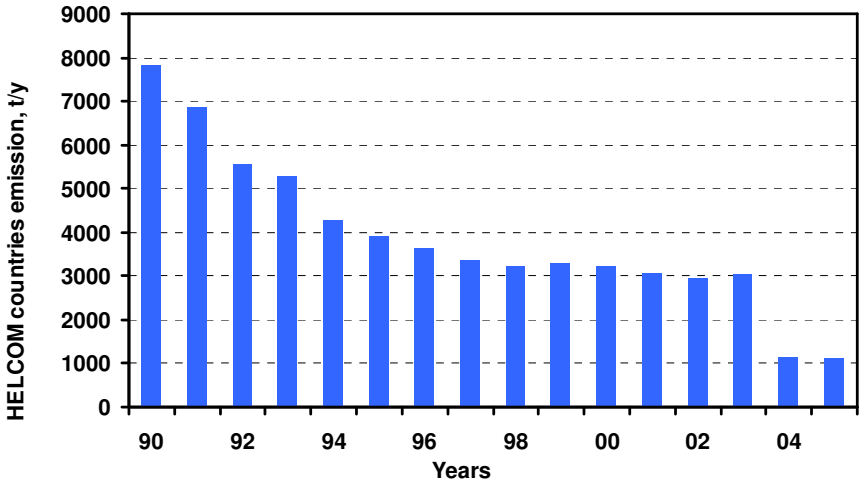


Figure 4.17. Time-series of total annual lead emissions of HELCOM countries in 1990-2005, tonnes/y.

4.2 Annual deposition of lead

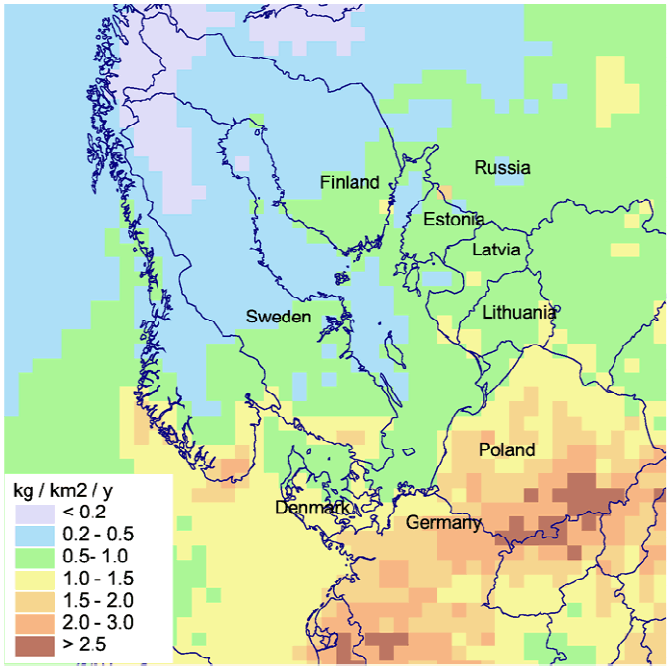


Figure 4.18. Annual deposition fluxes of lead over the Baltic Sea region for 2005, kg/km^2/year.

4.3 Monthly depositions of lead

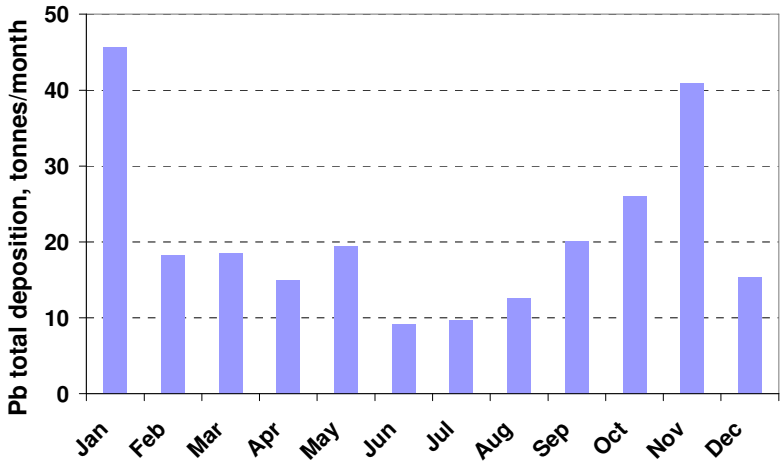


Figure 4.19. Monthly depositions of lead to the Baltic Sea for 2005, tonnes/month.

Table 4.3. Monthly depositions of lead to the Baltic Sea for 2005, tonnes/month.

Month	Deposition
Jan	46
Feb	18
Mar	18
Apr	15
May	19
Jun	9
Jul	10
Aug	13
Sep	20
Oct	26
Nov	41
Dec	15

4.4 Source allocation of lead deposition

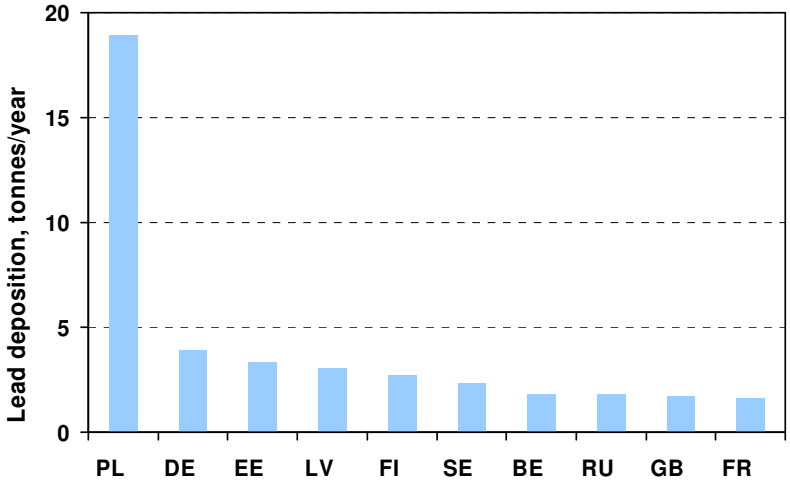


Figure 4.20. Top ten countries with the highest contribution to annual deposition of lead into the Baltic Sea for 2005, tonnes/year.

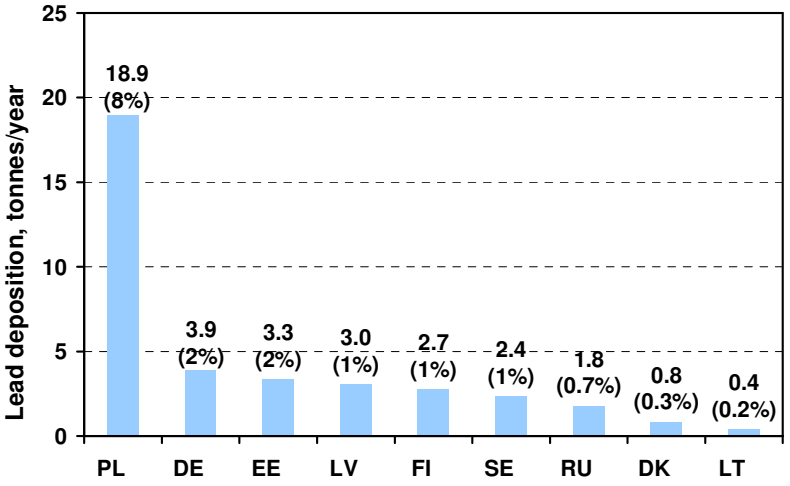


Figure 4.21. Sorted contributions (in %) of HELCOM countries to total depositions to the Baltic Sea for 2005. HELCOM countries emissions of lead contributed about 15% to the total annual lead depositions over the Baltic Sea in 2005. Contribution of other EMEP countries accounted for 6%. Significant contribution was made by other emission sources, in particular, remote emissions sources, natural emissions and re-emission of lead (79%).

Table 4.4. Two most significant contributors to the annual total depositions of lead to the six Baltic Sea sub-basins for 2005.

Sub-basin	Country	%	Country	%	*, %
GUB	**PL**	**6**	**FI**	**4**	**78**
GUF	**EE**	**13**	**PL**	**6**	**66**
GUR	**PL**	**8**	**LV**	**4**	**75**
BAP	**PL**	**9**	**DE**	**2**	**79**
BES	**PL**	**4**	**DE**	**3**	**86**
KAT	**PL**	**4**	**DE**	**2**	**86**
BAS	**PL**	**8**	**DE**	**2**	**79**

* - contribution of re-emission, natural and remote sources.

4.5 Comparison of model results with measurements

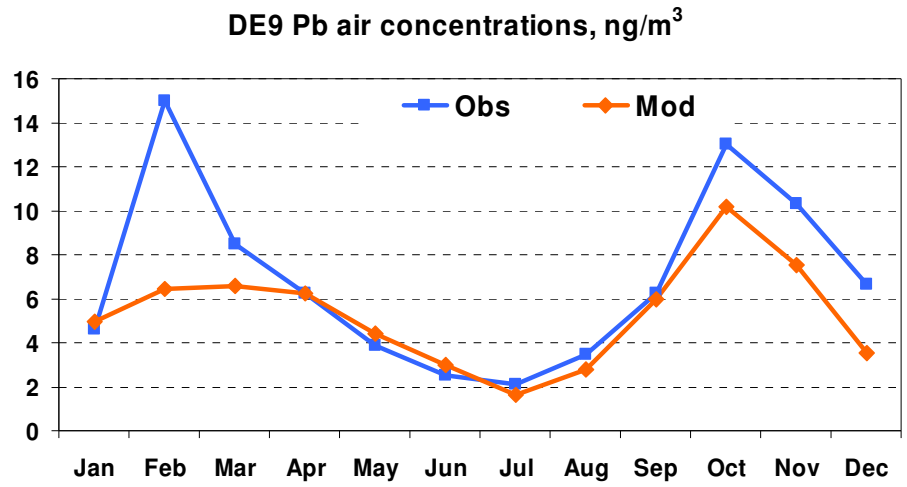


Figure 4.22. Comparison of calculated mean monthly lead concentrations in air with measured at station Zingst (DE9). Units: ng / m^3.

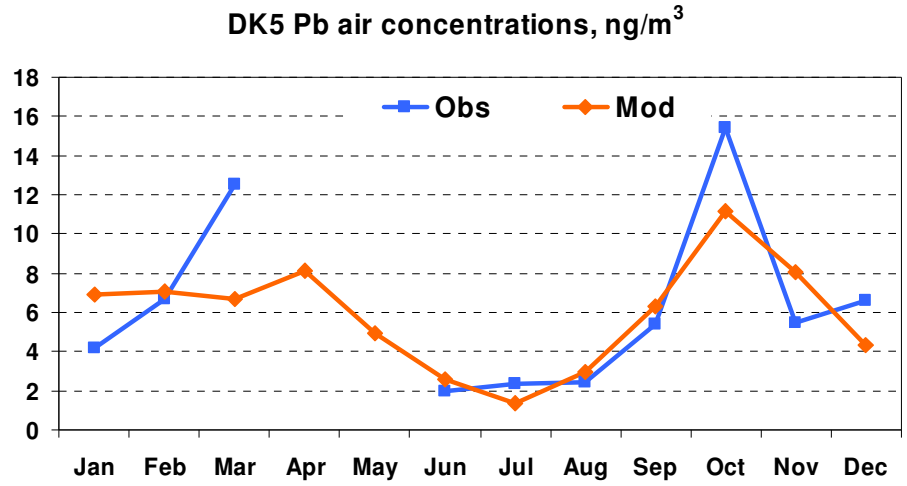


Figure 4.23. Comparison of calculated mean monthly lead concentrations in air with measured at station Keldsnor (DK5). Units: ng / m^3.

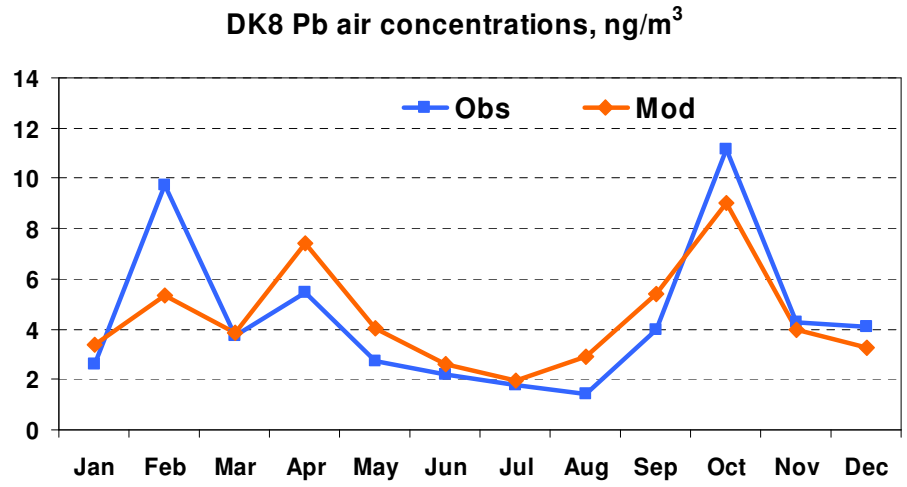


Figure 4.24. Comparison of calculated mean monthly lead concentrations in air with measured at station Anholt (DK8). Units: ng / m^3.

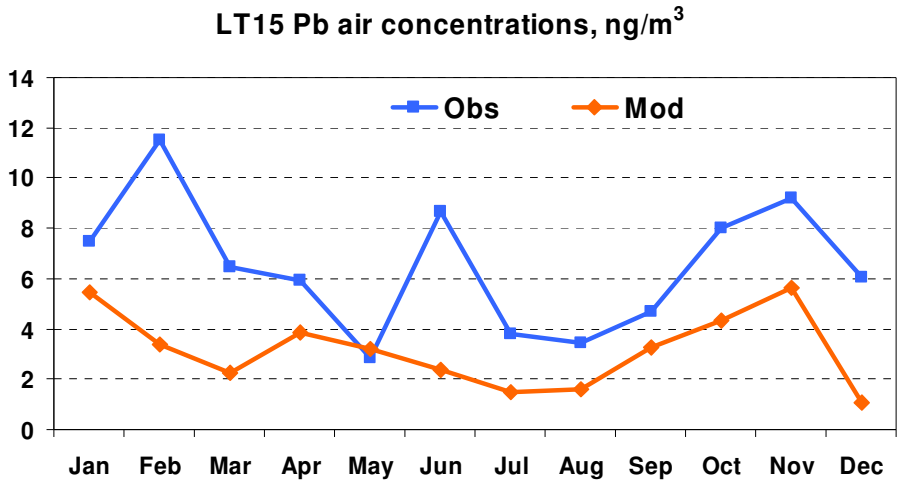


Figure 4.25. Comparison of calculated mean monthly lead concentrations in air with measured at station Preila (LT15). Units: ng / m^3.

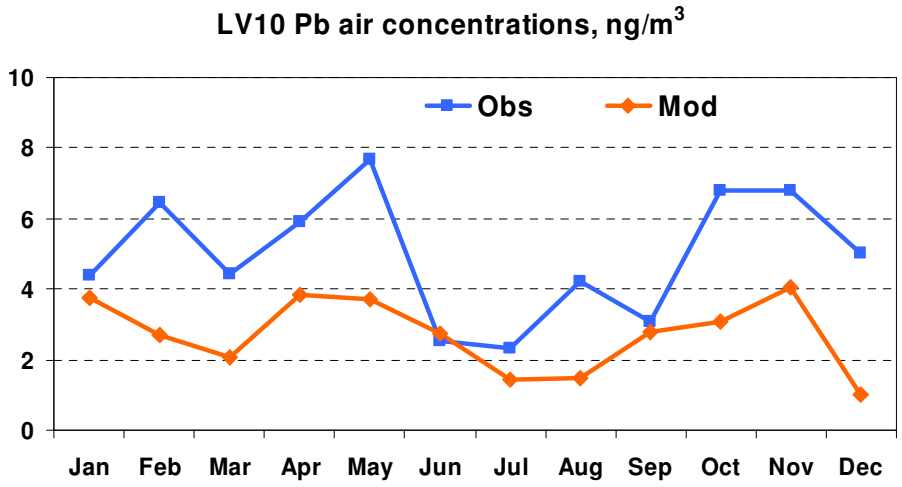


Figure 4.26. Comparison of calculated mean monthly lead concentrations in air with measured at station Rucava (LV10). Units: ng / m^3.

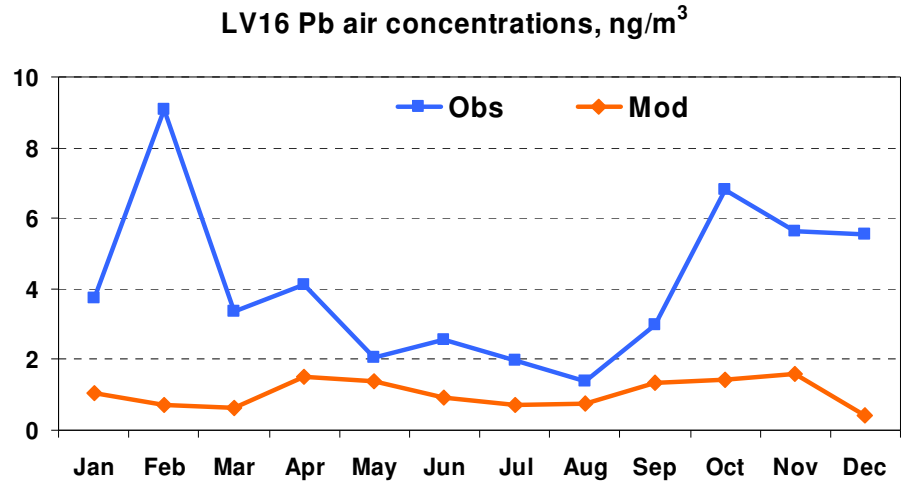


Figure 4.27. Comparison of calculated mean monthly lead concentrations in air with measured at station Zoseni (LV16). Units: ng / m^3.

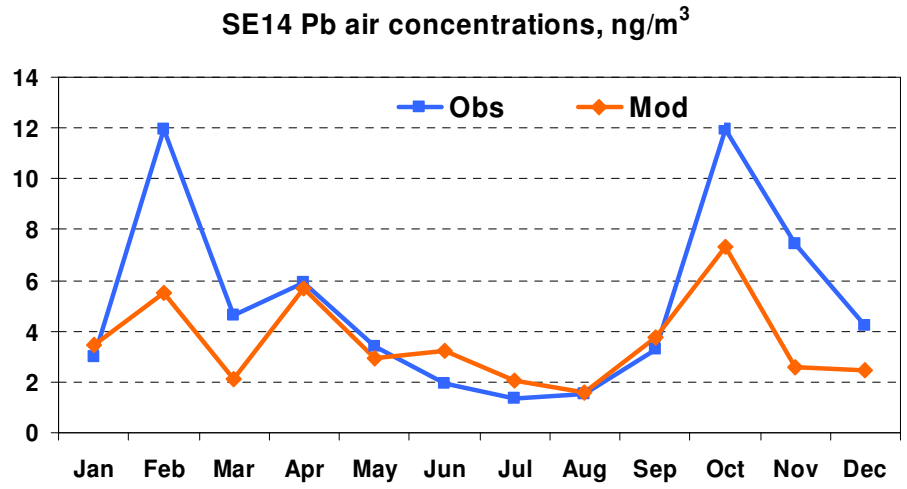


Figure 4.28. Comparison of calculated mean monthly lead concentrations in air with measured at station Räo (SE14). Units: ng / m^3.

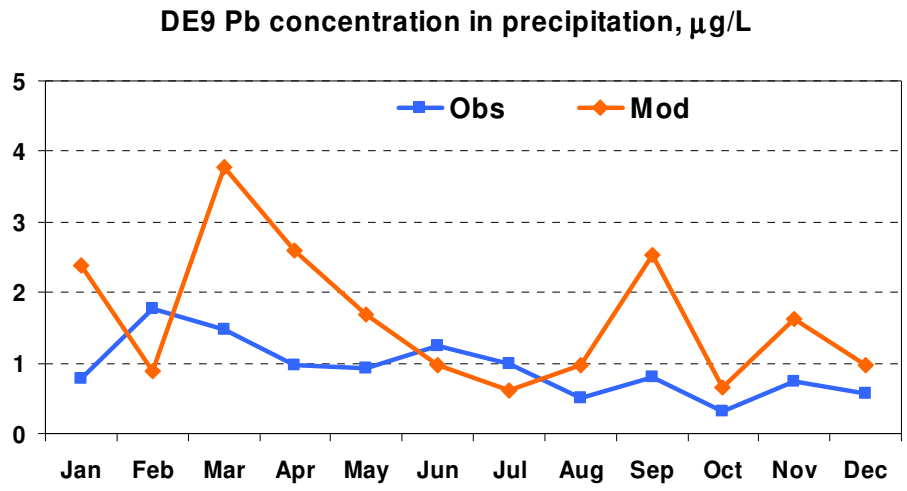


Figure 4.29. Comparison of calculated mean monthly lead concentrations in precipitation with measured at station Zingst (DE09). Units: µg / L.

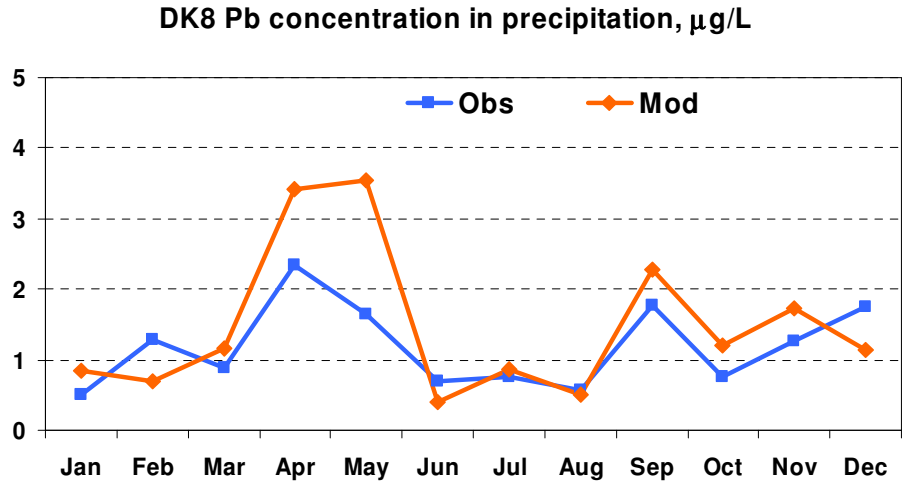


Figure 4.30. Comparison of calculated mean monthly lead concentrations in precipitation with measured at station Anholt (DK08). Units: µg / L.

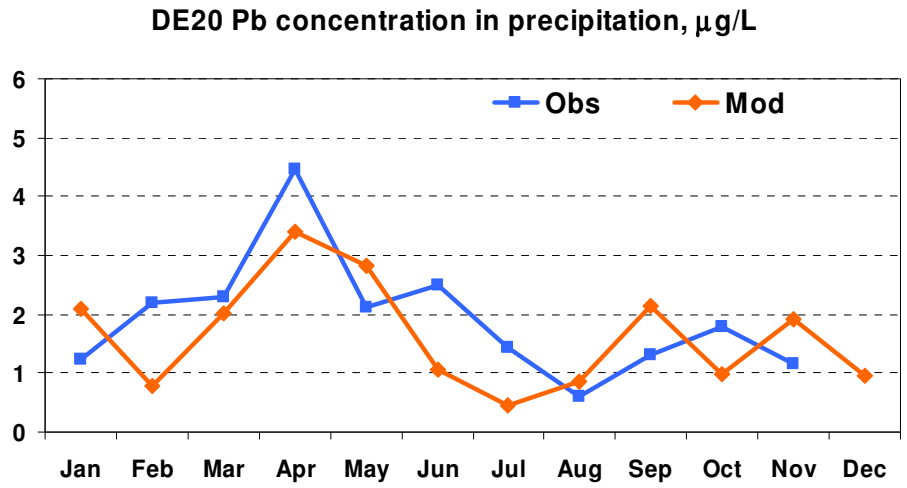


Figure 4.31. Comparison of calculated mean monthly lead concentrations in precipitation with measured at station Pedersker (DK20). Units: µg / L.

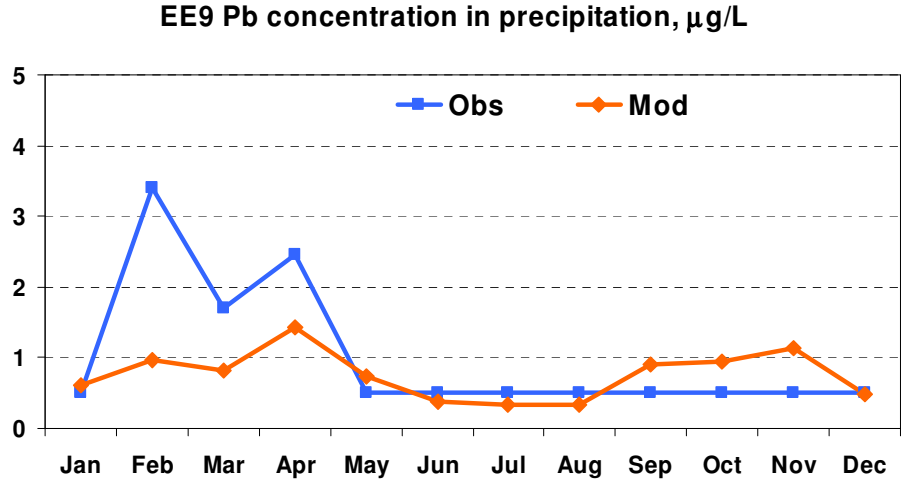


Figure 4.32. Comparison of calculated mean monthly lead concentrations in precipitation with measured at station Lahemaa (EE9). Units: µg / L.

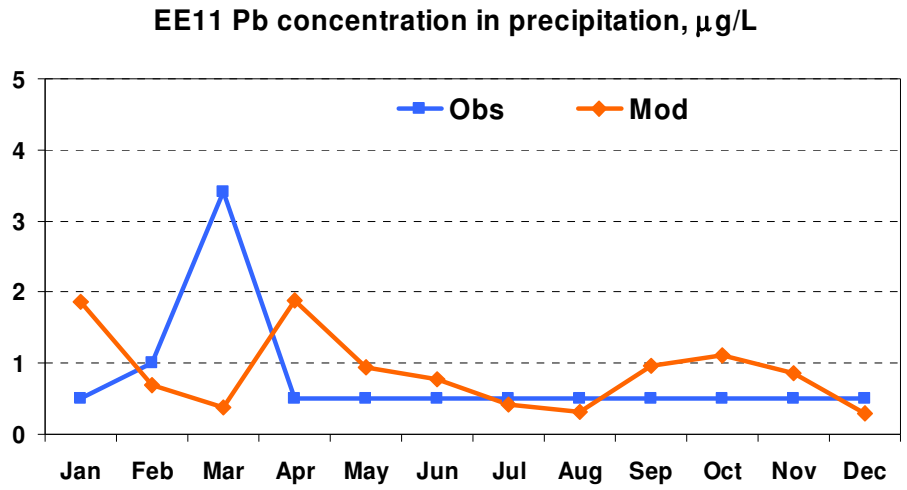


Figure 4.33. Comparison of calculated mean monthly lead concentrations in precipitation with measured at station Vilsandy (EE11). Units: µg / L.

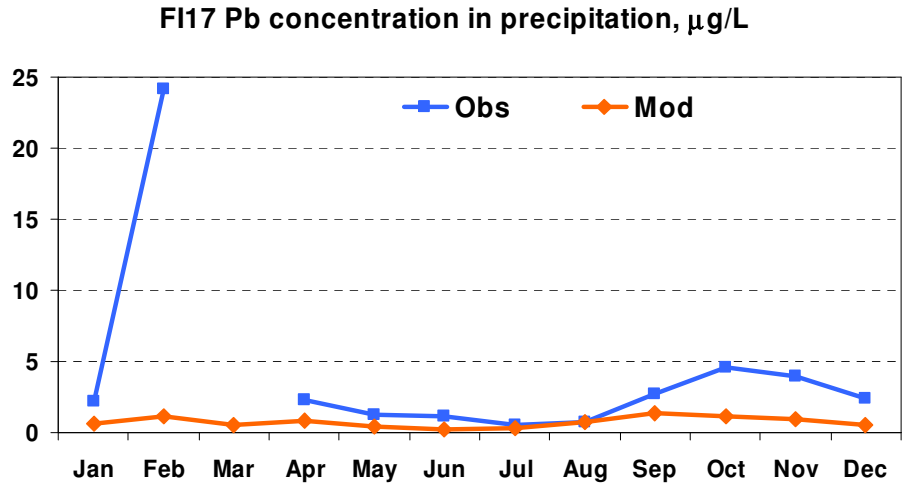


Figure 4.34. Comparison of calculated mean monthly lead concentrations in precipitation with measured at station Virolahty II (FI17). Units: µg / L.

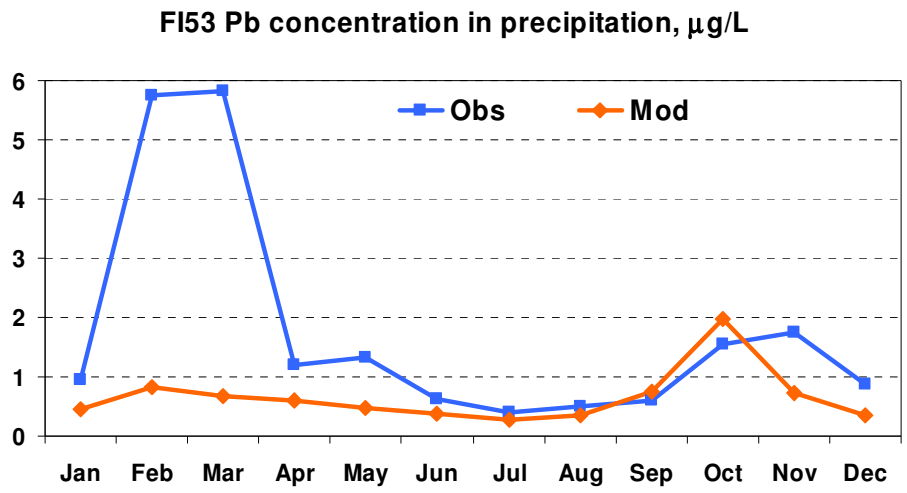


Figure 4.35. Comparison of calculated mean monthly lead concentrations in precipitation with measured at station Hailuoto (FI53). Units: µg / L.

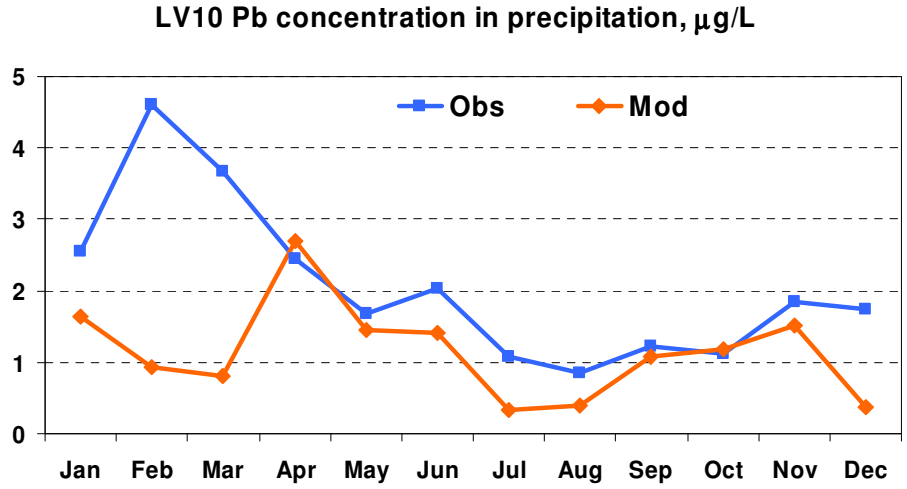


Figure 4.36. Comparison of calculated mean monthly lead concentrations in precipitation with measured at station Rucava (LV10). Units: µg / L.

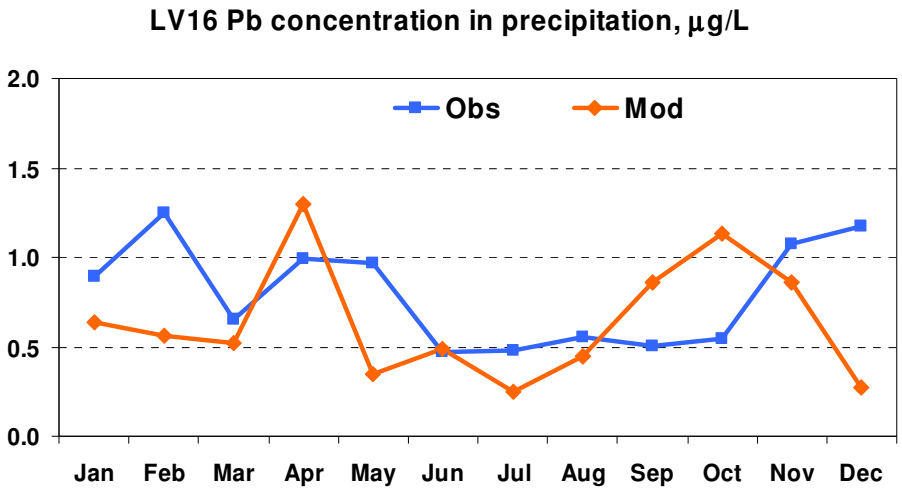


Figure 4.37. Comparison of calculated mean monthly lead concentrations in precipitation with measured at station Zoseni (LV16). Units: µg / L.

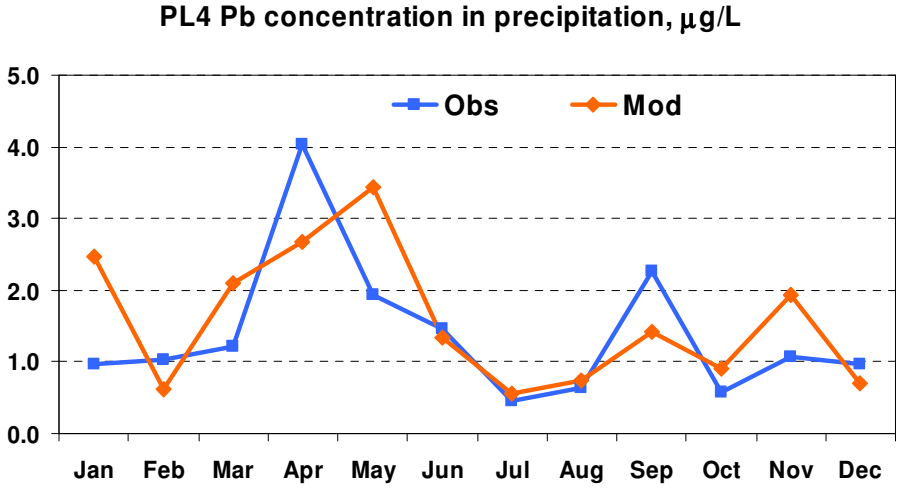


Figure 4.38. Comparison of calculated mean monthly lead concentrations in precipitation with measured at station Leba (PL04). Units: µg / L.

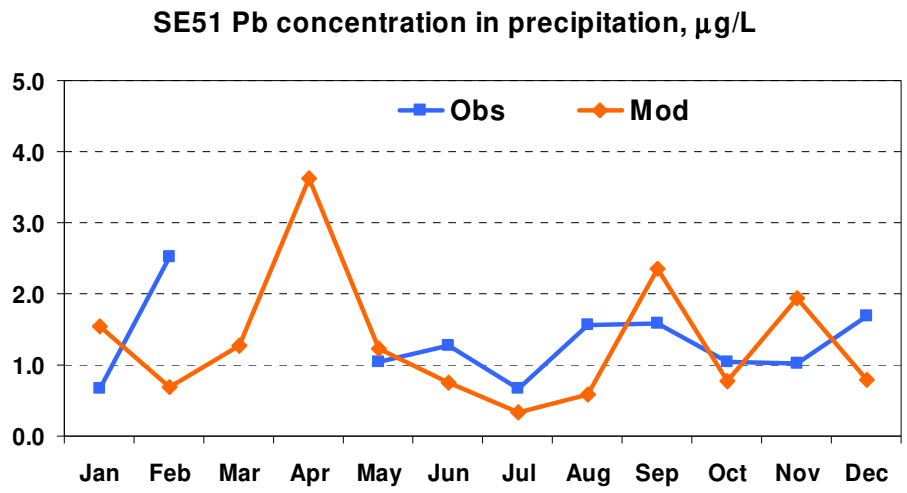


Figure 4.39. Comparison of calculated mean monthly lead concentrations in precipitation with measured at station Arup (SE51). Units: µg / L.

It can be seen that in general, computed concentrations of lead in air and in precipitation obtained for the selected monitoring sites around the Baltic Sea reasonably agree with the measured concentrations. Some deviations between simulated and observed monthly mean concentrations of lead can be connected with the uncertainties in seasonal variation of lead emission used in modeling, differences between measured precipitation amount and the one used in the model, and difficulties in measurements of heavy metals.