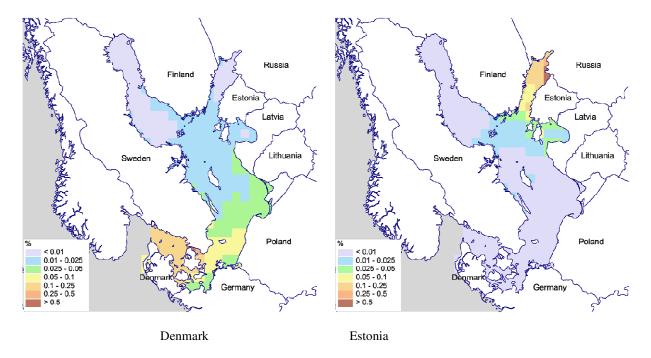
4. Atmospheric Supply of Lead to the Baltic Sea in 2005

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

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

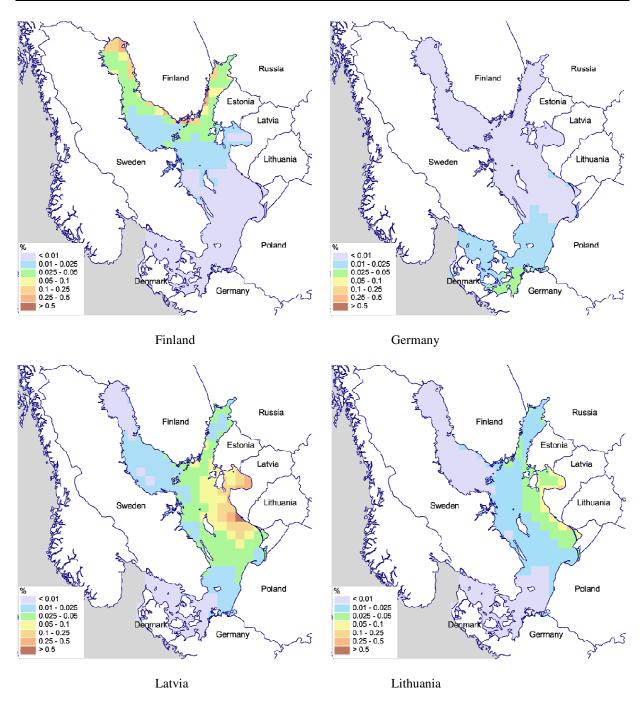
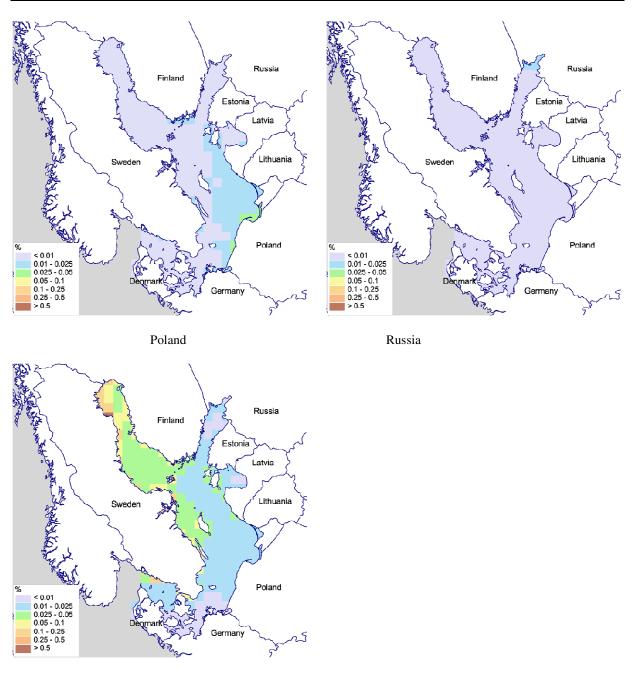


Figure 4.1 (cont.). Maps with the fractions (in %) of annual total anthropogenic lead emissions from HELCOM Parties deposited into the Baltic Sea in 2005.



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.

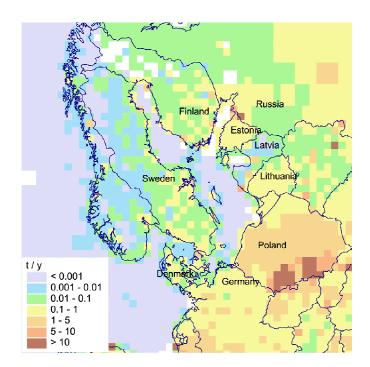


Figure 4.2. Annual total anthropogenic emissions of lead in the Baltic Sea region for 2005, t/y.

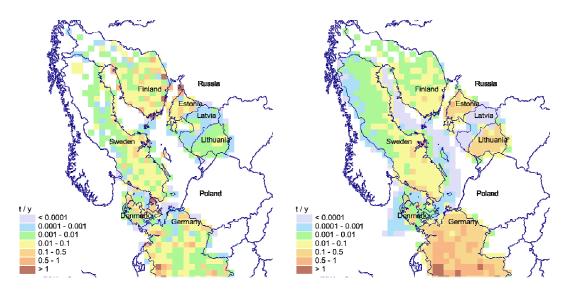


Figure 4.3. Annual lead emission from Combustion in Power Plants and Industry sector for 2005.

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

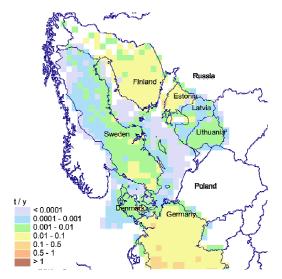


Figure 4.5. Annual lead emission from Commercial, Residential and Other Stationary Combustion sector for 2005.

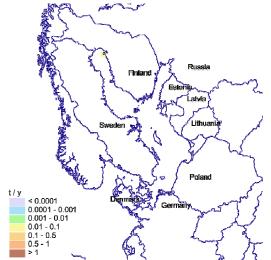


Figure 4.6. Annual lead emission from Fugitive emissions from fuels sector for 2005.

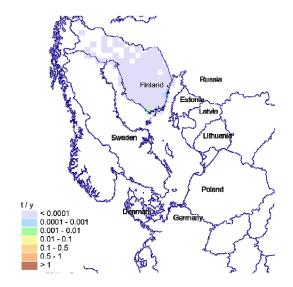


Figure 4.7. Annual lead emission from Solvent and Other Product Use sector in Finland for 2005.

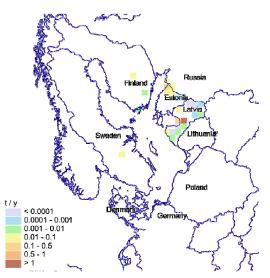


Figure 4.8. Annual lead emission from Waste sector in Latvia for 2005.

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

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

NA – not available

NE - not estimated

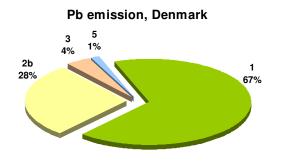


Figure 4.9. Percentage of annual total lead emission from different sectors in Denmark for 2005.

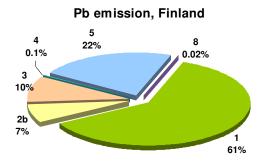


Figure 4.11. Percentage of annual total lead emission from different sectors in Finland for 2005.

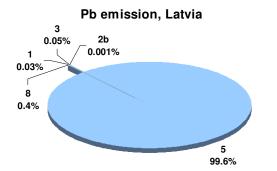


Figure 4.13. Percentage of annual total lead emission from different sectors in Latvia for 2005.

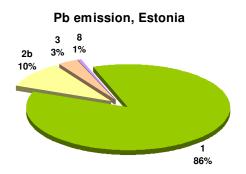


Figure 4.10. Percentage of annual total lead emission from different sectors in Estonia for 2005.

Pb emission, Germany



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

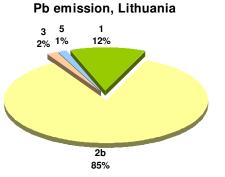
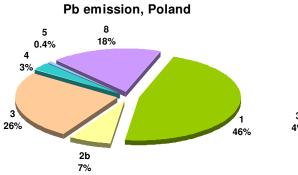


Figure 4.14. Percentage of annual total lead emission from different sectors in Lithuania for 2005.



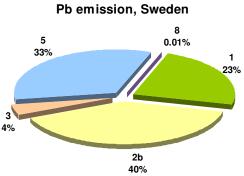


Figure 4.15. Percentage of annual total lead emission from different sectors in Poland for 2005.

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

Estonia Finland Finland Finland Germany 11 Latvia Finland Lithuania Finland Poland 11 Russia 33 Sweden Finland HELCOM 74 Albania Austria Austria Finland Belarus Finland Belgium Finland Bulgaria Finland Croatia Cyprus Czech Republic Finland	122 201 326 1801 21 47 1372 3591 352 7832 33 11 207 12 794 442	95 185 247 1055 17 49 1336 3553 307 6844 344 0.820	86 121 175 761 9.8 32 986 3095 287 5553 35	44 101 100 606 7.6 28 997 3276 135	11 124 60 405 9.6 33 966 2643	10 84 57 330 8.1 30 937	9.9 65 35 222 9.9 18	7.7 52 19 96 12	7.0 46 20 94	7.1 44 14 96	7.0 37 38 102	6.3 34 38 105	5.5 34 40 106	5.0 39 34 107	5.5 38 27	5.6 37 24
Finland I Germany 11 Latvia I Lithuania I Poland 11 Russia 33 Sweden I HELCOM 71 Albania I Austria I Austria I Belarus I Belgium I Bulgaria I Cyprus I Czech Republic I	326 1801 21 47 1372 3591 352 7832 333 11 207 12 794	247 1055 17 49 1336 3553 307 6844 34 0.820	175 761 9.8 32 986 3095 287 5553	100 606 7.6 28 997 3276 135	60 405 9.6 33 966	57 330 8.1 30	35 222 9.9	19 96 12	20 94	14	38	38	40	34	27	
Germany 11 Latvia 11 Lithuania 11 Poland 13 Russia 31 Sweden 31 HELCOM 71 Albania 71 Austria 32 Austria 33 Belarus 34 Belarus 34 Belgium 34 Bosnia and Herzegovina 34 Bulgaria 34 Cyprus 34 Czech Republic 34	1801 21 47 1372 3591 352 7832 33 11 207 12 794	1055 17 49 1336 3553 307 6844 34 0.820	761 9.8 32 986 3095 287 5553	606 7.6 28 997 3276 135	405 9.6 33 966	330 8.1 30	222 9.9	96 12	94				-	-		24
Latvia Ithuania Lithuania Poland Poland 11 Russia 33 Sweden 71 Albania 71 Albania 71 Austria 72 Azerbaijan 73 Belarus 73 Belgium 73 Bulgaria 73 Cyprus 74	21 47 1372 3591 352 7832 33 11 207 12 794	17 49 1336 3553 307 6844 34 0.820	9.8 32 986 3095 287 5553	7.6 28 997 3276 135	9.6 33 966	8.1 30	9.9	12	-	96	102	105	106	107		<u> </u>
Lithuania Poland 11 Poland 11 Russia 3 Sweden 7 Albania 7 Albania 4 Armenia 4 Austria 2 Azerbaijan 8 Belarus 7 Belgium 4 Bosnia and Herzegovina 9 Bulgaria 7 Croatia 7 Cyprus 7 Czech Republic 7	47 1372 3591 352 7832 33 11 207 12 794	49 1336 3553 307 6844 34 0.820	32 986 3095 287 5553	28 997 3276 135	33 966	30			4.4			105	100	107	109	107
Poland 11 Russia 33 Sweden 34 MELCOM 74 Albania 74 Austria 74 Austria 74 Austria 74 Belarus 76 Belarus 76 Bosnia and Herzegovina 76 Bulgaria 76 Croatia 76 Czech Republic 77	1372 3591 352 7832 33 11 207 12 794	1336 3553 307 6844 34 0.820	986 3095 287 5553	997 3276 135	966		18		14	13	13	13	13	14	14	17
Russia 33 Sweden 7 HELCOM 7 Albania 7 Armenia 7 Austria 7 Azerbaijan 7 Belarus 7 Belgium 7 Bosnia and Herzegovina 7 Bulgaria 7 Croatia 7 Cyprus 7	3591 352 7832 33 11 207 12 794	3553 307 6844 34 0.820	3095 287 5553	3276 135		937		20	22	19	16	15	15	15	5.2	5.7
Sweden Image: Sweden Image: Sweden Image: Sweden HELCOM Image: Sweden Image: Sweden Image: Sweden Albania Image: Sweden Image: Sweden Image: Sweden Armenia Image: Sweden Image: Sweden Image: Sweden Austria Image: Sweden Image: Sweden Image: Sweden Belgium Image: Sweden Image: Sweden Image: Sweden Bulgaria Image: Sweden Image: Sweden Image: Sweden Croatia Image: Sweden Image: Sweden Image: Sweden Czech Republic Image: Sweden Image: Sweden Image: Sweden	352 7832 33 11 207 12 794	307 6844 34 0.820	287 5553	135	2643		960	896	736	745	647	610	588	596	600	536
HELCOM 71 Albania Armenia Armenia Armenia Austria Belarus Belarus Belgium Bosnia and Herzegovina Bulgaria Bulgaria Groatia Cyprus Czech Republic	7832 33 11 207 12 794	6844 34 0.820	5553			2426	2304	2247	2262	2339	2352	2235	2118	2207	330	355
Albania Armenia Armenia Austria Azerbaijan Belarus Belgium Bosnia and Herzegovina Bulgaria Croatia Cyprus Czech Republic	33 11 207 12 794	34 0.820			41	27	23	24	23	21	19	19	17	18	18	17
Armenia Image: Austria Image: Austria Azerbaijan Image: Austria Belarus Image: Austria Belgium Image: Austria Bosnia and Herzegovina Image: Austria Bulgaria Image: Austria Croatia Image: Austria Cyprus Image: Austria Czech Republic Image: Austria	11 207 12 794	0.820	35	5294	4293	3910	3647	3371	3224	3298	3231	3074	2935	3035	1147	1103
Austria Image: Austria Azerbaijan Image: Belarus Belgium Image: Belgium Bosnia and Herzegovina Image: Bulgaria Bulgaria Image: Belgium Croatia Image: Belgium Cyprus Image: Belgium Czech Republic Image: Belgium	207 12 794		00	36	37	38	39	40	41	42	43	39	35	32	28	24
Azerbaijan Belarus Belgium Bosnia and Herzegovina Bulgaria Croatia Cyprus Czech Republic Statement Stateme	12 794	171	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
Belarus Belgium Belgium Bosnia and Herzegovina Bulgaria Croatia Cyprus Czech Republic	794	171	119	86	59	16	15	15	13	13	12	12	13	13	13	14
Belgium Image: Segment of the segmentof the segment of the segment of the segment of the segment	-	12	12	12	12	12	12	12	12	12	12	13	13	13	13	14
Bosnia and Herzegovina Bulgaria Croatia Cyprus Czech Republic	442	519	450	377	348	147	46	42	41	38	46	41	44	43	45	50
Bosnia and Herzegovina Bulgaria Croatia Cyprus Czech Republic		418	397	320	259	247	221	195	169	144	118	102	72	68	81	78
Croatia Cyprus Czech Republic	97	97	97	97	97	97	97	97	97	97	97	91	85	79	72	66
Croatia Cyprus Czech Republic	436	408	381	353	325	297	279	231	251	224	213	177	105	148	143	115
Cyprus Czech Republic	466	426	385	345	304	264	268	190	183	178	147	107	60	23	16	16
Czech Republic	31	31	33	33	33	34	33	32	31	29	59	66	59	50	9.8	3.8
	269	240	247	232	202	180	165	180	169	157	108	47	47	39	37	47
France 4	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
	505	499	493	488	482	476	470	470	470	470	470	470	470	470	470	470
	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
	116	111	107	96	84	76	65	54	39	24	15	11	9.1	8.2	8.4	7.9
	4375	3315	2437	2237	2046	1925	1801	1607	1447	1262	932	701	236	240	252	252
	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
	340	299	251	225	193	164	120	73	50	42	35	39	43	40	44	44
	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
	621	646	694	674	649	631	615	591	586	417	228	250	253	248	252	244
	249	220	103	71	23	34	28	22	7.9	11	2.8	3.4	3.3	11	2.3	5.1
	585	573	561	550	538	526	514	502	491	420	402	476	411	347	282	218
	597	567	538	508	478	448	419	389	359	329	300	275	250	225	202	176
	150	149	148	116	84	71	73	73	70	58	67	68	69	64	70	71
	462	398	402	409	406	196	98	80	60	50	43	18	15	16	14	14
	2681	1809	1220	1115	1104	932	902	839	779	709	589	389	268	265	261	266
	420	380	335	281	247	184	156	137	117	52	30	27	200	203	201	200
	210	198	185	173	161	148	136	124	112	99	87	83	79	74	70	66
	765	765	765	765	765	765	765	765	765	765	765	717	669	620	572	524
	3878	3586	3293	3001	2709	2417	2124	1832	1540	1248	955	663	145	123	195	195
					2109		2124	1052					140			118
EMEP 34	2912	2657	2434	2159	1859	1549	1314	1151	849	495	165	156	143	130	134	1 1 2 1

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)

Expert estimates:

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

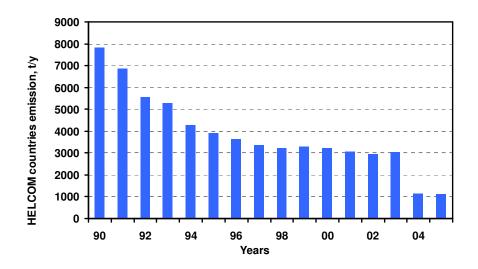


Figure 4.17. Time-series of total annual lead emissions of HELCOM countries in 1990-2005, tonnes/y.

4.2 Annual deposition of lead

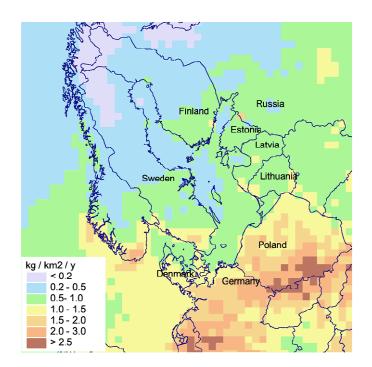
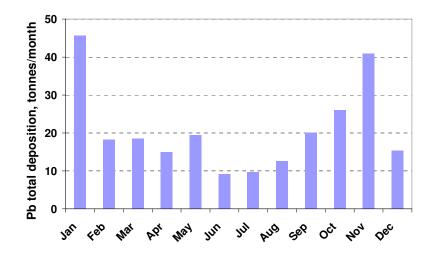


Figure 4.18. Annual deposition fluxes of lead over the Baltic Sea region for 2005, kg/km²/year.



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
Мау	19
Jun	9
Jul	10
Aug	13
Sep	20
Oct	26
Nov	41
Dec	15

4.4 Source allocation of lead deposition

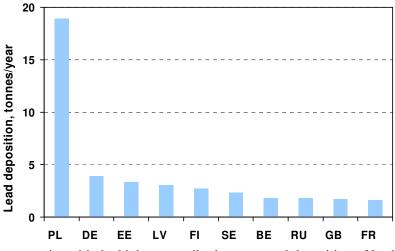


Figure 4.20. Top ten countries with the highest contribution to annual deposition of lead into the Baltic Sea for 2005, tonnes/year.

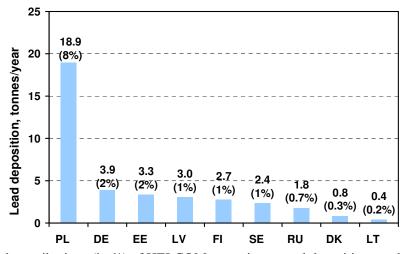


Figure 4.21. Sorted contributions (in %) of HELCOM countries to total depositions to the Baltic Sea for 2005. HELCOM countries emissions of lead contributed about 15% to the total annual lead depositions over the Baltic Sea in 2005. Contribution of other EMEP countries accounted for 6%. Significant contribution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

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
КАТ	PL	4	DE	2	86
BAS	PL	8	DE	2	79

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

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

4.5 Comparison of model results with measurements

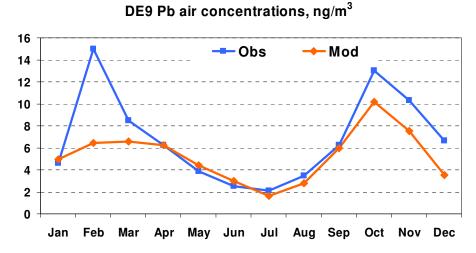


Figure 4.22. Comparison of calculated mean monthly lead concentrations in air with measured at station Zingst (DE9). Units: ng / m^3 .

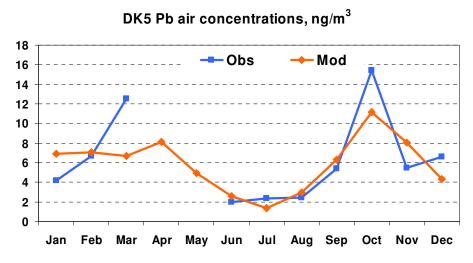


Figure 4.23. Comparison of calculated mean monthly lead concentrations in air with measured at station Keldsnor (DK5). Units: ng / m^3 .

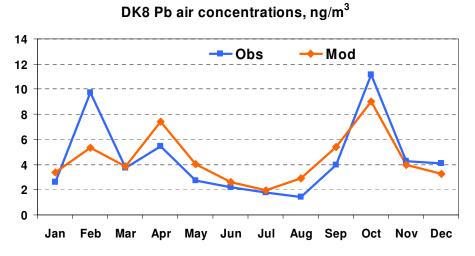


Figure 4.24. Comparison of calculated mean monthly lead concentrations in air with measured at station Anholt (DK8). Units: ng / m^3 .

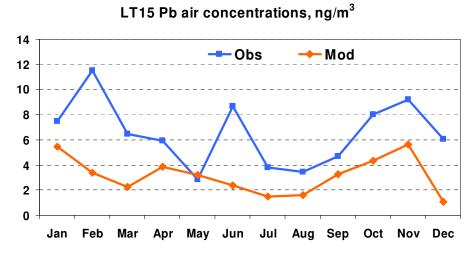


Figure 4.25. Comparison of calculated mean monthly lead concentrations in air with measured at station Preila (LT15). Units: ng / m^3 .

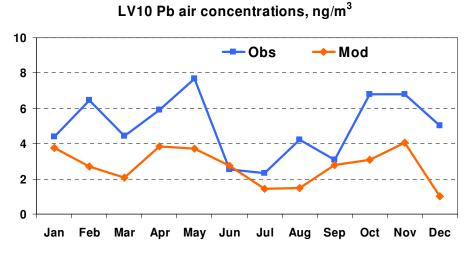


Figure 4.26. Comparison of calculated mean monthly lead concentrations in air with measured at station Rucava (LV10). Units: ng / m^3 .

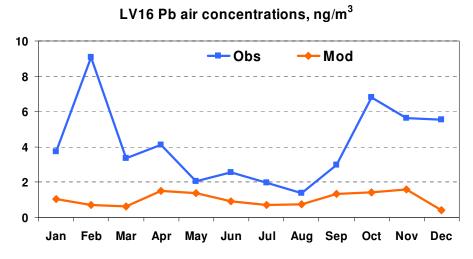


Figure 4.27. Comparison of calculated mean monthly lead concentrations in air with measured at station Zoseni (LV16). Units: ng / m^3 .

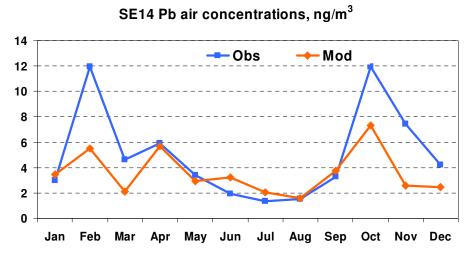
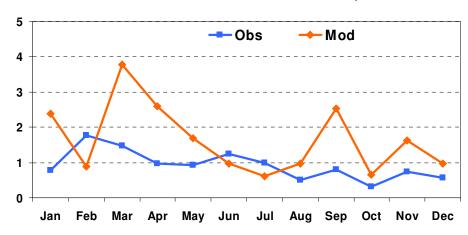


Figure 4.28. Comparison of calculated mean monthly lead concentrations in air with measured at station Räo (SE14). Units: ng / m^3 .



DE9 Pb concentration in precipitation, µg/L

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

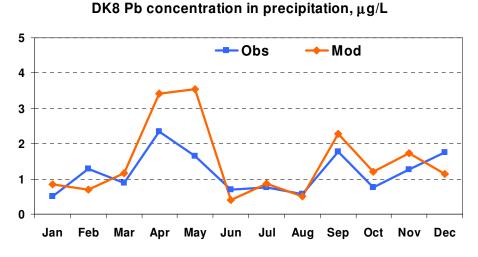
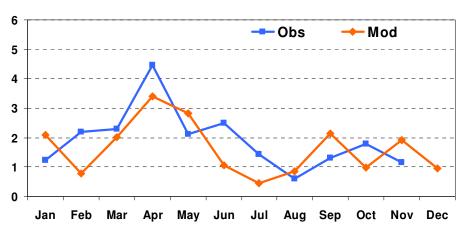
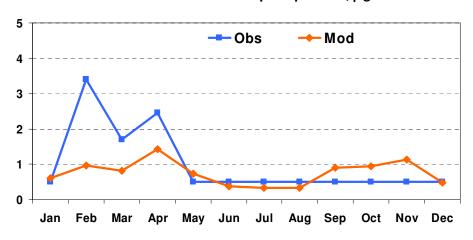


Figure 4.30. Comparison of calculated mean monthly lead concentrations in precipitation with measured at station Anholt (DK08). Units: $\mu g / L$.



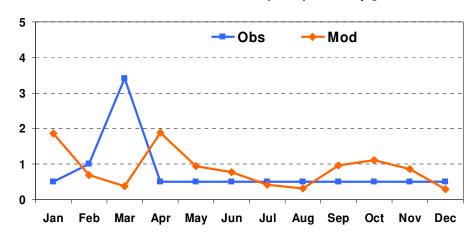
DE20 Pb concentration in precipitation, µg/L

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



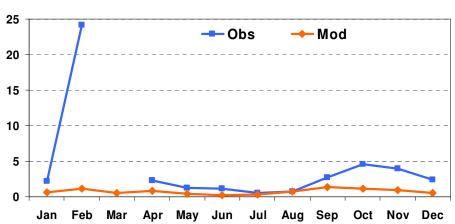
EE9 Pb concentration in precipitation, µg/L

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



EE11 Pb concentration in precipitation, µg/L

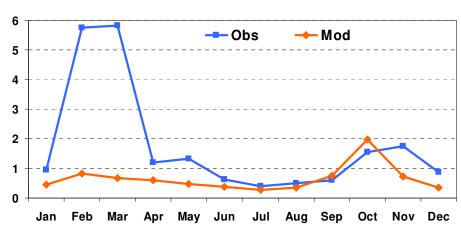
Figure 4.33. Comparison of calculated mean monthly lead concentrations in precipitation with measured at station Vilsandy (EE11). Units: $\mu g / L$.



FI17 Pb concentration in precipitation, µg/L

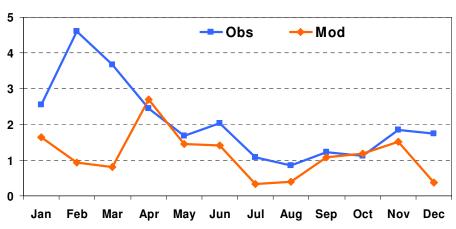
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

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



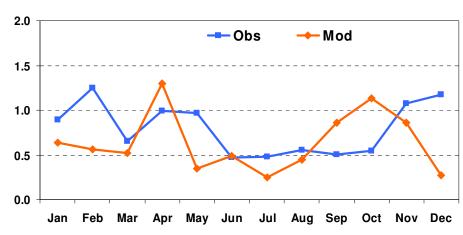
FI53 Pb concentration in precipitation, µg/L

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



LV10 Pb concentration in precipitation, $\mu g/L$

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



LV16 Pb concentration in precipitation, µg/L

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

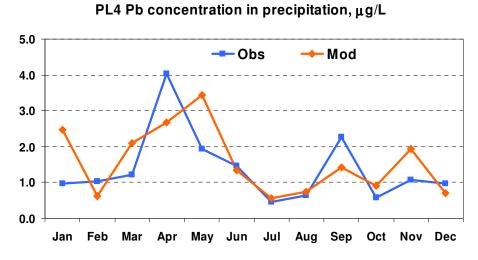
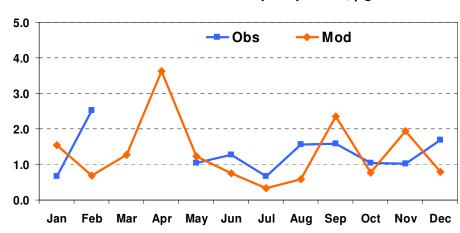


Figure 4.38. Comparison of calculated mean monthly lead concentrations in precipitation with measured at station Leba (PL04). Units: $\mu g / L$.



SE51 Pb concentration in precipitation, µg/L

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

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.