

6. Atmospheric Supply of Mercury to the Baltic Sea in 2007

In this chapter the results of model evaluation of mercury atmospheric input to the Baltic Sea and its sub-basins for 2007 is presented. Modelling of mercury atmospheric transport and deposition was carried out using MSC-E Eulerian Heavy Metal transport model MSCE-HM (*Travnikov and Ilyin, 2005*). Latest available official information on mercury emission from HELCOM countries and other European countries was used in computations. Based on these data annual and monthly levels of mercury deposition to the Baltic Sea region have been obtained and contributions of HELCOM countries emission sources to the deposition over the Baltic Sea are estimated. Model results were compared with observed levels of mercury concentrations in air and precipitation measured at monitoring sites around the Baltic Sea in 2007.

6.1 Mercury emissions

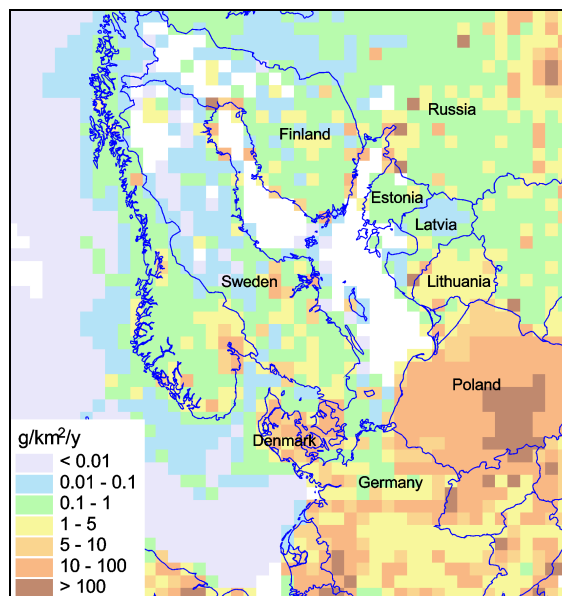


Figure 6.1. Annual total anthropogenic emissions of mercury in the Baltic Sea region for 2007, g/km²/yy.

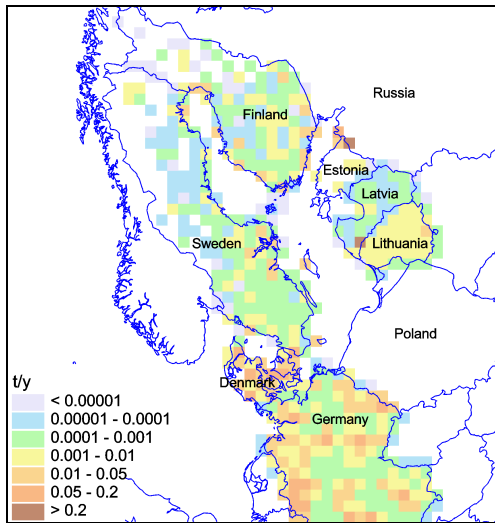


Figure 6.2. Annual mercury emission of HELCOM countries from Combustion in Power Plants and Industry sector for 2007, t/y.

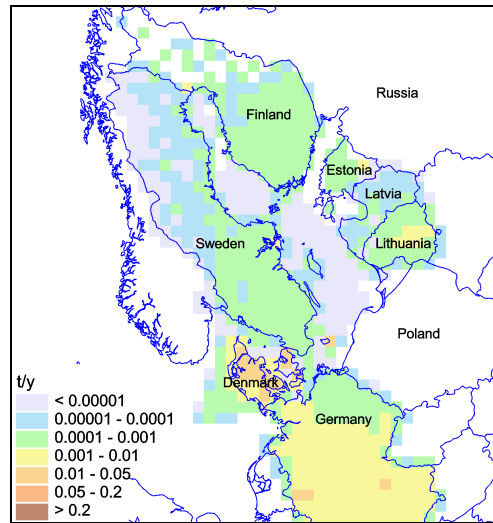


Figure 6.3. Annual mercury emission of HELCOM countries from Commercial, Residential and Other Stationary Combustion sector for 2007, t/y.

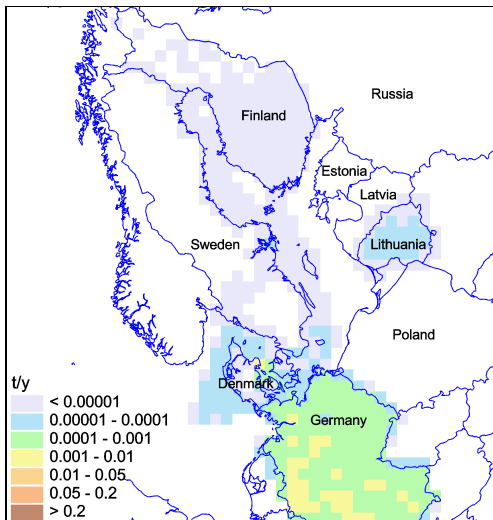


Figure 6.4. Annual mercury emission of HELCOM countries from Transport sources below 1000 m sector for 2007, t/y.

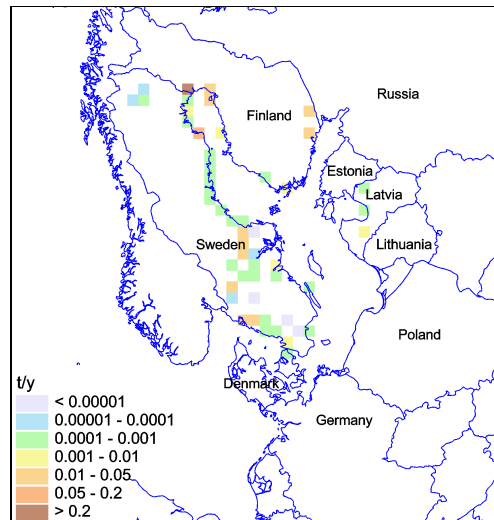


Figure 6.5. Annual mercury emission of HELCOM countries from Industrial Processes sector for 2007, t/y.

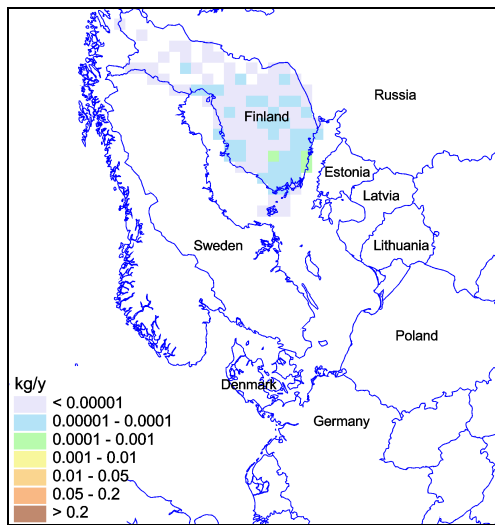


Figure 6.6. Annual mercury emission of Finland from Solvent and Other Product Use sector for 2007, kg/y.

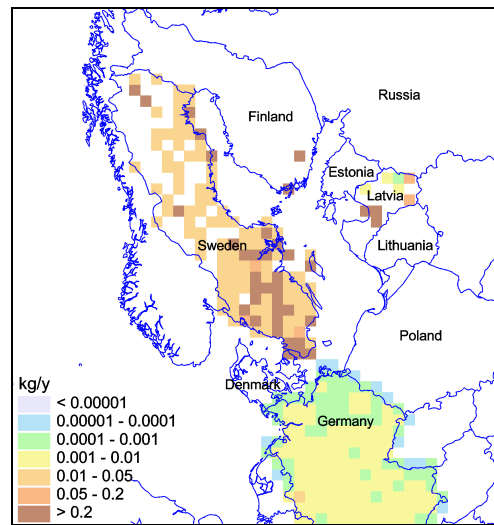


Figure 6.7. Annual mercury emission of HELCOM countries from Waste sector for 2007, kg/y.

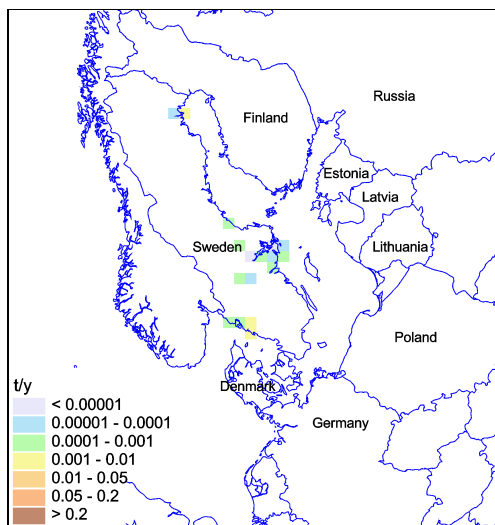


Figure 6.8. Annual mercury emission of HELCOM countries from Fugitive Emissions From Fuels sector for 2007, t/y.

Table 6.1. Annual total mercury anthropogenic emissions of HELCOM countries from different sectors for 2007, 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	0.74	0.63	0.389	2.664	0.012	0.407	13.51	14	0.264
2a	Transport above 1000m	0	NA	NA	NE	NA	NA	NA	NA	NE
2b	Transport below 1000m	0.005	0	< 0.001	0.107	NA	0.0004	0		< 0.001
3	Commercial, Residential and Other Stationary Combustion	0.327	0.02	0.028	0.329	0.003	0.021	1.29		0.031
4	Fugitive Emissions From Fuels		NA	NA				0.305		0.01
5	Industrial Processes	0	0	0.391	0.946	0.008		0.727		0.21
6	Solvent and Other Product Use	NA	NA	< 0.001				NA		
7	Agriculture							NA		
8	Waste		0	0.002	< 0.001	0.003		0.045		0.119
9	Other									
Total		1.07	0.65	0.81	4.05	0.03	0.43	15.88	14	0.63

NA □not available

NE □not estimated

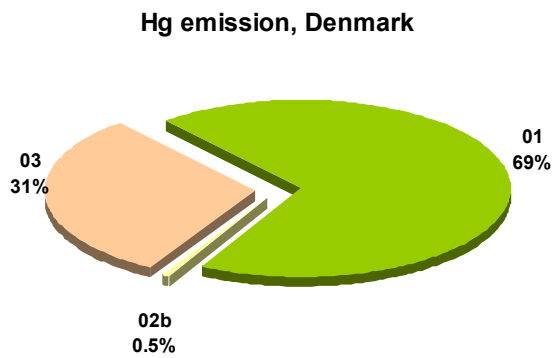


Figure 6.8. Contributions of different sector to total annual mercury emission of Denmark in 2007

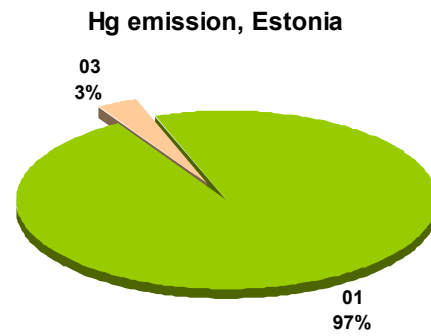


Figure 6.9. Contributions of different sector to total annual mercury emission of Estonia in 2007

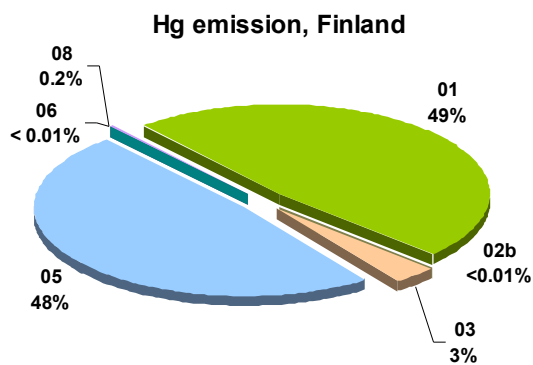


Figure 6.10. Contributions of different sector to total annual mercury emission of Finland in 2007

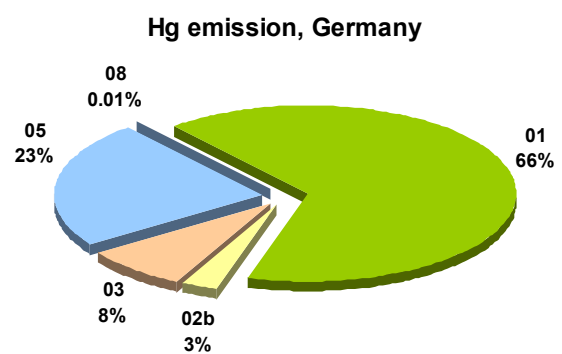


Figure 6.11. Contributions of different sector to total annual mercury emission of Germany in 2007

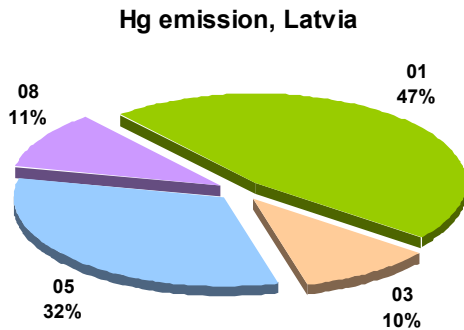


Figure 6.12. Contributions of different sector to total annual mercury emission of Latvia in 2007

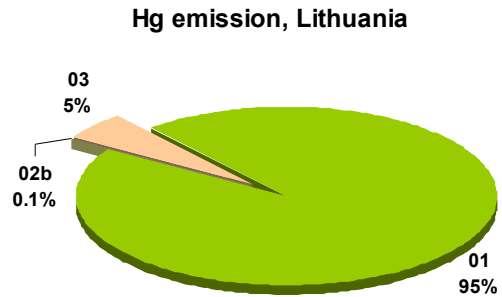


Figure 6.13. Contributions of different sector to total annual mercury emission of Lithuania in 2007

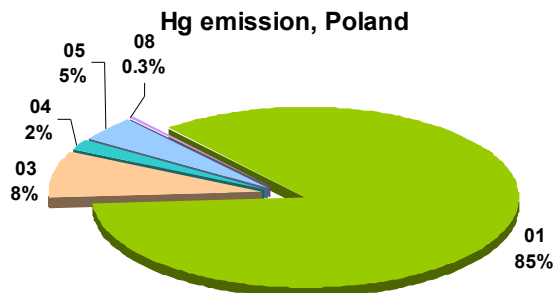


Figure 6.14. Contributions of different sector to total annual mercury emission of Poland in 2007

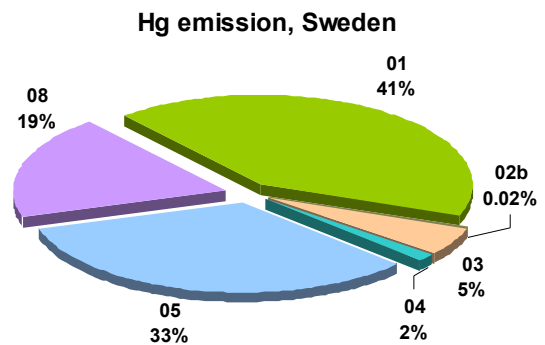


Figure 6.15. Contributions of different sector to total annual mercury emission of Sweden in 2007

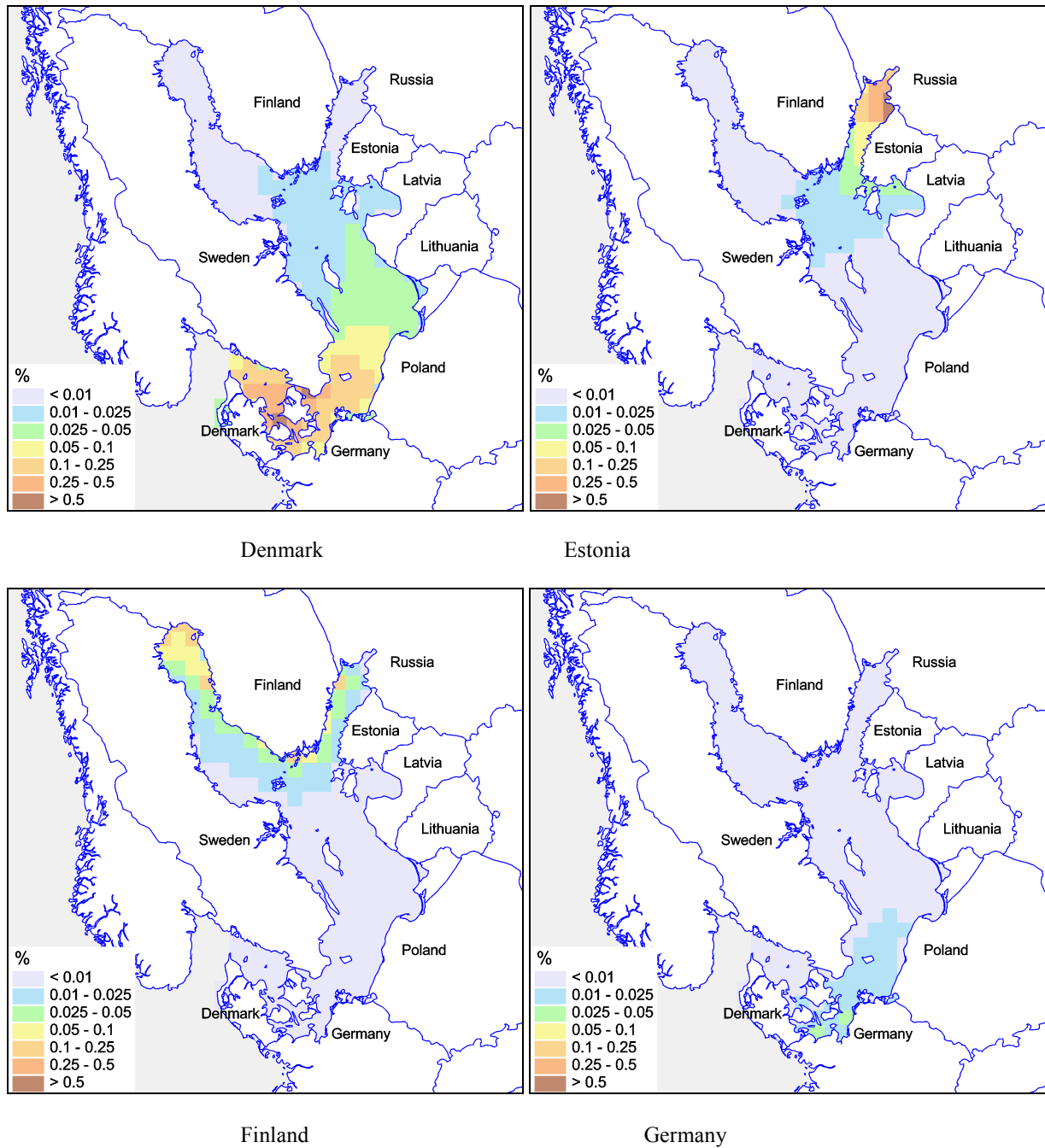


Figure 6.16. Maps with the contributions of annual total anthropogenic mercury emissions from HELCOM Parties to total mercury deposition over the Baltic Sea in 2007 (fraction of total deposition in % over the 50x50 km grid cell).

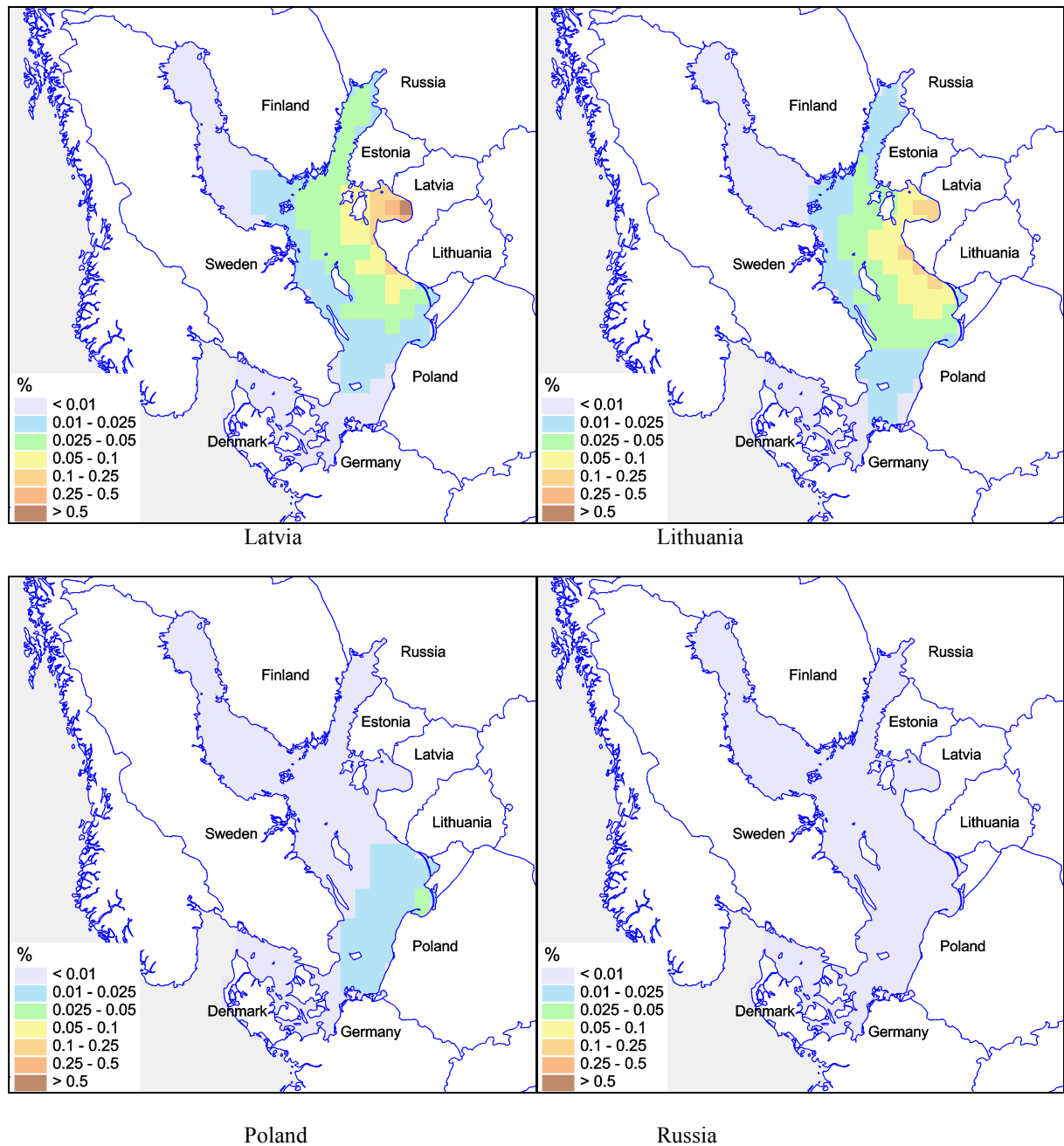
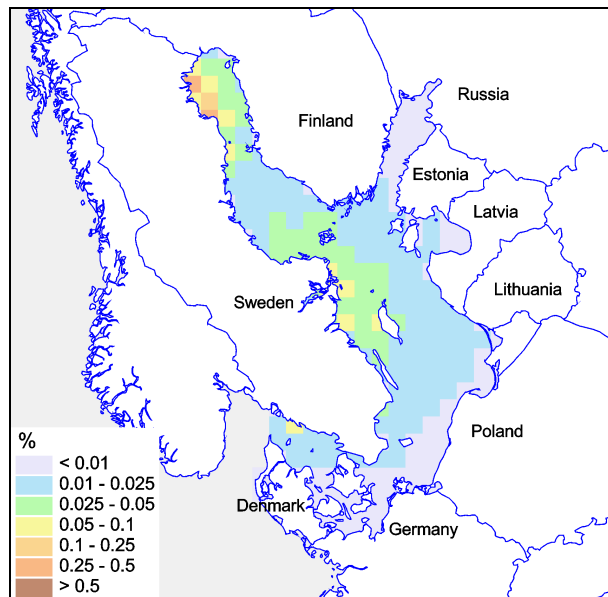


Figure 6.16. (cont.) Maps with the contributions of annual total anthropogenic mercury emissions from HELCOM Parties to total mercury deposition over the Baltic Sea in 2007 (fraction of total deposition in % over the 50x50 km grid cell).



Sweden

Figure 6.16. (cont.) Maps with the contributions of annual total anthropogenic mercury emissions from HELCOM Parties to total mercury deposition over the Baltic Sea in 2007 (fraction of total deposition in % over the 50x50 km grid cell).

Table 6.2. Annual total anthropogenic emissions of mercury of HELCOM countries and other EMEP countries in period 1990-2007, tonnes (Expert estimates of emissions are shaded).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Denmark	3.3	3.5	3.4	3.4	2.5	2.4	2.5	2.1	1.9	2.0	1.2	1.3	1.2	1.3	1.2	1.4	1.3	1.1
Estonia	1.1	1.0	0.830	0.640	0.640	0.600	0.600	0.600	0.530	0.510	0.550	0.500	0.500	0.580	0.540	0.520	0.520	0.650
Finland	1.1	0.865	0.800	0.609	0.656	0.713	0.726	0.570	0.548	0.561	0.574	0.731	0.659	0.778	0.744	0.851	0.981	0.812
Germany	20	14	9.2	6.1	3.6	3.3	3.3	3.3	3.4	3.3	3.6	3.5	3.5	3.6	3.6	3.8	3.9	4.0
Latvia	0.311	0.241	0.209	0.200	0.229	0.171	0.202	0.150	0.141	0.120	0.063	0.049	0.041	0.033	0.028	0.027	0.026	0.025
Lithuania	0.018	0.016	0.011	0.014	0.013	0.153	0.159	0.232	0.245	0.253	0.252	0.516	0.314	0.352	0.417	0.413	0.418	0.428
Poland	33	33	32	33	32	32	34	33	30	27	26	23	20	20	20	20	21	16
Russia	16	13	11	12	10	10	10	9.6	9.4	9.9	10	10	10	11	12	14	14	23
Sweden	1.6	1.3	1.3	1.1	1.1	1.1	1.1	0.970	0.943	0.927	0.770	0.653	0.673	0.758	0.781	0.726	0.591	0.633
HELCOM	76	67	59	56	52	51	52	50	47	45	43	41	37	39	39	42	43	46
Albania	0.511	0.480	0.449	0.419	0.388	0.357	0.326	0.296	0.265	0.234	0.203	0.202	0.202	0.201	0.200	0.199	0.199	0.198
Armenia	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.167	0.170	0.174	0.177	0.180	0.184	0.187
Austria	2.1	2.0	1.6	1.4	1.2	1.2	1.2	1.1	0.949	0.937	0.897	0.967	0.954	1.0	0.975	1.0	1.1	1.1
Azerbaijan	0.984	0.984	0.984	0.984	0.984	0.984	0.984	0.984	0.984	0.984	0.984	1.0	1.0	1.0	1.1	1.1	1.1	1.1
Belarus	1.1	1.1	0.879	0.721	0.602	0.511	0.297	0.310	0.392	0.380	0.358	0.522	0.565	0.603	0.632	0.649	0.716	0.741
Belgium	6.9	5.5	5.6	3.7	4.0	3.6	3.7	3.5	2.9	3.0	2.7	2.3	3.3	3.1	3.0	1.8	1.6	2.7
Bosnia and Herzegovina	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	1.9	1.9	1.9	1.9	1.9
Bulgaria	13	12	11	9.4	8.1	6.9	4.7	4.3	4.7	4.1	4.2	4.0	3.9	5.0	4.7	3.4	3.7	1.6
Croatia	1.4	1.146	0.931	0.717	0.502	0.287	0.297	0.318	0.320	0.307	0.410	0.405	0.449	0.563	0.710	0.693	0.588	0.624
Cyprus	0.655	0.674	0.8	0.8	0.8	0.8	0.8	0.8	0.8	1.0	1.0	1.0	1.1	1.2	1.2	1.3	1.3	1.4
Czech Republic	7.5	7.4	7.3	7.5	7.2	7.4	5.9	5.5	5.2	3.7	3.8	3.3	2.8	1.8	2.1	3.8	3.8	3.9
France	27	27	26	24	23	22	21	16	16	14	13	11	11	8.5	8.2	8.6	8.2	6.7
Georgia	0.253	0.253	0.253	0.253	0.253	0.253	0.253	0.253	0.253	0.253	0.253	0.258	0.264	0.269	0.274	0.279	0.284	0.290
Greece	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
Hungary	6.8	5.8	5.0	5.0	4.7	4.2	4.7	4.5	4.3	3.6	3.6	3.5	3.2	3.1	3.0	3.0	3.2	2.8
Iceland	0.048	0.054	0.060	0.066	0.072	0.078	0.084	0.091	0.097	0.103	0.109	0.108	0.108	0.108	0.108	0.107	0.107	0.107
Ireland	0.875	0.939	0.791	0.782	0.771	0.791	0.740	0.854	0.609	0.584	0.752	0.894	0.810	0.849	0.810	0.849	0.772	0.858
Italy	12	11	11	10	10	11	10	10	9.8	9.2	9.6	9.8	9.6	9.5	10	10	11	11
Luxembourg	0.300	0.275	0.250	0.225	0.200	0.100	0.100	0.100	0.100	0.286	0.275	0.293	0.288	0.288	0.288	0.288	0.288	0.288
Malta	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.627	0.535	0.582	0.582	0.602	0.602	0.626
Monaco	0.108	0.110	0.121	0.132	0.069	0.069	0.073	0.083	0.078	0.079	0.081	0.086	0.077	0.064	0.057	0.057	0.041	0.056
Netherlands	3.5	2.8	2.4	2.0	1.6	1.2	0.974	0.713	0.633	0.700	0.874	0.742	0.715	0.663	1.0	0.813	0.769	0.655
Norway	1.5	1.4	1.2	0.925	0.958	0.873	0.900	0.900	0.863	0.905	0.751	0.699	0.671	0.673	0.702	0.694	0.644	0.687
Portugal	3.8	3.9	4.3	3.9	3.7	4.0	3.6	3.9	4.1	4.2	3.7	3.6	3.8	3.1	3.1	3.4	2.9	2.8
Republic of Moldova	3.4	3.8	3.3	1.8	1.3	0.894	0.954	0.571	0.406	0.180	0.259	0.226	0.392	0.340	0.323	0.244	0.217	0.217
Romania	7.5	7.5	7.4	7.4	7.3	7.3	7.2	7.2	7.2	6.3	6.7	7.3	8.3	9.4	10	11	8.3	4.1
Serbia and Montenegro	3.9	4.0	4.2	4.3	4.5	4.7	4.8	5.0	5.2	5.3	5.5	5.5	5.5	5.4	5.4	5.4	5.4	5.4
Slovakia	12	9.3	6.2	5.0	3.9	3.9	3.4	3.7	4.1	3.7	4.3	3.8	3.6	2.9	3.2	2.9	3.4	2.7
Slovenia	1.2	1.1	1.1	1.1	1.0	1.0	1.0	1.1	1.1	1.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.2
Spain	13	14	15	14	13	13	12	10	11	11	11	11	12	10	10	10	9.5	9.0
Switzerland	6.6	6.1	5.8	5.4	4.9	4.1	3.8	3.5	3.3	2.4	2.1	1.8	1.4	1.0	1.1	1.1	1.1	1.1
The FYR of Macedonia	1.5	1.5	1.6	1.6	1.6	1.7	1.7	1.7	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Turkey	18	18	18	18	18	18	18	18	18	18	18	18	18	19	19	20	21	21
Ukraine	36	35	34	33	32	31	30	29	28	27	26	25	5.9	30	6.6	6.0	15.7	7.6
United Kingdom	38	38	36	22	21	20	15	12	10	8.1	8.1	7.8	6.9	7.4	6.4	7.1	7.4	7.2
EMEP	324	307	289	259	246	239	226	213	205	194	191	185	163	186	164	167	175	162

Expert estimates: Denier van der Gon, H.A.C., M. van het Bolscher A.J.H. Visschedijk P.Y.J. Zandveld [2006]

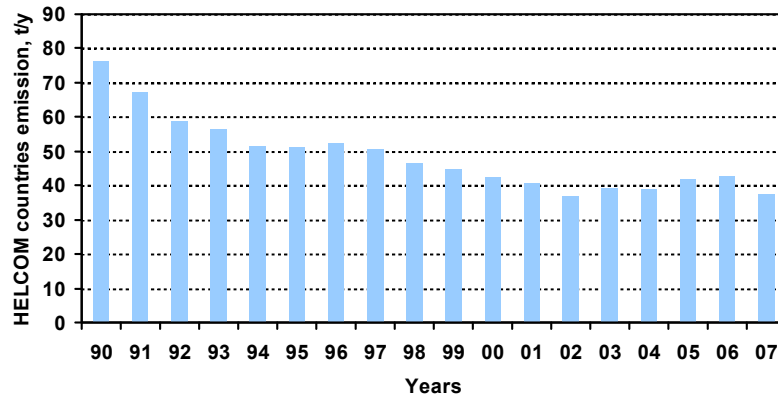


Figure 6.17. Time-series of total annual mercury emissions of HELCOM countries in 1990-2007, tonnes/y.

5.2 Annual total deposition of mercury

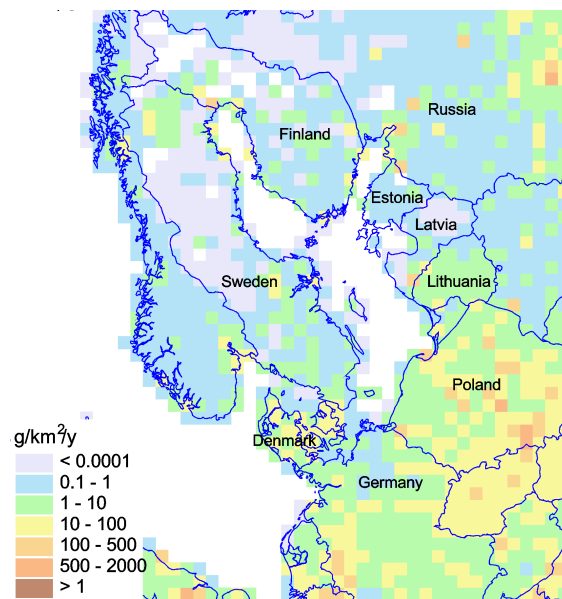


Figure 6.18. Annual total deposition fluxes of mercury over the Baltic Sea region for 2007, g/km²/y.

5.3 Monthly total deposition of mercury

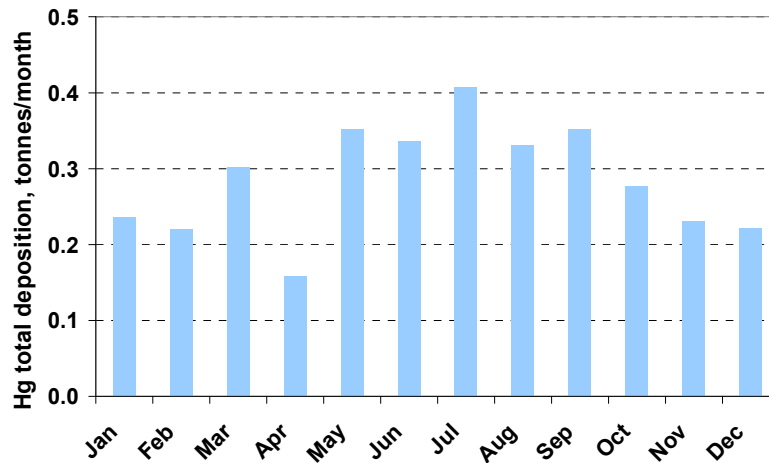


Figure 6.19. Monthly total deposition of mercury to the Baltic Sea for 2007, tonnes/month.

Table 6.2. Monthly total deposition of mercury to the Baltic Sea for 2007, tonnes/month.

Month	Hg
<i>Jan</i>	0.24
<i>Feb</i>	0.22
<i>Mar</i>	0.30
<i>Apr</i>	0.16
<i>May</i>	0.35
<i>Jun</i>	0.34
<i>Jul</i>	0.41
<i>Aug</i>	0.33
<i>Sep</i>	0.35
<i>Oct</i>	0.28
<i>Nov</i>	0.23
<i>Dec</i>	0.22

5.4 Source allocation of mercury deposition

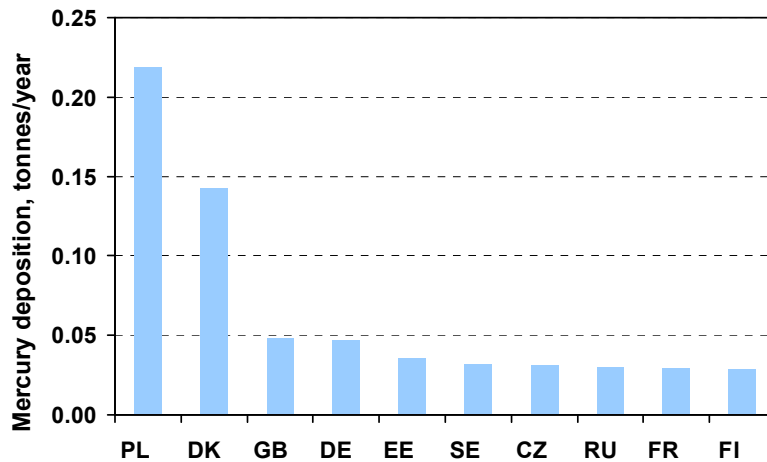


Figure 6.20. Top ten countries with the highest contribution to annual deposition of mercury over the Baltic Sea for 2007, tonnes/year.

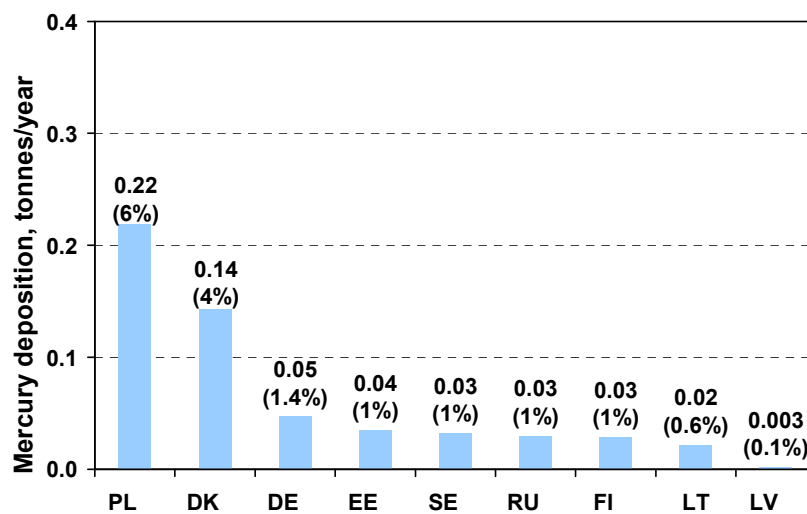


Figure 6.21. Sorted contributions (in %) of HELCOM countries to total deposition over the Baltic Sea for 2007. HELCOM countries emissions of mercury contributed 16% to the total annual mercury deposition over the Baltic Sea in 2007. Contribution of other EMEP countries accounted for 8%. Significant contribution was made by other emission sources, in particular, remote emissions sources, natural emissions and re-emission of mercury (76%).

Table 6.3. Two most significant contributors to the annual total deposition of mercury to the six Baltic Sea sub-basins for 2007.

Sub-basin	Country	%	Country	%	*, %
GUB	Finland	3	Sweden	2	86
GUF	Estonia	11	Russia	3	74
GUR	Poland	5	Lithuania	3	80
BAP	Poland	9	Denmark	3	75
BES	Denmark	20	Poland	4	61
KAT	Denmark	13	United Kingdom	3	71
BAS	Poland	6	Denmark	4	76

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

5.5 Comparison of model results with measurements

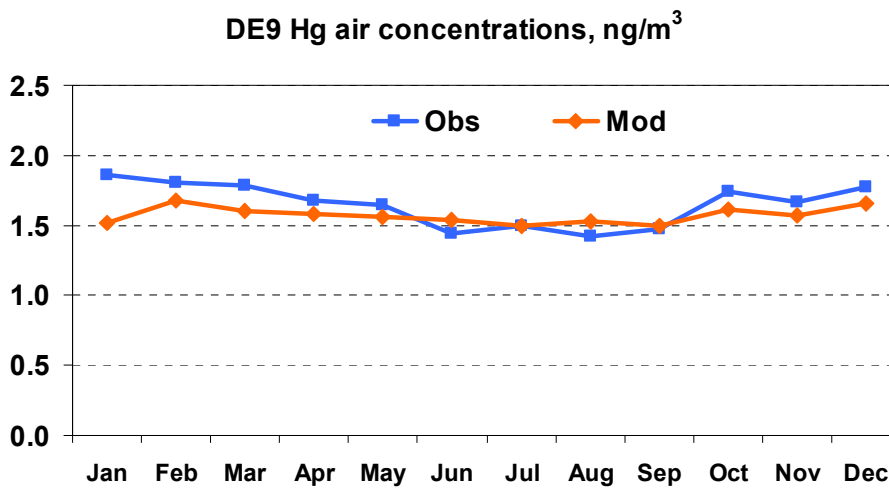


Figure 6.22. Comparison of calculated monthly mean Hg concentrations in air for 2007 with measurements of the station Zingst (DE9). Units: ng / m³.

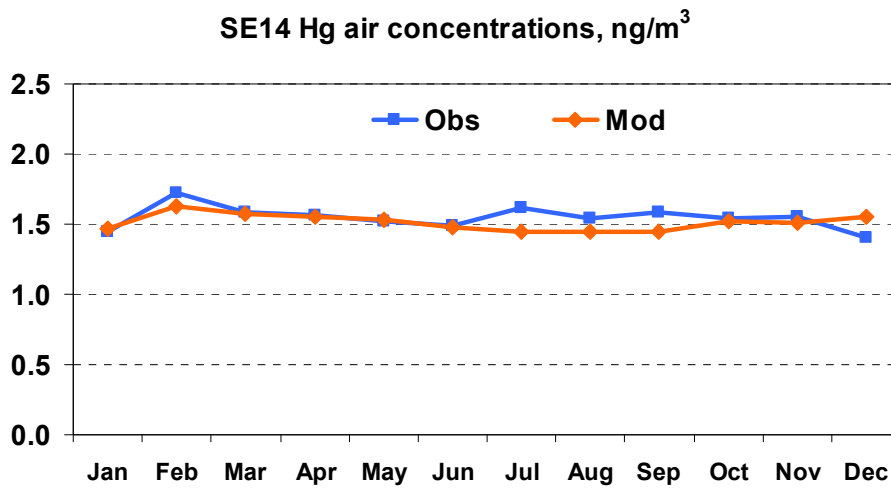


Figure 6.23. Comparison of calculated monthly mean Hg concentrations in air for 2007 with measurements of the station Råö (SE14). Units: ng / m³.

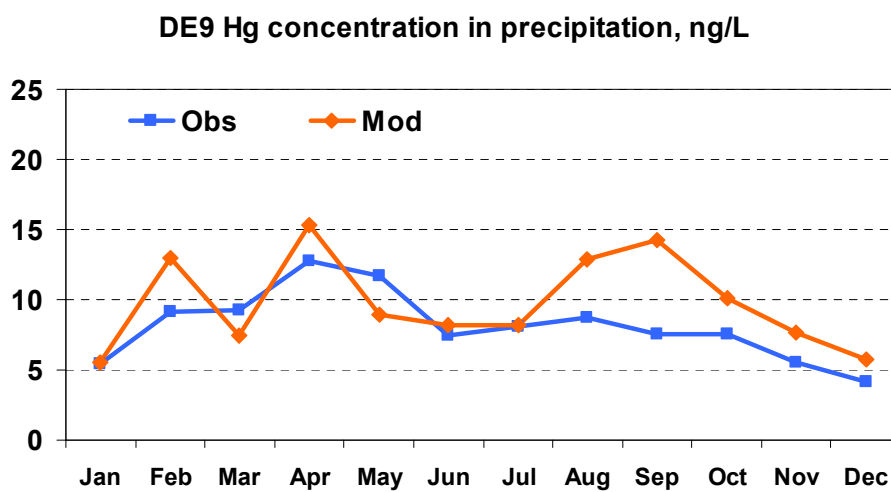


Figure 6.24. Comparison of calculated monthly mean Hg concentrations in precipitation for 2007 with measurements of the station Zingst (DE9). Units: ng/L.

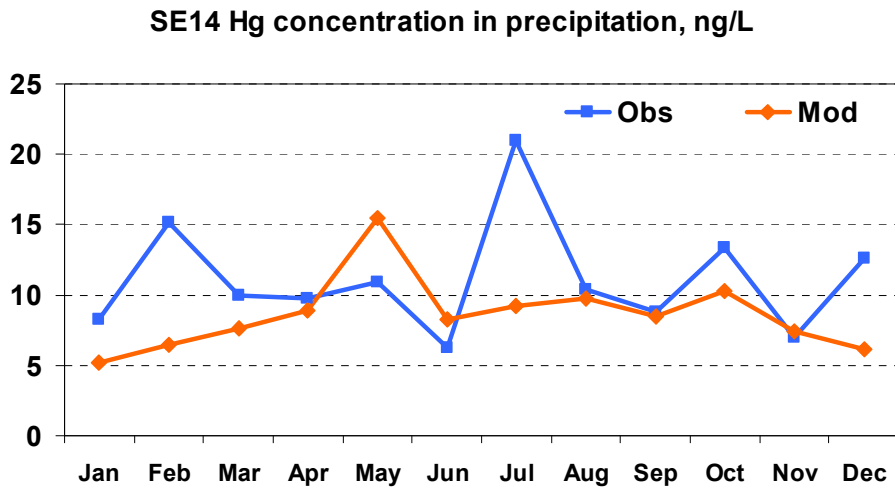


Figure 6.25. Comparison of calculated monthly mean Hg concentrations in precipitation for 2007 with measurements of the station Råö (SE14). Units: ng/L.

Computed concentrations of mercury in air and in precipitation were compared with the measurement data of four monitoring sites around the Baltic Sea. It can be seen that the model values reasonably agree with the measured concentrations. Some deviations between simulated and observed monthly mean concentrations of mercury can be connected with the uncertainties in seasonal variation of mercury emission used in modeling, differences between measured precipitation amount and the one used in the model, and difficulties in measurements of mercury.

6.6 Conclusions for Chapter 6

- Mercury emissions from HELCOM countries have decreased from 1990 to 2007 by 51%. At the same time there is some increase of mercury emission from 2006 to 2007 amounted to approximately 7%.
- Annual deposition of mercury to the Baltic Sea has decreased from 1990 to 2007 by 23%. Level of mercury deposition in 2007 was higher comparing to 2006 by 6%.
- The contribution of anthropogenic sources of HELCOM countries to total mercury deposition over the Baltic Sea was estimated to approximately 40%. Essential contribution belongs to the global and natural sources and anthropogenic sources of other EMEP countries.
- The most significant contribution to mercury deposition over the Baltic Sea was made by Poland and Denmark.
- Modelling results for mercury were within an accuracy of 30% in comparison with measurements made around the Baltic Sea in 2007.

