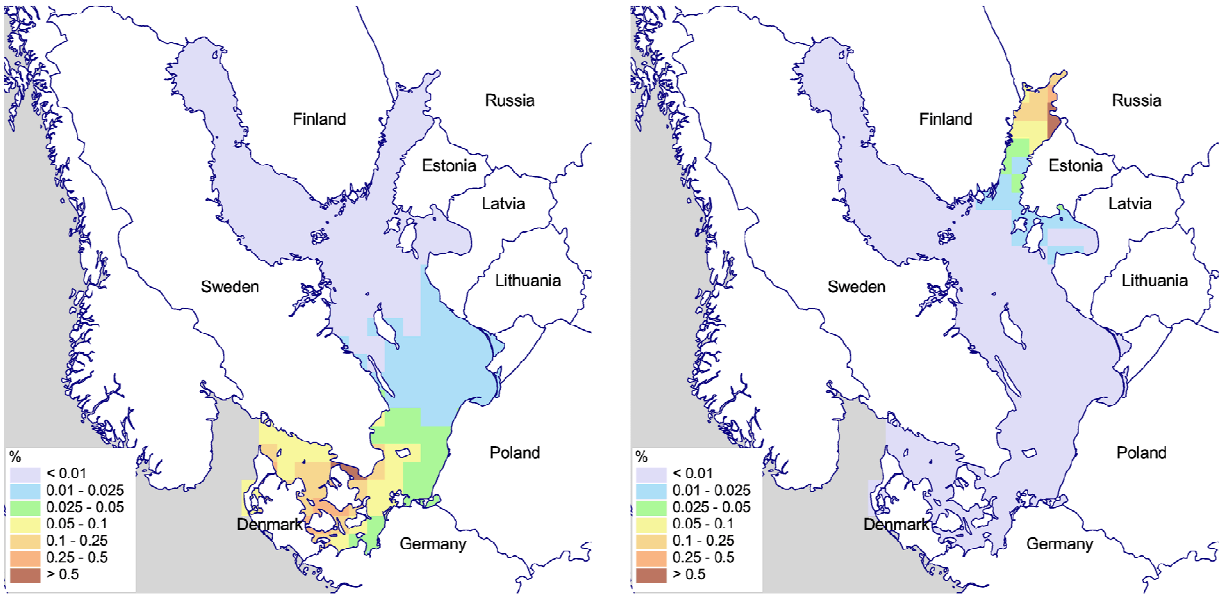
6. Atmospheric Supply of Mercury to the Baltic Sea in 2005

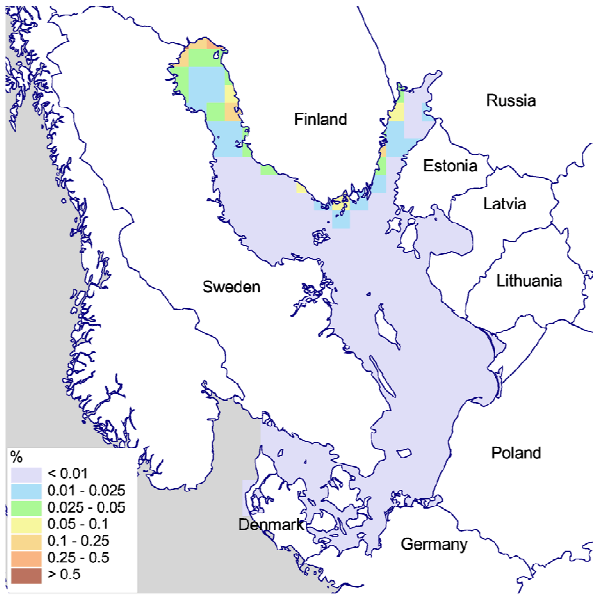
In this chapter the results of model evaluation of mercury atmospheric input to the Baltic Sea and its sub-basins for 2005 is presented. Modelling of mercury atmospheric transport and depositions was carried out using MSC-E Eulerian Heavy Metal transport model MSCE-HM (Travnikov and Ilyin, 2005). Latest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

6.1 Mercury emissions

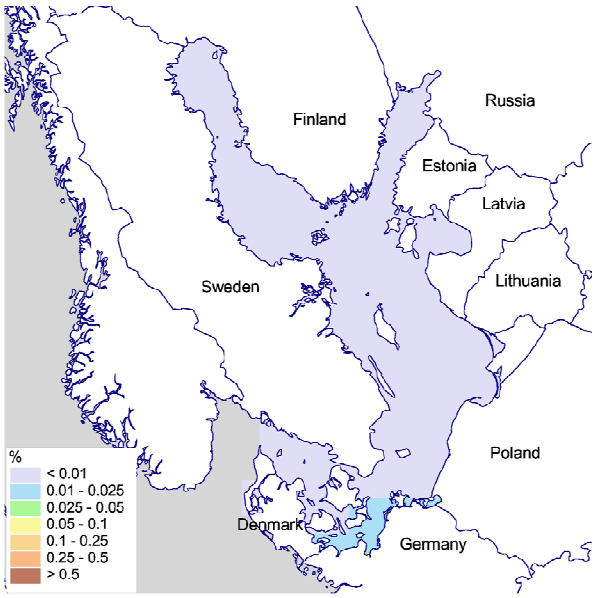


Denmark Estonia

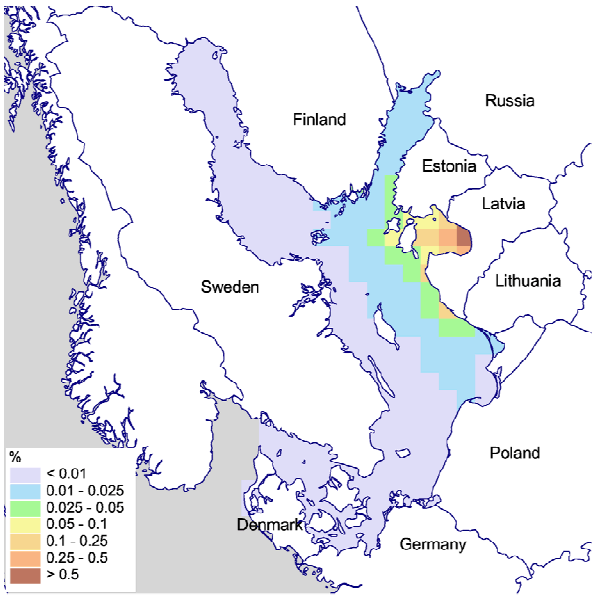
Figure 6.1. Maps with the fractions (in %) of annual total anthropogenic mercury emissions from HELCOM Parties deposited into the Baltic Sea in 2005.



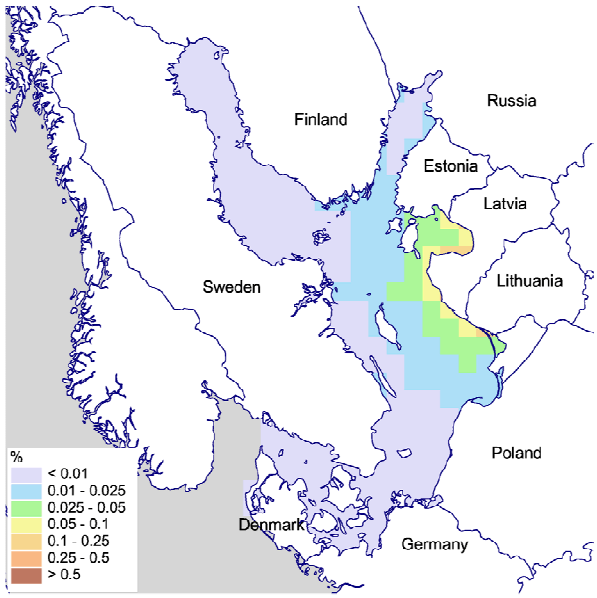
Finland



Germany

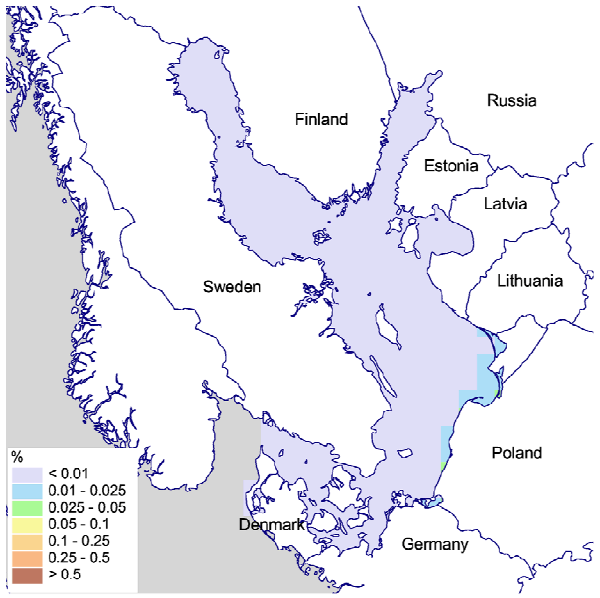


Latvia

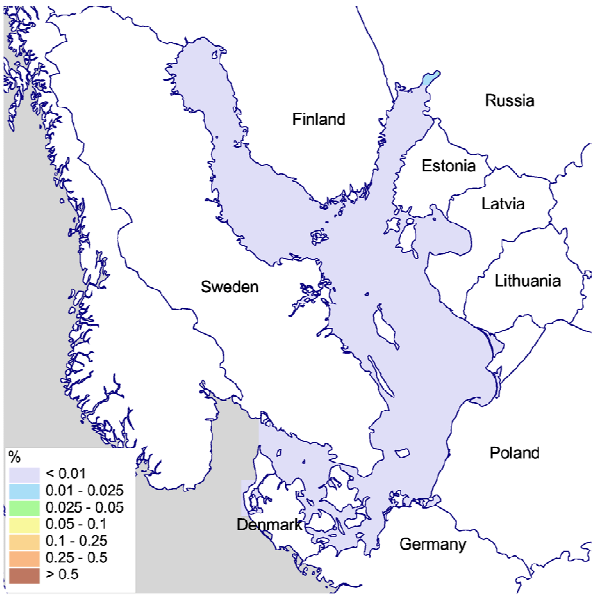


Lithuania

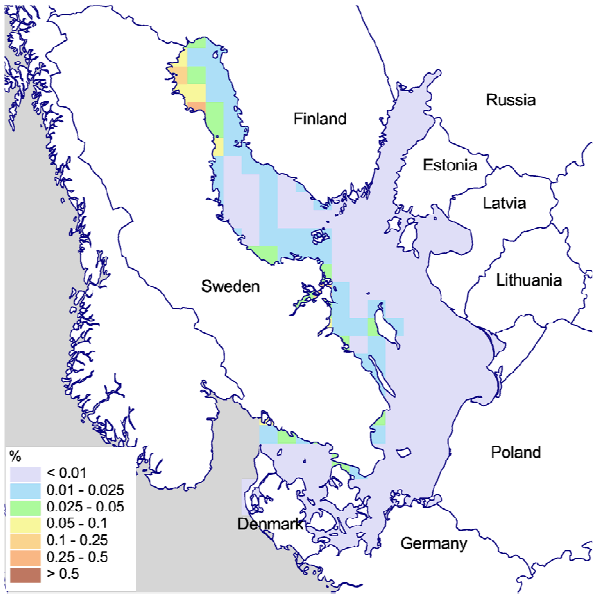
Figure 6.1 (cont.). Maps with the fractions (in %) of annual total anthropogenic mercury emissions from HELCOM Parties deposited into the Baltic Sea in 2005.



Poland



Russia



Sweden

Figure 6.1 (cont.). Maps with the fractions (in %) of annual total anthropogenic mercury emissions from HELCOM Parties deposited into the Baltic Sea in 2005.

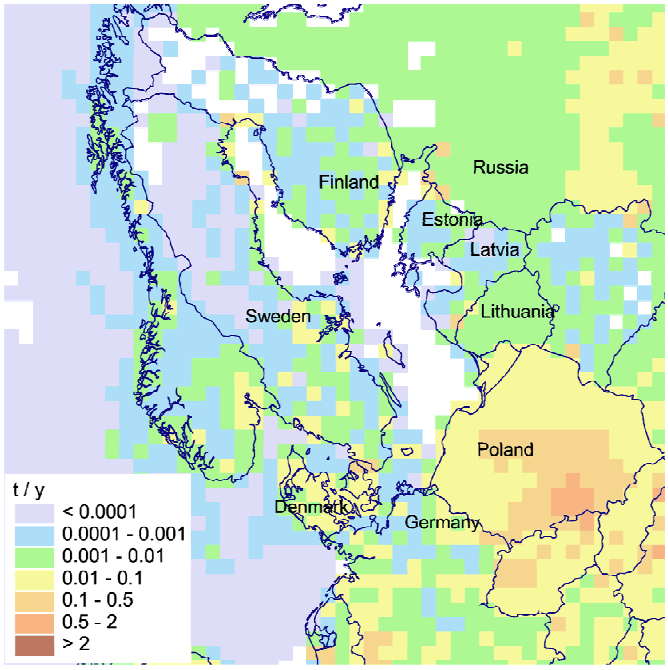


Figure 6.2. Annual total anthropogenic emissions of mercury in the Baltic Sea region for 2005, t/y.

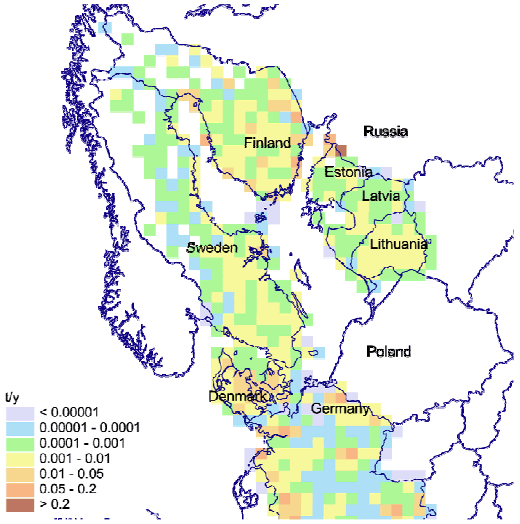


Figure 6.3. Annual mercury emission from Combustion in Power Plants and Industry sector for 2005.

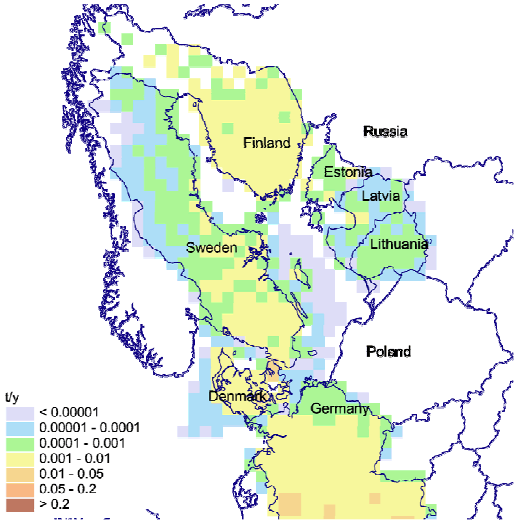


Figure 6.4. Annual mercury emission from Commercial, Residential and Other Stationary Combustion sector for 2005.

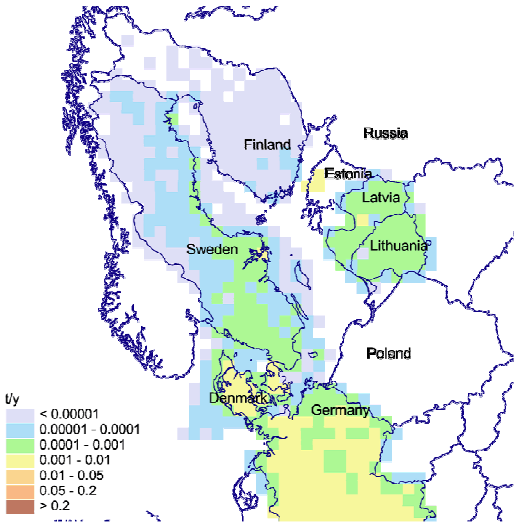


Figure 6.5. Annual mercury emission from from Transport sources below 1000 m sector for 2005.

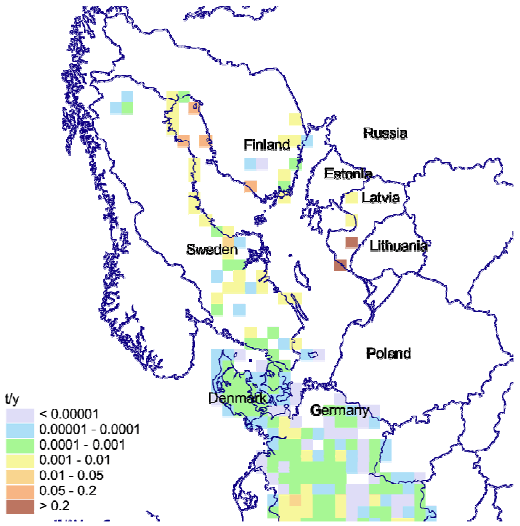


Figure 6.6. Annual mercury emission from Industrial Processes sector for 2005.

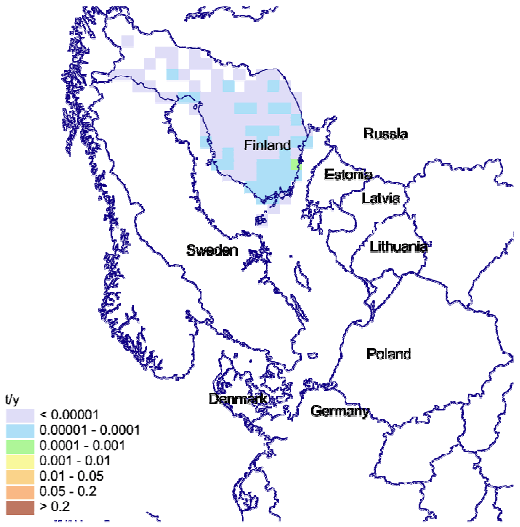


Figure 6.7. Annual mercury emission from Solvent and Other Product Use sector for 2005.

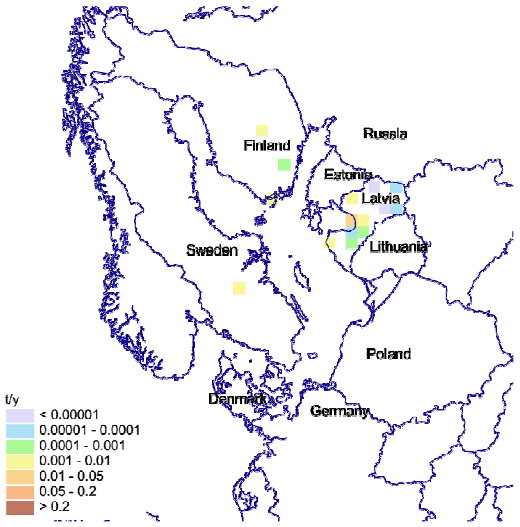


Figure 6.8. Annual mercury emission from Waste sector for 2005.

Table 6.1. Annual total mercury 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	0.37	0.55	0.714	1.62	0.038	0.353	16.527	14.0	0.217
2a	Transport above 1000m	0.0003	NA		NA		0			NA
2b	Transport below 1000m	0.042	0.006	0	0.297	0.09	0.014			0.02
3	Commercial, Residential and Other Stationary Combustion	0.206	0.02	0.25	0.64	0.008	0.004	1.881		0.137
4	Fugitive Emissions From Fuels	0	0		NA		0	0.256		0
5	Industrial Processes	0.005	0	0.333	0.097	0.443	0	1.013		0.153
6	Solvent and Other Product Use	0	0	0.002	NA		0			NE
7	Agriculture	0	NA		NA	0	0	0.159		NA
8	Waste	0	0	0.005	1.2E-06	0.044	0	0.261		0.004
9	Other				NA					
Total		**0.62**	**0.58**	**1.3**	**2.66**	**0.54**	**0.37**	**20.1**	**11.9**	**0.53**

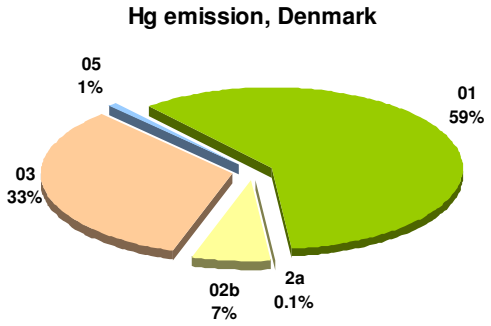


Figure 6.9. Percentage of annual total mercury emission from different sectors in Denmark for 2005

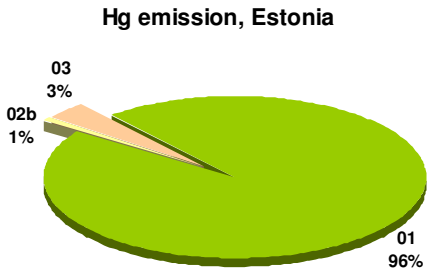


Figure 6.10. Percentage of annual total mercury emission from different sectors in Estonia for 2005

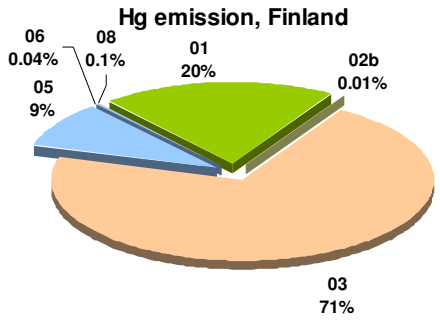


Figure 6.11. Percentage of annual total mercury emission from different sectors in Finland for 2005

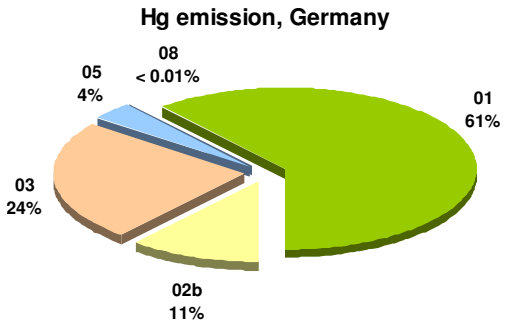


Figure 6.12. Percentage of annual total mercury emission from different sectors in Germany for 2005

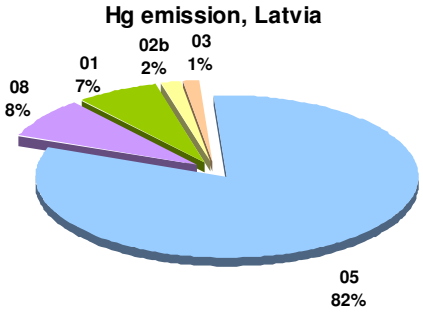


Figure 6.13. Percentage of annual total mercury emission from different sectors in Latvia for 2005

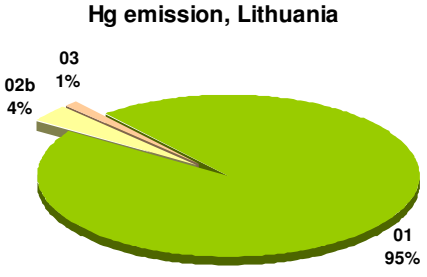


Figure 6.14. Percentage of annual total mercury emission from different sectors in Lithuania for 2005

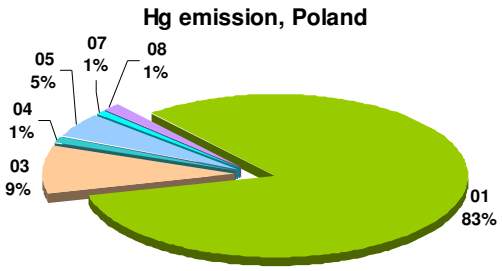


Figure 6.15. Percentage of annual total mercury emission from different sectors in Poland for 2005

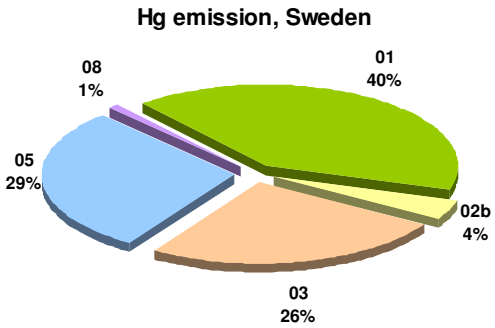


Figure 6.16. Percentage of annual total mercury emission from different sectors in Sweden for 2005

Table 6.2. Annual total anthropogenic emissions of mercury 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	3.3	3.3	3.2	3.2	2.3	2.2	2.5	2.0	1.9	2.0	1.2	1.4	1.3	1.3	1.2	1.3
Estonia	1.1	1.0	0.83	0.64	0.64	0.6	0.61	0.59	0.53	0.51	0.55	0.49	0.5	0.58	0.54	0.520
Finland	1.1	0.9	0.8	0.6	0.7	0.7	0.8	0.6	0.5	0.383	0.577	0.729	0.658	0.782	0.744	0.851
Germany	19	13	8.4	5.3	2.8	2.4	2.6	2.5	2.6	2.5	2.7	2.7	2.7	2.9	2.8	2.7
Latvia	0.303	0.238	0.203	0.198	0.227	0.169	0.2	0.148	0.14	0.123	0.069	0.055	0.043	0.034	0.029	0.059
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
Poland	33	33	32	33	32	32	34	33	30	27	26	23	20	20	20	20
Russia	16	13	11	12	10	10	10	9.6	9.4	9.9	10	10	10	11	12	14
Sweden	1.6	1.3	1.3	1.1	1.1	1.1	1.1	0.974	0.948	0.934	0.776	0.660	0.679	0.761	0.801	0.746
HELCOM	**72**	**66**	**58**	**55**	**51**	**50**	**52**	**50**	**46**	**44**	**42**	**40**	**36**	**38**	**38**	**41**
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
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
Austria	2.1	2.0	1.6	1.4	1.2	1.2	1.2	1.1	0.949	0.940	0.895	0.961	0.941	0.963	0.947	0.975
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
Belarus	1.1	1.1	0.880	0.720	0.600	0.510	0.297	0.310	0.392	0.380	0.358	0.522	0.565	0.603	0.632	0.649
Belgium	6.6	5.7	5.8	3.9	4.2	3.6	3.4	3.2	2.9	2.7	2.5	2.1	3.1	2.8	2.9	1.9
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
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
Croatia	1.2	0.977	0.805	0.632	0.460	0.287	0.297	0.318	0.320	0.307	0.410	0.405	0.449	0.563	0.710	0.710
Cyprus	0.880	0.880	1.0	1.1	1.1	1.1	1.1	1.1	1.2	1.2	1.3	1.3	1.4	1.4	1.2	1.3
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
France	27	28	26	24	23	22	21	16	16	14	13	11	11	8.7	8.5	8.6
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
Greece	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
Hungary	6.3	5.8	5.0	5.0	4.7	4.9	4.7	4.5	4.3	4.3	4.4	4.4	4.0	4.0	3.8	4.1
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
Ireland	1.0	1.1	0.994	0.991	0.944	0.938	0.860	0.728	0.621	0.495	0.418	0.442	0.426	0.410	0.414	0.413
Italy	12	11	11	10	10	11	10	10	9.8	9.2	9.6	9.8	9.6	9.5	10	10
Kazakhstan	10	10	10	10	10	10	10	10	10	10	10	11	11	11	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
Malta	0.601	0.601	0.601	0.601	0.601	0.601	0.601	0.601	0.601	0.601	0.601	0.601	0.601	0.601	0.601	0.618
Monaco	0.109	0.111	0.123	0.134	0.070	0.069	0.074	0.084	0.079	0.080	0.082	0.087	0.078	0.065	0.058	0.057
Netherlands	4.7	3.9	3.3	2.6	2.0	1.2	1.2	0.810	0.633	0.549	0.875	0.742	0.715	0.663	1.0	1.0
Norway	1.5	1.4	1.2	0.929	0.963	0.878	0.905	0.905	0.868	0.910	0.756	0.704	0.667	0.678	0.708	0.693
Portugal	3.8	3.9	4.3	3.9	3.7	4.0	3.6	3.9	4.1	4.3	4.4	4.2	4.5	3.8	3.8	4.1
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
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	6.5	5.7	4.9	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
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
Slovenia	0.770	0.610	0.600	0.540	0.600	0.650	0.570	0.610	0.620	0.590	0.610	0.650	0.640	0.630	0.650	0.640
Spain	13	14	15	13	13	13	12	9.9	10	11	11	11	12	10	10	10
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	1.0	1.0
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
Turkey	18	18	18	18	18	18	18	18	18	18	18	19	19	19	20	20
Ukraine	36	35	34	33	32	31	30	29	28	27	26	25	5.9	30	6.6	6.6
United Kingdom	38	38	36	22	21	20	15	12	11	8.6	8.7	8.4	7.4	8.1	7.0	7.6
EMEP	**334**	**317**	**299**	**269**	**255**	**249**	**236**	**222**	**215**	**204**	**202**	**196**	**172**	**194**	**170**	**172**

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

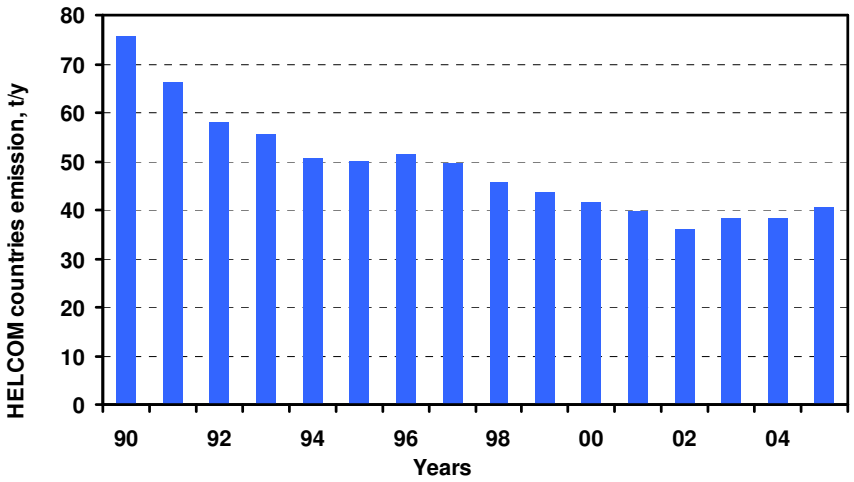


Figure 6.17. Time-series of total annual mercury emissions of HELCOM countries in 1990-2005, tonnes/y.

5.2 Annual deposition of mercury

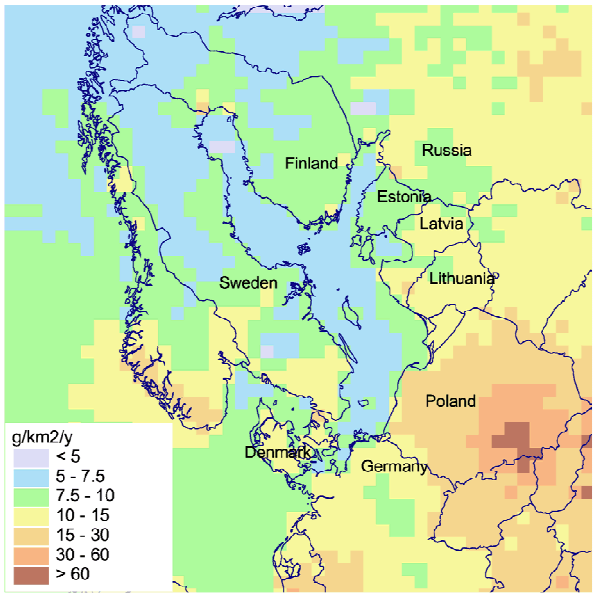


Figure 6.18. Annual deposition fluxes of mercury over the Baltic Sea region for 2005, g/km^2/y.

5.3 Monthly depositions of mercury

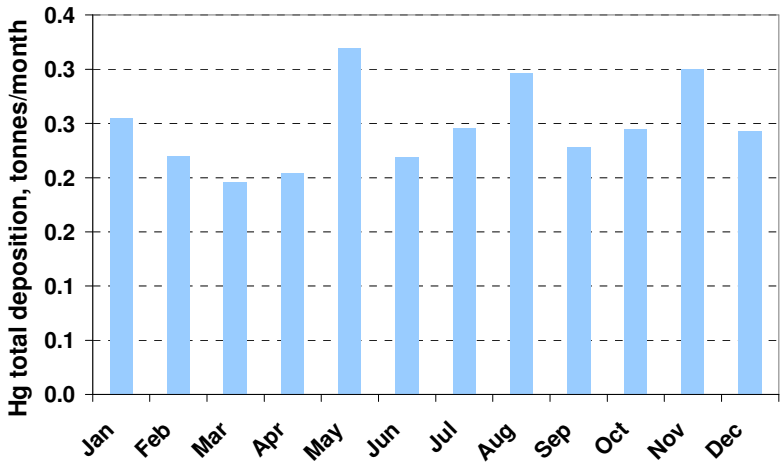


Figure 6.19. Monthly depositions of mercury to the Baltic Sea for 2005, tonnes/month.

Table 6.2. Monthly depositions of mercury to the Baltic Sea for 2005, tonnes/month.

Month	Hg
Jan	0.25
Feb	0.22
Mar	0.20
Apr	0.20
May	0.32
Jun	0.22
Jul	0.25
Aug	0.30
Sep	0.23
Oct	0.24
Nov	0.30
Dec	0.24

5.4 Source allocation of mercury deposition

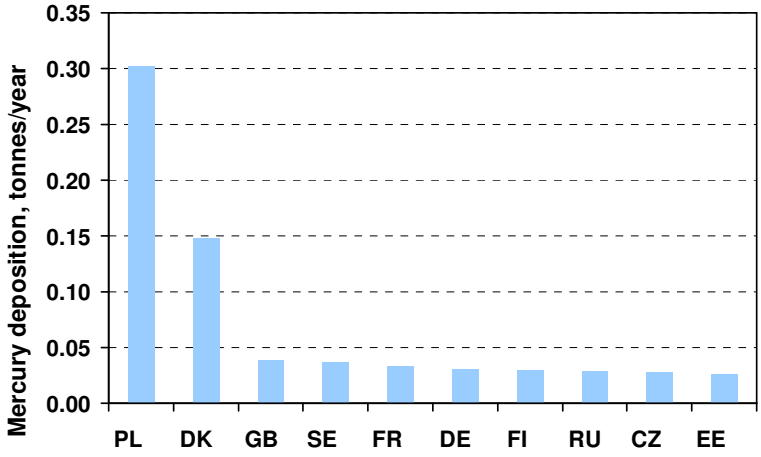


Figure 6.20. Top ten countries with the highest contribution to annual deposition of mercury over the Baltic Sea for 2005, tonnes/year.

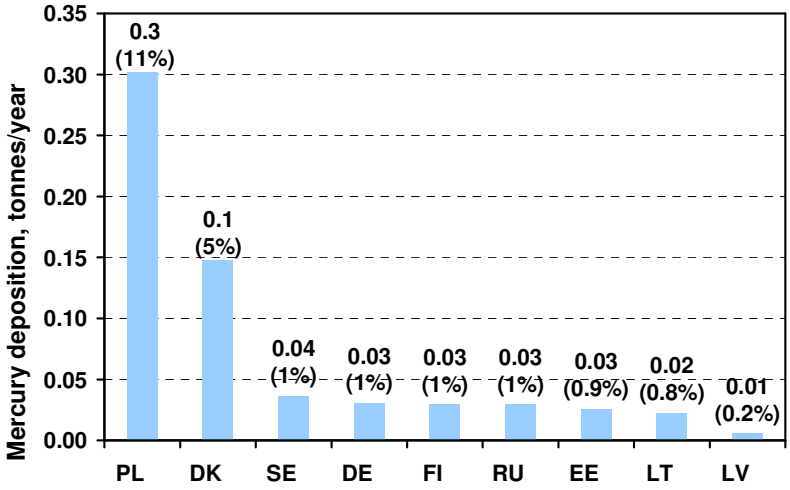


Figure 6.21. Sorted contributions (in %) of HELCOM countries to total depositions over the Baltic Sea for 2005. HELCOM countries emissions of mercury contributed 22% to the total annual mercury depositions over the Baltic Sea in 2005. Contribution of other EMEP countries accounted for 8%. Significant contribution was made by other emission sources, in particular, remote emissions sources, natural emissions and re-emission of mercury (70%).

Table 6.3. Two most significant contributors to the annual total depositions of mercury to the six Baltic Sea sub-basins for 2005.

Sub-basin	Country	%	Country	%	*, %
GUB	Poland	5	Finland	3	81
GUF	Estonia	9	Poland	6	71
GUR	Poland	10	Lithuania	3	73
BAP	Poland	16	Denmark	4	68
BES	Denmark	25	Poland	5	55
KAT	Denmark	19	Poland	5	64
BAS	Poland	11	Denmark	5	70

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

5.5 Comparison of model results with measurements

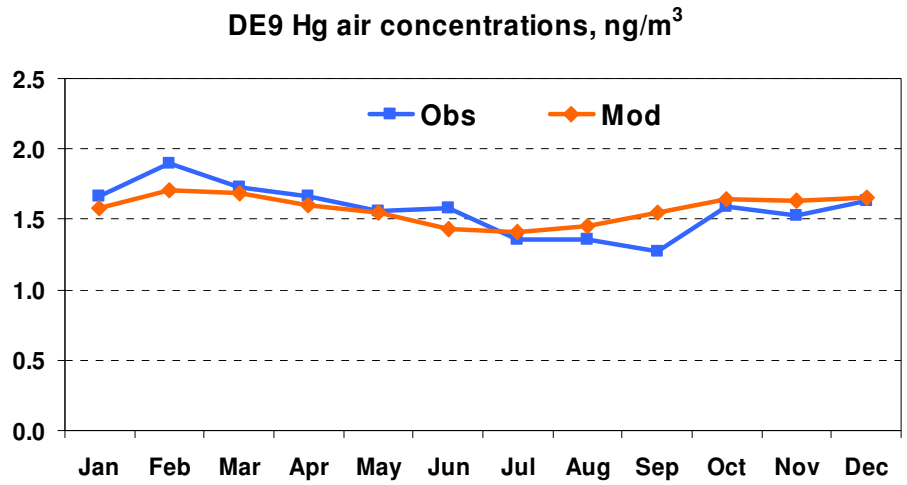


Figure 6.22. Comparison of calculated monthly mean Hg concentrations in air with measured at the station Zingst (DE9). Units: ng / m^3.

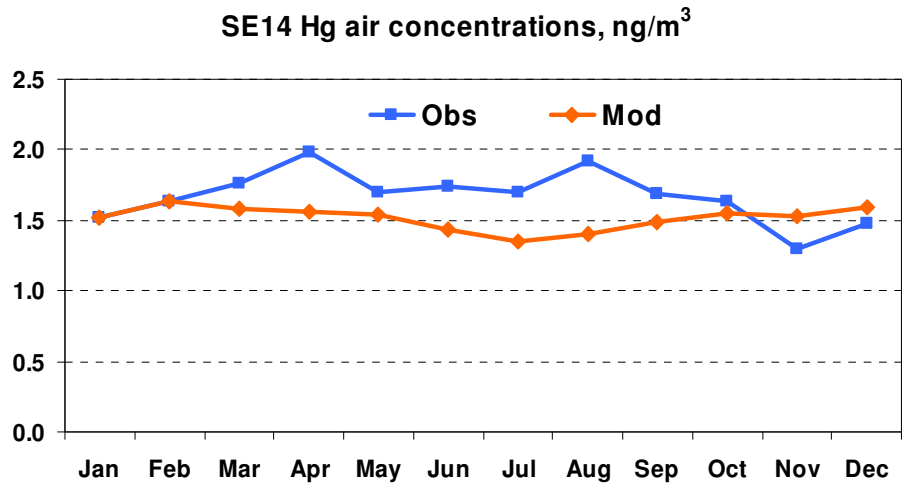


Figure 6.23. Comparison of calculated monthly mean Hg concentrations in air with measured at the station Råö (SE14). Units: ng / m^3.

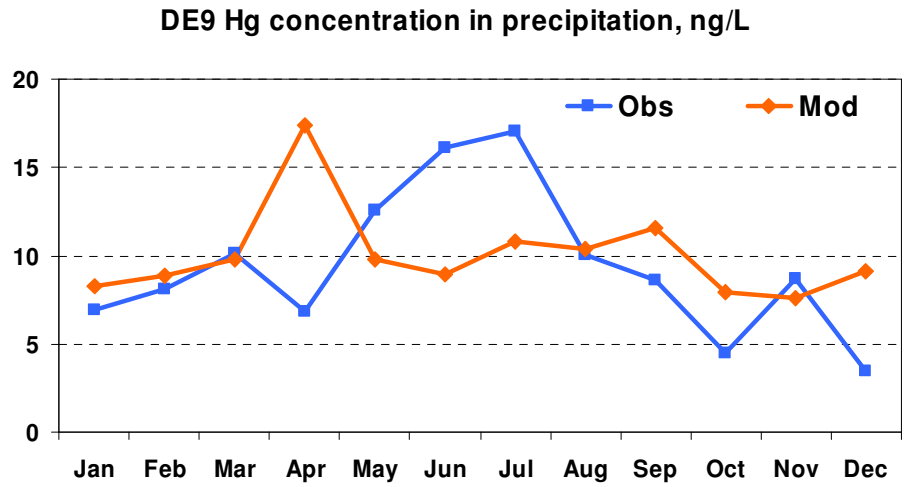


Figure 6.24. Comparison of calculated monthly mean Hg concentrations in precipitation with measured at the station Zingst (DE9). Units: ng/L.

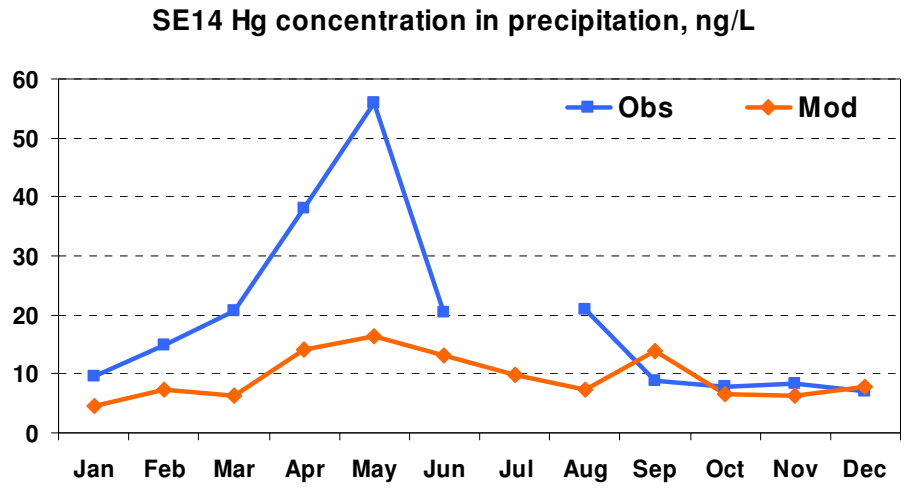


Figure 6.25. Comparison of calculated monthly mean Hg concentrations in precipitation with measured at the station Råö (SE14). Units: ng/L.

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 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.