EMEP Centres Joint Report for HELCOM
EMEP/MSC-W TECHNICAL REPORT 3/2007

Atmospheric Supply of Nitrogen, Lead, Cadmium, Mercury and Dioxines/Furanes to the Baltic Sea in 2005

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Summary

The results presented in this EMEP Centres Joint Report for HELCOM are based on the modelling and monitoring data presented to the 31th Session of the Steering Body of EMEP in Geneva in September 2007. It includes measurements, as well as emissions and depositions calculated by the EMEP models of nitrogen compounds, heavy metals and PCDD/F for the year 2005.

The measured monthly and annual 2005 concentrations in air and precipitation for nitrogen species, heavy metals, as well as air concentrations for lindane are presented in the report. Both for nitrogen and heavy metals a significant south-east gradient can be noticed in the measured concentrations in 2005. The temporal patterns of monthly Cd and Pb concentrations show a strong winter maximum and temporal pattern of Hg monthly concentrations weaker wintermaxim. During winter the atmospheric residence time is longer due to reduced vertical mixing.

Annual emissions from the HELCOM Contractig Parties in 2005 are shown below for all pollutants considered in the report. The annual nitrogen oxides emission from the international ship traffic on the Baltic Sea in 2005 is 343kt NO_2 (or 104 kt N).

Country	POLLUTANT					
	NO_2 kt N	NH3 kt N	Cd tonnes	Pb tonnes	Hg tonnes	PCDD/F g TEQ
Denmark	56,6	76,2	0,6	5,6	1,3	25
Estonia	9,8	7,6	0,6	36,7	0,5	3
Finland	54,0	29,8	1,3	23,5	0,9	26
Germany	439,0	510,1	2,7	106,8	2,7	74
Latvia	12,5	11,5	0,5	16,7	0,1	19
Lithuania	17,5	32,5	0,4	5,7	0,4	11
Poland	246,8	268,9	46,0	536,5	20,1	416
Russia	941,4	511,4	59,4	355	14,0	747
Sweden	62,4	43,1	0,5	16,5	0,7	39
HELCOM	**1840,1**	**1491,2**	**112**	**1103**	**41**	**1360**

Compared to 2004 emissions, annual emissions in 2005 are slightly lower for almost all pollutants except NO_2 ship emissions on the Baltic Sea which are 2.5% higher.

Annual depositions of all considered pollutants in 2005 are shown in the Table below for 6 sub-basins of the Baltic Sea and for the entire Baltic Sea.

Basin	POLLUTANT					
	Ox-N kt N	Red-N kt N	Cd tonnes	Pb tonnes	Hg tonnes	PCDD/F g TEQ
GUB	18,3	11,7	1,24	44	0,72	38
BAP	7,9	5,0	4,11	136	1,51	86
GUF	5,4	3,9	0,50	17	0,22	21
GUR	66,0	49,4	0,34	11	0,14	16
BES	9,2	12,3	0,54	21	0,19	26
KAT	9,6	9,2	0,54	22	0,20	12
BAS	**116,4**	**91,4**	**7,3**	**251**	**3,0**	**199**

Nitrogen depositions followed the nitrogen emission changes and were lower in 2005 than in 2004 in most of sub-basins and in the entire Baltic Sea Basin. Depositions of heavy metals to the entire Baltic Sea remain on the same level in 2005 as in 2004, but there are some differences in distributions among sub-basins. Deposition of PCDD/F to the entire Baltic Sea is approximately 6% higher in 2005 than in 2004. There is also an increase of PCDD/F deposition from 2004 to 2005 for most of the sub-basins.

Preface

The Co-operative Program for Monitoring and Evaluation of the Long-Range Transmission of Air Pollutants in Europe (EMEP) and the Baltic Marine Environment Protection Commission (HELCOM) are both conducting work on air monitoring, modelling and compilation of emission inventories. In 1995, HELCOM decided to rationalize its current programs by avoiding duplication of efforts with specialised international organizations. At the request of HELCOM, the steering Body of EMEP at its nineteenth session agreed to assume the management of atmospheric monitoring data, the preparation of air emission inventories and the modelling of air pollution in the Baltic region.

Following the coordination meeting held in Potsdam in Germany and the Pollution Load Input meeting held in Klajpeda-Joudkrante in Lithuania, both 1996, it was agreed that EMEP Centres should be responsible for regular evaluation of the state of the atmosphere in the Baltic Sea region and should produce an annual joint summary report which includes updated emissions of selected air pollution, modelled deposition fields, allocation budgets and measurement data.

This report was prepared for the HELCOM, based on model estimates and monitoring results presented to the thirtieth session of the Steering Body of EMEP. Following decision of the HELCOM /MONAS-9 Meeting, it presents the results for the year 2005.

Acknowledgements

The authors are indebted to the scientific teams at MSC-E, MSC-W and CCC for providing the results included in this.

We are most grateful to Marina Varygina, Ilia Ilyin and Victor Shatalov from MSC-E, and to Heiko Klein, Vigdis Vestreng and Per Helmer Skaali from MSC-W for their help in preparation of this report.

Contents

1. Introduction

The first EMEP Centres Joint Report for HELCOM was delivered in 1997 (Tarrason *et al*. 1997) and was followed by eight annual reports (Bartnicki *et al*. 1998, 2000, 2001, 2002, 2003, 2004, 2005, 2006). The present EMEP Centres Joint Report for HELCOM is focused on the year 2005. It is based on the modelling and monitoring data presented to the 31th Session of the Steering Body of EMEP in Geneva in September 2007.

Following decisions of the 9th HELCOM MONAS Meeting held in Silkeborg in 2006, the main deliverables expected from the EMEP Centres are the Indicator Fact Sheets for nitrogen, heavy metals and PCDD/Fs. These Indicator Fact Sheets include time series of emissions and depositions of selected pollutants, and are presented in Appendices C – H. In this report we present additional important information about emissions, depositions and source allocation budgets for nitrogen, heavy metals and PCDD/Fs in the year 2005.

The EMEP Unified Eulerian model system has been used for all nitrogen computations presented here. The model has been documented in detail in EMEP Status Report 1/2003 Part I (Simpson *et al.* 2003) and in EMEP Status Report 1/2004 (Tarrasón *et al*., 2004). In EMEP Status Report 1/2003 Part II (Fagerli *et al.* 2003) we presented an extensive evaluation of the acidifying and eutrophying components for the years 1980, 1985, 1990 and 1995 to 2000. In EMEP Status Report 1/2003 Part III (Fagerli *et al.* 2003), a comparison of observations and modelled results for 2001 was conducted, and in EMEP Status Report 1/2004 (Fagerli, 2004) we presented results for 2002 with an updated EMEP Unified model, version 2.0. This version differed slightly from the 2003 version, as described in EMEP Status Report 1/2004 (Fagerli, 2004), however the main conclusions on the model performance was the same. In 2005, we presented results for the year 2003 in EMEP Status Report 1/2005 (Fagerli, 2005) and last year we presented results for 2004 in EMEP Status Report 1/2006 (Fagerli *et al.* 2006). It has been shown that the EMEP model performance is rather homogeneous over the years (Fagerli *et al.* 2003), but depend on geographical coverage and quality of the measurement data. The EMEP model has also been validated for nitrogen compounds in Simpson *et al.*, 2006, and for dry and wet deposition of sulphur, and wet depositions for nitrogen in Simpson *et al*., 2006b with measurements outside the EMEP network. Since last year, no changes with significant effects on the results for acidifying and eutrophying compounds have been introduced in the model. Moreover, the comparison between model results and observations for 2005 give similar correlation coefficients and bias as the comparisons performed for earlier years. The previous evaluations of the model are thus still valid.

Atmospheric input and source allocation budgets of heavy metals (cadmium, lead, and mercury) to the Baltic Sea were computed using the latest version of MSCE-HM model. MSCE-HM is the regional-scale model operating within the EMEP region. This is a three-dimensional Eulerian model which includes processes of emission, advection, turbulent diffusion, chemical transformations of mercury, wet and dry depositions, and inflow of pollutant into the model domain. Horizontal grid of the model is defined using stereographic projection with spatial resolution 50 km at 60º latitude. The description of EMEP horizontal grid system can be found in the internet (http://www.emep.int/grid/index.html). Vertical structure of the model consists of 15 non-uniform layers defined in the terrain-following σ-coordinates and covers almost the whole troposphere. Detailed description of the model can be found in EMEP reports (Travnikov and Ilyin, 2005) and in the Internet on EMEP web page http://www.emep.int under the link to information on Heavy Metals.

Evaluation of PCDD/F atmospheric input to the Baltic Sea was carried out using the latest version of MSCE-POP model. MSCE-POP model is a three-dimensional Eulerian multimedia POP transport model operating within the geographical scope of EMEP region with spatial resolution 50 km at 60º latitude. Vertical structure of MSCE-POP is defined similar to MSCE-HM model. MSCE-POP considers the following compartments: air, soil, sea, vegetation and forest litter fall. The model includes the following basic processes: emission, advective transport, turbulent diffusion, dry and wet deposition, gas/particle partitioning, degradation, and gaseous exchange between the atmosphere and the underlying surface (soil, seawater, vegetation). Detailed description of MSCE-POP model is given in EMEP report (Gusev *et al.*, 2005) and in the Internet on EMEP web page http://www.emep.int under the link to information on Persistent Organic Pollutants.

The formulation of MSCE-HM and MSCE-POP models and their performance were thoroughly evaluated within the framework of activity of EMEP/TFMM on the EMEP Models Review (ECE/EB.AIR/GE.1/2006/4). One of the main conclusions of the TFMM Workshop held in Moscow in 2005 was that MSCE-HM and MSCE-POP models represent the state of the science and fit for the purpose of evaluating the contribution of long-range transport to the environmental impacts caused by HMs and POPs.

As decided by HELCOM all depositions, as well as, source allocation budgets have been calculated for the six sub-basins and catchments of the Baltic Sea. Names and acronyms of these regions, often used in the report are given below:

1. Gulf of Bothnia (GUB)
2. Gulf of Finland (GUF)
3. Gulf of Riga (GUR)
4. Baltic Proper (BAP)
5. Belt Sea (BES)
6. The Kattegat (KAT)

Depositions and source allocation budgets have been also calculated for the entire basin and the entire catchment of the Baltic Sea. According to HELCOM requirements, the present annual joint report includes mainly figures and tables describing emissions, depositions and source allocation budgets for nitrogen, heavy metals and PCDD/Fs.

2. Observed Concentrations of Nitrogen, Cadmium, Lead, Mercury and Lindane at HELCOM Stations in 2005

2.1 HELCOM measurement stations

Nine countries have submitted data from all together twenty HELCOM stations for 2005 (Table 2.1. and Fig. 2.1).

Table 2.1. Available measurements of nitrogen, lead, cadmium, mercury and lindane from HELCOM stations for 2005. Region shows HELCOM sub-basins, Green colour indicates data for at least one component.

Station			Concentrations in air					Concentrations in precipitation				
Region	Code	Name	N	Pb	Cd	Hg	HCH	N	Pb	Cd	Hg	HCH
GUB	FI053	Hailuoto										
GUB	SE05	Bredkälen										
GUB	SE53	Rickleå										
GUF	EE09	Lahemaa										
GUF	FI17	Virolahti										
GUF	RU16	Shepeljovo										
GUR	LV16	Zoseni										
BAP	DE09	Zingst										
BAP	DK20	Pedersker										
BAP	EE11	Vilsandy										
BAP	FI09	Uto										
BAP	LT15	Preila										
BAP	LV10	Rucava										
BAP	PL04	Leba										
BAP	SE51	Arup										
BAP	SE08	Hoburg										
BAP	SE12	Aspvreten										
BES	DK05	Keldsnor										
BES	SE11	Vavihill										
KAT	DK08	Anholt										
KAT	SE14	Råö										

The stations are distributed in the six sub-basins (Fig. 2.1) as following: One in the Gulf of Riga (GUR), three in the Gulf of Bothnia (GUB), Belt Sea (BES) and Kattegat (KAT), three in the Gulf of Finland (GUF) and ten in the Baltic proper (BAP). There is one station from: Germany, Lithuania, Poland and Russia, two stations from Latvia and Estonia, three stations from Denmark and Finland, and six stations from Sweden. No stations have delivered data for all the components in air and precipitation. In this section we provide a broad view of the patterns and levels evident in monitoring data from 2005. Where possible regional average values are provided for the principal regions within the Baltic Sea. For actual monthly values on a component-by-component basis, the reader is referred to Appendix A. A description of sampling and analytical methods is given in Appendix B.

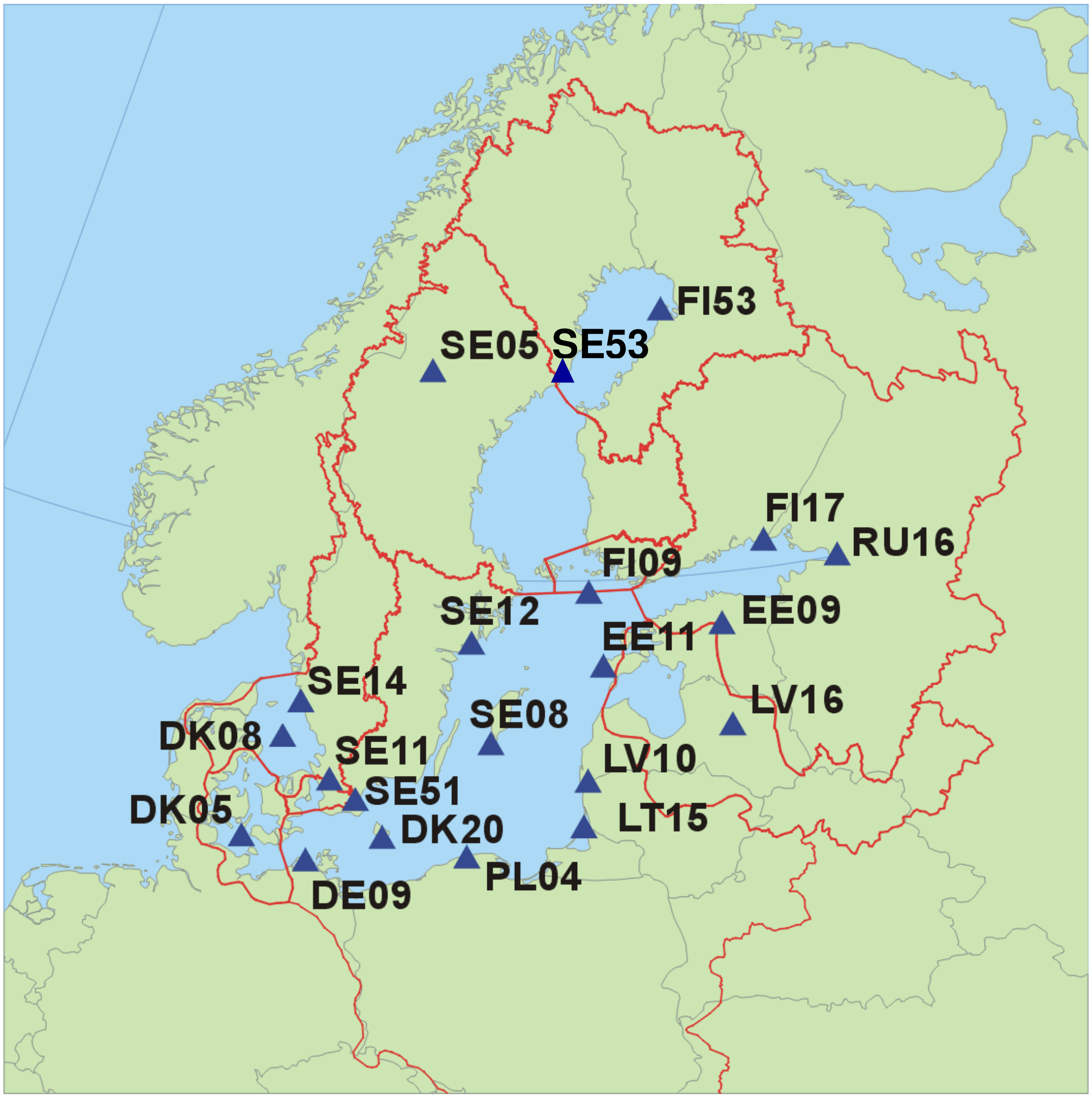


Figure 2.1. Geographical locations of the HELCOM stations with available measurements for the year 2005.

2.2 Nitrogen concentrations in air

Altogether 15 stations have delivered data for one or more nitrogen species in air: 10 for respectively total reduced nitrogen (NH_3+NH_4^+), 12 for total nitrate (HNO_3+NO_3^-), and 15 for nitrogen dioxide (NO_2). Stations from five of the six sub-basins have delivered data for total reduced nitrogen and total nitrate, whereas stations from all the sub-basins have delivered data for total nitrate. Annual averages of the different nitrogen species are presented in Figure 2.2. Average air concentrations are arithmetic averages of the reported values. The lowest concentrations for all the three nitrogen species were reported at the northernmost Swedish site (SE05) in 2005: The concentrations were 0.23, 0.09, 0.12 µg N/m^3 for respectively NH_3+NH_4^+, HNO_3+NO_3^- and NO_2 at this site. Highest concentrations were found at the German site DE09, almost 2 µgN/m^3 of ammonium and 1 µgN/m^3 for. The Estonian sites also show high levels.

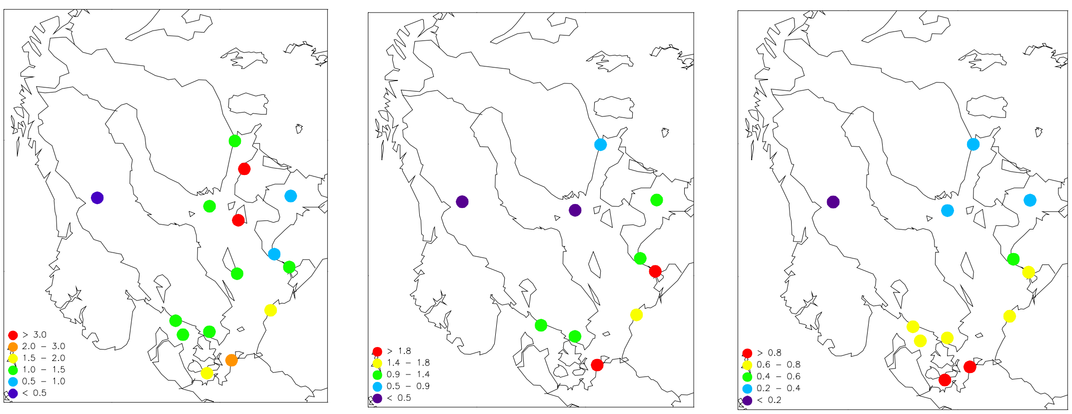


Figure 2.2. Concentrations of left: total reduced nitrogen (NH_3+NH_4^+), middle: total nitrate (HNO_3+NO_3^-), and right: NO_2 in air in 2005 Unit: µg N/m^3.

A similar south north gradient can also be noticed in Figure 2.3-2.5 displaying the station averages of NH_3+NH_4^+, HNO_3+NO_3^- and NO_2 observations across six sub-basins. As mentioned earlier some of the sub-basins have only one station whereas others have more.

Observations of the total reduced nitrogen (NH_3+NH_4^+), show a seasonal pattern similar for all the sub-basins with highest concentrations during April, and a peak is also common in August. Agricultural activities (manure) are the main source for NH_3+NH_4^+. During the summer half year NH_3 is normally emitted from the ground due to higher temperatures.

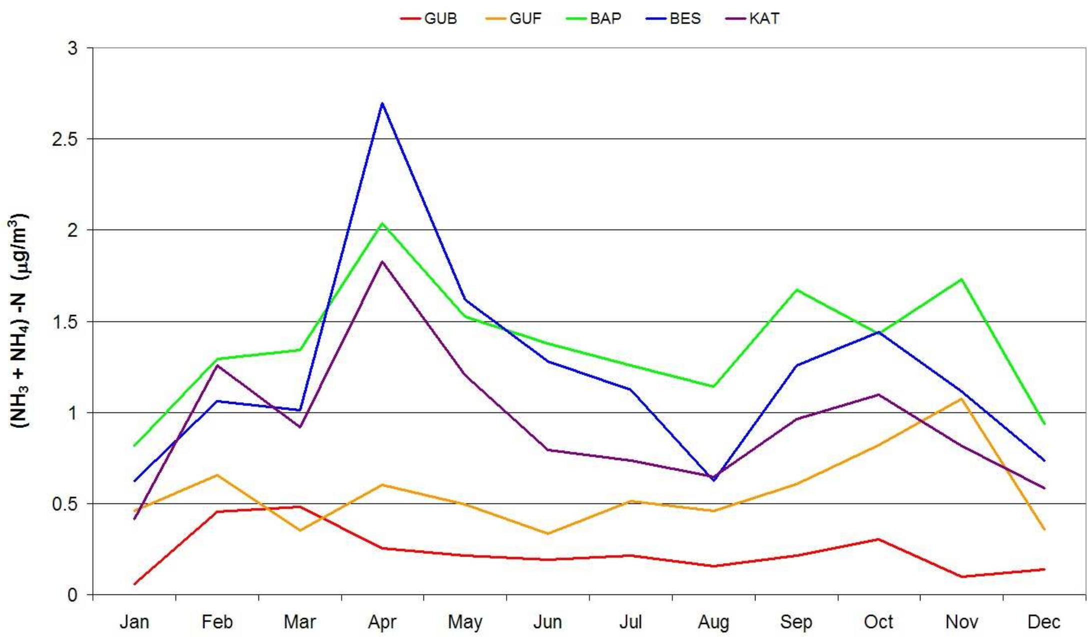


Figure 2.3. Monthly total reduced nitrogen (NH_3+NH_4) concentrations in the air in 2005 averaged for the sub-basins.

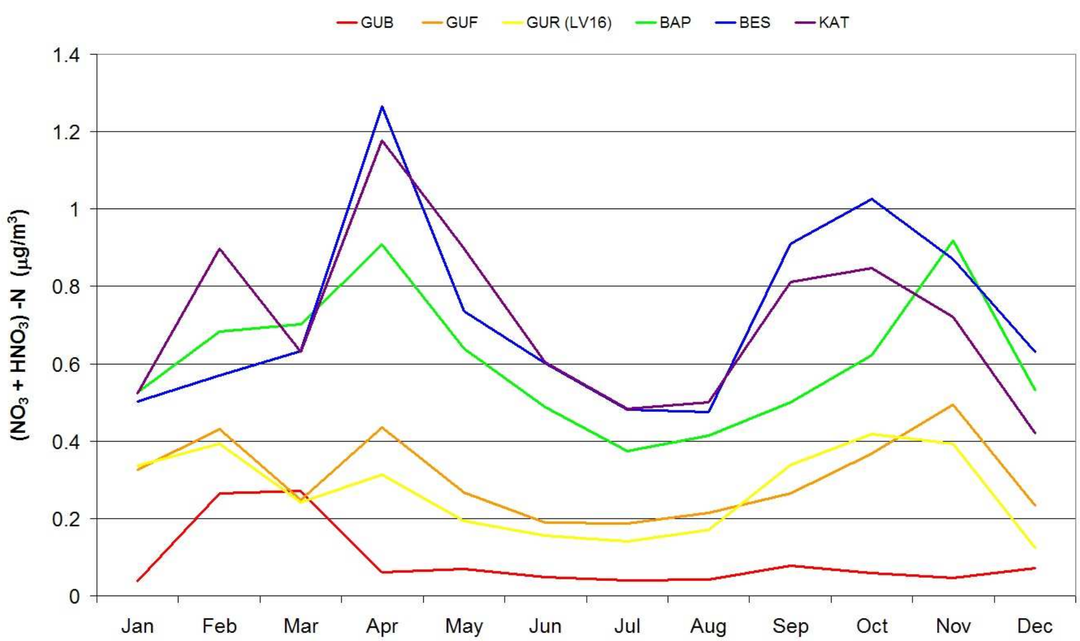


Figure 2.4. Monthly total oxidized nitrate (HNO_3+NO_3^-) concentrations in the air in 2005

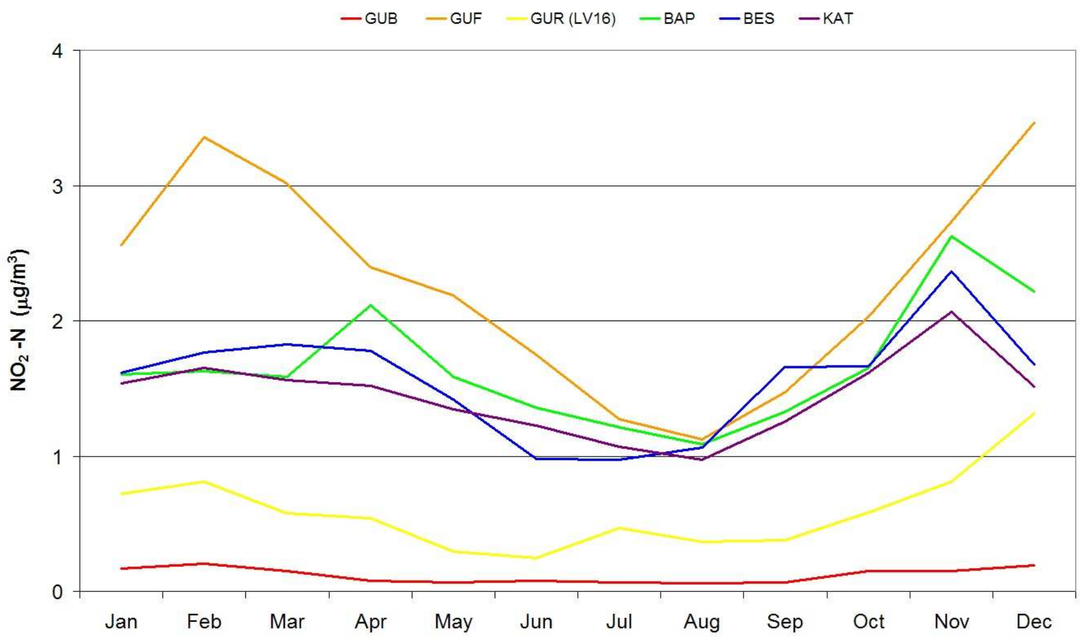


Figure 2.5. Monthly NO_2 concentrations in the air in 2005 averaged for the sub-basins: Top: total reduced nitrogen (NH_3+NH_4), middle: total nitrate (HNO_3+NO_3^-), bottom:.

Total nitrate (HNO_3+NO_3^-) concentrations show a clear seasonal pattern with highest concentrations in March and April. NO_2 is reacting photochemically and the reaction product is total nitrate. This reaction is mostly dominating during spring. However, total nitrate is dominated by particulate nitrate in the cold season, which has a higher residence time in the atmosphere than nitric acid. In the summer, more of total nitrate consists of nitric acid, which is dry deposited very fast. The overall effect is a less pronounced seasonal pattern. Concentrations of NO_2 show not unexpected temporal patterns with a winter maxima/summer minima. During winter the atmospheric residence time is longer due to high emissions, low photochemically activity and reduced vertical mixing. The ammonium concentrations also show seasonal pattern reflecting the agricultural activities in the spring and autumn.

2.3 Nitrogen in precipitation

Altogether 18 stations have delivered data for ammonium and nitrate in precipitation. Stations from all the six sub-basins have delivered data for ammonium and nitrate in precipitation. Annual averages of the two nitrogen species are presented in Figure 2.6.

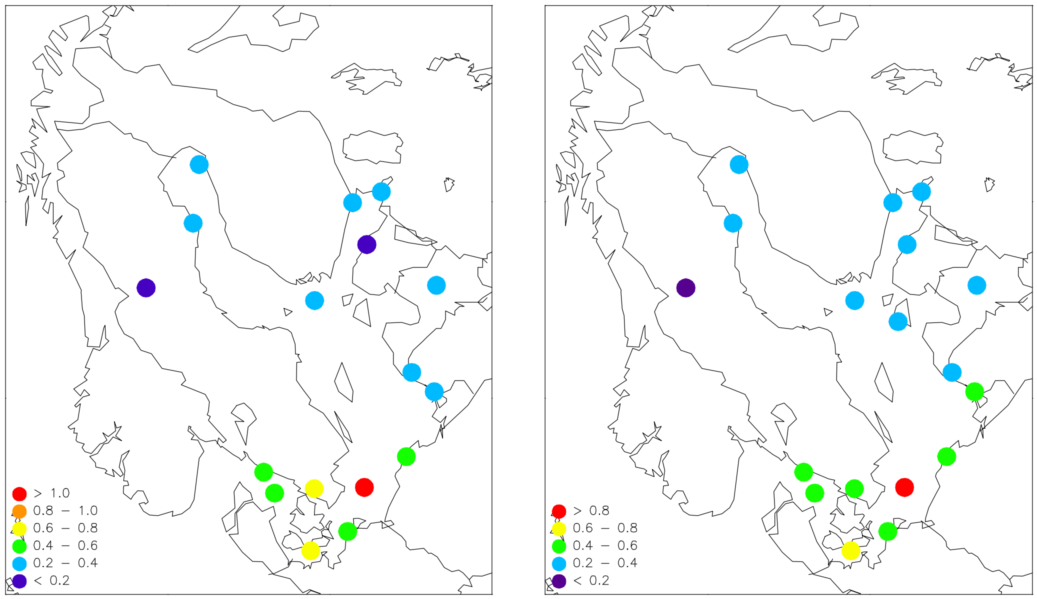


Figure 2.6. Concentrations of left: ammonium (NH_4^+), and right: nitrate (NO_3^-) in precipitation in 2005. Units: mg N/l.

The yearly mean concentrations in precipitation have been calculated from daily, weekly or monthly reported values as precipitation-weighted averages. A south-north gradient similar to air can also be seen for nitrogen in precipitation with higher concentrations in the south. But also a west-east gradient is seen. The concentration differences for ammonium are much higher than for nitrate, because stations can be affected by local agricultural activities. Lowest concentration for ammonium (0.13 mg N/l) was reported at SE05 and EE09. Lowest concentrations of nitrate were seen SE05 sites with 0.12 mg N/l. The highest concentrations were found at the DK20, 1.4 mg N/l and 0.9 mg N/l for ammonium and nitrate respectively. Figure 2.7 displays the station average deposition of oxidized and reduced nitrogen across the regions given.

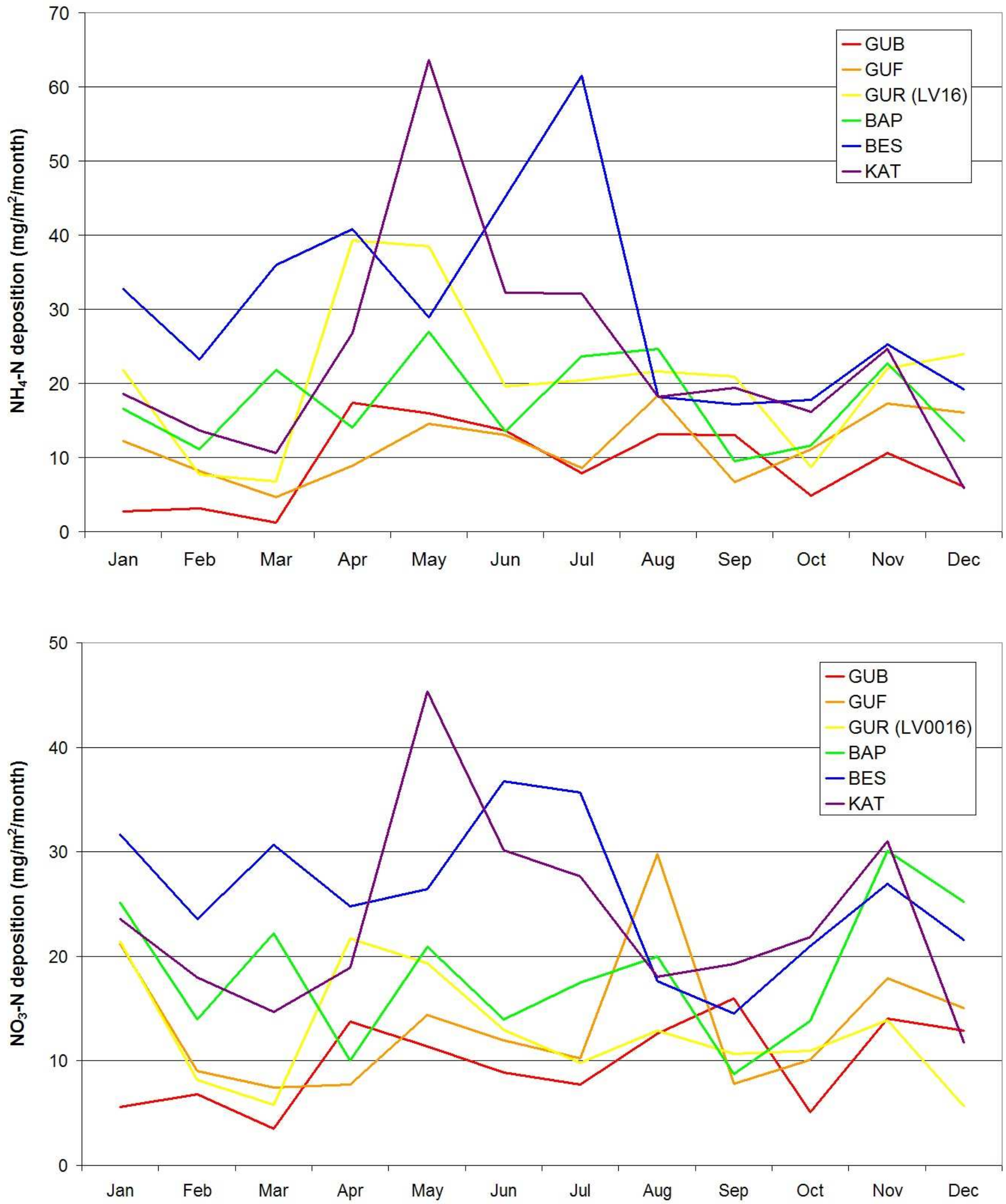


Figure 2.7. Monthly nitrogen depositions in 2005 averaged for the sub-basins: Top: reduced nitrogen (NH_4^+), and bottom: nitrate (NO_3^-).

It is to be observed that seasonal patterns are not as strong as for airborne components. This is due to the presence of the precipitation effect. Airborne nitrogen species will be washed out at precipitation events during transport. The spatial pattern persists, however, with clearly decreasing depositions with progression northwards. For example, the northern regions typically receive half the deposition of reduced nitrogen supplied to southern areas.

2.4 Heavy metals in the air

Altogether 7 stations have delivered data for Cd (5 sites) and Pb (7 sites) in aerosols in the HELCOM area, whereas only two (SE12 and DE09) has delivered data for Hg in air. Annual averages of Cd and Pb are presented in Figure 2.8. Average air concentrations are arithmetic averages of the reported values. The lowest concentrations for Cd in aerosols were reported at SE14, 0.14 ng/m^3. The lowest concentration (4.0 ng/m^3) for Pb in aerosols was reported at LV16. The highest concentrations were found at LV10 for cadmium (0.21 ng/m^3) and DE09 (6.8 ng/m^3) for lead

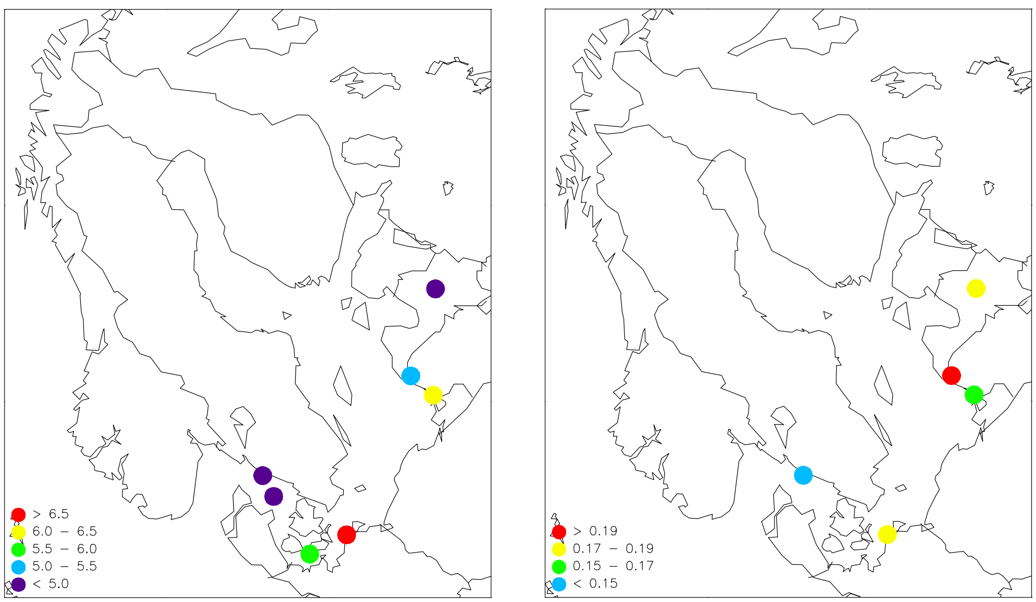
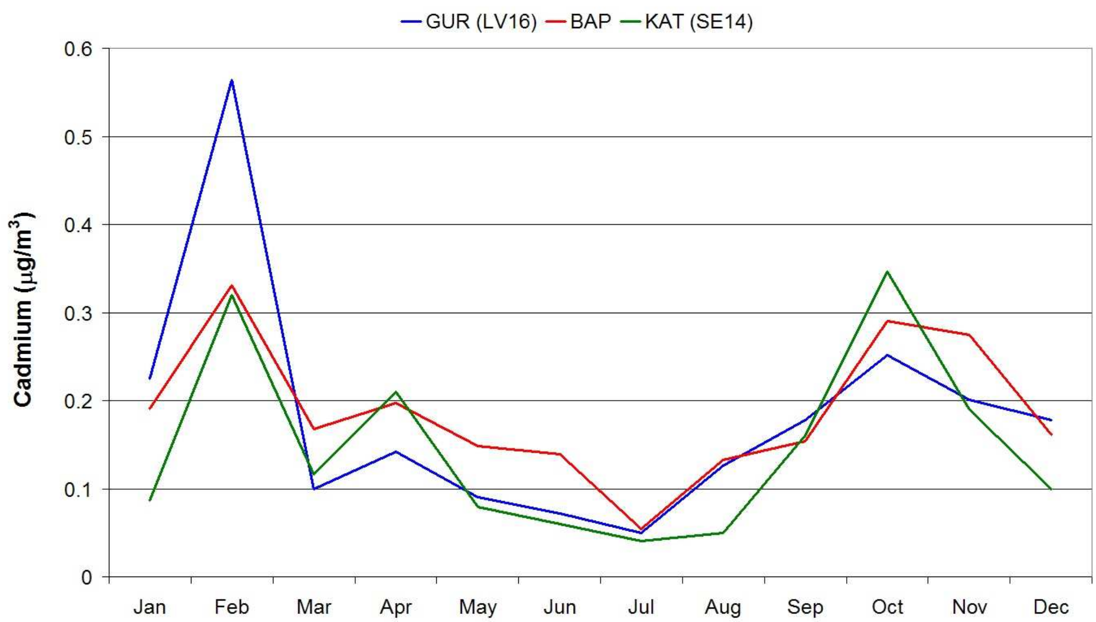


Figure 2.8. Concentrations of left: lead (Pb) and right: cadmium (Cd) in aerosol in air in 2005. Units: ng/m^3.

There are insufficient stations to reasonably represent regional patterns, hence the station data itself is presented here for some of the sites (Fig. 2.9).



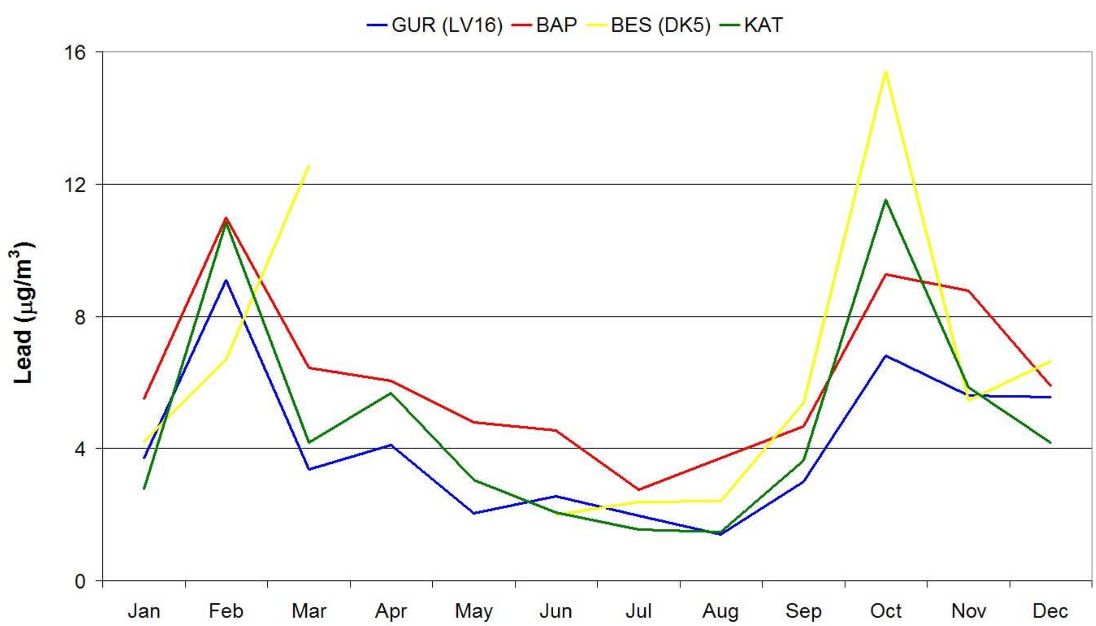


Figure 2.9. Monthly concentrations in air in 2005 averaged for the sub-basins: Top: cadmium, middle: lead and bottom: mercury.

From this, it is to be observed that the temporal patterns for Cd and Pb show a strong winter maximum. During winter the atmospheric residence time is longer due to reduced vertical mixing. Hg concentrations at the two sites are similar and show a weak winter maxima for the two stations, Figure 2.10

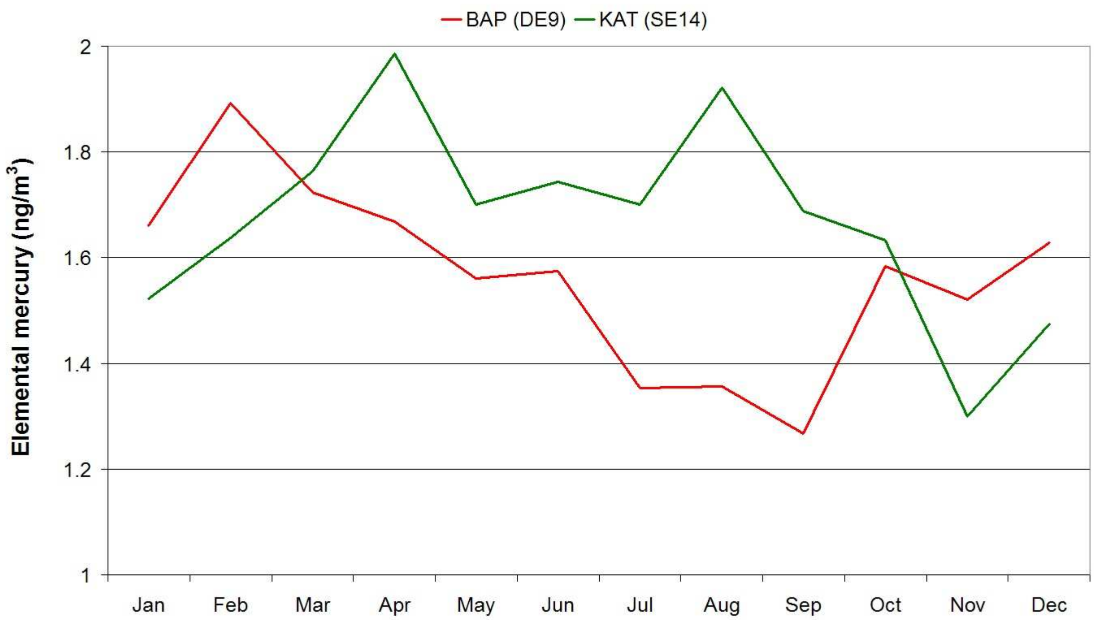


Figure 2.10. Monthly concentrations of Hg in air in 2005 averaged for the sub-basins: BAP (DE9) and KAT (SE14).

2.5 Heavy metals in precipitation

All 12 stations have delivered data for Cd and Pb in precipitation, and two have delivered data for Hg in precipitation. Stations from five of the six sub-basins have delivered data for Cd and Pb. Annual averages of Cd and Pb are presented in Figure 2.11. The yearly mean concentrations in precipitation have been calculated from daily, weekly or monthly reported values as precipitation-weighted averages. The lowest concentration for Cd in precipitation was reported at the DK08, DE09 and the Estonian sites, about 0.03 µg/l. The German and Estonian sites also reported the lowest concentrations for Pb with 0.87 and 0.6 µg/l respectively. The highest concentrations of Cd and Pb were measured at LT15.

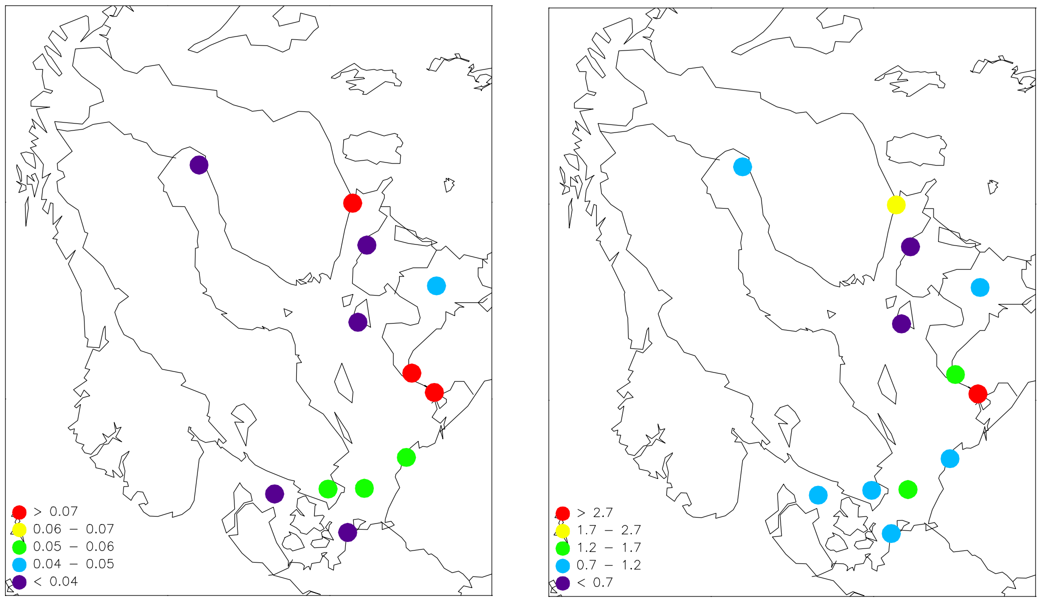


Figure 2.11. Concentrations of left: cadmium (Cd), right: lead (Pb) in precipitation. in precipitation in 2005. Units: µg/l.

2.6. Lindane (γ-HCH)

Only Sweden delivered data for γ-HCH in air, while Germany in addition delivered data for γ-HCH in precipitation.

Fig. 2.12 displays monthly averages of γ-HCH in air at SE14. From this, it is to be observed that the temporal patterns for γ-HCH show a summer maximum. In western countries the use of lindane (containing >95% γ-HCH) in agricultural application is still allowed, explaining the summer maximum. The deposition data are not shown, because different sampling methods make these difficult to compare. The data are found in appendix A.

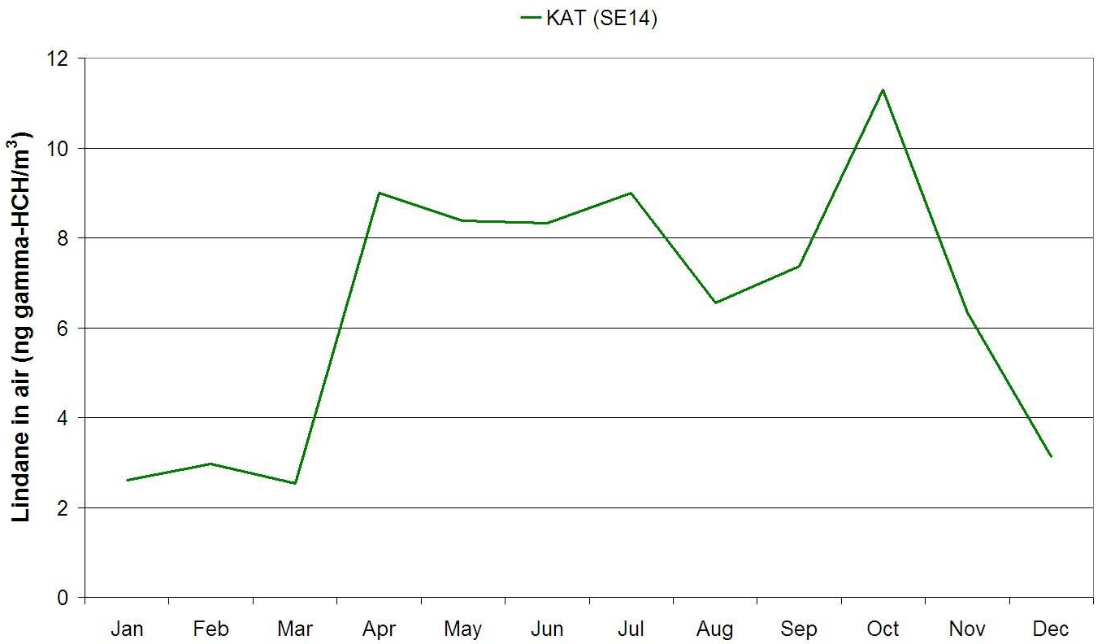


Figure 2.11 Monthly concentrations of γ-HCH in air at SE14in 2005

2.7. Laboratory and field intercomparisons

The HELCOM laboratories have participated in different laboratory and field intercomparisons in 2005 which have been presented in EMEP's QA/QC report (EMEP/CCC 3/2007). The results are given below:

2.7.1. Nitrogen

Measurements of airborne nitrate are expected to have a rather large uncertainity due to the very different physical characteristics of the compounds making up total nitrate. Whilst nitric acid is a spatially variable volatile gas with fast dry deposition, particulate nitrate dry deposits only slowly and hence concentrations are more determined by long range transport.

The results from the EMEP laboratory intercomparisons on main components in air and precipitation (Table 2.2) showed that there are some measurements with relatively high uncertainty, but in general the results are quite satisfactory

lab nr		Precip		Air	
		NO3	NH4	HNO3	NH3
8	DE	0.3	0.7	2.1	8.3
4	DK	0.3	1.2	3.8	
38	EE	1.4	32.7		
5	FI	1.7	2.6	2.1	4.8
32	LT	0.6	3.0	2.8	14.6
33	LV	2.4	1.2	12.4	6.3
22	RU	6.7	1.8	3.8	

> 10% RSD
>20% RSD

Table 2.2. Relativ standard error in nitrogen species in the EMEP's 23rd laboratory intercomparison for precipitation and air.

2.7.2. Heavy metals

The data quality objectives (DQO) in EMEP states that the accuracy in the laboratory should be better than 15% and 25% for high and low concentrations of heavy metals, respectively. Results from the EMEP laboratory intercomparisons in 2005 (Table 2.3) are quite good in general except for Estonia that needs to check their QA/QC routines for heavy metals.

	Cd		Pb	
	low	high	low	high
DK	0	6	25	3
FI	1	2	6	1
DE	4	2	3	5
LT	6	4	4	2
LV	0	3	6	1
EE	<DL	6	31	36

1/2 - 1 DQO
1 - 2 DQO
> 2 DQO

Table 2.3. Average per cent error (absolute) in low and high concentration samples, results from the heavy metal laboratory intercomparison in EMEP, 2005.

3. Atmospheric Supply of Nitrogen to the Baltic Sea in 2005

Nitrogen emission data, as well as the model results presented here have been approved by the 31th Session of the Steering Body of EMEP in Geneva in September 2007. The EMEP Unified Eulerian model system has been used for all nitrogen computations presented in this Chapter. Annual deposition of total nitrogen to the Baltic Sea basin in 2005 was 208 ktonnes approximately 3% less than in 2004. Deposition of oxidized nitrogen accounted for 56% of total nitrogen deposition in 2005.

3.1 Nitrogen emissions

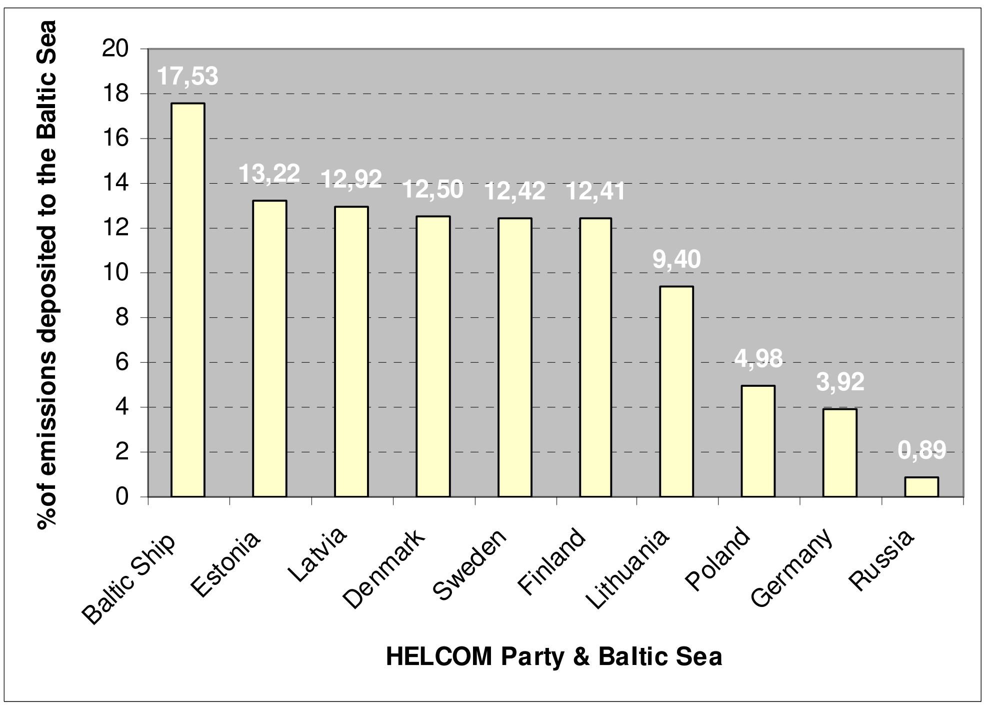


Figure 3.1. Percent of annual emissions of total (oxidized + reduced) nitrogen from the HELCOM Parties and international ship traffic emissions on the Baltic Sea (Baltic Ship) deposited to the Baltic Sea basin in 2005.

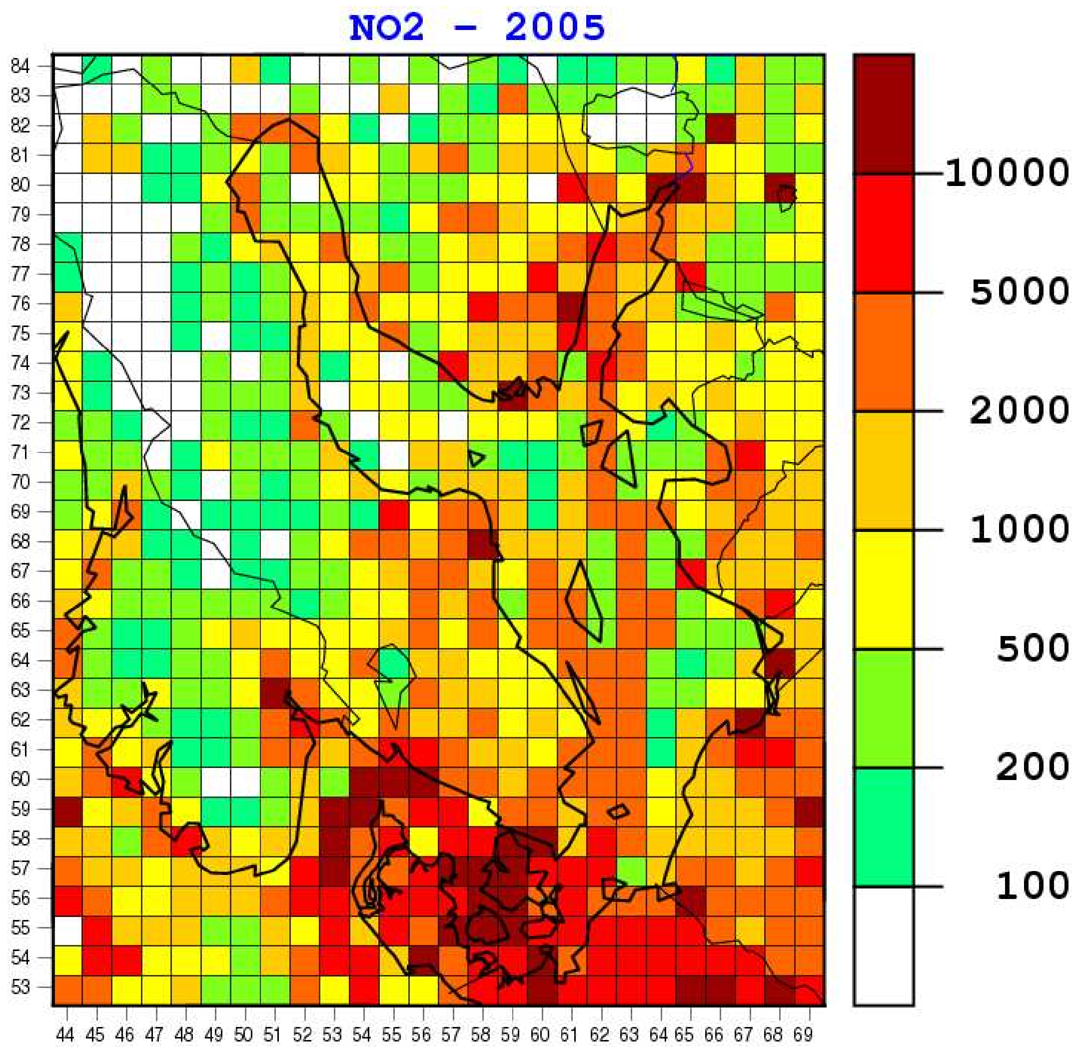


Figure 3.2. Map of annual emission of oxidized nitrogen (including emissions from the ship traffic) in the Baltic Sea region in 2005. Units: Mg (tones) of NO_2 per year and per 50×50 km grid cell.

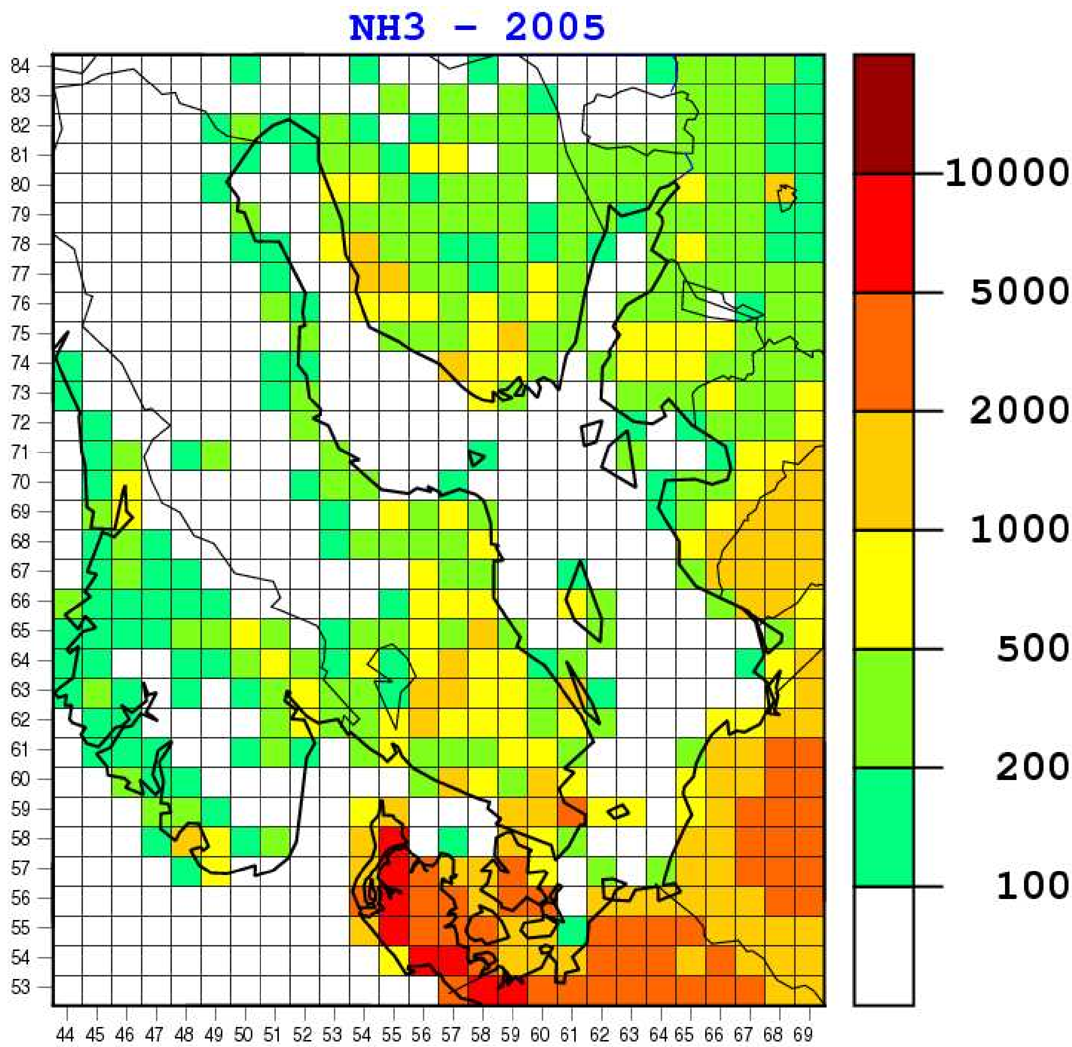


Figure 3.3. Map of annual emission of ammonia in the Baltic Sea region in 2005. Units: Mg of NH_3 per year and per 50×50 km grid cell.

Table 3.1. The list of 11 SNAP emissions sectors as specified in the EMEP-CORINAIR Emission Inventory Guidebook.

Sector 1	Combustion in energy and transformation industry
Sector 2	Non-industrial combustion plants
Sector 3	Combustion in manufacturing industry
Sector 4	Production processes
Sector 5	Extraction and distribution of fossil fuels and geothermal energy
Sector 6	Solvent and other product use
Sector 7	Road transport
Sector 8	Other mobile sources and machinery (including ship traffic)
Sector 9	Waste treatment and disposal
Sector 10	Agriculture
Sector 11	Other sources and sinks

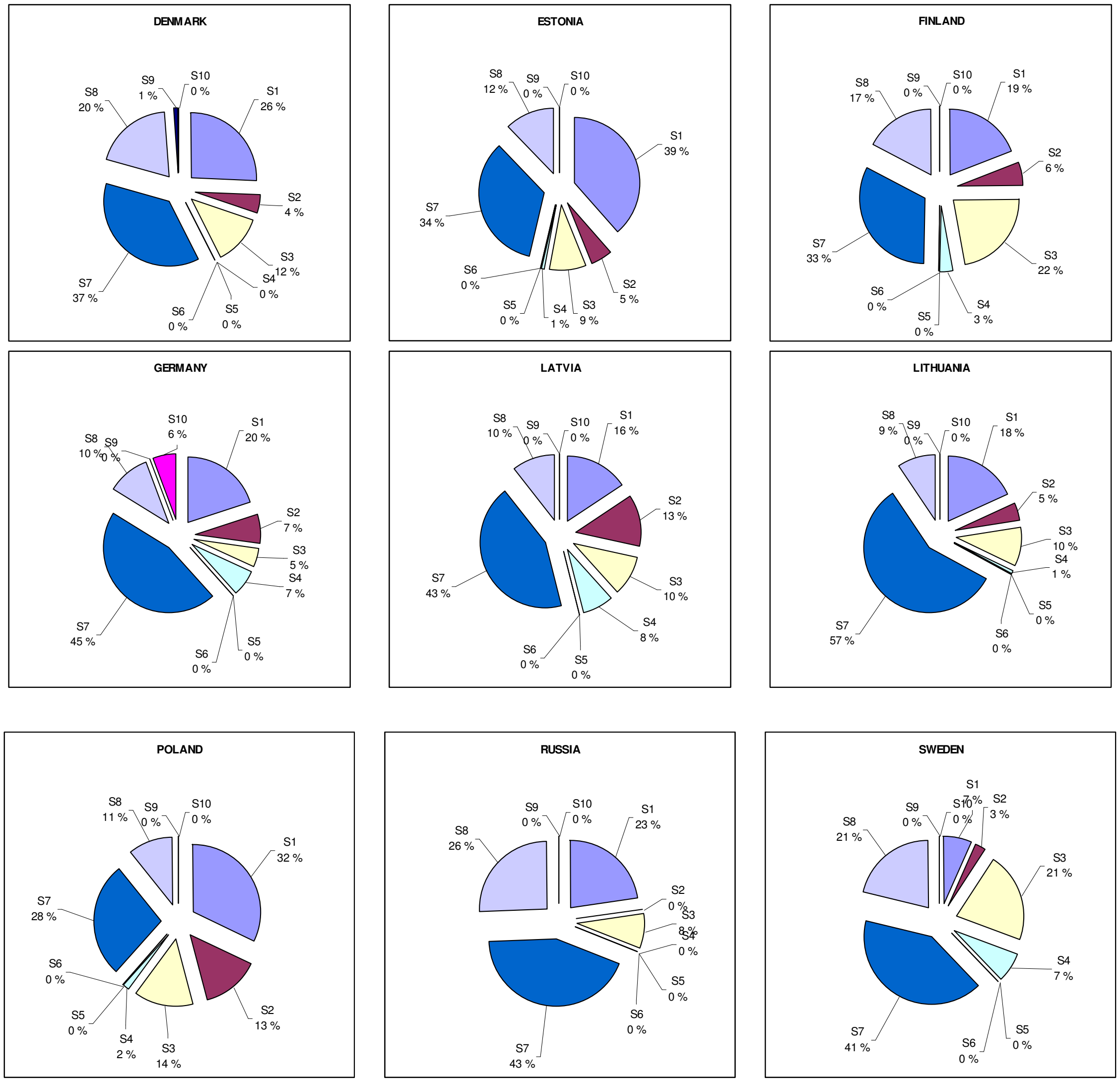


Figure 3.4. Annual 2005 nitrogen oxides emissions from the HELCOM Parties split into the SNAP sectors.

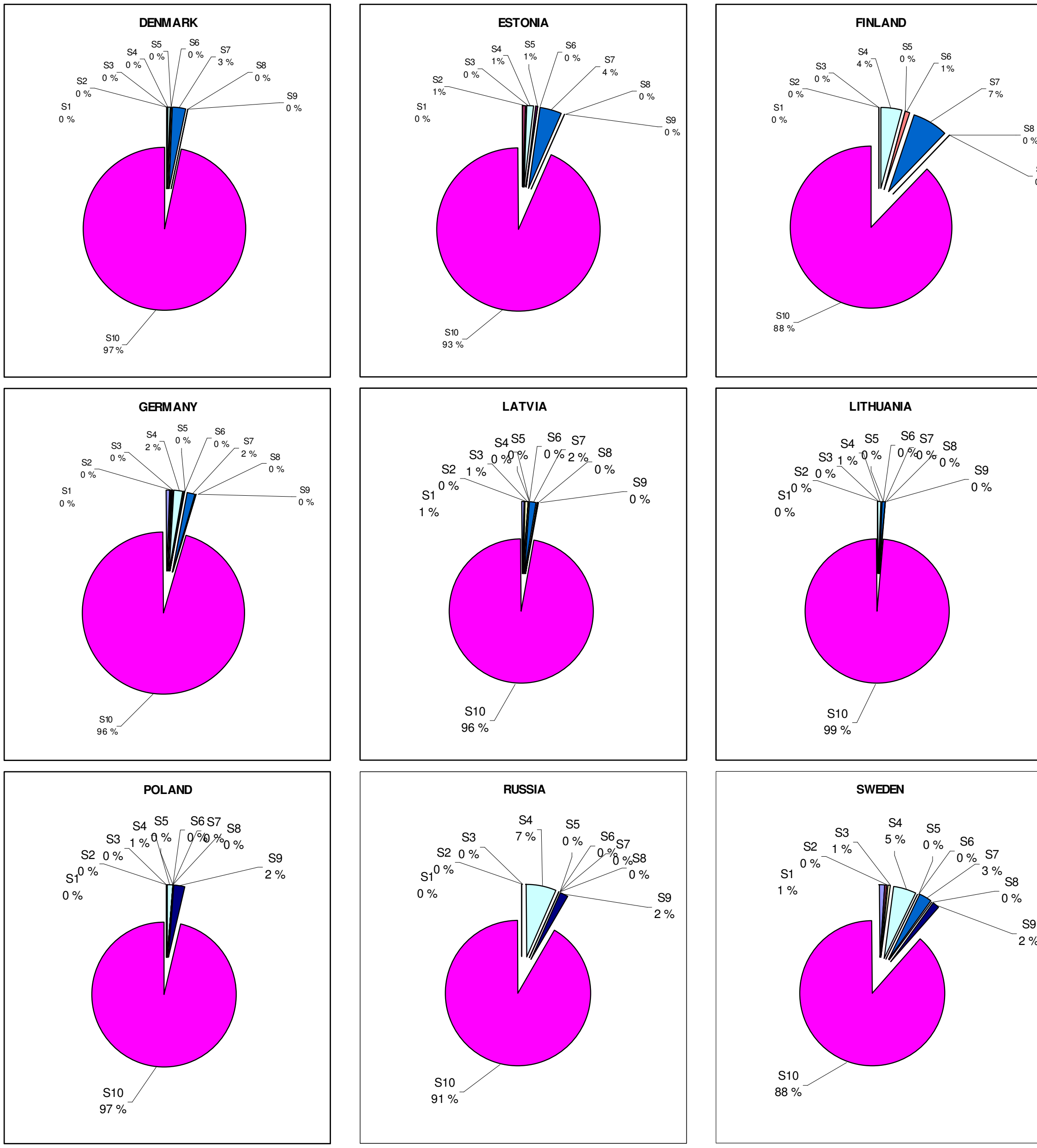


Figure 3.5. Annual 2004 ammonia emissions from the HELCOM Parties split into the SNAP sectors.

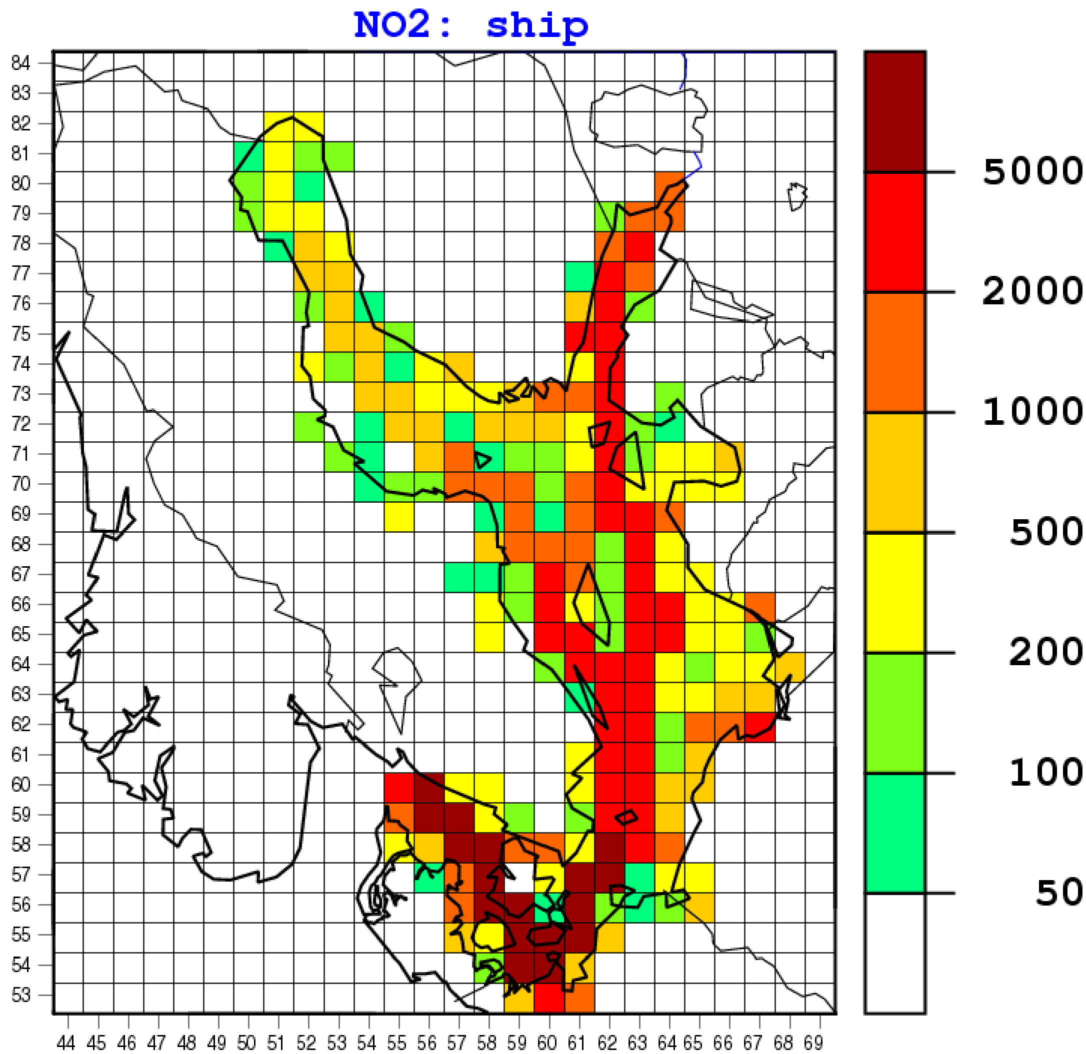


Figure 3.6 Map of annual emissions of nitrogen oxides from the international ship traffic on the Baltic Sea in 2005 used in the EMEP model calculations. Units: Mg of NO_2 per year and per 50×50 km grid cell. There are large uncertainties in the estimate for ship traffic emissions. The international ship emissions and their spatial distribution have been updated based on new emission estimates derived by ENTEC for the year 2000. Ship emissions for 2006, were deduced by applying an increase factor of 2.5 % per year on cargo vessel traffic and 3.9 % per year on passenger vessel traffic. The factors are the same as used by ENTEC for predicting emissions of nitrogen in 2010 based on the emission estimates for 2000.

3.2 Annual deposition of nitrogen

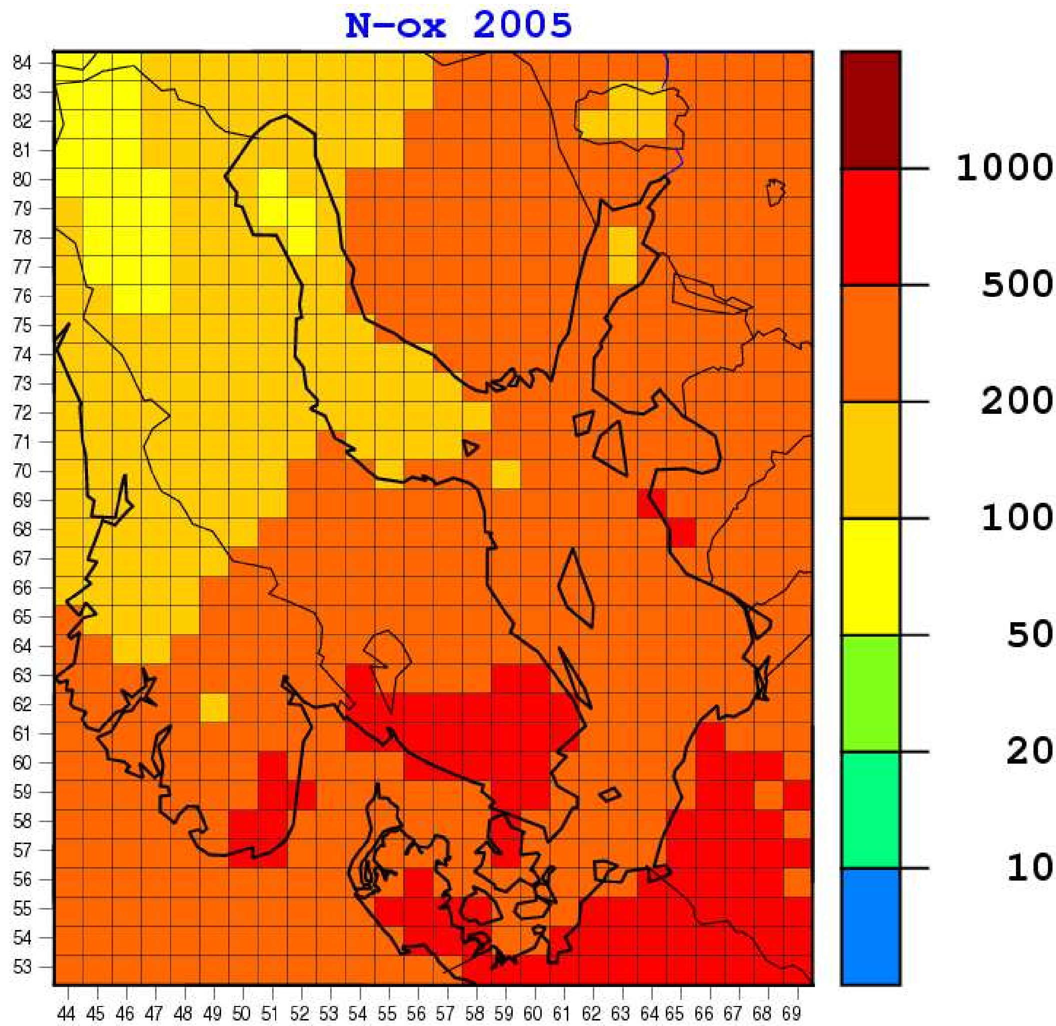


Figure 3.7. Map of annual deposition flux of oxidized nitrogen (dry + wet) in 2005. Units: mg N m^{-2} yr^{-1}.

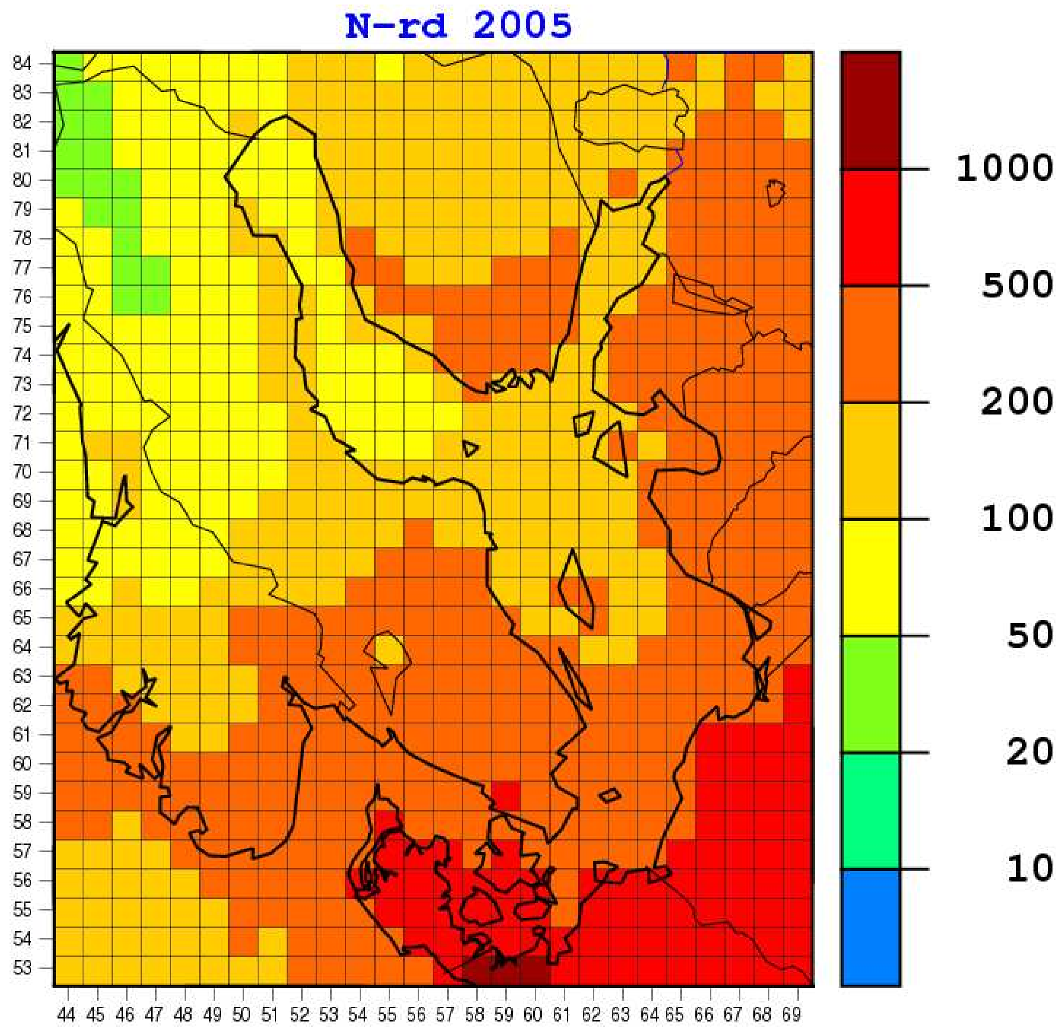


Figure 3.8. Map of annual deposition flux of reduced nitrogen (dry + wet) in 2005. Units: mg N m^{-2} yr^{-1}.

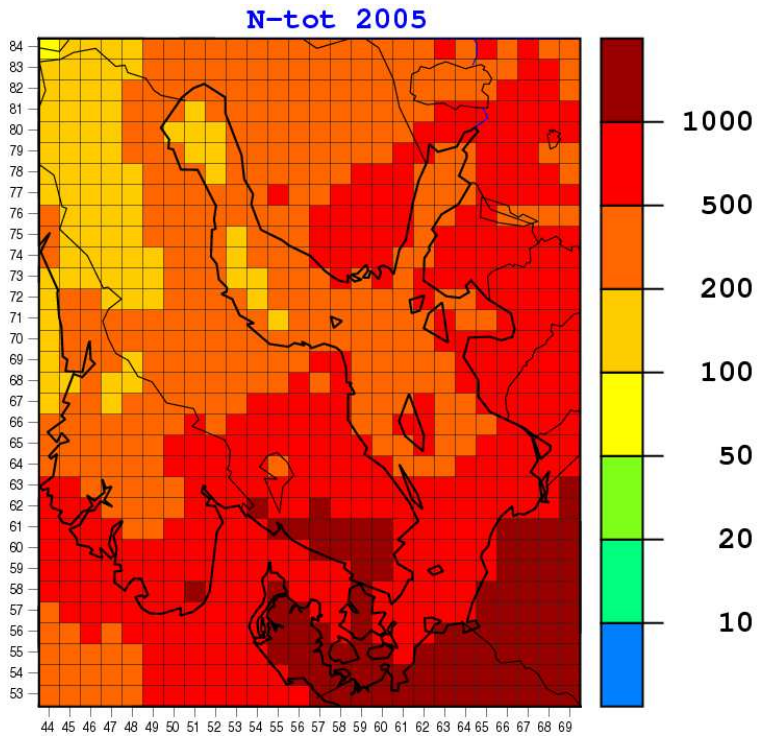


Figure 3.9. Map of annual deposition flux of total (oxidized + reduced) nitrogen in 2005. Units: mg N m^{-2} yr^{-1}.

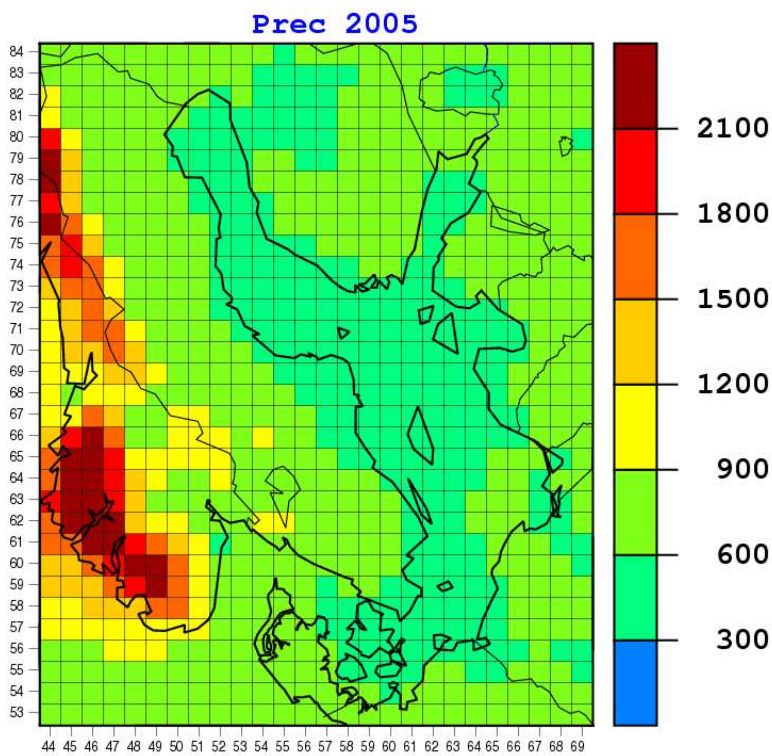


Figure 3.10. Map of annual precipitation in 2005. Units: mm yr^{-1}.

3.3 Monthly depositions of nitrogen

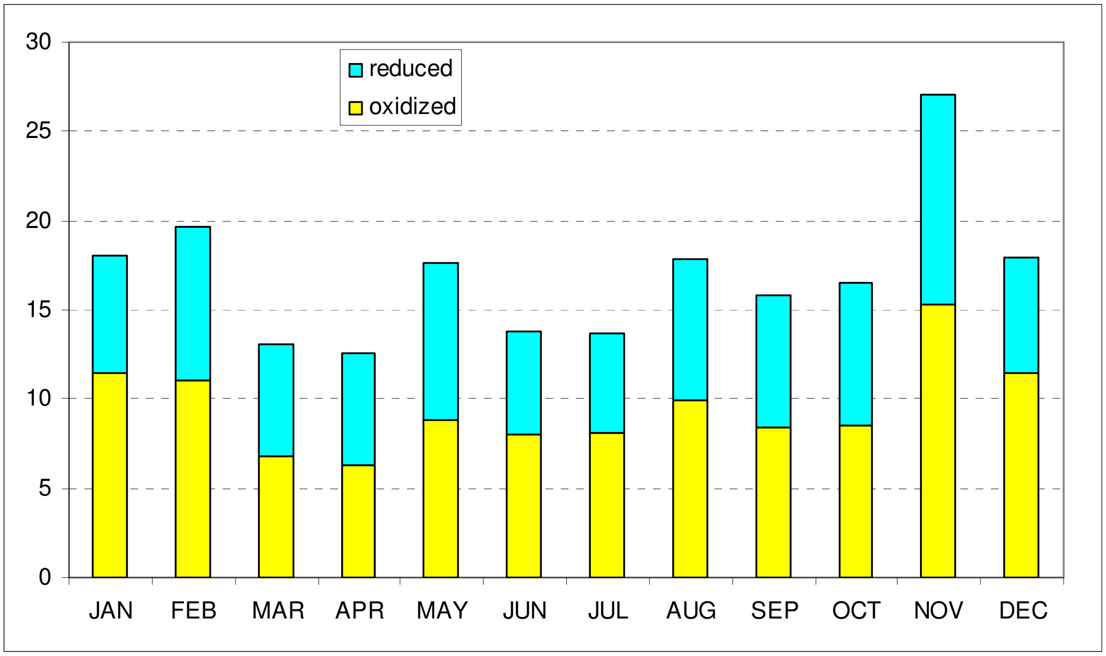


Figure 3.11. Monthly depositions of oxidized, reduced and total (oxidized +reduced) nitrogen to the entire Baltic Sea basin in 2005. Units: ktonnes N month^{-1}.

Table 3.2. Values of monthly depositions of oxidized, reduced and total (oxidized +reduced) nitrogen to the entire Baltic Sea basin in 2005. Units: ktonnes N month^{-1}.

Month	Oxidized	Reduced	Total
January	11,5	6,5	18,0
February	11,1	8,5	19,6
March	6,8	6,3	13,1
April	6,3	6,3	12,6
May	8,8	8,8	17,7
June	8,0	5,9	13,8
July	8,1	5,6	13,7
August	10,0	7,9	17,8
September	8,4	7,4	15,9
October	8,5	8,0	16,5
November	15,3	11,8	27,1
December	11,5	6,4	17,9

3.4 Source allocation of nitrogen deposition

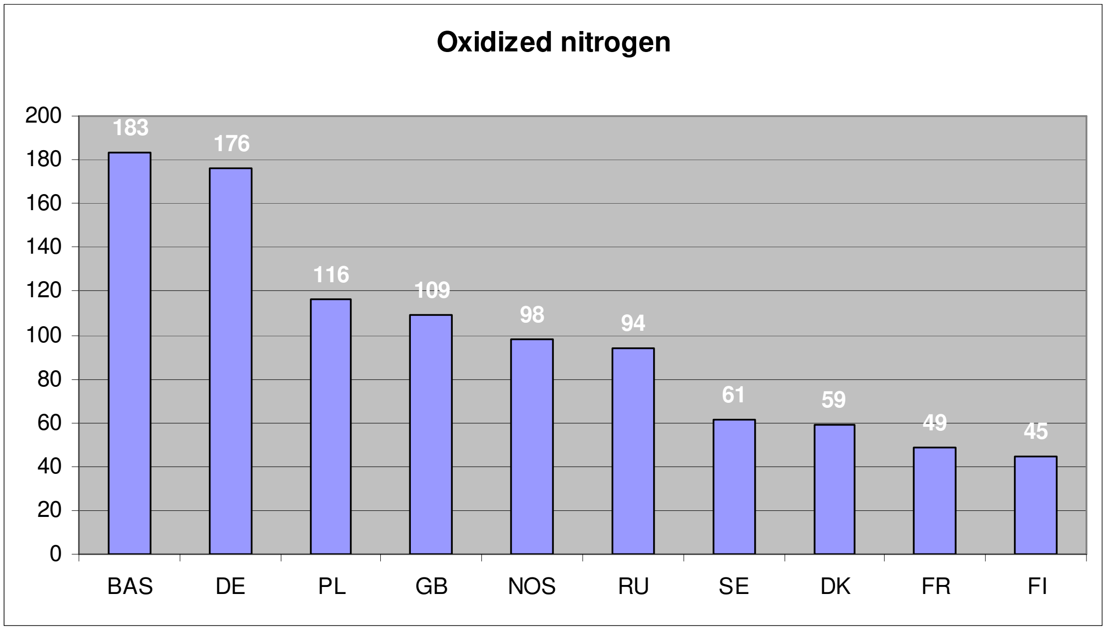


Figure 3.12. Top ten countries with highest contributions of nitrogen emissions to annual deposition of oxidized nitrogen into the Baltic Sea basin in the year 2005. Units: 100 tonnes N year^{-1}. BAS and NOS denote ship emissions form the Baltic Sea and from the North Sea, respectively.

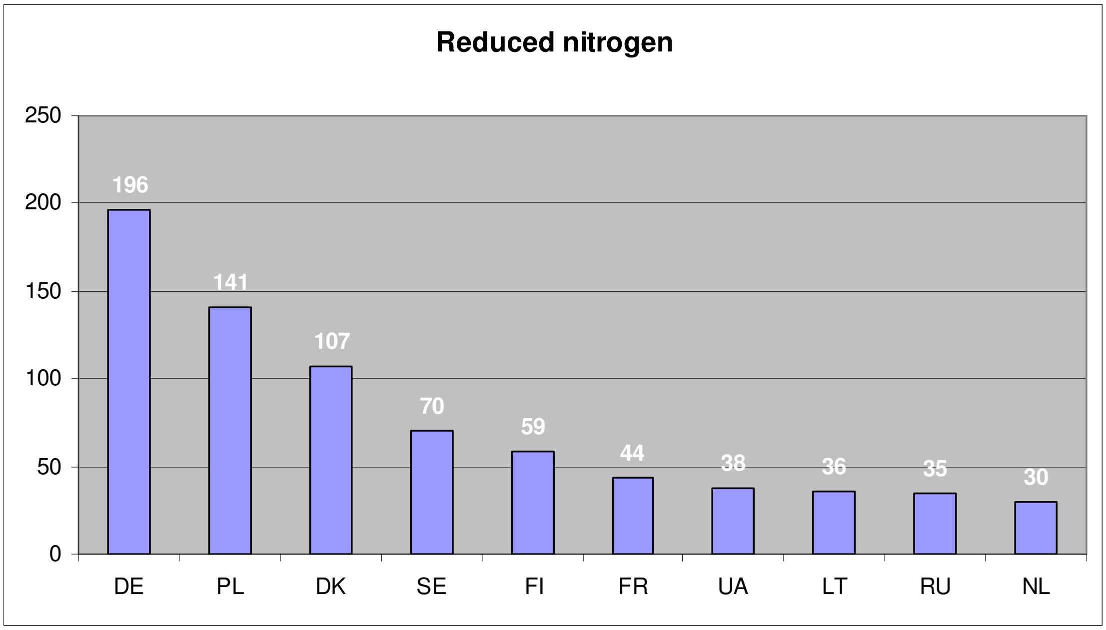


Figure 3.13. Top ten countries with highest contributions of nitrogen emissions to annual deposition of reduced nitrogen into the Baltic Sea basin in the year 2005. Units: 100 tonnes N year^{-1}. BAS and NOS denote ship emissions form the Baltic Sea and from the North Sea, respectively.

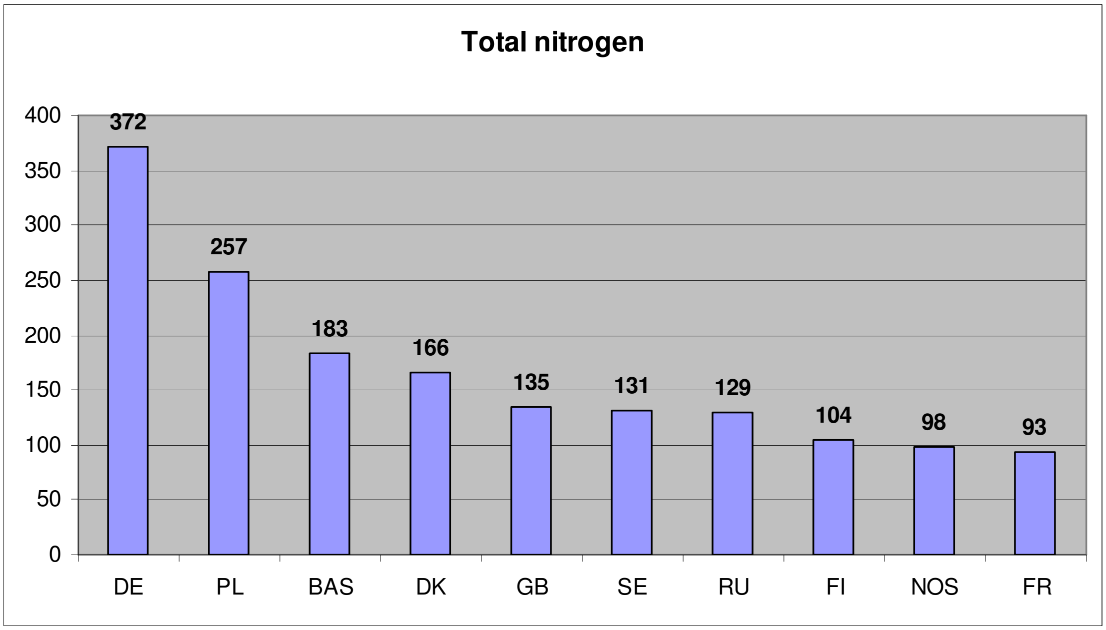
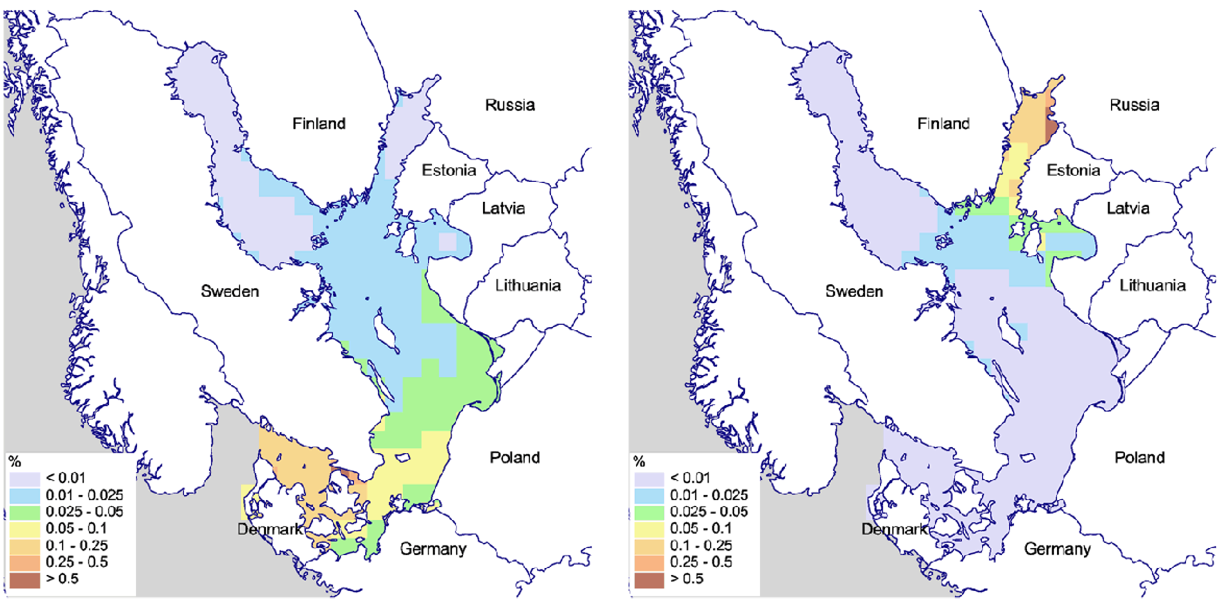


Figure 3.14. Top ten countries with highest contributions of nitrogen emissions to annual deposition of total(oxidized + reduced) nitrogen into the Baltic Sea basin in the year 2005. Units: 100 tonnes N year^{-1}. BAS and NOS denote ship emissions form the Baltic Sea and from the North Sea, respectively.

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.

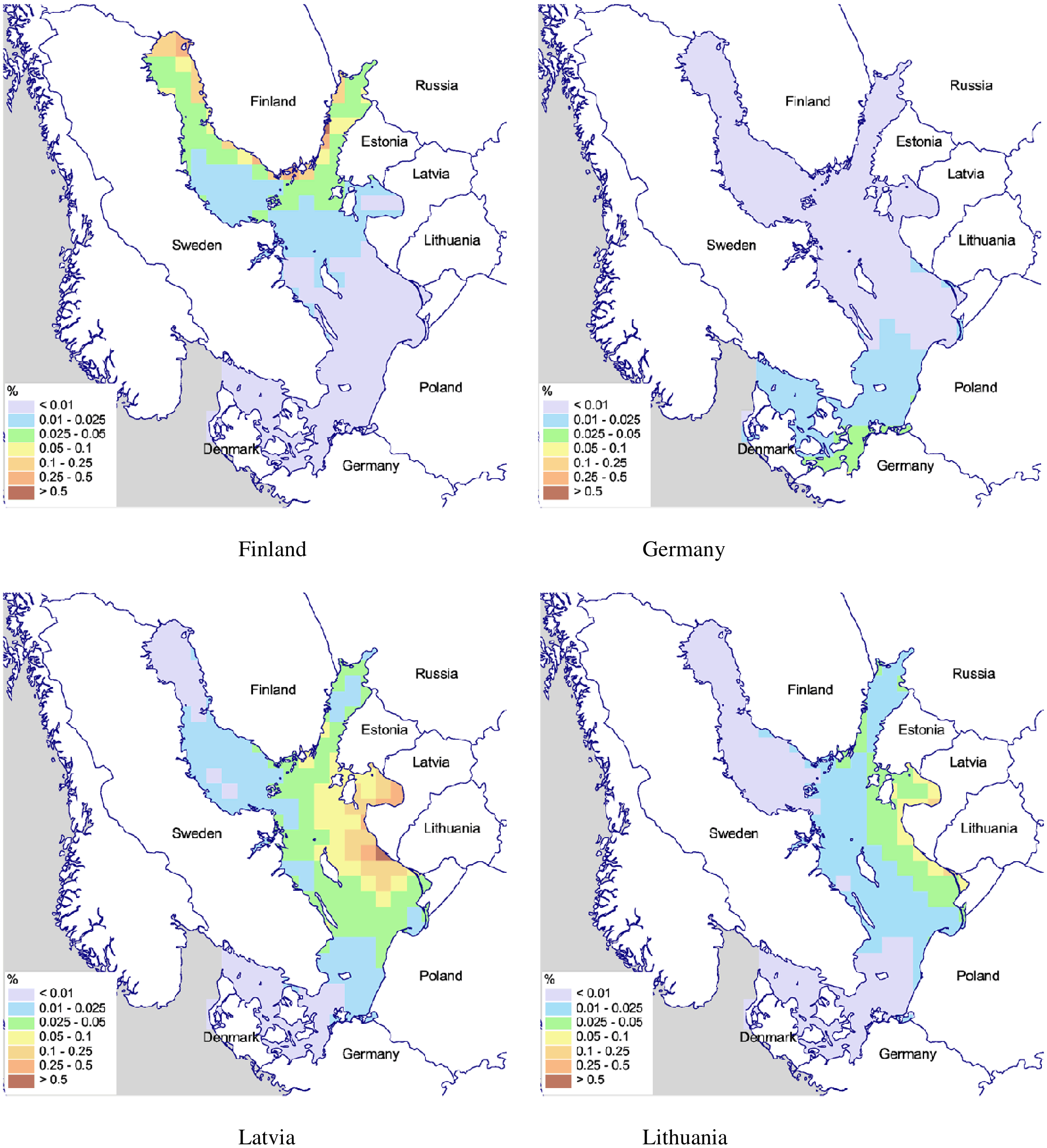
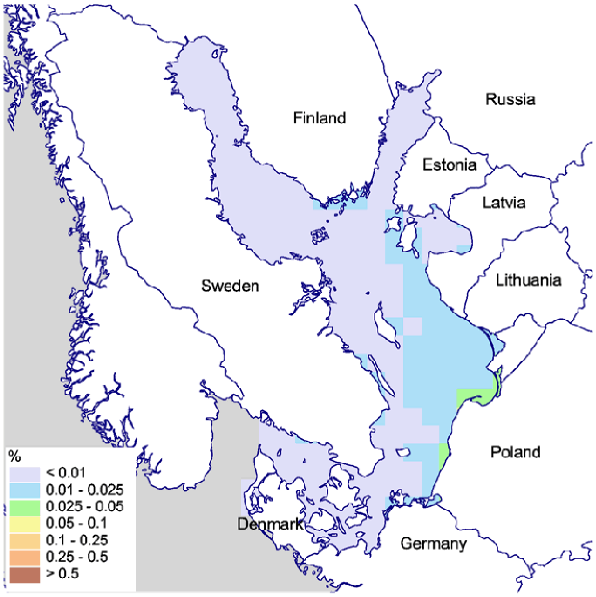
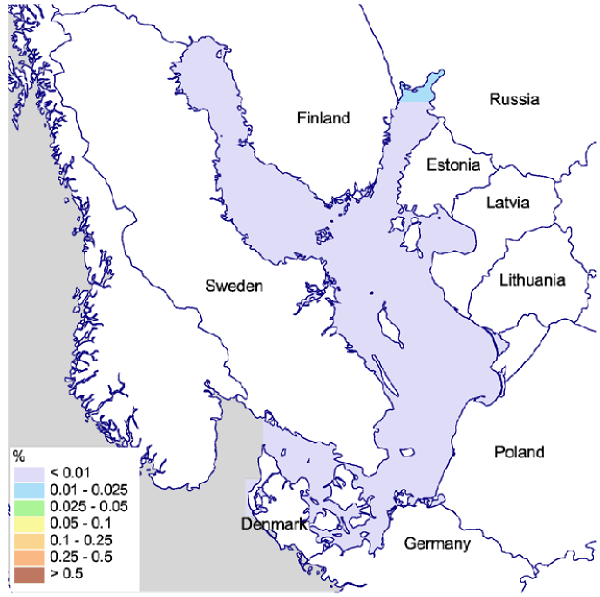


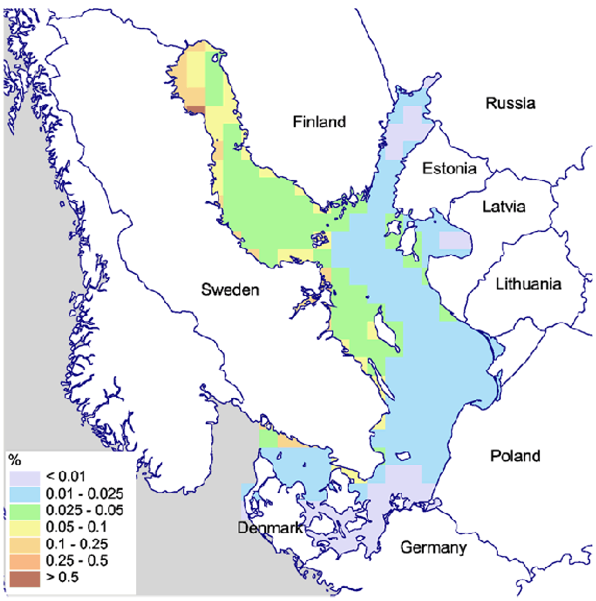
Figure 4.1 (cont.). Maps with the fractions (in %) of annual total anthropogenic lead emissions from HELCOM Parties deposited into the Baltic Sea in 2005.



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.

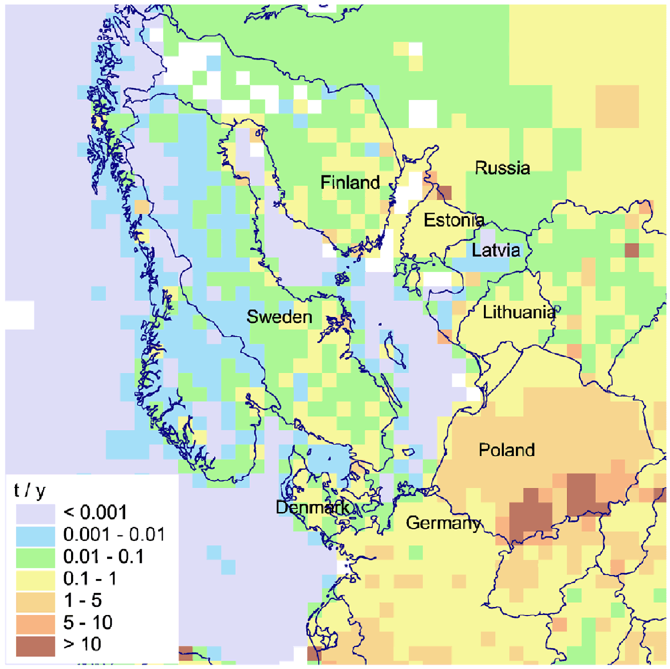


Figure 4.2. Annual total anthropogenic emissions of lead in the Baltic Sea region for 2005, t/y.

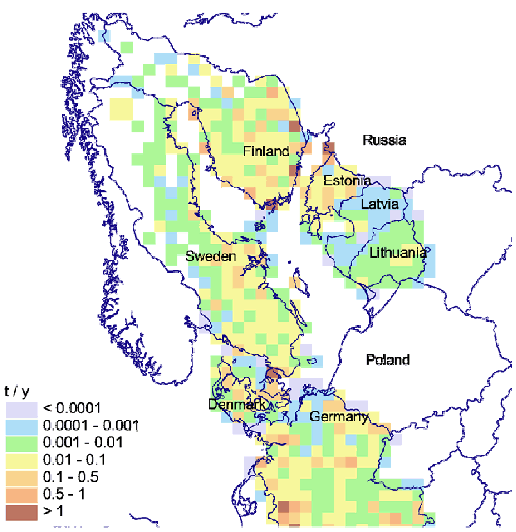


Figure 4.3. Annual lead emission from Combustion in Power Plants and Industry sector for 2005.

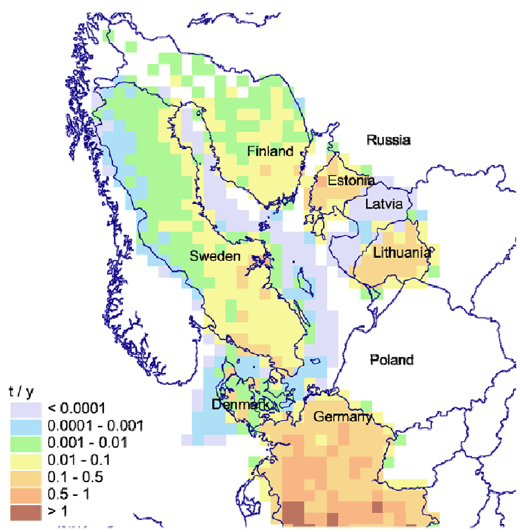


Figure 4.4. Annual lead emission from Transport sector for 2005.

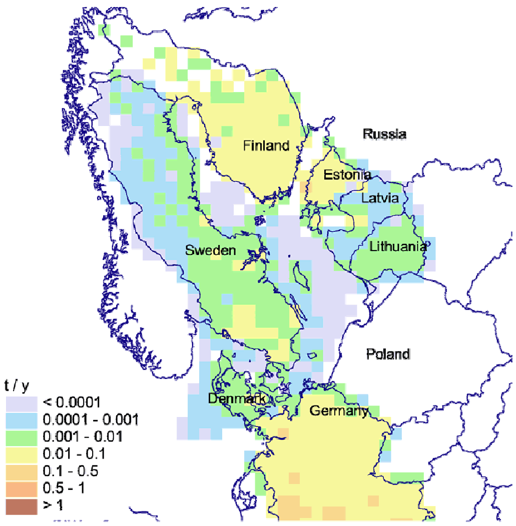


Figure 4.5. Annual lead emission from Commercial, Residential and Other Stationary Combustion sector for 2005.

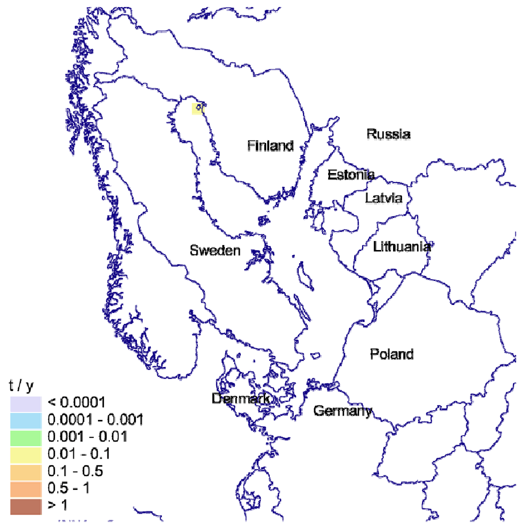


Figure 4.6. Annual lead emission from Fugitive emissions from fuels sector for 2005.

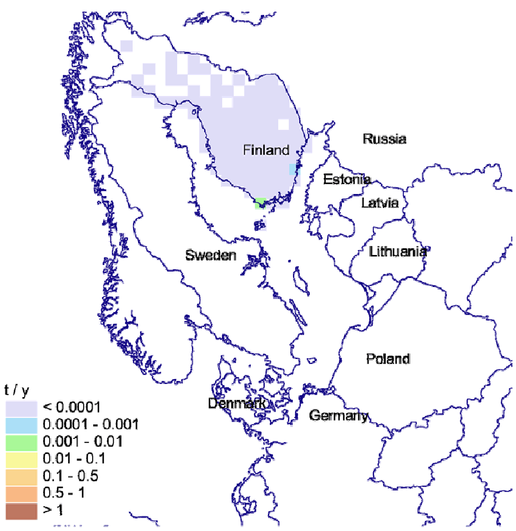


Figure 4.7. Annual lead emission from Solvent and Other Product Use sector in Finland for 2005.

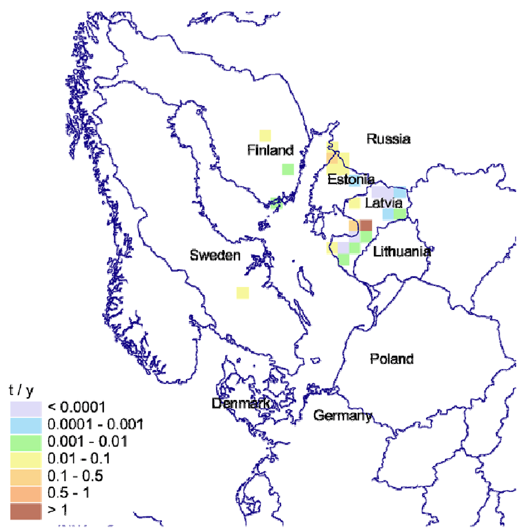


Figure 4.8. Annual lead emission from Waste sector in Latvia for 2005.

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

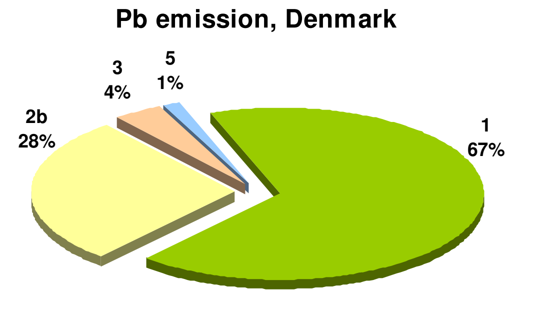


Figure 4.9. Percentage of annual total lead emission from different sectors in Denmark for 2005.

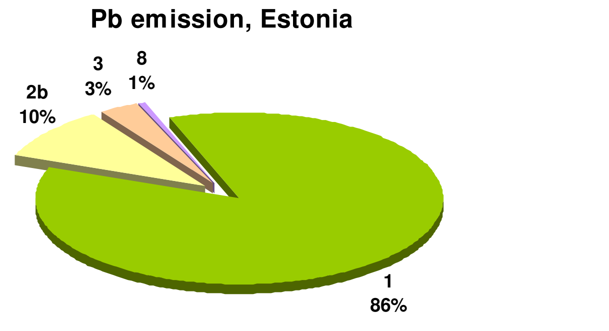


Figure 4.10. Percentage of annual total lead emission from different sectors in Estonia for 2005.

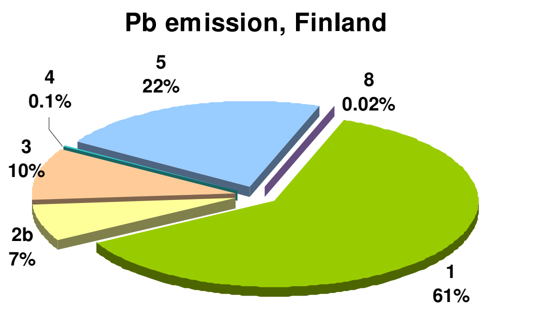


Figure 4.11. Percentage of annual total lead emission from different sectors in Finland for 2005.

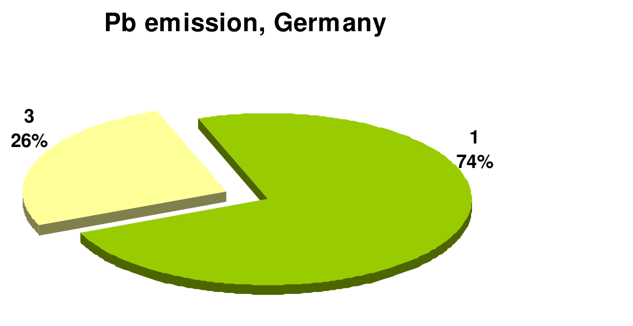


Figure 4.12. Percentage of annual total lead emission from different sectors in Germany for 2005.

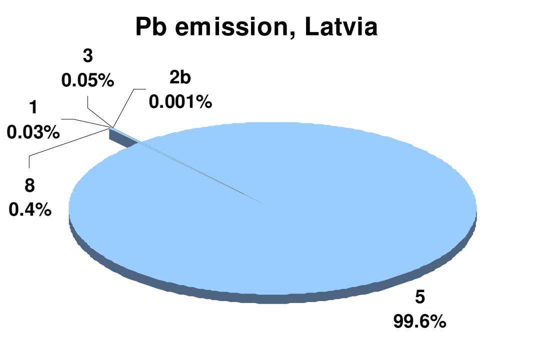


Figure 4.13. Percentage of annual total lead emission from different sectors in Latvia for 2005.

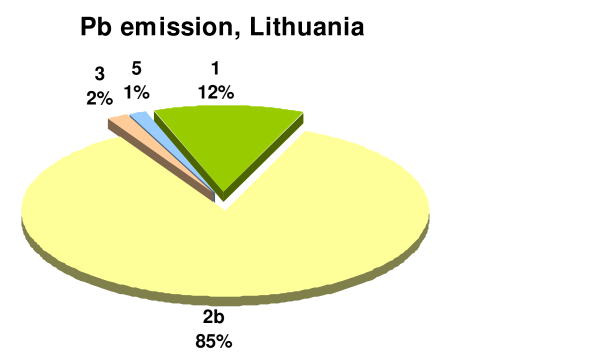


Figure 4.14. Percentage of annual total lead emission from different sectors in Lithuania for 2005.

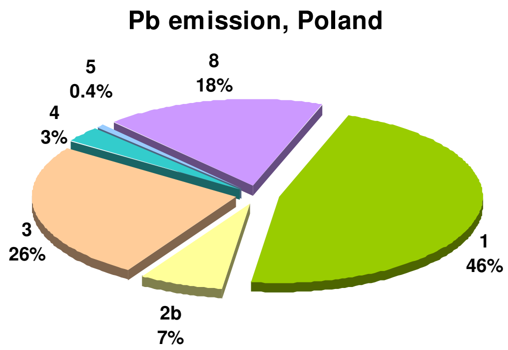


Figure 4.15. Percentage of annual total lead emission from different sectors in Poland for 2005.

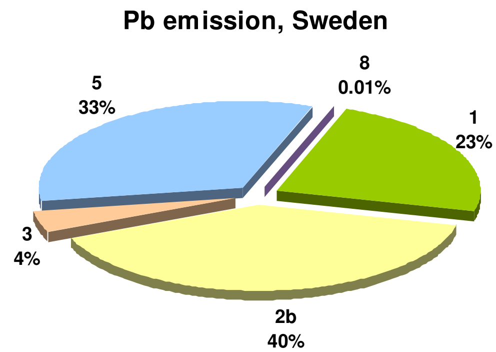


Figure 4.16. Percentage of annual total lead emission from different sectors in Sweden for 2005.

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]*

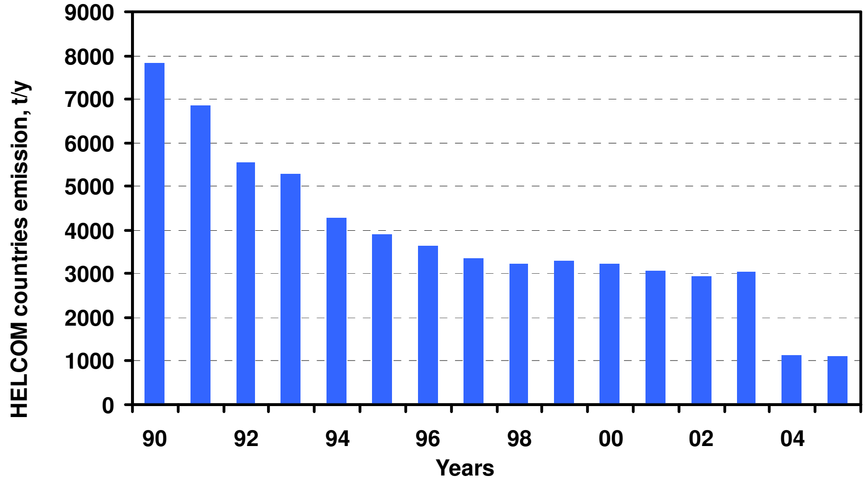


Figure 4.17. Time-series of total annual lead emissions of HELCOM countries in 1990-2005, tonnes/y.

4.2 Annual deposition of lead

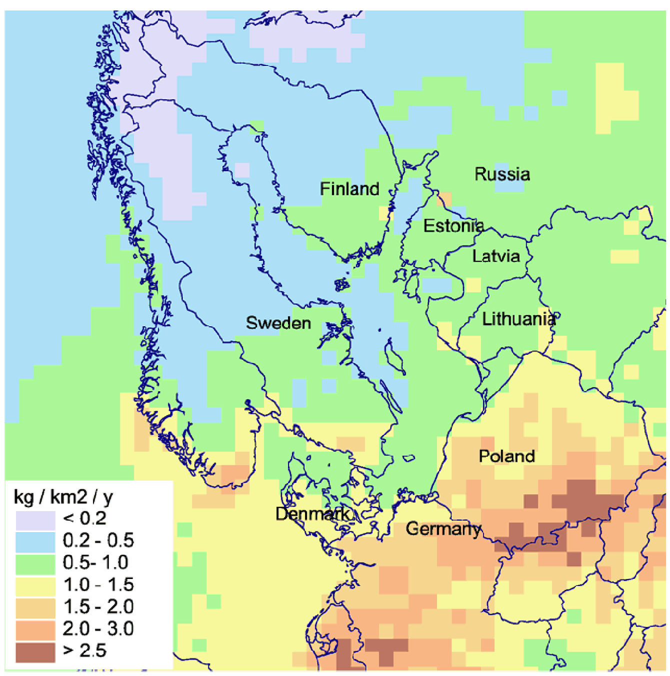


Figure 4.18. Annual deposition fluxes of lead over the Baltic Sea region for 2005, kg/km^2/year.

4.3 Monthly depositions of lead

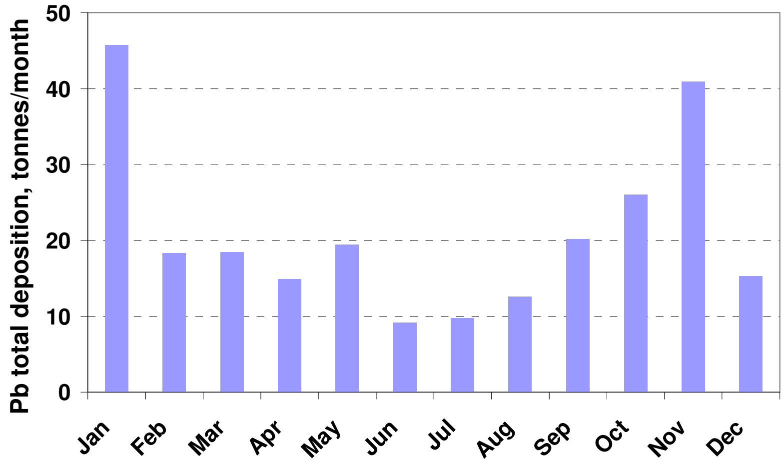


Figure 4.19. Monthly depositions of lead to the Baltic Sea for 2005, tonnes/month.

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

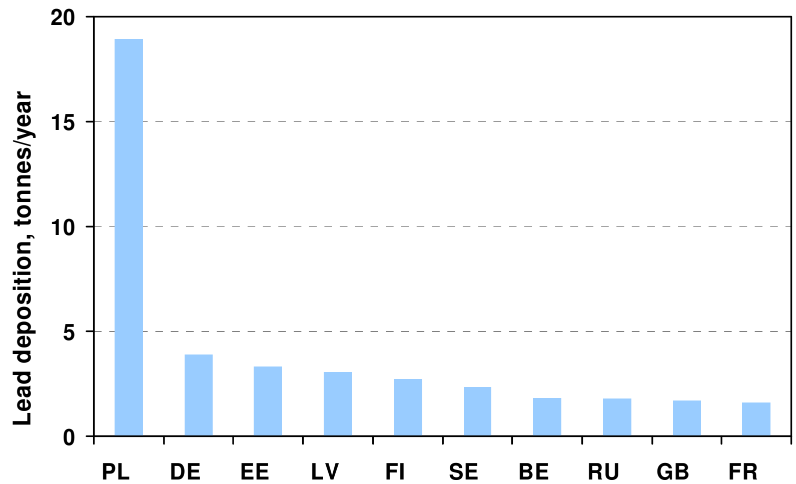


Figure 4.20. Top ten countries with the highest contribution to annual deposition of lead into the Baltic Sea for 2005, tonnes/year.

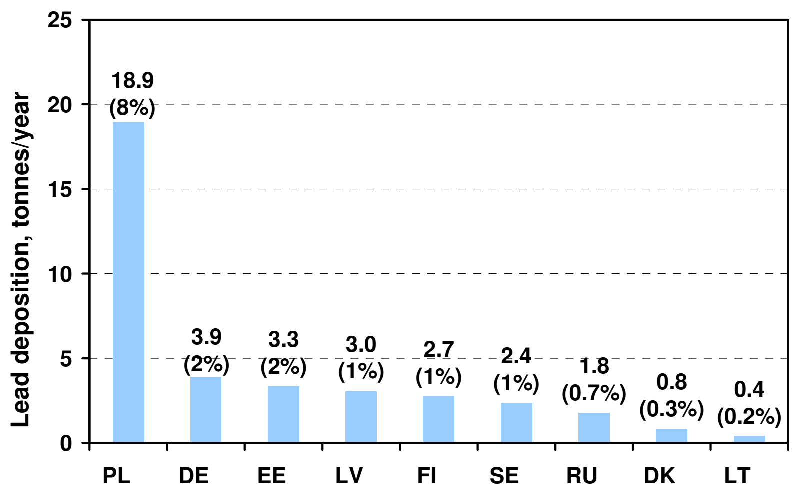


Figure 4.21. Sorted contributions (in %) of HELCOM countries to total depositions to the Baltic Sea for 2005. HELCOM countries emissions of lead contributed about 15% to the total annual lead depositions over the Baltic Sea in 2005. Contribution of other EMEP countries accounted for 6%. Significant contribution 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

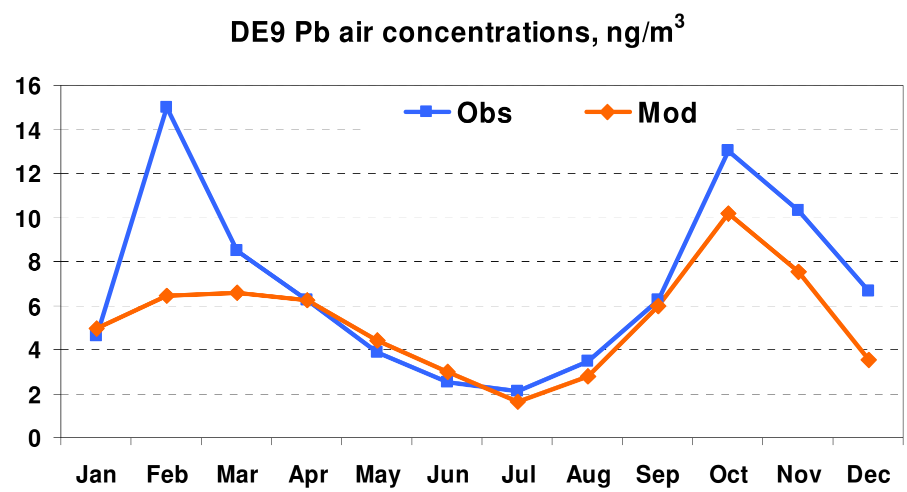


Figure 4.22. Comparison of calculated mean monthly lead concentrations in air with measured at station Zingst (DE9). Units: ng / m^3.

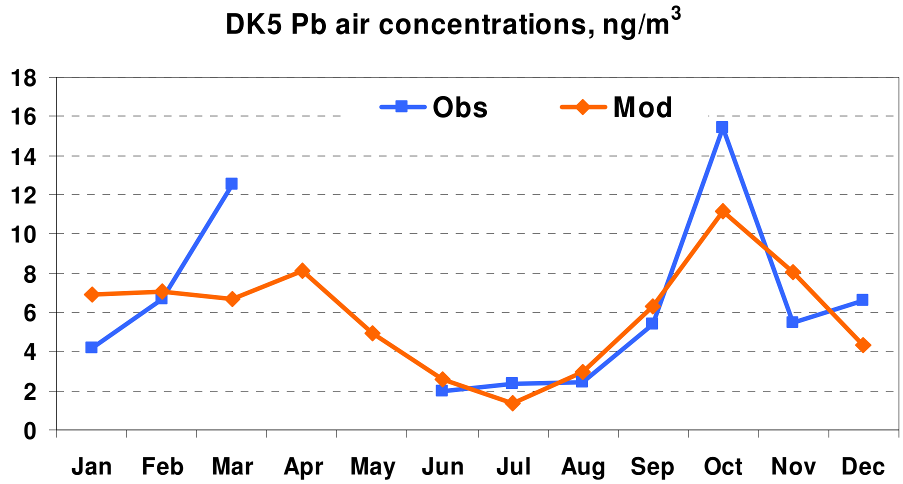


Figure 4.23. Comparison of calculated mean monthly lead concentrations in air with measured at station Keldsnor (DK5). Units: ng / m^3.

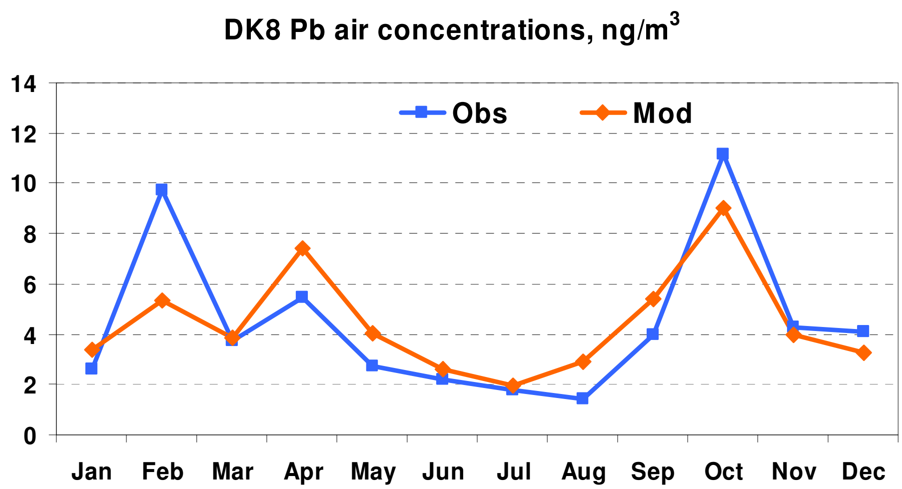


Figure 4.24. Comparison of calculated mean monthly lead concentrations in air with measured at station Anholt (DK8). Units: ng / m^3.

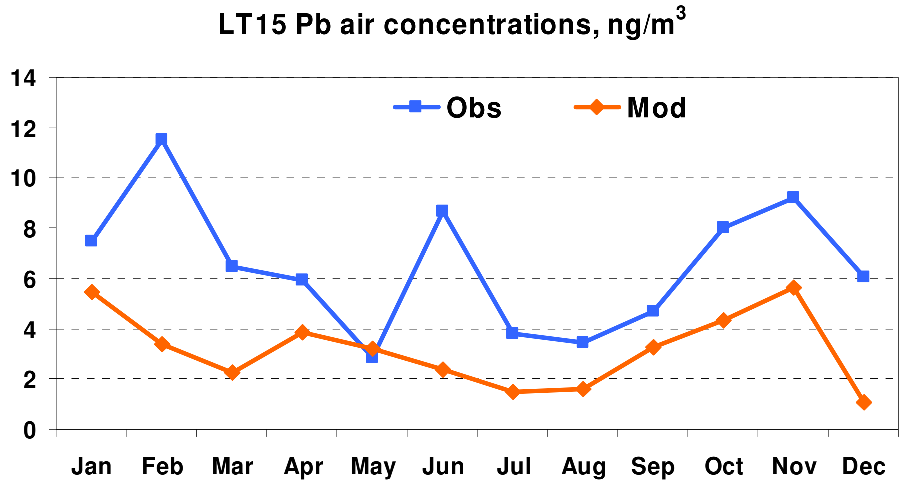


Figure 4.25. Comparison of calculated mean monthly lead concentrations in air with measured at station Preila (LT15). Units: ng / m^3.

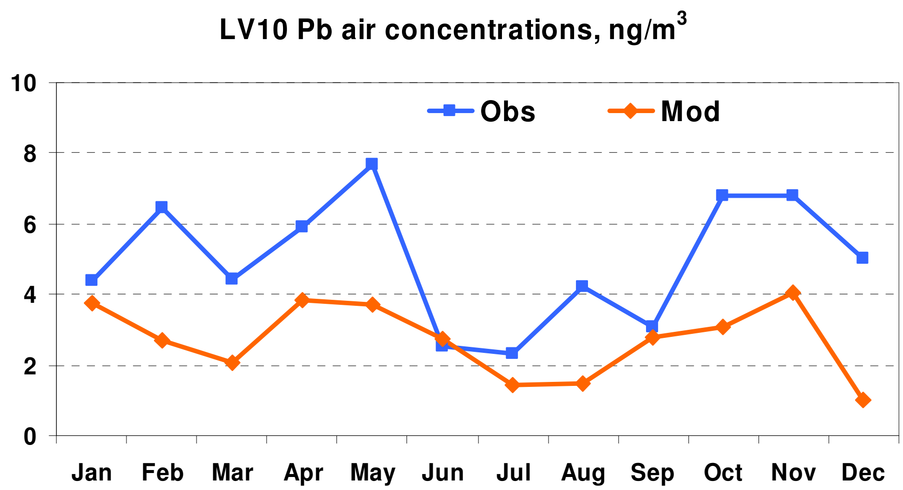


Figure 4.26. Comparison of calculated mean monthly lead concentrations in air with measured at station Rucava (LV10). Units: ng / m^3.

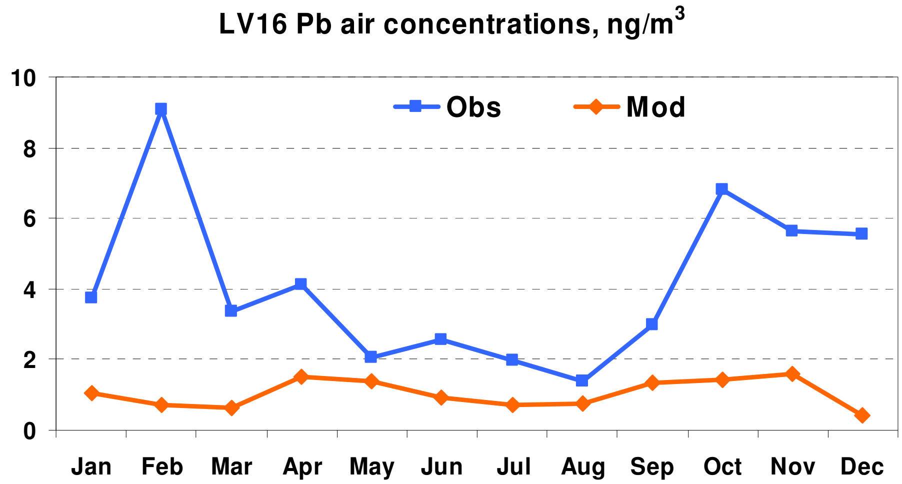


Figure 4.27. Comparison of calculated mean monthly lead concentrations in air with measured at station Zoseni (LV16). Units: ng / m^3.

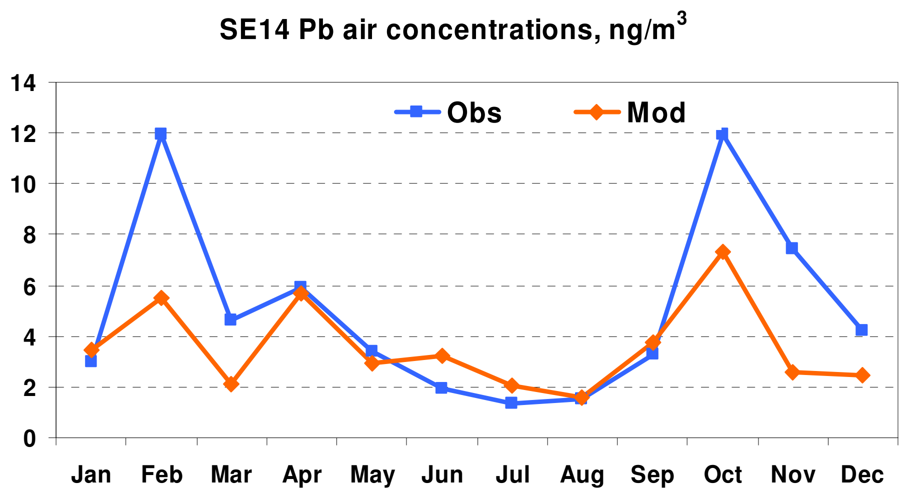


Figure 4.28. Comparison of calculated mean monthly lead concentrations in air with measured at station Räo (SE14). Units: ng / m^3.

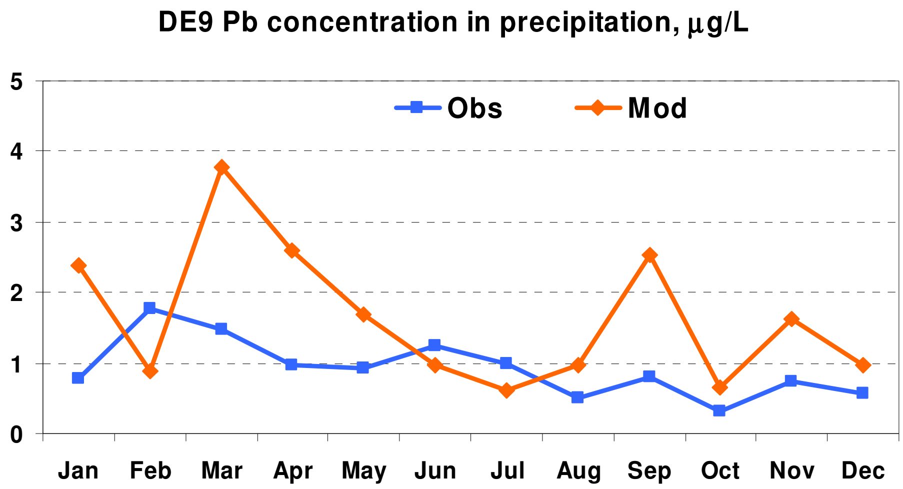


Figure 4.29. Comparison of calculated mean monthly lead concentrations in precipitation with measured at station Zingst (DE09). Units: µg / L.

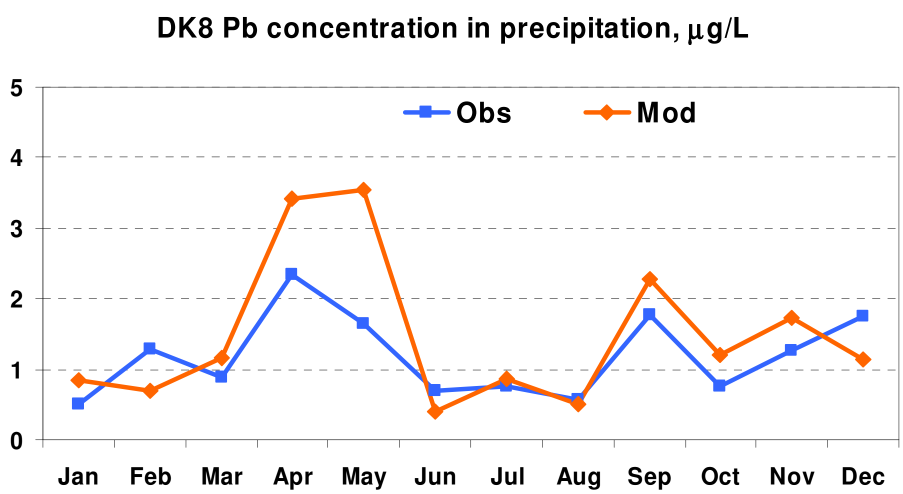


Figure 4.30. Comparison of calculated mean monthly lead concentrations in precipitation with measured at station Anholt (DK08). Units: µg / L.

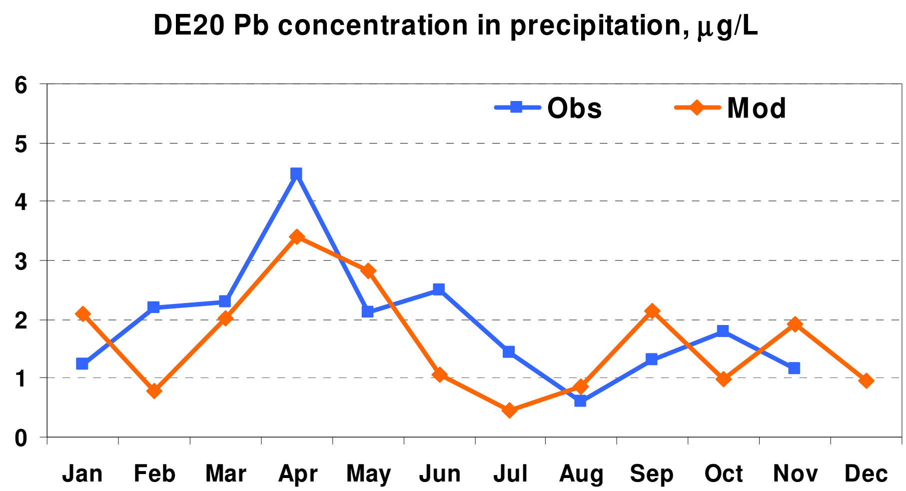


Figure 4.31. Comparison of calculated mean monthly lead concentrations in precipitation with measured at station Pedersker (DK20). Units: µg / L.

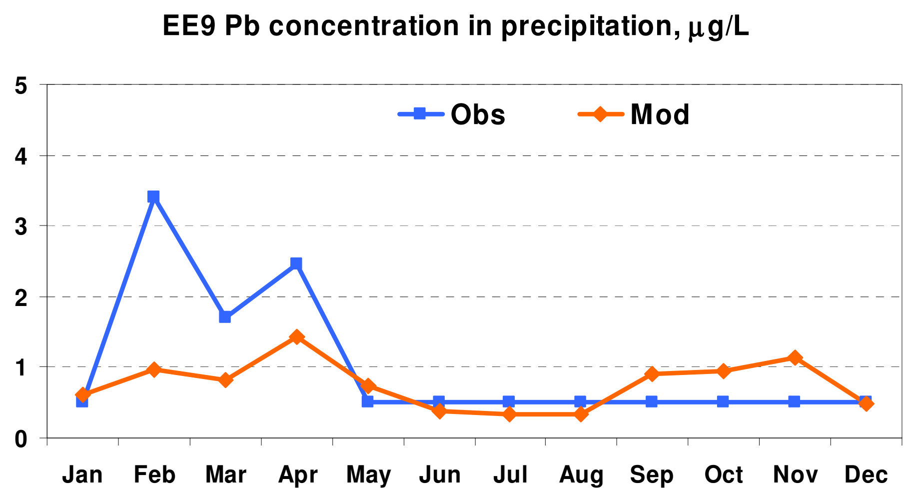


Figure 4.32. Comparison of calculated mean monthly lead concentrations in precipitation with measured at station Lahemaa (EE9). Units: µg / L.

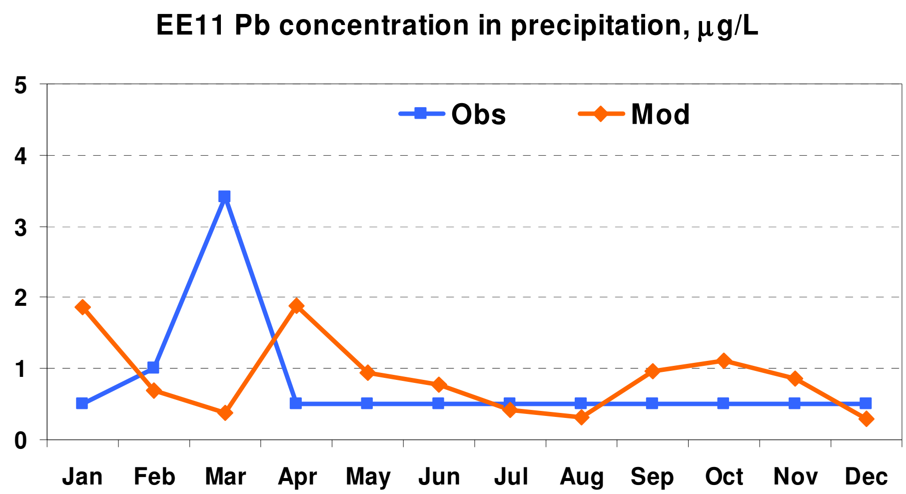


Figure 4.33. Comparison of calculated mean monthly lead concentrations in precipitation with measured at station Vilsandy (EE11). Units: µg / L.

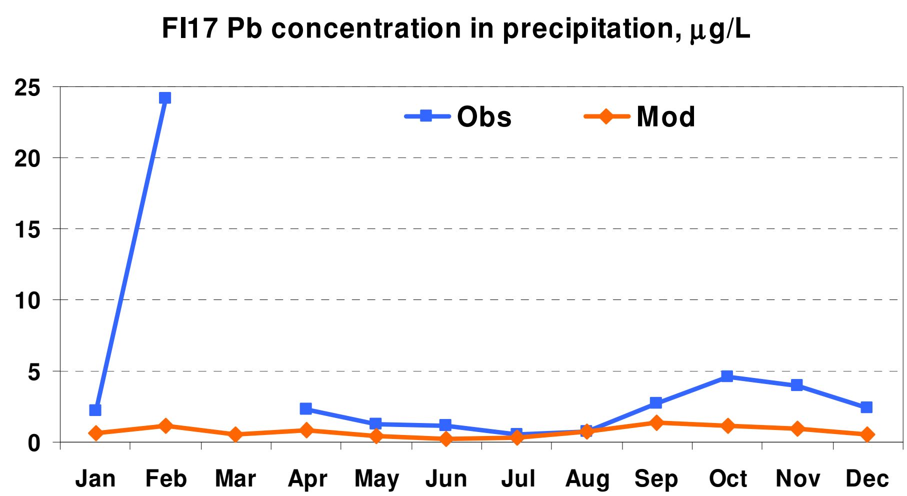


Figure 4.34. Comparison of calculated mean monthly lead concentrations in precipitation with measured at station Virolahty II (FI17). Units: µg / L.

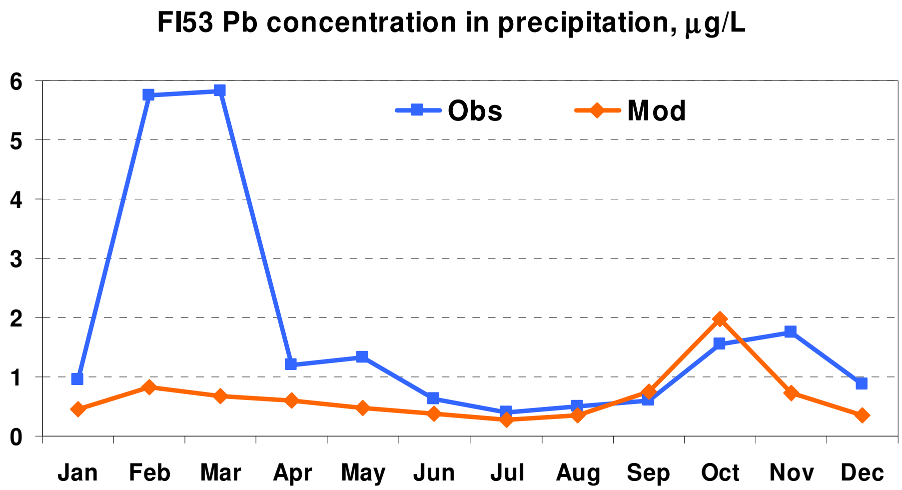


Figure 4.35. Comparison of calculated mean monthly lead concentrations in precipitation with measured at station Hailuoto (FI53). Units: µg / L.

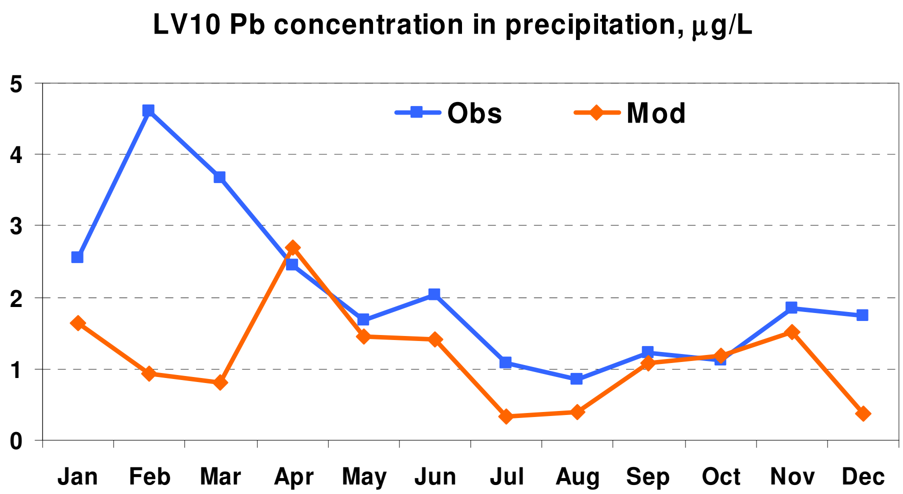


Figure 4.36. Comparison of calculated mean monthly lead concentrations in precipitation with measured at station Rucava (LV10). Units: µg / L.

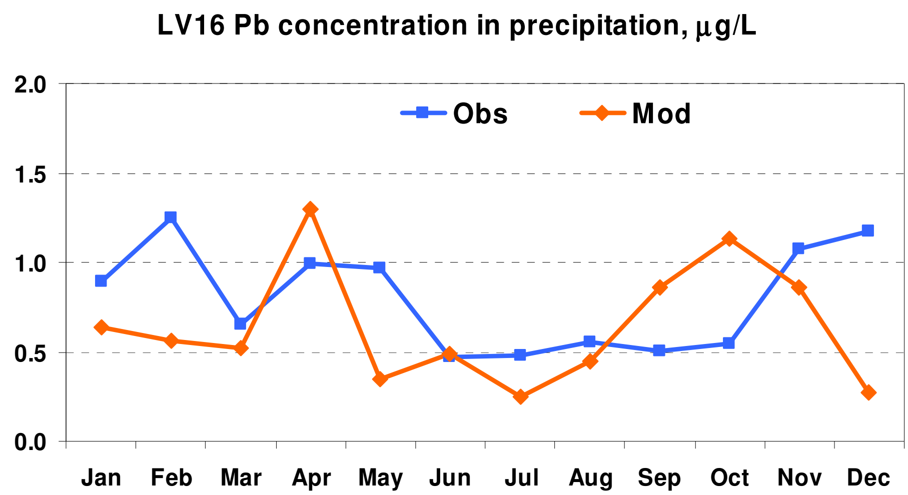


Figure 4.37. Comparison of calculated mean monthly lead concentrations in precipitation with measured at station Zoseni (LV16). Units: µg / L.

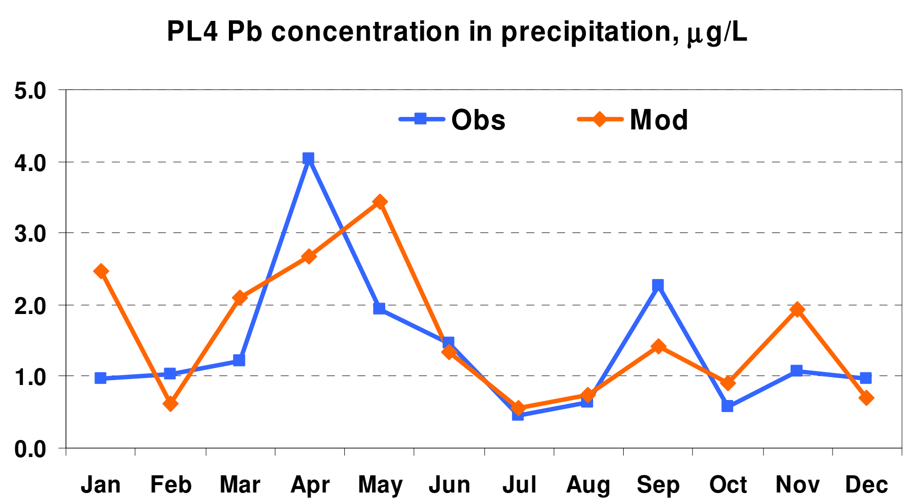


Figure 4.38. Comparison of calculated mean monthly lead concentrations in precipitation with measured at station Leba (PL04). Units: µg / L.

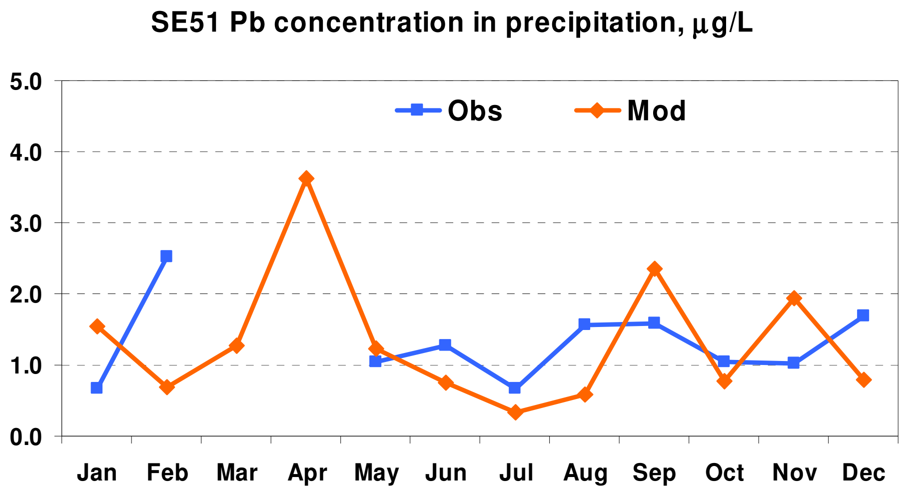


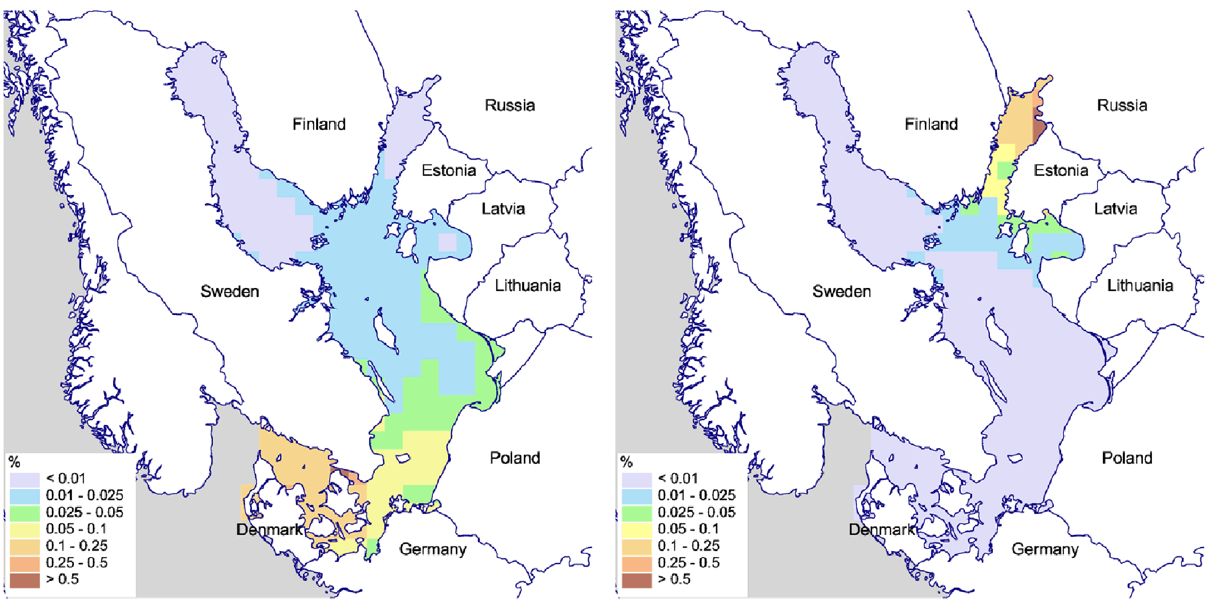
Figure 4.39. Comparison of calculated mean monthly lead concentrations in precipitation with measured at station Arup (SE51). Units: µg / L.

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.

5. Atmospheric Supply of Cadmium to the Baltic Sea in 2005

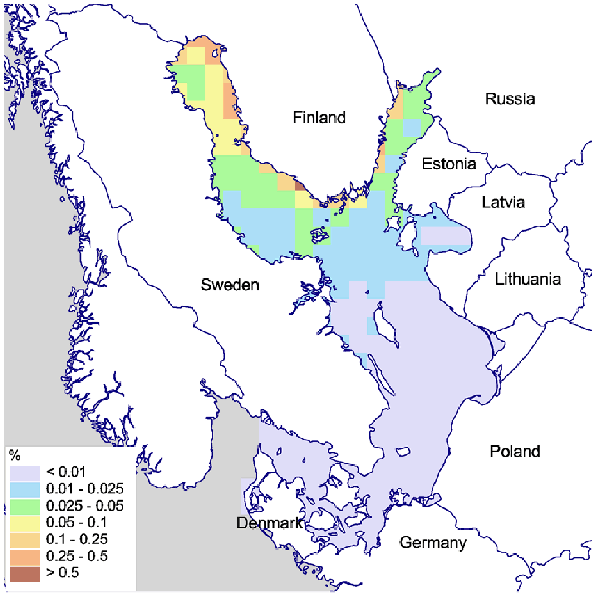
In this chapter the results of model evaluation of cadmium atmospheric input to the Baltic Sea and its sub-basins for 2005 is presented. Modelling of cadmium atmospheric transport and depositions was carried out using MSC-E Eulerian Heavy Metal transport model MSCE-HM (Travnikov and Ilyin, 2005). Latest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

5.1 Cadmium emissions

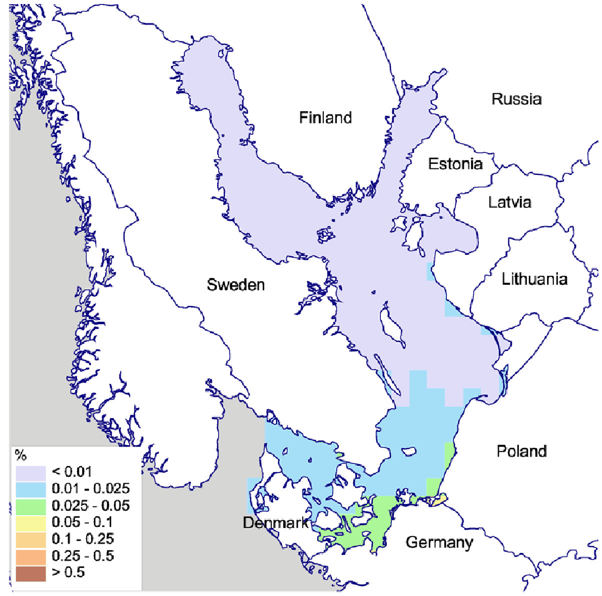


Denmark Estonia

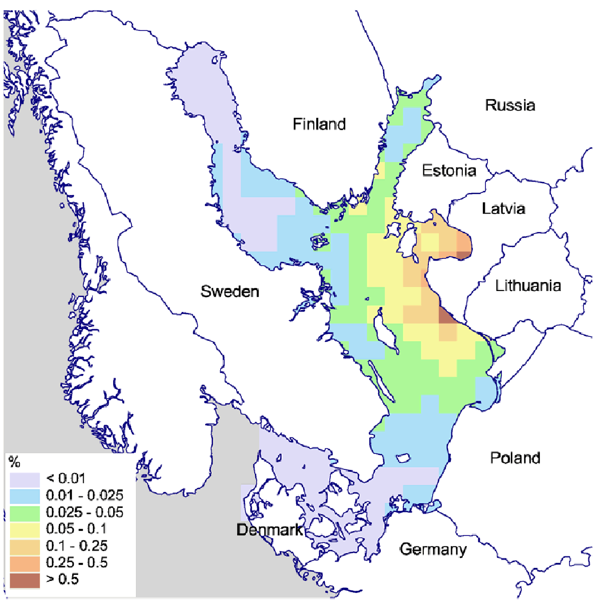
Figure 5.1. Maps with the fractions (in %) of annual total anthropogenic cadmium emissions from HELCOM Parties deposited into the Baltic Sea in 2005.



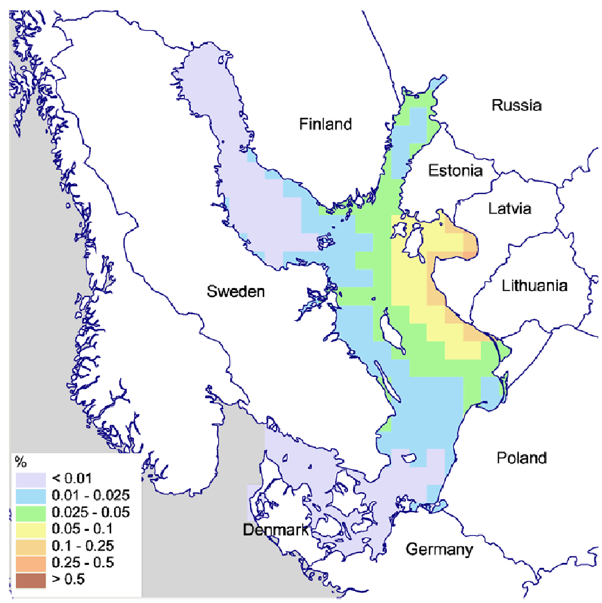
Finland



Germany

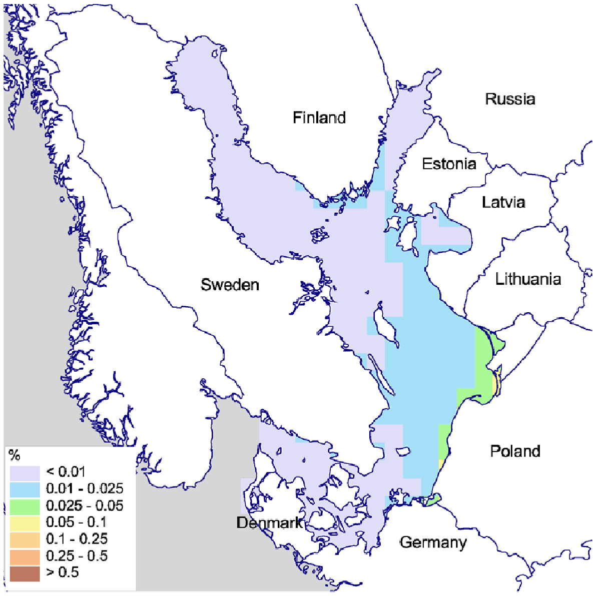


Latvia

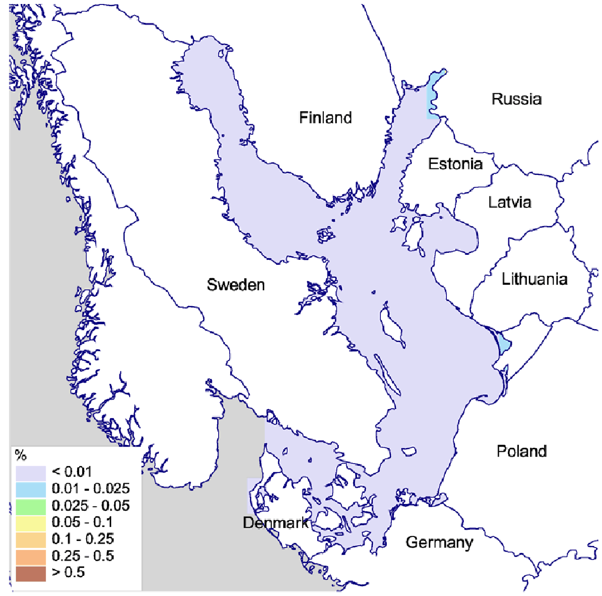


Lithuania

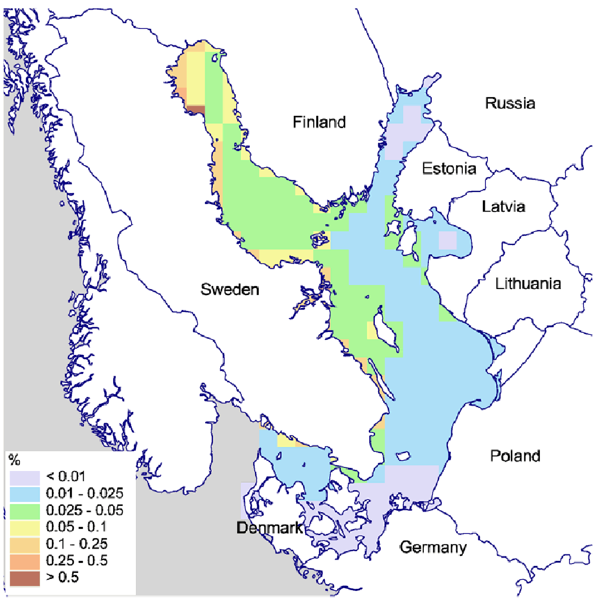
Figure 5.1 (cont.). Maps with the fractions (in %) of annual total anthropogenic cadmium emissions from HELCOM Parties deposited into the Baltic Sea in 2005.



Poland



Russia



Sweden

Figure 5.1 (cont.). Maps with the fractions (in %) of annual total anthropogenic cadmium emissions from HELCOM Parties deposited into the Baltic Sea in 2005.

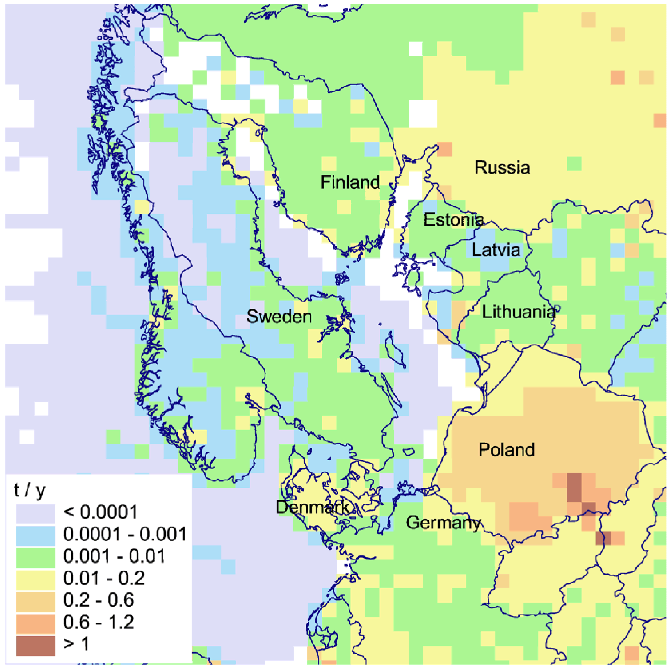


Figure 5.2. Annual total anthropogenic emissions of cadmium in the Baltic Sea region for 2005, t/y.

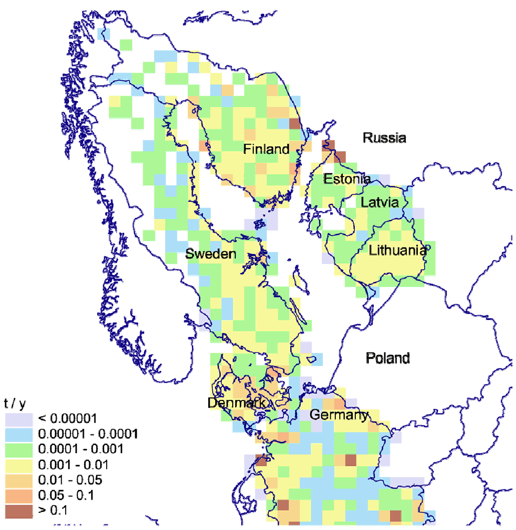


Figure 5.3. Annual cadmium emission from Combustion in Power Plants and Industry sector for 2005.

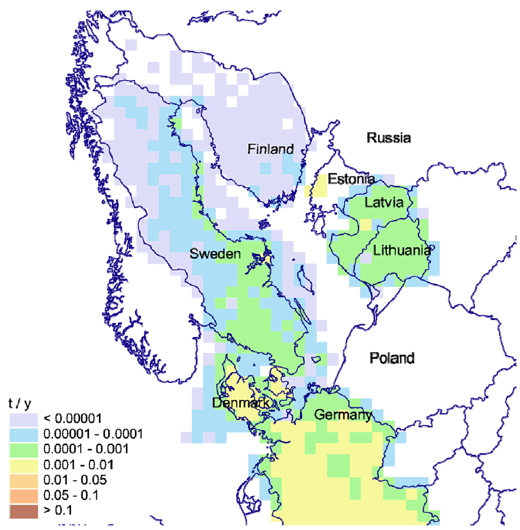


Figure 5.4. Annual cadmium emission from Transport sources below 1000 m sector for 2005.

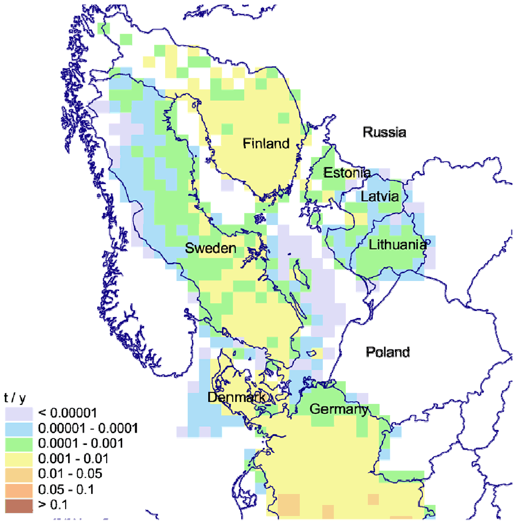


Figure 5.5. Annual cadmium emission from Commercial, Residential and Other Stationary Combustion sector for 2005.

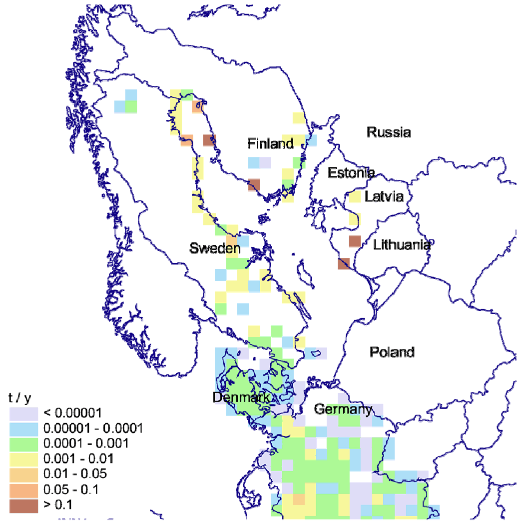


Figure 5.6. Annual cadmium emission from Industrial Processes sector for 2005.

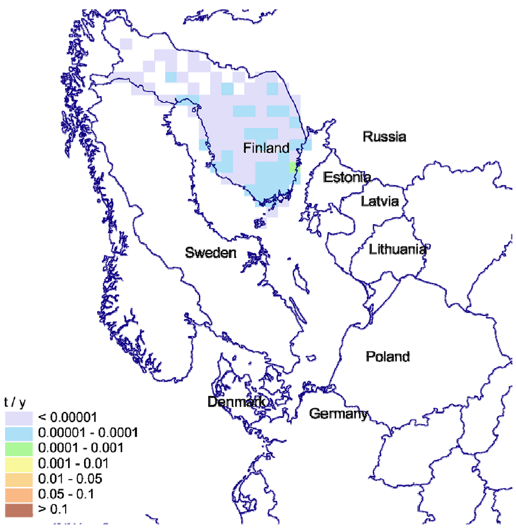


Figure 5.7. Annual cadmium emission from Solvent and Other Product Use sector for 2005.

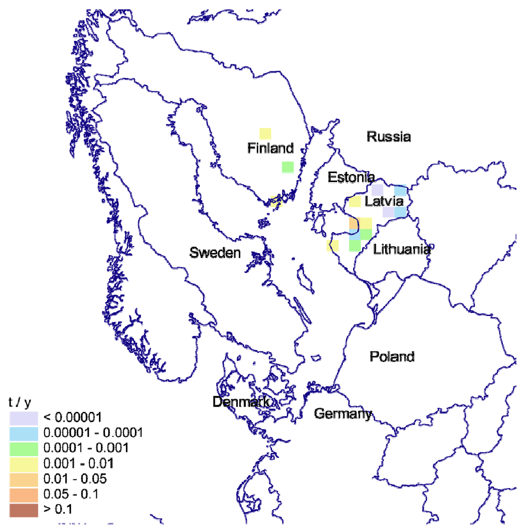


Figure 5.8. Annual cadmium emission from Waste sector for 2005.

Table 5.1. Annual total anthropogenic emissions of cadmium 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	0.71	1.6	0.04	0.35	11.76	59.4	0.22
2a	Transport above 1000m	0.0003	NA		NA		0			NA
2b	Transport below 1000m	0.04	0.006	0	0.3	0.009	0.014	0.35		0.02
3	Commercial, Residential and Other Stationary Combustion	0.21	0.02	0.25	0.64	0.008	0.004	25.82		0.14
4	Fugitive Emissions From Fuels	0	0	0	NA		0	0.43		0
5	Industrial Processes	0.005	0	0.33	0.1	0.44	0	1.86		0.15
6	Solvent and Other Product Use	0	0	0.002	NA		0			NE
7	Agriculture	0	NA		NA	0	0	5.55		NA
8	Waste	0	0	0.0005	1.24E-6	0.04		0.26		0.004
9	Other									
Total		**0.62**	**0.58**	**1.30**	**2.66**	**0.54**	**0.37**	**46.02**	**59.40**	**0.53**

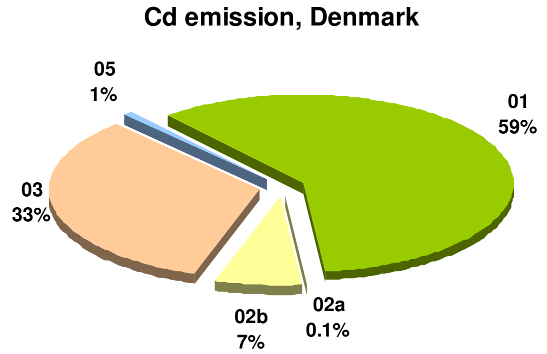


Figure 5.9. Percentage of annual total cadmium emission from different sectors in Denmark for 2005.

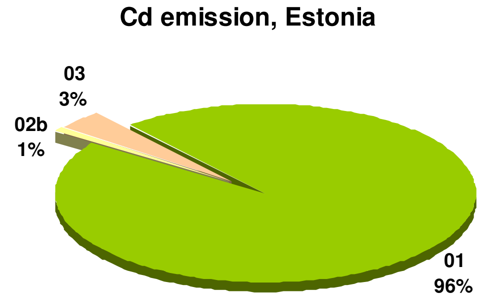


Figure 5.10. Percentage of annual total cadmium emission from different sectors in Estonia for 2005.

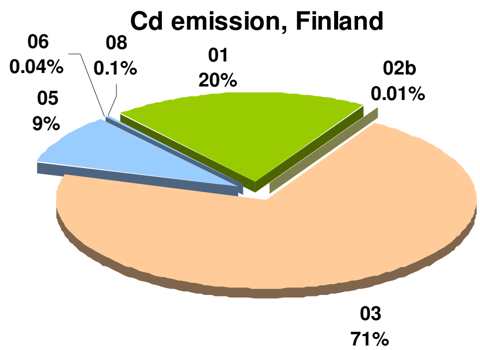


Figure 5.11. Percentage of annual total cadmium emission from different sectors in Finland for 2005.

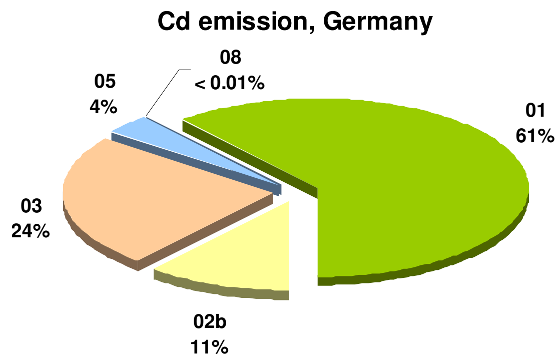


Figure 5.12. Percentage of annual total cadmium emission from different sectors in Germany for 2005.

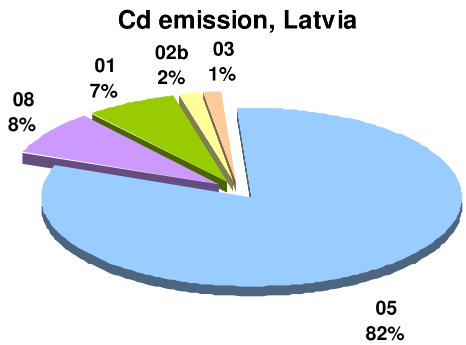


Figure 5.13. Percentage of annual total cadmium emission from different sectors in Latvia for 2005.

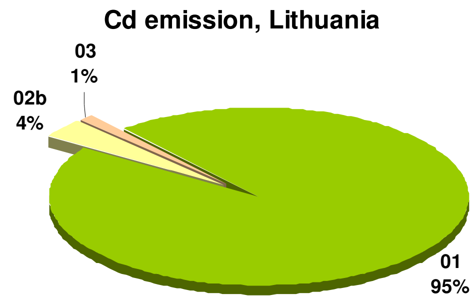


Figure 5.14. Percentage of annual total cadmium emission from different sectors in Lithuania for 2005.

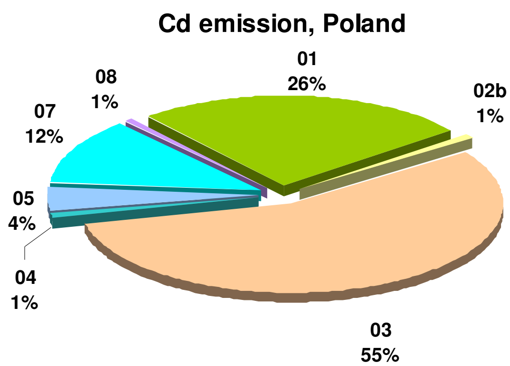


Figure 5.15. Percentage of annual total cadmium emission from different sectors in Poland for 2005.

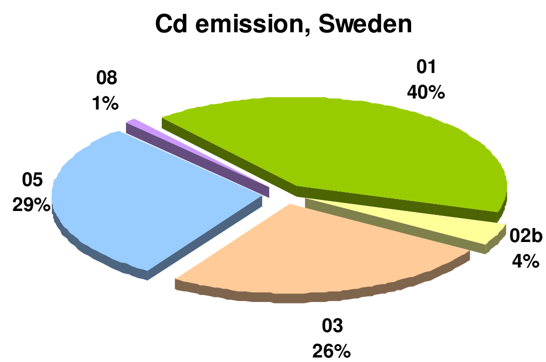


Figure 5.16. Percentage of annual total cadmium emission from different sectors in Sweden for 2005.

Table 5.2. Annual total anthropogenic emissions of cadmium 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	1.1	1.2	1.1	1.1	0.952	0.786	0.808	0.736	0.714	0.695	0.627	0.683	0.638	0.612	0.625	0.623
Estonia	4.4	4.2	3.0	2.2	2.9	2.0	1.0	1.1	1.0	0.945	0.605	0.560	0.560	0.620	0.586	0.576
Finland	6.3	3.4	2.9	2.9	2.4	1.7	1.5	1.1	1.3	0.600	1.4	1.6	1.3	1.2	1.5	1.3
Germany	12	8.0	5.2	3.7	2.6	2.3	2.2	2.4	2.2	2.7	2.4	2.6	2.7	2.7	2.7	2.7
Latvia	1.5	1.2	0.876	0.751	0.950	0.738	0.916	0.771	1.1	0.904	0.811	0.758	0.575	0.538	0.518	0.542
Lithuania	3.8	2.8	2.5	2.3	2.1	2.1	2.2	2.2	2.6	2.0	1.4	1.2	1.0	0.916	0.524	0.371
Poland	92	85	84	92	86	83	91	86	55	62	50	53	49	48	46	46
Russia	79	68	69	59	57	57	51	50	49	51	51	51	52	57	55	59
Sweden	2.3	1.7	1.4	1.1	0.766	0.744	0.713	0.708	0.627	0.543	0.526	0.607	0.533	0.517	0.532	0.530
HELCOM	**202**	**176**	**170**	**165**	**155**	**150**	**152**	**145**	**114**	**121**	**109**	**111**	**107**	**113**	**108**	**112**
Albania	0.647	0.602	0.557	0.513	0.468	0.423	0.378	0.333	0.289	0.244	0.199	0.199	0.198	0.198	0.198	0.197
Armenia	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.132	0.135	0.137	0.140	0.143
Austria	1.6	1.5	1.2	1.2	1.1	0.969	0.991	0.973	0.895	0.980	0.934	0.987	1.0	1.0	1.0	1.1
Azerbaijan	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.4	2.4	2.5	2.5
Belarus	2.2	2.3	2.0	1.7	1.3	1.1	1.2	1.3	1.5	1.4	1.4	1.8	1.9	1.8	1.8	2.1
Belgium	7.4	7.3	7.9	6.7	5.3	5.5	4.9	4.3	3.7	3.1	2.5	2.4	2.1	1.7	2.3	2.0
Bosnia and Herzegovina	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.6	1.6	1.6
Bulgaria	28	25	22	19	16	13	14	14	15	14	11	10	12	15	15	12
Croatia	1.6	1.5	1.3	1.2	1.1	0.950	1.0	1.0	1.1	1.1	1.0	0.874	0.929	0.948	0.877	0.877
Cyprus	0.550	0.570	0.650	0.710	0.740	0.670	0.710	0.750	0.820	0.870	0.920	0.910	1.0	0.890	1.1	1.1
Czech Republic	4.3	3.9	3.6	3.5	3.5	3.6	2.9	3.0	2.7	2.7	2.9	2.6	2.7	2.2	2.4	3.1
France	19	19	18	17	17	16	16	15	14	13	13	12	11	8.2	6.0	5.9
Georgia	0.210	0.210	0.210	0.210	0.210	0.210	0.210	0.210	0.210	0.210	0.210	0.215	0.221	0.226	0.232	0.237
Greece	4.5	4.2	4.0	3.7	3.5	3.2	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Hungary	5.5	4.7	4.0	4.1	4.1	3.8	3.4	3.3	3.1	3.0	3.0	3.0	2.8	2.9	2.7	1.5
Iceland	0.166	0.158	0.149	0.141	0.132	0.124	0.115	0.107	0.098	0.090	0.081	0.082	0.082	0.082	0.083	0.083
Ireland	0.831	0.835	0.860	0.849	0.928	0.919	0.904	0.937	0.979	0.974	0.973	0.812	0.638	0.559	0.592	0.578
Italy	10	11	10	9.7	9.4	9.4	9.1	8.9	8.6	8.5	8.8	8.7	7.0	7.3	7.8	7.8
Kazakhstan	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.8	5.9	6.0	6.1
Luxembourg	0.600	0.575	0.550	0.525	0.500	0.400	0.400	0.300	0.200	0.054	0.051	0.054	0.047	0.047	0.047	0.047
Malta	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.626
Monaco	0.057	0.058	0.064	0.070	0.006	0.006	0.007	0.008	0.007	0.007	0.008	0.008	0.007	0.006	0.005	0.005
Netherlands	2.1	2.4	2.1	1.7	1.4	1.1	1.9	1.9	1.2	1.1	1.0	1.6	2.2	2.4	1.8	1.7
Norway	1.1	1.0	0.997	1.1	1.1	0.955	1.0	1.0	1.1	0.992	0.660	0.655	0.652	0.630	0.573	0.512
Portugal	5.3	5.8	5.9	5.2	5.5	5.7	4.9	5.3	6.0	6.0	5.5	5.4	6.1	5.4	5.3	5.7
Republic of Moldova	2.4	3.5	1.7	1.4	0.819	0.594	0.659	0.364	0.328	0.148	0.173	0.114	0.226	0.122	0.114	0.145
Romania	22	20	19	18	17	15	14	13	12	12	8.7	7.4	6.3	5.1	3.9	2.7
Serbia and Montenegro	8.3	8.3	8.4	8.4	8.4	8.5	8.5	8.5	8.6	8.6	8.7	8.6	8.6	8.6	8.6	8.5
Slovakia	9.4	10	11	8.7	6.6	10	9.0	10	7.8	6.6	7.2	7.2	5.4	5.8	3.6	6.1
Slovenia	1.8	1.5	1.6	1.6	1.7	1.7	1.7	1.7	1.6	1.6	1.7	1.7	1.7	1.7	1.7	1.7
Spain	24	23	22	20	21	21	19	19	19	19	18	18	19	17	17	17
Switzerland	3.7	3.5	3.3	3.0	2.8	2.5	2.4	2.2	2.2	1.8	1.6	1.5	1.3	1.1	1.1	1.1
The FYR of Macedonia	9.1	9.2	9.3	9.3	9.4	9.4	9.5	9.6	9.6	9.7	9.8	9.8	9.7	9.7	9.7	9.7
Turkey	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17
Ukraine	54	50	46	42	38	34	30	26	22	18	14	10	2.0	28	3.1	3.1
United Kingdom	24	24	24	15	14	12	10	9.2	6.8	6.5	6.3	5.0	4.8	3.4	3.7	3.8
EMEP	**484**	**449**	**429**	**399**	**375**	**361**	**351**	**338**	**295**	**293**	**269**	**264**	**250**	**276**	**242**	**244**

Expert estimates:

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

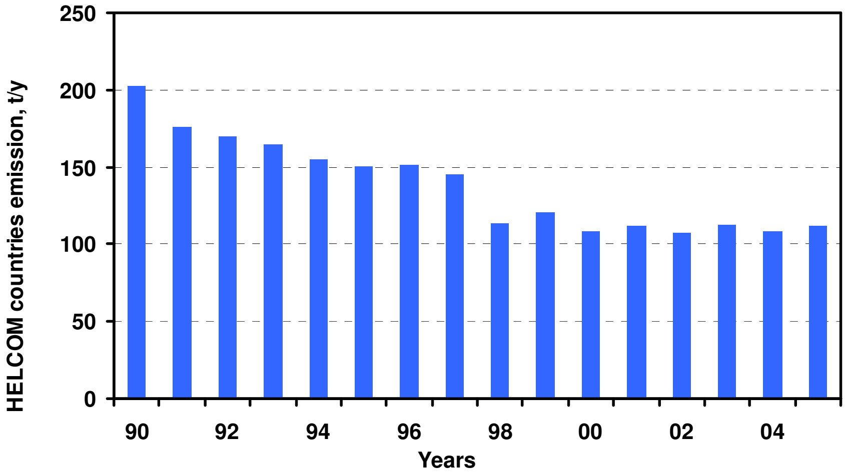


Figure 5.17. Time-series of total annual cadmium emissions of HELCOM countries in 1990-2005, tonnes/y.

5.2 Annual deposition of cadmium

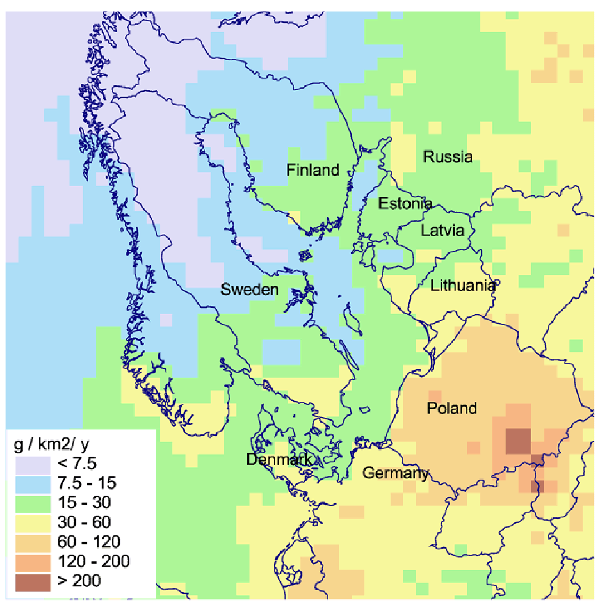


Figure 5.18. Annual deposition fluxes of cadmium over the Baltic Sea region for 2005, g/km^2/year.

5.3 Monthly depositions of cadmium

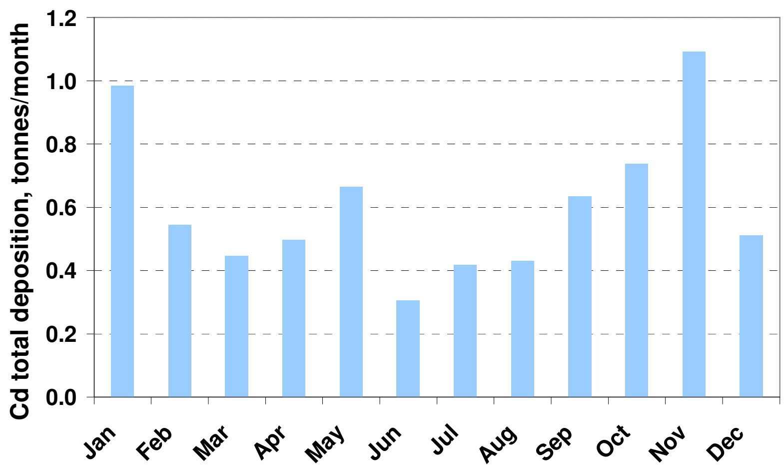


Figure 5.19. Monthly depositions of cadmium to the Baltic Sea for 2005, tonnes/month.

Table 5.2. Monthly depositions of cadmium to the Baltic Sea for 2005, tonnes/month.

Month	Cd
Jan	0.98
Feb	0.54
Mar	0.45
Apr	0.50
May	0.67
Jun	0.31
Jul	0.42
Aug	0.43
Sep	0.64
Oct	0.74
Nov	1.09
Dec	0.51

5.4 Source allocation of cadmium deposition

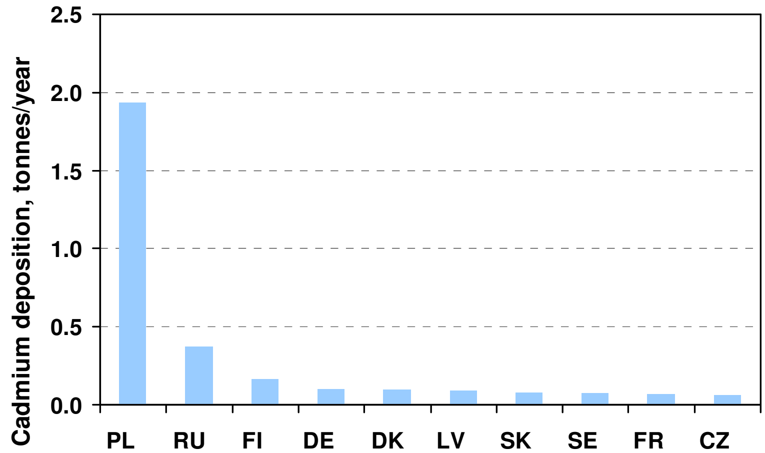


Figure 5.20. Top ten countries with the highest contribution to annual deposition of cadmium over the Baltic Sea for 2005, tonnes/year.

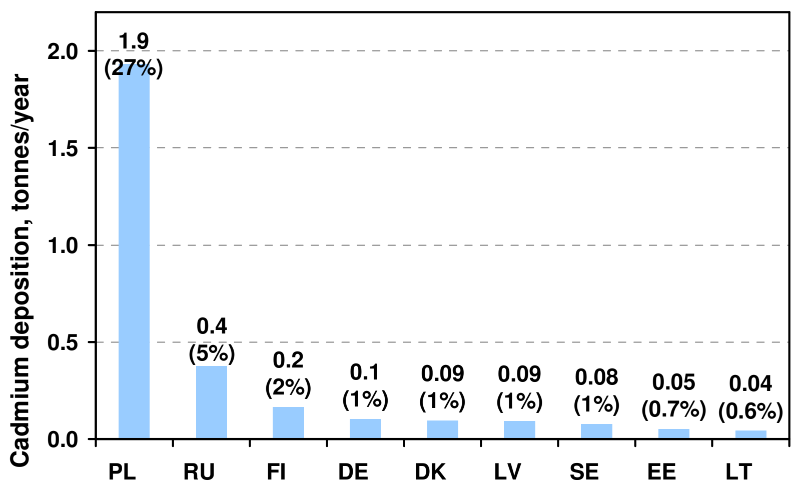


Figure 5.21. Sorted contributions (in %) of HELCOM countries to total depositions over the Baltic Sea for 2005. HELCOM countries emissions of cadmium contributed about 40% to the total annual cadmium depositions over the Baltic Sea in 2005. Contribution of other EMEP countries accounted for 8%. Significant contribution was made by other emission sources, in particular, remote emissions sources, natural emissions and re-emission of cadmium (52%).

Table 5.3. Two most significant contributors to the annual total depositions of cadmium to the six Baltic Sea sub-basins for 2005.

Sub-basin	Country	%	Country	%	*, %
GUB	Poland	21	Finland	10	50
GUF	Poland	19	Russia	18	41
GUR	Poland	27	Russia	8	46
BAP	Poland	33	Russia	4	49
BES	Poland	11	Denmark	4	71
KAT	Poland	13	Denmark	5	69
BAS	Poland	27	Russia	5	51

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

5.5 Comparison of model results with measurements

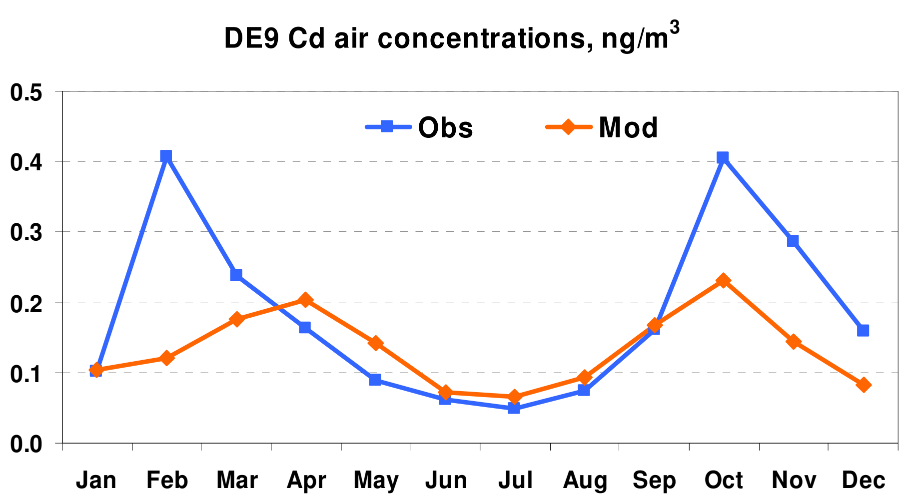


Figure 5.22. Comparison of calculated mean monthly cadmium concentrations in air with measured at

station Zingst (DE9). Units: ng / m^3.

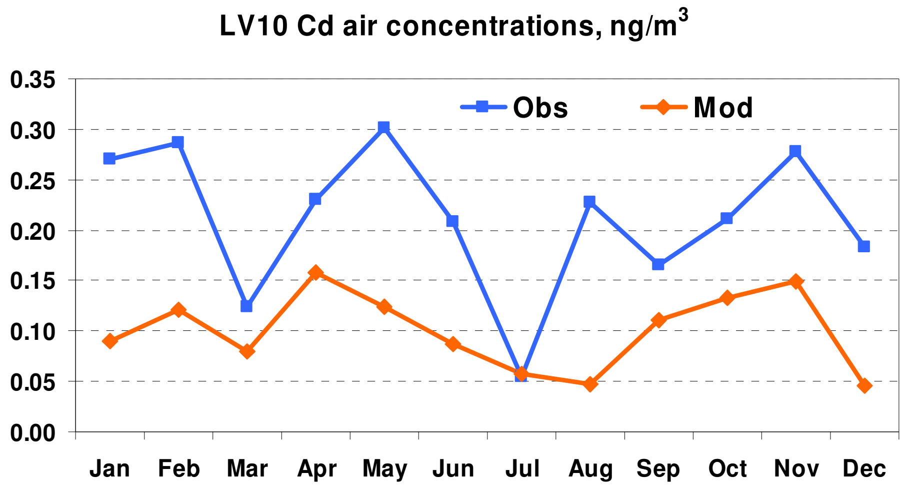


Figure 5.23. Comparison of calculated mean monthly cadmium concentrations in air with measured at station Rucava (LV10). Units: ng / m^3.

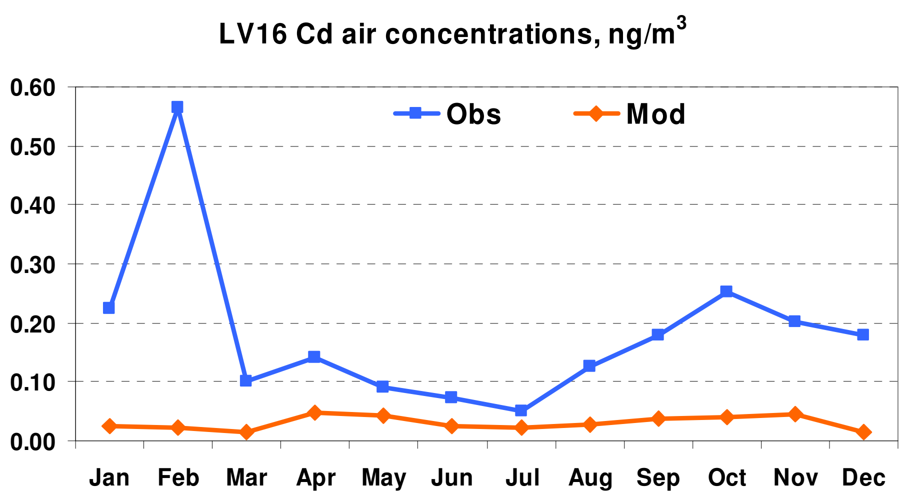


Figure 5.24. Comparison of calculated mean monthly cadmium concentrations in air with measured at station Zoseni (LV16). Units: ng / m^3.

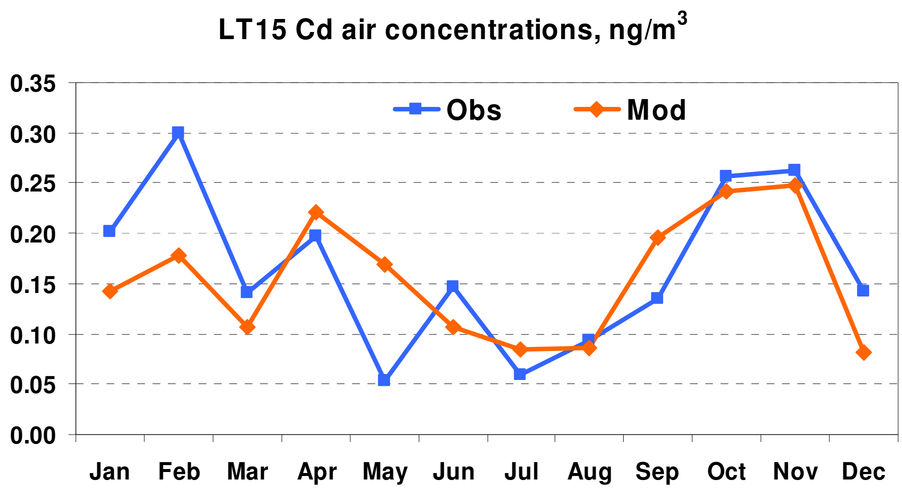


Figure 5.25. Comparison of calculated mean monthly cadmium concentrations in air with measured at station Preila (LT15). Units: ng / m^3.

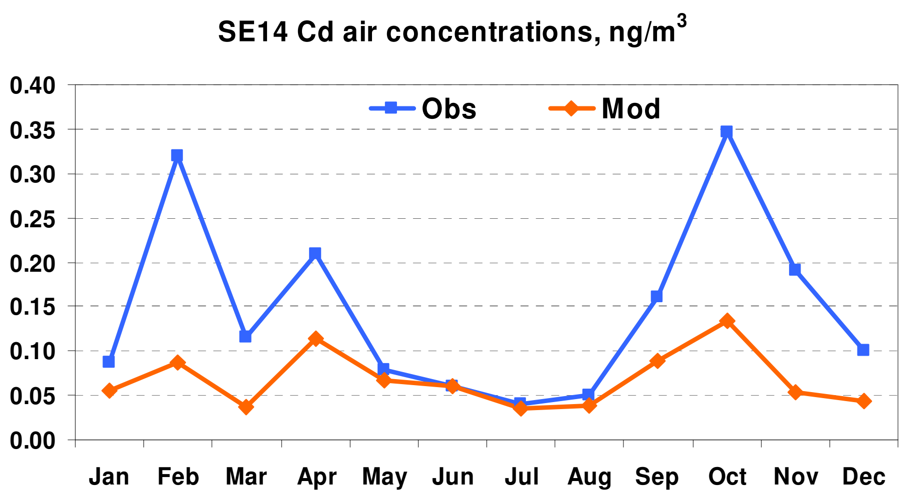


Figure 5.26. Comparison of calculated mean monthly cadmium concentrations in air with measured at station Räö (SE14). Units: ng / m^3.

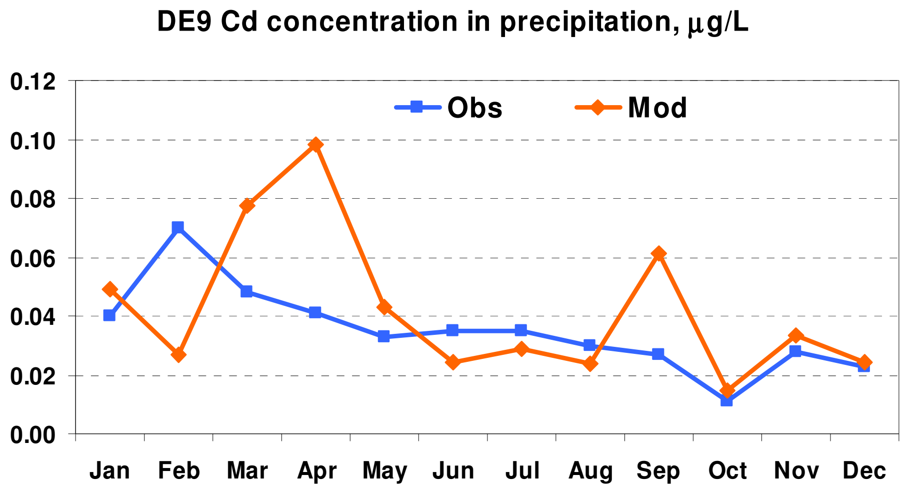


Figure 5.27. Comparison of calculated mean monthly cadmium concentrations in precipitation with measured at station Zingst (DE09). Units: µg / L.

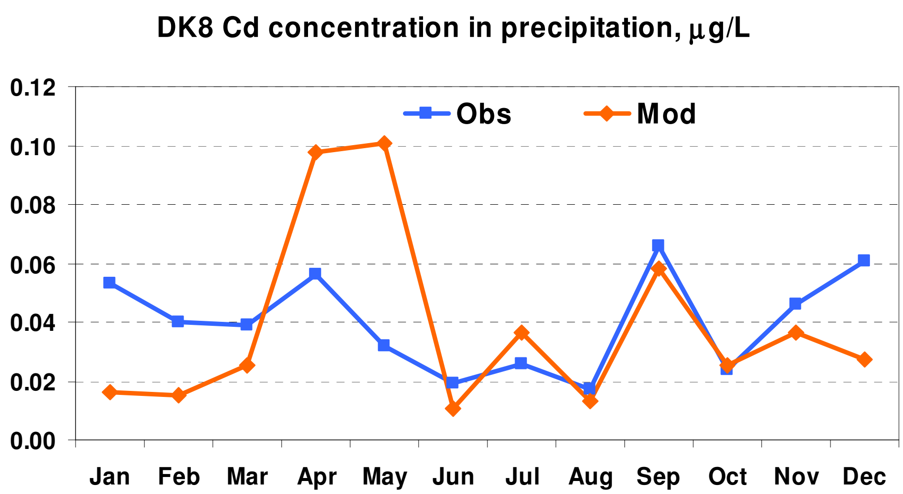


Figure 5.28. Comparison of calculated mean monthly cadmium concentrations in precipitation with measured at station Anholt (DK8). Units: µg / L.

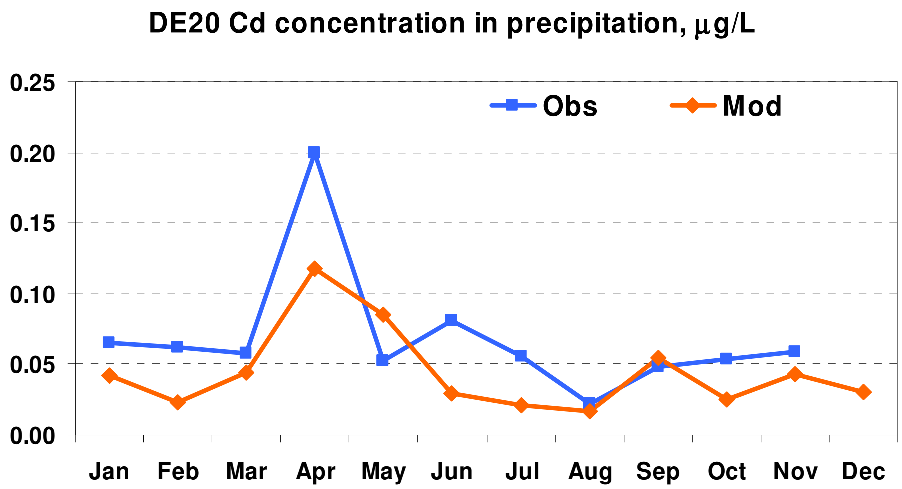


Figure 5.29. Comparison of calculated mean monthly cadmium concentrations in precipitation with measured at station Pedersker (DK20). Units: µg / L.

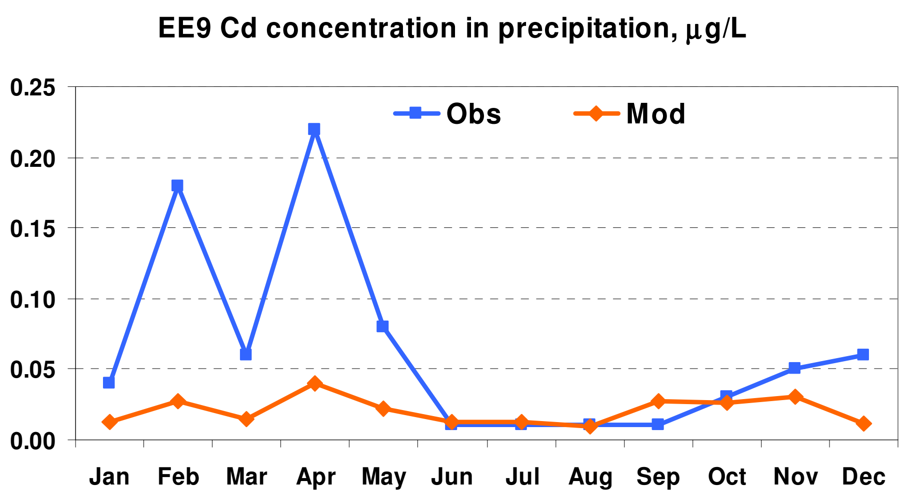


Figure 5.30. Comparison of calculated mean monthly cadmium concentrations in precipitation with measured at station Lahemaa (EE9). Units: µg / L.

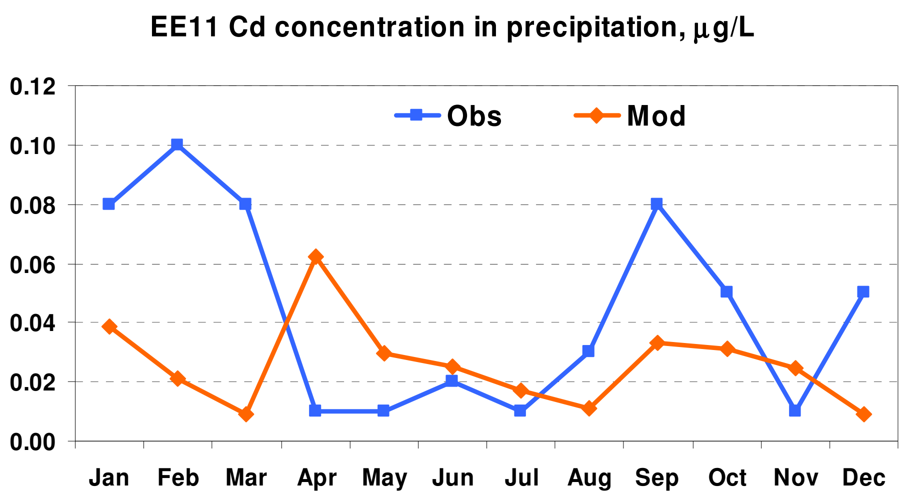


Figure 5.31. Comparison of calculated mean monthly cadmium concentrations in precipitation with measured at station Vilsandy (EE11). Units: µg / L.

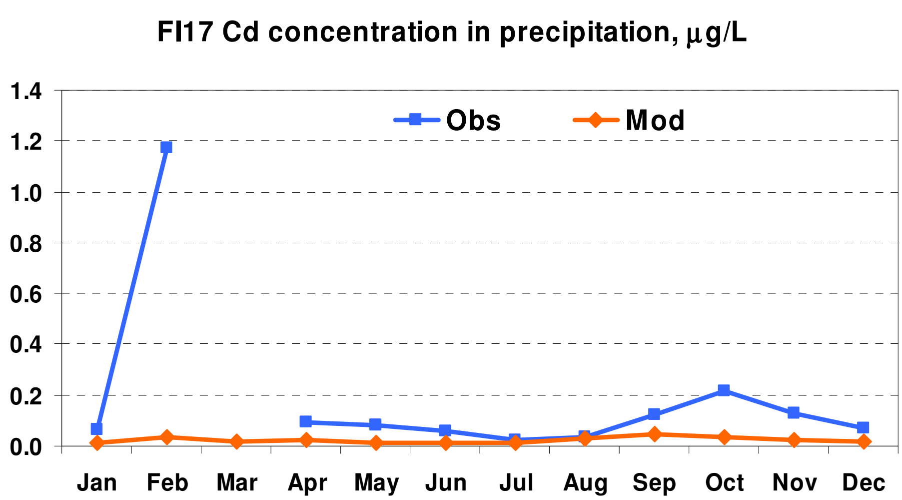


Figure 5.32. Comparison of calculated mean monthly cadmium concentrations in precipitation with measured at station Virolahty II (FI17). Units: µg / L.

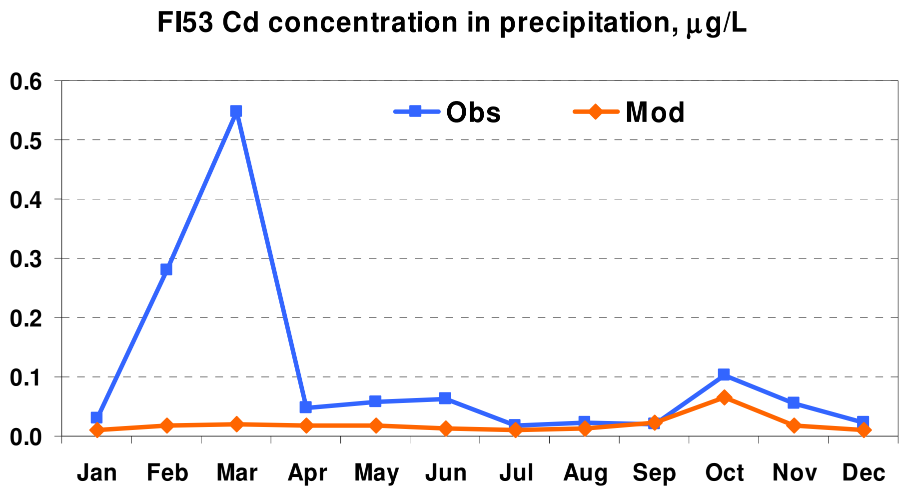


Figure 5.33. Comparison of calculated mean monthly cadmium concentrations in precipitation with measured at station Hailuoto (FI53). Units: µg / L.

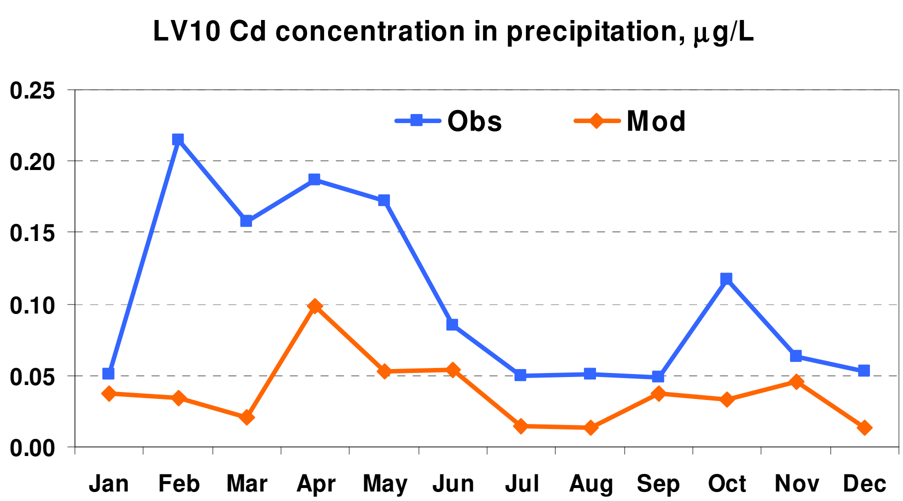


Figure 5.34. Comparison of calculated mean monthly cadmium concentrations in precipitation with measured at station Rucava (LV10). Units: µg / L.

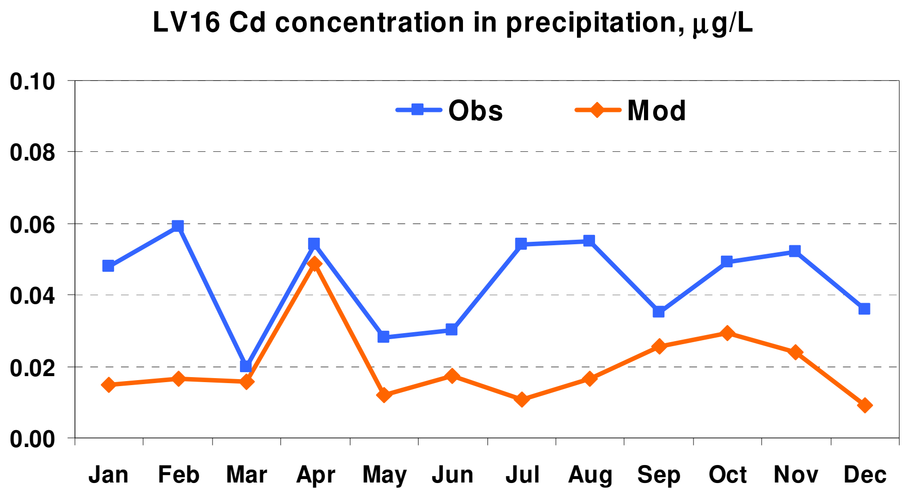


Figure 5.35. Comparison of calculated mean monthly cadmium concentrations in precipitation with measured at station Zoseni (LV16). Units: µg / L.

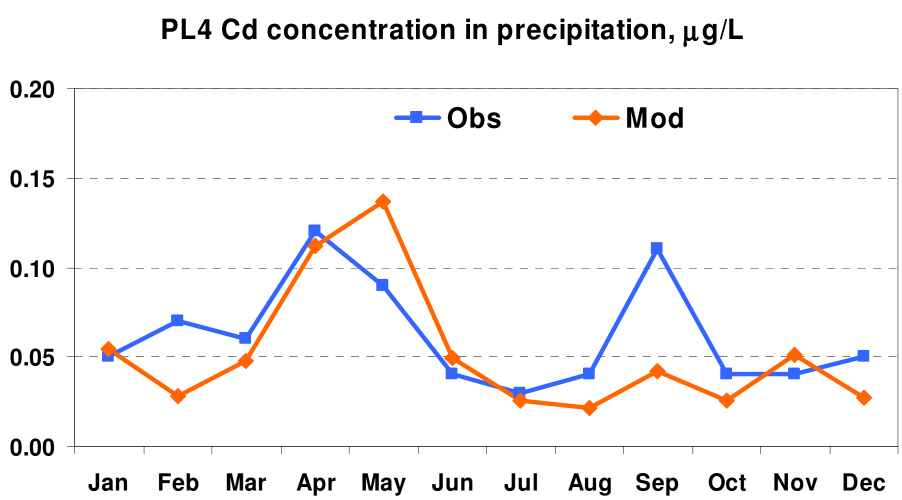


Figure 5.36. Comparison of calculated mean monthly cadmium concentrations in precipitation with measured at station Leba (PL4). Units: µg / L.

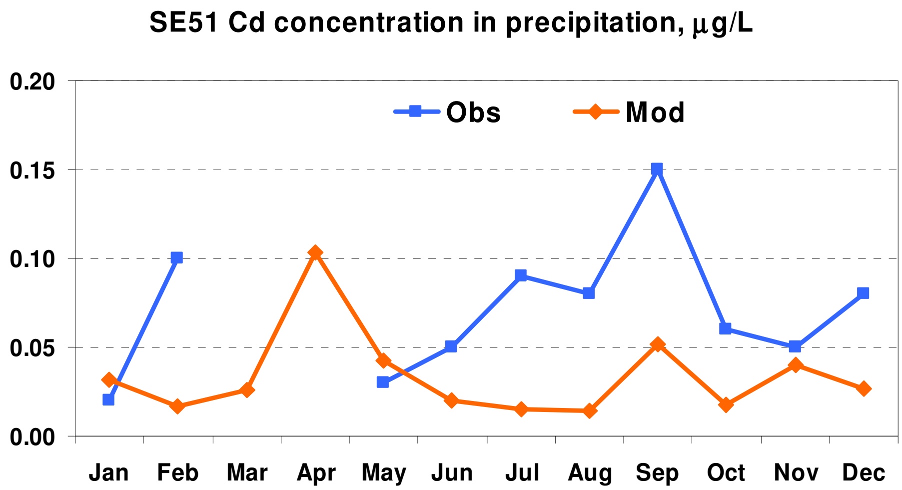


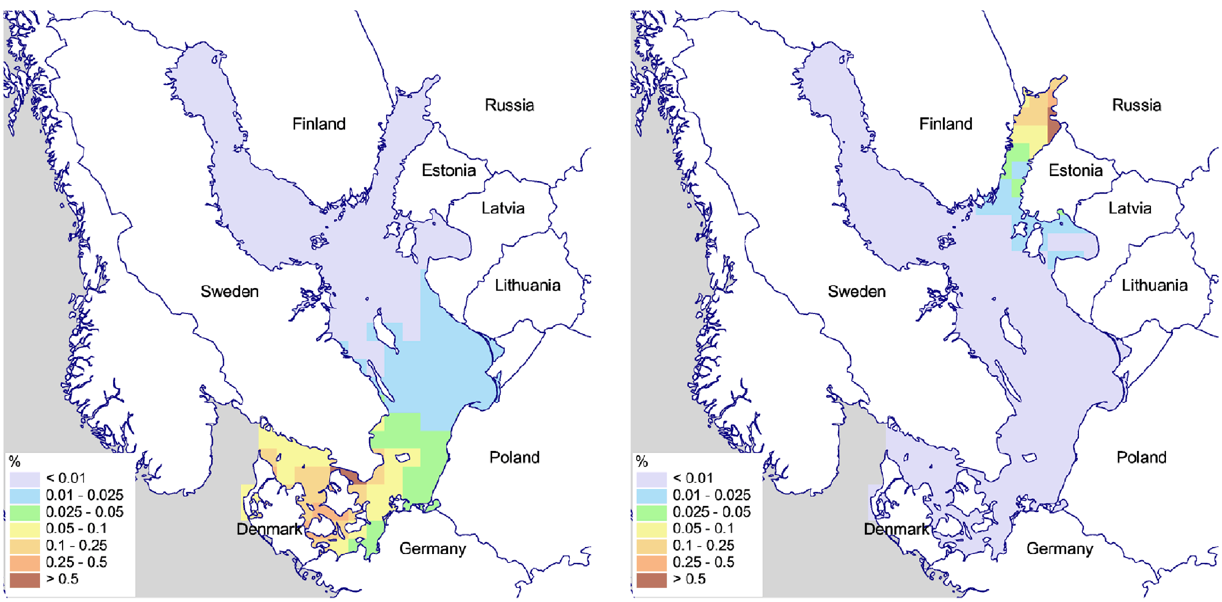
Figure 5.37. Comparison of calculated mean monthly cadmium concentrations in precipitation with measured at station Arup (SE51). Units: µg / L.

In general, reasonable level of agreement between the computed concentrations of cadmium in air and in precipitation is obtained for the selected monitoring sites around the Baltic Sea. Comparing to lead more significant deviations between simulated and observed monthly mean concentrations of cadmium can be mentioned. The reason of deviations is connected with the uncertainties in seasonal variation of cadmium emission, differences between measured precipitation amount and the one used in the model, and difficulties in measurements of heavy metals.

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

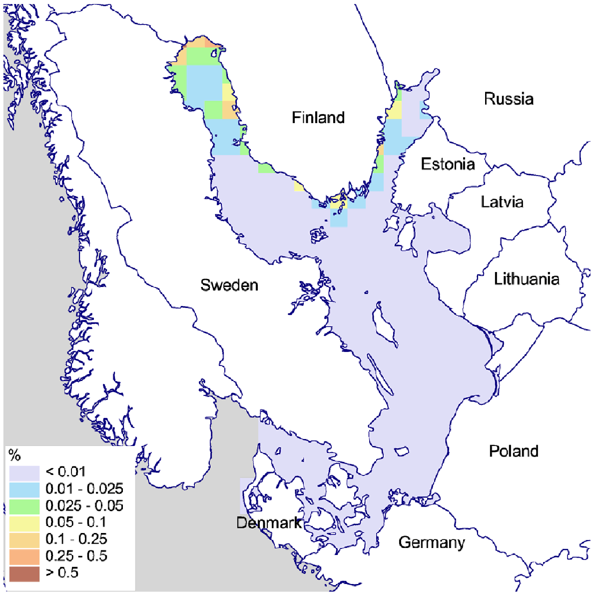
In this chapter the results of model evaluation of mercury atmospheric input to the Baltic Sea and its sub-basins for 2005 is presented. Modelling of mercury atmospheric transport and depositions was carried out using MSC-E Eulerian Heavy Metal transport model MSCE-HM (Travnikov and Ilyin, 2005). Latest 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

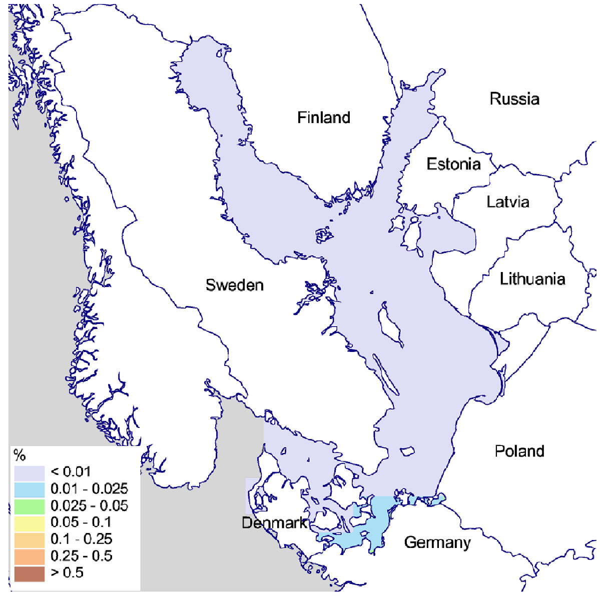


Denmark Estonia

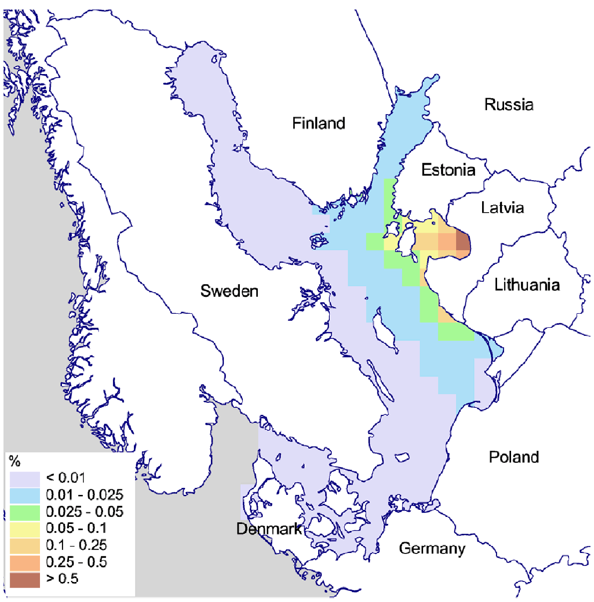
Figure 6.1. Maps with the fractions (in %) of annual total anthropogenic mercury emissions from HELCOM Parties deposited into the Baltic Sea in 2005.



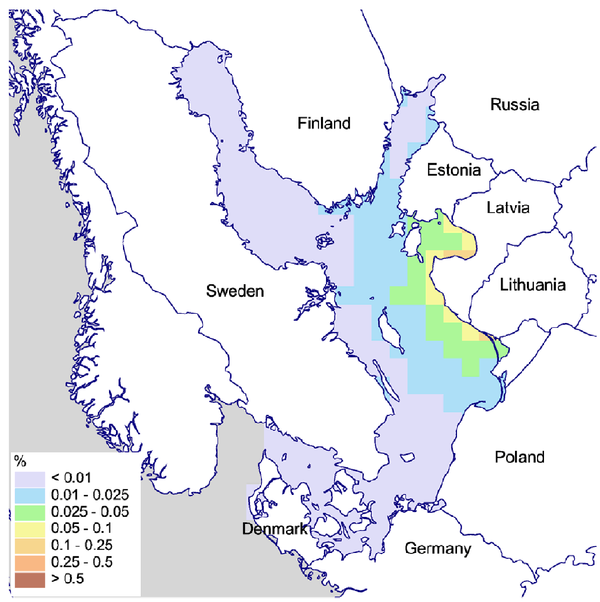
Finland



Germany

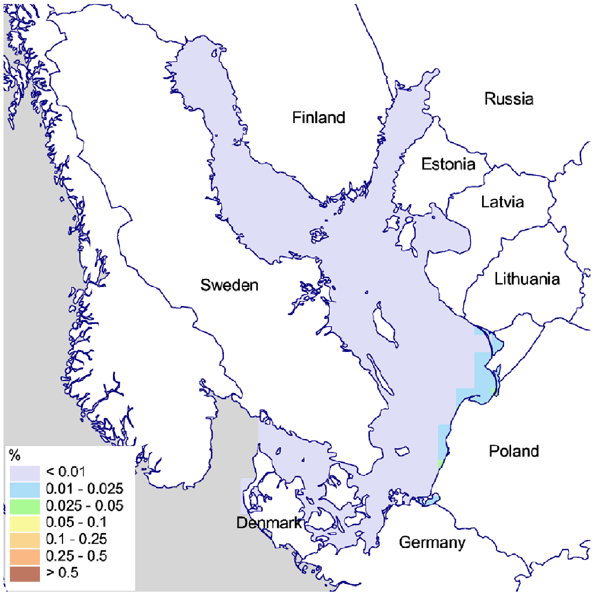


Latvia

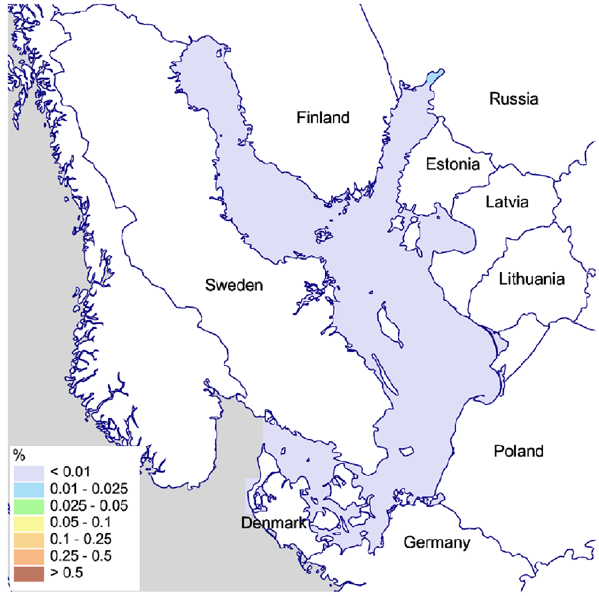


Lithuania

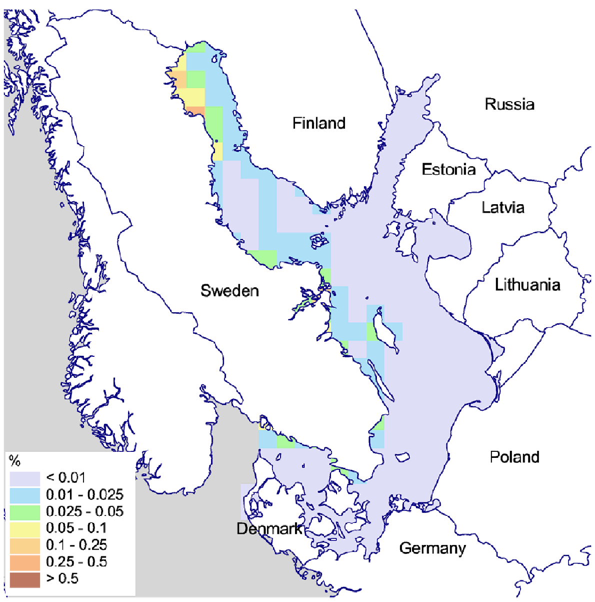
Figure 6.1 (cont.). Maps with the fractions (in %) of annual total anthropogenic mercury emissions from HELCOM Parties deposited into the Baltic Sea in 2005.



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.

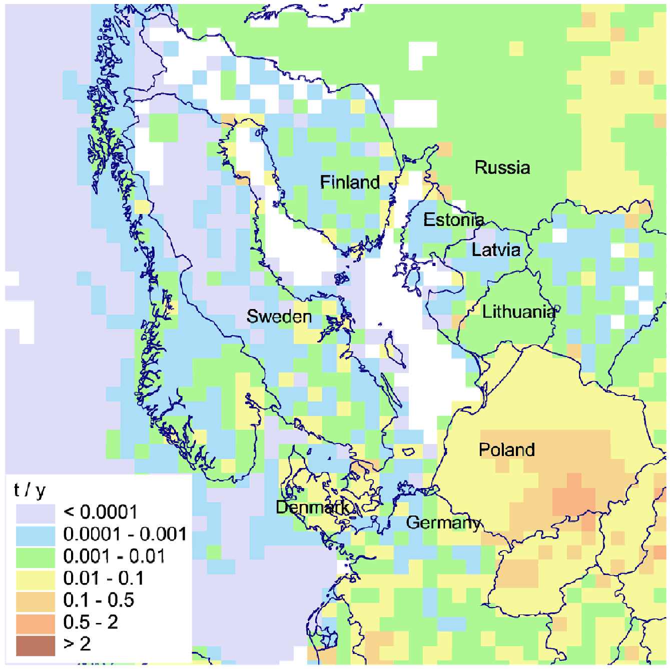


Figure 6.2. Annual total anthropogenic emissions of mercury in the Baltic Sea region for 2005, t/y.

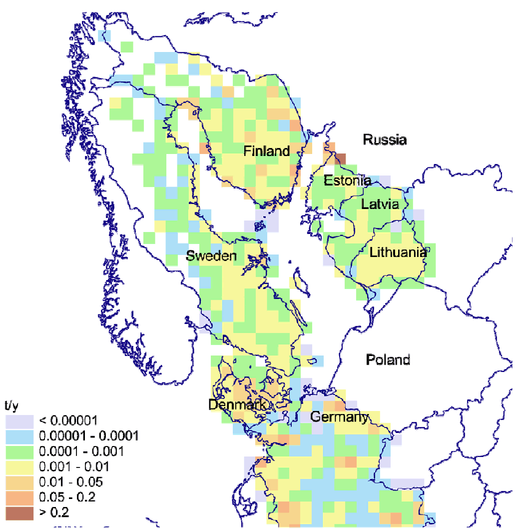


Figure 6.3. Annual mercury emission from Combustion in Power Plants and Industry sector for 2005.

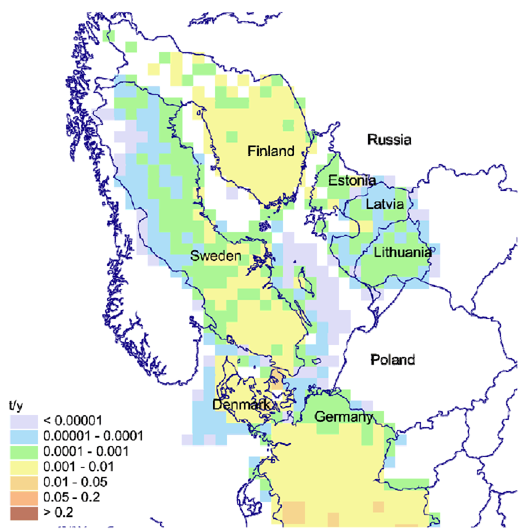


Figure 6.4. Annual mercury emission from Commercial, Residential and Other Stationary Combustion sector for 2005.

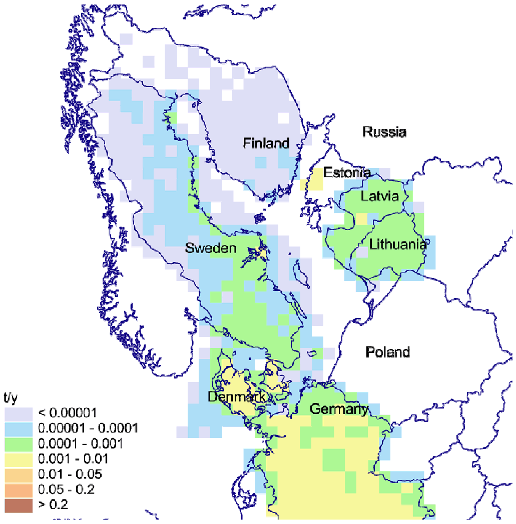


Figure 6.5. Annual mercury emission from from Transport sources below 1000 m sector for 2005.

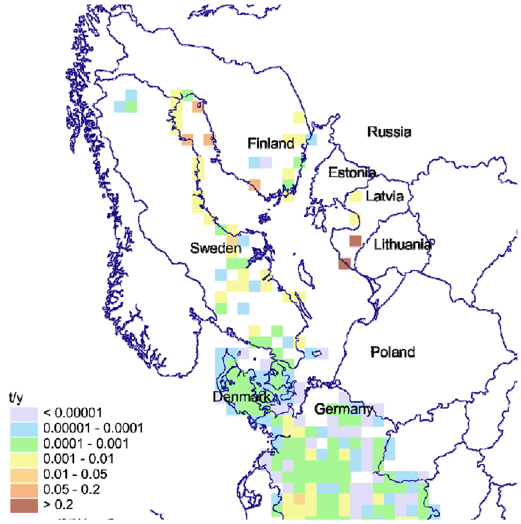


Figure 6.6. Annual mercury emission from Industrial Processes sector for 2005.

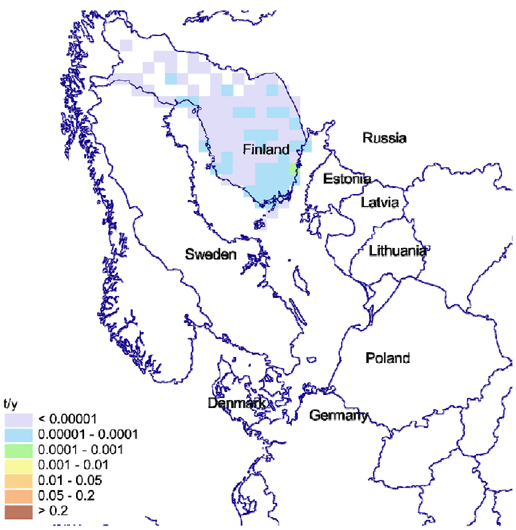


Figure 6.7. Annual mercury emission from Solvent and Other Product Use sector for 2005.

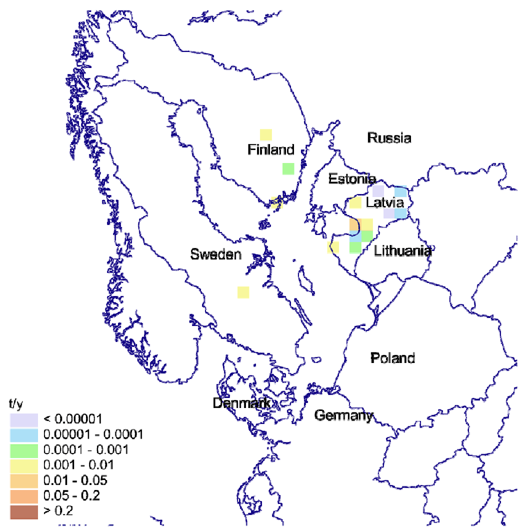


Figure 6.8. Annual mercury emission from Waste sector for 2005.

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**

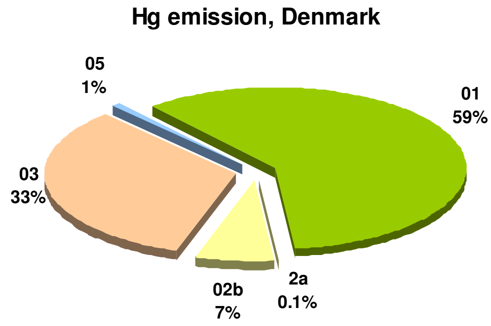


Figure 6.9. Percentage of annual total mercury emission from different sectors in Denmark for 2005

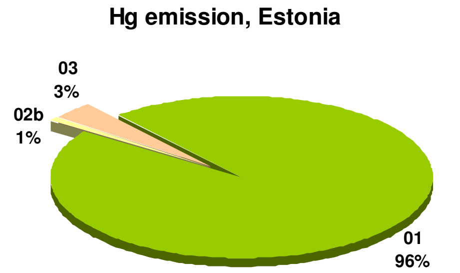


Figure 6.10. Percentage of annual total mercury emission from different sectors in Estonia for 2005

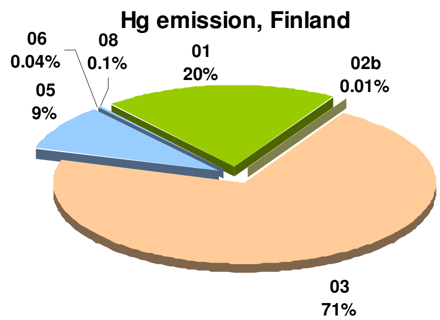


Figure 6.11. Percentage of annual total mercury emission from different sectors in Finland for 2005

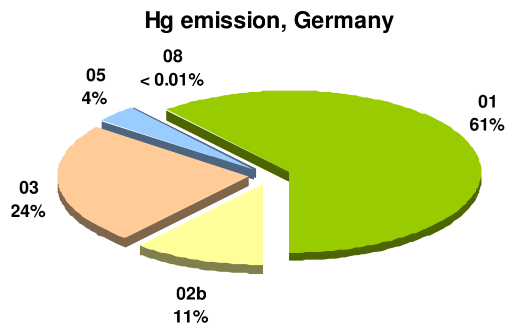


Figure 6.12. Percentage of annual total mercury emission from different sectors in Germany for 2005

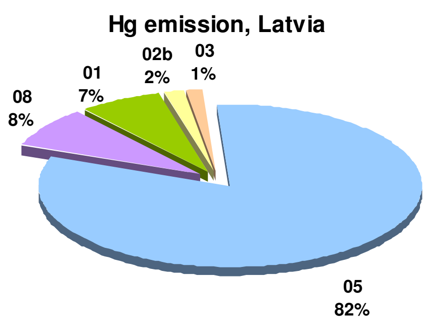


Figure 6.13. Percentage of annual total mercury emission from different sectors in Latvia for 2005

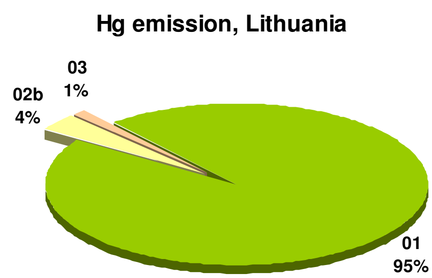


Figure 6.14. Percentage of annual total mercury emission from different sectors in Lithuania for 2005

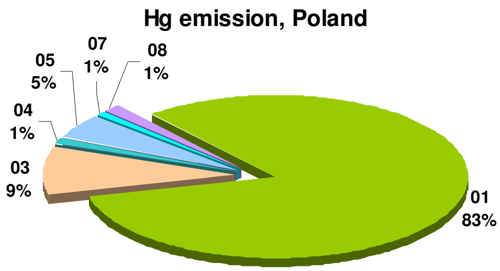


Figure 6.15. Percentage of annual total mercury emission from different sectors in Poland for 2005

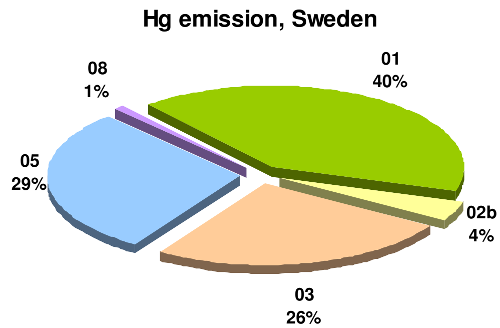


Figure 6.16. Percentage of annual total mercury emission from different sectors in Sweden for 2005

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]

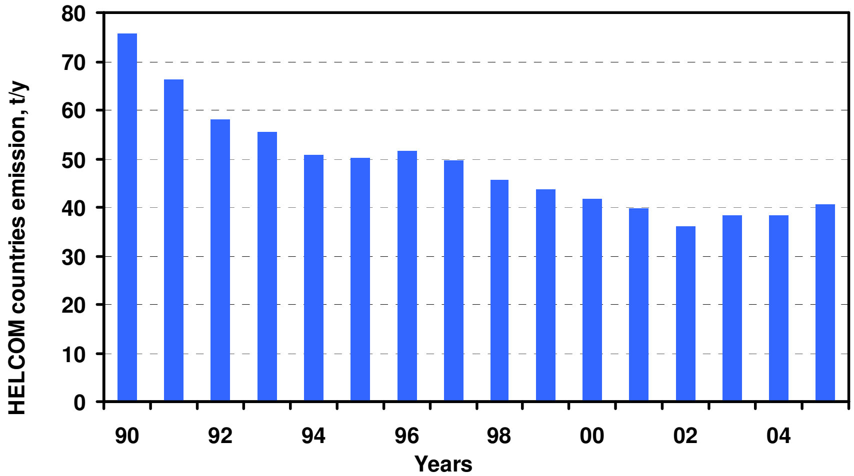


Figure 6.17. Time-series of total annual mercury emissions of HELCOM countries in 1990-2005, tonnes/y.

5.2 Annual deposition of mercury

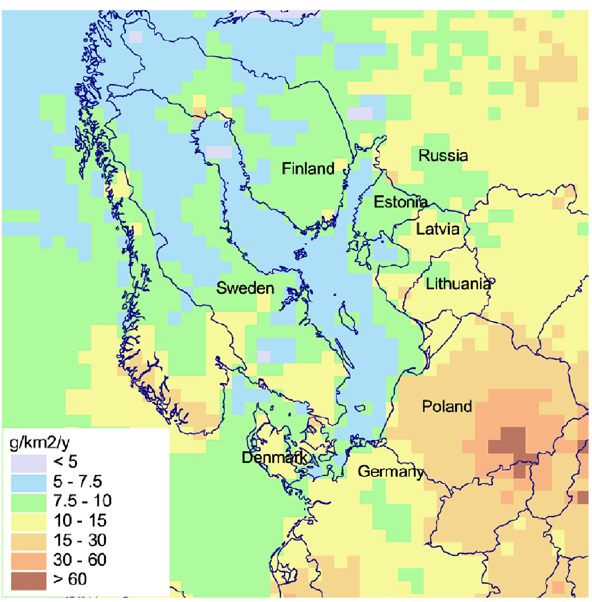


Figure 6.18. Annual deposition fluxes of mercury over the Baltic Sea region for 2005, g/km²/y.

5.3 Monthly depositions of mercury

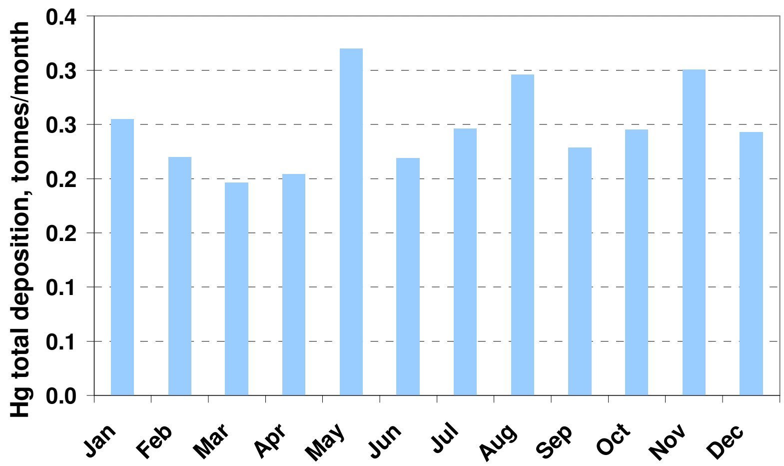


Figure 6.19. Monthly depositions of mercury to the Baltic Sea for 2005, tonnes/month.

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

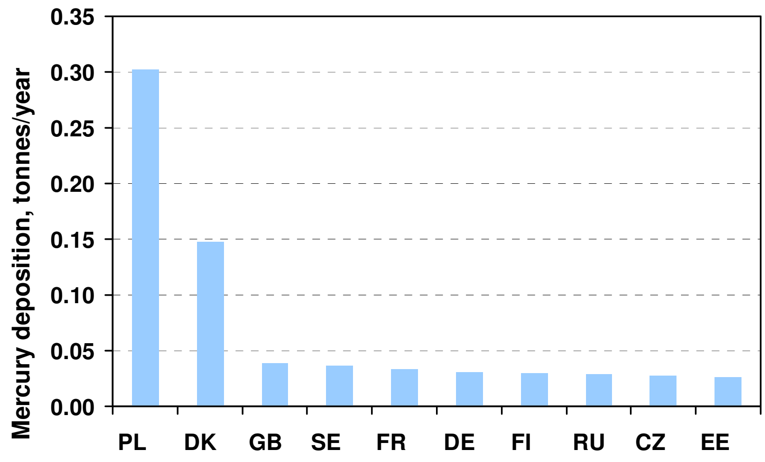


Figure 6.20. Top ten countries with the highest contribution to annual deposition of mercury over the Baltic Sea for 2005, tonnes/year.

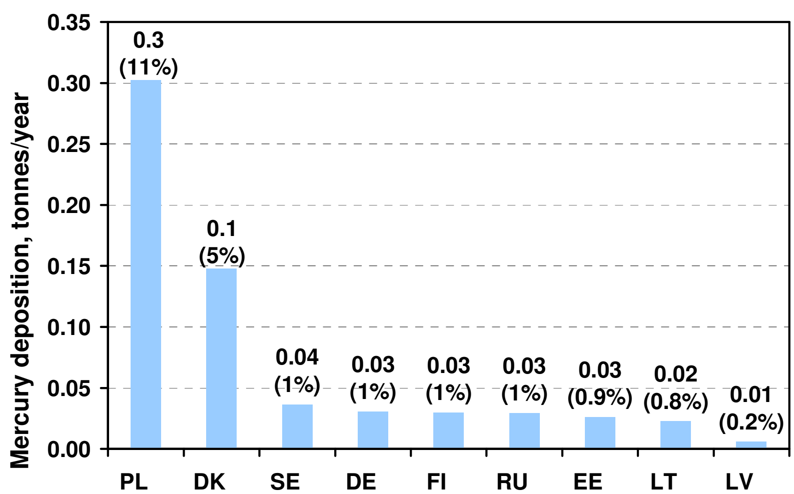


Figure 6.21. Sorted contributions (in %) of HELCOM countries to total depositions over the Baltic Sea for 2005. HELCOM countries emissions of mercury contributed 22% to the total annual mercury depositions over the Baltic Sea in 2005. Contribution of other EMEP countries accounted for 8%. Significant 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

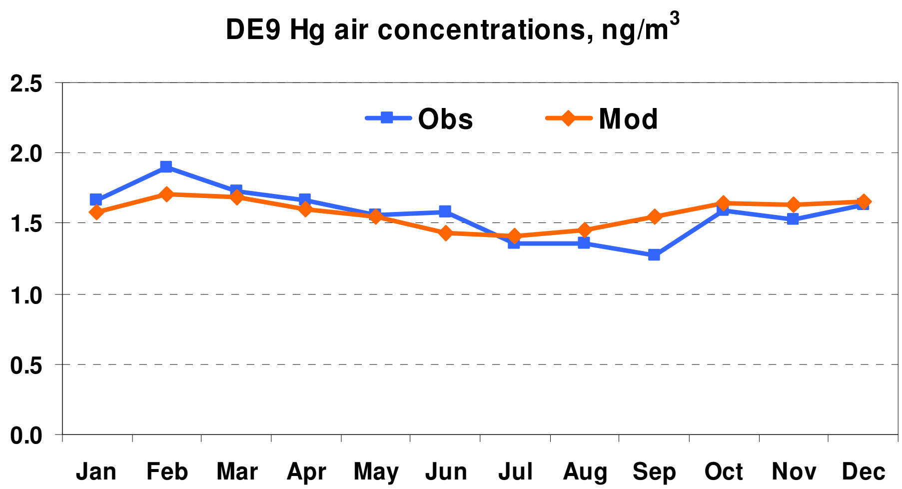


Figure 6.22. Comparison of calculated monthly mean Hg concentrations in air with measured at the station Zingst (DE9). Units: ng / m^3.

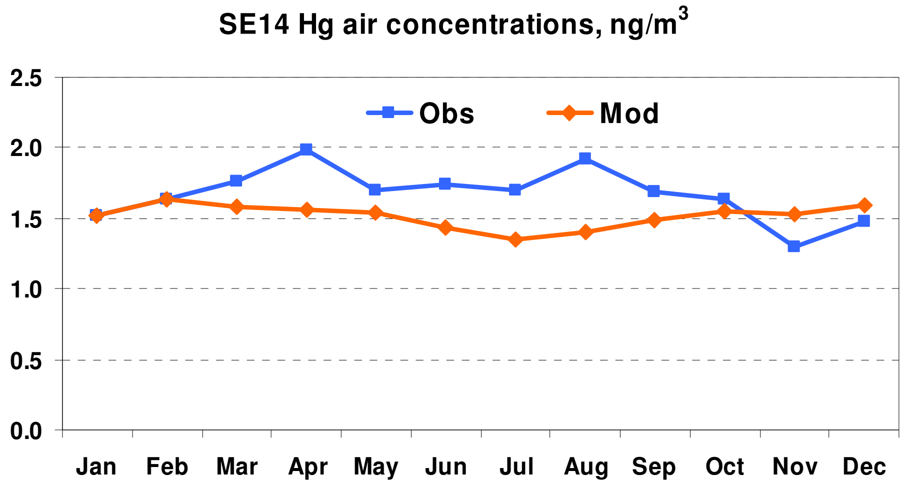


Figure 6.23. Comparison of calculated monthly mean Hg concentrations in air with measured at the station Råö (SE14). Units: ng / m^3.

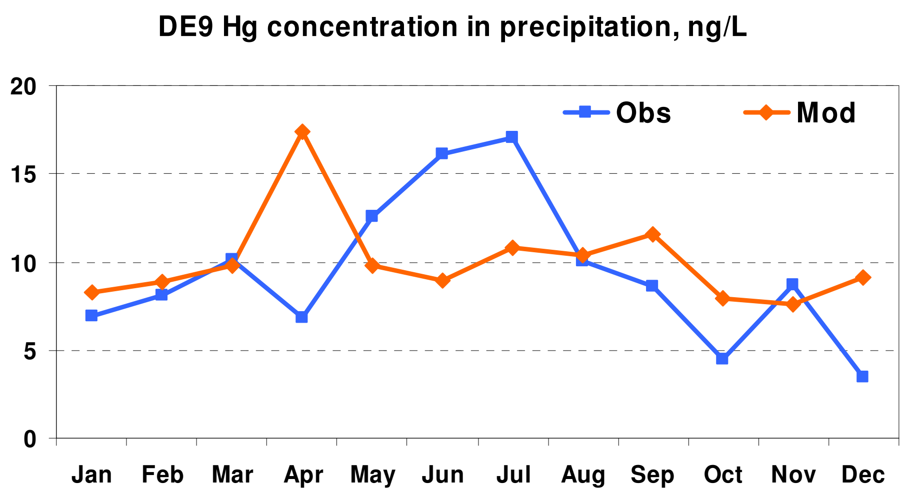


Figure 6.24. Comparison of calculated monthly mean Hg concentrations in precipitation with measured at the station Zingst (DE9). Units: ng/L.

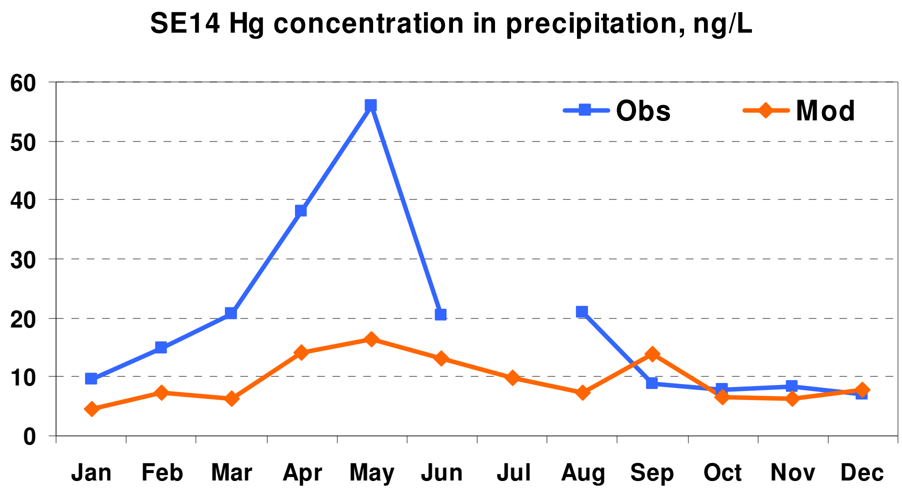


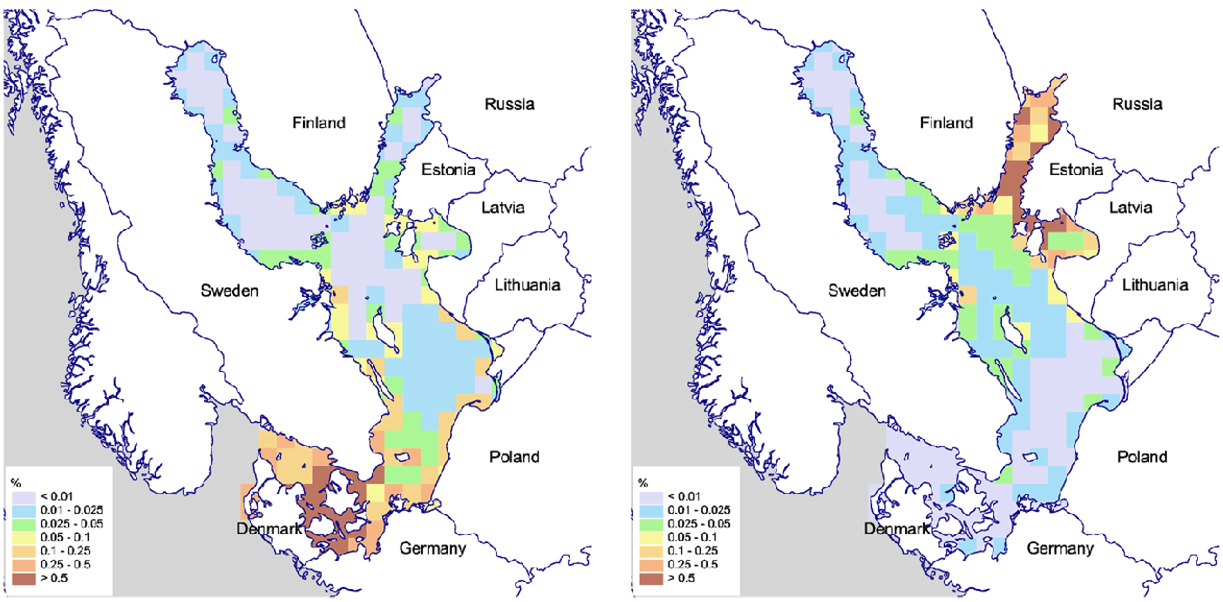
Figure 6.25. Comparison of calculated monthly mean Hg concentrations in precipitation with measured at the station Råö (SE14). Units: ng/L.

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.

7. Atmospheric Supply of PCDD/Fs to the Baltic Sea in 2005

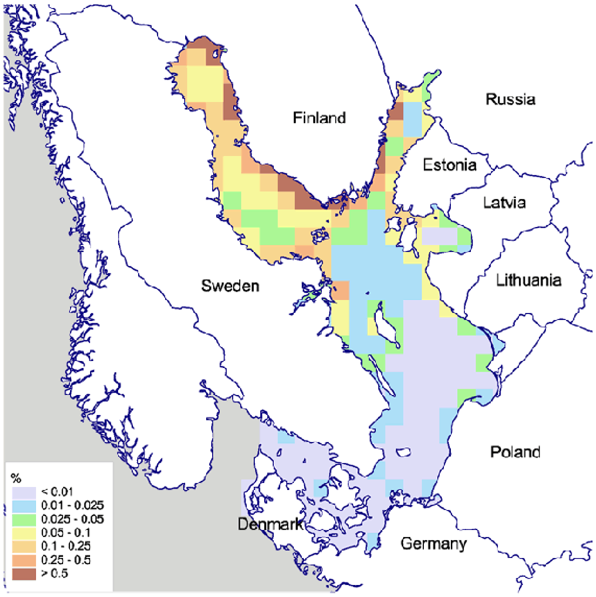
In this chapter the results of model evaluation of dioxins and furans (PCDD/Fs) atmospheric input to the Baltic Sea and its sub-basins for 2005 is presented. Modelling of PCDD/F atmospheric transport and depositions was carried out using MSC-E Eulerian Persistent Organic Pollutant transport model MSCE-POP (Gusev et al., 2005). Latest available official information on PCDD/F emission from HELCOM countries and other European countries was used in computations. Based on these data levels of annual and monthly PCDD/F 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.

7.1 PCDD/Fs emissions

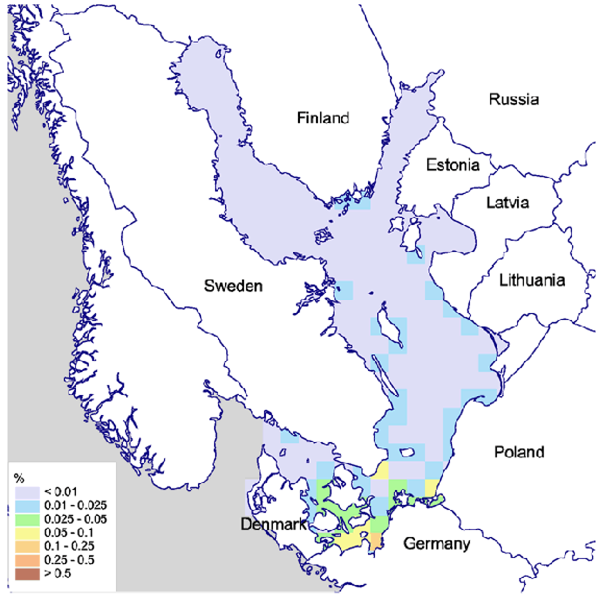


Denmark Estonia

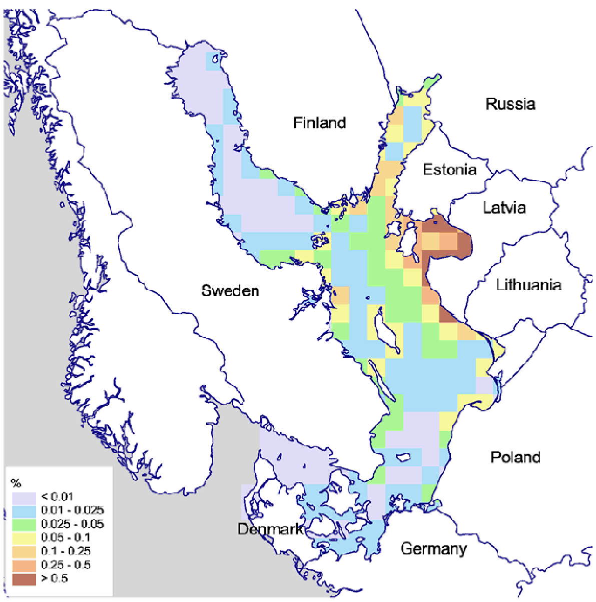
Figure 7.1. Maps with the fractions (in %) of annual total anthropogenic PCDD/F emissions from HELCOM Parties deposited over the Baltic Sea in 2005.



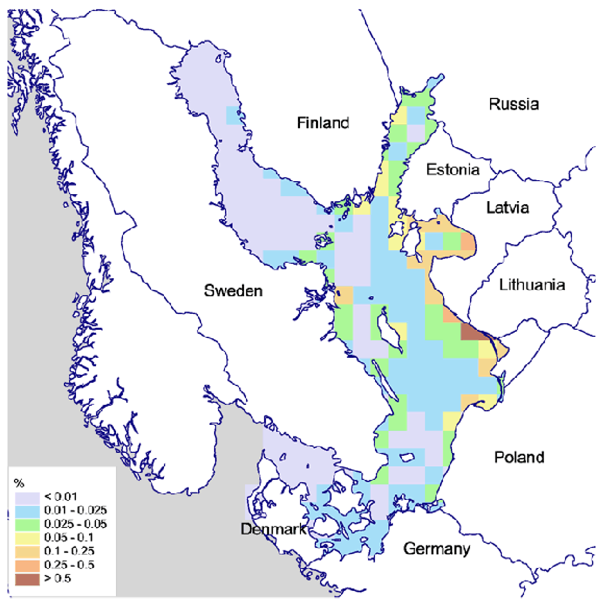
Finland



Germany

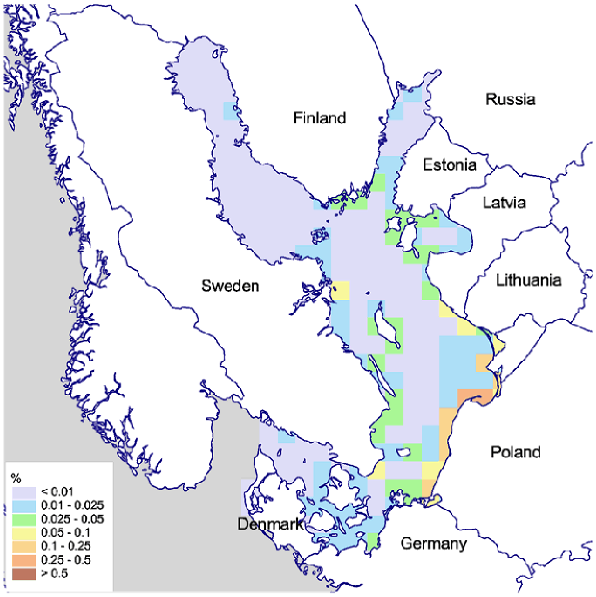


Latvia

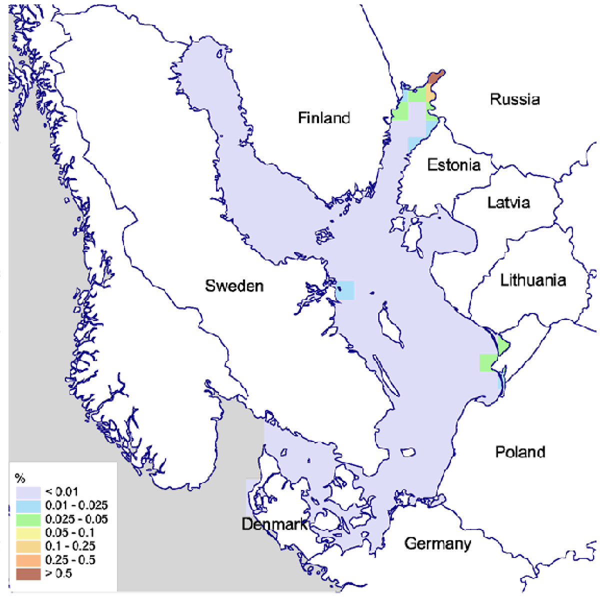


Lithuania

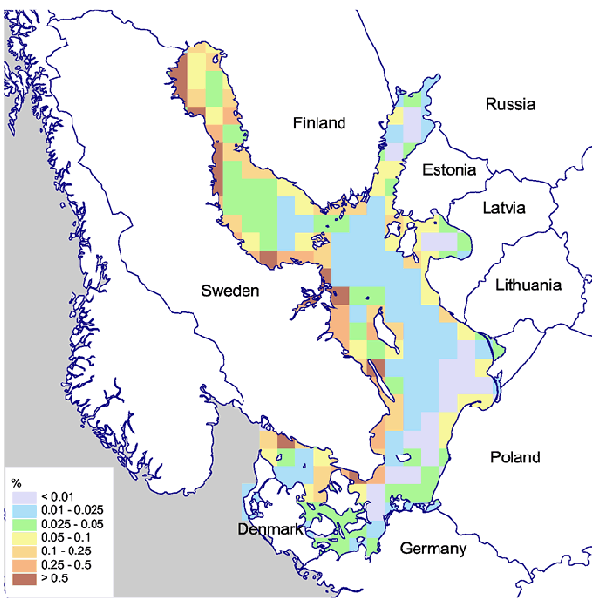
Figure 7.1 (cont.). Maps with the fractions (in %) of annual total anthropogenic PCDD/F emissions from HELCOM Parties deposited over the Baltic Sea in 2005.



Poland



Russia



Sweden

Figure 7.1 (cont.). Maps with the fractions (in %) of annual total anthropogenic PCDD/F emissions from HELCOM Parties deposited over the Baltic Sea in 2005.

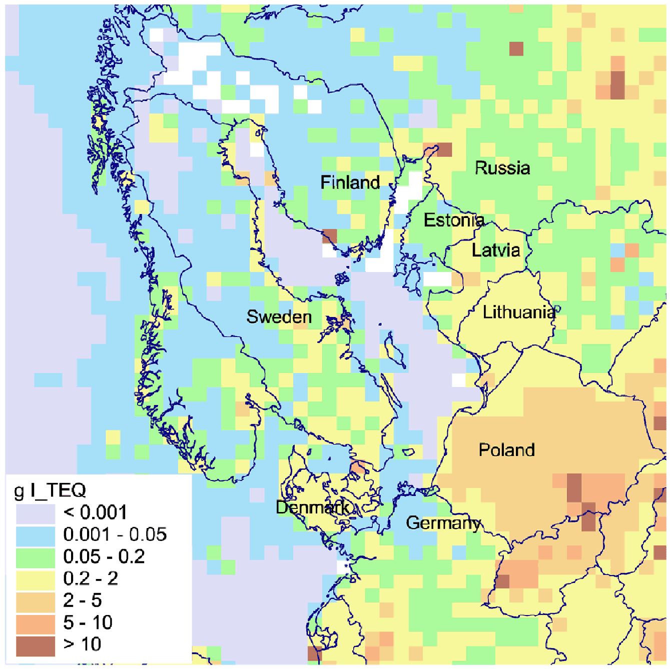


Figure 7.2. Annual total anthropogenic emissions of PCDD/F in the Baltic Sea region for 2005, g TEQ/y.

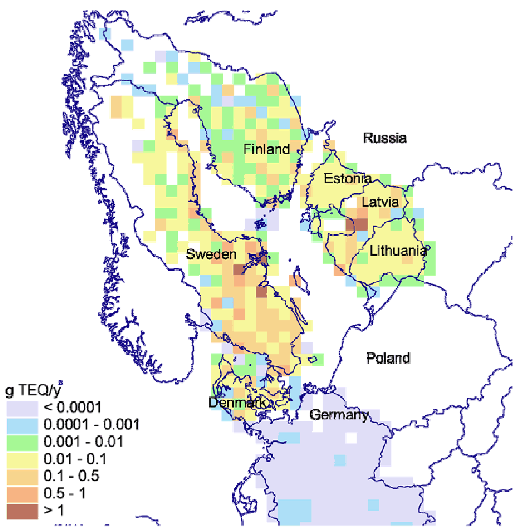


Figure 7.3. Annual PCDD/F emission of HELCOM countries from Combustion in Power Plants and Industry sector for 2005.

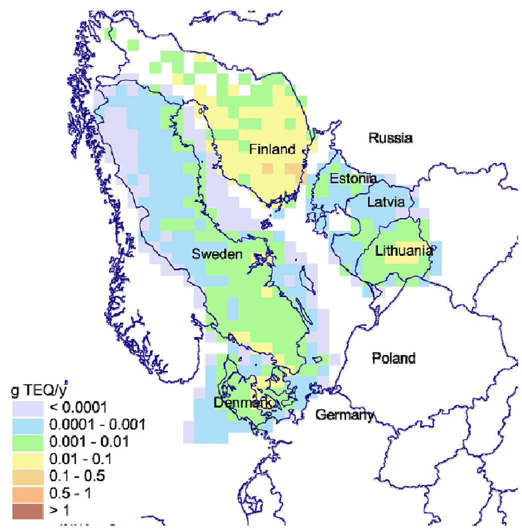


Figure 7.4. Annual PCDD/F emission of HELCOM countries from Transport sources below 1000 m sector for 2005.

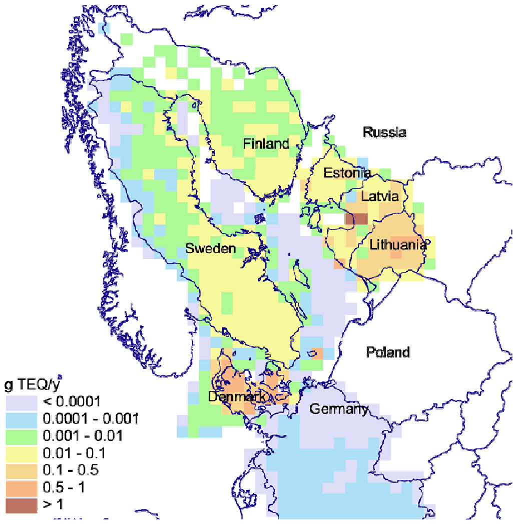


Figure 7.5. Annual PCDD/F emission of HELCOM countries from Commercial, Residential and Other Stationary Combustion sector for 2005.

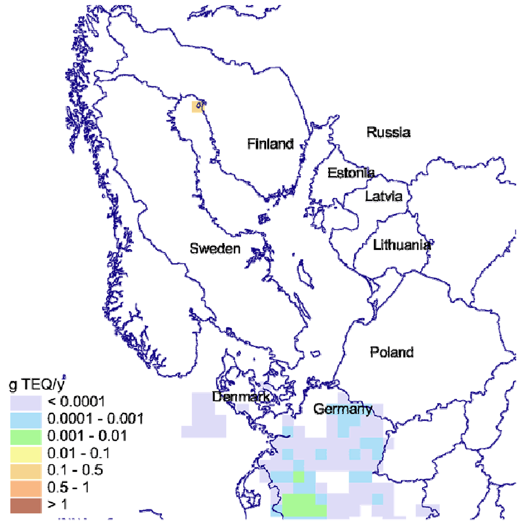


Figure 7.6. Annual PCDD/F emission of HELCOM countries from Fugitive Emissions From Fuels sector for 2005.

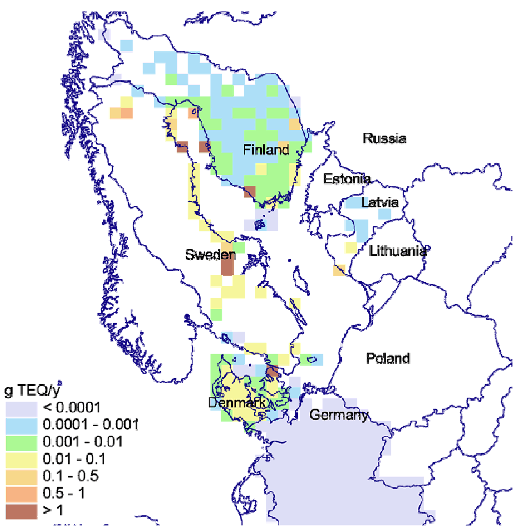


Figure 7.7. Annual PCDD/F emission of HELCOM countries from Industrial Processes sector for 2005

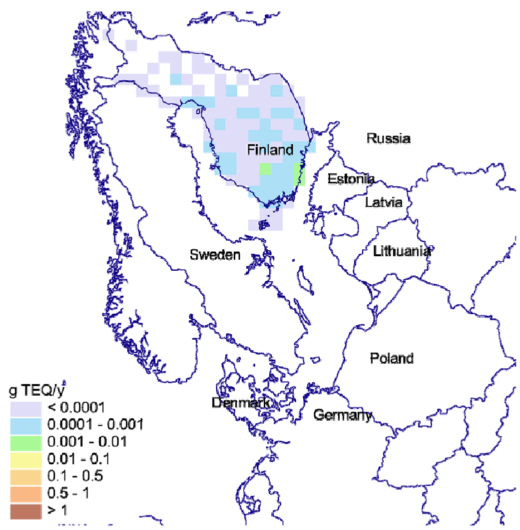


Figure 7.8. Annual PCDD/F emission of HELCOM countries from Solvent and Other Product Use sector for 2005.

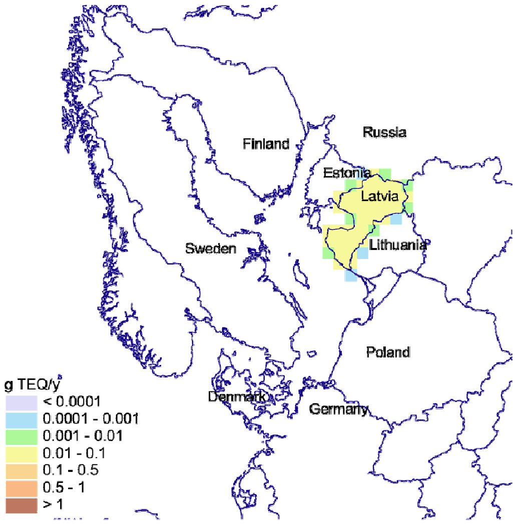


Figure 7.9. Annual PCDD/F emission of HELCOM countries from Agriculture sector for 2005

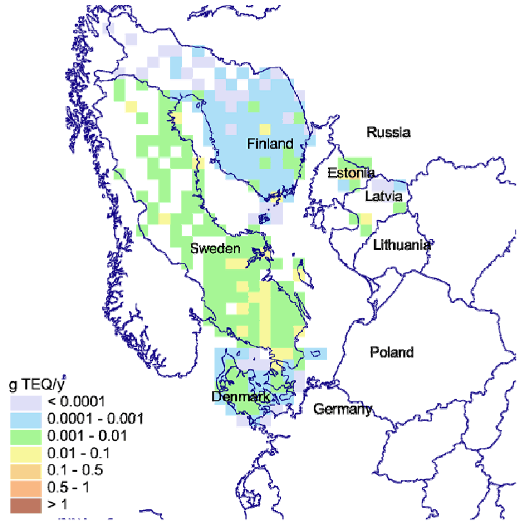


Figure 7.10. Annual PCDD/F emission of HELCOM countries from Waste sector for 2005.

Table 7.1. Annual total PCDD/F anthropogenic emissions of HELCOM countries from different sectors for 2005, in g TEQ per year

NFR emission sector	Sector name	DK	EE	FI	DE	LV	LT	PL	RU	SE
1	Combustion in Power Plants and Industry	2.4	1.2	17.2	0.01	10.04	1.4	40.9	655	25.4
2	Transport	0.3	0.05	2.7	NA	0.02	0.2	0.6		0.6
3	Commercial, Residential and Other Stationary Combustion	16.3	1.8	1.1	0.02	7.8	9.2	204.3		3.03
4	Fugitive Emissions From Fuels	< 0.01	NA	0.2	0.04	0	0	2.6		NE
5	Industrial Processes	6.3	0	4.9	< 0.01	0.3	0	12.3		8.5
6	Solvent and Other Product Use	0	0	0.02	NA	0	0	0		NA
7	Agriculture	0	NA	0	NA	1.05	0	0.7		NA
8	Waste	0.04	0.2	0.1	< 0.01	0.02	0	155.3		1.06
9	Other				NA					
Total		**25.3**	**3.2**	**26.2**	**0.1**	**19.2**	**10.9**	**416.4**	**655**	**38.6**

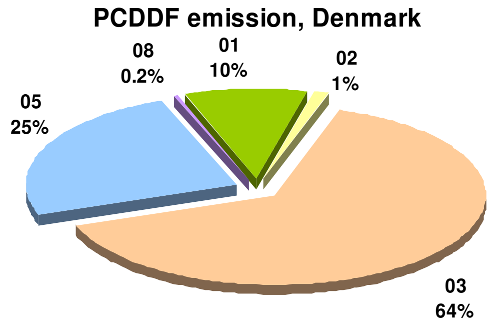


Figure 7.11. Percentage of annual total PCDD/F emission from different sectors in Denmark for 2005 5.1 7.01

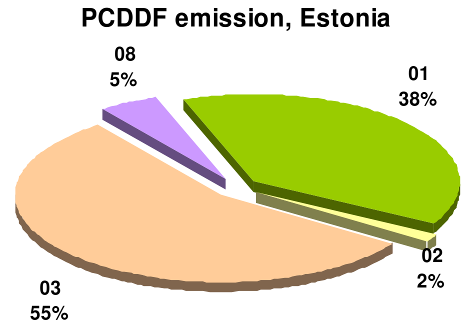


Figure 7.12. Percentage of annual total PCDD/F emission from different sectors in Estonia for 2005

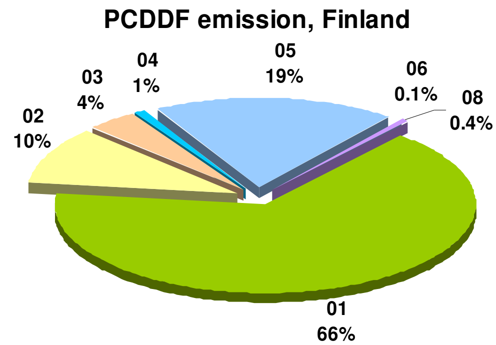


Figure 7.13. Percentage of annual total PCDD/F emission from different sectors in Finland for 2005

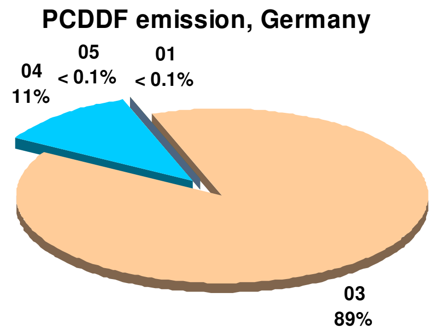


Figure 7.14. Percentage of annual total PCDD/F emission from different sectors in Germany for 2005

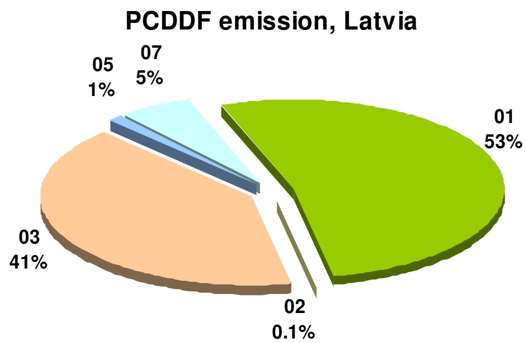


Figure 7.15. Percentage of annual total PCDD/F emission from different sectors in Latvia for 2005

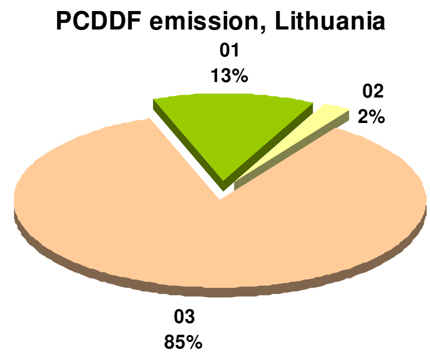


Figure 7.16. Percentage of annual total PCDD/F emission from different sectors in Lithuania for 2005

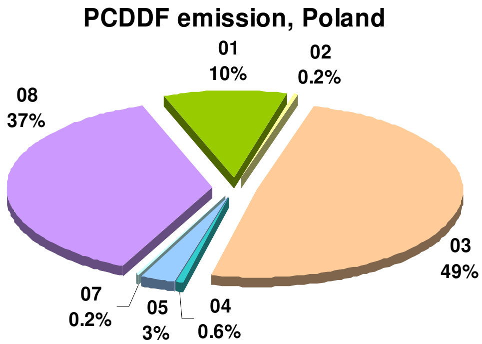


Figure 7.17. Percentage of annual total PCDD/F emission from different sectors in Poland for 2005

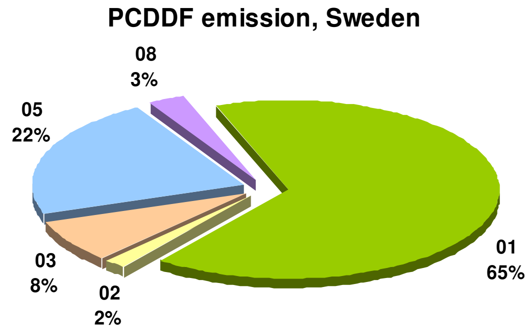


Figure 7.18. Percentage of annual total PCDD/F emission from different sectors in Sweden for 2005

Table 7.2. Annual total anthropogenic emissions of PCDD/Fs of HELCOM countries and other EMEP countries in period 1990-2005, g TEQ/year (Unofficial emissions are shaded).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Denmark	67	64	59	53	51	49	47	44	37	31	32	30	27	29	24	25
Estonia	5.7	5.4	4.3	3.6	3.8	4.5	4.9	4.8	3.8	3.4	3.4	3.5	3.7	4.1	3.7	3.3
Finland	30	33	31	32	33	34	32	32	32	32	31	31	32	32	32	26
Germany	102	93	75	71	69	78	75	81	75	72	74	74	72	72	74	74
Latvia	7	8	7	8	9	11	13	14	14	15	14	11	15	16	18	19
Lithuania	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	6.0	5.0	4.3	12.7	11.9	12.4	10.8	10.9
Poland	529	535	517	592	520	515	484	440	381	381	333	447	433	482	387	416
Russia	991	947	901	878	825	769	637	614	606	625	631	643	655	686	716	747
Sweden	60	53	50	53	44	40	38	37	35	34	33	34	34	33	36	39
HELCOM	**1796**	**1744**	**1650**	**1697**	**1559**	**1506**	**1337**	**1271**	**1190**	**1199**	**1156**	**1286**	**1285**	**1367**	**1302**	**1360**
Albania	43	43	43	43	43	43	43	43	43	43	43	43	44	44	44	44
Armenia	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47
Austria	160	135	76	67	56	58	60	60	56	54	52	55	42	42	41	43
Azerbaijan	98	98	98	98	98	98	98	98	98	98	98	99	100	101	102	102
Belarus	16	16	16	16	16	16	16	16	16	15	18	23	25	26	37	38
Belgium	569	563	529	496	489	402	347	291	235	180	124	88	59	62	65	65
Bosnia and Herzegovina	67	67	67	67	67	67	67	67	67	67	67	65	63	61	59	57
Bulgaria	554	535	515	495	476	456	341	310	288	245	233	201	219	255	239	230
Croatia	179	165	152	138	124	111	97	95	111	98	109	76	75	97	93	93
Cyprus	5.7	5.7	5.9	6.0	6.2	6.2	6.3	6.3	6.3	6.3	6.5	6.4	6.5	5.5	5.0	5.1
Czech Republic	1252	1220	1220	1140	1135	1135	922	830	767	643	744	620	177	114	187	179
France	1768	1817	1837	1895	1894	1695	1480	1044	939	614	524	390	363	240	303	220
Georgia	67	67	67	67	67	67	67	67	67	67	67	67	67	67	67	67
Greece	279	279	279	279	279	279	279	279	279	279	279	255	231	207	183	159
Hungary	172	148	104	103	100	95	90	84	74	77	74	76	75	74	74	92
Iceland	9	9	9	7.7	7.0	6.0	5.3	5.1	4.2	3.4	3.1	2.8	2.5	2.1	1.5	1.5
Ireland	27	27	27	27	27	27	27	27	27	27	27	27	27	26	27	26
Italy	529	551	532	491	478	503	454	466	446	416	396	308	293	288	298	298
Kazakhstan	40	40	40	40	40	40	40	40	40	40	40	40	41	41	41	42
Luxembourg	45	40	34	29	23	24	16	16	8	6.7	5.4	4.1	2.9	1.6	1.6	1.6
Monaco	2.4	2.4	2.7	2.9	3.2	3.2	3.4	3.8	3.6	3.6	3.7	4.0	3.5	2.9	2.6	2.6
Netherlands	743	979	752	525	297	66	56	116	44	33	31	30	29	26	28	28
Norway	130	98	96	95	94	71	50	41	35	39	34	33	32	29	32	24
Portugal	844	844	844	844	844	844	844	844	844	844	844	790	736	682	628	574
Republic of Moldova	14	11	7	5.5	5.1	3.0	3.4	2.9	6.4	2.4	2.4	2.2	2.5	3.9	5.2	5.5
Romania	113	113	113	113	113	113	113	113	113	87	101	104	103	102	100	99
Serbia and Montenegro	172	172	172	172	172	172	172	172	172	172	172	170	169	167	166	164
Slovakia	136	132	128	124	120	116	106	96	109	98	90	87	91	70	65	86
Slovenia	16	16	15	13	13	12	12	11	11	10	10	9	9	10	9	9
Spain	176	181	190	186	180	155	154	125	128	135	140	133	136	138	145	146
Switzerland	175	159	149	137	122	105	96	88	81	63	54	42	29	17	17	17
The FYR of Macedonia	166	166	166	166	166	166	166	166	166	166	166	166	166	163	163	163
Turkey	1012	1012	1012	1012	1012	1012	1012	1012	1012	1012	1012	1018	1024	1029	1035	1041
Ukraine	1022	1022	1022	1022	1022	1022	1022	1022	1022	1022	1022	1024	1026	1027	1029	1030
United Kingdom	1112	1091	1065	859	674	713	452	374	279	256	229	219	203	202	230	205
EMEP, kg TEQ/ y	**14**	**14**	**13**	**13**	**12**	**11**	**10**	**9**	**9**	**8.2**	**8.0**	**7.6**	**7.0**	**6.8**	**6.9**	**6.8**

Expert estimates:

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

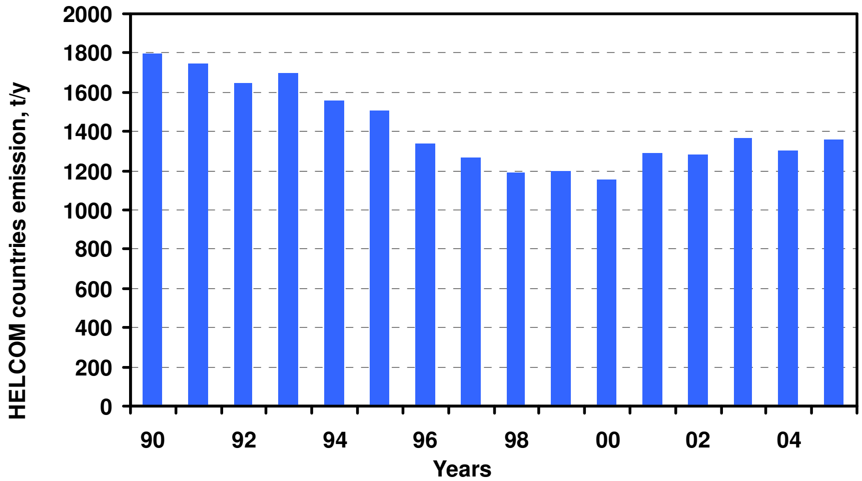


Figure 7.17. Time-series of total annual PCDD/F emissions of HELCOM countries in 1990-2005, g I-TEQ/y.

7.2 Annual deposition of PCDD/F

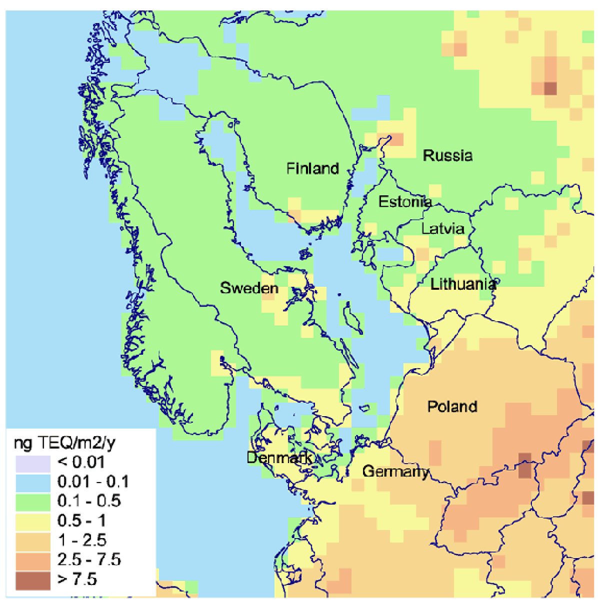


Figure 7.20. Annual deposition fluxes of PCDD/Fs over the Baltic Sea region for 2005, ng TEQ/m^2/y.

7.3 Monthly depositions of PCDD/F

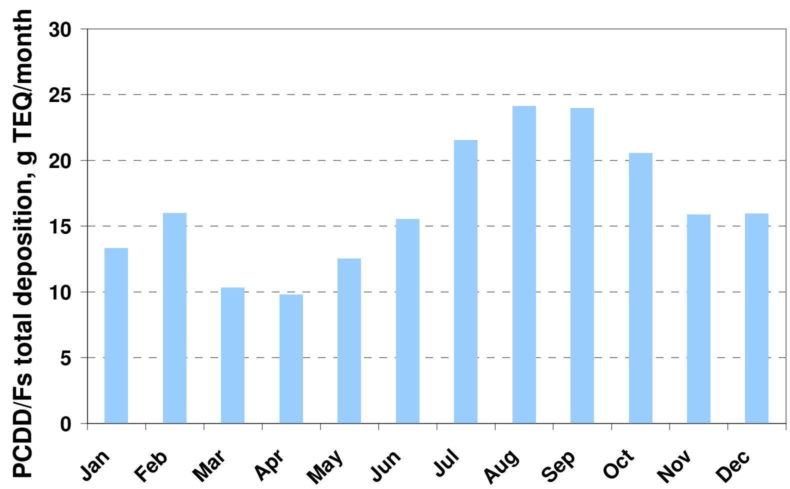


Figure 7.21. Monthly depositions of PCDD/Fs over the Baltic Sea for 2005, g TEQ/month.

Table 7.3. Monthly depositions of PCDD/Fs over the Baltic Sea for 2005, g TEQ/month.

Month	PCDD/Fs
Jan	13
Feb	16
Mar	10
Apr	10
May	13
Jun	16
Jul	22
Aug	24
Sep	24
Oct	21
Nov	16
Dec	16

7.4 Source allocation of PCDD/F deposition

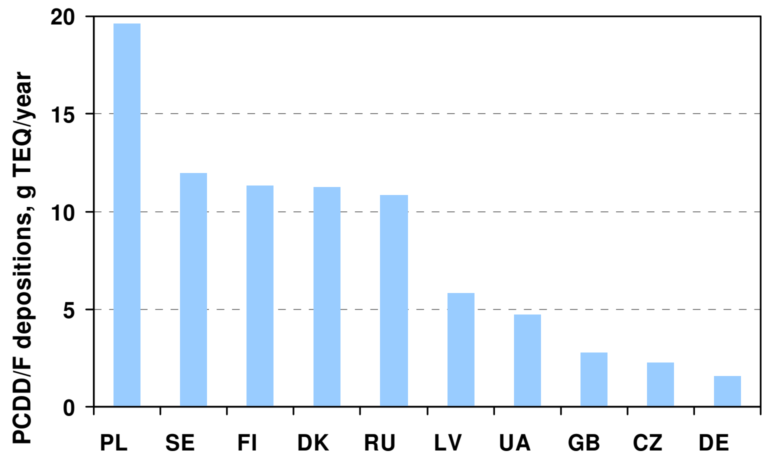


Figure 7.22. Top ten countries with the highest contribution to annual deposition of PCDD/Fs over Baltic Sea for 2005, g TEQ/y.

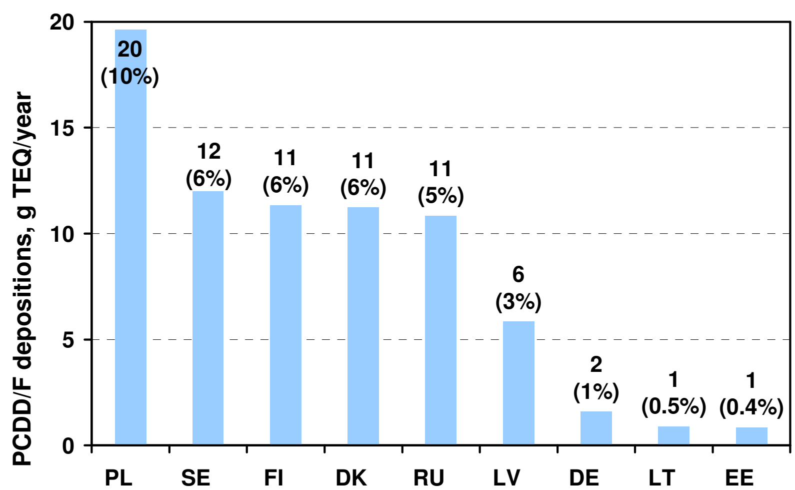


Figure 7.23. Contributions (in %) of HELCOM countries to the total PCDD/F depositions to the Baltic Sea for 2005. HELCOM countries emissions of PCDD/Fs contributed 37% to the total annual PCDD/F depositions over the Baltic Sea in 2005. Contribution of other EMEP countries accounted for 11%. Significant contribution was made by other emission sources, in particular, remote emissions sources and re-emission of PCDD/Fs (52%).

Table 7.4. Two most significant contributors to the annual total depositions of PCDD/Fs to the six Baltic Sea sub-basins for 2005.

Sub-basin	Country (1)	%	Country (2)	%	*, %
GUB	Finland	25	Sweden	14	45
GUF	Russia	35	Finland	4	43
GUR	Latvia	23	Poland	6	52
BAP	Poland	18	Sweden	6	54
BES	Denmark	21	Poland	4	62
KAT	Denmark	23	Sweden	6	55
BAS	Poland	10	Sweden	6	52

* - contribution of re-emission and remote sources.

7.5 Comparison of model results with measurements

The performance of MSCE-POP model for computation of PCDD/F pollution levels within the European region was evaluated during the model review carried out in the framework of EMEP Task Force on Monitoring and Measurements. In particular, MSCE-POP model results on long-range transport of one of the toxic PCDD/F congeners 2,3,4,7,8-PeCDF for the EMEP region and the period 1990-2003 were compared with measurements of EMEP monitoring network and observations of other studies within the European region. One of the main conclusions of the TFMM Workshop on the Review of the EMEP Models on Heavy Metals and Persistent Organic Pollutants in Moscow in 2005 was that "the MSCE-POP model represents the state-of-the-science and fits to the purpose of evaluating the contributions of long-range transport to the environment impacts caused by POPs". It was recognized that the MSCE-POP model results demonstrated its ability to provide spatially and temporally resolved air concentrations and depositions of POPs across Europe. The model provided reasonable agreement with long-term temporal trends of air pollution at most EMEP monitoring sites.

Modelling results for PCDD/Fs obtained for 2004 were compared with available measurement data of monitoring campaign carried out in Denmark. The results of the comparison are presented in the previous Joint report of EMEP Centres for HELCOM (*Bartnicki et al.*, 2006).

In this report no results of comparison of modeling results with measurement is presented since there was no available measurements of dioxins and furans within the European region for 2005 were found.

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Appendix A: Tables with measurements available at HELCOM stations for 2005

Deposition of reduced and oxidized nitrogen at HELCOM sites

Site	Comp		jan	febr	mars	apr	may	june	july	aug	sept	oct	nov	dec	year	Total N
DE0009R	ammonium	mg N m/2	21.9	30.5	29.8	14.7	37.3	22.7	33.7	23.9	8.7	15.3	17.9	11.6	266.4	
DE0009R	nitrate	mg N m/2	16.5	37.4	27.8	12.7	33.2	20.2	27.5	21.4	10.7	18.4	16.3	15.3	257.6	524.0
DE0009R	precipitation_amount	mm	30.6	39.5	29.7	21.8	59.9	28.8	53.6	56.5	26.5	61.7	38.5	44.5	491.8	
DK0005R	ammonium	mg N m/2	11.7	11.7	51.2	32.8	30.8	49.9	38.5	9.1	18.3	12.3	15.8	13.0	295.2	
DK0005R	nitrate	mg N m/2	11.2	10.8	38.1	21.7	28.4	39.2	36.6	9.5	15.5	18.1	18.0	16.6	263.8	559.0
DK0005R	precipitation_amount	mm	31.1	18.1	34.8	17.1	33.1	48.7	97.5	19.6	18.2	54.6	23.1	37.1	432.8	
DK0008R	ammonium	mg N m/2	12.0	9.3	11.6	19.2	77.0	23.0	31.1	21.2	21.0	16.4	26.5	7.5	248.2	
DK0008R	nitrate	mg N m/2	16.1	13.5	16.7	14.5	66.7	27.3	27.6	19.2	19.1	22.6	33.6	13.9	273.2	521.4
DK0008R	precipitation_amount	mm	43.6	34.5	23.4	14.4	89.9	67.7	102.1	58.1	32.8	60.0	46.4	19.0	591.9	
DK0020R	ammonium	mg N m/2	12.0	25.0	36.6	26.9	134.2	55.0	77.5	36.4	15.4	10.5	23.4	0.0	567.9	
DK0020R	nitrate	mg N m/2	19.6	37.0	44.1	6.3	39.4	31.2	53.9	40.7	19.1	13.7	33.0	0.0	359.5	927.4
DK0020R	precipitation_amount	mm	33.4	44.6	41.7	5.7	53.4	25.6	29.8	79.7	33.0	26.1	35.4	0.0	408.5	
EE0009R	ammonium	mg N m/2	11.3	3.4	1.0	1.0	16.4	13.0	4.2	2.1	0.5	4.5	12.1	3.1	73.6	
EE0009R	nitrate	mg N m/2	21.7	7.5	2.8	2.5	10.3	9.8	11.1	57.5	4.9	6.7	11.7	4.2	152.5	226.1
EE0009R	precipitation_amount	mm	88.7	17.6	7.3	6.6	58.9	84.6	59.6	80.6	33.4	41.1	47.5	29.3	555.0	
EE0011R	nitrate	mg N m/2	23.0	7.5	1.8	4.5	14.7	8.1	1.6	4.2	4.0	17.6	23.0	42.1	154.0	
EE0011R	precipitation_amount	mm	56.5	21.3	7.4	2.3	45.9	42.4	37.9	75.2	38.2	59.3	86.5	95.6	567.5	
FI0009R	ammonium	mg N m/2	11.5	3.3	-	7.5	12.5	5.8	6.4	18.7	3.4	5.5	11.0	6.4	89.1	
FI0009R	nitrate	mg N m/2	18.6	8.3	-	8.8	16.7	8.9	8.1	20.0	5.8	9.5	21.3	16.3	138.0	227.1
FI0009R	precipitation_amount	mm	17.4	3.8	0.3	6.8	24.3	32.6	69.2	117.6	8.2	26.7	26.5	16.5	349.8	
FI0017R	ammonium	mg N m/2	13.9	3.3	1.3	8.2	15.1	9.2	9.8	18.0	12.0	14.8	25.0	14.1	144.5	
FI0017R	nitrate	mg N m/2	25.8	4.6	1.2	8.7	14.8	14.1	9.9	22.4	15.6	16.1	31.1	20.5	184.8	329.3
FI0017R	precipitation_amount	mm	64.2	2.8	2.8	11.3	77.5	74.9	53.0	104.4	34.9	26.7	56.8	44.1	553.2	

Site	Comp		jan	febr	mars	apr	may	june	july	aug	sept	oct	nov	dec	year	Total N
FI0053R	ammonium	mg N m/2	6.5	1.7	0.7	21.3	20.2	1.3	8.3	11.9	4.3	8.2	15.0	8.9	108.2	
FI0053R	nitrate	mg N m/2	8.5	2.2	1.6	16.9	16.2	2.1	8.6	7.7	5.7	9.2	18.6	9.4	106.2	214.4
FI0053R	precipitation_amount	mm	26.5	4.5	2.4	33.8	53.5	11.4	66.7	57.8	53.0	22.5	54.1	28.4	414.2	
LT0015R	ammonium	mg N m/2	10.5	3.3	18.5	13.9	28.0	11.4	27.1	36.8	4.2	9.8	18.5	16.1	198.0	
LT0015R	nitrate	mg N m/2	34.3	5.6	29.4	11.0	19.9	18.8	25.5	32.3	3.9	12.2	29.2	25.4	247.5	445.5
LT0015R	precipitation_amount	mm	31.3	6.9	36.9	12.3	24.5	28.0	70.1	170.2	7.1	31.5	61.5	33.1	513.4	
LV0010R	ammonium	mg N m/2	21.4	11.0	18.6	9.0	8.7	13.7	32.8	22.6	8.7	22.4	46.5	11.3	221.2	
LV0010R	nitrate	mg N m/2	30.9	13.7	23.2	7.9	6.6	13.7	26.6	19.9	8.9	18.3	64.6	23.9	253.2	474.4
LV0010R	precipitation_amount	mm	69.2	24.3	33.9	7.4	23.0	21.4	123.0	151.8	16.6	48.6	101.9	58.1	679.0	
LV0016R	ammonium	mg N m/2	21.9	7.7	6.8	39.3	38.4	19.6	20.4	21.6	21.0	8.6	22.0	24.0	246.0	
LV0016R	nitrate	mg N m/2	21.4	8.2	5.8	21.7	19.3	12.9	9.8	12.9	10.7	10.9	13.9	5.7	145.0	391.0
LV0016R	precipitation_amount	mm	57.2	15.7	25.4	38.6	100.9	97.7	92.7	112.5	37.9	46.1	40.4	31.0	696.0	
PL0004R	ammonium	mg N m/2	17.5	7.6	20.4	25.0	48.3	14.2	18.5	21.0	22.2	5.0	20.0	15.6	227.8	
PL0004R	nitrate	mg N m/2	27.4	11.5	28.7	15.0	34.3	14.1	15.6	22.2	19.0	7.1	26.3	28.4	245.8	473.6
PL0004R	precipitation_amount	mm	46.5	21.0	35.0	9.8	52.0	12.9	52.4	58.6	34.9	28.6	66.1	60.8	477.0	
RU0016R	ammonium	mg N m/2	11.5	18.0	11.6	17.7	12.2	16.9	11.6	35.0	7.4	14.1	14.7	31.0	201.6	
RU0016R	nitrate	mg N m/2	16.0	14.8	18.5	12.1	18.2	12.1	9.7	9.5	3.0	7.5	10.8	20.3	152.5	354.1
RU0016R	precipitation_amount	mm	55.4	81.5	52.9	35.5	91.9	49.9	134.3	45.6	13.3	39.0	41.7	67.0	708.0	
SE0005R	ammonium	mg N m/2	1.5	1.3	0.8	6.7	10.8	22.6	11.0	5.8	12.1	6.0	7.9	3.6	90.1	
SE0005R	nitrate	mg N m/2	7.8	4.0	3.5	6.5	7.7	11.3	9.0	9.8	9.8	5.6	10.1	13.9	97.6	187.7
SE0005R	precipitation_amount	mm	51.0	20.5	19.1	27.5	95.3	85.5	115.0	114.1	87.7	25.7	40.5	50.3	729.7	
SE0011R	ammonium	mg N m/2	53.8	34.7	20.8	48.7	27.0	40.5	84.4	27.2	16.0	23.3	34.7	25.5	436.5	
SE0011R	nitrate	mg N m/2	52.1	36.4	23.2	27.9	24.5	34.3	34.8	25.7	13.5	23.8	35.9	26.5	358.5	795.0
SE0011R	precipitation_amount	mm	100.3	40.8	32.5	19.3	61.5	73.1	103.1	83.7	20.3	63.0	63.3	46.7	707.0	

Site	Comp		jan	febr	mars	apr	may	june	july	aug	sept	oct	nov	dec	year	Total N
SE0014R	ammonium	mg N m/2	25.1	18.1	9.7	34.4	50.3	41.5	33.1	15.2	17.8	15.9	22.8	4.3	287.3	
SE0014R	nitrate	mg N m/2	31.1	22.4	12.6	23.4	24.0	33.1	27.7	16.9	19.4	21.0	28.4	9.6	269.2	556.5
SE0014R	precipitation_amount	mm	71.1	22.3	23.8	21.8	49.2	54.7	105.8	47.1	45.7	67.3	63.3	24.3	596.4	
SE0053R	ammonium	mg N m/2	0.2	6.3	2.1	24.2	16.8	17.0	4.4	21.8	22.8	0.3	8.9	5.7	130.6	
SE0053R	nitrate	mg N m/2	0.5	14.2	5.4	17.9	10.4	13.2	5.7	20.2	32.5	0.5	13.6	15.3	149.4	280.0
SE0053R	precipitation_amount	mm	1.4	37.4	11.7	33.5	47.1	56.3	63.0	80.9	162.7	1.5	44.8	40.4	580.6	

Deposition of heavy metals (Pb, Cd and Hg) and lindane (γ HCH) at HELCOM sites

Site	Comp		jan	febr	mars	apr	may	june	july	aug	sept	oct	nov	dec	year
DE0009R	cadmium	µg Cd /m2	1.22	2.75	1.41	0.90	1.96	1.01	1.90	1.72	0.71	0.71	1.09	1.03	16.42
DK0008R	cadmium	µg Cd /m2	2.16	1.01	0.76	0.80	1.60	1.31	2.48	0.96	2.18	1.31	2.20	1.08	17.83
DK0020R	cadmium	µg Cd /m2	2.18	2.76	2.41	1.14	2.75	2.08	1.67	1.78	1.59	1.41	2.08	-	21.86
EE0009R	cadmium	µg Cd /m2	3.56	3.24	0.30	1.10	3.44	0.85	0.60	0.81	0.34	1.23	1.95	1.74	19.14
EE0011R	cadmium	µg Cd /m2	4.47	2.18	0.59	0.03	0.41	0.95	0.38	3.18	0.59	2.97	1.25	2.88	19.83
FI0017R	cadmium	µg Cd /m2	4.17	1.29	-	1.07	6.76	4.50	1.03	2.16	5.12	4.12	8.27	2.56	41.03
FI0053R	cadmium	µg Cd /m2	0.80	0.45	0.27	1.67	3.07	0.78	1.13	1.36	1.01	2.57	2.64	0.66	16.41
LT0015R	cadmium	µg Cd /m2	5.08	3.88	5.87	7.00	3.48	3.31	4.35	5.70	1.62	4.93	8.33	4.57	58.23
LV0010R	cadmium	µg Cd /m2	4.87	4.69	5.43	1.42	3.84	1.70	5.62	8.32	0.75	5.86	5.83	3.69	52.02
LV0016R	cadmium	µg Cd /m2	2.77	0.93	0.51	2.18	2.77	2.76	4.06	7.35	1.00	2.67	2.06	1.27	30.51
PL0004R	cadmium	µg Cd /m2	2.33	1.47	2.10	1.18	4.68	0.52	1.57	2.34	3.84	1.14	2.64	3.04	26.83
SE0051R	cadmium	µg Cd /m2	1.14	2.60	-	-	1.14	3.10	5.67	0.88	0.90	1.26	1.35	2.72	20.98
DE0009R	lead	µg Pb /m2	23.9	70.0	43.6	20.9	56.1	35.6	53.4	28.4	21.3	19.5	28.4	25.5	426.7
DK0008R	lead	µg Pb /m2	20.4	32.5	16.9	33.3	81.5	46.7	73.2	31.8	59.1	41.9	60.1	30.8	528.2
DK0020R	lead	µg Pb /m2	40.9	97.7	95.6	25.4	113.1	63.7	43.0	48.9	43.5	47.0	41.1	-	660.4
EE0009R	lead	µg Pb /m2	44.5	61.4	8.5	12.3	21.5	42.5	30.0	40.5	17.0	20.5	19.5	14.5	332.5
EE0011R	lead	µg Pb /m2	28.0	21.8	25.2	1.4	20.3	23.7	19.0	53.0	3.7	29.7	62.3	28.8	316.3
FI0017R	lead	µg Pb /m2	148.5	26.6	-	26.9	100.9	85.4	25.9	45.0	113.6	86.6	255.2	89.0	1002.9
FI0053R	lead	µg Pb /m2	25.5	9.2	2.9	42.1	70.0	7.7	27.2	29.5	32.3	39.1	83.8	26.3	395.3
LT0015R	lead	µg Pb /m2	105.5	67.3	63.7	38.0	36.1	38.9	41.5	213.2	97.2	808.2	198.5	90.4	1802.2
LV0010R	lead	µg Pb /m2	241.2	100.4	126.2	18.5	37.5	40.3	122.6	137.6	18.8	56.0	172.3	121.1	1192.4
LV0016R	lead	µg Pb /m2	51.9	19.8	16.8	40.2	95.3	44.3	36.1	74.7	14.4	30.0	42.8	41.0	506.7
PL0004R	lead	µg Pb /m2	45.1	21.4	42.4	39.5	100.4	18.8	24.1	37.5	79.2	16.6	71.4	59.0	554.9
SE0051R	lead	µg Pb /m2	37.6	65.5	-	-	39.9	78.7	42.2	17.3	9.5	21.8	27.8	57.5	402.1
DE0009R	mercury	ng Hg /m2	237.6	351.8	325.1	143.0	737.2	470.8	917.3	564.1	212.9	259.0	322.5	158.4	4695.4
SE0014R	mercury	ng Hg /m2	369.6	162.8	370.5	581.4	2100.0	1168.5	-9999.99	963.9	562.0	316.0	289.0	124.6	7008.3
DE0009R	gamma_HCH	ng γ HCH/m2	5.0	40.4	36.8	67.6	77.4	32.7	50.0	50.4	20.7	98.4	47.4	23.4	550.1

Air concentrations of reduced and oxidized nitrogen at HELCOM sites

Site	Component	Unit	Jan	Febr	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
DE0009R	nitrogen_dioxide	µg N/m3	2.264	2.264	2.196	1.792	1.817	1.56	1.663	1.758	2.165	2.216	3.45	2.986	2.174
DK0005R	nitrogen_dioxide	µg N/m3	1.285	1.786	2.151	2.37	1.591	0.95	1.055	1.074	1.847	1.747	1.98	1.715	1.612
DK0008R	nitrogen_dioxide	µg N/m3	1.518	1.651	1.446	1.481	-	1.187	1.031	0.875	1.277	1.766	1.799	1.401	1.396
EE0009R	nitrogen_dioxide	µg N/m3	3.458	4.782	4.248	3.143	2.645	2.175	1.658	1.35	1.723	2.871	3.89	5.2	3.115
EE0011R	nitrogen_dioxide	µg N/m3	3.146	3.207	2.987	5.26	3.303	2.893	1.968	1.262	1.838	2.768	4.567	3.731	3.057
FI0009R	nitrogen_dioxide	µg N/m3	1.185	1.41	1.505	1.969	1.739	1.227	1.37	1.071	1.233	-	-	-	1.418
FI0017R	nitrogen_dioxide	µg N/m3	1.663	1.93	1.782	1.649	1.732	1.317	0.891	0.897	1.221	1.187	1.581	1.729	1.461
LT0015R	nitrogen_dioxide	µg N/m3	1.263	1.185	1.067	1.613	1.038	1.016	0.926	0.815	0.854	1.154	1.961	1.685	1.212
LV0010R	nitrogen_dioxide	µg N/m3	1.03	0.691	0.791	0.893	0.733	0.611	0.532	0.55	0.618	0.741	1.365	1.413	0.828
LV0016R	nitrogen_dioxide	µg N/m3	0.721	0.809	0.574	0.539	0.295	0.247	0.469	0.365	0.381	0.582	0.812	1.315	0.592
PL0004R	nitrogen_dioxide	µg N/m3	1.413	1.832	1.632	1.932	1.094	1.063	1.284	1.389	1.653	1.997	2.84	2.548	1.722
SE0005R	nitrogen_dioxide	µg N/m3	0.169	0.203	0.15	0.081	0.066	0.081	0.069	0.061	0.069	0.151	0.153	0.19	0.12
SE0008R	nitrogen_dioxide	µg N/m3	0.942	0.814	0.919	1.326	1.391	1.112	0.768	0.763	0.94	1.02	1.573	0.932	1.04
SE0011R	nitrogen_dioxide	µg N/m3	1.948	1.75	1.506	1.187	1.247	1.01	0.887	1.053	1.467	1.583	2.755	1.633	1.475
SE0014R	nitrogen_dioxide	µg N/m3	1.555	1.653	1.675	1.559	1.346	1.263	1.109	1.074	1.231	1.466	2.328	1.624	1.49
DE0009R	sum_ammonia_and_ammonium	µg N/m3	0.834	1.834	2.75	3.913	2.398	1.58	1.572	1.413	2.1	1.635	2.021	1.377	1.955
FI0009R	sum_ammonia_and_ammonium	µg N/m3	0.455	0.538	0.306	0.709	0.386	0.33	0.352	0.276	0.424	0.559	0.843	0.212	0.431
FI0017R	sum_ammonia_and_ammonium	µg N/m3	0.461	0.657	0.354	0.603	0.497	0.336	0.512	0.459	0.606	0.822	1.073	0.356	0.539
LT0015R	sum_ammonia_and_ammonium	µg N/m3	1.342	1.85	1.492	2.432	2.358	2.471	1.273	1.659	2.826	2.139	2.24	1.184	1.934
LV0010R	sum_ammonia_and_ammonium	µg N/m3	0.688	0.644	0.857	1.161	1.065	1.098	0.999	0.845	1.248	1.145	1.373	0.816	0.994
LV0016R	sum_ammonia_and_ammonium	µg N/m3	0.789	1.038	0.564	1.188	0.916	0.959	1.017	0.818	0.925	1.295	1.301	1.038	0.985
PL0004R	sum_ammonia_and_ammonium	µg N/m3	0.755	1.592	1.293	1.967	1.412	1.412	2.086	1.508	1.753	1.674	2.172	1.094	1.557
SE0005R	sum_ammonia_and_ammonium	µg N/m3	0.058	0.456	0.482	0.254	0.212	0.191	0.216	0.155	0.216	0.301	0.099	0.137	0.23
SE0011R	sum_ammonia_and_ammonium	µg N/m3	0.624	1.06	1.014	2.695	1.617	1.279	1.125	0.625	1.258	1.439	1.115	0.734	1.248
SE0014R	sum_ammonia_and_ammonium	µg N/m3	0.416	1.259	0.917	1.828	1.204	0.794	0.735	0.648	0.962	1.098	0.816	0.582	0.947
DE0009R	sum_nitric_acid_and_nitrate	µg N/m3	0.762	1.165	1.234	1.449	1.148	0.721	0.563	0.63	0.939	1.109	1.2	0.856	0.969
DK0005R	sum_nitric_acid_and_nitrate	µg N/m3	-	-	-	-	-	0.836	0.67	0.635	1.255	1.299	0.961	0.862	0.931
DK0008R	sum_nitric_acid_and_nitrate	µg N/m3	0.614	0.912	0.643	1.417	1.014	0.681	0.498	0.522	0.933	0.972	0.799	0.49	0.787
FI0009R	sum_nitric_acid_and_nitrate	µg N/m3	0.275	0.397	0.304	0.539	0.346	0.359	0.335	0.278	0.377	0.53	0.536	0.257	0.375
FI0017R	sum_nitric_acid_and_nitrate	µg N/m3	0.326	0.431	0.247	0.435	0.268	0.19	0.188	0.214	0.264	0.367	0.494	0.234	0.304

Site	Component	Unit	Jan	Febr	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
LT0015R	sum_nitric_acid_and_nitrate	µg N/m3	0.598	0.622	0.814	0.982	0.691	0.447	0.346	0.455	0.537	0.488	1.05	0.546	0.63
LV0010R	sum_nitric_acid_and_nitrate	µg N/m3	0.451	0.441	0.467	0.701	0.413	0.379	0.247	0.261	0.271	0.396	0.73	0.351	0.423
LV0016R	sum_nitric_acid_and_nitrate	µg N/m3	0.337	0.393	0.241	0.314	0.193	0.155	0.141	0.171	0.339	0.418	0.393	0.125	0.267
PL0004R	sum_nitric_acid_and_nitrate	µg N/m3	0.537	0.792	0.689	0.87	0.593	0.531	0.384	0.446	0.376	0.592	1.073	0.646	0.625
SE0005R	sum_nitric_acid_and_nitrate	µg N/m3	0.038	0.265	0.272	0.061	0.069	0.049	0.04	0.043	0.077	0.059	0.046	0.071	0.09
SE0011R	sum_nitric_acid_and_nitrate	µg N/m3	0.502	0.569	0.632	1.265	0.735	0.368	0.293	0.315	0.567	0.751	0.779	0.399	0.601
SE0014R	sum_nitric_acid_and_nitrate	µg N/m3	0.432	0.884	0.62	0.939	0.782	0.525	0.469	0.477	0.688	0.724	0.644	0.349	0.632

Air Concentrations of heavy metals (Pb, Cd and Hg) and lindane (γ HCH) at HELCOM sites

DE0009R	cadmium	ng Cd/m3	0.102	0.406	0.238	0.164	0.09	0.062	0.049	0.075	0.161	0.404	0.285	0.158	0.181
LT0015R	cadmium	ng Cd/m3	0.201	0.3	0.141	0.197	0.054	0.147	0.06	0.094	0.135	0.257	0.262	0.143	0.165
LV0010R	cadmium	ng Cd/m3	0.27	0.286	0.124	0.231	0.301	0.208	0.054	0.228	0.165	0.211	0.277	0.183	0.21
LV0016R	cadmium	ng Cd/m3	0.225	0.564	0.1	0.142	0.09	0.072	0.05	0.126	0.178	0.252	0.201	0.178	0.179
SE0014R	cadmium	ng Cd/m3	0.087	0.32	0.116	0.21	0.079	0.06	0.041	0.05	0.16	0.347	0.19	0.1	0.145
DE0009R	lead	ng Pb/m3	4.644	14.955	8.446	6.265	3.84	2.509	2.095	3.425	6.24	13.021	10.338	6.64	6.805
DK0005R	lead	ng Pb/m3	4.212	6.693	12.566	-	-	1.994	2.372	2.417	5.391	15.414	5.445	6.634	5.874
DK0008R	lead	ng Pb/m3	2.591	9.704	3.755	5.474	2.717	2.184	1.76	1.406	3.951	11.133	4.247	4.101	4.367
LT0015R	lead	ng Pb/m3	7.474	11.532	6.452	5.947	2.819	8.65	3.819	3.468	4.697	7.981	9.19	6.041	6.458
LV0010R	lead	ng Pb/m3	4.393	6.467	4.416	5.897	7.698	2.511	2.325	4.238	3.092	6.8	6.775	5.035	5.011
LV0016R	lead	ng Pb/m3	3.723	9.093	3.368	4.109	2.048	2.556	1.972	1.393	2.992	6.803	5.613	5.548	3.965
SE0014R	lead	ng Pb/m3	2.98	11.96	4.599	5.89	3.402	1.93	1.32	1.55	3.3	11.925	7.44	4.24	4.991
DE0009R	total_gaseous_mercury	ng Hg/m3	1.661	1.892	1.724	1.668	1.56	1.575	1.353	1.356	1.267	1.584	1.521	1.629	1.563
SE0014R	mercury	ng Hg/m3	14.889	20.286	14.429	20	10	6.25	6.667	7.889	6.75	15.889	7.889	5.375	11.29
SE0014R	mercury	ng Hg/m3	1.522	1.638	1.763	1.986	1.7	1.744	1.7	1.922	1.688	1.633	1.3	1.475	1.683
SE0014R	gamma_HCH	pg γ-HCH/m3	2.613	2.964	2.536	9	8.387	8.333	9	6.548	7.367	11.29	6.333	3.129	6.435

Appendix B: Monitoring methods

The monitoring regime for nitrogen compounds, metals and lindane are summarised in tables B.1 to B.5:

Table B.1. General information about sampling and analysis of nitrogen compounds in precipitation in 2005.

Country		**Sampling period**	**Sampler**		**Analytical methods**
			Wet only	**Bulk**	
Denmark	Nitrate ammonium	Biweekly	x		IC Spect. (CFA)
Estonia	Nitrate Ammonium	Weekly		X	IC Spect (indophenol)
Finland	Nitrate Ammonium	Weekly		X	IC IC
Germany	Nitrate Ammonium	Weekly	X		IC IC
Latvia	Nitrate Ammonium	Daily	X (LV10)	X (LV16)	IC Spect (indophenol)
Lithuania	Nitrate Ammonium	Daily	X		IC Spect (indophenol)
Poland	Nitrate Ammonium	Daily		x	IC Spect (chloramin T)
Russia	Nitrate Ammonium	Daily		x	IC
Sweden	Nitrate Ammonium	Weekly	X		IC Spect (FIA)

*IC: Ion chromatograpy
**Spect Spectrofotometric detection

Table B.2. General information about sampling and analysis of nitrogen compounds in air in 2005.

Country		**Sampl period**	**Sampler**	**Analytical methods**
Denmark	NO_2 NO_2 (DK05) Sum of nitric acid and nitrate Sum of ammonia and ammonium	Daily Hourly Daily Daily	KI method 0.73m^3/day Chemiluminisence Millipore RAWP, 1.2 µm + KOH-impregnated Whatman 41, 58 m^3/day Millipore RAWP, 1.2 µm + Oxalic acid impregnated Whatman 41, 58 m^3/day	Spect IC Spect (CFA)
Estonia	NO_2	Hourly	Chemiluscence	
Finland	NO_2 Sum of nitric acid and nitrate Sum of ammonia and ammonium	Hourly Daily Daily	Chemiluscence Whatman 40 + NaOH impregnated Whatman 40 filter, 24 m^3/day Oxalic acid impregnated Whatman 40 filter, 24 m^3/day	 IC IC
Germany	NO_2 Sum of nitric acid and nitrate Sum of ammonia and ammonium	Daily Daily	NaI imp. Glass filters, 0.7m^3/day Aerosol + KOH impr W40 filter, 22 m^3/day Aerosol + Oxalic acid impr W40 filter	FIA IC FIA
Latvia	NO_2 Sum of nitric acid and nitrate Sum of ammonia and ammonium	Daily Daily Daily	KI method 0.2-0.4 m^3/day KOH-impregnated Whatman 41 filter, 14-20 m^3/day Oxalic acid impregnated Whatman 41 filter, 14-20 m^3/day	Spect. Griess IC Spect (indophenol)
Lithuania	NO_2, Sum of nitric acid and nitrate Sum of ammonia and ammonium	Daily Daily Daily	KI method 0.4-0.7 m^3/day KOH impregnated Whatman 40 filter, 16-17 m^3/day Oxalic acid impregnated Whatman 40 filter, 16-17 m^3/day	Spect. Griess IC Spect (indophenol)
Poland	NO_2 Sum of nitric acid and nitrate Sum of ammonia and ammonium	Daily Daily Daily	Abs.sol. TGS 0.73^3/day NaF impregnated Whatman 40 filter, 3.5-4 m^3/day Oxalic acid impregnated Whatman 40 filter, 3.5-4 m^3/day	Spect. Griess Spect. Griess Spect. Chloramin T)
Russia	Ammonium, Nitrate	Daily	Whatman 40 filter, 10-15 m^3/day	IC
Sweden	NO_2 Sum of nitric acid and nitrate Sum of ammonia and ammonium	Daily	NaI imp. glass sinters 0.7 m^3/day Aerosol filter as for sulphate + KOH-impregnated Whatman 40 filter, 20 m^3/day Aerosol filter as for sulphate + Oxalic acid impregnated Whatman 40 filter, 20 m^3/day	Spect IC FIA

GF-AAS: Graphite furnace atomic absorption spectroscopy
ICP-MS: Inductively coupled plasma - mass spectrometry
CV-AFS: Cold vapour atomic fluorescence spectroscopy

***Table B.3**. General information about sampling and analysis of heavy metals in 2005.*

Country	Precipitation		Air and aerosols		Laboratory method
	Field method	Frequency	Field method	Frequency	
Germany	wet only	Weekly	Low volume sampler	weekly	ICP-MS
Hg	wet only	Weekly	TGM:gold trap	daily	CV-AFS
Denmark	Bulk	Monthly	Filter-3pack	daily at DK3,8,31 weekly at DK11	Precip: GF-AAS Aerosols: PIXE
Hg	Bulk (Hg)	Monthly	Hg-monitor (Tekran)	hourly	
Estonia	Bulk	Monthly	Sampling High Volume Sampler	Weekly	GF-AAS, Zn: F-AAS
Finland	Bulk	Monthly	Teflon, Millipore, Fluoropore, 3 µm, 50 l/min, cut off 15 µm	weekly	ICP-MS
Hg	Bulk (Hg)	Monthly	Hg: gold traps (TGM)	2 X 24 h a week	CV-AFS
			Hg: mini traps (TPM)	weekly	CV-AFS
Lithuania	Bulk	Weekly	Low vol. 0.5-2 m3/h	weekly	GF-AAS
Latvia	Bulk	Weekly	Filter-1pack	Weekly	Cd, Cu, Pb, Ni, As: GF-AAS, Mn, Zn: F-AAS
Poland	Wet-only	Biveekly			GF-AAS (AVS from May); GF-AAS; Zn: F-AAS
Sweden	Bulk	Monthly	Low volume sampler, teflon filter	monthly	ICP-MS
Hg	Bulk (Hg)	Monthly	Hg: gold traps (TGM)	2 X 24 h a week	CV-AFS
			Hg: mini traps (TPM)	2 X 24 h a week	CV-AFS

AAS: Atomic Absorption Spectroscopy
GF-AAS: Graphic Furnace Atomic Absorption Spectroscopy
F-AAS: Furnace Atomic Absorption Spectroscopy
ICP-MS: Inductively Coupled Plasma - Mass Spectrometry
CV-AAS: Cold Vapour Atomic Fluorescence Spectroscopy

***Table B.4**. General information about sampling and analysis of γ-HCH, 2005*

Country	Precipitation		Air and aerosols		Laboratory method
	Sampling method	Frequency	Sampling method	Frequency	
Germany	wet only	Monthly			GC-MS
Sweden	Bulk (precip + dry dep)	monthly	High vol.	SE14 biweekly, SE12: 1 w a month	HPLC, GC-MS

HPLC: High Performance Liquid Chromatography
GC -MS: Gas chromatograph with Mass Spectrometry