EMEP/MSC-E Technical Report 5/2012

Transboundary Pollution of Germany by Heavy Metals and Persistent Organic Pollutants in 2010

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Introduction

This report provides country-specific information on transboundary pollution of Germany by heavy metals (HM) and persistent organic pollutants (POP) which complements EMEP Status Report on HMs (*Travnikov et al.*, 2012) and POPs (*Shatalov et al.*, 2012). It comprises officially reported emission data, modelled air concentrations and deposition fluxes for 2010 of lead (Pb), cadmium (Cd), mercury (Hg), benzo[a]pyrene (B[a]P), polychlorinated dibenzo(p)dioxins and dibenzofurans (PCDD/F), and hexachlorobenzene (HCB) and their long-term changes.

The section on emissions presents temporal changes of HM and POP annual emissions from Germany. Along with this, detailed information on sectoral splitting of emissions and their spatial distribution for 2010 is given which is available also from the database (Webdab) of CEIP: http://www.ceip.at/webdab-emission-database/.

The section on transboundary pollution of Germany provides results on model assessment of transboundary transport and deposition of selected HMs and POPs performed by MSC-E in accordance with the Work-plan of the Steering Body to EMEP for 2012. Model simulations were carried out for the EMEP domain (Figure 1) with spatial resolution 50×50 km^2 using the latest available emission data provided by CEIP and meteorological information for the period from 1990 to 2010.

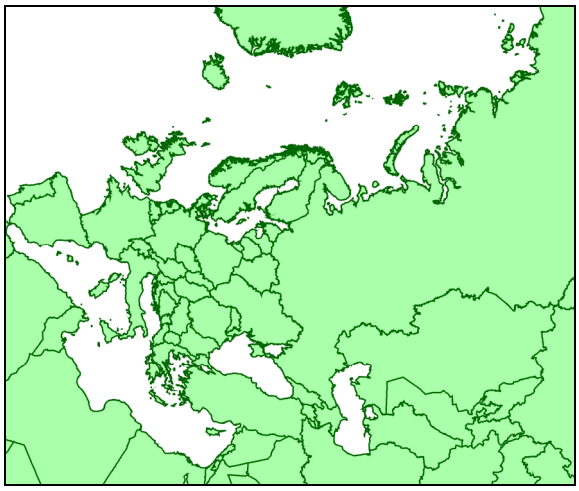


Figure 1. EMEP domain

Data on pollution levels in Germany includes maps of spatial distribution of HM and POP air concentrations and deposition fluxes including annual total and ecosystem-specific deposition. Data on POPs are accompanied by spatial distribution of their concentrations in media than air. Most of POPs resist to degradation and can be accumulated in the environmental compartments, namely, soil, vegetation, for long periods of time (years, decades) serving as additional sources of pollution.

The information on transboundary pollution of Germany is provided in the form of pie charts with contributions of domestic anthropogenic sources and sources of other EMEP countries. Along with this spatial distribution of contributions of transboundary deposition fluxes over Germany is given. The influence of Germany on the pollution of other countries is illustrated in the form of maps of spatial distribution of total annual deposition fluxes from Germany emission sources and diagrams of their distribution over the EMEP countries. Additional information on contributions of Germany HM and POP emission sources to the pollution of the Baltic and the North Seas can be found in the reports (*Bartnicki et al.*, 2012; *OSPAR commission*, 2008).

Final section of the report is devoted to the assessment of HM and POP effects on human health and biota performed in framework of activity of Working Group on Effects (WGE). It includes links to the results of evaluation of critical loads exceedances carried out by Coordination Centre for Effects (CCE) and information on long-term monitoring and scientific research in this field coordinated by several ICPs.

Table 1. Country codes

Country/Region/Sea	Code	Country/Region/Sea	Code
Albania	AL	Monaco	MC
Armenia	AM	Montenegro	ME
Austria	AT	Netherlands	NL
Azerbaijan	AZ	Norway	NO
Belarus	BY	Poland	PL
Belgium	BE	Portugal	PT
Bosnia and Herzegovina	BA	Republic of Moldova	MD
Bulgaria	BG	Romania	RO
Croatia	HR	Russian Federation (European part)	RU
Cyprus	CY	Russian Federation (Asian part)	RUA
Czech Republic	CZ	Serbia	RS
Denmark	DK	Slovakia	SK
Estonia	EE	Slovenia	SI
Finland	FI	Spain	ES
France	FR	Sweden	SE
Georgia	GE	Switzerland	CH
Germany	DE	The Former Yugoslav Republic of Macedonia	MK
Greece	GR	Tajikistan	TJ
Hungary	HU	Turkey	TR
Iceland	IS	Turkmenistan	TM
Ireland	IE	Ukraine	UA
Italy	IT	United Kingdom	GB
Kazakhstan	KZ	Uzbekistan	UZ
Kyrgyzstan	KY	Baltic Sea	BAS
Latvia	LV	Black Sea	BLS
Lithuania	LT	Caspian Sea	CAS
Luxembourg	LU	North Sea	NOS
Malta	MT	Mediterranean Sea	MDT

1. Emissions

1.1. Emission trends (1990 – 2010)

Table 2. Official emission data for Germany.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Heavy metals																					
Pb, t	2074.6	1304.9	989.1	817.9	626.1	693.5	558.8	450.5	436	436	433.5	418.4	397.3	381.8	372.7	352.5	347.8	338.5	199.1	174.3	191.4
Cd, t	17.26	13.59	10.82	9.29	8.66	11.40	10.70	11.17	10.45	10.45	10.23	9.66	9.11	8.71	7.96	7.32	6.92	6.39	5.49	4.73	5.31
Hg, t	28.26	22.16	17.80	15.05	13.46	13.85	13.74	13.82	13.80	13.80	13.88	13.59	12.98	12.80	12.35	11.68	11.38	11.01	9.80	8.88	9.29
Persistent organic pollutants																					
B[a]P, t	138.24	101.70	74.62	69.78	59.71	47.54	44.20	41.50	35.05	35.05	30.23	31.20	27.65	25.75	23.10	23.01	24.19	22.86	25.35	26.89	31.07
PCDD/Fs, g TEQ	747.3	622.3	492.9	363.8	243.7	229.4	206.2	196.9	184.2	184.2	151.6	131.2	109.8	92.3	69.2	68.7	70.3	70.6	71.4	61.4	67.7
HCB, kg	5.30	5.19	5.03	5.02	4.73	4.49	4.34	4.56	4.51	4.51	4.44	4.17	3.78	3.38	2.98	2.98	3.10	3.11	3.17	3.21	3.46

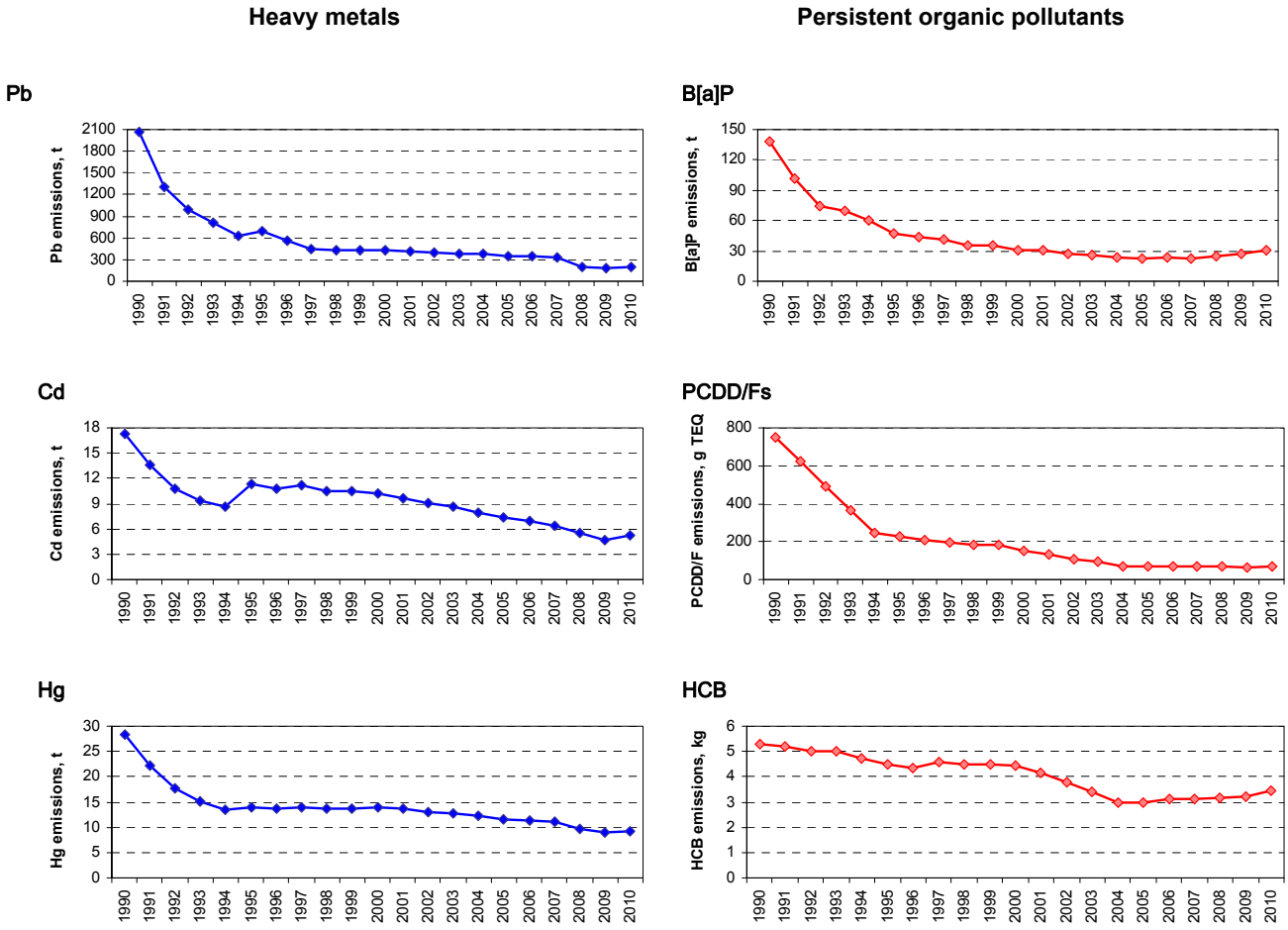


Figure 1. Temporal trends in emissions of HMs and POPs from Germany in period 1990-2010.

1.2. Spatial distribution of total emissions

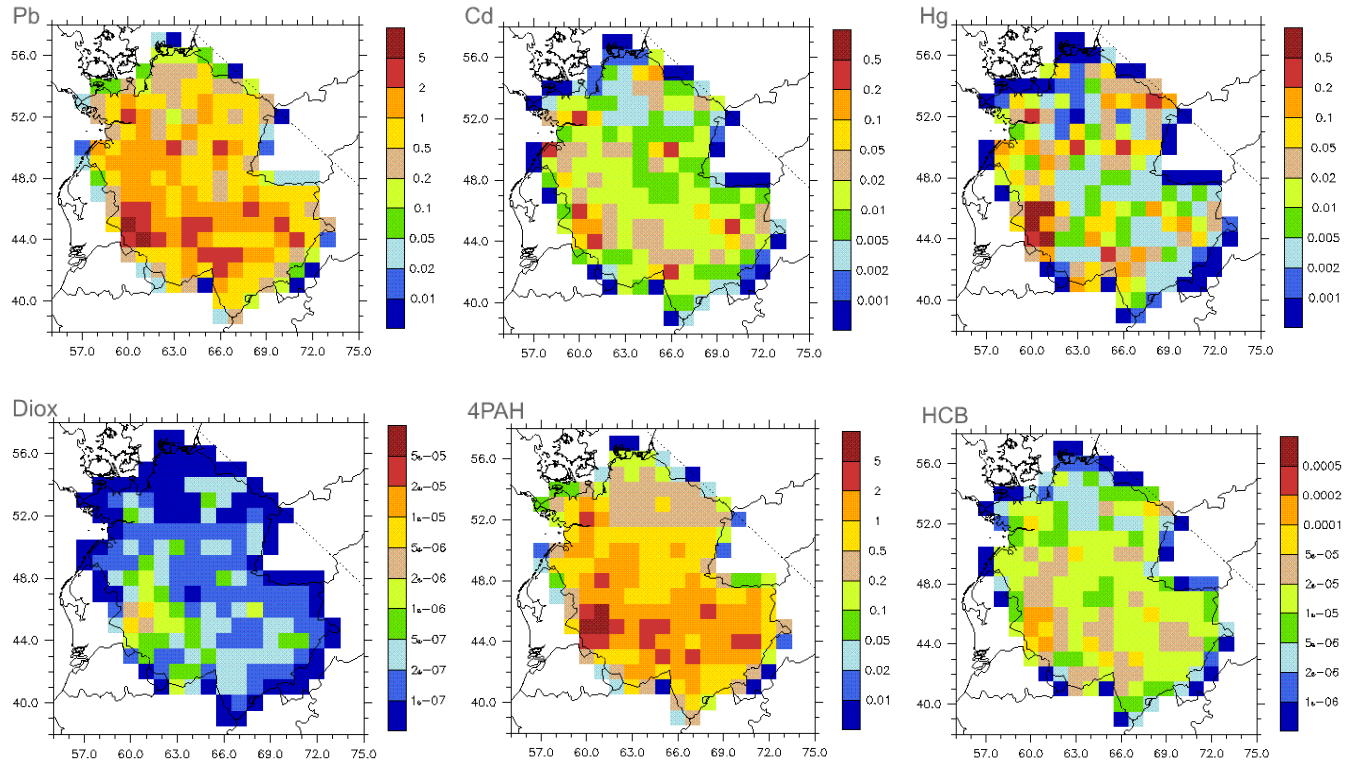


Figure 2. Spatial distribution of emissions from Germany in 2010, t/y (official data)

1.3. Spatial distribution of sectoral emission

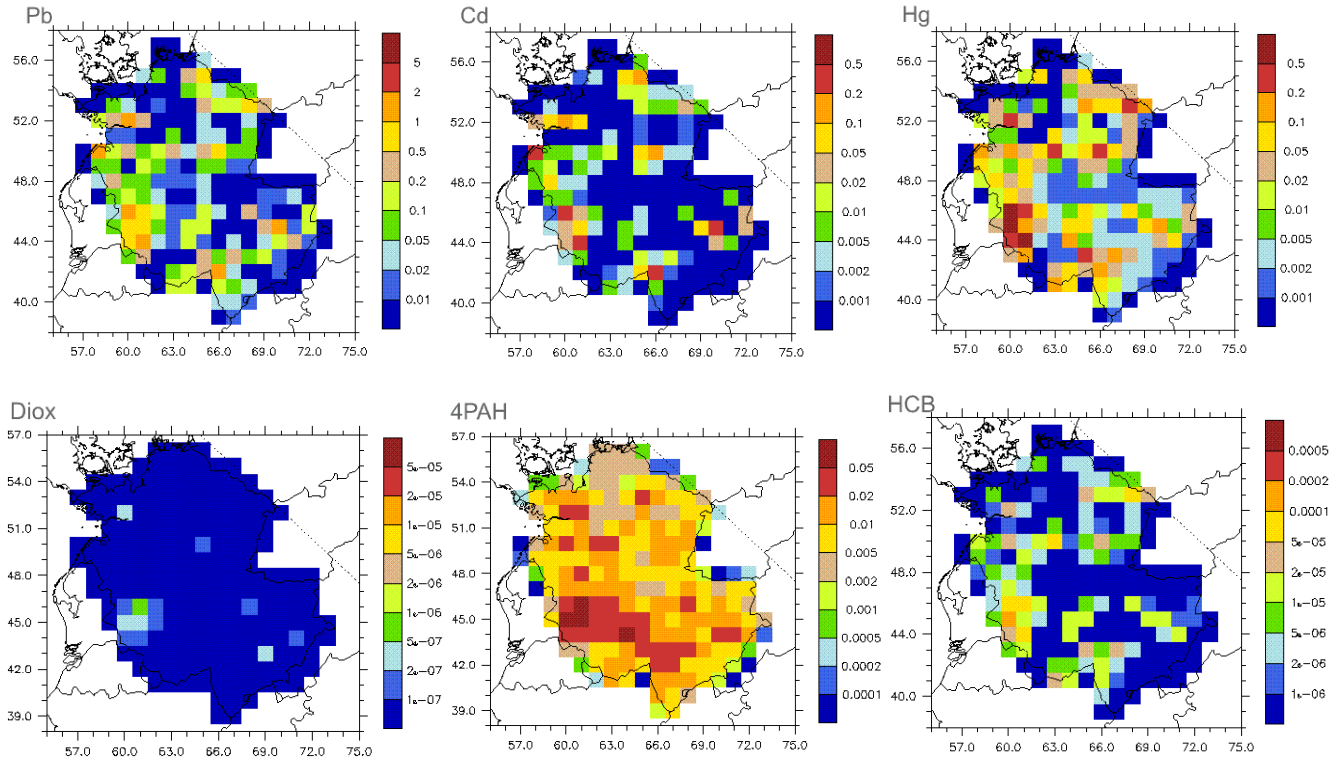


Figure 3. Spatial distribution of emissions from sector “Public power”, t/y

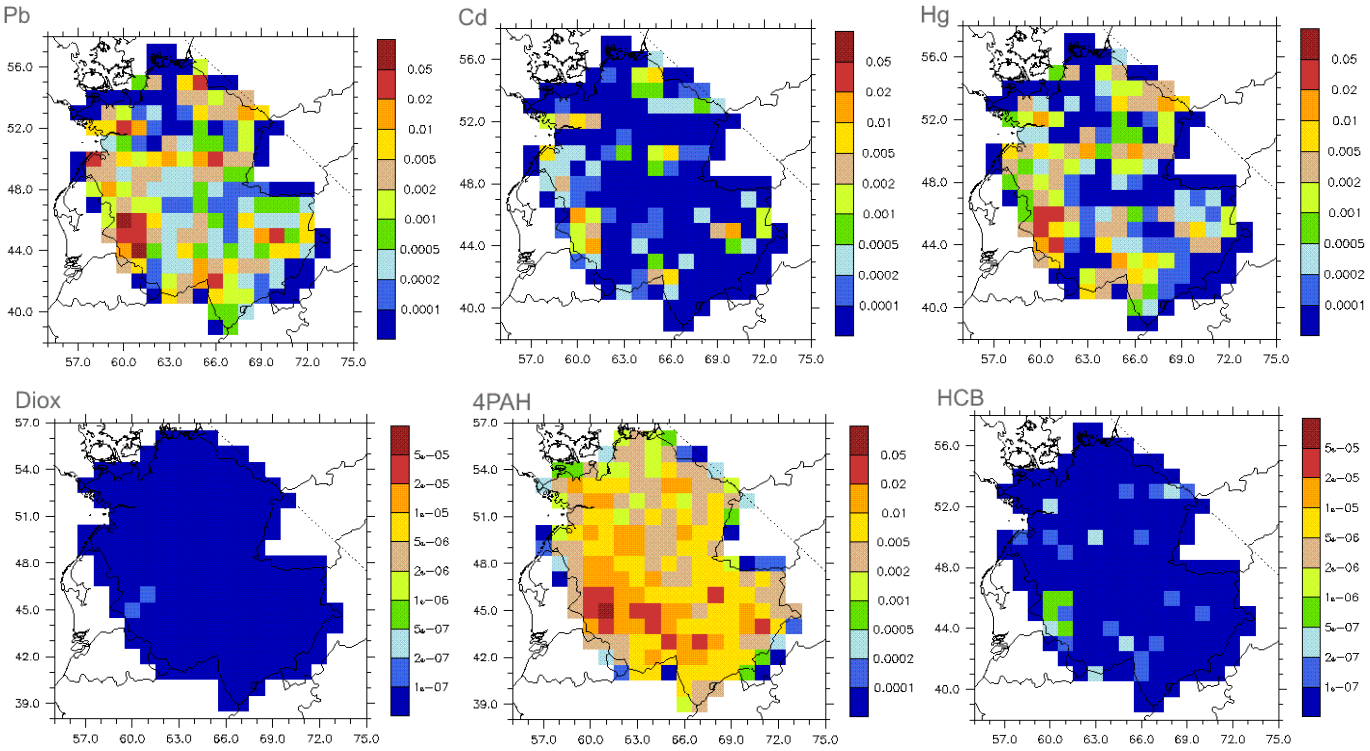


Figure 4. Spatial distribution of emissions from sector “Industrial combustion”, t/y

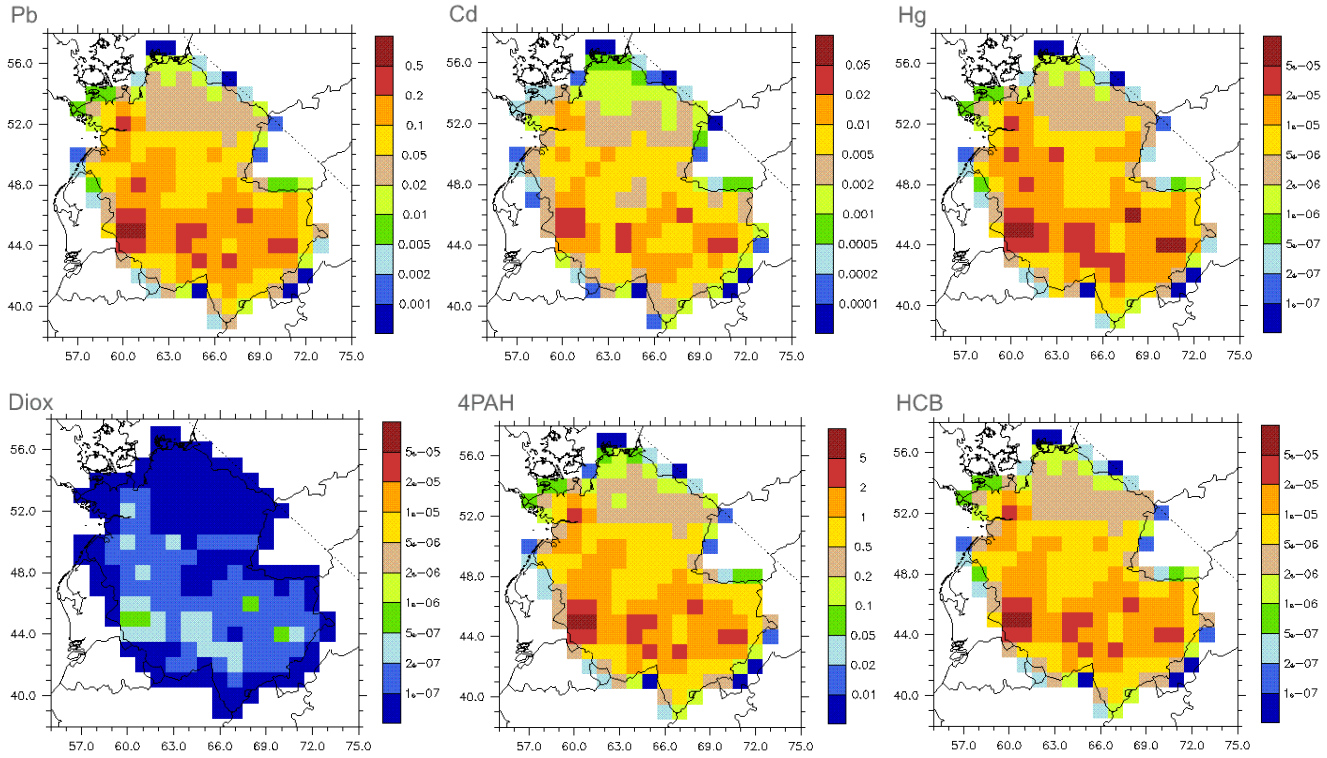


Figure 5. Spatial distribution of emissions from sector “Small combustion”, t/y

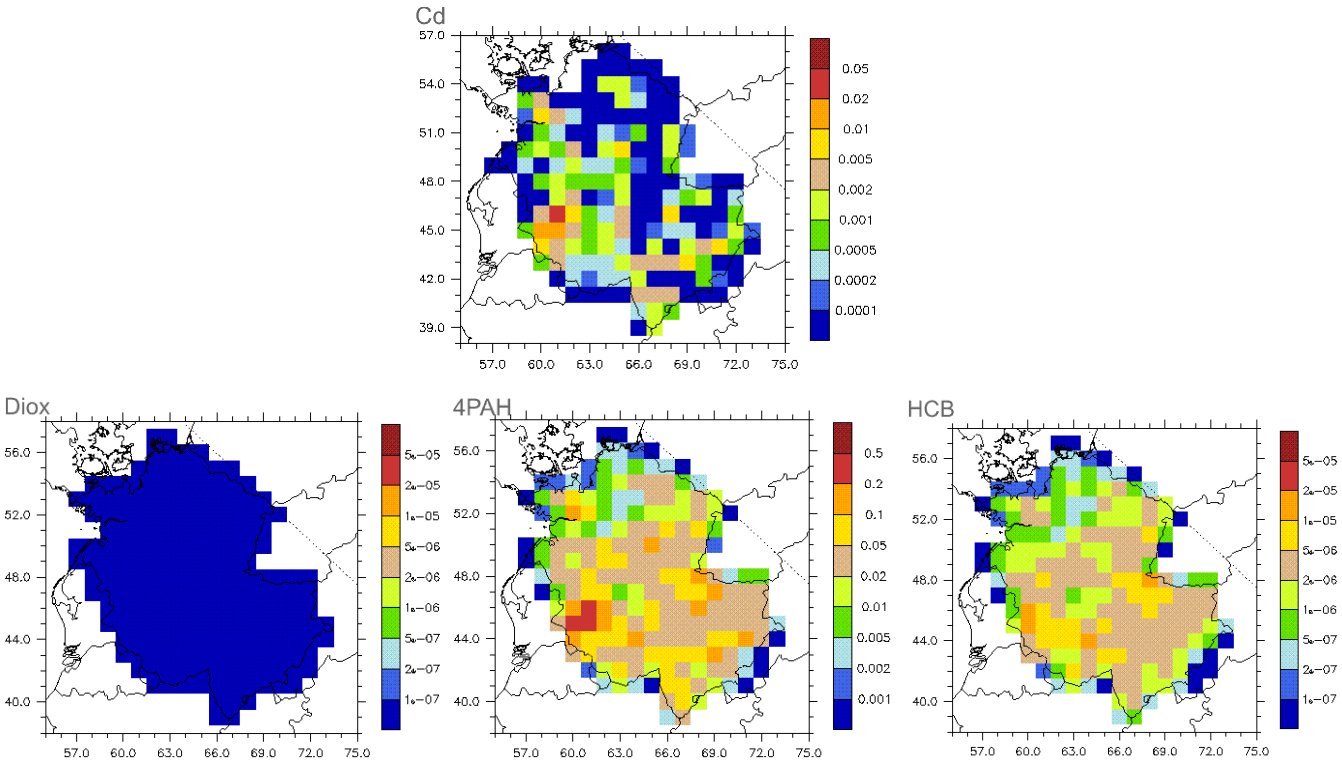


Figure 6. Spatial distribution of emissions from sector “Industrial process”, t/y

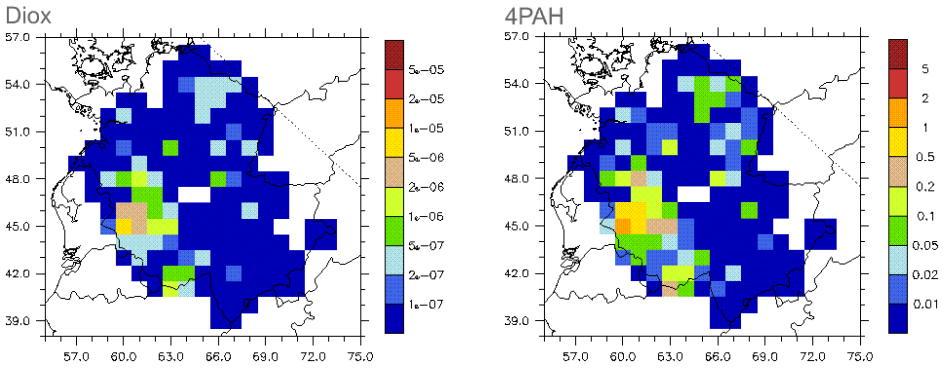


Figure 7. Spatial distribution of emissions from sector “Fugitive emissions”, t/y

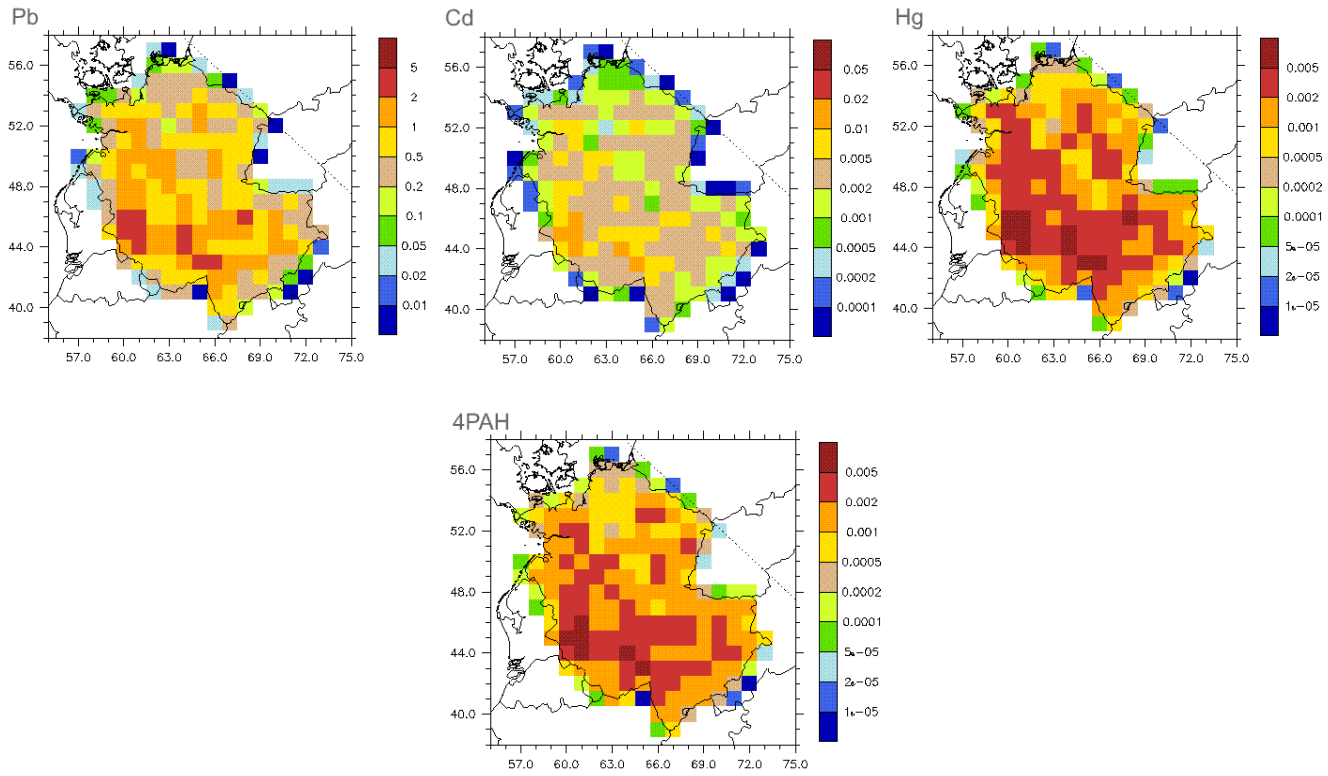


Figure 8. Spatial distribution of emissions from sector “Road rail”, t/y

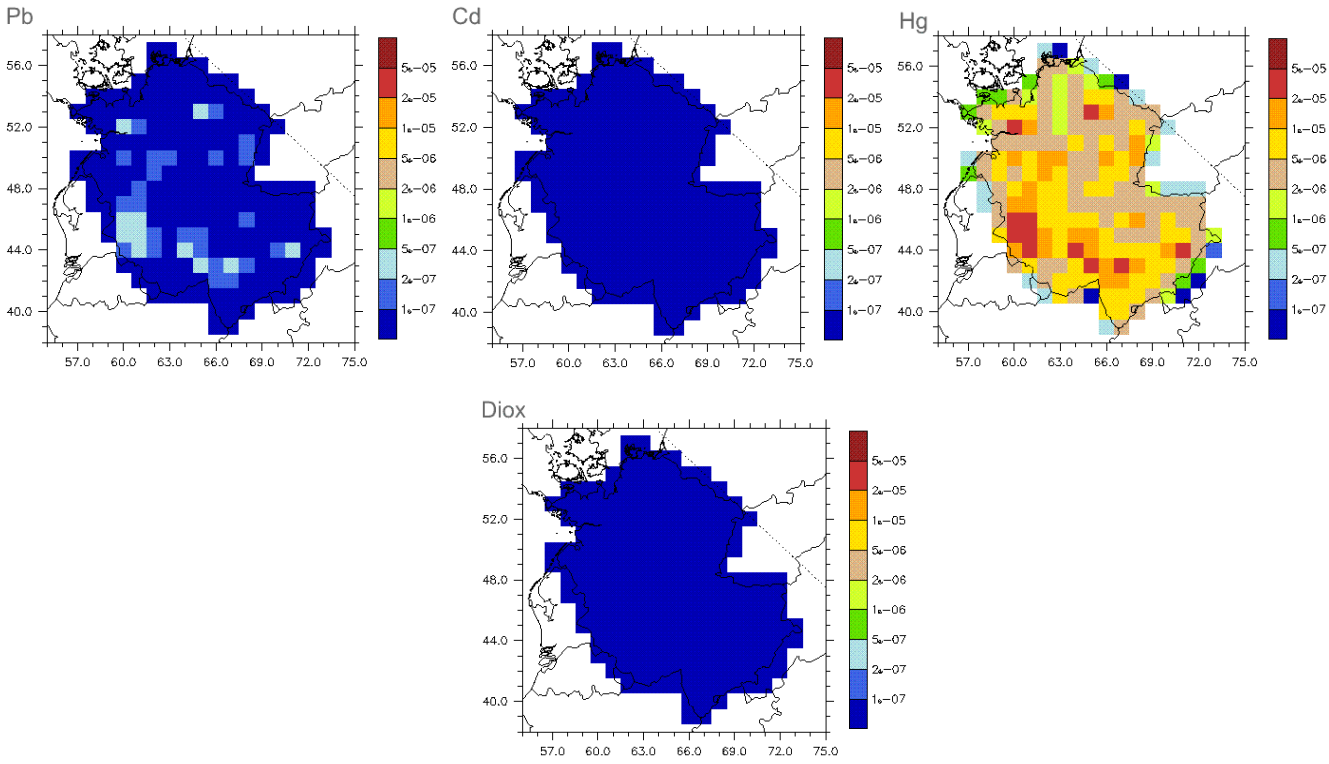


Figure 9. Spatial distribution of emissions from sector “Waste Water”, t/y

2. Transboundary pollution

2.1. Deposition fluxes trends (1990-2010)

Table 3. Heavy metals deposition fluxes for the period 1990-2010

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Pb, kg/km^2/y	7.86	5.90	5.81	4.88	4.19	3.93	4.22	3.38	3.76	3.08	2.84	2.19	2.42	2.53	2.35	2.31	2.07	1.85	1.28	1.20	1.12
Cd, g/km^2/y	126.3	113.1	120.8	97.4	87.9	90.6	109.6	90.2	97.6	83.8	83.9	65.1	75.3	76.5	71.4	71.8	62.9	57.4	44.4	40.7	38.6
Hg, g/km^2/y	34.2	28.0	27.4	24.4	23.9	22.8	21.0	19.6	21.0	18.9	20.0	19.0	18.2	15.3	15.9	16.5	15.6	16.6	14.7	14.5	14.6

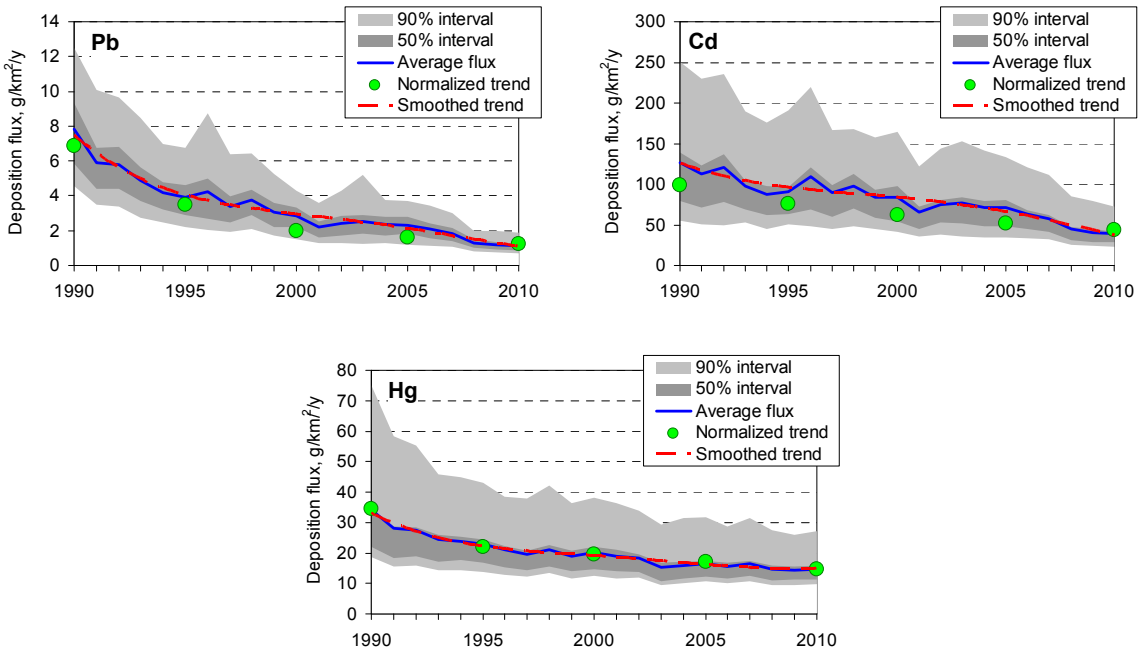


Figure 10. Temporal trends of HM deposition fluxes in Germany. Blue solid line presents area weighted average deposition flux; dashed red line is a smoothed trend; dark and light grey shadowed areas show 50% and 90% variation intervals over the countries' territories, respectively.

2.2. Spatial distribution of deposition fluxes and concentrations

HM deposition

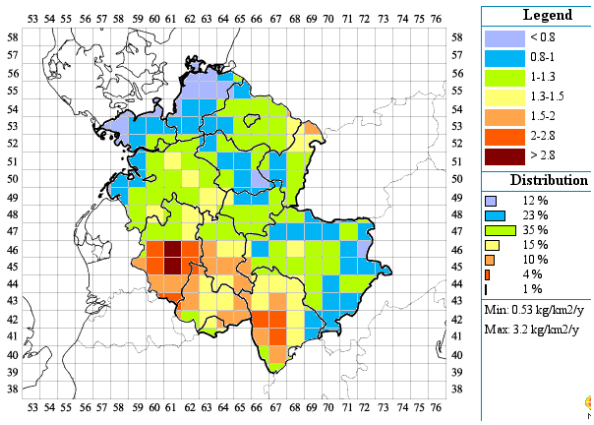


Figure 11. Spatial distribution of lead total deposition in Germany from national and foreign sources in 2010, kg/km^2/y

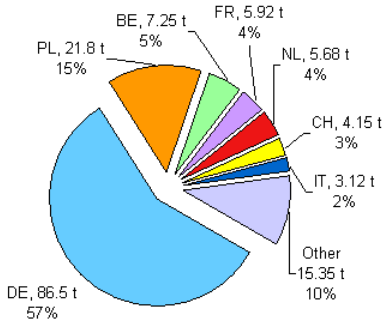
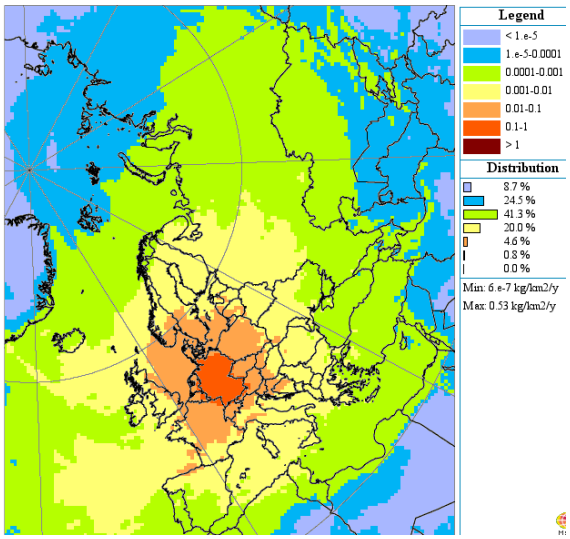


Figure 12. Total deposition of lead to Germany in 2010 is 400.4 t/y. Deposition from anthropogenic sources is 151.8 t/y. Contribution of global, natural, and historical emission sources to total deposition accounts for 62%.

a



b

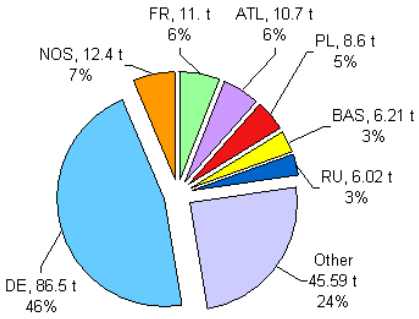


Figure 13. Total anthropogenic deposition of lead from national sources of Germany a) kg/km^2/y; b) t/y

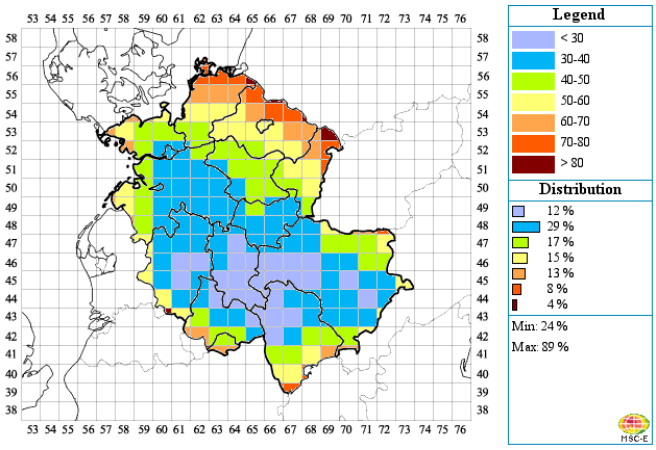


Figure 14. Contribution of foreign sources to lead anthropogenic deposition fluxes over Germany in 2010, %

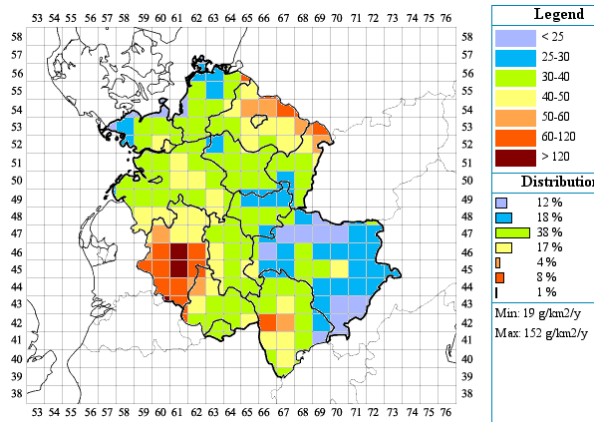


Figure 15. Spatial distribution of cadmium total deposition in Germany from national and foreign sources in 2010, g/km^2/y

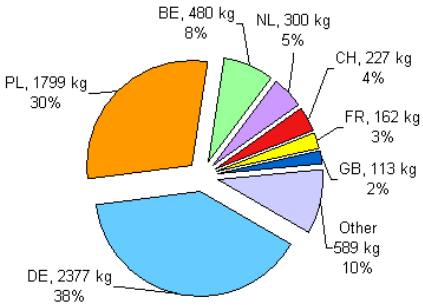
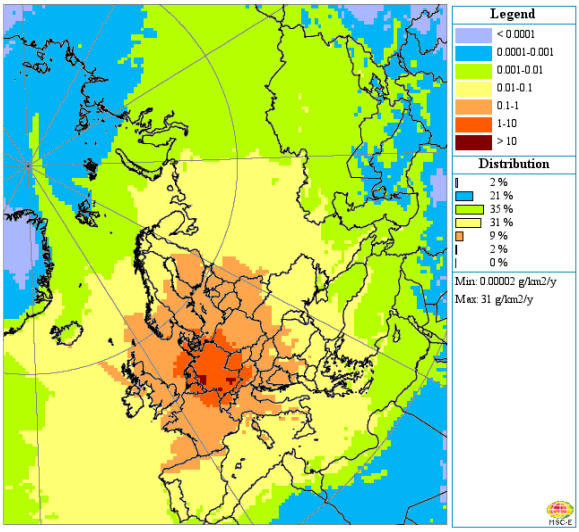


Figure 16. Total deposition of cadmium to Germany in 2010 is 13.0 t/y. Deposition from anthropogenic sources is 6.1 t/y. Contribution of global, natural, and historical emission sources to total deposition accounts for 53%.

a



b

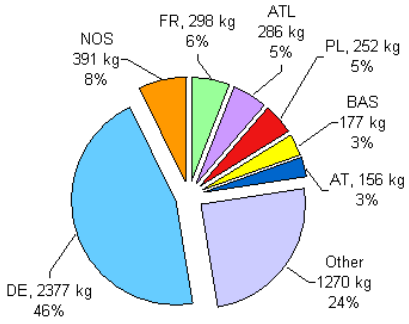


Figure 17. Total anthropogenic deposition of cadmium from national sources of Germany a) g/km^2/y; b) kg/y

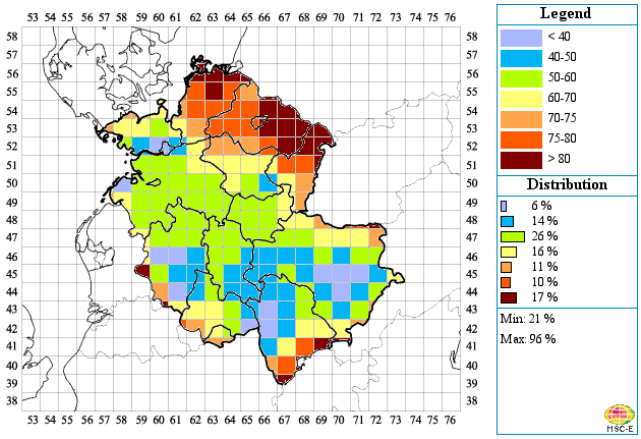


Figure 18. Contribution of foreign anthropogenic emission sources to cadmium deposition fluxes over Germany in 2010, %

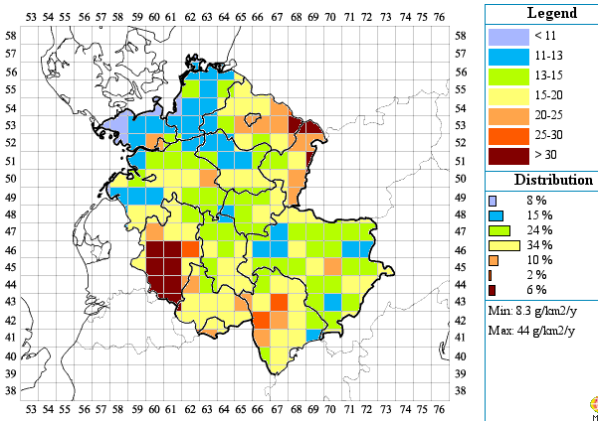


Figure 19. Spatial distribution of mercury total deposition in Germany from national and foreign sources in 2010, g/km^2/y

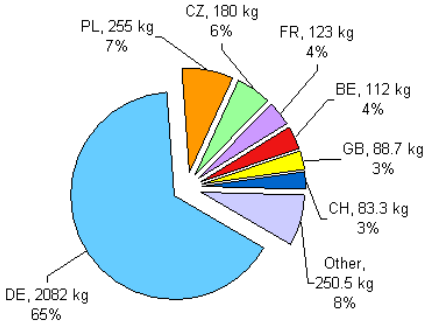
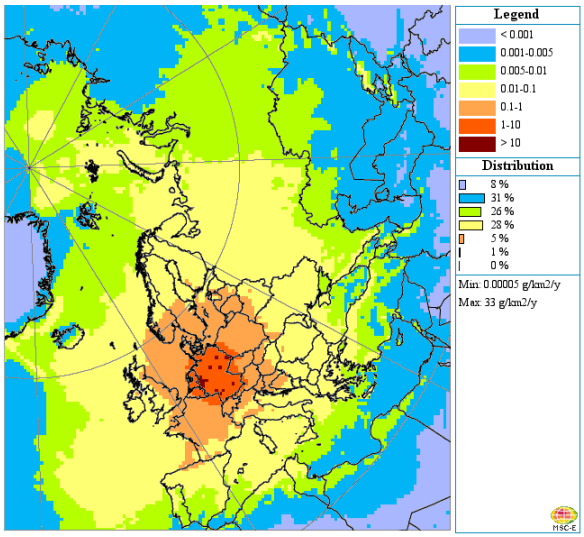


Figure 20. Total deposition of mercury to Germany in 2010 is 5.4 t/y. Deposition from anthropogenic sources is 3.2 t/y. Contribution of global, natural, and historical emission sources to total deposition accounts for 41%.

a



b

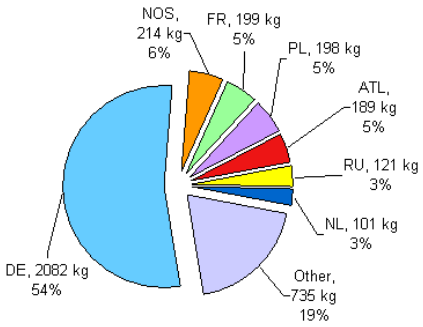


Figure 21. Total anthropogenic deposition of mercury from national emission sources of Germany in 2010 a) g/km^2/y; b) kg/y

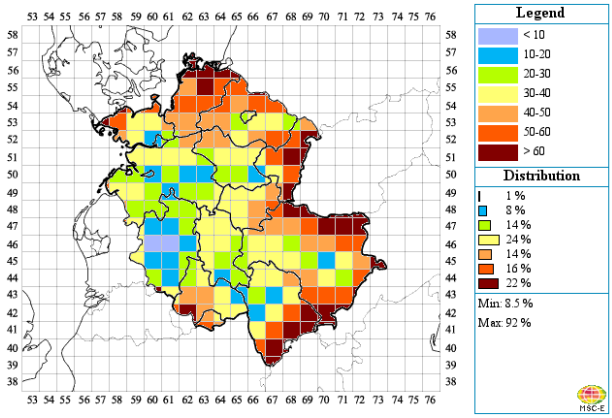


Figure 22. Contribution of foreign emission sources to mercury anthropogenic deposition fluxes over Germany in 2010, %

POP deposition

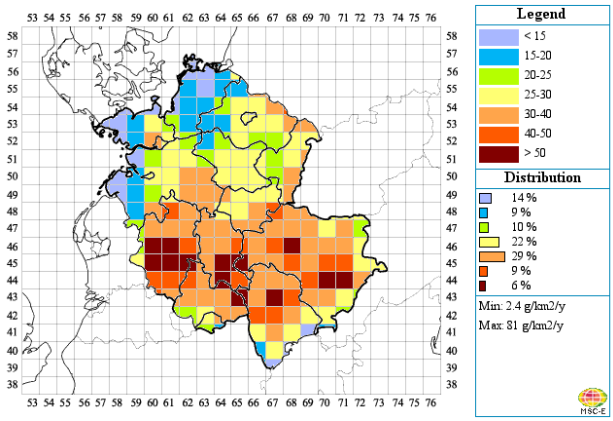


Figure 23. Spatial distribution of total B[a]P deposition fluxes in Germany from national and foreign emission sources in 2010, g/km^2/y

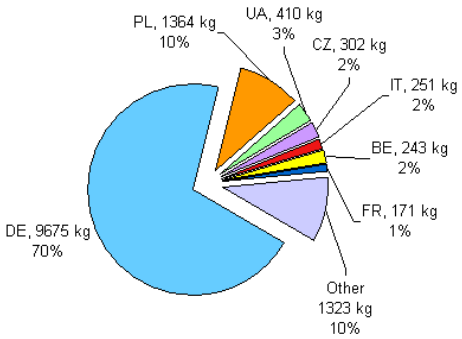
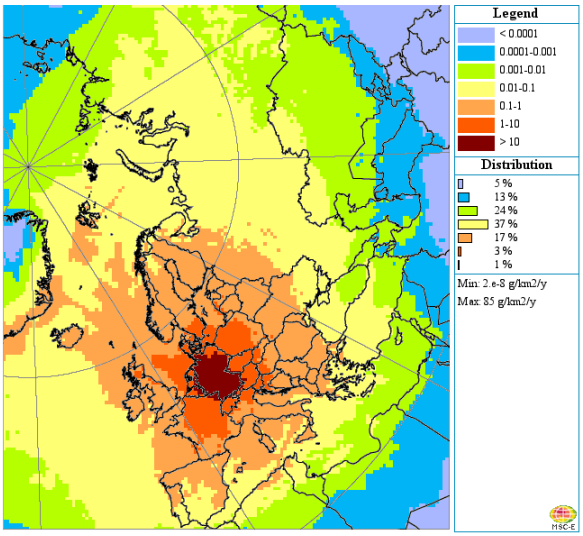


Figure 24. Contributions of countries to total anthropogenic B[a]P deposition in Germany for 2010.

a



b

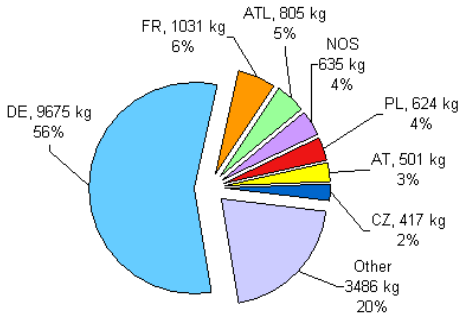


Figure 25. Total anthropogenic deposition of B[a]P from national emission sources of Germany in 2010 a) g/km^2/y; b) kg/y

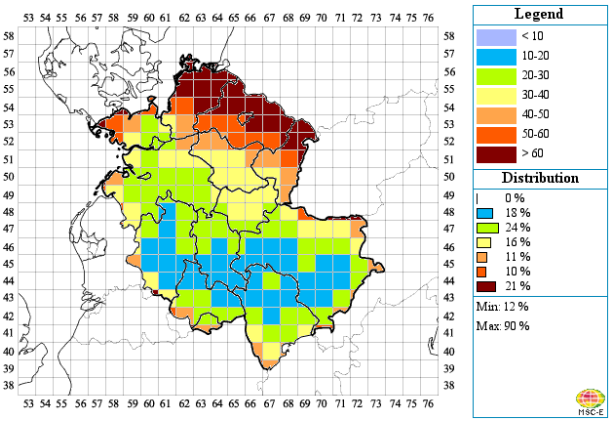


Figure 26. Contribution of foreign emission sources to B[a]P anthropogenic deposition fluxes over Germany in 2010, %

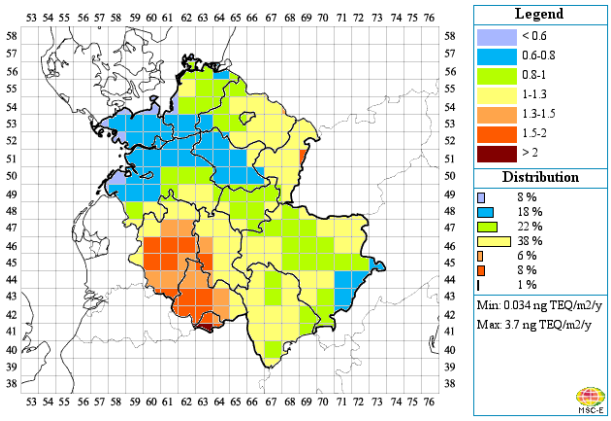


Figure 27. Spatial distribution of PCDD/F total deposition fluxes in Germany from national and foreign sources in 2010, ng TEQ/m^2/y

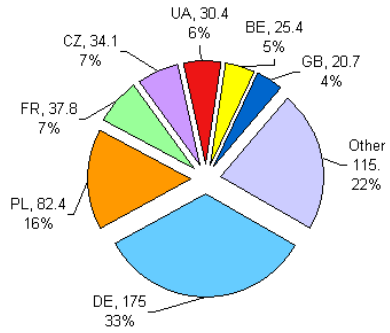
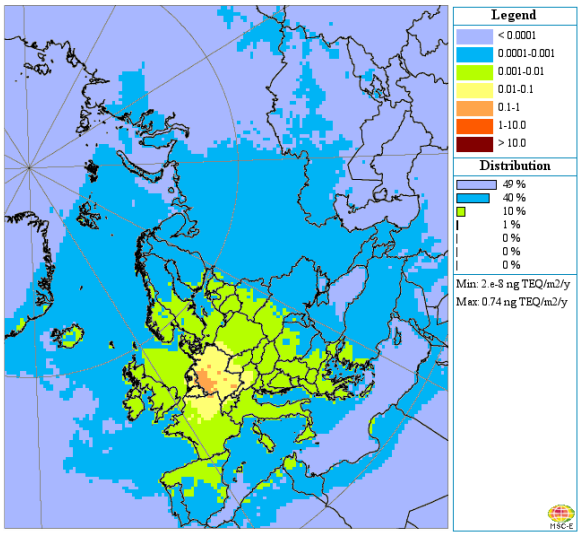


Figure 28. Contributions of countries to total anthropogenic PCDD/F deposition in Germany for 2010, g TEQ/y

a



b

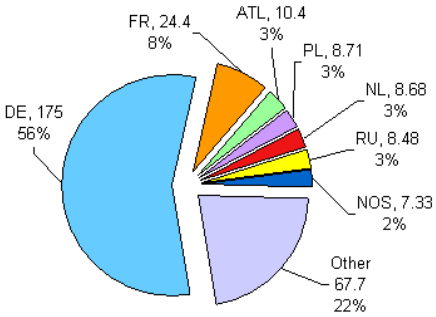


Figure 29. Total anthropogenic deposition of PCDD/Fs from national emission sources of Germany in 2010 a) ng TEQ/m^2/y; b) g TEQ/y

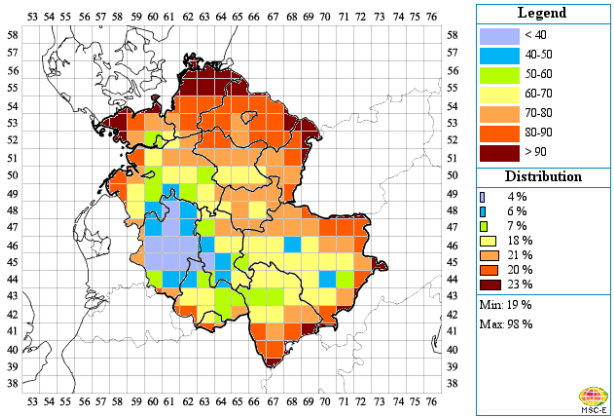


Figure 30. Contribution of foreign emission sources to PCDD/F anthropogenic deposition fluxes over Germany in 2010, %

HM and POP concentrations in air

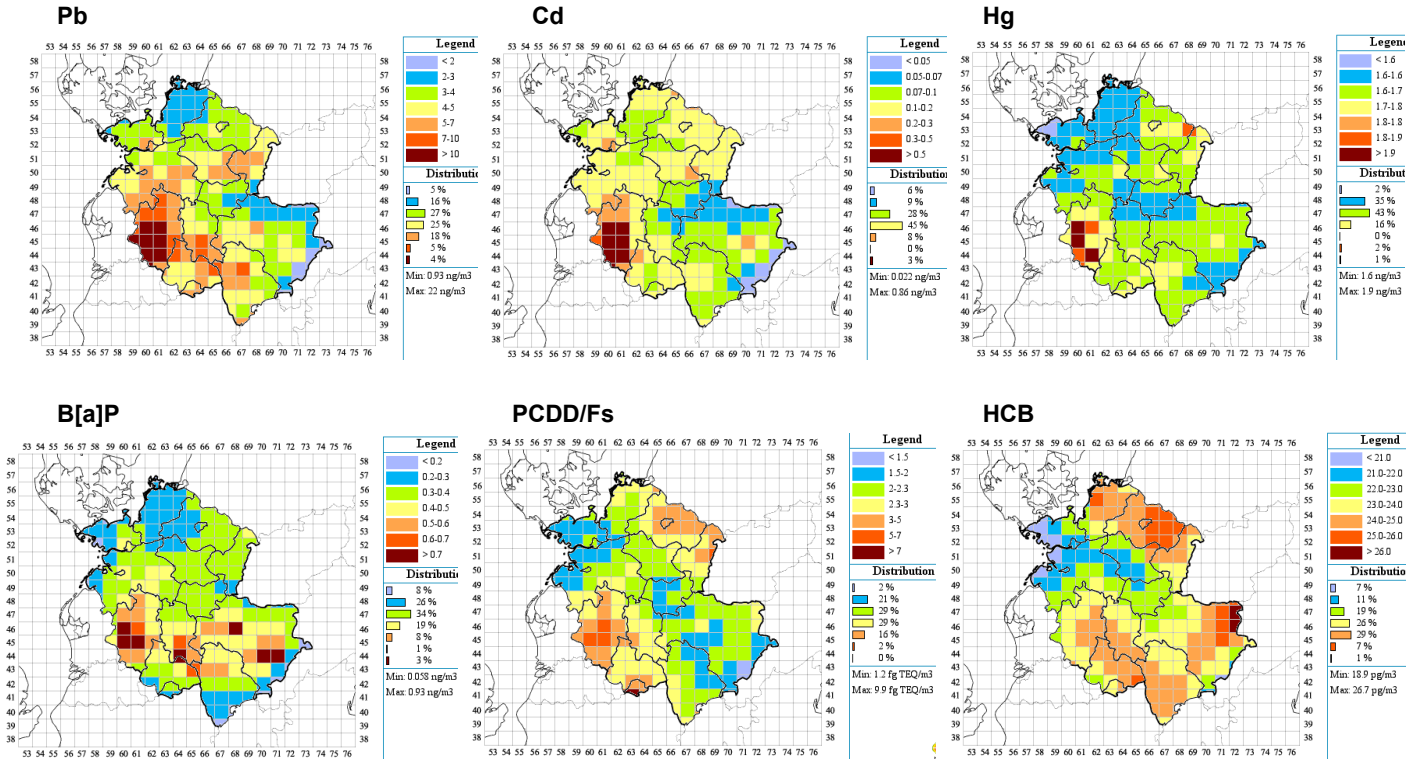


Figure 31. Spatial distribution of heavy metals and persistent organic pollutants in air for 2010 (Pb, Cd, Hg, B[a]P - ng/m^3; PCDD/Fs - fg TEQ/m^3; HCB - pg/m^3)

POP concentrations in soil

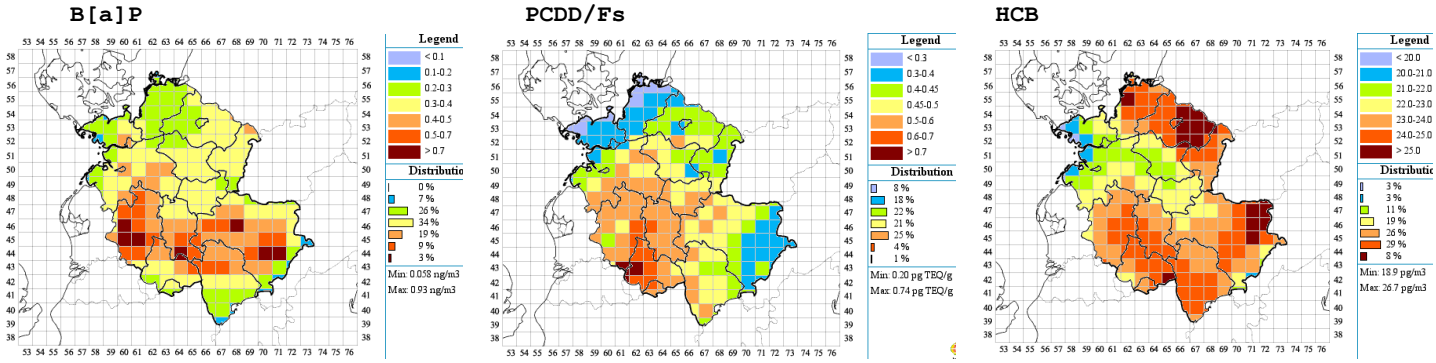


Figure 32. Spatial distribution of persistent organic pollutants in soil for 2010 (B[a]P - ng/g; PCDD/Fs - pg TEQ/g; HCB - pg/g)

POP concentrations in vegetation

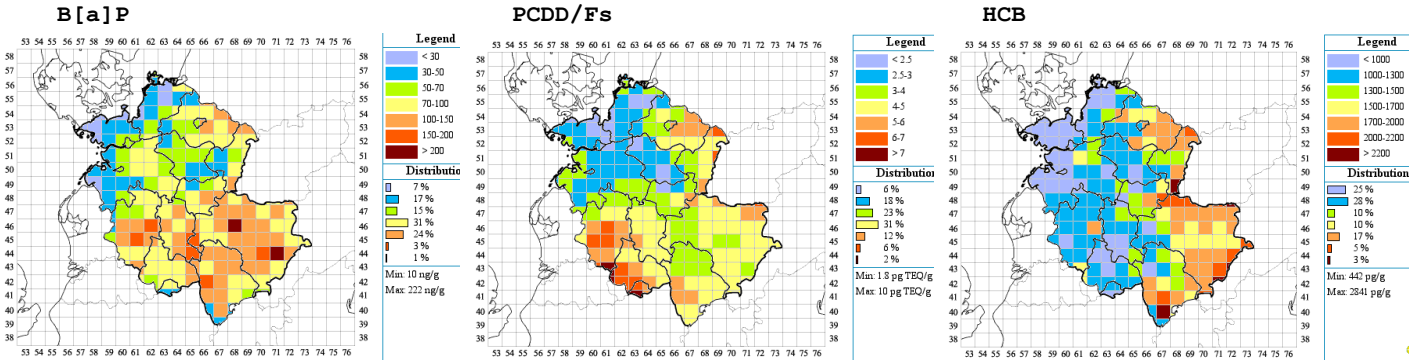


Figure 33. Spatial distribution of persistent organic pollutants in vegetation for 2010 (B[a]P - ng/g; PCDD/Fs - pg TEQ/g; HCB - pg/g)

2.3. Ecosystem-specific deposition

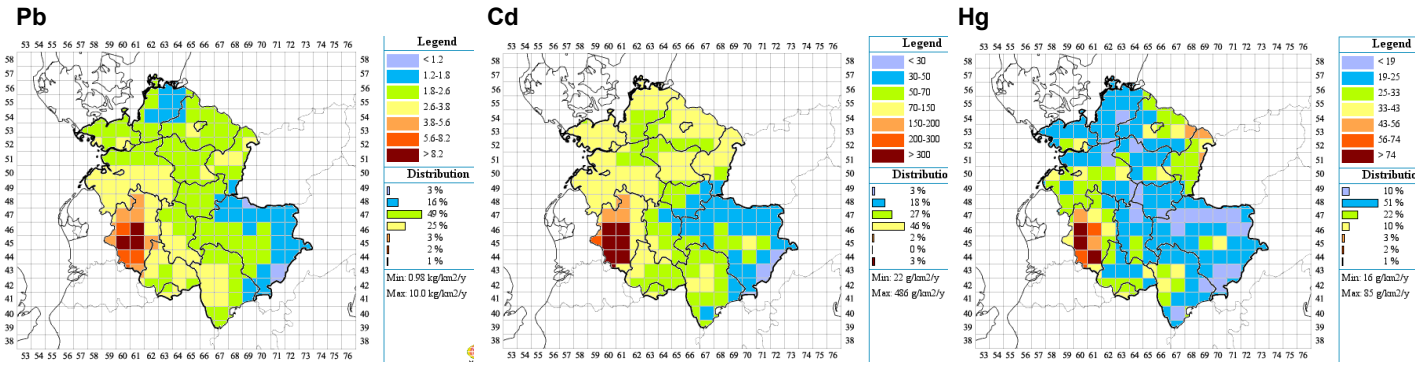


Figure 34. Heavy metals deposition to “temperate coniferous forest” land cover in 2010 (Pb - kg/km^2/y; Cd - g/km^2/y, Hg - g/km^2/y)

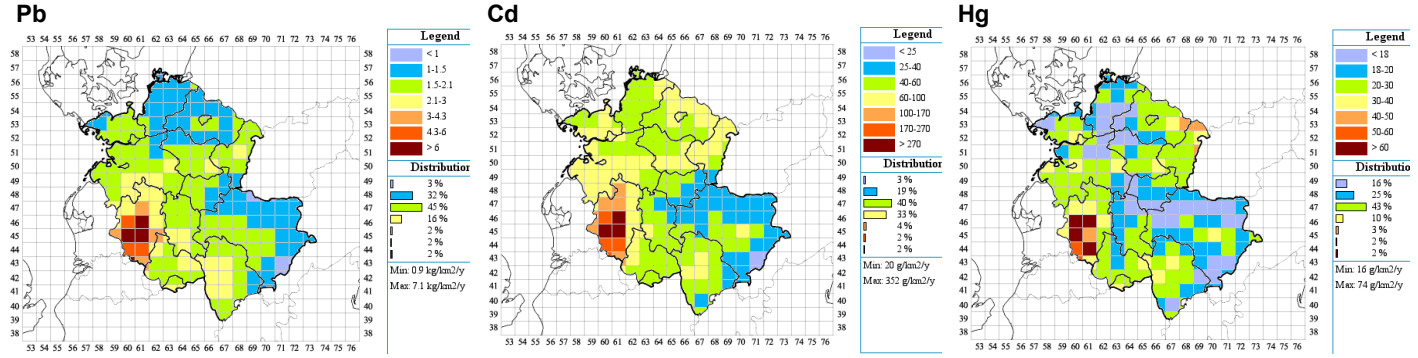


Figure 35. Heavy metals deposition to “temperate deciduous forest” land cover in 2010 (Pb - kg/km^2/y; Cd - g/km^2/y, Hg - g/km^2/y)

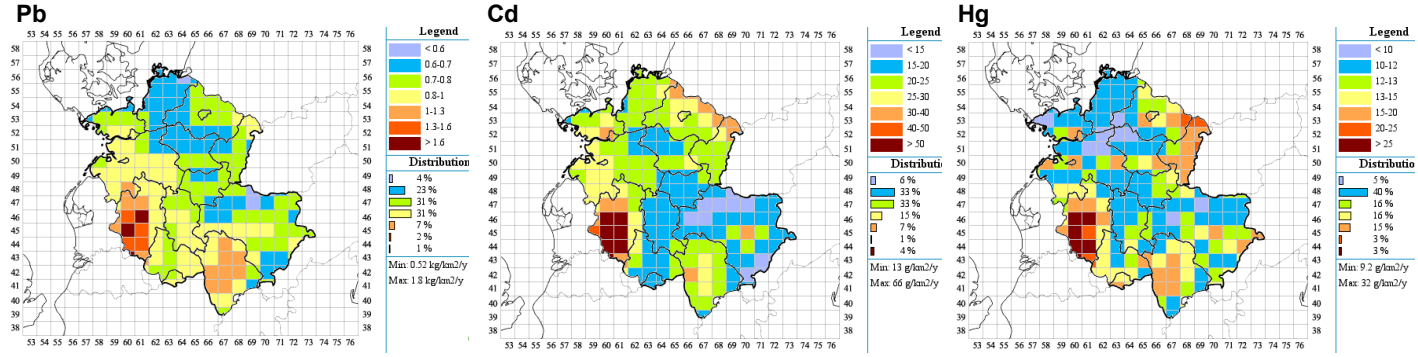


Figure 36. Heavy metals deposition to “temperate crops” land cover in 2010 (Pb - kg/km^2/y; Cd - g/km^2/y, Hg - g/km^2/y)

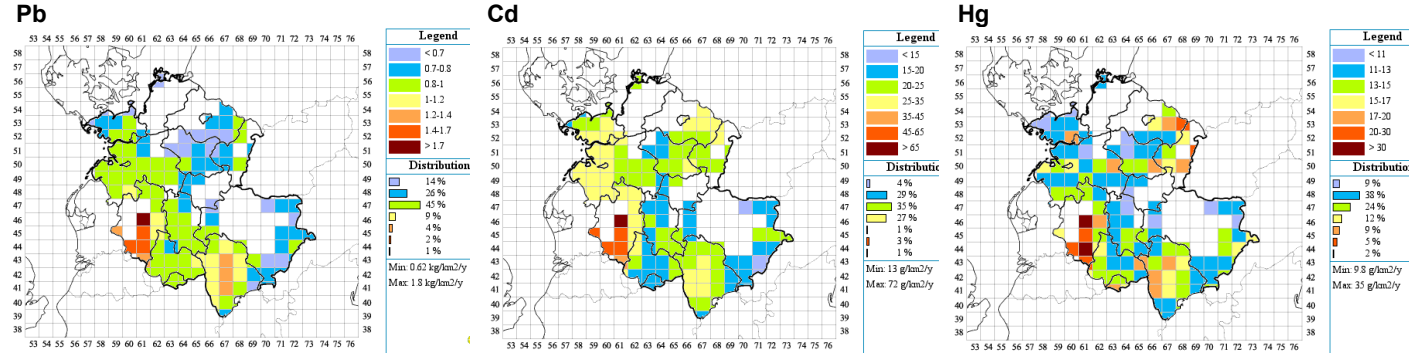


Figure 37. Heavy metals deposition to “Mediterranean crops” land cover in 2010 (Pb - kg/km^2/y; Cd - g/km^2/y, Hg - g/km^2/y)

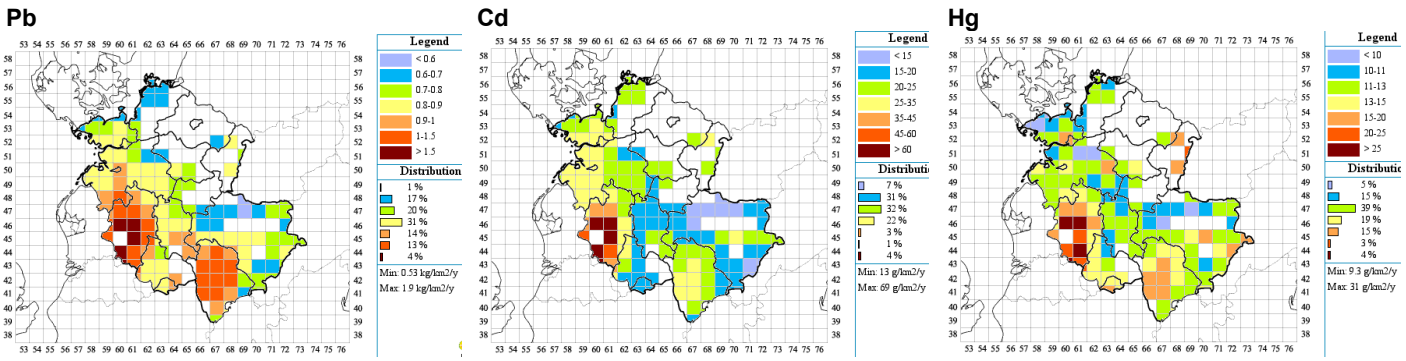


Figure 38. Heavy metals deposition to “root crops” land cover in 2010 (Pb - kg/km^2/y; Cd - g/km^2/y, Hg - g/km^2/y)

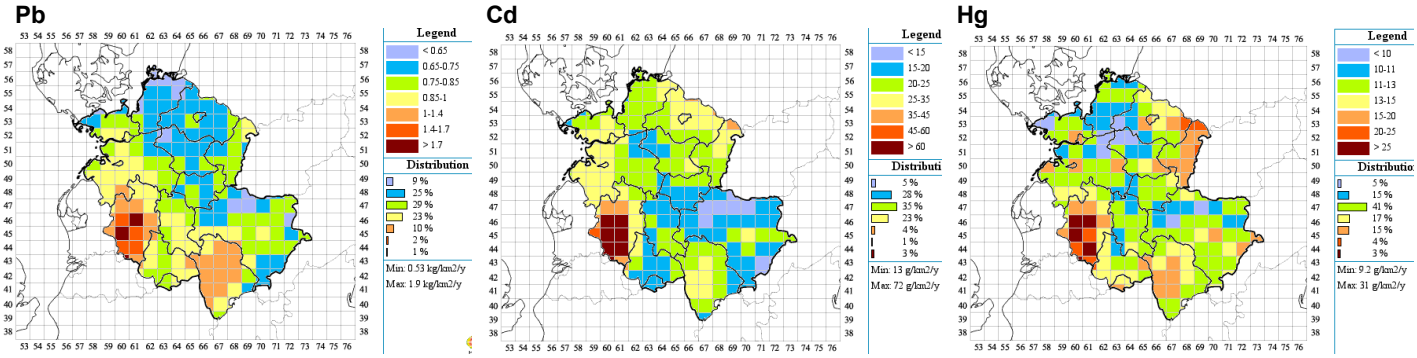


Figure 39. Heavy metals deposition to “grassland” land cover in 2010 (Pb - kg/km^2/y; Cd - g/km^2/y, Hg - g/km^2/y)

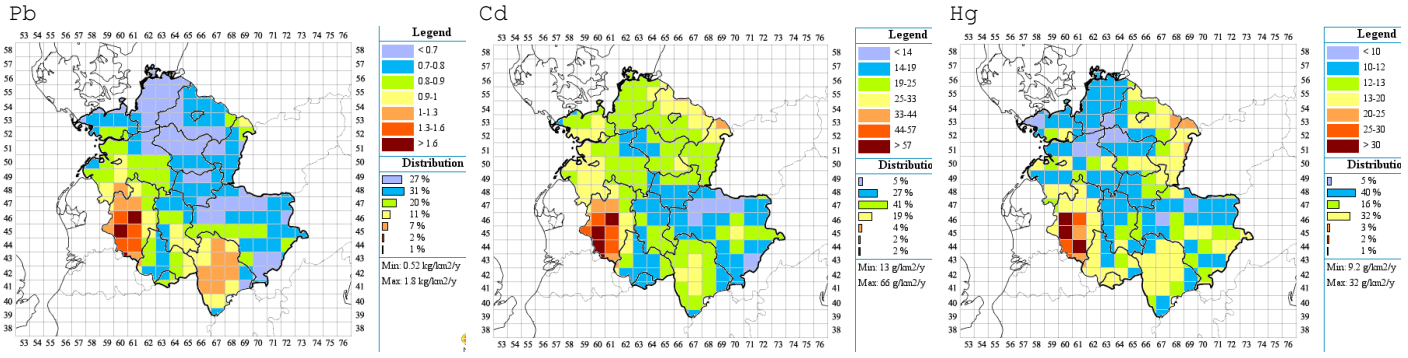


Figure 40. Heavy metals deposition to “wheat” land cover in 2010 (Pb - kg/km^2/y; Cd - g/km^2/y, Hg - g/km^2/y)

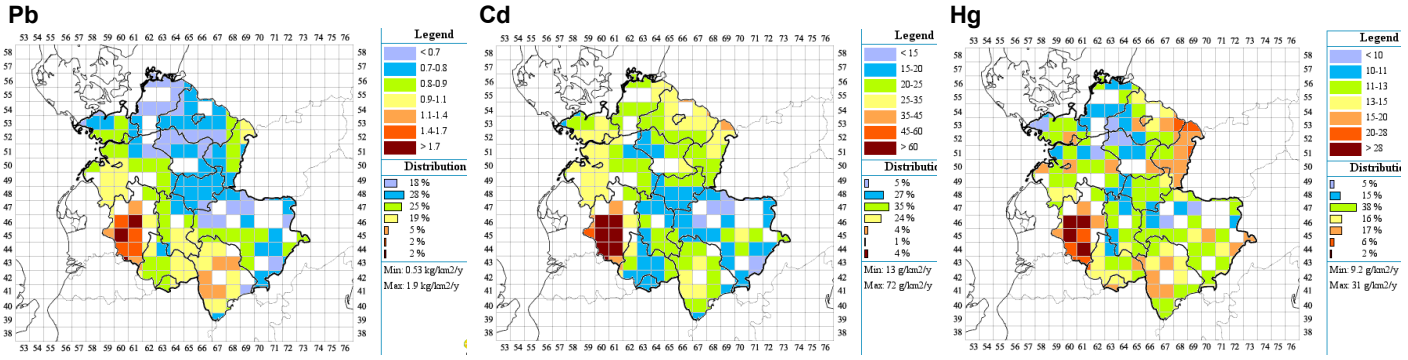


Figure 41. Heavy metals deposition to “semi-natural” land cover in 2010 (Pb - kg/km^2/y; Cd - g/km^2/y, Hg - g/km^2/y)

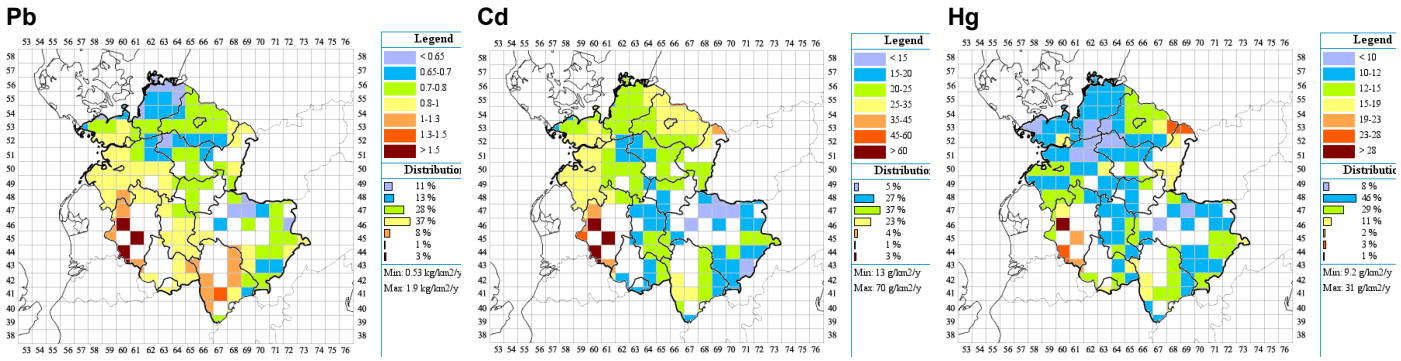


Figure 42. Heavy metals deposition to “wetland” land cover in 2010 (Pb - kg/km^2/y; Cd - g/km^2/y, Hg - g/km^2/y)

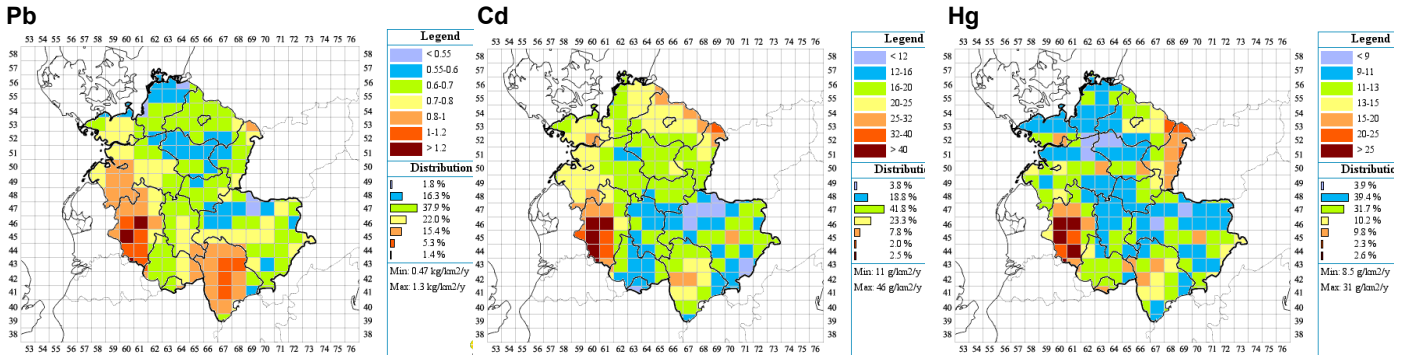


Figure 43. Heavy metals deposition to “desert/barren” land cover in 2010 (Pb - kg/km^2/y; Cd - g/km^2/y, Hg - g/km^2/y)

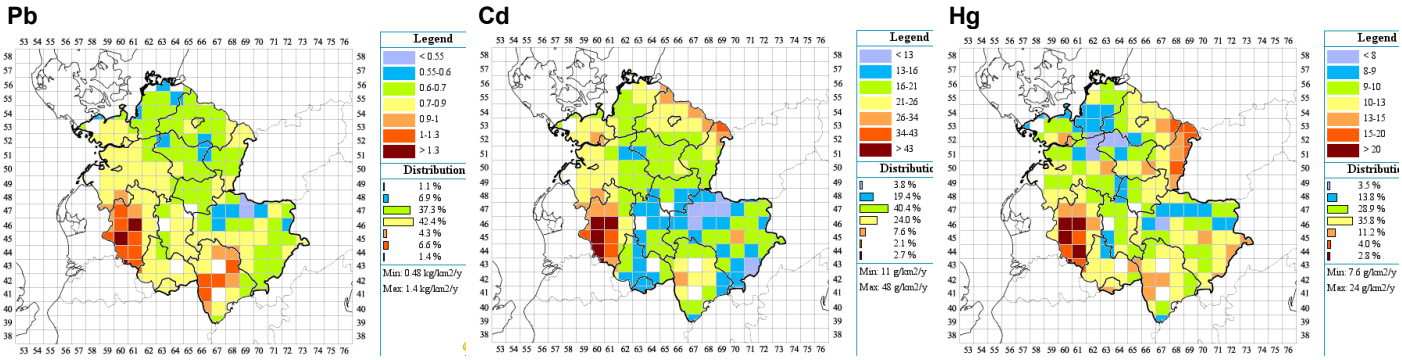


Figure 44. Heavy metals deposition to “inland water” land cover in 2010 (Pb - kg/km^2/y; Cd - g/km^2/y, Hg - g/km^2/y)

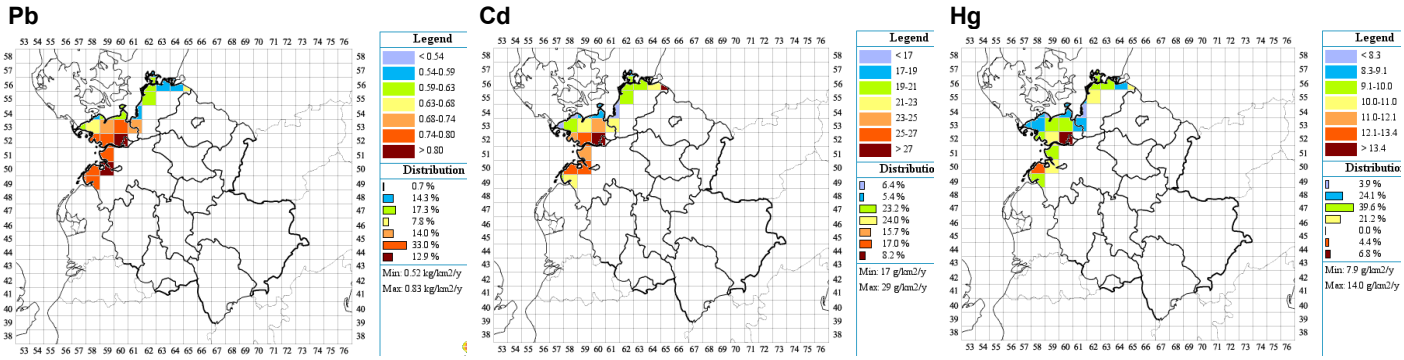


Figure 45. Heavy metals deposition to “sea water” land cover in 2010 (Pb - kg/km^2/y; Cd - g/km^2/y, Hg - g/km^2/y)

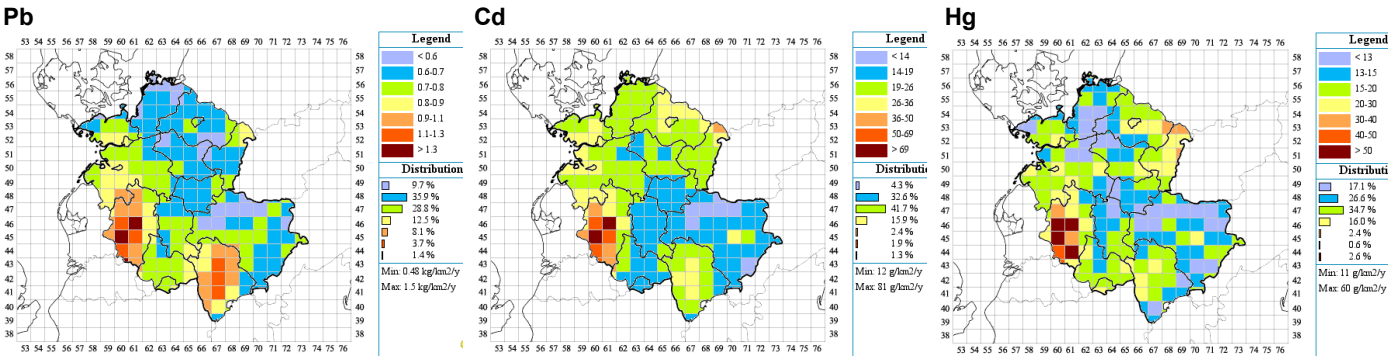


Figure 46. Heavy metals deposition to “urban” land cover in 2010 (Pb - kg/km^2/y; Cd - g/km^2/y, Hg - g/km^2/y)

3. Assessment of effects

- **Coordination Centre for Effects (CCE)**

  Critical loads databases and maps

  Critical thresholds and their exceedances

  Most recent critical load databases for Cd, Hg and Pb

- **ICP Vegetation (Programme Centre)**

  Annual report 2011/2012

  Spatial and temporal trends in heavy metal accumulation in mosses in Europe (1990-2005). Survey report.

  Spatial trends in nitrogen concentrations in mosses across Europe in 2005/2006. Survey report.

- **ICP Water (Programme Centre)**

  Reports

- **ICP Forest (Programme Centre)**

  National Reports

- **ICP Materials**

- **ICP on Integrated Monitoring of Air Pollution Effects on Ecosystems**

  National ICP IM programmes

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