Nitrogen emissions to the air in the Baltic Sea area

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Key Message

In all HELCOM Contracting Parties, *oxidized* nitrogen emissions were lower in 2017 than in 1995, with the largest reductions in Denmark (62%), followed by Finland (52%), Sweden (50%) and Germany (46%).

For *reduced* nitrogen (ammonia), annual emissions were lower in 2017 than in 1995 in six out of the nine HELCOM Contracting Parties, with the largest reductions in Denmark (30%), followed by Poland (16%), Sweden (13%) and Estonia (9%). In Russia, ammonia emissions increased from 1995 to 2017 by 8% and in Germany by 4%, while in Latvia the 1995 and 2017 emission totals of ammonia were the same.

In all HELCOM Contracting Parties, *total* nitrogen emissions were lower in 2017 than in 1995, with the largest reductions in Denmark (46%), followed by Finland (41%), Sweden (36%) and Germany (24%).

Results and Assessment

Relevance of the BSEFS for describing developments in the environment

This indicator shows the levels and trends of annual nitrogen oxides and ammonia emissions from anthropogenic sources included in the calculation of the deposition on the Baltic Sea. The sources include emissions from HELCOM Countries, Baltic and North Sea shipping and from other sources outside HELCOM area.

Policy relevance and policy references

The HELCOM Copenhagen Ministerial Declaration of 2013 on taking further action to implement the Baltic Sea Action Plan reconfirmed the need of reaching good environmental status for a healthy Baltic Sea. The declaration includes nutrient reduction targets, and thus also concerns airborne nitrogen input to the Baltic Sea. The Declaration sets targets on Maximum Allowed Inputs (MAI) covering both water- and airborne inputs.

The relevant policy to the control of emissions of nitrogen oxides and ammonia to the atmosphere on a global scale is set in the framework of the UN ECE Convention on Long-Range Transboundary Air Pollution (CLRTAP). For EU member states the policy frame is set by the EU NEC and IED Directives. For the Russian Federation the corresponding policy frame is embraced by Federal Acts on Environment Protection and the Protection of Atmospheric Air. The Gothenburg Protocol (1999, and revised in 2012) states that nitrogen oxides emissions in 2020 will be reduced by between 18% and 56% in 31 countries, with respect to 2005 annual emissions. The largest relative reductions will be in Denmark (56%), United Kingdom (55%) and France (50%). Ammonia emissions will also be reduced, but by smaller percentages (1% to 24%). The largest relative reductions of ammonia emissions will be in Denmark (24%), Finland (20%) and Sweden (15%). In the European Union, the revised Gothenburg Protocol is implemented by the new EU NEC Directive 2016/2284/EU, which sets 2020 and 2030 emission reduction commitments for five main air pollutants, including nitrogen oxides and ammonia.

Assessment

Here we show and discuss nitrogen emission data as used in the EMEP MSC-W model calculations performed in 2019 and presented to the Fifth Joint session of the Working Group on Effects and the Steering Body to EMEP which took place in Geneva in September 2019. The emission data have been derived from the 2019 official data submissions to the UN ECE LRTAP Convention as of June 2019. The gridded distributions of emissions have been provided by the EMEP Centre on Emission Inventories and Projections (CEIP) on the new 0.1° x 0.1° resolution. For the first time, nitrogen emission data were updated on this resolution also for the 1990s, so that new EMEP MSC-W model calculations could be performed for the entire period from 1995 to 2017 (see BSEFS "Atmospheric nitrogen deposition to the Baltic Sea"). Details about the methods of gridding and gap-filling emission data performed by CEIP can be found in the EMEP status report 1/2019 (EMEP, 2019, their section 3.8), which is publicly available on the web.

The gridded emission data used in the EME MSC-W model calculations are available on CEIP's WebDab at: http://www.ceip.at/webdab_emepdatabase/emissions_emepmodels

Time series of nitrogen oxides and ammonia annual emissions in the period 1995 – 2017 are shown for all HELCOM Contracting Parties in **Figure 1**. The figure also shows emissions from shipping in the North Sea and the Baltic Sea shipping, as well as all other sources within the EMEP MSW-W model domain. Time series of nitrogen oxides, ammonia and total nitrogen annual emissions, expressed as percentage of 1995 emissions, are shown for the same period in **Figure 2**. As usual, emissions from Russia are included only for that part of Russia that is included in the EMEP MSW-W model domain.

In all HELCOM Contracting Parties, a decline in total nitrogen emissions is reported for the period 1995 – 2017. The reduction of emissions from the Baltic Sea region in the years 1995 – 2017 is more significant for nitrogen oxides than for ammonia.

In HELCOM Contracting Parties, oxidized nitrogen emissions are by 7 to 62% lower in 2017 than in 1995, with the largest reductions in Denmark (62%), followed by Finland (52%), Sweden (50%), and Germany (46%). Reductions with respect to 1995 are also reported for all the other HELCOM Contracting parties, i.e. Estonia (31%), Latvia (26%), Poland (24%), Lithuania (20%), and Russia (7%). Oxidized nitrogen emissions from international shipping have also been reduced since 1995, both in the North Sea (22%) and in the Baltic Sea (19%).

For ammonia, the emissions from six out of nine HELCOM Contracting Parties were lower in 2017 than in 1995, with the largest reductions in Denmark (30%), followed by Poland (16%), Sweden (13%), and Estonia (9%). Reductions with respect to 1995 are also reported for Finland (6%) and Lithuania (3%). In Latvia, emissions of ammonia were the same in 1995 and 2017, while Germany and Russia have increased their ammonia emissions (by 4% and 8%, respectively).

It is also worth noting that the sum of ammonia sources *outside* the HELCOM Contracting Parties has increased by 48% from 1995 to 2017, causing a total nitrogen emission increase of 23% from there. Due to the relatively short lifetime of reduced nitrogen in the atmosphere, this does not have a big impact on the Baltic Sea. However, ship emissions of nitrogen oxides within the North Sea and Baltic Sea do matter. Emissions from international shipping are not reported by the Parties to the UN ECE LRTAP Convention. Therefore, gridded emissions for all sea regions were calculated by the EMEP Centre CEIP using the CAMS global shipping emission dataset (Granier et al., 2019) for the years 2000 to 2017, developed by the Finish Meteorological Institute (FMI), and provided via the ECCAD emission data base (ECCAD, 2019). Shipping emissions from 1995 to 1999 were estimated using CAMS global shipping emissions for 2000, adjusted with trends for global shipping from EDGAR v.4.3.2 (JRC/PBL 2016).

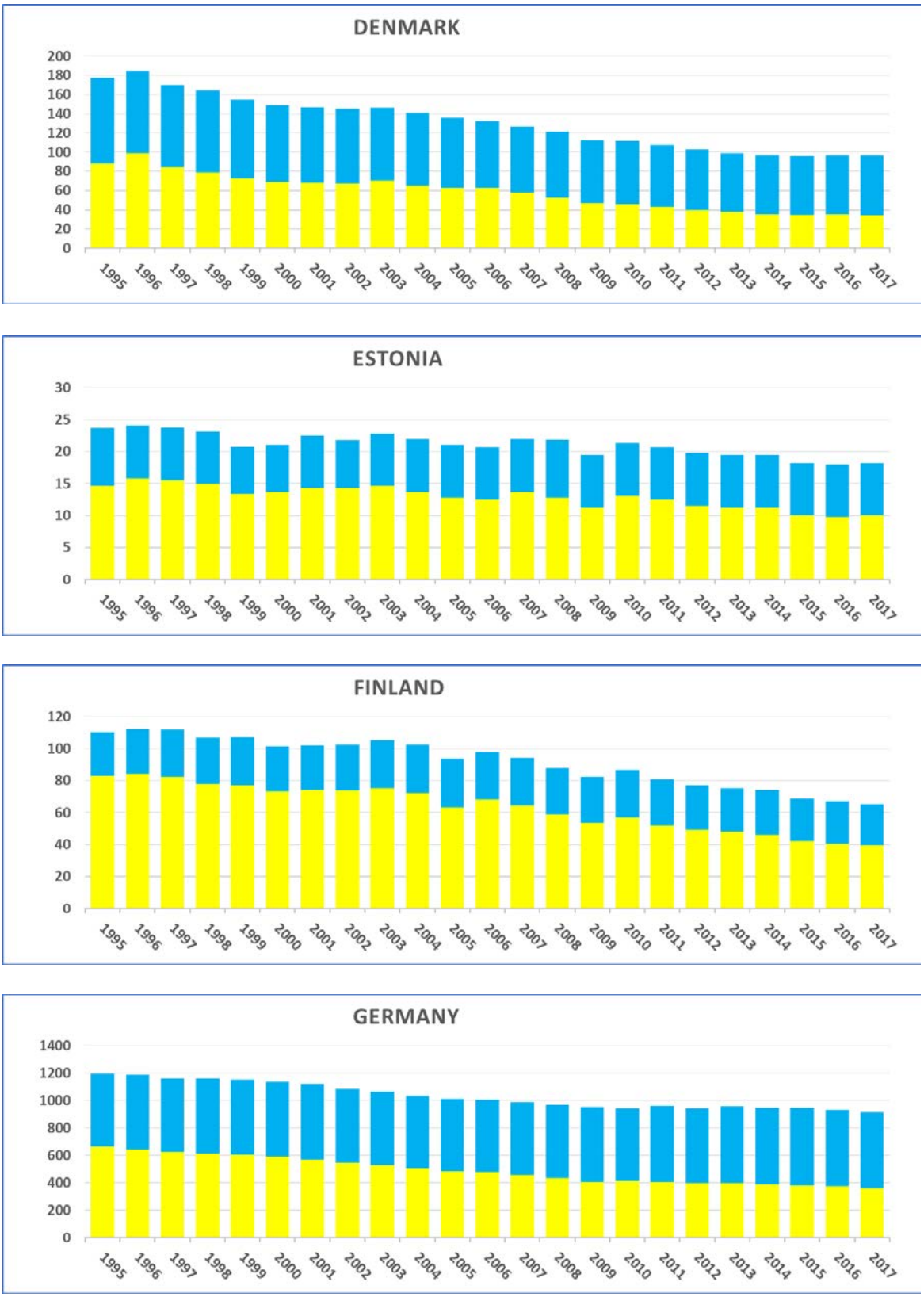

Figure 1. Annual atmospheric emissions of nitrogen oxides (NOx, yellow) and ammonia (NH_3, blue) from HELCOM Contracting Parties, international shipping (North Sea and Baltic Sea), and from other sources within the EMEP MSC-W model domain from 1995 to 2017. Unit: Gg(N)/year. Different vertical scales are used for the various sources. The data cover emissions from entire countries, except for Russia, where only emissions from the area covered by EMEP are included. The Figure continues on the next two pages.

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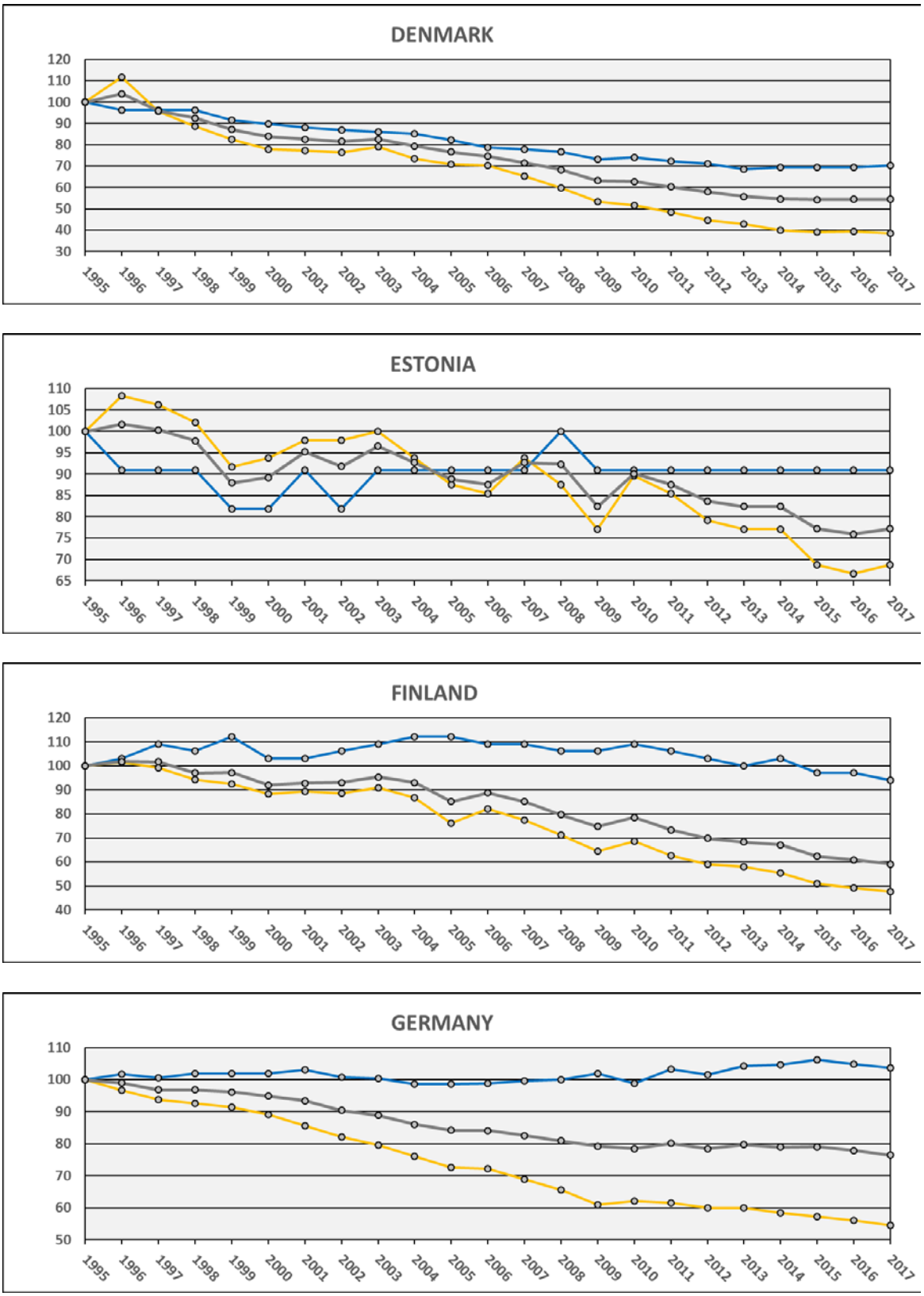
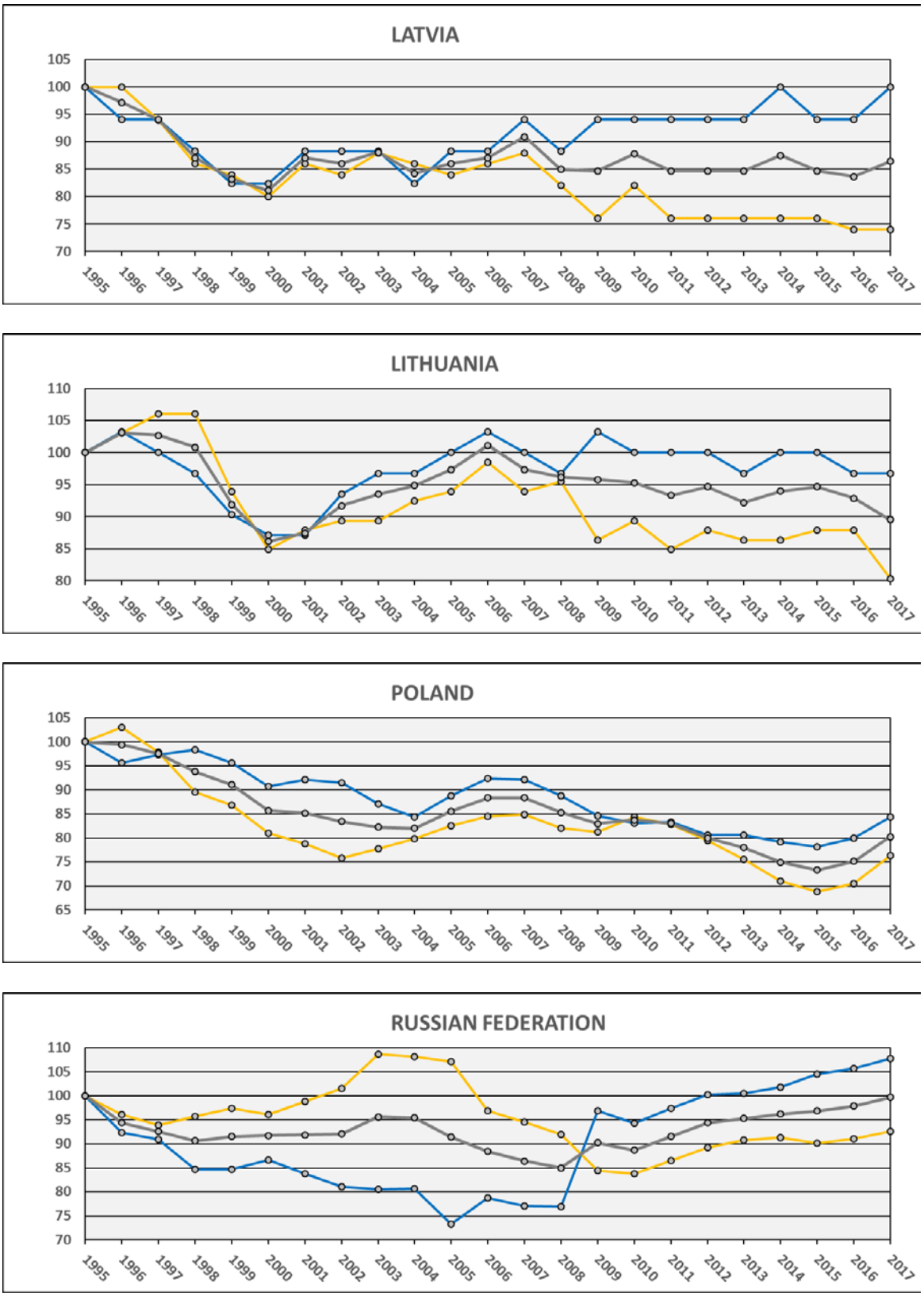


Figure 2. Trends in annual atmospheric emissions of nitrogen oxides (NOx, yellow), ammonia (NH_3, blue) and total nitrogen (NOx+ NH_3, grey) from HELCOM Contracting Parties, international shipping (North Sea and Baltic Sea), and from other sources within the EMEP MSC-W model domain from 1995 to 2017, plotted as percentage of the 1995 value. Unit: %. Different vertical scales are used for the various sources. The data cover emissions from entire countries, except for Russia, where only emissions from the area covered by EMEP are included. The Figure continues on the next two pages.



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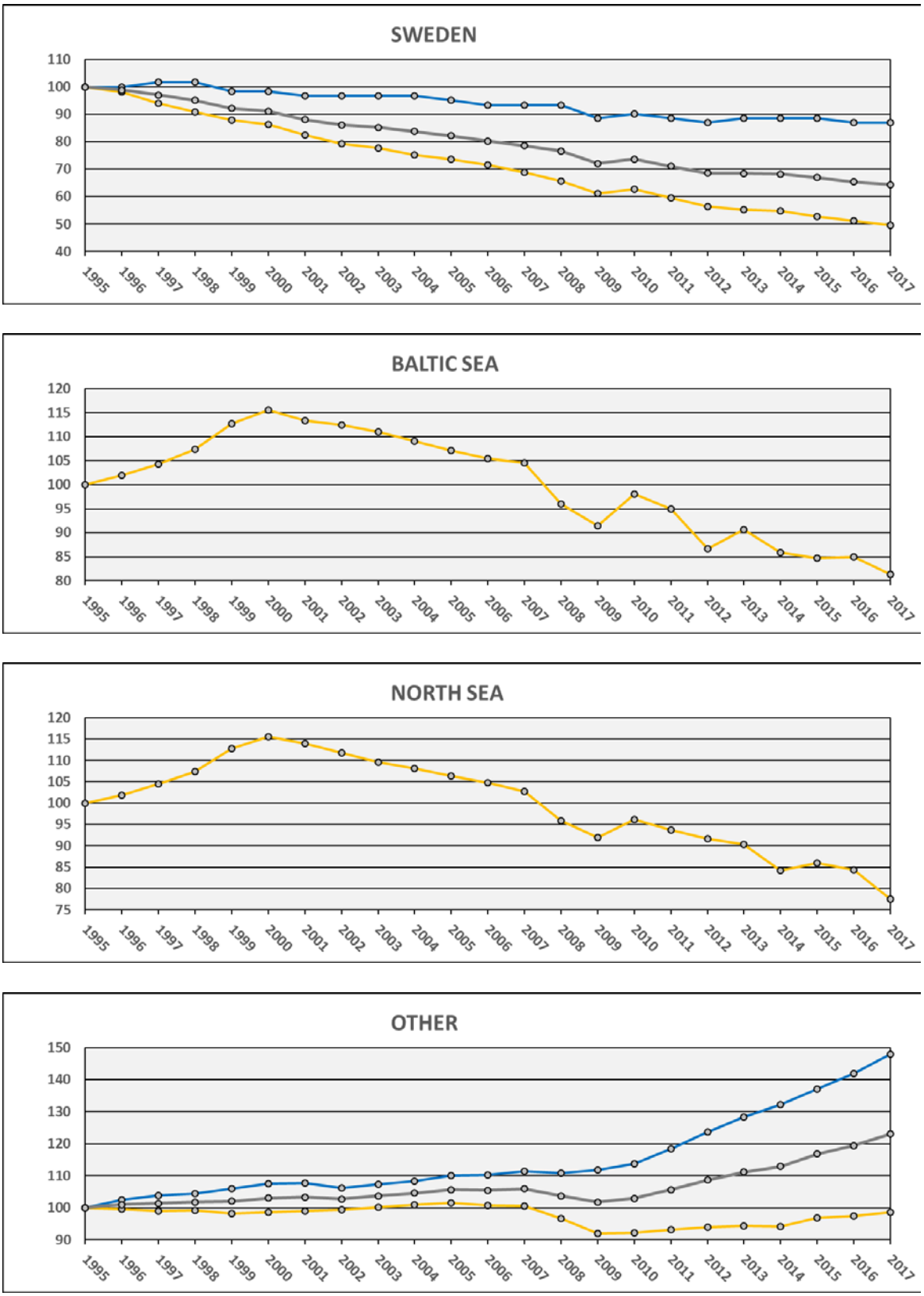

Figure 2. Continued.

References

ECCAD: Emissions of atmospheric Compounds and Compilation of Ancillary Data, URL: https://eccad.aeris-data.fr, 2019.

EMEP, 2019: EMEP Status Report 1/2019. "Transboundary particulate matter, photo-oxidants, acidifying and eutrophying components" Joint MSC-W & CCC & CEIP Report. Link for direct download: https://emep.int/publ/reports/2019/EMEP_Status_Report_1_2019.pdf

Granier, C., Darras, S., Denier van der Gon, H., Doubalova, J., Elguindi, N., Galle, B., Gauss, M., Guevara, M., Jalkanen, J.-P., Kuenen, J., Liousse, C., Quack, B., Simpson, D., and Sindelarova, K.: The Copernicus Atmosphere Monitoring Service global and regional emissions (April 2019 version), doi:10.24380/d0bn-kx16, Link for direct download: https://atmosphere.copernicus.eu/sites/default/files/2019-06/cams_emissions_general_document_apr2019_v7.pdf.

JRC/PBL: Emission Database for Global Atmospheric Research (EDGAR), Global Emissions EDGAR v4.3.1., European Commission, Joint Research Centre (JRC)/Netherlands Environmental Assessment Agency (PBL), URL http://edgar.jrc.ec.europa.eu, 2016.

Data

Table 1. National total emissions of nitrogen oxides from individual HELCOM Contracting Parties, international shipping (NOS: North Sea, and BAS: Baltic Sea), and from other sources within the EMEP MSC-W model domain in the period 1995 – 2017. Unit: Gg(N)/year. These emission data have been used in the EMEP MSC-W model calculations performed in 2019.

Year	DK	EE	FI	DE	LV	LT	PL	RU	SE	Sum HELCOM	Shipping		Other
											BAS	NOS	
1995	88.6	14.6	83.1	664	15.2	20.1	320	1064	76.1	2346	107	239	5953
1996	98.9	15.8	84.3	642	15.2	20.7	330	1023	74.6	2305	110	243	5927
1997	84.6	15.5	82.5	623	14.3	21.3	313	1000	71.5	2226	112	250	5890
1998	78.5	14.9	78.2	615	13.1	21.3	287	1018	69.1	2196	115	257	5904
1999	73.0	13.4	76.7	607	12.8	18.9	278	1037	67.0	2184	121	269	5844
2000	69.1	13.7	73.3	592	12.2	17.0	259	1023	65.7	2125	124	276	5864
2001	68.5	14.3	74.3	569	13.1	17.7	252	1052	62.7	2123	122	272	5893
2002	67.6	14.3	73.7	545	12.8	18.0	243	1080	60.3	2115	121	267	5914
2003	70.0	14.6	75.5	528	13.4	18.0	249	1157	59.0	2185	119	262	5962
2004	65.1	13.7	72.1	505	13.1	18.6	256	1151	57.2	2151	117	258	6003
2005	62.7	12.8	63.3	482	12.8	18.9	264	1140	56.0	2113	115	254	6040
2006	62.4	12.5	68.2	479	13.1	19.8	271	1031	54.5	2011	113	250	5995
2007	57.8	13.7	64.2	458	13.4	18.9	272	1006	52.3	1955	112	246	5985
2008	53.0	12.8	59.0	435	12.5	19.2	263	978	49.9	1882	103	229	5750
2009	47.2	11.3	53.6	405	11.6	17.3	261	899	46.6	1752	98.3	220	5471
2010	45.7	13.1	56.9	413	12.5	18.0	270	892	47.8	1769	105	230	5492
2011	42.9	12.5	52.0	408	11.6	17.0	265	920	45.3	1775	102	224	5547
2012	39.6	11.6	49.0	398	11.6	17.7	254	950	42.9	1774	93.1	219	5593
2013	38.0	11.3	48.1	398	11.6	17.3	242	965	42.0	1774	97.4	216	5616
2014	35.3	11.3	46.0	387	11.6	17.3	227	972	41.7	1750	92.2	201	5604
2015	34.7	10.0	42.3	380	11.6	17.7	221	960	40.2	1717	91.0	205	5771
2016	35.0	9.7	40.8	373	11.3	17.7	226	969	39.0	1721	91.3	201	5800
2017	34.1	10.0	39.6	362	11.3	16.1	245	986	37.7	1741	87.3	185	5875

Table 2. National total emissions of ammonia from individual HELCOM Contracting Parties and from other sources within the EMEP MSC-W model domain in the period 1995 – 2017. Unit: Gg(N)/year. These emission data have been used in the EMEP MSC-W model calculations performed in 2019.

Year	DK	EE	FI	DE	LV	LT	PL	RU	SE	Sum HELCOM	Other
1995	88.9	9.06	27.2	534	14.0	25.5	301	920	50.2	1970	5830
1996	85.6	8.24	28.0	544	13.2	26.4	287	849	50.2	1892	5970
1997	85.6	8.24	29.6	538	13.2	25.5	292	837	51.1	1880	6053
1998	85.6	8.24	28.8	545	12.4	24.7	296	779	51.1	1831	6090
1999	81.5	7.41	30.5	545	11.5	23.1	287	779	49.4	1815	6184
2000	79.9	7.41	28.0	545	11.5	22.2	273	796	49.4	1813	6272
2001	78.2	8.24	28.0	551	12.4	22.2	277	771	48.6	1796	6284
2002	77.4	7.41	28.8	539	12.4	23.9	275	745	48.6	1757	6186
2003	76.6	8.24	29.6	536	12.4	24.7	262	740	48.6	1738	6261
2004	75.8	8.24	30.5	527	11.5	24.7	254	742	48.6	1722	6316
2005	73.3	8.24	30.5	527	12.4	25.5	267	674	47.8	1665	6414
2006	70.0	8.24	29.6	529	12.4	26.4	278	724	46.9	1724	6427
2007	69.2	8.24	29.6	532	13.2	25.5	277	708	46.9	1710	6500
2008	68.4	9.06	28.8	534	12.4	24.7	267	707	46.9	1699	6466
2009	65.1	8.24	28.8	544	13.2	26.4	254	891	44.5	1876	6516
2010	65.9	8.24	29.6	528	13.2	25.5	250	867	45.3	1832	6637
2011	64.2	8.24	28.8	553	13.2	25.5	250	895	44.5	1883	6904
2012	63.4	8.24	28.0	543	13.2	25.5	242	922	43.6	1889	7205
2013	60.9	8.24	27.2	558	13.2	24.7	242	925	44.5	1903	7479
2014	61.8	8.24	28.0	559	14.0	25.5	238	936	44.5	1916	7707
2015	61.8	8.24	26.4	567	13.2	25.5	235	961	44.5	1943	7992
2016	61.8	8.24	26.4	561	13.2	24.7	240	972	43.6	1951	8279
2017	62.6	8.24	25.5	554	14.0	24.7	254	992	43.6	1978	8622

Table 3. National total emissions of total nitrogen from individual HELCOM Contracting Parties, international shipping (NOS: North Sea, and BAS: Baltic Sea), and from other sources within the EMEP MSC-W model domain in the period 1995 – 2017. Units: Gg(N)/year. These emission data have been used in the EMEP MSC-W model calculations performed in 2019.

Year	DK	EE	FI	DE	LV	LT	PL	RU	SE	Sum HELCOM	Shipping		Other
											BAS	NOS	
1995	178	23.7	110	1198	29.2	45.6	621	1984	126	4316	107	239	11783
1996	185	24.1	112	1186	28.4	47.0	617	1872	125	4196	110	243	11897
1997	171	23.8	112	1160	27.5	46.8	606	1836	123	4106	112	250	11943
1998	164	23.1	107	1161	25.4	46.0	582	1797	120	4026	115	257	11994
1999	155	20.8	107	1153	24.3	41.9	566	1816	116	3999	121	269	12028
2000	149	21.1	101	1137	23.7	39.3	532	1819	115	3938	124	276	12136
2001	147	22.5	102	1119	25.4	39.9	529	1822	111	3919	122	272	12177
2002	145	21.7	103	1084	25.1	41.8	518	1825	109	3872	121	267	12099
2003	147	22.8	105	1064	25.7	42.7	511	1897	108	3923	119	262	12223
2004	141	21.9	103	1032	24.6	43.3	509	1893	106	3873	117	258	12319
2005	136	21.0	93.8	1009	25.1	44.4	531	1813	104	3778	115	254	12454
2006	132	20.7	97.8	1008	25.4	46.1	548	1754	101	3734	113	250	12422
2007	127	21.9	93.9	990	26.6	44.4	548	1714	99,3	3665	112	246	12485
2008	121	21.8	87.9	969	24.8	43.9	529	1686	96,9	3581	103	229	12216
2009	112	19.5	82.4	949	24.7	43.7	515	1790	91,0	3628	98.3	220	11987
2010	112	21.3	86.6	941	25.7	43.5	520	1759	93,1	3601	105	230	12128
2011	107	20.7	80.9	960	24.7	42.6	516	1815	89,8	3657	102	224	12451
2012	103	19.8	77.0	940	24.7	43.2	497	1872	86,6	3663	93.1	219	12798
2013	99.0	19.5	75.3	956	24.7	42.1	484	1890	86,5	3678	97.4	216	13096
2014	97.1	19.5	74.0	947	25.6	42.9	465	1908	86,2	3665	92.2	201	13312
2015	96.5	18.3	68.7	948	24.7	43.2	455	1921	84,6	3660	91.0	205	13762
2016	96.8	18.0	67.1	933	24.4	42.4	466	1941	82,6	3672	91.3	201	14079
2017	96.7	18.3	65.1	916	25.3	40.8	498	1977	81,4	3719	87.3	185	14498

Metadata

Technical information

1. Source: EMEP Centre on Emission Inventories and Projections (CEIP).

2. Description of data: The gridded distributions of the 2017 emissions have been provided by the EMEP Centre on Emission Inventories and Projections (CEIP). The emissions for the 1995 to 2017 period have been derived from the 2019 official data submissions to UNECE CLRTAP as of June 2019.

3. Geographical coverage: EMEP domain covering Europe, a part of Asia and a part of Atlantic Ocean.

4. Temporal coverage: Data on nitrogen oxides and ammonia emissions are presented here for the period 1995 - 2017.

5. Methodology and frequency of data collection: National data on emissions are annually submitted by the Parties to the CLRTAP Convention to the UN ECE Secretariat. The methodology is based on a combination of emission measurements and emission estimates, based on activity data and emission factors. Submitted data undergo a QA/QC procedure and are stored in the webdab database of the EMEP Centre for Emission inventories and Projections (CEIP) in Vienna, Austria.

Quality information

6. Strengths and weaknesses: Strength: data on emissions are annually submitted, checked and stored in the CEIP database; Weaknesses: there are gaps in time series of national emissions, which have to be corrected by experts. Delays occur in updating historical emission data submitted by the EMEP Contracting Parties.

7. Uncertainty. No official information about the uncertainty of provided nitrogen emission data is available from CEIP. In general the emission data calculated in the gap-filling procedure are less certain than those submitted by the countries.

8. Further work required: Further work on emission uncertainty is required.