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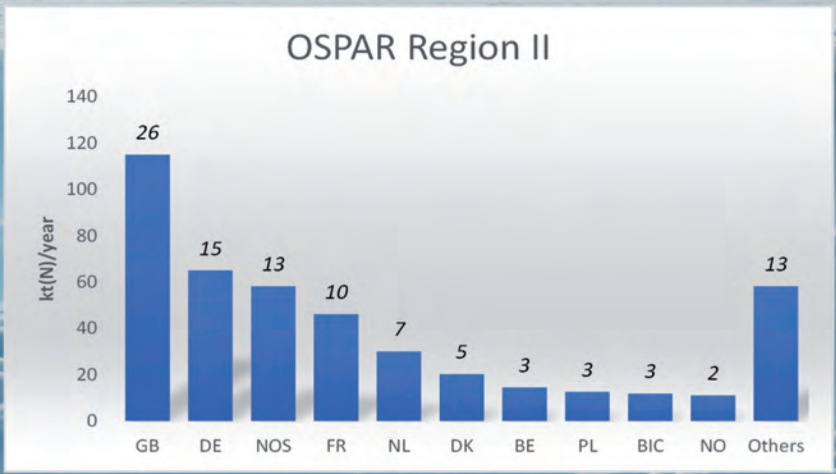
Nitrogen Depositions to the OSPAR Maritime Area in the period 1995-2019

by

Michael Gauss and Heiko Klein



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EMEP MSC-W Report for OSPAR
EMEP MSC-W TECHNICAL REPORT 2/2021

Nitrogen Depositions to the OSPAR Maritime Area in the period 1995-2019

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Contents

Executive Summary

Airborne nitrogen deposition to the OSPAR Maritime Area for the 30-year period 1990-2019 has been calculated with the EMEP MSC-W Chemistry Transport Model on a horizontal resolution of 0.1°lon x 0.1°lat. Emission data for the 2000-2019 period were updated by the EMEP Centre on Emission Inventories and Projections in 2021. Model results for the 1990s are based on official emission data reports of 2019.

Emissions from OSPAR Contracting Parties show statistically significant downward trends in the case of NOx ('oxidized nitrogen'), while downward trends in ammonia ('reduced nitrogen') emissions are less significant or even non-existent. Emissions of oxidized nitrogen come mainly from transport and power generation, while reduced nitrogen emissions are completely dominated by agriculture.

According to our model results, actual (non-normalized) depositions of *oxidised* nitrogen were clearly lower in 2019 than in 1995 in all OSPAR Regions, with the largest decline in Region V (57%). Annual deposition of *reduced* nitrogen decreased in all OSPAR Regions, but the reductions are much smaller than in the case of oxidised nitrogen, with the largest reduction in OSPAR Region I (19%). Concerning annual deposition of *total* (oxidised+reduced) nitrogen, there is a decline between 1995 and 2019 in all OSPAR Regions (in the range 28% - 46%), the largest decline being in Region V and the smallest in Region II.

In all considered Exclusive Economic Zones (EEZs) within the OSPAR Maritime Area, there is a clear decline in the actual depositions of *oxidised* nitrogen between 1995 and 2019 (in the range of 19% - 61%), while the annual deposition of *reduced* nitrogen was higher in 2019 than in 1995 in 7 EEZs. In the other 17 EEZs, deposition of reduced nitrogen has decreased, by up to 26%. In all 24 EEZs, the annual deposition of *total* nitrogen decreased from 1995 to 2019 (in the range of 9% - 50%).

It has to be noted, however, that percentage changes reported here with respect to the reference year 1995 can vary significantly from year to year due to meteorological conditions. This is especially true for the smallest EEZs. Therefore, we calculate changes in 5-year means as well, allowing for more robust results. In this year's report this has been done for the 2015-2019 period with respect to the 1995-1999 period.

Normalized depositions of oxidized and reduced nitrogen were lower in 2019 than in 1995 in all OSPAR Regions and in all EEZs. Among the OSPAR Regions, the largest decreases in oxidized nitrogen deposition (about 50%) occurred in OSPAR Region II and in EEZ189. Largest decreases in reduced nitrogen are modelled for EEZ188 (29%). Among OSPAR Regions, the largest decrease in reduced nitrogen is in Region II (18%).

The country to which the EEZ (or partial EEZ) belongs usually makes the largest contribution to nitrogen deposition in this EEZ (or partial EEZ). While actual (i.e. non-normalized) contributions show strong interannual variability due to changes in meteorology, normalized contributions better reflect changes in emissions (i.e. the effect of policy measures during the last 25 years). Thus, significant downward trends in normalized depositions of oxidized nitrogen are modelled in all considered receptor areas.

For the first time this year, EMEP MSC-W calculated nitrogen deposition also for the 67 COMP4 Assessment Units. Actual (non-normalized) and normalized depositions have been assessed. As many of the COMP4 Assessment Units are rather small and/or have a very thin and elongated shape, normalization was made with meteorological data only from the years since 2016, for which the EMEP MSC-W transfer coefficients (necessary for normalization) are available on 0.3°lon x 0.2°lat horizontal resolution, i.e. much finer than the earlier 50 x 50 km^2 grid. The normalized results for the smallest/thinnest COMP4 Assessment Units should nevertheless be considered as uncertain, as they are only poorly resolved by the model grid. Results for actual (non-normalized) deposition are more certain because they can be derived directly from EMEP's 0.1°lon x 0.1°lat model calculations.

In regard to actual depositions of *oxidized* nitrogen, there has been a decrease from 1995 to 2019 in all 67 COMP4 Assessment Units. The largest decrease (58%) is modelled in NAAC1B ("Noratlantic Area NOR-NorC1(D5)B"), while the smallest decrease (15%) is found in SK ("Skagerak"). For *reduced* nitrogen, there are decreases in most COMP4 Assessment Units, but not in all. The largest *decrease* (56%) is modelled in NAAC1D ("Noratlantic Area NOR-NorC1(D5)D") and the largest *increase* (32%) is in OWCO ("Ocean Waters CO (D5)"). It should be noted that NAAC1D is extremely small (only about 23 km^2), representing only a fraction of an EMEP model grid cell, so that the uncertainty in the exact magnitude of nitrogen deposition is large for NAAC1D (and Assessment Units of similar size).

Nevertheless, it is safe to say that actual oxidized nitrogen depositions have decreased over the 1995-2019 period in all COMP4 Assessment Units (and statistically significantly so), while for reduced nitrogen the trends are less significant, with depositions having decreased or increased slightly, depending on the Assessment Area in question.

Concerning normalized depositions, similar statements can be made. For *oxidized* nitrogen, the largest decrease (55%) is in ECPM2 ("East Coast (permanently mixed) 2"), while the smallest decrease (20%) has been modelled for SAAOC ("Sudatlantic Area SUD-OCEAN(D5)"). In the case of *reduced* nitrogen, the largest *decrease* (33%) is modelled for SCHPM1 ("Scheldt plume 1") while the largest *increase* (4%) is in SHPM ("Shannon plume"). Strictly speaking, SHPM is too small to be properly represented by the model grid used for the normalization procedure, so the 4% number should be taken as an indication only. It is very likely that there is no significant trend in normalized reduced nitrogen deposition in this Area.

Source-receptor relationships ('Source apportionment') have been calculated to assess Contracting Parties' contributions to nitrogen deposition in the OSPAR Maritime Area over the 1995-2019 period.

For the first time this year, source apportionment was also calculated for "partial EEZs", i.e. parts of those EEZs that fall within more than one OSPAR Region. This applies to 9 out of the 24 EEZs considered by EMEP MSC-W. EEZs can fall within up to five OSPAR Regions. In total, 25 partial EEZs are considered.

1 Introduction

Nitrogen deposition to OSPAR Convention Waters has been a subject of cooperation between EMEP MSC-W (Meteorological Synthesizing Centre – West) and OSPAR since 2003, starting with the first EMEP report for OSPAR delivered by Bartnicki and Fagerli (2003). This cooperation has been continued and documented in numerous reports until the present day.

This report covers results for all the three contracts that EMEP MSC-W had with OSPAR in 2021. The following Deliverables were listed in these contracts (all deliverables relate to nitrogen):

1. Emissions data by Contracting Parties (from national reports to EMEP) and by sector
2. Actual atmospheric deposition to each OSPAR Region
3. Actual atmospheric deposition to national EEZs in each OSPAR region
4. Actual atmospheric deposition divided up as EEZ within each OSPAR Region
5. Actual atmospheric deposition to each COMP4 Assessment Unit
6. Normalised nitrogen deposition to each OSPAR Region
7. Normalised nitrogen deposition to each COMP4 Assessment Unit
8. Source apportionment – by Contracting Party (CP) to OSPAR Region
9. Source apportionment – by Contracting Parties to national EEZ within each OSPAR Region
10. Quality Control of OSPAR's CAMP data

All products should be delivered with trends back to 1995 or, if feasible, 1990.

The Quality Control of OSPAR's CAMP data (item 10) was part of NILU's work (Norwegian Institute for air research) and is not subject of this report. Emission data (item 1) is provided annually by EMEP CEIP (Centre for Emission Inventories and Projections). EMEP MSC-W's work consisted of extracting data relevant for OSPAR and to present tables and analyses of trends and sector contributions.

For the first time this year, nitrogen depositions had to be calculated for "partial EEZs" (items 4 and 9), i.e. parts of those EEZs that fall within more than one OSPAR Region. This is the case for 9 of the 24 EEZs considered by EMEP MSC-W. EEZs can fall within up to five OSPAR Regions. In total, 25 partial EEZs are considered.

Also for the first time this year, nitrogen depositions had to be calculated for the COMP4 Assessment Units. Actual and normalized depositions have been calculated for 67 COMP4 Assessment Units (as defined in a table provided by OSPAR in May 2021), with trends back to 1990 in the case of actual (non-normalized) depositions, and back to 1995 in the case of normalized depositions. Since many of the COMP4 Assessment Units are rather small, we decided to base the normalization only on those 4 meteorological years for which EMEP MSC-W has calculated transfer coefficients on 0.3°(lon) x 0.2°(lat) resolution, i.e. 2016, 2017, 2018 and 2019. For consistency normalization is done with these years also in the results for all other receptor areas considered in this report.

After the description of the model setup in Chapter 2, we present the emission data (Chapter 3) and the definitions of receptor areas considered for OSPAR (Chapter 4), followed by the model results in Chapters 5 (depositions) and 6 (source apportionment). In Chapter 7, conclusions are listed, while Chapter 8 describes the data files that have been submitted to OSPAR along with this report.

2 Modeling

2.1 The EMEP MSC-W model

The EMEP MSC-W model, a multi-pollutant 3D Eulerian Chemical Transport Model, has been used for all nitrogen computations presented here. The model takes into account processes of emissions, advection, turbulent diffusion, chemical transformations, wet and dry depositions and inflow/outflow of pollutants into/out of the model domain. It was documented in detail in Simpson et al. (2012) and in the annual chapters on model updates in subsequent EMEP status reports (see Simpson et al., 2021, and references therein).

The model is regularly evaluated against measurements from the EMEP network under the LRTAP convention (e.g. Gauss et al., 2019; 2020), but also in a large number of international research projects and operational services, for example in the Copernicus Atmosphere Monitoring Service (CAMS, see http://www.regional.atmosphere.copernicus.eu/), where evaluation graphs are updated every day and quarterly evaluation reports are issued online on a quarterly basis. A detailed evaluation of this year's EMEP MSC-W model simulation (for 2019) can be viewed at the new AeroVal evaluation interface at https://aeroval.met.no/evaluation.php?project=emep&exp_name=2021-reporting

As in every model, deviations between model and observations do occur and are highly variable both in space and time, and these are subject of continuous investigation and model development. Nevertheless, the performance of the EMEP MSC-W model can be considered as state-of-the-art over a large range of both gaseous species and particulate matter, and thereby is among the best air quality models available today. The transparency of the EMEP MSC-W model results and activities is further ensured by the availability of the model code as Open Source at https://github.com/metno/emep-ctm. In this way, the scientific community as well as advanced policy users can check and apply the model themselves, both as a research tool and for underpinning of air quality legislation.

2.2 Experimental setup

Meteorological data have been generated by the ECMWF IFS model cy40r1 for the period 1990 to 2018 and cy46r1 for 2019 (see ECMWF model documentation). The version change for 2019 was inevitable because cy40r1 is not supported anymore, but changes in the meteorological driver have a relatively small effect on model results (changes in the chemistry transport model as well as the emission data are more important).

Emission data for the 1990-1999 period were obtained in June 2019 from the EMEP Centre CEIP and listed in the EMEP Status Report 1/2019 (EMEP, 2019). Some countries had not updated their emission data for PM (particulate matter) for the 1990s, which is why EMEP MSC-W had not calculated trends back to 1990 in recent reports. In the case of nitrogen deposition the importance of PM emissions is rather minor, so this year we decided to calculate nitrogen deposition all the way back to 1990 and to include these data in the tables provided to OSPAR. Nevertheless, this report focuses only on the period 1995 to 2019.

New emission data for 2000-2019 were obtained in June 2021 from the EMEP Centre CEIP and listed in the EMEP Status Report 1/2021 (EMEP, 2021) and were used in the model runs covering the 2000-2019 period. More details about the emission data used in our model calculations are given in Chapter 3 of this report.

EMEP MSC-W model version rv4.42 (documented and evaluated in EMEP Status report 1/2021) was run for the entire trend period 1990-2019, using the meteorological and emission data described above, on 0.1°lon x 0.1°lat resolution and within the longitude-latitude domain outlined in green in Figure 1.

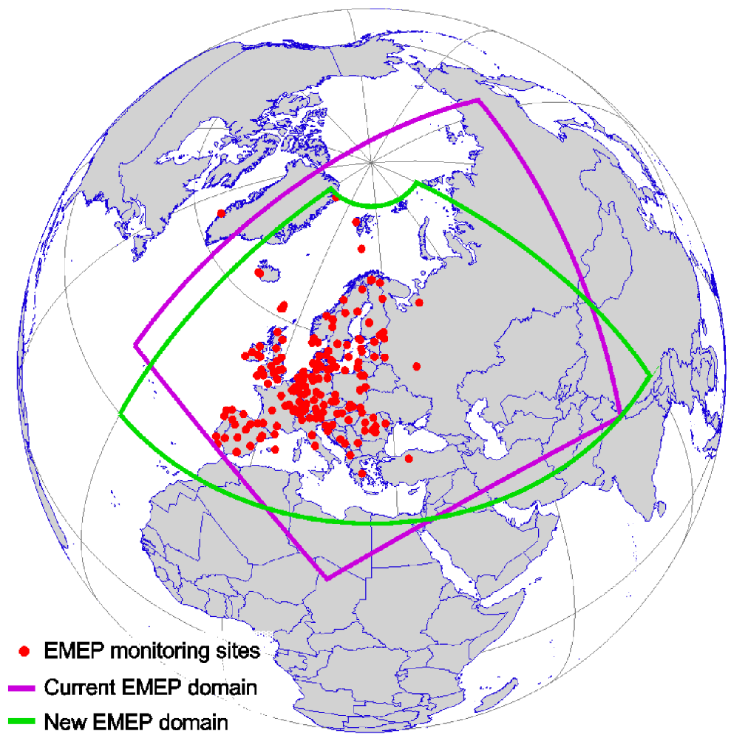


Figure 1: The old (purple) and new (green) official EMEP domains. The new domain was used for the first time for the EMEP status runs in 2017 (EMEP, 2017), and has 0.1°lon x 0.1°lat resolution in a regular longitude-latitude grid. All calculations for this report were done on the new official EMEP domain.

3 Emission data by Contracting Parties and by sector

In this chapter we present the emission data used for modelling at EMEP MSC-W. They are provided on an annual basis by the EMEP Centre on Emission Inventories and Projects (CEIP) and are publicly available (*WebDab Emission database* at https://ceip.at, see "Emissions as used in EMEP models").

Annual emissions of oxidized nitrogen (NOx) and reduced nitrogen (ammonia/NH_3) are listed in Tables 1 and 2, respectively, for the 1995-2019 period and the OSPAR Contracting Parties[1]. Figure 2 visualizes the evolution for the same period. Data for the European Union (EU) are not tabulated because the number of members has changed several times during the considered period. For NOx, emissions from international shipping are listed as well. For completeness, emissions of total nitrogen are listed in Table 3.

The Mann-Kendall test has been used to test the hypothesis of there being negative trends in the 2000-2019 time series for NOx and NH_3 emissions. All NOx emission trends from 2000 are negative and significant at the 5% level. All NH_3 emission trends from 2000 are negative and significant at the 5% level, except for Germany, Iceland, Ireland and Norway.

[1] Belgium (BE), Denmark (DK), Finland (FI), France (FR), Germany (DE), Iceland (IS), Ireland (IE), Luxembourg (LU), The Netherlands (NL), Norway (NO), Portugal (PT), Spain (ES), Sweden (SE), Switzerland (CH) and the United Kingdom (GB).

Table 1. Annual emissions of nitrogen oxides from OSPAR Contracting Parties, international shipping (NOS: North Sea, and ATL: Part of the Atlantic Ocean included in the EMEP MSC-W model domain, but not part of NOS) in the period 1995 – 2019, as used in the EMEP MSC-W model calculations of nitrogen deposition. Unit: ktonnes(N)/year. The period 2000-2019 is based on data submissions in 2021, while data for 1995-1999 are based on data submissions of 2019. The table continues on the next page. The last column shows the total of all emissions.

Year	BE	DK	FI	FR	DE	IS	IE	LU	NL
1995	116	89	83	545	664	11	52	11	169
1996	113	99	84	537	642	11	52	11	165
1997	109	85	83	517	623	11	51	11	157
1998	110	79	78	525	615	10	53	10	150
1999	103	73	77	509	608	10	53	11	148
2000	110	69	73	520	580	10	56	13	144
2001	106	68	74	509	562	8.9	55	13	140
2002	102	67	74	496	544	10	53	13	135
2003	101	70	76	483	530	9.4	53	14	133
2004	104	65	72	470	515	10	53	17	129
2005	99	62	63	455	500	8.6	54	17	127
2006	95	62	68	429	503	8.5	53	16	124
2007	91	58	64	409	489	9.3	51	14	120
2008	83	53	59	379	470	8.6	47	13	118
2009	74	47	54	355	443	8.5	39	12	108
2010	74	46	57	348	448	8.0	37	12	106
2011	69	43	52	331	440	7.3	33	12	101
2012	66	39	49	323	437	7.2	34	11	96
2013	63	38	48	316	437	7.0	34	10	92
2014	60	35	46	295	424	6.9	34	10	86
2015	60	35	42	289	415	7.1	35	8.7	86
2016	57	35	41	275	408	6.5	35	7.8	82
2017	54	34	40	265	393	6.6	34	6.9	79
2018	52	32	39	247	368	6.8	34	6.3	77
2019	49	30	36	236	346	6.3	31	5.9	73

Table 1. Continued from previous page.

Year	NO	PT	ES	SE	CH	GB[2]	NOS	ATL	*Total*
1995	67	87	418	76	35	808	239	302	3771
1996	70	81	402	74	34	780	244	308	3709
1997	73	82	403	72	33	718	250	315	3590
1998	74	86	399	69	33	690	257	324	3564
1999	72	89	407	67	33	650	269	340	3519
2000	68	89	411	66	31	624	283	355	3499
2001	67	88	402	63	30	609	279	350	3425
2002	65	90	412	61	29	579	273	343	3346
2003	66	83	409	60	28	566	268	337	3284
2004	65	83	416	59	28	547	264	334	3231
2005	66	84	410	58	28	541	260	327	3161
2006	66	78	395	57	28	520	256	322	3081
2007	67	75	393	56	28	498	251	317	2991
2008	65	69	331	54	28	447	234	290	2749
2009	62	65	296	50	26	387	224	275	2524
2010	64	60	277	51	26	379	235	296	2524
2011	64	55	275	49	25	355	229	290	2429
2012	63	51	262	47	25	363	227	285	2384
2013	61	50	232	47	25	344	221	276	2300
2014	58	49	234	46	23	322	202	244	2174
2015	55	50	235	45	22	312	204	259	2159
2016	52	48	221	44	22	285	204	255	2077
2017	49	49	220	43	21	275	198	255	2021
2018	49	47	210	42	20	267	199	258	1952
2019	46	45	197	39	19	256	231	283	1928

[2] Here and elsewhere in this report, the abbreviation 'GB' is used for the United Kingdom of Great Britain and Northern Ireland. This is because EMEP MSC-W under the UN LRTAP Convention is required to use ISO 3166-1 alpha-2 codes.

Table 2. Annual emissions of ammonia from OSPAR Contracting Parties in the period 1995 – 2019, as used in the EMEP MSC-W model calculations of nitrogen deposition. Unit: ktonnes(N)/year.

Year	BE	DK	FI	FR	DE	IS	IE	LU	NL	NO	PT	ES	SE	CH	GB	*Total*
1995	105	89	27	522	535	4.1	93	5.4	185	26	60	384	50	52	249	2387
1996	107	86	28	526	543	4.2	96	5.5	187	27	61	411	50	52	256	2440
1997	106	86	29	521	538	4.2	98	5.5	179	26	60	416	51	50	261	2432
1998	106	86	29	523	545	4.3	102	5.5	166	27	59	432	51	50	262	2446
1999	106	81	31	522	545	4.4	100	5.6	165	27	61	441	50	49	258	2445
2000	77	80	29	546	516	3.8	99	5.0	143	24	63	431	49	50	250	2365
2001	75	78	29	541	520	3.8	99	4.9	138	24	60	428	49	50	243	2343
2002	73	77	30	529	510	3.7	99	4.8	132	24	59	420	49	49	241	2298
2003	70	76	30	522	507	3.7	99	4.6	129	25	54	428	49	48	235	2280
2004	66	77	31	515	495	3.6	97	4.7	128	25	54	424	49	48	235	2251
2005	64	74	31	511	500	3.7	99	4.6	126	25	53	398	48	49	230	2216
2006	64	71	30	503	496	3.8	100	4.5	128	25	52	394	47	49	226	2194
2007	62	70	30	509	503	3.9	94	4.6	125	25	53	400	47	50	223	2199
2008	60	69	29	513	506	3.9	96	4.6	115	25	51	365	47	50	210	2145
2009	60	66	30	505	508	3.9	96	4.5	113	25	49	363	45	49	212	2129
2010	60	66	30	509	510	3.8	95	4.6	110	25	49	359	45	49	215	2130
2011	59	64	29	500	515	3.8	91	4.5	109	25	49	349	45	48	213	2103
2012	59	63	29	501	519	3.7	96	4.4	104	25	47	345	44	47	213	2099
2013	59	61	28	498	525	3.6	97	4.3	103	25	46	347	45	46	210	2099
2014	57	60	29	502	531	3.9	94	4.5	106	25	48	365	45	47	220	2137
2015	58	62	28	508	528	3.9	98	4.5	108	25	49	373	45	46	223	2157
2016	58	62	27	508	526	4.0	103	4.5	107	25	49	377	44	46	226	2165
2017	56	64	27	504	514	3.9	106	4.7	109	24	49	392	44	46	227	2171
2018	56	63	26	499	495	3.8	111	4.6	106	25	49	391	44	45	226	2146
2019	55	62	26	488	483	3.7	103	4.6	101	24	49	388	44	44	224	2099

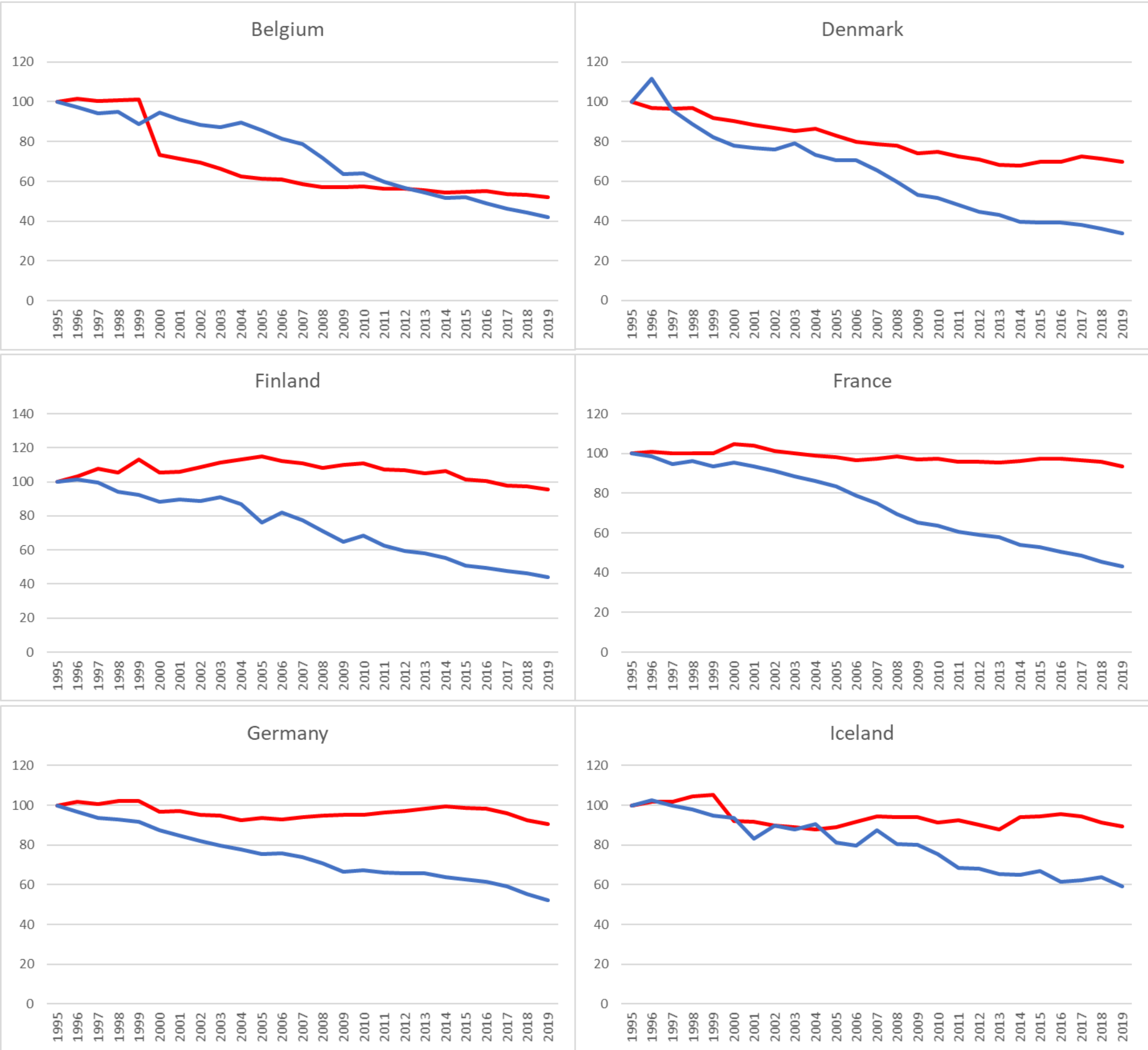
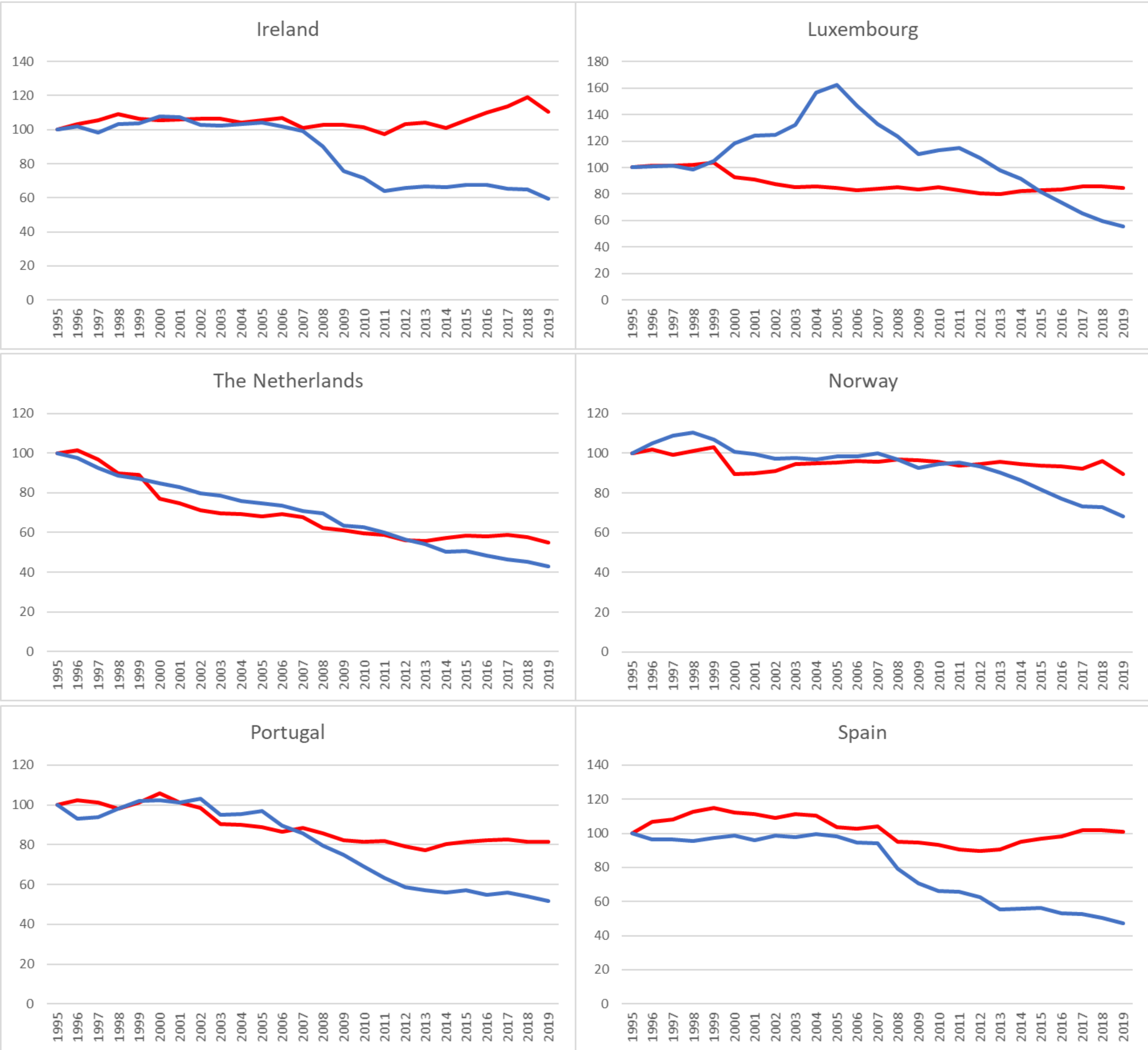


Figure 2: Change in emissions provided by the EMEP Centre CEIP for modelling, based on official data submissions by Contracting Parties. Blue: Oxidized nitrogen (NOx); red: reduced nitrogen (NH_3); 1995=100%. It has to be noted that the 1990s are based on submissions in 2019, while all years from 2000 are based on submissions from 2021. Unit: %. (Figure continues on next page.)



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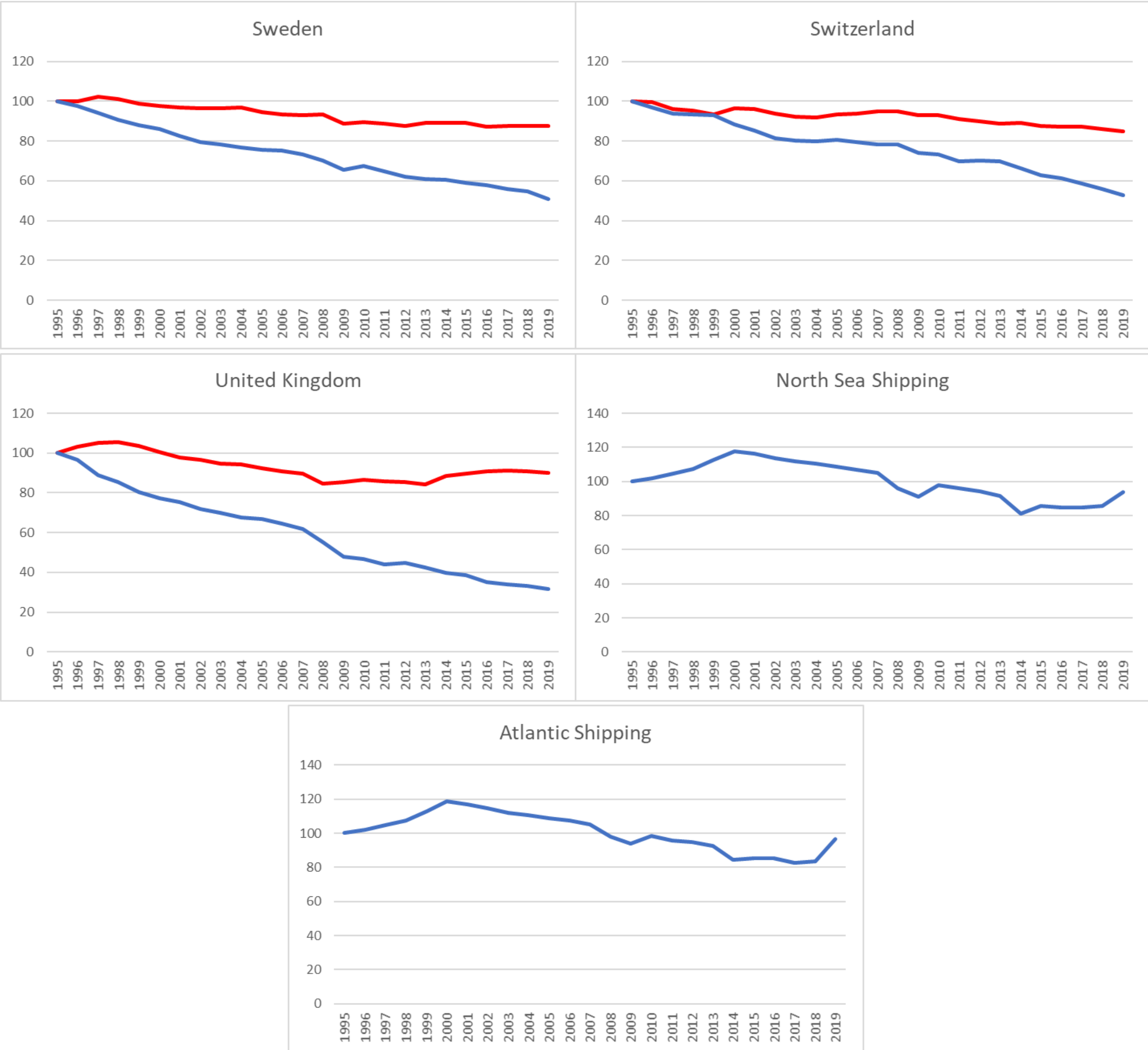


Figure 2: Continued.

Table 3. National annual emissions of total nitrogen from OSPAR 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 – 2019, as used in the EMEP MSC-W model calculations of nitrogen deposition. Units: ktonnes(N)/year. The table continues on the next page. The last column shows the total of all emissions.

	BE	**DK**	**FI**	**FR**	**DE**	**IS**	**IE**	**LU**	**NL**
1995	221	177	110	1067	1199	15	145	16	354
1996	219	185	112	1063	1186	15	149	16	353
1997	215	170	112	1038	1161	15	149	16	336
1998	216	164	107	1048	1161	15	155	16	316
1999	209	154	108	1030	1153	14	153	17	313
2000	187	149	102	1066	1096	14	154	18	286
2001	181	146	103	1050	1082	13	154	18	278
2002	175	144	103	1025	1053	13	152	18	267
2003	171	146	106	1004	1037	13	152	19	262
2004	170	142	103	985	1010	13	150	21	256
2005	164	136	95	967	1000	12	152	22	252
2006	158	133	99	932	999	12	152	20	252
2007	153	128	94	918	992	13	146	19	245
2008	143	122	88	892	976	12	143	18	233
2009	134	113	84	860	951	12	135	16	220
2010	135	112	87	857	957	12	132	17	217
2011	128	107	81	831	954	11	124	17	210
2012	125	102	78	823	956	11	130	16	199
2013	122	99	77	815	962	11	132	15	195
2014	117	95	75	797	954	11	128	14	191
2015	118	97	70	796	943	11	133	13	194
2016	115	97	68	782	934	10	138	12	189
2017	110	98	66	770	907	11	140	12	188
2018	108	95	65	747	864	11	145	11	183
2019	104	92	62	724	829	10	134	11	174

Table 3. Continued from previous page.

Year	NO	PT	ES	SE	CH	GB	NOS	ATL	*Total*
1995	94	147	802	127	88	1057	239	302	6157
1996	97	142	813	125	86	1036	244	308	6149
1997	99	142	819	123	83	979	250	315	6022
1998	101	144	831	120	83	952	257	324	6010
1999	99	149	849	117	82	908	269	340	5964
2000	91	152	842	115	81	873	283	355	5865
2001	91	149	829	112	80	853	279	350	5768
2002	89	149	831	109	78	820	273	343	5643
2003	90	136	837	108	77	801	268	337	5564
2004	90	137	841	107	76	782	264	334	5482
2005	91	137	807	105	77	771	260	327	5377
2006	91	130	790	104	77	746	256	322	5276
2007	92	127	793	103	77	721	251	317	5190
2008	91	120	696	101	77	657	234	290	4894
2009	88	114	658	94	75	600	224	275	4653
2010	89	109	636	96	74	594	235	296	4654
2011	89	104	623	94	72	568	229	290	4532
2012	88	98	607	91	72	575	227	285	4484
2013	86	96	579	91	71	554	221	276	4399
2014	83	97	599	91	70	541	202	244	4311
2015	80	99	608	90	68	535	204	259	4316
2016	76	97	598	88	67	511	204	255	4242
2017	73	98	612	87	66	502	198	255	4192
2018	74	96	601	86	65	492	199	258	4098
2019	69	94	585	83	63	481	231	283	4027

The contract with OSPAR also asked for emissions *by sector*. All data are summarized separately for oxidized and reduced nitrogen in two Excel sheets, submitted along with this report (see Chapter 8).

EMEP emissions reporting is based on the GNFR system (**G**ridded **N**omenclature **F**or **R**eporting), which has been in use in EMEP since 2017 and has many advantages over the older SNAP system, in particular a larger level of detail. Documentation on how GNFR (and the underlying NFR sector emissions) are grouped is given in the Reporting Guidelines of CEIP (CEIP, 2019), and in particular their Annex 1.

The Excel files submitted with this report to OSPAR contain data for all GNFR sectors, while Figures 3 and 4 visualize percentage shares only for the following 5 aggregated sectors:

- Transport (aviation landing/take-off, road traffic and offroad traffic, inland shipping)
- Power (including mainly combustion, but also other processes)
- OtherComb (stationary combustion other than power generation)
- Agriculture
- All other sources (this also includes some combustion from industry)

Table 4 shows how GNFR sectors were aggregated into these 5 sectors for the sake of visualization in Figures 3 and 4. There are clear differences between countries, but Transport is the single-most important sector in all countries for oxidized nitrogen, while Agriculture is the dominant sector in all countries for reduced nitrogen emissions.

Table 4. Aggregation of GNFR sectors to 'HELCOM sectors', also used for the figures produced for OSPAR below.

GNFR sectors	Simplified sectors used in this chapter
GNFR_A : Public Power	→ **Power**
GNFR_C : Other Stationary Combustion	→ **OtherComb**
GNFR_F : Road Transport	→ **Transport**
GNFR_G : Shipping	
GNFR_H : Aviation	
GNFR_I : Offroad	
GNFR_K : Agriculture Livestock	→ **Agriculture**
GNFR_L : Agriculture Other	
GNFR_B : Industry	→ **Other**
GNFR_D : Fugitive	
GNFR_E : Solvents	
GNFR_J : Waste	
GNFR_M : Other	

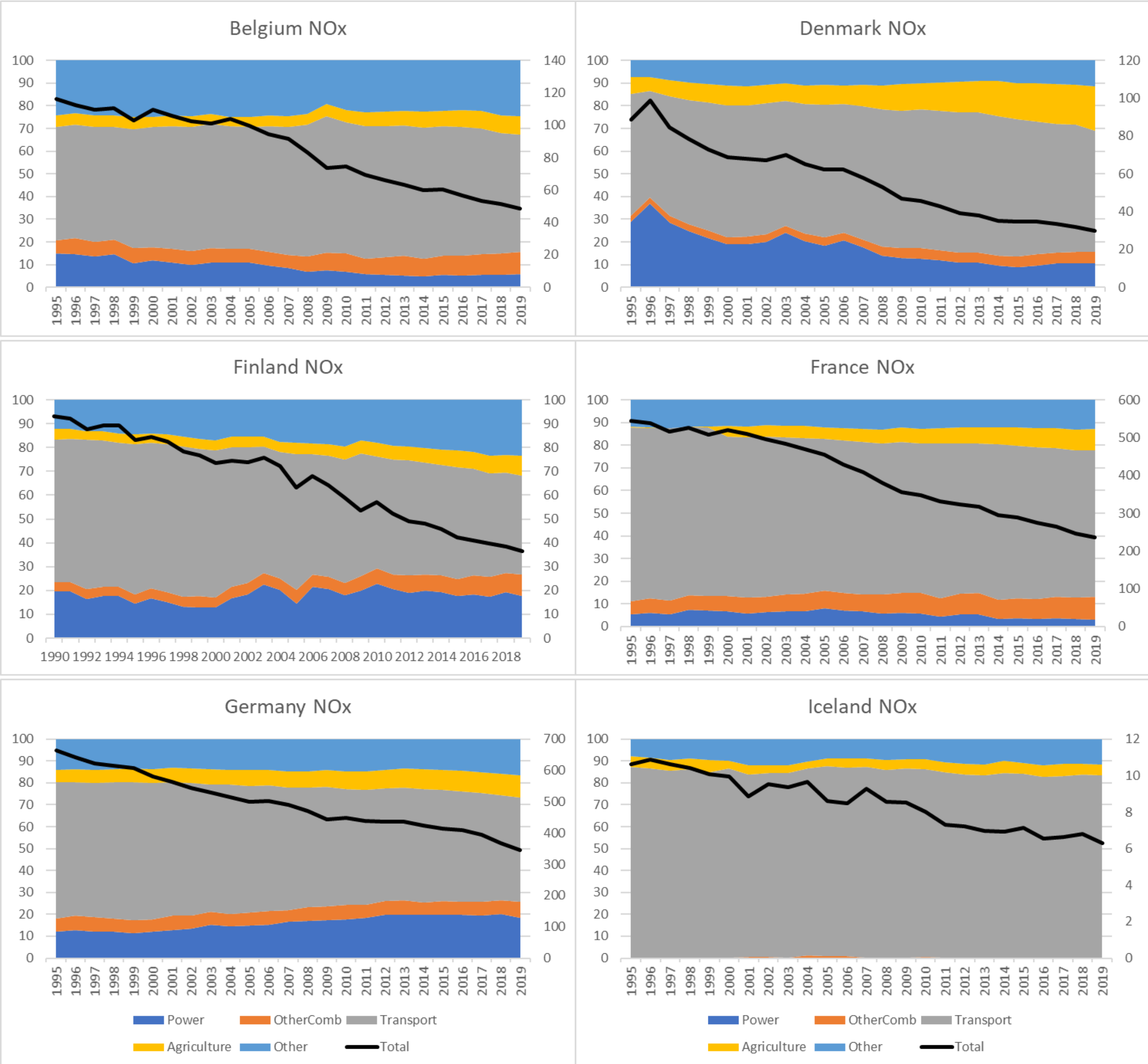


Figure 3: Percentage contributions from different sectors to annual emissions of oxidized nitrogen (NOx) in the OSPAR Contracting Parties from 1995 to 2019 (left axis, unit: %). Power (dark blue), Other stationary combustion (orange), Transport (grey), Agriculture (yellow), and 'Other' (light blue) are sums of several GNFR sectors, as described in Table 4. Transport makes the largest contribution to emissions of oxidized nitrogen in all OSPAR Contracting Parties. NOS (North Sea shipping) and ATL (shipping in parts of the Atlantic Ocean included in the EMEP MSC-W model domain, but not in NOS) are pure transport sources so that those two panels are grey (they are included here only for completeness). The black line in each plot shows total annual emissions of NOx (right axis, unit: ktonnes(N)/year). The figure continues on the next two pages.

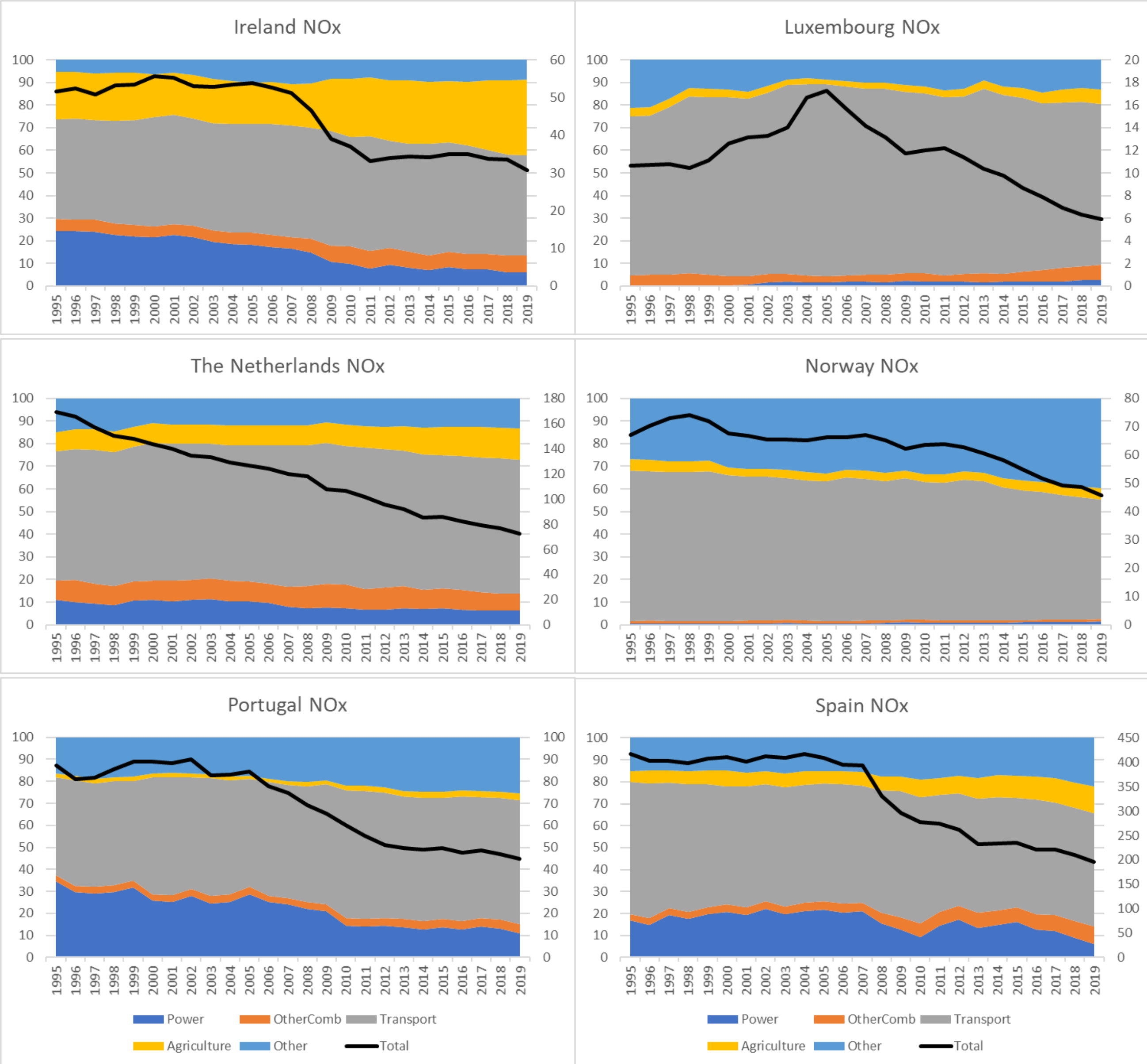


Figure 3: Continued.

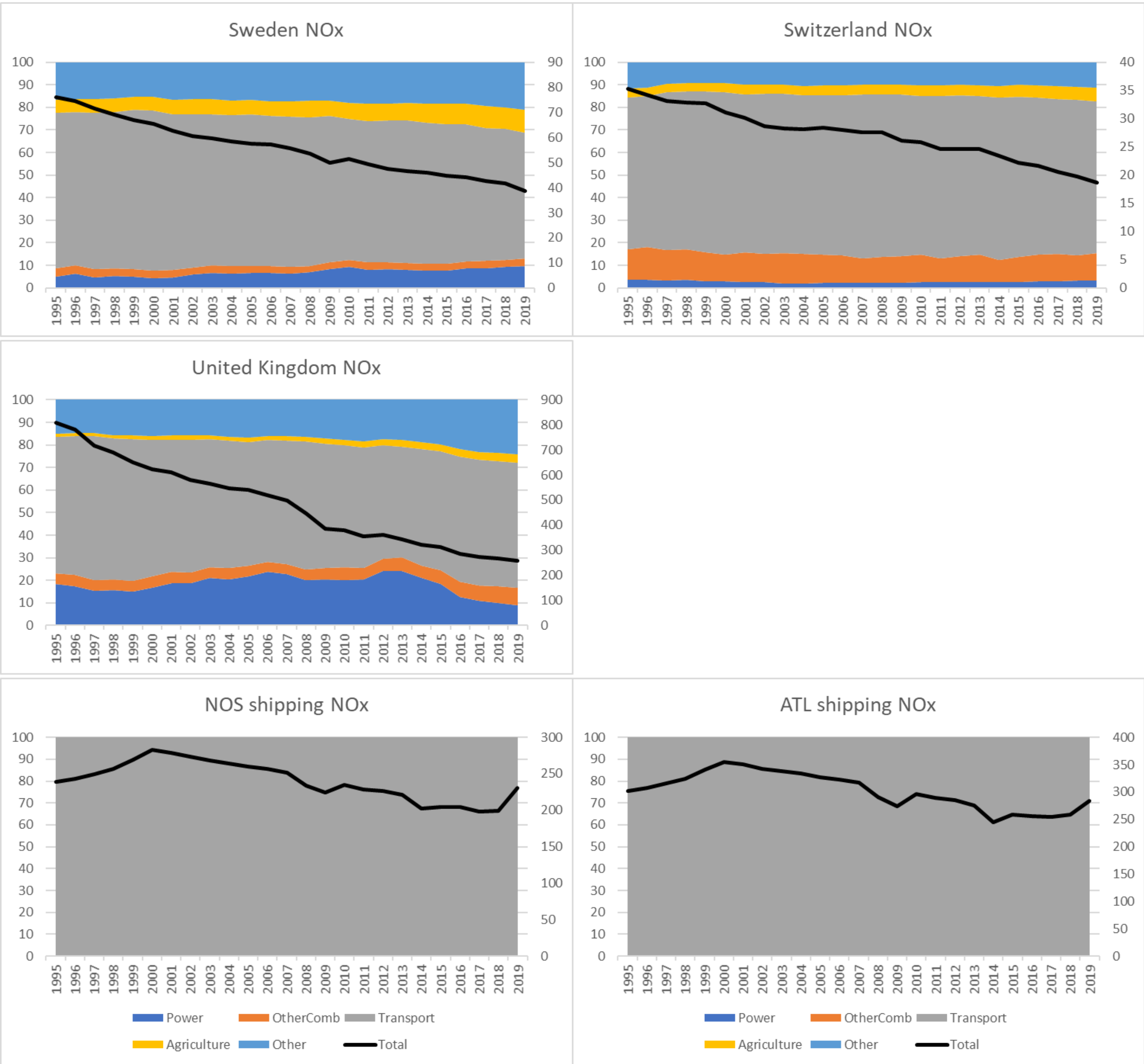


Figure 3: Continued.

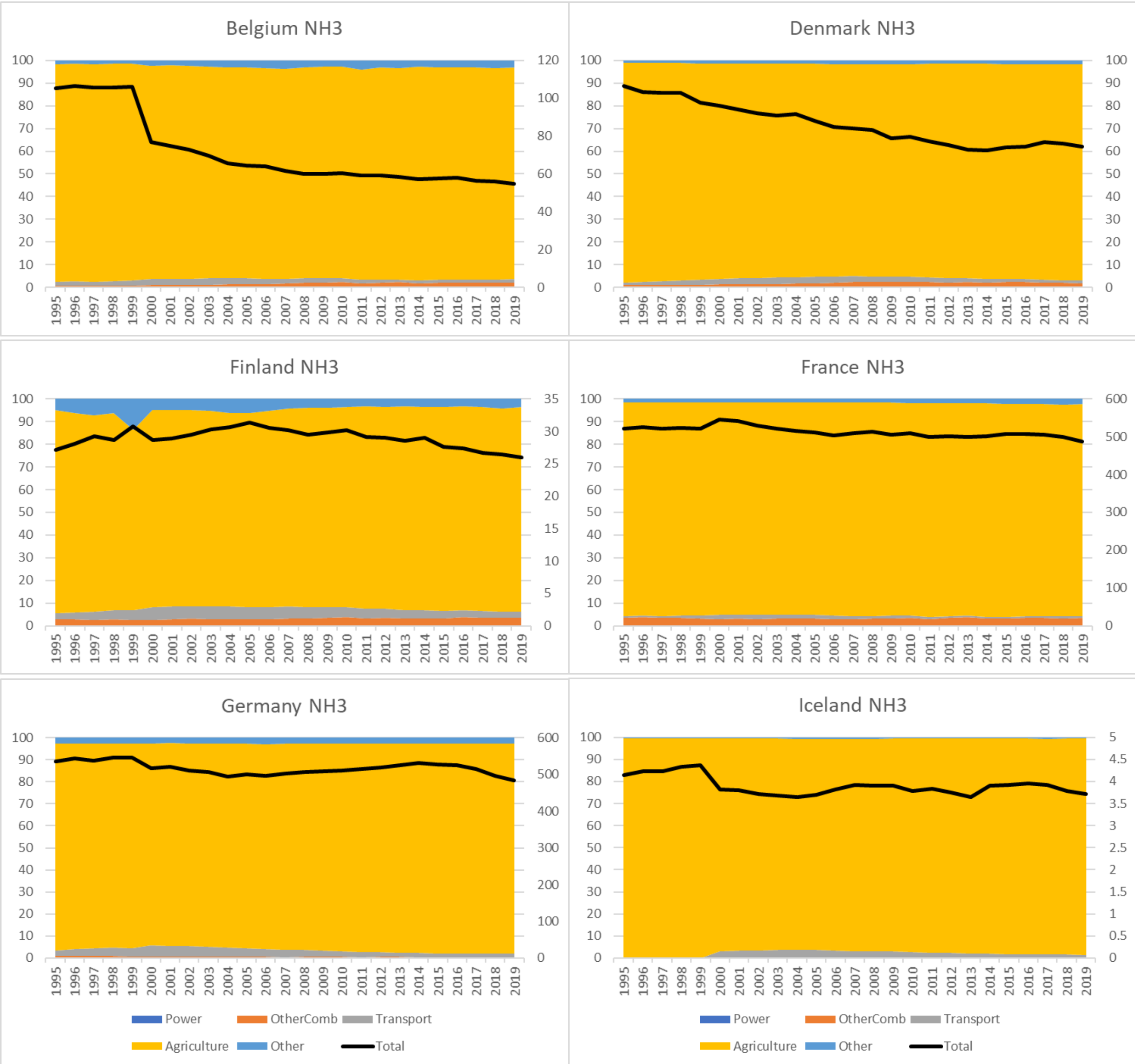


Figure 4: Percentage contributions from different sectors to annal emissions of reduced nitrogen (NH_3) in the OSPAR Contracting Parties from 1995 to 2019 (left axis, unit: %). Power (dark blue), Other stationary combustion (orange), Transport (grey), Agriculture (yellow), and 'Other' (light blue) are sums of several GNFR sectors, as described in Table 4. As obvious from the figure, agriculture largely dominates the emissions of reduced nitrogen in all OSPAR Contracting Parties. The black line in each plot shows total annual emissions of NH_3 (right axis, unit: ktonnes(N)/year). The figure continues on the next two pages.

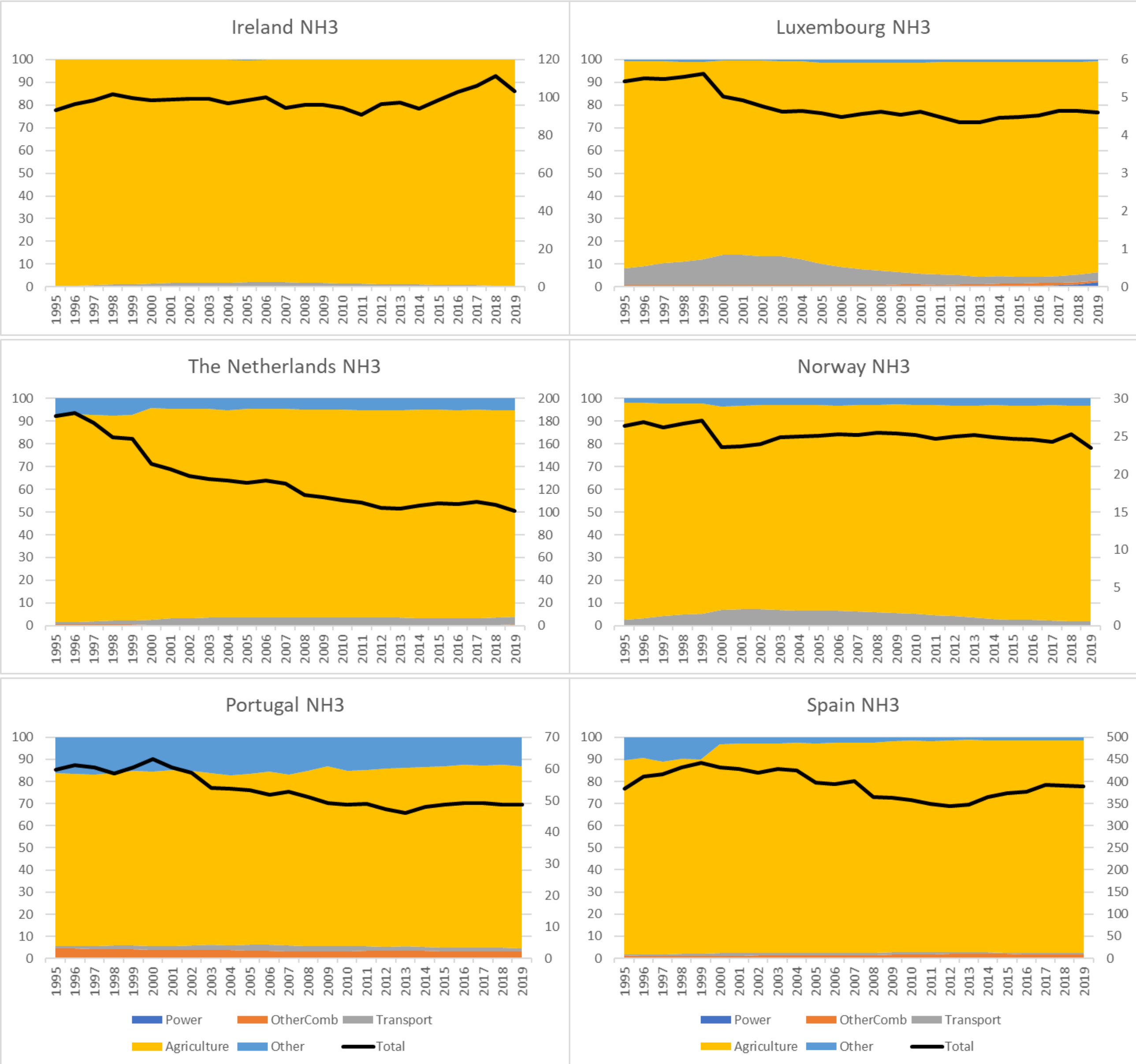


Figure 4: Continued.

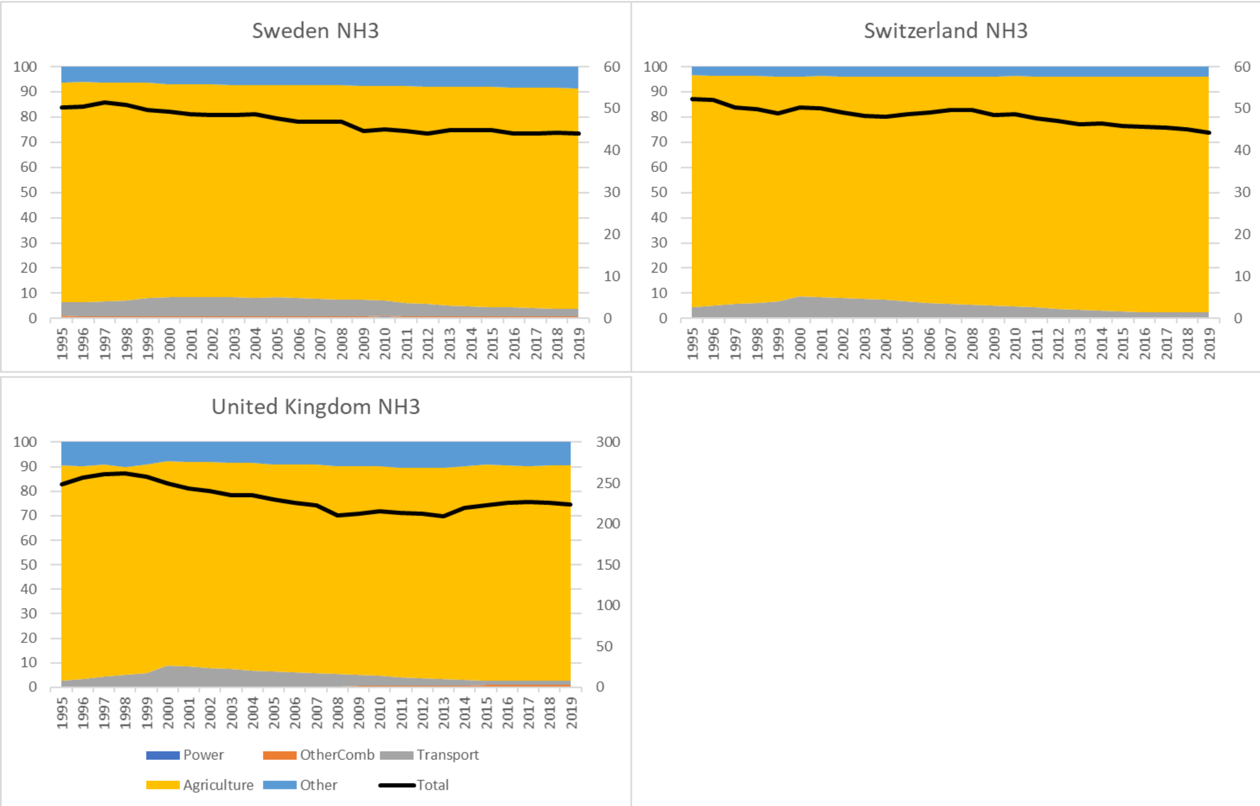


Figure 4: Continued.

4 OSPAR receptor areas

In this chapter we describe the receptor areas considered in the model calculations done by EMEP MSC-W for OSPAR. The term 'receptor areas' in this context means the regions for which nitrogen depositions are diagnosed, and contributions to which are calculated by the EMEP MSC-W model. Until last year, only the five OSPAR Regions and the 24 Exclusive Economic Zones (EEZs) in the OSPAR Maritime Area were considered. This year, for the first time, we calculate nitrogen depositions also for 'partial EEZs' (pieces of EEZs belonging to different OSPAR Regions) and for the COMP4 Assessment Units.

4.1 OSPAR Regions

All OSPAR Regions cover a certain number of grid cells in the EMEP grid system, either in full or in part. We have calculated this percentage for each EMEP grid square covered by each OSPAR Region. The results are illustrated in Figure 5 for the 0.1°lon x 0.1°lat grid.

Table 5 lists the OSPAR Regions and their areas within the EMEP model domain, calculated on the 0.1°lon x 0.1°lat grid.

Table 5. The five OSPAR Regions as implemented in the EMEP MSC-W analysis in the 0.1°lon x 0.1°lat grid. OSPAR Regions I and V are not fully covered by the EMEP model grid (actual areas as the shape files from OSPAR are shown in parentheses).

Region	Area covered by the EMEP model domain
OSPAR Region I	4 338 950 km^2 (of 5.53e6 km^2)
OSPAR Region II	761 897 km^2 (fully covered)
OSPAR Region III	391 622 km^2 (fully covered)
OSPAR Region IV	541 863 km^2 (fully covered)
OSPAR Region V	4 084 360 km^2 (of 6.35e6 km^2)

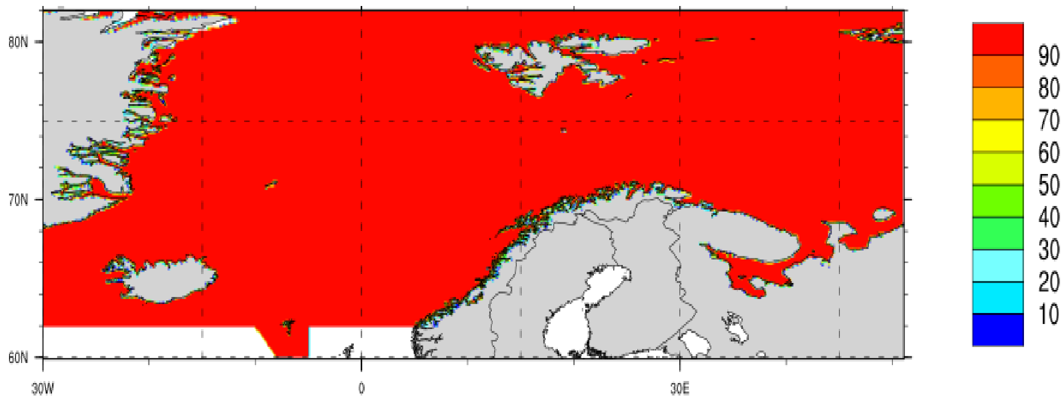


Figure 5a: Visualization of OSPAR Region I in the EMEP grid. The plot shows how large a percentage of each EMEP model grid cell lies within OSPAR Region I. EMEP model grid cells cover only 0.1°lon x 0.1°lat pixels, and thus appear very small in this plot. Red colour means that the model grid cell is fully within OSPAR Region I. Other colours mean that the grid cell is only partly within OSPAR Region I. OSPAR Region I is not fully covered by the EMEP model domain - it is cut at 30°W, which is the western boundary of the EMEP model domain (and this plot) and at 82°N, which is the northern boundary of the EMEP model domain (and this plot).

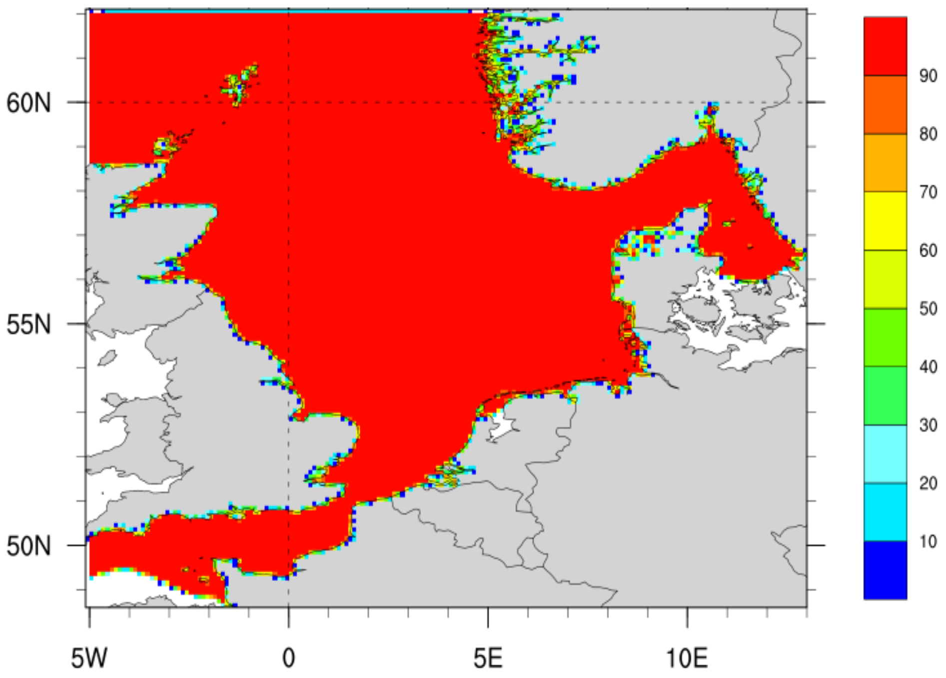


Figure 5b: As Figure 5a, but for OSPAR Region II.

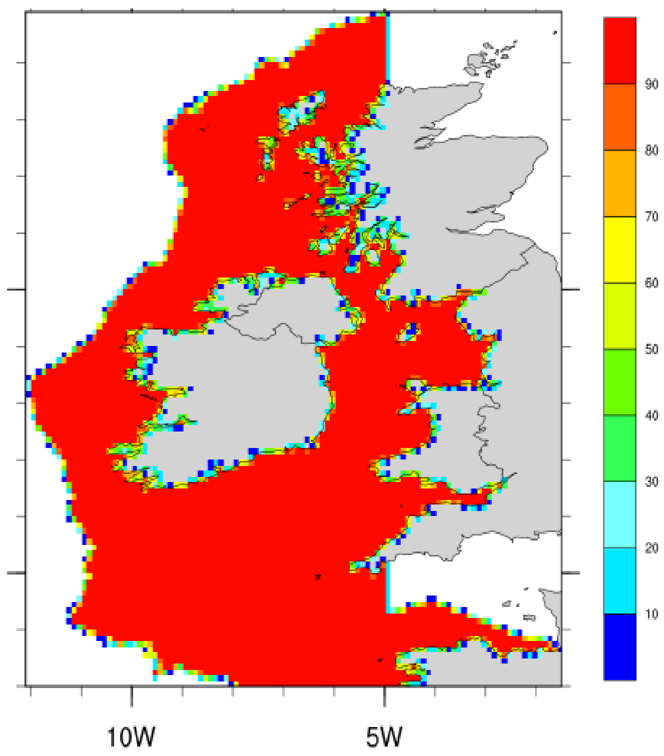


Figure 5c: As Figure 5b, but for OSPAR Region III.

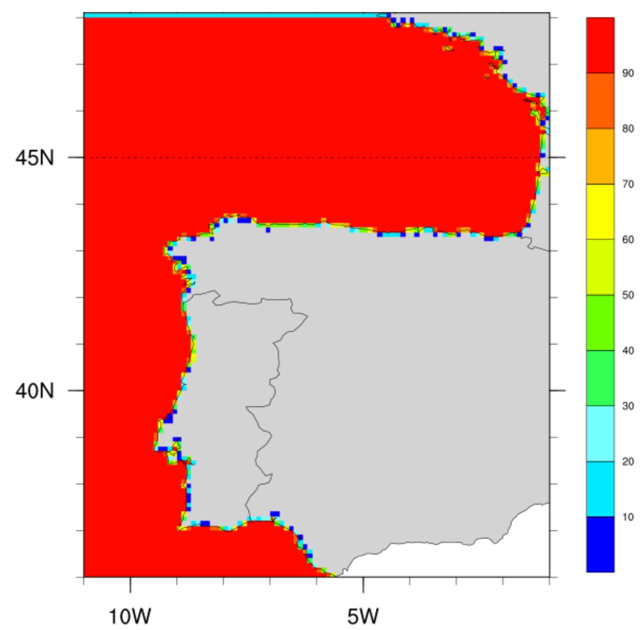


Figure 5d: As Figure 5a, but for OSPAR Region IV.

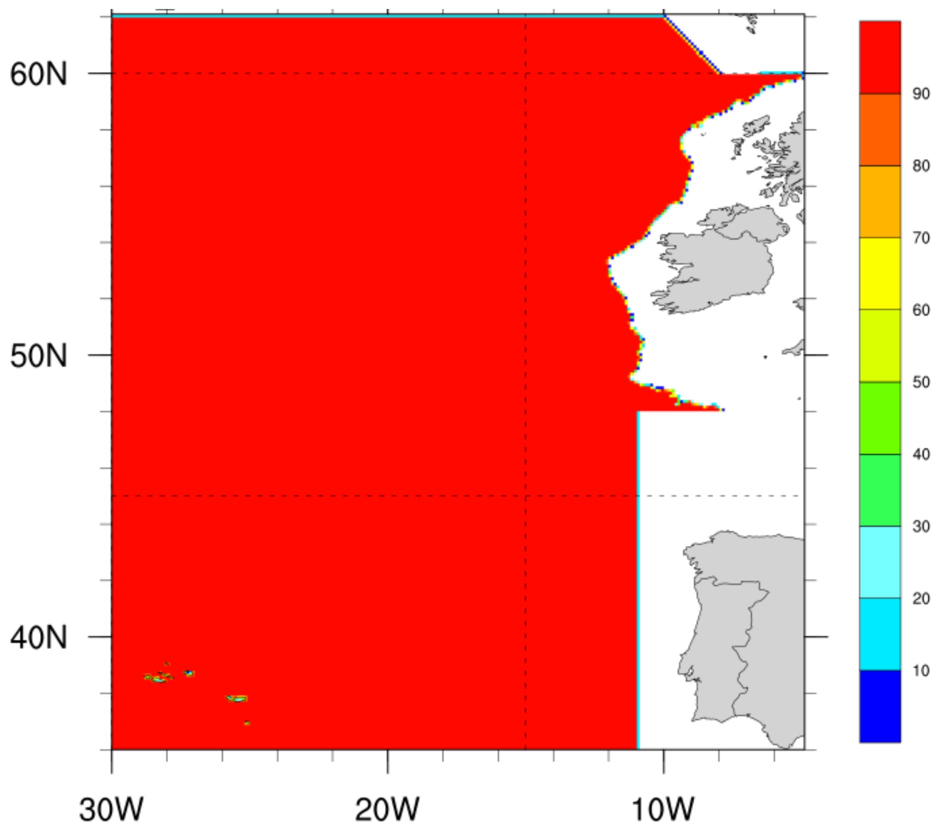


Figure 5e: As Figure 5a, but for OSPAR Region V.

4.2 Exclusive Economic Zones

National EEZs of OSPAR Contracting Parties were implemented in the EMEP 0.1°×0.1° grid system in 2019 according to the specification suggested by OSPAR (www.marineregions.org). In some cases (e.g. Sweden) only those parts of EEZs that belong to the OSPAR Maritime Area were implemented in the EMEP grid. Table 6 lists the regions and their areas within the EMEP model domain, calculated on the 0.1°lon x 0.1°lat grid. The percentages of EMEP grids covered by each EEZ are shown in Figure 6.

Table 6. The twenty-four Exclusive Economic Zones implemented in the EMEP MSC-W analysis in the 0.1°lon x 0.1°lat grid. Areas listed here include only the parts that are located within the OSPAR Convention area (i.e. within OSPAR regions). For example, those parts of the French and Spanish EEZs, which are located in the Mediterranean Sea are not included in this analysis. However, hyperlinks to marineregions.org are given in the table (last accessed 13 Dec 2021), showing the entire EEZs' definitions.

Number EEZ	**Name**	**Area in the EMEP MSC-W model domain (km^2)**
EEZ 48	Portuguese Exclusive Economic Zone (Azores)	489 112
EEZ 65	Faeroe Exclusive Economic Zone	264 129
EEZ 71	Icelandic Exclusive Economic Zone	754 957
EEZ 91	Portuguese Exclusive Economic Zone	270 655
EEZ 99	Joint regime area Spain / France	3 018
EEZ 100	Joint regime area UK / Denmark (Faeroe Islands)	8 330
EEZ 108	Irish Exclusive Economic Zone	429 347
EEZ 109	Guernsey Exclusive Economic Zone	6 755
EEZ 110	Jersey Exclusive Economic Zone	2 403
EEZ 119	Joint regime area Iceland / Denmark (Faeroe)	1 419
EEZ 123	Joint regime area Iceland / Norway (Jan Mayen)	45 270
EEZ 185	Swedish Exclusive Economic Zone	14 610
EEZ 187	Joint regime area Sweden / Norway	172
EEZ 188	Belgian Exclusive Economic Zone	3 628
EEZ 189	Dutch Exclusive Economic Zone	63 267
EEZ 190	German Exclusive Economic Zone	41 757
EEZ 191	Danish Exclusive Economic Zone	76 440
EEZ 209	French Exclusive Economic Zone	259 201
EEZ 212	Greenlandic Exclusive Economic Zone	642 488
EEZ 213	United Kingdom Exclusive Economic Zone	739 926
EEZ 215	Svalbard Exclusive Economic Zone	704 339
EEZ 216	Norwegian Exclusive Economic Zone	945 160
EEZ 224	Jan Mayen Exclusive Economic Zone	290 509
EEZ 273	Spanish Exclusive Economic Zone	301 088

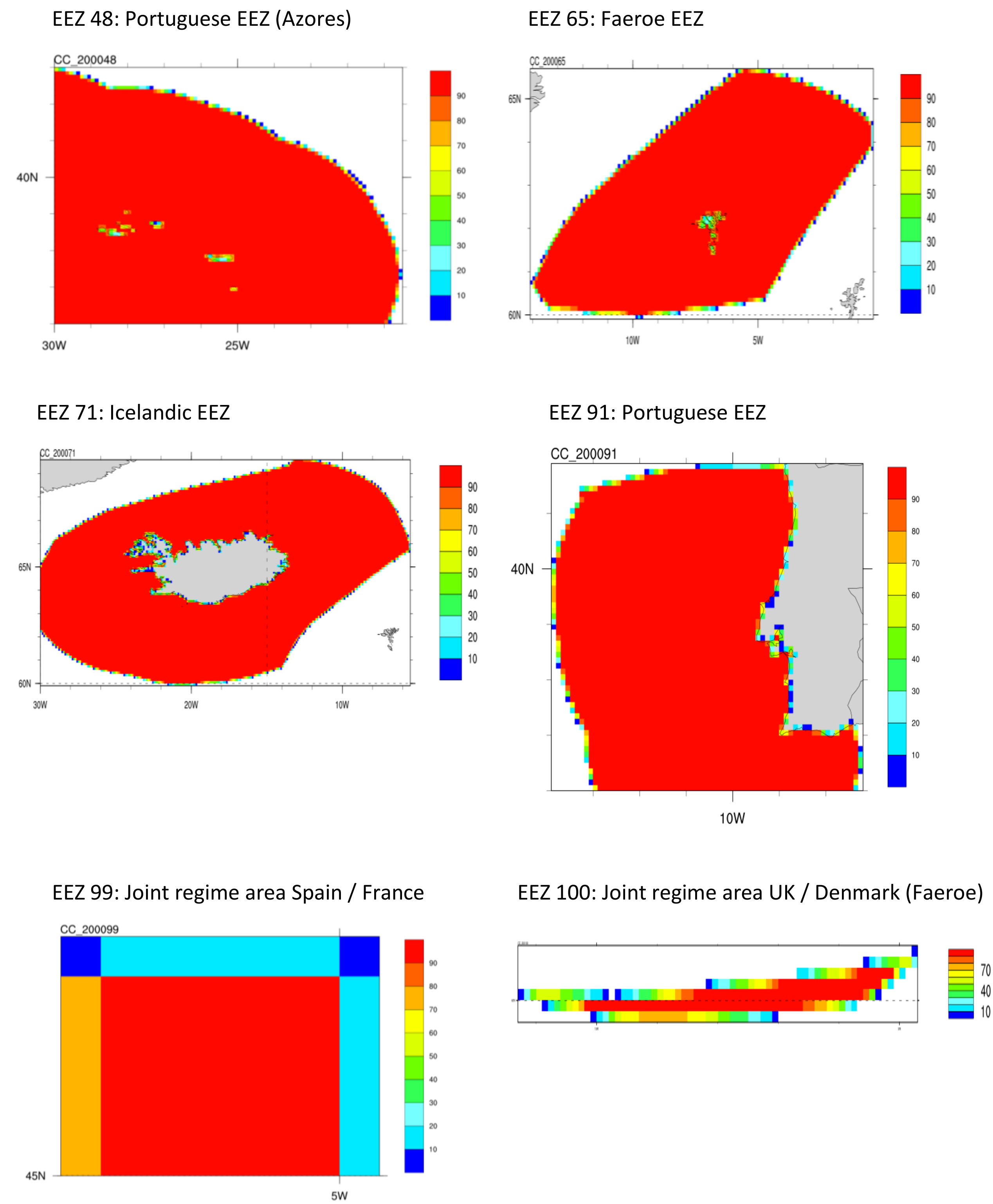
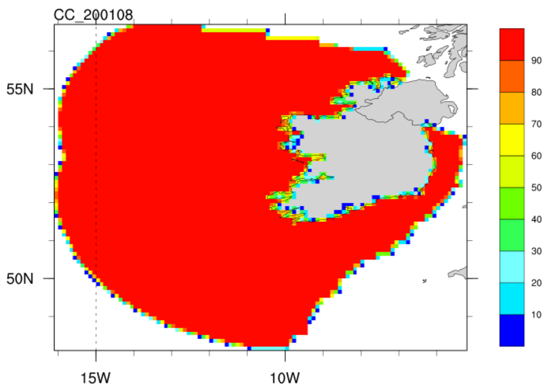
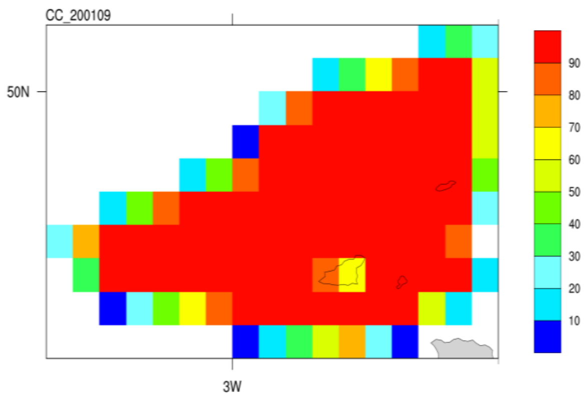


Figure 6: Visualization of EEZs in the EMEP grid. The plots show how large a percentage of each EMEP model grid cell lies within the respective EEZ. EMEP model grid cells cover 0.1°lon x 0.1°lat pixels and thus appear very small in some of the plots. Red colour means that the model grid cell is fully within the EEZ. Other colours mean that the grid cell is only partly within the EEZ. Some EEZs are not fully covered by the EMEP model domain, e.g. EEZ 48 (PT/Azores) is cut at 30W°, which is the western boundary of the EMEP model domain. Parts of EEZs outside the OSPAR regions are not included in the plots (and the analysis). The figure continues on the next 3 pages.

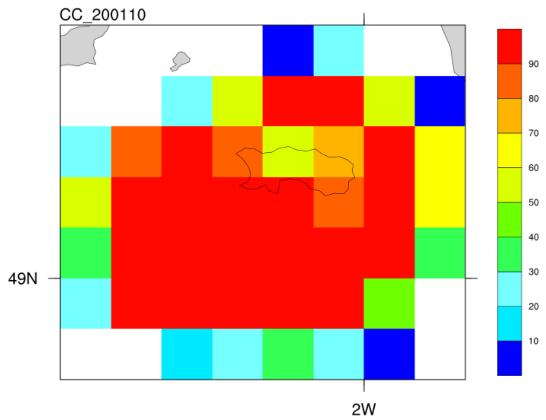
EEZ 108: Irish EEZ



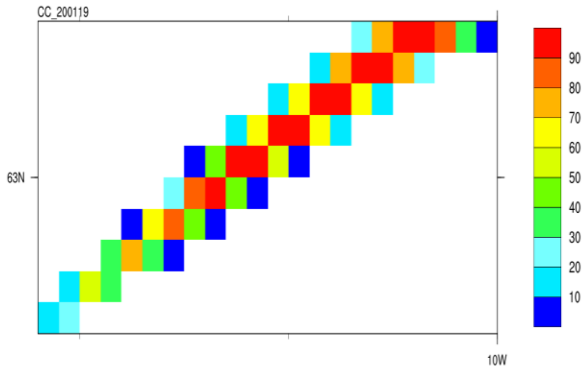
EEZ 109: Guernsey EEZ



EEZ 110: Jersey EEZ



EEZ 119: Joint regime area Iceland / Denmark (Faeroe Islands)



EEZ 123: Joint regime area Iceland / Norway (Jan Mayen)

EEZ 185: Swedish EEZ

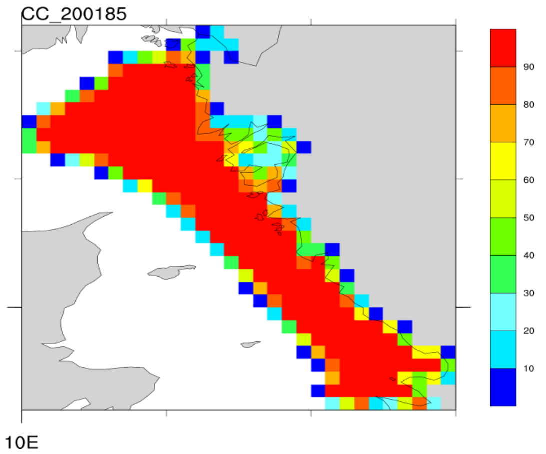
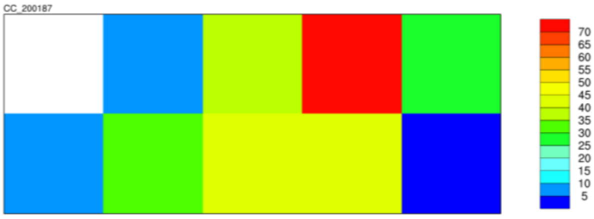
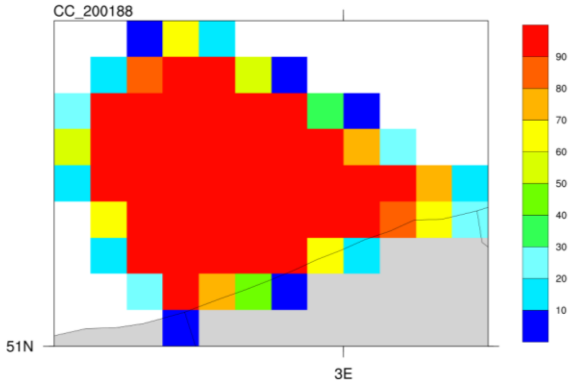


Figure 6: Continued.

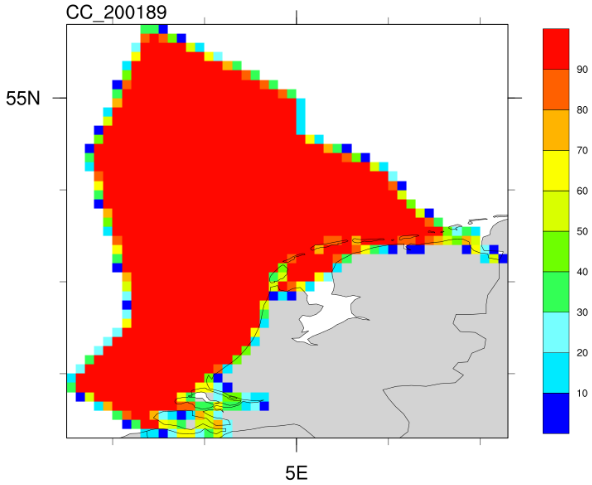
EEZ 187: Joint regime area Sweden / Norway



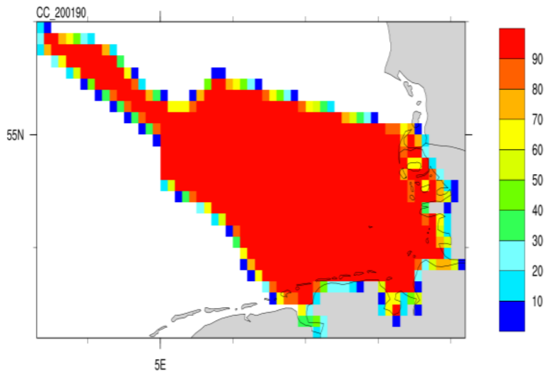
EEZ 188: Belgian EEZ



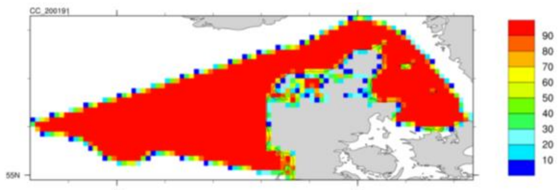
EEZ 189: Dutch EEZ



EEZ 190: German EEZ



EEZ 191: Danish EEZ



EEZ 209: French EEZ

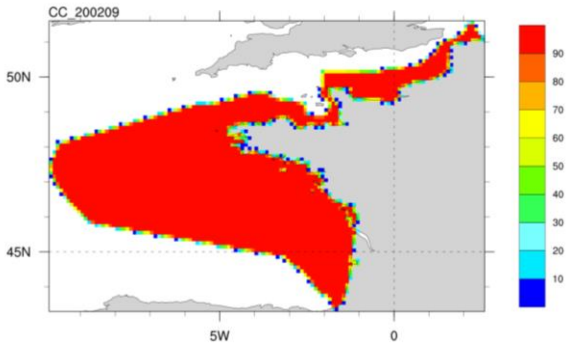
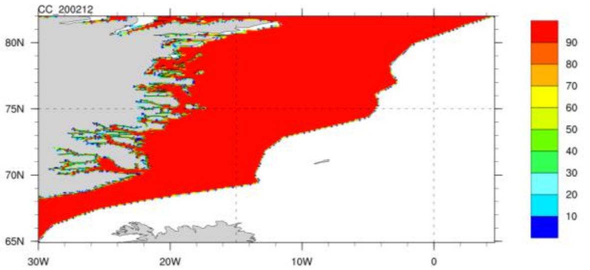
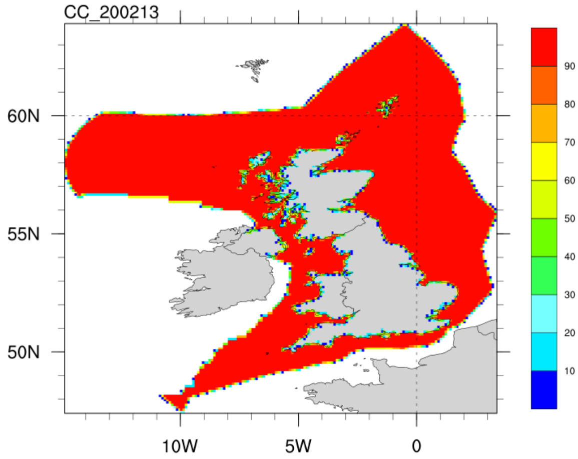


Figure 6: Continued.

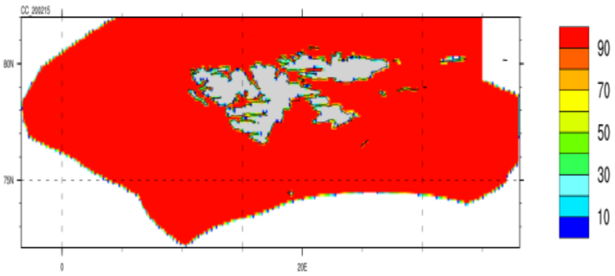
EEZ 212: Greenlandic EEZ



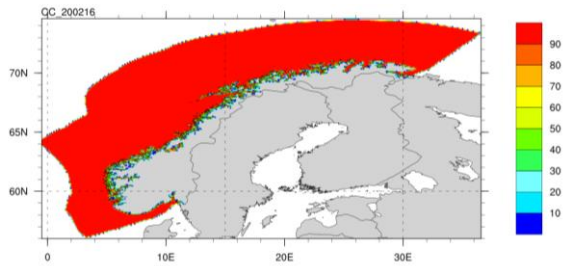
EEZ 213: United Kingdom EEZ



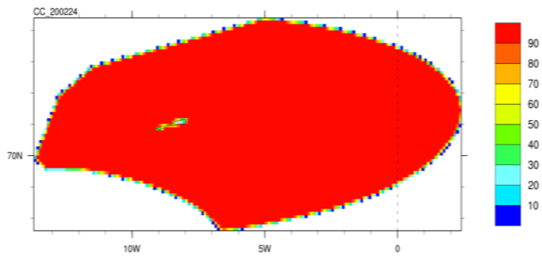
EEZ 215: Svalbard EEZ



EEZ 216: Norwegian EEZ



EEZ 224: Jan Mayen EEZ



EEZ 273: Spanish EEZ

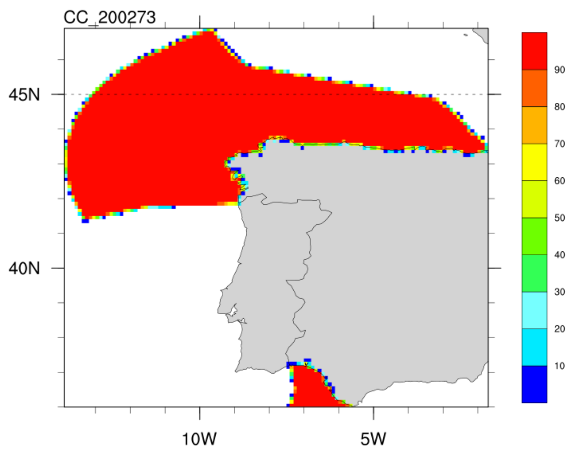


Figure 6: Continued.

4.3 Partial EEZs

Nine of the EEZs described in the previous section fall within more than one OSPAR region. This year, OSPAR requested that calculations of nitrogen deposition be made separately for these "partial EEZs". For example, the French EEZ covers parts of OSPAR regions II, III, IV and V, while the UK EEZ covers parts of all five OSPAR regions. The division into partial EEZs is visualized at the example of EEZ 65 (Faeroe Exclusive Economic Zone) in Figure 7. In total, 25 partial EEZs are considered (see Table 7).
Fifteen of the EEZs considered by EMEP MSC-W are entirely located in one OSPAR Region (e.g. the German EEZ in Region II), so that no additional receptor areas had to be defined in these cases. Thus, the total number of receptor areas for which nitrogen deposition is calculated has increased from 29 to 54.

Table 7. The twenty-five partial EEZs implemented in the EMEP MSC-W analysis in the 0.1°lon x 0.1°lat grid. Areas listed here include only the parts that are located within the OSPAR Convention area (i.e. within OSPAR regions).

Number of EEZ	Name	Located in:	Area in the EMEP MSC-W model domain (km^2)
EEZ_I_065	Faeroe Exclusive Economic Zone	OSPAR Region I	201 099
EEZ_II_065	Faeroe Exclusive Economic Zone	OSPAR Region II	10 530
EEZ_V_065	Faeroe Exclusive Economic Zone	OSPAR Region IV	52 500
EEZ_I_071	Icelandic Exclusive Economic Zone	OSPAR Region I	604 247
EEZ_V_071	Icelandic Exclusive Economic Zone	OSPAR Region V	150 710
EEZ_IV_091	Portuguese Exclusive Economic Zone	OSPAR Region IV	133 522
EEZ_V_091	Portuguese Exclusive Economic Zone	OSPAR Region V	137 133
EEZ_I_100	Joint regime area United Kingdom / Denmark (Faeroe Islands)	OSPAR Region I	3 789
EEZ_II_100	Joint regime area United Kingdom / Denmark (Faeroe Islands)	OSPAR Region II	94
EEZ_V_100	Joint regime area United Kingdom / Denmark (Faeroe Islands)	OSPAR Region V	4 447
EEZ_III_108	Irish Exclusive Economic Zone	OSPAR Region III	149 441
EEZ_V_108	Irish Exclusive Economic Zone	OSPAR Region V	279 906
EEZ_II_209	French Exclusive Economic Zone	OSPAR Region II	26 554
EEZ_III_209	French Exclusive Economic Zone	OSPAR Region III	41 792
EEZ_IV_209	French Exclusive Economic Zone	OSPAR Region IV	188 091
EEZ_V_209	French Exclusive Economic Zone	OSPAR Region V	2 765
EEZ_I_213	United Kingdom Exclusive Economic Zone	OSPAR Region I	29 298
EEZ_II_213	United Kingdom Exclusive Economic Zone	OSPAR Region II	356 027
EEZ_III_213	United Kingdom Exclusive Economic Zone	OSPAR Region III	199 788
EEZ_IV_213	United Kingdom Exclusive Economic Zone	OSPAR Region IV	2 585
EEZ_V_213	United Kingdom Exclusive Economic Zone	OSPAR Region V	152 229
EEZ_I_216	Norwegian Exclusive Economic Zone	OSPAR Region I	784 147
EEZ_II_216	Norwegian Exclusive Economic Zone	OSPAR Region II	161 013
EEZ_IV_273	Spanish Exclusive Economic Zone	OSPAR Region IV	205 509
EEZ_V_273	Spanish Exclusive Economic Zone	OSPAR Region V	95 579

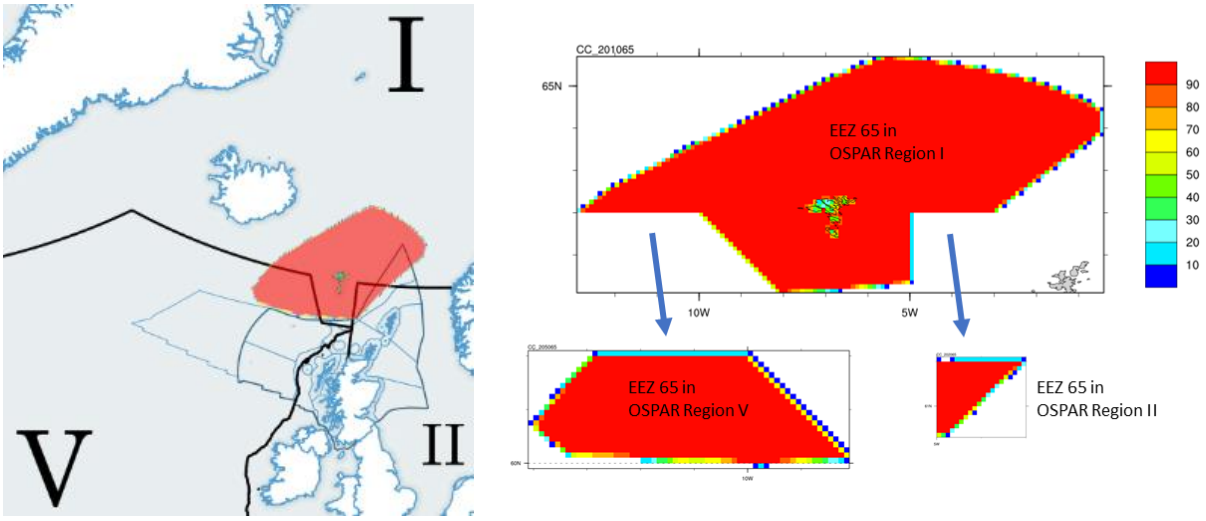


Figure 7: Left panel: OSPAR regions I, II and V, and EEZ 65 (Faeroe Exclusive Economic Zone) indicated in light red colour. Right panels: Division of EEZ 65 into three separate parts, belonging to OSPAR Regions I, II, and V, respectively. These three partial EEZs are listed in the first 3 rows of Table 7.

4.4 COMP4 Assessment Units

For the first time this year, EMEP MSC-W calculated nitrogen deposition also for the 67 COMP4 Assessment Units. The definitions of these Assessment Units were provided to EMEP MSC-W in May 2021 and implemented in the EMEP 0.1°×0.1° grid and in the tools to analyse nitrogen deposition and source-receptor relationships. The Assessment Units are listed in Table 8. Figure 8 shows the percentages of EMEP grids covered by each COMP4 Assessment Unit (only for those areas that are larger 10 000 km^2).

At the INPUT meeting in January 2022, EMEP MSC-W was informed that there are new definitions of COMP4 Assessment Units (now the number is sixty-four). The new definitions were provided to EMEP MSC-W in February 2022, but it was not possible to redo the calculations at this time. This can of course be done in future contracts.

Table 8. The sixty-seven COMP4 Assessment Units implemented in the EMEP MSC-W analysis in the 0.1°lon x 0.1°lat grid in 2021. Abbreviations and names are printed here as contained in the shape files provided to EMEP MSC-W in May 2021. The table continues on the next page.
Remarks: 1) Assessment Units marked by * are no longer included in the new table of definitions (provided to EMEP MSC-W in February 2022); 2) 'CO' is referred to as 'OC' in the new table of definitions; 3) NT: question marks in regard to 'Contracting Parties involved' are retained from new table of definitions.

Abbreviation	Long name	Area in the EMEP MSC-W model domain (km^2)	Contracting Parties involved[3]
CFR	Coastal FR channel	7512	FR, UK
CCTI	Channel coastal shelf tidal influenced	5281	FR, UK
ATL	Atlantic	929017	ES, FR, IE, UK, NO
SHPM	Shannon plume	450	IE
CNOR1	Coastal NOR 1	9054	NO
CNOR2	Coastal NOR 2	2803	NO
CNOR3	Coastal NOR 3	2050	NO
DB	Dogger Bank	15078	NL, DE, DK, UK
KD	Kattegat Deep	5214	DK, SE
NT	Norwegian Trench	59758	NO, SE?, DK?
SNS	Southern North Sea	62503	FR, BE, NL, UK
GBC	German Bight (deep)	4737	DE
ADPM	Adour plume	328	FR
GBSW	Gulf of Biscay shelf waters	21646	FR
SPM	Seine plume	1205	FR
GDPM	Gironde plume	2968	FR
CUKC	Coastal UK channel	6694	UK
CWMTI	Channel well mixed tidal influenced	21077	FR, UK
SCHPM1	Scheldt plume 1	688	BE, NL
ELPM	Elbe plume	8097	DE
SCHPM2	Scheldt plume 2	122	NL
MPM	Meuse plume	239	NL
RHPM	Rhine plume	2625	NL
EMPM	Ems plume	1593	DE
THPM	Thames plume	5770	UK
HPM	Humber plume	1493	UK
ECPM1	East Coast (permanently mixed) 1	3757	UK
ECPM2	East Coast (permanently mixed) 2	1681	UK
IS2	Intermittently Stratified 2	27225	IE, UK
CO	Coastal Offshore	19006	DE, DK
ENS	Eastern North Sea	61017	NL, DE, DK
CWCC	Coastal Waters CC (D5)	862	PT

[3] In this column, 'UK' is used as abbreviation for the United Kingdom of Great Britain and Northern Ireland, as it is based on a table provided by the OSPAR Secretariat and not on EMEP data.

Table 8. Continued.

Abbreviation	Long name	Area in the EMEP MSC-W model domain (km²)	Approximate location
OWCO	Ocean Waters CO (D5)	19104	PT
OWAO	Ocean Waters AO (D5)	98378	PT
IWCI*	Intermediate Waters CI (D5)	1423	PT
OWBO	Ocean Waters BO (D5)	182631	PT
ASS	Atlantic Seasonally Stratified	218564	FR, IE, UK
CIRL	Coastal IRL 3	9829	IE
CUK1	Coastal UK 1	11144	UK
IS1	Intermittently Stratified 1	74617	UK
IRS	Irish Sea	33399	IE, UK
KC	Kattegat Coastal	10108	DK, SE
NNS	Northern North Sea	265130	UK, DK, SE, NO
CWM	Channel well mixed	42618	FR, UK
LBPM	Liverpool Bay plume	1493	UK
SK	Skagerak	5968	DK, SE
SS	Scottish Sea	54934	UK
CWBC	Coastal Waters BC (D5)	3798	PT
IWBI*	Intermediate Waters BI (D5)	2057	PT
CWAC	Coastal Waters AC (D5)	2601	PT
IWAI*	Intermediate Waters AI (D5)	5881	PT
LPM	Loire plume	1615	FR
GBCW	Gulf of Biscay coastal waters	11514	FR
NAAP2	Noratlantic Area NOR-NorP2(D5)	9773	ES
NAAO1	Noratlantic Area NOR-NorO1(D5)	263322	ES
NAAPF	Noratlantic Area NOR-Plataforma	39104	ES
NAAC3	Noratlantic Area NOR-NorC3(D5)	3771	ES
NAAC2	Noratlantic Area NOR-NorC2(D5)	2961	ES
NAAC1A	Noratlantic Area NOR-NorC1(D5)A	884	ES
NAAC1B	Noratlantic Area NOR-NorC1(D5)B	150	ES
NAAC1C	Noratlantic Area NOR-NorC1(D5)C	59	ES
NAAC1D	Noratlantic Area NOR-NorC1(D5)D	23	ES
SAAP2	Sudatlantic Area SUD-P2(D5)	1207	ES
SAAOC	Sudatlantic Area SUD-OCEAN(D5)	10443	ES
SAAP1	Sudatlantic Area SUD-P1(D5)	2789	ES
SAAC1	Sudatlantic Area SUD-C1(D5)	619	ES
SAAC2	Sudatlantic Area SUD-C2(D5)	415	ES

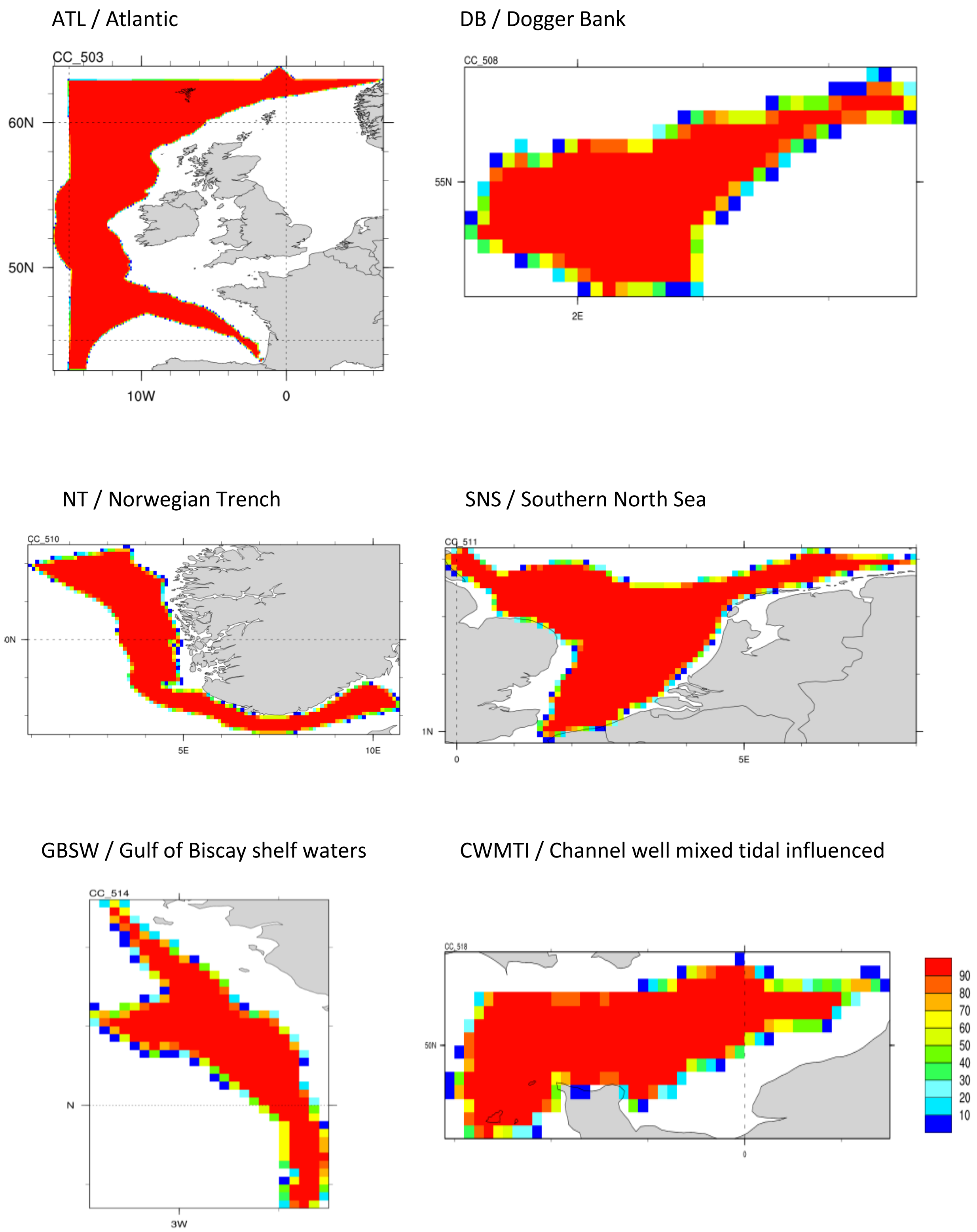


Figure 8: Visualization of COMP4 Assessment Units in the EMEP grid. The plots show how large a percentage of each EMEP model grid cell lies within the respective COMP4 Assessment Unit. EMEP model grid cells cover 0.1°lon x 0.1°lat pixels and thus appear very small in some of the plots. Red colour means that the model grid cell is fully within the COMP4 Assessment Unit. Other colours mean that the grid cell is only partly within the COMP4 Assessment Unit. Only those COMP4 Assessment Units covering more than 10 000 km^2 are shown. The figure continues on the next 3 pages.

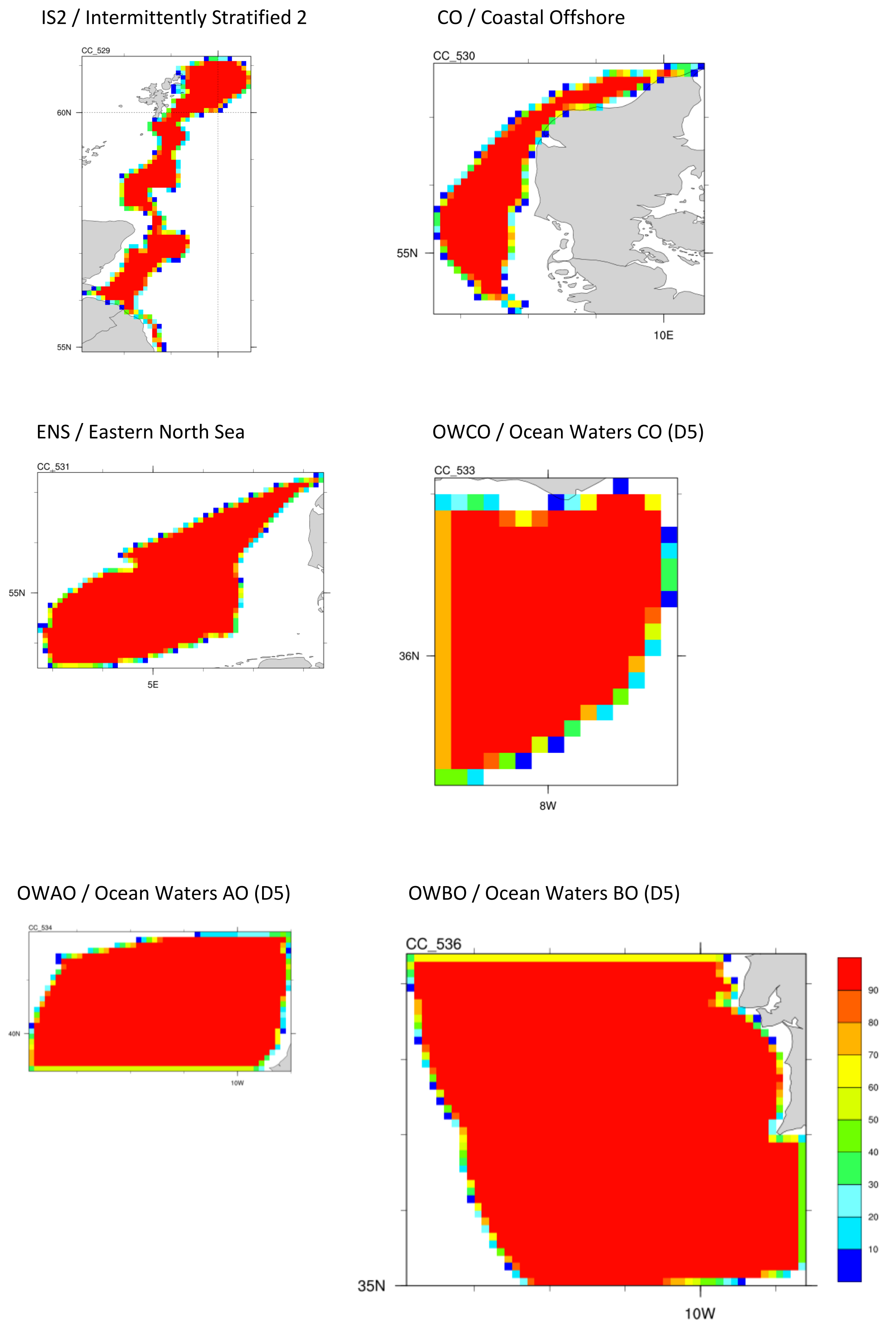


Figure 8: Continued.

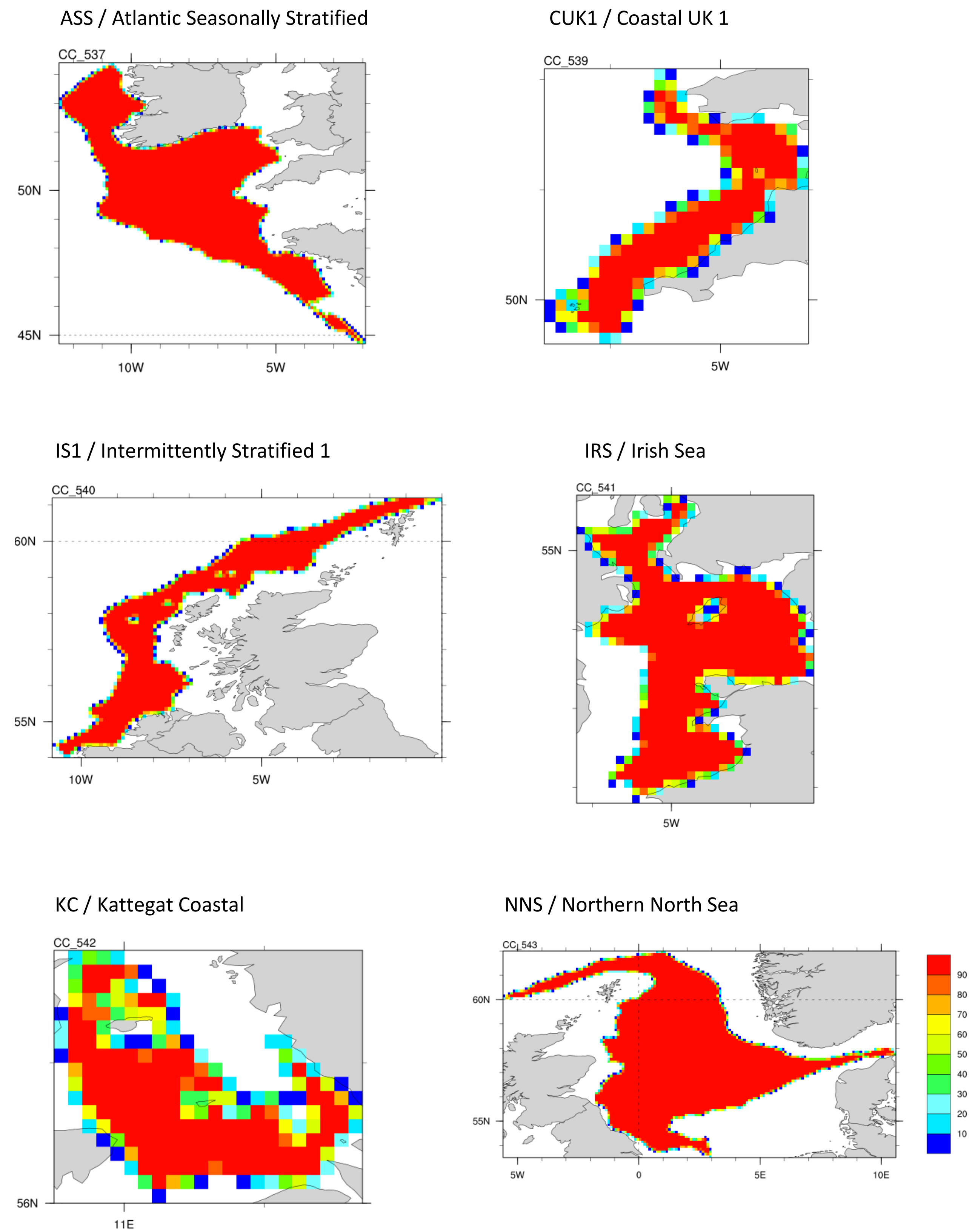


Figure 8: Continued.

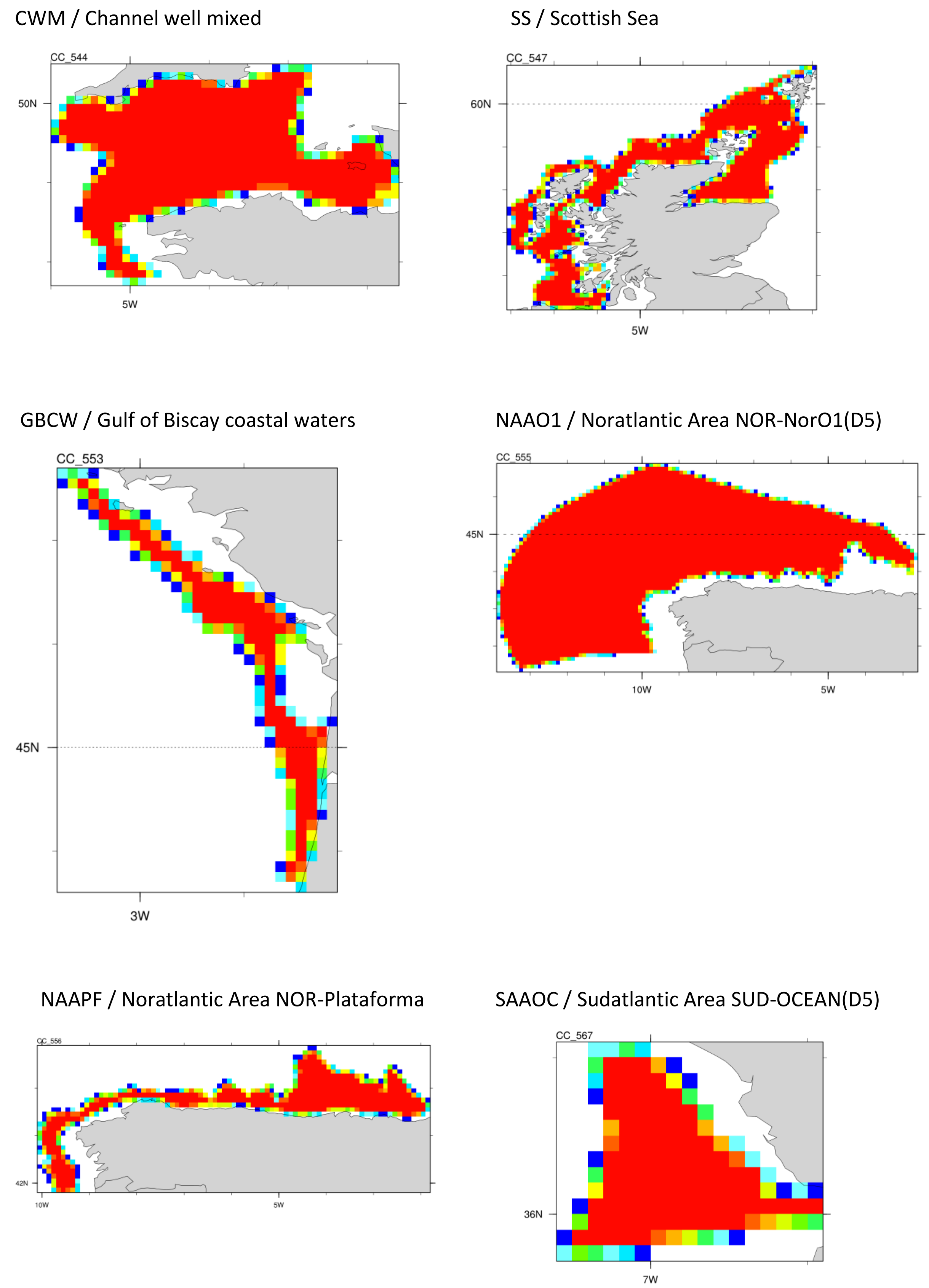


Figure 8: Continued.

5 Actual and normalized depositions of nitrogen

Actual and *normalized* depositions of nitrogen have been computed for the five OSPAR Regions, the twenty-four EEZs, the twenty-five partial EEZs, and the COMP4 Assessment Units, for each year of the period 1990-2019.

Normalized ('weather-averaged') depositions follow the changes in emissions better than actual depositions and thus illustrate the effect of policy measures on nitrogen emissions. In the normalization, only the years 2016-2019 have been used this year for OSPAR. In earlier reports, more meteorological years had been used, but now, as more (and smaller) receptors are considered, it appeared safest to rely only on those years for which transfer coefficients are calculated on a higher resolution than in earlier years (i.e. on the 0.3°lon x 0.2°lat grid rather than the old 50km x 50km polar-stereographic grid). Another reason, specifically for OSPAR, is that some of the receptors considered (e.g. EEZ048) are not fully covered by the EMEP model domain (see Sections 4.1 and 4.2 and in particular Figures 5 and 6). When the EMEP model domain was changed in 2017 (for reporting the status of 2015), the parts included in the domain changed for these receptors, both in shape and in area. This would lead to artificial changes in the transfer coefficients from early years before the grid change to the later years in the period.

All results have been submitted to OSPAR in separate data files (see Chapter 8). In this report we show plots and tables with results back to 1995.

5.1 Depositions to OSPAR Regions

Figure 9 shows actual (non-normalized) oxidized and reduced nitrogen depositions from 1995 to 2019 for all OSPAR Regions. Depositions of oxidised nitrogen have clearly decreased since the 1990s, while for reduced nitrogen the decreases are much smaller. Nevertheless, the trends in *total* (oxidized+reduced) nitrogen deposition are decreasing in all OSPAR Regions and are statistically significant at the 5% confidence level.

Table 9 lists the percentage differences between 1995 and 2019, and between the two 5-year periods of 1995-1999 and 2015-2019 for actual depositions. Due to the large inter-annual variability in meteorological conditions, differences between depositions in one year with respect to those in one reference year (1995 in this case) can change considerably from year to year. Therefore, 5-year averages are calculated to provide a more robust result for the changes since the 1990s.

Table 10 lists actual *and* normalized depositions in the 5 OSPAR regions for the year 2019, i.e. the most recent year for which model calculations have been made.

Figure 10 shows normalized results. The normalization is based on meteorological data from 4 years (2016, 2017, 2018 and 2019). Normalized depositions of oxidized and reduced nitrogen were lower in 2019 than in 1995 in all OSPAR Regions. The largest decreases occurred in OSPAR Region II, both for *oxidized* nitrogen deposition (49%) and for *reduced* nitrogen deposition (18%). An interesting feature is that normalized oxidized deposition to OSPAR Region V in the 1990s is much smaller than the actual values (see accompanying Excel sheet). It seems that recent meteorology (2016-2019) has been less favourable for oxidized nitrogen deposition than the meteorology of the 1990s. We aim to investigate this possible climate change signal further.

Tables 11 and 12 contain the normalized values for the five OSPAR Regions, i.e. the data Figure 10 is based upon.

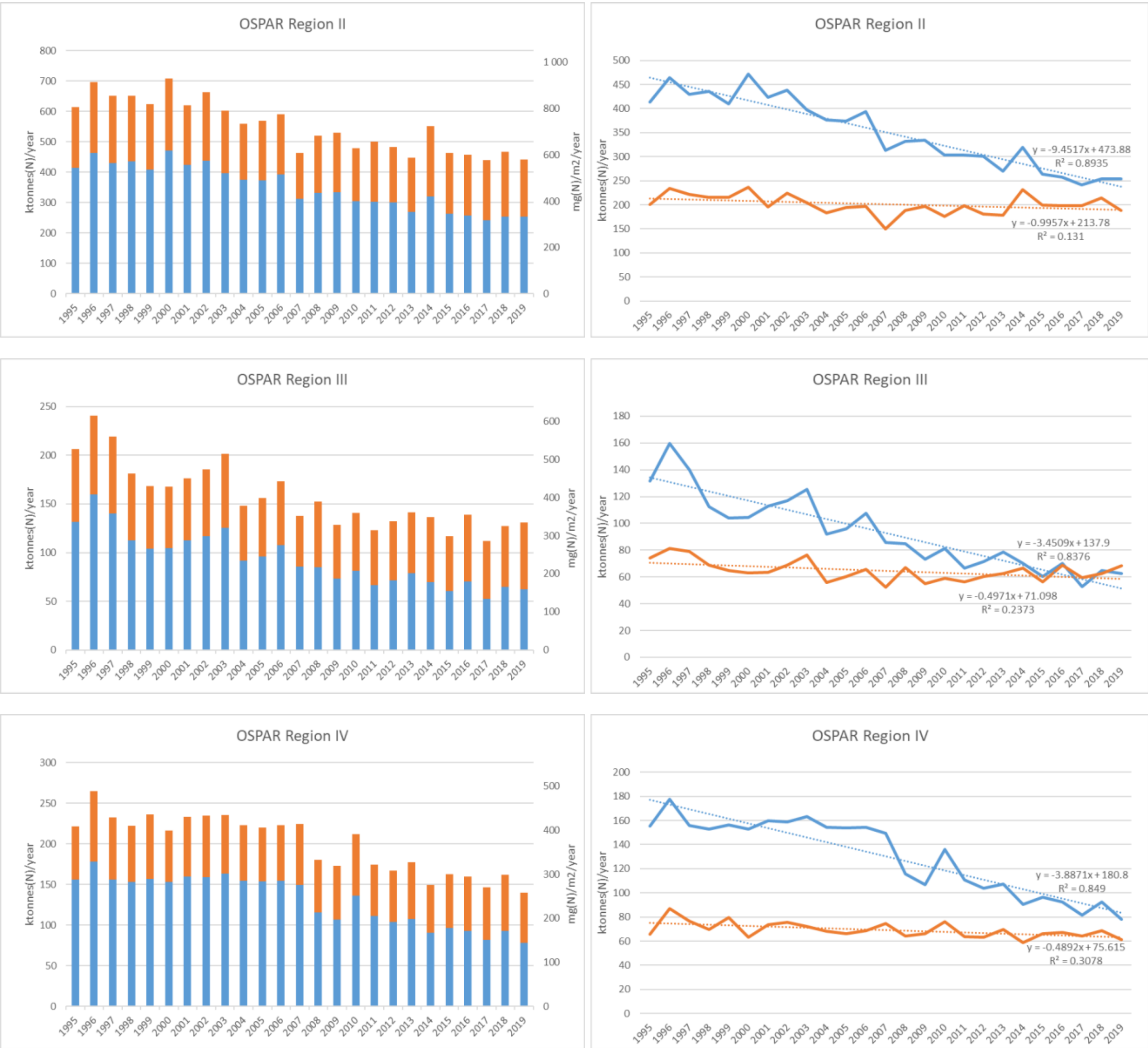


Figure 9a: Left panels: Time series of annual depositions of oxidised (blue), reduced (red) and total nitrogen (sum of blue and red) to OSPAR Regions II, III and IV, as calculated by the EMEP MSC-W model for the period 1995-2019. Unit: ktonnes(N)/year (left axis) or mg(N)/m^2/year (right axis). Right panels: Linear regression for oxidised (blue) and reduced (red) nitrogen deposition, with coefficients of determination (R^2) indicated in the figure.

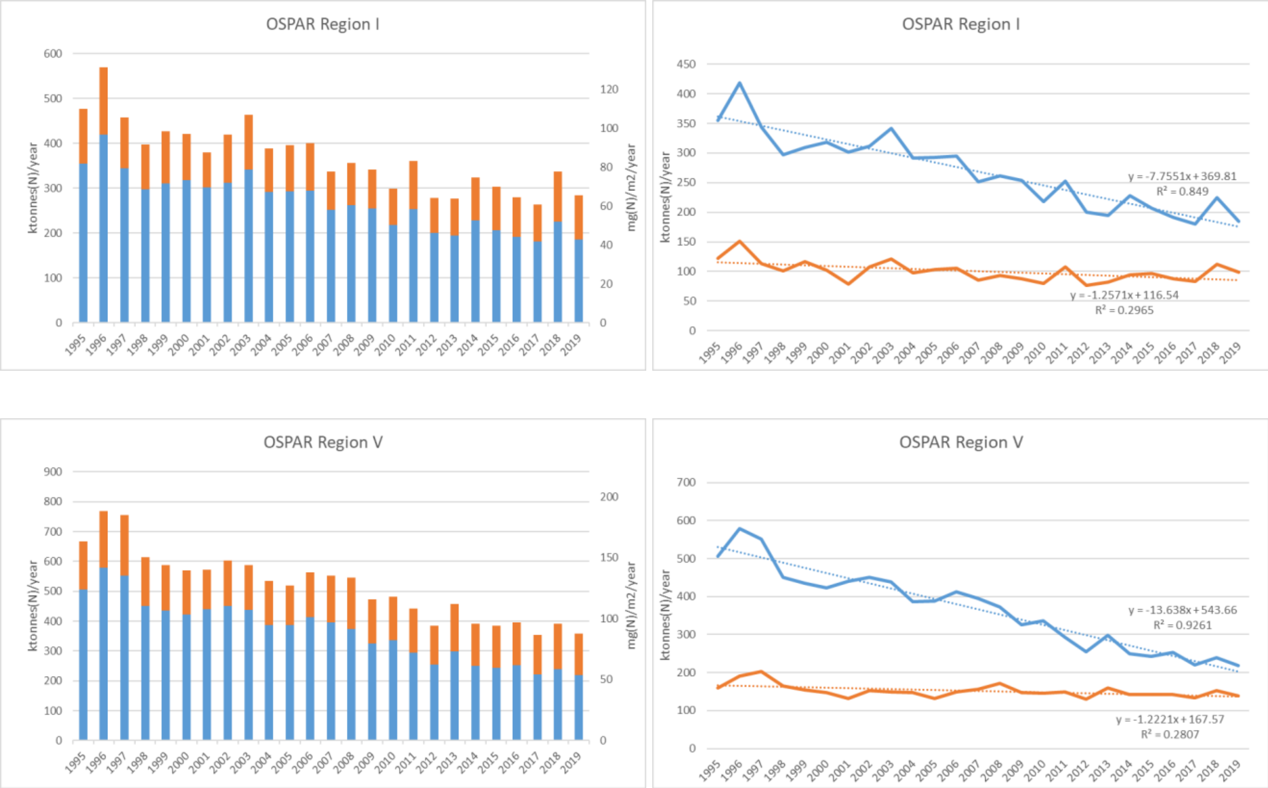


Figure 9b: As Figure 9a, but for OSPAR Regions I and IV.

Table 9. Percentage differences in actual (non-normalized) depositions between 2019 and 1995 for oxidised, reduced and total nitrogen, in the five OSPAR Regions. Also shown are the percentage differences between the 5-year periods of 2015-2019 and 1995-1999.

OSPAR Region	Oxidised N		Reduced N		Total N	
	1995→2019	(1995-1999) →(2015-2019)	1995→2019	(1995-1999) →(2015-2019)	1995→2019	(1995-1999) →(2015-2019)
I	-48 %	-43 %	-19 %	-21 %	-40 %	-37 %
II	-39 %	-41 %	-6 %	-8 %	-28 %	-30 %
III	-53 %	-52 %	-8 %	-14 %	-37 %	-38 %
IV	-50 %	-45 %	-6 %	-13 %	-37 %	-35 %
V	-57 %	-53 %	-13 %	-19 %	-46 %	-44 %

Table 10. Deposition of oxidised, reduced and total nitrogen, in the five OSPAR Regions in 2019. Both actual numbers (based on 2019 meteorology) and weather-normalized values (based on meteorological data of 2016, 2017, 2018 and 2019) are given. Results for other years are provided separately in Excel format (see Chapter 8). Unit: tonnes(N)/year.

OSPAR Region	Oxidised N		Reduced N		Total N	
	Actual	Normalized	Actual	Normalized	Actual	Normalized
I	185 116	193 742	99 028	94 459	284 144	288 201
II	253 671	248 115	188 215	195 168	441 887	443 284
III	62 465	61 830	68 314	63 535	130 779	125 365
IV	78 076	86 200	61 374	64 740	139 450	150 940
V	219 158	233 393	139 201	139 339	358 359	372 732

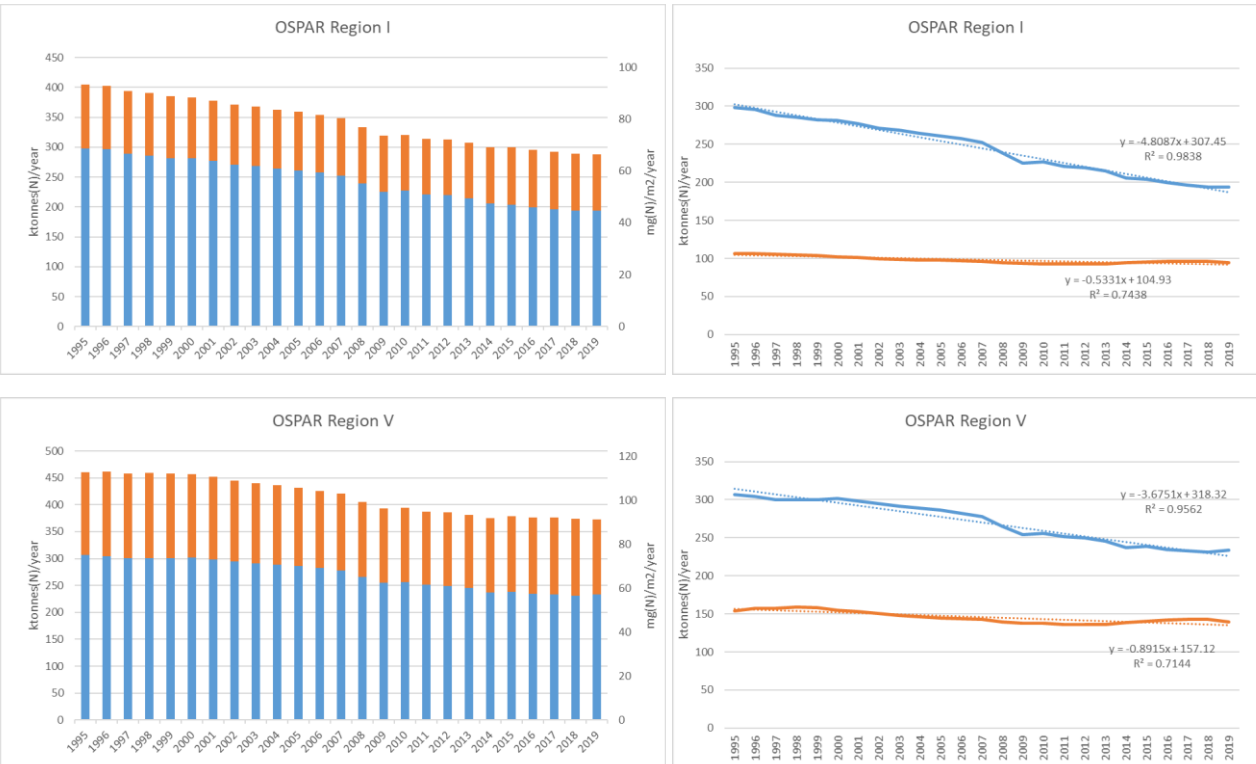


Figure 10a: Left panels: Time series of normalized depositions of oxidised (blue), reduced (red) and total nitrogen (sum of blue and red) to OSPAR Regions I and V, as calculated by the EMEP MSC-W model for the period 1995-2019. Unit: ktonnes(N)/year (left axis) or mg(N)/m^2/year (right axis). Right panels: Linear regression for oxidised (blue) and reduced (red) nitrogen deposition, with coefficients of determination (R^2) indicated in the figure.

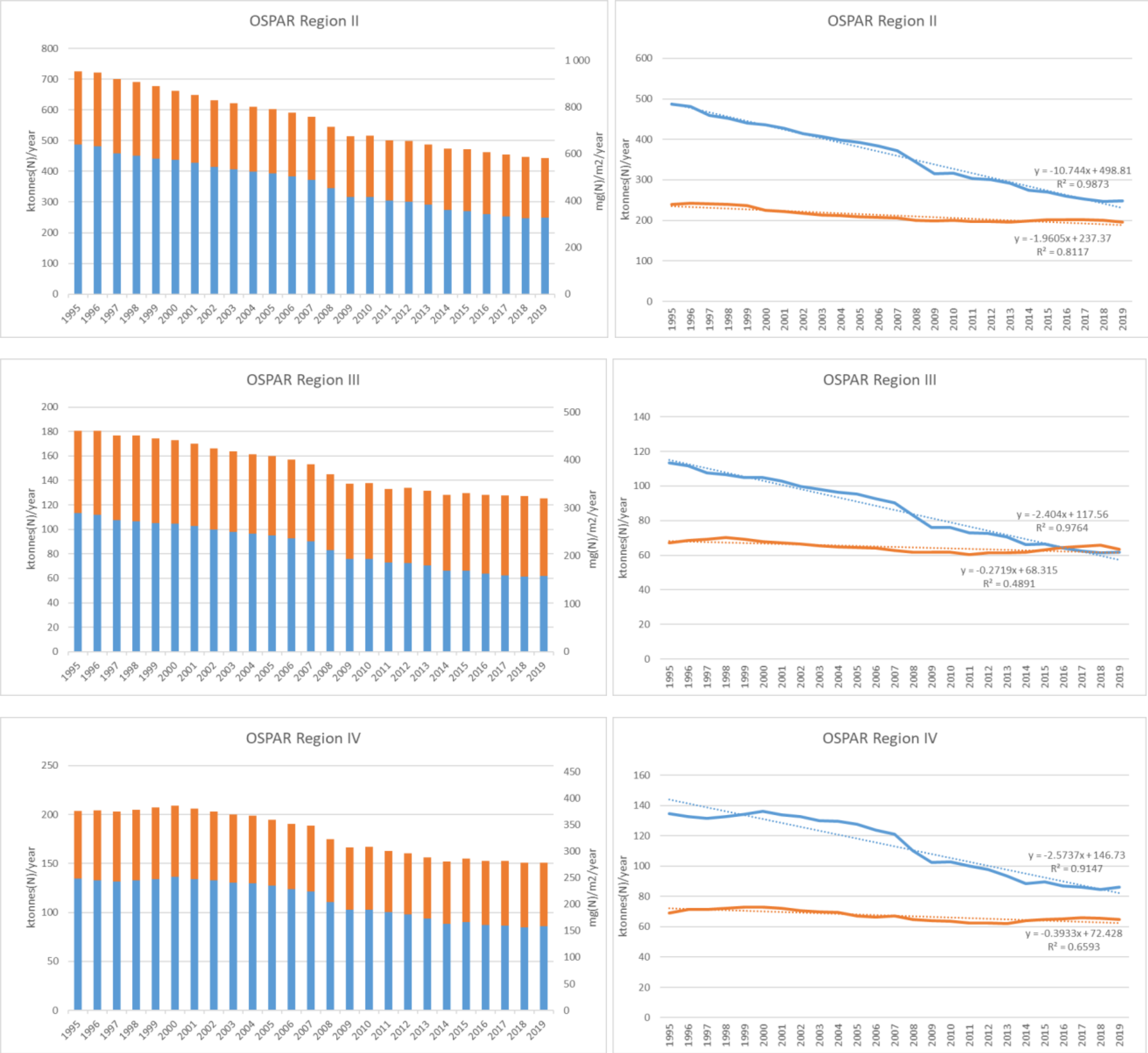


Figure 10b: As Figure 10a, but for OSPAR Regions II, III and IV.

Table 11. Normalized deposition of oxidized nitrogen to the 5 OSPAR Regions in the period 1995 to 2019. Unit: ktonnes(N)/year.

	Region I	Region II	Region III	Region IV	Region V
1995	298	487	113	135	307
1996	296	481	112	133	305
1997	289	459	107	132	300
1998	286	452	107	133	300
1999	282	441	105	134	300
2000	281	437	105	136	302
2001	277	428	103	134	298
2002	271	414	100	133	294
2003	268	407	98.1	130	291
2004	265	399	96.5	129	289
2005	261	393	95.3	128	287
2006	257	383	92.8	124	282
2007	252	372	90.2	121	278
2008	239	345	83.1	110	266
2009	226	316	75.9	103	254
2010	227	317	76.1	103	256
2011	221	304	72.8	100	251
2012	219	301	72.6	97.8	250
2013	215	291	70.4	93.7	245
2014	206	274	66.3	88.4	237
2015	204	271	66.3	89.8	238
2016	199	260	64.0	87.1	235
2017	196	253	62.5	86.3	233
2018	194	247	61.5	84.8	231
2019	194	248	61.8	86.2	233

Table 12. As Table 11, but for *reduced* nitrogen.

	Region I	Region II	Region III	Region IV	Region V
1995	107	239	67.0	69.0	154
1996	106	242	68.7	71.3	157
1997	106	240	69.3	71.4	158
1998	105	239	70.1	72.3	159
1999	104	236	69.2	73.0	158
2000	102	225	67.9	72.9	155
2001	101	221	67.1	72.0	153
2002	100	217	66.4	70.5	150
2003	99.0	214	65.6	70.0	148
2004	98.2	211	64.8	69.3	147
2005	97.9	209	64.4	67.3	145
2006	97.0	207	64.1	66.5	143
2007	96.5	206	62.8	67.1	143
2008	94.4	201	61.7	64.7	139
2009	93.5	199	61.7	63.9	138
2010	93.1	200	61.6	63.7	138
2011	92.7	198	60.4	62.6	136
2012	93.0	197	61.4	62.3	136
2013	92.9	196	61.3	62.2	136
2014	94.1	199	61.8	63.9	138
2015	95.4	201	63.2	64.9	141
2016	95.8	202	64.4	65.2	142
2017	96.3	202	65.1	66.1	143
2018	95.8	200	65.9	65.7	143
2019	94.5	195	63.5	64.7	139

5.2 Depositions to Exclusive Economic Zones

Actual (non-normalized) atmospheric nitrogen depositions to each of the twenty-four Exclusive Economic Zones during the period 1995-2019 are shown in Figure 11. There is a clear decline in the deposition of oxidised nitrogen between 1995 and 2019 in all EEZs. The deposition of reduced nitrogen was larger in 2019 than in 1995 in seven of the EEZs. Again, one has to keep in mind that the inter-annual variability in these depositions is large due to meteorological conditions (e.g. in last year's report - for 2018 - many more EEZs showed an increase with respect to 1995). Nevertheless, it is clear that, overall, the downward trend in reduced nitrogen deposition is much smaller than that of oxidised nitrogen deposition.

Table 13 lists the percentage differences between 1995 and 2019, and between the two 5-year periods of 1995-1999 and 2015-2019 for actual depositions, while Table 14 lists actual *and* normalized depositions in the 24 EEZs for the year 2019, i.e. the most recent year for which model calculations have been made.

Tables 15 and 16 contain *normalized* depositions of oxidized and reduction nitrogen to the twenty-four EEZs.

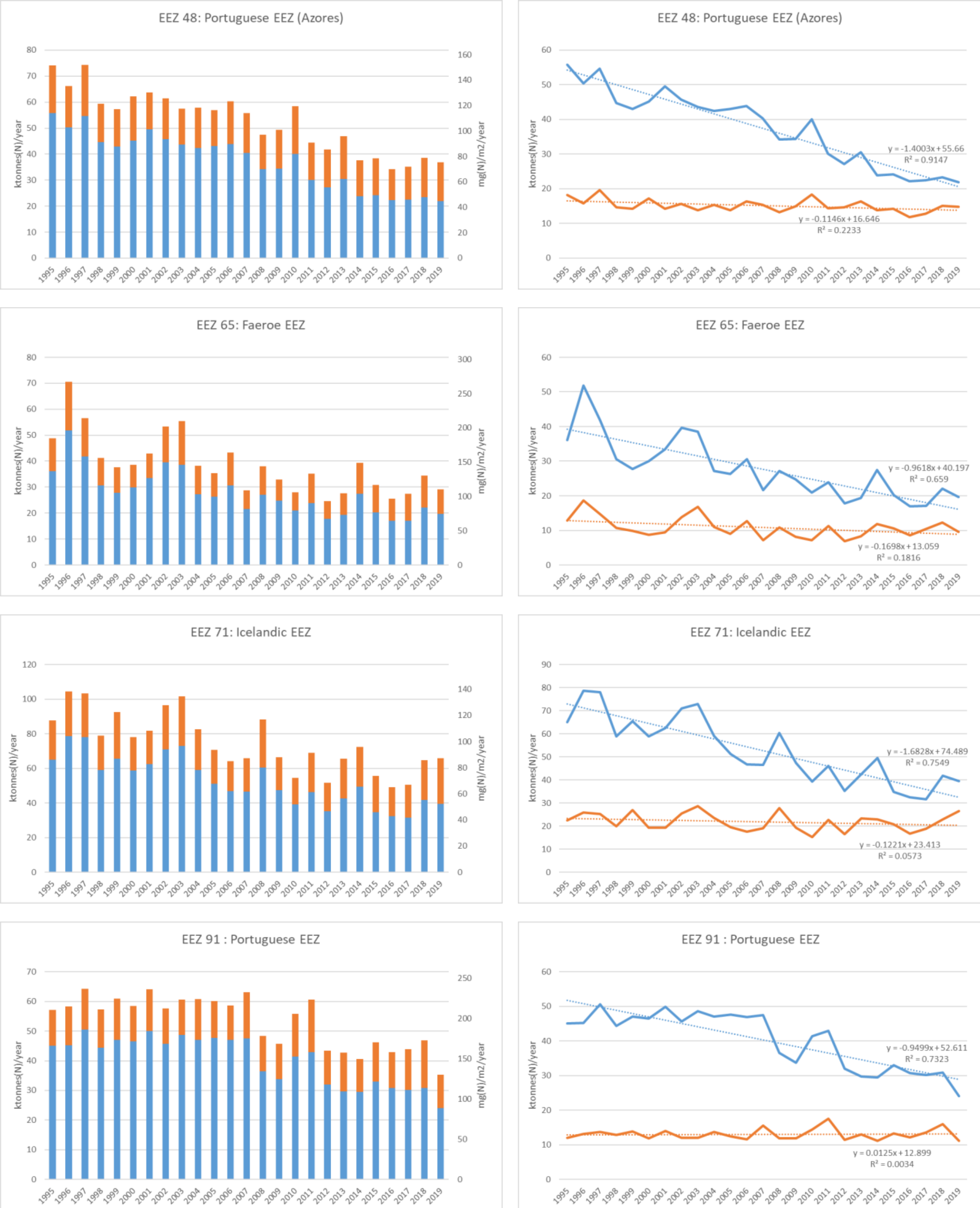


Figure 11: Left panels: Time series of actual (non-normalized) depositions of oxidised (blue), reduced (red) and total nitrogen (sum of blue and red) to selected EEZs, as calculated by the EMEP MSC-W model for the period 1995-2019. Unit: ktonnes(N)/year (left axis) or mg(N)/m^2/year (right axis). Right panel: Linear regression for oxidised (blue) and reduced (red) nitrogen deposition, with coefficients of determination (R^2) indicated in the figure. The figure continues on the next pages.

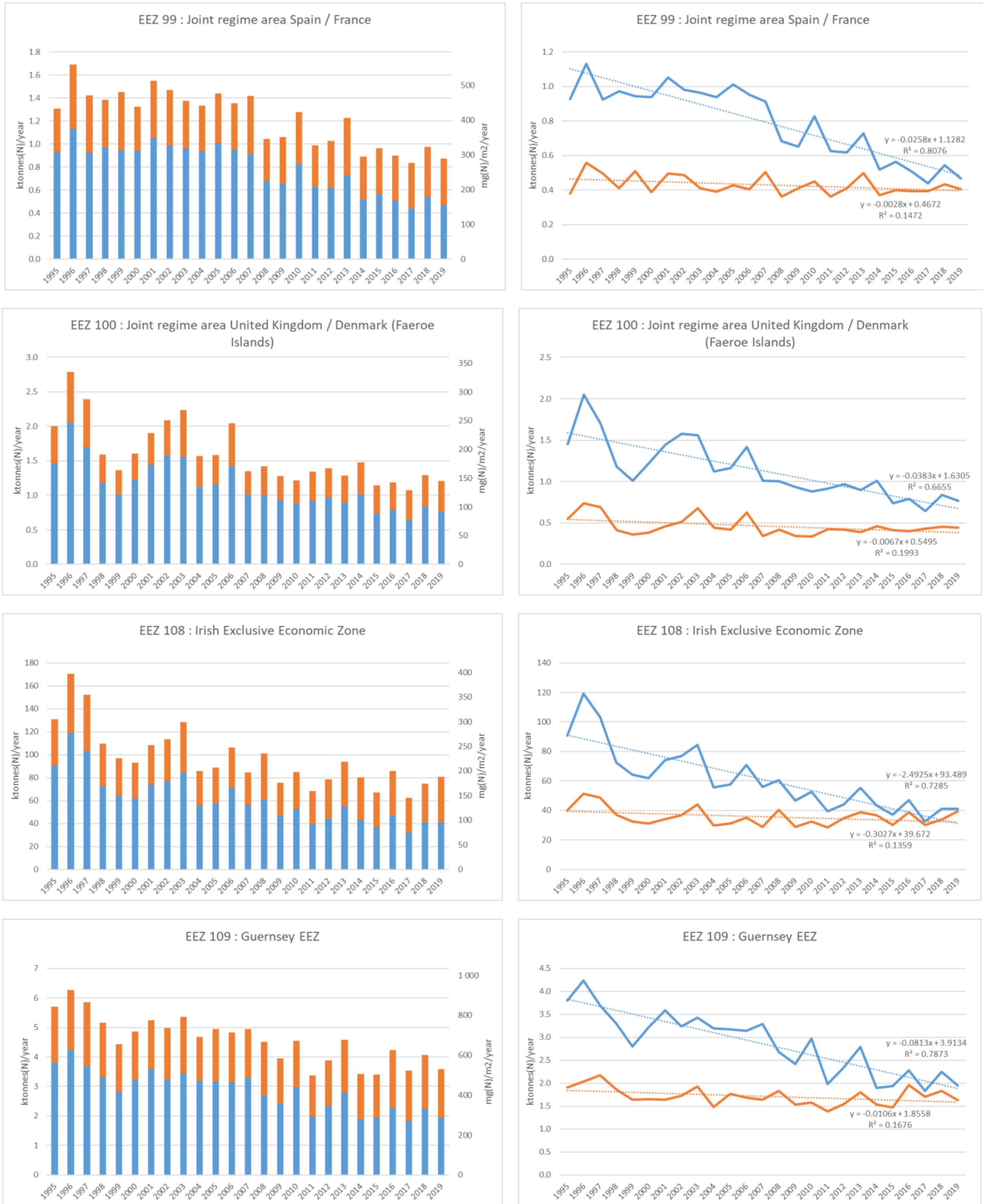


Figure 11: (continued)

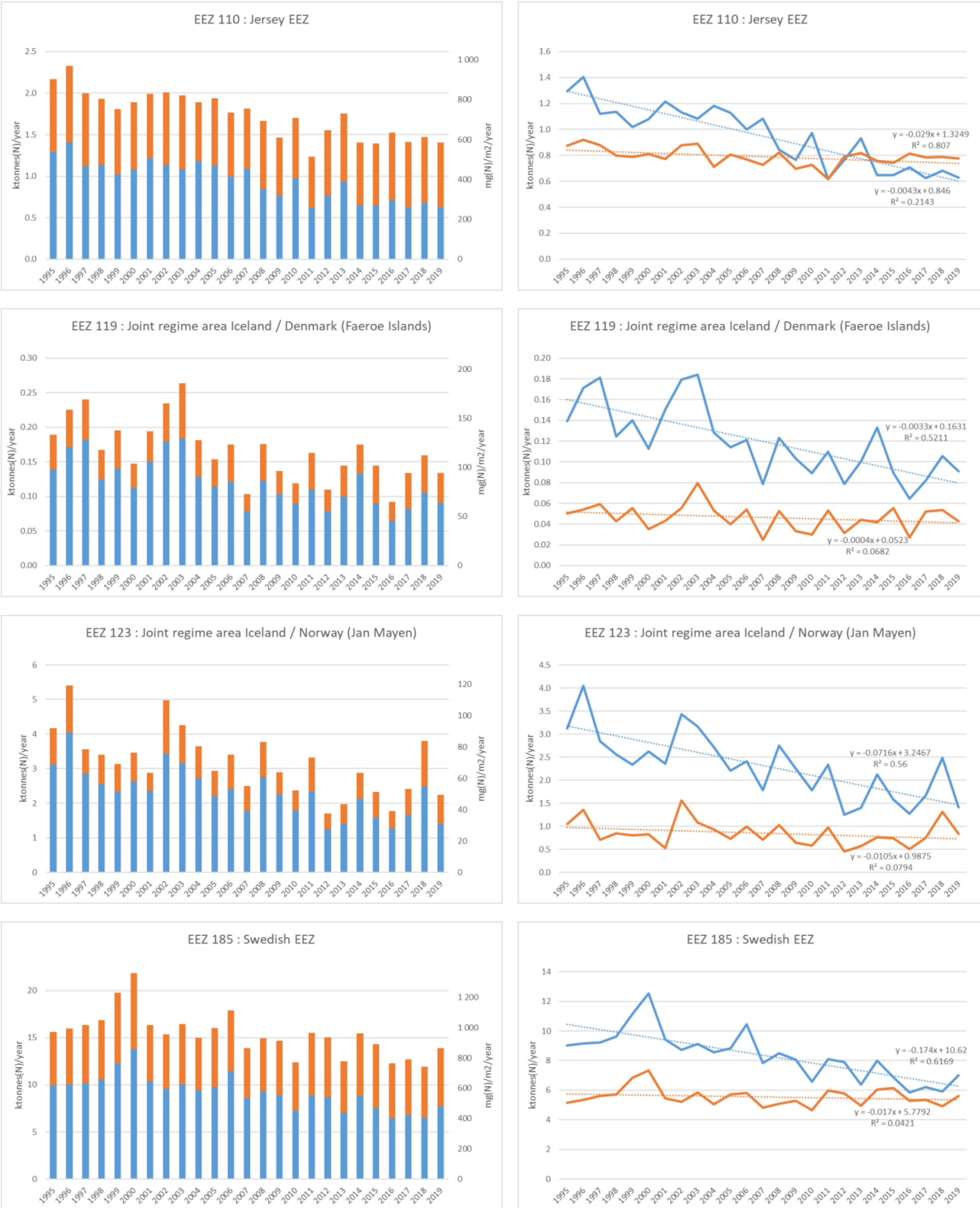


Figure 11: (continued)

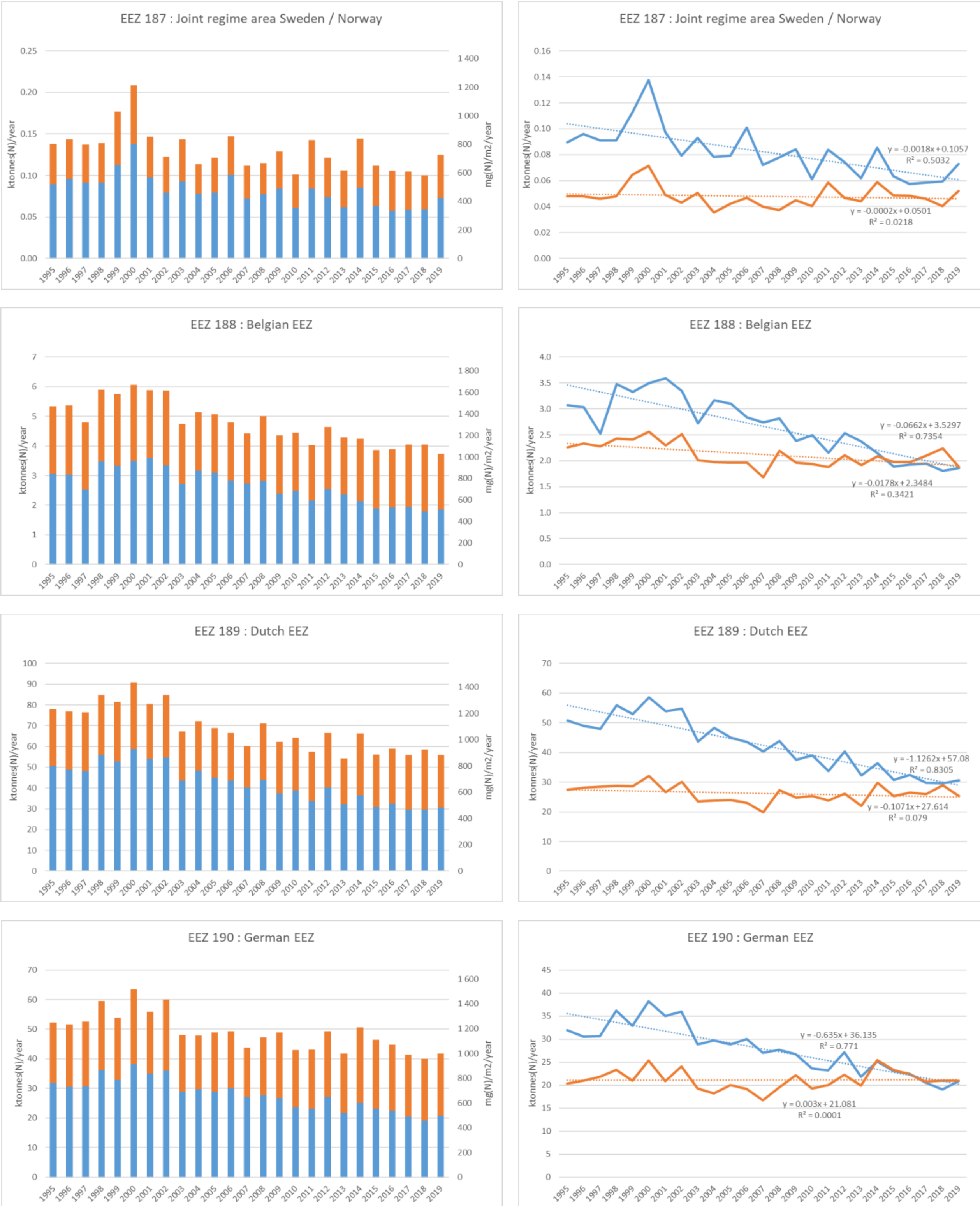


Figure 11: (continued)

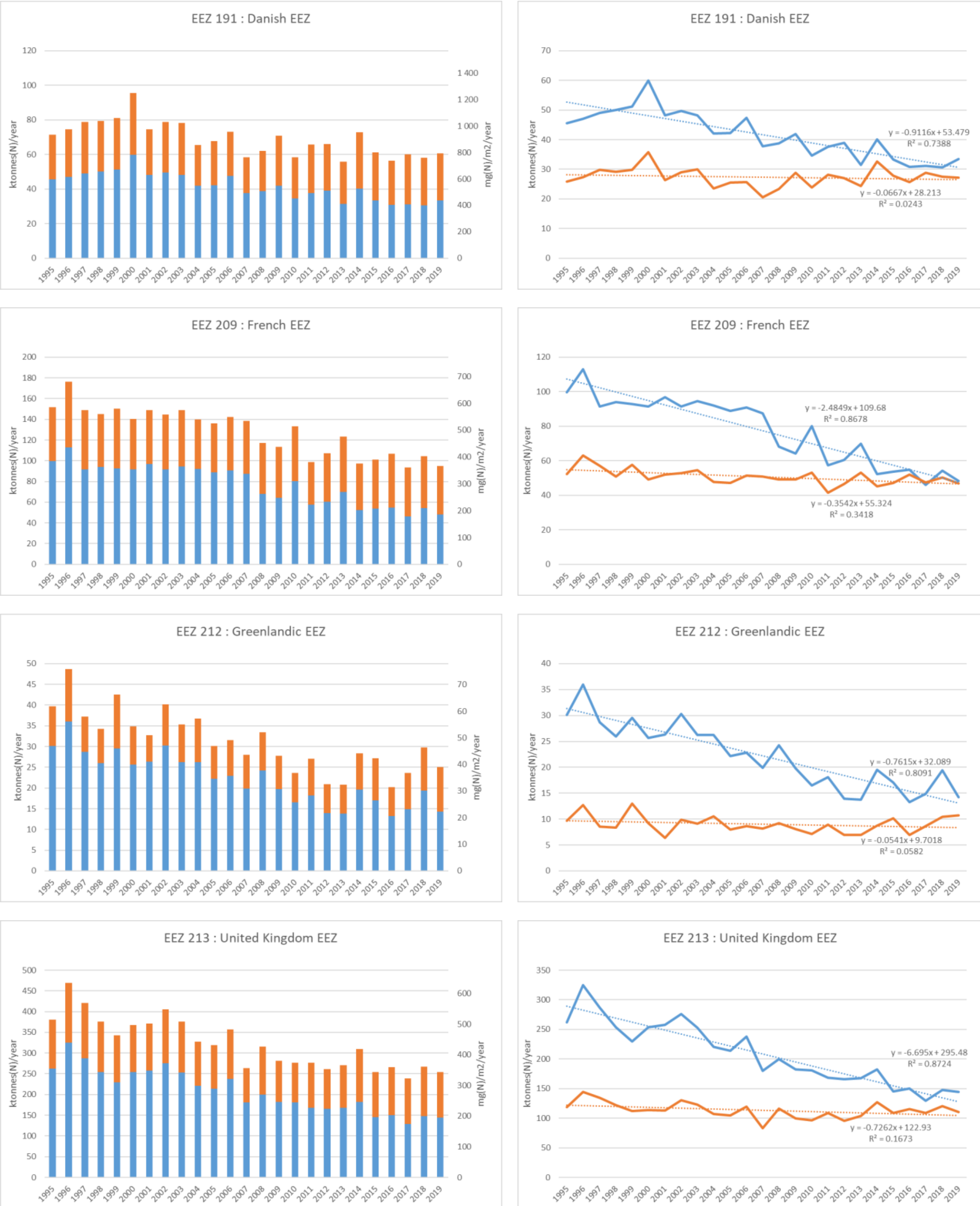


Figure 11: (continued)

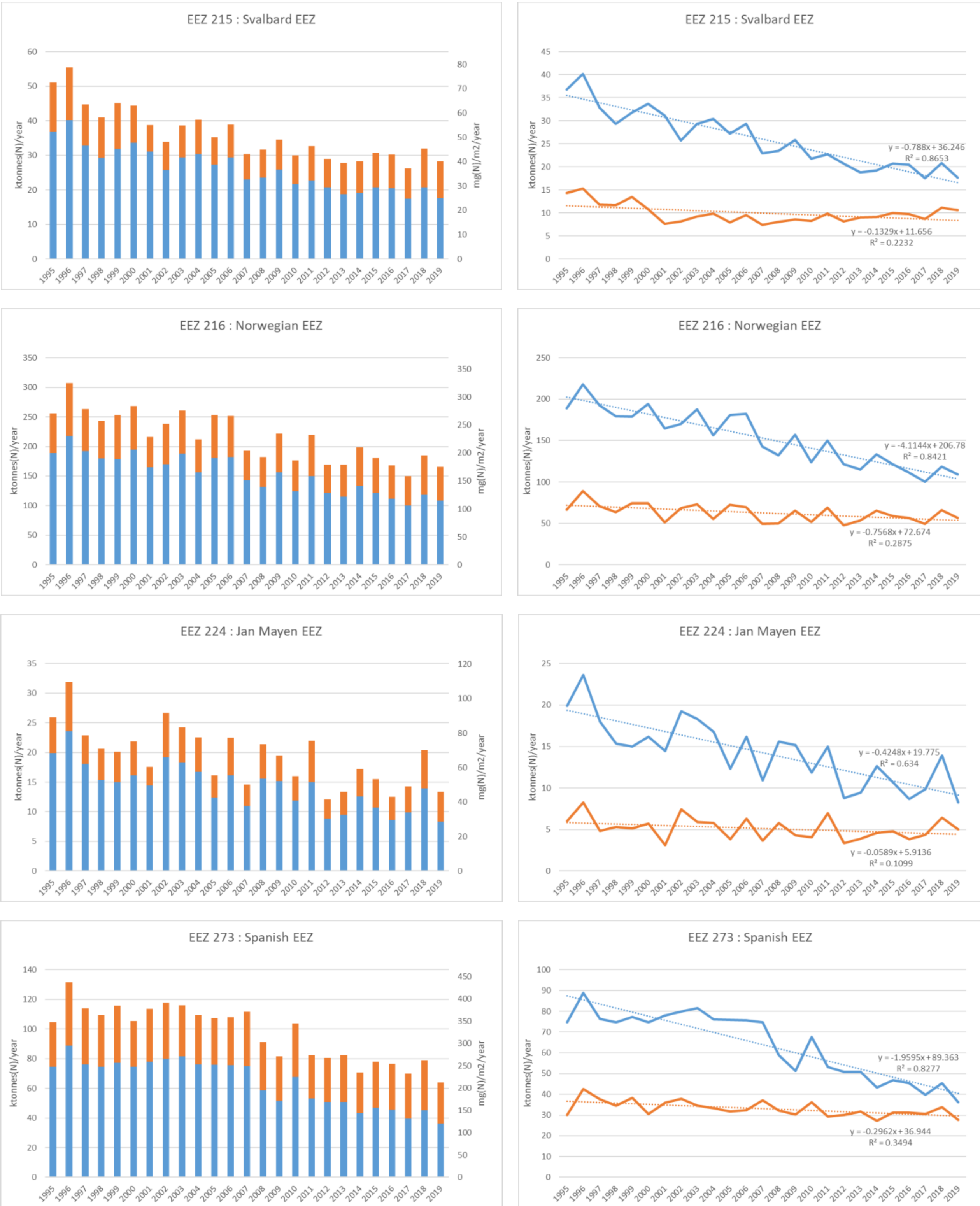


Figure 11: (continued)

Table 13. Percentage differences in 2019 compared to 1995 for oxidised, reduced and total nitrogen, in the twenty-four Exclusive Economic Zones listed in Table 6. Also shown are the percentage differences in the 5-year period 2015-2019 with respect to the 5-year period of 1995-1999.

EEZ	**Oxidised N**		**Reduced N**		**Total N**	
	1995→2019	**(1995-1999) →(2015-2019)**	**1995→2019**	**(1995-1999) →(2015-2019)**	**1995→2019**	**(1995-1999) →(2015-2019)**
EEZ 48	-61 %	-54 %	-19 %	-17 %	-50 %	-45 %
EEZ 65	-46 %	-49 %	-25 %	-23 %	-40 %	-42 %
EEZ 71	-39 %	-48 %	18 %	-12 %	-25 %	-39 %
EEZ 91	-47 %	-36 %	-7 %	1 %	-38 %	-28 %
EEZ 99	-50 %	-49 %	7 %	-14 %	-33 %	-37 %
EEZ 100	-47 %	-49 %	-20 %	-22 %	-40 %	-42 %
EEZ 108	-55 %	-56 %	-2 %	-18 %	-38 %	-44 %
EEZ 109	-49 %	-43 %	-14 %	-11 %	-37 %	-31 %
EEZ 110	-52 %	-45 %	-11 %	-8 %	-35 %	-30 %
EEZ 119	-35 %	-43 %	-15 %	-12 %	-29 %	-35 %
EEZ 123	-55 %	-44 %	-20 %	-13 %	-46 %	-36 %
EEZ 185	-23 %	-34 %	10 %	-5 %	-11 %	-23 %
EEZ 187	-19 %	-35 %	8 %	-8 %	-9 %	-26 %
EEZ 188	-40 %	-39 %	-17 %	-13 %	-30 %	-28 %
EEZ 189	-40 %	-40 %	-8 %	-7 %	-29 %	-28 %
EEZ 190	-35 %	-35 %	3 %	1 %	-20 %	-20 %
EEZ 191	-26 %	-34 %	5 %	-4 %	-15 %	-23 %
EEZ 209	-52 %	-48 %	-10 %	-13 %	-37 %	-35 %
EEZ 212	-53 %	-48 %	11 %	-10 %	-37 %	-38 %
EEZ 213	-45 %	-47 %	-7 %	-11 %	-33 %	-36 %
EEZ 215	-52 %	-43 %	-26 %	-25 %	-45 %	-38 %
EEZ 216	-42 %	-41 %	-15 %	-21 %	-35 %	-36 %
EEZ 224	-58 %	-44 %	-17 %	-17 %	-49 %	-38 %
EEZ 273	-52 %	-46 %	-8 %	-16 %	-39 %	-36 %

Table 14. Deposition of oxidized, reduced and total nitrogen, to the twenty-four EEZs in 2019. Both actual numbers (based on 2019 meteorology) and weather-normalized values (based on meteorological data of 2016, 2017, 2018 and 2019) are given. Results for other years are provided separately in Excel format (see Chapter 8). Unit: tonnes(N)/year.

EEZ	Oxidised N		Reduced N		Total N	
	Actual	Normalized	Actual	Normalized	Actual	Normalized
EEZ048	21 956	22 752	14 813	13 519	36 769	36 270
EEZ065	19 599	18 724	9 594	10 031	29 193	28 755
EEZ071	39 487	36 011	26 422	20 837	65 909	56 848
EEZ091	24 088	29 511	11 176	13 184	35 263	42 695
EEZ099	468	485	405	401	873	886
EEZ100	766	749	440	423	1 206	1 172
EEZ108	41 066	39 858	39 470	34 787	80 536	74 645
EEZ109	1 949	2 081	1 634	1 745	3 583	3 827
EEZ110	628	660	775	775	1 402	1 434
EEZ119	91	85	43	43	134	128
EEZ123	1 405	1 692	835	836	2 240	2 528
EEZ185	6 991	6 156	5 629	5 192	12 621	11 348
EEZ187	73	61	52	46	125	107
EEZ188	1 857	1 865	1 880	1 996	3 737	3 861
EEZ189	30 557	30 143	25 260	25 953	55 817	56 096
EEZ190	20 843	20 356	21 012	20 599	41 855	40 955
EEZ191	33 439	30 966	27 088	26 678	60 527	57 644
EEZ209	48 173	50 636	46 858	48 236	95 031	98 872
EEZ212	14 268	15 355	10 728	9 058	24 996	24 413
EEZ213	144 206	140 631	110 133	111 748	254 338	252 379
EEZ215	17 632	18 961	10 566	10 056	28 197	29 016
EEZ216	108 946	108 575	56 516	56 010	165 462	164 585
EEZ224	8 280	10 103	5 028	4 834	13 309	14 937
EEZ273	36 252	41 520	27 761	30 485	64 013	72 005

Table 15. Normalized deposition of oxidized nitrogen to the 24 EEZs in the OSPAR Maritime Area in the period 1995 to 2019. In the headers, only the numbers of the EEZs are given. For example, '065' means EEZ065 (Faeroe Exclusive Economic Zone). Unit: ktonnes(N)/year. The table continues on the next page.

	048	**065**	**071**	**091**	**099**	**100**	**108**	**109**	**110**	**119**	**123**	**185**
1995	25	34	57	40	0.8	1.4	68	3.7	1.2	0.2	2.8	11
1996	25	33	56	40	0.8	1.4	67	3.6	1.2	0.1	2.8	11
1997	25	32	54	40	0.8	1.3	65	3.5	1.1	0.1	2.7	11
1998	25	32	54	41	0.8	1.3	64	3.5	1.1	0.1	2.7	10
1999	25	31	53	42	0.8	1.3	63	3.5	1.1	0.1	2.6	10
2000	26	31	53	43	0.8	1.3	63	3.5	1.1	0.1	2.6	10
2001	25	30	52	42	0.8	1.2	62	3.4	1.1	0.1	2.5	10
2002	25	29	51	42	0.8	1.2	61	3.3	1.1	0.1	2.5	10
2003	25	29	50	41	0.8	1.2	60	3.3	1.0	0.1	2.5	10
2004	25	28	50	41	0.8	1.2	59	3.2	1.0	0.1	2.4	9.3
2005	25	28	49	40	0.7	1.1	58	3.1	1.0	0.1	2.4	9.2
2006	25	27	48	39	0.7	1.1	57	3.1	1.0	0.1	2.3	9.0
2007	24	27	47	39	0.7	1.1	55	3.0	1.0	0.1	2.3	8.8
2008	24	25	45	35	0.6	1.0	52	2.7	0.9	0.1	2.2	8.2
2009	23	23	42	33	0.6	0.9	48	2.5	0.8	0.1	2.0	7.6
2010	24	23	42	34	0.6	0.9	48	2.6	0.8	0.1	2.0	7.7
2011	23	22	41	33	0.6	0.9	46	2.5	0.8	0.1	2.0	7.4
2012	23	22	41	32	0.6	0.9	46	2.4	0.8	0.1	2.0	7.3
2013	23	21	40	31	0.5	0.9	45	2.4	0.8	0.1	1.9	7.1
2014	22	20	38	29	0.5	0.8	42	2.2	0.7	0.1	1.8	6.7
2015	23	20	38	30	0.5	0.8	42	2.2	0.7	0.1	1.8	6.6
2016	23	19	37	29	0.5	0.8	41	2.1	0.7	0.1	1.8	6.4
2017	22	19	37	29	0.5	0.8	40	2.1	0.7	0.1	1.7	6.3
2018	22	19	36	29	0.5	0.7	40	2.0	0.6	0.1	1.7	6.1
2019	23	19	36	30	0.5	0.7	40	2.1	0.7	0.1	1.7	6.2

Table 15. Continued.

	187	188	189	190	191	209	212	213	215	216	224	273
1995	0.1	3.6	61	40	59	87	22	279	25	190	16	65
1996	0.1	3.6	60	39	58	85	22	274	25	189	16	64
1997	0.1	3.4	57	37	56	83	22	262	25	183	16	63
1998	0.1	3.4	56	37	55	83	21	258	25	181	15	64
1999	0.1	3.3	55	36	53	83	21	251	24	177	15	64
2000	0.1	3.3	54	36	53	84	21	249	24	175	15	66
2001	0.1	3.3	53	35	52	82	21	244	24	172	15	64
2002	0.1	3.2	51	34	50	81	20	236	24	167	14	64
2003	0.1	3.1	50	33	50	79	20	232	24	165	14	63
2004	0.1	3.0	49	33	49	78	20	227	23	162	14	63
2005	0.1	3.0	49	32	48	77	20	224	23	160	14	62
2006	0.1	2.9	47	31	47	75	19	218	23	157	14	60
2007	0.1	2.8	46	30	45	73	19	212	23	154	13	59
2008	0.1	2.6	42	28	42	67	18	196	22	144	13	53
2009	0.1	2.4	39	26	39	62	17	178	21	134	12	50
2010	0.1	2.4	39	26	39	62	18	178	21	135	12	50
2011	0.1	2.3	37	25	38	60	17	171	21	131	12	48
2012	0.1	2.3	37	25	37	59	17	170	21	129	12	47
2013	0.1	2.2	36	24	36	57	17	164	20	125	11	45
2014	0.1	2.0	33	22	34	53	16	155	20	119	11	43
2015	0.1	2.0	33	22	34	54	16	153	20	117	11	43
2016	0.1	1.9	32	21	33	52	16	147	19	113	10	42
2017	0.1	1.9	31	21	32	51	16	143	19	110	10	42
2018	0.1	1.8	30	20	31	50	15	140	19	108	10	41
2019	0.1	1.9	30	20	31	51	15	141	19	109	10	42

Table 16. As Table 15, but for *reduced* nitrogen. The table continues on the next page.

	048	**065**	**071**	**091**	**099**	**100**	**108**	**109**	**110**	**119**	**123**	**185**
1995	16	12	24	14	0.4	0.5	36	2.0	0.8	0.0	1.0	6.5
1996	16	12	24	15	0.4	0.5	37	2.0	0.9	0.0	1.0	6.4
1997	16	12	24	15	0.4	0.5	37	2.0	0.9	0.1	1.0	6.4
1998	16	12	24	15	0.4	0.5	38	2.0	0.9	0.1	1.0	6.4
1999	16	12	24	15	0.4	0.5	37	2.0	0.9	0.0	1.0	6.2
2000	16	11	23	15	0.4	0.5	37	2.0	0.9	0.0	0.9	6.0
2001	16	11	23	15	0.4	0.5	36	1.9	0.9	0.0	0.9	6.0
2002	15	11	22	15	0.4	0.5	36	1.9	0.8	0.0	0.9	5.9
2003	15	11	22	14	0.4	0.4	36	1.9	0.8	0.0	0.9	5.8
2004	15	11	22	14	0.4	0.4	35	1.8	0.8	0.0	0.9	5.7
2005	14	10	22	14	0.4	0.4	35	1.8	0.8	0.0	0.9	5.7
2006	14	10	22	14	0.4	0.4	35	1.8	0.8	0.0	0.9	5.6
2007	14	10	22	14	0.4	0.4	34	1.8	0.8	0.0	0.9	5.6
2008	14	10	21	13	0.4	0.4	34	1.8	0.8	0.0	0.8	5.5
2009	13	10	21	13	0.4	0.4	34	1.8	0.8	0.0	0.8	5.4
2010	13	10	21	13	0.4	0.4	34	1.8	0.8	0.0	0.8	5.4
2011	13	10	21	13	0.4	0.4	33	1.7	0.8	0.0	0.8	5.3
2012	13	10	21	12	0.4	0.4	34	1.7	0.8	0.0	0.8	5.3
2013	13	10	21	12	0.4	0.4	34	1.7	0.8	0.0	0.8	5.3
2014	13	10	21	13	0.4	0.4	34	1.8	0.8	0.0	0.8	5.3
2015	14	10	21	13	0.4	0.4	35	1.8	0.8	0.0	0.9	5.4
2016	14	10	21	13	0.4	0.4	35	1.8	0.8	0.0	0.9	5.3
2017	14	10	22	13	0.4	0.4	36	1.8	0.8	0.0	0.9	5.4
2018	14	10	21	13	0.4	0.4	36	1.8	0.8	0.0	0.9	5.3
2019	14	10	21	13	0.4	0.4	35	1.7	0.8	0.0	0.8	5.2

Table 16. Continued.

	187	188	189	190	191	209	212	213	215	216	224	273
1995	0.1	2.8	35	26	34	53	11	127	11	66	5.6	32
1996	0.1	2.9	35	26	34	54	11	129	11	67	5.7	33
1997	0.1	2.8	35	26	34	54	11	130	11	67	5.6	33
1998	0.1	2.8	34	26	33	54	11	130	11	66	5.6	34
1999	0.1	2.8	34	25	33	54	10	129	11	66	5.6	34
2000	0.1	2.4	31	24	31	54	10	124	11	63	5.4	34
2001	0.1	2.4	31	24	31	54	10	122	11	62	5.3	34
2002	0.1	2.3	30	23	30	52	10	120	10	61	5.2	33
2003	0.1	2.3	29	23	30	52	10	119	10	60	5.2	33
2004	0.0	2.2	29	22	30	51	10	117	10	60	5.1	33
2005	0.0	2.2	28	22	29	50	10	116	10	60	5.1	32
2006	0.0	2.2	28	22	29	50	9.4	115	10	59	5.0	31
2007	0.0	2.1	28	22	29	50	9.4	114	10	59	5.0	32
2008	0.0	2.1	27	22	28	49	9.2	110	10	58	4.9	30
2009	0.0	2.1	27	22	28	49	9.1	110	10	57	4.9	30
2010	0.0	2.1	27	22	28	49	9.1	111	10	57	4.9	30
2011	0.0	2.1	27	21	27	48	9.1	109	10	57	4.8	29
2012	0.0	2.0	26	21	27	48	9.1	110	10	57	4.8	29
2013	0.0	2.0	26	21	27	48	9.1	109	10	57	4.8	29
2014	0.0	2.1	27	22	27	49	9.2	111	10	57	4.9	30
2015	0.0	2.1	27	22	28	49	9.3	113	10	58	4.9	30
2016	0.0	2.1	27	22	27	49	9.3	114	10	58	5.0	31
2017	0.0	2.1	27	22	28	50	9.3	115	10	58	5.0	31
2018	0.0	2.0	27	21	27	49	9.2	114	10	58	4.9	31
2019	0.0	2.0	26	21	27	48	9.1	112	10	56	4.8	30

5.3 Depositions to partial EEZs

Actual (non-normalized) atmospheric nitrogen depositions have been computed for each of the twenty-five partial Exclusive Economic Zones listed in Table 7, for each year of the period 1990-2019. Results are shown for total nitrogen depositions during the 1995-2019 period in Figure 12.

Table 17 lists the percentage differences between 1995 and 2019, and between the two 5-year periods of 1995-1999 and 2015-2019 for actual depositions.

Normalized results are listed for oxidized and reduced nitrogen in Tables 18 and 19, respectively, and for the whole period from 1995 to 2019.

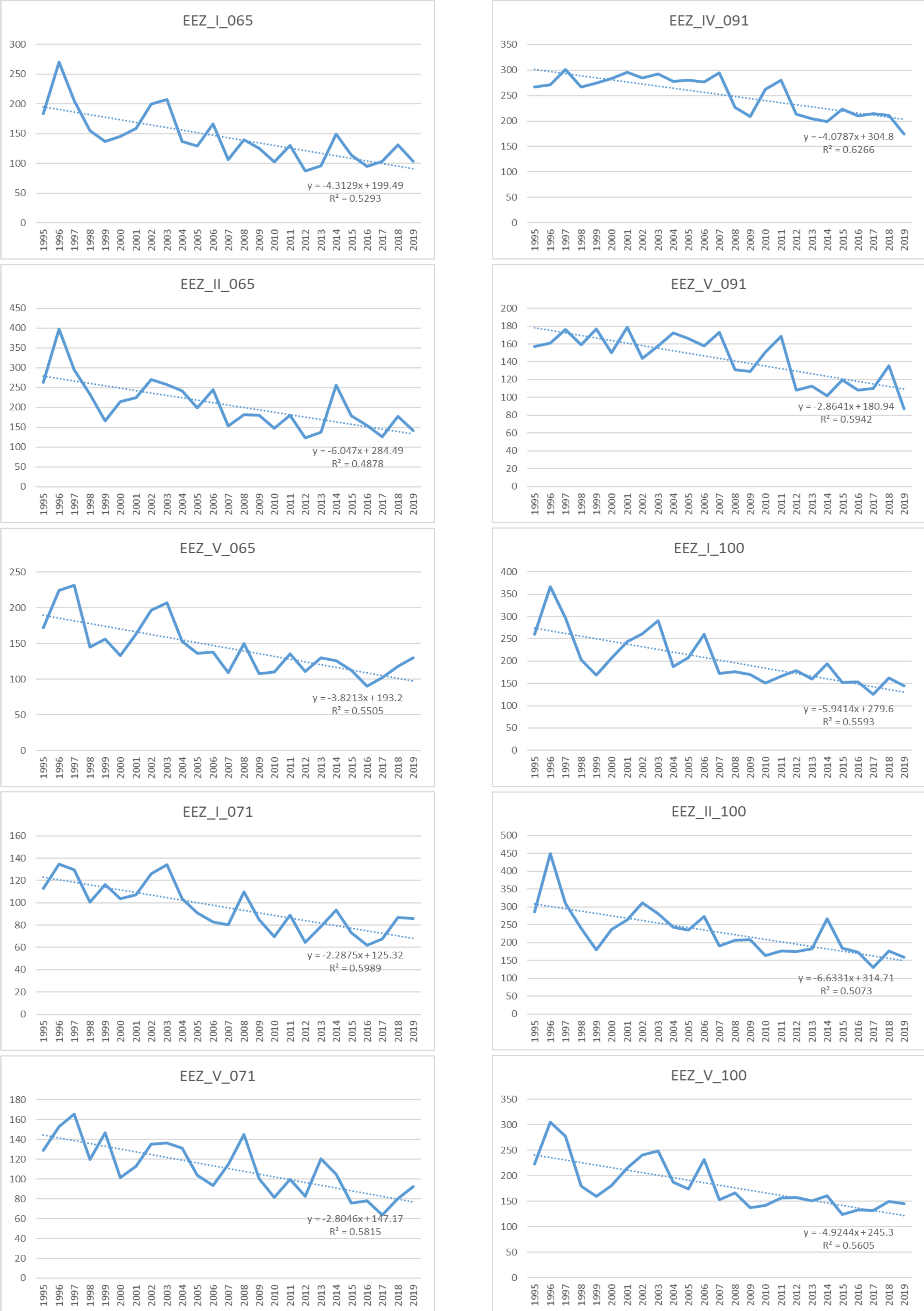


Figure 12: Time series of actual depositions of total nitrogen to the partial EEZs listed in Table 7, as calculated by the EMEP MSC-W model for the period 1995-2019. Linear regression lines, with coefficients of determination (R^2), are indicated in the figure. Unit: mg(N)/m^2/year. (Figure continues on the next 2 pages.)

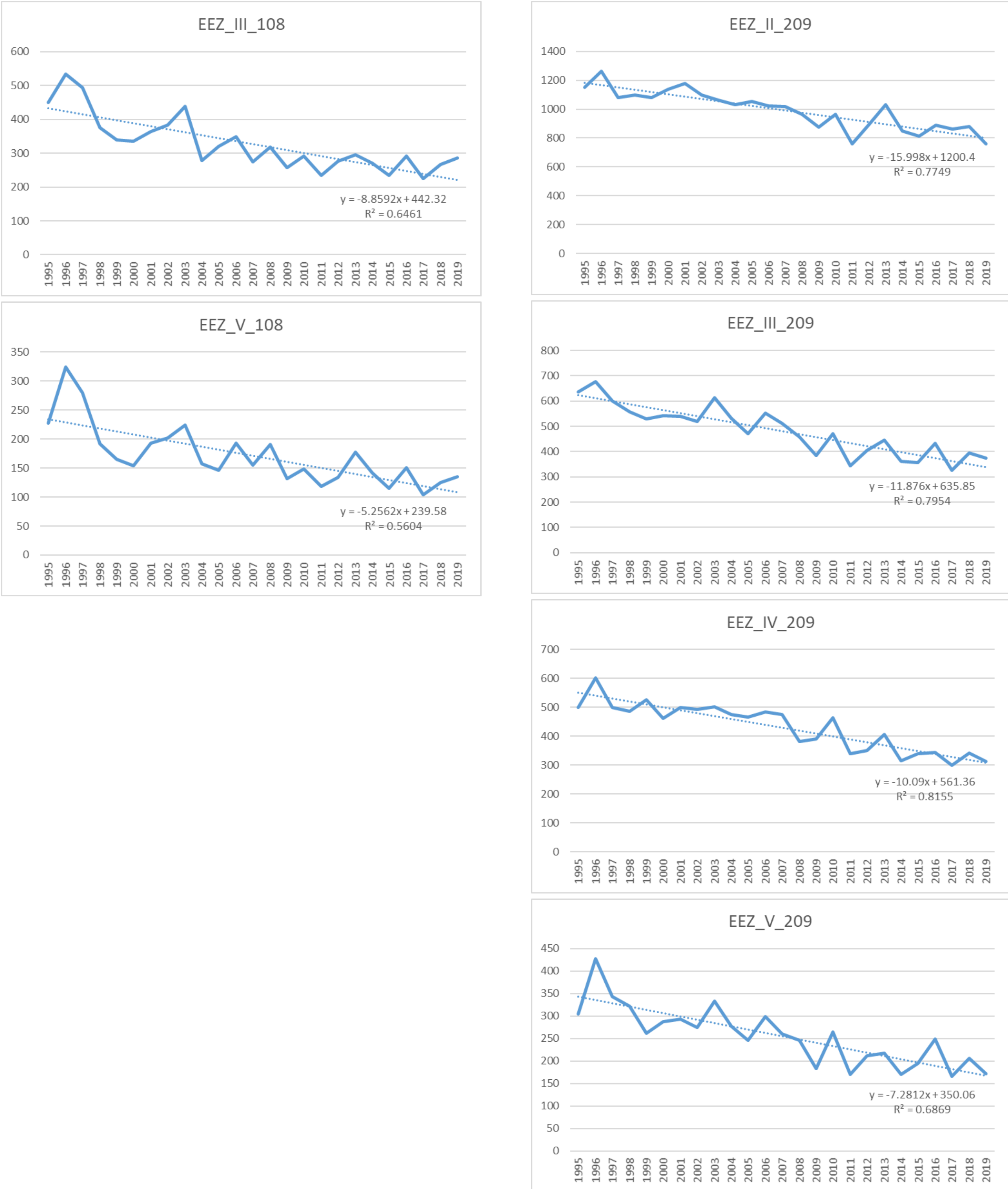


Figure 12: Continued.

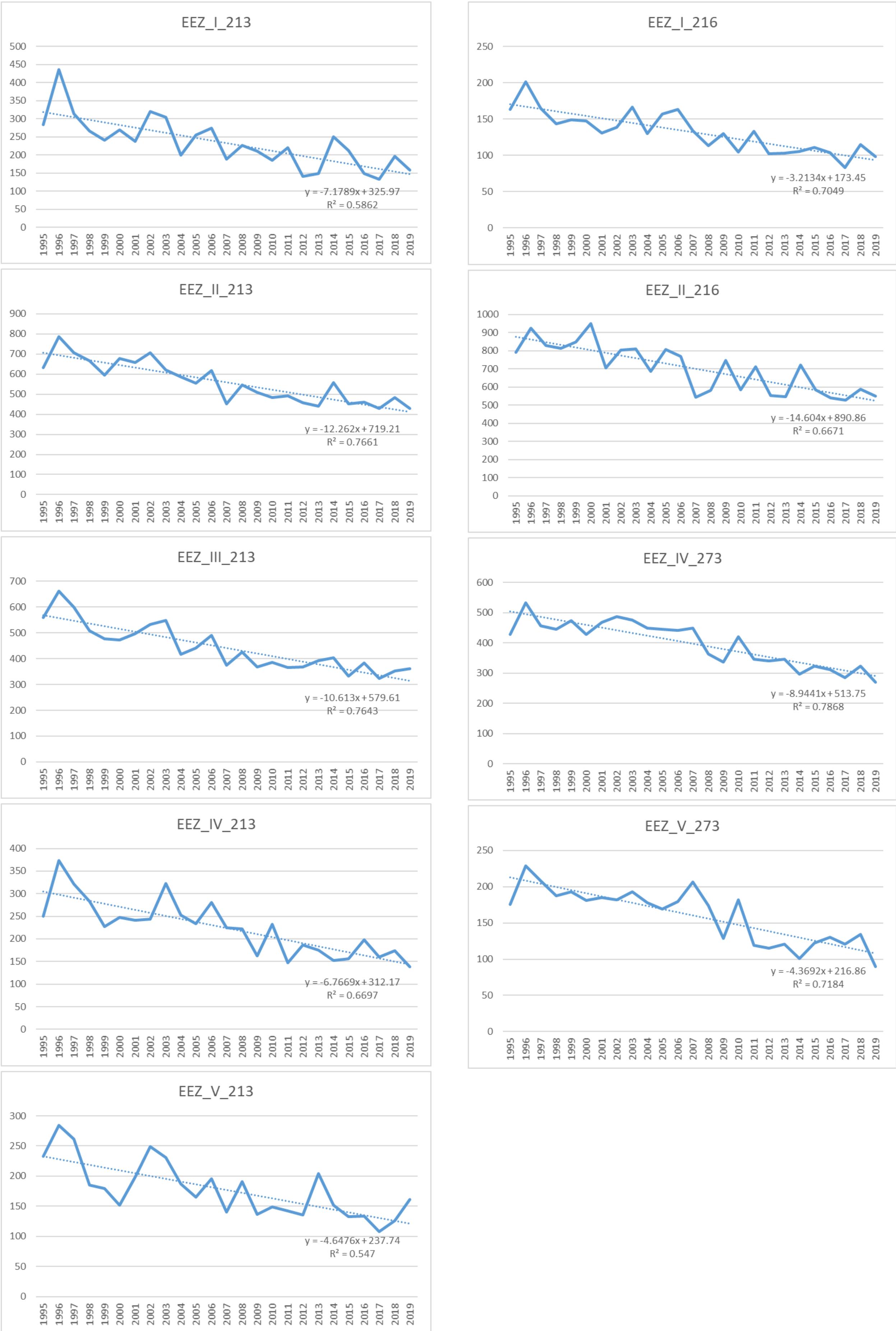


Figure 12: Continued.

Table 17. Percentage differences in 2019 compared to 1995 for oxidised, reduced and total nitrogen, in the twenty-five partial Exclusive Economic Zones listed in Table 7. Also shown are the percentage differences in the 5-year period 2015-2019 with respect to the 5-year period of 1995-1999.

EEZ	**Oxidised N**		**Reduced N**		**Total N**	
	1995→2019	**(1995-1999) →(2015-2019)**	**1995→2019**	**(1995-1999) →(2015-2019)**	**1995→2019**	**(1995-1999) →(2015-2019)**
EEZ_I_065	-48 %	-49 %	-32 %	-24 %	-44 %	-42 %
EEZ_II_065	-49 %	-50 %	-38 %	-23 %	-46 %	-43 %
EEZ_V_065	-36 %	-49 %	5 %	-17 %	-25 %	-41 %
EEZ_I_071	-39 %	-46 %	20 %	-9 %	-24 %	-37 %
EEZ_V_071	-42 %	-54 %	9 %	-22 %	-28 %	-45 %
EEZ_IV_091	-43 %	-33 %	-2 %	4 %	-34 %	-25 %
EEZ_V_091	-52 %	-40 %	-15 %	-5 %	-44 %	-32 %
EEZ_I_100	-51 %	-49 %	-28 %	-26 %	-45 %	-43 %
EEZ_II_100	-50 %	-50 %	-29 %	-25 %	-44 %	-44 %
EEZ_V_100	-44 %	-48 %	-11 %	-19 %	-35 %	-40 %
EEZ_III_108	-56 %	-56 %	-2 %	-14 %	-36 %	-41 %
EEZ_V_108	-54 %	-56 %	-2 %	-23 %	-41 %	-47 %
EEZ_II_209	-49 %	-41 %	-11 %	-4 %	-34 %	-26 %
EEZ_III_209	-53 %	-48 %	-19 %	-17 %	-41 %	-37 %
EEZ_IV_209	-52 %	-49 %	-7 %	-16 %	-37 %	-37 %
EEZ_V_209	-55 %	-51 %	-11 %	-11 %	-44 %	-40 %
EEZ_I_213	-47 %	-49 %	-36 %	-34 %	-44 %	-45 %
EEZ_II_213	-42 %	-45 %	-7 %	-7 %	-32 %	-34 %
EEZ_III_213	-51 %	-51 %	-9 %	-14 %	-36 %	-38 %
EEZ_IV_213	-56 %	-52 %	-9 %	-18 %	-45 %	-43 %
EEZ_V_213	-44 %	-51 %	3 %	-19 %	-31 %	-42 %
EEZ_I_216	-46 %	-43 %	-18 %	-23 %	-40 %	-38 %
EEZ_II_216	-38 %	-40 %	-13 %	-19 %	-31 %	-34 %
EEZ_IV_273	-50 %	-45 %	-6 %	-15 %	-37 %	-35 %
EEZ_V_273	-58 %	-48 %	-16 %	-17 %	-49 %	-40 %

Table 18. Normalized deposition of oxidized nitrogen to *partial EEZs*. In the headers, only the numbers of the EEZs are given. For example, 'II_065' means the part of EEZ065 (Faeroe Exclusive Economic Zone) that falls within OSPAR Region II. Unit: ktonnes(N)/year. The table continues on the next page.

	I_065	**II_065**	**V_065**	**I_071**	**V_071**	**IV_091**	**V_091**	**I_100**	**II_100**	**V_100**	**III_108**	**V_108**
1995	26	1.9	6.5	46	11	26	14	0.7	0.0	0.7	33	35
1996	25	1.9	6.4	46	11	26	14	0.7	0.0	0.7	32	35
1997	24	1.8	6.2	44	10	26	14	0.6	0.0	0.7	31	34
1998	24	1.8	6.1	44	10	26	14	0.6	0.0	0.7	31	34
1999	23	1.7	5.9	43	10	27	15	0.6	0.0	0.7	31	33
2000	23	1.7	5.9	43	10	28	15	0.6	0.0	0.7	31	33
2001	23	1.7	5.8	42	10	27	15	0.6	0.0	0.7	30	33
2002	22	1.6	5.6	41	10	27	15	0.6	0.0	0.6	29	32
2003	22	1.6	5.5	40	10	27	15	0.6	0.0	0.6	29	31
2004	21	1.6	5.4	40	10	26	14	0.6	0.0	0.6	28	31
2005	21	1.5	5.4	39	10	26	14	0.6	0.0	0.6	28	30
2006	21	1.5	5.3	39	9.4	25	14	0.5	0.0	0.6	27	30
2007	20	1.5	5.1	38	9.2	25	14	0.5	0.0	0.6	27	29
2008	19	1.4	4.8	36	8.8	23	13	0.5	0.0	0.5	25	27
2009	17	1.3	4.4	34	8.4	21	12	0.4	0.0	0.5	22	25
2010	17	1.3	4.4	34	8.4	22	12	0.4	0.0	0.5	22	25
2011	17	1.2	4.2	33	8.1	21	12	0.4	0.0	0.5	22	25
2012	17	1.2	4.2	33	8.1	20	11	0.4	0.0	0.5	21	24
2013	16	1.2	4.1	32	7.9	20	11	0.4	0.0	0.5	21	24
2014	15	1.1	3.9	31	7.7	18	10	0.4	0.0	0.4	20	23
2015	15	1.1	3.9	31	7.7	19	11	0.4	0.0	0.4	20	23
2016	15	1.0	3.8	30	7.5	19	10	0.4	0.0	0.4	19	22
2017	14	1.0	3.7	29	7.4	19	10	0.4	0.0	0.4	19	22
2018	14	1.0	3.6	29	7.3	18	10	0.4	0.0	0.4	18	21
2019	14	1.0	3.6	29	7.3	19	11	0.4	0.0	0.4	18	21

Table 18. Continued.

	II_209	III_209	IV_209	V_209	I_213	II_213	III_213	IV_213	V_213	I_216	II_216	IV_273	V_273
1995	19	14	53	0.5	5.7	185	66	0.4	21	87	103	54	11
1996	19	14	52	0.5	5.6	182	65	0.4	21	87	102	54	10
1997	18	14	51	0.5	5.4	174	63	0.4	20	85	98	53	10
1998	18	14	51	0.5	5.3	170	62	0.4	20	84	96	53	10
1999	18	14	51	0.5	5.2	166	61	0.4	20	83	94	54	10
2000	18	14	52	0.5	5.2	164	60	0.4	20	82	93	55	11
2001	18	14	51	0.5	5.1	161	59	0.4	19	81	91	54	10
2002	17	13	50	0.5	4.9	155	57	0.4	19	79	88	54	10
2003	17	13	49	0.5	4.8	152	56	0.4	18	78	87	53	10
2004	17	13	49	0.5	4.7	149	55	0.4	18	77	85	53	10
2005	16	13	48	0.5	4.7	147	55	0.4	18	76	84	52	10
2006	16	12	46	0.5	4.6	143	53	0.4	17	75	82	50	10
2007	15	12	45	0.5	4.5	139	52	0.4	17	73	80	49	10
2008	14	11	41	0.4	4.2	128	48	0.3	16	69	75	45	8.8
2009	13	10	38	0.4	3.8	116	43	0.3	15	65	69	41	8.2
2010	13	10	38	0.4	3.9	117	43	0.3	15	66	69	41	8.3
2011	13	10	37	0.4	3.7	111	41	0.3	14	64	66	40	8.1
2012	12	10	37	0.4	3.7	111	41	0.3	14	63	66	39	8.0
2013	12	10	35	0.4	3.6	107	40	0.3	14	62	64	38	7.7
2014	11	8.9	33	0.3	3.4	101	38	0.3	13	59	60	36	7.3
2015	11	8.9	33	0.3	3.4	99	38	0.3	13	58	59	36	7.4
2016	11	8.7	32	0.3	3.2	95	36	0.3	12	56	57	35	7.2
2017	10	8.5	32	0.3	3.1	92	35	0.3	12	55	55	35	7.1
2018	10	8.3	31	0.3	3.1	90	35	0.3	12	54	54	34	7.0
2019	10	8.6	31	0.3	3.1	91	35	0.3	12	54	54	34	7.2

Table 19. As Table 18, but for reduced nitrogen. The table continues on the next page.

	I_065	**II_065**	**V_065**	**I_071**	**V_071**	**IV_091**	**V_091**	**I_100**	**II_100**	**V_100**	**III_108**	**V_108**
1995	8.6	0.6	2.3	19	5.0	9	5.0	0.2	0.0	0.3	21	15
1996	8.7	0.6	2.4	19	5.1	10	5.3	0.2	0.0	0.3	22	16
1997	8.7	0.6	2.4	19	5.1	10	5.3	0.2	0.0	0.3	22	16
1998	8.7	0.6	2.4	19	5.1	10	5.3	0.2	0.0	0.3	22	16
1999	8.6	0.6	2.4	19	5.0	10	5.4	0.2	0.0	0.3	22	16
2000	8.3	0.6	2.3	18	4.9	10	5.3	0.2	0.0	0.3	22	15
2001	8.2	0.6	2.3	18	4.8	10	5.3	0.2	0.0	0.3	21	15
2002	8.0	0.6	2.2	18	4.7	9.5	5.2	0.2	0.0	0.2	21	15
2003	7.9	0.6	2.2	17	4.7	9.2	5.1	0.2	0.0	0.2	21	15
2004	7.8	0.6	2.2	17	4.6	9.2	5.1	0.2	0.0	0.2	21	14
2005	7.8	0.6	2.2	17	4.6	8.9	4.9	0.2	0.0	0.2	21	14
2006	7.7	0.6	2.1	17	4.6	8.7	4.9	0.2	0.0	0.2	21	14
2007	7.7	0.6	2.1	17	4.5	8.9	4.9	0.2	0.0	0.2	20	14
2008	7.5	0.6	2.1	17	4.4	8.4	4.7	0.2	0.0	0.2	20	14
2009	7.4	0.5	2.1	17	4.4	8.2	4.6	0.2	0.0	0.2	20	14
2010	7.4	0.6	2.1	17	4.4	8.2	4.6	0.2	0.0	0.2	20	14
2011	7.3	0.5	2.0	16	4.4	8.1	4.5	0.2	0.0	0.2	19	14
2012	7.4	0.5	2.0	16	4.4	7.9	4.5	0.2	0.0	0.2	20	14
2013	7.3	0.5	2.0	16	4.4	7.9	4.5	0.2	0.0	0.2	20	14
2014	7.5	0.6	2.1	17	4.4	8.2	4.6	0.2	0.0	0.2	20	14
2015	7.6	0.6	2.1	17	4.5	8.3	4.7	0.2	0.0	0.2	21	14
2016	7.6	0.6	2.1	17	4.5	8.4	4.7	0.2	0.0	0.2	21	14
2017	7.6	0.6	2.1	17	4.5	8.6	4.8	0.2	0.0	0.2	21	14
2018	7.6	0.6	2.1	17	4.5	8.5	4.8	0.2	0.0	0.2	22	14
2019	7.4	0.5	2.1	16	4.4	8.5	4.7	0.2	0.0	0.2	21	14

Table 19. Continued.

	II_209	III_209	IV_209	V_209	I_213	II_213	III_213	IV_213	V_213	I_216	II_216	IV_273	V_273
1995	13	8.0	31	0.2	1.7	79	38	0.2	8.6	27	40	28	4.5
1996	14	8.1	32	0.2	1.8	80	39	0.2	8.8	27	40	29	4.6
1997	14	8.1	32	0.2	1.8	80	39	0.2	8.9	27	40	29	4.6
1998	14	8.1	32	0.2	1.8	80	39	0.2	8.9	27	40	29	4.6
1999	14	8.1	32	0.2	1.7	79	39	0.2	8.8	26	39	30	4.7
2000	13	8.2	32	0.2	1.7	76	38	0.2	8.5	25	37	29	4.6
2001	13	8.1	32	0.2	1.6	75	37	0.2	8.4	25	37	29	4.6
2002	13	7.9	31	0.2	1.6	73	37	0.2	8.3	25	36	29	4.5
2003	13	7.8	31	0.2	1.6	72	37	0.2	8.2	25	36	29	4.4
2004	13	7.7	31	0.2	1.6	71	36	0.2	8.1	24	36	28	4.4
2005	12	7.6	30	0.2	1.6	71	36	0.2	8.1	24	35	27	4.3
2006	12	7.5	30	0.2	1.6	70	36	0.2	8.0	24	35	27	4.2
2007	12	7.6	30	0.2	1.5	69	35	0.2	7.9	24	35	27	4.3
2008	12	7.5	29	0.2	1.5	67	34	0.2	7.7	24	34	26	4.1
2009	12	7.4	29	0.2	1.5	67	34	0.2	7.7	23	34	26	4.1
2010	12	7.4	29	0.2	1.5	67	34	0.2	7.7	23	34	26	4.1
2011	12	7.3	29	0.2	1.5	66	34	0.2	7.6	23	33	25	4.0
2012	12	7.3	29	0.2	1.5	66	34	0.2	7.7	23	33	25	4.0
2013	12	7.3	29	0.2	1.5	66	34	0.2	7.6	23	33	25	4.0
2014	12	7.4	29	0.2	1.5	68	34	0.2	7.7	23	34	26	4.1
2015	12	7.5	29	0.2	1.5	68	35	0.2	7.9	24	34	26	4.2
2016	12	7.5	30	0.2	1.5	69	36	0.2	8.0	24	34	26	4.2
2017	12	7.5	30	0.2	1.5	69	36	0.2	8.0	24	34	27	4.2
2018	12	7.5	30	0.2	1.5	68	36	0.2	8.1	24	34	27	4.2
2019	12	7.3	29	0.2	1.5	67	35	0.2	7.8	23	33	26	4.1

5.4 Depositions to COMP4 Assessment Units

For the first time this year, airborne nitrogen depositions were calculated for the COMP4 Assessment Units. Some of these areas are very small and/or have a rather thin and elongated shape, so that they are poorly resolved by the EMEP model grid.

A detailed uncertainty analysis was beyond the scope of this contract, but as a rule of thumb, areas should extend over at least 3 model grid cells (both in east-west and in south-east direction) to give numerically stable results in source-receptor calculations. Since source-receptor calculations are used to calculate transfer coefficients, and transfer coefficients are needed for our normalization procedure, the resolution of our source-receptor calculations (i.e. 0.3°lon x 0.2°lat) is a limiting factor. A 3x3 array of grid cells (fulfilling the above-mentioned criterion for numerical stability) in this resolution has sizes between about 1000 and 6000 km^2, depending on the latitude within the OSPAR Maritime Area. However, since many of the COMP4 Assessment Units also have a very thin and elongated shape, we recommend that only the results for those Units larger than about 10 000 km^2 be considered as reasonably certain (this applies to the 24 Units shown in Figure 8).

In the case of actual (non-normalized) results the requirement is much less strict because they are based on our 0.1° x 0.1° trend simulations and do not make use of any transfer coefficients. Actual depositions for COMP4 Assessment Units as small as 1000 km^2, and even smaller (if they are not too thin and elongated), can be considered as reasonably certain. Statements about long-term trends and the relative differences between depositions to COMP Assessment Units are in any case more certain than the absolute numbers.

Independently of these uncertainty considerations, normalized and actual atmospheric nitrogen depositions have been computed in this contract for all the sixty-seven COMP4 Assessment Units (as defined in a table provided by OSPAR in May 2021), and for each year of the period 1990-2019. All results have been provided to OSPAR in a separate file in Excel format, together with this report (see Chapter 8).

Figure 13 shows *actual* total nitrogen deposition from 1995 to 2019 for COMP4 Assessment Units that are larger than 10 000 km^2, while Table 20 lists the percentage differences between 1995 and 2019, and between the two 5-year periods of 1995-1999 and 2015-2019 for actual depositions in all COMP4 Assessment Units. Due to the large inter-annual variability in meteorological conditions, differences between depositions in one year with respect to those in one reference year (1995 in this case) can change considerably from year to year. Therefore, 5-year averages are calculated to provide a more robust result for the changes since the 1990s.

In regard to actual depositions of *oxidized* nitrogen, there has been an increase from 1995 to 2019 in all 67 COMP4 Assessment Units. The largest decrease (58%) is modelled in NAAC1B ("Noratlantic Area NOR-NorC1(D5)B"), while the smallest decrease (15%) is found in SK ("Skagerak"). For *reduced* nitrogen, there are decreases in most COMP4 Assessment Units, but not in all. The largest *decrease* (56%) is modelled in NAAC1D ("Noratlantic Area NOR-NorC1(D5)D") and the largest *increase* (32%) in OWCO ("Ocean Waters CO (D5)"). However, it should be noted that NAAC1D is extremely small (only about 23 km^2), representing only a fraction of an EMEP MSC-W model grid cell. The numbers for this assessment area (and areas of similar size) should thus be considered as an indication only. Nevertheless, it is safe to say that (actual) oxidized nitrogen depositions have decreased in all COMP4 Assessment Units (and statistically significantly so), while for reduced nitrogen the trends are less significant, with depositions having both decreased and increased slightly, depending on the Area.

Figure 14 shows *normalized* total nitrogen deposition from 1995 to 2019 for COMP4 Assessment Units that are larger than 10 000 km^2. The normalization is based on meteorological data of 4 years (2016-2019).

Trends *in total* nitrogen deposition are decreasing in all COMP4 Assessment Units shown in Figure 8 and they are statistically significant at the 5% confidence level. Further analysis shows that oxidized nitrogen deposition has decreased significantly since the 1990s, while for reduced nitrogen the decreases are much smaller. For *oxidized* nitrogen, the largest decrease (55%) is in ECPM2 ("East Coast (permanently mixed) 2"), while the smallest decrease (20%) is modelled for SAAOC ("Sudatlantic Area SUD-OCEAN(D5)"). In the case of *reduced* nitrogen, the largest *decrease* (33%) is modelled for SCHPM1 ("Scheldt plume 1") while the largest *increase* (4%) is in SHPM ("Shannon plume"). Strictly speaking, SHPM is too small to be properly represented by the model grid used for the normalization procedure, so that the 4% number should only be taken as an indication. It is very likely that there is no significant trend in this Area.

Table 21 lists actual and normalized depositions in all 67 COMP4 Assessment Units for the year 2019, i.e. the most recent year for which model calculations have been made.

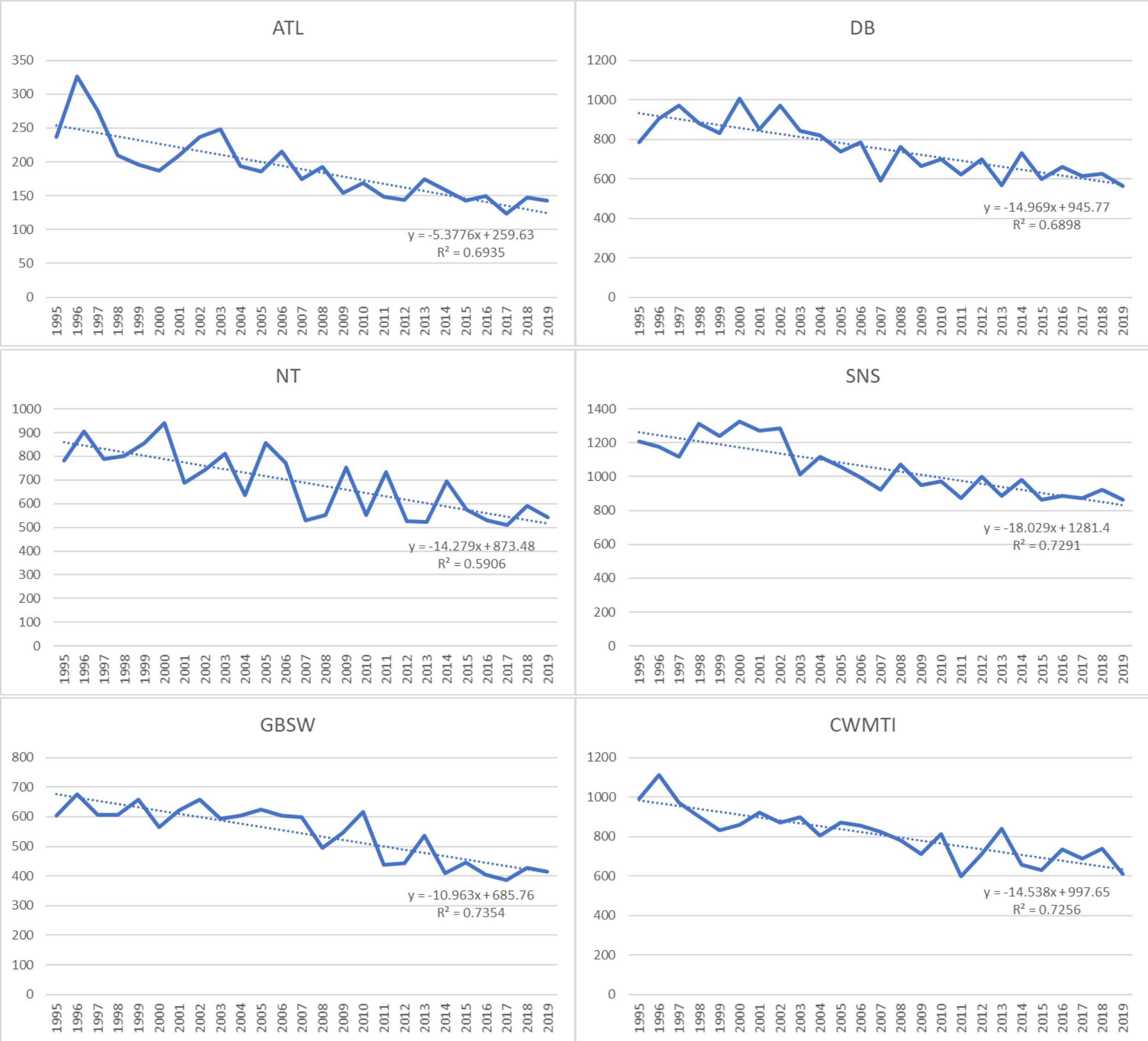


Figure 13: Time series of actual (non-normalized) depositions of total nitrogen to COMP4 Assessment Units larger than 10 000 km^2, as calculated by the EMEP MSC-W model for the period 1995-2019. Unit: mg(N)/m^2/year. Linear regression lines, with coefficients of determination (R^2), are indicated in the figure. (Figure continues on the next 3 pages.)

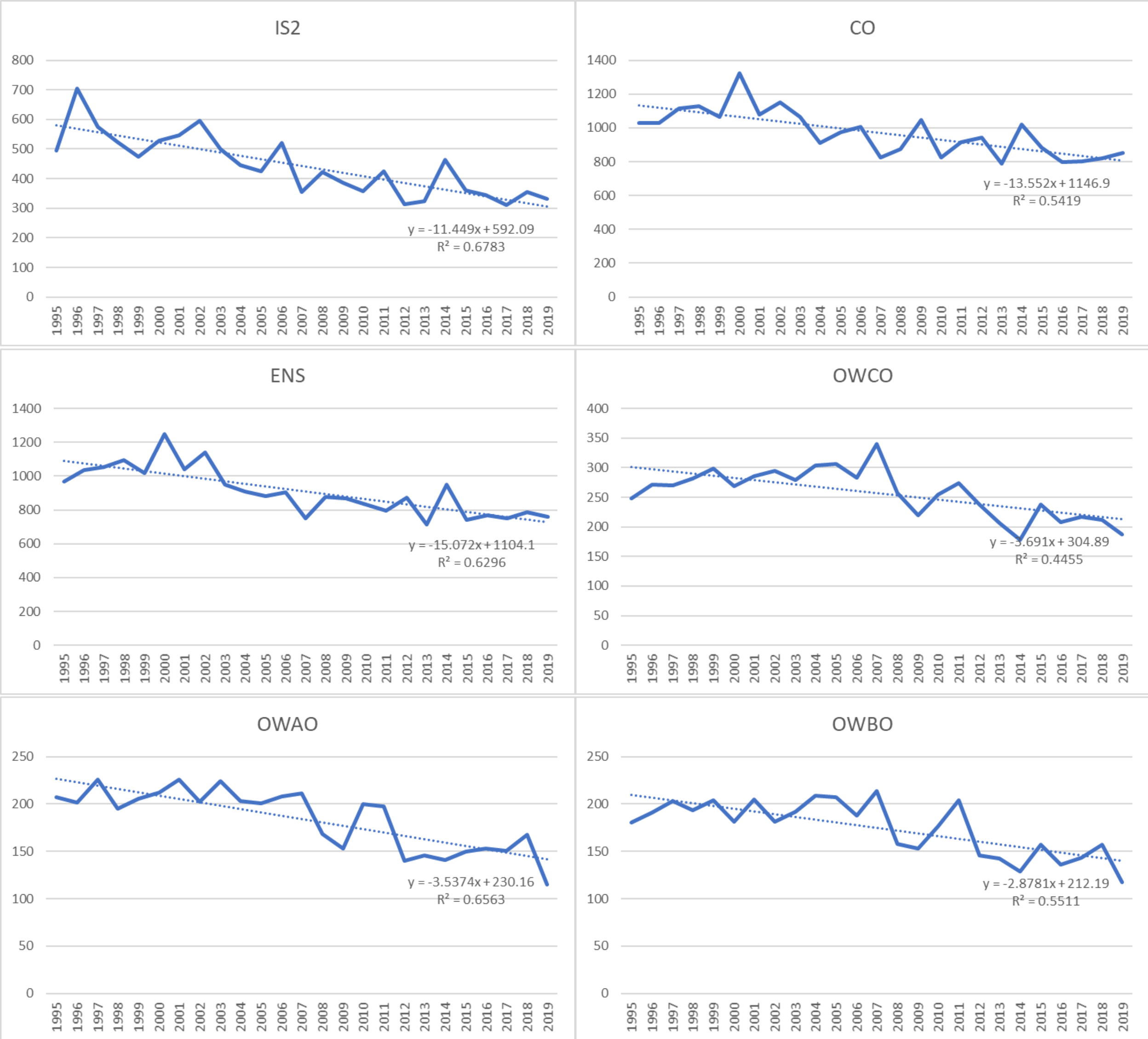


Figure 13: Continued.

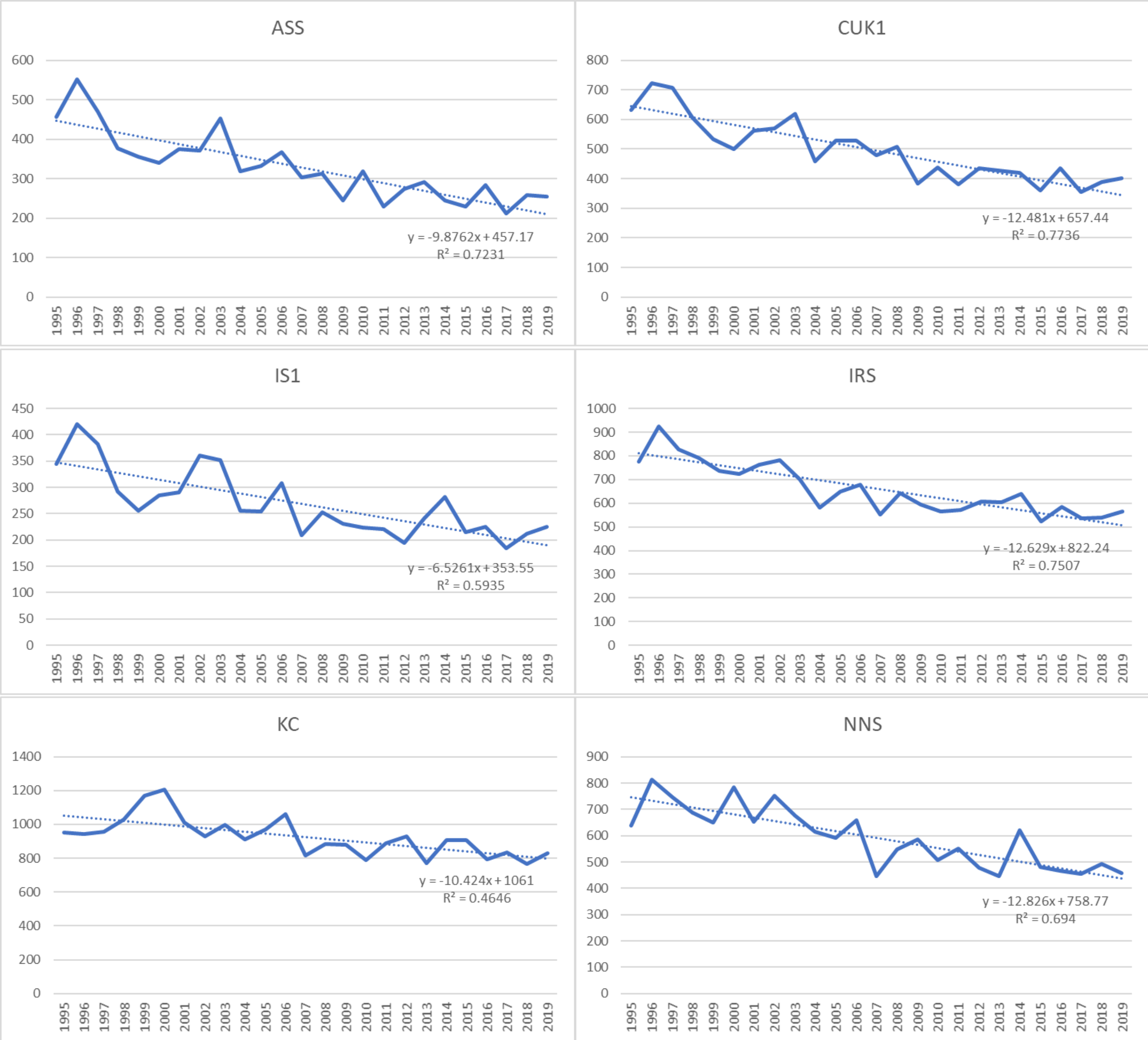


Figure 13: Continued.

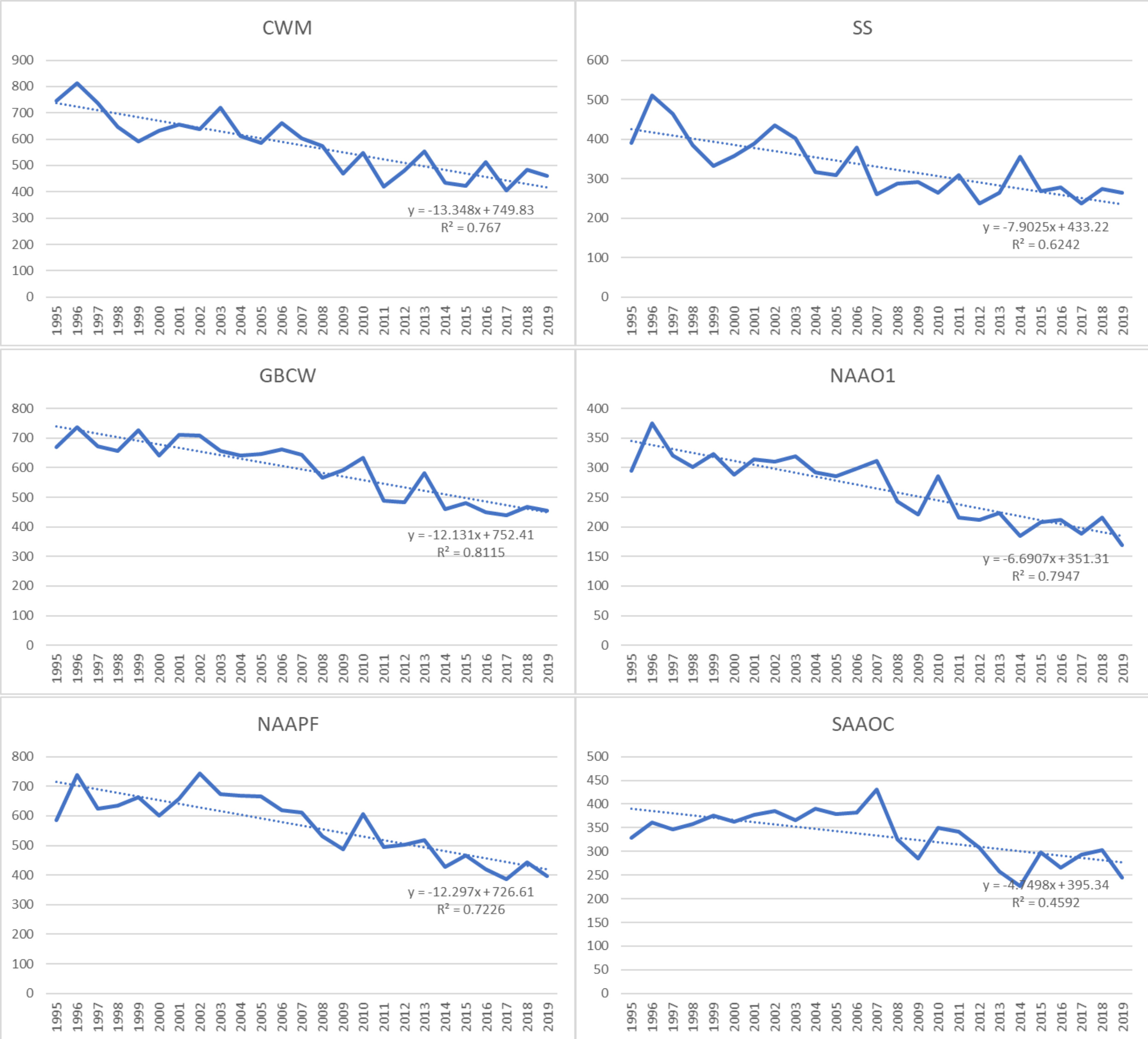


Figure 13: Continued.

Table 20. Percentage differences in 2019 compared to 1995 for oxidised, reduced and total nitrogen, in the sixty-seven COMP4 Assessment Units listed in Table 8. Also shown are the percentage differences in the 5-year period 2015-2019 with respect to the 5-year period of 1995-1999. (Table continues on the next page.)

COMP4 Assessment Unit	Oxidised N		Reduced N		Total N	
	1995→2019	(1995-1999) →(2015-2019)	1995→2019	(1995-1999) →(2015-2019)	1995→2019	(1995-1999) →(2015-2019)
CFR	-50 %	-41 %	-7 %	0 %	-33 %	-23 %
CCTI	-41 %	-40 %	-2 %	1 %	-27 %	-25 %
ATL	-50 %	-52 %	-10 %	-21 %	-40 %	-43 %
SHPM	-52 %	-55 %	22 %	-3 %	-21 %	-33 %
CNOR1	-43 %	-39 %	-29 %	-19 %	-40 %	-34 %
CNOR2	-46 %	-41 %	-31 %	-29 %	-41 %	-37 %
CNOR3	-23 %	-36 %	1 %	-13 %	-15 %	-27 %
DB	-40 %	-42 %	4 %	0 %	-28 %	-30 %
KD	-22 %	-32 %	16 %	3 %	-8 %	-19 %
NT	-38 %	-40 %	-13 %	-20 %	-30 %	-33 %
SNS	-40 %	-41 %	-6 %	0 %	-28 %	-27 %
GBC	-34 %	-33 %	2 %	2 %	-20 %	-20 %
ADPM	-51 %	-46 %	-18 %	-16 %	-36 %	-32 %
GBSW	-50 %	-49 %	-1 %	-10 %	-31 %	-34 %
SPM	-52 %	-41 %	-11 %	-1 %	-34 %	-23 %
GDPM	-53 %	-51 %	0 %	-7 %	-31 %	-33 %
CUKC	-50 %	-45 %	-20 %	-8 %	-39 %	-32 %
CWMTI	-50 %	-42 %	-18 %	-6 %	-39 %	-29 %
SCHPM1	-42 %	-39 %	-21 %	-22 %	-32 %	-31 %
ELPM	-33 %	-34 %	1 %	0 %	-20 %	-20 %
SCHPM2	-41 %	-38 %	-15 %	-14 %	-31 %	-28 %
MPM	-43 %	-39 %	-15 %	-14 %	-32 %	-29 %
RHPM	-41 %	-40 %	-11 %	-11 %	-29 %	-28 %
EMPM	-40 %	-35 %	0 %	1 %	-22 %	-19 %
THPM	-42 %	-43 %	-2 %	9 %	-28 %	-25 %
HPM	-46 %	-47 %	16 %	24 %	-25 %	-23 %
ECPM1	-45 %	-50 %	-16 %	-17 %	-36 %	-39 %
ECPM2	-39 %	-48 %	12 %	-2 %	-21 %	-31 %
IS2	-41 %	-47 %	-12 %	-17 %	-33 %	-39 %
CO	-29 %	-34 %	2 %	-3 %	-17 %	-22 %
ENS	-33 %	-38 %	5 %	-2 %	-21 %	-26 %
CWCC	-52 %	-37 %	3 %	8 %	-42 %	-27 %

Table 20. Continued.

COMP4 Assessment Unit	Oxidised N		Reduced N		Total N	
	1995→2019	(1995-1999) →(2015-2019)	1995→2019	(1995-1999) →(2015-2019)	1995→2019	(1995-1999) →(2015-2019)
OWCO	-33 %	-29 %	32 %	15 %	-24 %	-22 %
OWAO	-52 %	-38 %	-18 %	2 %	-44 %	-29 %
IWCI	-53 %	-38 %	9 %	10 %	-41 %	-27 %
OWBO	-43 %	-34 %	0 %	2 %	-35 %	-27 %
ASS	-57 %	-54 %	-17 %	-22 %	-44 %	-44 %
CIRL	-48 %	-52 %	5 %	-3 %	-26 %	-32 %
CUK1	-51 %	-51 %	-11 %	-18 %	-36 %	-39 %
IS1	-48 %	-49 %	-5 %	-11 %	-35 %	-37 %
IRS	-48 %	-50 %	5 %	-6 %	-27 %	-32 %
KC	-25 %	-32 %	6 %	2 %	-13 %	-18 %
NNS	-38 %	-43 %	-3 %	-12 %	-28 %	-34 %
CWM	-51 %	-46 %	-15 %	-15 %	-38 %	-35 %
LBPM	-42 %	-47 %	6 %	-11 %	-22 %	-32 %
SK	-15 %	-34 %	23 %	-4 %	-2 %	-24 %
SS	-43 %	-48 %	-9 %	-13 %	-33 %	-37 %
CWBC	-40 %	-34 %	9 %	1 %	-27 %	-24 %
IWBI	-43 %	-34 %	-6 %	2 %	-35 %	-26 %
CWAC	-41 %	-34 %	-23 %	-15 %	-34 %	-26 %
IWAI	-46 %	-37 %	-17 %	-8 %	-37 %	-27 %
LPM	-55 %	-53 %	-14 %	-16 %	-38 %	-37 %
GBCW	-51 %	-50 %	-4 %	-11 %	-32 %	-34 %
NAAP2	-49 %	-44 %	-7 %	-13 %	-32 %	-31 %
NAAO1	-54 %	-47 %	-9 %	-17 %	-43 %	-39 %
NAAPF	-47 %	-45 %	-6 %	-17 %	-32 %	-35 %
NAAC3	-48 %	-43 %	-2 %	-7 %	-28 %	-26 %
NAAC2	-47 %	-42 %	-6 %	-10 %	-28 %	-26 %
NAAC1A	-50 %	-40 %	0 %	6 %	-28 %	-19 %
NAAC1B	-58 %	-50 %	-27 %	-29 %	-43 %	-39 %
NAAC1C	-49 %	-39 %	-52 %	-56 %	-51 %	-49 %
NAAC1D	-43 %	-43 %	-56 %	-59 %	-51 %	-53 %
SAAP2	-44 %	-38 %	20 %	7 %	-31 %	-27 %
SAAOC	-33 %	-27 %	17 %	10 %	-26 %	-21 %
SAAP1	-41 %	-34 %	18 %	7 %	-31 %	-26 %
SAAC1	-49 %	-42 %	24 %	12 %	-32 %	-28 %
SAAC2	-46 %	-38 %	17 %	6 %	-31 %	-25 %

Table 21. Deposition of oxidised, reduced and total nitrogen, to the sixty-seven COMP4 Assessment Units in 2019. Both actual numbers (based on 2019 meteorology) and weather-normalized values (based on meteorological data of 2016, 2017, 2018 and 2019) are given. Results for other years are provided separately in Excel format (see Chapter 8). Unit: tonnes(N)/year. (Table continues on the next page.)

COMP4 Assessment Unit	Oxidised N		Reduced N		Total N	
	Actual	Normalized	Actual	Normalized	Actual	Normalized
CFR	2 767	3 106	3 441	3 904	6 208	7 010
CCTI	2 311	2 358	2 064	2 343	4 374	4 701
ATL	80 685	79 431	52 256	49 881	132 941	129 312
SHPM	48	44	88	72	137	117
CNOR1	2 170	2 251	933	1 076	3 103	3 326
CNOR2	1 138	1 127	693	682	1 831	1 809
CNOR3	1 001	885	740	686	1 740	1 571
DB	5 183	5 411	3 340	3 694	8 524	9 105
KD	2 348	2 099	1 979	1 876	4 327	3 975
NT	20 443	19 790	12 068	12 131	32 512	31 921
SNS	29 142	28 407	24 970	25 993	54 112	54 400
GBC	2 485	2 411	2 359	2 297	4 844	4 707
ADPM	93	99	122	137	215	236
GBSW	4 093	3 960	4 888	4 712	8 981	8 672
SPM	423	487	602	694	1 025	1 181
GDPM	577	565	843	803	1 420	1 368
CUKC	2 179	2 351	1 948	2 287	4 127	4 637
CWMTI	6 877	7 508	5 948	6 923	12 825	14 431
SCHPM1	388	399	473	490	861	889
ELPM	4 068	3 898	4 143	4 034	8 212	7 932
SCHPM2	72	73	69	72	141	145
MPM	144	146	141	144	284	290
RHPM	1 522	1 528	1 581	1 590	3 102	3 118
EMPM	813	845	1 113	1 088	1 925	1 933
THPM	2 665	2 579	2 376	2 592	5 041	5 170
HPM	558	554	611	665	1 168	1 220
ECPM1	902	861	645	713	1 547	1 574
ECPM2	580	547	604	610	1 184	1 158
IS2	5 699	5 396	3 308	3 597	9 007	8 993
CO	8 818	8 169	7 351	7 089	16 169	15 258
ENS	27 237	26 289	19 232	19 583	46 469	45 873
CWCC	112	143	60	71	172	213

Table 21. Continued

COMP4 Assessment Unit	Oxidised N		Reduced N		Total N	
	Actual	Normalized	Actual	Normalized	Actual	Normalized
OWCO	2 720	3 097	866	936	3 586	4 034
OWAO	7 609	9 759	3 706	4 781	11 314	14 540
IWCI	173	219	97	115	270	334
OWBO	15 523	18 920	5 912	6 798	21 436	25 718
ASS	29 227	30 155	26 465	24 457	55 692	54 612
CIRL	2 293	2 153	3 248	3 187	5 540	5 340
CUK1	2 232	2 220	2 242	2 151	4 474	4 370
IS1	9 346	8 712	7 494	6 819	16 840	15 531
IRS	8 094	7 850	10 731	10 368	18 825	18 218
KC	4 352	4 024	4 033	3 964	8 385	7 988
NNS	75 900	74 007	45 183	47 521	121 083	121 528
CWM	10 271	10 632	9 305	9 120	19 576	19 752
LBPM	500	487	654	627	1 153	1 114
SK	2 636	2 199	1 971	1 695	4 606	3 894
SS	8 330	7 967	6 160	6 256	14 490	14 222
CWBC	687	762	459	445	1 146	1 207
IWBI	292	342	138	156	430	498
CWAC	509	560	414	479	923	1 038
IWAI	978	1 101	763	885	1 740	1 986
LPM	279	278	381	385	660	664
GBCW	2 233	2 188	3 007	2 925	5 240	5 113
NAAP2	2 172	2 421	2 602	2 791	4 774	5 213
NAAO1	26 597	31 100	17 781	20 248	44 378	51 349
NAAPF	7 891	8 299	7 584	7 592	15 475	15 891
NAAC3	936	1 029	1 319	1 420	2 255	2 449
NAAC2	893	969	1 426	1 520	2 319	2 489
NAAC1A	256	278	397	432	653	709
NAAC1B	46	50	74	76	120	127
NAAC1C	25	28	27	29	52	57
NAAC1D	12	12	13	13	25	25
SAAP2	244	280	137	152	381	432
SAAOC	1 965	2 282	586	678	2 551	2 960
SAAP1	550	650	244	279	794	928
SAAC1	118	136	83	93	201	229
SAAC2	80	93	58	65	138	157

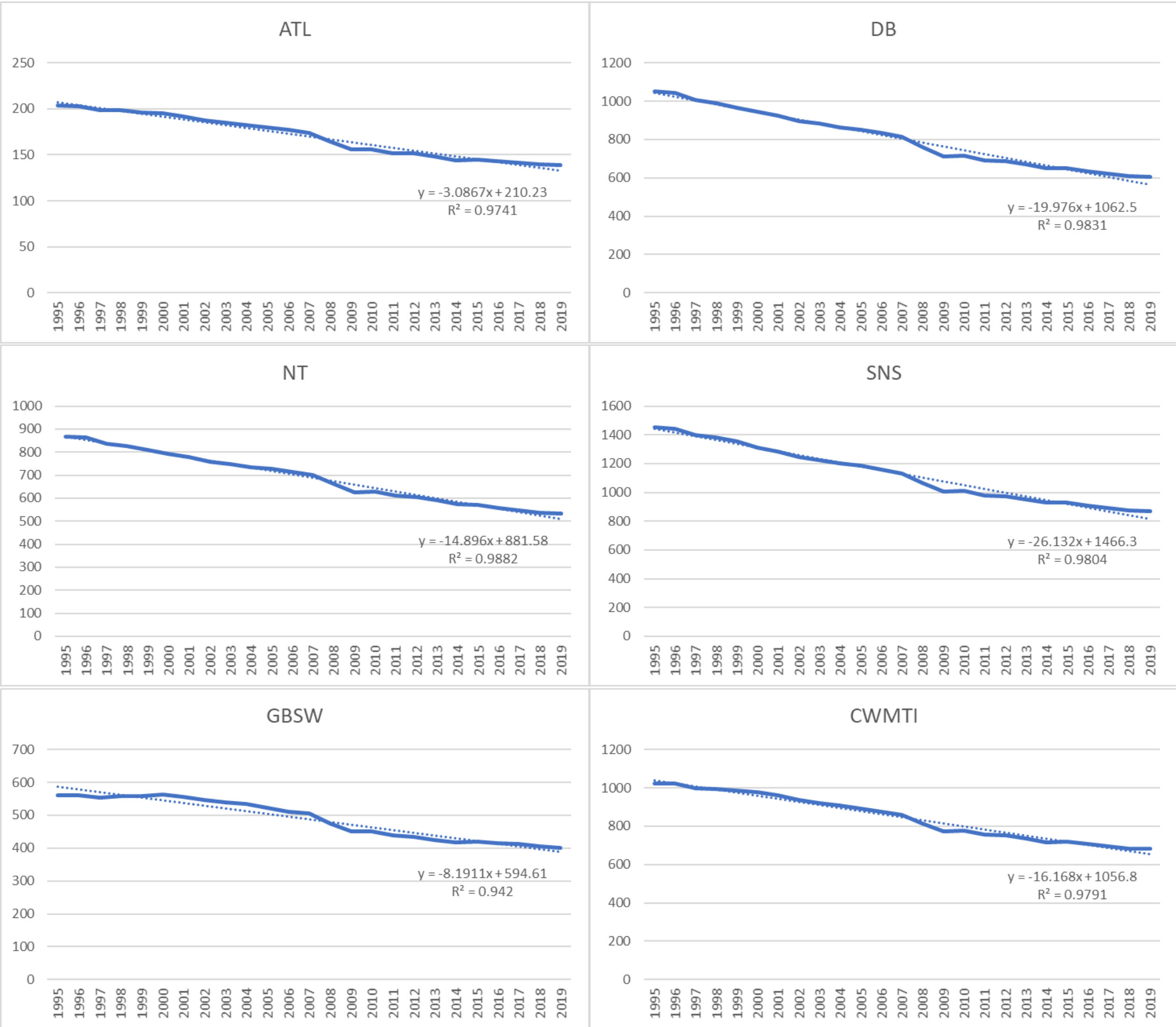


Figure 14: Time series of normalized depositions of total nitrogen to COMP4 Assessment Units larger than 10 000 km^2, as calculated by the EMEP MSC-W model for the period 1995-2019. Unit: mg(N)/m^2/year. Linear regression lines, with coefficients of determination (R^2), are indicated in the figure. (Figure continues on the next 3 pages.)

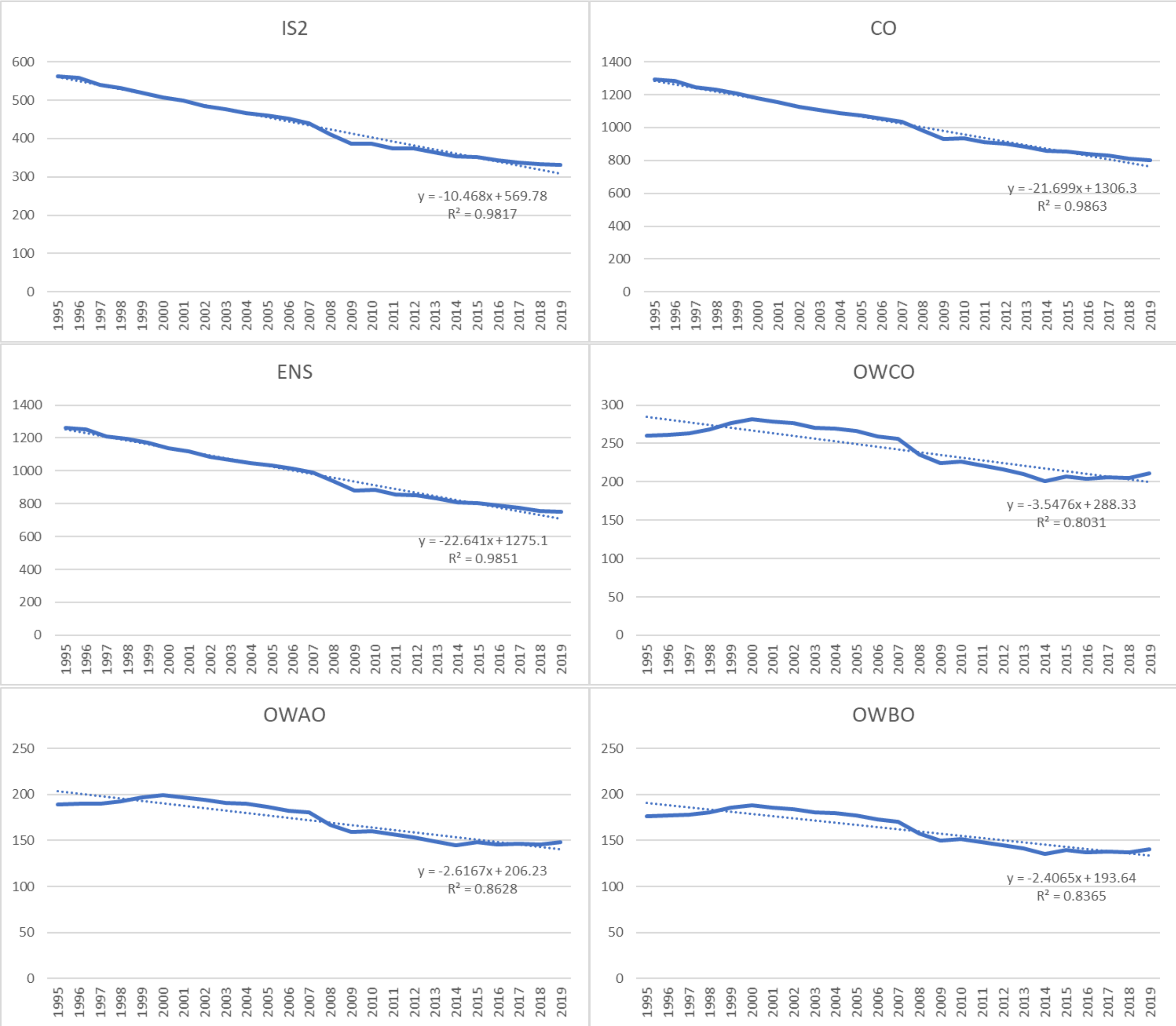


Figure 14: Continued.

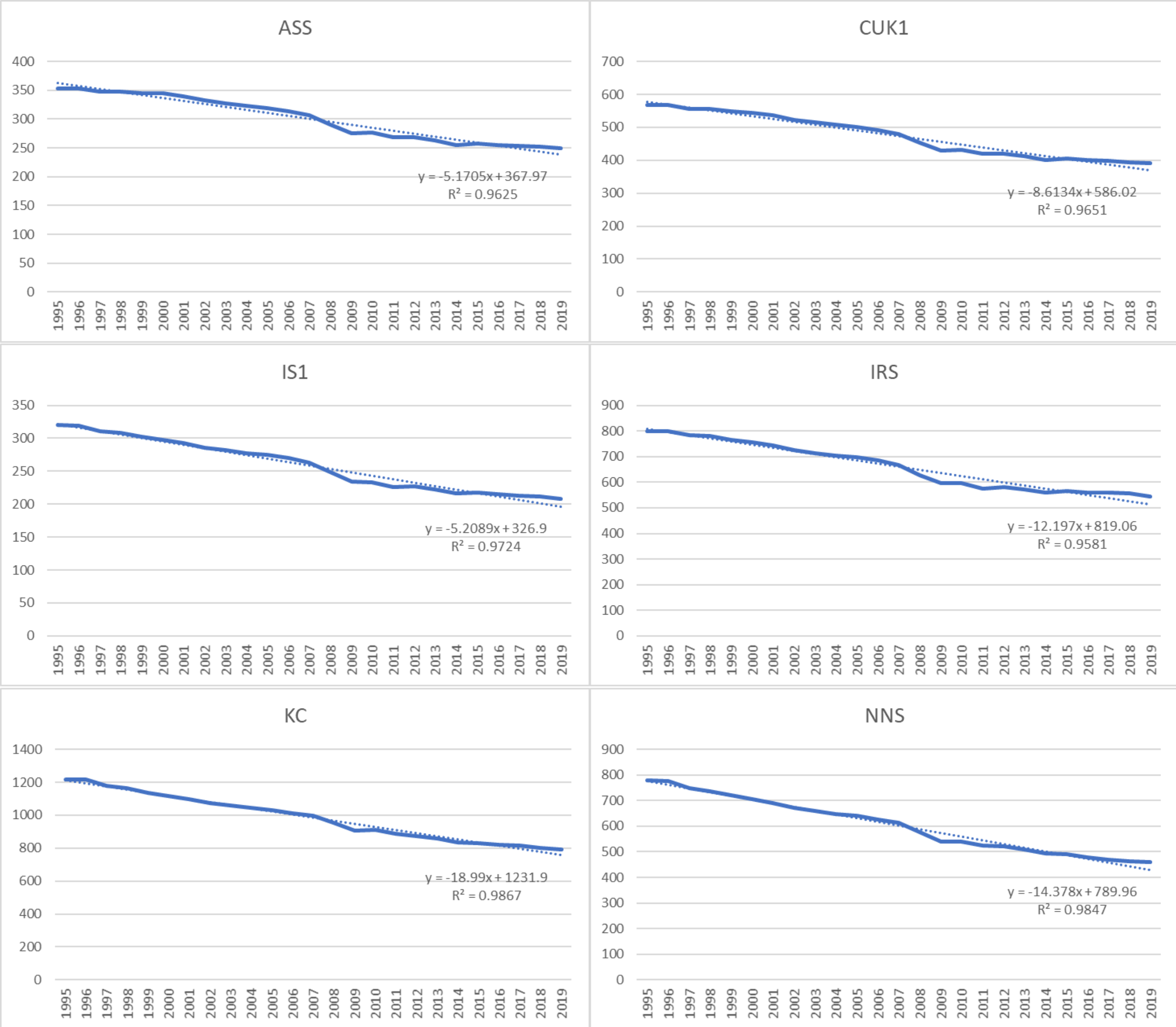


Figure 14: Continued.

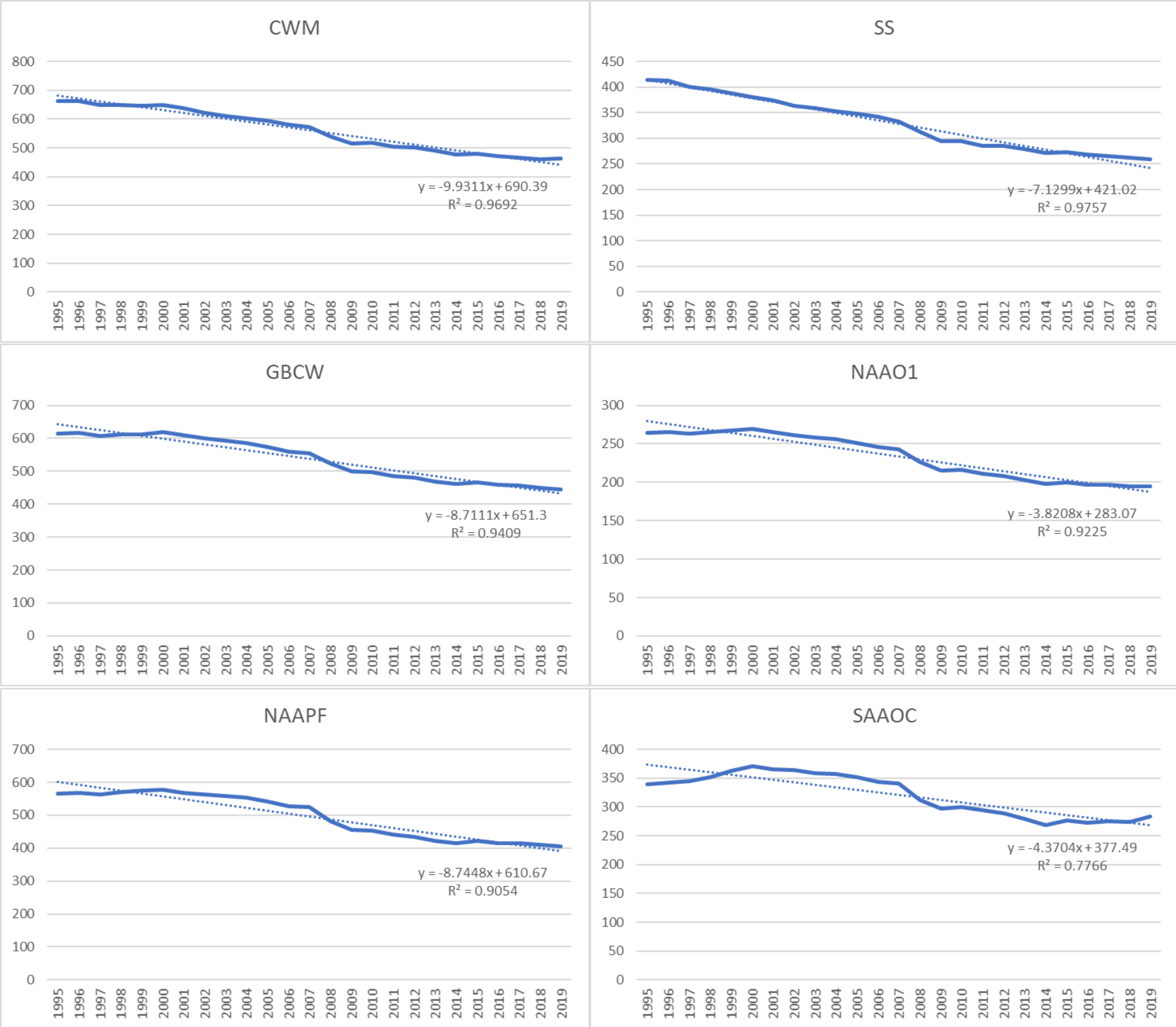


Figure 14: Continued.

6 Source apportionment by Contracting Parties

Source apportionment has been calculated for OSPAR Regions, EEZs and partial EEZs. For source apportionment, normalized results are considered more relevant than actual (non-normalized) depositions because they are less influenced by meteorological year-to-year variability and thus are a better measure for the influence of the various emitters (emitting countries or areas). The next two sections are thus based on *normalized* results for 2019. The accompanying data tables provide results also for earlier years (see Chapter 8).

6.1 Source apportionment to OSPAR Regions

Contributions from OSPAR Contracting Parties (and all other sources) to oxidized and reduced nitrogen deposition in OSPAR Regions have been provided to OSPAR in a separate file in ASCII format (see Chapter 8). Figure 15 summarizes the results by showing the Top-10 contributors to total normalized nitrogen deposition in each of the 5 OSPAR Regions. The normalization has been done with meteorological data for the years 2016 to 2019.

The two largest OSPAR Regions (I and V) receive the largest contributions from the boundary (abbreviated 'BIC' in EMEP MSC-W terminology, originally meaning 'Boundary and Initial Conditions'), while OSPAR Regions II, III and IV receive their largest contributions from the United Kingdom (II and III) and Spain (IV). Other important contributions are made by international shipping and other large countries such as Russia, Germany, and France. The Top-10 contributions typically make up around 90% of the total, except for Region I.

Table 22 lists the numbers Figure 15 is based upon, but also gives hints as to how much of the contributions is due to oxidized nitrogen and how much is reduced nitrogen. As far as international shipping contributions are concerned, they are entirely oxidized as ships do not emit reduced nitrogen in any significant amounts. The sum of total nitrogen deposition is usually dominated by (the longer-lived) oxidized nitrogen species, but individual contributions *can* be dominated by (the shorter-lived) reduced nitrogen, especially if the emitting country has large emissions of agriculture and/or is close to the receptor region.

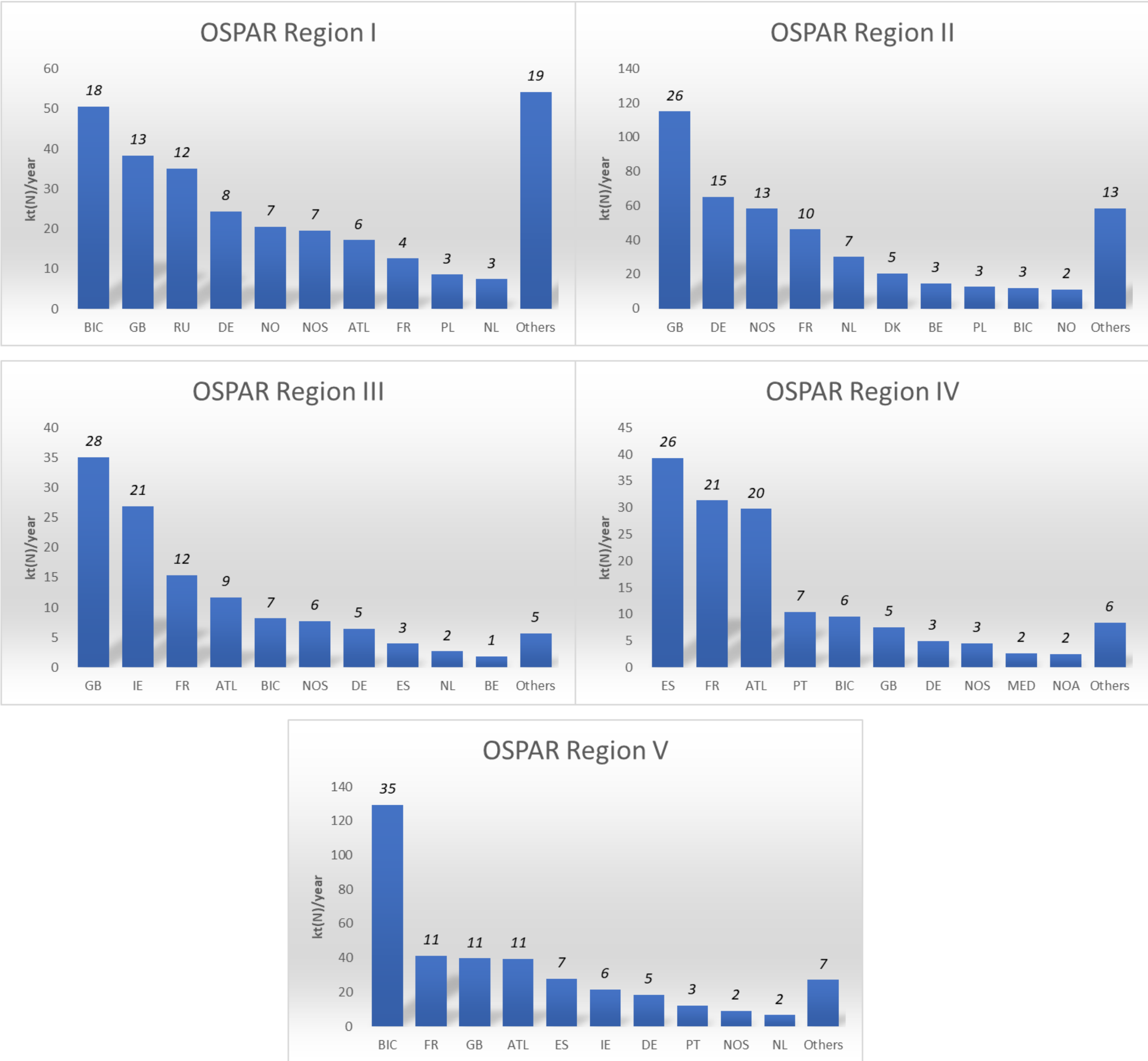


Figure 15. Top-10 contributors to normalized total nitrogen depositions in the 5 OSPAR Regions. Unit: ktonnes(N)/year. The numbers on top of each bar indicate the percentage of the total deposition to the respective Region. All numbers are based on 2019 emissions and 2016-2019 average meteorology. For example, France contributes 41.4 ktonnes(N)/year to OSPAR Region V, corresponding to about 11% of the total nitrogen deposition to that Region. All numbers are listed in Table 22. ('BIC': Influence from sources outside the EMEP model domain, 'NOS': North Sea shipping, 'ATL': North Atlantic shipping except North Sea, 'Others': All contributions that are not among the Top-10.)

Table 22. Top-10 contributors to normalized total nitrogen depositions in the 5 OSPAR Regions. Unit: ktonnes(N)/year. The numbers on top of each bar indicate the percentage of the total deposition to the respective Region. All numbers are based on 2019 emissions and 2016-2019 average meteorology. ('BIC': Influence from sources outside the EMEP model domain, 'NOS': North Sea shipping, 'ATL': North Atlantic shipping except North Sea, 'Others': All contributions that are not among the Top-10.) (ox-N)% gives the percentage of oxidized nitrogen within the country's contribution, while (re-N)% gives the percentage of reduced nitrogen. For example, Norway is number 5 among the Top-10 contributors to total nitrogen deposition in OSPAR Region I, with a contribution of 20.6 ktonnes(N)/year, corresponding to about 7% of the total nitrogen deposition in that Region. 68% of Norway's contribution to OSPAR Region I is oxidized nitrogen, the rest (32%) is reduced nitrogen.

Region I	1	2	3	4	5	6	7	8	9	10		
Source	BIC	GB	RU	DE	NO	NOS	ATL	FR	PL	NL	Others	Sum
kt(N)/yr	50.6	38.4	35.0	24.4	20.6	19.5	17.1	12.6	8.5	7.4	54.2	288.2
%	18	13	12	8	7	7	6	4	3	3	19	100
(ox-N)%	100	57	52	47	68	100	100	35	48	52	53	67
(re-N)%	0	43	48	53	32	0	0	65	52	48	47	33
Region II	1	2	3	4	5	6	7	8	9	10		
Source	GB	DE	NOS	FR	NL	DK	BE	PL	BIC	NO	Others	Sum
kt(N)/yr	115.0	65.0	58.3	46.2	30.1	20.3	14.5	12.6	11.8	11.1	58.3	443.3
%	26	15	13	10	7	5	3	3	3	2	13	100
(ox-N)%	55	40	100	32	39	27	45	55	100	63	62	56
(re-N)%	45	60	0	68	61	73	55	45	0	37	38	44
Region III	1	2	3	4	5	6	7	8	9	10		
Source	GB	IE	FR	ATL	BIC	NOS	DE	ES	NL	BE	Others	Sum
kt(N)/yr	35.0	26.9	15.4	11.7	8.2	7.7	6.4	4.0	2.7	1.8	5.7	125.4
%	28	21	12	9	7	6	5	3	2	1	5	100
(ox-N)%	43	19	25	100	100	100	47	38	52	54	59	49
(re-N)%	57	81	75	0	0	0	53	62	48	46	41	51
Region IV	1	2	3	4	5	6	7	8	9	10		
Source	ES	FR	ATL	PT	BIC	GB	DE	NOS	MED	NOA	Others	Sum
kt(N)/yr	39.3	31.3	29.7	10.4	9.6	7.5	5.0	4.6	2.7	2.5	8.4	150.9
%	26	21	20	7	6	5	3	3	2	2	6	100
(ox-N)%	36	24	100	48	100	62	52	100	100	62	48	57
(re-N)%	64	76	0	52	0	38	48	0	0	38	52	43
Region V	1	2	3	4	5	6	7	8	9	10		
Source	BIC	FR	GB	ATL	ES	IE	DE	PT	NOS	NL	Others	Sum
kt(N)/yr	129.4	41.4	39.7	39.3	27.7	21.7	18.6	12.3	8.9	6.6	27.2	372.7
%	35	11	11	11	7	6	5	3	2	2	7	100
(ox-N)%	100	18	38	100	25	18	32	27	100	35	40	63
(re-N)%	0	82	62	0	75	82	68	73	0	65	60	37

6.2 Source apportionment to EEZs and partial EEZs

Contributions from OSPAR Contracting Parties (and all other sources) to oxidized and reduced nitrogen deposition in EEZs and partial EEZs have been provided to OSPAR in a separate file in ASCII format (see Chapter 8). Figure 16 summarizes the results for a selection of large EEZs by showing the Top-10 contributors to total normalized nitrogen deposition. The normalization has been done with meteorological data for the years 2016 to 2019. Table 23 lists the numbers Figure 16 is based upon, but also includes all other EEZs. As far as international shipping contributions are concerned, they are entirely oxidized as ships do not emit reduced nitrogen in any significant amounts. The sum of total nitrogen deposition is usually dominated by (the longer-lived) oxidized nitrogen species, but individual contributions can be dominated by (the shorter-lived) reduced nitrogen, especially if the emitting country has large emissions of agriculture and/or is close to the receptor region.

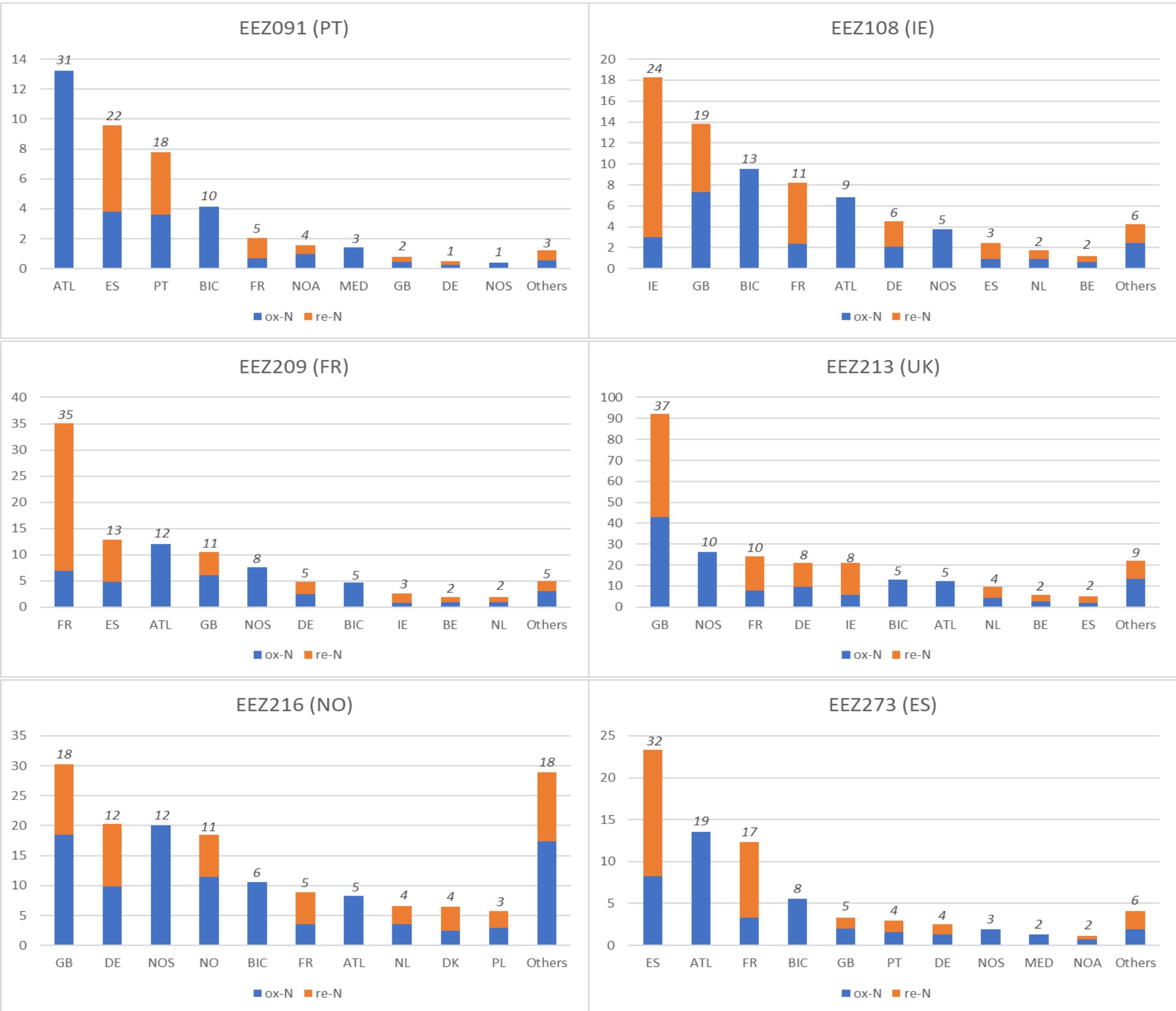


Figure 16. Top-10 contributors to normalized total nitrogen depositions in 6 of the 24 EEZs. Unit: ktonnes(N)/year. The numbers on top of each bar indicate the percentage of the total deposition to the respective Region. For example, Germany contributes 20.3 ktonnes(N)/year to EEZ216, corresponding to about 12% of the total nitrogen deposition to that EEZ. About half of this contribution is reduced nitrogen, and the other half oxidized. All numbers are based on 2019 emissions and 2016-2019 average meteorology. 'BIC': Influence from sources outside the EMEP model domain, 'NOS': North Sea shipping, 'ATL': North Atlantic shipping except North Sea, 'MED': Mediterranean shipping, 'Others': All contributions that are not among the Top-10. As reduced nitrogen emissions from shipping are considered negligible, their contributions are oxidized only (bars entirely blue). Numbers for all 24 EEZs are listed in Table 23.

Table 23. As Table 22, but for the 24 Exclusive Economic Zones.

EEZ048	1	2	3	4	5	6	7	8	9	10	
Source	BIC	PT	ATL	ES	FR	GB	DE	IE	NOA	NL	Others	Sum
kt(N)/yr	16.8	7.4	4.0	2.7	2.4	0.8	0.5	0.3	0.3	0.2	0.8	36.3
%	46	20	11	7	7	2	1	1	1	1	2	100
(ox-N)%	100	7	100	14	11	21	21	11	23	20	47	63
(re-N)%	0	93	0	86	89	79	79	89	77	80	53	37
EEZ065	1	2	3	4	5	6	7	8	9	10		
Source	GB	BIC	NOS	DE	IE	FR	ATL	NO	NL	PL	Others	Sum
kt(N)/yr	7.8	3.5	2.9	2.7	1.8	1.8	1.6	1.0	1.0	0.7	3.9	28.8
%	27	12	10	9	6	6	6	4	3	2	14	100
(ox-N)%	57	100	100	47	33	35	100	77	52	48	53	65
(re-N)%	43	0	0	53	67	65	0	23	48	52	47	35
EEZ071	1	2	3	4	5	6	7	8	9	10		
source	BIC	GB	DE	IS	FR	NOS	ATL	IE	NL	PL	Others	Sum
kt(N)/yr	13.7	10.1	5.1	4.5	4.1	3.2	3.0	2.8	1.7	1.2	7.3	56.8
%	24	18	9	8	7	6	5	5	3	2	13	100
(ox-N)%	100	49	40	48	29	100	100	29	46	40	49	63
(re-N)%	0	51	60	52	71	0	0	71	54	60	51	37
EEZ091	1	2	3	4	5	6	7	8	9	10		
source	ATL	ES	PT	BIC	FR	NOA	MED	GB	DE	NOS	Others	Sum
kt(N)/yr	13.2	9.6	7.8	4.2	2.1	1.6	1.4	0.8	0.5	0.4	1.2	42.7
%	31	22	18	10	5	4	3	2	1	1	3	100
(ox-N)%	100	40	47	100	32	62	100	57	48	100	46	69
(re-N)%	0	60	53	0	68	38	0	43	52	0	54	31
EEZ099	1	2	3	4	5	6	7	8	9	10		
source	ES	FR	ATL	GB	BIC	DE	NOS	PT	IE	BE	Others	Sum
kt(N)/yr	0.2	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.9
%	26	26	16	6	6	4	4	3	2	1	5	100
(ox-N)%	39	25	100	64	100	51	100	57	33	58	60	55
(re-N)%	61	75	0	36	0	49	0	43	67	42	40	45
EEZ100	1	2	3	4	5	6	7	8	9	10		
source	GB	BIC	IE	NOS	DE	FR	ATL	NL	NO	PL	Others	Sum
kt(N)/yr	0.4	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.1	1.2
%	32	12	9	9	8	6	6	3	2	2	11	100
(ox-N)%	57	100	33	100	46	36	100	51	78	52	52	64
(re-N)%	43	0	67	0	54	64	0	49	22	48	48	36
EEZ108	1	2	3	4	5	6	7	8	9	10		
source	IE	GB	BIC	FR	ATL	DE	NOS	ES	NL	BE	Others	Sum
kt(N)/yr	18.3	13.8	9.5	8.2	6.8	4.5	3.8	2.4	1.8	1.2	4.3	74.6
%	24	19	13	11	9	6	5	3	2	2	6	100
(ox-N)%	16	53	100	29	100	47	100	37	53	54	57	53
(re-N)%	84	47	0	71	0	53	0	63	47	46	43	47
EEZ109	1	2	3	4	5	6	7	8	9	10		
source	FR	GB	NOS	DE	ATL	ES	BIC	IE	NL	BE	Others	Sum
kt(N)/yr	1.1	0.7	0.6	0.3	0.3	0.2	0.1	0.1	0.1	0.1	0.2	3.8
%	30	19	16	7	7	5	4	3	3	2	5	100
(ox-N)%	20	52	100	52	100	37	100	30	50	49	62	54
(re-N)%	80	48	0	48	0	63	0	70	50	51	38	46

Table 23. Continued.

EEZ110	1	2	3	4	5	6	7	8	9	10		
Source	FR	GB	NOS	ATL	DE	ES	IE	BIC	NL	BE	Others	Sum
kt(N)/yr	0.6	0.2	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.1	1.4
%	44	14	12	6	5	5	3	3	2	2	4	100
(ox-N)%	15	58	100	100	54	39	30	100	52	48	63	46
(re-N)%	85	42	0	0	46	61	70	0	48	52	37	54
EEZ119	1	2	3	4	5	6	7	8	9	10		
Source	GB	BIC	NOS	DE	IE	FR	ATL	NL	NO	IS	Others	Sum
kt(N)/yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
%	26	15	9	9	7	7	6	3	3	2	13	100
(ox-N)%	58	100	100	45	33	33	100	50	75	67	53	66
(re-N)%	42	0	0	55	67	67	0	50	25	33	47	34
EEZ123	1	2	3	4	5	6	7	8	9	10		
Source	GB	BIC	DE	NOS	FR	NO	ATL	NL	IE	PL	Others	Sum
kt(N)/yr	0.5	0.5	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.5	2.5
%	19	18	10	8	6	5	5	4	4	3	18	100
(ox-N)%	55	100	48	100	36	74	100	52	32	49	54	67
(re-N)%	45	0	52	0	64	26	0	48	68	51	46	33
EEZ185	1	2	3	4	5	6	7	8	9	10		
Source	DE	DK	NOS	GB	SE	BAS	PL	NL	FR	NO	Others	Sum
kt(N)/yr	2.1	1.6	1.1	1.1	1.0	0.8	0.8	0.5	0.5	0.2	1.6	11.3
%	19	14	10	9	9	7	7	5	5	2	14	100
(ox-N)%	43	25	100	64	27	100	51	54	43	63	59	54
(re-N)%	57	75	0	36	73	0	49	46	57	37	41	46
EEZ187	1	2	3	4	5	6	7	8	9	10		
Source	DE	NOS	DK	GB	PL	SE	BAS	FR	NO	NL	Others	Sum
kt(N)/yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
%	19	11	10	8	7	7	6	5	5	5	16	100
(ox-N)%	45	100	30	67	50	38	100	40	60	60	59	57
(re-N)%	55	0	70	33	50	63	0	60	40	40	41	43
EEZ188	1	2	3	4	5	6	7	8	9	10		
Source	GB	FR	BE	NOS	DE	NL	BIC	ATL	IE	ES	Others	Sum
kt(N)/yr	0.8	0.8	0.7	0.6	0.3	0.3	0.1	0.1	0.1	0.1	0.2	3.9
%	22	20	17	15	8	7	2	2	1	1	4	100
(ox-N)%	54	31	11	100	45	29	100	100	40	43	68	48
(re-N)%	46	69	89	0	55	71	0	0	60	57	32	52
EEZ189	1	2	3	4	5	6	7	8	9	10		
Source	GB	NL	NOS	DE	FR	BE	BIC	IE	PL	ATL	Others	Sum
kt(N)/yr	14.2	8.2	8.1	8.0	6.3	3.4	1.2	1.0	0.9	0.9	3.8	56.1
%	25	15	14	14	11	6	2	2	2	2	7	100
(ox-N)%	58	24	100	36	37	34	100	39	61	100	61	54
(re-N)%	42	76	0	64	63	66	0	61	39	0	39	46
EEZ190	1	2	3	4	5	6	7	8	9	10		
Source	DE	GB	NOS	NL	FR	BE	DK	PL	BIC	IE	Others	Sum
kt(N)/yr	12.8	6.8	5.2	4.9	2.9	1.5	1.1	1.1	0.7	0.6	3.3	41.0
%	31	17	13	12	7	4	3	3	2	1	8	100
(ox-N)%	23	63	100	32	42	54	33	60	100	41	70	50
(re-N)%	77	37	0	68	58	46	67	40	0	59	30	50

Table 23. Continued.

EEZ191	1	2	3	4	5	6	7	8	9	10		
Source	DE	DK	GB	NOS	NL	FR	PL	BAS	BE	SE	Others	Sum
kt(N)/yr	11.5	9.1	8.5	6.6	3.6	3.4	2.9	2.2	1.5	1.2	7.2	57.6
%	20	16	15	11	6	6	5	4	3	2	12	100
(ox-N)%	41	16	63	100	49	42	53	100	58	42	63	54
(re-N)%	59	84	37	0	51	58	47	0	42	58	37	46
EEZ209	1	2	3	4	5	6	7	8	9	10		
Source	FR	ES	ATL	GB	NOS	DE	BIC	IE	BE	NL	Others	Sum
kt(N)/yr	35.0	12.8	12.1	10.5	7.6	4.8	4.7	2.7	1.9	1.9	4.9	98.9
%	35	13	12	11	8	5	5	3	2	2	5	100
(ox-N)%	20	38	100	59	100	52	100	32	46	51	62	51
(re-N)%	80	62	0	41	0	48	0	68	54	49	38	49
EEZ212	1	2	3	4	5	6	7	8	9	10		
Source	BIC	GB	DE	NOS	FR	RU	PL	NO	NL	ATL	Others	Sum
kt(N)/yr	7.4	3.1	2.8	1.2	1.1	1.1	0.9	0.9	0.8	0.8	4.5	24.4
%	30	13	11	5	5	4	4	4	3	3	18	100
(ox-N)%	100	47	34	100	27	32	33	61	39	100	41	63
(re-N)%	0	53	66	0	73	68	67	39	61	0	59	37
EEZ213	1	2	3	4	5	6	7	8	9	10		
Source	GB	NOS	FR	DE	IE	BIC	ATL	NL	BE	ES	Others	Sum
kt(N)/yr	92.2	26.1	24.3	21.1	20.9	13.0	12.4	9.5	5.7	4.9	22.2	252.4
%	37	10	10	8	8	5	5	4	2	2	9	100
(ox-N)%	47	100	32	46	28	100	100	48	49	39	61	56
(re-N)%	53	0	68	54	72	0	0	52	51	61	39	44
EEZ215	1	2	3	4	5	6	7	8	9	10		
Source	BIC	RU	GB	DE	NO	ATL	NOS	PL	FR	NL	Others	Sum
kt(N)/yr	8.8	5.1	2.3	2.2	1.4	1.4	1.0	1.0	0.9	0.6	4.5	29.0
%	30	18	8	8	5	5	3	3	3	2	15	100
(ox-N)%	100	38	47	37	76	100	100	37	28	42	47	65
(re-N)%	0	62	53	63	24	0	0	63	72	58	53	35
EEZ216	1	2	3	4	5	6	7	8	9	10		
Source	GB	DE	NOS	NO	BIC	FR	ATL	NL	DK	PL	Others	Sum
kt(N)/yr	30.3	20.3	20.0	18.4	10.6	8.9	8.3	6.6	6.5	5.7	29.0	164.6
%	18	12	12	11	6	5	5	4	4	3	18	100
(ox-N)%	61	48	100	62	100	40	100	54	37	52	60	66
(re-N)%	39	52	0	38	0	60	0	46	63	48	40	34
EEZ224	1	2	3	4	5	6	7	8	9	10		
Source	BIC	GB	DE	NOS	FR	NO	ATL	NL	IE	RU	Others	Sum
kt(N)/yr	3.0	2.5	1.5	1.2	0.9	0.8	0.7	0.5	0.5	0.4	2.9	14.9
%	20	17	10	8	6	6	5	3	3	3	19	100
(ox-N)%	100	55	47	100	35	74	100	52	32	52	53	68
(re-N)%	0	45	53	0	65	26	0	48	68	48	47	32
EEZ273	1	2	3	4	5	6	7	8	9	10		
Source	ES	ATL	FR	BIC	GB	PT	DE	NOS	MED	NOA	Others	Sum
kt(N)/yr	23.3	13.6	12.3	5.5	3.3	2.9	2.6	1.9	1.3	1.2	4.1	72.0
%	32	19	17	8	5	4	4	3	2	2	6	100
(ox-N)%	35	100	27	100	61	55	51	100	100	61	48	58
(re-N)%	65	0	73	0	39	45	49	0	0	39	52	42

7 Conclusions

The main outcome from this work can be summarised as follows:

- Emission data have been provided by the EMEP Centre for Emission Inventories and Projections (CEIP) for the 1990s (based on 2019 data submissions from Contracting Parties) and for the 2000 to 2019 period (based on 2021 data submissions from Contracting Parties);
- emissions of oxidized nitrogen show statistically significant reductions in all OSPAR Contracting parties, while emissions of reduced nitrogen have been decreasing significantly only in some countries;
- emissions of oxidized nitrogen come mainly from transport and from power generation, while reduced nitrogen emissions are mainly due to agriculture;
- based on emission data from CEIP and meteorological data from ECWMF (European Centre for Medium-Range weather forecasts), EMEP MSC-W has calculated nitrogen depositions to OSPAR regions and Exclusive Economic Zones (EEZs) for the 1990 to 2019 period;
- in all OSPAR Regions, actual (non-normalized) deposition of *oxidised* nitrogen was clearly lower in 2019 than in 1995, with the maximum decline in Region V (57%);
- the difference between 1995 and 2019 shows a decrease in the actual deposition of *reduced* nitrogen, too, in all OSPAR Regions, in the range of 6-19%, although this decrease is much lower than in the case of *oxidised* nitrogen;
- concerning actual deposition of *total* nitrogen, there is a decline between 1995 and 2019 in all OSPAR Regions, in the range of 28-46%, with the largest decline in Region V and the smallest in Region II;
- in all considered EEZs, there is a clear decrease in the actual deposition of *oxidised* nitrogen between 1995 and 2019, in the range of 19-61%;
- in 17 EEZs, actual deposition of *reduced* nitrogen was smaller in 2019 than in 1995 (by up to 26%), while in the other considered EEZs it has increased (by up to 18%) with respect to 1995;
- in all considered EEZs, the actual deposition of *total* nitrogen has decreased from 1995 to 2019, in the range of 9-50%;
- it has to be noted that inter-annual variability in nitrogen depositions is large, mainly due to meteorological conditions. Therefore, changes have been calculated for this report also for the 5-year period 2015-2019 with respect to the 5-year period 1995-1999. That calculation shows decreases in all OSPAR Regions and EEZs (except EEZs 91 and 190 in the case of *reduced* nitrogen deposition);
- normalized depositions of oxidized and reduced nitrogen were lower in 2019 than in 1995 in all OSPAR Regions and in all EEZs. Among the OSPAR Regions, the largest decreases in oxidized nitrogen deposition (about 50%) occurred in OSPAR Region II and in EEZ189. The largest decrease in reduced nitrogen is modelled for EEZ188 (29%). Among OSPAR Regions, the largest decrease in reduced nitrogen is in Region II (18%);
- source-receptor relationships (source apportionment) have been calculated, and the Top-10 contributors have been identified for all OSPAR Regions and EEZs;
- in general, receptor areas are most influenced by the countries adjacent to them, but large emitters can make important contributions even if they are far away, mainly as oxidized nitrogen deposition;

- contributions tend to be larger for sources located upwind of the receptor area, ‘upwind’ usually meaning ‘west of’ in the annual average;
- the largest contribution to nitrogen deposition in OSPAR Regions II and III is made by the United Kingdom, while OSPAR Region IV receives the single-largest contribution from Spain; the more remote Regions I and V are strongly influenced by the boundary condition (i.e. sources outside the EMEP model domain);
- for the first time this year, also ‘partial’ EEZs’ (parts of EEZs within different OSPAR Regions) and COMP4 Assessment Units (as defined in a file provided by OSPAR in May 2021) have been considered;
- in all COMP4 Assessment Units, normalized deposition of *oxidized* nitrogen was clearly lower in 2019 than in 1995, with the largest decrease in ECPM2 (55%);
- among COMP4 Assessment Units, normalized deposition for *reduced* nitrogen shows both decreases and increases since 1995: the largest *decrease* (56%) is modelled in NAAC1D (“Noratlantic Area NOR-NorC1(D5)D”) while the largest *increase* (32%) is in OWCO (“Ocean Waters CO (D5)”);
- the 5-year average oxidized nitrogen deposition decreases in all COMP4 Assessment Units, and reduced nitrogen deposition in most of them. Some increases are seen, the largest one (24%) in HPM (“Humber Plume”);
- a detailed uncertainty analysis for the results concerning COMP4 Assessment Units was beyond the scope of this study but we consider uncertainties for the smallest COMP4 Assessment Units as rather large (as was already mentioned in the contract); this is particularly true for those Areas that have a very thin and elongated shapes.

This year the trend calculation was extended back to 1990. However, in this report we focus only on the 25-period from 1995-2019 in order to be consistent with previous report and also because the emission data for the 1990s were not updated for modelling this year. Nevertheless, model results for all years back to 1990s are included in the Excel data sheets provided to OSPAR as an attachment to this report (Chapter 8).

8 Accompanying data sheets

As the numbers of sources and receptors relevant to OSPAR have become quite large, not all results could be shown in this report. Several data files have thus been submitted along with this report. They can be downloaded from https://emep.int/publ/ospar/2021.

a) N_depositions_OSPAR_2021 (Excel format) : Actual and normalized depositions of oxidized, reduced and total nitrogen to all OSPAR receptors of interest in the period 1995-2019. The data for actual depositions extend back to 1990. The Excel file also contains a 'README' sheet for information about versions, units, contact details, etc., as well as a sheet with definitions of all receptor areas considered in this work (i.e. OSPAR Regions, EEZs, partial EEZs and COMP4 Assessment Units, as included in the EMEP MSC-W model domain).

b) SR_OSPAR_normalized_2021 (ASCII format) : All contributions to OSPAR Regions, EEZs and partial EEZs. Tables for each source-receptor pair are preceded by a header specifying:

- the species, i.e. oxidized nitrogen ("ox-N") or reduced nitrogen ("re-N")
- the unit (Mg(N)/year = tonnes(N)/year)
- the receptor ("Basin"), and the source country ("Source") abbreviated by its Alpha-2 code.

OSPAR regions I to V are abbreviated as 'OR1', 'OR2', … 'OR5' in the file. An example screenshot is shown in Figure 17. Minimum and maximum values are given in addition to the Normalized value. The column 'Annual' is for internal checks only and should not be used.

c) NOx_emis_for_OSPAR_2021 (Excel format) : Emissions for oxidized nitrogen (NOx) from OSPAR Contracting parties, as provided by CEIP for modelling purposes. The Excel file also contains a 'README' sheet for information about versions, units, contact details, etc.

d) NH3_emis_for_OSPAR_2021 (Excel format) : Emissions for reduced nitrogen (ammonia) from OSPAR Contracting parties, as provided by CEIP for modelling purposes. The Excel file also contains a 'README' sheet for information about versions, units, contact details, etc.

```
Ox-N deposition in Mg(N)/year: Basin=OR4; Source=SI
Year     Minimum  Normalised      Annual     Maximum
1995       26.61       30.37        0.00       31.94
1996       27.61       31.51        0.00       33.14
1997       27.14       30.97        0.00       32.57
1998       24.54       28.01        0.00       29.46
1999       22.05       25.17        0.00       26.47
2000       21.89       24.98        0.00       26.27
2001       22.02       25.13        0.00       26.43
2002       21.86       24.95        0.00       26.24
2003       20.57       23.48        0.00       24.69
2004       20.06       22.89        0.00       24.07
2005       20.28       23.14        0.00       24.34
2006       20.48       23.37        0.00       24.58
2007       19.95       22.77        0.00       23.95
2008       21.32       24.32        0.00       25.58
2009       18.10       20.65        0.00       21.72
2010       17.89       20.42        0.00       21.47
2011       17.58       20.06        0.00       21.10
2012       17.00       19.40        0.00       20.41
2013       15.99       18.25        0.00       19.19
2014       14.43       16.47        0.00       17.32
2015       13.02       14.86        0.00       15.63
2016       12.80       14.61       15.36       15.36
2017       12.59       14.37       14.86       15.11
2018       11.99       13.68       14.19       14.39
2019       10.88       12.42       10.88       13.06

Ox-N deposition in Mg(N)/year: Basin=OR4; Source=SK
Year     Minimum  Normalised      Annual     Maximum
1995       11.63       21.57        0.00       32.75
```

Figure 17: Screenshot of the source-receptor data table provided along with this report, containing contributions from all OSPAR Contracting Parties and other sources in the EMEP model domain to the OSPAR Regions, EEZs and partial EEZs. The example shows SI (Slovenia) and SK (Slovakia) contributions to OSPAR Region IV (OR4). The column 'Annual' is for internal checks only and should not be used.

9 References

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